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British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Amendment Procedure

Amendments to the Field Operations Manual will be made in the form of replacement pages. At every issue of an amendment, the following will be included:

i) A summary of pages to be removed and pages to be inserted.

ii) A checklist of pages (identified by page number and date).

iii) An acknowledgement slip.

Once the manual has been amended, the record of amendments shown below must be signed and dated. The acknowledgement slip should be signed and returned to the Operations Manager at BAS Cambridge.

RECORD OF AMENDMENTS

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British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Introduction

The purpose of this manual is to provide a concise reference for all British Antarctic Survey (BAS) field operations.

For safety and efficiency in field travel, it is necessary to be familiar with the skills and techniques covered in this manual. It is unlikely that new recruits will be suitably experienced as many of these techniques are specific to BAS and Antarctic operations. Extensive training is given and an experienced staff member often mentors new recruits.

Compliance with the procedures and advice contained in this guide does not absolve staff of their responsibilities, particularly with respect to awareness of hazards and the safety of companions. It cannot be stated too often that safety is the prime consideration when operating in the Antarctic.

If more detailed information is needed the following BAS manuals and documents should be consulted:

- The Field Manual.
- The Work Manual.
- Air Operations Manual.
- Boating Manual.
- Rothera Sea-Ice Guide.
- Procedures database.
- Kurafid.
- Training Syllabus.
- Waste Management Handbook.

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1 Planning and training for field travel

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Introduction

BAS activities cover a large geographic area, ranging from the subantarctic islands to below 80° south. Despite the variety of conditions and locations the same basic rules apply when undertaking Antarctic fieldwork.

BAS field travel is a year round activity. Summer field travel is for scientific purposes. Winter field travel is for recreational purposes. Wintering staff are given the opportunity to have time away from the stations. This can either be in tents or field huts.

BAS employs dedicated Field Assistants in the role of field travel specialists. They are selected because of their mountaineering knowledge and experience.

New Field Assistants are expected to take responsibility for field logistics and safety. In their first season, however, they usually work with experienced field staff in order to develop Antarctic specific knowledge.

Key skills for operating in the field

- The ability to make safe decisions.
- Alpine mountaineering experience and ability.
- Appropriate training for the tasks being undertaken.
- The ability to learn new skills and techniques.
- A methodical and organised approach.
- Knowing your limits and the group's limits.
- Effective communication with the group.
- Not putting your personal ambitions first.
- Common sense.
- An aptitude for practical problem solving.

Judgement

The Antarctic is a very large and remote continent where extreme weather and environmental conditions combine to make it a very serious place. There are no quick fixes if problems occur. In winter there are no aircraft on a continent bigger than Australia.

The underlying principle behind all Antarctic travel is the need to apply conservative and reasoned judgements to all decisions. Accidents often result from a chain of events caused by a number of small errors and bad decisions that eventually snowball into a serious situation.

The more you stack the odds against yourself, the greater the chance of coming to grief. Take the safe approach every time.

1.1 Pre-deployment training

Before undertaking fieldwork it is necessary to familiarise yourself with all the relevant skills outlined in this manual.

BAS puts field staff through basic training programmes starting with the Cambridge Induction Conference, then on to field training in Derbyshire before further training on station.

It is essential that the skills taught are reinforced through practise, the consultation of peers and reading other source material.

Listed below are the field-related training schedules that are undertaken by staff as part of the induction process into the working methods and practices of BAS.

Cambridge Induction Conference

For new recruits this will be their first contact with BAS operations and field matters. The conference deals with broad principles and in particular, attitudes towards safety. It does not cover field travel techniques in any depth. A basic first aid course makes up part of the conference.

Derbyshire field training

This three-day training course is primarily intended for all staff that will travel off-station. The topics covered include campcraft, safety in tents, radio operation, mountaineering equipment, crevasse rescue techniques and navigation. The training is modular and is reinforced as one proceeds through the system. A training log is started at the field course.

Station induction

Training varies according to the station but the following topics are commonly covered on arrival - station equipment, waste management, station vehicles, communications, meteorological observations, aircraft safety/shutdown, field medicine and Ski-Doo operation (while BAS uses a variety of different makes, all snowmobiles are commonly referred to as Ski-Doos).

Station field training

Staff will undergo varying levels of field training depending on their role. Modules will cover areas such as campcraft, snow craft, introductory mountaineering skills, crevasse rescue and unit travel.

Field Assistants and some wintering staff will receive additional training in sea-ice travel, paramedic training, search and rescue training and Ski-Doo maintenance.

1.2 Preparation for field travel

Equipment preparation

Standard field equipment lists are included in Chapter 26. Depending on the circumstances, equipment for a given trip will vary. What should not vary is the standard of preparation applied to any equipment to be taken into the field.

Although field equipment maintenance and overhaul is carried out over the winter, all equipment should be checked prior to departure. It is the individual's responsibility to check their equipment.

Check the history of the tents or sledges from their maintenance logs. If a procedure is unfamiliar, ask for advice. Do not use out of date equipment (see Section 8.11 for information on equipment redundancy).

Preparation for transport to and from field areas

At stations where air operations are run, it is essential to ensure that all equipment is weighed before departure from the station and the aircraft load sheets are filled in. Pilots have preset weight limits and will sanction what is taken. New load sheets should be made up in the field for flight transfers to the station or another work area.

NB. If not travelling with your field kit during site transfers, ensure essential equipment is retained until you are transported. This should include equipment such as sleeping bags, radio, tent, food, fuel and cooking equipment. This applies to boat pick-ups, helicopter or fixed wing flights.

Do not leave yourself without essential equipment and a partner.

In preparation for a move by boat or aircraft ensure that all equipment, except the radio, is packed and ready to be moved. The pyramid tent will usually be left up but the pegs and valance should be dug out so that it can be packed away quickly.

Special preparation may be required for a boat-deployed field party. It is essential that all equipment is packed in watertight packaging and that the equipment is cleaned with fresh water immediately after boat transfers.

For more information about air transport see the BAS Air Operations Manual and Chapter 16 of this manual. For more information on support by helicopter operations see Chapter 25.

1.3 Planning field work

There are various sources of information that should be consulted before deployment into the field.

These include:

- Maps.
- Reports from previous field parties.
- Aerial photographs.
- Depot log.
- BAS personnel with area knowledge.

Although they are constantly being improved, Antarctic maps are often of very poor resolution and accuracy (see Chapter 6). Aerial photographs are excellent as navigational aids and also for planning purposes. Reports from previous field parties can provide a wealth of relevant information.

The depot log should also be consulted. This is kept in the Field Operations Manager (FOM)/Base Commander (BC) office and gives information on the position of depots, stocks held, escape routes and dates of the most recent visits. This information should be built into the project logistics planning.

Take care when trying to correlate information from maps and GPS fixes. Ground truthing on many Antarctic maps is not good and map errors can be large.

1.4 Pre-deployment procedures for scientific parties

A party will be deemed ready for the field only after meeting all the requirements for training, preparation and planning. Once ready, the BC/FOM should be informed. They will check that you are ready for deployment. Aircraft load sheets should also be submitted to the BC/FOM.

When deployment is imminent, your aircraft loads will be depoted on the runway apron at Rothera or on the skiway at Halley. They should be clearly labelled and an aircraft load sheet tied to them.

An operations brief takes place each morning for the pilots. You should be ready to go at this time. Weather and other logistical constraints may mean delays and having to remain on constant standby for days or even weeks.

Pre-departure requirements for field staff

- Complete all the necessary training modules.
- Field unit check and shake down (see the Field Assistant's Work Manual for guidance).
- Acquire any specialist equipment/clothing.
- Advise BC/FOM of readiness for field input.
- Attend BC/FOM briefing, check final project details and submit aircraft load sheets.
- Transfer loads to apron/skyway.
- Ensure lab space is clear, equipment is stored and bedroom space is cleared.

1.5 Recreational field travel

The main purpose of recreational field travel is for staff to have an enjoyable break from station life whilst learning useful Antarctic field skills. They are not intended to be high-risk affairs for the achievement of extreme personal goals.

The Operations Manager (OM) has delegated authority from the Director to approve recreational trips. In winter, the Winter Base Commander (WBC) must submit winter trip requests to the OM for trips of more than two nights in duration.

Trips are scheduled to fit in with the work requirements of the station and other logistical considerations. Recreational travel varies according to station where the nature of the terrain and the levels of experience vary.

Recreational trips are a privilege - not a right.

Short Trips

Permission to conduct trips of up to two nights are granted at the WBC/BC's discretion and only after suitable substitution arrangements have been made for work programmes.

Trips vary according to the station and could be taken by Ski-Doo, boat or ski/foot using sledge-haul techniques.

Permission for trips will only be granted if there is a suitable level of experience within the group. This often means second year winterers going out with new staff. The criteria applied to undertaking scientific fieldwork apply equally to recreational trips. Chapter 26 outlines the equipment required for travel away from station.

Winter trip requests

Two trips are usually allowed each winter within the constraints of normal station operations - one before and one after midwinter. The WBC makes winter trip requests to the Operations Manager, Base Commander and the Field Operations Manager (FOM).

The Base Commander's Handbook gives specific instructions on the requirements for winter recreational trips.

1.6 Post-trip responsibilities

Responsibilities do not end with the return to station or ship at the end of a field trip. A number of tasks need to be completed.

Reports/logs

All Field Assistants are required to write a field report. Reports should cover all aspects of working practices and logistics. It is important that field reports are done conscientiously as they are often the best source of information about a given area for future parties.

Scientists write their own report on the field project and the methods used.

Logs such as the depot logs must be updated with all the necessary information. Unofficial depot equipment must be reported and documented so that it can be retrieved later.

Ensure that the tent and sledge diaries are filled in, noting the usage and condition of equipment and any repairs undertaken. This is very important for on-going maintenance.

A debrief with the BC (or FOM at Rothera) is held when back on station.

Field equipment maintenance

A poorly prepared and maintained field unit can jeopardise the lives of field staff. It is therefore essential that all equipment is dried and packed away ready for subsequent use or servicing over the winter.

Field projects are expensive to mount. The failure or omission of even small items can delay projects, cause inefficient use of aircraft or make daily life difficult. It is imperative that all field equipment is thoroughly and rigorously maintained as per the maintenance schedules set out in the Field Assistant's Work Manual.

The FOM should be notified about any suggestions for changes to equipment or maintenance procedures. They should be recorded in the reports that are returned to BAS Cambridge each season.

Field equipment maintenance logs should be kept up to date so that a complete record is available to all future equipment users.

2 Clothing

Introduction

BAS operations involve a variety of activities in a wide range of climates and locations. Clothing issue will depend on your location and the work being undertaken. This manual will deal only with clothing relevant to fieldwork.

Failure to wear the correct clothing can lead to several potential problems such as:

- Hypothermia.
- Frost nip and frostbite.
- Skin damage due to ultra violet (UV) radiation.
- Eye damage due to UV radiation.
- Cuts and abrasion damage to skin.
- Eye damage through physical means.

For information on the above see the BAS Medical Handbook, Kurafid.

Polar clothing must satisfy the following criteria:

- Withstand wet, cold and windy conditions.
- Keep the body warm.
- Allow the release of perspiration.
- Allow free movement.
- Be easily adjustable.
- Comfortable in all conditions.
- Protect from risks at work.

2.1 The layer system

The basic aim of all polar clothing is to reduce heat loss from the body.

Heat can be lost through:

- Conduction - The transfer of heat through direct contact with colder objects. Insulation slows this process down. This process is exacerbated if clothes and skin become damp or wet from sweating or environmental conditions.
- Convection - The loss of heat through air circulation. Windproof clothing helps to prevent this.
- Radiation - Heat lost by direct transfer to a cooler medium.
- Evaporation - Sweating will increase the risk of heat loss through conduction as clothes become wet.

The layer system works on the theory that it is better to wear several thin layers than one or two thick layers. This allows you to adjust your level of insulation according to activity levels and conditions. Experience has shown that this system is the most effective method of staying warm in the outdoors.

For this system to be effective you need to adjust your clothing when necessary. Be aware of over dressing as well as under dressing as overheating and sweating can result. This can then lead to rapid cooling once your activity level is reduced. Ventilate or adjust the clothing layers to avoid excessive sweating that will dampen clothes. Moisture conducts heat away from the body almost twenty times faster than dry air.

In extreme cold, water vapour on inner garments can freeze. On entering a warmer environment such as a tent, vehicle or building this will thaw out. If ice crystals form within the inner layers of clothing, shake them out before the thawing process starts.

Clothing can be divided into inner and outer layers. The inner layers should provide insulation by trapping air. The outer windproof or waterproof/windproof layer should provide protection against the elements and the tasks being undertaken.

Base layer

The thin first layer is designed to wick moisture away from the skin and provides little insulation. A damp layer next to the skin will increase the heat lost by conduction and also heat loss through evaporation.

This base layer is manufactured from a range of synthetic materials. Materials such as cotton should never be worn next to the skin.

Mid-layers

The insulating mid-layers of clothing are manufactured from fleece and designed to trap air. They can be added or removed in order to regulate body temperature according to activity levels and the prevailing conditions. Other than wool, natural fabrics are not suitable for mid-layers.

Outer layer

The choice of outer garments depends upon both the environment and the activity being undertaken. This outer shell is the main protective layer and guards against hazards such as wind, water, fuels and abrasion. Without a windproof outer layer the risk of hypothermia from wind chill is greatly increased. For information on wind chill see Kurafid.

Outer layers should be roomy enough to allow several layers of inner clothing to be worn beneath and yet still permit easy movement. If the outer layer is too large and loose, a bellows effect develops and the warm, trapped air is lost.

In extreme conditions the outer layer may also be insulated and some BAS stations stock down clothing. Down clothing is very easily damaged and should not be used unless absolutely necessary. One piece, insulated Ski-Doo suits are also supplied. These are very robust and for many activities are much more appropriate than down gear.

2.2 The extremities

The extremities are particularly vulnerable in the Antarctic environment. The main risks come from:

- Cold injury (e.g. frostbite).
- Ultra violet (UV) radiation damage to the eyes and skin.

Cold injury

The extremities are the most vulnerable to cold injury because they are shut down first when the body attempts to maintain warmth.

Ultra violet radiation

The level of UV radiation is far higher in the Antarctic than in Northern Europe and consequently the eyes and skin need special protection.

Sunscreen should be applied frequently to exposed parts - especially the face, neck and ears. Pay special attention to parts that receive reflected UV such as the nostrils.

Eyes

Eyes are particularly vulnerable to the effects of UV radiation. Without eye protection, snow blindness and permanent damage can result. Don't forget that you are equally at risk on dull and overcast days, not just sunny days.

Snow blindness is incredibly painful so don't let it happen. See Kurafid for treatment.

The two main items provided for eye protection are snow goggles and snow glasses (including prescription sunglasses if necessary). In blowing snow and during blizzards, goggles should be worn. Goggles can be worn over most types of spectacles. Before going into the field, check that your goggles and spectacles are compatible. **Always** wear some form of eye protection.

When in the field, both glasses and goggles must be carried to provide a back-up should one form of protection be lost or broken. In an emergency, improvising protection by wearing a balaclava over the eyes is possible. Alternatively, emergency goggles can be fashioned from leather, rubber or cardboard. Cut a narrow slot about 2mm x 30mm for each eye in a strip of material. This can then be attached to the head with string or elastic.

Industrial safety goggles may be required for certain tasks in the field, just as they would be used on station. For most tasks, however, snow goggles will provide adequate protection.

Clear goggles are available for working in windy weather and low light in the winter.

Head

Headgear is issued to protect against the following:

- Cold - Up to 30% of the body's heat can be lost through the head, so wearing the correct headgear is important. The main types of headgear issued are peaked windproof hats, which cover the ears, fabric tubes (headovers), which can be worn as a neck scarf or as a thermal balaclava, fleece balaclavas and neoprene face masks.
- Impact - When travelling on a Ski-Doo, ATV (quad bike) or sledge, a crash helmet must be worn to provide protection in the event of an accident. A helmet also helps to keep the head warm and reduce engine noise. Most crash helmets are fitted with press-studs onto which visors can be attached. These can help to reduce the effects of wind chill on exposed flesh.
- UV Radiation - Hats also protect against sunburn. A sun hat is a basic and essential item of polar clothing for warm sunny days.

Hands

Great care should be taken to keep your hands warm. A large selection of gloves and mittens are available and your choice of protection depends on the conditions and the work being undertaken.

Make sure that gloves are not too tight and do not underestimate the dangers caused by constriction. Tight cuffs can also cause restricted blood flow.

Mittens are warmer than gloves because the fingers are in contact and keep each other warm. The down side to mittens is a loss of dexterity.

Leather and rubber coated work gloves are provided to protect hands from cuts, abrasion and other damage. These are not as warm as other hand-wear but give better dexterity for some handling tasks.

Powered hand tools can be a factor in causing cold injury. Operators should ensure that they check periodically on the condition of their hands and take breaks when using power tools in the extreme cold.

It is a good idea to keep gloves on elastic wrist loops or a tape harness to avoid loss when taking them off in windy conditions. It is essential to carry spare gloves in the field.

Be very careful not to spill fuel on your gloves or hands because:

- Fuels remain liquid at very low temperatures.
- Wet gloves will increase heat-loss through conduction.
- Evaporation causes cooling.

Never use bare hands when handling cold objects (not just metal) because they can freeze to the object. As skin may be lost attempting to tear fingers free, use a warm liquid (a readily available source is urine) to thaw them apart.

Feet

Your choice of footwear depends upon climate, conditions and any special applications.

Where the weather is wet (such as at Bird Island) rubber boots with plastic insoles and two pairs of loop stitch socks are effective. In colder areas, plastic mountain double-boots with an exchangeable inner may be more applicable. In extreme cold, Mukluks with felt insulation, insoles and special inner socks are more appropriate.

Whatever type of boot is being used it is important that they should be large enough to fit feet and socks without being tight. Tight footwear will restrict blood circulation and frostbite could result.

Wet or damp feet are at much greater risk of cold injury. Dampness can be caused by the environment or by sweat. Socks, liners and insoles should be kept dry if possible. They must be removed at night for drying.

Hang them in the apex of the tent or, if the fuel supply is tight, then put damp (not wet) clothing into the sleeping bag overnight. Body warmth will help to dry them avoiding the need to put on cold, wet or frozen socks the next morning.

Do not wear cotton socks in the field as cotton stays damp and insulates poorly.

2.3 General points

Snow glasses, a balaclava and mittens should always be carried. Antarctic weather can change rapidly and clothing is the first defence against it. On all field trips (even a one day trip) carry some spare clothing especially gloves, socks and a balaclava. Emergency clothing bags are part of the standard field kit (see Chapter 26).

Clothing should be kept clean and in good repair. Clean clothing is thermally more efficient than dirty clothing. (See Section 5.6 on Hygiene and health). It is important to avoid contaminating clothes with fuel.

Use the buddy system to ensure your working partners are not suffering from cold injury. Check for frost nip on the face when outside in cold temperatures, especially if there is a breeze or when riding a Ski-Doo.

Some special items of clothing such as down suits and over-boots are not issued as standard. These items are made available through the clothing stores on the stations where necessary. Other items of specialist clothing may be supplied when identified at the project planning stage.

3 Objective dangers

Introduction

Besides the hazards associated with weather, many other natural dangers exist that are beyond your control. The threat from these hazards can be reduced by the application of common sense, knowledge and experience.

3.1 Crevasses

Crevasses are a constant threat on glaciers and present the greatest danger encountered in Antarctic fieldwork. The skills necessary to travel safely on glaciers can only be learnt through time and experience. For more detailed information on glacier travel and crevasse formation see Chapter 9.

Where the risk of crevassing exists it is essential that all party members are roped together, have the necessary equipment and are fully versed in the necessary rescue techniques. This applies whether you are travelling on foot or Ski-Doo.

Great caution needs to be exercised when riding a Ski-Doo in crevassed areas. Although the ground pressure of a Ski-Doo is small, the total mass of the machine, driver, sledge and equipment can be as much as a tonne. These loads will put a weak snow bridge to a severe test.

Always walk through any uncertain areas before driving through them. It is far better to find a hidden crevasse with your foot than drive into it with a snowmobile. A snowmobile entering a crevasse could have serious consequences, even if the correct travel procedures are observed.

Crevasse bridges can be appreciably weaker in the late afternoon after the sun has warmed the snow. Travelling at night may be preferable in some locations. They are usually at their strongest at the end of winter due to maximum snow cover and cold temperatures.

3.2 Altitude sickness

The reduction in the partial pressure of oxygen with height can lead to altitude sickness. Field parties occasionally operate at altitudes of 3,000 metres. Although problems at this altitude are rare, it should not be ruled out.

Acclimatising gradually is the most effective technique in avoiding altitude sickness. Because the use of aircraft makes field deployment so rapid, the risk of succumbing to altitude sickness is increased. For this reason a portable hyperbaric chamber may be taken when staff are deployed to altitudes around 3,000 metres by aircraft. This requirement would be assessed at the project planning stage.

Doctors on station can give advice about prophylactic drugs to protect against altitude sickness before deployment.

Kurafid should be consulted for more information on the prevention, symptoms and treatment of altitude sickness.

3.3 Water hazards

Fieldwork can involve contact with a number of water hazards. Chapter 20 (Sea-ice) should be read in conjunction with this chapter.

Melt-pools

Melt-pools can form in wind scoops, at the base of nunataks/mountain faces or in depressions on glaciers and ice shelves. They can vary enormously in depth and may be open water or ice covered. Great care should be taken when walking over ice-covered melt-pools. Test the ice thickness. For information on ice testing see Chapter 20.

The load bearing capacity of freshwater ice is only half that of sea-ice.

Move very carefully on slopes above bodies of open water. Take a belay if it is necessary to negotiate steep terrain above melt-pools (see Chapter 10).

Working with Ski-Doos on shelf ice may involve travelling through shallow melt-pools and deep slushy snow. To reduce the risks, scout ahead on foot or travel at night when surface conditions are firmer.

Melt-streams

Streams and fast-moving water can be found in the Antarctic Peninsula area. Streams feeding into lakes and the sea can cause areas of thinner ice. Be particularly careful in these areas.

If streams are a problem you may need to:

- Re-route to avoid the obstacles.
- Bridge the obstacle using equipment carried.
- Move by aircraft.

- Work at night if there is a diurnal variation. Lower temperatures may make crossings easier and safer.

Tides

Tidal range can affect coastal travel. A rising tide can result in a party being unable to retreat. Crevassing is often at its most chaotic around the coast and retreat inland may not always be possible.

3.4 Snow conditions

Throughout the Antarctic Peninsula, glare ice, soft wet snow, waterlogged slush, melt-pools, deep dry powder snow and hard wind packed surfaces are all encountered.

These differing surface conditions can affect your route, its timing and fuel consumption. At worst they may even preclude travel completely during certain times of the day or season. If wet conditions are encountered it is often more efficient to travel at night when temperatures are lower and surfaces firmer.

Snow conditions vary with:

- Latitude.
- Altitude.
- Time of year.
- Diurnal variations.
- Wind.

Plan ahead and think about the effect that poor surfaces will have on travel and aircraft pick-up. Forward thinking and the ability to reschedule your plans are essential skills. Never leave yourself without an escape route.

Snow surfaces are often covered in many parallel ridges called sastrugi. They can range in size from a few centimetres, to serious obstacles as large as two metres from trough to crest. They can be as hard as concrete. Sastrugi can indicate the prevailing wind direction and strength.

3.5 Cornices

Cornices are overhanging lips of snow that build up on the leeward edge of ridges, mountains and plateaus. They are often present at the lip of wind-scoops. Cornice collapse is unpredictable and they must always be treated with extreme caution.

Cornices present two main dangers:

- Falling through them.
- Being hit by a collapse when underneath.

From above, cornices are difficult to see. On reaching a summit, or when travelling close to a ridge or plateau edge, be wary of their presence. You should appreciate that the fracture line will be well back from the edge.

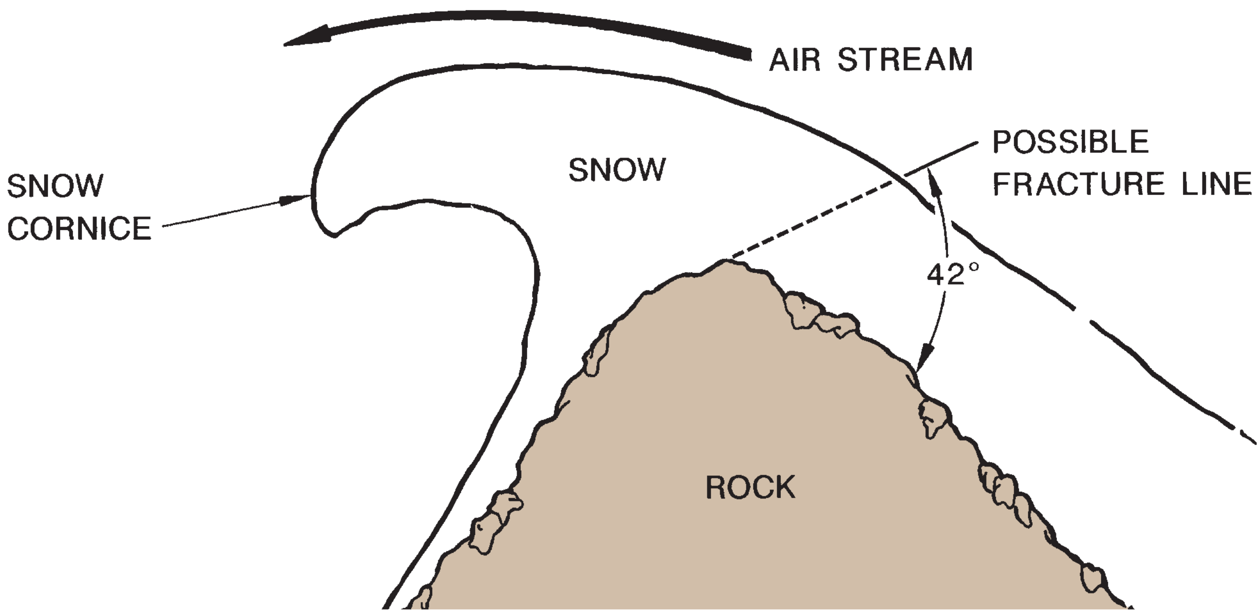


Figure 3.5 Snow cornice showing potential fracture line

Only one person at a time should approach an edge. In many circumstances the risk of approaching a badly corniced summit or ridge is unacceptable.

From beneath, the danger exists that a breaking cornice could trigger an avalanche or the cornice itself could be large enough to injure anyone in its path. Cornices can also hold large icicles that can become lethal projectiles.

Avoid working under cornices especially in confined areas such as gullies that can channel falling debris.

3.6 Coastal ice cliffs and seracs

Coastal ice cliffs and seracs are in a state of constant movement. The stability of these areas is impossible to assess and the risk of collapse is always present. They should always be treated with extreme caution.

Try to avoid coastal routes that traverse under ice cliffs. Take care when traversing close to the coast above ice cliffs as these areas are often heavily crevassed.

Seracs should be avoided. If there is a need to work under them for short periods, work under buttresses or spurs that provide some protection. Faces with seracs should be given a wide berth when travelling beneath them.

3.7 Rockfall

Prevention is the safest option. Would choosing a different route or a different work site reduce the risk?

If you have to work or travel on or near an outcrop:

- Always wear an approved safety helmet.
- Avoid areas of loose rock in zones of concentration such as couloirs and gullies.
- Keep to ridges and prominent buttresses that shed rather than concentrate rock fall.
- The risk will be higher in the afternoons as the ice bonding the rock together melts.
- Do not travel in the fall line beneath another person. If you are above another party be wary of disturbing loose rock. It is better to travel close together so that any dislodged rock can't gather momentum.
- Look for rock in the snow. This indicates recent stone fall.

3.8 Avalanche

Avalanches are the biggest killers in the mountains. They do not discriminate between climbers, skiers, boarders or Ski-Doo riders.

An avalanche risk will always be present when snow settles on sloping terrain. Avalanches occur throughout the year in the mountainous regions of Antarctica. This applies especially to the Antarctic Peninsula and the island groups where BAS operates.

If caught in an avalanche, the risk of injury or death is very high. Due to the very limited rescue back-up available, an avalanche in the Antarctic would be particularly serious.

Types of avalanche

There are two principal avalanche classifications - loose snow and slab avalanches.

Loose snow avalanches

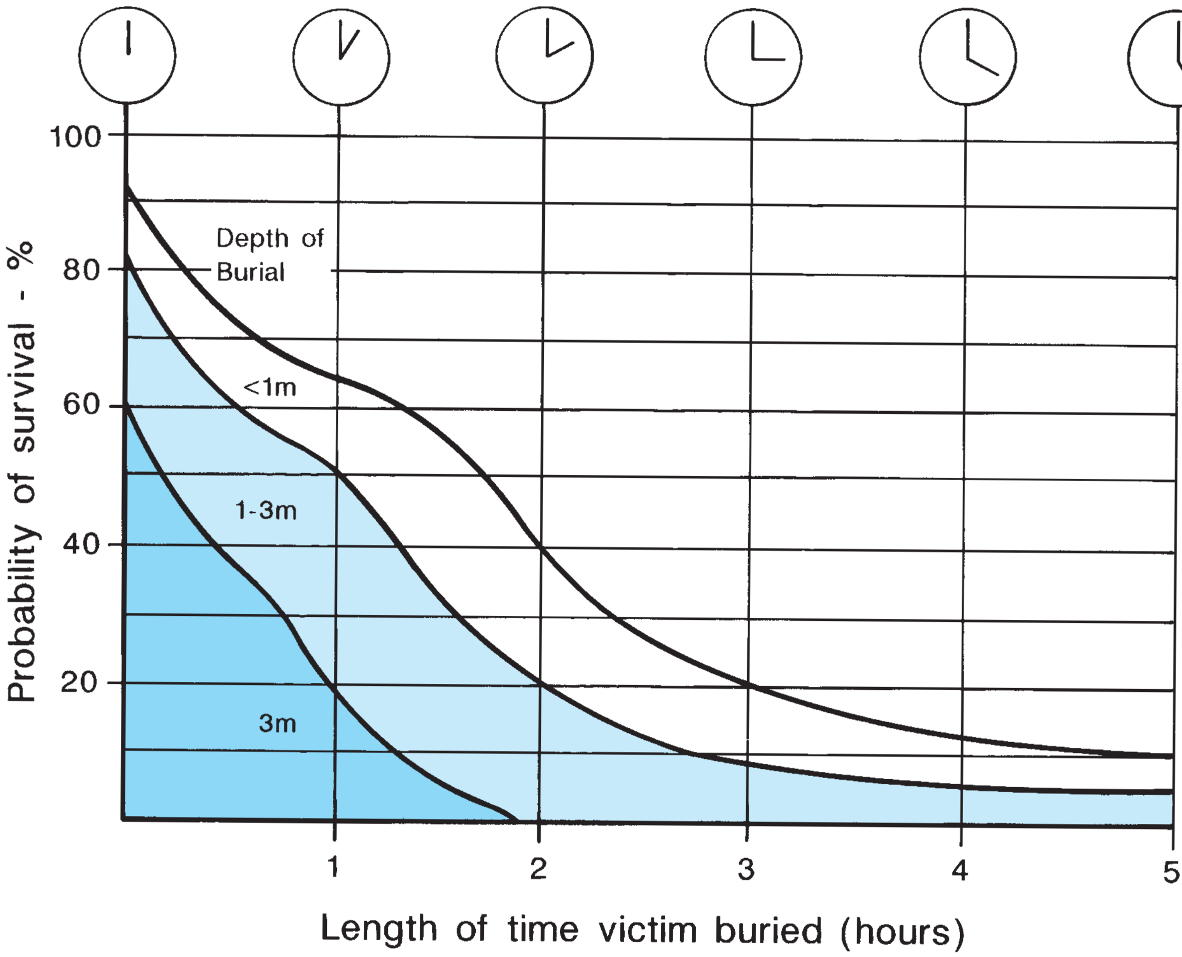
These arise when snow accumulates on a slope steeper than its natural angle of repose and it becomes unstable.

This can happen as a result of:

- Snow falling in little wind.
- Reduction of internal cohesion among snow crystals by metamorphic changes.
- Lubrication of the snow surface from percolating melt-water.

There are two main types of loose snow avalanche:

- Powder - Snow accumulation of more than 35cm poses a strong avalanche danger especially if the rate of accumulation has been greater than 2.5cm per hour. A powder avalanche resulting from this freshly fallen snow is explosive, travelling at very high speeds.
- Wet snow - The most dangerous avalanches involve wet snow in the spring or summer. High temperatures, especially a rise of three to five degrees Celsius after a heavy snowfall, will cause melt-water to break down the bond between snow crystals. This acts as a lubricant on any crusty surfaces below. A wet snow avalanche usually travels slowly, freezing solid when it stops.



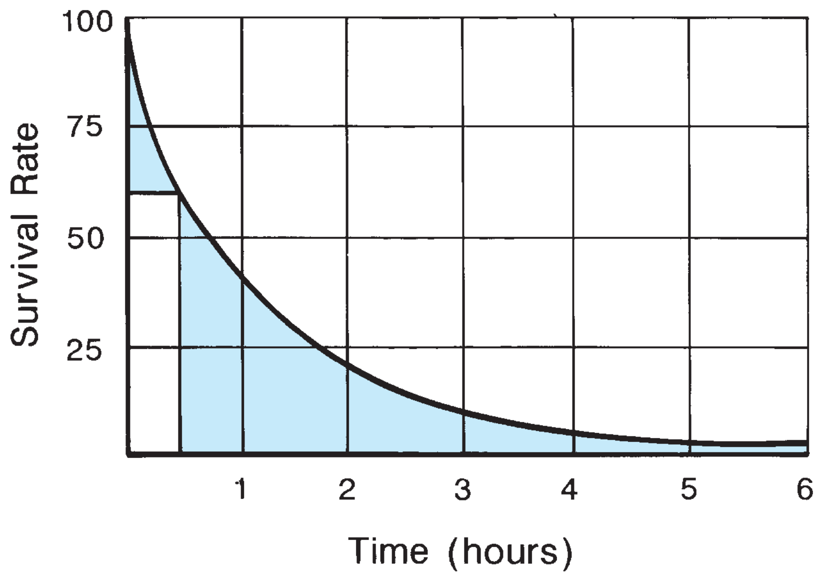


Figure 3.8a **(Top)** *Probability of survival for avalanche victims as a function of time also showing the effect of depth of burial. In Switzerland the survival rate for completely buried victims is 19% (From a study of avalanche accidents by de Quervain).*

(Bottom) *Survival probabilities for buried victims decrease rapidly with time. After half an hour the victim's chances of survival drop to less than 50%. Victim Detectability by Position of Burial*

Person lying on back or stomach	95%
Person on side	75%
Person in vertical position	0%
Person in average position	0%

Rainstorms in winter or spring should always be regarded with caution until the snow has slid or proved itself stable.

Slab avalanches

These usually occur on lee slopes where low temperatures combined with wind-drifted snow result in a hard surface crust/slab. Internal temperature variations within the snow cause hoarfrost crystals to form between this crust and the snow beneath. Hoarfrost has the appearance of sugary snow. These crystals act like ball-bearings between the two surfaces, resulting in the whole of the upper slab avalanching.

Slab avalanches can also be caused when fresh snow or old wind slab are poorly bonded to a harder substrate such as glacial ice or the previous season's neve.

As with many avalanche conditions, they can be hard to spot. Indicators that a slab avalanche risk exists include:

- Any lee slopes. Consider any recent wind direction, not just the prevailing wind direction.
- Hollow sounding snow.
- Squeaky sounding snow.
- Any surfaces which sounds as if there is slumping beneath your feet.
- Crusty snow breaking off under your boots or skis.

Assessment of slope stability

The following criteria should be considered when assessing a slope's likelihood to avalanche.

- Past weather and temperature. What effects will these events have had on the snow pack and its stability?
- Lee slopes. These are particularly prone to slab avalanche and even more so if facing north towards the midday sun.
- Convex slopes. These create areas of tension in the snow pack and are more likely to avalanche than concave slopes.
- Slope angle. The optimum angle for avalanches to occur is 37.5°. Falling snow cannot accumulate on very steep slopes and will slide off before it can build up to a dangerous depth. On very shallow slopes the snow is too stable to move. This "in between" angle is therefore the most dangerous. These are broad principles and there will always be exceptions to the rule - slopes as shallow as 15° have been known to avalanche.

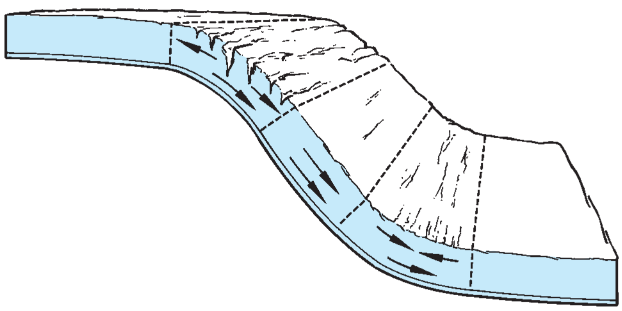


Figure 3.8b *The tendency for the snow to creep and glide downhill under the influence of gravity creates an area of compression at the bottom of the slope where it is concave and an area of tension at the top where it is convex. It is in the convex part of the slope that an avalanche is most likely to be released.*

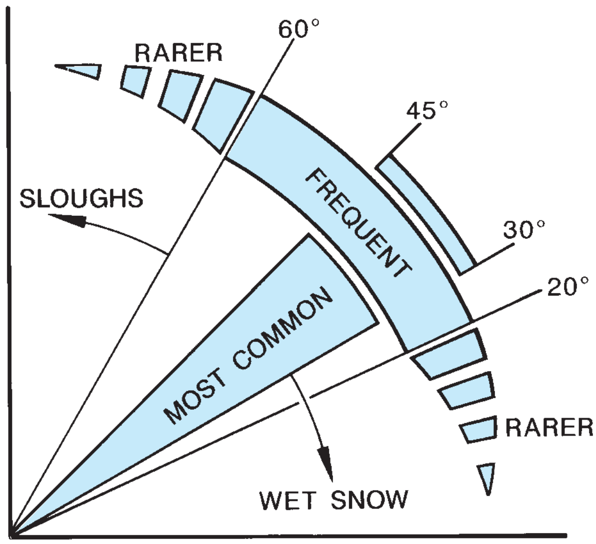


Figure 3.8c The frequency of avalanches in relation to slope angle

The most frequent and devastating avalanches occur on slopes between 30° and 45°.

- Snow pack. A cross-section through the snow pack will show the structure of the various layers and their cohesion to one another.
- Slope surface. What is the snow-pack itself bonded to? A higher risk will exist if is lying over a smooth grass slope or a large slab of rock.

Avalanche triggers

When a snow-covered slope reaches a critical state of instability there is often a definite triggering force that sets it in motion.

External triggers include:

- Falling cornices.
- Icicles.
- Rock fall.
- Human activity.

Internal triggers include:

- Temperature changes.
- Overloading by snowfall.

Assessing the snow pack

A cross-section through the snow pack will show the structure of the various layers and their cohesion to one another. If no weak layers or unusual influences are present it may be safe.

Basic assessment

Probing with an axe or ski stick can provide a quick assessment of the snow pack. This is a very basic test and is limited to the depth of the ice axe.

Push the shaft of the axe into the snow at right angles to the slope. Use a repetitive tapping action to penetrate the snow. With practice it is possible to feel the resistance of the different layers through the pack. An increased resistance with depth and no variation in the layers would be the safest result.

Snow pits

Snow pits enable the hardness of snow layers to be assessed. Large variations in snow hardness in adjacent layers will suggest a higher avalanche risk. Gradual changes of snow hardness with depth indicate a stable snow pack.

Figure 3.8d shows how to dig a snow pit and do a shear test on the snow pack. Once the cuts are made next to the test block, the likely point of shear within the snow-pack can be assessed. This method needs a good deal of practice to develop interpretive skills.

Digging a snow pit will only tell you about the snow conditions at that exact location. To know the exact state of a slope, you need to know the condition at the most avalanche prone part of the slope. However, do not put yourself at risk in order to make a representative assessment.

Wet snow avalanche assessment

If water can be squeezed out of the snow, then the pack is in a high state of saturation. In these conditions there is a high risk of a wet snow avalanche.

Precautions when travelling in avalanche prone areas

- If you suspect there is a risk, find an alternative route.
- Study the terrain and consider the weather history.
- Be wary after weather changes such as new falls of snow, wind-deposited snow, a thaw or rain.
- Keep clear of lee slopes and corniced slopes.
- Keep high on the slope or on the ridges to avoid being the trigger.
- Ascend or descend a doubtful slope directly as traverse lines can trigger avalanches.
- Stick to buttresses and ridges and avoid gulleys and bowls.
- Consider belaying your partner if a suspect slope has to be crossed.
- Be on the lookout for warning signs such as cracking snow, snowballing caused by the sun or wind, a hollow sound or feeling to the snow or the collapse of the crust under your weight. The most reliable clue will be evidence of previous avalanches. However yours may be the first.
- Avoid dubious slopes above hollows and depressions (terrain traps). The snow from an avalanche would accumulate to a much greater depth in these areas than if it was strewn across an open slope.

Actions if caught in an avalanche

The following may improve your chances of survival:

- Throw off skis and rucksack. Ski leashes should be removed if an avalanche risk exists. Consider using ski brakes instead of leashes.
- Estimate your position and best chance of escape.
- Try to hold partners caught in the track of an avalanche. Ice axe brake to arrest your fall.

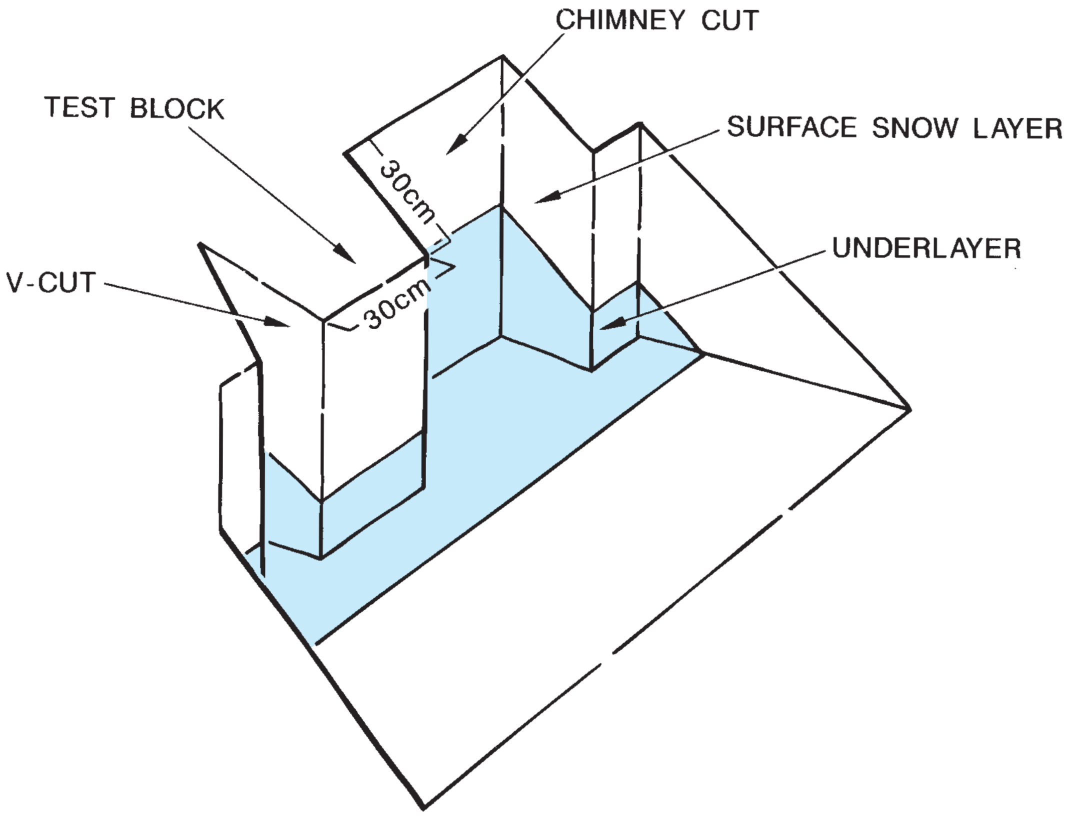
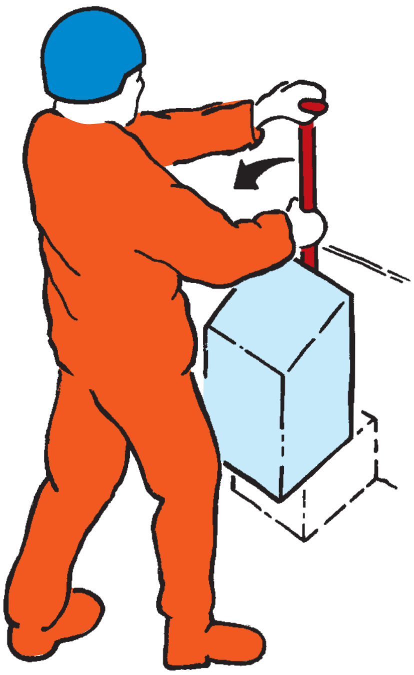


Figure 3.8d Constructing an ice pit to measure the risk of avalanche
(Top) *The vertical back wall of the bench is excavated to leave a pillar standing out.*

(Bottom)
a) *A bench is cut into the snow to expose the surface layer and the top of the underlayer.*
b) *A shovel (or an ice axe or the heel of a ski) is carefully inserted at the back of the pillar. A gentle pull is then applied to the shaft in a horizontal direction until the pillar of surface snow separates from the underlayer. The ease of separation is a measure of the adhesion of the surface layer to the layer below and provides useful evidence of the likelihood of a slab avalanche.*

Degree of risk	Indication
Very high risk	Surface slab slides-off when axe or shovel is inserted.
High risk	Light pressure releases the slab.
Some risk	Moderate pressure releases the slab. In this case other evidence should be carefully evaluated before making a decision.
Low risk	Sustained pressure required to release the slab.
No risk	Surface slab cannot be released even with sustained pressure.



- Attempt to stay near the surface. Being close to the surface will greatly increase your chances of survival.
- Swim on your back and if possible roll to the side of the flow.
- Keep your mouth shut. An avalanche victim will usually have lumps of snow in both the mouth and the nose.
- Thrust your arm up as you stop moving. Orientate yourself by using saliva from your mouth.
- If buried it is essential to maintain an air space.
- Stay calm and try to control your breathing rate. This will extend your air supply.

Avalanche search techniques

These are covered in Chapter 22.

Avalanche prediction is a complex subject and it is beyond the scope of this manual to cover it in any depth.

3.9 Wildlife considerations

Work on the coast may involve contact with both seals and birds. There are a number of potential risks to consider.

Seals

A number of species of seal may be found in the BAS operational area. Some species are more aggressive than others but all seals should be treated with caution. Beaches with breeding seals are particularly dangerous for those with limited experience of dealing with marine mammals.

All seals are large, carnivorous and have sharp teeth. Although some species may appear sluggish on land they can all turn and move surprisingly quickly over short distances. Treat them with respect and do not approach too closely.

Fur seals are highly aggressive and actively chase people. The following precautions should be followed when passing near fur seals:

- Choose a route that minimises contact with the seals.
- Carry a stick to provide protection. Touching of the whiskers is usually enough to deter a threatening seal. Avoid overzealous use of the stick such as prodding as this can make the seal more aggressive.
- Loose clothing should be worn. The seal will often attack the clothing rather than the person.
- In areas of high seal density try and work in pairs.
- Take extra care when wearing hoods or sunglasses with side-shades, these will cause a loss of peripheral vision.

Seal bites can be extremely nasty and often become infected. Any seal bite, however minor, must be reported to either a doctor or the Base Commander.

Leopard seals may present a hazard onshore or on sea-ice. There have been known attacks of people through sea-ice. These are extremely aggressive carnivores and should be treated with extreme caution.

Penguin colonies

Movement around penguin colonies can be hazardous as heavy guano contamination makes underfoot conditions extremely slippery. This is a particular hazard on sites where there is potential for falling into the sea.

Nesting birds

Birds will adopt attacking or warning behaviour in order to protect their eggs and offspring. This can lead to slips and falls so try to avoid nest sites.

4 Campcraft

Introduction

BAS uses a variety of tents. The most commonly used, and the basis for Antarctic travel, is the pyramid tent. A small emergency tent called a pup tent is always taken as a back-up.

Although heavy and very traditional in design and construction, the pyramid has proved itself to be the best tent for the Antarctic. A properly pitched and anchored tent can withstand winds in excess of 80 knots. The penalty is a pyramid's weight - approximately 47kg.

Traditionally the BAS camping system has been based around a two-person set-up, but three people sharing is becoming increasingly common. Three person pyramid tents are available for these projects.

Other tents that may be used include:

- North Face VE25 (aircraft, SAR, lightweight work tents).
- Weatherhaven work tents.
- North Face two metre dome (Dash 7).
- Collapsible pyramid (northern Peninsula).
- Old pyramids converted to work tents.

Although modern geodesic mountain tents are very strong, none are capable of withstanding the high winds and pressure of snow accumulation as successfully as the Antarctic pyramid. The pyramid also has to undergo the rigours of life in the field. This is very hard on both people and equipment.

If geodesic tents are to be used for purposes other than emergency use, the FOM should be consulted.

Before embarking on any trip it is essential that all the kit is checked and that all party members are familiar with it. Never leave on a trip without inspecting your tent and knowing how to erect it in strong winds.

BAS policy states: There is no single user occupancy of tents.

4.1 Camp location

Before setting up a camp, be it permanent or temporary, careful thought should be given to its location. It is beyond the scope of this manual to go into great depth on this subject. As with many field decisions the question should be asked, "what if?"

It is almost impossible for a correctly pitched pyramid to blow away, but a poorly pitched, or poorly sited pyramid will greatly reduce your chances of survival.

Things to consider when selecting a camp site:

- The relationship of the site to the hills, cols and other topographic features in the area. Could you relocate to a less exposed or a less turbulent area?
- Is the site likely to suffer from high accumulation (such as in the lee of hills)?
- Is there an avalanche, serac fall, rock fall or crevasse risk?
- Consider tide and wave action on beach sites particularly along the coast of the northern Peninsula.
- What do the sastrugi tell you about the predominant wind direction?

Basic actions when setting up camp:

- Plan ahead if possible to select a safe site.
- Think about where the strongest wind will come from.
- On arrival decide on a clean area (upwind) for snow blocks and a dirty area (downwind) for the toilet. Put in a pee flag at this stage.
- Try to minimise the amount of carrying you will have to do by setting up the tent close to the sledge.
- Depot surplus equipment and sledges across the wind to reduce drift.

4.2 Basics of pyramid pitching

In good weather pitching a pyramid is relatively straightforward. The first thing to consider is where the strongest winds are likely to come from. Figure 4.6b shows the correct orientation of the pyramid tent to the wind. This will cause the wind to scour away from the tent door. It will also result in better ventilation through the ventilation tube (dongler).

It is important to be proficient at pyramid pitching before going into the field. Good communication and teamwork will make this job much easier.

- Assess where the strongest wind will come from (sastrugi) and work out the correct orientation for the tent.
- Dig out a level platform for the tent to sit in. If the surfaces are soft, dig in well.

- If surfaces are hard, the poles will need to be dug in. In the platform, measure out the width between poles and dig diamond shaped holes to take each of the four pole ends. Have these measurements already in your head or carry a length of string showing the exact distance - tents vary a little. Use whatever method you find most suitable. The holes should be deep enough for the poles to “hang”. See Figure 4.6a for dimensions.
- Lift the tent into position.
- Extend the guys. It is important to extend the guys to the maximum extent whilst still leaving room for tightening. This gives the best angle of pull on the tent fabric.
- Place the pegs so that the guys are at 90° to the tent.
- Go to opposite sides of the tent and tension the guys simultaneously.
- Back-fill the pole holes.
- Peg out the valance. The tent fabric should be taught and smooth. The valance seams should touch the ground.
- Place equipment and snow blocks on the valance as per Figure 4.6a. If using snow blocks, put the crust side to the wind.
- Fine-tune the tent tension if necessary.

Every time you pitch your tent, regardless of the weather at the time and the forecast, it is worth pitching as if a 100-knot blow was expected. Plan for the worst.

4.3 Tent anchors

The pyramid is supplied with tubular pegs and it is essential to place these correctly. If you are pitched in soft conditions, it is wise to check peg placements regularly.

In soft snow conditions, when temperatures rise or when solar radiation is intense, tent pegs often pull through the snow. In these conditions a long thin item can be buried as a deadman anchor (See Section 10.4).

4.4 Ventilation

It is essential to ensure that ventilation is adequate as stoves and lanterns are used in the tent. The ventilation hose (dongler) must be long enough, correctly positioned and secured to both the inner and outer fabrics.

Check that the hose does not become choked with ice due to a build-up on the antenna T-section where it attaches to the end of the dongler.

Check ventilation frequently.

4.5 Storm pitching

Storm pitching should be viewed as a last resort and is to be avoided if at all possible. If the weather is worsening, the decision to set up camp should be made earlier rather than later.

If two parties are travelling together, pool resources to get the tents up. If the wind is too strong then use the pup tent.

Basic actions when storm pitching:

- Dig out a platform and the pole holes.
- Have some heavy boxes and full jerries ready to weigh the valance down.
- Lay the tent down with the apex into wind.
- Put a loop of spare rope around the apex of the tent when it is lying flat. Guy this rope with an Italian Hitch to a snow stake upwind of the tent. As the tent is stood erect pay out the rope and tie-off once the tent is upright.
- Extend the guys.
- Put the two windward pegs through the two windward guys.
- Place the remaining pegs ready for the guys.
- Work as a team on either side of the tent. Grasp the two poles on your side.
- Erect the tent, lifting up the leeward poles to ensure they don’t dig in - this is the trickiest part of the operation.
- One person should hold the windward side of the tent. The other person should peg-out the tent and position the boxes on the valance.
- Finally the tent can be fine-tuned and snow blocks placed on the valance.

Storm pitching will result in the tent door being in the lee or at 90° to the wind. This is normal when storm pitching.

4.6 Setting up camp

The quickest method of organising camp is to have an inside and outside person.

- Once the tent is secure the inside person can enter and lay out the groundsheet.

- Before the inside equipment is passed in, the tent door should be tied open.
- The jerry board, sleeping boards, inside boxes, radio and P-bags are then passed in by the outside person. These are laid-out by the inside person and both beds made ready. The jerry board should be turned upside down and placed beneath the pots and tent box. This will increase the stability of these boxes and create a stable cooking platform. This is much safer than not using the jerry board.
- The pots box and tent box are placed in line from the back of the tent to the entrance. A cooking board separates the two boxes. The inside food box is placed crosswise nearest the door. This locks the boxes in place. See Figure 4.6b and Section 4.8 for further information on the box system.
- The tent valance is weighed down with the jerries and boxes from the sledge. Snow blocks should be used in addition to the boxes. Make sure the valance is fully covered.
- The outside person completes the task of securing the tent, gathers the items needed from the sledge and lashes this securely. The sledge should be anchored in line with the prevailing wind to reduce drifting. Store equipment so that it does not drift-up other equipment or the tent.
- Make sure all the equipment is well marked with flags.
- Ski-Doos should be re-fuelled fully to avoid contamination of the fuel system with condensation and then covered with a tarpaulin.
- The radio aerial needs setting-up, facing the correct direction, with the coaxial feeder running through the ventilation tube to the radio in the tent. Make sure that nothing is in contact with the tent fabric.
- Snow blocks should be cut and placed between the inner and outer tent on the right-hand side looking in. A snow block bag makes carrying blocks easier, keeps storage simple and prevents any contamination. The peg bag, tent bag and footwear normally sit on the left-hand side. To avoid water contamination it is important to conform to the above guidelines. Different parties use tents and common systems should stop tent fabric causing snow block contamination.

  WateR - **Right** as you look in.
  FueL - **Left** as you look in.

  Between the two, a small gash pit may be started for wet waste.
- Once the outside jobs are complete the outside person (usually the Field Assistant) can go indoors to a welcome brew. It is their responsibility to check outside through the night should the need arise.

From arriving to sitting inside with a brew will normally take one to two hours. Breaking camp is only marginally quicker but may take longer if it has snowed.

4.7 Practical hints on tent living

The hallmark of a good traveller is to live as comfortably as possible using the minimum of equipment. In addition you must work as a team. If one person goes out in a blow the other should stand by to help him on his return - take wet clothes in, brush off snow and make a brew.

- Hang as much as is practical in the tent apex to dry but be vigilant to the risk of fire. If using the Tilley lantern with clothes hanging in the apex, suspend the Tilley at the very end of the hanging cord. The cord should have a slipknot so that the lantern can be raised and lowered. Beware of the lantern hood, it gets very hot and can cause serious burns.
- Avoid bringing snow into the tent. Brush it off outside or between the inner and outer.
- Enter and leave the tent as carefully as possible. Take care not to put unnecessary strain on the tent by leaning on the guys, tent outer or entrance tunnel.
- Don't leave pots boiling as this will lead to condensation and rime ice. Never leave a stove or lantern burning in an empty tent or go to sleep with either burning. Untended appliances greatly increase the risk of fire and carbon monoxide poisoning (see Kurafid and Section 5.5). Take the utmost care while cooking on the stove. If it becomes necessary to move around in the tent with the stove running, take any pans off the stove momentarily.
- Sleeping boards are often carried to put under the sleeping set-up. These make life more comfortable and reduce snowmelt under the Lilos. Similarly, placing a jerry rack upside down under the centre boxes will prevent ablation and boxes becoming unstable.
- If the same camp is used for a long period, the tent should be moved periodically. The boxes will

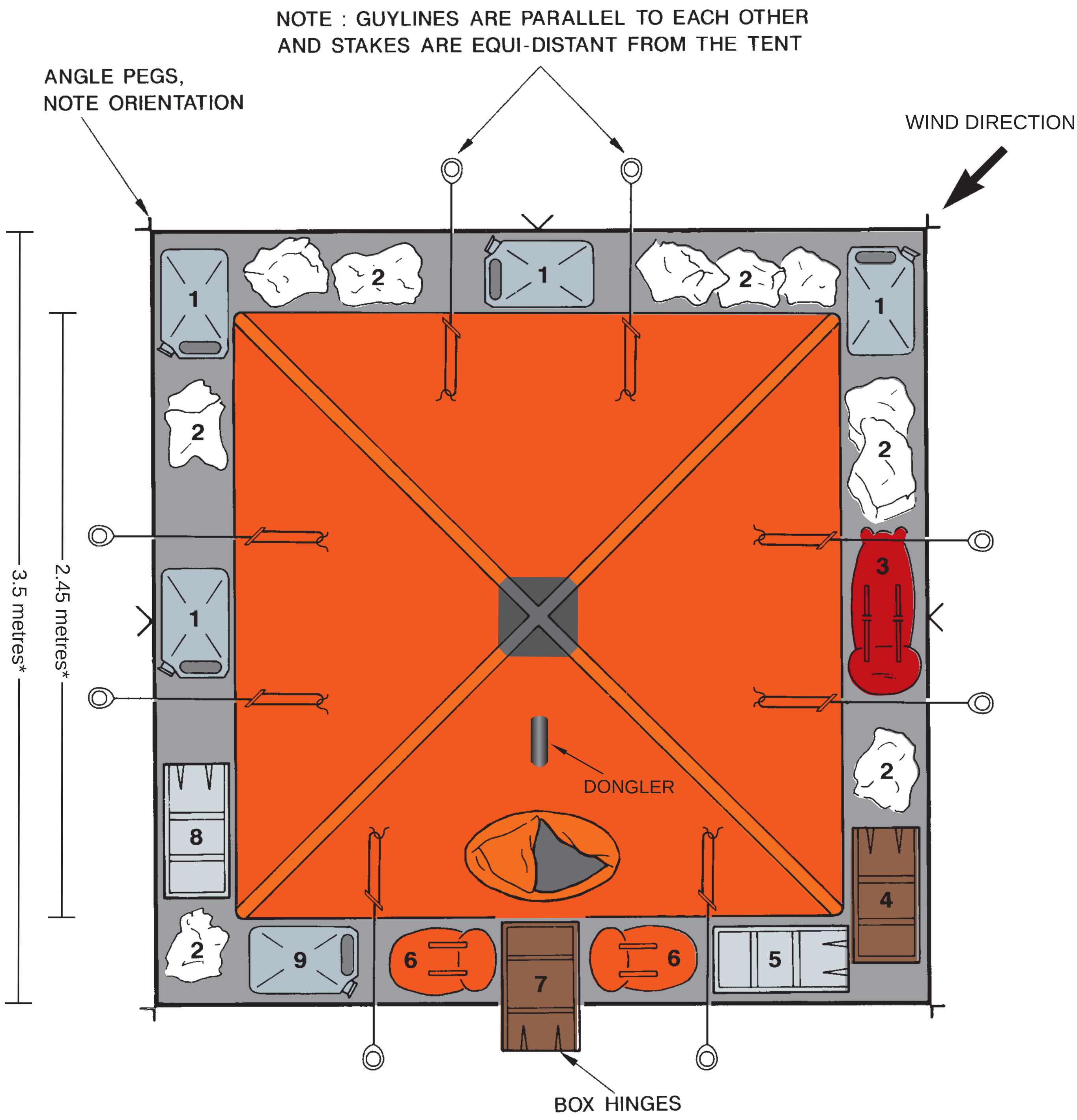


Figure 4.6a External pyramid tent plan

1 Fuel.
2 Snow blocks to add weight to the valance.
3 Rescue sack.
4 Banded 20 man-day food box.
5 Radio box.
6 Day sack.
7 Current food box.
8 Medical box.
9 Paraffin.

* All sizes are approximate as tents vary.

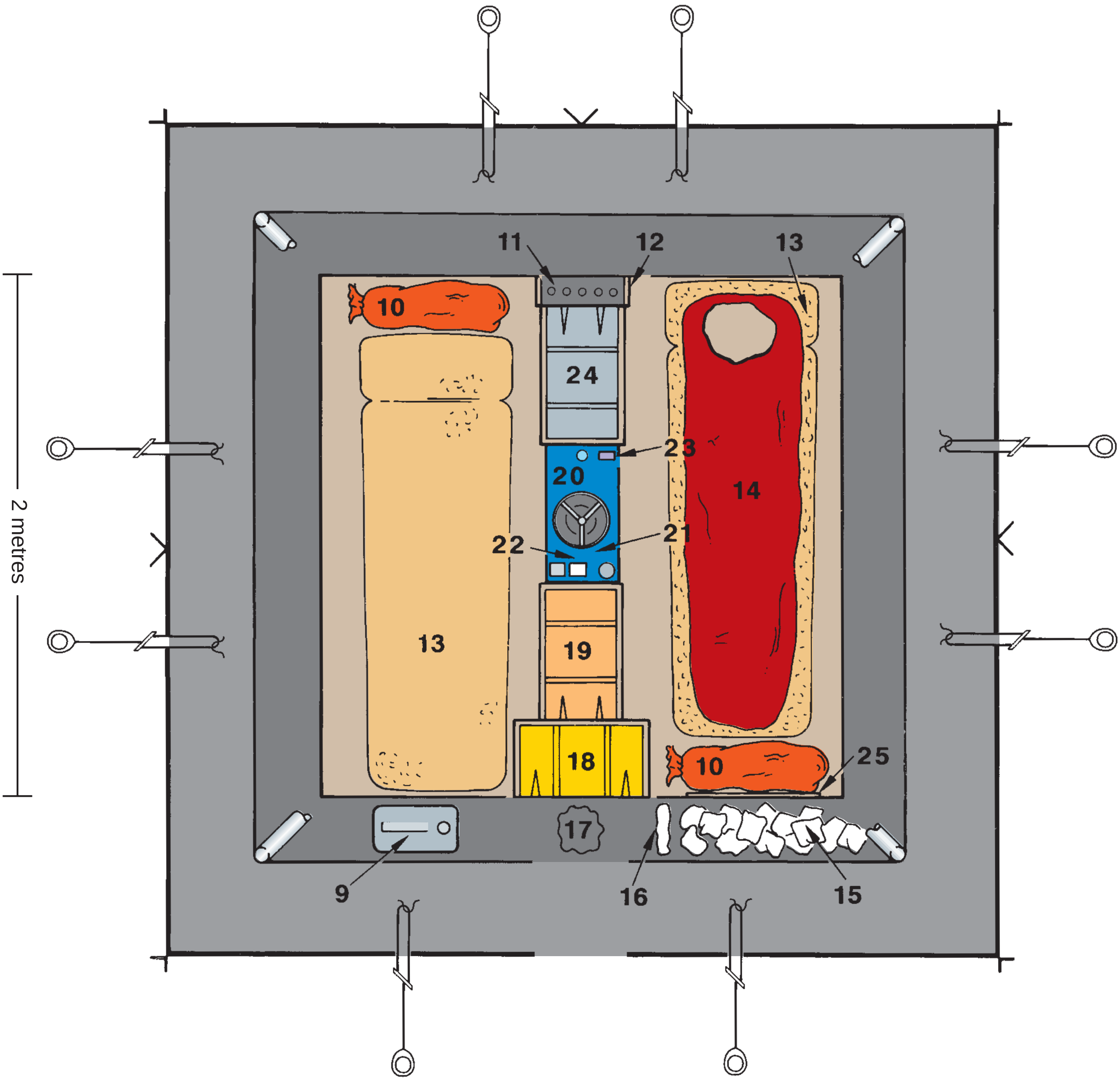


Figure 4.6b Pyramid tent plan

9 Paraffin.
10 P-bag.
11 Radio.
12 Foam mattress to insulate and protect radio
13 Sheepskin on top of airbed and on top of foam mattress.
14 Sleeping bag complete with liner and cover.
15 Snow blocks for water.
16 Partition block.
17 Gash hole.
18 Tent box.
19 Inside food box.
20 Stove.
21 Cooking board.
22 Tea, sugar, milk etc.
23 Meths.
24 Pots box.
25 Piece of foam mattress.

become unstable and the tent fabric strained if the tent is not re-sited occasionally. It also increases the risk of stove accidents
- At night, place important items (e.g. a torch) where they can be found easily.
- Prepare for the following morning by melting snow and filling flasks.
- When leaving the tent during the day, leave a note stating **your intentions for the day, destination, time of return and proposed routes.**

4.8 The BAS box system

Equipment is packed into purpose built wooden boxes that fit onto the Nansen sledges. These boxes are colour-coded for easy identification. Each type of box has the same contents to ensure that there is one standard system.

The inside food box (beige), the tent box (yellow) and the pots box (blue), containing all the cooking equipment, are all set up in the tent as in Figure 4.6b. The inside food box is used as the working food box for items decanted from the man-food boxes (see Section 5.1). The tent box holds domestic provisions such as cutlery and plates, toilet rolls, repair materials and books.

While half-unit travelling (see Chapter 11), fuel and man-food boxes will be carried, as will the spares box (orange). This box contains spare/emergency domestic items such as meths, paraffin, pots and stove. If forced to camp away from the main field-unit, you would still be able to cook and melt-water.

See Chapter 26 for details of box contents.

4.9 The P-bag (sleeping system)

The sleeping bag and all associated equipment are carried in what is known as a P-bag. Before going on a trip all staff should check the contents of their P-bag to ensure everything is in good order. Down sleeping bags are susceptible to damp, so dry and air them in the sun whenever possible.

The Karrimat is best placed on top of the Lilo/Thermarest as it helps to keep the sheepskin dry. If possible Thermarests should be allowed to self-inflate. Moisture from exhaled breath damages the internal foam structure when it freezes. The items are laid out as follows on the ground sheet and sleeping board:

- Thermarest or Lilo.
- Karrimat.
- Sheepskin.
- Sleeping bag.

The fleece liner and bivvy bag may be used as a pillow when not in use. The cotton/canvas sleeping bag cover must be used. This keeps the outside of the sleeping bag clean and protects it from stove damage.

4.10 Striking camp

Collapsing the pyramid is the reverse of the procedure used for its erection. The windward anchors should be left in place if there is any wind. As the tent is collapsed, care must be taken to point the apex into wind. If the poles are not properly dug out before collapsing the tent, the pole ends will be bent. Take care that poles and tensioning lines are not damaged when digging them out.

Brush off as much snow as possible. Do not bunch or knot the guys. The toggles should be in the skirt of the tent.

Roll up the tent, wrapping the groundsheet around the outer surface of the roll. The white (underside) of the groundsheet should be against the tent fabric as this is the cleanest side. This helps to protect the tent material from possible chafing and abrasion by the sledge lash lines.

This bundle is then tied around with short lengths of rope using simple, quick-release knots. Tie-up the dongler to the apex to stop it snagging when placing in the tent bag. The bundle is then ready to slide into the tent bag.

To reduce the risk of abrasion damage, carry the pegs and hammer in their own canvas bag, separate from the pyramid tent. If travelling on hard snow or ice it is worth wrapping the tent in the Ski-Doo tarp before lashing as further protection from abrasion.

Beware of the cut-and-run approach. Pay attention to detail when striking camp. Get into the habit of striking camp with the thought that the weather could be bad when you next pitch. Don't take shortcuts.

Clear up the area of your camp (See Chapter 19 for more information). If you know that you or another party are likely to visit the site in the future, mark soiled areas.

This applies particularly to low snow accumulation sites and sites that are visited frequently such as depots.

Note: When camping close to aviation fuel depots, soiled areas (such as pits and snow caves) must be marked on the ground and on depot plans. Remember that slumping into these hidden hazards could seriously damage a taxiing aircraft.

4.11 Bad weather

The penalty for failing to pitch correctly could be at best a sleepless night as loose material flaps in the wind, and at worst the loss of your tent.

There are other potential problems related to bad weather:

- Strong winds can cause drifting and/or scouring. Such drifting has been known to bury tents completely. In a buried tent the risk of carbon monoxide poisoning increases as the tent walls become iced and cease to breathe. Clear the vent regularly and brush off snow and ice. Keep digging if you have to.
- Strong wind and/or warm conditions can cause rapid snow loss. Tents pitched in a 60cm deep pit have ended on a pedestal of snow after only a few days. Try to divert scouring winds. It is possible to lower the tent in-situ. Snow may have to be shovelled out of the door to do this. A rope enclosing the valance boxes may be necessary.
- In all camping conditions a shovel should be to hand just outside the tent door. If there is risk of the tent being buried, keep a shovel between the inner and outer. In extreme cases, digging your way out by shovelling snow into the tent may be necessary.
- If your tent is heavily snowed-up, sound will be restricted. Maintain hourly checks during bad weather. Mark all your outside equipment with flags. To save time when digging out, mark the corners of the tent valance and the peg positions. In poor visibility use a hand-line to move to and from the tent.
- During windy periods the tunnel entrance can become a nuisance by billowing or inflating inside the tent. Standing a jerry between inner and outer tent can reduce this. Tying the door tightly and securely will also help.
- With severe cases of buffeting or strong gusts, guy rope tensioning sliders/toggles can work loose. This is especially so if the tent material is slack and flapping or the slider holes are worn. In such circumstances the slider can be 'seized' to the guy rope with a short piece of cord to prevent them slipping.
- An event that cannot really be guarded against is that of wind blown ice grains, ice chips or moraine grit. Abrading or even shredding the outer material of the tent can result. Choice of site is therefore important.

4.12 Pyramid loss

It should be stressed that this is a very rare occurrence. Pitched properly and in a suitable location the pyramid tent is a secure and extremely safe living unit.

Prevention is better than cure so always remain vigilant and self-disciplined. Check outside regularly - every hour if necessary. It is better to foresee a situation developing than to be caught out.

When venturing outside in strong winds, low visibility, obscuring drift or slippery surfaces, it is wise to be secured to a rope. Remain belayed by your companion from inside the tent or shelter. Fatalities have occurred in such conditions when people have lost their sense of direction and died of exposure only yards away from their tent or snow hole.

It may also help to carry a whistle and use prearranged signals. People have been standing at the end of the guy ropes unable to see the tent. When checking outside in extreme conditions, you should stay within the radius of the tent guys.

If things go wrong you should at least be prepared. With loss of the tent imminent the following actions might help:

- Melt and store as much water as possible.
- Pack away items in boxes but keep food, water, pee bottle and knife handy.
- Place your airbed, sleeping bag and sheepskin inside a survival bag along with the radio, outer garments, spare clothes, boots and other essentials. You may decide at this point to put on outer clothing.
- Place an anchor beneath the groundsheet securing yourself and the bivvy bag to it. In cases where the wind is trying to lift the tent a rope secured to the apex internally and anchored to the snow inside

the tent can give added security.

- Secure as many other items as possible.

It is a very rare occurrence to lose a tent. However, if you act sensibly, your situation should be one of severe discomfort rather than life threatening.

4.13 After use tent care

The tent should be dried out at the first opportunity when back on station. Ventile is a natural fibre and is therefore prone to mildew and rotting.

If possible any deficiencies should be rectified immediately. Fill in the tent diary with details of use and repair. Include notes of exposure to severe weather conditions and other such events. Enter the same details for the pup tent.

Updating tent records is important. Tents are a shared facility and you may not be the next person to take it out. They are thoroughly checked each season. The tent outer is changed after 250 days' use.

5 Rations and cooking

Introduction

Although this chapter is aimed primarily at living within the pyramid tent, it will apply equally to any situation where you are living away from station. BAS operates a standard system for living in pyramid tents. As with many aspects of fieldwork this is a tried and tested system that has been developed through time and experience.

The extreme nature of the environment makes it necessary to cook within the tent. This carries a number of attendant risks which are covered in this chapter. Cooking equipment and food are packed in robust ply boxes. They are designed to be stacked onto Nansen sledges and are colour-coded for quick and easy identification.

5.1 Field rations

Food is packed into ply boxes called man-food boxes and these contain provisions for two people for 10 days (or 20 person-days). Man-food boxes are expensive and the cost of feeding a person in the field is more than double the cost of feeding someone on station.

Man-food boxes are relatively light and compact with the contents being easy and quick to prepare (to save fuel). The boxes can be depoted in the field for years, as they are robust and weather tight with contents that do not deteriorate rapidly. Dried and tinned provisions predominate. Dehydrated food does not freeze, is very lightweight and has a long shelf life. Man-food boxes are often transported large distances by aircraft and overland by sledge parties.

Stock rotation and shelf life

Field rations boxes should be used on an oldest first basis so organised stock rotation is vitally important. Inefficient stock management is wasteful and costly.

BAS policy on man-food states:

- **Boxes have a useable life of four years (48 months) from the month of packing (dated on each box).**
- **Contents of boxes are to be disposed of in accordance with the BAS Waste Management Handbook in year five. Disposal is to be noted on a gear/equipment loss form and countersigned by the FOM/Base Commander.**
- **It is recognised that certain escape dump supplies will fall outside the guidelines of this policy statement. Circumstances at the time of any such emergency may dictate that these supplies are used to sustain life.**

Nutritional requirements

Extreme cold and hard work require a great deal of energy. A person travelling by Ski-Doo requires about 3350 calories per day. A person man-hauling may require around 5000 calories. Energy requirements will be affected by influences such as temperature variations associated with altitude and latitude.

Man-food boxes contain food for a balanced and varied diet giving around 3700 calories per person, per day. Ample calories are provided from man-food boxes and in an emergency even half rations will provide around 1900 calories per person, per day. Keep a record of when food boxes are opened and continually assess how many days are left. Stick to the ration.

Man-food box contents are subject to ongoing revision to improve the appeal of the rations and to meet changes in dietary habits. The overall calorific value and nutritional balance are subject to review by the BAS Medical Unit (BASMU) but to date have not been changed.

5.2 Fluid intake

Guard against dehydration. As a rough guide, your body in a normal situation (e.g. Britain) requires two and a half litres (four and a half pints) of liquid per day. Antarctica is very dry. Even without physical activity you will lose considerably more moisture through the simple act of breathing. An increased intake of 750ml is required for every 1000 calories expended.

Avoid drinks that have a strong diuretic effect, particularly alcohol and strong coffee. The simplest method of checking whether your fluid intake is sufficient is the colour of your urine. It should be colourless or a very light straw colour. Ensure that food is properly rehydrated.

Collect snow for water from a designated spot upwind of the tent. Use an area downwind of the tent or hut for the toilet and washing. Take care if camping in an area that has been used before. If the area is likely to be used again, mark toilet and water spots for future years.

Be wary of the glacial dirt often present in glacier ice and more importantly take care not to consume glacial flour (sediment) from the melt-pools and streams at the base of glaciers. Watch out for potential contamination from wildlife.

Without paraffin, producing water is difficult. If fuel is short, paraffin must be conserved and other water sources utilised. In a real emergency, body heat can be used to melt snow for water but this could well produce a descending spiral of energy expenditure. On a sunny summer day, a black snow block bag left outside on a box will produce a few litres of water with no effort or fuel use.

5.3 Alternative diets and supplements

BAS man-food boxes are often supplemented with a few goodies carried in the inside food box of your sledging unit. This relieves the monotony of the basic foods in the man-food boxes. By simple means an oven can be made out of a cooking pan, so that pizza, scones and lasagne can be cooked in the field.

When sourcing special food additions from the ships or stations, don't just help yourself. Consult the catering staff so they can keep a tally of their stocks.

Vegetarians

Vegetarians will have to make up their own supplements from the stores on station. This should be done in consultation with the Chef. Staff must accept that pursuing a vegetarian diet may not always be possible if only standard field rations are available.

BAS policy on vegetarian food in the field states:

Anyone going into the field intending to follow a vegetarian diet must ensure they take the full amount of standard food rations and add vegetarian rations as supplements.

Vitamin tablets

Vitamin tablets are not supplied in the man-food boxes. In-date vitamin tablets should be taken into the field if a project of several weeks is being undertaken. The station doctor will supply these.

5.4 Paraffin stoves and lanterns

Before leaving station it is essential that you are competent with the operation and maintenance of Primus stoves and Vapalux lanterns. Familiarisation should involve stripping down and reassembling these items. Check the compatibility of all spares to the model of stove you are taking. Don't forget to check the stove and spares in the spares box.

The Vapalux pressure lanterns provide light and heat. Lanterns use less fuel than stoves, do not have naked flames and usually burn cleaner. They are less likely to produce carbon monoxide (CO) than the stove but the risks of CO poisoning are still present. During lie-up days it is tempting to keep the lantern burning for hours but remember to assess your fuel stocks carefully.

Paraffin consumption

See also Chapter 17. An approximate guide to expected fuel use is:

- **Summer - 0.6 litres per field unit per day.**
- **Winter - 1.0 litre per field unit per day.**

In cold conditions these estimates can easily be exceeded. Always take plenty of surplus paraffin and keep a careful eye on stocks.

BAS Policy states:

An overstock of 30 days' food and fuel should be carried as a reserve. This reserve should be kept up all the time. Do not rely on getting to a depot.

Meths consumption

Meths is used for priming stoves and lanterns.

- **0.75 to 1 litre per month. Approximately one litre per jerry of paraffin.**

Filling

Only fill the fuel tank three quarters full using a small filter funnel. An air gap must be left to allow for expansion as the fuel warms up. If an attempt were made to release the pressure with no expansion gap, fuel would shoot out of the airscrew. Replace the tank lid firmly but leave the airscrew slightly open. On a lantern make sure the on/off screw is closed.

Priming and lighting

It is essential that both the stoves and the lanterns are primed for a long enough period. Paraffin appliances (particularly Vapalux lanterns) are susceptible to flare-up if they are not properly primed (see below). In cold conditions longer priming periods are required.

Pour meths into the spirit cup to prime. Light the meths and then prick the nipple to ensure it is free of soot. On a lantern the jet is automatically pricked when the on/off switch is fully closed.

When the meths has almost burnt out, close the airscrew and pump a few times. Don't go mad at this stage as you could introduce cold fuel into the vaporiser and this would cause a flare-up. If the dying priming flame does not ignite the paraffin, quickly light it with a match.

If the appliance flares-up, release the airscrew and start again with the meths once the spirit cup has cooled off.

Fuel identification

Paraffin is stored in blue Sigg bottles and meths in silver Sigg bottles. No other colours should be used. Always check the smell to confirm the correct fuel is being used. Meths in a stove will cause it to pop and flare. See also Chapter 17.

5.5 Cooking in the tent - the risks

Operating stoves and lanterns in a tent is a potentially hazardous activity. As well as the obvious risk of fire, burns and scalds, perhaps the greatest risk of all comes from carbon monoxide (CO). CO poisoning due to inadequate ventilation and/or a poorly maintained stove is an ever-present danger.

CO is a colourless, odourless gas. It is formed from the incomplete burning of any carbon-based fuels. It binds to haemoglobin in the blood and prevents it from carrying oxygen.

The main cause of CO build-up is the incomplete combustion of fuel vapour. Make sure stoves and lanterns are well ventilated and burning correctly. A common indicator of incomplete combustion is the colour of the flame. When burning correctly, the mantle should glow with a clear white light and a stove will burn with a clean blue flame. If the flame is orange, red or sooty, it is likely that incomplete combustion is occurring. Another common sign is a strong smell of paraffin vapour, although this could also be from a leak.

There have been a number of serious CO poisoning incidents so guard against it. It is particularly dangerous because the symptoms are not immediately apparent. However, there are certain signs that can help to give a warning that incomplete burning is taking place.

These can be:

- Burning eyes.
- Dizziness.
- Throbbing temples.

This can lead on to:

- Headaches.
- Nausea.
- Vomiting.
- Chest pain.
- Confusion and personality changes.

Ultimately this can lead to:

- Loss of consciousness.
- Coma.
- Death.

The immediate course of action is to get into fresh air. Put out the stove or lantern and ventilate the tent. Refer to Kurafid for further information on the symptoms and treatment of CO poisoning.

To minimise carbon monoxide emissions:

- Keep the stove well maintained and ensure the jet is clean.
- Learn to recognise and fix faults, particularly incomplete combustion and leaks.
- Change worn jets. Worn jets do not allow for the correct fuel/air mix and cause incomplete combustion.
- Ensure the tent dongler is clear at all times.
- Whenever possible, increase the ventilation by opening the door.
- Add snow blocks in small quantities - keep the flame hot. If condensation is forming on the sides of the pan then you are adding snow too quickly.
- Keep some water back in order to start the melting process - keep the flame hot.
- Don't use pots that are too large - keep the flame hot.
- Use clean fuel. Water contamination will cause the stove to flare-up intermittently with a yellow flame.
- Don't run the stove with the flame too low.
- Use the lantern for heat not the stove. Lanterns generally burn much more cleanly than the stoves.
- Don't burn the lantern with a damaged mantle.
- Make sure the stove legs are the correct length. If

they are too short, they can cause the flame to be starved of oxygen.

Carbon monoxide detectors are used in tents and huts but do not rely on these to cover poor practice.

To reduce the risk of burns, scalds and fire:

- Use a jerry board inside the tent as a platform for the tent and pots box. This will greatly increase the stability of the boxes and the cooking platform, especially in soft snow and/or during extended periods in the tent.
- Don't overfill the stove.
- Use a stove board that holds the stove legs captive.
- Use a pourer cup to avoid spills.
- Do not burn the stove with the lantern immediately above it. Make sure the lantern is raised.
- Don't keep paraffin bottles near the stove. Keep them in the pots box or near the door.
- Keep movement to a minimum when cooking.
- Don't stack pans on top of each other on the stove.
- Don't leave pan handles attached to the pans and don't leave the pump handle out on the stove. This will increase the chance of knocking everything over.

If a fire occurs in the tent, smother it quickly by starving the fire of oxygen. A sheepskin makes a good fire blanket, leather side down.

5.6 Hygiene and health

With water relatively difficult to come by, it can be tempting to skimp on its use for drinking and washing utensils as well as yourself. This is not a good way to live in the field.

Washing in the field

It is important to keep the body as clean as possible over a long field season. The easiest way of doing this is to use moist travel wipes. Pay special attention to the feet, groin area and armpits.

An old biscuit box or a plastic washing-up bowl is good for a regular flannel wash. Talcum powder and foot powder can help to stay dry. Changing to aired dirty underwear is better than leaving the same underwear on. Clothes can be washed in the field. On clear days, clothes will dry in a matter of hours, even if they freeze solid as soon as they are hung out.

Privacy

Remember that people require different levels of privacy. For some, modesty will not be an important issue but be aware that for others it may be. Discuss with your partner ideas about performing simple functions.

Toilet matters

Do not cut down on fluid intake to avoid going outside to the toilet. A pee tin/bottle makes life much more comfortable in bad weather. It is important to keep bowel movements regular. Constructing a toilet pit sheltered from the wind or using a toilet tent on static camps can make the experience far less trying. Always wash your hands after going to the toilet.

See Kurafid for health hints and further advice on personal hygiene.

6 Navigation

continued over page

6.12 Practical navigation techniques and tips

Aiming off
Flagging routes
Using a rope
Altimeters
Binoculars

6.13 Ski-Doo travel

Ski-Doo compass
Warning

Introduction

Antarctica is the least explored and the least mapped of the World's continents. Only recently have satellite imagery and modern survey techniques improved the accuracy of the region's maps. However the topography of the continent is not yet fully known.

A variety of tools are available to facilitate accurate navigation and route planning. These include maps, compass, GPS, Ski-Doo odometer, aerial photographs and travel reports.

Crevasses can only be seen in good contrast. Because many field operations are carried out on glaciated terrain it follows that travel generally takes place in good contrast and reasonable weather. It will therefore be unusual to have to navigate without some visual reference to topographical features.

This chapter gives a brief outline of navigation techniques pertinent to BAS field operations. It is beyond the scope of this manual to teach the basics of map work. To understand this chapter fully, some prior knowledge or training is necessary. Whether travelling close to stations or deep field, good navigation skills are essential.

6.1 Navigation basics

In order to navigate from A to B you need to:

- Work out where you are on a map.
- Work out the bearing for the route and know how to transfer this to a compass.
- Know how to use a compass.
- Calculate the distance you need to travel on the map.
- Know how to assess the distance you've travelled.

To be able to do this you will need to understand the following concepts:

- Map scale and distance.
- The topographic information a map conveys.
- Contour lines.
- Referencing and plotting your position on a map.
- How to orientate a map to the terrain.
- Magnetic variation and its effects.
- Taking bearings.
- Transferring bearings to a compass.
- Using a compass.
- Calculating the distance you've travelled (speed and time/pacing/odometer).
- Finding your position by angular re-section.

6.2 Polar maps

A range of map scales are available for field operations. They can vary from highly detailed 1:7,500 maps to 1:3,000,000 maps that cover large areas. More featureless terrain generally has smaller scale maps. Small-scale maps are useful for plotting routes over large distances but are unsuitable for micro-navigation. At 1:250,000 scale, 1cm on the map represents 2.5km.

Maps are constantly being improved and updated by the BAS Mapping and Geographic Information Centre (MAGIC). It is possible for new maps to be produced for specific projects. However, it is a very large continent and many areas will only have basic maps for some time to come.

Maps used for overland travel are generally 1:100,000 to 1:500,000 topographic or satellite image maps.

- Topographic maps are compiled from aerial photographs that have limited ground control and other field survey information.
- Satellite image maps are composites or mosaics of Landsat imagery, again controlled by limited ground survey information.

Other map types are used by BAS. These include hydrographic and aeronautical charts and maps produced by other Antarctic operators. For example, United States Geological Survey (USGS) maps are often used on deep field projects.

Accuracy of polar maps

The latitude and longitude of features on a map may not correspond to GPS position fixes. Sometimes quite large errors exist. These inaccuracies are being improved over time but be aware of potential discrepancies when using older maps.

6.3 Referencing your position on a map

Lines of latitude (the horizontal lines across a map) and longitude (the vertical lines) are used to refer to positions on maps. By using this global grid system it is possible to give an accurate reference to any point on the Earth's surface. The units of measurement are degrees, minutes and seconds. Positions are stated as latitude and then longitude (the opposite of how you would give a UK grid reference).

Latitude positions can be north or south of the equator and longitude can be east or west of the Greenwich Meridian, hence the terms east and west Antarctica. Below is an example of how a position should be given:

Rothera: S 67° 34.230 W 068° 08.760 (degrees and decimal minutes)

If seconds are noted they are given as a three figure decimal. This should be installed as part of the GPS set-up.

One degree of latitude (but not longitude) equals 60 nautical miles and one minute equals one nautical mile (1.85km). Because the latitude scale on the map relates to distance, it is relatively simple to plot latitude positions. Plotting longitude is more complex.

One degree of longitude will be a much greater distance at the equator than it will be near the South Pole. To plot longitude it is necessary to divide-up the graticule lines on the map. The projections used on BAS maps are chosen to minimise scale errors. Gnomic projection maps are often used at low and high latitudes due to the excessive convergence of the lines of longitude at the Poles.

6.4 The compass

The main type of handheld compass used by BAS is the Silva 54 NL. Ski-Doos are fitted with Silva 70 NBC compasses.

As a compass gets closer to the magnetic poles, the needle is drawn below the horizontal as the Earth's magnetic flux lines flow towards its core. This is called declination. BAS compasses are fitted with a needle weighted to compensate for this. These compasses are weighted for Magnetic South and are marked MS in small letters underneath the bezel to identify this. In South Georgia, southern magnetic equator weighted compasses are necessary. These are marked SME on the bezel.

Compass scales used on all BAS compasses are graduated in 360°.

In the regions of the Antarctic where BAS operates, compasses behave normally and point to Magnetic North. In certain parts of the Antarctic they are affected by the proximity of the magnetic pole. This is not an issue for BAS fieldwork.

Taking bearings with a Silva 54 NL compass

Taking a bearing in the field using the type 54 NL compass is very simple. The housing should be orientated north/south on the protractor base so that the desired object may be viewed across the base plate.

Viewing from this orientation places the eye as near as possible to the lens, thus avoiding parallax errors. The hairline on the mirror will fall over a scale reading. This is the magnetic bearing to the viewed object. The larger figure is the bearing to the object and the smaller figure is the back bearing. The back bearing is the bearing from the object to the user of the compass and is always 180° opposite the bearing.

6.5 Global Positioning System (GPS)

A Global Positioning System (GPS) receiver fixes its position from a network of navigation satellites that orbit the Earth. A GPS receiver computes its position by measuring the distance to at least three satellites. GPS is standard issue for field party travel.

GPS is well suited to Antarctic travel as many areas are featureless and some maps lack detailed topographic information making it difficult to fix a position from bearings. Despite making Antarctic navigation easier, GPS should always be regarded as a back-up to traditional navigation techniques. If you are working in the hills, there should be less need to use GPS than if you are working in areas of little or no topographic reference.

As mentioned previously, travel in new areas can only take place in good contrast, so the map, compass and your "Mark 1 Eyeball" are still the most important navigation aids you possess.

GPS should not be used as a means of navigating over unknown terrain in bad weather. The risks associated with travel on glaciers do not go away because it is possible to navigate a route with GPS in poor visibility.

BAS uses a variety of different models of GPS. The principles are the same for each make but it is important to learn how to use your particular model. Read through the reference manual and take it with you.

Power

GPS can be hungry on batteries, so make sure you take sufficient spares. The GPS receiver should be wired into the Ski-Doo to save on battery power. The vehicle mechanics mount the GPS to field Ski-Doos with power terminals connected to its battery. With this set-up, GPS will run off the Ski-Doo battery whether or not the vehicle is running.

A GPS's internal batteries drain rapidly, particularly in the cold. Below -35°C they will not work at all. It is important to keep the internal batteries in working order as they prevent data loss should the external power fail. If you lose all power, you will have to re-initialise the GPS and re-enter all waypoints. It is therefore very important that you always carry a hard copy of your waypoints.

In very cold temperatures, the LCD screen can freeze and become very difficult to read. If necessary, keep the GPS in your jacket pocket to keep it warm.

Accuracy

Depending on the satellite coverage at the time, GPS has a horizontal accuracy of about 10 metres. For accurate measurements of altitude, a minimum of four clear satellite signals need to be received. Altitude data are often poor at low latitudes because satellites are low in the sky and therefore hard to receive.

The position of the aerial is important. It should be mounted as high on the Ski-Doo as possible as GPS will not work if the antenna is obstructed. GPS will work in the tent but it will not work in buildings or close to steep rock. Check the quality of your fix by looking at the satellite status screen.

6.6 Magnetic variation

There is a difference between north on the map and the north a compass points to. This difference is known as magnetic variation. Magnetic variation is the difference in angle between the Magnetic North Pole and the Geographic North Pole (True North). A compass needle points to the Magnetic North Pole while lines of longitude on a map run through the Geographic North and South Poles.

Magnetic variation alters relative to your position on the Earth's surface. In the Antarctic areas covered by BAS operations, the lines of magnetic variation are closely spaced. It is essential that you know the magnetic variation for the area you are travelling in otherwise your compass will be useless. This information can be found on all recent BAS maps as well as from a variation chart or GPS receiver.

Magnetic variation must be factored in when going between a map and a compass. This is explained below. Variation is sometimes referred to as declination or deviation. This is incorrect and it should be referred to as variation only.

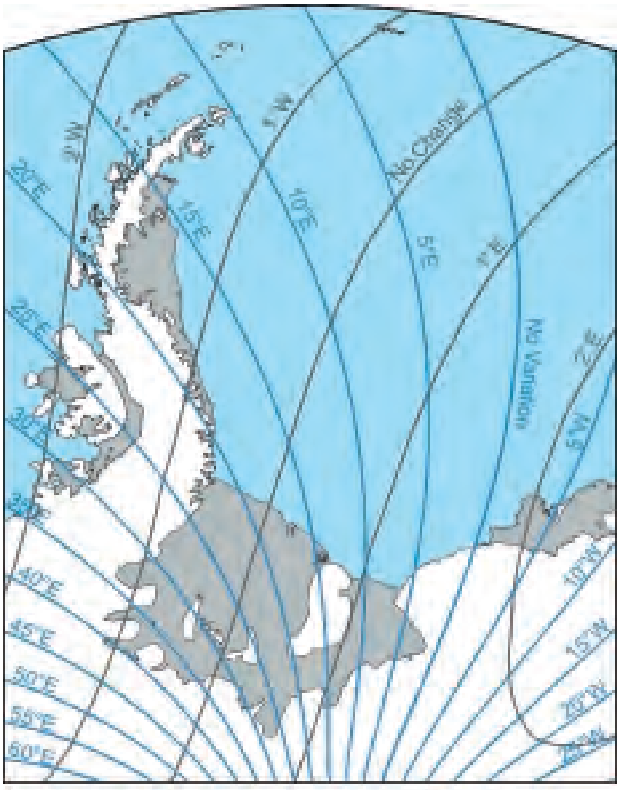


Figure 6.6 Magnetic variation
Blue lines are isogonic lines of equal magnetic variation in degrees. Grey lines show annual change in minutes of arc. (Data taken from BAS (Misc) 8, Antarctic Peninsula and the Weddell Sea. 1997)

Remember that magnetic variation changes over time but the current magnetic variations at BAS stations are as follows:

- Rothera 021° east.
- Signy 001° east.
- Halley 002° west.
- KEP 007° west.
- Bird Island 006.30° west.

6.7 Bearings

Bearings are angles in the horizontal plane that define direction in relation to north.

True bearings

Bearings taken from a map are known as True bearings. This is because they are in relation to True North.

Magnetic bearings

Bearings taken using a compass are known as Magnetic bearings as they are in relation to Magnetic North.

When giving a bearing you must state whether it is True or Magnetic, otherwise it is meaningless. When writing a bearing down it should be written as follows:

- Magnetic bearing: for example one hundred and twenty degrees, 120°(M).
- True bearing: for example seventy five degrees, 075°(T).

Back bearings

A back bearing is a bearing that is diametrically opposed to the original bearing. Back bearings are used for returning along your outward travel route and for finding your position by re-section (see 6.10 below).

For bearings less than 180° the back bearing is the original bearing plus 180°. For bearings greater than 180° the back bearing is the original bearing minus 180°. Alternatively you can read it off the compass card, which saves having to do the mental arithmetic.

6.8 Taking a magnetic bearing from a map (True to Magnetic)

In order to find the direction of travel, it is necessary to:

- Work out the bearing from the map in relation to True North.
- Convert this to a magnetic bearing.
- Transfer this to the compass.
- Orientate you body to the direction of travel.

To do this:

1 Before using the compass protractor to measure the angle accurately, estimate the angle. This is a useful check that reduces the possibility of being 180° out. This is a common error.

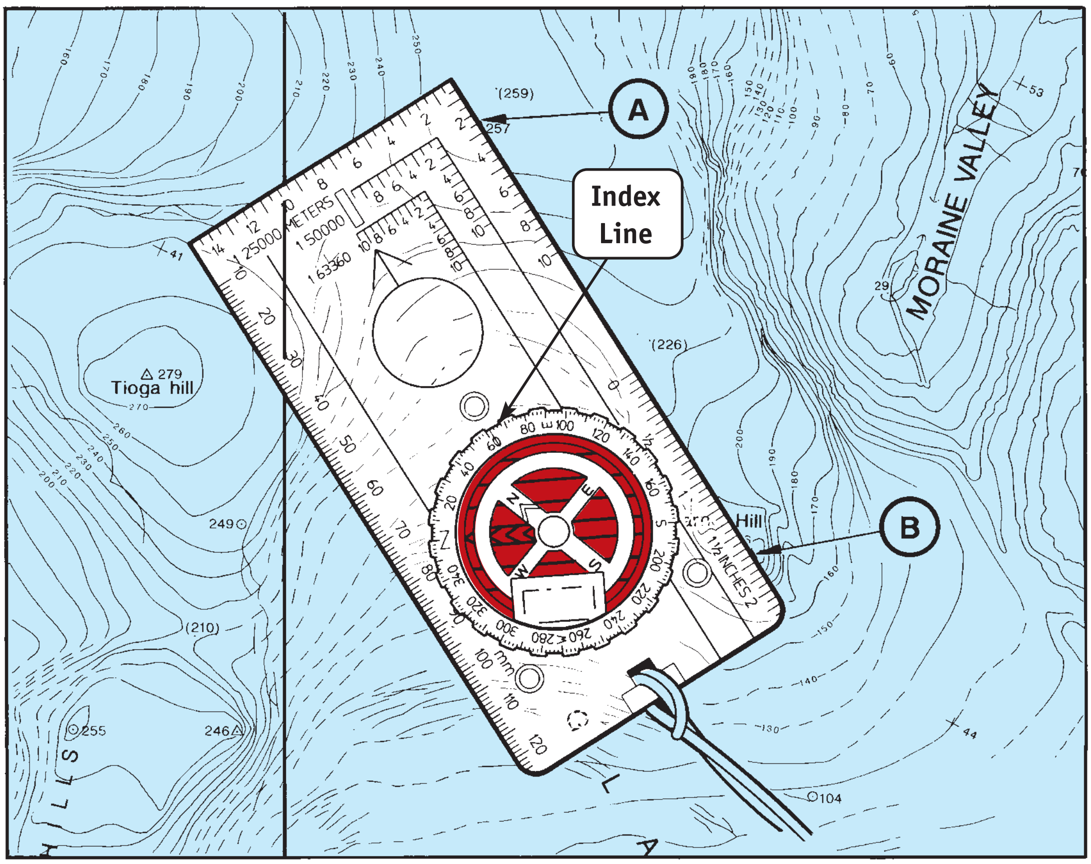


Figure 6.8a Taking a bearing, on map (misaligned)
Set protractor base between known position A and objective B.

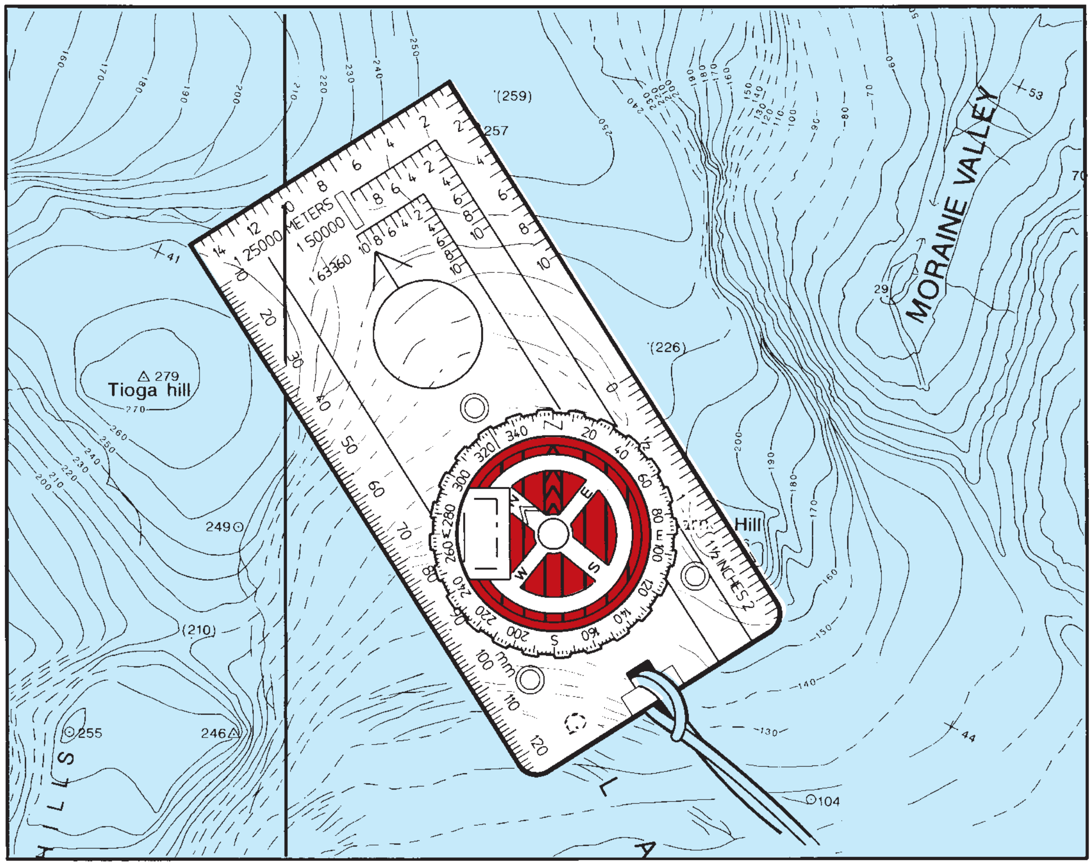


Figure 6.8b Taking a bearing, on map (aligned)
Move the compass housing so the lines are parallel to the lines of longitude and the N pointer north.

2 Place the edge of the compass base plate along the desired line of travel. The arrow on the base plate shows the direction to be followed.

3 Turn the compass housing so that the lines within the housing (red) align with the lines of longitude. The arrow within the housing must point to north on the map. At this stage the compass is simply a protractor and the moving compass needle is irrelevant.

4 Remove the compass from the map and read the bearing at the index line (see Figure 6.8a). Check that it corresponds to your earlier estimate.

5 Factor in the magnetic variation. When working from True to Magnetic (i.e. a bearing taken off the map) a good method of remembering is:

"East is Least and West is Best"

This means that an easterly variation is subtracted and a westerly variation is added.

Remember, when working from Magnetic to True this will be the other way round.

6 The Magnetic bearing should now be set at the index line. Hold the compass to your chest with the direction arrow pointing forward and look down at it. Rotate your body until the compass needle lines-up with the marker arrow in the base plate. Make sure you are not 180º out.

7 Look up and sight on something in the distance. This is your direction of travel. Alternatively the bearing can be sighted through the compass bezel. This is the most accurate method.

6.9 Transferring a magnetic bearing to a map (Magnetic to True)

The procedure is the reverse of the above section.

A magnetic bearing may need to be taken to:

- Find your position by reference to surface features or landmarks.
- Identify a feature or landmark when you know your position on a map.

This would be done as follows:

1 Sight the object and read off the Magnetic back bearing. Use the smaller back bearing figures on the compass card to save having to calculate it. Make sure that you are well away from any metal objects.

2 Add or subtract the variation (add if easterly or subtract if westerly). Set the housing so that the True bearing is given at the index line. The compass protractor is now set as a True bearing.

3 Place the compass on the map. The lines within the housing should be parallel to the lines of longitude and the arrow should point north. With the edge of the compass base touching your known position, the object sighted will lie on an extension of the line drawn along the compass base.

6.10 Finding your position by angular re-section

This method is used to find your position when distant, known objects can be seen. Obvious features such as peaks should be used to take bearings. A minimum of three objects should be sighted. Ideally, each object should be approximately 120° apart. If only two objects can be sighted they should preferably be at 90° to each other.

To do a re-section:

1 Sight on the known objects and read off the back bearing. Use the smaller back bearing figures on the compass card.

2 Convert the Magnetic bearings to True bearings.

3 Draw the back bearings from the objects on the map. The lines from the objects will form a triangle, which will hopefully not be too large. The position of the person taking the bearings will lie within this enclosed area.

6.11 Estimating distance covered

Being able to calculate accurately how far you have travelled is one of the basic skills of navigation. There are a number of methods that can be used to work this out:

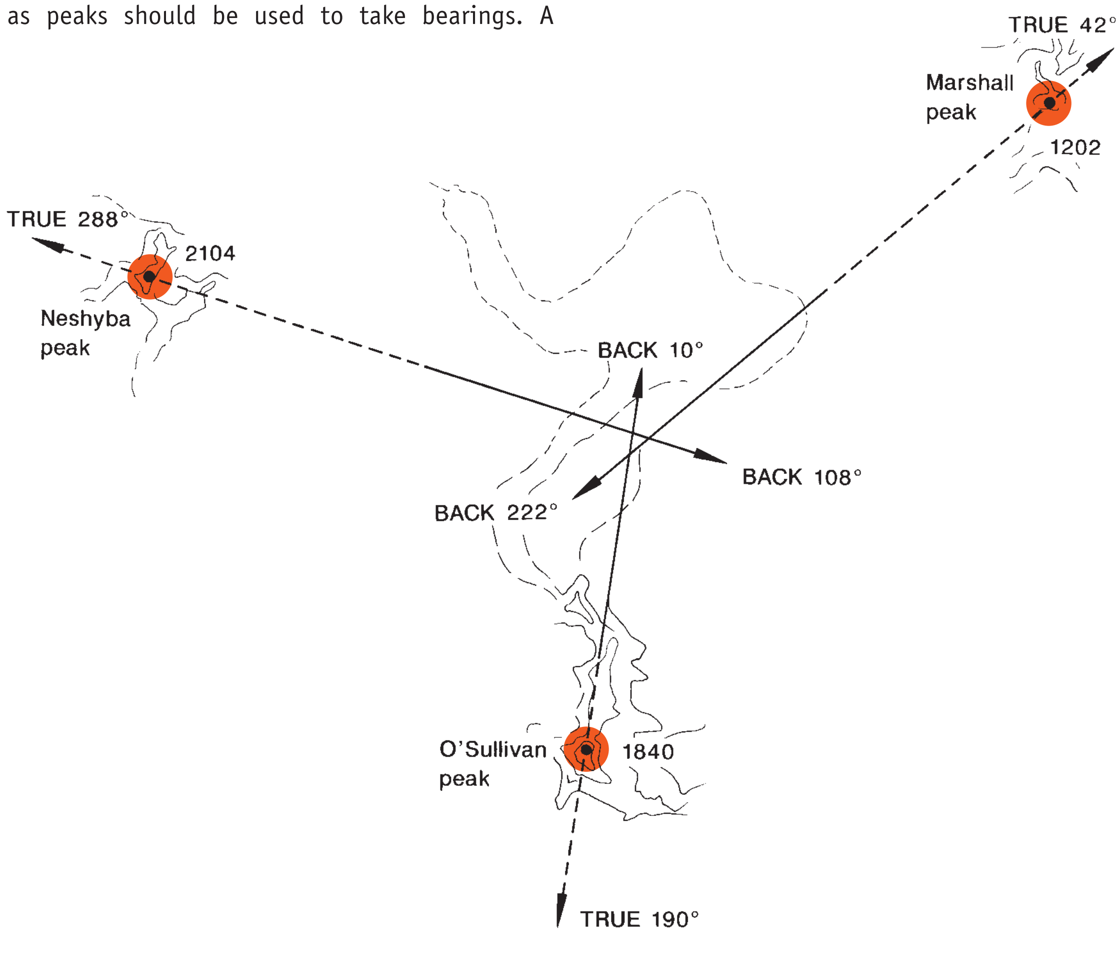


Figure 6.10 Plotting an angular resection

Time

If you know how fast you are moving it is a simple matter to calculate how far you have travelled in a given time. It is a good idea to learn what sort of speed you travel in different conditions and with different equipment. For example, learn to estimate your walking speed on hard snow and soft snow as well as when skinning and snow shoeing. Remember, bad weather will slow you down and a tail wind may speed you up.

One method of estimating journey time is Naismith's Rule. This states the average walking pace (not on snow) is 5km/hour or 1km every 12 minutes. 30 minutes is added for each 300 metres climbed (one minute added for every 10 metres of ascent). Descent is not considered as your faster pace while descending is offset by the increased distance you have to travel - the actual distance up and down a slope is greater than the horizontal distance measured on a map. This is a good rule of thumb for foot travel over reasonable ground, but it will need adapting to your situation in the Antarctic.

Pacing

This can be a very accurate method of measuring distance. It is only suited to short distances, but it is an excellent technique for micro-navigation. It can be used with ski strides or paces on foot.

When pacing, calculate the number of double paces required to cover 100 metres. Learn how many paces you require for each mode of travel and how much you need to compensate for different surfaces and topography.

Use snowballs to keep count. For example, if you needed to travel 500 metres you could make five snowballs. As the number of double paces for every 100 metres is reached, drop a snowball. When no more snowballs are left you will have covered that leg of the journey.

Once mastered, this technique can be very accurate.

Ski-Doo odometer

This is the best way of measuring the distance travelled when Ski-Dooing. Remember to set the odometer at the start of each leg. Spinning tracks will obviously affect the accuracy of the odometer, but this is generally not a problem.

GPS

This is a very accurate method of calculating distance travelled.

The first two methods can only be perfected with experience. Practise these techniques so that you can fall back on them when things become challenging. Don't wait until you are in bad weather to try to learn them.

6.12 Practical navigation techniques and tips

Aiming off

In some instances it pays to navigate slightly to one side of your desired destination. Imagine that you had to find a gateway into a forest that was five kilometres away. If you travelled on a bearing to the gateway and deviated off-track slightly you wouldn't know if you had deviated to the left or to the right when you arrive at the forest.

In some situations it is better to deliberately aim off to one side of your destination. You will then know which way to turn to find it.

Flagging routes

Whether on foot or vehicle, flagging routes at regular intervals is prudent. This aids a safe return to camp if the weather deteriorates. It also allows worksites to be accessed in more marginal conditions, although caution must be exercised when doing this. Do not rely on routes that have been flagged for an extended period. Ground conditions can change and flags can melt-out and fall over.

When working on crags and leaving vehicles away from the crag, take a magnetic bearing on the vehicle from a known point. Take a note of the time taken to arrive at that point and the approximate paced distance. Write down the bearing and distance in a notebook.

Using a rope

If caught out in very poor conditions, away from shelter, it will be necessary to travel as a pair with the front person travelling on a bearing and the back person checking the bearing. The back person can then give instructions to keep the front navigator on course. This is a good habit to get into. Don't rely on your partner to do the navigation. Both party members should pace the distance.

Altimeters

Although not issued to BAS staff, people may use their own altimeters. Altimeters can be useful for retracing your route over a short period. As there are few accurate heights marked on maps from which to reset the altimeter, their use for navigation is a bit limited.

If used with discretion, the altimeter can be a useful guide in micro-navigation. It can help to define the exit point off a ridge and contouring at a given height can be done with greater accuracy.

Remember that barometric pressure will alter as the weather changes.

Binoculars

These can be a very useful navigation aid, either for spotting landmarks and routes or for spying a route through crevassing.

6.13 Ski-Doo travel

Following a planned route by Ski-Doo will require new skills. In theory it is similar to wandering around the hills with a handheld compass, but in practice it is very different. Having to drive with a full-unit and maintain an accurate heading can be challenging. It is unlikely that you will need to do this in bad weather for reasons mentioned previously.

Ski-Doo compass

The engine and its electrical field affect Ski-Doo compasses. There will be a difference between Magnetic North and the direction the compass points on a vehicle. This is known as magnetic deviation. Where the compass points on a machine is called Compass North.

Ski-Doo compasses can be adjusted to compensate for the effect of the Ski-Doo's metalwork. This is covered in the Field Assistant's Work Manual. Swinging the compass in this manner will not compensate the compass for errors caused by the Ski-Doo's electrical field. This will alter depending on the engine revs.

It is best to check each leg you are driving with a handheld compass held away from the Ski-Doo. A GPS can also be used to back-up the Ski-Doo compass. Engines and metalwork do not affect GPS.

To maintain an accurate heading using a Ski-Doo mounted compass:

- Put out two flags that align with the bearing you need to travel along.
- Line-up on the flags and drive towards them at a constant speed. This speed should reflect the speed you will be travelling.
- Once you are lined-up and driving at the correct speed, read the bearing off the Ski-Doo compass. This is the bearing you should drive on for that leg. If your speed and engine revs change it may alter the Ski-Doo compass and your heading.
- Back up your driving with the GPS. Despite having a GPS, it is still easier to maintain your heading by using the Ski-Doo compass.
- Stop at regular intervals and take a back bearing down your tracks to check your line. Make sure you step off the Ski-Doo to take a bearing with the handheld compass.
- Don't forget to zero the Ski-Doo odometer at the start of a leg.
- Where a vehicle is used for an outward and return journey, mark the route with flags at strategic places and regular intervals.
- Note bearings, distances and times between flags in a notebook. Remember that journeys in poor conditions will take longer than in good conditions.
- Do not attempt to retrace complicated routes in poor conditions.
- The sun can be used as an aid to navigation in featureless places, but don't forget that it moves at 15° per hour.
- Old Ski-Doo tracks from the inward route may be followed. Turn the Ski-Doo at the end of a journey, so that it lies in or across the outward tracks. The outward trip tracks are therefore more easily picked up in poorer contrast.

Warning

Even with GPS it is still possible to make errors and GPS will not stop you driving into a crevasse or over a wind scoop. When travelling by Ski-Doo in the field you should always have shelter to hand, be it the half-unit or the full-unit. A safe camp can be made with this equipment and there is generally no pressing need to return to the main camp, station or caboose.

The clarity of the air in the Antarctic can make judging distances very difficult. Beware of miraging, which is a relatively common phenomenon. Mirages can easily be mistaken for distant peaks.

7 Basic snow and ice skills

Introduction

BAS uses a standardised system for technical equipment and work practices that all personnel should adhere to. This policy may appear rigid and inflexible at first, but it means that all staff at all stations use identical methods. This reduces potential confusion.

7.1 Moving on snow and ice

Before using any technical equipment it is essential that you become competent at moving on snow and ice, especially on steep ground. Before moving onto more complicated techniques you should practice and be competent at:

- Walking with the ice axe.
- Kicking steps.
- Cutting steps.
- Walking with crampons.
- Ascending, descending and traversing steep slopes. Try doing this on both hard and soft surfaces.
- Ice axe self-arrest.

Always practice on a safe slope with a good run-out.

7.2 The ice axe

This is the basic tool for movement over snow and ice. It is a versatile tool and can be used for:

- Balance and support.
- Cutting steps and handholds.
- Probing.
- Anchoring.
- Emergency braking.

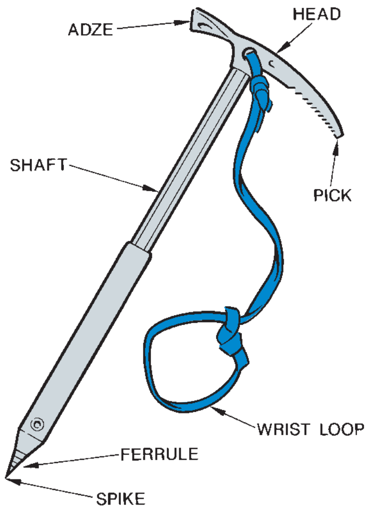


Figure 7.2a Parts of the ice axe

BAS ice axes vary in length from about 60-80cm. Climbing tape should be attached to the head of the axe to form a wrist loop so that the axe cannot be dropped and lost. This loop should be about the length of the axe so the base of the shaft can be held while climbing.

Holding the ice axe

The axe should always be carried with the pick to the rear. This makes it much easier and faster to ice axe self-arrest. It should always be carried in the uphill hand. If carried in the lower hand it puts the body out of balance and makes it harder to adopt the self-arrest position.

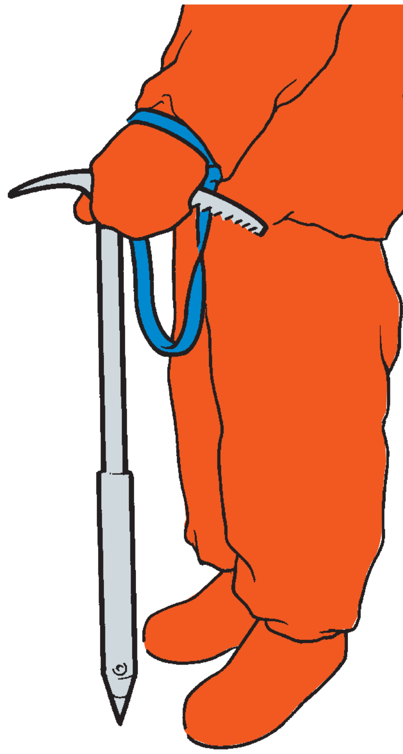


Figure 7.2b How to hold an ice axe
Note how the "adze" faces forward.

Cutting steps

Cutting steps can increase your security on steep ground. If you have forgotten or lost your crampons you will have to fall back on this technique.

Always make sure you have a positive stance as you cut. Swing from the shoulder not the elbow. Cuts should follow the line you would naturally take if you were kicking steps. Descending is more difficult than ascending when step cutting.

It is often best to fit crampons than to try to cut steps.

7.3 The ice hammer

The ice hammer is essentially the same tool as an axe but a hammerhead is attached instead of an adze. The hammer is necessary for placing snow stakes, deadmen anchors and some types of ice screws. It should be kept on the outside of the rucksack when not in use.

7.4 Ice axe self-arrest

The ability to check a slip or fall by adopting the ice axe self-arrest position is one of the most important and basic of all mountaineering skills. It should be practised until it becomes instinctive, even when falling head first and on your back.

To practise the techniques described below, wear full waterproofs and a helmet. Choose a concave patch of snow that has a long, safe run-out. Remove the tape loop on your axe. If you let go of it while practicing it will fall clear of you rather than whirling around near your head. Do not wear crampons for practising. Practise using the axe on both the left and right so that you are competent to arrest any fall.

In a real situation you may well be wearing crampons so practise with your feet up. If your feet contact the snow with crampons on, they can catch and flip you head over heels.

The basic braking position

With your hand on the head of the axe in the standard carrying position, grasp the end of the shaft and the ferrule with the other hand, covering the spike. This protects your body and reduces the chance of the spike catching on the snow and the axe being wrenched out of your hands.

Hold the axe across your body with the adze held under your right shoulder (assuming that your right hand is holding the axe head) and the left hand and spike by the left side. This is the basic braking position that should always be used.

When you are lying on the snow, the pick of the axe should be forced into the snow by pushing as hard as possible onto your right shoulder. By doing this you will find your stomach comes off the ground and some weight comes onto your knees.

Make sure that you keep the adze tucked below your collarbone for maximum braking power. If the adze slips up and away from this position there is little point in trying to force it back in again. It is better to withdraw the pick from the snow and relocate it below the collarbone. Arching your back helps when relocating the adze.

To practice, lie face down in the basic position and withdraw the pick from the snow. As you start to slide, gradually apply weight to the pick until you come to a halt. Try it again until you are sliding at full speed and stopping effectively. As you come to a halt, kick your feet into the snow to ensure you do not slide off again when the pick is removed.

This basic braking position works if you fall feet first on your front. Described below are the techniques required to put you into this basic position from any type of fall.

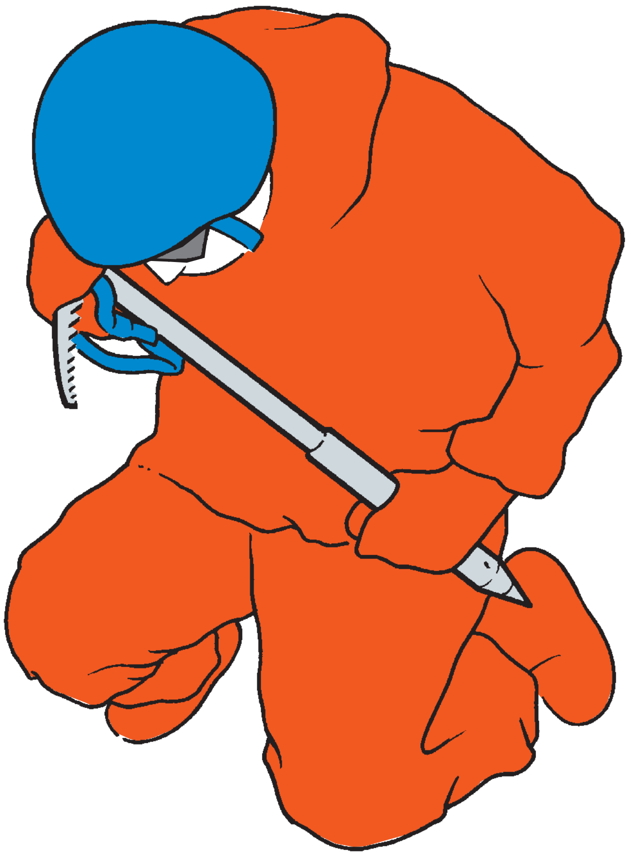


Figure 7.4a The "basic braking position" viewed from underneath
Note how all the weight is concentrated on the shoulder and knees.

Sliding feet first on your back

From this position, it is important to roll over into the basic position as soon as possible. It is vital that you roll towards the head of the axe. Rolling the other way may cause the spike to catch in the snow and the axe to be wrenched from your hand.

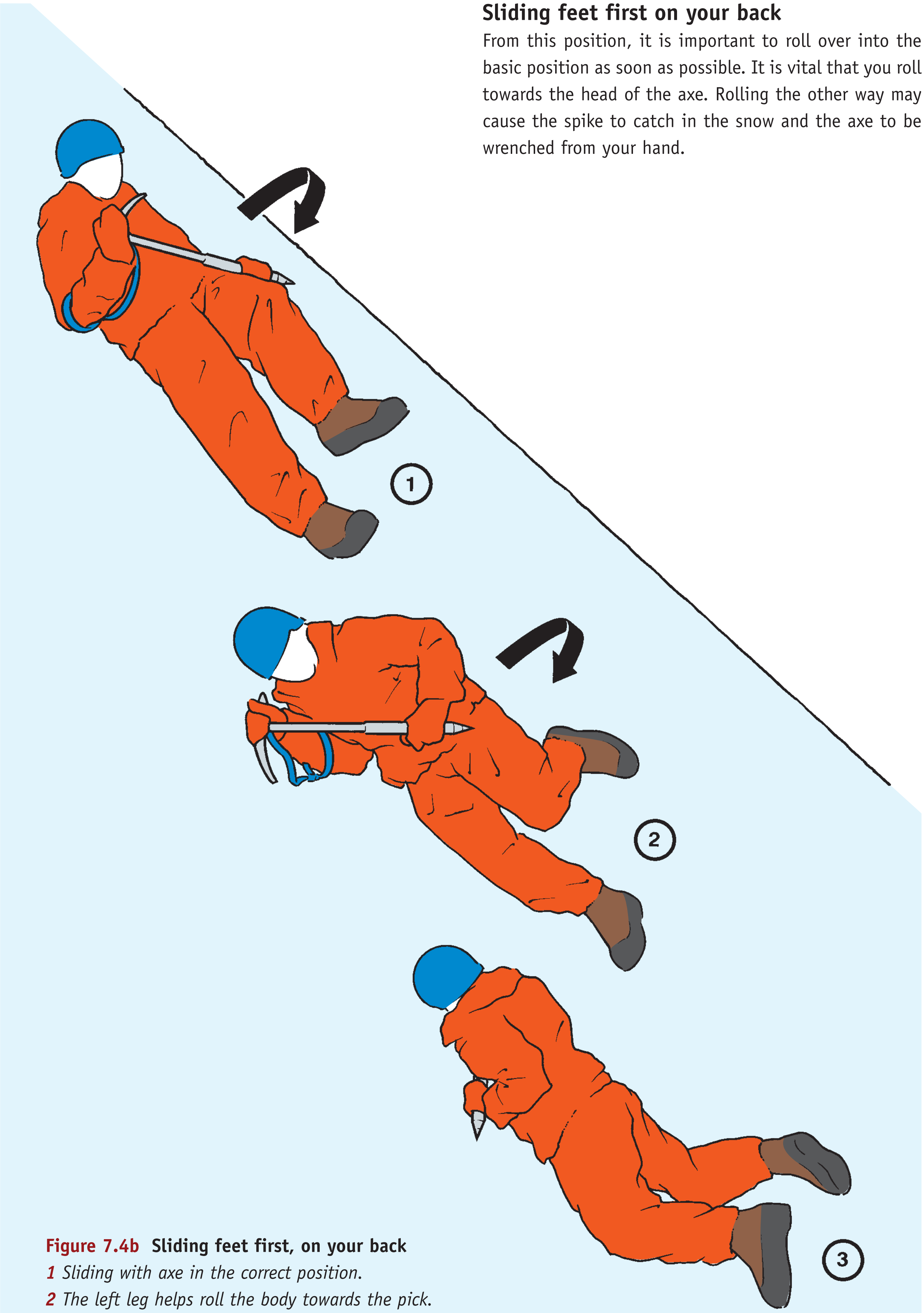


Figure 7.4b Sliding feet first, on your back
1 Sliding with axe in the correct position.
2 The left leg helps roll the body towards the pick.
3 Full pressure onto the pick in the basic braking position.
(Note how the feet are raised away from the snow.)

Sliding head first on your front

To practise this technique, get somebody to hold your feet as you get into the correct position. The aim here is to use the pick of the axe as a pivot point to turn your body round before braking.

- While facing downhill on your front, hold your axe in front of you and out to one side so that the axe head is furthest from you but level with your shoulders.
- As you start to slide forward, place the pick in the snow as far from your body as you can reach. As soon as the pick takes hold, your body will start to swing around. This swing can be very fast.
- Remove the axe before you turn beyond 180°.
- As soon as you have removed the pick, arch your back so you can relocate the adze under your collarbone and start the braking process.

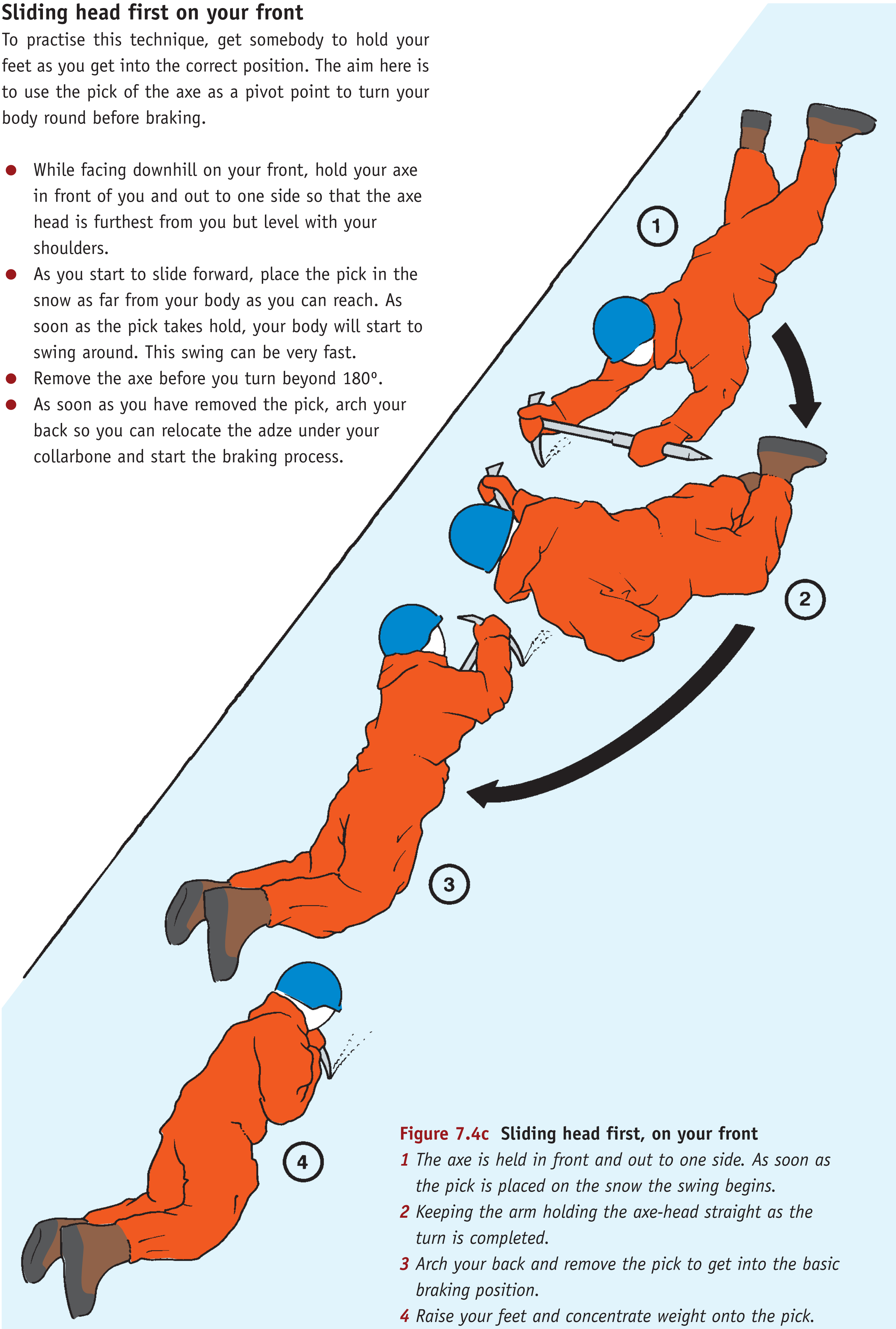


Figure 7.4c Sliding head first, on your front

1 The axe is held in front and out to one side. As soon as the pick is placed on the snow the swing begins.

2 Keeping the arm holding the axe-head straight as the turn is completed.

3 Arch your back and remove the pick to get into the basic braking position.

4 Raise your feet and concentrate weight onto the pick.

Sliding head first on your back

This is probably the most complex of all self-arrest techniques and it requires a confident approach. The pick provides a resistance point from which your movement will land you in the basic braking position. Again, get somebody to hold your feet while you set-up to practise this method.

- Hold the head of the axe in the right hand and the base of the shaft in the left. The axe should be held at hip level and out to the right-hand side so that your right arm is straight.
- As you start to slide, the pick grips the snow and your body will begin to pivot round. To facilitate this, move your weight onto the hip nearest the axe. This helps to produce a twisting or unwinding motion that should land you close to the basic braking position.

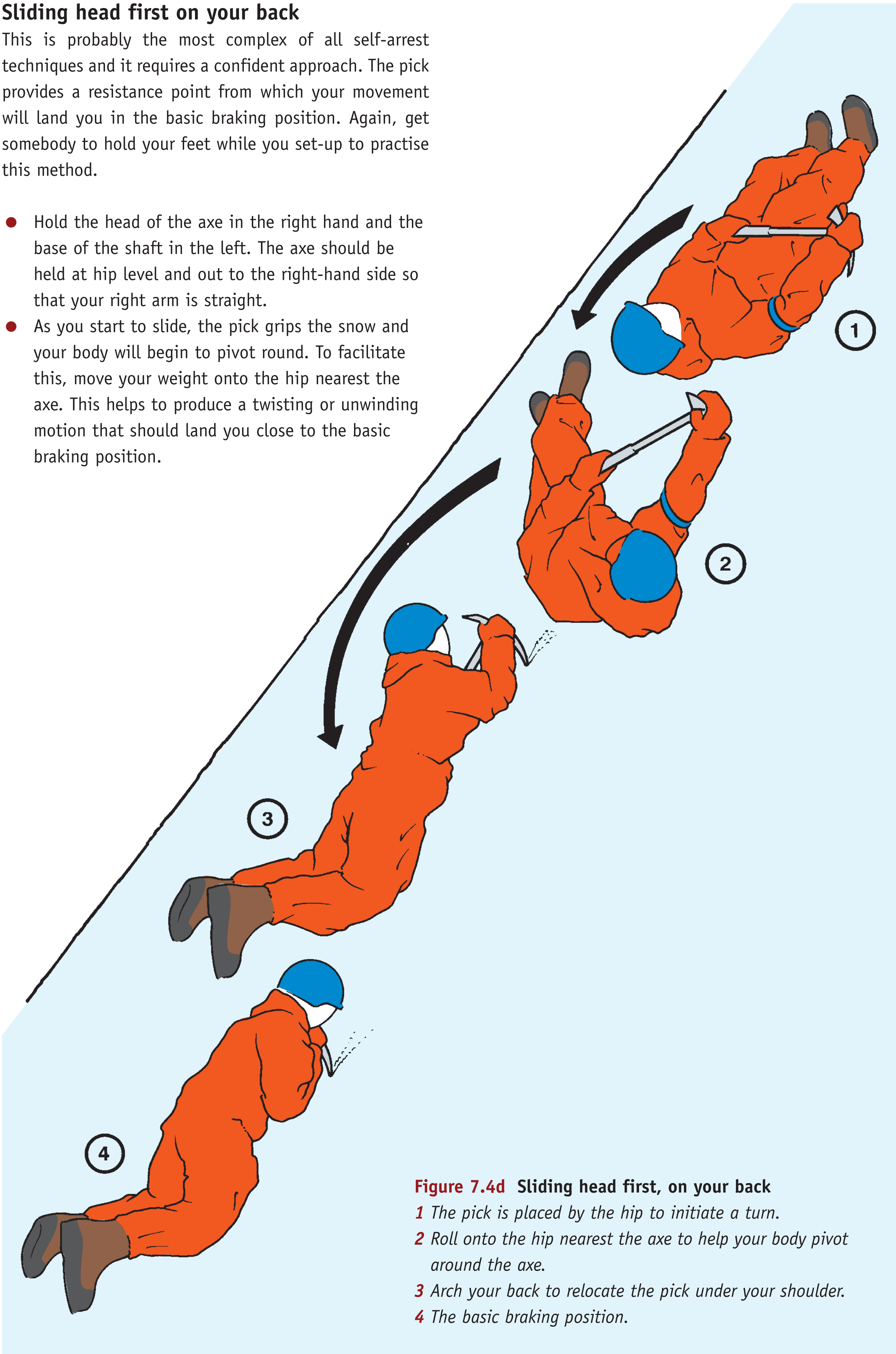


Figure 7.4d Sliding head first, on your back

1 The pick is placed by the hip to initiate a turn.

2 Roll onto the hip nearest the axe to help your body pivot around the axe.

3 Arch your back to relocate the pick under your shoulder.

4 The basic braking position.

Practise all the above techniques on both sides. As your ability and confidence grows, try a few tumbles and somersaults. In an uncontrolled tumble you need to stabilise your fall by throwing your arms and legs out into a star shape and then apply the appropriate technique to arrest the fall.

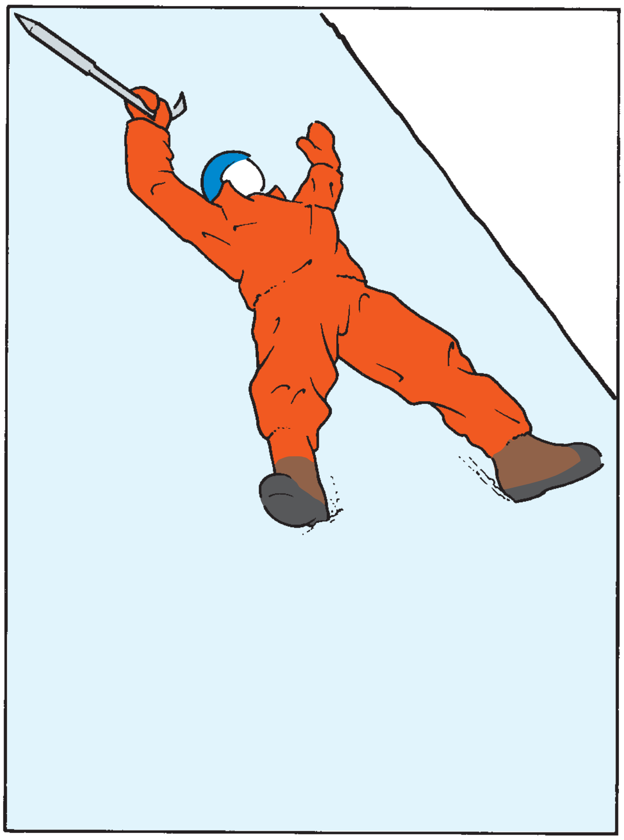


Figure 7.4e Forming a star shape will stabilise a fall that is out of control
Once stabilised the axe can be used to arrest the fall.

7.5 Crampons

BAS supplies step-in crampons which are designed to fit plastic mountaineering boots.

Initial fitting and maintenance

It is important that crampons are fitted correctly. Follow the manufacturer's instructions and ensure that they are set up for the boot size. Front points should protrude about two centimetres.

After extended use on mixed ice and rocky ground the points will require sharpening with a file. Don't make them razor sharp as this increases the risk of personal injury and will result in them becoming blunt very quickly. The crampon's nuts, bolts and straps should be checked periodically.

Figure 7.5 Crampons fitted to boot

Attaching the crampon to the boot

- Make sure you have them the right way round (buckles to the outside).
- Clear snow from the boot soles.
- Make sure the heel clamp is located correctly in the boot groove.
- Fasten all retaining straps.
- Make sure you have no loose clothing or bootlaces exposed that could catch in the front points.
- Before walking, check they are attached properly. Insert your ice axe between the boot heel and the crampon and try to pry them off gently. This checks whether the heelpiece is located correctly.

7.6 Crampon techniques

Practise the various techniques required for different gradients. Try to walk with your feet further apart than normal to avoid catching your front points on the opposite boot or gaiter. This form of tripping is one of the most common causes of a fall.

French technique

Having walked around on flat ground, try moving on slopes angled up to 30° using the same method.

Keep your feet completely flat to the surface by flexing your ankles and even your knees. With this flatfoot position (called the French technique) it is possible to keep all the downward pointing spikes of the crampon in the snow or ice, providing maximum traction.

Figure 7.6a Using the French, "flat foot" technique to descend
Note how the toes point straight downhill and are flat on the snow/ice surface.

Figure 7.6b French technique being used to cross and ascend a steep snow/ice slope
Note that the ankles need to be very relaxed to ensure feet remain flat.

With practise this becomes a very fast and easy way of moving up, across and down slopes of surprising steepness.

Front pointing

On steeper slopes the front points can be used to ascend or descend. This method strains the calf muscles and becomes strenuous over prolonged periods. Front pointing is the most appropriate technique for very steep ground.

Combining techniques is possible so that you have one foot front pointing and one foot in the flatfoot position. By swapping feet from time to time both legs are given an equal workload.

Balling-up

This is the term used when snow sticks to the crampon's metal structure in wetter snow conditions. This snow builds-up to a point where the crampon points can no longer make contact. It can take place over several steps or, in bad conditions, just one step.

To dislodge this snow, the frame of the crampons should be tapped frequently with the end of your ice axe. If your crampons are balling-up badly, they may be unnecessary because the snow has become soft enough to kick your boots into.

Effective and durable anti-ball plates can be fashioned easily from duct tape.

7.7 Top tips for moving on snow and ice

- Always use an ice axe.
- Make sure the pick is to the rear and the axe is in the uphill hand.
- Maintain an upright, confident posture.
- Become proficient at all aspects of ice axe self-arrest.
- Wear crampons when necessary.
- Make sure your crampons are fitted correctly.
- Don't let your crampons ball-up badly.

8 Technical equipment for glacier travel

Introduction

The hazards encountered when working and travelling on glaciers means a considerable amount of technical climbing equipment needs to be carried. To travel safely on glaciers you must be familiar with the functions and limitations of all this equipment.

8.1 The rescue sack

The technical equipment used for BAS field travel is stored in a standard package called the rescue sack. When travelling by Ski-Doo, the rescue sack should be kept on the rear of the machine. For a full list of rescue sack contents see Chapter 26.

8.2 Ropes

A number of different types of rope are used in the BAS system and it is important to understand their different properties and applications.

Construction

Rope can be split into two main categories regarding construction - kernmantel and hawser laid.

Kernmantel ropes

Kernmantel rope is made up of a central core of filaments protected by an outer braided sheath. Their handling properties are superior to hawser laid ropes and they are easier to knot. All modern climbing ropes are of kernmantel construction.

Hawser laid ropes

These are made up of three strands twisted together. In an emergency it is possible to unravel and tie these strands together to produce a single rope almost three times the original length. This type of rope can be spliced if one section becomes damaged.

Shock-absorbing qualities

Rope can also be split into two categories regarding their ability to absorb shock-loads.

Dynamic ropes

These are designed to stretch when shock-loaded. This dissipates the energy of a fall and greatly reduces the shock-loading on both people and anchors. Climbing ropes are therefore dynamic.

Static ropes

These ropes do not stretch and are therefore suitable for hauling. They should never be used for climbing.

Visually it is very difficult to tell dynamic and static ropes apart. Both dynamic and static ropes can be of kernmantel or hawser laid construction.

As a general rule it is worth remembering that dynamic ropes can be used for all applications but static ropes can only be used for hauling/lowering. If a dynamic rope is used for hauling it will be harder work due to rope stretch, but it is not necessarily unsafe.

Do not use static rope for dynamic applications.

Diameter

Within a field-unit, rope diameters range from 5mm cord to 20mm towing rope with a static load limit of 8,300kg. Knots can reduce the strength of a rope by 20-40 per cent. Wet and frozen ropes will also be weakened. When selecting rope, choose the largest diameter practical for the application and use the correct knots.

8.3 Karabiners

BAS policy is to use screw-gate karabiners only. Screw-gate karabiners have a sleeve on the keeper section that screws over the gate and locks the karabiner shut. This ensures that the rope, figure of eight, Ski-Doo leashes or other attachments cannot be released accidentally. In order for these karabiners to be effective it is essential that they are screwed-shut.

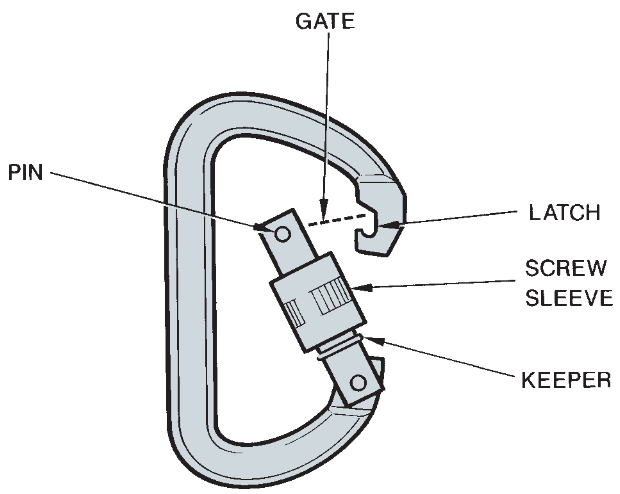


Figure 8.3a Parts of the karabiner

Do not put a three-way load onto a karabiner as its strength is on the long axis. A sideways pull can drastically reduce its strength. The sleeve on screw-gates is vulnerable if a figure of eight is lying across it. It takes very little force to snap this sleeve so always ensure the figure of eight is not twisted over it.

Figure 8.3b Figure of eight over karabiner gate

8.4 Harness

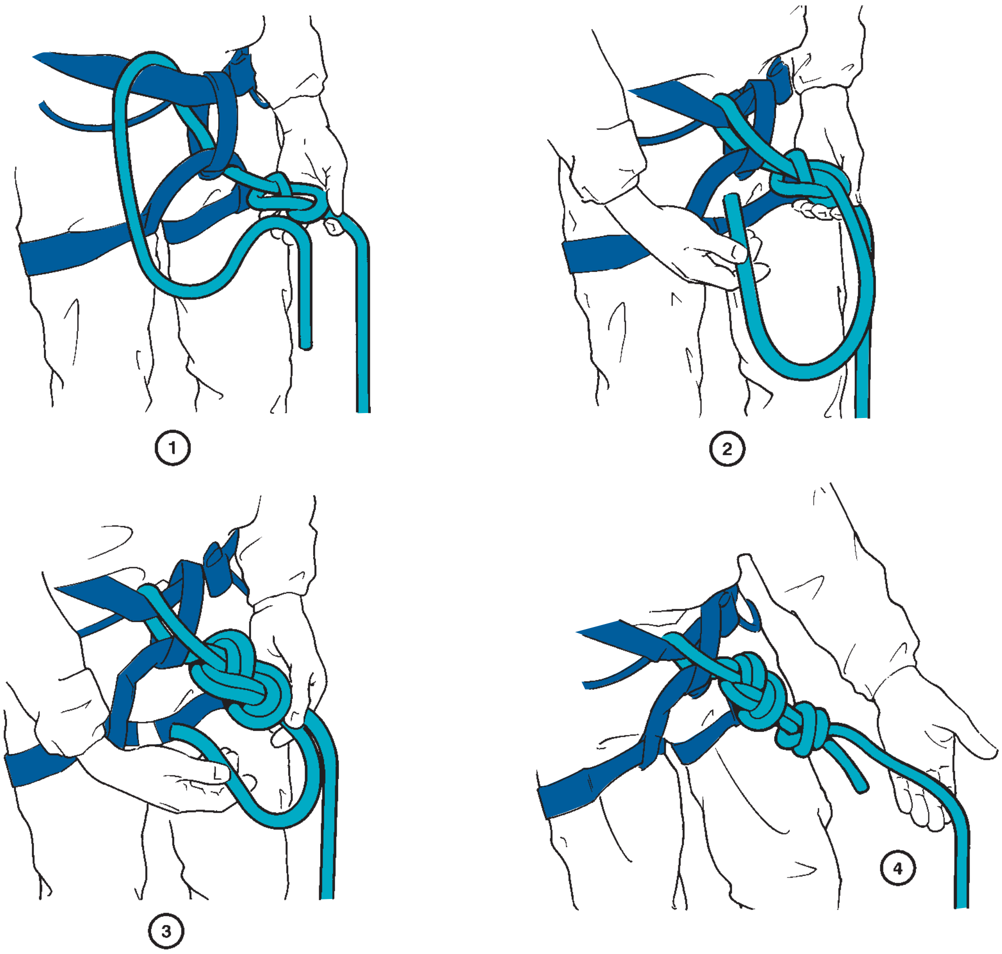
Harnesses provide a means of attachment to a rope. In the event of a fall, the force on the individual is distributed evenly around the seat area. A rope tied directly around the waist could cause severe damage to the internal organs. A loss of consciousness would occur within minutes if suspended directly from the waist.

BAS uses a standard mountaineering sit harness. They are supplied in three sizes and have fully adjustable waist and leg loops. The harness should fit securely with the waist section sitting above the hips. This prevents the user falling out of the harness if hanging upside down. Be particularly careful that there is a close fit when wearing bulky clothing.

It is essential that the buckles are rethreaded after being done up. A minimum of 10cm of webbing should be left after rethreading the buckles. Instructions for fastening the buckles are printed on the manufacturer's label on the waist section.

The rope is attached by threading it through the waist section and the central part of the leg loop section. A Figure of Eight knot is used for tying-on. This must be backed-up with a Stopper knot to increase the security of the main knot. A Double Overhand knot is used as a Stopper knot.

Figure 8.4a Tying to a sit harness



Ancillary equipment such as friction devices, Jumars and Ski-Doo safety lines are attached to the belay loop at the front of the harness. This is the only attachment point on the harness. Gear loops are solely for storing karabiners and other hardware. Beware of accidentally clipping into these loops as the consequence of this error could be fatal.

Chest harness

A disadvantage of sit harnesses is that an unconscious casualty will hang upside down. A chest harness, however, supports the upper body when hanging in free space.

Chest harnesses are not worn in the field because when moving as an Alpine pair (see Chapter 9) the rope is tied in such a way that it makes a full body harness.

Improvising a chest harness may be necessary for crevasse rescue of an injured or unconscious victim. A chest harness can be improvised using a large sling (at least 2.4 metres long) and tying it off with a Sheet Bend knot.

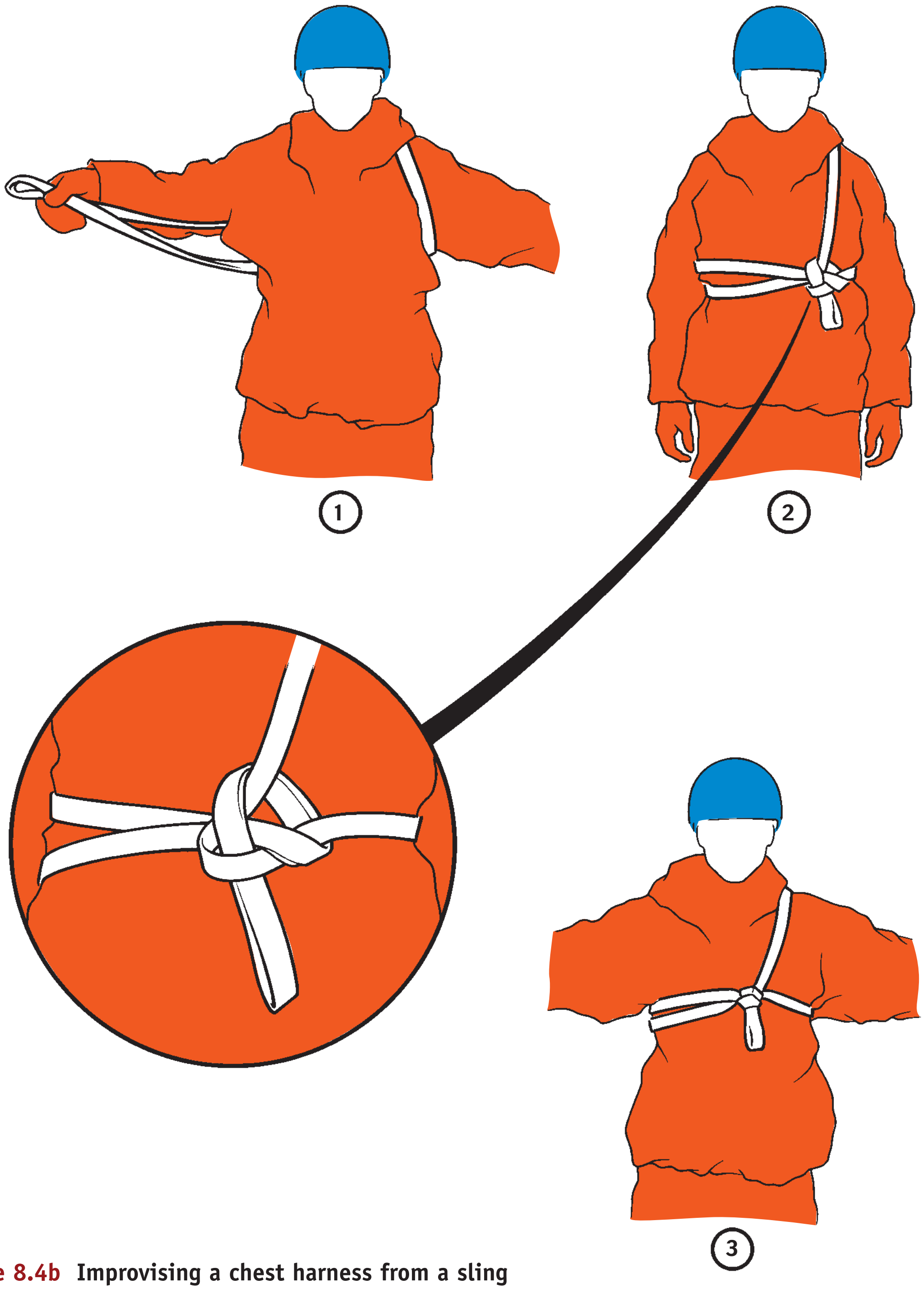


Figure 8.4b Improvising a chest harness from a sling

8.5 Pulleys

Four emergency pulleys are carried to reduce friction when operating hauling systems. BAS uses Petzl swing-cheek pulleys in the standard field kit. These are lightweight pulleys for emergency use only. Check that the karabiners and pulleys on your harness are compatible.

8.6 Mechanical ascenders (Jumars)

Mechanical ascenders (such as Jumars) are used for self-rescue when climbing out of a crevasse and in hoisting systems. These are described in detail in Chapter 10.

Two mechanical ascenders are carried on your harness for use in crevasse rescue situations. Sewn slings are attached to the Jumars by steel Maillons. Check that the Maillons are tight and the slings are in good condition. The foot Jumar should have a waist back-up sling in addition to the foot sling.

Mechanical ascenders should only be used on 10mm and 11mm diameter ropes. Jumars can be used on both kernmantel and hawser laid ropes.

When a load is applied to the Jumar, a serrated cam bites onto the rope and grips it. The cam can damage the rope's sheath if the load is too great. If a load becomes stuck and more than one person is pulling, a hauling system can put enormous loads on the front pulling Jumar. 400kg is the manufacturer's recommended maximum load for a Jumar. Think hard about the forces at play when you are setting-up and using hauling systems. It is relatively easy to exceed manufacturers guidelines.

Shock-loads should be avoided due to the high forces induced and the subsequent risk of rope damage. Do not attach Jumars to the rope when walking as an Alpine pair as shock-loadings would occur in the event of a fall.

Care should be taken to ensure that a Jumar's trigger is not accidentally released while ascending. This can cause it to become detached from the rope. Before going into the field, check that you can get a karabiner through the top hole of your Jumars. Not all karabiners are compatible.

All mechanical ascenders are prone to failure on icy ropes.

8.7 Ice screws, deadmen and snow stakes

All these devices are designed to provide a secure anchor in either ice or snow. The knowledge and skill required to place sound anchors can only be gained through experience. The holding power of each device depends greatly on the conditions and the skill with which they are placed.

It is critical that anchors are placed correctly as you are often trusting your life to them.

The most useful anchor for glacier travel is the snow stake. Snow stakes are very versatile and can be buried as deadmen. Each party member should carry two snow stakes on their packs.

Do not rely on one anchor point. Two anchors should always be linked together. See Chapter 10.

8.8 Figure of eight descender

BAS uses the figure of eight descender as a friction device for abseiling and for lowering applications. It can also be used for belaying by using it as a Sticht plate through the small hole. The Italian Hitch (Chapter 10) is a better method for this application, although it does kink the rope badly.

It is important that the rope is lying over the upper side of the brake bar when abseiling. If the rope is on the underside it can result in the rope locking off in an unintentional Lark's Foot knot.

The braking hand controls the speed of descent. If the braking hand is removed, a freefall descent will result. For this reason **abseiling must always be backed-up with a French Prusik** (see Section 10.2). This will lock in the event of the hand being released and stop any further descent.

It is very easy to abseil off the end of a rope hanging in free space so a knot must be tied at the end of any rope being used for abseiling and lowering.

8.9 Electron ladders

Electron ladders are wire ladders that can be rolled-up. These are kept in the rescue sacks and provide a very useful aid to escaping from crevasses. By laying an

Electron ladder over the lip of a crevasse the final, awkward moves out are made easier. Ensure you know how to use them before venturing into the field.

Electron ladders should never be climbed up or down without the added protection of a rope.

8.10 Jockey Winches

Jockey Winches are lightweight mechanical winches. Their main function is for raising heavy items such as Ski-Doos and sledges. They should not be used for lifting people except as a last resort. Before using these winches make sure you understand how they operate. The instructions supplied should be kept with the winch in the rescue sack.

Loads can be lifted or lowered with Jockey Winches. The handle position nearest the load will release tension. The handle position furthest from the load will raise or pull.

Points to consider when using Jockey Winches:

- Never connect ropes or slings directly to the haul wire, use a karabiner.
- Ropes should be tied with a knot that releases easily after being loaded such as an Alpine Butterfly (Chapter 10).
- If using rope with these winches only use static rope.
- Never use a Jumar with a Jockey Winch.

A Jockey Winch must only be used with the handle supplied. These handles act as a weak link. They are designed to operate within the specified lifting capacity of 300kg or the pulling capacity of 550kg. A safety factor is built into the device, but this should not be relied upon.

Jockey Winches are not recommended for lifting people. The loads generated can be large and injury or death could result from an obstructed pull or lift.

See also Chapter 11.

8.11 Safety equipment redundancy regulations

Minimum standards based on the age and condition of safety equipment are maintained. Out of date equipment should not be in service. Equipment should be inspected regularly and damaged or excessively worn gear should be taken out of service, regardless of its age.

The table opposite lists the redundancy age of safety equipment. The date starts when gear is taken off the shelf and put into service. Additionally there is a shelf life of five years for safety equipment. Therefore a rope could come onto a station in 2005, come into service in 2010 and expire in 2013.

- Dynamic safety equipment has a three-year working life before it is removed from service.
- Static safety equipment has a five-year working life before it is removed from service.

Gear should be taped with a colour appropriate to its age (see table). Do not write the date on functional components of harnesses and helmets with marker pens, use date tape instead. Out of date climbing equipment should be chopped-up and disposed of.

Safety equipment redundancy regulations table

Climbing tapes and slings	Five years	Any fraying on tape should be considered carefully.
11mm climbing rope	Three years	Particular care with inspection after any suspected crampon damage and heavy Jumar use.
11mm Ski-Doo safety lines	Three years	Probably the item most susceptible to damage, and most likely to sustain the greatest shock-load in a Ski-Doo fall. May well not last three years.
Prusik loops	Three years	Excessive use can lead to unacceptable twists. High risk of damage through friction.
11mm static Kernmantel	Three years	For rescue purposes only. Used for hauling and lowering only.
20mm sledge centre lines	Three years	Check for wear especially around eye splices.
20mm tow and link lines	Three years	Check for wear especially around eye splices and overrun areas.
20mm sledge towing pennant	As wear and tear dictates	NB. Not integral to the link system. Life expired spare link line can be used.
10mm hawser (static)	Five years	In rescue sacks. Uses - hauling, lowering and extending anchors. Can be used for sledge standing lash-line when life expires.
7/8mm hawser (static)	Five years	In rescue sacks. Can be used for linking anchors. Use for sledge running lash-line when life expires.
Climbing harness	Five years	Write date on label, not harness.
Climbing and Ski-Doo helmets	Five years	Date mark on chinstrap.
Flares		Flares must be in date for the season of use.

Date tape code

Items should be date taped. Re-tape with the same colour if the tape is wearing off.

1999/00	White
2000/01	Yellow/green stripes
2001/02	Green
2002/03	Yellow
2003/04	Blue
2004/05	Red
2005/06	White
2006/07	Yellow/green stripes
2007/08	Green
2008/09	Yellow
2009/10	Blue
2010/11	Red

9 Glacier travel techniques

Introduction

This chapter will cover non Ski-Doo travel. Ski-Doo travel techniques can be found in Chapter 11 but the principles remain the same.

Most glaciers close to BAS stations have safe routes marked with posts and flags. However, these routes need regular inspection and updating as the summer season progresses. Areas thought to be safe for years may be harbouring large crevasses.

9.1 Glaciers and crevasses

A glacier gradually flows downhill, constrained by the topography around it and affected by the topography beneath it. This movement creates its main hazard - crevasses.

The brittle surface layer of a glacier is liable to crack when subject to forces such as a change in angle or speed of flow. The ice beneath this brittle layer is more plastic and tends to bend rather than crack. Therefore crevasses are rarely deeper than 50 to 80 metres - although this is hardly a reassuring figure.

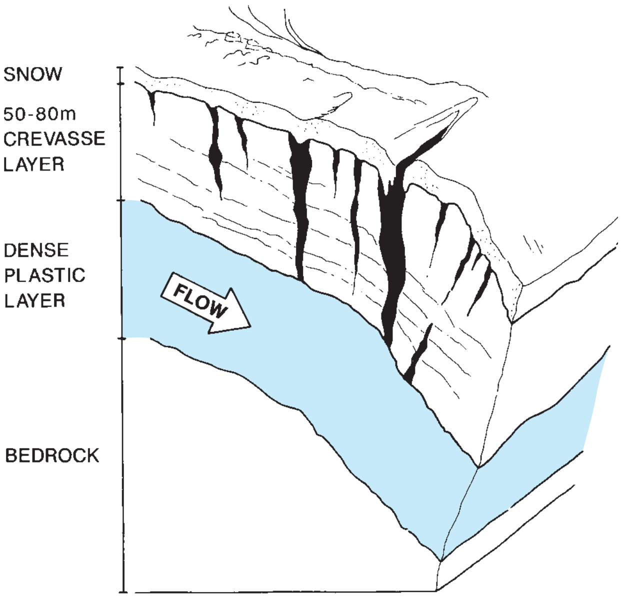


Figure 9.1 Movement of a glacier

Glaciers in the Antarctic are usually covered by several feet of snow. This makes it very difficult to see what is happening below the surface. There are some general principles that can help predict the best and worst routes on a glacier.

Crevasses tend to appear in similar places on any given glacier. They are most likely to form when the brittle upper layer is unable to resist the stresses being imposed on it. What therefore, will cause a glacier to undergo these stresses?

Shape of slope

Convex slopes are more likely to be crevassed than concave slopes. These are areas of tension whereas concave slopes are areas of compression. Try to picture the flow and shape of the glacier below the surface. Think:

- Compression is a good thing.
- Tension is a bad thing as it causes cracking.

Speed of flow

The faster the ice travels, the greater the stresses within the ice. Glaciers will flow faster in the middle and slower at the sides. Therefore crevasses are often larger in the middle of a glacier.

Glacier shape

As a glacier flows around a bend the outside edge of the glacier is in tension. Crevasses are therefore more likely to occur on the outside edge of a bend.

Type of glacier

Most glaciers in the Antarctic are very large and slow moving. They may look smooth and flat but the topography underneath can mean huge crevasses orientated at any angle, not necessarily in the direction you would expect them.

Crevassing will form on ice shelves around shear zones and grounding lines. These can be very dangerous areas so don't get lulled into a false sense of security when working on flat, white and often featureless ice shelves. Ice piedmonts often have crevasses radiating out in a fan shape.

Crevasses can exist for long distances downstream of the feature that has caused them.

9.2 Crevasse spotting

In areas where no crevasses are visible you will have to predict their likely position and orientation. Knowing the orientation of crevasses is as important as spotting where they are.

The presence of crevassing is often marked by slumped snow bridges. These will show up as faint linear depressions.

Top tips for spotting crevasses:

- Find a good vantage point.
- Make sure that you have good contrast. Surface features will show up best if the sun is at a low angle and is in front of you. Remember that if the sun is lying in the same plane as the crevasses they will be less apparent.
- Think about where you would expect them to occur.
- Look at the terrain on either side of your track when travelling.
- Where possible use aerial photographs, maps and field reports to give you additional information. However, don't forget that glaciers do alter even in quite short spaces of time. It is always best to make your own assessment.
- Walk through any suspect areas first as an Alpine pair. Better to find crevasses with your foot than with a Ski-Doo.
- If in doubt get the probe out. Take the basket off a ski stick or use an avalanche probe.

9.3 Bergschrunds

A Bergshrund is the terminal crevasse that forms between a permanent snowfield and the glacier flowing past it. When trying to access rock outcrops from a glacier you are likely to encounter Bergschrunds.

Crossing a Bergschrund from below is generally safer than crossing from above. If the leader falls in when crossing from above the second person may follow. If in doubt set up a belay or abseil over the gap (see Chapter 10).

9.4 Moving over glaciated terrain

Where the risk of crevassing exists it is essential that all party members are roped together, have the required equipment and are fully versed in the necessary rescue techniques (see Chapter 10). The method used for travelling safely on glaciated terrain is known as an Alpine pair. This forms the basis for all field travel in the Antarctic.

For glacier travel, the optimum number of people in a party is three. This will make any crevasse rescue much easier. In reality, field parties often consist of just two people. The BAS system is based around a two-person set-up but it can be easily adapted to three.

9.5 Roping-up

The purpose of roping-up is to safeguard party members against crevasse falls. The most experienced party member leads the way and selects an appropriate route. On descent the more experienced person will stay at the back to safeguard the other member of the team. In the event of the leader falling into a crevasse, the second person will arrest the fall and take the necessary action to retrieve the leader if they can't self-rescue (see Section 10.13).

To travel safely, a party must rope-up in such a way that in the event of someone falling into a crevasse the other party member is in a position to escape from the rope and perform a rescue.

Rope choice

A 50 metre, dynamic climbing rope is used for glacier travel. A static, non-stretch rope should **never** be used.

Rule of thirds

Roping-up is known as the rule of thirds. A party of two will have a third of the rope connecting them and a third of the rope around each of them in coils. The general principle when roping-up for glacier travel is that you have a gap of over 10 metres between each person. The party members must also have sufficient rope to set up a hoisting system.

The rope is carried around the body as coils. This shortens the rope and also produces an improvised chest harness. This is invaluable if you fall into a crevasse wearing a heavy sack because it prevents you from hanging upside down. This would obviously be problematic with an unconscious crevasse victim.

9.6 Roping-up as a party of two

1. Put on a sit harness. Make sure that all the buckles are threaded back on themselves. Ensure that 10cm of webbing is left after threading the buckles.

2. Tie-in with a Figure of Eight knot backed-up with a Double Overhand Stopper knot. See Section 8.4.

3. Divide the rope as per Figure 9.6a.

4. Tie an Overhand knot into the bight removed from the karabiner to mark the rope.

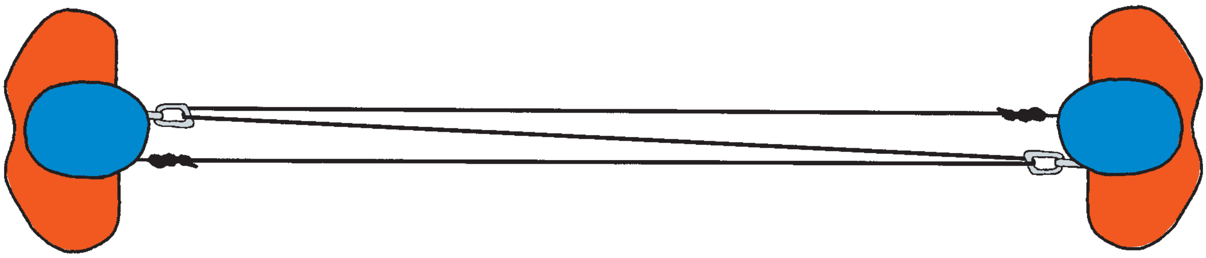


Figure 9.6a Two person rope-up
50 metre rope, three 16 metre lengths and two metres for knots.

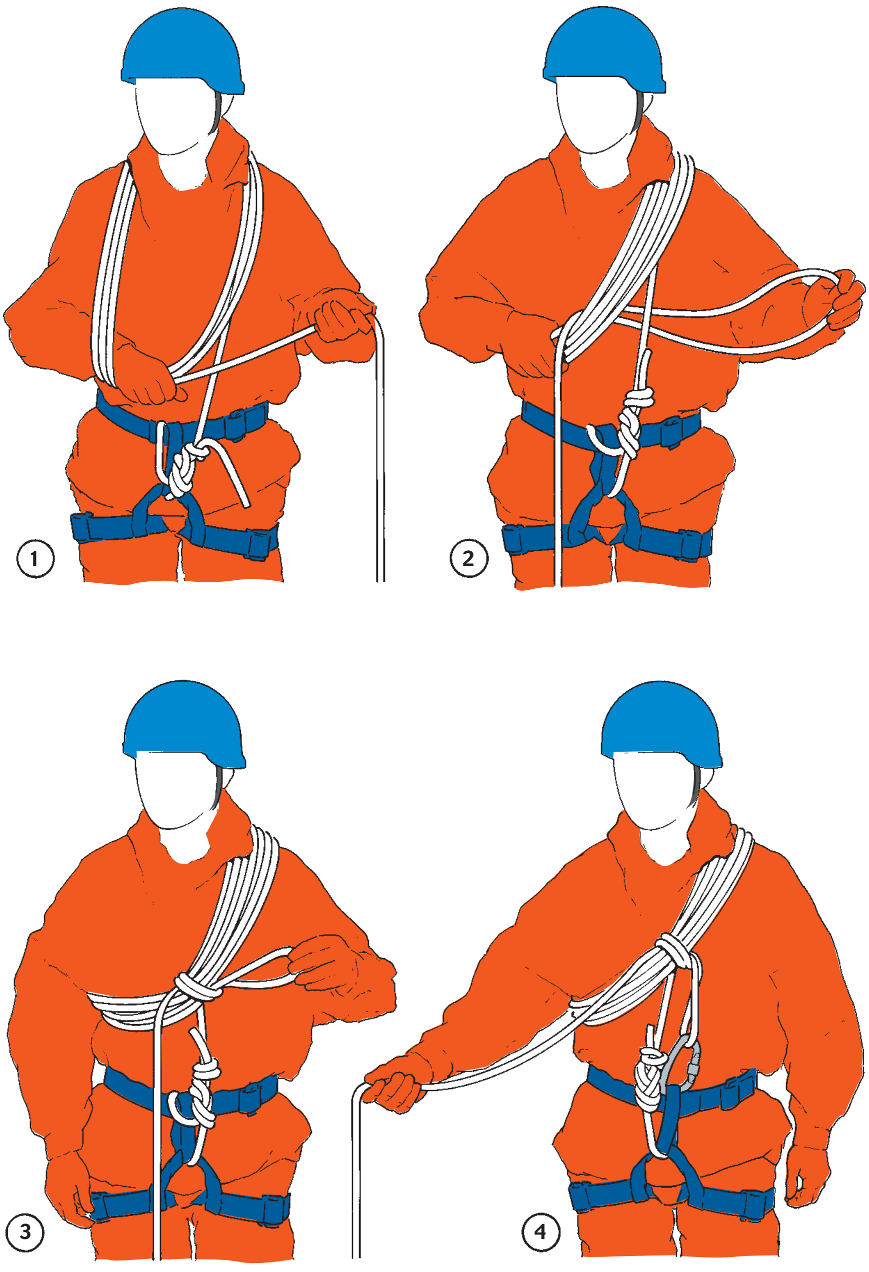


Figure 9.6b Taking on coils

1 *Measure out the rope into thirds, remembering that each person needs to take an extra three metres each. Take the coils over the shoulder until the correct amount of rope is taken in.*
2 *Take a bight of the live rope behind the coils.*
3 *Tie an Overhand knot on the rope leaving a short loop.*
4 *Clip the loop with a screw-gate karabiner into the belay loop or the loop of the tie-in knot.*

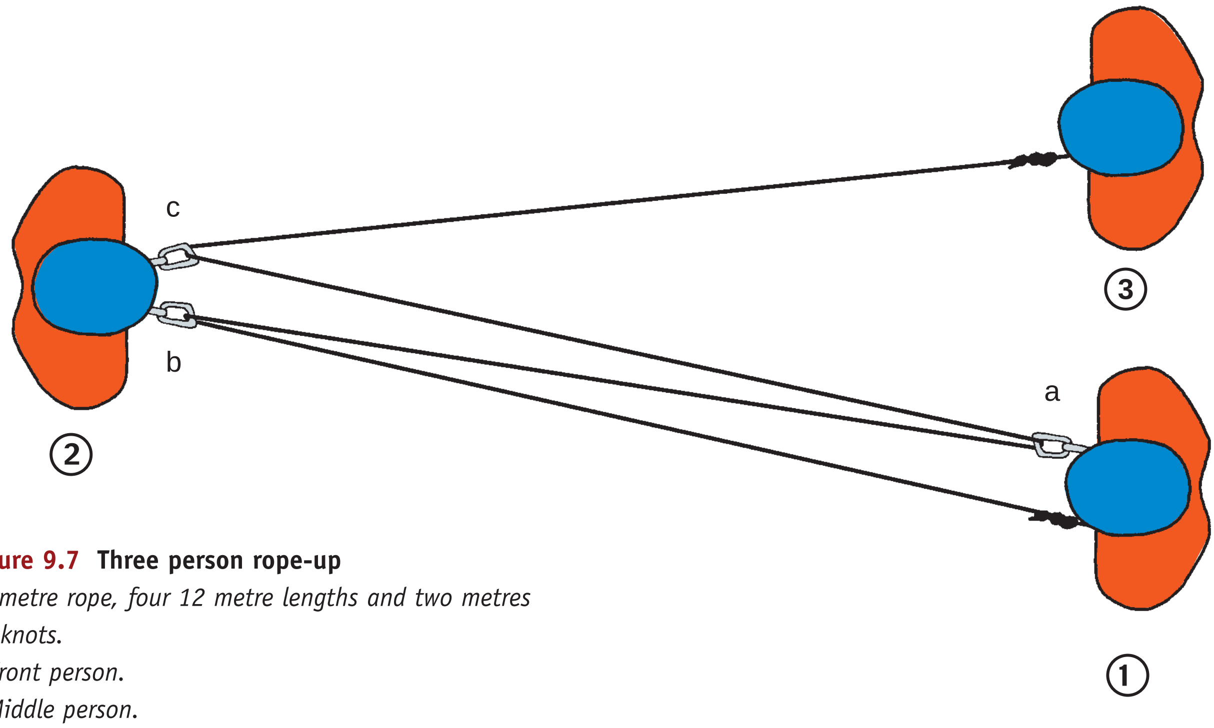


Figure 9.7 Three person rope-up
50 metre rope, four 12 metre lengths and two metres for knots.
1 *Front person.*
2 *Middle person.*
3 *Rear person.*

5 Take-on coils until the Overhand knot is reached. Take on one more coil after the knot. The coils should hang halfway between your armpit and your harness. See Figure 9.6b.

6 Undo the knot and tie-off the coils using an Overhand knot. Clip this into your belay loop.

7 Tie the long Prusik into the rope in front of the coils with a standard Prusik knot (see Section 10.2). Tuck the free end into the coils.

8 Put your rucksack on after the coils.

Warning - Do not have less than 10 metres of rope between party members.

9.7 Roping-up as a party of three

This is slightly more complicated than the two person set-up. Tie-on as in steps one and two in the previous section.

1 The most experienced member of the party should tie-into the front end of the rope. The person at the back ties-into the rear of the rope.

2 The party should divide the rope as illustrated.

3 Tie Overhand knots into the bights at "a", "b" and "c" to mark the rope.

4 Party members "1" and "3" take-on coils until the Overhand knots "b" and "c" are reached. Undo the knots and tie-off the coils.

5 Party member "2" finds the middle of the remaining rope using Overhand knot "a".

6 Party member "2" then takes out the Overhand knot and ties-in with an Alpine Butterfly. This is the normal method for the middle person to tie-in. However the middle person does not have the benefit of chest coils. A simple method of getting around this is to clip the rope from the rear person into the rucksack carry loop. The carry loop can be backed-up with a sling that also goes through the shoulder straps. This system will be most effective if the rear person checks the middle person's fall.

7 Each member ties the long Prusik into the rope and tucks the excess into their coils. The middle person should tie it into the rope in front of them.

Warning - Do not have less than 10 metres of rope between party members.

9.8 Equipment

The basic equipment required per person for safe travel on glaciers is as follows:

- Sit harness.
- Ice axe.
- Ice hammer.
- Jumars (one pair).
- Prusik loops (one long and one short).
- Figure of eight descender.
- Four slings (include at least two long slings).
- Two snow stakes.
- Three ice screws.
- Four lightweight pulleys.
- Screw-gate karabiners (minimum of 10).
- Rucksack.
- Crampons.
- Helmet.
- Immediate aid pack.
- Water and spare clothing.

For more information see Chapter 26.

9.9 Moving together on a glacier

Route choice is largely a matter of experience and using available information.

The principle of roped travel is to keep the rope between you and your partner as tight as is practical and at right angles to the crevasse orientation. Keeping at right angles to any crevasse reduces the risk of the whole party walking along the same snow bridge.

Never carry hand coils when moving on a glacier.

9.10 Arresting crevasse falls

Holding a fall should not be difficult if the rope is kept taut between party members. Most falls stop before the faller is chest deep.

If the leader falls, the second person should react quickly and move backwards to tighten the rope. Assume a low position with your heels dug into the snow. As the leader's rope cuts into the edge of the crevasse, the friction produced will help to hold the fall. If this fails, use the ice axe arrest technique.

9.11 Top tips for avoiding crevasse falls

- Always travel roped with the correct equipment.
- Don't have any slack in the system.
- Cross crevasses at 90° to their orientation.
- Don't travel in flat light.
- Be careful in the afternoons, particularly after a warm day.
- At higher Antarctic latitudes consider travelling and working at night at warmer times of the year.
- If in doubt probe.
- Put the most experienced party member at the front except when descending.
- When crossing suspect bridges, spread your weight. Crawl or swim if necessary.
- If crossing wide crevasses with suspect bridges, consider setting-up a belay with good anchors.
- Skis and snowshoes will reduce your ground pressure.
- If carrying heavy loads such as rock samples, consider using a pulk sledge to spread the load (see Chapter 12).
- **If dificulties are too great, find an alternative route or turn back.**

10 Ropework and rescue techniques

Introduction

This chapter is the most complex part of the Field Manual. The consequences of getting these techniques wrong could be extremely dangerous, perhaps even fatal.

In order to carry out the procedures in this chapter you need to be competent in a number of key areas:

- Knots.
- Types of anchors and their uses.
- Linking anchors.
- Belaying.
- Ascending and descending the rope.
- Hoisting systems.

10.1 Knots

The BAS system uses a number of different knots with each one having particular applications. You should be capable of tying them all, even with gloves on.

All knots will reduce the strength of a rope. A Figure of Eight will reduce the strength of the rope by about 30 percent.

Figure of Eight

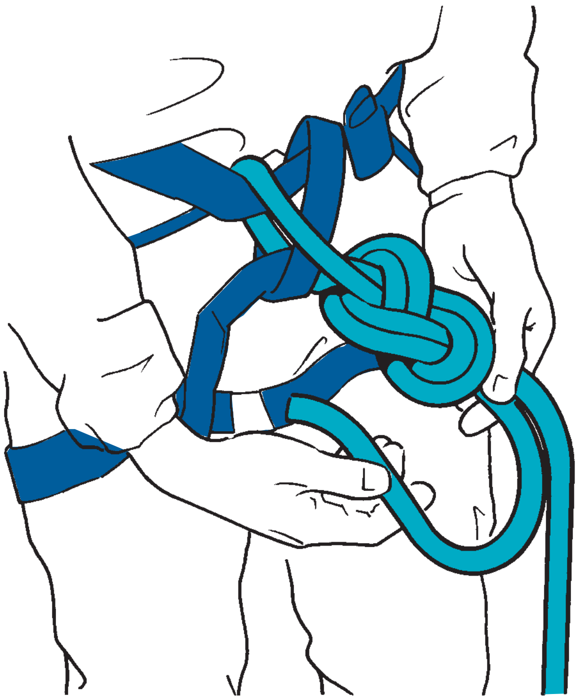


Figure 10.1a Figure of Eight knot

Uses: Tying into the rope. Constructing belays.
Advantages: One of the strongest knots available. Easy to tie.
Disadvantages: Difficult to untie after heavy loading. This knot can work loose if the tail is not long enough. Difficult to adjust.
Comments: Ensure a long enough tail remains and finish with a Double Overhand Stopper knot.

Clove Hitch

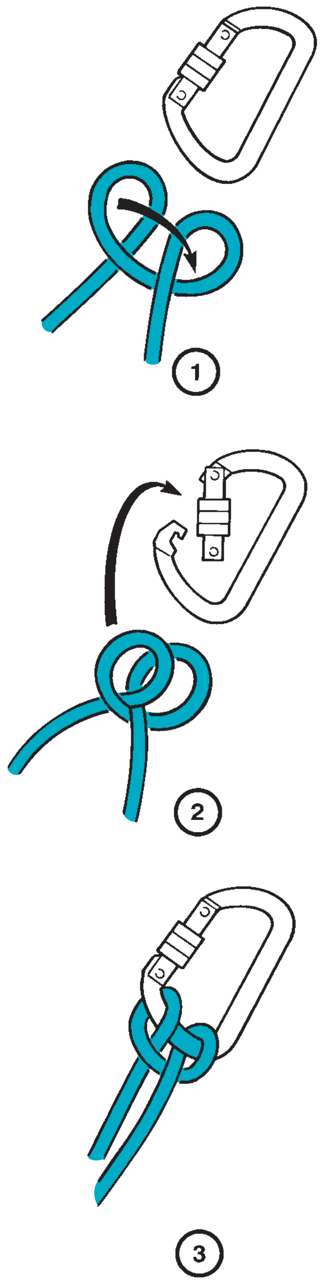


Figure 10.1b Clove Hitch

Uses: Tying into belays. Tying-off ice screws and axes. Backing up the clutch Jumar when escaping the system.
Advantages: Very quick to tie. Uses very little rope. Easy to adjust. Can be tied in tape slings.
Comments: Ensure the knot is tight before loading as some initial slipping will occur.

Italian Hitch

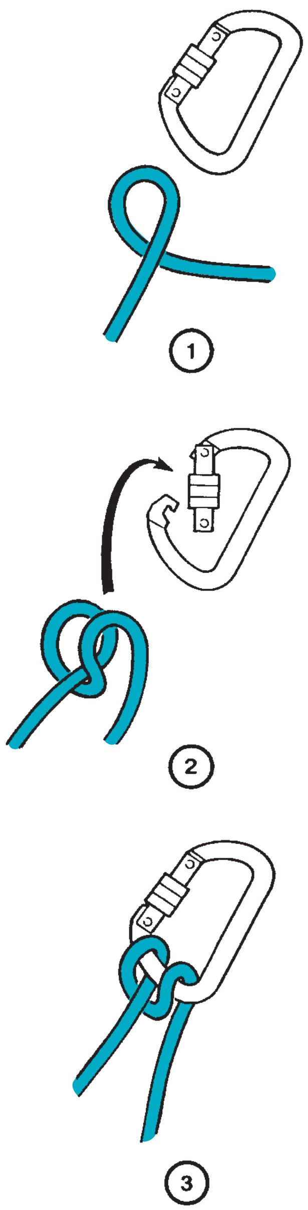


Figure 10.1c **Italian Hitch**

Uses: Friction hitch for abseiling or belaying. An HMS (pear shaped) karabiner must be used with this knot.
Advantages: A safe and simple belay method.
Disadvantages: Twists the rope badly after prolonged use. It is not as smooth or easy to operate as using a figure of eight or a belay plate.
Comments: The knot can be used to take-in or pay-out the rope, as it will capsize to align itself.

Italian Hitch tied off with two Half Hitches

Uses: Tying off abseiling and Jumaring ropes in training situations.
Advantages: Can be released under load.
Comments: This knot should be used in all training situations where a fixed rope needs to be tied-off. This includes indoor situations.

Figure 10.1d **Italian Hitch tied-off with two Half Hitches**

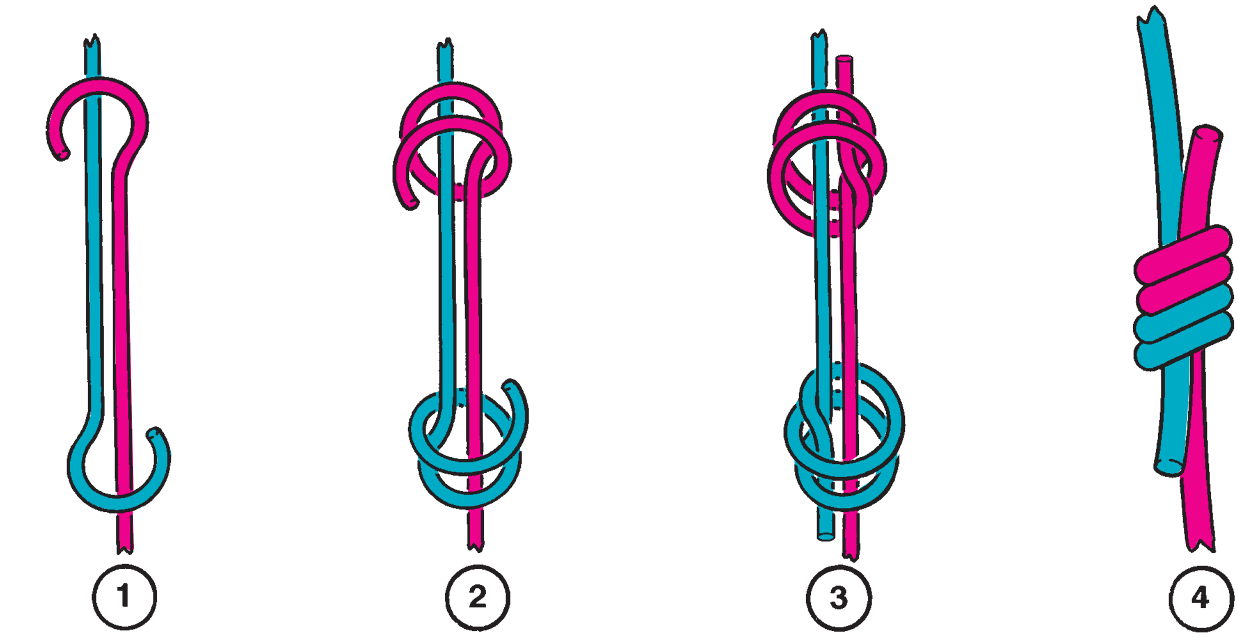


Figure 10.1e Double Fisherman's knot

Double Fisherman's

Uses: Joining two ropes of equal diameters together.
Advantages: Won't work loose easily. Relatively strong.
Disadvantages: Difficult to untie after loading.
Comments: It is essential to leave about 10cm of tail to allow for any slippage during tightening.

Overhand knot for joining ropes

Uses: Joining ropes for abseiling or lowering.
Advantages: Easy to tie. The main advantage is that the rope always lies flat with the knot away from the surface. It is much less likely to jam when the ropes are pulled-through when abseiling.
Disadvantages: No real disadvantages. The tails must be long enough so they cannot pull through the knot.
Comments: A simple but highly useful knot that can significantly reduce the risk of the rope jamming.

Figure 10.1f Overhand knot

Alpine Butterfly

Uses: Tying onto the middle of the rope. Normal application is for the middle person in a rope of three.
Advantages: Very easy to untie after loading. Can be loaded in several directions.
Disadvantages: Difficult to tie.
Comments: There are several ways of tying this knot with various results. Beware of imitations.

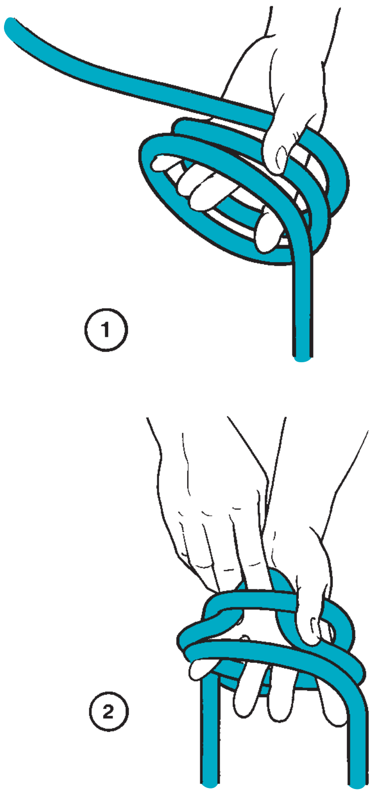


Figure 10.1g Alpine Butterfly (continued over)

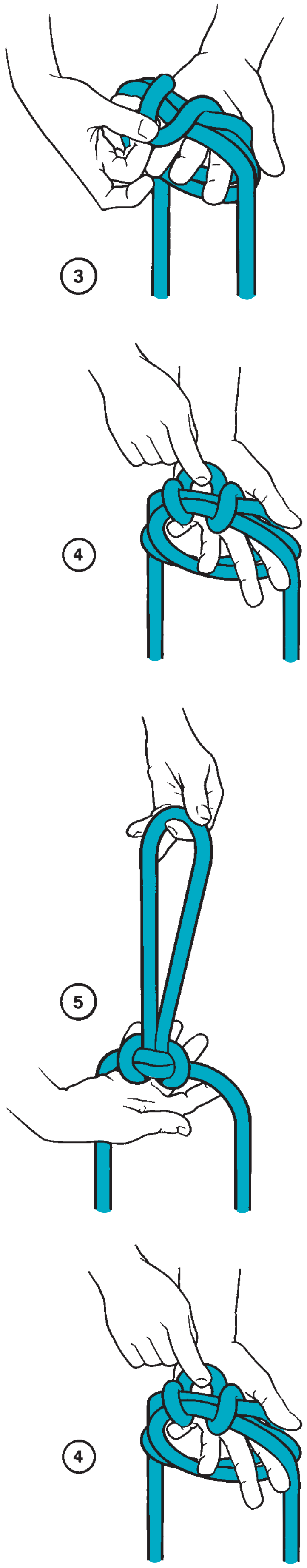


Figure 10.1g Alpine Butterfly

Tape knot

Uses: Joining two pieces of nylon webbing climbing tape.

Advantages: Forms a strong link.

Disadvantages: Can work loose even after heavy loading. People have been known to clip the eye of the taped end and not the tape loop. Even when taped or stitched the knot can work itself over the tape end. The sling can still look okay but it is only the electrical tape that is holding it together.

Comments: After tying, this knot should be tightened with at least body weight. A close check should be kept on all tape knots. Do not tape the tails to the body of the sling.

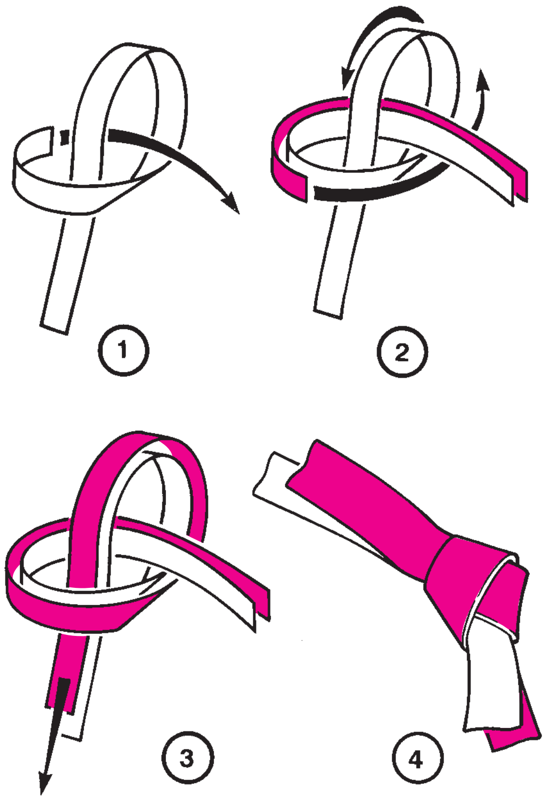


Figure 10.1h Tape knot

Stopper knot (Double Overhand knot)

Uses: Securing the tail of the rope after tying in with a Figure of Eight.

Comments: A Double Overhand knot should be used. Always use a Stopper knot when tying in.

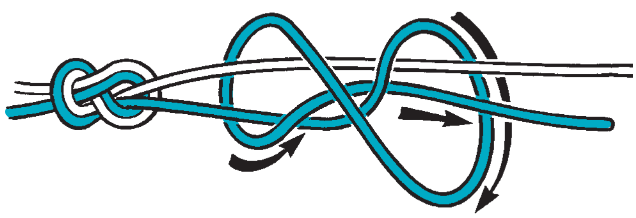


Figure 10.1i Stopper knot

10.2 The Prusik loop

Prusik loops have a variety of uses and at least two should be carried on your harness. Prusik loops are used to tie Prusik knots. These are jamming knots that grip the rope and can be used in a similar manner to Jumars. One advantage of Prusik loops over mechanical ascenders is that they do very little rope damage. They can also be used to ascend double ropes.

They can be used for a number of different applications:

- To ascend or descend a rope.
- To protect an abseil.
- To protect yourself as you go forward to the edge of a crevasse after escaping the system (see Section 10.13).
- For hauling. They are much less damaging than Jumars for this application.

Prusik loops should be made in two standard lengths from 5mm cordage.

- The long Prusik should be a 2m loop (including the knot).
- The short Prusik should be a 1.2m loop (including the knot).

There are several different types of jamming knots but to avoid confusion BAS only uses two - the standard Prusik and the French Prusik.

The standard Prusik knot

Uses: Many, including ascending, hauling and protection when probing for crevasses.
Advantages: Can be tied with one hand.
Disadvantages: Tends to jam easily. Must be tightened before loading.
Comments: One of the easiest ways to tie this knot is to lay the knot of the Prusik loop on the rope. Roll it around the rope three times and thread it through itself. Ensure that the knot is neat and symmetrical otherwise it will not grip correctly. After loading, the Prusik knot may jam and be difficult to move. To release it, simply roll the strand of rope that lies over the back of the knot away from the knot itself.

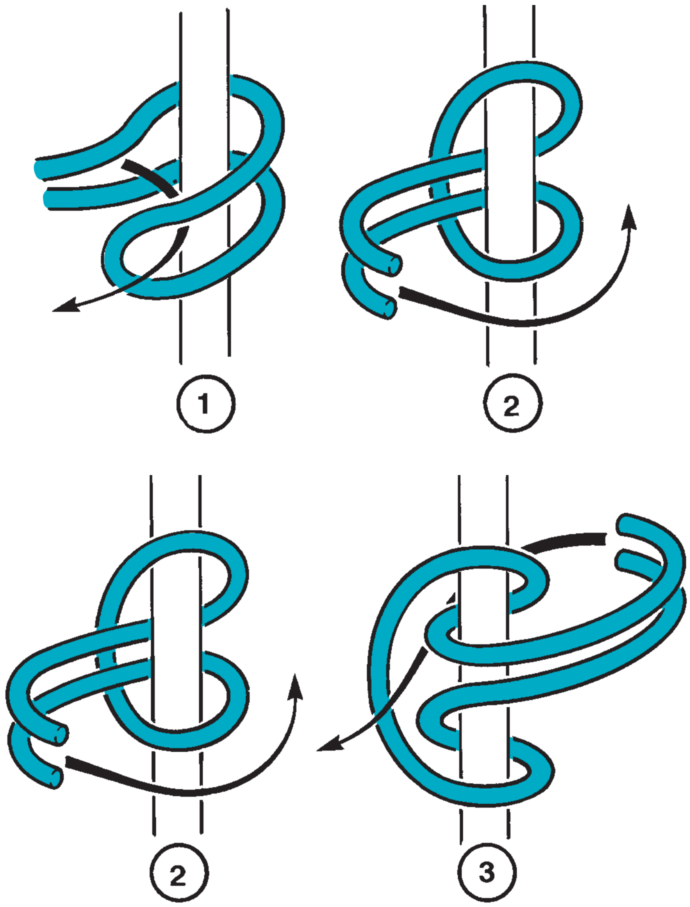


Figure 10.2a The standard Prusik knot

French Prusik

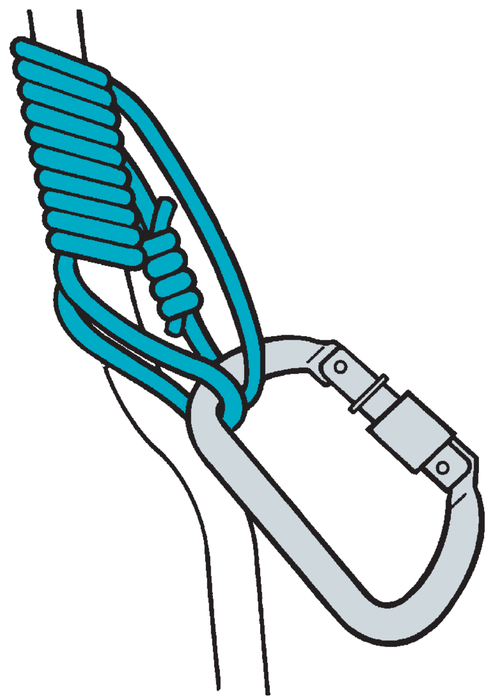


Figure 10.2b The French Prusik knot

Uses: Abseil protection. They are used during crevasse rescues as an autoblock (locking knot).
Advantages: Very easy to tie. Can be released under tension. Good in wet conditions.
Disadvantages: The Prusik must be the correct loop length (1.2m) for abseil protection. It must also have sufficient wraps around the rope for it to be effective.
Comments: The loop needs to be wrapped around the rope several times to ensure the knot grips the rope effectively. The correct number of wraps can only be learnt through experimentation. It is important that the two ends are relatively short when clipped together (with a screw-gate karabiner). To release when under tension, place the thumb and forefinger on top of the knot and pull down firmly. Make sure the knot does not rub over a hard surface as this may release the knot prematurely.

10.3 Anchoring on snow and ice

It is critical that anchors are capable of holding the loads placed on them. Your life and your partner's life may depend on it. The holding power of each device depends greatly on the conditions and the skill with which they are placed.

The placement of sound anchors is one of the most difficult things to teach due to the variable nature of snow and ice. Experience, common sense and the understanding of a few key principles will increase your chances of success.

Do not rely on one anchor point. A minimum of two linked anchors should always be used (see Section 10.6).

10.4 Manmade anchors

Snow stakes

This is the most useful anchor for glacier travel. Each party member should carry two snow stakes on their packs. Two types of snow stakes are available - the older style angle stakes and the newer, T-section MSR stakes.

Placement

They should be hammered into the snow just past the vertical (in relation to the snow surface) and tilted away from the direction of the load . The V (or T) of the stake should face the direction of the expected load. Angle stakes should have a pre-tied sling at the top. Care should be taken that this does not lie across the top of the stake as it is hammered in.

Alternatively they can be buried as a deadman if the surface snow is very soft (see Figure 10.4b).

Attachment

It is critical that stakes are tied-off level with the surface. MSR stakes can be clipped through one of the holes. Angle stakes should be Clove Hitched with a sling. Do not clip a karabiner through the holes of an angle stake.

Comment: If stakes have slings attached, these must be checked regularly for damage.

Ice screws

BAS supplies both drive-in and screw-in tubular ice screws. Drive-ins are gradually being replaced with the screw-ins due to their greater holding power. Warthogs are redundant and should only be used as sea-ice daggers.

Placement

Clear away any rotten snow or ice that will get in the way while turning the screw. To make placement easier, clear away a bit more ice than originally estimated. Take care not to disturb the placement area with heavy axe blows as this may weaken the ice and reduce the strength of the anchor. A nick in the ice about 1cm deep will aid placement.

Place ice screws at an angle of 90º to the ice. In some situations it is better to place modern ice screws angled slightly towards the direction of pull. However, for most applications go for the simple option of 90º.

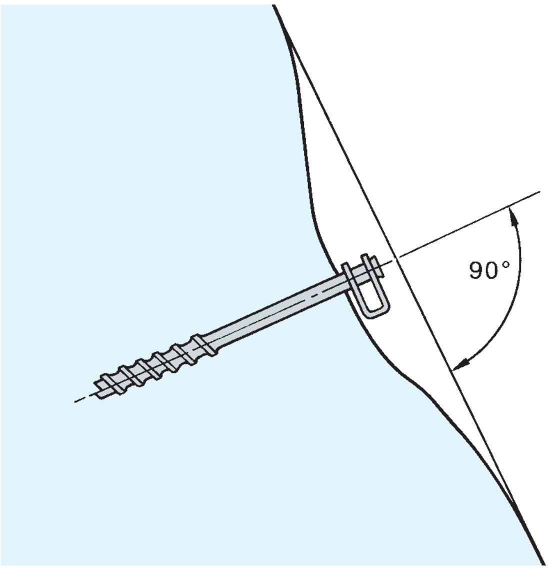


Figure 10.4a *Both drive-in and screw-in ice screws should be placed at 90º to the ice surface.*

If the ice "dinner plates" off as the screw goes in, try a different location. The strength of the placement will be severely compromised if this happens.

Attachment
The eye of the screw should face the direction of pull and this should be clipped with a screw-gate karabiner. If more then 30mm of the screw is protruding from the surface of the ice you should either use a shorter screw or try another placement. **Do not tie off.**

Comment: Always use at least two linked ice screws. This second screw is best placed to one side and slightly above the first. Multiple screws should be placed at least one metre apart to lessen the risk of cracking.

When removed, ice screws will contain a core of ice. This must be removed before they can be re-used. The easiest way to remove it is to warm the screw slightly. Place it in the sun or under your jacket. After a short time the ice can be flicked out. Tap the hanger and not the shaft to remove ice.

It is unlikely that you will need to use ice screws when crossing a glacier. However, you may need them if you fall into a crevasse and you need to get your weight off the rope.

The high levels of radiation present on a clear day in the Antarctic can warm ice screws and loosen them. To reduce this effect, cover screws with snow or ice chips.

Deadmen

Understanding how to construct a sound deadman anchor is a basic field skill. Because a variety of different materials can be used to construct them, they are very versatile. When placed correctly they are the strongest anchors that can be constructed on snow because the load is spread over a large surface area.

They are particularly appropriate where long thin items are available. A variety of objects can be used such as skis, snow stakes or timber. Even a rucksack filled with snow can be used as a deadman anchor.

Deadmen anchors are very useful in warm conditions when snow stakes can melt out. A buried length of timber is ideal in this situation.

Placement
A trench or slot in which to sit the anchor is cut at 90° to the expected load. Halfway along this slot a smaller trench is cut in the direction of the load for a sling.

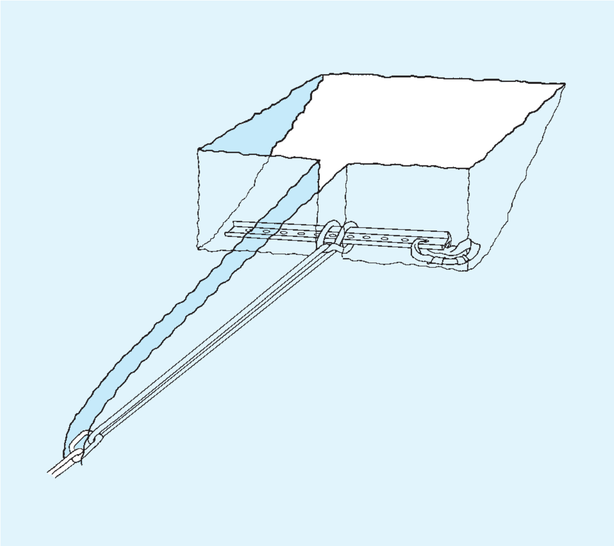


Figure 10.4b The basic deadman anchor

Attachment
Make sure that the anchor does not receive an upward pull by ensuring the sling slot is deep enough. However, take care not to disturb the snow in front of the anchor when cutting this slot. It is a good idea to angle the front wall of the anchor trench slightly so the deadman is pulled deeper into the snow when it is loaded.

T-axe anchor

An effective anchor can be constructed using ice axes or hammers. A T-axe belay is an effective method of anchoring a rope if nothing else is available.

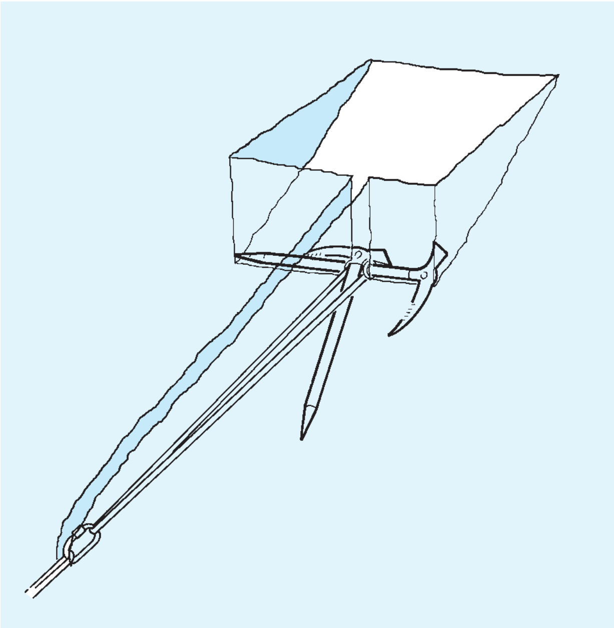


Figure 10.4c The T-axe anchor

Placement
An ice axe or hammer is buried horizontally in a slot and a sling is attached with a Clove Hitch to the shaft of the tool. To give an even pull, the sling should be at the balance point closer to the head of the tool and the pick should be pointing into the snow. A second axe or hammer is placed through the sling in front of the horizontal hammer or axe. In hard conditions stamp this tool in with your foot. Beware of disturbing the snow that supports the anchor and ensure that the slot containing the sling is deep enough.

Attachment
The sling must be long enough that no upward pull can take place. Extend it with spare rope if necessary.

10.5 Natural anchors

Snow/ice bollards
A bollard is a simple yet very effective anchor that can be cut in either snow or ice. A teardrop shape is cut or dug using the adze of an axe. The size of the bollard depends on the type of snow. In soft snow the bollard may need to be up to three metres in diameter.

The danger with bollards is that the rope may cheese-wire through the snow with potentially disastrous results. To prevent the rope cutting into the snow it should be padded with whatever is available. This could be a rucksack, spare clothes or ice axes. Two ice tools placed at the shoulders are particularly effective at preventing the rope cutting-in. Never step on the snow in a bollard and try not to disturb the surrounding snow.

A bollard can also be cut into ice (minimum diameter 40cm). Ensure there is a good lip on the back and shoulders to prevent the rope from slipping off.

Ice thread (Abolokov thread)
This is an effective method of constructing a very strong anchor in ice. It has a number of uses:

- When protection is limited.
- In warm conditions when metal ice screws would ablate out.
- When protection cannot be retrieved.
- As an aircraft tie-down on blue ice areas.

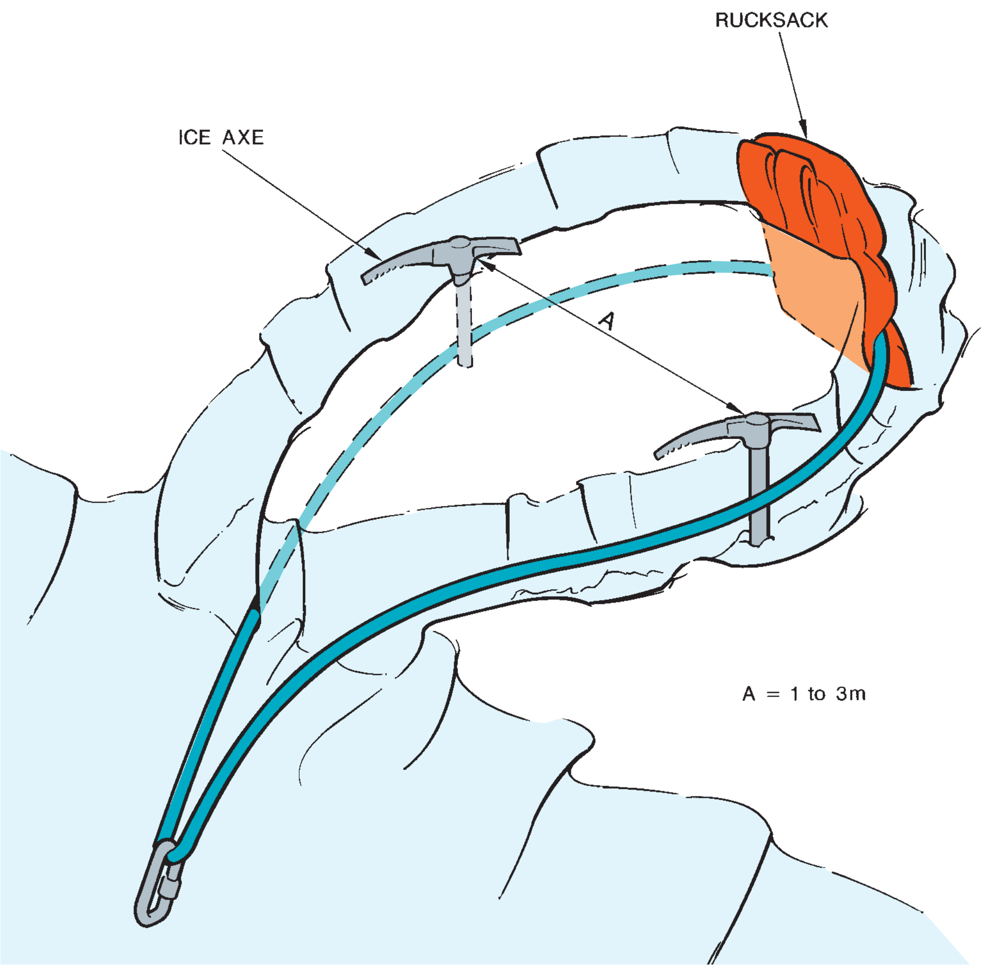


Figure 10.5a A snow bollard
The use of axes on the "shoulders" and a rucksack at the back prevents the rope from cutting into the snow.

Placement
The holes required to construct this anchor are made using an ice screw. These holes are made at about 45° to the face of the ice, usually in the horizontal plane. Longer screws and therefore holes will give stronger anchors. Do not use screws shorter than 22cm nor a hole angle greater than 45°.

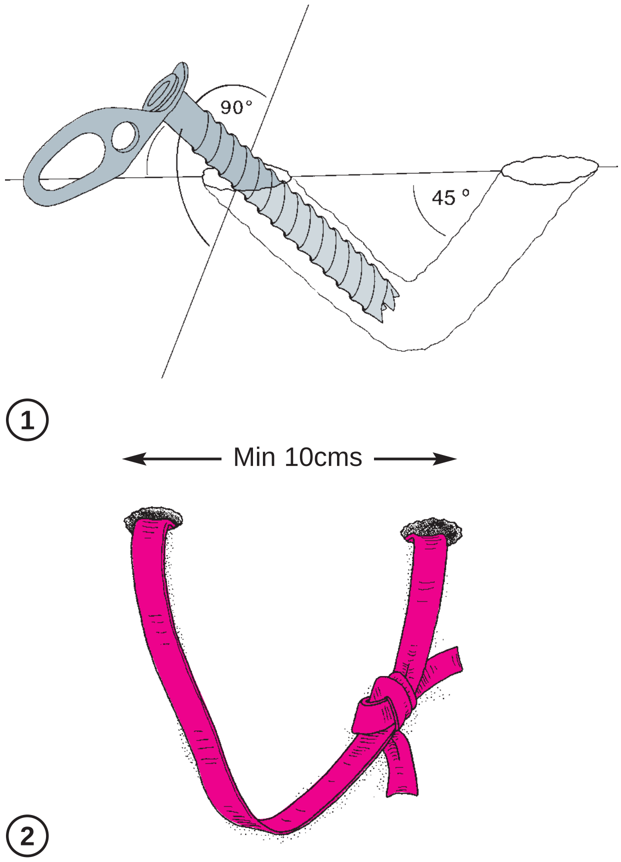


Figure 10.5b Ice or Abolokov thread
1 *Two connecting holes are bored into the ice using an ice screw.*
2 *A length of tape is threaded through the holes and tied to form an anchor point.*

A piece of wire with a hook such as an old wire coat-hanger is essential for this. If you have any concerns over the strength of the ice, construct another ice thread anchor and link them together.

Rock anchors
Natural rock anchors such as flakes or chock stones can be employed as anchors using long tape slings. They can be belayed off directly or indirectly (see Section 10.8).

Test all natural anchors before using them. Give them a good pull or kick to detect whether they are loosely frozen in place or unstable.

10.6 Linking anchors

Having placed two or three anchor points it is necessary to link them together to form a single attachment point. There are a number of methods of linking anchors and choosing the most suitable can only be learnt through time and experience.

Points to consider when linking anchors:

- All the linked anchors must be loaded evenly.
- If one anchor fails, the remaining anchors should not be shock-loaded.
- When two or more points are linked **the angle at the main tie-in/attachment point must not exceed 60° otherwise the forces induced will be considerably larger than the load being applied.** See figure 10.7a.
- When working on snow the distances between anchors can be large. A five or six metre sling will make life much easier.
- **Always test anchor points before using them.**

Linking with a single sling

Sling tied-off with a Figure of Eight

Figure 10.6a Sling tied-off with a Figure of Eight knot

This is the simplest method of linking anchors providing you have a long enough sling.

To tie, pull the bight of sling in the direction of the intended pull and tie off with a Figure of Eight or an Overhand knot. Both sides of the sling should be under equal tension when loaded. If the sling is too short it can be extended using the methods below.

Overhand knot

Figure 10.6b The Overhand tie-off

This is a simple and effective method of linking and uses less tape than the Figure of Eight method. This can help to reduce the angle created at the tie-in point. The illustrations are self-explanatory but it is essential to clip the karabiner into the sling correctly.

This method can increase the risk of the karabiner undergoing a three-way loading across its axis. Turning the karabiner so that the widest part is clipped into the sling as per the illustrations can reduce this.

Clove-hitched sling

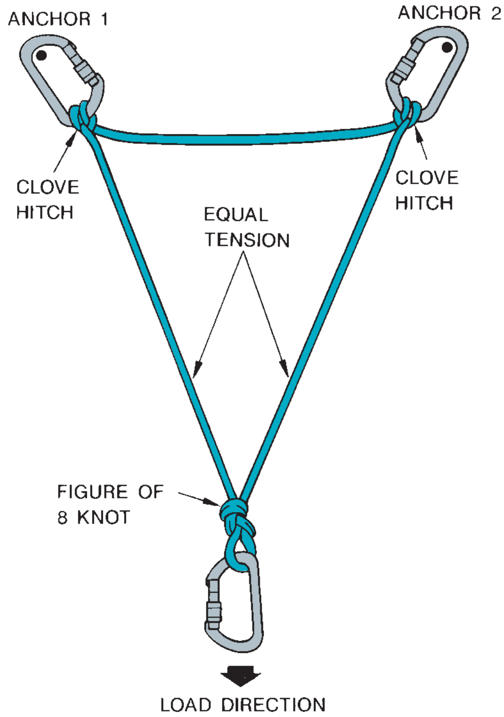


Figure 10.6c Linking two anchor points with an eight foot, clove-hitched sling

The sling is clove-hitched into the two anchor points with the knotted or sewn section slightly slack between the two. The rest of the sling should then be knotted with either an Overhand or Figure of Eight knot so that both anchor points are under equal tension.

Linking with separate slings

In many situations the two anchor points are too far apart to use a single sling.

Two slings shortened on one side

Figure 10.6d Shortened sling

Tie an Overhand or Figure of Eight in the longest sling to shorten it to the correct length. This method could also be used with multiple anchors but be careful not to put a three-way load on the main screw-gate. This will drastically reduce its strength. In this situation it may be necessary to use additional karabiners to reduce any three-way loading.

Rigging rope method

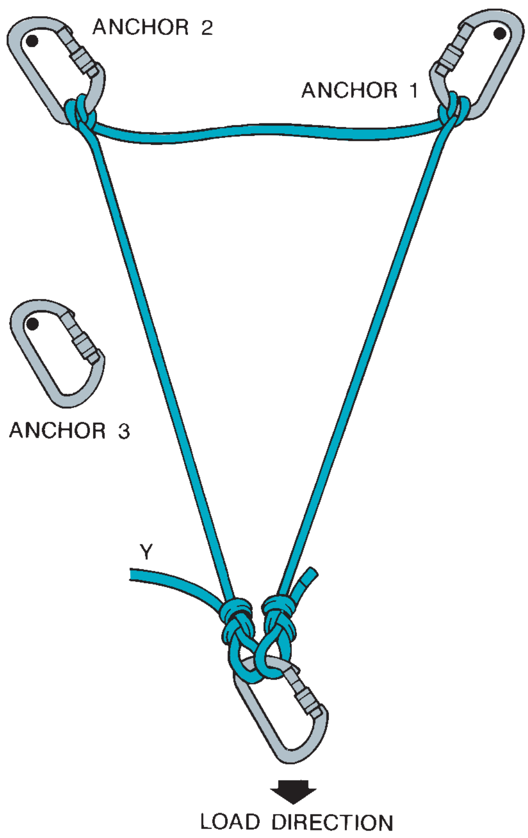


Figure 10.6e Linking two anchor points with a rope when the anchor points are far apart
Anchor 3 could be included in the system by clove-hitching it to rope Y.

A rope often has to be used to link snow anchors together. This can be done with either a spare rope or the one that is to be loaded. A Figure of Eight knot is tied in the end of the rope and this is held in roughly the position required for the single attachment point. The rope is then clove-hitched into the first and second anchors and finally a Figure of Eight is tied alongside its partner. These two Figure of Eights are then clipped with a screw-gate karabiner to form the attachment point.

Alternatively a Figure of Eight can be tied on the two bights of rope. This will give a double loop into which the karabiner can be attached. This gives a pull along the back bar of the karabiner instead of the three-way pull of the above example. If a third anchor point exists, it can be clove-hitched with the rope from the second Figure of Eight. Clove Hitches are easily adjusted to ensure the anchor points are loaded equally.

By using a combination of these techniques, any number of anchors can be linked together. As the numbers increase, the ropework becomes more complicated. Try to keep everything as simple (but as safe) as possible. Any spare rope should be coiled out of the way.

10.7 How not to link anchor points

Angle greater than 60º

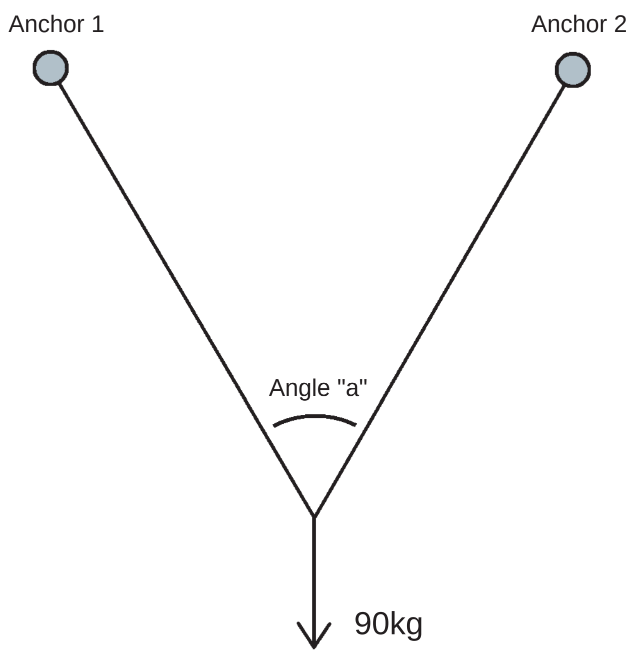


Figure 10.7a The loading effect of anchor angles

Angle "a"	Load on each anchor
30º	46kg
45º	49kg
60º	52kg
75º	57kg
90º	63kg
120º	90kg
150º	174kg
175º	1035kg

Never have an angle of greater than 60º.

This puts a load on the anchors that is in excess of the actual load being applied. The greater the angle, the greater this load becomes.

The Death Triangle

Figure 10.7b The death triangle

The method of linking illustrated in Figure 10.7b seriously compromises the strength of the anchors. In effect, the load on the anchors becomes the same as if the angle at the attachment point is greater than 60°. **Never rig anchors with these methods.**

10.8 Belaying

Belaying is the technique of using a rope to provide protection in the event of a fall. The belayer is attached to an anchor whilst protecting the person who is moving. Belaying can be carried out using a friction device, an Italian Hitch or a body belay.

It is beyond the scope of this manual to go into any depth on this subject. The most appropriate methods can only be learnt through time and experience. If in doubt, use the most bombproof method.

It is better to take the time and get it right, than to try and save time and get it wrong.

Direct belay techniques are necessary for speed when Alpine mountaineering. BAS field travel rarely has these time pressures.

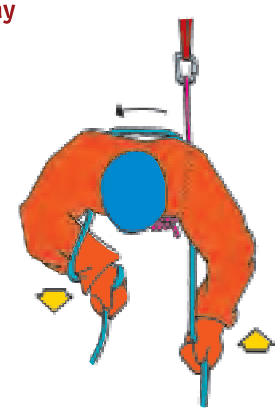
There are two types of belays - indirect and direct.

Indirect belays

With an indirect belay, the belayer's body is part of the system. The mass of the body helps to make this type of belay more secure. It is also dynamic as the body can "give" a little. This type of belay should always be used on snow and ice anchors.

The body belay

1



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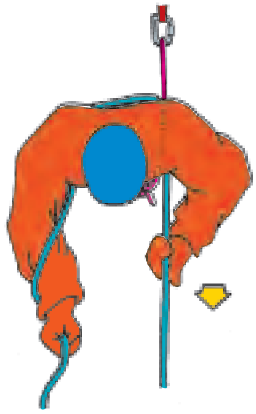

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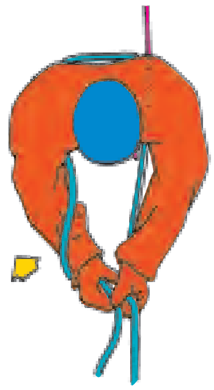
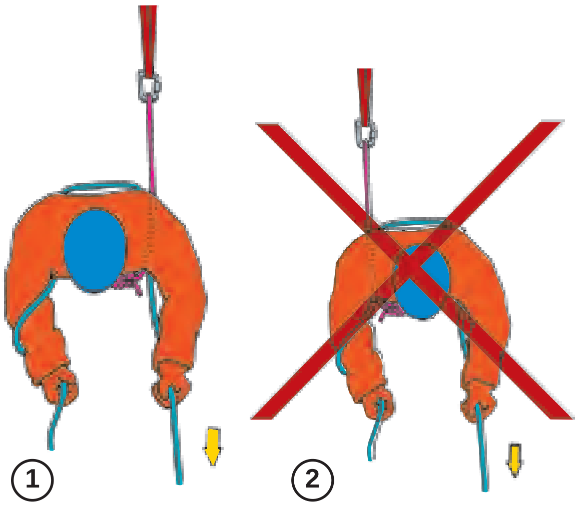


Figure 10.8a *The sequence of actions for taking-in rope using a body belay.*

1 *The live hand pulls the rope up and the dead hand pulls forward.*
2 *The dead hand stays forward and the live hand slides down the rope until it is further from the body.*
3 *The live hand grips the dead rope lightly under the thumb so that the dead hand can be slid back to begin the next cycle.*

In an indirect belay, the rope is taken around the belayer's back, above the harness and anchor attachment. Never let go of the dead rope. In a fall, the dead hand is brought across the body to increase the friction.

It is essential to have the live rope on the same side as the rope from the anchor. If they are on separate sides, you will be twisted out of the rope in a fall.



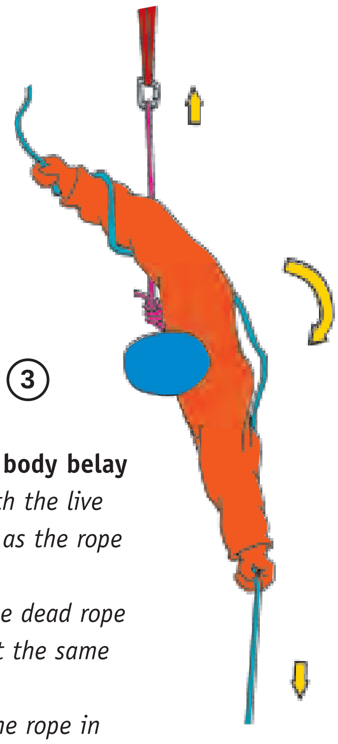


Figure 10.8b Incorrect body belay

1 *The correct method with the live rope on the same side as the rope to the anchor.*

2 *The wrong way with the dead rope and the anchor rope at the same side.*

3 *Being twisted out of the rope in the event of a fall.*

Direct belays

In a direct belay, the belayer is not part of the system. The force of a fall is therefore taken directly on the anchor. Direct belays should only be used where the anchor is totally secure such as with a large rock spike.

10.9 Locking-off a belay

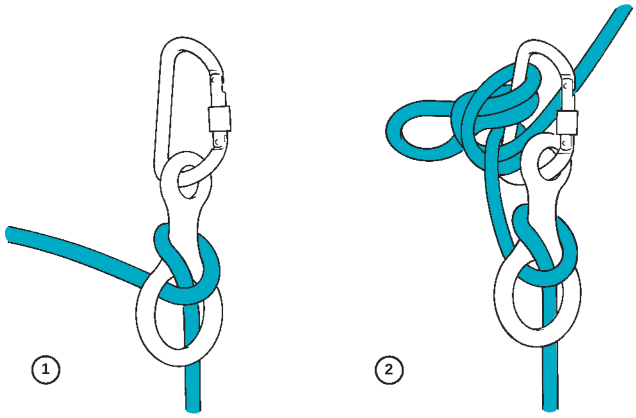


Figure 10.9a Locking-off a belay

The illustrations in Figure 10.9a show how to lock-off a figure of eight. This may be required to back up the Prusik loop in lowering situations (see Figure 10.10). To lock-off an Italian Hitch see Figure 10.1d.

If two Half Hitches are used, the load can be released but make sure the tails are long enough.

10.10 Passing a knot through a friction device

This technique needs to be employed when lowering using joined ropes. It is a basic skill for Search and Rescue (SAR) situations. You should practise this sequence before using it in an emergency. See Figure 10.10.

10.11 Abseiling

Abseiling is the technique of descending a rope using a friction device to control your rate of descent. Proficiency in this technique is a basic mountaineering and glacier travel skill.

Abseiling has a great deal of potential for accidents to occur. More climbers have probably been killed abseiling than actually climbing. Many of these accidents could have been avoided if the ictims had stuck to a few basic principles:

- The anchors must be capable of taking the loads involved.
- The rope must be tied-off correctly.
- Always use a dynamic rope. This reduces the shock-loading on the anchors as you move about.

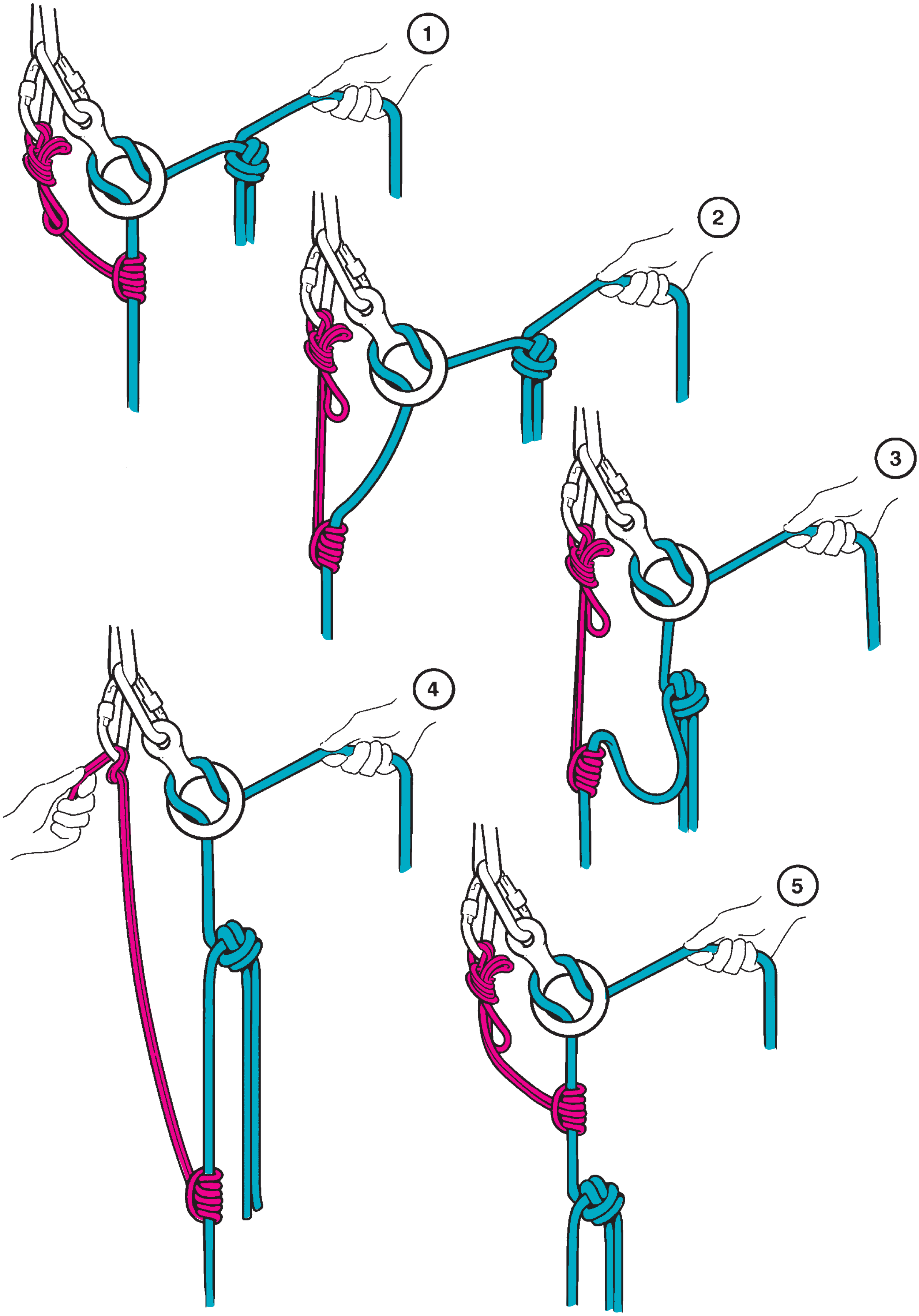


Figure 10.10 **Passing a knot through a friction device**

- The harness must be buckled correctly.
- Make sure all the karabiners in the system are screwed shut.
- Make sure the friction device is clipped into the belay loop on the harness, not the gear loops.
- Don't let the figure of eight lie over the sleeve of the screw-gate karabiner as you go over the edge - it can snap the sleeve and become detached. See Figure 8.3b.
- Make sure the rope is on the upper side of the brake bar of the figure of eight. It can lock-off unintentionally with a Lark's Foot knot as you go over the edge if the rope is the wrong side.
- Always use a French Prusik to protect an abseil.
- Wear a helmet.
- Tie a knot in the end of the rope to prevent abseiling off the end.
- Always carry the necessary equipment to climb back up the rope.
- Always have your Jumars pre-clipped to the belay loop in the correct order with the karabiners screwed shut. This avoids the possibility of dropping them. It also reduces the chance of clipping them in incorrectly, particularly when you are about to ascend and may be a bit stressed. This would be a prime time to make mistakes. The Jumars should be tucked away in the Jumar pouch to stop them getting in the way.
- Before you go over the edge, always check your gear and that of anyone else with you.
- Try to descend as gently as possible. Don't bounce up and down.

The BAS system for abseiling

BAS uses the figure of eight friction device. Other devices are available but this traditional device is still the most suitable for the BAS system:

- It is easy to use with gloved hands.
- It gives a smooth braking action which does not kink the rope.
- It is relatively easy to pass a knot through in rescue situations.

A major drawback of the figure of eight is that if you let go with the braking hand it ceases to provide any braking action. When this happens a free fall descent will occur. For the reason it must be backed up with a French Prusik.

With the BAS system, the French Prusik is attached to the belay loop and it goes below the figure of eight. The figure of eight needs to be extended otherwise the Prusik will end up in it. The French Prusik will cease to function if this happens. The figure of eight should be extended using a 300mm quick-draw as per illustration 10.11.

Where no friction device is available an Italian Hitch can be used. A pear shaped (HMS) karabiner should be used with this knot.

Figure 10.11 The BAS abseil system

10.12 Ascending the rope

Climbing back up a rope is usually necessary after abseiling into a crevasse. In a crevasse fall, the simplest way to get out is to climb back up the rope that links you with your partner.

Two equipment options are open to you - mechanical ascenders and Prusik loops. Mechanical ascenders are the most efficient means of ascending a rope. However, Prusik loops are an effective back-up and still have many uses.

Mechanical ascenders (Jumars)

Two Jumars are used to ascend a rope - the waist Jumar and the foot Jumar. These are handed for left- and right-hand use. Petzl Jumars are contrasting colours.

Waist Jumar

This is the top Jumar and it is attached to the belay loop on the harness. It is linked to the harness with a 300mm sewn sling. Slings are attached to Jumars using steel Maillons. When ascending you will be hanging from this Jumar while the foot Jumar is moved up the rope.

Foot Jumar

The lower Jumar is the foot Jumar. A long sling-loop is attached to this Jumar. Standing in this sling allows the waist Jumar to be moved up the rope. A second sling (1.15m of 7mm dynamic rope) is attached to the foot Jumar and this is clipped into the belay loop on the harness. This provides a back-up to the top Jumar.

Figure 10.12 shows the correct procedure for climbing out of a crevasse

Upward progress will be made easier if your rucksack is removed and clipped to the rope as in the illustration. Be careful not to drop it. Clipping your rucksack into the rope has several advantages:

- You no longer have the weight of the rucksack on your back trying to flip you over.
- It will act as a counterweight. This makes it easier to move the foot Jumar up the rope.
- The rucksack ends up on a 2:1 pulley system so its lifted weight is reduced by half (as you move two metres it will move one metre).

Prusik loop ascent

Two Prusik loops are required - a waist loop and a foot

Figure 10.12 Ascending a rope using Petzl jammers
A back-up sling is fitted to the lower jammer and clipped to the harness belay loop.

loop. Prusik loops should be made out of 5mm cord. Thicker cord may not grip the rope properly. See also Figure 10.2a.

Waist loop

This is the shorter of the loops (1.2m long including the knots). This is the top loop and it is attached to the belay loop in the harness. This is the loop you will hang from.

Foot loop

This is the longer of the two loops (2m long including the knots). The foot is placed in this loop and standing up allows the waist loop to be moved up the rope. Progress is made in much the same manner as with

Jumars. Unlike Jumars, the waist loop has no back-up from the foot loop.

There is a tendency for the foot to slip out of the foot loop. A Lark's Foot knot around the boot will help to prevent this.

It can be unnerving ascending any rope. This is particularly so when Prusiking as you are hanging off a 5mm thick cord. It is good practice to Clove Hitch the rope beneath you into a screw-gate karabiner attached to the belay loop. As you move up, the knot can be moved up without the need to remove it from the karabiner. This should be done every four or five metres.

10.13 Crevasse rescue

When travelling on glaciated terrain it is essential that you know what to do if a party member falls out of sight through a snow bridge. In most situations the person in the crevasse will be able to self-rescue (Jumar back up the rope) but this cannot be guaranteed.

In order to hoist an injured or unconscious person from a crevasse it is necessary to construct some form of hoisting system. BAS uses a hoisting technique called the Z-pulley system. This provides enough mechanical advantage to pull an unconscious person out of a crevasse. The BAS Z-pulley system can be adapted to most rescue situations.

There are several steps that will have been carried out before a hoisting system can be constructed:

1. Arresting the fall.
2. Placing suitable anchors and linking them together.
3. Escaping from the system.
4. Going forward to the edge of the crevasse to establish the seriousness of the situation.
5. Preparing the lip of the crevasse.
6. Possibly descending to the casualty to administer first aid.
7. Constructing a hoist.
8. Hoisting.

Arresting the fall

It is essential that if someone falls into a crevasse, they fall as short a distance as possible. In soft conditions, it is usually quite easy to stop the fall as the rope "cheese-wires" into the edge of the crevasse. In harder conditions, descending down a slope or with partners of unequal weight, this may be more problematic.

The first action should be to adopt the ice axe self-arrest position. This should halt any further progress. If you are still creeping towards the crevasse, push your ice axe into the snow and put the loose end of the long Prusik over the ice axe (this should already be tied into the coils). Push the Prusik up the rope and this will hopefully stop any further creep towards the edge of the crevasse. **Do not take the coils off at this stage.** This simply allows you to set up an anchor and escape the system.

Placing the anchors

Placing safe, secure anchors and linking them together whilst lying in the snow is not easy. This should be practised while the rope from your chest-coils is under tension. **It is essential that the anchors you place are secure enough to withstand the forces that will be placed on them**. See Section 10.3 for information on anchor placement.

If your partner can self-rescue then all that may be required is to remain in the ice axe arrest position while they climb out.

Escaping the system

Once two secure anchors have been linked together you will be in a position to escape the system.

1. Take one of the Jumars (usually the foot Jumar due to the length of the sling) and clip it into the tie-in point of the anchor sling. Make sure the karabiner is screwed shut, as eventually the whole system is dependant on this Jumar. The first Jumar you place will become the clutch (or brake) Jumar.

2. Attach this Jumar in front of the coils and push it as far towards the edge of the crevasse as you can. You can now move forwards slightly as the weight has now been transferred to the Jumar and the anchor.

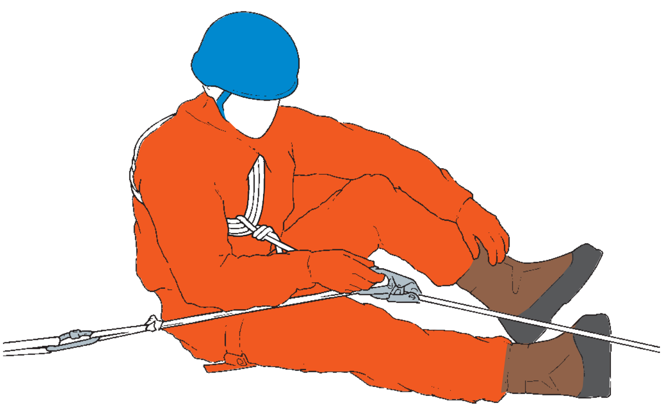


Figure 10.13a Escaping the system

3 The Jumar should now be backed up with a Clove Hitch tied-in to a karabiner clipped into the main anchor point (see Figure 10.13b). To do this, remove **one** coil from your chest coils in order to gain enough slack to tie this knot. **Do not remove all your coils at this stage**, as you would introduce approximately 16 metres of slack into the system. This would be a bad thing.

4 Once the Jumar has been backed up with a Clove Hitch it is safe to remove all the coils and escape the system. Do not untie at this stage.

Assessing the situation

To do this you need to go forwards to the edge of the crevasse and find out what action is required.

1 Put a Prusik on the non-live rope.

2 Go forward to the edge of the crevasse. Make sure that the Prusik is behind you and is kept tight. It could easily be shock-loaded if you fell through the lip of the crevasse.

3 As you approach the lip it may be better to crawl to reduce the chance of falling though. Look over the edge and check out your partner's situation.

4 If they are okay, the easiest way of helping them to self-rescue is to throw the non-live rope down to them. This will not have cheese-wired in and will therefore be far easier to Jumar out on. The edge will still need some preparation to stop this rope cutting in. To do this, you will have to take yourself off the rope. Make sure that you protect yourself as you move around on the surface. Do not become a second casualty.

5 If the person in the crevasse cannot self-rescue, you will have to go onto the next step.

Figure 10.13b Moving forward

Preparing the lip of the crevasse

Life will be much easier once you start hauling if you have prepared the crevasse edge. Failing to prepare the edge could mean the difference between success and failure.

Cut a ramp into the crevasse lip where the rope has cut in if necessary. It will be virtually impossible to pull someone through the slot cut by a rope. Attempting this will test the anchors severely and also risks injuring the casualty. Be careful when cutting a ramp that you do not injure the casualty by hitting them with debris.

Pad the lip of the crevasse with a rucksack or ice axe. Make sure that these items are secured so that they cannot fall in and injure the casualty.

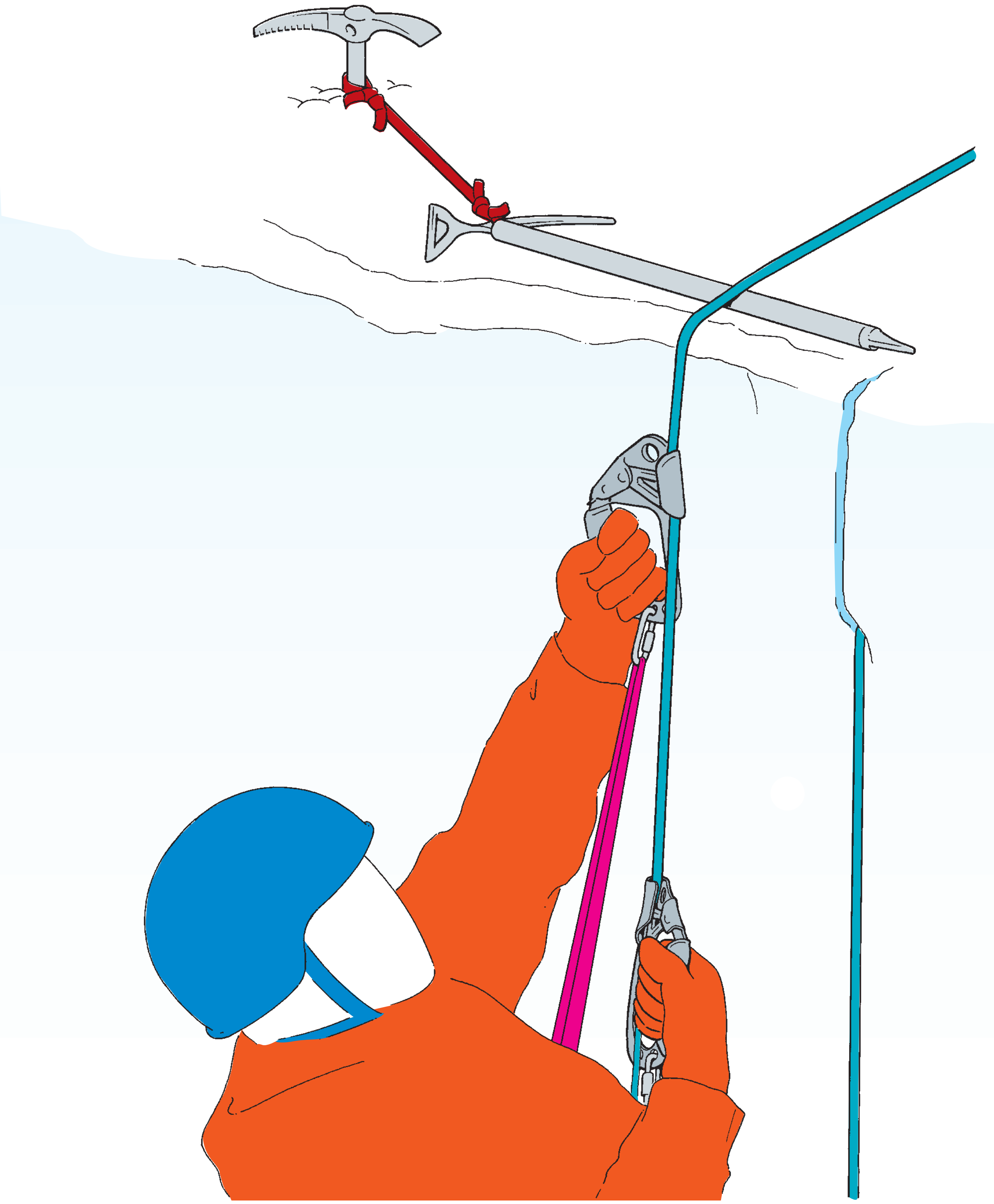


Figure 10.13c Re-ascending the prepared abseil rope

Descending to the casualty

The clove-hitched, non-live rope can be used for descending and ascending.

Make sure you go through all the checks mentioned in Section 10.11. You will probably be very "hyped-up" at this stage, so take your time and get it right. Don't become a casualty yourself. Your first priority is to look after yourself.

Constructing a hoisting system

If the casualty needs to be hoisted out of the crevasse, now is the time to set up the Z-pulley system. This is relatively simple to set up if it is done in a logical, step-by-step sequence. To reduce friction, don't have any ropes running over each other.

1 Attach the clutch Jumar and back it up with a Clove Hitch.

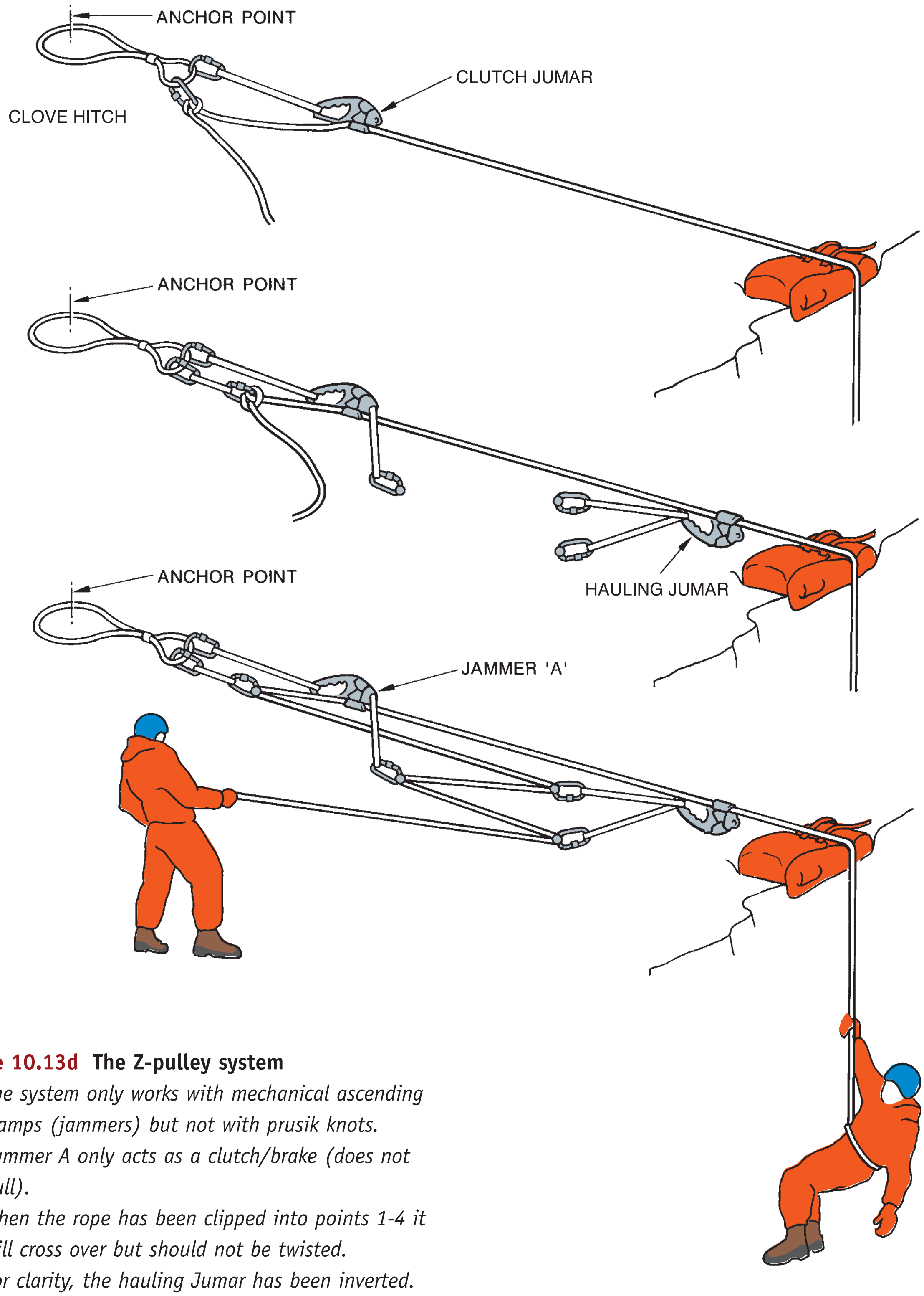


Figure 10.13d The Z-pulley system

- *The system only works with mechanical ascending clamps (jammers) but not with prusik knots.*
- *Jammer A only acts as a clutch/brake (does not pull).*
- *When the rope has been clipped into points 1-4 it will cross over but should not be twisted.*
- *For clarity, the hauling Jumar has been inverted.*

2 Attach the other Jumar in front of the clutch Jumar. This is the hauling Jumar.

3 Place a pulley on the rope and attach it behind the clutch Jumar. This can normally be placed at the main anchor tie-in point.

4 Put a second pulley on the rope and attach it to the sling on the hauling Jumar.

5 Put a third pulley on the rope and attach it through the top "eye" of the clutch Jumar. This keeps this Jumar under tension when hauling.

6 Put the fourth pulley on the rope and attach it to the sling on the hauling Jumar.

7 Tie a knot in the end of the rope. This prevents the rope unstitching when you move the hauling Jumar up it.

8 Remove the Clove Hitch from the system.

Hoisting

Once the Z-pulley system has been set up you are ready to hoist.

- Don't get too close to the edge as you are in an exposed situation.
- If you require more pull, tie the rope into your belay loop and walk backwards. This allows you to use your leg muscles. It also exerts a pull from low down which is more efficient.
- The hauling Jumar will eventually run up against the clutch Jumar. To start the process again simply slide the front Jumar forwards until the knot in the end of the rope is reached.
- As the casualty nears the lip of the crevasse you may need to go forwards to help them over the edge.

Make sure you are protected as you do this and in all other actions close to crevasses.

11 Field unit travel

Introduction

Field unit travel calls on the majority of the skills and techniques covered in this manual. Before travelling overland with Ski-Doos and sledges it is essential that you are familiar with all the relevant skills.

Learning all the skills required and bringing them together can be a daunting prospect. Many of the techniques are specific to BAS and the Antarctic, and it is unlikely that new staff will be suitably experienced.

Extensive training is given and an experienced staff member often mentors new recruits.

A Field Assistant will accompany all parties involved in unit travel. Suitably experienced scientists may also be Field Assistants.

11.1 What is a BAS field unit?

The basic components of the BAS travel system are the full-unit and the half-unit.

Full-unit
The basic unit is made up of two Ski-Doos pulling two Nansen sledges. These sledges can carry all the necessary equipment for extended trips in the field.

Half-unit
The half-unit is made up of two Ski-Doos, one sledge and enough gear to make a safe shelter for an unplanned overnight stay. On some field projects, a main camp is set up in a central location to several sites of interest. The half-unit will be used to travel to and from these sites on a daily basis.

11.2 The Ski-Doo

A variety of snowmobile models may be encountered but the operating principles remain the same for all types and they are all commonly known as Ski-Doos.

Before they enter field service, some minor modifications are made. The most important of these is to fit a steel wire loop that links the rear towing point with the forward bumper or "cow-catcher". This enables the Ski-Doos and sledges to be linked together as a continuous chain for safe glacier travel.

Shackles and steel Maillons are used to attach link ropes to the front and rear of the Ski-Doo. The shackle pin should be inserted from above so that if it works loose it does not drop out.

All Ski-Doos should be fitted with a kill switch cord so that if you part company with your vehicle the engine will stop immediately.

Always wear a crash helmet when Ski-Dooing.

See Chapters 14 and 17 for further information on Ski-Doos.

11.3 Sledges

Wooden Nansen sledges are used for carrying equipment in the field. One of their main properties is the ability to bend and flex over the snow surface. It is this flexibility that gives them their strength. Simple construction techniques are used to manufacture these sledges and this makes field repairs possible.

Key features of Nansen sledges

Link line attachment
The 20mm ropes that link the Ski-Doos to the sledges are fastened to a steel Maillon at the front and rear of the sledge. In addition, a length of 20mm line (the centre line) runs underneath the sledge to link these karabiners and complete the chain.

Keels
Midway along each runner is a metal blade that can be dropped at selected depths into the snow. Keels stop the sledge from slipping sideways on traverses and weaving about on hard snow. The keels can also be used to brake the sledge when descending.

Rope brakes
At the front end of a Nansen several loops of rope are tied around each runner. When running on the flat they are tied up out of the way. For descending they are slipped under the front of the runners to make a very effective brake.

Chain brakes
These are for use on ice and very hard surfaces. The main drawback with this type of brake is that they can damage the runners.

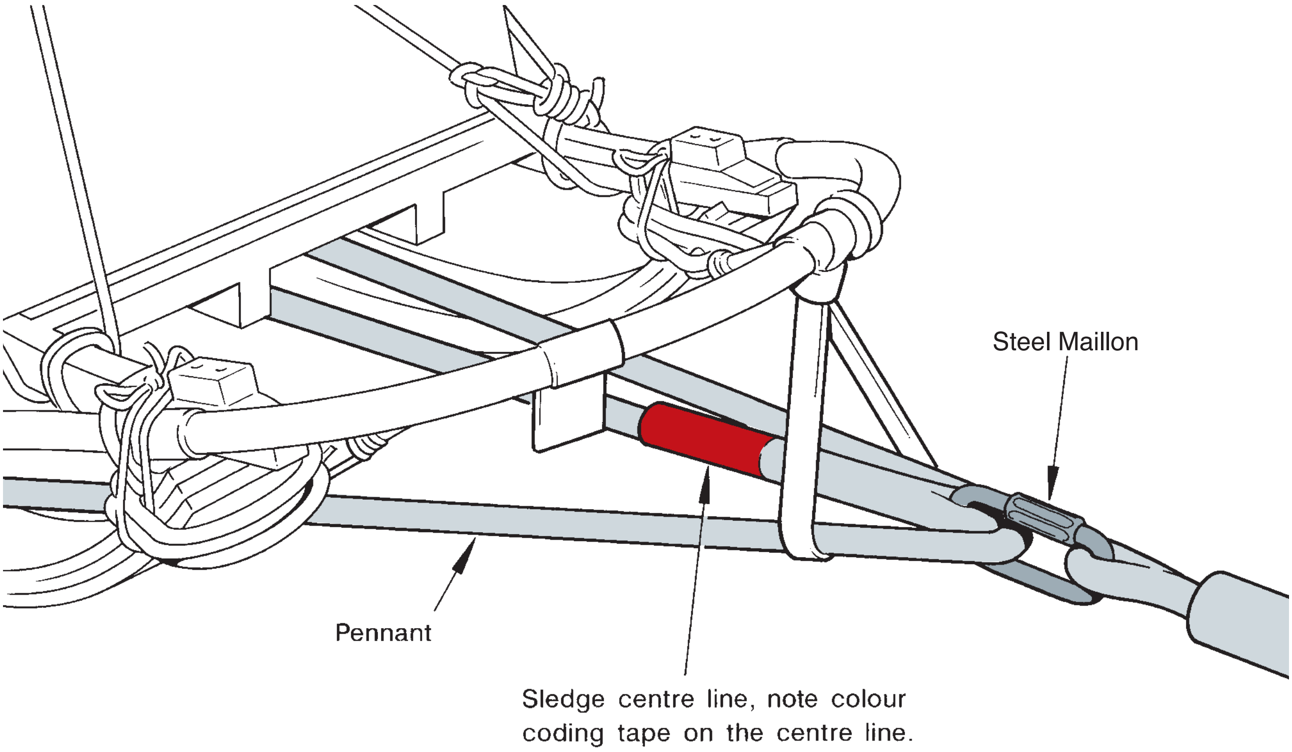


Figure 11.3 Link-line attachment

Cow-catcher

The large bamboo loop at the front end of a Nansen is known as the cow-catcher. It acts as a bumper bar and prevents the sledge being damaged if it is in collision with a Ski-Doo.

11.4 Linked travel

Some areas around BAS stations have been marked as safe for unlinked travel. In all other areas you should always travel as a linked unit (except on sea-ice). Never travel with two people on one Ski-Doo in the field.

The linked unit

In order to protect the riders in a crevasse fall, Ski-Doos always travel linked together. The system of linking is relatively simple and works in a similar manner to an Alpine pair. Instead of a climbing rope, the Ski-Doos and sledges are connected together with 20mm hawser laid rope.

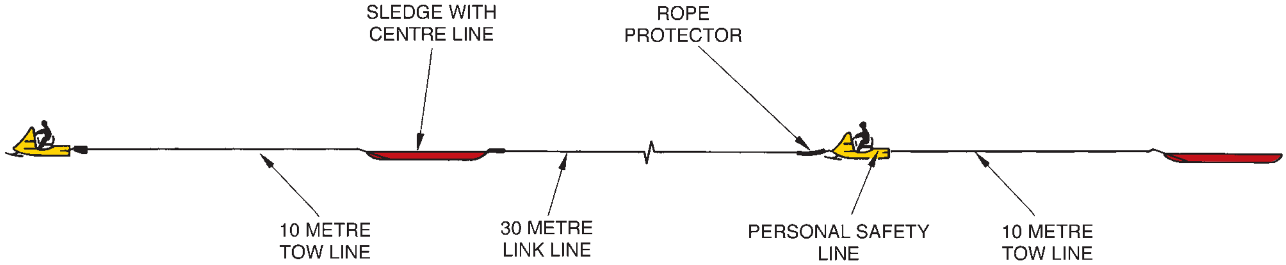


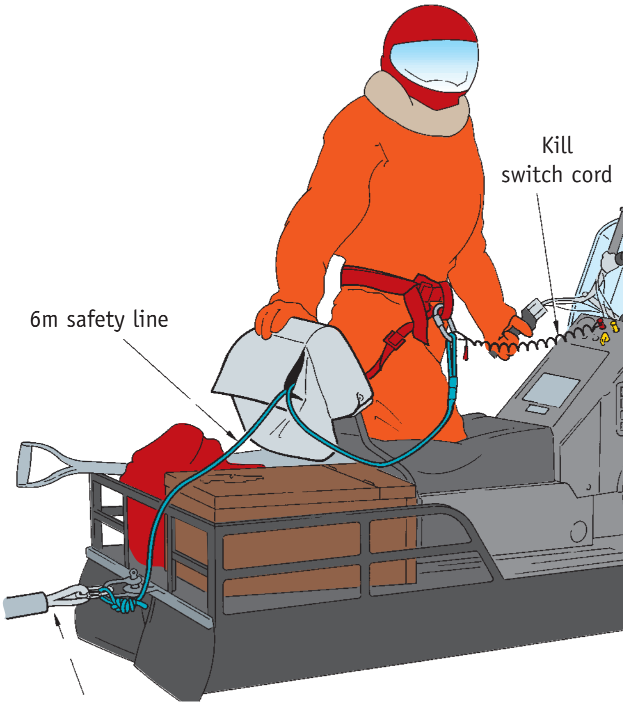
Figure 11.4a The linked unit

Operator attachment
The operators are connected into the system with a six metre length of 11mm dynamic rope.

Crevasse fall
The link system works on the principle that if one part of the unit were to fall into a crevasse then the other parts would hold the fall. This system works and has saved lives. Experience shows that the rear half of the unit is usually dragged forward until the first sledge reaches the lip of the crevasse. The sharp angle formed at this point normally stops the fall.

In the event of the first Ski-Doo falling into a crevasse the driver will end up hanging below their machine. You should therefore know how to extricate an injured casualty from this position before venturing into the field. Remember that you could be the injured person. **Could your partner perform this procedure?** See Section 11.11.

Figure 11.4b The snowmobile operator



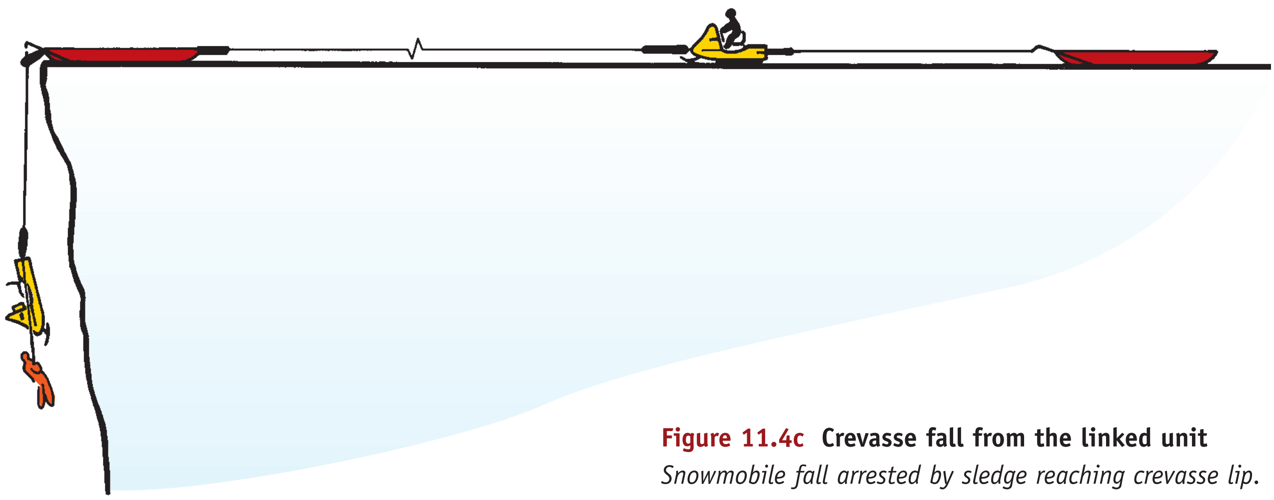


Figure 11.4c Crevasse fall from the linked unit
Snowmobile fall arrested by sledge reaching crevasse lip.

11.5 Sledge loads

Full-unit travel
When loading your sledge for full-unit travel follow the principle that if you lose one of the sledges you will still be able to live and survive with the contents of the other. It makes sense to put the main items of the living unit, such as the pyramid tent, pots box, tent box, inside food box, medical box and radio on the rear sledge as this is the least likely to fall into a crevasse.

Fuel and man-food boxes should be split between the sledges. A complete P-bag and one emergency clothing bag on each sledge are sufficient to survive in a pyramid or pup tent.

Try and balance the weight of the loads between the sledges. If anything, the front sledges should be a bit lighter as the lead Ski-Doo has to break trail as well as pull a sledge. Heavy boxes such as man-food and rocks boxes should be kept as low as possible to increase stability. Delicate equipment is best carried towards the rear of the sledge where the ride is smoother.

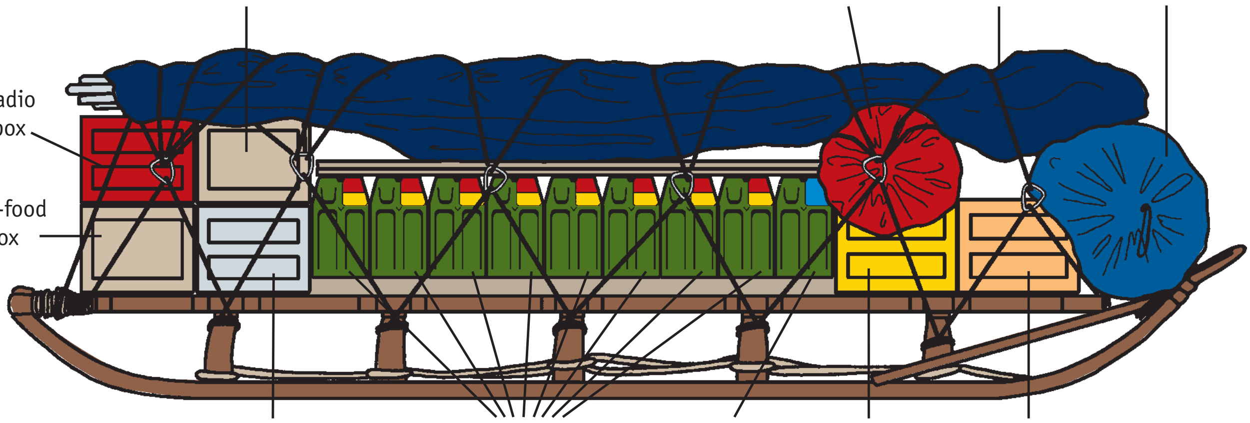


Figure11.5a Full-unit sledge

Half-unit travel

Whenever you are working away from station or field camps, the half-unit sledge should be taken. If an unforeseen incident prevents your return to station (weather, breakdown, accident), you will have enough equipment to initiate a rescue, give comprehensive first aid, contact your station and live away from the full-unit for several days.

The half-unit sledge should contain:

- Two emergency clothing bags (spare footwear needs to be put in this bag).
- P-bags.
- One jerry of paraffin.
- A jerry of Ski-Doo fuel (one is the minimum).
- Radio box (this is often kept in the P-bag).
- Medical box.
- Ski-Doo spares box.
- Spares box.
- Man-food boxes (three minimum).
- Pup tent.
- Skis or snowshoes.

If a half-unit is to be used over several consecutive days it is possible to load the sledge and tie it off so that only the radio and P-bag need to be removed at the end of the day. This speeds things up in the morning and saves getting cold hands lashing the sledges every day.

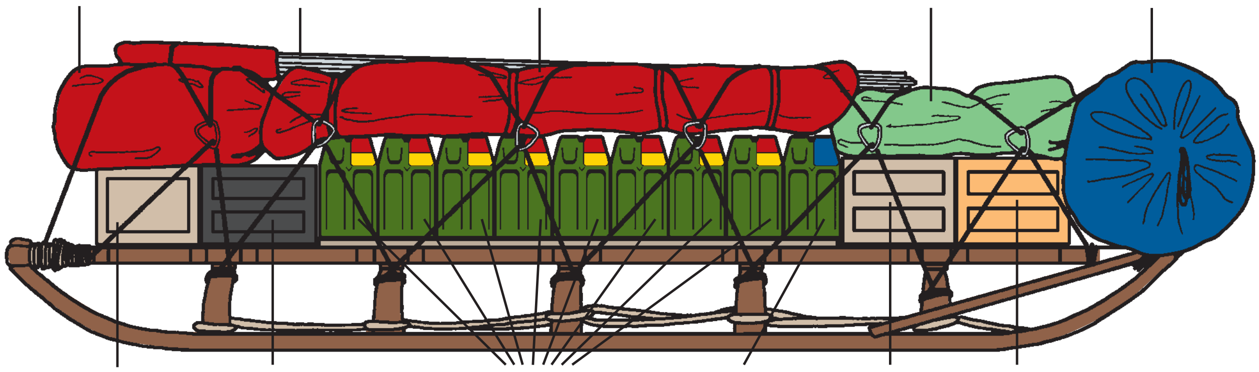


Figure 11.5b Half-unit sledge

11.6 Equipment carried on the Ski-Doo

The following standard equipment must be carried on the Ski-Doo:

- Driver's personal safety line.
- Shovel.
- Bog chisel.
- Shackle and Maillon.
- Funnel (one per unit).
- Snow stakes.
- Ice axe and hammer.
- Small brush (one per unit).
- Rescue sack.
- Personal day sack.
- Probe rope with Petzl shunt or Prusik loop (lead Ski-Doo).
- Probe (could be a ski stick with the basket removed).

Keep personal equipment to a minimum by carrying it on the sledge. For detailed information, see Chapter 26.

11.7 Lashing equipment onto sledges

The lashing system is simple and effective and can tie down sledge boxes up to three layers high. Stability is severely compromised over this height.

There are various methods of arranging the lash lines and it is best to consult people with field experience for their opinions. Use whichever method suits you best, but remember that others may do it differently.

Heavy items should go at the bottom to make the sledge as stable as possible. Try and pad the edges of the boxes with softer items such as the Ski-Doo tarps to reduce wear on the lash lines and tent. The secret of reducing wear and tear is to have the lash lines as tight as possible. Ask to be shown the Trucker's Hitch as it will make this job much easier.

After travelling for the first couple of kilometres it is worth stopping to check the tension of the lash lines as the load settles. Be careful of loose lash lines running over the pyramid tent as tent fabric can be abraded in a very short period of time. It is worth shifting the lash lines around the sledge periodically to reduce the amount of wear in any one spot. A worn hawser lash line is easily spliced back together.

Fuel jerries are carried in the middle of the sledges on specially made boards. Look closely at the boards when fitting them. They are designed so that the jerries are offset to keep the weight of the fuel centred over the sledge.

Bungees can be used to attach last minute items or items that will be needed during the day. This saves having to unlash the whole sledge.

11.8 Driving as a unit

When driving as a full- or half-unit, a great deal of co-ordination between the leader and following driver is required.

The lead driver has to select a safe route and speed. The following driver has the task of keeping sufficient tension in the link system and avoiding running over the link line. The following driver often has the more difficult job and it is one that requires a great deal of concentration.

A common mistake made by lead drivers is not checking what is happening behind them often enough.

Signals

As in all mountaineering and fieldwork situations effective communication is essential. When travelling on Ski-Doos it is necessary to establish a few simple signals with your partner in order to communicate.

The front person can easily signal to their partner but it can be more difficult for the following person to get the attention of their partner. One method is to reduce speed. This will be felt by the leader and should cause them to look back.

Below is a selection of commonly used signals:

- A hand held straight up shows that you want to stop straight away - this may be an emergency stop.
- A low waving motion shows that you want to slow and may finish with a stop signal.
- Thumbs-up obviously means okay. It is used before driving away and to check that all is well.
- A pointing hand can show direction to either the left or the right.

- A throat cutting action with the hand means switch off the Ski-Doo. This can be useful if you need to shout to each other.
- Making the V-sign at each other indicates a break down in communications!

Feel free to develop your own signals but ensure that they remain simple, self-explanatory and easily interpreted. It is a good idea to come up with hand signals for rope brake deployment and keel positions. This saves time, as the leader does not have to walk back along the whole chain to talk to the second person.

Make sure that both members of the party are using the same sign language and that your signals receive responses.

Manoeuvring a unit

Making sharp turns when linked together should be avoided if possible although it may be necessary in crevassed areas. When stopping, ensure you slow down gradually to prevent the rear sledge colliding with the rear Ski-Doo. Try to make all movements as smooth as possible and make sure your partner knows and understands your intentions.

11.9 Difficult terrain

Steep ground

When moving as a full-unit it might be necessary to ascend and descend steep slopes. Steep ground will often result in two Ski-Doos being used to pull one sledge. A fully laden sledge can weigh more than 700 kilos so ferrying each sledge up and down steep slopes one at a time is often the best approach.

For safety reasons do not ferry each sledge more than five kilometres at a time. If you have a problem, you will always be within walking distance of your unit. Detailed below are the standard techniques for ascending and descending steep slopes.

Ascending

This technique is known as double-heading. Two Ski-Doos will be used to pull one sledge.

Make the decision to double-head as early as possible rather than leave it until no further progress can be made. Sorting things out half way up a slope risks:

- Injury.
- Damage to equipment.
- Ending up in a crevasse.

The down side to double-heading is that you will have to make two journeys. Also, as you descend to collect the second sledge you will be parted from the bulk of your survival equipment. For this reason, rescue sacks should be carried on the Ski-Doos, not the sledges.

Do not travel further than it is possible to walk back to a sledge.

Descending

Due to the sledge towlines being a non-rigid link, the sledges will run into the back of the Ski-Doos when going downhill.

There are various methods of braking the sledges:

- Use one or both keels for moderate slopes.
- Use the rope brakes on steeper slopes. **When deploying rope brakes make sure the keels or chain brakes are down** otherwise the sledge can pivot around the rope brakes and a loss of control will occur.
- Use the second Ski-Doo to brake the sledge.
- If the surfaces are hard or icy consider deploying the chain brakes.

All of the above methods can be used on their own or in a variety of combinations. The most appropriate method can only be learnt through experience and applying common sense.

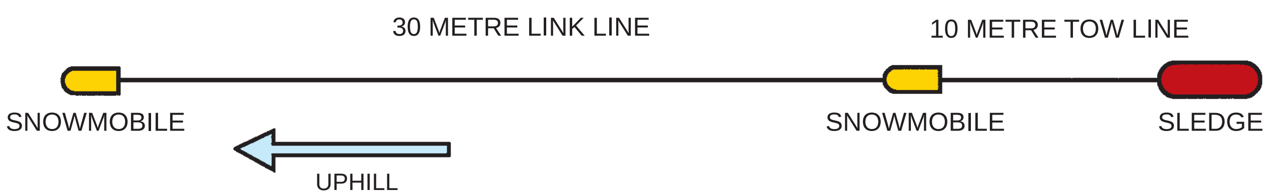


Figure 11.9 Double-heading

Traversing

Taking a unit across a slope requires careful management. To prevent the sledges slipping sideways, the keels should be lowered.

On steep slopes it may be necessary to ferry each sledge across one at a time. The second Ski-Doo should take an uphill position to prevent the back of the sledge sliding downhill. Remember that a fully laden sledge is top-heavy and will roll easily if not driven with care.

Traversing is one of the few times you might travel on half-length towlines as it helps the sledge track behind the Ski-Doo. If this technique has to be used, make sure that you return to full-length towlines once the slope has been traversed.

Soft snow

Deep, soft snow conditions can present problems for Ski-Doos even when pulling light loads. Heavy use of the throttle will cause a Ski-Doo to bog down, as will reversing in soft snow. Try to make your movements as smooth as possible and avoid stopping and starting.

If you do start to bog down, do not try to use engine power to get out. This will bog the Ski-Doo in further. Dig away the snow at the front of the Ski-Doo and then try wobbling it from side to side as you apply power. This packs down the snow and increases traction.

Even on flat ground, it may be necessary to double-head if the snow is soft. The lead Ski-Doo breaks a trail and the second Ski-Doo can pull the sledge. Shallow keels will help to keep the sledge in the Ski-Doo track.

11.10 Crevassed areas

Route choice

If you are in any doubt about the safety of your route, stop and probe ahead on a rope. It is far better to find a hidden crevasse with your foot, than to drive into it with a Ski-Doo.

If at any point you feel a route is not feasible - do not continue. Remember, you are in the Antarctic and help could be several days away. It may mean you are unable to reach an important worksite, but that is the nature of Antarctic fieldwork. Safety is always the first priority.

If you have to cover the same ground twice, consider marking the route with flags. Ski-Doo and sledge tracks are easily filled by winds over 10-15 knots. If a route is flagged when the contrast is good, it may be possible to access a work site when the weather is poor. Even when a route is flagged you must watch out for crevasses. Snow bridges do not always break on the first crossing and are more likely to give way at the end of a day.

The link system works best if the unit is travelling at right angles to the crevasse orientation. Try to maintain this orientation at all times.

Probing for crevasses

If the route ahead needs to be checked you should rope-up and check it out on foot as an Alpine pair. Do not be tempted to leave it too late to investigate a potentially unpleasant area. Turning a unit around in a crevassed area is a highly risky manoeuvre.

A "probe rope" may be the best option if you need to check something that you spot just in front of you. This is a half-length rope chained into a pouch and stored under the Ski-Doo seat. It is clipped into the eye of the towrope and used to move forward whilst protected by a Petzl Shunt or a Prusik.

Make sure you are tied into the other end of the rope and that you are familiar with the operation and limitations of the Shunt. A Prusik knot is more than adequate for this task. Do not use a Jumar for this application, as it could be shock-loaded.

Moving between sledges

If you need to stop the unit and get together to discuss routes, crevasses, shutter speeds or anything else, it is a good idea to clip onto the link line and meet at the first sledge.

A sling clipped into your belay loop, passed around the 20mm line and clipped back again is a handy way of doing this. If you need to get past the sledge, it is worth tying an 11mm line between the front and rear of the sledge to act as a continuation of the link line.

It is very easy to get lulled into a false sense of security when working around a unit and it is tempting to unclip from the system to make movement easier. This is a very unsafe work practice - just because you can't see any crevasses, doesn't mean they aren't there.

11.11 Crevasse rescue of a casualty hanging beneath a Ski-Doo

This is a very serious situation and there are several points that should be considered:

- There is a high possibility that the casualty will be injured.
- The casualty may be trapped between the wall of the crevasse and the Ski-Doo.
- In all probability it will be the lead person who ends up in the crevasse. This means the most experienced person has to be rescued by the least experienced. Could your partner perform this complex operation?
- You will be under a great deal of stress at this time.
- It is a much more complex rescue than setting up the normal Z-pulley system.
- You are obviously in a dangerous area for it to have happened in the first place.
- It will take a long time to sort out, even under ideal conditions.
- If the casualty is injured you would have to set up camp on your own and await rescue.

From all of the above it can be seen that this is a situation that you simply cannot afford to get into. Prevention is always better than cure, so always take the safe approach to field travel.

Actions to retrieve a person hanging below a Ski-Doo

If a Ski-Doo has gone down a crevasse the driver could be either:

- Uninjured and capable of self-rescue.
- Incapacitated and in need of rescue.

In both these situations your main priority is to look after your own safety. **Do not become a second casualty.**

Uninjured Driver

This is relatively simple to sort out compared to an incapacitated driver. Your basic actions should be:

1. Make sure the unit is properly anchored. It is beyond the scope of this manual to go into every particular scenario. Follow the guidelines given in Chapter 10 for placing and linking anchors.

2. Don't become a casualty yourself, stay calm and clear-headed.

3. Establish the seriousness of the situation by moving to the edge. Make sure you are attached to a dynamic rope and are protected by a Prusik.

4. If your partner is okay, throw them a dynamic rope to Jumar out on.

5. Alternatively use the Electron ladder. If you choose this option it is essential that you provide a top rope as a safety back-up. Never climb an Electron ladder without the security of a rope.

6. Sort yourselves out and contact your station.

Incapacitated Driver

Go through steps 1 to 3 above. If you then find that your partner is injured you will need to:

1. Go down to them and administer first aid.

2. Get them off their personal safety line and onto a rope that you can haul them out on.

3. Jumar back to the surface.

4. Haul your partner out.

This may sound relatively simple, however, several key difficulties can be identified:

- It will be necessary to get the casualty off one system and onto another system. Could you perform this?
- You will need to rig a chest harness and link this to their waist harness. Coils are not worn on a Ski-Doo so the casualty may be hanging upside down.
- If the casualty is hanging below the Ski-Doo, they may become tangled up with the machine as you try to haul them past it. This would mean having to go back down and trying to haul them up from inside the crevasse.
- In all probability you will be extremely stressed during this process.

This scenario should be practised before going into the field.

Could your partner cope if you were hanging beneath a Ski-Doo?

11.12 Crevasse rescue of Ski-Doos and sledges

As mentioned, your first priority is to look after yourself and the next priority is to look after your partner. Once you have achieved this, you will be in a position to retrieve the Ski-Doo and other equipment.

The techniques for rescuing sledges and Ski-Doos will vary with each case and it is well worth reading the reports on crevasse incidents and the methods used. See particularly R/1983/H1 (Weyerhauser Glacier) and R/1986/H1 (Sloman Glacier).

Prepare and assemble all the necessary equipment and ensure that you always safeguard yourselves. The contents of the rescue sack should be sufficient to cope with most situations. The non-stretch ropes and the Jockey Winch can be used to retrieve heavy items.

A ramp will need to be cut at the lip of the crevasse to help with the final stages of recovery. If possible, lighten the load to be hoisted by abseiling into the crevasse and extracting the smaller items first. A sledge could be unloaded and Ski-Doo engines have been removed in the past.

All personnel must be belayed on different anchors to the Ski-Doo haul anchors. Never attach yourself to a Ski-Doo during a hauling operation.

Ski-Doo anchor

Very strong anchors are required to hoist Ski-Doos and sledges. A combination of a sideways facing Ski-Doo and standard snow anchors can provide a suitable anchor point. At a safe distance from the rescue site, dig a shallow pit large enough for the ski and tracks of a Ski-Doo. Park the Ski-Doo so that it is side-on to the direction of pull. Reinforce the Ski-Doo with an additional anchor.

Link the front and rear tie-in points and tie-off to form an anchor point.

Jockey Winch

A Jockey Winch and two non-stretch ropes are the most suitable equipment for hoisting. Beware of using pulley systems with Jockey Winches because the forces produced will exceed the recommended limits for items such as Jumars.

Jumars should not be used for winching with a Jockey Winch. They should only be used for holding the load while the winch cable is moved forwards. See Figure 11.2b.

As the winch runs out of cable, the Jumar can take over the load. The second rope takes over the hoist after resetting the winch. If two Jockey Winches are available it is possible to alternate their use and speed up the recovery.

Cantilevered sledge

One of the main problems with hoisting items out of a crevasse is that the load rope cuts into the crevasse edge and makes the final part of the rescue very difficult.

A crane's arm can be improvised from a sledge over the site of a fallen Ski-Doo. This helps to keep the haul ropes clear of the crevasse edge. It also reduces friction and makes it easier to complete the final stages of the rescue. As the rescued Ski-Doo rises above the surface level, it can be winched to one side. See Figures 11.12c and 11.12d.

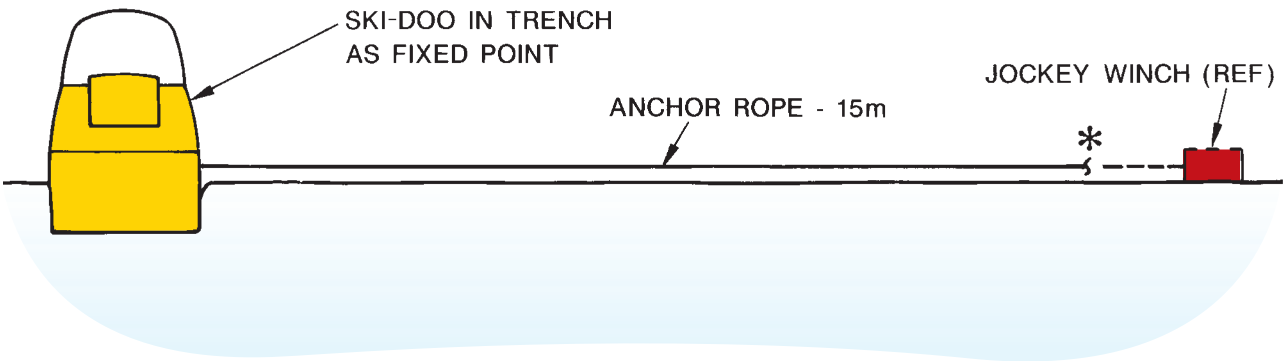


Figure 11.12a A snowmobile anchor

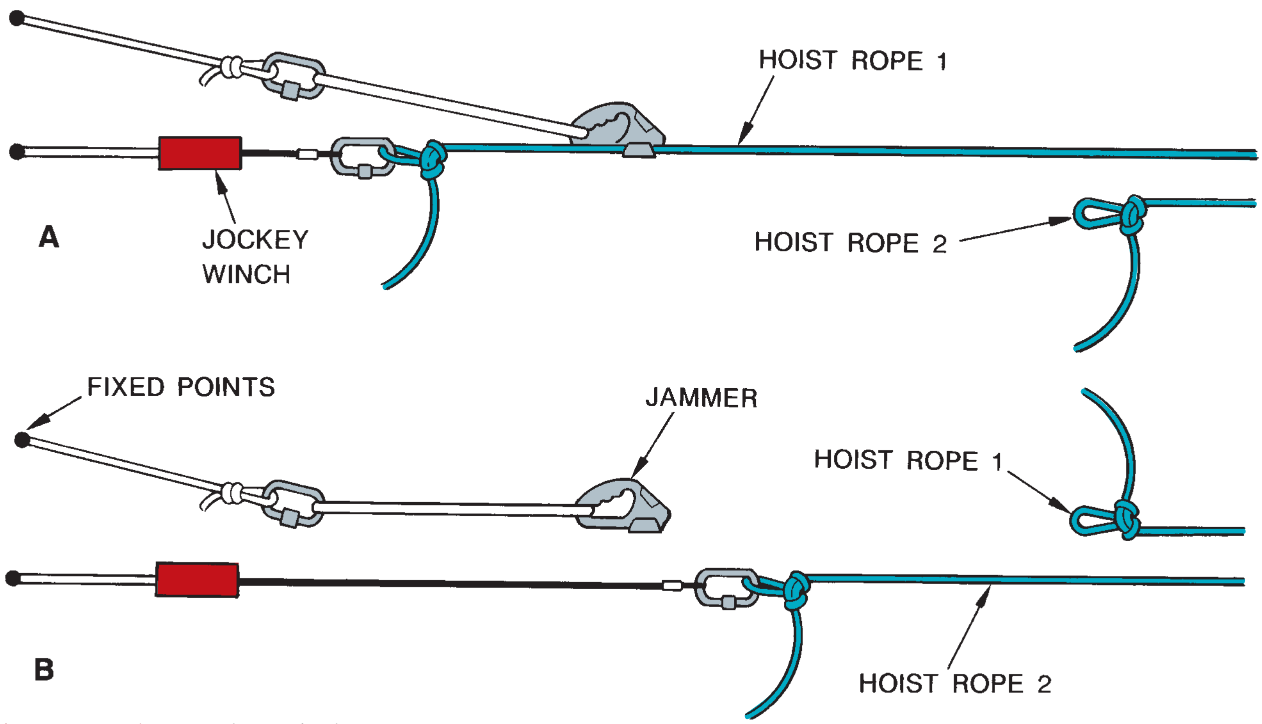


Figure 11.12b A Jockey Winch set-up

1. *Rope 1 is hoisted until there is no more cable available. At this point a jammer is clamped onto the rope and the load is transferred by reversing the Jockey Winch.*
2. *By resetting the cable in the winch, rope 2 can be clipped and the hoisting can continue. As rope 2 takes over the load, the jammer can be removed from rope 1 and left ready to be clamped onto rope 2.*

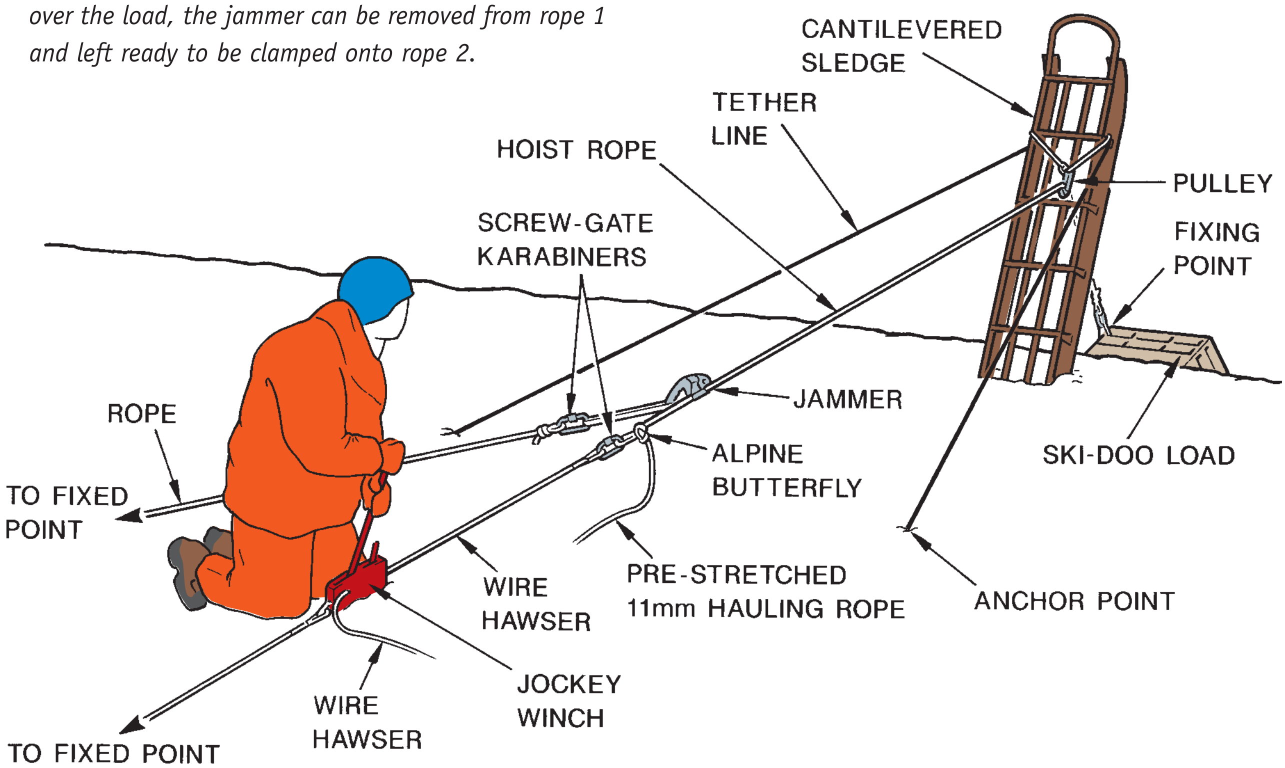


Figure 11.12c A cantilevered sledge

By tethering a sledge over the site of a fallen Ski-Doo/sledge, a "crane's arm" is improvised to keep the haul ropes clear of the crevasse edge. This reduces friction and makes it easier to complete the final stages of the rescue.

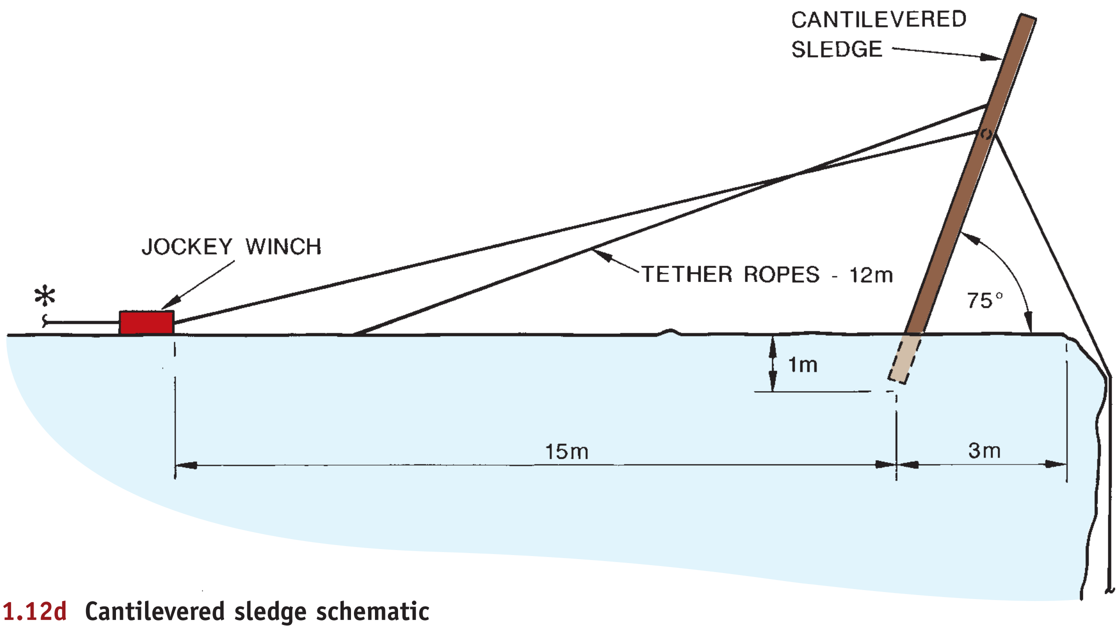


Figure 11.12d Cantilevered sledge schematic

11.13 Some dos and don'ts of unit travel

Do

- Travel linked-up.
- Keep your speed down.
- Check any doubtful ground on foot first. It is far safer to find a crevasse with your foot than to find it with a Ski-Doo. You will be much more aware of what you are travelling over if you are on foot. Do not use skis or snowshoes to check out routes as this defeats the object of the exercise.
- Wear a suitable helmet at all times.
- Practise casualty evacuation and rescue of a person hanging below a Ski-Doo before going into the field.
- Carry rescue sacks on the back of the Ski-Doos.
- Use the kill cord at all times.
- Communicate your intentions to your partner.
- Pack each sledge as an independent unit.

Don't

- Travel over new terrain in flat light. Only travel in poor visibility and poor contrast if the route is clearly flagged. Even flagged routes should be treated with caution.
- Rely solely on the GPS. Use a variety of navigational techniques. Do not be tempted to push on in poor weather relying only on the GPS.
- Travel two-up on Ski-Doos in the field. Never travel linked-up carrying someone on a Ski-Doo.
- Travel unlinked unless it is a marked, safe area.
- Carry jerries on the back of Ski-Doos.
- Carry the radio on the Ski-Doos.
- Travel on half length sledge ropes unless traversing.

12 Sledge hauling (manhauling)

Introduction

Manhauling is used for both science projects and recreation. This traditional technique is still relevant as not all science projects require Ski-Doos for access. The technique can also be the safest method of getting equipment to an accident site or for casualty evacuation where Ski-Doo travel would be too risky.

The weight and bulk of loads will be more of an issue than with Ski-Doo travel but it is essential not to compromise on survival equipment, spares or safety gear. Overnight trips will require extra careful planning, but all equipment for manhauling should be thought out well in advance.

Pulking in glaciated terrain will require knowledge of more specialist techniques than are required for travel as an Alpine pair. It is essential that you are conversant with these techniques and that you have practised them before committing yourself in the field. Could you rescue your partner if they were hanging below their Pulk? Could they rescue you?

The FOM/BC must approve all overnight trips.

12.1 Hauling equipment

BAS supplies three types of sledges for manhauling:

- Lightweight Nansen sledges (twelve and eight feet).
- Fibreglass Pulk sledges.
- Lightweight plastic sledges.

The lightweight Nansen is rarely used these days as it is best suited to crevasse-free terrain. The fibreglass Pulk is now used for both winter travel and summer fieldwork. Lightweight, plastic sledges are surprisingly robust. They can be strapped onto the outside of a rucksack and can be used to pull very heavy loads. Their usefulness should not be underestimated.

Manhaul Nansen

The manhaul Nansen sledge is of a lighter construction than the standard Nansen towed by Ski-Doo. The twelve-foot sledge is the easiest means of carrying a pyramid tent, which is a requirement for any winter travel.

These sledges can be difficult to drag due to their narrow runners that dig-in badly in soft snow.

Pulk sledge

This is a boat-shaped sledge made from a fibreglass shell with integral runners. They are usually fitted with straps and a nylon cover and can range in length from 1.6 to 2.2 metres.

Their uses include casualty evacuation, movement of stores at depots, transportation of large unwieldy science equipment and the recovery of rock samples. The larger Pulks are able to carry either collapsible or standard BAS pyramid tents.

The connection between puller and Pulk can be either rigid or rope traces. Rigid traces are the preferred option as they prevent the sledge running into the back of the puller on slopes and sastrugi. In glaciated terrain this is a much safer option because:

- The rear person's sledge is unbraked. This increases the risk of the sledge following them into a crevasse.
- If you do fall through a snow bridge, the rigid trace may support your body and help to prevent a more serious fall.

Field Pulks should be fitted with an internal rope strop to serve as a secure tie-in system for use in linked travel. This acts like a sledge's centre line and reinforces the attachment points at the front and back of the sledge. These reinforcement points preserve the integrity of the sledge so it is not pulled apart in a crevasse fall. A rear attachment point allows the sledge to be held from behind which reduces the chance of the sledge following you into a crevasse.

Front and rear rope brakes should be made and attached so that they either self deploy or can be deployed manually.

Hauling harnesses

The hauling harnesses supplied by BAS are for hauling only and are not to be used for linked glacier travel.

Glacier travel must be done using a normal climbing harness in conjunction with the hauling harness. Some hauling harnesses are available that were originally full safety harnesses. These are out of date for climbing use so should only be used as hauling harnesses.

Use a chest harness for the sledge attachment and a climbing harness for the rope attachment.

12.2 Hauling techniques

Linking up

For linked Pulk travel a distance of 25-30 metres is required between individuals. Pulking requires a greater distance between the party members than with the standard Alpine pair set-up.

Tie-in procedures are exactly the same as for an Alpine pair. A 50 metre rope is used and approximately 10 metres of coils are taken on. Additional 50 metre ropes should be carried in each Pulk. Without this additional rope it would be extremely difficult to perform a rescue if one of the team went into a crevasse.

Each Pulk needs to be attached to the main climbing rope so that in the event of a crevasse fall you can detach yourself from your Pulk without losing it. This ensures that the Pulk and the equipment it contains are not lost.

Front person

The front person attaches a short Prusik loop from the rear tie-in point of the Pulk onto the rope.

Rear person

The rear person clips a short length of rope from the front tie-in point of his Pulk onto the rope immediately in front of him with a karabiner. Use a karabiner to clip the Pulk onto the rope as a Prusik loop may slip. In the event of a fall into a crevasse the rope, and not the person, takes the weight of the sledge.

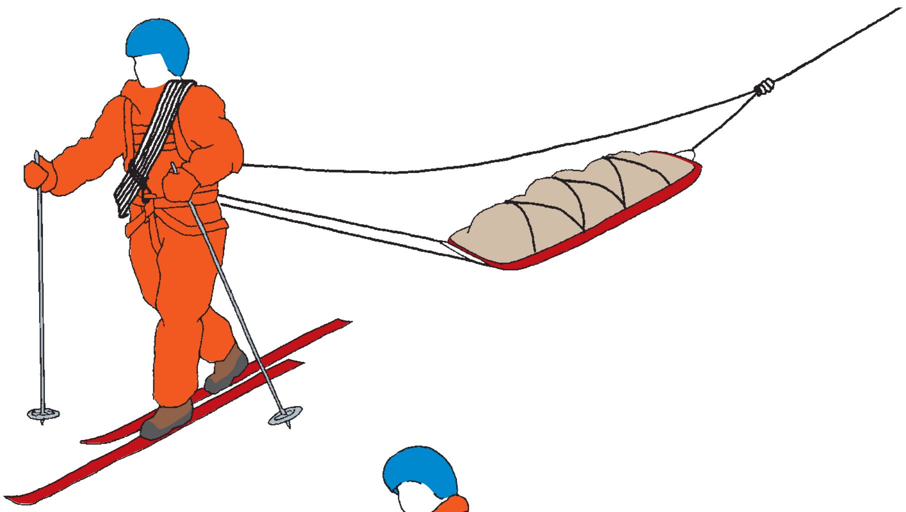
To be able to Jumar up to the surface you will have to untie from the rope. Unlike a normal crevasse fall, the sledge will be hanging on the rope, hence the need to take the rope off. The climbing rope should therefore be clipped to the harnesses with a screw-gate karabiner to aid escaping the system.

Great care must be exercised when doing this and you must practise this technique before going into the field.

Snow stakes should be carried on the rucksack or in a holster on the trace. The normal equipment for glacier travel should be carried on the harness. See Chapters 8, 9 and 10.

Could you rescue an injured partner hanging below a Pulk? Could you cope with all the possible situations that might arise when manhauling? Think about the potential problems and practise the solutions.

Figure 12.2a Front person Pulk set-up



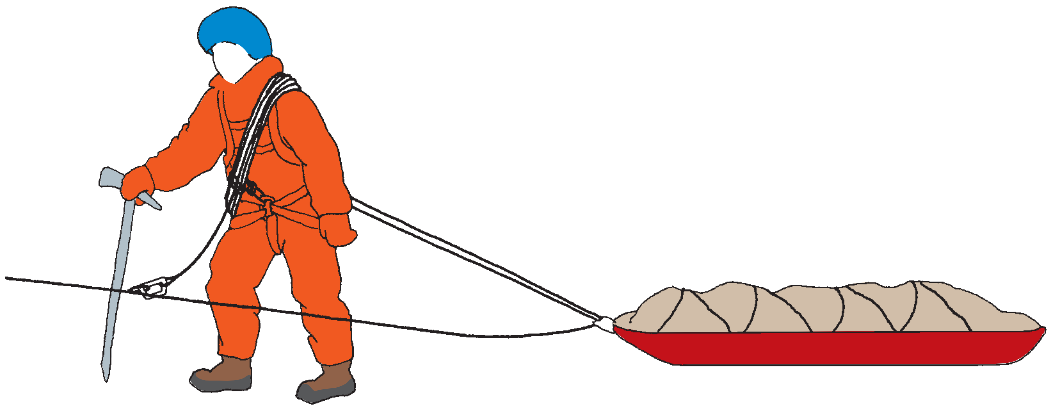


Figure 12.2b Rear person Pulk set-up

Descending

Descending has great potential for accidents when manhauling. If you are uncertain about a slope, check it out first without a load.

Once committed to descending a slope, rope brakes may need deploying and at least one person will need to go up-slope of the sledge to brake it. Two people may be needed if the slope is steeper and all may be required to lower the sledge down the fall line on a steep slope. Belaying the sledge may be necessary.

Traversing

Unlike the Nansens that are towed by Ski-Doos, manhaul sledges do not have keels. Sledges will tend to slew sideways during traverses and careful management is required. Practise for these situations before committing yourself in the field.

Relaying loads

If surfaces or slopes prevent fully loaded sledges from being pulled, it is standard practise to relay half loads forward before returning with empty sledges for the remaining loads.

Relaying by carrying loads on your back may also be an alternative in this situation. Do not become separated by too great a distance from your survival equipment.

12.3 Manhauling on sea-ice

Great care should be taken when manhauling on sea-ice. It is very important that you are able to detach yourself from the system if the sledge falls through the ice. If you were tied-in the consequences could be extremely serious.

The quick-release manhaul harnesses available at some stations are ideal for this purpose. Make sure you know how to operate them before heading onto the ice.

Pulk sledges are preferable to manhaul Nansens because they float. If a sledge breaks through the ice it may be less serious with a Pulk. Sea-ice travel does not require linking up. See Chapter 20 for further information.

13 Skiing and snowshoeing for field travel

Introduction

Skis are used for both work and recreation in the Antarctic. Recreational skiing is not covered in this manual. Un-roped, off-piste glacier skiing is permissible within BAS operations. The Field Operations Manager or the Base Commander will assess each situation in consultation with the Field Assistants.

Skis used for fieldwork should be viewed as a type of snowshoe. Skis are often of limited use for fieldwork. The reasons for this are:

- Conditions in the Antarctic are rarely conducive to good skiing. Hard icy surfaces, breakable crust and sastrugi are often present, sometimes within metres of each other.
- It is rare that all members of a project have the necessary skiing ability to cope with these conditions.
- Heavy packs are not conducive to easy skiing.
- You are roped together. This is not a problem when skiing with skins, but skiing downhill at speed whilst roped together is a somewhat esoteric pastime. It is not an appropriate technique for BAS field operations.
- There is a high risk of incurring lower limb injuries when downhill skiing, particularly given some of the above factors.
- Should an injury occur, you are a long way from help and treatment.
- The aim of the exercise is to get the work done in the safest and most efficient manner, not to have a skiing holiday.

For these reasons, skiing on field projects is generally for access to and from work sites. In certain situations skis can be very useful but most field skiing will be of a modest nature.

Advantages of skis:

- They significantly lower your ground pressure. This can make travel in soft conditions much easier.
- They reduce your chances of falling into a crevasse.
- They are generally safer on sea-ice than travel on foot.

Knowing when skis are appropriate and when they are not will only come with experience. If you are in doubt about you or your partner's ability to hold a fall on skis or snowshoes, wear boots and crampons.

13.1 Snowshoes

Snowshoes have often been under utilised for fieldwork. For many projects and applications they are more appropriate than skis.

The best type of snowshoes are those with an integral crampon and quick-release buckles to speed their fitting and removal. When working on sloping terrain, snowshoes with crampons are essential. If you or your partner have little experience of skiing, it would be more appropriate to take snowshoes. If you can walk, then you can snowshoe.

They have several advantages over skis:

- They are easy to use.
- They are small and lightweight and can be carried easily on your pack when not in use.
- They are robust and virtually maintenance free.
- They don't require skins which can be the cause of much frustration - in very cold weather, skins are difficult to keep on the skis and in warm weather they can ball-up.
- They are cheap.

If you take snowshoes, don't forget to take ski poles. See below for sizing.

13.2 Ski type

Two types of skis are available:

- Ski mountaineering skis with Alpine touring (Silvretta 404) bindings.
- Skis fitted with plastic Berwin bindings.

Ski mountaineering skis

In more mountainous terrain, ski mountaineering skis may be appropriate as they are used with plastic mountaineering boots.

Silvretta 404 bindings are still the most appropriate for BAS fieldwork as they are the only bindings that fit the toe-piece on a plastic mountaineering boot properly. They are very robust, which is an important consideration for field equipment.

Berwin binding skis

Berwin bindings are simple plastic bindings that can be used with a variety of footwear including Mukluks. For many projects, such as those on ice shelves, skis fitted with Berwin bindings will be the most appropriate choice.

Berwin bindings are much better in cold temperatures because:

- Mukluks are warmer than plastic boots.
- Metal ski mountaineering bindings conduct heat away from the foot.
- You don't have to change footwear to go skiing if you are wearing Mukluks.

Berwin bindings are also much more comfortable if skiing on the flat, particularly when pulling a sledge. Plastic boots tend to rub the shins and the soles of your feet.

Skis for Berwin bindings need to be wide due to the width of the binding. One disadvantage of Berwin bindings is that they can be brittle in very cold temperatures. It is worth taking a spare binding into the field and some repair materials.

13.3 Ski length

Field skis are generally 160-180cm long. Choose a ski length equal to your eye height. Short skis are easier to turn and kick-turn but may suffer from reduced flotation in soft snow and breakable crust.

13.4 Bindings

Silvretta

It is essential that Silvretta bindings are set up correctly for each individual. The penalty for not doing this could be a broken leg in a remote location. For information on setting up these bindings, see the Field Assistant's Work Manual. Ski leashes should be fitted to skis to prevent their loss in the event of a binding release or crevasse fall.

Berwin

Berwin bindings are simple to adjust and have no release mechanism.

13.5 Footwear

Depending on the type of ski, either plastic mountaineering boots or Mukluks will be worn. Ski mountaineering boots have been tested but were found to be too specialised.

13.6 Poles

The correct length of ski poles is important:

- Field parties working in non-mountainous areas may prefer to use Nordic type poles. The handles should fit under your armpits when the poles are held vertically.
- For mountaineering and downhill skiing, the correct pole length is found by holding ski pole upside down just below ski basket. Your forearm should be parallel with the ground.

Check that wrist straps are large enough to accommodate the thickest gloves you might wear. Make sure there are no twists in the straps otherwise blistering and unnecessary glove wear may result.

Ski poles can be very useful for all foot travel in mountainous areas. They take considerable strain off the joints and spine, especially when descending slopes. On uphill sections you can maintain a more upright stance. They are also good as an aid to balance on slippery ground, boulder fields, in windy conditions and when carrying a heavy rucksack.

Geology field parties might want to consider using telescopic ski poles. These are not issued.

13.7 Ski skins

Ski skins should match the width of your skis. If the skin lies too close to the edges of the ski it will be difficult to hold an edge on steep traverses. A skin that is too narrow may not give sufficient grip. Make sure that you have the correct length of skins. Many skins are top and tail fix with only a small amount of adjustment. Top fix skins are less size dependant but top and tail fix skis are usually the most secure.

There is nothing more annoying than skins that don't stick properly, so it is important to look after them. Skins stick best if the skis are warm. Put your skins on before leaving station if possible. During the day keep skins in an inside jacket pocket. Rub them vigorously with the palm of your hand when fitting to help them to stick. Make sure you are wearing gloves as it is easy to cut yourself on the ski edges.

Duct tape is a quick and effective method of attaching skins when the glue will not stick. However in very cold weather it can be difficult to get duct tape to stick. Make sure that skins are well glued and take some glue into the field. Don't get dirt or grit on the glue and make sure that they are dried after use. The glue will dry out if skins are left to dry for too long. They should be stored in a skins bag with the glued sides stuck to each other.

For maintenance advice on skins see the Field Assistant's Work Manual.

Balling-up

In wet conditions snow may stick to the skins causing them to ball-up. If this occurs try tapping the side of your ski with a ski pole. If this doesn't work scrape the snow off. A thin layer of silver wax or spraying the skins with silicon may help to prevent balling-up.

Emergency skins

Thin rope can be used in an emergency to improvise skins. Using a single, long piece of rope (6mm is ideal) or a double length of rope, tie Half Hitches or an interlocking criss-cross pattern on the base of the ski. Tie firmly at the tip and tail of the ski.

13.8 Waxes

There are two broad categories of ski waxes - glide wax and grip wax. General-purpose glide wax should be thought of as ski base protection rather than something to make you ski faster. Wax protects the bases and prevents the P-tex from drying out. Grip waxes are unlikely to be used in the field as skins are used to provide grip.

For information on waxing see the Field Assistant's Work Manual.

13.9 Ski fitting

Only competent personnel are permitted to set up and fit skis. See the Field Assistant's Work Manual for more information.

13.10 Roping up for skiing

The only skiing permissible when roped together is skiing with skins. As mentioned previously, roped downhill skiing is not appropriate for fieldwork.

Roping up as an Alpine pair is the correct procedure (see Chapter 9). If skiing with Pulks, roping up should be done in accordance with the procedures outlined in Chapter 12.

13.11 Self-arrest with skis

A ski pole can be used for self-arrest although they are much less efficient than ice axes. If there is a risk of falling, remove your hands from the leashes. Try and get your skis across the slope to produce further resistance and braking.

14 Ski-Doos

Introduction

A variety of snowmobile models may be encountered but the operating principles remain the same and they are all commonly referred to as Ski-Doos. The main difference between machines is whether they use straight petrol and have a separate oil tank or whether they use mixed fuel (see below).

Kill-cords and helmets must be used at all times in the field.

See also Chapter 11 for information on unit travel with Ski-Doos.

14.1 Fuel consumption

See also Chapters 17 and 26.

A Ski-Doo in the field can be expected to cover about 2.6km per litre of fuel in the field. Surface conditions, speed travelled and sledge loads can all affect fuel consumption. For field travel where two Ski-Doos are always used, a figure of 26km per jerry, per unit, is a good rule of thumb for planning purposes.

14.2 Fuel type

Ski-Doos use two-stroke engines and these require lubrication oil. Depending on the age of the machines this can either be mixed in with the fuel or injected into the inlet manifold. It is very important to know the type of fuel that the machine being used requires.

Older Ski-Doo models use a fuel mix in the ratio of 50:1 petrol to two-stroke oil. This is known as “doo mix”. Newer machines use straight petrol and the oil is added to a separate injection tank. It is essential that this tank is checked and topped up regularly with the correct type of oil.

If the wrong type of fuel is used, the engine could be destroyed within a few kilometres. The worst scenario would be to put straight petrol in a Ski-Doo that requires a 50:1 mix. This would result in the engine receiving no lubrication. Putting mixed fuel into an injection Ski-Doo would be less serious as it would simply mean that it gets twice the amount of oil required. This would weaken the mixture and could foul the plugs. It could also cause overheating and subsequent engine damage.

If using a 50:1 mix, ensure that it is mixed in the correct ratio.

14.3 Ski-Doo operation

The following points should be observed:

- Do not exceed 25kph, especially over hard snow surfaces or ice.
- Check the vehicle is not in gear when starting.
- Don’t park Ski-Doos pointing at aircraft, tents, people, buildings or any other hazard.
- Make sure you use the correct type of fuel.
- Take care when fuelling not to get water, snow, paint flakes or other contaminants into the fuel by using a filter funnel. If uncertain of the petrol/oil ratio, seek advice.
- Avoid fuel spills. These are bad for the environment and, in cold conditions, cause cold injury.
- Always wear a suitable helmet.
- Always use the kill-cord.

14.4 Pre-start procedures

1. Make sure the Ski-Doo is not frozen in. If it is, dig it out and free the front ski. Turn the machine on its side and knock the tracks, sprockets and bogie wheels free of snow. Clear until the tracks will turn by hand.

2. Remove loose snow from around the engine and air intake.

3. Turn the driven pulley by hand. Make sure the flange turns freely. This ensures the engine is out of gear.

14.5 Start-up procedures

Ski-Doos must be in neutral before starting. If a Ski-Doo is started in gear and the throttle sticks open, the consequences could be very serious. Ski-Doos have been written off and buildings damaged because of this. There are no excuses. Imagine the consequences of a Ski-Doo hitting a tent full of people at 60kph.

These risks can all be avoided by following the correct start-up procedures:

1. **Make sure the Ski-Doo is out of gear.**

2. **Check the throttle and brake cables are free and not frozen.**

3 **Attach the kill-cord.**

4 Pump the primer until fuel is seen going into the manifold through the clear pipe leading into the carburettor. Warm weather and warm engines require little or no priming. In very cold weather they will require several pumps. Newer Ski-Doo models have a choke, not a primer pump.

5 Turn the ignition key and allow the engine to tick-over. Do not rev excessively at this stage. If you do, the engine will stall and it causes unnecessary engine wear. In cold weather it is best to pump the primer if the revs are dying. On models with a choke it should be turned off as soon as the engine fires.

6 If the engine will not start due to flooding - don't prime. Open the throttle fully and turn the engine over to clear out the excess petrol. Removing the crankcase breather pipe will help. **Caution: do not try and refit the crankcase breather pipe when the engine is running or injury may result.**

7 Do not drive the machine until the engine is hot and warm air is being vented. The air intake ducts can be blocked temporarily with your hands to speed this up.

8 **Test that the handlebar kill-switch and the kill-cord stop the engine. Do this every day.**

14.6 Initial running

1 If the area around camp is safe, it is a good idea to drive the Ski-Doos for approximately 300 metres before linking up to the sledges. This clears out the engines and warms them up.

2 Before trying to pull the sledge, break it free by hand. Do not take a running pull at the load as this will damage the Ski-Doo's transmission as well as the sledges.

3 If using Alpine 1 Ski-Doos in powder snow conditions, fit louvre covers over the cowling vents to prevent snow entry into the engine compartment. Snow on the drive belt and pulleys will cause the drive belt to slip. Watch out for overheating when using powder covers.

14.7 Stopping overnight

1 Fill the fuel tank to reduce condensation build-up and to save time in the morning.

2 Check the bogie wheels have not flipped (Alpine I only).

3 Repair any mechanical faults.

4 Ski-Doos should be covered at night to stop snow entry and prevent digging out in the morning. Use either individual Ski-Doo tarpaulins (tarps) or larger single tarps for this. Single tarps are the easiest to use. If the larger tarps are used, the engine canopies need to be taken off and laid up against the front of the machines. A link line bag or similar should be placed behind the windscreen to prevent the screen being damaged by wind or snow mass.

14.8 Ski-Doo servicing

Field staff undergo training in Ski-Doo maintenance and basic fault finding and fixing. A mechanic is usually available at the other end of a radio if things get difficult. A comprehensive spares kit and tool box is carried on all Ski-Doo based projects. See Chapter 26.

Every 400km or 30 hours the following maintenance checks should be carried out:

- Remove spark plugs, clean and check gap. *
- Check gear box oil level. *
- Check track tension. *
- Check drive chain tension.
- Check drive belt condition.
- Grease steering arm.
- Grease ski legs.

(* Ideally these checks should be made more frequently)

Turn the machine on its side for the following:

- Check ski bolts and pins for condition and security.
- Check track for damage and condition.
- Check bogie axle bolts for security.
- Check bogie axle springs.
- Grease bogie wheels.
- Grease rear axle bearing.
- Ensure all bolts on the engine mounting are tight.

For more information, consult the manufacturer's handbook in the Ski-Doo spares box. Record all service information, miles covered and any faults. This information should be passed on to the vehicle mechanic at the end of the trip or season.

14.9 Ski-Doo problems

If the engine turns over but fails to start or starts with difficulty - proceed through the following list in the order shown:

1 No fuel to the engine.

- Fill up with the correct fuel.
- Check the fuel lines.

2 Spark plugs. Check for fouled or defective spark plugs.

- Disconnect HT lead, unscrew plug and remove from the cylinder head.
- Reconnect HT lead and earth the exposed plug on the engine, keeping it away from the spark plug hole.
- Follow engine-starting procedure and check for spark. If no spark appears, the spark plug or the ignition system could be faulty.
- Change the spark plugs. This is one of the main causes of poor starting and running problems. If trouble persists, go on to step 3.

3 Faulty ignition system.

- Check the kill-cord is not disconnected.
- Check the kill-switch circuit is not faulty. This can be done by unplugging the connector block on the right hand side of the engine. This will isolate the engine cut-off circuits.
- If there is still no spark then check the wires from the CDI unit (capacitor discharge ignition unit).
- If the wiring appears okay, the CDI unit will need replacing. A spare unit is kept in the Ski-Doo spares box.

4 Flooded engine.

- Remove wet spark plugs and the crankcase breather pipe.
- Turn the ignition off and crank the engine several times.
- Turn the ignition on, install clean, dry spark plugs and refit the crankcase breather pipe. Make sure that the new plugs are not defective by checking for a spark.
- Start the engine following the usual starting procedures.

5 Clogged fuel line (water or dirt).

- Remove and clean the fuel filter.
- Change the cartridge filter if necessary.
- Check the cleanliness of the fuel tank.
- Check the condition of the fuel line and its connections.

6 Faulty carburettor.

- Unscrew the top of the carburettor.
- Remove the carburettor.
- Remove the float bowl and check for water or ice.
- Check the floats are still sealed.
- Check the jets and needle valve. If the jets are blocked, warm up the carburettor in the tent. Don't blow into the carburettor as it will make it worse. Don't use wire to unblock the jets.

7 Poor engine compression.

- Check the spark plugs are sealing correctly. If compression is still low, the engine could have serious problems.

8 If you are still having problems, it's time to get on the radio.

15 Field communications

Introduction

Radio communications (or comms) are essential for safe and efficient field operations in the Antarctic. This applies equally to local travel as it does to remote fieldwork.

Field communications are largely carried out using HF (high frequency) radios. Marine VHF (very high frequency) radios are used for inter-party communication. When working at aircraft refuelling depots, field parties may use aeronautical VHF radios. Iridium satellite phones are used as a back-up for the HF radios.

15.1 General principles of radio communications

It is essential to use the correct operating protocols when using radios. The following points should be observed:

- Due to the large amounts of radio traffic in and out of the stations, information passed should be clear and precise. Do not send superfluous signals.
- The station or aircraft will normally contact the field party on HF radio first. It can be very disruptive if parties broadcast at unexpected times.
- Observe proper radio etiquette. When using HF radios, you should remember that your transmissions could be picked up anywhere in the world. Bad language, indiscreet personal gossip and confidential information should not be passed over the radio.
- If communications are poor, try changing channels.

15.2 HF radios

HF radios can transmit over a range of thousands of kilometres but are subject to disturbance as changes take place in the ionosphere. The principal influence on the ionosphere is the sun. HF radio transmission is consequently affected by the time of day, the season and other sun related activity.

During periods of high sunspot activity, radio signals can be so badly disturbed that no HF communication is possible. This can last for several days. This is not a localised phenomenon and the controlling station will probably be experiencing the same problems.

BAS currently uses Racal PRM radios. Although there are several different models in use, the operating principles remain the same. These military radios are very robust and can function in low temperatures.

HF radio schedules

Field parties are required to communicate with their station once a day on HF. The main purpose of these radio schedules (or scheds) is to ensure that all is well and to record intentions for the following day. Any flight plans or requirements for a field party to pass weather observations can be arranged during the sched. It is essential that the information passed is concise and accurate, particularly when comms are poor.

Field scheds will be conducted at a prearranged time and frequency. Each field party is given a 15 minute time-slot. The controlling station will normally call the field party, so wait for your turn. Given reasonable comms, there is usually enough time to pass information on status, intentions and any messages. After your sched you should leave the radio on for a couple of minutes in case someone else is trying to contact you.

If you need to transmit at other times, listen out for a couple of minutes to ensure that you are not transmitting over the top of someone else. The most appropriate time for field parties to chat amongst themselves will be after all the field parties have been contacted.

It is important that parties come up at their prearranged schedule times. A search and rescue (SAR) response can be initiated after failed radio contact (see Section 15.3 below).

Times are given as Zulu or UTC (GMT). For example, Peninsula local time is UTC minus three hours. Thus at Rothera 19:30Z will be 16:30 local time.

Pre-field actions

Before going into the field you should:

- Familiarise yourself with the radio. Check it is operating by doing a radio check with the station. This should include setting up and actually using it off-station.
- Be able to diagnose simple faults and understand how to rectify them.
- Know the radio contact frequencies and times.
- Check the radio box to ensure all equipment is present and working.
- Ensure the batteries are fully charged.

Setting up an HF radio

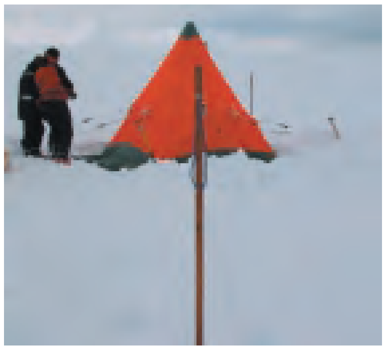
1 Open radio box and remove the PRM radio, one battery, one handset, the dipole antenna and coax cable.

2 Outside the tent, insert coax feeder through the tent dongler leaving the looped end hanging outside.

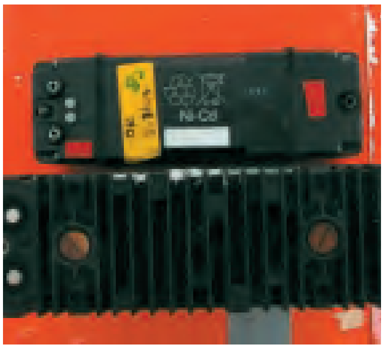
3 Connect coax to dipole T-piece and tie T-piece to dongler with attached cord. Attach metal clip from coax loop to T-piece hook for strain relief. A flag or bamboo can also be used to suspend the T-piece.

4 Extend the first dipole leg to the yellow frequency marker of the approximate frequency you want to transmit on. If in doubt, go longer.

5 After unwinding, tie the cable reel to a bog-chisel or ski-pole to keep the antenna off the ground and reasonably taut. Alternatively, loop the bog-chisel's cord through the reel and back over the chisel.



6 Extend the second leg as before, inline with the first. A dipole antenna should be orientated at right angles to the station for best communications.



7 Inside the tent, turn the radio upside down. Align the battery terminals with the posts on the rear of the radio.

8 Place the battery on top of the radio and turn the thumbscrews to attach it firmly to the radio.

Setting up an HF radio (continued)

9 Turn the radio the right way up. Ensure the knobs are set as in the photo (*, OFF, USB and volume somewhere above WH).

10 Insert the handset plug into the socket labelled 1 or 2 on the left side of the radio. Rotate plug until it drops down then turn collar to lock.

11 Connect antenna coax to DIPOLE socket on the right side of the radio. The long wire also plugs into the DIPOLE socket.

12 Turn the power switch to the HIGH position. The radio should perform a self-test and show PASS on the display.

13 Turn the channel select knob until the frequency you want to transmit on appears on the display. The display is in Megahertz.

14 Tune the radio to the selected frequency by double clicking the handset button or by turning the power knob to TUNE. Display should show GOOD on tuning. If not, check your antenna.

15 Press and hold the handset button to transmit, then talk. Release the button to receive.

Actions after input into the field

A radio check must be carried out before the aircraft (or ship) departs. If the radio is defective and can't be fixed straight away, a substitute radio needs to be given to the field party or the field party must return to station (or ship).

Make sure your radio stays with you when moving from one location to another. It is an essential and integral part of your basic survival equipment.

Common faults with HF radios

A diagnostic prompt sheet with corresponding repair tips should be in the radio box. The most common faults usually relate to power and antenna problems. Batteries can be checked using the charge indicator on the radio or by using the multi-meter in the radio box.

Antenna faults are often caused by:

- Wrong antenna length for the frequency used.
- Direction incorrect.
- Ice in the dipole socket of the radio.
- Ice in the dipole socket at the centre of the aerial.
- Broken antenna wire. Use the multi-meter to check for continuity.

Charging HF batteries

HF battery packs can be recharged in the field using a solar panel. In good conditions, the discharged cells take approximately 16 hours to trickle charge to full power. Batteries should be fully discharged prior to recharging. Discharging is carried out using the resistor in the radio box.

When charging, make sure the terminal connectors are the right way round when connecting the solar panel. During periods of darkness it is a good idea to disconnect the solar panel from the batteries.

After charging, make sure the battery is properly tightened to the radio case otherwise it may blow the fuse in the battery.

Warning

There has been one incident of a faulty battery exploding when it was being charged due to a build-up of gas in the sealed casing. The plastic outer casing exploded with considerable force. This could have been serious had someone been next to it or if it had been in a tent.

When recharging radio batteries in a tent or field hut, try to place them under a sheepskin or cover them up in some way. They could be charged in the radio box outside the tent or hut. All it needs is a bit of thought and common sense.

15.3 Missed HF radio scheds/poor HF comms

If a field party does not come up for **two primary and two secondary sheds**, a SAR response will be initiated. This applies to both summer and winter operations. Initiating a SAR response can be very costly and disruptive to station life as well as causing stress and worry. Unless there is a genuine problem, every effort should be made to contact station once the first sched has been missed.

If you miss a radio sched you should contact your station using the Iridium phone (see section 15.5 for guidance). Using the Iridium is not a get-out clause for missing scheds due to poor planning, work pressures or setting up the radio incorrectly. The phone is a back-up to the HF radio and HF is the primary method of communication.

If your HF radio is not working then try the following:

- Check that the radio is set up correctly.
- Have you got the correct times and frequencies?
- If you can hear the station, check the battery, aerial and handset. Antenna faults are one of the most common problems.
- If the radio checks-out okay, try contacting the station during the day. There will be a number of pre-arranged scheds with other stations, aircraft and field parties.
- In summer, a listening watch is kept throughout the night as the night watchperson on the stations does a round that includes the radio room. This will be at pre-arranged times through the night. Make sure you know these times and frequencies.
- Try contacting other BAS stations, ships or other Antarctic operators. For example if you are deep field on the continent you could try to contact Patriot Hills or the South Pole. Before you go into the field, make sure you have a current list of Antarctic frequencies. Try to contact stations that are both close and far away as signal propagation can alter with distance depending on the atmospheric conditions.
- After some time out of contact, the station radio

operator should be trying every option to make some form of contact. It is often the case that the field party can hear the station, but the station cannot hear the field party. The radio operator may therefore be able to pass on some instructions such as using the tune signal of the radio to break through.

Not all radio operators have the same level of training, knowledge and experience so the BC/FOM should also be involved. This action should be initiated after one primary and one secondary sched have been missed. Do not wait until it is almost at the aircraft launching stage to try these last-gasp measures. Every effort should be made on both sides to make contact once the first primary sched has been missed.

- Even if a field party hears no response from station they should transmit blind on the assumption that they may be heard.

If you have had no contact since arriving at a site and giving your position do not move from that location unless safety dictates otherwise. The Antarctic is a very big continent and it is surprisingly hard to spot a field camp from the air - even in good light and when you know where it is.

See also Chapter 21.

15.4 Communication with aircraft

Normally the aircraft or station will initiate the first contact with field parties. If field parties need to speak to aircraft, they should listen for a couple of minutes on the frequency to ensure they are not breaking over another conversation. The pilot should be given time to reply and should not be called when approaching finals unless safety is compromised by not calling. BAS aircraft normally monitor 5080 USB, 7775 USB and 118.1 MHz (aeronautical VHF)

15.5 Iridium phones

Introduction

HF radio is the primary means of communication for BAS Antarctic operations. The Iridium satellite phone system complements this HF radio set-up. Iridium handsets are primarily used for official business between stations, ships and field parties.

The Radio Officers and station Communication Managers will manage the issue of HF and Iridium sets in consultation with the Field Operations Manager.

Iridium phones will occasionally be used for official communication with Cambridge. Some phones are data enabled which allows text to be sent. Although signal strength can vary, Iridium coverage is broad and Iridium phones provide a more comprehensive cover than HF or VHF.

When to use the Iridium phone

The Iridium should be used or carried in these situations:

- Emergency use.
- As a back-up to HF field communications.
- HMS *Endurance* deployed field parties.
- Back-up communication where VHF is not reliable.
- At stations where VHF is unreliable.
- When working away from the half-unit in the field.
- For communicating confidential imformation.

Emergency use

- **All emergency calls should be conducted through the controlling station, such as ship or station, using the Iridium phone.** The emergency contact numbers should be loaded into the memory before going into the field.
- If you are unable to contact the controlling station, make contact with Operations Group's on-call emergency numbers in the UK or, failing this, another BAS station or ship. Control will be returned to the controlling station as soon as possible. For more information see Chapter 21.

Personal Iridium use and billing

- Field staff use a dedicated SIM card to access the Iridium system for personal use. These cards can be acquired from the stations and ships prior to deployment.
- Data enabled phones can be used to send e-mail using the SIM cards.

Iridium handsets purchased by individuals for personal use will not be supported by BAS.

15.6 VHF radios

VHF radios are essentially for line-of-sight use and are used predominantly for short distance communication. When used in an aircraft they can have a much greater range due to the effective increase in the line-of-sight. Where topography blocks the signal, VHF repeaters can increase their range.

On field projects, VHF is used for local work with the HF set being used for communication with the station.

A number of different makes of marine-band VHF radios are used but the operating principles remain the same. Make sure you are familiar with the radios you are using before embarking on a project or journey.

VHF batteries

Nickel cadmium or lithium cells will be used on field projects. Battery consumption is high in cold conditions so ensure you take sufficient spares. Used batteries must be returned to station for correct disposal. Make sure the battery pack and spare batteries are compatible with the radios you are taking.

VHF frequencies

The two main channels used on BAS stations are channel 1 and channel 18. Aero VHF use 118.1 MHz.

Using a VHF radio

To use a VHF handheld radio:

- Switch the set on and select the correct channel (normally the station's working channel or aero 118.1 MHz). Some models of radio have a channel lock that you should know how to override to change channels.
- Turn the squelch knob until static can be heard.
- Adjust the volume to the correct level.
- Adjust the squelch until no static is heard.
- Use the PTT (press to talk) button to transmit a signal.
- Release the PTT button to receive.

VHF repeaters

VHF repeaters bring out-of-sight radios into range. Do not use repeaters if line-of-sight contact is possible. Repeater sets are powered by solar panels so use them only when necessary.

When working through a repeater, the radio transmits on one channel and receives on another. When not operating through a repeater, radios should be on the same frequency for transmitting and receiving. Before leaving station make sure you understand this principle.

Common faults with VHF handheld radios

- Low battery power (particularly in the cold).
- Squelch set too high.
- The wrong channel selected.
- Volume control set too low.

Warning: when working on or near water, always use a waterproof protection bag with VHF radios or use waterproof radios.

15.7 World Service

The radio can also be an important means of keeping up morale. The World Service and other stations can be heard on the PRM sets. A list of the frequencies can be obtained from the Communications Manager before departing from station. Receiving uses a lot less power than transmitting, but take care not to drain your batteries.

15.8 HF time signal

This is transmitted every minute of the day on 5, 10 and 15 MHz USB. It is broadcast for a few seconds after the minute, so don't expect to hear it as soon as you tune to the frequency. The signal is a useful method of setting your watch in order to be punctual at sched times.

15.9 Air-letters

The system of air-letters is explained in the BAS Participants' Handbook.

The system is subject to change but normally air-letters are read out to a field party at the end of the evening field schedule. During the field schedule, staff with mail will be informed and told to "come up" at a specified time. If communications are poor, it will be better to wait until conditions improve.

Field staff wishing to send an air-letter should arrange a suitable time to send it. When sending an air-letter, read it out a sentence at a time, pausing between lines. Check the radio operator has copied the transmission correctly. The Comms department will make every effort to deal with your requests promptly but this is not always easy due to other priorities.

15.10 Field party requests

Items for delivery can be requested over the radio if an aircraft is heading your way. This should not be used as a get-out clause for poor planning and preparation.

Requests should be restricted to essential items, not long lists of luxuries. If a “goodies box” is wanted at a re-supply, the field party should have packed it in advance. Aircraft loads are limited by weight.

The station Field Assistant will have to devote a significant amount of time to source, pack and dispatch your order correctly. Don’t wait until eight o’clock at night to pass on a request for the following day’s flight when it could have been given two days previously.

16 Aircraft weather and air operations

Introduction

Field staff will be involved in air operations and aircraft ground support. Staff expected to work closely with aircraft will do so under the instruction of the pilots.

Before travelling as a passenger in BAS aircraft you will be given a thorough briefing by the pilot. All passengers must ensure they have a P-bag, full outer clothing and spare warm clothing. An aircraft going out for a two hour flight could be diverted and you might spend days or even weeks in the field.

Safety around aircraft

Staff should exercise extreme caution when working around aircraft. You must:

- Only approach an aircraft after the engines have been shut down and the pilots have made their intentions clear.
- On some occasions an engine may be kept running. This will generally be the right hand engine so never approach an aircraft from this side. This is also the pilot's blind side.
- Stay clear of aircraft landing sites, particularly when operating on snow or ice. Give the aircraft plenty of space (at least 30 metres off the line of approach during landing). Aircraft can slew badly if they are caught by a gust or when traversing a side slope.
- Ensure landing sites are free of obstructions.

While taking-off and landing, pilots have to undertake many tasks and process much information. Staff on the ground can help by reducing vehicle movement, staying out of the way and not talking on the radio.

For more detailed information on air operations, see the BAS Air Operations manual. For information on helicopter operations, see Chapter 25.

16.1 Field meteorological observations for aircraft operations

Field personnel are required to assist aircraft operations by making meteorological observations and passing these over the radio. Decisions as to whether it is safe to fly or not will be based on your observations, so it is important that they are accurate.

Meteorological observations from the field are simple reports of current weather conditions and require no instruments. The observation must be made from outside the tent, not through the entrance hole. Ideally the observation should be made from the intended runway area (referred to as the skiway). Write the observation on one of the weather observation forms provided. See Figure 16.1a.

Speak clearly and slowly when reading a meteorological observation over the radio. The observation must be read in the order shown on the weather observation form. All numbers must be read a digit at a time, e.g. "zero-six-zero degrees", **not** "sixty degrees". Cloud heights may be read as hundreds or thousands, e.g. "six-hundred feet" for 600 feet or "one-five-thousand feet" for 15,000 feet.

The weather observation forms require the following information:

Time

This is the time at which the observation was made. The time must be Coordinated Universal Time (UTC) which is the same as Greenwich Mean Time (GMT) and generally referred to as Zulu time. Rothera local time is three hours behind UTC, so 7:30am Rothera local time is 1030 Zulu. Halley local time is the same as UTC, so 7:30am Halley local time is 0730 Zulu.

Wind direction

This is the direction **the wind is blowing from**, e.g. 090° if the wind is blowing from the east. The direction is always given as a magnetic bearing. Wind directions should always be read over the radio as three digits, e.g. 060° ("zero-six-zero degrees"), not just 60° ("six-zero degrees"). Give the direction to the nearest 10°.

Wind speed

This can be estimated from the state of a bamboo flag. If the snow on the ground is loose and dry, the wind speed may also be estimated from the amount of snow being picked up by the wind (if the snow surface is compact or wet, this method is unreliable). See Figure 16.1b for details.

Wind speed is given in knots (one knot is approximately one mile per hour). Wind speeds should always be read over the radio as two digits, e.g. "zero-five" knots, not just "five" knots. If the wind direction is around three knots from no definite direction it may be reported as "light and variable". If the wind speed is less than three knots it may be reported as "calm".

Station / Sledge: .... Date: ....

Time (UTC)	1030 Zulu	Zulu	Zulu	Zulu	Zulu	Zulu
Wind direction	060 degrees	degrees	degrees	degrees	degrees	degrees
Wind speed	09 knots	knots	knots	knots	knots	knots
Visibility	5 km to north unlimited elsewhere					
Contrast	Poor					
Horizontal definition	Nil to north, poor elsewhere					
Total cloud	8 oktas	oktas	oktas	oktas	oktas	oktas
Consisting of (oktas type height)	4 St 1000' 7 As					
Present weather	Slight snow					
Comments	None					

Figure 16.1a Field party weather observations form

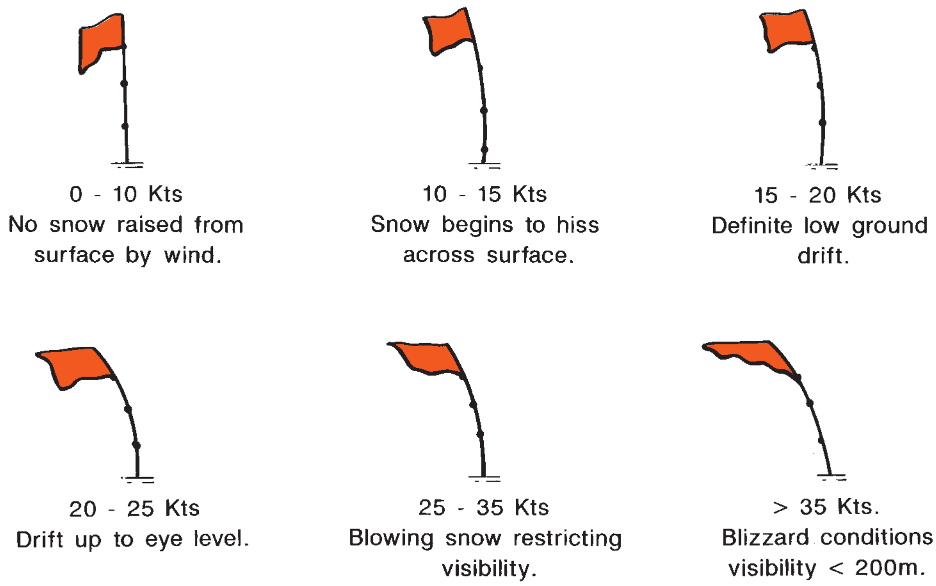


Figure 16.1b Flags as wind speed indicators

Visibility

This is how far you can see in kilometres. It should be stated as the least distance you can see not the greatest. For meteorological observations, visibility is reduced by weather (snow, blowing snow and fog for example) not by topography (such as mountains). Therefore if you can see only 1km to the north because there is a mountain there, but can see 10km in all other directions, the visibility is 10km, **not** 1km. You should make it known that the mountain obscures the view to the north.

In mountainous regions, visibility is most easily estimated from features such as mountains. On ice shelves, where there are no such features, a line of flags at known distances can be observed through binoculars.

Visibility greater than 20km should be reported as "unlimited". If the visibility is different in different directions you should give a different visibility for each direction, starting with the worst, e.g. "10km to the east, unlimited elsewhere". Directions for giving these positions should be given in relation to True North.

Contrast

This quantifies the degree of definition by which surface snow features can be seen. Thick cloud cover diffuses sunlight and reduces contrast. Contrast is reported as follows:

- Nil — Footprints and undulations are indiscernible at more than a couple of paces.
- Poor — Footprints and tracks become indistinct at more than 50 metres.
- Moderate — Footprints and tracks become indistinct at more than a few kilometres.
- Good — Surface features are clearly defined as far as the eye can see.

If the contrast varies as clouds pass overhead, or if it falls between two of the above definitions, it may be reported as a combination, e.g. "moderate to good". Remember that definition is less apparent from the air than it is on the ground.

Horizontal definition

This is the ease with which the sky can be distinguished from the land, in other words the ease with which a horizon can be seen. It does not have to be the actual horizon, just *a* horizon. This applies more to ice shelves than to mountainous regions. Horizontal definition is reported as follows:

- Nil — Sky and land appear as one, no horizon visible.
- Poor — Sky can be distinguished from land, but no distinct horizon visible.
- Moderate — Sky can be distinguished from land, horizon visible.
- Good — Obvious difference between sky and land, horizon distinct.

If the horizontal definition falls between two of the above definitions, it can be reported as a combination, e.g. "moderate to good".

Total cloud

This is the amount of cloud cover and is measured in "oktas" or "eighths". Imagine all the clouds collected together in a single part of the sky, and estimate the number of "eighths" of the sky covered by them.

- No cloud report, zero oktas.
- If the sky is completely covered with cloud, report eight oktas.
- If there is the smallest amount of cloud, report one okta.
- If there is the smallest gap in the cloud, report seven oktas.
- If there is heavy snow, blowing snow or fog, report "sky obscured". Don't guess.

Cloud layers

Each layer of cloud that can be seen must be reported. Start with the lowest layer and work up, reporting:

Cloud amount

The number of oktas of the sky covered by a particular layer of cloud. Note that the amounts for the different layers might add up to more than eight because the layers might overlap.

Cloud type

The type of cloud in a particular layer. The type should be determined from the descriptions and illustrations in the section below. If you are unable to determine the cloud type, describe the cloud as best you can (for example thick, grey, low cloud).

Cloud height

This is the height in feet of a particular cloud layer **above the skiway**. In mountainous regions, this can be estimated from the heights of the surrounding mountains. When using this method it is extremely important to subtract the height of the skiway from the height of the mountain. For example, if the skiway is at 2000 feet, and there is a layer of cloud level with the summit of a mountain at 3000 feet, then the cloud should be reported as being at 1000 feet. This is its height above the skiway.

On ice shelves, the cloud height must be estimated from such clues as the size of the elements (the smaller the cloud elements appear, the higher the cloud) and the speed of the cloud (the faster the cloud seems to move, the lower the cloud). The section below shows the typical heights of clouds. Clouds lower than 1000 feet above the skiway should be reported to the nearest 100 feet. Report their height to the nearest 1000 feet above this.

Therefore four oktas of Stratus at 1000 feet and seven oktas of Altostratus at 7000 feet should be reported as: 4 St at 1000′, 7 As at 7000′.

Temperature and pressure

Field parties are not provided with thermometers or barometers so this information is not required.

Present weather

This can be categorised as either:

- Snow.
- Rain.
- Drizzle.
- Drifting snow (snow blown along the ground, below eye level).
- Blowing snow (snow blown from the ground to above eye level).
- Mist (visibility greater than 1000 metres).
- Fog (visibility less than 1000 metres).

The intensity of the weather can be reported as “slight”, “moderate” or “heavy”. The duration may be reported as “intermittent” (stopping and starting over the last hour) or “continuous” (continuous over the last hour), e.g. “slight, intermittent snow”.

If there is no weather at the skiway but you can see weather elsewhere, report the distance and direction, e.g. “snow five kilometres to north”. Any direction should be given in relation to True North. If there is no weather anywhere, report the present weather as “nil”.

Comments

Information about the general situation may also be reported, particularly trends in the weather such as whether it is improving or deteriorating. Include any other information that may be useful to the aircraft. In particular the state of the skiway may be reported.

16.2 Cloud types

Clouds are split into three different types - low clouds, medium clouds and high clouds. Figure 16.2 is a handy reference for working out the types and heights of clouds.

Element size

Understanding element size will help in identifying cloud types. If you hold you hand out at full arm’s length and the element size is smaller than your thumb, the element size is less than 1%. If you do the same with your whole hand held flat and the element size is bigger than your hand, the element size is greater than 5%. If it is smaller than your hand and bigger than your thumb then it is between 1% and 5 %.

Low clouds

These lie between zero and 6000 feet. The height of low clouds above the skiway is particularly important if aircraft are to land.

Stratus (St)

Low cloud in a flat, featureless layer. It may produce light snow or drizzle (heavier snow or rain can fall through stratus from a higher layer of cloud). The sun can appear as a disk through a thin layer of stratus. Sometimes stratus can appear as low, ragged patches.

Stratocumulus (Sc)

Low cloud in a layer with a rolling structure, with or without breaks. It may produce isolated snow flakes.

Cumulus (Cu)

Small, individual, cauliflower-shaped clouds. They may produce showers of snow or rain if they are very tall. Sometimes the main part of the clouds can be brightly lit by the sun while the undersides are dark.

Medium clouds

These lie between 6000 and 15,000 feet.

Nimbostratus (Ns)

Thick, dark cloud in a flat featureless layer. It generally produces snow or rain that can be moderate or heavy. Although it is classed as medium cloud, nimbostratus can appear below 6000 feet, right down to the ground or sea surface.

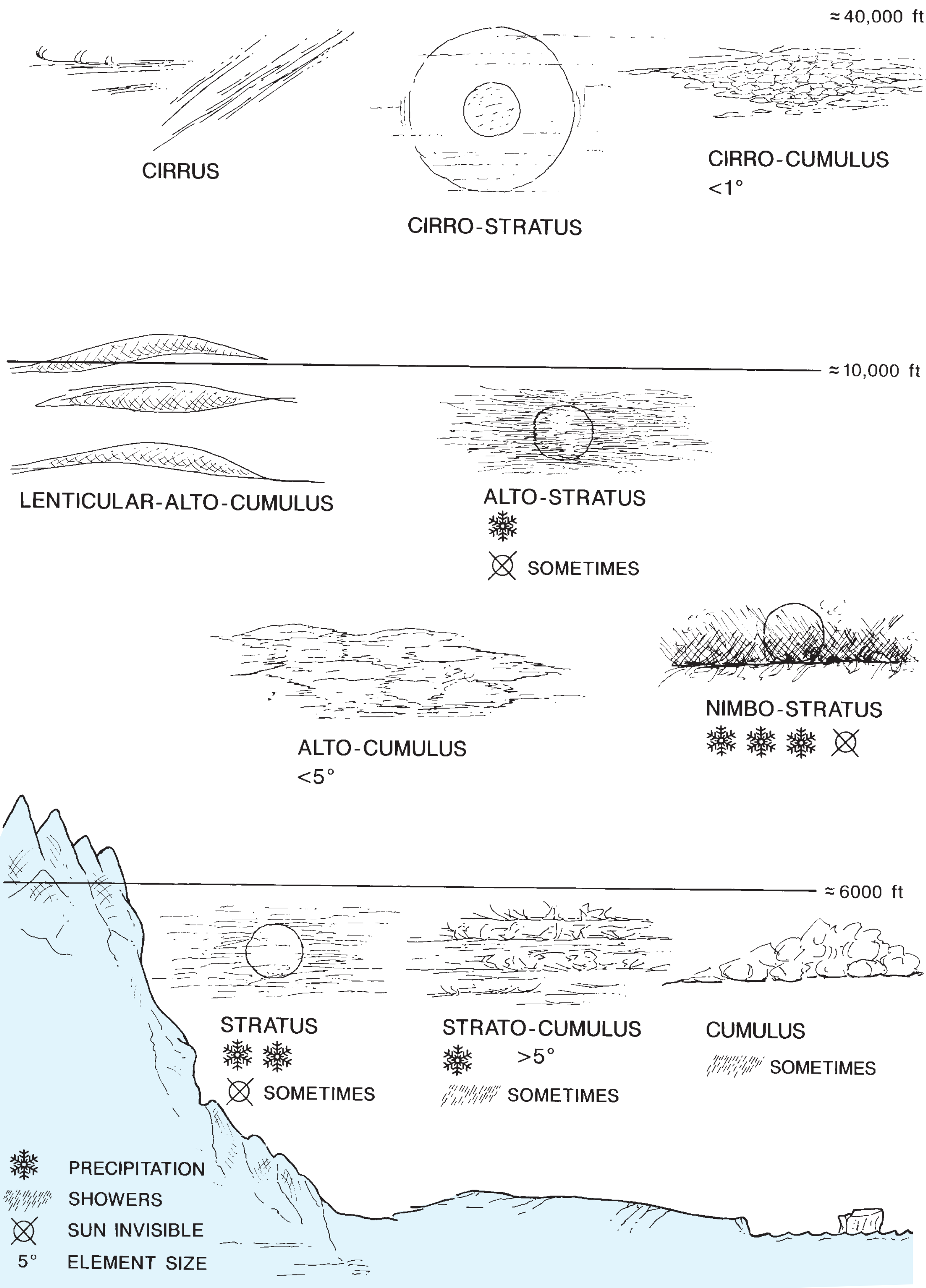


Figure 16.2 **Cloud types**

Altostratus (As)
Medium cloud in a flat, mostly featureless layer (similar to stratus). It may produce snow or rain. The sun can appear as a fuzzy disk through a thin layer of altostratus.

Altocumulus (Ac)
Medium cloud in a layer with a rolling structure, with or without breaks in it (similar to stratocumulus but with a smaller structure) or with small, individual, regularly spaced patches.

Lenticular altocumulus (lenticular Ac)
Smooth, individual, almond-shaped clouds with a well-defined outline. They form over mountains. Lenticular altocumulus clouds are particularly important for aircraft because they indicate strong winds.

High clouds

These lie between 15,000 and 35,000 feet.

Cirrus (Ci)
Fibrous clouds in the shape of filaments, bands or hooks.

Cirrostratus (Cs)
High cloud in a flat, featureless layer. It is often thin and appears as a milky-white, semi-transparent veil. The sun appears as a disk through cirrostratus, often with a halo (this optical effect is due to the refraction of the sunlight through the ice crystals that make up the cloud).

Cirrocumulus (Cc)
High cloud in a layer with tiny ripples or with tiny, individual, regularly spaced patches (similar to altocumulus but with smaller patches).

16.3 Marshalling

Only Air Unit staff should marshal aircraft. If a signal is necessary, simply point at the spot you want the load to be dropped.

16.4 Cargo handling

Aircraft cargo handling should always be carried out under the direction of the pilot. Snow under foot and the large height to which items must be lifted dictates that extreme caution should be exercised when loading and unloading.

Double lift heavy items and try to ensure that boxes of geological samples are restricted to 30kg or less. Try not to introduce snow into the aircraft when loading. Exercise caution when loading or unloading aircraft on gradients as the aircraft may shift.

16.5 Aircraft loads

Cargo should be clearly identified. If there is a split load, all items should be marked with their destination (with the field party call sign). Perspex depots tags can help to reduce confusion as they can be tied to the load. These can be written on with a chinagraph pencil.

Any hazardous cargo must be clearly marked and the pilot must be made aware of this cargo. IATA labels should be fixed to hazardous cargo and packaging should meet regulation standards. Items of extreme concern include battery acid and mercury. The FOM and Chief Pilot should be consulted about the proper storage of these items and other hazards before field input.

Notification of the requirement to carry explosives will have been given at the project planning stage and a rigorous procedure is undertaken in the transport of explosives. These procedures are detailed in Chapter 18.

16.6 Load sheets

Aircraft load sheets must be completed before a load can be transported. Copies should be submitted to the FOM and the pilot of the aircraft. There are standard weights listed for various items on the load sheets. Non-standard items must be weighed accurately and the load sheets must give a true picture of the load carried.

All weights should be in pounds not kilograms.

16.7 Vehicles and aircraft

- Do not park or start vehicles pointing towards an aircraft.
- Do not drive under the wings of aircraft with large vehicles, drive around the wing tip.
- If reversing to an aircraft, get someone to give you hand signals.
- Ensure vehicles are properly braked near aircraft.

16.8 Loading Ski-Doos into aircraft

Pilots will supervise the loading of Ski-Doos onto aircraft. Loading Ski-Doos onto aircraft is a risky procedure and driving up the ramps has great potential for accidents.

The following points should be observed:

- Make sure the ramps are stable.
- Remove the Ski-Doo cowl.
- Attach the kill cord and ensure the Ski-Doo is in neutral and pointing away from the aircraft before starting.
- Only drive up the ramps if you are familiar with the correct procedures.
- Do not stand between the ramps while moving a Ski-Doo up them.
- Ensure a minimum 10cm air gap in the fuel tank.

16.9 Field deployment of cargo

When a field party is being transferred or uplifted, think carefully about the loads. The essentials of a half-unit, excluding the vehicles and sledges, must stay with a field party if they are to remain on the ground. When flying, you must ensure that **your survival gear** is with you at all times on **your aircraft.**

Even for the shortest of transfer flights no one should be left on the ground alone and the minimum safety equipment must be retained until uplift of personnel. This must include a radio that should be tested before the aircraft departs.

If cargo is to be depoted, make sure it is well secured and clearly marked.

16.10 Communication with aircraft

Field staff will have to speak to the aircraft in the course of their duties to give weather and ground condition reports or other information. Contact will usually be initiated by the aircraft or through the controlling station at a set time. Aircraft occasionally arrange schedules directly with ground support staff rather than through the controlling station.

Ground staff should not contact aircraft approaching on finals unless the aircraft initiates contact or there are clear safety reasons for making a call.

16.11 Field skiways

Setting up skiways

Field parties are often required to set out skiways for field landings at temporary depots or campsites.

Skiways should ideally be:

- Level. Avoid areas of sastrugi, particularly if they are large and hard.
- Orientated into wind.
- 1000 metres long.
- Located with an unobstructed approach and overshoot.

If all the above cannot be achieved then the following points should be considered:

- In winds of less than 10 knots, align the strip so the aircraft can land uphill and take-off downhill.
- In winds of 30 knots or more, the aircraft needs to land and take-off into wind (plus or minus 30°).
- If the crests of sastrugi are more than 15cm high, the aircraft will need to land along the wave-lines unless the snow is very soft.
- Sastrugi taller than 30cm are normally too high for a safe landing.
- Soft snow, deeper than 45cm, may make take-off difficult or impossible.

All the above factors should be considered when assessing suitable landing sites. If both the second and third points cannot be met concurrently an alternative must be found or the aircraft's arrival should be postponed until suitable conditions prevail.

Selected landing site should be probed for crevasses. Any crevasse or obstruction close to the landing area should be clearly marked (crossed bamboos can be used). The pilot must be informed by radio of any hazards before landing.

Marking skiways

The skiway should be marked with black marker flags, in a straight line, at 50m intervals. If flags are unavailable use other objects that will stand out against the snow. Gash bags filled with snow, hand smoke or even cocoa can be used if necessary.

In good contrast, Ski-Doo tracks can make very good markers. An arrow can be marked at the threshold with Ski-Doo tracks. Alternatively, stamp an arrow at the threshold by foot. This arrow should be on the landing side of the markers. The aircraft will normally land with the markers on its left.

In poor contrast, a smoke flare can be set-off next to the threshold. The pilot may request this but do not set-off the hand smoke until the aircraft is making an approach to land.

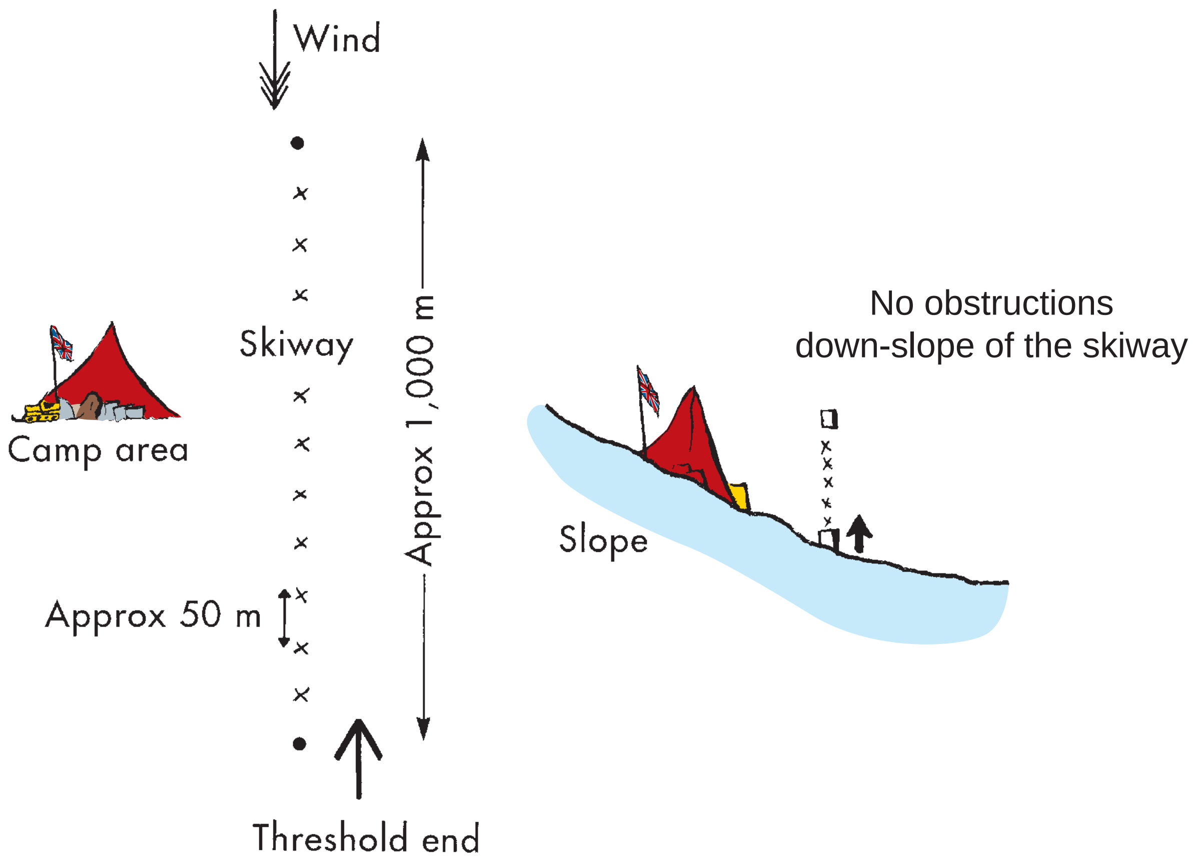


Figure 16.11 Markers for skiway on transverse slope

Lay the skiway out so that aircraft do not have to land or take-off towards tents or other obstructions. If there is a transverse slope, the skiway should be down-slope of tents and other ground obstructions.

Skiway management

Skiways rapidly become unusable if they are not well managed. Ablation is a big problem if the snow is contaminated by urine, fuel, two-stroke oil or other contaminants. It is essential that staff keep the working areas of the skiway clean.

Areas that receive heavy vehicle and aircraft passage will suffer from dips, hollows and rutting. Taxiways may have to be changed to keep depots and refuelling sites usable.

Tie-down points are also subject to heavy wear and extreme care needs to be taken when aircraft are approaching these areas. The dips at tie-downs can cause aircraft to overshoot so don't stand directly in front of the aircraft as it approaches these sites. If there are melt-pools or depressions at the tie-downs, ensure the dip is not too great or there is a risk that the tail-plane will be fouled as the aircraft comes to a halt. This could cause serious aircraft damage.

16.12 Information required by inbound aircraft

An inbound aircraft requires the following information:

- Your position in degrees, minutes and seconds. A magnetic bearing and a distance to a feature on the map may be useful.
- The location of the skiway in relation to the camp.
- How it is marked and the magnetic bearing on which it is aligned.
- Surface conditions.
- Surface hazards such as crevasses (these should be marked).
- Tall obstructions. Give their direction, distance and height.
- Weather conditions as explained above.

16.13 Fuelling aircraft

Field staff will be required to assist with refuelling in the field. The following safety points must be observed:

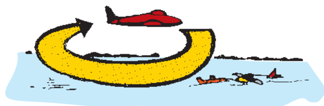
- No smoking near aircraft.
- Check each fuel drum for damage. The seal must be intact and the drum must be full. If this is not the case, the drum should not be used. The correct procedure should be followed for disposal of this potentially contaminated fuel. Only use part drums if it is within a few hours of them being opened.
- Snow and ice should be brushed off drums before opening. Do not open drums ahead of use and do not let windblown snow enter the drum or the tanks of the aircraft. Make sure the end of the standpipe and refuelling nozzle are capped when not in use.
- Water contamination tests should be done on each drum if the water block filter system is not being used.
- Flush the hoses before fuelling. The fuel flushed through should be collected in a part-full or an empty drum for disposal.
- Do not leave filler caps off longer than necessary.

MESSAGE RECEIVED AND UNDERSTOOD:
Aircraft will indicate that ground signals have been seen and under stood by -

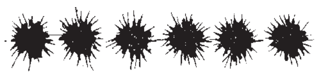
DAY OR MOONLIGHT:
Rocking from side to side

NIGHT:
Making green flashes with signal lamp.

MESSAGE RECEIVED AND NOT UNDERSTOOD
Aircraft will indicate that ground signals have been seen but not understood by -



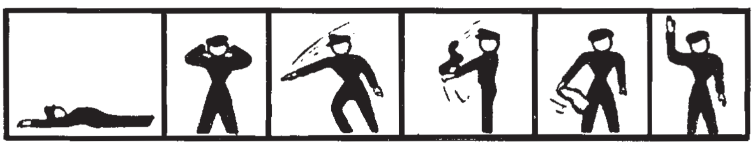
DAY OR MOONLIGHT:
Making a complete right hand circle.



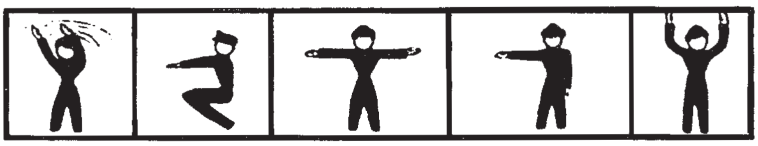
NIGHT:
Making red flashes with signal lamp.

Figure 16.14a Standard aircraft acknowledgements *(Taken from the BAS Air Operations Manual)*

INSTRUCTIONS : If you are able to attract the attention of the pilot of a rescue airplane, the body signals illustrated below can be used to transmit messages to him as he circles over your location. Stand in the open when you make the signals. Make sure that the background, as seen from the air, is not confusing. Go through the motions slowly and repeat each signal until you are positive that the pilot understands you.



Need medical assistance | Our receiver is operating | Use drop message | Affirmative (yes) | Negative (no) | All OK do not wait



Do not attempt to land here | Land here | Need mechanical help or parts | Can proceed shortly wait if practical | Pick us up plane abandoned

Figure 16.14b Body signals *(Taken from the BAS Air Operations Manual)*

16.14 Emergency procedures

If there are problems in flight, pay attention to the pilot's instructions. Safety briefings will have been given before flying in BAS aircraft. Aircraft carry emergency equipment on board. This includes a PRM HF field radio, an emergency locator beacon and an Iridium satellite phone. In the event of communications failure, use ground to air signals (see below). Field parties and aircraft carry flares and hand smoke. Use these to contact aircraft if necessary. Take care not to fire at them. Heliographs or torches can be used to give light signals. A heliograph (or mirror) can be an excellent method of attracting attention and can be seen from several miles away.

If all else fails, the international distress signal "SOS" can be written in the snow.

GROUND-AIR SIGNALS FOR USE BY SURVIVORS

Message	Symbol
Require assistance	V
Require medical assistance	X
No or negative	N
Yes or affirmative	Y
Proceeding in this direction	↑

GROUND-AIR SIGNALS FOR USE BY RESCUE PARTIES

Message	Symbol
Operation completed	LLL
We have found all personnel	LL
We have found only some personnel	++
We are not able to continue. Returning to base.	XX
Have divided into two groups. Each proceeding in direction indicated.	⇄
Information received that aircraft is in this direction	→ →
Nothing found. Will continue to search.	NN

(a) Lay out symbols by using strips of fabric or parachutes, pieces of wood, stones, or any available material.

(b) Provide as much colour contrast as possible between material used for symbols and background against which symbols are exposed.

(c) Symbols should be at least 10 feet high or larger. Care should be taken to lay out symbols exactly as shown.

(d) In addition to using symbols, every effort is to be made to attract attention by means of radio, flares, smoke, or other available means.

(e) On snow covered ground, signals can be made by dragging, shovelling or tramping. Depressed areas forming symbols will appear black from air.

(f) Pilot should acknowledge message by rocking wings from side to side.

IF IN DOUBT, USE INTERNATIONAL SYMBOL SOS.......

Figure 16.14c Ground air signals for use by survivors and rescue parties *(Taken from the BAS Air Operations Manual)*

17 Fuels and depots

Introduction

Each type of fuel used by BAS can be identified by a colour code. This code reduces the risk of accidents and equipment damage. It must be adhered to. In the field a number of different fuels are used. In addition to the colour coding on the container, it is important that staff can identify fuel type by smell and colour.

Safety tips for working with fuels

- Do not smoke near stored fuels.
- Never refuel a machine with petrol when it is still running or has just been running. Leave time for it to cool.
- Let camp stoves cool before re-priming or refilling them.
- Use only proper fuel containers for fuel storage or transport.
- Use the correct type of fuel. A mistake such as putting meths in a camp stove could cause serious injury.

17.1 Fuel colour codes

The BAS-wide colour code for marking fuel containers is:

Black	Diesel
Blue	Paraffin (Kerosene)
White	Avtur
Red	Petrol
Red/Yellow	Petrol/Oil mix in a ratio of 50:1 (unless otherwise marked)
White/Yellow	Avtur/Oil mix, a ratio will be marked on the container
Silver	Meths

17.2 Fuels and their use

The following guide shows the applications for different fuels:

Petrol (red)

- Ski-Doo - Alpine III.
- All Terrain Vehicle (ATV).
- Portable generators (check for specific model).

Petrol/oil mix (red/yellow)

- Ski-Doo - Alpine I and Alpine II.
- Portable generators (check for specific model).

Paraffin (blue)

- Vapalux lanterns.
- Field camp stoves.
- Heaters and stoves in cabooses and huts.

Avtur (white)

- Sno-Cat.
- Aircraft.

Avtur/oil mix* (white/yellow)

- Sno-Cat (some run on neat Avtur).
- Sky Blu John Deere.
- Snow blower.

* The ratio of petrol or Avtur/oil mix differs according to the engine type. Check with station mechanics or BAS vehicle staff before deployment. Engine damage may result from the use of inappropriate fuel.

Everything that runs on diesel can also run on an Avtur/oil mix. The waxing temperature of Avtur is lower than diesel hence its use in cold conditions. However, Avtur is more expensive than diesel. Other Antarctic operators may refer to Avtur as jet fuel (or Jet A1).

Making up a 50:1 petrol/two-stroke oil mix

For a 50:1 mix put 400ml of two-stroke oil into a 20 litre fuel jerry and pump in 20 litres of neat petrol. Make sure the mixing is thorough. **Don't put the two-stroke oil into the 205 litre drum to save time - incorrect ratios may result.** This could cause serious engine damage.

17.3 Fuel consumption

The following figures should be used for planning purposes. In winter these amounts may well be exceeded. Figures are based on a field unit of two Ski-Doos and two people. **A minimum reserve of 30 days food and fuel must be taken on all trips.**

Paraffin

Summer Peninsula

- 0.6 litres per day.
- One jerry (20 litres) per 33 days.

Winter trips and Summer deep field trips

- One litre per day.
- One jerry per 20 days.

One litre burn times

- Lantern* 14 hours and 42 minutes.
- Stove* five hours and 46 minutes.

*This test was done with new equipment. Older equipment may be less efficient. Using the same stove, it took 16 minutes to boil one litre of water from ice and 16.5 minutes from powder snow.

Meths

The use of meths will increase considerably during cold weather and lie-up periods. During lie-up, the stove will go on and off more as you "brew-up" throughout the day. Using flasks will help to reduce this although the process of "brewing-up" is a bit of a lie-up ritual.

A rough guide to meths use is:

- 0.75 to one litre per month (summer and winter).
- Approximately one litre per jerry of paraffin.

Petrol for Ski-Doo travel

A single Ski-Doo will travel approximately 2.6km on a litre of petrol. However as a field unit is always made up of two Ski-Doos, it is far easier to think about the fuel consumption per unit.

Petrol per unit (two Ski-Doos)

- 1.3km per litre.
- 26km per jerry.
- 416km per full-unit jerry rack (16 jerries).
- 266km per drum (205 litres).

These fuel consumption figures will vary greatly according to the load, terrain, snow and conditions. This can be taken as a conservative figure for summer snow conditions. Deep soft snow and hilly terrain can drastically reduce this figure. In good conditions ,consumption can go to over three kilometres per litre.

17.4 Emergency fuel for stoves and lanterns

The following survival tips should only be used in absolute emergencies. Understand the risks.

Avtur

In an emergency, mixing Avtur with paraffin or using neat Avtur is possible. Extreme care needs to be used in these circumstances as additives within the fuel give off noxious fumes.

Petrol/oil mix

Petrol/oil mix (or straight petrol) can be mixed with paraffin up to a ratio of one to one. The flame will be sooty due to the oil in the Ski-Doo two-stroke mix. If it becomes necessary to resort to fuel mixes of this sort the tent must be extremely well ventilated.

Petrol

Do not use neat petrol in the Primus type 45 stove unless as a very last resort. Petrol is highly volatile. Never use petrol in the lantern.

17.5 Fuelling vehicles

Care should be taken during refuelling to ensure that snow or dirty fuel does not enter the fuel tank. Water in fuel tanks can be drawn up into the Ski-Doo's carburettor resulting in ice blocking the jets.

If water is suspected in the fuel tank, the best solution is to drain the tank of the contaminated fuel and clean it out. Ice crystals or water will be obvious in the tank. Removing and cleaning the tank is not very practical in the field. If water in the tank is a recurring problem try adding a small amount of meths to the fuel tank. The meths mixes with any water and it will be burnt off in combustion. This solution should not be used in the long term as engine damage can result.

Do not use jerries that contain contaminated fuel. If icing occurs after cleaning the tank then it is likely that the fuel is contaminated.

All machines should be filled at the end of the working day. This prevents condensation occurring in the tank. Always use a filter funnel when fuelling and ensure that the filler cap is replaced securely. Do not introduce snow into the tank by inadvertently picking up snow in the filler cap or on the funnel.

Water in aircraft fuel is a very serious matter. If unfiltered fuel is being pumped into the aircraft make sure that you use the water-finding paste. Depot staff are trained in this technique and you will be shown if you need to assist with field depot fuel checks.

17.6 Depots

It is essential that all depots are well marked and that the contents are secure. Equipment can be lost if this is not done. If equipment cannot be found and is needed in an emergency this could be a very serious matter.

Use only tested, leak-proof jerries in the field. When depoting surplus jerries, top them up so that they are completely full. This will reduce the build-up of condensation. Check fuel containers to ensure they are full. Containers that are part-full may have leaked. Often the source of the leak is not readily apparent, as the hole may be only a pinprick. If drums are available, transfer the fuel to a good drum or turn the container to stop the leak. The Ski-Doo spares box contains Pig Putty that can be used to repair leaks.

If visiting a depot, make a record of the quantities and its condition. This information should be passed on to the FOM.

17.7 Setting up depots

Field parties covering large distances or operating with very large loads may need to place depots in advance. Depot requirements should be discussed with the FOM and Chief Pilot at the earliest possible opportunity. Some depots may be placed in the field a year or more ahead of a project. The decision to do this will be made by the FOM as part of field operations planning.

When setting up depots, the following factors should be considered:

- Access by aircraft and Ski-Doo.
- Avoiding objective hazards such as seracs, crevassing or areas of rock fall.
- Accumulation. Try to avoid areas of high drift such as bowls and lee areas.
- When finding and marking a depot, consider the proximity of defining geographical features such as rock spurs and obvious peaks. These features should be obvious from large distances on the ground and in the air. Take their bearings and distance from the depot.
- All depots should be fixed with GPS.
- Depots should be marked with black marker flags on three to four metre “glacio poles”. Make sure they will not ablate out and secure them to something solid such as a full fuel drum. Timber uprights (75mm section and four metres long) with an empty drum on top are often used to mark depots on ice shelves. These guyed drums can be detected by an aircraft’s weather radar and are easier to spot by Ski-Doo parties.
- Secure individual items with rope. If there are 205 litre fuel drums in the depot these can be used as a sheltering wall to the prevailing wind. If you are unsure of the wind direction, look at the sastrugi. Small items, such as meths tins, should be placed in empty food boxes.
- Place depots on outcrops of rock with easy access if possible. This will not apply to aircraft refueling depots.
- Draw an accurate depot map that includes every item. Include all information that will help to locate the depot and the items within it. Draw everything with respect to the site markers and any nearby features. Remember that depots may be under a few metres of snow when they are next visited. See Figure 17.7.
- Ensure that all the information and any photographs are put in the depot log on station. A full list of the depot contents should be part of that information, including the dates of any food boxes.
- Make sure the depot book is always up to date.

17.8 Temporary uplift depots

Field parties may set up depots of equipment for uplift by consultation with the FOM/BC. A passing aircraft may pick these up, or a special flight may be required.
All depots should be put together with the thought that it may be next year when the equipment is collected. For various reasons, aircraft may not get to a depot when planned.

Glaciology parties may leave ice cores for uplift after the scientists have left the work site. These need to be buried in snow pits to keep the cores from warming. Make sure the entrance to the snow pit is properly covered and well marked.

The following points should be considered to ensure trouble free uplift of depoted equipment:

- Aircraft access. Some areas may become inaccessible as the season progresses. A good example is George VI Sound where crevassing, surface conditions and melt-pools will become progressively worse during the summer. Try to avoid depots in these types of area.
- Do not put depots for aircraft uplift in areas that are subject to difficult conditions such as bad sastrugi and katabatic winds.
- GPS fix the site and mark it properly.
- Secure everything. A windblown item on the landing area could damage an aircraft.

- Consider the hazards for an aircraft on approach and overshoot.
- In the depot report, give a full description of the depot contents and of any hazards near the landing area. If necessary, show preferred landing areas and directions, giving magnetic bearings to the landing site and the distance to the depot. Markers, such as crossed bamboos, may be required to define hazards.

17.9 Aircraft refuelling depots

These are kept open during the summer and are manned by station staff. They will be responsible for refuelling aircraft, managing the depot and passing weather observations.

At the start of the season, staff may have to dig out hundreds of drums of aviation fuel. Once the drums have been dug out and broken free, they are normally pulled up to the surface using a Ski-Doo and drum chains. Care should be exercised when using drum-chains as there is a risk of personal injury and damage to drums and Ski-Doos. Mark all of the holes created when digging-out fuel drums with flags or bamboos.

Many of these depots are used from one season to the next and new locations for aircraft refuelling depots are rare. Snow accumulation can therefore be a serious problem. Plan the depot layout carefully, giving thought to potential drift problems. Do not leave objects where they will cause unnecessary drifting.

The set-up of skiways is described in Chapter 16.

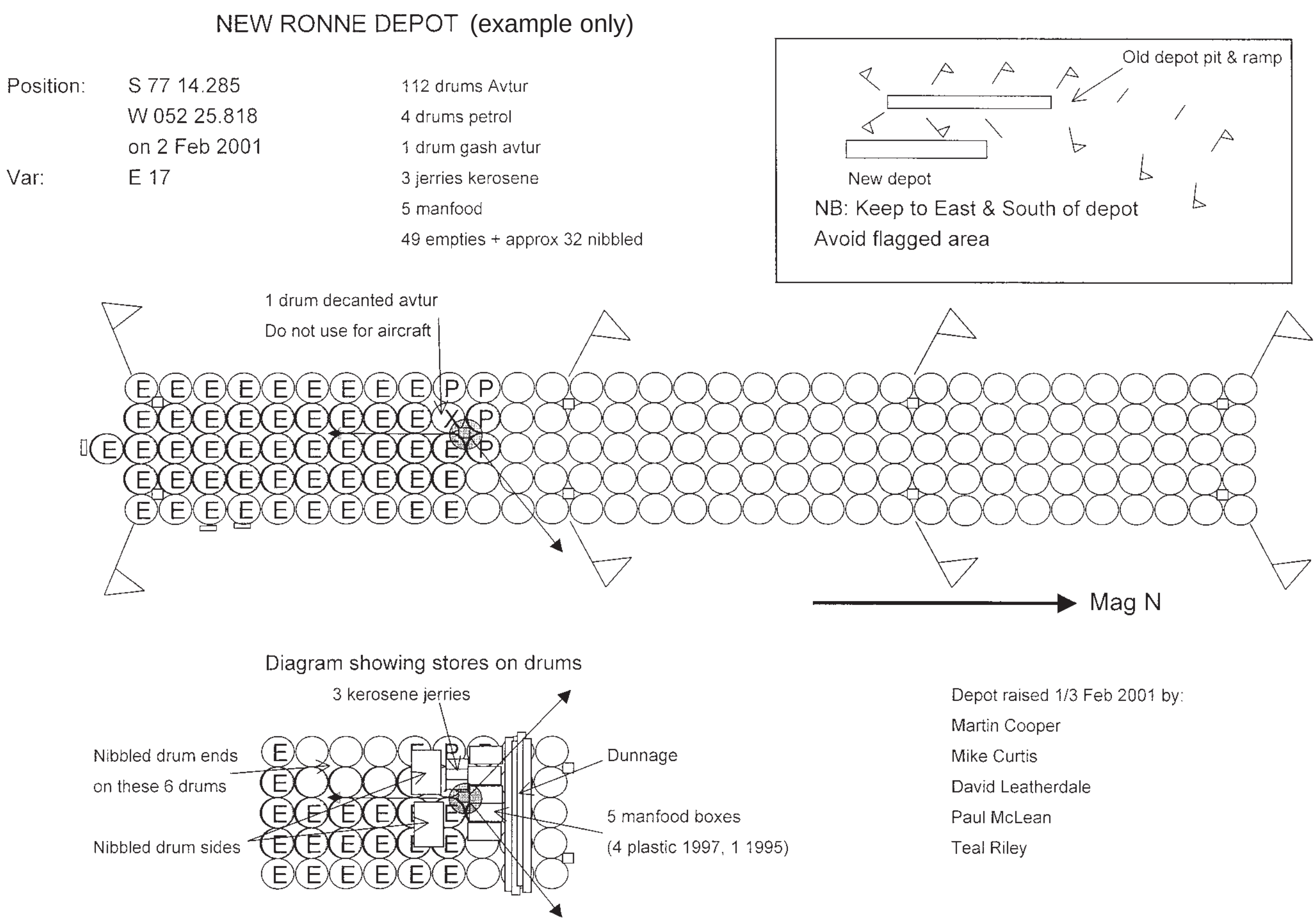


Figure 17.7 Depot layout

18 Explosives and detonators

Introduction

Explosives are used by BAS for over-snow seismic surveys. Staff using explosives in the field will have undergone specialist training as "shot-firers". Operations staff, aircrew and Field Assistants may also receive training in the safe handling of explosives.

This chapter is aimed primarily at staff that may encounter explosives during general duties with the aircraft or on field projects. In these situations a trained person will always be in charge of the operation. Advance warning will be given if explosives or detonators are to be handled.

This chapter should be read in conjunction with The Code of Practice - Explosives. This document is available at all stations, field huts and ships where explosives are being used or handled. The document is also available on the BAS Cambridge intranet site under Station Procedures.

18.1 Transport

Staff are required to follow the Code of Practice while explosives are being transported. The senior scientist involved on the project will take responsibility to ensure that these rules are carried out. However, at some stages in their transport they may not be present. To reduce the risks, the following instructions must be followed.

Aircraft transportation

As with all cargo, the pilot has sole discretion about whether detonators or explosives will be carried on the aircraft. To reduce the risks it is therefore essential to comply with the following instructions:

- The aircraft should be fuelled before loading explosives.
- Explosives and detonators are to be flown on separate flights.
- No bulk fuel (drums or jerries) should be flown on these flights. Minor quantities of fuel in Ski-Doo tanks and pots boxes are acceptable provided good separation from the explosives can be achieved to avoid contamination of explosives by fuel.
- Only essential radio communications, consistent with safe flight procedures, are to be sent during flights with detonators on board. No radio transmissions should be made during loading and unloading.
- The pilot will supervise the loading and unloading of detonators and explosives. These items should be taken a minimum of 100 metres from the aircraft and explosives must not be stored with detonators. These caches should be well away from the taxi area and uphill of the line of take off.
- Radio silence should be exercised during handling operations.

Handling on field projects

Detonators and explosives should be carried on separate sledges when being transported. For day-to-day use, small quantities of detonators may be carried in a ready-to-use container on a Ski-Doo. Always maintain separation between detonators and explosives until their point of use.

Detonators and explosives should be stored at least 100 metres from tents. They should also be separated from each other by at least 10 metres. Detonators should be stored in specially marked and constructed detonator boxes. They should not be taken to within 10 metres of a Ski-Doo without being in these boxes.

All radio transmitters should be turned off during the loading of shot holes.

Ships

For security reasons, all explosives and detonators are stored in special stowage whilst onboard ship. Staff will not encounter them until unloading operations take place.

It is essential that any staff involved with the unloading of explosives follow the instructions set by the Chief Officer or the ship's officer designated for this task. Onshore control of the operation should be carried out under the direction of the Base Commander. It is the responsibility of everyone involved to be vigilant and to report anything that is a cause for concern.

18.2 Storage

The following instructions apply to storage at all fieldwork sites, huts and stations.

Storage areas

Detonators and explosives should always be separated and stored at least 100 metres from accommodation, fuel dumps, vehicles as well as work and storage areas. These storage sites should be clearly identified as holding explosive material.

Transport from storage areas to the aircraft should be undertaken without delay when the materials are being moved for transport to field sites. Never leave explosives uncovered or unattended.

Storage containers

The specially constructed and marked detonator and explosive boxes should be used for storage and transport. Detonator boxes are yellow with a red cross. Explosive boxes are yellow with a red disc. These boxes are similar in size to food boxes.

The large volumes of explosives used on some projects can result in explosives being transported in their proprietary packaging. This packaging will be marked with the appropriate hazard warnings. When explosives and detonators are being moved, the person in charge should ensure that all personnel in the vicinity are aware of what is happening. Staff not required should be excluded from the area.

Temporary storage in the field

Explosives left during a field season in temporary field depots must be documented and the contents well marked. This should be done in consultation with the controlling station where all relevant information should be recorded. If any other field parties, including those from another nation, are working in the area they should be made aware of any stored explosives. This should be done through their controlling station.

18.3 Static electricity

There is a small risk that electric detonators can be set off by static electricity. Static electricity is generated in the dry Antarctic environment, particularly during blowing snowstorms. Great care should be taken during these conditions. Unless static-proof detonators are used, the senior scientist will suspend detonator handling operations during these periods.

18.4 Fire

The explosives used by BAS are chosen for their stability and long shelf life. The only thing that is likely to cause these explosives to detonate by accident is fire. **If a fire occurs in the vicinity of explosives the only safe action is to evacuate all personnel immediately to a safe distance.** Do not compromise your evacuation by trying to stop a fire reaching explosives - get away as quickly as possible and let the fire burn.

18.5 Ammonium nitrate

Ammonium nitrate is an oxidising agent, not an explosive. It is used as a component in making an explosive known as ANFO (ammonium nitrate and fuel/oil mix). In the past this has been used for some large-scale experiments. Although it is unlikely that ANFO will be used in the future, these notes are included for completeness.

Ammonium nitrate can be made unsafe with contamination from fuel oils. In the field it is mixed with diesel fuel to make it explosive. Care should be taken not to store it where contamination by fuel oils is possible. Storage areas should be well ventilated.

Ammonium nitrate is not particularly flammable but it will burn. The resulting fumes are toxic and any requirement to fire-fight should be at a distance using a fire hose. Flooding with water is the only effective way of combating an ammonium nitrate fire.

18.6 Warning information: detonators and explosives

There are a few simple rules that must be followed when handling explosives or detonators.

- A trained person is to supervise all handling of detonators and explosives.
- Handle with care. No smoking and no rough handling.
- Always separate explosives and detonators.
- Do not store detonators or explosives within 100 metres of facilities such as accommodation, workshops, storage buildings and fuel dumps.
- Depots and field dumps should be clearly marked and documented. Explosives and detonators should be carried separately and, where possible, in their special storage boxes.
- Transport of detonators and explosives should be on separate sledges and separate flight loads.
- No VHF radios should be used within 25 metres during transport.
- No radios at all should be used within 100 metres of any store, blasting operation or during the loading and unloading of an aircraft.
- Only essential aircrew should travel on aircraft transporting explosives or detonators.
- If explosives or detonator boxes are visible, assume that they contain explosives or detonators.
- If a fire occurs near explosives, evacuate all personnel to a safe distance immediately.

19 Environmental protection

Introduction

Antarctica covers an area of nearly 14 million square kilometres. It is the largest and most pristine wilderness on Earth.

All activities undertaken in the Antarctic, even scientific research, have some form of impact on the environment. BAS field projects have their environmental impact assessed before being allowed to proceed. All activities must be conducted in a manner that limits any adverse environmental impact.

Animals and plants in Antarctica live under extreme conditions and care must be taken to avoid disturbing sensitive ecosystems. A shortcut across a moss bank may leave footprints that last for decades. Litter and rubbish do not decompose in the freezing temperatures and will blight the landscape for centuries.

For detailed information on BAS environmental policy, the BAS Waste Management Handbook should be consulted.

19.1 Staff environmental obligations

All staff are expected to play their part in protecting the Antarctic by reducing their own impact on the continent to a minimum. Staff must be aware of, understand and comply with the Guidance for Visitors to the Antarctic section of the BAS Participants' Handbook and the BAS leaflet "Environmental Protection in Antarctica".

Considerations for minimising your environmental impact in the field:

- In ice-free areas, try to pitch tents and place depots on sites that have already been disturbed by previous parties.
- Keep to established paths and tracks if possible.
- Make accurate records of your camps and include this information in your field party report.
- When leaving a campsite, look around for loose rubbish and pick it up. Try to leave each campsite as you found it or in an improved state.
- Do not paint or engrave graffiti on rocks.

19.2 Conservation of flora and fauna

Killing or harmful interference with Antarctic wildlife is prohibited, except in accordance with a permit issued under the Antarctic Act 1994.

The following points should be observed:

- Do not feed, touch or handle any wildlife.
- Do not approach or photograph wildlife in a way that causes them to alter their behaviour. As a guide, keep a minimum distance of five metres from any animal. A permit is needed to handle, tag or kill animals, collect eggs or collect significant quantities of plants.
- Do not walk or drive vehicles on vegetation, particularly extensive moss or lichen-covered areas.
- Do not use aircraft, vessels, small boats or vehicles in a way that disturbs wildlife. Avoid taking aircraft, particularly helicopters, within 200 metres of bird or seal colonies. The noise of low-flying aircraft can cause them to panic.
- Do not collect biological or geological specimens unless they are taken as part of an approved BAS project. Items brought back to the UK such as plant specimens or seal and whalebone will require import licences. Ensure that Cambridge and your BC are aware that your project needs such import licences.

19.3 Waste disposal for field parties

All waste, other than sewage or wet domestic waste, should be brought out from field camps wherever it is practical and safe to do so. Everything that goes into the field should come out again.

The BAS waste disposal system involves the separation of waste materials at source. All field parties are issued with colour-coded, heavy duty plastic bags for storing and transporting waste. Sort your waste as follows:

- Blue - plastics, paper and card.
- Red - cans, metal and glass.
- Yellow - medical and sanitary wastes.
- White - solid hazardous waste such as batteries.

19.4 Top tips for waste management in the field

- Wherever practical, all wastes (other than biodegradable wastes) should be returned to a station or ship in the waste bags provided. Crush your cans and compact boxes to reduce volume. Gash bags can be stored and transported in your empty man-food boxes. Use returning resupply flights to remove your waste.
- Hazardous waste has top priority for removal. Record the number and type of waste bags that you produce and tell the BC/FOM so that cargo space can be organised on outgoing flights.
- Hazardous wastes such as used batteries, waste chemicals, paints and glues must be returned to stations or ships to await shipment back to the UK for safe disposal. It is your responsibility to pack, label and document all of your hazardous waste. The BAS Waste Management Handbook contains detailed packing and labelling instructions.
- Get rid of excess packaging and non-essential items before going into the field. Use bubble wrap for packing breakable items. Only use vermiculite for packing chemicals and other hazardous materials.
- The BC/FOM must be notified if waste is to be left at depots or unoccupied field camps. Record the location, amount and types of waste. Mark all items at the depot site and secure them carefully against being blown away. Follow the instructions in Chapter 17 for depoting procedures.
- Return empty fuel drums to the stations wherever it is practical and safe to do so. If drums cannot be flown out, make sure they are safely depoted and their location recorded for later recovery.
- Mark and return waste fuels, oils and lubricants to the stations or ships. Surplus fuel may be needed for field depots. Check with the BC/FOM before removal.
- The open burning or burying of wastes is prohibited. Do not bury rubbish.
- Sewage, used toilet tissue, wet food wastes and grey water should be disposed of into the sea at coastal locations. This should be through a tide crack, ice hole or on the shore below the high water mark. If you are located on permanent snow and ice, these wastes should be disposed of into an ice pit or crack. This should be downwind and well away from any research sites, particularly those involving snow or ice sampling.
- Never site toilets or dispose of sewage, used toilet tissue, wet food wastes or grey water in ice-free areas, vegetated areas or near freshwater streams or lakes.
- If a camp is likely to be reused, mark the toilet area when you leave.
- Take special care with the disposal of medical and sanitary wastes such as tampons. All syringe needles, blades and other “sharps” should be stored in a small tin or other protective container.

19.5 Prevention of pollution

Fuel, oils and chemicals should be used carefully in the field. To prevent the risk of pollution occurring you should:

- Minimise the storage and handling of fuels and oils in ice free areas, particularly near to freshwater lakes and streams, vegetation or bird and seal colonies.
- Transfer paraffin from fuel jerry cans to Sigg bottles by siphoning. All pots boxes contain flexible siphon tubing.
- Use a funnel when refuelling vehicles, equipment and generators. Engine oil changes must be carried out over drip trays. Any waste fuel or oil should be collected, properly packaged and sent out for safe disposal.
- Handle scientific chemicals as carefully as you would in the laboratory.
- If spills occur it is your responsibility to stop, contain and recover the fuel, oils or chemicals. Pig Putty (which is kept in the spares box) is excellent as a temporary repair for leaking drums and containers.

19.6 Protected and managed areas

Some areas in the Antarctic require special protection or management because of their ecological, scientific, historic or other values. The greatest concentration of these sites is on the Antarctic Peninsula and the maritime Antarctic Islands.

Antarctic Specially Protected Areas (ASPAs)

These are areas that have outstanding wilderness, scientific or environmental values and may include:

- Important or unusual animal or plant communities or habitats.
- Unusual landforms.
- Special historic, aesthetic or wilderness value.

Entry to ASPAs requires a permit and these are only issued on proof of compelling scientific reasons. Permit application forms and guidance notes are available from the Environmental Office at BAS Cambridge.

Activities within an ASPA must be conducted in accordance with its Management Plan. ASPAs include all Specially Protected Areas (SPAs) and Sites of Special Scientific Interest (SSSIs), designated by past Antarctic Treaty consultative meetings.

Antarctic Specially Managed Areas (ASMAs)

These are areas where human activities need to be coordinated to avoid the risk of mutual interference such as where there are two or more research stations. A permit is not required to enter an ASMA but a Code of Conduct set out in the Management Plan directs activities.

Historic Sites and Monuments (HSMs)

These are sites that have been deemed to have historic status in order to preserve and protect them. If these sites are visited, record their condition and inform Cambridge/FOM/BC.

- Do not remove, disturb or damage anything associated with an HSM. Take care of Antarctica's heritage.
- If you visit huts, make sure windows, shutters and doors are properly closed when you depart. Report any problems. Any significant maintenance at these sites should be done in consultation with BAS Cambridge.
- Do not smoke in or around historic huts. Fire is a serious risk and there is no fire protection in these old buildings.

In order to protect all these sites you should:

- Know the locations of ASPAs, ASMAs and HSMs near to where you are working and be aware of their Management Plans.
- A permit is required to enter ASPAs. Carry this permit with you in the field. If entering an ASPA, the Management Plan must be followed.
- The use of vehicles in ASPAs is prohibited.

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19.7 Further information

For further information, contact the BAS Environmental Office or visit the Environmental Office's intranet site at http://basweb.nerc-bas.ac.uk/environmental_office/.

20 Sea-ice travel

Introduction

Sea-ice can be a fickle and risky medium on which to travel. The risks can be reduced by common sense, good decision-making and understanding your local sea-ice conditions.

Many meteorological and oceanic factors can contribute to fast-ice deterioration and melting. These include changes in air and sea temperature, wind, solar radiation, snow cover, albedo, tides and currents. Although sea-ice presents many hazards it can also be highly useful. At Halley it can make a relatively safe and reliable discharge platform for unloading ships. In the Ross Sea area it is used routinely for landing large aircraft.

Ice formation and conditions vary from season to season and between BAS stations. Before going into the field it is essential to gain an understanding of local sea-ice conditions. This information can be gathered from past travel reports and from more experienced personnel. Do not treat past reports as authoritative because annual variations must be taken into consideration.

Never become nonchalant about sea-ice travel - it can be unpredictable and there are many hazards to catch out the unwary.

Changes to sea-ice can be slow and subtle as well as rapid and dramatic.

20.1 Sea-ice formation

See also Section 26.

Seawater freezes at -1.63°C. Once this water temperature becomes stable under the influence of cold air temperatures, ice spicules or small plates start to form in the water surface layer. These coagulate to form grease-ice. This new-ice will then take on different forms according to influences such as sea state and wind strength.

In calm conditions, fast-ice forms in five stages:

1. Grease-ice - an oily appearance in the water.
2. Porridge-ice - a slushy layer.
3. Pancake-ice - circular plates of newly formed ice which usually have raised edges caused by the movement and contact between adjacent plates.
4. Young-ice - where the pancakes have consolidated into a continuous sheet but only a few centimetres thick.
5. Fast-ice - the ice matures and snow covers the surface.

This process can be short-circuited and pack-ice can form by the consolidation of old sea-ice, brash-ice and bergy bits. These freeze into an irregular but continuous surface of blocks and pressure ridges. Travel over such sea-ice can be strenuous and time-consuming unless snow cover has levelled the irregularities.

Newly formed sea-ice has resilience akin to soft rubber and this provides comparatively better support than freshwater ice.

Before travel can take place on sea-ice, it will need to reach a suitable thickness (see below) and travel should not be undertaken on young sea-ice until it has been tested by a significant storm (winds in excess of 40 knots for a long period). This is especially important if there is no safe alternative return route should the ice breakout.

First year sea-ice can form to a thickness in excess of 1.2 metres under stable conditions. Multi-year ice can be in excess of three metres thick.

20.2 Fast-ice

Fast-ice is defined as ice that is attached to the coast. The coast may be a land mass or a floating ice shelf and the ice may extend just a few metres from the shore or for hundreds of kilometres.

Fast-ice can be locked in by shoals or grounded bergs. During tidal change, the ice may rise and fall with the sea. If the ice is consistently two metres or more above sea level, it is termed shelf ice.

Fast-ice should not be confused with an ice foot. This is unaffected by tide and is merely a narrow fringe of ice. When fast-ice breaks off, an ice foot will remain.

20.3 Pack-ice

Pack-ice is the name for collective ice floating in an area of water. This ice is not attached to the coast, so is unsafe for travel. It is mobile and can break up, even in very calm conditions. **Do not travel on pack-ice.**

The density of pack-ice is stated in tenths and varies from 1/10 (very open) to 10/10 (compact).

Various deformation features can form within bodies of pack-ice and can become features within fast-ice bodies. These include hummocking, ridging and rafting.

20.4 Gauging ice for travel

Bearing capacities of new sea-ice:

Mode of travel	Theoretical minimum thickness	BAS Policy
Person on skis	10cm	20cm
Person on foot	13cm	25cm
Loaded Nansen sledge	15cm	30cm
Ski-Doo, one-person	15cm	30cm
Nodwell (RN- 75)	46cm	
Twin Otter	51cm	
C-130	157cm	

These figures do not include any surface snow layer. The bearing capacity of rotten ice is at best only half that of new ice.

Testing ice

The most reliable method of testing sea-ice is to drill through it and measure its thickness. The surface snow must be removed, as it is only the ice thickness that is important.

Testing the ice with a bog chisel is too subjective. However, a bog chisel can be useful for testing narrow tide cracks and leads. If a lead or crack is too wide to drive or ski across, it should be drilled and measured in the normal manner.

During decay, the ice becomes honeycombed with layers of water. Assessing the strength of the sea-ice in these conditions needs to be done very conservatively. See also Section 20.7.

Before venturing onto the ice you should:

- Ensure that you have the correct equipment.
- Check the weather forecast and the current weather conditions.
- Think about the overall picture, not just the ice you are standing on.

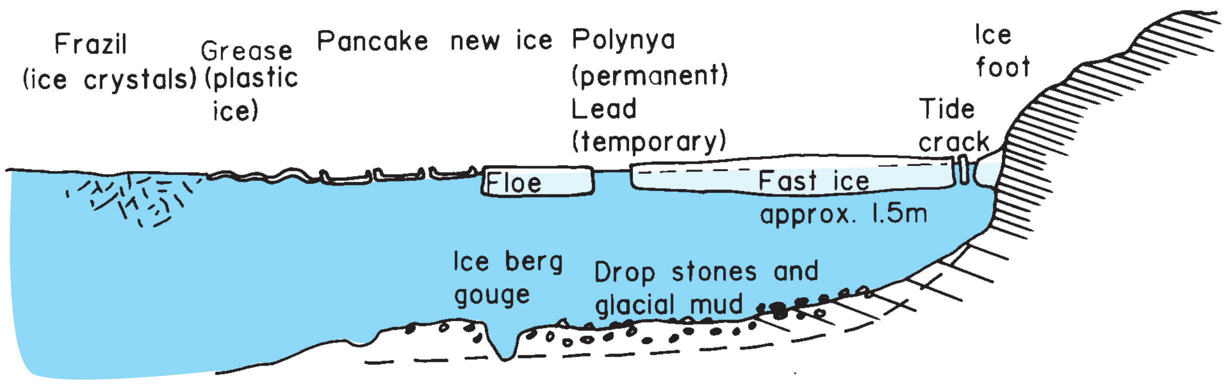

Figure 20.2 **Sea-ice formation**

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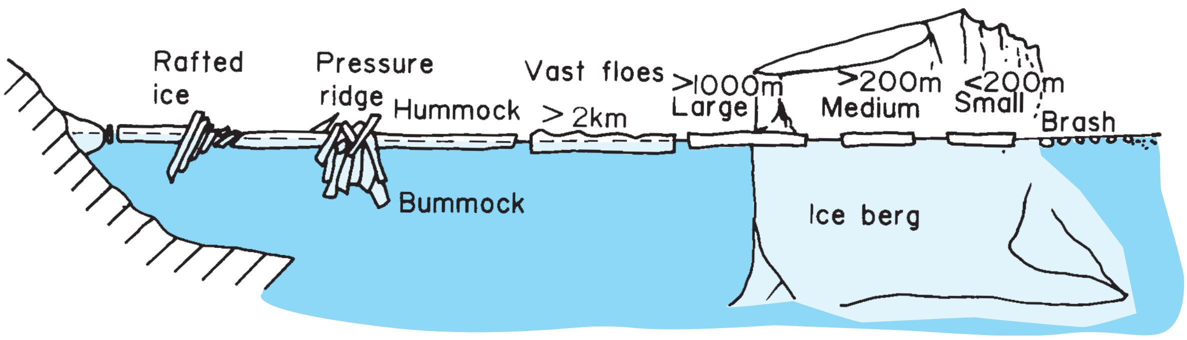

Figure 20.3 **Pack-ice**

Illustration reproduced by kind permission of the Australian Antarctic Division.

- Think about the proximity of any open water. Wave action and swell are serious dangers.

If you are in any doubt about the strength or quality of the ice, stay off it.

When venturing onto sea-ice you must test it frequently in order to gain a representative picture of the conditions. To do this:

- Drill frequently.
- Clear away any surface snow and only measure the sea-ice thickness.
- Don't build up a false picture by drilling into old floes and brash.
- Drill more frequently around headlands and areas where the ice will be thinner (see Section 20.7).

Once an area has been drilled and deemed safe it may not need re-drilling for some time. But it should be re-drilled after a significant period of time has elapsed or if the conditions have changed. Local travel rules can be found in the station travel regulations. The BC/WBC should be aware of these.

Travel outside locally defined areas will be permitted only after permission is granted from the Operations Manager in Cambridge. In order to be able to make informed decisions on the current conditions it is essential that Cambridge be passed accurate and objective observations.

20.5 Records

It is important that the information collected about the state of the ice (including satellite pictures) is recorded in a dedicated sea-ice file and on a sea-ice map. The following information should be recorded:

- Thickness measurements - positions and spacing.
- The state of the drilled ice.
- Any large leads or tide cracks. Include information on their size, direction and whether they are open or thinly iced.
- Areas of newly broken or reformed ice.
- Percentage cover in tenths.
- The position of large icebergs.
- Outstanding weather events such as wind direction, strength, duration and temperature. The general weather history should also be recorded to help build a picture for future years.
- Any water-sky (see below).
- Aries satellite images (if available).

A high vantage point and a pair of binoculars will make observations more accurate.

Seeing beyond the horizon

Unless a very high vantage point is available, it will be difficult to see any great distance. Water-sky and Aries images will help you to overcome these limitations.

Water-sky appears as dark streaks on the bottom of low clouds. This gives an indication of open water. Low cloud above ice will appear light in colour. High resolution satellite images such as AIRES and Dartcom, are an excellent tool for assessing sea-ice cover.

20.6 Weather hazards

Bad weather and its effect on the sea-ice is perhaps the greatest hazard of all. **Good weather conditions are a prerequisite for sea-ice travel.** Poor weather can result in:

- Wind.
- Ocean swell.
- Poor visibility.
- Rising temperatures resulting in surface melt.

Above all other factors, wind and ocean swell have the most profound effect on the ice stability. Given the right conditions, sea-ice can be destroyed within minutes.

Wind

Windy conditions can break up the ice and open up leads that can bar a safe return. Do not travel in windy conditions or when strong winds are forecast. Offshore winds are particularly hazardous.

Ocean swell

Even in apparently good conditions, the influence of the sea state must be considered. Ocean swell will cause a very rapid break-up of the ice, irrespective of thickness. If open water with a large "fetch" is present, you should be very wary. Ocean swell can be caused by weather events thousand of miles away. Stations with exposed coastlines should exercise great caution when open water is close by.

Poor visibility

Do not travel in poor visibility as areas of weak ice may be encountered before any avoiding action can be taken.

20.7 Other hazards

Tide cracks

Sea-ice is often weak where it joins the shoreline. Tide cracks are caused as the ice hinges during tidal movements and can be wide enough to swallow a Ski-Doo. As their cross-section is often in the form of an inverted 'V' with rotten edges, their true width is disguised.

Tide cracks can make access on and off the ice difficult, particularly after warm periods and during periods of large tidal range. They should be crossed at 90° and only after thorough investigation.

Leads

The ice will often crack into a long thin channel called a lead. Many of the rules regarding tide cracks apply to leads.

Leads commonly run between points of land or icebergs and give a good indication of the amount of ice movement. Open water in such leads often refreezes and may become snow covered. This makes them indistinguishable from the surrounding sea-ice. Check refrozen leads by drilling them and note their position.

Icebergs

Large icebergs offer a very large surface area to the wind and currents so they can cruise around like giant icebreakers. Unless very well grounded they are likely to have been moving as the sea-ice was forming. The area around the edge of a grounded iceberg will also be the last to freeze, as the tide will move the ice up and down around the iceberg. Always suspect thinner ice for a wide area around icebergs. The best policy of all is to give them a wide berth.

Currents

Be wary of areas where there is a persistent current. These areas are dangerous as the sea-ice can be scoured away from underneath. Currents will be strongest in the following areas:

- Headlands.
- Narrow constricted channels.
- Reefs, shoals and other shallow areas.

These areas will cause an increase in the speed of the tidal flow. It is generally safer to travel about 200 to 300 metres offshore. Accumulations of icebergs (if assumed to be grounded) often indicate reefs or shoals. Take note of local knowledge.

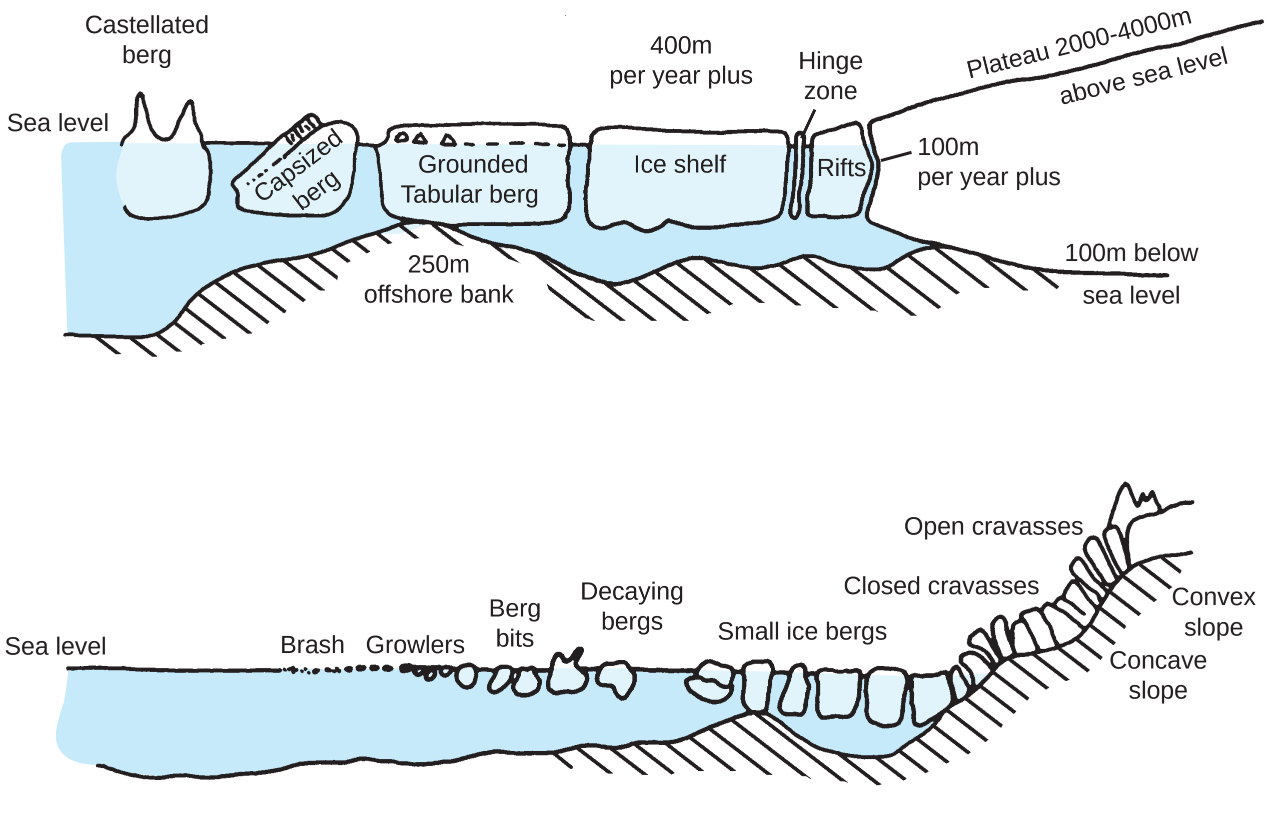

Figure 20.7 Icebergs

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Melt-water
In the late winter and early summer there may be considerable melting on the land. This melt-water runs onto the surface of the sea-ice creating pools and causing deterioration in the ice. It may run under the sea-ice resulting in thinner areas. In both circumstances these areas should be avoided. Study the shoreline as you approach it and avoid access points near potential run-off channels.

Wildlife
Seals on the surface will have come through the ice. They commonly exploit weaknesses such as tide cracks. If seals are present be wary of holes and cracks. Also watch out for birds as their presence can mean open water is nearby.

Ice quality
Measuring ice thickness is suitable only for assessing its safety for travel when the ice itself is sound. Having sufficient thickness will not count for much if the ice is so rotten it can't support your weight.

Danger areas and signs are:

- Darker ice usually indicates newer and therefore thinner areas.
- A dullish, grey colour in the snow cover can indicate wet areas.
- Dirt in or on the ice surface will cause an increase in the absorption of solar radiation and therefore the rate of melting.
- Large masses of snow, especially near cracks in the ice, can cause flooding and boggy areas.
- Melt-pools formed by ablation. If there is a need to cross melt-pools on sea-ice, drill the ice to ensure it is strong enough.
- Flooded sea-ice can be heavily loaded by water and wet snow. This melt-water can also come from snow melt on land that has flowed out onto and under the sea-ice.
- Thaw holes. These are vertical holes in the sea-ice formed when surface pools melt through to the underlying seawater.
- Rotten ice that has become honeycombed and is in an advanced state of disintegration.
- Algal blooms may form cavities in the ice and thus weaken it.

You should learn to recognise these types of ice. Remember that snow cover makes assessment difficult as it can mask danger areas.

Glaciers and ice cliffs
Where glaciers meet the coast their tongues often extend seaward. They are often crevassed chaotically and because of their buoyancy are subject to ocean movements. Sea-ice in such areas tends to be chaotic due to either pressure or being broken up and loosened. Do not approach close to icebergs or ice cliffs.

20.8 Travel on sea-ice

Travel on sea-ice is one of the most risky operations that can be undertaken on recreational or field science trips. There have been seven British fatalities associated with sea-ice travel since the inception of the Falkland Islands Dependencies Survey in 1945.

Journey planning
Before undertaking any sea-ice journey you must be conversant with the local conditions and your station's travel regulations. When assessing the viability of a journey you should consider not just the immediate locality, but also the overall picture:

- What is the extent of pack-ice beyond the fast-ice? The pack-ice will help to deaden and reduce the effect of swell upon the fast-ice.
- What sort of testing has the ice had from strong winds?
- What is the weather forecast?
- Are there potential escape routes should conditions change?
- Are there depots in the locality of your route and final destination?

Strong winds combined with a swell should preclude any journeys. Journeys should always be planned in regular stages where you contact land. Permission must be sought from BAS Cambridge before sea-ice travel can commence and after significant changes in sea-ice conditions. Any winter trip of more than two nights must be sanctioned by the Operations Manager. The BC/WBC can sanction local sea-ice travel. For more information consult the station's Sea-Ice Travel Regulations.

Equipment
It is essential that you travel in pairs and carry the necessary safety equipment. The minimum equipment to be carried is detailed in Chapter 26.

In the event of falling through the ice it is essential that you can either:

- Dagger out using a sharp implement.
- Be pulled out by your partner.

To be able to perform these actions you must have:

- A sharp implement such as a warthog ice screw, knife and spike or ice axe. They must be easily accessible.
- A waist belt with a karabiner. This is normally an old climbing harness with the leg loops removed.
- A throw line.

Travelling in pairs provides added safety only if you are spaced apart and both carrying a throw line.

Skis reduce your ground pressure and are generally safer and more efficient than foot travel. They can be difficult to use on uneven surfaces such as consolidated brash. Ensure that skis can be removed easily and don't wear leashes.

Falling through the ice

If you break through sea-ice, shed any items that could obstruct getting out such as skis and your rucksack. Clothing will insulate and provide an element of buoyancy. The rucksack should float with the sealed clothing bag in it.

Move to the ice edge and attempt to "belly out" like a seal. Always have your ice hammer, ice screws or a knife handy to enable you to dagger out. If the ice is thin use skis to spread the load. Thin ice will tend to break away as you pull yourself out.

A second person should be able to throw a line to the person in the water. Use any materials available to spread your weight.

The second person must ensure that they do not become a victim themselves.

Ideally your emergency clothing bags should be sea-ice specific. The most useful clothes will be those that can be put on in a hurry. Thermals, a fleece layer and a "doo-suit" are the most suitable. Dry gloves and hats are essential. All emergency clothing bags should contain spare footwear and socks that will fit the biggest foot size in the group. Emergency heat packs are a useful addition to the bag. Do not think that you will be able to easily put wet clothing and footwear back on after immersion at -30°C.

Local travel by Ski-Doo on sea-ice

Ski-Doo usage over sea-ice varies from station to station so you should be aware of the local regulations. The following rules, however, are common across all stations:

- Never travel alone on sea-ice.
- Ski-Doo and sledge units must not be linked on sea-ice.
- The driver must not be attached to the Ski-Doo apart from via the kill cord.
- Never ride two-up on a Ski-Doo. If there is more than one person for each Ski-Doo, the passenger should ride on a sledge.
- Keep a close eye on each other as well as on the prevailing conditions. Do not travel too close to each other, but do not lose sight of each other either.
- Do not travel too fast, even if the surfaces allow for this. Excess speed can result in insufficient reaction time if hazards are met. It also risks damaging equipment, particularly the sledges. You cannot afford to have breakdowns and problems on sea-ice. Unlike land travel you cannot simply stop and pitch a tent if you have a problem.
- Carry a shovel, bog chisel and tool kit on each Ski-Doo.
- If travelling with two Ski-Doos, carry a link line/length of rope on one of the Ski-Doos This can be used as a tow rope in case of bogging down.
- Wear a helmet.
- Emergency clothing should be carried on each Ski-Doo.
- A couple of strong plastic gash bags and some thin rope can be carried under the Ski-Doo seat. If the Ski-Doo becomes bogged, these bags can be pulled over your mukluks and tied at the tops to keep your feet dry.
- You should always be equipped to return to station on ski or foot (in most situations).
- When travelling over ice covered with snow, remember that any hazard may be masked. Snow can cover flooded areas where it is easy to become bogged down. Lumps of ice covered by a light snow cover can capsize or do serious damage to sledges and Ski-Doo suspension.

Full-unit travel on sea-ice

For longer journeys (outside local sea-ice limits), full field travel equipment will be necessary. See Chapter 26. A full set of link lines should be carried for overland Ski-Doo travel. A change of ice conditions may require you to travel overland to a depot or station. The 30m link line should be easily accessible to help pull out a bogged Ski-Doo or sledge. As with full-unit travel over land, split the load so that survival gear is equally distributed. If you lose one sledge you should still have food, fuel, sleeping equipment and a tent. Make sure the emergency clothing bags are easily accessible.

Before setting out make sure you know the location of all the relevant depots, escape ramps and possible campsites.

Never camp on sea-ice, not even close to the shore.

20.9 Work on sea-ice

Ship relief work

Immersion suits and lifejackets should be worn when undertaking relief from ships.

Diving and water sampling

See the Diving Manual.

20.10 Sea-ice breakout

Sea-ice breakout can occur with little warning and can cover many square miles. Breakout can occur in numerous ways and not always from the outer edge. Huge rafts of ice can break away from the shore before breaking into smaller floes and this can happen extremely quickly. Small leads can open up quickly and cut off retreat, so think about the larger picture before crossing cracks or leads.

If the weather deteriorates severely and if it stays warm and windy for long enough then the sea-ice will break up. Even if it is minus 30°C with 10/10 excellent ice cover when you set off on your trip, given enough bad weather it could all go. It is important that all personnel who undertake overnight trips on the sea-ice understand this.

When planning trips, it is essential that there are sufficient reserves of food and fuel either at your destination or accessible overland from your destination. If the ice blew out would there be sufficient supplies to last the party until an aircraft or ship returns?

20.11 Actions in a breakout

Much will depend upon your situation. Above all do not panic or take foolish risks to get to the shore. At the first sign of a possible break-up of the ice you should consider all the options open to you. If it is unlikely that you can make a retreat to station then you should immediately make for the nearest safe landfall.

- Check your map immediately to ascertain your position. Try to estimate drift and plot this. Contact the station with details as soon as possible and attempt to maintain regular status updates. There may be landfall near to or in line with your drift.
- Getting to land is your highest priority. If possible “floe-hop” to get to land. Try improvising a boat with a Ski-Doo tarp or a small floe. Remember that getting wet will greatly reduce your chances of survival.
- If landfall cannot be made, all is not lost. A change of wind direction could result in the ice blowing back to shore. If you need to wait for changes in the weather, try and get onto a grounded berg. If this is not possible try to get on an old floe - the biggest you can reach.
- Try not to get separated from your equipment.

Your chances of survival will be greatly increased by remaining positive and level-headed whilst exploring all your possible options.

Imagine the scenario of being caught in a sea-ice breakout. It is a seriously unpleasant thought. Think about this when you are planning your sea-ice journey.

21 Emergency procedures for field operations

Introduction

A search and rescue (SAR) incident in the Antarctic could be a complex affair that may involve a large number of people, different organisations and various modes of transport from Ski-Doos to ships. A rescue operation could involve pilots, doctors, paramedics, field assistants, air mechanics, radio operators, domestic staff, station management, Cambridge staff, vehicle mechanics and the meteorology team.

It is very important that there is a good flow of information to the overall controller who will oversee the "bigger picture". Make sure the correct information is passed up and down the chain.

21.1 How to respond effectively to an accident or emergency

Key points in incident management:

- Strong leadership.
- Making sure you have all the relevant information before committing to a plan.
- Not rushing. Good preparation and planning will result in a more effective response.
- Good communication between team members and particularly from the team leaders.
- Delegating tasks effectively and creating a good command structure.
- Appointing suitable leaders for specific areas.
- Knowing the strengths and weaknesses of the team members.
- Effective teamwork.
- Seeking outside help where necessary.
- Staying flexible and adjusting the overall plan accordingly while informing the team of the changes.

21.2 Field response to an emergency

The first priority is to remain calm and level-headed. Panic kills, so collect your wits. Ensure the immediate safety of yourself and the group and then assess your priorities. These are:

- First aid/extraction.
- Stabilisation.
- Shelter.
- Communication.

21.3 Emergency communication protocol

If an incident occurs, your controlling station should be informed at the earliest opportunity.

- All emergency calls should be through your controlling station using the Iridium phone. The emergency contact numbers should be loaded into the phone's memory before going into the field.
- In the event of not being able to contact your controlling station, make contact with Operations Group's on-call emergency numbers in the UK. Failing this, call another BAS station or ship. Control will be returned to the controlling station as soon as possible.

21.4 Contact with the "outside world"

In the event of a SAR incident, do not pass information to the "outside world" until you have been told that it is okay to do so by the FOM/BC.

21.5 Legal implications

In the case of serious injury or death there will be legal implications. It is vital that the reporting and recording of events, witness statements and any failed equipment are kept for BAS internal reports and possible external enquiry. Photographic or video evidence is also important.

22 Search techniques

Introduction

All field personnel should have a basic knowledge of search techniques. Not only will they enable you to find a missing individual but they may also help you to find shelter if you get lost yourself.

This chapter will deal only with search techniques appropriate for land travel. Some of these techniques will also be appropriate for aircraft and marine searches, but for more detailed information on these techniques the relevant manuals should be consulted.

Prevention is always better than cure, so use work practises that reduce the chance of getting lost:

- Don't go out in bad weather unless you really have to.
- If you are in any doubt, get your partner to belay you with a rope from inside the tent.
- Set up hand lines around your camp to link tents. Don't wait until the weather has deteriorated to do this.
- Learn how to navigate accurately in bad weather.

22.1 Actions if lost or disorientated in bad weather

In unfamiliar or obscured terrain it is very easy to become disorientated, particularly in strong winds. This can happen when moving between tents or huts in the field and even station buildings. In really bad conditions visibility can be less than five metres.

Even if you are poorly equipped you will survive if you:

- Don't panic.
- Plan your actions.
- Remain positive and alert.

Initial actions:

- Don't do anything that will lessen the chance of searchers finding you.
- Establish comms if you have a radio - broadcast blind if necessary. Use a whistle and blow six short blasts every minute. Keep doing this.
- If a search is imminent, stay where you are and protect yourself from the weather.
- If you do move, try and leave an indication of your intentions.

If a search is not imminent:

- Do not wander aimlessly about, hoping to find a landmark. By doing this you might move far from the location of a search area.
- Minimise your heat loss. Fasten clothing and stay dry.
- Stop and think. Use available shelter or sit with your back to the wind. Try to remember your movements and work out how to find your way back.
- Take a note of the wind direction. It is your reference point for subsequent movement. Use any other navigation aids you possess.
- Signal with whatever means you have available. This could be a radio, whistle, flares or a torch. Listen for the sounds of searchers.
- Try a search pattern. This could be a square search or a spiral search (see below).

If searching doesn't work then:

- Go to ground before you become exhausted.
- Bivvy or lie down in the lee of a rock, snowdrift or sastrugi. It is essential to shelter from the wind as much as possible.
- Bury your body as much as possible or allow yourself to become covered by drifting snow.
- Curl up and keep your back to the wind.
- Cover your face with gloves or balaclava and wait calmly for an improvement in the conditions.
- Keep listening for the calls of a search party.
- Place an obvious marker so a search party can find you if you become buried.
- Don't fall asleep - the weather will get better eventually.

22.2 Search procedures for missing persons

If you are looking for a missing person, your first priority is the safety of the search party. Don't let them or yourself become additional casualties.

Actions

- Question all personnel thoroughly to find out where the person or party was last seen and gain as much background information as possible.
- Make a plan and make sure that all concerned are aware of it. The plan and the type of search pattern used will depend on the type of terrain,

the size of the area to be searched, the weather, the number of searchers available and their level of experience.
- Search the obvious areas first and as quickly as possible.

22.3 Search methods

The reconnaissance search
This covers a large area and reduces the search area into manageable portions. The method broadly covers the intended route of the missing party and the likely alternatives.

The general search
This search covers all the main features in the area where a missing party might be. It uses small fast parties to investigate these areas.

The sweep search
This is a saturation technique used in the area of highest probability. A formation line of people is used to cover a small area. Each person in the line maintains visual contact and searches the intermediate ground. This method is slow and is not used until there is a reasonable certainty of success.

22.4 Practical search techniques

It is likely that your search options will be limited in the field. At field camps and depots there is usually only a maximum of three people.

Rope search
This is a useful method of searching the area in the immediate vicinity of a tent, hut or building. It is a very safe technique. If the rope is anchored securely, it should always be possible to return to safety.

This technique is fairly self-explanatory and is perhaps the safest method of looking for a missing tent partner. Ropes should always be available at field locations. One of the rescue sacks should be kept on the tent valance.

Square box search
The square box search is a useful technique if you become disorientated whilst moving around camp. Do not move too far in the initial box pattern.

- Move upwind for ten or twenty steps - it may be necessary to crawl.
- Move across the wind (left or right) the same distance, then downwind and back to your starting

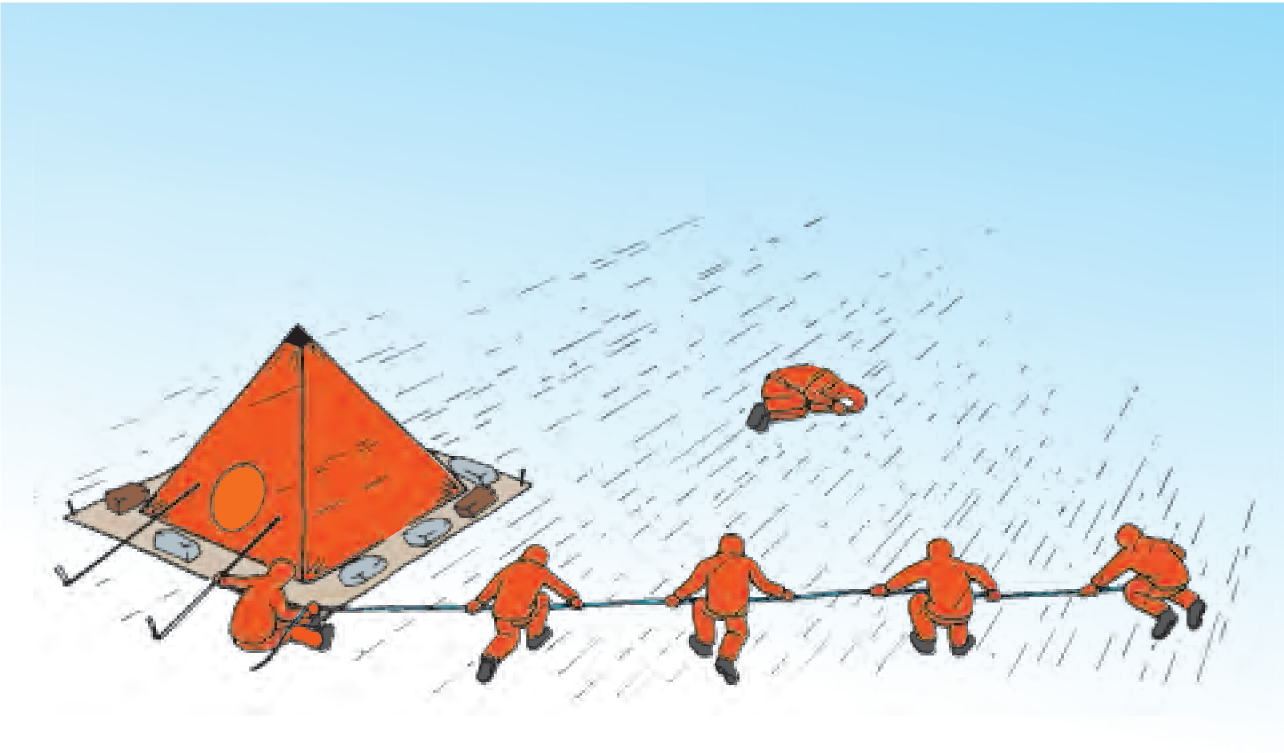

Figure 22.4a Rope search
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point having completed a square. You may not be at exactly the same spot but you should be close to it.

- If nothing is found and you have not regained your bearings, then go upwind the same distance again and complete a square in the other direction. This process can be repeated upwind and downwind of the starting point. The distance covered in each box will depend on the visibility.
- When you are sure you have covered the four squares, repeat the process with larger squares.

Don't panic if your first efforts reveal nothing as you have only covered an area of about 40 square metres.

Spiral box search

This is a very useful search technique as it can be used to search both large and small areas. The time taken to search an area is dependent on the visibility.

The principle behind this technique is that you travel on an ever-increasing spiral with the expanding area always within your range of visibility. To conduct this search pattern on foot you will need a compass. If no compass is available you can use the wind direction to determine your heading. The length of each leg travelled will depend on the visibility.

- From the start point, walk towards Magnetic North. Count your paces and stop when you can no longer see the start point.
- Turn 90° to your right and travel on a bearing of 090° (M) for twice the distance you could see. If you had no compass, walk towards the wind and then turn right and go through the same steps.
- Turn 90° again and travel three times the original distance on a bearing of 180° (M).
- Keep turning through 90° and increase the length of each leg as per the illustration.

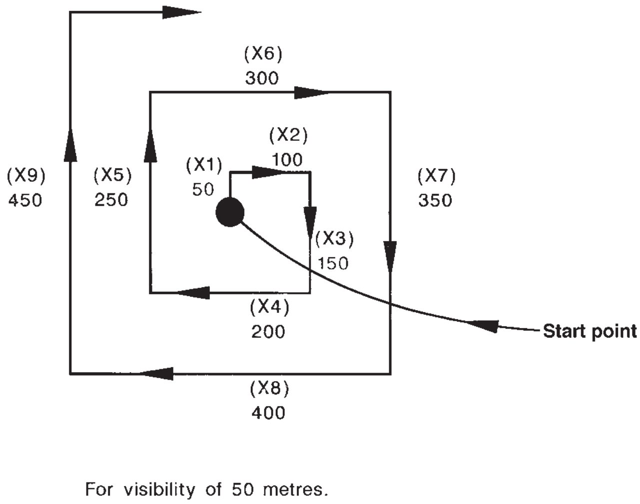

Figure 22.4c Spiral box search

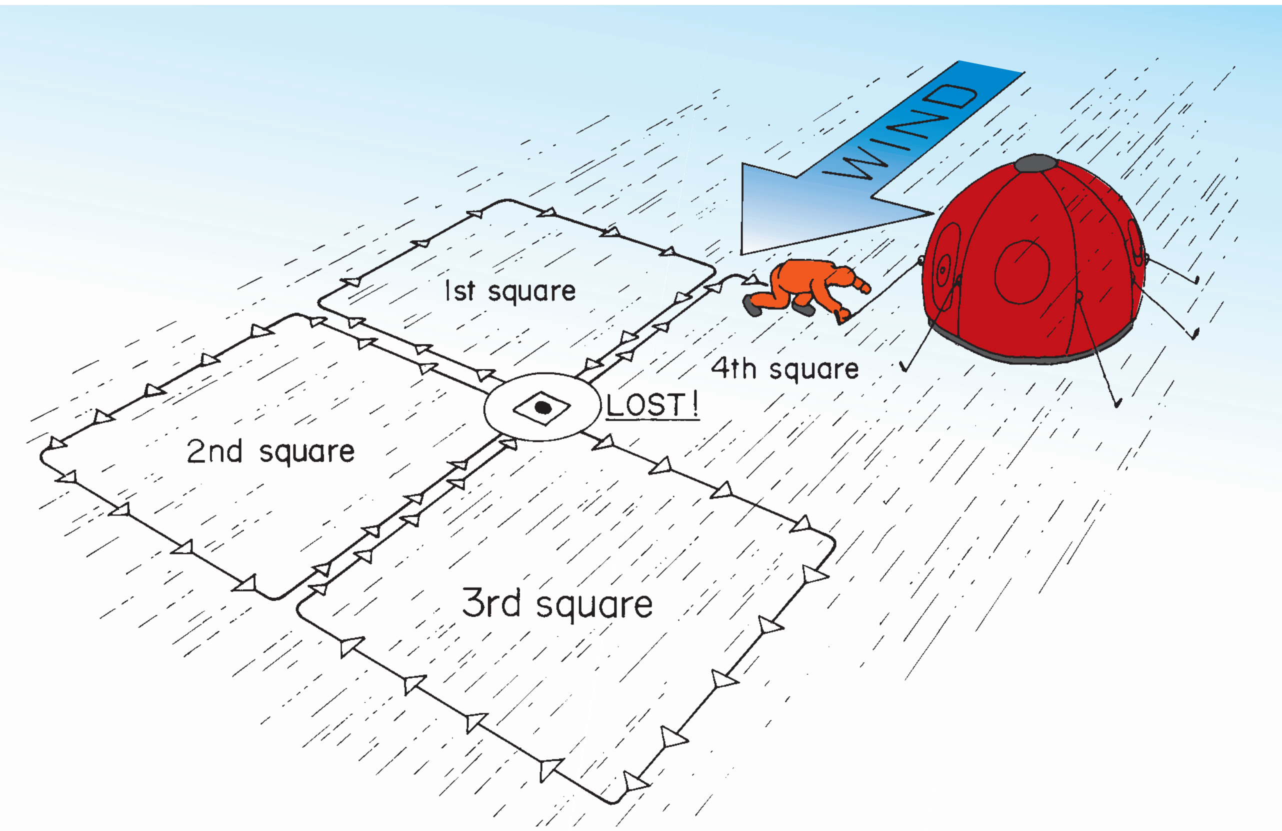

Figure 22.4b Square box search

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This technique can be adapted to a number of different situations. For a large search area, in good visibility, measuring time instead of distance could be used for working out the length of each leg.

22.5 Avalanche search techniques

See also Section 3.8 for information on avalanches.

Situations will vary but speed is vitally important. After two hours, the survival rate for a person buried by an avalanche is exceedingly low.

If you witness an avalanche where someone becomes buried you should:

- **Take care not to endanger yourself or others.**
- Mark the spot from where the victim was avalanched and the place they were last seen during the avalanche. The likely burial point will be below this point and on a line linking the two points.
- If possible, send for help immediately.
- Conduct an immediate search for the buried person. It is absolutely vital that this initial search is done as quickly and as thoroughly as possible.
- Unless help can be with you within 15 minutes, no attempt should be made to seek outside help until this search has been carried out. Survival time decreases rapidly after one hour of burial.
- Much will depend on how quickly help can be summoned. After two hours, a buried victim's chances of survival are extremely low.

Search patterns

The initial search is a visual one. Look for anything protruding from the snow and also for clothing and personal items that may have been ripped off. These may give some clue to the burial spot. This hasty search is vital.

If your visual search is unsuccessful, the slope should be probed in a systematic manner with whatever is available. The area of maximum debris accumulation is searched first. If this is not successful, check any places in the avalanche's path where the victim could be buried. A human body is bulky and is likely to be thrown towards the surface or to the side.

Group search

If a large number of people are available then a group search will be the most efficient search technique. To understand the difficulty of searching for avalanche victims, it should be noted that a coarse search could take 20 people four hours to cover a 100 square metre area. The chance of finding a victim with a coarse search is 76%. A fine search over the same area takes 16-20 hours. Figure 22.5c shows the spacing between searchers and the spacing of probe holes.

- Avoid duplication of the search areas by using flags or other markers to show where you've been. Above all, be systematic.
- If your probe finds something buried in the snow, dig down gently. It would be unfortunate to shovel-damage an otherwise healthy survivor. Remember the victim could be trapped vertically as

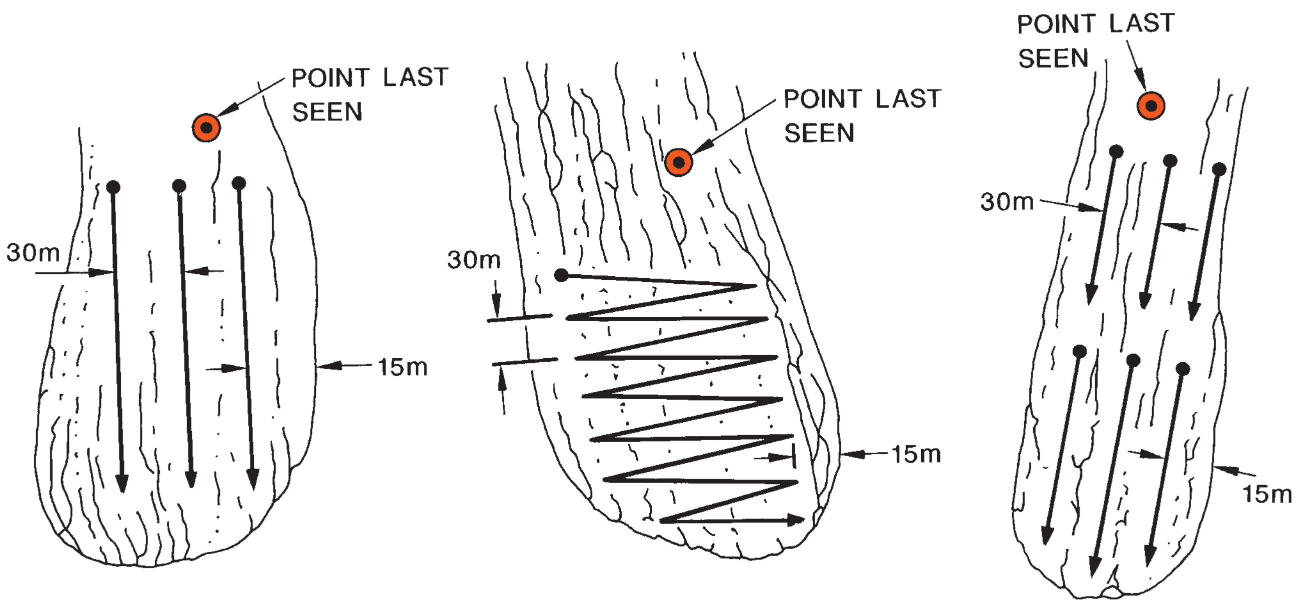

Figure 22.5a Type 1 hasty search patterns for one team (left and centre) and two teams (right)

well as horizontally or any other way in between.

- If the victim is alive, they will probably be suffering from a combination of shock, hypothermia and cold tissue damage. Other injuries such as fractures and lacerations may also be present. Guard against the patient having a spinal injury (see Kurafid).

At some stage the team leader may have to decide to abandon the search.

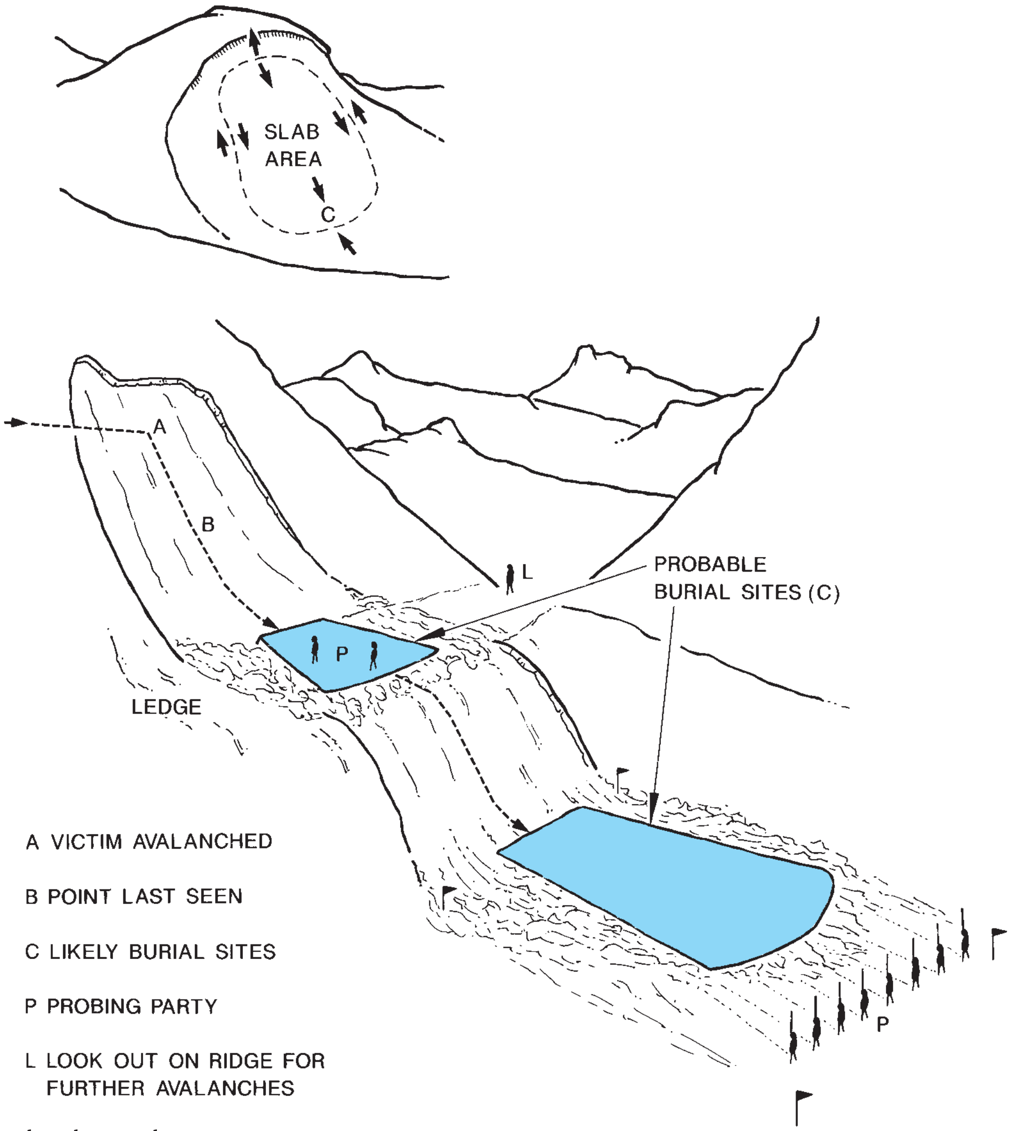

Figure 22.5b Avalanche track

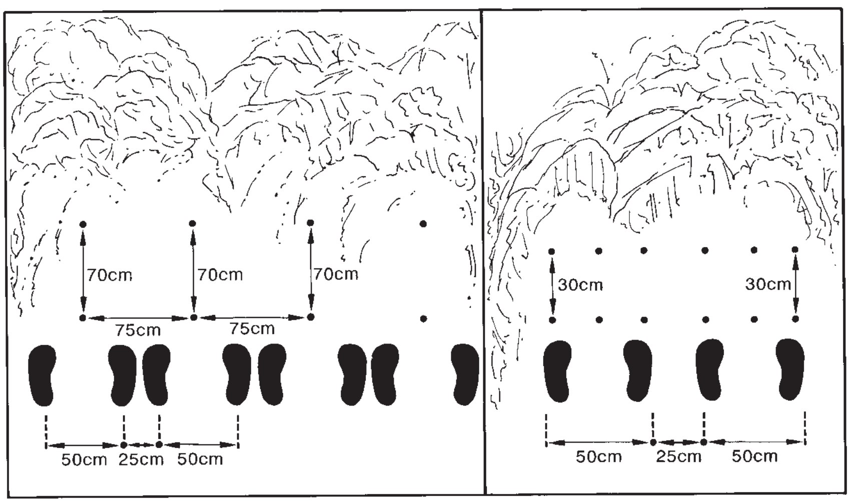

Figure 22.5c Probe spacing

24 Field huts

Introduction

BAS uses a variety of field huts and cabooses. Some are modular structures that can be taken apart and moved, while others are fixed installations. They may be wooden, fabric or fibreglass shelters. Some huts are fully equipped, while others require additional equipment.

These huts are used for recreation, fieldwork and as emergency refuges. Any hut-specific instructions should normally be posted inside. Hut information will also be held at the stations.

Do not rely on getting to a hut when travelling. Always remain independent with normal survival and camping equipment.

24.1 Considerations when using huts

It is very important to use huts considerately. A number of procedures should be followed that will make life easier for everyone:

- Leave the hut clean and tidy, even if it wasn't when you arrived. Take away your rubbish in accordance with Chapter 19 and do not leave part-opened food. In some huts there is a policy of leaving no food, apart from emergency boxes.
- Before you depart, fill stoves, lanterns and heaters so they are ready for others. Report fuel stocks and any problems when back on station.
- Do not open emergency clothing, food or fuel unless absolutely necessary.
- Daily radio scheds are necessary when living in huts. The times and type of communication must be established before you leave station.
- Some huts have logbooks and these should be filled in. If you go out, leave a note stating your intentions. Your intentions for the day should also be given over the radio. Remember that if you are overdue, a SAR callout may be initiated.
- Make sure that you have an organised plan for toilet matters if no specific hut policy exists. Do not foul the area around a hut.
- Huts such as Horseshoe, Blaiklock and Stonington are designated Historic Sites and Monuments (HSMs). It is important that these buildings are treated with due consideration. Snow and ice can do irreparable damage to buildings in a short space of time so make sure that doors and windows are secured correctly. Do not remove artefacts as their historical value is integral to the hut. Report the condition of infrequently visited huts to the FOM or BC.

24.2 Risks in huts

The two greatest risks in huts are fire and carbon monoxide poisoning.

Fire

Most huts will have no fire detection and these buildings may be very flammable. Although fire extinguishers and fire blankets are provided in huts used for accommodation, extreme care should always be taken. Cooking, heating and light are generally provided by paraffin appliances. Make sure these are functioning properly and repair them if they are not.

Carbon monoxide

Carbon monoxide poisoning is a very real risk when living in huts. Keep the hut well ventilated when using appliances. Make sure any vents are open and check they are not iced-up. See Section 5.5 and Kurafid for further information on carbon monoxide poisoning.

24.3 Refleks stoves

Many field huts are fitted with Refleks stoves. These are run on paraffin, although Avtur can be used in an emergency. **Do not use petrol in a Refleks stove.**

Before using a Refleks stove it is essential that you have received some training from a competent person. Instructions for these stoves should be available in the hut.

25 Northern Peninsula and helicopter operations

Introduction

Northern Peninsula operations differ from normal fieldwork in that helicopters are often used instead of Twin Otters and ATVs (all terrain vehicles or quad bikes) are normally used instead of Ski-Doos. Boats may also be used for input. Whatever the mode of transport the same rules, principles and procedures apply as for normal BAS field operations.

BAS does not operate helicopters. The Royal Navy ship HMS *Endurance* (HMSE) provides Lynx helicopter support for BAS operations that require this method of input and access. These helicopters have a limited range, will not fly in poor visibility and have a limited internal load area compared to a Twin Otter. However they can access very small landing sites and can fly in high winds.

When working with the *Endurance* helicopters it should be remembered that, as well as the demands of BAS fieldwork, they have to service the needs of the ship, hydrological surveying and station visits by the Captain.

25.1 Safety issues

As with normal field operations it is essential that you have your standard survival gear with you at all times. When being transferred or uplifted, think carefully about your loads. The essentials of the half-unit survival gear (see Chapter 11) must stay with a field party if they are to remain on the ground. You must ensure that **your basic survival gear** is with you at all times on **your aircraft.**

Even for the shortest of transfer flights, no one should be left on the ground alone and survival equipment must be retained until uplift of personnel. This must include a radio that should be tested before the aircraft departs.

Safety around helicopters

- Never stand on or near the landing area when a helicopter is making an approach. Remain behind cover or stand far enough away to avoid injury in the event of an accident.
- Do not approach the aircraft until given a thumbs-up sign by the pilot. Always follow instructions from crew.
- Don't rush when moving around a helicopter - think about what you are doing.
- Approach and leave from the front of the aircraft, staying within sight of the pilot.
- Approach the cargo door keeping your head well below the level of the rotor disc.
- Take care if the aircraft is on a slope. Approach from the downhill side. On the uphill side of the helicopter the clearance between the rotor and the ground will be reduced.
- Wear the clothing provided including ear defenders and helmets. Ensure that clothing is secure.
- Keep a firm hold of equipment being carried. The turbulence under the rotors can be severe.
- If you are responsible for ground control during disembarkation, give clear hand signals as to where people should go. They should disembark forward of the aircraft to remain within sight of the pilot. Make sure anyone else is well outside the landing area and not on the line of approach or overshoot.
- All equipment should be stowed securely for uplift. Ensure that nothing can blow away or get into the rotors. It is advisable to lie down on top of your kit during a landing.
- Do not marshal helicopters unless specifically asked to do so by the pilot.
- No one should smoke within 50 metres of stationary or moving helicopters.

25.2 Landing sites

Safety considerations

On arrival at a site, the following factors must be taken into account:

- **If a landing site is potentially unsafe, for example on a tidal beach, there must be an exit to safe ground or the helicopter must stay with the party.**
- Beach landing sites should be away from dangerous cliffs. When assessing beach sites you should consider the risk of it being swamped by waves created by the weather, ice-cliff collapse or overturning icebergs.
- Assess cliff stability. Prior agreement should be reached with the pilot about the suitability of a landing site. The pilot is responsible for flight safety and the ultimate decision will be his/hers.
- Even suitable looking sites can be hazardous. Before committing to input, make a thorough assessment of risks such as weather and tidal range.
- Check your radio works before committing to a site and arrange any necessary scheduled calls.

Helicopter input is relatively swift and straightforward but don't assume that extraction will be. Remember that uplift could be delayed for various reasons.

- Do not rush decisions.
- Do not commit to a location if unsure of its suitability.
- Take all the required safety equipment and ensure that it can be moved to a safe campsite if necessary.

Landing site considerations

Although the pilot and navigator will make the final decision, BAS staff must try to ensure that a suitable landing site is chosen.

If awaiting a pick-up, the most suitable landing spot should be marked and essential information concerning it passed to the aircraft or the control ship. Stamp down and compact any snow in the landing area to prevent blowing snow obscuring the pilot's vision.

The pilot's primary concern will be a clear approach path, free from overhead obstructions. Wherever possible choose a flat landing spot with good landing-gear clearance. Boulders will prevent a touchdown and the aircraft may hover instead of landing.

In strong winds the pilot may require a smoke flare. Smoke flares must only be used by consent of the pilot and discharged downwind of the landing area.

25.3 Helicopter loads

Internal

Lynx helicopters have a very limited internal load-space. Both cargo and passenger space on Lynx helicopters is limited by volume rather than weight. Objects longer than 1.8 metres need to be stowed diagonally and personal belongings and equipment need to be packed tightly to maximise space. In addition, safety considerations limit the number of passengers (pax) onboard.

Under-slung

The Lynx helicopter has a maximum payload of 1500kg and most items can be carried in an under-slung cargo net. If nets are used, *Endurance* ground crew will have to be put on the ground. This will result in extra flights as the crew are taken out in advance of the load-carrying flight.

Large objects need specific flying permits (Joint Air Transport Establishment Clearance) that must be issued in advance in the UK. Long, thin objects are a particular problem. Pyramid tents have to be flown in 'the large black box'.

External loads will only be flown short distances as the observer must watch the load throughout the flight by looking out of the door or window. Flying time will be limited to about half an hour, so the maximum distance that can be covered is approximately 20km.

In order to stop the load flapping around, there is also a minimum weight for under-slung loads.

Fuel

Fuel must be stored in sealed, metal jerry cans. Only completely full or empty and vented jerries will be carried and careful planning is needed to avoid fuel being left behind. Small amounts of meths and paraffin in pots boxes is generally not a problem.

Load sheets

Although BAS aircraft load sheets are recorded in pounds, the *Endurance*'s helicopter crews use kilograms. Metric load dimensions are also required by *Endurance* in advance of a flight. A photograph can help to give the pilots some idea of the loads involved. Ensure that all sharp points are well covered or taped.

Separating loads

The senior pilot usually takes responsibility for splitting cargo loads and deciding on their flying order. Ensure the loads are clearly identifiable before taking them to the flight deck.

It is important to specify which kit must fly with personnel so as to comply with BAS travel regulations. This includes emergency tent, P-bags, pots box with spare food, personal bags, HF and VHF radio and Iridium phone.

25.4 HMS *Endurance* helicopters - general information

Flight plans

It is important to liaise with the senior pilot as early as possible to help with their advance planning. Flight plans are only worked out in detail the night before a flight. At this point the pilot must have clear details of final loads and intentions. Do not change your loads after this time as this could compromise the whole operation. Sort out pick-up arrangements at this time otherwise plans will be made without your input.

Maps
It is worth bringing an extra copy of your location maps to give to the helicopter observer (co-pilot). They will also need a photocopy of landing restriction details for Antarctic Specially Protected Areas (ASPAs). These should be contained within the ASPA permit.

Flight briefing
A flight briefing is held every morning at 08:00 prompt on the Bridge to confirm the day's plans. Attendance is compulsory for all personnel who are flying from the ship. All BAS personnel who are flying must also sign their flight authorisation. The flight brief is wher you will receive your instructions, it is not the time for discussion.

Communications
Helicopters use International Marine VHF channel 10 with channel 16 as a back-up. BAS VHF radios will scan more than one channel so make sure you are familiar with VHF radio operation.

HMSE uses location as the call sign, not the BAS sledge name. *Endurance* can generally be contacted on VHF channel 10 for line-of-sight communications. Check to confirm flight plan details half an hour before pick-up. The *Endurance* can be difficult to contact on HF so make arrangements with their comms room before flying.

In-flight communication
The noise inside a helicopter makes communication difficult. If you need to talk to the pilots during the flight, make arrangements before boarding so that a headset can be supplied. A small pen and board tied together can be useful as long as it can be stowed safely.

Drop-off
Wait for the pilot or observer's signal before releasing seat belts and opening the sliding doors. The flight crew may get out first to check the site. If you are unhappy with the site make this clear before unloading. Check your radio comms are operational before the helicopter departs.

Unload the kit and lie on top of it while waiting for the helicopter to take off. There is considerably less downdraught below the rotor disk than off to one side. Survival suits may be left with you during away-days or they may need to be packaged into postbags and returned on the helicopter.

Pick-up
Expect a VHF call two to five minutes before the helicopter's arrival. Kit should be divided into separate loads otherwise equipment can be left behind if the last load overfills the helicopter. Suit up and lie on top of the kit as the helicopter approaches. Do not approach the helicopter except from near the front and with the approval of the aircrew.

Do not rush - safety always comes first.

25.5 ATVs (all terrain vehicles)

BAS uses ATVs (all terrain vehicles, also called quad bikes) in ice-free areas to support geological and terrestrial biology projects. The use of ATVs over glaciated terrain is very unlikely on northern Peninsula projects.

ATV use
The same points regarding refuelling and driving at low speeds apply as for Ski-Doos. Helmets must be worn and ATVs should not carry passengers. The type of terrain these vehicles can cover is generally limited by the ground clearance of their sump protectors.

ATV load carrying
In the field, trailers are usually used with ATVs. They are capable of towing 400kg, but 200kg to 250kg is the practical load limit. The weight must be balanced over the axles of the trailer. If this is not done correctly the towing hitch can be overloaded or conversely the rear wheels of the ATV may be un-weighted.

Extreme caution should be exercised when towing trailers. Take particular care during sharp turns. Trailer stability is reduced on side slopes where there is an increased risk of overturning.

The front carrier can take up to 30kg and the rear carrier up to 60kg.

25.6 ATV riding hints

Safety matters
- Keep your speed down. Careful, safe riding will avoid injury and damage.
- Wear a helmet.
- Do not carry passengers.
- Use the kill switch to cut the engine in an emergency.

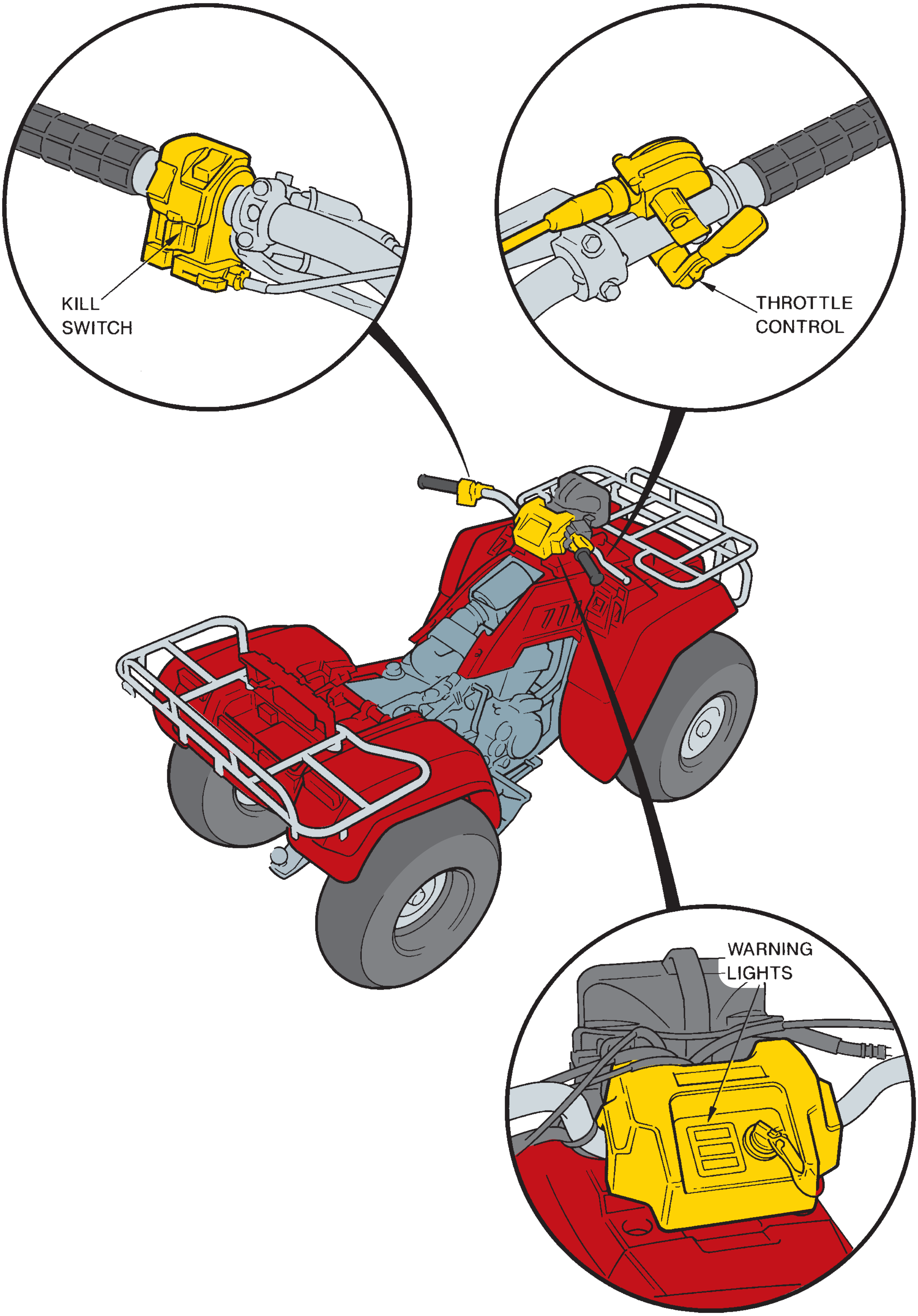

Figure 25.6 ATV controls

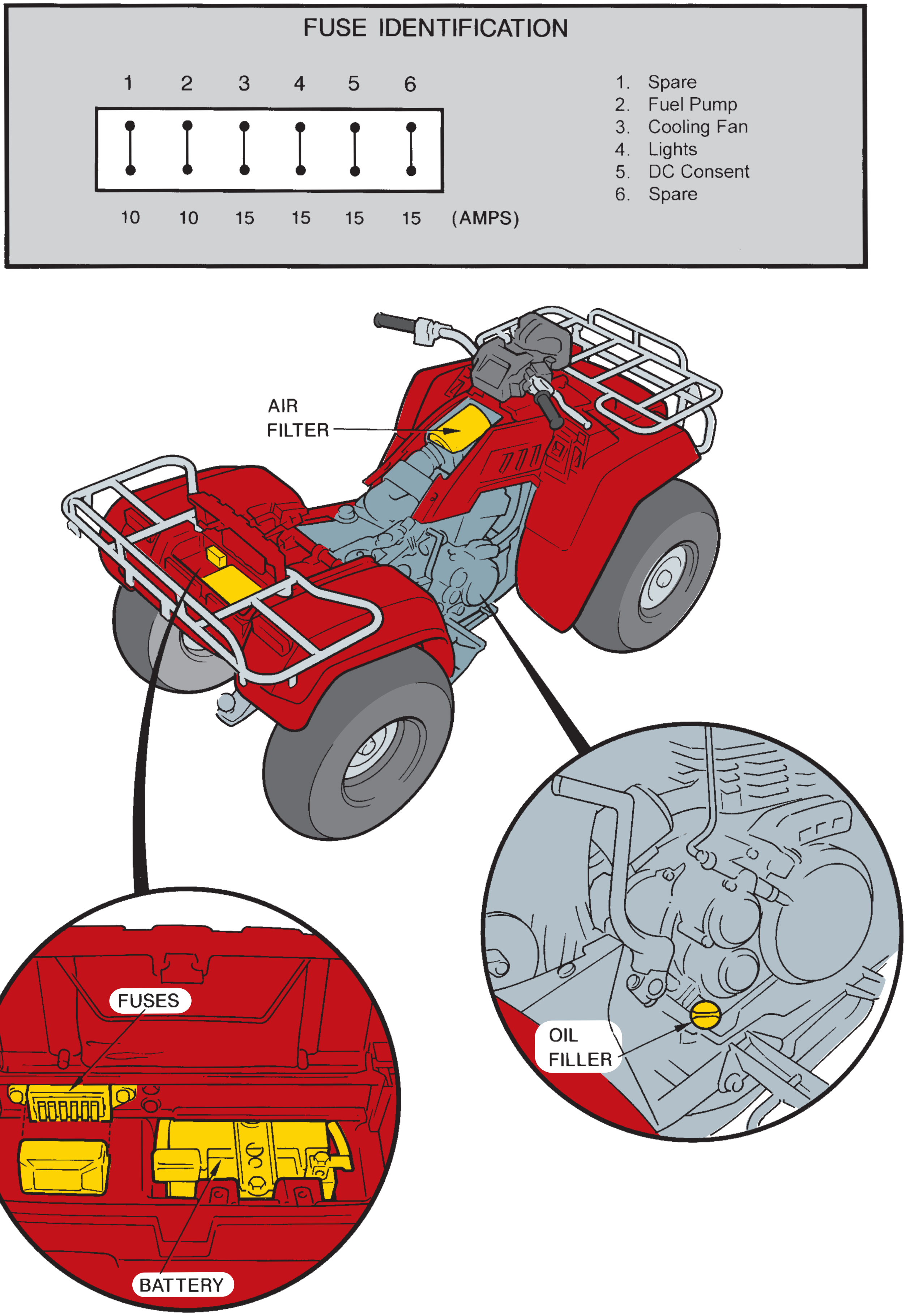

Figure 25.7 **ATV parts**

When pulling a load over boggy ground or deep snow, it may be necessary to dismount the vehicle and walk along beside it. Take care not to drive the machine over your feet. Tuck loose clothing out of the way to avoid it getting caught in the machine.

ATVs will float in deep water but do not cross very deep water as the vehicle could invert.

25.7 Spares and maintenance

Field repairs are not a simple matter on these complex, four-stroke machines. Consequently the spares package is far less comprehensive than with a Ski-Doo.

25.8 ATV fuel consumption

As with Ski-Doo travel, the figures for fuel consumption vary greatly. Factors such as the load carried, the type of terrain and snow cover will all affect fuel consumption.

In good conditions, **five to seven kilometres per litre** should be used for planning purposes. The tank capacity is eight and a half litres with a two litre reserve. The fuel tap position must be changed to engage the reserve fuel.

26 Appendices

26.1 Sea-ice theory

Initial ice formation
Consolidation and development
Sea-ice terminology

26.2 Equipment lists

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ATV unit
Boat, helicopter and aircraft day-landings

26.3 Facts and figures

Equipment weights
Fuel weights
Ski-Doo fuel consumption
ATV fuel consumption
Paraffin usage
Meths usage
Conversion tables

26.4 Glossary

26.5 Trade names

26.1 Sea-ice theory

Initial ice formation

At the start of the Antarctic winter, the ocean surface cools rapidly as the air temperature drops. The sea will start to freeze when the surface water temperature reaches approximately -1.8°C. The freezing point of seawater is dependant on its salt content, with the freezing point falling as the salinity increases. At 30% salinity, seawater will freeze when it reaches -1.63°C.

As the sea cools and the surface begins to freeze, **frazil-ice** crystals start to form in the water, giving it an oily appearance. These ice crystals float to the surface to create a soupy layer of ice spicules and plates called **grease-ice**. Calm conditions during this initial freezing period will result in an **ice-rind** forming on the surface.

As the temperature continues to fall, the surface ice coagulates into a solid layer. Wind and waves break this layer into irregular cakes that collide with each other to form **pancake-ice**. These pancakes may freeze together and break up several times before forming into a solid cover. The initial elastic crust that forms on the surface of the sea is referred to as **nilas**.

All of these types of ice are termed **new-ice**. This is a general term for recently formed ice. During these initial stages of formation new sea-ice grows quickly.

Consolidation and development

Given the right conditions, the ice will gradually increase in thickness and will become either **pack-ice** or **fast-ice**. Ice attached to the coast is called fast-ice. Pack-ice is not attached to the coast and is moved by the wind and ocean currents.

Pressure and movement will cause both fast-ice and pack-ice to deform and fracture. This can be caused by the wind, swell, tidal movement and coastal glaciers.

Unless the sea-ice is broken up by wind and ocean swell, it will continue to build over the winter, reaching its maximum thickness around October. After this time the ice weakens as it rots or is swept away and broken up by wind and waves.

Salinity decrease in old sea-ice

Sea-ice consists of clear ice crystals that enclose a multitude of small cavities filled with highly saline water. The ice will become less saline as the salt dissolves down through the ice and is eventually carried away. After one or more summers, sea-ice will be pure without any salt content. Melt-water that forms in pools on the ice surface in summer will be fresh water.

Specific weight of sea-ice

Sea-ice is approximately nine tenths the density of seawater so only one tenth is seen above the sea's surface. Snow cover on the sea-ice will cause it to sink.

Glacier ice has approximately the same specific weight as sea-ice. Melting glacier ice is recognised by a crackling sound. The air bubbles trapped in glacier ice are under pressure and burst as the ice melts.

Sea-ice terminology

Forming sea-ice

Frazil-ice Fine spicules or plates of ice suspended in water.

Grease-ice A later stage of freezing than frazil-ice when the crystals have coagulated to form a soupy layer on the surface. Grease-ice reflects little light, giving the sea a matt appearance.

Slush Snow which is saturated and mixed with water on land or ice surfaces or as a viscous, floating mass in water after a heavy snowfall.

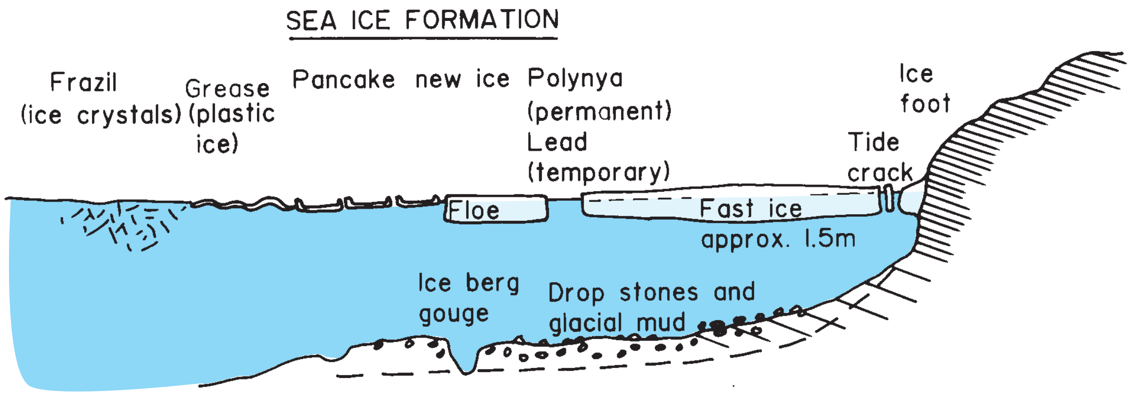

Figure 26.1a **Sea-ice formation**

Illustration reproduced by kind permission of the Australian Antarctic Division.

Shuga An accumulation of spongy white ice lumps a few centimetres across. They are formed from grease ice or slush.

Ice rind A bright, shiny crust of ice formed on a quiet surface.

Nilas A thin, elastic crust of ice.

Dark nilas Nilas under five centimetres thick and dark in colour.

Light nilas Lighter in colour than dark nilas and more than five centimetres thick.

Developing sea-ice

Young ice Ice in the transition stage between nilas and first year ice, 10-30cm in thickness.

Grey ice Young ice, 10-15cm thick.

Grey-white ice Young ice, 15-30cm thick

First year ice Sea-ice not older than one winter.

Thin first year ice/white ice First year ice, 30-70cm thick.

Medium first year ice First year ice, 70-120cm thick.

Thick fist year ice First year ice over 120cm.

Old ice Sea-ice that has survived at least one summer's melt.

Second year ice Thicker and less dense than first year ice. In contrast to multi-year ice, summer melting produces a regular pattern of numerous small puddles.

Multi-year ice Three or more metre thick ice that has survived at least two summers. Hummocks are even smoother than in second year ice and the ice is almost salt free. Colour where bare is usually blue.

Forms of floating ice

Sea-ice Any form of ice found at sea which has originated from the freezing of seawater.

Pancake ice Circular pieces of ice ranging from 30cms to three metres in diameter and up to 10cm thick. They have raised edges due to the pieces striking against one another. Pancake ice can be formed on a slight swell from grease ice, shuga or slush. They can also form due to the break-up of ice rind or nilas. As this ice can also form at depth, it may appear rapidly, covering large areas of water. At depth it forms at the interface of water bodies with different physical characteristics.

Floe Any relatively flat piece of sea-ice more than 20 metres across. Floes are subdivided according to their horizontal extent - Giant > 10km, Vast 2-10km, Big 500-2000m, Medium 100-500m and Small 20-100m across.

Ice cake Any relatively flat piece of sea-ice less than 20m across.

Floeberg A massive piece of sea-ice composed of a hummock or a group of hummocks frozen together and separated from any surrounding ice. It may float up to five metres above sea level.

Ice breccia Ice pieces of different ages frozen together.

Brash ice Accumulations of floating ice made up of fragments not more than two metres across. The wreckage of other forms of ice.

Ice of land origin Ice formed on land or in an ice shelf, found floating in water. The concept includes ice that is stranded or grounded.

Lake ice Ice formed on a lake, regardless of observed location.

Fast-ice

Fast-ice Sea-ice which forms and remains attached to the coast. It can be attached to the shore, to an ice wall, to an ice front, between shoals or to grounded icebergs. Vertical fluctuations may be observed during changes of sea level. It may extend a few metres or several hundred kilometres from the coast.

Ice shelf Fast-ice more than two metres above sea level.

Young coastal ice The initial stage of fast-ice formation consisting of nilas or young ice, its width varies from a few metres up to 100-200m from the shoreline.

Ice foot A narrow fringe of ice attached to the coast, unmoved by tides and remaining after the fast-ice has moved away.

Anchor ice Submerged ice attached or anchored to the bottom.

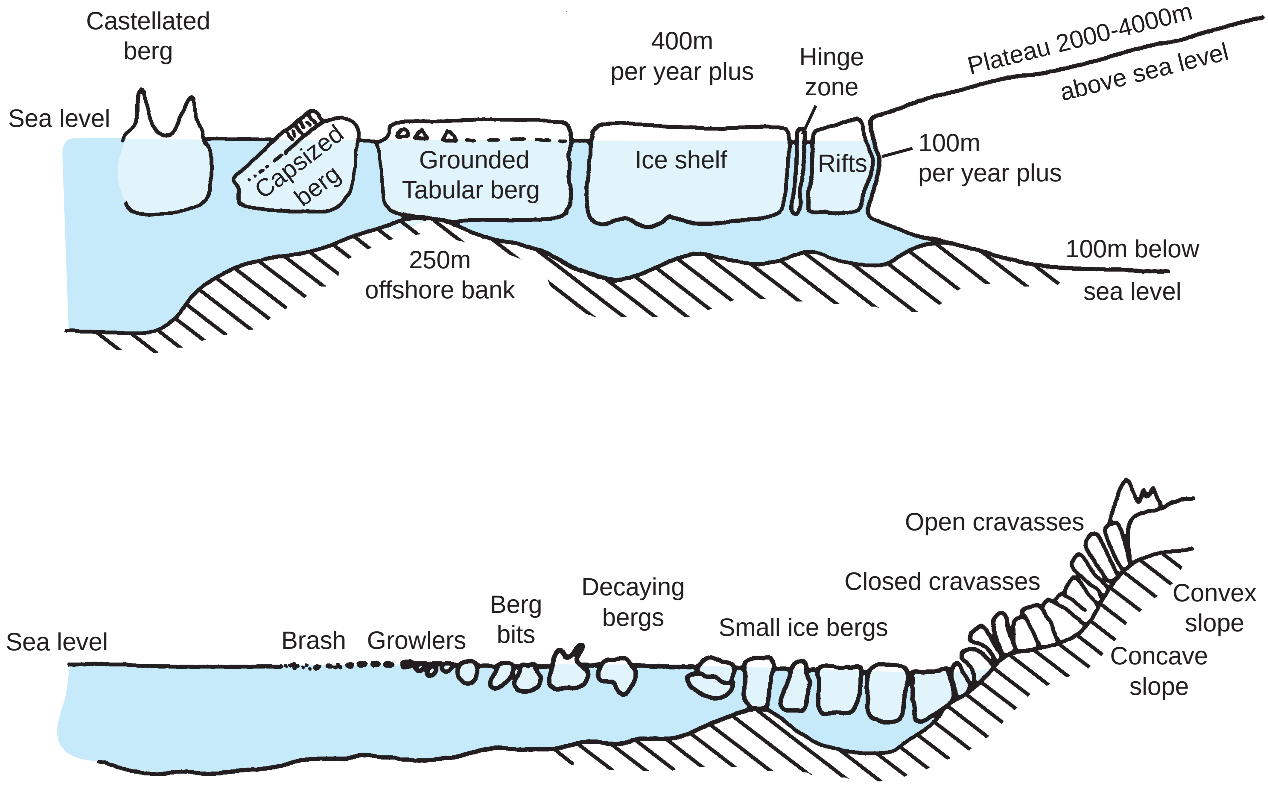

Figure 26.1b Icebergs

Illustration reproduced by kind permission of the Australian Antarctic Division.

Grounded ice Floating ice that is aground in shoal water (stranded ice).

Pack-ice

Pack-ice Sea-ice not attached to the coast. Pack-ice concentration is dependant on wind and ocean currents.

Ice cover

Concentration The ratio of an area of ice compared to the total area of sea surface not covered by ice. The ratio is given in tenths of sea surface covered by ice. Varies from compact (10/10), very close (9/10), close (7,8/10), open (4-6/10) and very open (1-3/10).

Types of ice cover

Ice field Area of pack-ice consisting of any size of floes, which is greater than 10km across. Large > 20km, Medium 15-20km and Small 10-15km.

Ice patch An area of pack-ice less than 10km across.

Ice massif A concentration of sea-ice covering hundreds of square kilometres, which is found in the same region every summer.

Belt A large area of pack-ice longer than it is wide, ranging in width from one kilometre to more than 100km.

Tongue A projection of the ice edge up to several kilometres in length, caused by wind or current.

Strip Long narrow area of pack-ice, about one kilometre or less in width.

Ice edge The demarcation between open sea and sea-ice of any kind. This ice can be fast or drifting, compact or diffuse.

Bight An extensive crescent-shaped indentation in the ice edge, formed by either wind or current.

Ice jam An accumulation of broken river or sea-ice caught in a narrow channel.

Ice deformation

Deformed ice A general term for ice that has been squeezed together and in places forced upwards and downwards.

Level ice Ice unaffected by deformation.

Fracturing Pressure process whereby the ice is permanently deformed and rupturing occurs.

Rafted ice Type of deformed ice formed by one piece of ice over-riding another.

Finger rafting Floes join together as interlocking fingers which raft over and under each other.

Ridge A line or wall of broken ice up to 30 metres thick formed by pressure. The submerged volume of broken ice under a ridge is termed an ice keel.

Hummock A hillock of broken ice that has been forced upwards by pressure. The submerged volume of broken ice under the hummock is termed a bummock.

Weathering Ablation and accumulation gradually eliminate irregularities in an ice surface.

Fracture Any break or rupture through very close pack ice, consolidated pack-ice, fast-ice or a single floe resulting from the deformation processes. Length may vary from a few metres to many kilometres.

Crack Any fracture that has not parted.

Tide crack Crack at the junction between an immovable ice foot or ice wall and fast-ice.

Flaw A narrow separation zone between pack-ice and fast-ice, where the ice is in a chaotic state. It forms when pack-ice shears under the effect of a strong wind or current along the fast-ice boundary.

Fracture zone An area that has a great number of leads.

Lead Any lead or passage through sea-ice that is navigable by surface vessels.

Polynya Any non-linear shaped opening enclosed in ice. Polynyas may contain brash ice and/or be covered in new ice, nilas or young ice.

Stages of melting

Puddle An accumulation of melt-water from surface snow and, in the more advanced stages of melting, the ice.

Thaw holes Vertical holes in sea-ice formed when surface puddles melt through to the underlying water.

Dried ice The remaining sea-ice surface after melt-water has disappeared through cracks and thaw holes. During the drying period the surface whitens.

Rotten ice Honeycombed sea-ice in an advanced state of disintegration.

Flooded ice Sea-ice which is heavily loaded by melt-water, river water or wet snow.

Indications of open water/ice

Water sky Dark streaks on the underside of low clouds that indicate the presence of open water.

Ice blink A whitish glare on the underside of low clouds that indicates the presence of ice in open water.

Frost smoke Fog can appear over openings in the ice or leeward of the ice edge when relatively warm, moist air cools as it mixes with the colder air over the ice. This causes the moisture-laden air to condense and form frost smoke.

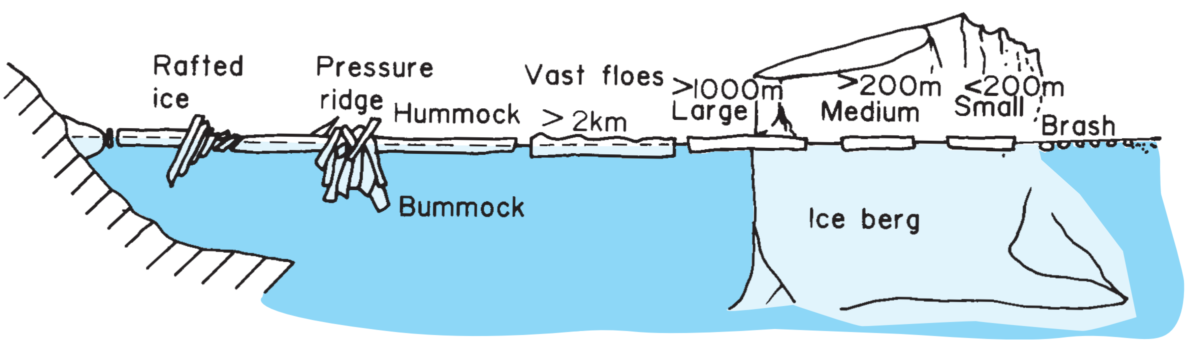

Figure 26.1c Pack-ice

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26.2 Equipment lists

Introduction

The following lists comprise the minimum safe equipment to be taken on a given type of trip. Additional items may be taken to make the trip easier and more comfortable. The local travel regulations dictate what equipment should be taken for recreational and scientific field trips near the station.

Sledge unit

The following gives a breakdown of the equipment needed for a two-person sledge party, using Ski-Doos as the mode of transport.

A half-unit will have the same equipment packed in the unit boxes. Smaller quantities of some equipment needs be taken for half-unit travel and some equipment is omitted altogether. See Section 26.4 for weights.

A static field unit will be equipped with very similar items, minus the Ski-Doos, sledges and associated travel equipment. It is important that static field parties take a small assortment of tools as there will be no Ski-Doo box with them to provide tools.

Transport (2003)

- ○ 2 Ski-Doos modified for field use with encircling wire strop.
- ○ 2 Nansen sledges (with centre lines).
- ○ 2 Towing Maillon and shackle on back of Ski-Doos.
- ○ 2 Towing shackles on front bumper of Ski-Doos.

Ski-Doo seat box/under-seat tool kit (one of) breakdown of contents:

- ○ 1 Large filter funnel with snow brush to clean snow off jerries.
- ○ 1 Spare towing shackle and Maillon.

Tentage (2003)

- ○ 1 Pyramid tent wrapped in its ground sheet with 4 x tent ties and tent bag.
- ○ 1 Peg bag with 9 x aluminium tube pegs (90cm) or 9 x angle iron pegs, 9 x aluminium short, narrow gauge tube pegs (75cm) or 9 x angle iron valance pegs (depending on ground type), lump hammer and snowbrush.
- ○ 1 Pup tent wrapped in a pyramid tent ground sheet with 8 x aluminium, narrow gauge tube pegs (75cm). Skis and poles can be used as additional pegs.

The following tables describe the contents of the various field boxes and sacks. Again this is the minimum required equipment and other items may be added to ease efficiency.

Note that emergency clothing bags should have their contents sealed inside waterproof, dry bags.

Comprehensive clothing must be taken on all fieldtrips. For all trips, take both sunglasses and goggles and lots of spare gloves, headwear and socks. Additional items such as neoprene overboots, down clothing, onitsukas, special gloves and mitts can be obtained from the clothing store or from Cambridge by prior arrangement through the FOM. All Ski-Doo parties will need to take mukluks as well as plastic boots.

Boxes (2003)

- ○ 1 Inside food box (beige).
- ○ 1 Pots box (blue).
- ○ 1 Tent box (yellow).
- ○ 1 Radio box (red).
- ○ 1 Ski-Doo spares box (black).
- ○ 1 Spares box (orange).
- ○ 1 Medical box (plain wood) (includes 2 x immediate aid packs. Contents as stipulated by BASMU).
- ○ Field ration boxes - sufficient for field trip with 30 days surplus minimum. More required for certain locations.

Fuel (2003)

- ○ 16 Ski-Doo fuel jerries. This is the maximum that will fit on the jerry rack. Fewer may be required for recreational trips or more static field parties.
- ○ 2 Paraffin jerries - sufficient for one litre per person per day for the field trip, with 30 days surplus minimum. Always maintain a 30 day reserve*. (See Chapter 14).
- ○ 2 Jerry boards.
- ○ 2 Sleep boards.

(*An additional jerry is required for winter trips)

General (2003)

- ○ 2 Emergency clothing kitbags (breakdown follows).
- ○ 2 Rescue sacks (breakdown follows).
- ○ 1 Link line bag with spare link line and spare safety lines.
- ○ 10 Flags and bamboos.
- ○ 2 P-bag, plastic bag lined, containing sleeping bag in sleeping bag cover, fleece inner sleeping bag, cotton sleeping bag liner, sheepskin, Thermarest or Lilo, Karrimat, bivvy bag, tent guy and pee bottle.
- ○ 2 pairs skis, sticks and skins (stored in bag).

Rescue sacks

Two total, one per sledge/Ski-Doo. There are different ways of carrying the rescue sacks, however, in most circumstances it is safer to carry the sacks on the back of the Ski-Doo. Some technical equipment needs to be removed from the rescue sack for personal use. See below for equipment per person on each Ski-Doo. This list constitutes the minimum equipment for over-snow Ski-Doo travel.

- ○ 2 Snow stake.
- ○ 1 Ice hammer.
- ○ 1 Ice axe.
- ○ 1 Pair crampons (make sure spares in spares box are compatible).
- ○ 1 Climbing helmet.
- ○ 1 Harness.
- ○ 10 Screw-gate karabiners.
- ○ 1 Pair Jumars.
- ○ 1 Pair Prusik loops.
- ○ 6 Ice screws.
- ○ 1 Figure of eight descender.
- ○ 4 Tape slings.
- ○ 4 Swing cheek pulleys.
- ○ 1 45 or 50m, 11mm Kernmantel dynamic rope (chained).
- ○ 1 100m, 7/8 mm hawser (dynamic).
- ○ 1 50m, 11mm static.
- ○ 4 Rock pegs including angles, kingpins, knife blades.
- ○ 1 Electron ladder.
- ○ 1 Jockey winch with lifting strop, handle, hang wire x 2.
- ○ 1 Jumar, spare, besides personal issue pair.
- ○ 1 Mini flare kit*.
- ○ 2 Orange handsmoke*.
- ○ 1 Red parachute rocket*.
- ○ 1 Pinpoint red handflare*.

(*Pick up from "Haz" store prior to deployment)

Equipment per person on each Ski-Doo (2003)

- ○ 1 Personal safety line (6m dynamic rope) and karabiners.
- ○ 1 Ski-Doo helmet.
- ○ 1 Bog chisel.
- ○ 1 Shovel, steel shafted only.
- ○ 2 Snow stakes*.
- ○ 1 Ice hammer *.
- ○ 1 Ice axe *.
- ○ 1 Pair crampons* (pre-fitted to boots).
- ○ 1 Climbing helmet* (pre-fitted).
- ○ 1 Harness* (pre-fitted).
- ○ 10 Screw-gate karabiners * on harness.
- ○ 1 Pair Jumars* (pre-fitted) on harness.
- ○ 1 Pair Prusik loops* on harness.
- ○ 3 Ice screws * on harness.
- ○ 1 Figure of eight * on harness.
- ○ 4 Tape slings * on harness.
- ○ 4 Swing cheek pulleys * on harness.
- ○ 1 20-25m forward probe rope and shunt (Field Assistant's Ski-Doo only).
- ○ 1 Immediate aid pack (from medical box).
- ○ 1 Each lock knife, compass and whistle. Maps as necessary.
- ○ 1 GPS as necessary.
- ○ 1 Notebook and pencil.

One 50m, 11 mm Kernmantel dynamic rope is required to be carried on the Ski-Doo if the rescue sack is not onboard.

(* All taken from the rescue sacks)

Link line bag (before using for linked travel)

- ◯ 1 30m, 20mm link line.
- ◯ 2 10m, 20mm tow ropes.
- ◯ 2 6m, 11mm dynamic safety rope.
- ◯ 1 Spare 30m, 20mm link line (with only one eye splice).

Emergency clothing contents (2003)

- ◯ 1 Pair socks.
- ◯ 1 Thermal long sleeve top.
- ◯ 1 Thermal long-johns.
- ◯ 1 Thin fleece.
- ◯ 1 Fleece jacket.
- ◯ 1 Pair fleece trousers or salopettes.
- ◯ 1 Ventile/Gore-Tex jacket.
- ◯ 1 Pair Ventile/Gore-Tex salopettes (replace with a “doo suit” for sea ice travel).
- ◯ 1 Pair polypropylene liner gloves.
- ◯ 1 Pair fleece gloves.
- ◯ 1 Pair work gloves.
- ◯ 1 Pair warm mitts (pile and outer two part mitt).
- ◯ 1 Balaclava.
- ◯ 1 Head over.
- ◯ 1 Pair sunglasses.
- ◯ 1 Pair goggles.
- ◯ 1 pair Boots for each person in the party.

Pots box contents (Blue)(2003)

- ◯ 1 Vapalux lamp with oven cloth wrap.
- ◯ 1 Primus stove with pot ring, legs and tank lid (Model 45K).
- ◯ 1 Set of pans with lids and handles (with small mug inside pan set).
- ◯ 1 Syphon tube.
- ◯ 2 Meths dispensers.
- ◯ 1 Small filter funnel.
- ◯ 1 0.6 litre bottle of meths (silver).
- ◯ 2 One litre paraffin transfer bottle (blue).
- ◯ 1 Cleaning kit containing scourers, J-cloths and tea towels.
- ◯ 12 Box matches in sealed tin.
- ◯ 1 Cooking board.

Primus spares Model 45K containing:

- ◯ 1 Burner with connector tube.
- ◯ 3 Nipples.
- ◯ 1 Tank lid with air screw (ensure correct model).
- ◯ 1 Pump complete with spare tank lid on handle.
- ◯ 3 Pump leathers or neoprene ‘O’ rings.
- ◯ 2 Pump valve complete.
- ◯ 3 Burner connector tube washers (lead).
- ◯ 8 Fibre burner washers.
- ◯ 3 Spare legs.
- ◯ 4 Pkts jet prickers.
- ◯ 1 Nipple spanner.
- ◯ 1 Pump valve spanner.
- ◯ 2 Burner spanner.

Vapalux lantern spares containing:

- ◯ 1 Burner complete.
- ◯ 1 Mantle holder.
- ◯ 1 Spirit cup plus wick.
- ◯ 2 Vaporisers.
- ◯ 1 Riser tube.
- ◯ 2 Washer sets.
- ◯ 1 Pump complete.
- ◯ 1 Pump valve.
- ◯ 1 Tank lid plus air screw.
- ◯ 10 Mantles.
- ◯ 1 Glass.
- ◯ 1 Small wire brush and pipe cleaner.
- ◯ 1 Small bottle of oil.

Spares box contents (Orange) (2003)

- ◯ 1 Each spare D ring and hook (sledge lashing).
- ◯ 6 Jubilee clips.
- ◯ 10 Cable ties, various lengths.
- ◯ 1 25 ml bottle tautening dope (in heat-sealed bag).
- ◯ 1 Ball 4oz balloon cord.
- ◯ 1 5m Helvetian hide thonging plus threading wire.
- ◯ 1 Roll adhesive tape.
- ◯ 1 Length of ash for splinting.
- ◯ 1 Lashing toggle.
- ◯ 1 Junior hacksaw and blades.
- ◯ 1 Pad saw and blades.
- ◯ 1 Bradawl.
- ◯ 1 Tin of nuts, screws and bolts for sledge repair.
- ◯ 1 Fid.
- ◯ 1 Primus Type 45K stove, with legs and pan support ring.
- ◯ 2 0.6 litre meths bottles (silver).
- ◯ 1 0.6 litre paraffin bottle (blue).
- ◯ 2 Jerry seal.
- ◯ 1 Small filter funnel, spanner and pkt of jet prickers (2).
- ◯ 1 Meths dispenser tin.
- ◯ 1 Tin of sealed matches (12 boxes).

- ◯ 1 Spare Lilo.
- ◯ 1 Ski skins adhesive.
- ◯ 1 Tube Pig Putty.
- ◯ 1 Drum tap.
- ◯ 1 Drum key.
- ◯ 2 Toilet roll.
- ◯ 1 Spare box liner and P-bag liner.
- ◯ 1 Medium pan and lid, mugs (2), knife, fork, spoon (2).
- ◯ 1 Crampon spares. For both sets of crampons.
- ◯ 1 Ski binding spares. For both sets of skis, spare ski basket.
- ◯ 1 Stove spares kit: 6 x fibre washers, 2 x lead washers, 3 x nipples, nipple spanner, pump valve, 2 x pump leathers, pump valve spanner, 2 x pkts jet prickers.
- ◯ 6 Candles.
- ◯ 1 Torch plus spare bulb and 4 x spare batteries.

Tent box contents (Yellow) (2003)

- ◯ 1 Wooden spoon/spatula.
- ◯ 2 Each desert spoons, knives, forks and tea spoons.
- ◯ 2 Mugs.
- ◯ 2 Bowls.
- ◯ 1 Pack of sealed matches (12 boxes).
- Toilet rolls (as much as space allows, rest in medical box and P bags), one roll per person per week.
- ◯ 1 Minor first aid kit including Jelonet, Disprin, Elastoplast.
- ◯ 1 Torch, spare batteries (4), spare bulb.
- ◯ 16 Blanket pins.
- ◯ 1 Alarm clock.
- Toothpaste, soap, toothbrush, soap powder as required.
- ◯ 2 Stainless steel Thermos, one litre.
- ◯ 2 Plastic drinks bottle, one litre (preferably wide neck).
- ◯ 1 Each protractor, ruler, compass or divider.
- ◯ 1 Each spare compass and spare whistle.
- ◯ 1 Field Operations Manual.
- Stationary including 3 x felt tip markers, 3 x pencils, writing paper, envelopes.
- ◯ 1 Notebook.
- ◯ Copies of all maps carried.
- ◯ Gash bags and small food bags as required.
- Assorted personal items as space allows (paperbacks, personal stereo etc.).
- ◯ 1 Mending kit

Mending Kit

- ◯ 1 Pkt domestic needles.
- ◯ 1 Sailmakers' palm.
- ◯ 1 Pkt sailmakers' needles.
- ◯ 1 Reel of Terylene thread.
- ◯ 2 Whipping twine, one thick and one thin.
- Canvas or Cordura material patches.
- Tent inner material.
- ◯ 1 2m of elastic for clothing and 4mm and 8mm bungee cord.
- ◯ 1 Ventile (one square metre) - tent repairs.
- ◯ 1 Scissors.
- ◯ 1 Araldite (fast set).
- ◯ 1 Tube seam sealer.
- ◯ 1 Tube Freesole.
- ◯ 1 Roll sail tape and part roll of duct tape.
- ◯ 1 Lilo/Thermarest repair kit.
- Velcro.
- ◯ 1 3m tent pole cord, 12 H and 8 H cord each.

ATV unit

Equipment for an ATV-borne field party is the same as for a Ski-Doo field party, with a few exceptions:

- ATVs replace Ski-Doos.
- Fuel is neat petrol.
- Sledges are replaced by trailers and covers, plus a spare wheel per trailer.
- There is no need for personal safety lines, shackles, link lines and tow ropes. Without this provision, glaciated terrain must not be crossed by ATV.
- Clothing will be similar to that used for Ski-Doo travel, though Wellington boots or waders may be required.

The Ski-Doo spares box is replaced by an ATV box listed below. These boxes are supplied with the vehicles from Cambridge and come with the appropriate oils and grease. They are expected to cover a half season project. A longer season project may require some additional items. See the Vehicle Logistics Officers and FOM in Cambridge.

ATV tools and spares in two boxes containing

- ○ 1 Set combination spanners, 8, 10, 12, 13 and 14mm.
- ○ 1 1/2″ socket drive with 17 mm and 11/16″ sockets.
- ○ 1 T-bar.
- ○ 1 Long and short extension.
- ○ 1 Socket set with 3/8″ drive.
- ○ 1 Adjustable 8″ spanner.
- ○ 1 Spanner set in roll.
- ○ 1 Junior hacksaw and blades.
- ○ 1 Vice grip pliers.
- ○ 1 Combination pliers.
- ○ 1 Ball pein hammer.
- ○ 1 Cold chisel.
- ○ 1 Screw drivers, flat point and Philips no. 1 (each).
- ○ 1 Grease gun.
- ○ 2 Grease gun cartridges.
- ○ 1 Bead buster tyre remover and set of tyre levers.
- ○ 1 Valve key, valve inserter tool and spares valves (each).
- ○ 1 Foot pump.
- ○ 1 Drum key and drum tap (each).
- ○ 1 Oil measure and oil drain tray (each).
- ○ 4 Sparking plug.
- ○ 1 Throttle cable.
- ○ 1 Choke cable.
- ○ 1 Brake cable.
- ○ 1 Carb. gasket.
- ○ 1 Rocker cover cap plus O-ring.
- ○ 4 Wheel nut and stud (each).
- ○ 1 Fuel pump.
- ○ 2 Fuel filter.
- ○ 1 Wheel hub front.
- ○ 1 Wheel hub rear.
- ○ 2 General spares panniers for bike front rack.
- ○ 2 Trailer hub cap.
- ○ 1 Litre OKO tyre sealant.
- ○ 1 Litre gear oil.
- 5 Litre engine oil.
- ○ Brake fluid.
- ○ 1 Puncture/tyre repair kit and materials.
- ○ 1 Roll insulating tape.
- ○ 1 Silicone sealer for punctures and gaskets.
- Self-tapping screws for tyre repair.
- Selection of nuts, bolts and split pins.
- Hand wipes and cleaner.
- 20mm tow line (10 metres long).
- ○ 2 Towing shackles.

Boat, helicopter and aircraft day-landings

It is difficult to define a list of equipment for daytrips. When parties are landed ashore away from the BAS station boat limits and left in the field, a minimum amount of equipment must remain with the party. Take normal clothing for fieldwork and safety equipment for glacier travel, if required. Remember that load sheets for helicopter operations are drawn up in kilos.

- ○ 1 Dry-bag rucksack, with sleeping bag, thermarest and bivvy bag (per person).
- ○ 1 Geodesic tent/Pup tent with iron pegs and lump hammer.
- ○ 1 Spare clothing.
- ○ 1 VHF radio (marine or aero depending) and spare battery pack.
- ○ 1 HF radio with charged batteries, aerials, connectors and sched list.
- ○ 1 Thermos and food.
- ○ 1 Iridium phone, charged.
- ○ 1 Map, whistle, note book and pencil and compass (per person).
- ○ 1 GPS.

Away-day box (green) or dry-bag for helicopter operations
The list below is for two person party, increase quantities according to the numbers of personnel

- ◯ 1 Primus model 45K stove, with legs, pan support ring and windshield.
- ◯ 1 Spare burner complete.
- ◯ 2 Pkts jet prickers.
- ◯ 1 Pump valve and spanner and pump washer.
- ◯ 1 Spare stove leg.
- ◯ 2 Burner spanners.
- ◯ 6 Boxes matches sealed in plastic.
- ◯ 2 Pans, lids and handle.
- ◯ 2 Sets of cutlery and mugs.
- ◯ 1 0.6 litre bottle of meths (silver).
- ◯ 2 1 litre bottle of paraffin (blue).
- ◯ 1 Meths dispenser.
- ◯ 1 Small filter funnel.
- ◯ 1 Scourer and J cloth.
- ◯ 1 Petzl head torch with two batteries.
- ◯ 2 Toilet rolls.
- ◯ 1 Assorted needles and polyester thread. Duct tape.
- ◯ 1 Miniflare kit and handsmoke (each).
- ◯ Emergency food packs to fill box space.

Sea-ice local travel
The following should be packed into a rucksack.

- ◯ 1 Throw rope.
- ◯ 1 Belt harness with karabiner.
- ◯ 2 Ice hammer or ice screws.
- ◯ 1 Spare clothing.
- ◯ 1 Food and drink.
- ◯ 1 Survival bag.
- ◯ 1 Miniflares.
- ◯ 1 VHF in waterproof bag or waterproof VHF and spare battery.
- ◯ Map, compass, whistle, notebook and pencil.
- ◯ Sunscreen.
- ◯ 1 Immediate aid medical pack.

26.3 Facts and figures

Equipment weights

The following figures are intended as guidelines only. For accurate figures the current aircraft load sheets should be consulted. The weight of certain items can alter and individual items should be weighed if there is any doubt about their weight.

All weights are in pounds as all BAS aircraft use imperial measures for loads and fuel weights. However if equipment is to be transported on HMS *Endurance* Lynx helicopters you will need to convert to metric.

	Weight
Ski-Doo	700lbs
Nansen sledge	140lbs
Pyramid tent (with aluminium tube pegs)	85lbs
Pyramid tent (with aluminium and steel pegs)	100lbs
Pup tent (with aluminium tube pegs)	30lbs
Rescue sack	55lbs
Emergency clothing	20lbs
Radio box	50lbs
Pots box	45lbs
Inside food box	55lbs
Medical box	45lbs
Ski-Doo spares box and tools	65lbs
Spares box	60lbs
Tent box	50lbs
Tarpaulin	35lbs
Bog chisels and shovels x 2	30lbs
Jerry board x 2	34lbs
Fuel jerry (full)	50lbs
P-bags x 2	70lbs
Tow lines	62lbs
Man-food boxes	65lbs
Pax (person) includes P-bag	200lbs

Fuel weights

	Weight
Drum Avtur (205 litres)	400lbs
Drum paraffin	400lbs
Drum petrol	375lbs
Empty drum	40lbs
Jerry petrol	48lbs
Jerry paraffin	50lbs
Empty jerry	10 lbs

Ski-Doo fuel consumption

A single Ski-Doo will travel approximately 2.6km on one litre of petrol. However, as a field unit is always made up of two Ski-Doos, it is far easier to think about the fuel consumption per unit.

Petrol consumption per unit (two Ski-Doos)

1.3 km per litre
26 km per jerry
416km per full-unit jerry rack (16 jerries)
266 km per drum (205 litres)

These fuel consumption figures will vary greatly according to the load, terrain, snow and conditions. This can be taken as a conservative figure for summer snow conditions. Deep soft snow and hilly terrain can drastically reduce this figure. In good conditions consumption can be over 3km per litre.

ATV fuel consumption

As with Ski-Doo travel, the figures for fuel consumption vary greatly. Factors such as the load carried, the type of terrain and snow cover will all affect fuel consumption.

In good conditions 5 to 7km per litre should be used for planning purposes. The tank capacity is 8.5 litres with a 2 litre reserve.

Paraffin usage

Summer, Peninsula

0.6 litres per day
1 jerry (20 litres) per 33 days

Winter/Summer deep field

1 litre per day
1 jerry per 20 days

1 litre burns for

Lantern	14 hrs 42 min
Stove	5 hrs 46 min

(This test was done with new equipment. Older equipment may be less efficient. Using the same stove, it took 16 minutes to boil one litre of water from ice and 16.5 minutes from powder snow.

Meths usage

An approximate guide to meths usage is:

0.75 to 1 litre per month (summer and winter)
Approximately 1 litre per jerry of paraffin

These figures will increase considerably during cold weather and lie-up periods.

Conversion tables

Length

1 centimetre = 0.394 inches
1 metre = 39.4 inches
1 metre = 3.28 feet
1 metre = 1.09 yards
1 kilometre = 0.621 statute miles
1 kilometre = 0.54 nautical miles
1 statute mile = 0.87 nautical miles

1 inch = 2.54 centimetres
1 foot = 30.5 centimetres
1 foot = 0.305 metres
1 yard = 0.914 metres
1 statute mile = 1.609 kilometres
1 nautical mile = 1.853 kilometres
1 nautical mile = 1.151 statute miles

Weight

1 gram = 0.035 ounces
1 kilogram = 2.2 pounds
1 metric tonne = 0.984 Imp tons
112 pounds = 1 Cwt = 50.8 kilograms
1 metric tonne = 2200 pounds

1 ounce = 28.3 grams
1 pound = 0.454 kilograms
1 Imp ton = 1.02 tonnes
20 Cwts = 1 ton = 1016 kilograms

Capacity

1 fl ounce = 28.4 millilitres
1 pint = 0.568 litres
1 Imp gallon = 4.55 litres
1 Imp gallon = 1.2 U.S. gallons
1 U.S. gallon = 3.78 litres

1 millilitre = 0.035 fl ounces
1 litre = 1.76 pints
1 litre = 0.22 Imp gallons
1 U.S. gallon = 0.833 Imp gallons

Volume

1 cu inch = 16.4 cu cms
1 cu foot = 0.028 cu metres
1 cu yard = 0.765 cu metres

1 cu cms = 0.061 cubic inches
1 cu metre = 35.3 cu feet
1 cu metre = 1.31 cu yards

Temperature

Celcius to Fahrenheit = (deg C x 9/5) + 32
Farenheit to Celsius = (deg F - 32) x 5/9

26.4 Glossary

Ablation An erosive process usually referring to the loss of snow or ice.

Abseil Also called rappelling. A controlled means of roped descent using a friction device.

Albedo The ratio of reflected to incident light.

Alpine pair The name given to two people, roped together for glacier travel.

Anchor The secure, attachment point of a rope. It can be a natural feature, such as a rock spike, or it may be a placed device, such as a deadman.

ANFO Ammonium Nitrate Fuel Oil - an explosive mixture.

Antarctic Treaty International agreement by which treaty members agree to allow the peaceful, scientific research of Antarctica and the suspension of all territorial claims.

ARIES A satellite receiver weather system. Receives National Oceanic and Atmospheric Administration (NOAA) satellite images that are useful in weather forecasting.

Avtur Aviation kerosene used in BAS aircraft. Also called jet fuel.

Back-up A secondary anchor that comes into use if the first fails.

Balling-up The adherence of soft or wet snow to the soles of boots, crampons and ski skins.

BAS British Antarctic Survey.

BASMU BAS Medical Unit.

BC Base Commander. The chief administrator, station logistics officer and the local magistrate.

Belay loop Tape loop on the front of a climbing harness to which the friction device or ascender is attached.

Belay The combination of the belayer, the belay method and the anchor to which they are attached. To belay is to manage the rope to stop a fall, usually using a friction device.

Bergschrund Crevasse that forms at the head of a glacier between the permanent snowfield and the moving glacier.

Bergy bit A fragment of floating ice.

Bight (of rope) A loop of rope that can be formed anywhere in the rope and can be of any size. The starting point of many knots.

Bivvy or Bivouac To spend the night in the open or in a very basic shelter such as a Gore-Tex bivvy bag.

Bog chisel Ice chisel. Useful as a crevasse probe, with a two metre long handle.

Brash ice Accumulations of floating ice made up of fragments not more than two metres across, the wreckage of other forms of ice.

Call sign Radio contact name, given to identify specific field parties.

Comms An abbreviation of communications referring to all communications but radio contact in particular.

Cornice Overhanging mass of snow formed by the wind along the lee edge of a ridge or plateau.

Crampons Metal frame with downward pointing spikes attached to the sole of the boot and used for moving on ice or hard snow.

Dead rope The rope that has been round the belayer's body or through a belay device and which must be controlled to arrest a fall. Also known as the inactive rope.

Deep soft Deep soft snow. It can make travel very difficult.

Dingle Perfect, calm, clear weather.

Doo mix The two stroke oil and petrol fuel mix for pre-mix Ski-Doos.

Doo Short for Ski-Doo and the generic term for all snowmobiles used by BAS.

Duvet A down-filled jacket or pair of salopettes for deep field use.

Fast-ice Sea-ice which forms and remains attached to the coast.

Field Assistant Dedicated field staff who acts as guides for BAS scientists and station staff. Experienced mountaineers employed for their mountain-craft skills and judgement.

FID Slang for a BAS Antarctic employee. From the predecessor of BAS, the Falkland Islands Dependencies Survey.

FOM Field Operations Manager.

FOWG Field Operations Working Group. The committee which, under the Head of Administration, coordinates a viable Antarctic field programme.

Gash Waste or rubbish. Originally a naval term. Also refers to station and ship domestic duties.

Glacio poles Tubular aluminium poles similar in section to pyramid tent poles.

Gore-Tex Trade name for a breathable, waterproof fabric.

Grease ice A soupy layer of ice crystals that forms in the surface layer of the water.

Ground truthing The use of a ground survey to confirm the findings of an aerial survey or to calibrate quantitative aerial observations often used to produce maps.

Growler A bergy bit of ice that is near pure water ice. It floats awash and thus is difficult to see. It can thus be a navigation hazard.

HMSE Her Majesty's Ship (HMS) *Endurance*. The Royal Navy's ice patrol ship.

IATA International Air Transport Association.

Ice foot A narrow fringe of ice attached to the coast, unmoved by tides and remaining after the fast ice has

moved away.
Ice shelf Ice consistently over two metres above sea level that is attached to land but projects out to sea.
Jumar Trade name now used as the generic term for a mechanical device used for ascending or hauling ropes. Jumaring refers to climbing a rope using mechanical ascenders.
Karrimat Trade name for a foam sleeping mat.
Lead Any gap or crack in sea ice.
Lie-up Remaining in the tent due to bad weather. Enforced inactivity.
Live rope The rope between the belayer and the climber. Also known as the active rope.
Magnetic variation The difference between True North and Magnetic North in degrees.
Man-food Food rations used in the field.
Mank Overcast weather conditions, low cloud or fog.
Met round Meteorological schedule where BAS and other Antarctic operator stations pass synoptic weather observations.
Mukluks Insulated boots for the cold.
Nansen Wooden sledge held together with string and leather thonging.
Neve Permanent snow lying at the head of a glacier. More commonly used to describe consolidated snow resulting from freeze/thaw action.
NERC Natural Environment Research Council, the parent body of BAS.
NOK Next of kin.
Ops Abbreviation for Operations Group.
P-bag The BAS sleeping bag system.
Pack-ice Includes any area of sea-ice, other than fast-ice.
Pancake ice Predominantly circular pieces of ice from 30cm - 3m in diameter, and up to about 10cm in thickness, with raised rims due to the pieces striking against one another.
Parallax The apparent shift of position of an object, actually caused by a change in the position of the observer. Or, with a prismatic compass, the change of position of the observer's eye.
Pax Radio vernacular for people.
Polynya Any non-linear opening enclosed in ice. Polynyas may contain brash ice and/or be covered in new ice.
Prusik A knot that can be tied onto a rope to ascend it or to grip it for hauling. Named after Karl Prusik.
Pulk A fibreglass sledge. Trade name.
SAR Search and rescue.
Sastrugi Ridges of windblown snow. Their direction indicates the prevailing wind.
Sat photo Short for satellite photographic image. Received from various systems.
Sched or sked A radio schedule.
Sea-ice Frozen sea water.
Serac A pinnacle, block or tower of ice. Seracs are continually forming and falling so are a serious objective danger.
Shunt A mechanical rope clamp. Trade name.
Sledge party A field unit. Can be mobile or static.
Slot Slang for a crevasse.
Snow bridge A bridge of snow spanning a crevasse.
Thermarest Inflatable foam filled mattress. Trade name.
Tide crack Crack at the junction between an immovable ice foot or ice wall and fast ice, the latter subject to the rise and fall of the tide.
Unit The equipment used by a field party camp and transport.
UV Ultra violet.
Ventile A closely woven windproof cotton fabric. Trade name.
Water sky Dark streaks on the underside of low clouds, indicating the presence of water features in the vicinity of sea-ice.
WBC Winter Base Commander.
Whiteout Bad weather resulting in poor contrast so that ground and sky appear as one. Surface features will disappear in poor contrast.
Windies Slang for Ventile windproof clothing.
Wind slab Snow which has been deposited by the wind and can form an avalanche danger. It can be soft or hard slab depending on the strength of the wind that has moved it. It is most likely to be found on lee slopes.
Wx Radio vernacular for weather.

26.5 Trade names

Araldite
Aries
ATV
Cordura
Dartcom
Dash 7
Disprin
Elastoplast
Fastex buckles
Gore-Tex
HMS karabiner
Iridium phone
Jelonet
Jerry can
Jockey Winch
Karrimat
Lilo
Lynx
Maillon
MSR snowstakes
North Face
OKO Tyre Sealant
Petzl Shunt
Pig Putty
Primus
Pulk sledge
Racal PRM radio or PRM
Silva compass
Shunt
Ski-Doo
Sno-cat
Sticht plate (belay device)
Thermarest
Thermos
Twin Otter
Vapalux lantern
Velcro
Ventile