



**Hæren**

**UD 6-81-9 E**

**INSTRUCTION IN WINTER SERVICE  
AVALANCHE RESCUE**



**English edition**





## ABOUT UD 6-81-9E

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# 1 INTRODUCTION

## 1.1 Objective

**1.1.1.1** These regulations have been prepared by the Norwegian School of Winter Warfare in collaboration with other avalanche rescue professionals.

The object of this publication is to increase an officer's understanding and knowledge regarding the choice of safe marching routes for rescue personnel in the event of avalanche accidents, as well as to describe routines, procedures and national guidelines for avalanche rescue.

This publication should also contribute to an officer's theoretical knowledge about rescue services in the event of an avalanche accident.

It should be emphasised, however, that a full and comprehensive understanding of the respective subjects may only be achieved through practice and training.

This publication focuses primarily on training concerning selection of safe marching routes, assisted rescue and avalanche rescue. This publication is also intended to be a reference work for personnel responsible for providing training in winter service in individual units, staff officers with planning responsibility for winter training, as well as personnel trained in avalanche preparedness.



## 2 ENTRY INTO FORCE

UD 6-81-9 Instruction in Winter Service – Avalanche Rescue came into force on 1 January 2011. At the same time, UD 6-81-9 Snow, Avalanche and Rescue Service, dated June 1997, was withdrawn.



# 3 SAFE MARCHING ROUTES FOR RESCUE PERSONNEL IN THE EVENT OF AVALANCHE ACCIDENTS

## 3.1 Introduction

### 3.1.1 Objective

An important element of any avalanche rescue operation is to ensure that a safe marching route has been chosen for rescue personnel. Since the prevailing conditions have already triggered an avalanche, it must be assumed that further avalanches may occur. In order to ensure safety, an assessment of the marching route should be undertaken beforehand, as well as a continuous assessment being carried out en route. The assessment must also take into account the available human resources and equipment, developments in the weather and recent forecasts, weather history, as well as snowpack and terrain factors. Assessments will take too much time in a live situation if not mastered properly and proper preparations and training have been made in advance. Thus, it is important that these skills are practised in a similar fashion to technical rescue skills.

Route planning prior to entering terrain is the first and probably the most important 'filter' to ensure safety during movement in avalanche-prone terrain. During a unit's work in avalanche preparedness, a general risk assessment must form part of the learning process. Upon implementation of a rescue operation, the unit will, through such preparatory work, have established a basis upon which to carry out an updated risk assessment. The only remaining task will then be to obtain detailed information about the rescue zone, as well as updated weather reports, in order to carry out a swift, but thorough, safety evaluation of a rescue attempt, versus the risk of loss of human life.

Knowledge and experience regarding choice of route and safe marching routes involve a combination of theory, practical skills and training. This chapter summarises some of the factors surrounding safety, snowpack, weather, terrain, as well as the human factor. In order to understand the relationship between these factors, experience of mountain movement during the wintertime is required. It is also important that personnel needing to develop appropriate and safe skills practise regularly, discuss their options with others on an ongoing basis and keep themselves updated on avalanche theory, avalanche forecasting, meteorology, navigation, etc. In other words, an individual's proficiency in the selection of a safe route must be regularly honed and knowledge of local conditions is also important.

Upon implementation of an avalanche rescue operation, the avalanche risk will remain imminent as an avalanche has already occurred. Route planning must take into account the fact that the unit will be entering an avalanche risk area to render assistance to a rescue operation. Thus, two intersecting factors must be considered: the rescue group's safety, where a hasty choice of route should be avoided, and the chances of survival of the avalanche victims themselves, where the rescue team is subject to significant time pressure.

*A rescue operation must be planned before the alarm has been raised. A risk assessment and sufficient knowledge in respect of choice of route, as well as a safe marching route, are imperative to the rapid implementation and safe execution of a rescue operation.*

## 3.2 Safety provisions of "The Norwegian Armed Forces Safety Rules and Regulation for Land based military activities" (UD 2-1)

### 3.2.1 What is stipulated in UD 2-1 regarding conduct in avalanche risk terrain?

The most recent updated version of UD 2-1 governs conduct in avalanche risk terrain (chapter 6). There are only two situations in which personnel may find themselves in avalanche risk terrain: search and rescue operations, and when unintentionally and unexpectedly entering an avalanche risk area. Exercises in themselves are not cogent grounds to travel across and/or assemble in an avalanche risk area.

In the case of search and rescue operations, the unit commander must select a marching route which, based on his/her knowledge and experience, as well as the prevailing conditions, represents the least possible risk to the unit. The unit commander should also select an escape route(s).

When a unit has unintentionally entered an avalanche risk area, the officer in charge must assess the various courses of action and either remain in the area or exit by the safest possible route.

*Exercises in themselves are not cogent grounds to pass through or assemble in avalanche risk areas.*

### 3.2.2 Movement across ice

Movement across ice requires control measurements of the ice's quality and thickness throughout the length of the march and is therefore time-consuming. In addition to equipment requirements, there are also requirements in respect of the ice's thickness, depending on the type of movement on ice and the number of measurement points along the line of march, as illustrated in UD 2-1, chapter 8.

Movement on ice is strictly confined to service assignments and must be assessed by the unit commander. In respect of rescue operations, personnel must have received prior information regarding the ice's condition. The unit commander's recommendations regarding movement on ice must be clarified before an accident occurs.

### 3.3 Handling and management of risk during transit in and around avalanche-prone terrain

Movement in and around avalanche prone terrain and avalanche rescue involve handling and managing risk in such a way as to avoid any situation that may result in injury to personnel, or materiel damage.

A number of civilian-developed methods have been developed to minimise avalanche risk. These methods systematise the processing of avalanche factors and are intended to provide a go-ahead signal, or warn against further transit. Generally acceptable risk is often compared with the level of risk that is present in motoring, and these methods attempt to reduce the risk to this level. Examples of such risk-reduction methods are the Avaluator Card (Canadian Avalanche Centre), STOP or GO (Austrian Alpine Club), Snow Card (German Alpine Club), NivoTest (French Alpine Club) and 3x3 filter assessment (Munter, 1999). Other methods attempt to eliminate or reduce risk by only permitting passage in safe areas such as along ridges and outside runout zones. An example of this is the Norwegian Geotechnical Institute's (NGI) evaluation form/model.

The first-mentioned reduction methods are based on statistics and probability calculations developed in North America and the Alps, and should not, therefore, be applied to transit across avalanche-prone terrain in Norway without sufficient scrutiny. Nevertheless, an understanding of the basis of these methods will facilitate the process of selecting a safe route across avalanche risk terrain, such as during a rescue operation, for example. Avalanches inform us that there is an avalanche risk in the area but explain nothing about the trigger factors. An analysis of weather, terrain and snowpack factors will provide information about the conditions that led to an avalanche being triggered, as well as where in the terrain an avalanche risk exists.

During a rescue operation, there is a known avalanche risk in the area. A rapid advance is vital if a successful rescue is to be accomplished. Thus, during an advance and during a rescue operation, personnel forming part of a rescue organisation must be well trained in continuously assessing the factors which may lead to an avalanche occurring. In order to minimise the risk to rescue personnel, and aided by prior knowledge of safe marching routes, the safest possible axis in the terrain must be selected. During a rescue operation, the danger of a parallel avalanche and secondary avalanche occurring must be continuously assessed.

### 3.4 Risk assessment

The objective of risk management in this context is to establish a basis upon which to manage risk in such a way that avalanche-related service and rescue operations may be carried out with the least amount of injury or loss.

Risk assessment should be carried out before, during and after all activities/operations. As specified in UD 2-1, a five stage risk assessment process has been developed.

The process comprises a generic risk assessment that may be applied to education and training in avalanche rescue. The process also forms part of work in relation to

avalanche rescue preparedness and is subject to re-assessment during an avalanche rescue operation. These assessments should be carried out continuously during the implementation and execution of an avalanche rescue.

The purpose of risk assessment is to reduce risk to an acceptable level that is in direct proportion to the benefit achieved from resolving an assignment.

For a complete introduction to risk assessment, refer to UD 2-1, chapter 1, General Safety Regulations, and item 4.9 of this publication.

## 3.5 Safe route

### 3.5.1 Literature

The majority of literature on avalanches makes few or no references to choice of route during a rescue operation. Most publications on avalanche rescue are limited to descriptions of the technical aspects of the search. This may be interpreted in two ways: On the one hand it may appear that the authors of such literature have not focused on the choice of route during a rescue operation. On the other hand, it is the sum total of information in avalanche manuals that provides the basis for assessing route choices in avalanche risk terrain, and thus also in a rescue operation.

However, this creates a paradox. Great swathes of avalanche literature focus on providing the necessary knowledge to personnel attempting to identify potential avalanche risk terrain in order to reduce risks associated with recreational activities such as climbing, summit hikes, skiing and snowboarding. In principle, these activities cease when the avalanche risk exceeds a certain critical level. A rescue operation, however, is implemented when the avalanche risk has already exceeded this critical level. So the challenge for rescue personnel is to carry out a rescue operation during a significant avalanche risk, while also ensuring the safety of personnel.

***Once an avalanche has been triggered there is a significant risk of further avalanches occurring.***

### 3.5.2 Planning phase: initial assessments

The planning of avalanche rescue operations should commence long before the alarm has been raised and, even in this phase, safety will be affected. Ideally, a unit – with some degree of rescue preparedness – should possess prior knowledge of the areas in which military units intend to train during the course of the winter and should plan possible marching routes into the terrain and, preferably, reconnoitre the terrain. During the course of the winter, personnel should keep themselves updated regarding the periods that respective units plan to enter the various areas. Parallel to the onset of winter, personnel should also keep themselves updated regarding the development of the snowpack and the prevailing weather conditions. The unit on standby should have carried out a risk reduction process in order to identify known and probable safety challenges (refer to item 4.9).

Against this background, and based on a unit with avalanche rescue preparedness, the importance of prompt and thorough preliminary work in relation to any rescue operation becomes apparent. Because of the time aspect, it is not advisable to start

risk reduction processes, procurement of information regarding the snowpack, and planning safe marching routes, once the rescue operation has commenced. The majority of this work must have been undertaken before the alarm is raised.

**3.5.3 The three ‘walls of defence’**

In respect of movement in and around avalanche-prone terrain, the ‘three walls of defence’ comprise: stability assessment, risk assessment and rescue options, which are the safety walls designed to reduce the risk of being struck by an avalanche or reduce the consequences of same. A rescue operation will be implemented when the snowpack is already unstable and an avalanche risk is present. The risk of any rescue must be assessed in relation to the probable benefits and the risk should be reduced through active risk assessment measures. Prior to entering the terrain, rescue options should be analysed, assessed and made ready.

During the rescue operation, the ‘three walls of defence’ should be assessed as follows:

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<b>The three walls of defence</b>	<b>Comments</b>
Stability assessment. How stable is the snow in the area?	<b>UNSTABLE (in a rescue situation)!</b>
Risk management. Minimise the consequences of an inaccurate stability assessment!	Steepness, visibility, route?
Rescue. Be prepared in the event that the first two items are inaccurate.	The rescue has already been implemented as the assessments in the first two items above have proved inaccurate! It is primarily companion rescue that saves lives. The outcome of the rescue is conditional upon the equipment and level of training in the group that was struck by the avalanche, as they are able to save the most lives.

*Table 3.1 - The three walls of defence with comments regarding assessments to be carried out.*

***The three walls of defence are stability assessment, risk management and rescue options.***

**3.5.4 The human factor: the fourth factor**

Avalanche risk assessments are carried out based on terrain, snowpack and weather. The fourth factor – the human factor – brings a subjective influence to the assessment. This subjective influence may be intentional or unintentional and is caused by our attitudes and also by external pressures. Since 90% of avalanche accidents are triggered by avalanche victims themselves, it is clear that such accidents are dependent upon both people and snow.

Information about avalanche risk should be interpreted and translated into decisions regarding selecting a safe route in the terrain. It is likely that the answers reached will be coloured by the need to carry out specific activities, whether this be skiing in avalanche-prone terrain, climbing, task-solving or something as basic as 'short cuts' in avalanche-prone terrain. Thus, the human factor constitutes an important part of the assessments. If we permit assessments to be subjectively influenced then our decisions may be affected by particular needs or a given task rather than constituting a professional decision.

In retrospect it can be seen that avalanche accidents occur in spite of clear signs of instability or foregoing weather conditions that lead to instability. Sufficient knowledge about the types of terrain that create an avalanche risk and the weather conditions that lead to instability in the snowpack, as well as the skills to analyse the stability of the snowpack, is imperative to the professional and objective procurement of information about prevailing conditions. The quality of the information depends on the level of knowledge and proficiency. In order for the information to be of any value, it must be analysed and seen in context.

Through increased experience, it will be easier to arrive at the most accurate picture of the avalanche risk.

<b>Factor</b>	<b>In connection with avalanche rescue:</b>
Is this <b>avalanche terrain</b> ?	YES! (As an avalanche has already occurred.)
Is the <b>snowpack</b> unstable?	YES! (i.e. a new avalanche may occur.)
Does the <b>weather</b> contribute to instability?	YES? (i.e. an avalanche risk is present on an increasing number of slopes.)
<b>The human factor</b>	How do we interpret these factors? Are we listening out for warning signals? What alternatives are there for avoiding an avalanche? Is there willingness to adapt plans?

*Table 3.2: The four factors in avalanche risk assessment In respect of avalanche rescue, the first two questions will have been answered as an avalanche has already occurred in the area.*

The manner in which information is analysed is an important part of an avalanche risk assessment and the human factor means that, to a greater or lesser extent, we unintentionally influence the outcome of information processing. In our daily work we are affected by our attitudes, our self-belief, peer pressure, loyalty to the assignment and to our superiors, fulfilment of our duty, the need to stand out or position ourselves, a good or bad day at work, time pressure, etc. Such factors are capable of causing us to wrongly interpret specific signals and thus miscalculate the avalanche risk.

An example of underestimating the conditions is where we use our knowledge and proficiency to move over increasingly steeper terrain and deeper snow. It need not be

intentional, but at a subconscious level we play down the steepness and the significance of the snowpack because experience tells us that everything up to now has been fine. However, if such a development should continue, there will be an upper limit before, sooner or later, things will go wrong. Another example is the kind of assessment undertaken by a skier on the first day of loose snow following an extended period without fresh snow, or after a major snowfall. It is likely that the inviting loose snow will cause the skier to filter information regarding the prevailing conditions in order to suit his/her immediate desire to ski in loose snow.

In the same way, we can also permit our analyses and assessments to be influenced by our loyalty to a military assignment. When the need to complete the assignment weighs more heavily than personnel safety, assessments of the snow conditions may favour implementation of the assignment rather than dictating a change, postponement or cancellation of the assignment. In the Alps, during both World Wars, there were many examples of military assignments that had been exposed to major avalanche accidents, where the assignment's objective was prioritised above the safety of personnel.

***Consideration of, or loyalty to, an assignment must not influence an assessment of conditions in such a way as to increase the element of risk.***

In some cases it is also about the inherent willingness to take into account our accumulated knowledge of conditions. Thus, a culture must exist where it is possible to abandon or change an assignment because of the prevailing avalanche conditions. Our actions cannot be based on assumptions, feelings or a specific mood but must be based on facts.

***A willingness to change means that, from the outset of planning, there is scope to change the plan in the event that snow, weather or terrain factors dictate this.***



Figure: 3.1

***The four factors: Terrain, snowpack, weather and the human factor***

*The human factor is central to the four factors. The human factor can subjectively influence information about an avalanche risk and thus also influence decisions made in relation to the prevailing conditions.*

**3.5.5 The terrain factor**

We will now look more closely at the terrain, which is a decisive factor in selecting a safe marching route. The snowpack may be very unstable but there must be a degree of slope steepness for an avalanche to occur, as it is the terrain that forms the foundation beneath the snowpack.

As can be seen from the graph below, the majority of dry slab avalanches occur on slopes of between  $30^{\circ}$  and  $50^{\circ}$ . Thus, the safest terrain will have a slope of less than  $30^{\circ}$ . It is important to assess the slope in the terrain above, as a section that is  $30^{\circ}$  or steeper is sufficient to trigger an avalanche, which may also have a runout zone in the area in which personnel are assembled.

Where conditions are appropriate, dry slab avalanches may also occur in terrain with less than  $30^{\circ}$  slope steepness. Nevertheless, such terrain is regarded as being relatively safe in dry snow and up to "considerable avalanche hazard (level 3)". If the snow is wet, a slush avalanche may occur in terrain significantly less steep than  $30^{\circ}$ .

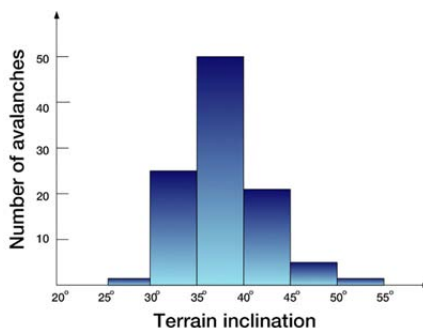


Figure: 3.2

### *Dry slab avalanche frequency in relation to terrain gradient*

*From the outset, rescue personnel must choose an axis into the terrain with a slope on which the avalanche risk is minimal. In order to reduce the level of risk, a route across the terrain must be chosen that is less than 30° in dry snow and up to "considerable avalanche hazard (level 3)". This also applies to terrain located above the marching route. Source: NGI.*

### 3.5.6 Methods for measuring steepness and identifying safe zones

There are a number of methods for measuring the steepness of terrain. In addition to measuring terrain steepness using a map, personnel should be trained in quick and efficient ways of continuously measuring terrain steepness. Once these methods have been mastered, their accuracy can be tested by first estimating the terrain steepness and then verifying the angle. With a little practice and experience it will be possible to estimate relatively accurate values in respect of terrain steepness, thus determining whether or not the terrain exceeds a steepness of 30°. It is also important to practise identifying safe zones by calculating the avalanche's runout zone.

The fastest way to measure steepness en route is to use ski poles. There are two methods of measuring steepness with poles: the pole method and the pendulum method. Refer to figures 3.3 and 3.4 for more comprehensive information.

Steepness may also be measured with an (in)clinometer which, in most cases, is a compass with a built-in scale and needle for reading steepness (figure 3.5). There are also devices that only measure steepness, as well as compasses that may be used to measure the angle of a line of sight.

On slopes with a gradual transition to less steep terrain, the runout zones may be estimated by calculating the vertical drop (H) and multiplying this by 3 (3xH). This will provide an estimate of how far out into the terrain the avalanche will be capable of extending horizontally from its crown. The safe zone will be outside of this area. The 3xH method is roughly similar to the 20° method, in which the angle of the line of sight up to the avalanche crown is measured. A line of sight of 20° or lower indicates a safe zone. The 3xH method gives a line of sight of 18°. On slopes with a

sudden transition from steep to less steep terrain, the runout zone will be shorter. In the table below, the methods for measuring terrain steepness and calculating runout zones are summarised.

<b>Steepness</b>	<b>On a map (30°)</b>	Distance between <b>height contours</b> : <0.7 mm between <b>height contours</b> (1:50,000) <0.35 mm between height contours (1:100,000)
	<b>In terrain</b>	<b>Pole method</b> : 27° <b>Pendulum method</b> : 30° <b>Clinometer</b> , usually built into the compass (gradient meter)
<b>Runout zone</b>	<b>On a map</b>	<b>3 x vertical drop (H)</b> : similar to the 20° rule. The vertical drop (H) from the valley bottom up to a potential avalanche crown is multiplied by 3 to obtain a rough estimate of the avalanche's horizontal range.
	<b>In terrain</b>	<b>20° rule</b> : When the avalanche crown is gauged and a 20# line of sight, or less, is obtained, this indicates an area outside of the runout zone.

*Table 3.3: Calculating steepness and the runout area*

There are simple methods of calculating steepness and the runout zone, both on a map and in terrain.

*There are simple methods of measuring terrain steepness employing either ski poles, a compass, or height contours on a map.*

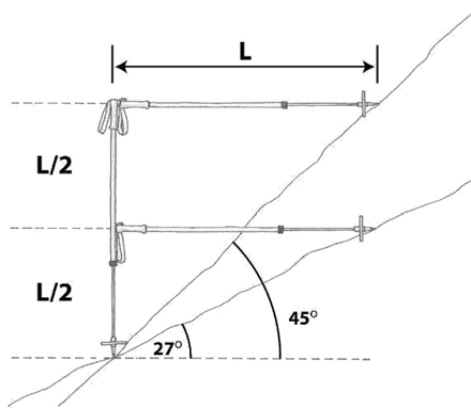


Figure: 3.3

### ***The pole method***

*The angle of the slope may be measured by using poles as shown in the diagram above. When the horizontal pole is held in the middle of the vertical pole and the tip of the pole touches the surface, the angle of the slope is 27°. When it is held against the top of the vertical pole, the angle of the slope is 45°. It is important to achieve accuracy in the following areas when using the pole method: There should be an angle of 90° between the poles; the poles must be held completely vertically and horizontally; the centre of the vertical pole must be known and the poles must be of equal length. All of these factors could contribute to a miscalculation of the slope's steepness.*

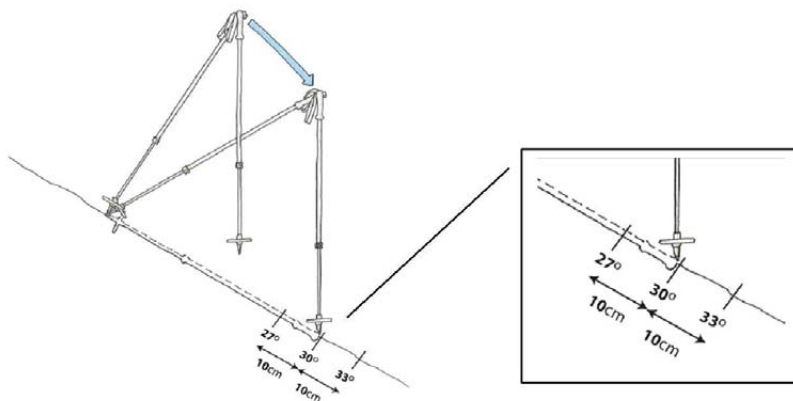


Figure: 3.4

### **The pendulum method**

*An impression of one of the poles should be made in the snow with the pole tip pointing up the slope. The pole grip should be lifted up with the tip remaining at the point where it was marked in the snow. The grip of the second pole should be held against the grip of the first pole and hung vertically. The poles should then be lowered so that a 'triangle' is formed between the poles and the impression in the snow. If the tip of the vertical pole touches the lowest end of the impression, the angle of the slope will be  $30^\circ$ . If the pole makes contact below the mark, the angle of the slope will be more than  $30^\circ$  and a distance of 10 cm on the lower side will be the equivalent of an increase of around  $3^\circ$ , i.e.  $33^\circ$ . 20 cm corresponds with  $36^\circ$ , etc. The upper side may also be read in this way, which will give lower values for the terrain gradient, where 10 cm is equivalent to  $27^\circ$ . It is important to check that the poles are of equal length, particularly when using poles with adjustable length.*



Figure: 3.5

### ***Clinometer and gradient meter***

Chap-3

*The picture shows examples of (in)clinometers and gradient meters for use in terrain. On the left in the picture is a compass containing a gradient meter with the option of gauging the angle of an avalanche crown. In the centre is a pure gradient meter and on the right is a gradient meter with the option of gauging angles.*

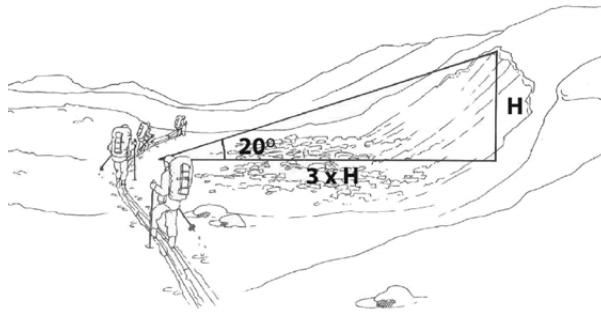


Figure: 3.6

### ***Runout zone: The 20° rule and 3x vertical drop (H)***

*The runout zone may be calculated by finding the vertical drop from the avalanche crown, the release point, and multiplying this height by 3. By doing this we can obtain an estimate of how far out horizontally into the terrain the avalanche will extend. This will give an angle of 18°. Alternatively, the avalanche crown may be gauged with a gradient meter. An angle of 20° or lower indicates a position outside of the runout zone.*

### 3.5.7 Other particularly exposed areas or situations

With common sense and a little knowledge of avalanches, the majority of people will avoid exposure to avalanches on large, snow-covered slopes. Large mountainside areas also represent a type of terrain which military patrols will expend a lot of energy attempting to pass and will therefore wish to avoid. Also, military safety provisions do not permit movement in such terrain. It is therefore not usually the biggest avalanches that represent the most imminent danger for military personnel. When personnel are moving through avalanche-prone terrain it is easy to overlook smaller formations that constitute an avalanche hazard. The following areas are examples of terrain formations that require special attention:

#### **Stream valleys (figure 3.7)**

Stream valleys provide cover, both tactically and from the weather, and may be tempting to use during an advance. Stream valleys often become steeper and deeper during the winter. Snow banks and an accumulation of snow can result in snow bank breakages and/or minor slippages, large enough to bury personnel. In addition, stream valleys, which may be several metres deep, could cause military personnel to fall off snow banks. Caution should also be exercised in respect of digging snow holes on the edges of stream valleys, due to the risk of landslides. The edges of stream valleys should be closely inspected before any activity is undertaken.

#### **Snow banks between 3-5 metres and higher**

The safety provisions specify an upper limit of 5 metres for snow banks in which snow holes can be dug. In principle, steep slopes or snow banks should be closely assessed when they have reached a height of 2 metres or more in order to avoid slippages. Hard-packed drifting snow has a density of 300-400 kg/m<sup>3</sup>, and so no great snow mass is needed before a slippage or a block of snow can weigh up to several hundred kilograms.

#### **Leeward sides (figure 3.8)**

During snow transport, snow is deposited on the leeward side of terrain formations. Snow transport may occur even when fresh snow has not fallen, and increased wind velocity will cause further accumulation. Small leeward side formations may appear harmless but in reality can contain large amounts of snow. Such slopes must be investigated thoroughly. Snow transport can occur at wind speeds of as low as 5 m/s and stronger.

#### **Solar-heated slopes (most relevant in southerly latitudes)**

The sun's rays heat up the uppermost part of the snowpack, causing the bonding in the snowpack to weaken. This can give rise to a sudden and unexpected instability in the snowpack. This specific effect is most relevant in southerly latitudes, although the sun can also have a similar effect in Norway on sunny days late into the winter. When the snowpack is then subject to a further spell of cold, the bonding in the uppermost section is further strengthened.

#### **'Hidden' steep slopes (figure 3.9)**

To a certain extent, hidden steep slopes can be read on a map from the extreme unevenness of the contour lines. However, these may be difficult to read from a map immediately. The placement of height contours on a map will never be completely accurate, and so small, but steep, slopes may be hidden. The snowpack can also

conceal steep slopes insofar as the surface of the snow may be less steep than the ground below. Larger slopes will be more visible on a map as there will be a high density of height contours. Smaller slopes have a greater tendency to be hidden on a map.

**Convex slopes (less compressive strength, high tensile force) (figure 3.10)**

Due to the shape of the terrain, convex slopes provide less compressive strength to the snowpack. The snow is constantly creeping and, in the convex part of a slope, stress fractures will eventually occur in the uppermost part of the snowpack. There will also be a weakening of the forces that counter gravity. Convex areas represent the type of terrain in which avalanches are most frequently registered (29%), followed by mountain passes and gorges (27%), glacial cirques (12%), below anchoring zones (12%), open synclines and stream valleys (10%) and, finally, bare rock-face (10%).

**Remotely triggered avalanches**

When an unstable layer of faceted crystal snow or depth hoar forms in the snowpack, an avalanche on a nearby slope may be triggered from a distance (refer to UD 6-81-8 for details about snow crystals). This type of unstable layer is characterised by a snowpack that collapses under its own weight, which may cause a rumbling sound in the snowpack. The remote triggering of an avalanche is caused by a collapse in the weak layer and a subsequent release of air. The collapse propagates to a nearby slope. The forces holding the snowpack in place become unbalanced and an avalanche may occur. Personnel may also trigger an avalanche on a slope by moving across the slope's lower edge and slicing through the compressive forces, causing parts of the snowpack to slide out.

**Terrain traps (figures 3.11, 3.12, 3.13 og 3.14 )**

Terrain traps are areas in which the terrain will worsen the situation if an avalanche occurs. Examples of this are where avalanche paths enter a forest, or run over cliffs, as well as avalanche paths with visible rock formations and stream gorges.

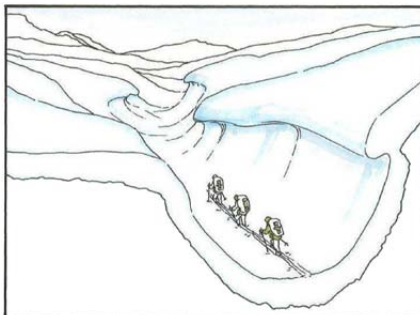


Figure: 3.7

### **Stream valleys**

*In stream valleys it may be tempting to seek shelter or dig snow pits, or to use the valley to conceal an advance. In reality, stream valleys represent a major hazard and must be avoided when snow banks have accumulated in them.*

***Movement at the bottom of stream valleys poses a major risk of avalanches and snow bank breakages occurring.***

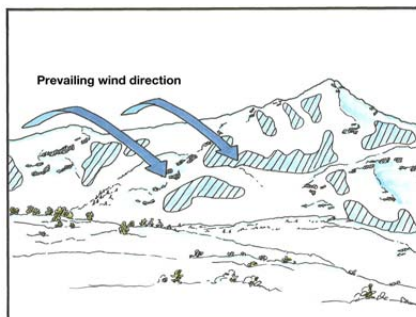


Figure: 3.8

### **Leeward side**

*The sketch illustrates how snow accumulates on the leeward side. Snow transport can commence at wind speeds of as low as 5 m/s.*

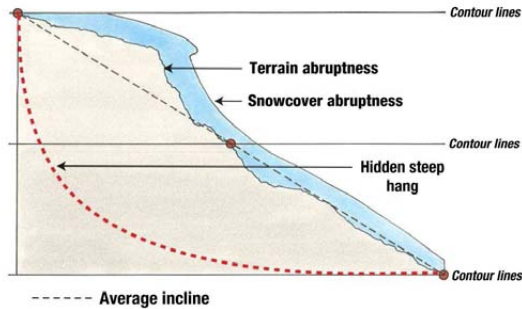


Figure: 3.9

**Concealed steep slopes: Terrain gradients on a map and in terrain**

The diagram shows that the snow surface is not as steep as the actual terrain. Thus, the snowpack may conceal small steep slopes or appear steeper than the terrain actually is. At the same time, the terrain may actually contain more small steep slopes than appear on the map. The red dotted line indicates how steep it can be between 3 height contours where the map shows a less steep slope of 40 metres and if a contour has been drawn incorrectly in relation to the contour lines on either side. The thin dotted line indicates the average gradient of the contour lines.

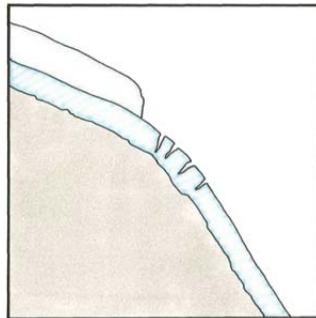


Figure: 3.10

**Convex slopes**

Convex slopes increase the tensile forces in the snowpack due to their convex shape. The snowpack may be awaiting a final triggering factor, or possibly trigger itself.

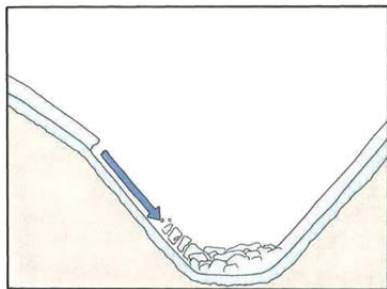


Figure: 3.11

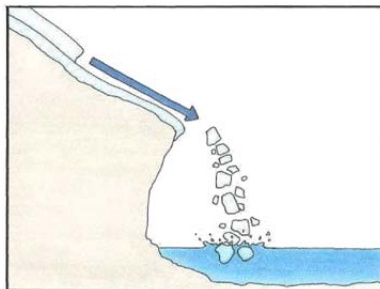


Figure: 3.12

***Terrain trap: Avalanche path down into a stream gorge***

***Terrain trap: Avalanche path over a cliff/into water/frozen water***

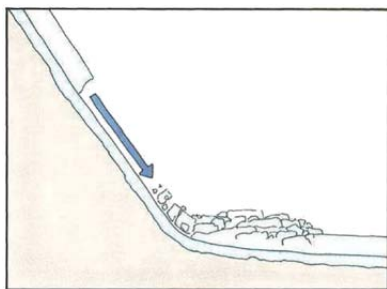


Figure: 3.13

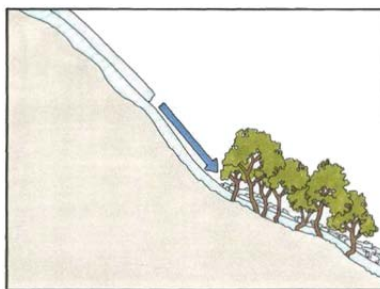


Figure: 3.14

***Terrain trap: Avalanche path down into flat terrain***

***Terrain trap: Avalanche path into a forest***

***Regarding the risk of remotely triggered avalanches, it must be noted that there can be differences on the map between the terrain gradient, snow gradient and steepness.***

***There need not be 30° steepness at your specific position in order for an avalanche to be triggered – it is sufficient that part of the slope has a gradient of 30°.***

### 3.5.8 Safer types of terrain

Examples of safer types of terrain are slopes on which the snowpack is anchored by trees or rocks, wind-eroded ridges or ridges with permanently drifting snow, terrain less than 25° steep and the windward side of formations.

To a certain extent the snowpack may be anchored by the terrain or objects in the terrain (figure 3.15). It must be understood that anchors not protruding out of the snow may represent an area in which there is a significant degree of snowpack transformation, thus having an undermining, and not an anchoring, effect on the snowpack.

Terrain with well-anchored snowpack:

- Trees and rocks anchor the snowpack
- This is most effective when the anchors are of a high density and size, as well as that the snowpack is possessing a high degree of compactness (shear/stress/compressive strength). The anchors must have a density of less than 10 metres and tree trunks should be as thick as a leg.

NB: Rock anchors, particularly when buried, as well as smaller bushes and brushwood, may be trigger points because of constructive transformation as a result of a thin snowpack and/or heat from the ground.

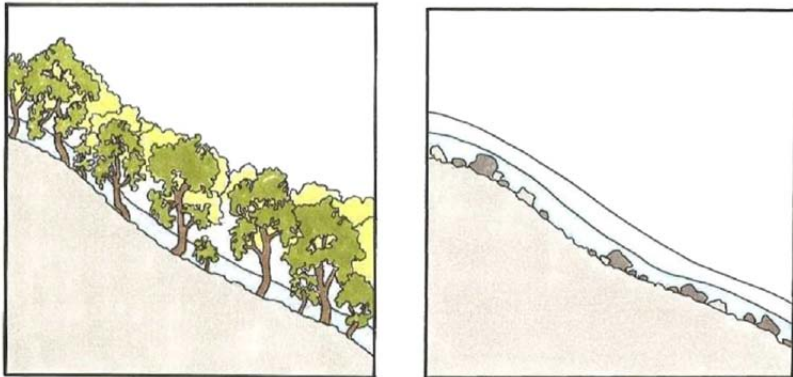


Figure: 3.15

#### ***Snowpack anchoring***

*The diagram on the left shows an example of good anchoring with a high density of trees (<10 m) and on the right are examples of anchoring objects that have no connection to the uppermost layer of snow.*

***Be aware that seemingly good anchoring points in the snowpack may actually be weak points from which an avalanche can be easily triggered.***

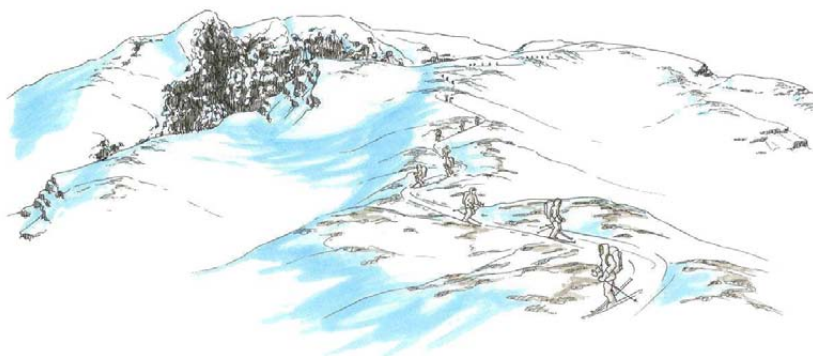


Figure: 3.16

***'Follow ridges, be safe'***

*This statement presupposes that ridges are less steep and have proportionally less snow on them. It should be noted that ridges can be steep enough to represent an avalanche risk, be covered by a hazardous snowpack, and possibly be exposed to a more rapid transformation of the snowpack.*

Wind-eroded ridges may generally be regarded as safe (figure 3.16). However, ridges must not lie in the path of other avalanches. Ridge sections must not be steeper than 30°. Be aware that even if ridges are less steep and are often wind-eroded and contain less snow, the snowpack may be thinner and transform more quickly into faceted crystal snow. Thus, there may be weak points along and up to ridges.

Ridges can be steep enough for an avalanche to occur. It may be difficult to assess a ridge at a distance and it should be noted that parts of a ridge may be concealed, making it difficult to undertake a complete assessment.

***Both on, and along, ridges, the snowpack can be thin and may have many weak points.***

### 3.5.9 Terrain summary

The table below summarises hazardous avalanche terrain compared with safer terrain (table 3.4). Be aware that this section refers to safer terrain, not safe terrain, as it is not possible to be absolutely safe from avalanche accidents by simply following a set of regulations. Regulations are static, whereas terrain conditions are extremely dynamic and constantly changing or difficult to determine.

Hazardous avalanche terrain	Safer types of terrain
- 30-50 °	- 0-25 °
- leeward sides	- windward side
- few anchors protruding out of the snow	- great density of anchoring points
major consequences	fewer or no consequences

Table 3.4: Summary of hazardous and safer terrain

## 3.6 Continuous assessments whilst marching

### 3.6.1 Stability tests

Stability tests take a relatively long time to complete. A compression test will often take 20-30 minutes to complete (refer to part UD 6-81-8 Snow Awareness).

According to statistics specifying the chances of survival of avalanche victims, it is within the first few minutes that there is the greatest chance of finding survivors.

Rescue personnel will normally be unable to focus on carrying out stability tests whilst on a rescue mission because of the shortage of available time. However, there is a known avalanche risk in the area. Thus, any advance must be based on the best possible planned safe marching route, as well as continuous assessments of the weather and the snowpack from the surface during the march.

A high degree of training is required in order to become proficient at carrying out continuous assessments.

### 3.6.2 Prevailing wind direction/leeward sides

It is important to be aware of the prevailing wind direction in the area, as well the prevailing wind direction during and after the last snowfall. This will determine the sides of the terrain that leeward slopes and snow accumulation will be found on.

When entering the terrain, wind-swept surface snow will be able to provide useful information:

- **Snow banks** will accumulate on the leeward side of a ridge as a result of snow transport (when wind velocity is above 5 m/s).
- **Snow dunes** on slopes point towards snow transport and indicate on which side the snow has settled.
- **Ridges in loose snow** indicate a wind direction of 90° on the ridges. The steep part of the ridges is on the leeward side.

- **Wind-created small snow banks** in terrain containing harder snow will erode so that the bow ends up facing the wind as the wind erodes the loose snow, with only hard snow remaining.
- **Snowdrifts** behind trees and rocks accumulate on the leeward side and the snowdrift's tip points in the direction of the wind.

Be aware that local wind conditions can result in a considerable degree of variation within a small area.

### **3.6.3 Ski pole test in the snowpack**

The snowpack can be continuously tested by inserting the pole into the snow to gain an impression of stratification, strong and weak layers, as well as snow crust. It is advantageous to practise the test while also undertaking examinations of the snowpack. It will then be possible to compare the snow profile with the impression gained from the pole test.

The pole test is very quick and may be performed several hundred times during the course of a march. However, it does not provide an adequate picture of deep and weak layers, thin sliding layers and weak bonding. The pole test enables rapid detection of changes in the snowpack's composition from one areato another.

### **3.6.4 Slope-/ski cuts**

By slicing through the snow with a ski on the upper side of a ski track on a slope, it is simple to determine whether the surface will slide out easily. This test will give an impression of the upper layer of the snowpack, but does not provide a good picture of hard slabs or of deeper layers in the snow.

### **3.6.5 Rumbling/collapse in the snow layer**

A rumbling sound and a collapse in the snow is a sign of weaker layers in the snowpack collapsing. The collapse may propagate and even trigger an avalanche at a distance.

### **3.6.6 Crack formations**

Crack formations in the snowpack are an indication of active creep and tensile forces. The cracks are also a clear sign of stratification and sliding layers. In certain conditions, cracks will also appear in the snowpack, in front of the skis or snowmobile, which 'shoot' outwards across the gradient (shooting cracks). This is an indication of sliding layers and tension in the snowpack and thus also unstable layers (figure 3.17).



Figure: 3.17

### ***Crack formations in the snowpack***

*This crack occurred in connection with a smaller slippage. Tension and instability in the snowpack may reveal itself through crack formations (shooting cracks) in the upper part of the snowpack.*

### **3.6.7 Recent avalanches or small formations that slide out**

In many parts of the terrain it will be possible to observe past avalanches or small formations that have slid out. Even without examining the snowpack it is possible to form an opinion and gain an indication of the avalanche risk in the area.

### **3.6.8 Avalanche paths and forest regrowth**

Old **avalanche paths** and forest **regrowth** may be observed in the terrain. Avalanche paths indicate avalanche terrain in which previous avalanches have occurred. This may be from major non-frequent avalanches or it may be avalanche paths along which avalanches frequently occur. On old avalanche paths, forest regrowth may also be found. The regrowth manifests as forest with a different density, height or composition to the surrounding forest. The regrowth may also have partially regained the size of the surrounding forest if an extended period has elapsed since the last avalanche occurred. Major regrowth of the forest provides anchoring points, but it is still an avalanche path (100-year avalanche?).

In coniferous forests, the regrowth in the first post-avalanche years will often comprise deciduous forests which, during the winter, will appear as paths of leafless trees.

*Continuous assessment of the surface of the snowpack will provide a firm basis upon which to establish where the snow has accumulated and will also be a time-saving method in terms of carrying out stability tests. It should be noted that it will be necessary to dig down into the snow to undertake a thorough examination of the snowpack.*

## 3.7 Navigation

### 3.7.1 General

An advance through avalanche-prone terrain demands good navigational skills. In order to master navigation, a certain basic level of proficiency and knowledge is required in reading and understanding both a map and the terrain. In addition to being able to follow a planned route, including any route in the terrain that may be the most suitable, personnel must be aware of their location at any given time.

An area that is covered in snow places greater demands on navigational skills than bare ground. The snowpack conceals terrain objects that otherwise would have been useful navigation points. A map is a topographic representation of the terrain as it appears without snow. It is therefore important to practise navigation during the wintertime in order to minimise the challenges presented by the snowpack.

In addition to practising planning using a map and map reading, personnel transiting in terrain during the wintertime must train in methods relating to the advance itself. In poor visibility it may be necessary to use a compass patrol. If personnel are uncertain about their location on a map, resection is a technique for determining their precise location. The intersection method will indicate where terrain objects viewed on a map are located in the terrain, or where terrain objects seen in the terrain are located on a map. In order to utilise the techniques of resection and intersection, good visibility is required.

### 3.7.2 Compass patrol

In poor visibility, a compass patrol should be used in order to ensure that a patrol keeps to a set course in the terrain. The person assigned the task of navigating should send two persons forward along the course. They will provide a line of sight for the navigator, who can then easily adjust the line of march. In order to verify distances, the number of paces taken should be counted. The pace counter(s) may use a cord with beads, or similar. Each bead that is pulled down to the other end of the cord represents, for example, 100 metres.

It would be advantageous to use the compass patrol continuously without stopping, with the distance between personnel determined by the prevailing level of visibility. In extremely poor weather and poor visibility, an assessment should be made as to whether the advance should be permitted to proceed on an ad hoc basis. The most forward member of the patrol then continues to advance as far as visibility permits. The rest of the patrol will then follow. This can be a very time-consuming process but is also accurate when carried out correctly.

### 3.7.3 Resection

Resection may be used to determine a specific position. A compass sight line should be taken of geographical points in the terrain, the compass bowl should be orientated in relation to the compass needle, and the compass courses should then be transferred to the map as lines. If the lines are traced back towards the estimated location, and 3 points are used, a triangle will be drawn between the lines' intersection points. Depending on the accuracy of these calculations, the patrol's own position should be within this triangle. This technique requires good visibility.

### 3.7.4 Intersection

In order to locate a geographical point in the terrain on a map, the line of sight towards the point should be identified and subsequently drawn as a line on the map. The line should be drawn from the point where the patrol is located, thence forward in the direction of the unknown point. The line will then intersect the relevant terrain object. Equally, a compass course may be taken on a map and the compass may be used as a line of sight in order to identify a terrain object visible on the map. Both these techniques require good visibility.

### 3.7.5 Some hints on navigation in snow-covered terrain

A topographic map is a 'picture' of the terrain without snow so that, technically, a 'summer picture' of the terrain is being used when navigation is undertaken during the winter. The closest approximations of a 'winter picture' of the terrain are avalanche maps, which show release zones (Zone 1) and runout zones (Zone 2), calculated in accordance with the Norwegian Geotechnical Institute's calculation model (The Norwegian Defence's Avalanche maps).

The most difficult aspect of navigation during the wintertime is when visibility is poor, either as a result of fog, drifting snow, precipitation (and wind) or darkness. Similar to navigating in darkness, an understanding of distance is affected by poor visibility. Distances within the field of vision appear longer than they really are and it is common for personnel to feel they have walked further than the actual distance when visibility is poor, or in darkness. When snow covers most of the ground, rocks and trees, and streams and small lakes become frozen, the landscape 'evens out', both in shape and in colour. The number of reference points and the distinctness of such points is reduced and it becomes important to count the number of paces in order to check the elapsed distance, so as to establish the rate of progress and to identify the patrol's location at any given time. If a patrol finds itself in avalanche-prone terrain, an assessment must be made as to whether the advance should be halted until visibility improves, to avoid the patrol being struck by an avalanche.

A degree of practice is required in order to completely master navigation during the wintertime, but it is not necessarily a complicated process. The tables below contain an overview of factors that disappear or that are strengthened by the presence of snow.

<b>Factors that are impaired or that disappear completely:</b>	<b>Comments</b>
Streams	Difficult to follow or use as interception lines
Lakes, especially small lakes	Crossing is more difficult to avoid and requires accuracy
Transition from water to marshland	Requires careful navigation
Small, steep sections	Risk of passing through on avalanche prone zones
Roads and tracks above the tree line	Difficult to follow or use as interception lines
Reference points	Fewer/more difficult to see

*Table 3.5: Factors that are impaired or that disappear completely beneath the snowpack*

<b>Factors that are strengthened in snow-covered terrain:</b>	<b>Comments</b>
Ravines and gorges	Large holes or snow banks can occur
Some steep slopes	The terrain may be less steep than the snow, or v.v.
Roads, cleared rights-of-way, demarcation lines in the forest	Visible at greater distances
Dense forestation	Increased impenetrability
Source of water in marshland	Unsafe on skis or with a vehicle

*Table: 3.6: Factors that are strengthened in snow-covered terrain*

## 3.8 Route cards

### 3.8.1 General

When planning a safe route in avalanche-prone terrain, it is very useful to have a detailed plan of the intended route in the form of a route card. The route card will guide the rescue team through safe corridors and result in fewer shortcuts and random choices. As in any plan in avalanche-prone terrain, personnel must be prepared to formulate an alternative plan in the event that the terrain and the snowpack demand a change in plan. Units on standby should prepare marching routes into areas in which winter exercises have been planned or in which training takes place regularly.

### 3.8.2 DATIT – route card reference word

The route card is a matrix/overview of the route divided into shorter sections with

map extracts, sketch and a description of the terrain. The reference word for the route card is DATIT, which stands for *Distance, Direction, Terrain/guide line, Interception point and possibly Time*(DATIT). In a tactical setting a patrol will have to learn the different sections and pass through them without using a map. This will force the patrol to prepare itself on the map, plan a route through safe zones and pay careful attention to the terrain en route. These are also good principles to adhere to for a unit advancing to an avalanche accident, even though in such cases there is less time available to formulate a detailed plan of the marching route.

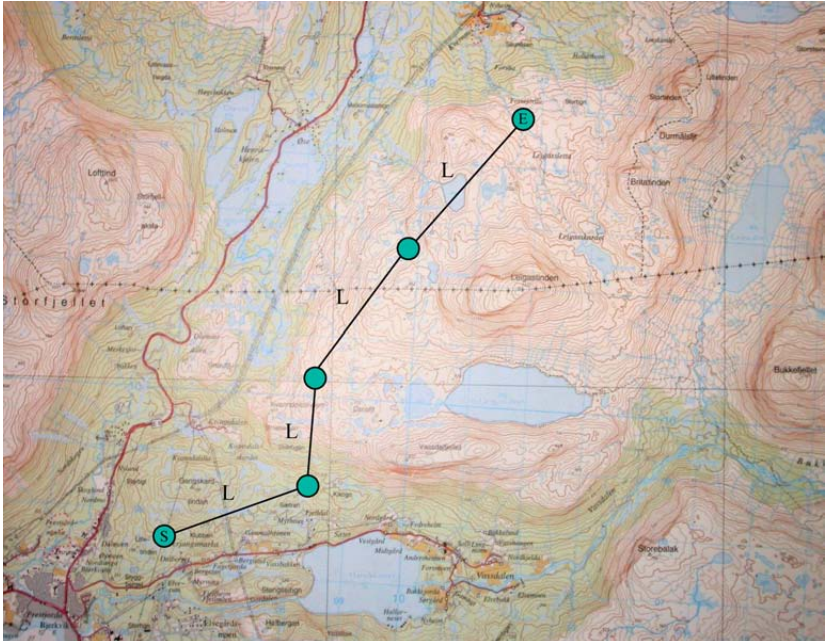


Figure: 3.18

***Planned route drawn on a topographic map to the scale of 1:50.000***

*The route is divided into 4 LEGS/sections. Each section is then entered into the DATIT table below with details.*

LEG	Dist	Dir	Terrain	Interception point	Time
SP			Base 1		
L1	2,5 km	60 °	Initially steep. Marshland. Lightly undulating	Steep gradient. Height to the EAST	1,5 t
L2	1,7 km	15 °	Gradient to lake in map reference 295 398 followed by high alpine terrain	Tree line. Lake. Lightly undulating high mountain terrain	2 t
L3	3 km	45 °	High alpine terrain. Gradient	Loss of elevation(Slope) to the WEST LEIGAST-IND EAST	2 t
L4	3 km	40 °	High alpine terrain. Lake	Lakes to the West and East of the leg. Downhill towards end position	2,5 t

*Table 3.7: DATIT table. This table represents DATIT itself, in which each section, or LEG, of the route is entered in with details of Distance, Azimuth, Terrain, Interception and Time.*

***DATIT is a useful tool for ensuring a safe marching route and also for ensuring that personnel adhere to the planned route. The unit must practise frequently in the use of DATIT in order to reduce the amount of time spent on planning.***

### 3.8.3 Examples of choice of marching route

This section looks at an example of a choice of marching route. The choice of route is initially outlined on a topographic map to the scale of 1:50.000. The same route is then outlined on an avalanche map with comments about hazardous terrain. Finally, the same route is outlined on an avalanche map with a suggested alternative route.

Prerequisite:

AVALANCHE HAZARD level 2 (Moderate avalanche risk)

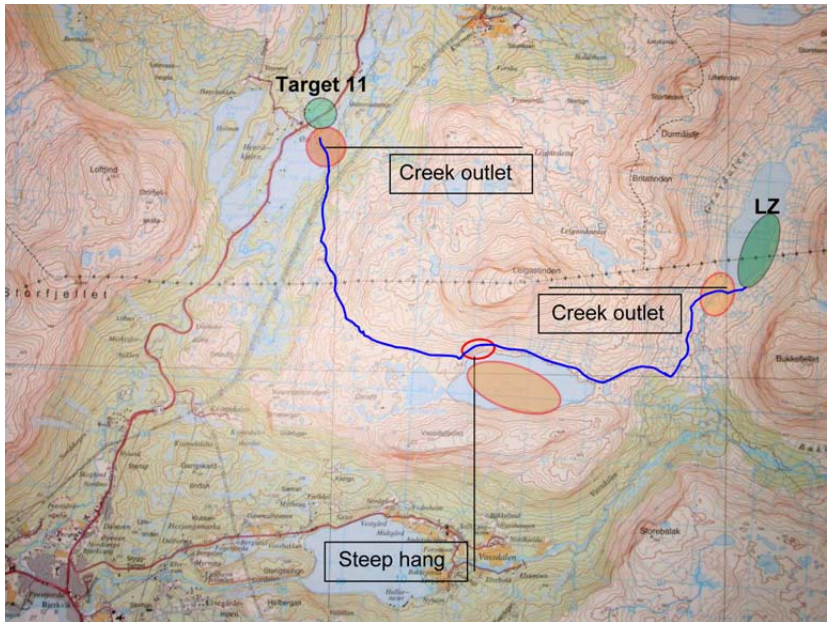


Figure: 3.19

*The originally planned route is outlined on a topographic map to the scale of 1:50.000*

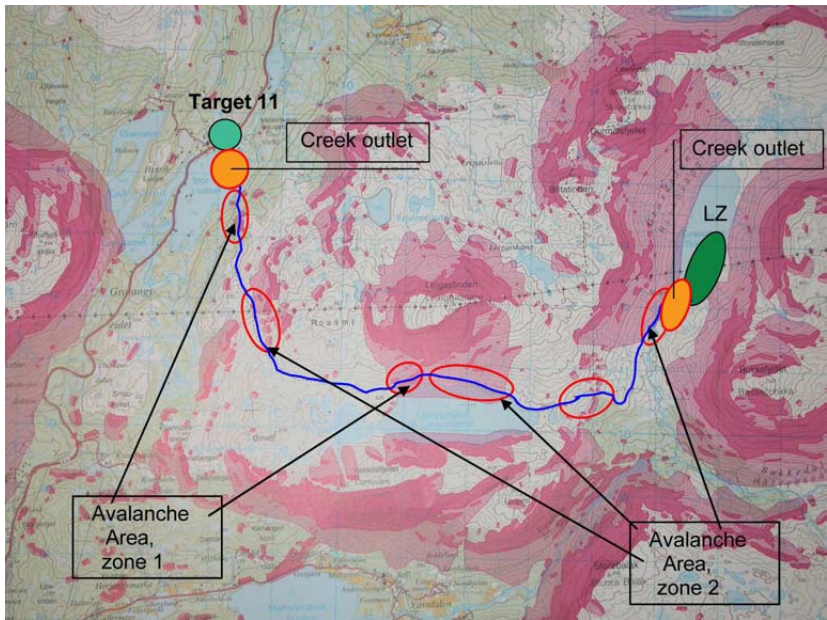


Figure: 3.20

*The route is outlined on an avalanche map with comments about any hazardous areas*

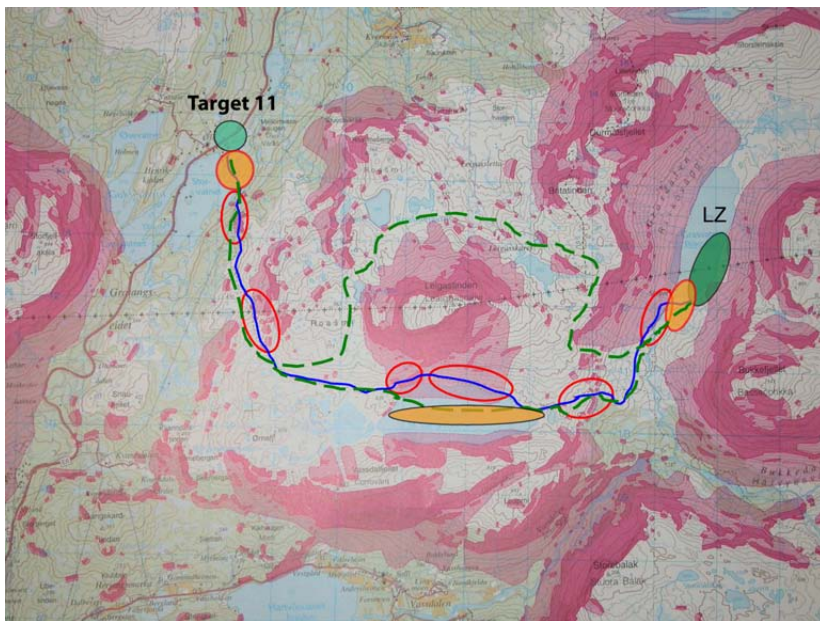


Figure: 3.21

**The route is outlined on an avalanche map with suggested alternative routes (green dotted line)**

*Note that the southernmost route involves crossing a frozen lake, with all the implied safety measures that will require.*

Even though a route has been planned through avalanche-prone terrain in which any possible avalanche hazard areas have been taken into account, the terrain must still be continuously assessed en route. There may, for example, be concealed steep slopes and stream valleys in the area. It is also possible that the terrain factor has been underestimated, either in terms of steepness or with regard to snow accumulation (leeward sides).

## 3.9 At the accident site

### 3.9.1 Parallel avalanches

During an avalanche rescue operation, the danger of parallel avalanches occurring in nearby areas must be assessed. In the worst case scenario it will be necessary to consider whether any rescue operations at all can be carried out if there is a danger of further avalanches occurring. Particular attention must be paid to stream valleys and ravines that could carry new avalanches down into the avalanche path, as well as any

avalanches that have the same runout zone as the avalanche that has already occurred, i.e. parallel avalanches. Also, attention must be paid to secondary avalanches or parallel avalanches, which may have the same runout zone in the area in which the rescue organisation is established.

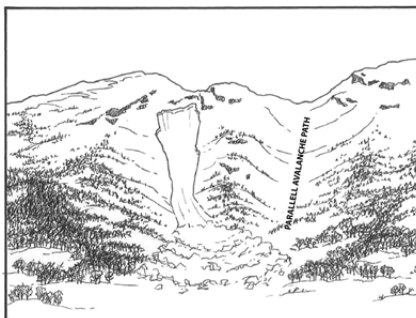


Figure: 3.22

### ***Parallel avalanche paths***

*Be aware of potential parallel avalanche paths, with a common runout zone, along which an avalanche has not yet occurred. Parallel avalanche paths can represent a major risk to rescue personnel and, at best, may result in a rescue operation being suspended.*

### **3.9.2 Secondary avalanches**

Secondary avalanches occur along previous avalanche paths after new snow has accumulated. Without any accumulation of new snow it is very uncommon for a new avalanche to occur along the same avalanche path. Even though the fracture line may appear threatening, under normal circumstances it will not break loose. The forces above fracture lines are usually in balance/equalised. However, we know that we are dealing with a slippery avalanche path. If a strong wind (gale) is present in the area, snow accumulation along the avalanche path may occur as much as 10 times faster than in an ordinary snowfall. (Moderate wind = 4 times faster.) In the course of 1-3 hours there may already be a risk of a secondary avalanche occurring.

A strong wind may also cause a new snowpack to accumulate without any precipitation, i.e. with snow transport of previously fallen snow (redistribution).

If sufficient personnel are available and any doubt exists regarding snow accumulation along the avalanche path, one person should be assigned as avalanche watch in order to monitor snow accumulation along the avalanche path.

***When establishing accident site management, consideration must be given to parallel avalanche paths, as well as the risk of new avalanches and secondary avalanches occurring.***

### 3.10 Suspension criteria

With a view to establishing the criteria for suspending a rescue operation, it is difficult, if not impossible, to provide specific answers. The officer in charge of the accident site/avalanche must continuously assess the safety of personnel involved in rescue work. The moral aspect of not intervening in a situation in which human lives are at stake must be directly weighed against the risk to life and limb of rescue personnel (cost versus benefit). There will also be uncertainty as to whether any survivors will be found and this uncertainty will increase with the passage of time.

This can be a very difficult decision to make. However, when rescue personnel themselves, who are part of an organised rescue, face a significant risk of being struck by an avalanche, the officer in charge of the accident site must strongly consider postponing any movement into the area until the situation has stabilised or has been more carefully assessed.

It is assumed that every civilian organisation involved in avalanche rescue is subject to its own provisions or has formed some kind of opinion regarding the criteria for suspending rescue operations, i.e. which criteria expose its personnel to an unacceptable level of risk. It is important for a military commander in charge of a rescue operation in which civilians are also involved to take into consideration assessments made by external participants or their organisation(s).

The purpose of risk assessment is to reduce risk to an acceptable level that is in direct proportion to the benefit achieved from resolving an assignment. Thus, the officer in charge of a rescue operation must consider the risks of the assignment and the possible consequences of such risks. These must then be weighed against the likelihood of saving lives. A risk assessment during organised avalanche rescue operations must be seen in the context of the chances of survival of avalanche victims in relation to the elapsed time. The time it takes to organise a rescue operation and advance to the accident site reduces the likelihood of saving lives. Taking into account that after around 35 minutes there is less than a 34% chance of survival for personnel who have been buried alive, and that there is an extremely low probability of survival after 90 minutes, it is unacceptable to expose rescue personnel to risk beyond this time frame.

***When the lives of rescue personnel could be endangered, it must be considered whether it would be advisable to suspend the rescue operation.***

## 4 AVALANCHE RESCUE

### 4.1 Introduction

#### 4.1.1 General

Each year an average of 5-6 people loose their lives in avalanches in Norway. Norwegian Armed Forces personnel have also been involved in several avalanche accidents. In respect of such accidents, the Norwegian Armed Forces lost sixteen soldiers in Vassdalen in 1986, one cadet in Setesdalen in 1992 and one soldier at Kvamskogen in 1994.

For avalanche victims the chances of survival diminish rapidly and it is therefore important that the Norwegian Armed Forces has the materiel and knowledge to locate avalanche victims as quickly as possible. In the Norwegian Armed Forces both officers and soldiers undertake basic training in companion rescue.

#### 4.1.2 Competence requirements

The directive for competence requirements in winter service for units on land-based operations in the Norwegian Armed Forces came into force in autumn, 2008. The directive should ensure that officers in Norwegian Armed Forces units possess an equal level of competence within winter service, including competence within avalanche alerts and avalanche rescue. Such competence should comply with the regulations, safety provisions and training requirements within winter service.

### 4.2 Rescue organisation on a national level and within the Norwegian Armed Forces

#### 4.2.1 Responsibility and authority

The Rescue and Emergency Planning Department of the Ministry of Justice and the Police has primary administrative responsibility for coordinating land, sea and air rescue services.

The rescue service is operationally organised with two Joint Rescue Coordination Centres (HRS) and 28 local rescue centres (LRS), corresponding with the number of police districts, including the Governor of Svalbard, as well as 16 air and sea rescue centres.

The Norwegian rescue service operates via an interaction between public bodies, voluntary organisations and private companies with the appropriate resources.

In the event of an avalanche accident, the police will use whatever civil and military services are available, or required. Units of the Norwegian Armed Forces are organised in such a way that they may be efficiently used in any rescue operation: in sections, troops and companies with all-terrain vehicles, communications, medical and bivouac service, as well as a command structure. Throughout the winter Brigade North has a strengthened avalanche rescue preparedness in Inner Troms county, where up to three training battalions have personnel and materiel on standby in rotation.

*Throughout the winter the Norwegian Armed Forces is on avalanche rescue standby in Inner Troms.*

#### **4.2.2 The Joint Rescue Coordination Centre (HRS)**

The Joint Rescue Coordination Centres have primary operational responsibility for search and rescue operations. Operational coordination is conducted either directly from one of the two Joint Rescue Coordination Centres, which are located in Bodø and at Sola in Stavanger, or via one of the 28 local rescue centres.

The respective areas of responsibility between the Joint Rescue Coordination Centre in North Norway and the Joint Rescue Coordination Centre in Southern Norway is divided at the 65th parallel north – along the border between the counties of Nord-Trøndelag and Nordland.

Notification of accidents should be given via the emergency number 112, which will be routed to the nearest police authority. Notification of missing persons should be given to the police, or to one of the Joint Rescue Coordination Centres.

#### **4.2.3 Local rescue centres (LRS)**

Local rescue centres have been established in Norway's 27 police districts, and with the Governor of Svalbard. These also include a rescue executive comprising representatives from public bodies, with the chief constable as chairman. The centres are manned by police officials and officers, as well as other personnel who may be of practical use to the individual rescue operation (advisers assigned by the chief constable). The local rescue centre will keep the relevant Joint Rescue Coordination Centre continuously updated on incidents in its own district.

In the event of accidents or emergencies, the local rescue centre must usually establish an advanced command post at the accident site itself. An incident commander will be assigned by the local rescue centre and will normally be supplied by the police, with assistance from a chief medical supervisor or a fire supervisor, for example. Certain patterns have been established as to how this should be accomplished. It is a flexible system that may be adapted to the specific accident.

In the case of accidents in rural areas, the police representative in the local community, i.e. the local police office, will be assigned the role of incident commander. The local knowledge of such a body will be of great use.

*The rescue service in Norway is organised into two Joint Rescue Coordination Centres and 28 local rescue centres.*

#### **4.2.4 Incident commander (Innsatsleder)**

The incident commander is the representative of the local chief constable. This post is sometimes referred to as the commander of the accident site. The first party arriving at the site of the accident, independent of organisational belonging, must take charge of the rescue work until the incident commander appears. All personnel is under the command of the incident commander. The incident commander coordinates the rescue efforts, and is responsible for the requisitioning of necessary

resources via the local rescue centre. The incident commander wears a reflective vest marked with “Incident Commander”. The incident commander establishes an Incident Command Post from which the rescue work is lead.

*The incident commander is assigned by the local rescue centre and is the chief constable’s local representative.*

#### **4.2.5 The incident commander’s command post (ILKO) and manning of the command post (KO)**

The incident commander’s command post may be established in a house, car, tracked vehicle or outdoors. It should be located as close to the accident site as possible without interfering with other work being carried out there. The command post should be safe and well organised, should provide peace and quiet, as well as being visible to other personnel connected to the accident site. The command post must have communications links to the local rescue centre/Joint Rescue Coordination Centre.

The incident commander’s command post should be manned by the incident commander and his/her staff.

An assessment of the scope of the accident and the amount of time and resources available, should determine the number of personnel assigned to work at the command post. In the event of an avalanche accident, the following personnel should assist the incident commander:

- Officer in charge of the avalanche (Fagleder skred)
- Chief medical supervisor (Fagleder helse)
- Chief coordinator (Fagleder orden)
- Chief communications supervisor (Fagleder samband)

All supervisors should work in accordance with the prevailing action card<sup>1</sup> for their respective role.

*Personnel possessing technical skills within health, avalanches, order and communications provide assistance to the incident commander at the command post.*

#### **4.2.6 Assistance provided to an avalanche rescue by the Norwegian Armed Forces**

Units of the Norwegian Armed Forces may become involved in an avalanche rescue in two different ways:

- The local police authority requests assistance from a military unit in a rescue that has already been implemented or is in the process of being implemented. The request may cover both personnel and materiel. When human life is at

1) Action cards are issued by the emergency service/mountain rescue service of the Norwegian Red Cross and are revised annually.

stake, a request of this nature must be complied with.

- A military unit implements the rescue itself when either military or civilian personnel have been involved in an avalanche accident. The police will take charge of the rescue operation when they reach the accident site and the incident commander will notify when he/she has assumed command.

***Following a request from the civil authorities, the Norwegian Armed Forces may assist in an avalanche rescue operation.***

When a local police authority requests support, the rescue operation will be led by the police. Units of the Norwegian Armed Forces will then contribute with personnel and materiel, where required. Officers may be used as supervisors or in other supervisory roles. A unit arriving at an accident site as a rescue party should wait in the holding area for rescue personnel, and the unit commander should establish contact with the incident commander.

In the event that a military unit itself has been involved in an avalanche accident, the military commander should immediately implement a rescue operation with the resources at his/her disposal.

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It is important from the outset that rescue work is organised as effectively as possible in accordance with prevailing national guidelines. The police will then be able to take charge of the rescue operation without any change in procedures, which will be familiar to both the police and other institutions from exercise drills. The local rescue centre and the nearest available unit must be notified at the point when the rescue operation commences.

A military unit that has started a rescue operation before the police have taken charge should implement all necessary measures. The commander of the military unit will be referred to as the 'officer in charge of the avalanche'.

The title 'incident commander' is not used for military personnel, as this is a police operation. The officer in charge of the accident site will perform the duties assigned to the incident commander until he/she assumes command. The officer in charge of the accident site will assign officers from among his/her subordinates. Depending on which organisations have been summoned and the extent of the avalanche accident, once the incident commander has assumed command, officers will be engaged as advisors, placed in charge of avalanche operations, or assigned other roles.

A prerequisite for effective rescue is that the officer in charge of the avalanche and personnel in the stipulated supervisory roles have received training. Rescue work will be more effective if there has been a prior connection with institutions and authorities so that the respective parties are aware of each other and are also clear about what is expected of them. Rescue work with avalanche probes also requires trained personnel, ideally 30 persons or more, depending on the size of the avalanche. Such personnel can form a vanguard and eventually provide other less experienced personnel with sufficient instruction to ensure that they are also able to make a valuable contribution to the rescue operation. Implementation and organisation of activities should preferably be planned and practised so that the core group may begin to search without delay. Given the geographic conditions in

Norway, however, an officer in charge of a rescue operation should be prepared to improvise in respect of both personnel and equipment.

During the wintertime, a unit (battalion or similar) should have an overview of who is trained in rescue work, and earmark such personnel for supervisory roles.

The unit must be aware of where the nearest avalanche dogs are located and how their dog handlers should be alerted. Approved dog equipages may be found in the local community, particularly in areas in which avalanches frequently occur. In addition to avalanche dogs trained by the Norwegian Armed Forces, avalanche dogs are also trained through the organisation Norwegian Search and Rescue Dogs (Norske Redningshunder).

*In an accident involving military personnel, the local unit commander will assume command of the rescue operation until the local chief constable's representative takes charge.*

#### **4.2.7 Avalanche rescue preparedness**

##### **General**

Any unit undertaking training and practice in avalanche risk terrain must plan the necessary measures to be adopted in the event of an avalanche accident. Rescue options may comprise an established avalanche standby, or designated personnel in their own units who are capable of advancing to the accident site at short notice and organising a search. Training and assessment in companion rescue capability forms part of the unit's rescue options.

##### **Civilian preparedness in the event of an avalanche accident**

In the event of an accident, the civil emergency services will conduct the rescue operation in conjunction with one of the Joint Rescue Coordination Centres (refer to item 4.2).

##### **Avalanche preparedness in Inner Troms county**

In the event of a situation in which personnel have been struck by an avalanche and have not been located immediately, Brigade North, with its available resources, will undertake and/or continue the search operation. Time is the most critical factor.

Brigade North has therefore established an avalanche standby in Inner Troms county capable of rapidly taking over a search for missing personnel in the event that companion rescue is unsuccessful.

Emergency plans involve trained personnel advancing from the garrison most closely located to the accident site. The brigade instructs sub-units training on an individual and unit level within the fields of, respectively, companion rescue and organised rescue, as well as training in avalanche dog equipages for avalanche searches. The brigade also manages avalanche rescue sets for use in training and genuine accidents. In the event of an avalanche accident, the brigade will alert the most suitable unit to advance and carry out the rescue operation. If helicopter resources are available, air transport will also be utilised during the rescue operation.

Brigade North is responsible for commanding and coordinating all units involved in the operation.

### **Training level of military personnel**

Every unit moving in terrain in which avalanches occur should prioritise training in companion rescue. Personnel must receive basic training in the avalanche-related materiel they have been supplied with. This includes training in the use of avalanche transceivers, use of avalanche probes, excavation of avalanche victims, basic first aid and evacuation. Training in companion rescue should include training at section level so that personnel involved in the search may be organised and utilised as systematically and efficiently as possible.

It is important that training in individual skills and companion rescue is undertaken at section level, and that such skills are mastered, before training is escalated to bigger and more complex scenarios.



*Figure: 4.1*

### ***Personnel undertaking a surface search***

#### **Training level for sections and patrols**

Smaller units, including patrols and sections, intending to transit through avalanche-prone terrain should be equipped with companion rescue equipment and be trained in the use of such materiel. Each member of the patrol/section should be trained in the use of companion rescue equipment and, in addition, sections should be trained in companion rescue within the framework of a section. Patrol leaders/Section leaders should be capable of assessing the risk of secondary avalanches, parallel avalanches, as well as safe evacuation axes, in order to ensure safety during the search.

#### **Training level of military personnel on avalanche standby**

Personnel on avalanche standby must possess thorough knowledge of companion rescue and organised search work, including the use of search tools, excavation and evacuation of avalanche victims, accident site organisation, as well as possible coordination with other avalanche rescue participants. Personnel should also be knowledgeable about the materiel in avalanche rescue sets, and the use of same. As

part of preparations, training and exercises must have been completed prior to the start of the standby period.



Figure: 4.2

*Soldier equipped with avalanche probe, shovel and avalanche transceiver*

#### **Training level for an officer in charge of an avalanche**

The officer in charge of the avalanche is the incident commander's adviser and is responsible for coordinating and supervising avalanche work.

The officer in charge of the avalanche must have completed an avalanche rescue course and should also have completed an avalanche hazard warning course and Norwegian winter course. Courses take place at the Norwegian School of Winter Warfare. The officer in charge of the avalanche must also possess several years' experience of winter service and mountain operations.

*Personnel on avalanche standby must master the use of search tools, as well as the excavation, handling and evacuation of avalanche victims. Personnel must also have knowledge of the organisation of an accident site and an organised avalanche rescue.*

## 4.3 Companion rescue

### 4.3.1 General

Officers operating in avalanche risk areas are responsible for their units safety. Through training and attitude formation, the Norwegian Armed Forces will do everything in its power to prevent personnel from being struck by an avalanche. If, however, an avalanche should occur, it is companion rescue that most often saves lives. Companion rescue means that a unit or personnel will conduct a search with the available tools as soon as an avalanche has occurred. The chances of survival diminish dramatically the longer an avalanche victim remains buried in snow.

Thus, companion rescue is the method that can save the most lives. Any personnel moving through terrain in which an avalanche may occur must possess the necessary companion rescue equipment, as well as master the use of the supplied equipment. This means that all personnel should receive the necessary training in the use of avalanche probes and avalanche transceivers. Basic first aid training should also be completed and personnel should be familiar with avalanche victim excavation techniques.

***Companion rescue is the most important measure for saving lives. It is in the first few minutes after an avalanche has occurred that there is the greatest chance of finding survivors.***

### 4.3.2 Equipment

Any personnel moving in avalanche-prone terrain should carry companion rescue equipment comprising, as a minimum:

- avalanche probe
- shovel
- avalanche transceiver



Figure: 4.3

#### ***Companion rescue equipment***

*The minimum equipment requirement for companion rescue is a shovel, avalanche probe and avalanche transceiver.*

Time is a critical factor and it takes time to locate avalanche victims who are not visible from the surface. The above-mentioned materiel is necessary to the rapid localisation and excavation of avalanche victims.

***A combination of avalanche probe, shovel and avalanche transceiver offer a significant chance of rapidly locating an avalanche victim. If only two of the aforementioned items are utilised, the time it takes to locate and excavate an avalanche victim will increase dramatically.***

#### **4.3.3 Implementation of companion rescue**

When an accident has occurred it is important to know what to do. Below, the most important tasks are listed.

- Try to be aware of what happens when the avalanche occurs.
- Call 112 if possible.

- Assess your own safety.
- Estimate the most likely area for locating casualties
- Start searching with an avalanche transceiver.
- Parallel to the avalanche transceiver search, start a rapid search, point probing and marking, if necessary.
- Start a systematic and thorough surface search of the whole area.
- Continue with an avalanche transceiver and a thorough surface search until an organised rescue operation has been established. If no casualties have been located with an avalanche transceiver or on the surface, implement a search line following a thorough surface search and designate a primary search zone.
- Prepare to receive the organised rescue team (after 45 mins at the earliest)(refer to appendices in section 5.1 and 5.2).

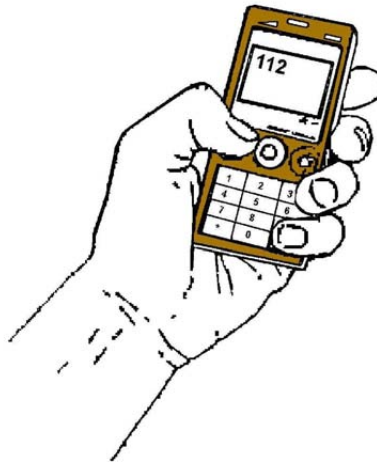


Figure: 4.4

*Alerting the local rescue service on 112*

**4.3.4 Alerts**

Avalanche accident alerts are important but are dependent upon mobile phone coverage, available communications equipment, distance to inhabited areas, as well as the possibility of a rescue operation being conducted. In the event that communications equipment is available, the alarm should be raised immediately.

***If communications equipment is available the alarm should be raised immediately.***

Here are some guidelines for raising an alarm in the event that communications equipment is not available or there is no mobile phone coverage:

**Several persons present**

One person seeks help and the remaining personnel carry out companion rescue. In the event of poor or unstable weather, two people should seek help immediately.

**Only two persons present**

Both persons commence companion rescue and continue for 40 minutes. After this, one person may seek help, providing weather and surface conditions, as well as the situation generally, permit. If there is a considerable risk of getting lost, both parties should seek help.

**Only one person present**

He/she carries out companion rescue for 40 minutes and then seeks help.

These are just guidelines for raising an alarm and must be regarded as such. The reason for carrying out companion rescue for 40 minutes is that it is during this period that the greatest chance of finding survivors exists. Avalanche victims who have survived for 40 minutes will often survive for up to a further 90-120 minutes as they have an air pocket around the nose and mouth. If only a few people are present it is important to supplement the search with rescue personnel so that they may also take part in the rescue operation.

***In the event that communications equipment is not available personnel must search for 40 minutes before possibly leaving the accident site to raise the alarm.***

#### **4.3.5 Companion rescue – training and check list**

As a basis for training, and also as a check list for companion rescue, an Assisted Rescue card has been prepared (Appendices 5.1 and 5.2). The purpose of the card is to simplify training in, and implementation of, companion rescue. The card should also be laminated so that it may be used as a check list in a genuine situation. The content has been simplified so that personnel in training do not become preoccupied with tasks that form part of the actual organised rescue operation. It has also been assumed that affected personnel are equipped with avalanche transceivers.

In the event that companion rescue is to be conducted without avalanche transceivers, the items describing electronic detection should be omitted. Instead, a primary search zone must be designated based on observations, finds, and the likelihood of finds, as well as tracks. Further, a search line should be implemented after the surface search has concluded.

A rapid surface search should be undertaken several times before switching to a thorough surface search. Search lines must not be implemented before it has been

ascertained that the surface has been carefully searched. The only exception to this is when it has been established beyond reasonable doubt that a person lies buried within a limited area and that this area may be designated as a primary search zone. In such cases, it will take less time to conduct a surface search before a search line is implemented.

## 4.4 Organised rescue



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Figure: 4.5

### *Schematic diagram for organisation of an accident site*

#### 4.4.1 Initial rescue

##### **Background and general measures**

The time aspect is vital to the outcome of an avalanche accident. Based on this, the rescue operation has been divided into phases in order to more easily identify ways of saving time. The respective phases are: raising the alarm, mobilisation, response and rescue. The most demanding phases are response and rescue because the emergency route, weather and surface conditions, means of transport and conditions at the accident site vary from one incident to another.

Rescue parties will be subject to great demands in everything from navigation and physical fitness to technical knowledge and skills. The initial task force must have trained together and be physically fit. These factors must be taken into consideration

when selecting personnel for the initial task force.

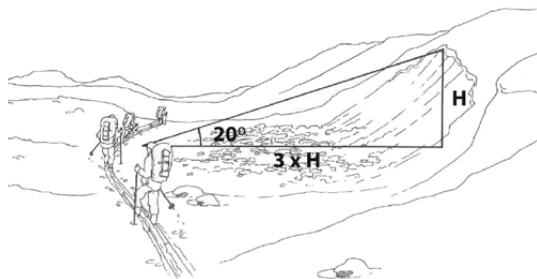
It is vital that routines are practised so that the need to improvise does not arise in respect of WHAT should be done, nor in respect of HOW individual measures should be implemented. The initial task force in an organised avalanche rescue operation has two primary objectives: to safely and swiftly commence searching for avalanche victims (life-saving measures); to prepare a rescue operation by major rescue forces.

### **Safety**

The initial safety assessment must relate to the actual choice of route to the avalanche area. A plan must be drawn up as to how the response should proceed and must be submitted to higher echelon in order to familiarise the chain of command with the choice of route and means of transport. This will provide the rescue executive with an indication of how long it will take the initial task force to reach the accident site. The chosen route must be safe, set against the background of topography, as well as snow and weather conditions (refer to chapter 3).

The actual chosen route must be constantly checked against the planned route and outlined on the map. The coordinating authority must be notified as quickly as possible of the precise choice of route, with further reports on particularly avalanche-prone and unsafe areas. If possible, the route to the accident site should be marked with marking ribbon, lightsticks or similar. The main force will often select the same route as the initial task force so consideration should be given to the fact that a large number of persons and heavy equipment on vehicles will follow.

When the group is in transit, it should also note previous avalanche activity in the area and possible runout zones for self-triggered avalanches in proximity to the chosen route. The steepness of leeward slopes close to the chosen route must also be taken into account in respect of possible adjustments to the planned route (refer to chapter 3).



*Figure: 4.6*

### ***The 20 degree rule***

When the initial task force arrives at the accident site, it must assess the risk of a secondary avalanche occurring. In this respect, significant factors are the view of the relevant release areas, as well as weather, snow and terrain conditions.

In addition, the map reference for the avalanche area must be verified and the size and shape/type of avalanche assessed. Special terrain formations, power lines, buildings and any other infrastructure must be registered and reported to the rescue executive with a view to helicopter traffic into and out of the area.

If there is a danger of a secondary avalanche occurring an avalanche look-out must be assigned. The task of the avalanche look-out is to assess the accumulation of snow along the avalanche path, as well as the danger of secondary avalanches occurring. The avalanche look-out should alert personnel in the avalanche area in the event that the danger of a secondary avalanche increases. The avalanche look-out must be positioned in such a way that he/she has the opportunity to assess the snow along the avalanche path. He/she should raise the alarm immediately with appropriate warning equipment (signal pistol, whistle, shout) and also alert the appropriate authority in the event that the weather or darkness means that he/she can no longer see the relevant area. The avalanche look-out should be changed frequently, particularly in poor weather.

If, from the outset, many people are involved in the rescue operation, a registration gate should be established on the outer edge of the avalanche where a registration guard maintains an overview of who is in the avalanche area. The registration guard is also responsible for informing personnel of the agreed escape route in the event of a secondary avalanche occurring.

It may be seen immediately that safety-related tasks could impact upon the efficiency of the search. The most effective measure for reducing risk and achieving greater efficiency may be to reduce the number of personnel involved in the rescue, or to temporarily withdraw personnel who are not directly involved in the organised rescue operation. Before engaging in the rescue operation, rescue personnel should wear suitable clothing. Personnel should also be equipped with avalanche transceivers.

***Focus should be placed on the safety of rescue personnel at the accident site at all times.***

#### **Organisation and management**

The initial task force should relieve itself of any superfluous equipment at the equipment assembly point/depot, which should be selected with safety and wind direction in mind (out of consideration for avalanche dogs). This is important because subsequent rescue personnel and vehicles will set out from the area where the equipment has already been placed and will also establish themselves there. One person should be assigned the task of identifying a suitable landing place at an early stage and should direct any helicopter attempting to land. The rescue group should wear reflective vests marked with job titles and should be informed in advance as to who will assume command of the rescue operation.

The initial task force should gain an overview of the avalanche situation. The officer

in charge of the initial task force should draw a sketch of the avalanche following a rapid search and a thorough surface search, as part of the work to determine the primary search zone. Sketch details are important and should contain all vital information, including ski tracks into and out of the avalanche, finds, etc. The sketch is also an important way of communicating with participants both within and outside of the avalanche. As many persons as possible should be assigned to the active search and search party personnel should be changed regularly, if possible! If there are sufficient personnel resources, preparations should be made for a larger organised rescue operation.

A major challenge at the accident site is how to work efficiently and rapidly, as well as how to utilise available personnel as effectively as possible. This means that the most effective and useful search tool for the organised rescue operation, the dog equipage, must receive both priority and the necessary level of support if it is present at the accident site.

The initial task force must be coordinated in such a way as to provide dog equipages with optimum search conditions. This may mean that personnel intending to carry out a surface search cannot become actively engaged until after the avalanche dog search has commenced, possibly starting the surface search at the trailing edge of the dog equipage. It may also be necessary to temporarily withdraw personnel already forming part of the rescue operation. Such measures must be agreed directly with the dog handler (or the officer in charge of the avalanche dog service).



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*Figure: 4.7*

***Initial task force undertaking a surface search***

Most avalanche dogs have been trained to search even when there are disturbances in the rescue area. The dog handler is best qualified to assess whether personnel and avalanche dogs can be in the avalanche area simultaneously. However, the rescue operation should be organised in such a way as to keep disturbances to a minimum. This is the responsibility of all rescue personnel!

Some rescue service helicopters are equipped with special antennas to search with avalanche transceivers and/or Recco detection equipment. This type of search must also be coordinated with avalanche dog searches. Experience from abroad would suggest that such searches may be undertaken simultaneously as long as the helicopter search and the avalanche dog search do not take place in the same part of the avalanche area at the same time. Searches utilising electronic search tools will be highly prioritised in the initial rescue phase. It is important to note that a helicopter is often not included in an initial rescue operation. Response time, availability of resources and weather conditions will determine whether the helicopter arrives before, during or after the initial rescue operation.

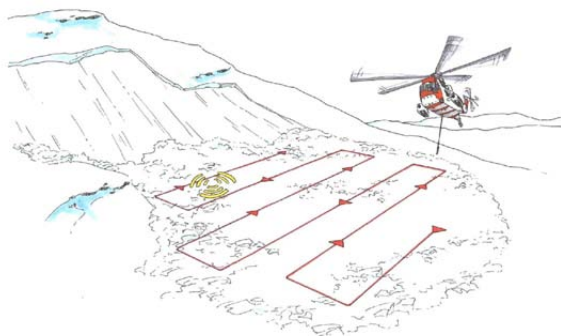


Figure: 4.8

***Helicopter search with underslung antenna***



Figure: 4.9

***Helicopter search with Recco detection system***

*One person sits in the door hatch with the Recco detection system.*

***The selection of search methods at an early phase of the search will be decisive to the effectiveness and outcome of the rescue operation.***

### **Search methods and marking**

#### ***Avalanche transceiver and Recco***

A search with an avalanche transceiver and Recco should be conducted immediately and in tandem with the surface search. The search with electronic tools should continue until the whole avalanche area has been thoroughly searched.

#### ***Equipment***

When rescue personnel commence searching it is recommended that they take with them a rucksack and possibly ski poles. This will avoid the need to return to collect equipment that may be required early in the search (avalanche probe, shovel, first aid equipment, warm clothes and wind protection). If an avalanche victim is located during the rapid search as a result of a foot protruding out of the snow, for example, it is unacceptable for personnel to have to travel a long way in order to locate a shovel. Rapid excavation may save the life of a person buried beneath the snow. This also applies to avalanche probes. If an avalanche victim is located with an avalanche transceiver, it should not be necessary to obtain an avalanche probe and shovel to fine search and excavate the victim. Ski poles will permit personnel to move swiftly and efficiently in the avalanche area. They may also be used as markers.

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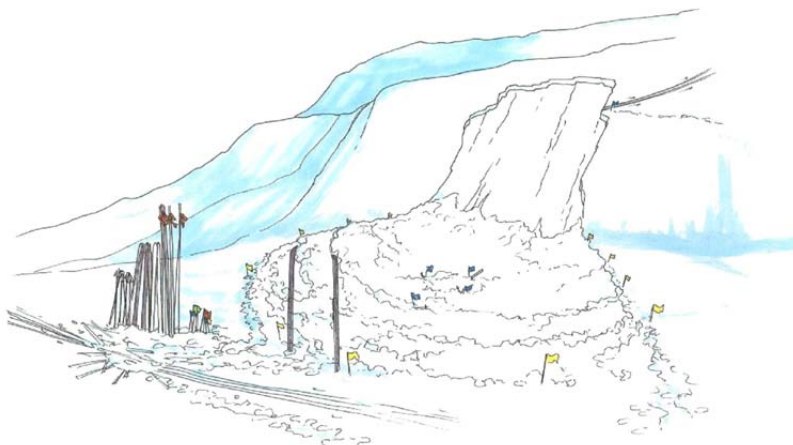
*Figure: 4.10*

***Rescue personnel locate an avalanche victim during a surface search***

***To avoid loss of time, take the necessary search and excavation equipment as you enter the avalanche area.***

***Marking***

Any objects or traces of missing persons, ski tracks into the area, disappearance points and avalanche dog markings should be marked in blue (flags, marker sticks). Reliable observations such as ski tracks into the area and disappearance points should be marked with blue marker flags or marker sticks placed in a cross.



*Figure: 4.11*

***The correct use of marking equipment at the accident site is important***

The weather conditions will often determine whether the outer edges need to be marked. If possible, the fracture line and the avalanche's outer edges should be marked, without impacting upon the efficiency of the search. If necessary, marking may commence in the transition phase between the surface search and search lines being established. The fracture line and outer edges should be marked in yellow (or possibly yellow/black). Yellow marking is not urgent.

At locations where a systematic coarse search/pinpoint search has been carried out (in proximity to located objects, avalanche dog markings, etc.), the searched area should be marked with red flags/marker sticks. Such markings (blue flag encircled by red flags) will allow other rescue personnel (for example dog handlers) to see immediately that the area has been checked.

<b>Marking equipment</b>	<b>Signification</b>
Blue marking	Surface find/tracks/avalanche dog markings
Blue marking in a cross shape	Ski tracks into the area/entrapment point/disappearance point
Yellow marking	Fracture line and outer edges
Red marking	Searched area, also around blue markers
Green marking	Zone (primary search zone)

*Table 4.1 - Marking equipment and avalanche colour codes*

***Finds and tracks must be marked as quickly as possible. All rescue personnel should carry marking equipment during a surface search.***

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#### ***Avalanche transceiver searches***

Unclear routines in the start phase of a search with an avalanche transceiver may result in significant confusion and delay, and reduce the possibility of an avalanche victim surviving. Thus, all rescue personnel, including dog equipages, must switch their units to search mode. If a sufficient number of rescue personnel are available to conduct an effective search with avalanche transceivers, other personnel may switch off their devices completely. In such cases, these personnel must remain in a safe location.

The first person to receive a signal must alert all other members of the search party (via shouting/communications equipment) and swiftly conclude the search.

Personnel with avalanche probes and shovels may offer immediate assistance to a person whose avalanche transceiver has detected something.

***All personnel in and around the search area must switch their avalanche receivers to search mode.***

#### ***Rapid surface search***

A rapid surface search is conducted as a swift surface search throughout the whole avalanche area with all available personnel in tandem with a transceiver search.

Search, shout and listen. Objects should be examined and marked, but not moved.

This must be carried out swiftly and in a concentrated manner. The officer in charge should participate in the surface search and follow the avalanche's flow paths downwards. Personnel should walk or run across the area several times. This part of the search may not be concluded before it has been confirmed that no clearly visible body parts or objects are evident in the avalanche area, and that the whole avalanche

area has been covered.

Skis/ski poles/snowboards/snowshoes must not be pulled directly out of the snow but carefully extracted to verify whether the equipment is attached to the avalanche victim or not. They may then be placed upright in the snow and marked with blue flags/marker sticks after a pin-point search with a probe has been done.

***By carrying out a rapid surface search it will be possible to quickly determine whether there are visible body parts or materiel on the surface of the avalanche.***

***Thorough surface search***

A thorough surface search should be conducted with a search party. A search using avalanche transceivers should be undertaken in tandem with a thorough surface search. The search party should be organised with a distance of two arm's length between personnel (determined by placing fingertip to fingertip). A thorough search should be made for any partly hidden objects or body parts. Initially, the area in the line of dip should be covered, upwards and downwards, then sideways, in both directions. Blocks of snow should be overturned, if necessary. Personnel should listen, shout and search.

***Pinpoint search (figure 4.12)***

A pinpoint search with an avalanche probe should be conducted in the event that objects, avalanche dog markings or other signs of avalanche victims are found. A pinpoint search is carried out as a rapid spiral search with an avalanche probe in which holes should have a 25 cm distance to the side and across. A spiral search is an effective and rapid pinpoint search procedure.

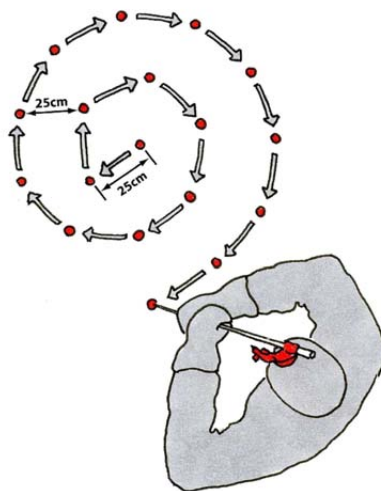


Figure: 4.12

*A pinpoint search is undertaken when a relevant find has been made and is conducted by probing out from the centre in a spiral shape with the avalanche probe. The holes should have a 25 cm distance to the side and across*

***Do not progress to establishing search lines before it has been confirmed that there are no visible body parts or materiel on the surface, as well as ensuring that the whole area has been thoroughly searched for signals from avalanche transceivers.***

### Search lines

#### *Primary search zone*

As search lines take a long time to complete they should be limited as much as possible to a primary search zone in a smaller area that offers a greater likelihood of a find being made. By selecting a primary search zone, rather than searching the whole avalanche area, the likelihood of finding victims alive increases. The officer in charge of the avalanche will determine the primary search zone based on the following:

- The entrapment point is the point where the avalanche victim is struck by the avalanche and carried down the mountainside.
- The disappearance point is the point where a person disappears from the

surface of the avalanche and is carried further down the mountainside within the avalanche itself. The flow path from the entrapment point/point of disappearance provides a sound basis upon which to estimate the area in which an avalanche victim may be found. It will not be possible to restrict the probable find spot to one point. Thus, an area is designated – the primary search zone.

- The profile of the slope on which the avalanche was triggered may provide some clues. If the transition is even, like a ski jump, it is likely that a person struck by the avalanche high up the slope will be situated slightly behind the avalanche debris. However, if there is an abrupt transition from the slope to more level terrain, the snow from the upper part of the slope will pile up over the snow that has accumulated at the foot of the slope. Thus, personnel struck by the avalanche near the foot of the slope will be carried a shorter distance than those who were struck higher up and possibly be buried under large volumes of snow.
- Obstacles along the avalanche's path will lead to congestion upstream or accumulation downstream of the obstacles.
- The avalanche velocity is greatest on the surface, in the centre and on the outer bend. The least velocity is along the edge of the avalanche.
- Avalanche victims may end up in the wake of natural obstacles or after narrow passages.
- Other signs such as ski tracks and objects must be factored into the assessment when a primary search zone is being determined.
- The search should extend from the disappearance point or points where objects have been found and down the avalanche path, unless it is evident that the avalanche victim is located further down.



*Figure: 4.13*

***Sketch with outline of primary search zone proposal***

Finds, ski tracks, terrain formations, flow paths, etc. should be outlined on the sketch as the basis for determining a primary search zone. Information should be sought from witnesses. A primary search zone should be selected that should be marked with green flags/marker sticks. The primary search zone applies to all search tools and may only be adjusted by the officer in charge of the avalanche or the second in command.

The avalanche dog search continues in the primary zone. The dog equipage must be closely monitored at all times so that dog handlers may be free to focus solely on dog handling. This is particularly important if the avalanche dog marks a find and it becomes necessary to carry out a pinpoint search and excavate.

***The determination of a primary search zone is vital in order to limit the use of search lines to the area in which it is most likely that avalanche victims will be found.***

### 3-point coarse search

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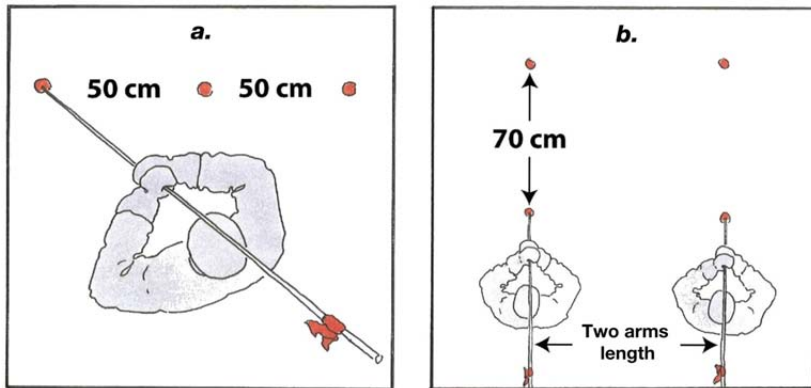


Figure: 4.14

***Figure 4.14 a: 3-point coarse search with distances and figure 4.14 b: Distance sideways and longways between each search. Personnel in the search line position themselves at two arms' length of each other (fingertip to fingertip)***

The time factor demands that the search line must work as rapidly and efficiently as possible, i.e. the search pattern is conducted swiftly, though carefully. If avalanche probes are not available, ski poles should be used. The baskets should be removed and the ski poles assembled into a long avalanche probe. One ski pole will be too short, but is better than nothing. The search must be conducted with the pointed end of the ski pole facing downwards in order to penetrate the snow. This method may result in the avalanche victim being harmed by the pole tip but this is of little

consequence compared to the benefits of rapid localization of the avalanche victim.

A 3-point coarse search should be preferably conducted with avalanche probes, or otherwise with ski poles. Personnel should remember to carry out a coarse search of the area several times before undertaking any fine search. In special cases (very small or restricted areas when large rescue forces are available) a fine search may be carried out directly without a coarse search being conducted beforehand. However, this does not occur very often. The officer in charge of the avalanche will determine if a fine search should start directly.

In the case of a 3-point coarse search, it would be advantageous to limit the search lines to 5 persons per line. The officer in charge of search lines should participate in the search with his/her own avalanche probe. This will provide better communication and a higher level of efficiency. The various search lines may be positioned in different parts of the primary search zone, possibly to the rear of, and a little staggered, in relation to the other search lines. This will achieve both flexibility and thoroughness.

A 3-point coarse search should be carried out as follows:

- Fingertip distance (two arms' length)
- 3 holes per search command
- Approximately 50 x 70 cm, to a maximum depth of 2 metres
- Search teams comprising up to 5 persons
- Every 4th search marked with red flags
- Speed is critical. Use less time on organisation
- Exaggerated caution will delay the search and must be avoided
- Several 3-point coarse searches should be conducted before a fine search is considered
- The avalanche probe should be inserted **vertically** into all three holes

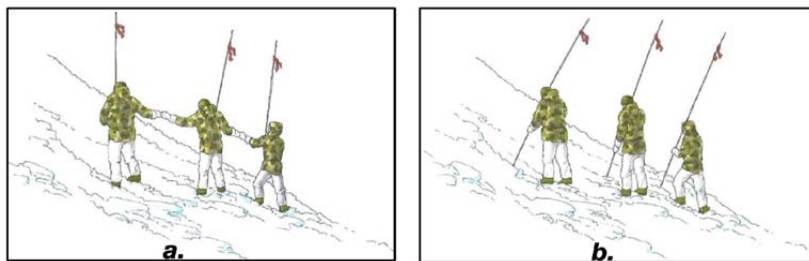


Figure: 4.15

*Figure 4.15 a: Two arms' length distance between personnel in the search line and figure 4.15 b: Conducting a 3-point coarse search*

*A 3-point coarse search should be carried out many times before switching to a fine search. In the case of a coarse search, the search lines may move more rapidly within the primary search zone. This increases the chances of finding avalanche victims alive, compared to a fine search.*

#### ***Pinpoint search***

A pinpoint search should continue in hollows, in the wake of natural obstacles, as well as in any smaller primary areas, and also around avalanche dog markings. Personnel should remember to mark (red flags/marker sticks) areas that have already been searched.

#### ***Fine search***

A fine search is conducted when there are enough clues regarding the location of an avalanche victim or it is considered unlikely that avalanche victims will be found alive, or if a significant number of search party personnel become available, having concluded a coarse search.

A fine search should be conducted as follows:

- Shoulder to shoulder
- 3 holes per search command
- Approximately 25 x 25 cm, the whole probe to a depth of 3 or 5 metres
- The avalanche probe should be inserted vertically into all three holes

It is assumed that a fine search will give a 100% detection rate when a search pattern of 25 x 25 cm is maintained and the avalanche probe is inserted vertically into the snowpack. If the avalanche probe is not long enough, it may be necessary to obtain longer avalanche probes or dig trenches in the avalanche mass. However, this is a last resort.

*It is the responsibility of the officer in charge of the avalanche to determine when to switch from a 3-point coarse search to a fine search.*

#### ***Organisation***

The search work continues as specified above until the influx of personnel necessitates expansion and reorganisation. In this phase, the officer in charge of the avalanche, who is responsible for the organised search, may, to a greater extent, withdraw in order to focus on receiving large rescue forces. This will involve designating assembly points, depot, helicopter landing site, the establishment of a registration guard, as well as the requisitioning of equipment and personnel. However, these tasks must not be at the expense of the efficiency of the search. The second in command to the officer in charge of the avalanche will be responsible for

the work continuing in the zone of the avalanche.

*It is important to locate avalanche victims before the site becomes crowded and 'chaotic'.*

#### 4.4.2 Organisation and tasks at the accident site

##### **Incident commander (IL)**

The incident commander is the chief constable's local representative. The incident commander's duties are described in detail in item 4.2.4.

##### **Officer in charge of the avalanche (Fagleder skred)**

The officer in charge of the avalanche is responsible for work within the avalanche area, including:

- conducting a continuous avalanche assessment
- assigning a second in command as operational supervisor of the avalanche (NK Fagleder skred)
- planning further searches in collaboration with the second in command
- providing advice to the incident commander in respect of safety, the search and personnel
- coordinating resources and assuming command of further planning
- organising the avalanche area and assigning the necessary roles

*The officer in charge of the avalanche is responsible for supervising work in the avalanche area.*

##### **Chief coordinator(Fagleder orden)**

The chief coordinator should be a police employee. He/she should be responsible for everything connected with order, management and registration.

In consultation with the officer in charge of the avalanche and the incident commander, he/she should designate a helicopter landing site, ambulance control point, assembly point for evacuated persons, assembly point for rescue personnel and assembly point for deceased persons. He/she is responsible for assigning supervisors to the areas he/she has designated, as well as a supervisor for the cordon service. This service should regulate the accident site in order to prevent personnel from going missing, among other things. Personnel evacuated from the accident site should be registered at the ambulance control point. The chief coordinator should wear a reflective vest with 'Chief coordinator' printed on it.

##### **Log keeper/officer in charge of intelligence (Logfører/etterretningsleder)**

The log keeper should maintain a rescue journal at the accident site that includes all incoming and outgoing messages.

The officer in charge of intelligence should procure information regarding:

- evacuated and missing personnel

- when the avalanche occurred
- who has/may have seen something
- who and how many persons are missing, including a description
- what has actually happened and what has been accomplished

**Chief communications supervisor (Fagleder samband)**

The chief communications supervisor is responsible for establishing and carrying out communications with the local rescue centre, as well as with the various roles assigned at the accident site.

**Officer in charge of resources (Ressursleder)**

The officer in charge of resources should procure the necessary resources for the accident site via the local rescue centre. This will include personnel, materiel, transport, provisions, supplies and bivouacs. The officer in charge of resources is responsible for setting up the operation of the depot.

**Press and information officer (PIO)**

In accordance with the guidelines of the incident commander, the officer in charge of the press and information should provide the press with information and, if conditions permit, limited access to the accident site itself. Consideration of personnel affected by the accident should be weighed against the need to provide information. Otherwise, the mass media should be provided with as much information as possible. The local rescue centre will notify the media of the accident, in addition to the information provided at the accident site. In many instances this will be the responsibility of the incident commander.

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**Chief medical supervisor (Fagleder helse)**

The chief medical supervisor should preferably be a doctor or the person most qualified within medical service/first aid in the avalanche area. He/she has primary medical responsibility for the medical service and should take charge of medical treatment. In collaboration with the officer in charge of the avalanche, he/she will designate an assembly point for the injured. He/she reports to the incident commander, as well as coordinating and alerting the local rescue centre regarding hospitals and evacuation. He/she will assign an operational medical supervisor and a supervisor for the assembly point for the injured. The chief medical supervisor should wear a green vest with his/her role printed in green.

**Operational medical supervisor (Operativ leder helse)**

The operational medical supervisor should be a person with experience of practical medical service management. He/she is responsible for evacuating the injured to the assembly point and organising further transport to hospital. He/she should have materiel, personnel and medical vehicles at his/her disposal.

**The second in command to the officer in charge of the avalanche (NK Fagleder skred)**

The role of the second in command to the officer in charge of the avalanche reports directly to the officer in charge of the avalanche and will be assigned in the event that several searches are conducted in the avalanche area simultaneously. This individual should have operational experience of major avalanche exercises and a

good knowledge of all rescue techniques. He/she should also distribute duties and zones between search lines and avalanche rescue dogs, as well as provide instruction in the use of avalanche transceivers. In addition, he/she should maintain communications with the command post and the preparation area.

**Officer in charge of search lines(Søkelinjeleder)**

- Communicates with the search supervisor, and/or outside of the avalanche area
- Forms part of the search line
- Inspects finds

**Avalanche look-out (Skredvarsler)**

In many cases it may be appropriate to assign and position personnel in the role of avalanche look-out. The role of the avalanche look-out is to reinforce the safety of all personnel working on, and in connection with, an avalanche. The avalanche look-out monitors parallel avalanche paths and any new accumulation of snow that may represent a threat to long-term safety.

***Requirements for observation post placement***

- outside of avalanche risk terrain
- wind direction should be taken into account
- the distance from other activities should not be too excessive and access from the accident site should be easy and safe
- view of snow accumulation, and of the avalanche

***Necessary equipment***

- communications with the officer in charge of the avalanche
- audio signal, plastic whistle, gas horn
- base to stand on
- snow/slalom goggles
- binoculars

***Duties of the avalanche look-out***

- observe snow accumulation along the fracture line and in other areas, including leeward slopes
- alert the officer in charge of the avalanche of any secondary avalanche risk
- observe any new avalanches or parallel avalanches
- plan for a relief look-out to take over

*One person is assigned as an avalanche look-out in a well-positioned area and warns rescue personnel if there is a danger of new avalanches occurring. The avalanche look-out must be equipped with observation and warning equipment.*

### **Registration gate (Telleport)**

The registration gate is usually sited at the 'entrance' to the avalanche in order to maintain an overview of who is working at any given time. However, it also performs the role of liaison regarding important information between personnel within and outside of the avalanche itself, as well as verifying personnel moving in and out of the avalanche.

#### **Placement**

- on the edge of the avalanche at the natural point of entry/exit
- physical barrier – path from the preparation area should be marked

#### **Duties**

- maintain an overview of who is in the avalanche area at any given time
- inspect clothing, including caps and mittens (other equipment)
- inspect avalanche transceivers (On or off? Verify with the officer in charge of the avalanche!)

### **Maintaining a log**

#### **IN:- Mark in: O (ring)**

- notify of avalanche look-out, escape route, signals
- assign a personal number from the personnel list to all personnel
- if necessary write the number on the hand of rescue personnel with a permanent marker

#### **OUT:- Mark out: ⊗ (cross inside the ring).**

- provide directions to the personnel assembly point
- maintain a separate log for patients/avalanche victims

### **After any avalanche:**

- assemble personnel and conduct a roll call
- NB: Within an emergency organisation, it may be time-saving to have ready-laminated lists. Each person entering the avalanche will be assigned a number which will be inspected upon entry to and exit from the avalanche. Names should be entered on the laminated list.

*It is important to have a full overview of the number and identity of all personnel in the avalanche area at any given time.*

### **Helicopter landing site**

#### **Placement**

- Approach and departure usually take place against the wind
- there should be open terrain along the approach and departure path



*Figure: 4.16*

#### ***Sea King Search and Rescue helicopter from 330 Squadron of the Norwegian Armed Forces***

#### **Dimension requirements for landing zone**

- **Sea King** – at least 25 x 25 metres, flat terrain
- **Air ambulance/police helicopter** – at least 15 x 15 metres, flat terrain
- the landing zone should be sited at least 100 metres from the avalanche area
- it should be free from obstructions; the surface should be hard; loose snow should be trampled flat. The terrain must be flat

#### **Safety**

- communications channel 5 (rescue channel)
- be aware of the powerful rotor wind
- remove loose objects, secure equipment
- use snow/slalom goggles! (applies to personnel receiving the helicopter)

- always comply with the instructions of the helicopter crew
- ensure that all personnel remain calm and adhere to commands
- ensure that nobody approaches the helicopter until the helicopter crew has given the go- ahead signal
- approach from the front, avoid the tail rotor
- extra caution should be exercised on sloping terrain
- never shine a light directly at the pilot (nor a flash)

***Receiving a helicopter***

- arms raised, back to the wind, landing site to the front
- personnel should remain still. They should sit down and protect their faces as the helicopter approaches
- await a signal before moving

***The helicopter landing site should be trampled flat and sited at least 100 metres from the avalanche in order to not disturb the search operation.***

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**Depot**

Major rescue operations require many different types of materiel in order to run efficiently and continuously, including search equipment, lighting materiel and heating units, medical materiel, warm clothing for rescue personnel, supplies and bivouacs. Thus, it is practical to establish a depot for the specific purpose of assembling available materiel in one place. This will also make it easier to identify important and critical shortages and subsequently bring these to the attention of the incident commander so that the necessary materiel may be ordered and procured swiftly and efficiently.

***Placement***

- the depot should be sited in an area away from potential avalanche paths
- it should preferably be sited to the 'rear' of the wind direction so that smells, in particular, do not affect the avalanche dogs in their search efforts
- it should also be sheltered, i.e. in a tent or permanent structure, so that materiel not being used is not exposed to precipitation, for example
- it should be sited close to the avalanche itself, and to personnel
- accessibility: transport to and from the avalanche area and access path should be available

***Officer in charge***

- communicates with KO (command post)/rescue executive
- collaborates with preparation area and assembly points

- maintains an overview of, and makes ready equipment for, the preparation area
- assesses and communicates equipment requirements
- requisitions equipment via the command post/rescue executive

***Equipment available in the depot***

- avalanche probes
- shovels
- marking materiel
- first aid equipment
- pulk sleds, backboards, survival canvases
- shelter and warmth (tents and cooking stoves)
- food & drink
- power generator, spotlights, searchlights
- lights, batteries, avalanche transceivers
- extra clothes and footwear

***Personnel assembly point***

Personnel who are either waiting to be assigned tasks or who require a rest should assemble at the personnel assembly point. The assembly point must be sited in such a way that it cannot come into conflict with potential avalanche paths or in any other way represent a risk to personnel assembled there. Meals are taken at the personnel assembly point and it would thus be natural to site it to the 'rear' of the wind.

***Placement***

- safety
- wind direction
- sited close to the avalanche but must not disturb avalanche dog work
- expansion options

***Function***

- establish shelter for personnel
- establish a resting zone for avalanche dogs (covered)
- provide basic provisions (food/drink)
- organise transport
- organise volunteer training
- information for personnel

***Officer in charge***

- communicates with preparation area and command post/rescue executive

- overview of available personnel
- evaluates qualifications (who can do what)

**Assembly point for the injured (deceased)**

***Placement***

- safety
- wind direction
- sheltered from the elements, preferably heated
- sited close to the avalanche but must remain undisturbed
- accessibility: continuous transport chain to hospital
- expansion options
- hidden from the personnel assembly point
- deceased persons should not be placed in such a way that they are visible to other personnel or other personnel have access to the location where they are being kept

***Officer in charge***

- reports to the chief medical supervisor
- communicates with the command post/chief medical supervisor
- number of rescue personnel
- equipment (first aid/heating)
- registers patients in/out

***Plan and prepare***

- equipment and specialised personnel made ready
- expect a prolonged rescue operation
- patient pulk sleds with equipment and wrapping gear upon casualty extraction
- dry, wrapping gear with heating and option to supply heat to the assembly point for the injured

***Ambulance control point (AKP)***

- police responsibility!
- registers patients who are removed from the avalanche area
- who should be transported? Prioritise according to requirements
- where and when should the patient be transported?

## 4.5 Medical service

### 4.5.1 Causes of death in connection with avalanches

- in 80% of cases avalanche victims die due to oxygen deficiency

- in around 10-15% of cases death is due to mechanical injuries
- in around 5% of cases avalanche victims die due to general hypothermia

The number of fatalities may be primarily reduced by implementing and mastering companion rescue within the first 15-20 minutes.

*It is within the first few minutes that the possibility of finding avalanche victims alive is greatest.*

#### 4.5.2 The likelihood of surviving an avalanche

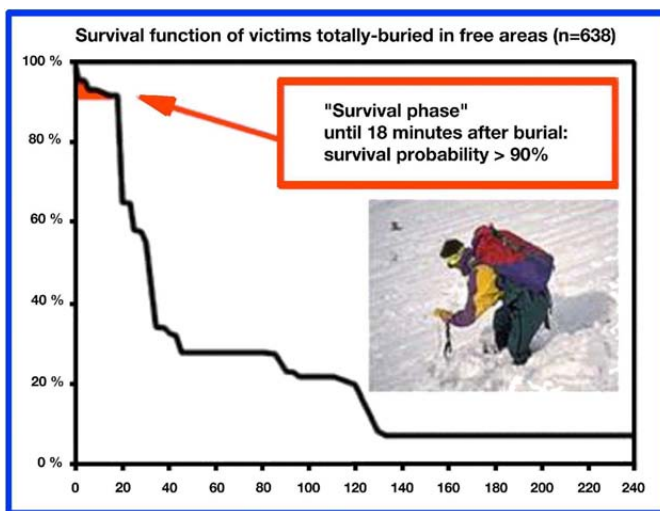


Figure: 4.17

#### *"The survival phase"*

Brugger et al. have accumulated data from over 600 avalanche accidents in the Swiss Alps and have arrived at a much used graphic representation of the chances of surviving an avalanche. The chances of survival may be roughly divided into 3 phases:

- **The survival phase:** Avalanche victims who are alive when the avalanche stops stand the greatest chance of being rescued alive in this phase, which is estimated at lasting 18 minutes. This phase is also referred to as the 'companion rescue phase' in which companion rescue is the method that saves the majority of lives
- **The suffocation phase:** From 18-35 minutes the chances of survival decrease to 34%. Avalanche victims who do not have an air pocket die of asphyxia and

other fatal injuries

- **The waiting phase:** Between 35 and 90 minutes the chances of survival for avalanche victims who have an air pocket is relatively constant (25-30%) Such victims may survive for up to 1½-2 hours and then die of hypoxia, hypercapnia or hypothermia ('Triple H syndrome'), depending on type of clothing, the snow's properties, and other reasons
- there is around a 50% survival rate for avalanche victims who have been completely buried by an avalanche.
- 91 % of victims survive up to 18 minutes. This underlines the importance of implementing and mastering companion rescue
- the larger the air pocket, the longer the survival period

The figures referred to above are derived from accident statistics in the Swiss Alps. More recent research from Canada would suggest that the chances of survival in an avalanche are significantly lower. In Canadian avalanche accidents, a much lower percentage of victims are alive when an avalanche stops, compared to accidents in Switzerland. The survival phase, during which avalanche victims without an air pocket eventually die of suffocation, has shown itself to be considerably shorter. In Canadian accidents the survival phase may be as low as 5 minutes. It is believed that the increased number of fatalities is due to the snow being more compact. A greater percentage of avalanche victims die during the suffocation phase in Canada, compared to Switzerland. In Canadian avalanche accidents fewer than 10% survive the suffocation phase and have an air pocket to survive into the waiting phase.

In an avalanche context, many experts and researchers compare Norway with Canada. Both countries have coast-lying mountain regions and many avalanche paths end in forest terrain. Coast-lying mountain terrain provides more compact snow. Also, avalanche paths that end in forest terrain increase the likelihood of mechanical injuries being sustained.

### **Definitions**

#### *Asphyxia*

Too little oxygen due to suffocation/obstruction of air supply through the windpipe

#### *Hypoxia*

Oxygen deficiency. Hypo = insufficient/deficiency in, oxi = oxygen

#### *Hypercapnia*

Hyper = too much, capnia = carbon dioxide (CO<sub>2</sub>), too little oxygen, hyperventilation, unconsciousness, lung failure

#### *General hypothermia*

Hypo = too little/low, thermia = temperature

*Look for air pockets when excavating victims. Victims with an air pocket may survive for up to 90-120 minutes. Avalanche victims without an air pocket have little or no chance of surviving after 18 minutes and will die of suffocation.*

#### **4.5.3 Locating an avalanche victim**

The following procedure applies when an avalanche victim is located:

- leave the avalanche probe in place at the point of location
- summon medical personnel
- stand on the downside of the avalanche probe and dig a horizontal shaft down along the probe

*The avalanche probe should remain at the point of location. The probe guides the excavation work down towards the avalanche victim.*

#### **4.5.4 Examination and treatment during excavation**

##### **Excavation**

- time is critical – rapid detection and excavation is vital
- do not dig directly down towards the casualty, i.e. do not stand on top of the casualty
- dig down along the avalanche probe in a V-formation (refer to figures 4.18 and 4.19)
- attempt to reach the respiratory passages as quickly as possible
- uncover the casualty quickly and free the head and chest Perform CPR immediately!



Figure: 4.18

**Schematic diagram for excavation of a casualty viewed from the side**

The excavation team digs down along the avalanche probe in a V-formation. The V-formation is outlined in figure 4.19.

Chap-4

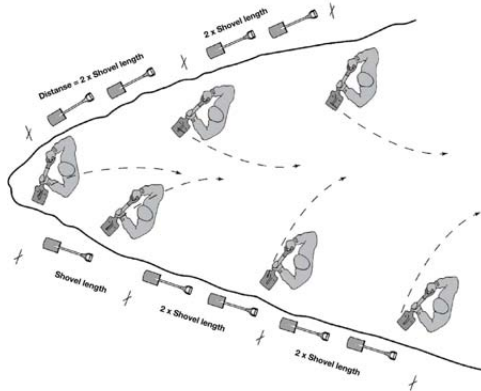


Figure: 4.19

**Schematic diagram for V-formed excavation of a casualty viewed from above**

The 1st person is positioned at the front of the V-formation. The 2nd person is positioned one shovel length behind the first person. The remaining personnel should be 2 shovel lengths' distance from the person in front. This will ensure that everyone can work at a whole shovel's length without disturbing each other. The snow should be shovelled backwards into the middle of the formation. In steep terrain, the length of the V-form should ideally be equivalent to the depth of the avalanche victim. In flat terrain, the length of the V-form should be equivalent to twice the depth of the avalanche victim. After 3-4 minutes, personnel should rotate in the formation in a clockwise direction to counter the effects of tiredness.

### **Examination and treatment**

- one person should stand at the head of the casualty, maintain contact and observe – do not let go of the casualty!
- look for air pockets<sup>2</sup> during excavation
- is there an air pocket or ice shield in front of the mouth, ice or snow in the throat, nose and/or mouth? If so, medical personnel should be notified of this
- check for breathing, free the respiratory passages, check for bleeding and hypothermia
- carry out ABC principles, commence life-saving first aid; if necessary prioritise opening up the respiratory passages and administering assisted ventilation
- other personnel should dig around you and the casualty and provide assistance
- in respect of hypothermia/further reduction of core temperature, avoid moving the casualty's limbs
- place a cap on the casualty
- protect/cover the find spot with a survival canvas, tent or similar
- wrap the casualty well in a survival canvas, patient warming blanket or bubble wrap
- free the casualty so that he/she may be transferred to a pulk sled or backboard
- the casualty should be carefully transported to the assembly point for the injured
- do not remove the casualty from the snow before wrapping gear or heating equipment is ready

***Avoid moving the limbs of a hypothermic casualty. Cold blood from the extremities may cause cardiac arrest.***

### **Heat loss – avalanche victim**

- the temperature loss for casualties buried in snow is around 3° Celsius per hour
- the temperature loss for casualties excavated and uncovered is around 6° Celsius per hour

Thus, all equipment to prevent further hypothermia should be ready before the avalanche victim is removed from the snow.

2) An air pocket is defined as an absence of densely packed snow and ice in the mouth, throat and nose.

**4.5.5 Treatment at the assembly point**

- check regularly for signs of consciousness, breathing, bleeding and hypothermia
- commence life-saving first aid if necessary
- insulate the outside of the wrapping gear and provide heat if possible
- give the casualty heated oxygen (and possible infusion) if available
- carefully transport the casualty to hospital

**4.6 Electronic detection materiel****4.6.1 Avalanche transceiver – Basic setting****Avalanche transceiver – introduction**

The Norwegian Armed Forces avalanche transceiver, the Barryvox Pulse, is an electronic transmitter and receiver which, when switched on, transmits radio signals in the form of an electromagnetic field. The unit is switched to search mode during a search for avalanche victims and will then be capable of receiving signals from avalanche transceivers located in the avalanche itself.

The signal strength is dependent on the depth at which the victim is buried, the direction of the victim's transmitter and the distance to the victim. It is important to note that it is not possible to search in a straight line towards the victim but that the search is conducted along imaginary, curved flux lines in the signal field. The device calculates the direction and distance to the avalanche victim via the three built-in antennas.

The device also contains a movement detector that registers whether or not the avalanche victim has a pulse.

The avalanche transceiver should always be switched on before any movement or response is undertaken. It should also be subject to a function test at least once per day before any movement is undertaken (refer to table 4.2).

Avalanche transceivers should always be used in conjunction with an avalanche probe and shovel and will not provide the same potential for saving lives when used on their own (refer to figure 4.20). Working without an avalanche probe, or both an avalanche probe and a shovel, will result in at least twice as much time being spent on detecting and excavating an avalanche victim.

For supplementary information refer to Appendix 3, 5.3.

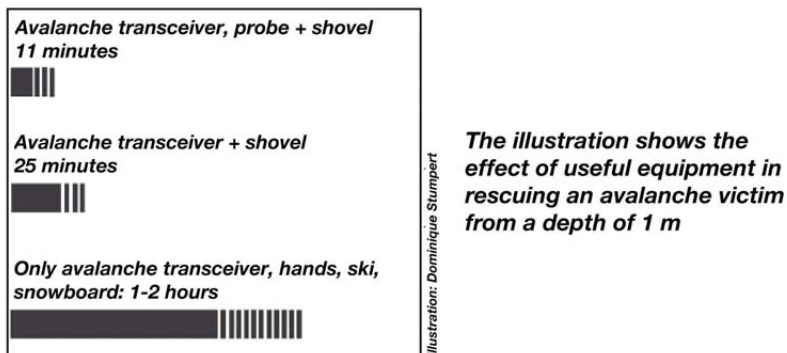


Figure: 4.20

*Elapsed time in an avalanche search in relation to available avalanche search and rescue equipment. If an avalanche probe and/or shovel are not used in the search, the elapsed search time will increase dramatically. (Source: Ortovox Instruction Manual)*

**IMPORTANT:**

- Mobile phones, radios, LED head lamps, cameras, pulse watches, communications equipment, emergency beacons, GPS, knives, weapons, ammunition, magazines, high-voltage cables, transformer substations all affect an avalanche transceiver's performance. The above-named items, as well as other metallic items, electric and electronic devices, should not be kept closer than 20 cm from an avalanche transceiver in transmit mode. In search mode this distance should be increased to 50 cm and mobile phones should be switched off to increase the device's capacity.
- Magnetic items may switch on/off some avalanche transceivers, affecting both the compass and the electromagnetic field. Personnel should ensure that clothing or bags carried on the body do not contain magnetic buttons.
- When carrying weapons and magazines, the avalanche transceiver should be attached to the side of the body furthest away from materiel. If magazines are carried on the chest/stomach, the avalanche transceiver may be attached to the side of the body.
- It should be noted that if the search is being conducted from a motorised vehicle, the vehicle itself may interfere with signals.
- The antennas and electronics in avalanche transceivers are sensitive to shock damage and must therefore be handled with care. An avalanche transceiver should never be thrown or hurled.

**Testing an avalanche transceiver**

The subsequent test date is specified in the avalanche transceiver's start-up window. All functions on the device should be tested and inspected by qualified personnel within this date. If the avalanche transceiver has not been tested by the specified date, it will not be authorised for use.

**Group test**

The device must be function-tested daily before being used. The remaining battery capacity should be checked, as well as the device's capacity to send and receive signals. The group test should be conducted before commencing any movement and at least once per day. The group test should also be conducted after devices have been used in search and training activities.

The Barryvox Pulse has a built-in group test. The group test is activated by depressing any key on the side as soon as the initial start-up picture appears on the screen after the avalanche transceiver has been switched on. After the start-up test, the group test is activated automatically.

When a double group test is being conducted, each device is tested for transmission and reception of signals. The officer in charge of the group lines up personnel with a minimum distance of 2 metres between each person. The distance between each person should be equivalent to around one ski length.

The officer in charge of the group walks past the personnel in the line at a distance of 1 metre with a separate avalanche transceiver in transmit mode in order to verify whether each device is capable of receiving signals. Each member of the group sets their own avalanche transceiver to group test mode by depressing any key when starting up the unit. Group members should hold the device so that the screen is visible to the person conducting the group test. It is important to keep the devices apart when the test is being conducted and to maintain a distance of 1 metre. The test distance will then be one half of the distance between each person in the group, thus ensuring that it is the closest device that is being tested. The device will emit pulse tones as soon as it has received a signal from the avalanche transceiver belonging to the officer in charge of the group.

When the officer in charge has walked past and tested everyone in the line, the group members should set their units to transmit mode by depressing any key and placing the device in the carrying position. The officer in charge sets his/her device to group test mode. The group walks past the officer in charge. The officer in charge holds his/her device at a distance of 1 metre as each member walks past and verifies that it is receiving a signal from each device in transmit mode. When everyone has walked past, the officer in charge switches his/her avalanche transceiver to transmit mode by depressing any key and showing it to the last person in the group.

Experience from group testing suggests that if the test is not conducted properly from the outset, the process will become disrupted and the officer in charge of the group will end up moving around a disorganised group, testing each member individually. This may mean that distances are not maintained and it therefore cannot be established with absolute certainty that every device has been checked. When a double group test is carried out as described above, this will also ensure that the group is ready to depart immediately and that each device remains in transmit mode.

The procedure for conducting a double group test is outlined in table 4.2. A double group test involves devices being tested for both transmission and reception of signals.

<b>Officer in charge of the group</b>	<b>The group in a line (2 m between each person)</b>	<b>How</b>	<b>Comments</b>
1. The officer in charge of the group sets his/her device to 'transmit'	Group personnel set their devices to 'group test'	The officer in charge of the group walks past each person in the line (1 m distance)	Personnel devices are checked for signal reception; the device belonging to the officer in charge of the group is tested for signal transmission
2. The officer in charge sets his/her device to 'group test'	Personnel set their devices to 'transmit' by depressing any key and place the device in the carrying position	Two alternatives (1 m distance): - The officer in charge walks past each person in the group  - Or the group walks past the position of the officer in charge	Each individual's device is tested for signal transmission
3. The officer in charge of the group sets his/her device to 'transmit'			The officer in charge shows this to the last person in the group

*Table 4.2: Schematic representation of a group test*

Devices are function-tested for both transmission and reception of signals.

The avalanche transceiver will switch to 'transmit' automatically after 4 minutes if the device is in 'search' mode and no motion is detected.. This function is designed to prevent the group members' devices from being in 'search' mode during movement and to ensure that devices will automatically switch to 'transmit' mode if an individual is struck by a new avalanche during a search. The device will provide a warning via an alert tone and text before switching to 'transmit' mode. This may be cancelled by depressing any key on either side of the device.

When the device is set to 'group test' mode it will automatically switch to 'transmit' mode after 5 minutes. This function is also designed to ensure that the avalanche transceiver switches to transmit mode if an individual is struck by an avalanche and

has failed to switch the device to ‘transmit’ mode following a group test. The device will provide a warning via an alert tone and text before switching to ‘transmit’ mode. This may be cancelled by depressing any key on either side of the device.

***A group test must be conducted every time avalanche transceivers are being used.***



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Figure: 4.21

**Barryvox Pulse avalanche transceiver**

*The front and rear of the avalanche transceiver. Note the expiry date in the start-up window, which refers to the annual test date. On the rear of the device is an illustrated overview of the search phase, from signal search, via coarse search, fine search and spiral search, to excavation.*

**Carrying position for avalanche transmitter in transmit mode**

Avalanches transceivers should be carried in accordance with figure 4.22. The carrying position will ensure that radio waves emitted from the avalanche transceiver reach the surface effectively regardless of the position an avalanche victim ends up in following an avalanche accident. It is important to note that the device must **not** be placed in a backpack or outer pockets but should be carried on the body *inside an*

*outer garment* in order to minimise the risk of the unit being torn off in connection with an avalanche accident. Mobile phones, communications equipment, knives and other metallic items interfere with the device's performance and a distance of around 20 cm should be maintained from such items to the device. Under no circumstances should such items be stored in direct proximity to the device.

It should also be noted that magnetic items must not be stored in proximity to an avalanche transceiver when it is in use. Certain garments and carrying cases, particularly for cameras, have magnetic buttons and all equipment must be examined to ensure that an avalanche transceiver is not affected by magnetism. Mobile phones, communications equipment and other electronic items must be removed or switched off when a search is being conducted.



*Figure: 4.22*

***Carrying position for avalanche transmitter in transmit mode***

*The avalanche transceiver must be carried in such a way that the distance to other electronic and metallic items is at least 20 cm.*

***Be aware that electronics, magnets and metallic items will affect the avalanche transceiver and may affect the results of a search. Mobile phones must be switched off during a search.***

***Barryvox Pulse avalanche transceiver – General search information***

The Barryvox Pulse is equipped with three antennas in order to calculate the distance and direction to an avalanche victim in possession of an avalanche transceiver. This means that during an individual search, a specific direction (arrow) and distance (in metres) may be followed to an avalanche victim. When the indicated direction is followed, the tracks that are then left in the snow will be parallel to the flux lines in the signal field, in a curved line. The specified distance provides an indication as to whether rescue personnel are moving towards or away from the victim, i.e. rescue personnel's position along the flux line in relation to the transmitter. A search of this nature is referred to as the flux line method. It is important to note that it is the distance along the flux line that is specified and not a straight line to the device transmitting the signal. The directional function is not as reliable as the specified distance and therefore only the distance indicator may be completely trusted. If the specified direction 'jumps' 180°, rescue personnel should continue in the direction that results in the distance decreasing. Another way of resolving this issue is to reduce speed, possibly stand still for a while, so that the device may be given time to interpret the signals it receives.

As the site where the victim is buried draws closer, a fine search close to the ground in an angular search pattern should be conducted ( 4.29: Bisection method) as the direction indicator will cease specifying the direction at a distance of 3 metres from the avalanche victim. The search should continue at a gentle pace on the snow surface in the most recently specified direction and the distance indicator should be carefully monitored. At less than 3 metres, the avalanche transceiver will emit an acoustic support signal in the form of beeps that increase in frequency as the distance decreases. When the lowest value on the snow surface has been found, the search should continue at an angle of 90° to one of the sides until the lowest value is found again. The bisection method should be repeated until an acceptable distance is found from which to conduct a spiral search with an avalanche probe. Personnel should avoid spending too much time on the bisection method but should conduct a spiral search when values have stopped noticeably decreasing. The remaining distance reflects the approximate depth of the avalanche victim.

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***Flux lines are lines drawn to outline what a signal field looks like. Flux lines do not really exist but outline the dispersion and direction of the field.***

**4.6.1.5 Avalanche transceiver search methods*****Speed versus accuracy***

It is vital that the initial search is conducted rapidly in order to cover the greatest distance in the shortest possible time. As the distance decreases, e.g. from 10 metres and less than 3 metres, the pace may be reduced and the accuracy of localisation increase (figure 4.23: Speed versus Accuracy). This principle must be applied because personnel with a minimal amount of practical experience will often primarily focus on the search unit and search accuracy, thus spending a lot of time on the initial phase, when a significant distance still remains to the avalanche victim.

Personnel should also avoid spending too much time on decreasing the distance by 10-50 cm in the final part of the search and should instead conduct a spiral search with an avalanche probe.

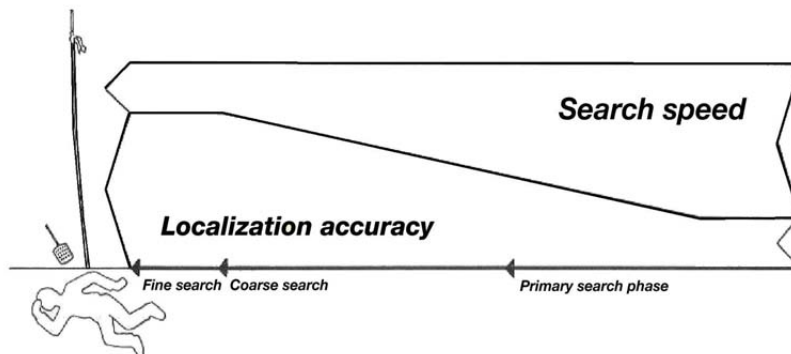


Figure: 4.23

#### **Speed versus Accuracy**

*The figure shows the principle of speed in the initial stage of an avalanche transceiver search. This will permit great distances to be covered in the shortest time. As the search draws closer to the avalanche victim, accuracy is increased but the pace decreases.*

#### **Initial avalanche transceiver search – signal search**

This part of the search is shown on the screen and on the rear of the avalanche transceiver by the following signs:



Figure: 4.24

#### **Signal search – initial search**

*A signal search is carried out until the first signal is received. Once personnel are close enough to the avalanche victim the avalanche transceiver will switch to a coarse search.*

Figure 4.25 shows the procedure when the entrapment point is known (A), when the entrapment point is not known and the search is being conducted alone (B), as well as when several persons are conducting the search and the entrapment point is not known (C). In all of these procedures the unit (antennas) should be rotated in 3 dimensions, i.e. it should be moved gently along the x, y and z axis, while passing through the area in which there is the greatest chance of locating avalanche victims. This procedure should be conducted with the device held close to the ear in order to hear the signal. It is important to note that avalanche transceivers emit approximately one signal per second. Movement along the x, y and z axis should therefore be slow enough for any possible signal to be received. When the device is rotated, one attempts to optimize the antenna direction in relation to the signal, enabling weak signals at a great distance to be captured more easily.

If a person is searching an avalanche alone it will be necessary to move throughout the whole avalanche in a tacking motion with a maximum of 50 m between each tack. In this way, 25 m or more will be covered on either side of the track and the sectors will overlap. If several persons are searching, it will be possible to assign a 50 m wide corridor to each person, in which the outermost corridors should not be more than 25 m from the outer edges.

If the entrapment point or disappearance point is known, it will be possible to concentrate on the area extending from this point and down the avalanche path.

As soon as the unit receives a signal that is strong enough to process, it will emit a confirmation tone and the direction and distance to the avalanche victim will be visible on the screen. The avalanche transceiver should then immediately be held horizontally in front of the chest so that the screen is readable. When changing direction from this point, the whole body should be turned in the new direction, while the avalanche transceiver is held in the same position in front of the chest.

***Signal search: The device's antennas should be rotated along the x, y and z axis close to the ear in order to optimise reception of weak signals at a greater distance during the initial signal search.***

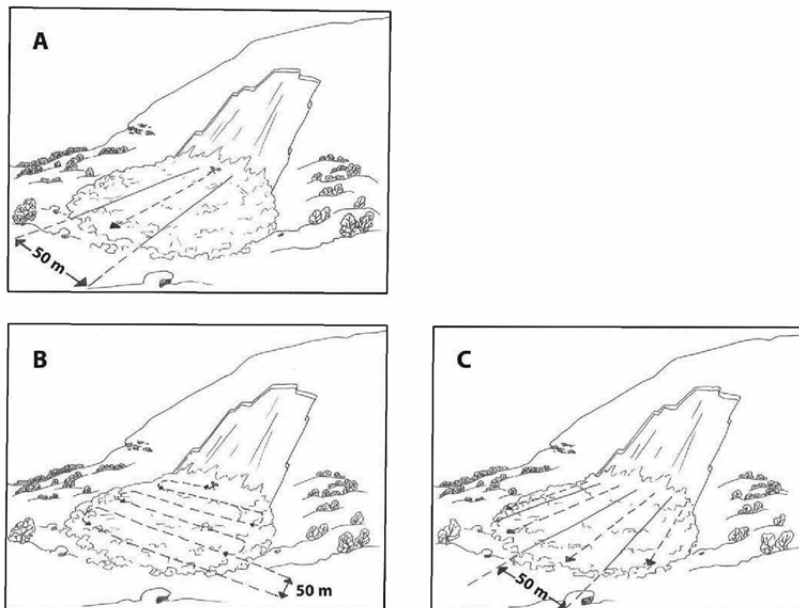


Figure: 4.25

**A, B and C: Signal search**

*The procedure for the initial signal search with an avalanche transceiver when A) the entrapment point is known, B) when the entrapment point is not known and C) when several persons are conducting the search and the entrapment point is not known. The procedure continues until the first signal is received. Movement should continue in accordance with these models until a continuous signal is received.*



Figure: 4.26

**D: Signal search**

*The various phases of the signal search are illustrated on the rear of the Pulse Barryvox; to the left when there are several persons conducting the search, to the right when one person is conducting the search alone. The figures indicate distances between search corridors.*

***The procedure adopted in the signal search will be crucially determined by whether or not the entrapment point is known, and whether or not the search is being conducted alone or in a group.***

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**Coarse search – following reception of an initial signal – the flux line method**

This part of the search is shown on the screen and on the rear of the avalanche transceiver by the following signs:



Figure: 4.27

**Coarse search**

*The coarse search should commence as soon as a strong enough signal is received for the avalanche transceiver to calculate the direction and distance to the avalanche victim. The avalanche transceiver emits an alert tone and the screen changes to show the direction and distance. During a coarse search, the avalanche transceiver should be held horizontally in front of the chest. If the signal is weak the avalanche transceiver may revert to signal search mode. If this happens it will be necessary to continue the signal search until the avalanche transceiver reverts back to coarse search mode.*

As soon as the unit receives a signal it will emit a confirmation tone and the direction and distance will be displayed on the screen. At the same time a message will appear instructing the user to hold the unit horizontally. If the signal persists the unit should be held horizontally in front of the body during the coarse search. When the direction of the arrow changes, the body should be turned in the new direction without changing the position in which the avalanche transceiver is held in relation to the body.

The avalanche transceiver will now receive a signal that is strong enough to calculate distance and direction. The direction and distance to an avalanche victim is indicated by an arrow and a number on the screen. The specified distance must be interpreted as an approximate value, insofar as it is basically whether search personnel are approaching or moving away from the victim that really matters. The direction indicator (arrow) is not as accurate as the specified distance. The direction indicator may 'jump' forwards and backwards during phases of the search. It is therefore important to carefully follow the specified distance, and that this distance diminishes. During this phase the search should proceed at a rapid pace to a more precise location and it will therefore be necessary to move quickly over relatively great distances (refer to figure 4.23).

***An avalanche transceiver calculates the direction and distance to the nearest victim. This makes it possible to follow the signal field towards the victim and quickly localise him/her.***

***Fine search – transition from the flux line method to the bisection method***

This part of the search is shown on the screen and on the rear of the avalanche transceiver by the following signs:



*Figure: 4.28*

***Fine search***

*During a fine search (<3m) the indicated direction will be lost due to the short distance to the avalanche victim, as well as the three-dimensional aspect. The symbol displayed on the screen indicates that a ground search should be conducted*

*in an angular search pattern (figure 4.29: Bisection method) until the lowest value is obtained. During this phase the avalanche transceiver should be held in the same direction without being turned.*

As the search draws closer to the avalanche victim the focus will change from speed to accuracy of localisation. In order to excavate the victim as quickly as possible, a search with an avalanche probe should not start at too great a distance from the victim. The bisection method in a fine search should significantly reduce the remaining distance (figure 4.29 The Bisection method).

As the direction indicator does not give a three-dimensional representation of the direction, and therefore is unable to point downwards towards the avalanche victim, this function will automatically switch itself off within a predetermined distance, set to 3 metres. Once the direction indicator has switched itself off, the fine search commences. The distance to the avalanche victim will now be specified with one decimal point.

The fine search should be conducted as specified in figure 4.29. The unit should be held horizontally and in the same direction it was facing when the direction indicator automatically switched itself off. From here, the search should proceed in a straight line until the point with the lowest distance is found, then 90° out to the sides until a new point with the lowest possible distance is found. The search should continue in this manner with 90° changes in direction until the point with the lowest possible value is found. An acoustic signal will also indicate whether the user is getting closer to or moving away from the victim. The signal will increase in intensity as the distance to the avalanche victim decreases. It is important to hold the device on the snow surface during the fine search.

When the distance has reached its lowest attainable value, prodding with an avalanche probe should commence. During a fine search it is important to note that the lowest attainable distance is an indication of how deep the victim is buried. Nothing will be gained from spending time with an avalanche transceiver attempting to precisely locate a victim when the distance has decreased to around 50 cm, or when the distance displayed on the avalanche transceiver has not decreased by more than a couple of decimal points. In such a situation it should be assumed that the victim is located at approximately this depth and a rapid spiral search with an avalanche probe should be conducted immediately. Moreover, a spiral search will be a quicker method of locating the avalanche victim at such small distances.

***The direction indicator will switch itself off 3 metres from the avalanche victim. A fine search should then be conducted in accordance with the bisection method.***

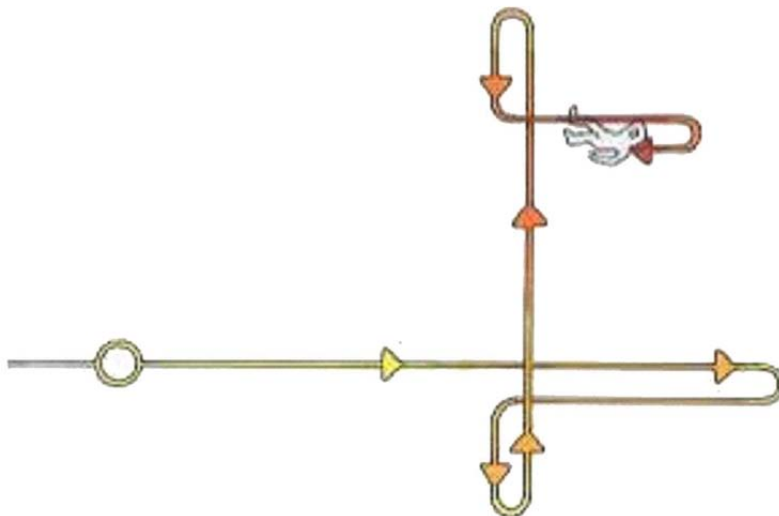


Figure: 4.29

### ***The bisection method***

*The bisection method is used in the final fine search when search personnel are so close to the victim that the directional function switches itself off (< 3m). From this point the device is held on the snow's surface and its orientation should not be altered.*

### ***Spiral search with an avalanche probe***

If there are several persons available to participate in the search, excavation should be undertaken at the same time that the spiral search commences. In order to not interfere with the spiral search, excavation should commence around one metre below the spiral search. When the person carrying out the spiral search with an avalanche probe makes contact, valuable time will be saved by already having started excavation work.

When searching with an avalanche probe after the avalanche victim's position has been determined with an avalanche transceiver, probing should be carried out in a spiral pattern. Probing must be conducted at  $90^\circ$  in relation to the snow surface as the avalanche transceiver has specified that this is the shortest distance to the avalanche victim, i.e. at right angles to the snow surface. The probe should be inserted into the snow in a spiral pattern extending outwards from a central point. Each hole should have a distance of 25 cm to the side and across from the preceding hole (figure 4.30: Spiral search). The avalanche probe should be inserted into the snowpack to a depth of 2 metres. In this way, prodding will be focused on a small area and will not extend

beyond the avalanche victim. By this stage, a lot of time will already have been spent on localisation and every second will count. The spiral search must therefore be conducted at the highest pace possible. If the avalanche transceiver search has been thorough and correct the find spot will have been identified and efforts must focus on the swift extraction of the avalanche victim. Thus, it is important to conduct the spiral search as quickly as possible.

Important: When an avalanche probe makes contact it is important that the avalanche probe remains in the same hole. The avalanche probe will then form the basis of excavation.

***When an avalanche probe makes contact it is important that the avalanche probe remains in the same hole. The avalanche probe will then form the basis of excavation.***

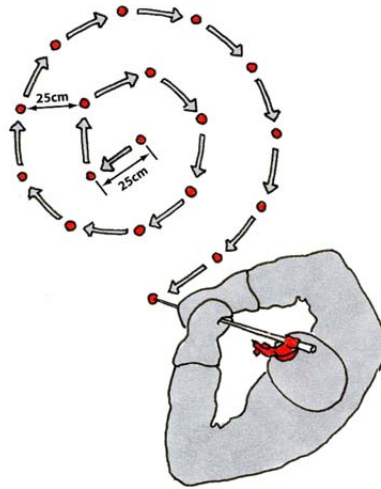


Figure: 4.30

### ***Spiral search***

*A distance of 25 cm must be maintained between holes, which should be prodded in a spiral form starting with the first hole. The avalanche probe should be inserted into the snowpack to a depth of 2 metres. It is important that the search is conducted swiftly. In a spiral search following a find with an avalanche transceiver, the search should be conducted at 90° in relation to the snow surface.*

For further information on searching with an avalanche probe refer to chapter 4.3 Companion Rescue and chapter 4.4 Organised Rescue.

**Excavation**

When the search has attained the lowest possible distance value and a positive find has been made with an avalanche probe, it is important that excavation work is carried out as carefully and efficiently as possible. If several persons are available, excavation work may commence even at the spiral search stage. When an avalanche probe makes contact, valuable time will be saved if excavation work has already commenced during the spiral search.

Once the avalanche has stopped and a search has been conducted with an avalanche transceiver and avalanche probe, a certain amount of time will have elapsed. It is therefore important that excavation work takes place as systematically and swiftly as possible. A positive find with an avalanche transceiver and avalanche probe will necessitate concentration of the rescue operation on the relevant avalanche victim. Therefore, as many personnel as possible should be included in the excavation work. In order for the excavation work to proceed as efficiently as possible it is important that all personnel are assigned an active role and that the digging operation may be rotated before personnel become too tired. Digging should be concentrated towards the avalanche probe in a sharp V-form. The V-form means that excavation work is concentrated and that unnecessary amounts of snow will not be dug away. It will also be easy to adjust the tip of the formation as the avalanche victim is reached (refer to figure 4.31).

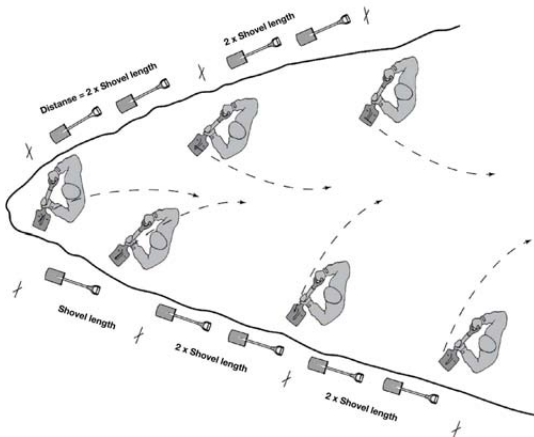


Figure: 4.31

*Schematic diagram for excavation of an avalanche victim viewed from above*

*The 1st person is positioned at the front of the V-formation. The 2nd person is*

*positioned one shovel length behind the first person. The remaining personnel should be 2 shovel lengths' distance from the person in front. This will ensure that everyone can work at a whole shovel's length without disturbing one another. The snow should be shovelled backwards into the middle of the formation. In steep terrain, the length of the V-form should ideally be the same as the depth of the avalanche victim. In flat terrain, the V-form should be equivalent to twice the depth of the avalanche victim. After 3-4 minutes, personnel should rotate in the formation in a clockwise direction to counter the effects of tiredness.*

The person standing at the centre of the V-formation chips the snow loose, shovels it towards the rear and controls the direction of the excavation work. To the rear LH side of this person a second person should be positioned at a distance equivalent to 1 shovel length (80 cm). A third person is positioned on the RH side of the first person at a distance of two shovel lengths. To the rear of both the second and third person, several persons should be positioned at a distance of 2 shovel lengths, depending on how many personnel are available for digging. These distances permit a person to work efficiently within a radius of a full shovel length without interfering with persons in front, to the rear and to the side.

In steep terrain, the length of the V-formation should be equivalent to the depth of the avalanche victim. In flat terrain, the length of the V-formation should be equivalent to twice the depth of the avalanche victim. It is important that the excavated shaft is as horizontal as possible in order to facilitate evacuation. It is equally important that the excavated snow is cleared and not permitted to accumulate to the rear, even when the terrain is flat.

### **Situations involving several buried victims(multiple burials)**

#### ***Marking find spots when signals have been received from several buried victims***

If signals are received from several avalanche transceivers, the number of signals will be shown on the left side of the screen, which will also display a corresponding number of 'heads'. It is important to note that a Barryvox Pulse in the Basic setting will only specify the direction and distance to the nearest avalanche victim. Nor is it possible in the Basic setting to 'scroll through' the menu between the avalanche victims. The distance and direction is locked onto the closest avalanche victim. If another avalanche transceiver's sector is entered, and this is closer, the direction and distance will change to the avalanche victim who is now nearest.

The Barryvox Pulse offers the option of 'marking' a find so that the search for other avalanche victims may continue in situations where more than one person has been struck by an avalanche. The marking function is activated at distances of less than 6 metres. If several persons are conducting a search for the same avalanche victim, it is possible to mark the signal within 6 metres so that every rescue attempt is not directed towards the same signal, with a subsequent loss of time. A signal from an avalanche transceiver that has been marked is 'excluded' from the further search and the marked avalanche transceiver is indicated by a '#' sign behind the icon in the screen menu. Thus, it will not be necessary to wait until the victim is recovered before the signal can be excluded. Nor will all avalanche transceivers be locked into searching for the same avalanche victim. As soon as the location has been marked, the avalanche transceiver will switch to the next closest signal. Caution should be

exercised when using this function. It will be necessary to ensure that the signal already identified continues to be included in the search and that a fine search and excavation are conducted. It must also be established that the avalanche victim in question is the same, before one or more rescue personnel 'mark' the signal. If only a few rescue personnel are available and the search involves several avalanche victims, the search should become concentrated. If rescue personnel elect to search and excavate all avalanche victims simultaneously, they may run out of time and be unable to save anyone, as opposed to the possibility of some victims being rescued in time.

To remove the marking of a signal in the Basic setting, it will be necessary to switch off the avalanche transceiver and switch it back to 'search'. The avalanche transceiver will then process the search without taking previous searches into account and the search may start again from scratch.

#### ***Overlapping signals***

When a rescue party is searching for several avalanche victims it is possible that, over time, signals from avalanche victims will overlap one another. When impulses from the signals overlap there will be periods when the avalanche transceiver is unable to separate the signals. In such cases the avalanche transceiver will instruct the user to stand still until the situation is resolved. This particularly applies to signals from older avalanche transceivers, which have longer impulses that lead to overlapping. If the situation is not one in which several avalanche victims are located within a small area, after a short period the avalanche transceiver will specify the direction and distance again to the nearest avalanche victim.

***When several victims are buried in the same area it may be difficult to distinguish between signals. If the signals are overlapping, the avalanche transceiver will instruct the user to stand still. After a short period the avalanche transceiver will specify the direction and distance again to the nearest avalanche victim.***

#### ***Vital data in the Basic setting***

Vital data is information regarding a registered pulse or small movements when the transceiver is buried. The Barryvox transmits vital data in the Basic setting via a W-link. The avalanche transceiver also stores vital data regarding the time of burial and registered time with vital data. In Basic setting it is possible to read the burial time on the screen in transmit mode by depressing both keys for 3 seconds. The first line that appears shows the last burial time and it is also possible to search back to the last 5 burials (from -1 to -5 in the menu). Specific burial times are not numbered. If an avalanche victim is excavated with a Barryvox it is possible to estimate the total burial time and the period during which vital signs were registered. It is important to provide medical personnel with this information. Medical personnel will be able to base their treatment on the duration of the burial and the period during which vital signs were registered

## 4.6.2 **Avalanche transceiver – instructor setting**

The instructor setting is suitable for personnel whose daily work is providing instruction in avalanche transceivers, companion rescue and organised rescue. The instructor setting is also intended to be used by personnel on standby. The menu options in the instructor setting are fixed and include some additional functions.

### **Analogue mode**

If any problems should occur in the analysis of received signals, the device may be switched to analogue mode. The distance and direction to the strongest signal will be shown on the screen and the analogue search tone will be audible. The directional arrow will only point forward and the distance must be monitored to ensure that the user is moving in the right direction. In the event that signals from several buried avalanche victims are received, an icon with two heads will appear on the screen. The analogue tone will help verify the number of signals received.

The analogue mode may be activated by depressing both rubber keys simultaneously for 3 seconds. This should be repeated in order to return to digital mode.

The audio signal strength may be adjusted in analogue mode. Initially, it will adjust itself automatically. The right hand key raises the volume and the left hand key lowers the volume. To increase the avalanche transceiver's range, it is possible in analogue mode to adjust the volume up to one level above maximum (i.e. one level above A8). The screen will then shut down and maximum range will be achieved.

In practice, adjusting the volume will adjust the avalanche transceiver's sensitivity. A flashing display indicates that the device's sensitivity must be increased or decreased in relation to the signals being received. With increased sensitivity it is possible to receive signals from avalanche transceivers at a long range. When sensitivity is decreased, long range signals will eventually cease. Finally, signals will only be received from avalanche transceivers at close range. Thus, sensitivity may be reduced in order to facilitate a search and swiftly locate the nearest avalanche victim. When manually adjusting the volume in analogue mode the bisection method is used during a coarse search and a fine search. The avalanche transceiver should be held vertically throughout the search. If the avalanche transceiver is turned, the strength of received signals will change. The strongest signal will be detected along a straight line, which also gives the shortest distance. The volume should be decreased to a barely audible level. Following this, a 90° search to the side should be carried out to re-locate the strongest signal and the volume should be adjusted to a barely audible level. The bisection method should continue until it is due to be started a spiral search with an avalanche probe.

### **Analogue tone**

An analogue tone means that rescue personnel may listen to the number of actual signals being received, thereby verifying the number of avalanche victims. In Basic mode, only an artificially generated signal is emitted for buried avalanche victims being searched for, i.e. the closest.

### **Choosing between avalanche victims**

The instructor setting offers the option of choosing between the specified avalanche victims by depressing one of the two rubber keys. This means that the user will not necessarily have to move towards the nearest victim. This is a useful function when

several persons are conducting a search or when the user wishes to classify avalanche victims and prioritise them in relation to the specified vital data (refer to vital data below).

#### **Audible support during a fine search – off**

An acoustic support signal will not be emitted during a fine search. The screen will display the icon for a fine search, which is a cross. The distance to the avalanche victim will also be specified.

#### **Vital data**

This function means that, during a search, vital data may be received from Barryvox avalanche transceivers buried in the avalanche. Vital data is information from buried Barryvox units regarding whether a heartbeat or movement has been registered. In the menu option, a 'heart' will appear to the side of the head icon. Vital data makes it possible to prioritise avalanche victims when a heartbeat or movement has been registered. Avalanche victims with a registered heart rate have the greatest chance of survival.

#### **"Hostile mode"**

The basic setting and instructor setting may also be set to 'hostile' mode. This function is intended for use in live operations and means that the avalanche transceiver will not emit either light or audio signals.

### **4.6.3 Training and practice in the use of avalanche transceivers**

A training programme must take into account the various types of avalanche transceivers available. It is important that time is set aside for thorough training. The object of training should be for participating personnel to master avalanche search techniques involving more than one avalanche victim and that personnel also practise a complex situation in which several victims are buried within a limited area, as well as at varying depths. These types of situations result in overlapping signal fields that are difficult to read. This presents challenges to both the avalanche transceiver receiving the signals and to personnel conducting the search. Units on avalanche standby should prioritise training with avalanche transceivers so that personnel master more complex scenarios.

#### **Basic Companion Rescue**

As an appendix to the regulations, two different levels of companion rescue have been formulated. The first level provides basic knowledge in the use of companion rescue equipment and ensures that personnel are capable of performing simple searches with an avalanche transceiver, spiral searches with an avalanche probe and efficient excavation. The course plan is called 'Basic Companion Rescue' (Appendix: 5.1).

#### **Companion Rescue Card**

A companion rescue card has also been formulated that may be used for training a section or a patrol. The companion rescue card focuses on organisation of a section, raising the alarm, searching, excavation, medical service and evacuation. While the companion rescue card has been formulated as a point list for training, it may also be carried in the field and used as a check list in the event of an avalanche accident (Appendix: 5.2).

#### 4.6.4 Maintenance

##### Daily maintenance

The unit should be tested during start-up and via daily group tests. If the unit does not function as it should during the group test, the batteries should be changed. If the device continues to malfunction it should be replaced and delivered to the party in the unit responsible for maintenance.

##### Annual maintenance/Testing the unit

The battery cover should be inspected and replaced if it is defective or loose. If the unit itself is damaged, it should be sent to the Norwegian Defence Logistics Organization (NDLO).

The battery terminals should be inspected and replaced if there is evidence of corrosion or damage.

All units should be tested once annually with the Barryvox testing unit. Testing units are administered by the party in the unit responsible for avalanche transceivers. Units should be tested within the test date, which is specified in the start-up window. Any avalanche transceiver that fails the test should be forwarded to the NLDO. While the test is being conducted it should also be verified that the unit has been configured correctly (Basic setting/Instructor setting). The Norwegian School of Winter Warfare issues configuration files to be used in testing/configuring. Units that have passed their test date should not be used in the field.

During the annual test, necessary firmware updates will also take place.

#### 4.6.5 RECCO detection system

##### Introduction

The Norwegian Armed Forces has used the detection system manufactured by RECCO since the avalanche accident in Vassdalen in 1986. Since the time of the first procurement, newer versions have been introduced. Recco's later models have increased sensitivity and lower weight (< 1 kg), as well as being able to detect avalanche transceivers and other electronic equipment even when such equipment is switched off. The RECCO system is not intended to replace avalanche transceivers and companion rescue. Organised rescues are equipped with the detection unit for use in rescue operations.

The RECCO system used by the Norwegian Armed Forces is based on a system in which personnel carry two passive **reflectors**. Searches for avalanche victims are conducted with Recco detection units. Personnel are equipped with 2 reflectors per person in order to optimise the reflection of radar signals from the detector unit during a search. The radar signal will diminish when it passes through water (the human body/wet snow). When a signal makes direct contact with the reflector, the signal quality will increase and maximise the detection distance. The reflectors double the signal frequency transmitted by the detection unit. The advantage of RECCO reflectors is that they are maintenance-free and are of very low weight, volume and cost. Nor do they require batteries as the system is passive.

The latest versions of the **RECCO detection unit** have a range of 150-200 metres in open terrain. High snow density (water content) and diverse layering in the snowpack decreases the range. In hard-packed snow the range is reduced to 20-30

metres. In wet snow the range is reduced to around 10 metres. The detection unit comprises a relatively compact detector that transmits radar signals in a straight line. When the unit receives reflected signals it is already pointing in the direction of the avalanche victim, as opposed to avalanche transceivers that receive signals in an elliptical signal field. Detection unit efficiency is increased when a search is being conducted from a helicopter as the volume of snow that the signal has to pass through is reduced and the signal strength does not diminish to the same extent.



Figure: 4.32

***RECCO detection system and associated RECCO reflectors***

***One of the main advantages of the RECCO system is that all personnel can be equipped with passive reflectors at a relatively low cost. The reflectors require no maintenance, are of low weight and may be placed diagonally in relation to each other on the body in order to increase the likelihood of locating an avalanche victim.***

**RECCO detection system – equipment**

Below is a list of equipment associated with the RECCO detection unit:

- detection unit with antenna, handle and function switches to be carried in one hand (the user will carry an avalanche probe in the other hand)

- earplug
- carrying case and extra batteries if required
- battery charger

Each individual soldier is equipped with 2 RECCO reflectors which are attached to the uniform.

### **Function**

The RECCO detection system utilises the so-called frequency doubling principle. A radar signal (917 MHz) is transmitted via a directional antenna that the user may rotate and turn in various directions. When the signal makes contact with a reflector, its frequency doubles (1834 MHz) and is captured by the antenna. In the receiver, the signal is converted to an audible, variable tone in the earphones. The strength of the audible tone varies depending on the strength of the return signal, which is again dependent on the distance and angle in relation to the reflector. If the transmitted signal is not reflected by a reflector, only a constant, weak base tone will be heard, indicating that search signals are being transmitted. In other words, the angle of impact of the transmitted signal and the reflector's position beneath the snowpack will influence the range.

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### **Recco reflectors – placement**

All personnel should be supplied with two reflectors. One of the reflectors should be attached to the **bottom of the side pocket** in field trousers. The other reflector should be attached to the **opposite side of the body, in an upper arm pocket** of a field jacket. By placing reflectors on each side of the body, the most optimum reflection of radar signals will be achieved in a search, thus increasing the chances of an avalanche victim being located. The reflectors must be attached in such a way that they cannot fall off in an avalanche accident, which involves huge forces and the extreme likelihood that loose items will be torn off.

### **Searching with the RECCO system**

#### ***Introduction***

An avalanche search with the RECCO system should be conducted by walking through the avalanche as shown in figure 4.33 The search corridors should be 10-20 metres wide. The user should rotate the device in order to vary the angle of the antenna during the search by:

- swinging the antenna in a gentle motion 45° out on both sides
- turning the antenna in a gentle motion away from and towards the ground
- twisting the antenna in a gentle motion in a clockwise and anti-clockwise direction

The specified variations of the antenna angle may be achieved by rotating the avalanche transceiver in a figure of 8.

As the signals are directional, the operator will be able to follow a reflected signal in a straight line towards the source and, thus, the avalanche victim.

Search personnel must be aware that the signal may be reflected from their own RECCO reflectors, or the RECCO reflectors of other personnel, as well as from

other materiel capable of reflecting signals. In order to simplify the search for an inexperienced member of the search party, other personnel in the avalanche area should remove their reflectors and the avalanche should be cleared of electronic items that may interfere with the avalanche transceiver.

Search personnel must be aware that all electronic materiel (cameras, radios, etc.) contain in-built diodes. Such materiel may also emit audible signals to the passive device. If personnel are carrying such equipment themselves, it should be carried on the back so that it does not interfere with the search. If it is not possible to clear the avalanche area of RECCO reflectors or other reflective materiel, the RECCO detector must be lowered towards the ground, thereby narrowing the search.

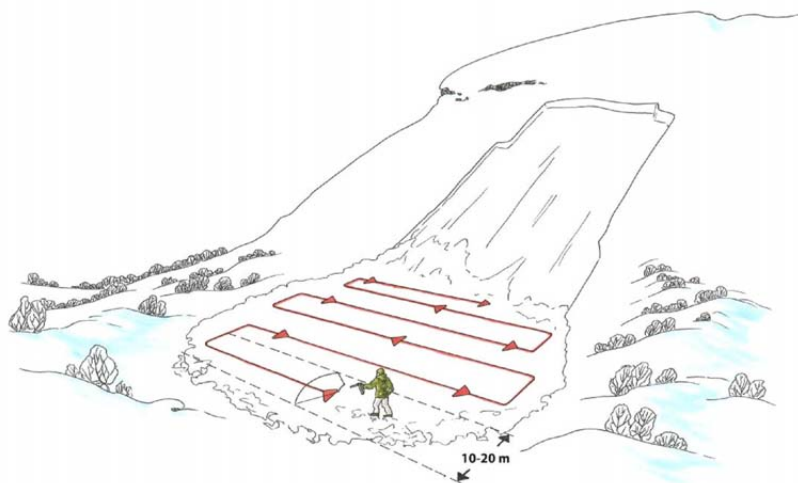


Figure: 4.33

### ***Searching with the RECCO system***

*A RECCO search is conducted by rotating the unit in a figure of 8 while moving through the search zone in corridors 10-20 metres wide. In the basic position the RECCO unit should be held 30° below the horizontal line.*

#### ***Sweep***

The first task to be performed in an avalanche is a 'sweep' of the area with the detection unit. This type of search is capable of detecting avalanche victims who are easily accessible and whose RECCO reflectors are in a favourable position in relation to the radar signal from the detection unit. In theory, it should be possible to search entire small avalanches from their outer edges.

**Coarse search**

If no signals have been detected through a sweep of the avalanche area, a coarse search must be conducted as outlined in figure 4.33. The basic position for the search unit is  $30^\circ$  below the horizontal line. The search unit should be rotated in a figure of 8 while moving through the search area.

**Fine search**

If no avalanche victims are located during the initial coarse search, a fine search of the avalanche area must be conducted. In the fine search, the width of the corridor being searched should be halved (10 m). The basic position for the search unit should be increased to  $60^\circ$  below the horizontal line.

**Detected signals**

In the event that a signal is detected, the location must be marked, the volume reduced and the user should then move towards the signal. The search unit should be held  $30^\circ$  below the horizontal line. When the signal ceases, the user will be right above the victim. The earphone volume should be turned down and a cross search should be conducted with the detection unit pointing at right angles to the surface. The find spot should be marked and the location searched with an avalanche probe.

**Other capacities**

The latest RECCO system is also able to locate mobile telephones, digital cameras, avalanche transceivers and other electronic equipment, even when such items are turned off. The detection unit is connected to earphones in order to protect the signal from noise in the area, such as helicopters or personnel, for example. RECCO system searches may also be conducted from a helicopter in order to save time (refer to chapter 4.4 Organised Rescue). This is particularly beneficial in large avalanches and the unit may also be connected to an underslung antenna to increase the range of the search.

To search for avalanche transceivers the RECCO detector should be switched to 457kHz. The device will then transmit RECCO signals while simultaneously searching for avalanche transceiver signals. In the earphones, both the characteristic RECCO signals and the avalanche transceiver signal may be heard.

More recent RECCO detection units are equipped with analogue avalanche transceivers. In order to search for active avalanche transceivers, the Bisection method (figure 4.29) must therefore be used from the moment that avalanche transceiver signals are received. In order to increase the efficiency of the search, i.e. both the RECCO search and the active avalanche transceiver search, the search should continue with an avalanche transceiver when impulses from an active avalanche transceiver have been received with RECCO. This particularly applies at great distances.

If a RECCO unit is used to locate an avalanche transceiver, a fine search may be conducted by switching off the 457kHz function and finding the precise location of the avalanche victim via RECCO signals.

***Signals to RECCO are directional. Thus, the direction from which signals are received will be the direction in which the victim is located.***

#### 4.6.6 Searches with active and passive tools – various capacities

The overview below (refer to table) shows the various capacities of tools, the likelihood of finds, detection depth, advantages and disadvantages. The information is likely to vary to a degree, depending on the user and the avalanche conditions.

<b>Tools</b>	<b>Capacity (estimated)</b>	<b>Probability of locating a victim</b>	<b>Detection depth (ca.)</b>	<b>Advantages</b>	<b>Disadvantages</b>
<b>20 avalanche probes</b>	Coarse search 2-3,000 m <sup>2</sup> /h Fine search 500 m <sup>2</sup> /h	High	2 m 3-5m	Easy to use. Easy to carry. May be improvised/use ski poles Avalanche victims may be located without being equipped with avalanche transceivers or RECCO reflectors	Limited detection depth. Requires sufficient number of personnel. Low detection capacity (time-consuming). Might detect an avalanche victim without being aware of it
<b>Avalanche dog</b>	Coarse search 20-45,000 m <sup>2</sup> /h	High	2-5 m	Avalanche victims may be located without being equipped with avalanche transceivers or RECCO reflectors Very high probability of locating an avalanche victim Relatively high detection capacity	Time-consuming in respect of alerting and transporting dog equipages to the search area. Avalanche dogs must be replaced after a short search period

*Table 4.3: Summary of the various tools available for avalanche searches*

Tools	Capacity (estimated)	Probability of locating a victim	Detection depth (ca.)	Advantages	Disadvantages
<b>RECCO detector</b>	15-30,000 m <sup>2</sup> /h	Very high	10-30m	High detection rate - High detection capacity	Training required. Avalanche victims must carry RECCO reflectors. Time required for the device to arrive at the accident site/search area. Battery dependent.
<b>Avalanche transceiver</b>	70-80 000 m <sup>2</sup> /th	Very high	10-20m	High detection rate. A search may commence as soon as an avalanche has occurred. High detection capacity Easy to carry	Training required. The avalanche victim must carry a transceiver. Battery dependent

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*Table 4.3: Summary of the various tools available for avalanche searches cont'd*

## 4.7

### Exercises

#### 4.7.1

##### Whole-part-whole method

When conducting major avalanche rescue exercises, it will always be necessary to provide inexperienced rescue personnel with an impression of an ideal rescue operation. It is recommended that trained personnel are used in this type of operation. It is important to train in simple scenarios before advancing to major, complex avalanches scenarios. If training is undertaken in scenarios that are too complicated, this may in itself reduce the benefits of training. An avalanche rescue can easily become chaotic and simplicity is the key if basic skills are to be practised. After a demonstration of the methodology, the activity may be broken down into several smaller phases and personnel will then train in each individual sub-phase of the rescue operation. The recommended sub-phases are as follows: training with an avalanche transceiver, companion rescue, excavation, first aid and evacuation, initial rescue and escalation of the rescue operation.

When all sub-phases have been practised, provision should be made for a general exercise in which rescue personnel are given the opportunity to view themselves and their role in a wider context. An exercise of this nature always concludes with a summary of the whole operation. Little will be gained from conducting major

avalanche rescue exercises with external collaborators unless military personnel master their own duties and possess effective individual skills.

*Integrated exercises with other participants should not be conducted before the personnel involved master search techniques, excavation and evacuation of avalanche victims.*

#### 4.7.2 Mock victim pit

##### General

During training in avalanche rescue work it is important that the party responsible for the activity carefully assesses the avalanche risk in the training terrain. A slope should be chosen that is not so steep that it could trigger an avalanche, even if the weather should change and the avalanche risk increase. It should be remembered that courses and demonstrations often form the pattern for future exercises.

If mock victims are to be completely buried, provisions regarding the design of the mock victim pit must be complied with. The exercise executive will assign a party responsible for safety to the mock victim(s). In addition, items such as sleeping bags, backpacks, base mats, avalanche transceivers and Recco reflectors may also be buried.

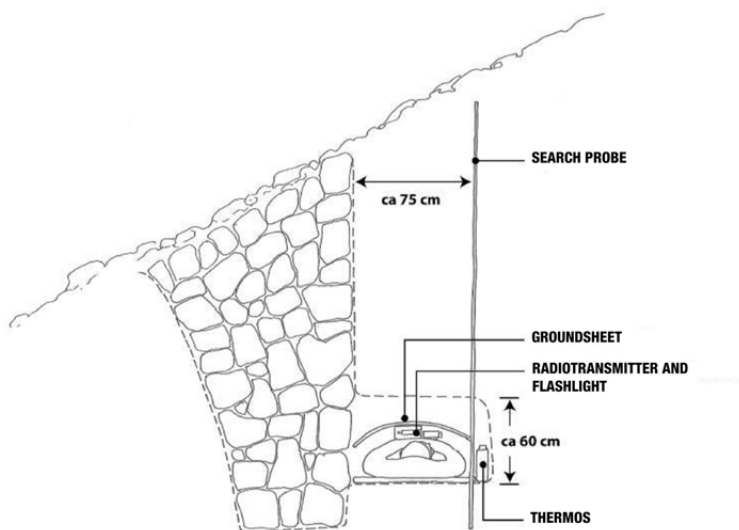


Figure: 4.34

*Schematic diagram of a mock victim pit*

**Design of a mock victim pit**

Ensure that the snow above the mock victim pit is compact. Loose snow may cause the pit to collapse, which may have serious consequences for the mock victim. The depth of the pit must be suited to the exercises being conducted.

The pit should be excavated by at least 2 persons. Personnel should dig directly into the snow to a depth of around 2 metres. Personnel should then dig in under compact snow, preferably around 75 cm towards the slope, and around 220 cm wide.

The pit should be high enough to permit the mock victim to lie freely, minimum 60-75 cm.

The avalanche probe must be assembled and inserted through the snow to the mock victim's hand. It should be inserted in such a way that it is not visible from the surface.

It should be possible to locate the mock victim pit's position in at least two independent ways (cross-bearing/avalanche transceiver/Recco/radio-controlled training kit).

Radio communications must be established, positioned and checked with the other equipment accompanying the mock victim before he/she is buried.

**Burial**

The officer in charge of the exercise is responsible for the burial and for the verification of reference points in the terrain. When the mock victim has entered the pit and confirmed that he/she is comfortable, a communications check should be conducted.

Further, the officer in charge of the exercise should assign a person to maintain contact with the mock victim(s) throughout the whole exercise until the mock victim(s) has been extracted.

Personnel should 'brick up' the opening in front of the mock victim with large blocks of snow to prevent the wall from collapsing on top of the mock victim and filling the pit.

In the event that there is a breakdown in communications, the mock victim may use the avalanche probe to alert the exercise executive of the exercise if he/she requires help. The mock victim should then be extracted from the snow immediately. If, however, training staff are unable to make contact with the mock victim, he/she should be extracted immediately. In such cases the reference points and surveying system described above should be used. An avalanche transceiver or Recco detector may also be used if they are available and are considered less time-consuming.

**Mock victim(s) requirements**

- the mock victim must be a volunteer and should not suffer from claustrophobia.
- the mock victim should not be buried for more than 3 hours and, in any case, must not be buried for more than 4 hours.
- the mock victim must possess an avalanche probe that is partly assembled and inserted through the roof.
- the mock victim must be provided with radio communication (two-way) with

- an extra battery. A communication check should be conducted BEFORE the mock victim is buried!
- the mock victim must be provided with sleeping mats, at least one to lie on and preferably one to protect the body.
- the mock victim must wear clothes that are warm and close-fitting (e.g. sleeping bag/lined survival canvas).
- the mock victim's comfort must be prioritised. He/she must be provided with a warm drink, food, flashlight and, for example, reading material and a pocket radio.
- depending on the exercise, Recco reflectors may be attached to the mock victim.
- the mock victim must have protection in front of the face from avalanche probe injuries, e.g. a shovel.
- depending on the exercise, the avalanche victim may be provided with an avalanche transceiver that is turned on or off. It is recommended that a radio-controlled training kit is used, if available.
- prior to being buried, the mock victim should visit the toilet if necessary. He/she should also avoid sweating.

***Mock victims must be volunteers and should not be buried for more than 3 hours, and never more than 4 hours.***

## 4.8 Avalanche rescue materiel

### 4.8.1 Individual equipment

Individual equipment comprises companion rescue equipment with an avalanche transceiver, avalanche probe and shovel in order to carry out immediate life-saving rescue in the event of an avalanche occurring.

### 4.8.2 Avalanche rescue set

Avalanche rescue sets are supplementary materiel resources to be used in an organised avalanche rescue. The sets are distributed to provide units throughout Norway with the opportunity to plan, practise and conduct their own rescue operations.

The set has been developed to cover a unit's requirements in an organised avalanche rescue operation. The materiel comprises detection materiel, medical and evacuation materiel, marking materiel, communications equipment, provisions, spotlights and heating units, as well as tent materiel for assembly points and command posts.

Refer to Appendix 5.4 for a detailed breakdown.

## 4.9 Safety and risk assessment during rescue operations (primary)

### 4.9.1 Methodology

In The Norwegian Armed Forces Safety Rules and Regulation for Land based military activities(UD 2-1), risk assessment is described as a 5-step process. This methodology forms the basis of all activity and should be used as extensively as possible to detect risk prior to commencing any activity. In this way the highest possible degree of safety will be achieved.

The party responsible for conducting training, exercises or genuine rescue operations should use the provisions as a framework for risk management, which must be adapted to the risk picture that has emerged through the risk assessment. This may involve additional measures to those described in UD 2-1.

Units on avalanche standby should familiarise themselves with the methodology prior to taking over a standby role.

*A review of the risk assessment must be carried out as part of preparations before a unit assumes standby responsibility. This will also be a valuable time-saving measure for the final risk assessment during a response to an avalanche emergency.*

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### 4.9.2 Risk during an avalanche rescue

The very nature of an avalanche rescue operation implies risk. In order to ensure the safety of a rescue party, personnel must be capable of relating to risk. This means having the capacity to assess risk (formulate a risk picture) and then manage this risk during a rescue operation. A risk assessment will provide an overview of the inherent dangers of any given operation and may provide answers in respect of the measures personnel may implement in order to reduce risk to an acceptable level.

At all levels, prior to and during any rescue operation, a risk assessment must be carried out that is suited to the complexity and scope of the specific operation.

### 4.9.3 Objective and purpose of a risk assessment

The objective of risk management is to establish a basis upon which to manage risk in such a way that avalanche-related exercises and rescue operations may be carried out with the minimum amount of injury or loss.

A risk assessment should contribute to a reduction in the number of unfortunate incidents as well as reducing costs in connection with compensation/damages (personal, material and/or property), make provision for a more efficient use of resources, make training more realistic and effective, and result in improved avalanche preparedness.

Regarding avalanche rescue, a written generic risk assessment should be carried out that may be applied to training and education in avalanche rescue. When an avalanche rescue is to be undertaken, the risk assessment should be re-evaluated

based on the prevailing conditions. These assessments should be conducted continuously during transit to the avalanche area, as well as during the actual rescue. After the avalanche rescue has been concluded it should be evaluated and, if necessary, the generic assessments adjusted.

#### 4.9.4 The risk assessment process

Risk assessment methodology is described in UD 2-1 and it is here that the prevailing version of the methodology will be updated. The basics of the methodology are presented below. The process comprises a total of 5 steps:

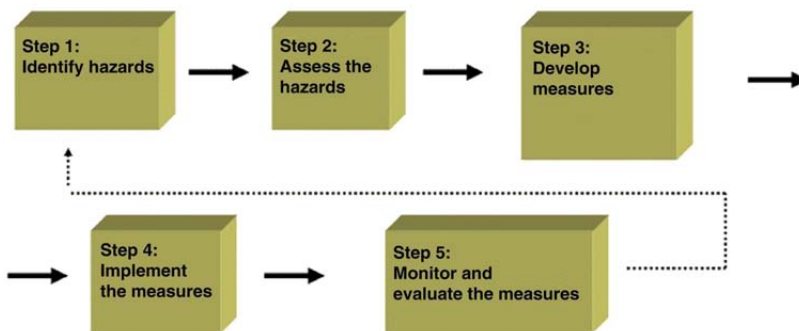


Figure: 4.35

#### *Schematic representation of a 5-step risk assessment*

##### **Step 1: Identify hazards**

Analyse the assignment and conduct a preliminary risk assessment. Similarly, list all possible hazards associated with the different phases of the operation. Also specify reasons why the hazards arise.

##### **Step 2: Assess the hazards**

Assess the degree of risk for each individual hazard, emphasising the degree of seriousness/consequences and probability. Determine the seriousness of the various hazards. Divide this into: slight – low/minor – moderate – severe – critical/very serious.

Determine the probability of the various hazards occurring. Divide this into: very improbable - low probability – moderate probability – high probability – very high probability.

##### **Step 3: Develop measures**

Here, measures are developed that counteract the individual hazards. Initially, prioritise measures that counteract high risk hazards. Determine whether there is any remaining risk and assess the risk associated with each individual hazard one more time (repeat step 2). Further, the necessary measures should be developed in order to determine whether there is any remaining degree of risk.

Make a decision. Once the measures are in place, assess whether the benefits outweigh the risk.

If the benefits outweigh the risk, the measures may be approved in principle.

If the risk outweighs the benefits, the assignment should be suspended or a higher authority consulted.

**Step 4: Implement the measures**

Fixed measures may be specified in regulations, training programmes, other orders.

Ensure that the chosen measures are communicated down to the lowest level. Clarify the division of responsibilities and introduce the measures.

**Step 5: Monitor and evaluate the measures**

Ensure that the measures are carried out and complied with at all levels. Be aware that changes may occur and that adjustments may need to be made. Implement any adjusted measures.

The form to be used for risk assessment may be found on the Norwegian Armed Forces intranet under the library and regulations portal.

## 4.10 Guidelines for rescue services in the event of an avalanche (national)

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### 4.10.1 Objective

The objective of ‘Guidelines for rescue service in the event of an avalanche’ is to ensure that search and rescue operations may be conducted without any danger to life and limb, as well as ensuring the most effective cohesion between the various organisations, participants and public bodies involved. The detection and rescue of avalanche victims should employ the most efficient methods. The guidelines stipulate requirements to organisations/participants undertaking organised avalanche rescue operations. The guidelines offer a degree of predictability in respect of requisitioning the potential and capacity of rescue personnel.

The guidelines stipulate requirements for all participants contributing to rescue operations, including requirements for minimum standards, basic training, as well as ensuring that all involved parties work to a common standard.

The ‘Guidelines for rescue services in the event of an avalanche’ should specify:

- national requirements
- risk management
- joint methods
- laws/regulations
- Joint Rescue Coordination Centres (HRS)/Local rescue centres (LRS)

The guidelines have been developed by participants involved in avalanche rescue.

*The guidelines for the avalanche rescue service are a shared tool for all participants involved in avalanche rescue in Norway.*

#### **4.10.2 Rescue personnel competence**

Rescue services make demands on personnel participating in rescue groups. Emphasis is placed on personal aptitude, theoretical knowledge and practical skills in respect of avalanches. In addition to being capable of working in a team, personnel must also be able to work independently and unsupervised.

The following sub-items should be emphasised during preparations:

- physical and mental fitness
- motivation
- cooperation skills
- the ability to take charge of personal skills updating and development

#### **4.10.3 Requirements for personnel in the avalanche rescue service**

Before personnel participate in avalanche standby, every organisation must ensure that such personnel satisfy a set of minimum requirements.

##### **General requirements for personnel**

- basic first aid
- safety and risk assessment
- organisation
- patient and colleague rescue
- search methods

##### **Specific requirements for personnel**

- familiar with the organisation of an accident site
- capable of assuming command of the organisation of an accident site
- capable of conducting companion rescue
- capable of carrying out a risk assessment suited to his/her level and activity
- capable of assessing the quality of his/her own work
- capable of complying with set procedures and methods, as well as carrying out assignments safely and correctly
- capable of using the relevant equipment in a satisfactory manner
- capable of complying with instructions and receiving guidance from superiors
- capable of working independently, responsibly and systematically
- capable of using basic maps and navigational tools to locate an accident site
- capable of reporting completed tasks and maintaining the necessary documentation
- capable of communicating and collaborating with other rescue personnel
- capable of preventing cold injuries from occurring to him/herself and others

#### 4.10.4 Collaborating partners and other participants

Examples of organisations working within avalanche rescue in Norway:

##### **Air rescue**

- air ambulance
- police helicopter
- search and rescue helicopter

##### **Dedicated avalanche groups**

- the Norwegian Armed Forces' Avalanche Standby
- avalanche dog equipages from Norwegian Search and Rescue Dogs, the police, the Norwegian Armed Forces
- the Norwegian Red Cross' avalanche groups

##### **Other organised rescue services**

- ski patrols (at alpine facilities)
- the ambulance service
- The emergency service/mountain rescue service of the Norwegian Red Cross
- Norwegian Alpine Rescue groups
- mountain guides
- Norwegian People's Aid



## 5 APPENDICES

### 5.1 Appendix 1: Course Plan – Basic Companion Rescue

Course Plan – Basic Companion Rescue as a [web document](#) and as a [pdf document](#)

### 5.2 Appendix 2: Companion Rescue Card

Companion Rescue Card – as a [web document](#) and as a pdf document: [Companion Rescue Card - section organisation, raising the alarm, search, excavation, medical service and evacuation](#)

### 5.3 Appendix 3: Instruction Manual – Barryvox Pulse

[Instruction Manual – Barryvox Pulse](#)

### 5.4 Appendix 4: Organized Avalanche Rescue Set

Content for – Organized Avalanche Rescue Set (will be prepared during the course of spring 2011)

## APPENDIX 1

### Basic Companion Rescue



*Figure: 1*

#### **INTRO:**

This short but effective training session has been tested on inexperienced subjects. The test demonstrated that 15-30 minutes of training gave positive results in relation to time spent on detecting and excavating avalanche victims. As it is within the first 18 minutes that there is the greatest chance of finding avalanche victims alive, it is important that training in detection and excavation focuses on finding avalanche victims within this time frame. The test site was 50 m wide and 80 m high and participants located and excavated two avalanche victims in an average of 15 minutes and 43 seconds. The first avalanche victim was extracted in an average of 6 minutes and 39 seconds.

- **Training objective: Instructor versus soldiers**
  - Companion rescue. Refer to label on battery cover, prioritise raising the alarm.
  - This is a brief but effective method of ensuring resonance among soldiers.
  - The course plan should be mastered and demonstrated by the instructor with as much accuracy as possible.
- **Materiel: Review of companion rescue equipment**
  - Shovel, clarify use with mittens in respect of effectiveness, material fatigue, flexibility.
  - Avalanche probe: Assemble and collapse an avalanche probe efficiently and without unnecessary breakage or wear and tear. Use: With handwear on, conduct a surface search at an angle of 90°.
  - Avalanche transceiver: Explain how the unit works (keys, switch, carrying strap), switch to transmit, switch to search, switch back to

transmit and switch off. Verify that everyone has carried out this procedure. Demonstrate the carrying position with the carrying strap (avoid metallic items).



*Figure: 2*

- **Search procedure:** Explain how a search is conducted from the initial phase to the final phase. Signal search, coarse search and fine search. Refer to the symbols on the rear of the unit for each phase.



*Figure: 3*

- **Demonstration search:** Walk-through, talk-through, during which each phase is demonstrated and each participant performs identical tasks. Each individual should demonstrate that every stage has been understood and mastered. Detection unit at an angle of 45° and a distance of around 50 m. The search will result in a curve in which the direction must be adjusted regularly. Do NOT discuss flux lines. The group should halt at the end of each phase.
  - Signal search: Refer to the symbols on the rear of the unit, rotate the avalanche transceiver next to the ear in a gentle motion (1-2 seconds on each axis). 50 m search corridors. Movement is crucial to saving lives!

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*Figure: 4*

- Coarse search: Follow the direction and distance at a rapid pace, focusing on distance, until reaching a distance of 10 m. Slow down close to the 'target point' at a distance of 3 m from the surface.
- Fine search: 'Home in on the target' as soon as a distance of under 3 m is attained. At the lowest distance value along the snow surface, conduct a spiral search with an avalanche probe. Mark the find spot. NO GRID SEARCH (to be explained to instructors).



*Figure: 5*

- Communications: Communicate with other members of the search party.

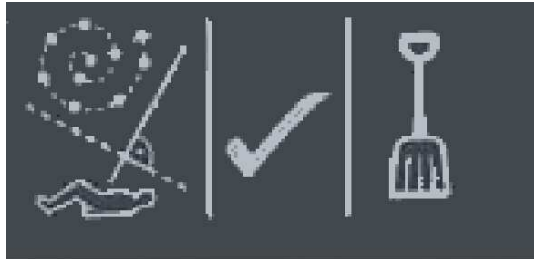


Figure: 6

- **Spiral search:** Search in a spiral
  - 25 cm distance between each hole and 25 cm between each spiral round. Search at an angle of  $90^\circ$  on the surface, to the length of the probe. Following contact, the avalanche probe should remain in place at the find spot.

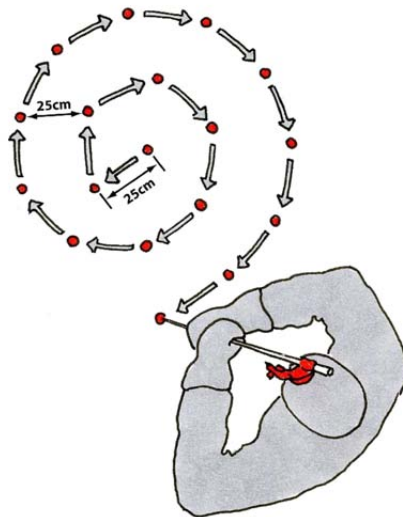


Figure: 7

App.

- Available personnel should commence excavation just below the spiral search.
- Activate another avalanche transceiver at a distance of 25 m. All

personnel should mark avalanche transceiver finds. At the next signal, each course participant should continue searching.

- **Excavation**

- Demonstrate and explain the appropriate use of a shovel, including hacking semicircular blocks of snow.

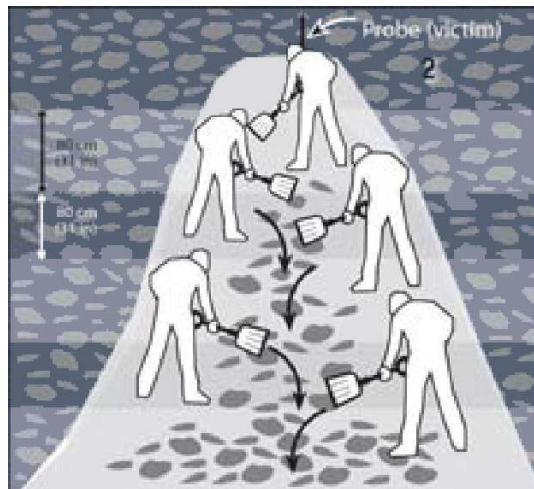


Figure: 8

- Position personnel in the formation. Chip loose and shovel snow as an excavation team.
- Allow excavation work to continue for 3-4 minutes and rotate the excavation team clockwise on the command of the team leader.
- Basic first aid will be used in the treatment but will NOT be commented on.

2 **Group test**

The 'group test' function is designed in such a way that the device tests the range of the unit without the need to adhere to a distance of 50 m. The device's sensitivity is set automatically so that a distance of 1 m equates to its maximum range. A positive test indicates that the device is working properly and that its antennas are intact.

A double group test should be conducted every day prior to departure.

A single group test should be conducted after longer intervals or following avalanche exercises (use of avalanche transceivers).

**Single group test:**

Explain how avalanche transceivers are switched to 'group test'. All personnel

switch their avalanche transceivers to transmit, the officer in charge switches to 'group test' and inspects the devices of all personnel at a distance of 1 m. The officer in charge then reports and shows the last member of the group that his/her own avalanche transceiver has been switched to transmit.

**Double group test:**

All personnel participate in the group inspection ('group test' group first), the officer in charge switches to 'transmit'. The officer in charge walks past everyone in the group with an avalanche transceiver at a distance of 1 m and listens and looks at each individual's avalanche transceiver. Personnel then switch their devices to 'transmit' and place the devices in the carrying position. The officer in charge sets his/her device to 'group test'. Each member of the group is inspected at a distance of 1 m and the officer in charge holds the avalanche transceiver to his/her ear to listen for a signal. When the last man in the group has walked past, the officer in charge sets his/her device to 'transmit' and places it in the carrying system.

**Calibration**

In the event of any queries regarding calibration, the unit may be calibrated by moving it gently in a 360° motion.

**457- Error message**

The unit is too close to metal, magnetic objects or electronics that are interfering with the signal. Maintain a distance of 20 cm or more from weapons, metallic objects or electronics.

## APPENDIX 2

### Companion rescue

The avalanche has stopped. Survivors must commence companion rescue on the snow surface immediately.

TIME IS CRITICAL!

- 1 Organizing the group**
  - Report the accident
  - One person takes charge: give a short briefing on the situation. Distribution of tasks
  - Assess the risk of new avalanches occurring (parallel and secondary avalanches)
  - Set avalanche transceivers to receive
  - Establish an entry/exit point. Mark the position with ski poles. Unnecessary equipment (skis, pulk sleds and large backpacks) should be left at the entry/exit point
  - Retain a small backpack and take a shovel and avalanche probe
  - The avalanche transceiver search and surface search should commence simultaneously
  
- 2 Surface search: rapid and thorough, including pinpoint search**
  - Mark the entrapment point and the disappearance point
  - Rapid surface search
  - Thorough surface search: arm's length, move blocks of snow
  - Pinpoint search all findings with the avalanche probe
  - Objects should be examined and marked, but not moved
  - Loud and continuous communication is important: **OBSERVE, SHOUT, LISTEN!**
  
- 3 Avalanche transceiver search (in tandem with surface search)**
  - All avalanche transceivers should be set to 'search'
  - Dedicated personnel conduct an avalanche transceiver search
  - Probing should be undertaken at an angle of 90° to the snow surface (shortest distance)

**4      Excavation: most effective method**

- The avalanche probe should remain at the find spot (marks the find spot, depth and direction in which to dig)
- Dig a V-shaped horizontal excavation shaft
- Avoid standing on top of the snow covering the avalanche victim

**5      First aid and evacuation (refer to [Avalanche first aid](#) for details)**

- Check for an air pocket
- Do not move the victim's limbs unnecessarily
- CPR should be performed as soon as the casualty is reached. Start with 5 insufflations
- The casualty should not be removed before being wrapped and made ready to evacuate
- Further heat loss should be avoided (wrap the casualty in blankets/plastic/etc.)
- The casualty should be evacuated on a pulk sled, stretcher or improvised sled
- Re-heating should only be carried out by qualified personnel. The casualty may only be declared dead by a doctor

## Avalanche first aid

The following points specify the first aid element of companion rescue:

**1      Excavate the head first**

- Digging should be conducted horizontally to the victim
- Look for an air pocket and snow in the nose/mouth

**2      Examine the respiratory passages**

- Remove snow from the mouth and throat
- Ensure that nothing is strapped around the casualty's neck

**3 If the victim is not breathing**

- Ensure the respiratory passages are free
- Excavate around the chest region as quickly as possible
- Commence CPR immediately
- 5 initial insufflations – then repeat 30 compressions – 2 insufflations
- Continue until the casualty can be handed over to medical personnel

**4 If the victim is breathing**

- Ensure the respiratory passages are free
- Continue with careful excavation and release of the casualty
- Place the casualty in the recovery position
- Protect the casualty from further heat loss

**5 Rapid excavation**

- Careful, horizontal excavation
- Do not move the victim's limbs unnecessarily

**6 Protect the casualty from further heat loss**

- Cover the casualty during excavation (Jerven bag/tent, etc.)
- Remove wet clothes
- Wrap the casualty in dry clothing, sleeping bag, Jerven bag, etc.
- The casualty should not be removed from the snow before he/she has been made ready for wrapping and evacuation

**7 Evacuation (refer to page 1)**

- Prepare stretcher/sled, or similar
- Observe the patient carefully during evacuation