1. Introduction
basic member, by the ASNE Training Guide. First Edition. Several other technical procedure are also treated, but victim rescue is not.
II. MATERIALS FOR MOUNTAIN RESCUE

Materials for mountain rescue generally fall into two categories: software and hardware. Software includes items like rope and webbing, and also things made from them. Universally, software items have limited life and therefore particular care must be paid to their maintenance and periodic inspection. Accurate and complete use records are essential to the maintenance program.

Hardware, on the other hand, comprises items like saws; axes; axes; and pulleys, which are considerably more durable than software. Nevertheless, hardware items too, demand care and frequent inspection, and must not be considered to have unlimited life.

The need for continuous vigilance in the care of mountain rescue equipment can hardly be overemphasized. The safety and success of any mountain rescue
operation depend directly on the reliability of the materials used, and carelessness in maintaining those materials can have disastrous consequences. Take care of your gear.

A) SOFTWARE

Ropes and other softwore used in mountain rescue are almost always made of nylon (or "perlon" as it is called in Europe) with some special purpose items being made of polypropylene and other synthetic fibres. The chief advantages of nylon over other fibres is its combination of high strength, shock absorbing elasticity, and nice handling characteristics. Its chief disadvantage is a low melting point—about 250°C.

Natural fibre ropes are not even considered for use in mountain rescue; they have unreliable strength and stretch characteristics, absorb large amounts of water, and deteriorate through decay.
1) Rope

There are two general types of rope construction: twisted lay and kernmantle (core and sheath). These two types of construction are illustrated in Figure 2.1.

![Diagram of rope construction types]

A. Twisted Lay

B. Kernmantle

Figure 2.1. Rope construction types.

Twisted lay rope, of which the primary example is Plymouth Goldline, has several important disadvantages. Its worst feature is its great elasticity. Most of the stretch in a twisted lay rope is due to uncoiling of the strands as the rope is loaded; consequently, the rope tends to twist as it is loaded and kink as
it is unveiled. In most mountain rescue applications, this elasticity is difficult to deal with.

Twisted lay ropes of mountaineering or rescue quality (such as Goldline) are also quite stiff, difficult to handle, and do not take knots nearly as well as kernmantle.

The great advantage of twisted lay rope is its low cost for high quality, and the property that the strands can be separated for internal inspection. This feature is deemed sufficiently important by some rescue organizations that Goldline is the only rope they will use, despite its many drawbacks.

Kernmantle rope is constructed of a core of parallel or loosely braided continuous nylon filaments covered by a close-fitting, woven nylon sheath. The core is the load-bearing element, while the sheath provides protection and an excellent handling surface. The smooth sheath of kernmantle rope slides more easily through hardware and over rock.
than have the corrugated surface of twisted
day rope, but at the same time it provides adequate
friction for belaying. Since the core is braided
rather than twisted, the elastic properties
of kernmantle are due largely to the elastic
properties of the nylon itself, and the
rope stretches slowly without twisting or
kinking.

The electricity of nylon can be controlled
during manufacture by a heat-treatment
process called curing. When the fibers are
first drawn, the long polymer chains making
up the nylon are stretched out along the
length of the fiber making it relatively inelastic.
Upon heating, however, the polymer chains kick up
to form microscopic springs, thus making the fiber more elastic. Using
this process, manufacturers can produce ropes with
different characteristics for different purposes.
Mountaineering ropes are cured to have the right
electricity to provide a cushioning effect
in a fall, while climbing ropes (such as
Bluewater and PMI) are cured to minimum
elasticity for ease in rappelling and ascending. The
For tactical (and high strength) of carrying ropes makes them nearly ideal for belaying ladders in mountain rescue, but dangerous as climbing ropes. Mountaineering ropes, because of their greater cost, lower tensile strength and special elastic properties, are best reserved for belaying people rather than ladders; although in a pinch they can be used for ladder belaying.

Rope is manufactured in several different sizes, ranging from 4.5 to 11 mm for kernmantle, and 1/4 to 7/16 inch for slickline. The smaller sizes are used mainly for slings and accessory lines while the larger sizes are used for belaying. The 11 mm and 7/16" sizes are the usual ones for belaying with the "single rope" technique used almost exclusively in America, while a doubled 9 mm or 3/8 inch rope is used for the "double rope" technique popular in Europe. A single 9 mm or 3/8 inch rope is adequate for top roping or low angle belaying, but is not adequate for belaying a ladder.
Standard climbing rope lengths are 120, 150, 165, and 300 feet, with the two most popular lengths being 150 and 165 feet. The 300 ft length is usually 9 mm for use as a double rope. Caving rope is supplied in 1000 ft, spoke, end cut lengths. For mountain rescue, 45 m lengths seem to provide a good compromise between length and maneuverability. Since caving rope is supplied in such long lengths, it contains core splices, which appear as sections of the rope slightly thicker than the rest. Although it can be quite unnerving to discover a splice while halfway across a tyrolean traverse, core splices are quite strong and should cause no alarm.

The manufacturing specifications and quality control of reputable rope manufacturers are very high, and consequently their products may be treated fully, Good European

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Metric standard lengths are 25, 30, 35 and 45 m, and are becoming available in the U.S.
Climbing ropes are manufactured to the specifications of the Union Internationale d'Association d'Hippisme (UIAA), which requires that ropes pass several tests before being approved. The two most important of these tests for elongation under static load and for impact force in a head fall.

In order to pass the static load test, the rope must elongate less than 6% under a load of 100 kg. This assures good preserving and repelling characteristics.

The UIAA maximum impact force test measures the rope's ability to properly cushion in some harder fall. From a rigorous anchoring 2.8 m of rope is run up through a carabiner 0.3 m above the anchor and thence to an 80 kg weight. When the weight is dropped, it falls through twice the length of free rope (5 m) before being caught thus simulating the worst possible fall. Interestingly, the force required to catch
successive falls, the rope must not meet or the weight or impact force greater than 1200 kg.

Since they are not intended for belaying, saving ropes do not meet the UIAA specifications. These ropes are used for low elasticity and consequently have very high impact forces.

Table 2 lists the characteristics of several common ropes.

Table 2. Rope Characteristics

A fall does not depend solely upon the height of the fall, but rather depend upon the ratio of the distance fallen (twice the runout) to the total length of rope in the system (at most, just the runout): the more rope there is in the system, the more cushioning it provides. The worst possible fall, therefore, is one in which the climber falls through a distance twice the length of rope in the system. This will occur whenever there are no anchors above the belayer.
2) Rope Care

Ropes (and other software) used in mountain rescue are susceptible to four categories of damage: chemical, radiative, thermal, and mechanical. If a rope is to give long and reliable service, all of these agents must be guarded against in both storage and use.

The most common chemical agent responsible for rope damage are battery acid and petroleum products, both of which are found around cars. Accordingly, care should be taken to insure that ropes carried in car trunks are protected. In general, all chemicals should be considered harmful and should be kept away from ropes, with the exception that poisons or dyes may be used to mark the ends of a rope.

Fortunately, water does not permanently damage rope (although a wet rope is slightly weaker, a bit heavier, and stiff when frozen), so one shouldn't fear moisture, except for the inconvenience.
Reduction damage occurs when a rope is exposed to the ultraviolet rays of sunlight. Fortunately, most of this damage takes place in the short, modern rope dyes mitigate the problem quite effectively, and at altitudes found in the mid-Atlantic region, the UV flux in sunlight is relatively low. Nevertheless, it is good practice to keep softwear out of the sun except when it is being used.

Thermal damage is a severe problem. Nylon melts at about 250°C, but structural damage (changes in the elastic properties and strength) can occur at much lower temperatures. Damaging temperatures can easily be attained in the careless employment of normal techniques, friction being the usual mechanism for generating the heat. The worst problem is nylon rubbing against nylon, but nylon on brake can also result in severe
To guard against thermal damage, brakes should be run slowly (a hot brake can melt right through a rope), nylon on nylon friction must be assiduously avoided, and the rope must be protected from hot objects.

Mechanical damage seems like an obvious problem, but actually can be quite subtle. An obviously cut or abraded rope may be safe if the damage is only to the sheath, whereas an obviously undamaged rope may have been greatly weakened by previous strain or by the incisions cutting action of dirt ground into the core. The only sure way to know...

An interesting demonstration of the weld-abrasion phenomenon can be performed in the following way: take a short loop of webbing or light rope around your foot and then attempt to saw through it with another length of webbing or rope. The resulting failure of the nylon is rapid and awe-inspiring.
that a rope is sound is to know its history and to know that it has been handled competently.

Typical agents of mechanical damage are surface abrasion or cutting of the rope by sharp rocks or ice, internal cutting of core fibers by dust forced into the core when the rope is stepped on a rockfall (which can produce severe core damage with no apparent sheath damage), wear from mechanical oscillation and torque, and strain from hard falls or unusually heavy loads. These things must be avoided as much as possible, of course, but to a certain extent they are unavoidable. Consequently, all ropes eventually wear out. The decision to retire or not, but not obviously damaged, rope is a difficult one, but one which can be made much easier by the keeping of accurate records of rope use and wear. To insure their usefulness, these
The records must be faithfully made and periodically reviewed.

Although the comprehensive testing of a rope is impossible, inspection can augment history as a valuable gauge of a rope's integrity. In a visual inspection, one looks for any irregularity: abrasions, cuts, welded spots, discoloration, and dirt. A twisted lay rope can be twisted apart to inspect the inner fibers. A kernmantle rope should definitely be retired if the core shows through the sheath anywhere, and a twisted lay rope should certainly be retired when a quarter of the fibers are worn to fuzz. For less extreme cases, some judgment is called for, but conservatism is the rule.

Just as important as visual inspection is tactile inspection. Touch is very sensitive to abraded or cut spots and allows one to detect telltale irregularities in diameter. The bumps sometimes felt
in new crossing ropes are spilled, and
are no cause for alarm; but a newly
discovered lump or thin spot in cause
for a rope's immediate retirement; the
we places where the core fibers are
broken.

Coiling of the rope provides frequent
opportunity for both visual and tactile
inspection.

It is possible to perform a limited test
of a rope in the field by tying one end
to a solid anchor and having five or
six people pull on the other end. This is
called "pull testing." A good pull test
loads a rope perhaps 200 kg, or about
10% of its rated strength, thus ruling
out failures at that stress and below.
No attempt should be made to pull test
at larger loads (by pulling with more
people, for example) since if the rope
should break, like a rubber band it
will snap back at the pullers with
vicious intensity.
Since a rope may be loaded above 1200 kg in service, pull testing is no great insurance against failure; but it is some. Frequent pull testing is therefore advisable, but it should not lead to overconfidence. The purpose of pull testing is to reveal incipient damage, not to test a possibly injured rope. If a rope is damaged or strained, it must be considered faulty; successful pull testing does not guarantee its soundness. There is no substitute for proper rope care.

Although good rope care practices are largely a matter of common sense, a few points bear mentioning. Ropes should be stored neatly coiled and ready for use in a clean, dry, temperate place. A newly cut rope and must be treated to prevent the spectacular unraveling process that would otherwise occur. Before cutting, the spot to be cut should be wrapped with tape (metallic tape is good).
and often cutting into and should be thoroughly fused (not burned!) in a match or small flame. The singed tip can then be replaced with plastic tape of an appropriate color or bearing some identifying mark. Glad-side of webbing must also be fused, but taping is not necessary.

All software should be washed occasionally to remove the dirt which cuts core fibers. The wash can be done in an automatic washing machine; cold water and mild detergent must be used. Wet ropes should always be hung in the shade to dry.

A modern rope is a remarkably strong, resilient and reliable tool, but if it is to be trusted, its vulnerabilities must be respected. In using software, the mountain rescuer should cultivate the mountaineer's sense of jealous protectiveness of his gear -- a sentiment which is summarized by the ancient dictum, "Don't step on the rope!"
3) Webbing

Nylon webbing is manufactured in two forms: flat and tubular. See Figure 2.2. Flat webbing is fairly stiff, so it is useful in applications where the webbing must hold its shape, as in struts. It is most popular for straps on equipment because it holds well in bundles.

Tubular webbing is quite limp and easy to work. It is therefore more popular than flat for runners and general purpose applications. Both flat and tubular webbing hold knots well, but knots in tubular are easier to untie.

Webbing properties are included in Table 1. Principles of care are covered in Section B.2.牵带.
4) Parachute Cord

The small-diameter (2.5 mm) braided
nylon rope used for parachute shock lines
is very useful in mountain rescue. The
genuine article is of high quality and
has a rated tensile strength of 450 lb (250 kg). Most of the "j-cord"
in circulation, however, is not genuine
braided line and has a much lower tensile
strength. Although this commonly
available cord is marvelously useful
(and should be found in every rescue
gear kit), it must not be trusted to
hold a person's weight.

3) HARDWARE

The techniques of modern mountain
rescue employ a bewildering array of
sophisticated and often highly specialized
tools. The description and usage of most
of them is far beyond the scope of this
manual. The items which are discussed have
clear application and should be familiar to
all aspects. The mountain rescuer who seeks to learn the use of other tools can find much information in the books cited in Chapter I, and can learn from his own experience and that of his colleagues. He should, however, take pains to guard against the temptation to trust his safety and rescue effectiveness to the fascinating accoutrements of technology. The most valuable of all the tools of mountain rescue are polished skill and prudent judgment.

1) Carabiners

The most important and frequently used article of climbing hardware used in mountain rescue is the carabiner. A carabiner is a strong metal campline used primarily for making convenient but high-strength connections among the various parts of a belay system and to eliminate regular or regular junctions. There are numerous other uses as well.
2) Construction. The parts of a carabiner are illustrated in figure 2.3. Carabiners are manufactured in many different shapes, but there are basically three categories of these: the oval, the "D", and the modified "D". These are illustrated in figure 2.4.

![Carabiner Diagram](image)

**Figure 2.3. Carabiner Construction.**

![Carabiner Types](image)

**Figure 2.4. Carabiner Types.**

The weakest part of a carabiner is the catch. The "D" shape relieves stress.
on the catch, thereby increasing the major
axis strength of the carabiner. The "D"
type are therefore stronger than the oval.
The modified "D" shape reduces weight
without sacrificing strength or usability.
The strength of a carabiner is
reduced drastically (from above 2000 kg
to below 1000 kg, typically) when the gate is
open, so in applications where the gate
might accidentally be opened, the locking
(or "safety") carabiner is used. The
locking sleeve screws down over the
catch to keep the gate closed, or in some
lockers, the sleeve can be positioned to
hold the gate open — a feature which can
sometimes be quite convenient.

Most modern carabiners are made from
very strong aluminium alloys, but there are
still a few steel carabiners available.
Inexpensive steel carabiners are, oddly
enough, not as strong as aluminium ones
of similar dimensions, but there are available
several steel models of very high strength.
b) Selection. In choosing a carabiner for rescue work, the main consideration is strength. In most applications, any well-made carabiner will do, but in litter-lifting systems, forces can occasionally rise as high as 2000 kg under ordinary conditions. Since any available carabiner might be pressed into service in a litter-lifting system, 2000 kg should be regarded as the minimum acceptable strength. (Many one, gate closure, for carabiners to be used in rescue work.

The gate of the carabiner should operate smoothly, and should be designed so that it will open freely while two 11 mm ropes are clipped in and while supporting a person's weight. Unfortunately, very few carabiners (except for some large steel types) will open widely enough to
be clipped onto a little rail.

A further desirable feature is a small projection near the catch to make clipping in easier to do by feel.

c) Care. In caring for carabiners, the main consideration is smooth and reliable operation of the gate. Usually, very little maintenance is required, but occasionally, grit must be cleared from the hinge or locking sleeve. Petroleum solvent are good for this, but the solvent must be completely removed before the liner is used again. A very small drop of penetrating lubricant (such as 405 or CRC 5-50) may be applied to a stubborn hinge, but, in general, no lubrication is necessary or desirable.

If the catch on wings of a carabiner is bent so that the gate does not work properly, the carabiner should be retired. Even if the part can be bent back into position, the bine will have been seriously weakened.
Burr are a threat to rope passing through the carabiner: they may be removed with every paper or a file.

3) Application. For the most part, the use of carabiners are fairly obvious, but there are several dangers that must be avoided. The low-open gate strength has already been mentioned. A lock-open should be used whenever there is significant danger of a gate opening accidentally, but if a lock is not available, two regular carabiners with gates opposed make a good substitute (see figure 2.5). For true opposition,

\begin{center}
\includegraphics[width=0.5\textwidth]{figure25}
\end{center}

Figure 25. Opposed gates.
the catch of the two carabiners must be on opposite sides if one of the biners should accidentally turn so that the gates are together. Figure 2.6 illustrates this distinction.

![Diagram showing true and false opposition]

**Figure 2.6.** True and false opposition.

When a carabiner is used resting against a surface, the gate should be positioned away from the surface so that it will not be pushed open. Figure 2.7 illustrates.

![Diagram showing correct and incorrect use of carabiner against a surface]

**Figure 2.7.** Carabiner against a surface.
The strength of a carabiner is very low for loading on the minor axis. This configuration, called cross loading, must not be permitted to occur. Figure 2.8 illustrates the two most common causes of cross loading.

![Cross loaded carabiner](image)

Cross loaded double runner. The runner should be longer or a girl's hitch should be used.

Figure 2.8. Cross loading.

The strength of a carabiner is also degraded when it is loaded in a way that tends to bend it, as in figure 2.9. This configuration is called side loading and should be avoided.

![Side loaded carabiner](image)

Figure 2.9. Side loading.
2) Pulleys

Although the friction of a kernmantle rope running over a carabiner is remarkably low, the use of pulleys can substantially increase the efficiency of a hauling system. A pulley designed for rescue service is illustrated in figure 2.10. Notice that the rope may be mounted or dismounted from the pulley without the need for threading the end through the block.

Figure 2.10 Rescue Pulley.
Both bushing and ball bearing sheaves are available for rescue pulleys, but it is not clear that the slightly better performance of the ball bearing models justifies their greater cost. Bushings are certainly more reliable in severe use. The block pieces on better pulleys are made large enough to protect the rope from abrasion as it passes over the pulley, a feature which is rightly regarded as highly desirable. Nevertheless, narrow-block rescue pulleys should not be scorned on this account. Small, narrow-block pulleys are nearly as strong as their larger brethren, weigh and cost considerably less and remain safe and useful in applications where abrasion is not troublesome. Their major drawback is somewhat higher friction due to small sheave diameters, but they are still much better than plain carabiners. Rescue pulleys are generally strong enough that overloading is not a problem, but the user should keep in
mind that the load on the pulley is twice the load on the rope passing through it. The anchor supporting the pulley should be made corresponding sturdy.

Rescue pulleys require no routine maintenance or lubrication, but, like any other tool, they should be kept clean and should be checked frequently for proper operation.

3) Ascenders

A complete discussion of mechanical ascending devices is beyond the scope of this manual, but brief description of the four principal types are included for general information.

a) Tumars - The original mechanical rope climbing device is the Tumor, illustrated in figure 2-11. It consists of a cast aluminum frame and a swinging cam which clamps the rope when the Tumor is pulled and allows the rope to slide when it is pushed. Although the Tumor is
Figure 2.11. Tumer ascenders.

a highly efficient rope climbing device, its low strength makes it unsafe for use as a ratchet in a litter hauling system. Tumars have also been known to pop off the rope when improperly applied or loaded to the side.

b) CMI and Cloj Ascenders. Two new ascenders, which are really modifications of the older Tumor design, are the CMI ascender and the Cloj ascender. They are illustrated in figure 2.12. The main differences between the CMI and the Tumors are improved metallurgy and modification of the safety catch design. CMI guarantees
Figure 2.12. The CM1 and Clog Ascenders.

a strength of 2200 kg, which is quite adequate for lutter hauling systems; but, as of this writing, insufficient experience has been gained to know whether the device is stable enough for such applications.

The Clog ascender operates on the same principal as the Toman and the CM1, but is designed more for efficiency as a rope climbing device than for safety as a general purpose retainer.

c) Gibbs Ascender. The Gibbs ascender, which is very popular in canoe circles, eliminates the problem of immobility by having the rope entirely enclosed. This
Fig. 2.13 The Gibbs Ascender

design also increases the strength. See figures 2.13. Each Gibbs ascender is tested by
the manufacturer to 450 kg, but the
actual strength is certainly much higher than
that. Unfortunately its wrap-around design
makes the Gibbs more clumsy to rig than
other ascenders because it must be
disassembled before mounting, and then
reassembled around the rope.

The Gibbs also differs from the
Jumars, in that the load is applied
cot to the body, but to the cam
itself. This design precludes the
necessity of spring loading of the cam,
But without the spring the device must be "set" with each advance of the rope. Newer models have spring loaded cams.

The reliability of the Gilkes ascenders has made them quite popular in technical rescue, but because they are somewhat complicated to rig and use, they should not be employed unless the user is well practiced in dealing with their idiosyncrasies.

4) Braking Devices.
Over the years, a bewildering array of mechanical rope-breaking devices has been offered for use in mountainary, rescue and rescue work. Each device, and the technique of using it, presents strengths and weaknesses, advantages and disadvantages, while the perfect brake has not yet been invented. The ideal brake would be lightweight, yet have a large burst capacity; it would be simple to use, yet provide a wide range of breaking force in a single configuration. It would be easy to load and unload, and it would be strong enough to withstand heavy rescue loads. Six of the most commonly used breaking methods are described in this section (the Figure-8 brake is also discussed in ?-??). The treatment is far from exhaustive, but covers the methods the mountain rescuer will probably find most useful.

4) The Carabiner Wrap

The simplest (and perhaps oldest) mechanical brake is the carabiner wrap, shown in figure 2.14.
The brake performs quite well with kernmantle ropes, but twisted lay ropes are somewhat more difficult because they tend to bind. The heat capacity of the kernmantle wrap is relatively low, but is entirely adequate for rappelling. Additional kernmantles can be ganged for more friction and heat capacity, however, making the system practicable, if not convenient, for little braking. A double or triple wraps around the kernmantle results in more friction but no more heat capacity. This trick is particularly useful when braking small-diameter ropes.
b) The Six-Biner (Yosemite) Buke

The six-biner buke requires no specialized equipment, is strong, provides excellent friction and control, and has a high heat capacity, but it is somewhat clumsy to rig and requires four cardinews (the classical version used two biners with gates opposed, rather than a locker, hence the name). The rigging technique is illustrated in figure 2.15.

The gates on both pairs of biners are in opposition; however, the rope runs over the backers of the two traverser biners.
a) The Brake-Bar Brake

The brake bar is a specialized rappel device which is light, easy to use, and effective on both twisted-lay and kernmantle ropes. However, it can only be used on the oval carabiner for which it was designed, and oval carabiners are generally not strong enough to be trusted supporting a lifter. The brake-bar brake also provides less friction than most other brakes, although it provides enough for rappelling. The best capacity is greater than that of a Werner-wrap, but less than that of a 5/16 Werner brake. Rigging is illustrated in figure 2.10.

Figure 2.11a. The Brake-Bar Brake.
Both the control range and load capacity of the brake-bar rig can be enhanced by ganging brakes into a "brake-bar chain" as shown in figure 1.7. The entire load, however, still falls on a single oval carabiner, and consequently, ganging brakes does not increase the strength of the system. Brake-bar chains are most useful for long, free rappels or for lowering a tragic.

d) The Rappel Rode

The rappel rode is a special purpose brake having the advantages of extremely high strength, range of control, and load capacity. It is well suited for long, free rappels, hence its popularity among vertical climbers; and it is nearly ideal for vertical rescue applications. Its disadvantages are its weight and complexity. Rigging is illustrated in figure 2.17. Note that the rope does not run over the end of the rode itself, but over the short brake bar. This precaution prevents wear.
of the rope at a critical point. It is also advisable to tie the rope directly to the anchor, or to at least place a runner between the rope eye and the anchor biner. If a biner is clipped directly to the rock, the eye, because of its width, does not sit in the bottom of the carabiner, develops forces which tend to unbend the biner, thus decreasing its strength.

![Figure 2.17 The Rappel Rock]

The brake bars are pushed together to increase friction and separated to decrease friction. As necessary, the number of
break bars in use can also be changed even while the rope is loaded. These manipulations require some practice, but a skilled operator can rig, derig, and flip break bars in and out with amazing facility. The brake can be securely locked and tied off in the manner shown in figure 2.17.

b) The Figure-8 Brake

As a rappel device and as a brake for semi-technical events, the figure-8 brake (often called an "8-ring") is nearly ideal except for the peculiar drawback that it must be disconnected from the anchor to be rigged. Otherwise it is strong, light, provides a good range of control, works with all kinds of rope, can be locked and unlocked under load, and has a reasonably high-knot capacity.

A further desirable feature not to be overlooked is that its great popularity makes the figure-8 ubiquitous among climbers. It is
a great advantage not to require exotic hardware to run an effective code.

Figure 2.19: The Figure-8 Brake

Rigging of the Figure-8 brake is shown in figure 2.19. It is further discussed in section II-C-2.
III. ROPE HANDLING

The extensive use of rope is surely a hallmark of mountain rescue, and consequently the mountain rescuer prides himself in his rope handling skills. This chapter describes those rope management, knot tying and anchorage skills that are used in semi-technical rescue and general roped travel, and which form an essential foundation for technical rescue. The specialized techniques required for high-angle rescue and fifth class climbing are beyond the scope of this manual. Further information can be found in the references mentioned in Chapter I.

A) ROPE MANAGEMENT

A flexible cylinder some 45 meter long and 11 mm in diameter is found to be somewhat awkward to manage, but with attention to detail, a little patience, and a measure of persistence, the rope can be handled with remarkable ease and efficiency. Although the trouble taken in
avoiding "rope salvage" consumes valuable time, the much greater time required to unscrew a wayward rope can be far more costly.

1) Stacking
   The first step in preparing a rope for use is always to uncoils and stake it; the coil is held in one hand while the other carefully uncoils it and drops it onto the ground in a random pile or "stack." Amazingly, this stack will run more freely than the clearest coil, and it will run from the top or the bottom. It is important, however, to pick a place for the stack which is safe from vehicle and errant feet, and which is free of projections on which the rope might swing. The rope should also be stacked in a clean place, of course, but that is not always possible.

2) Coiling
   There are far too many useful methods of rope coiling to describe them all here.
Nevertheless, these useful methods which, for the sake of uniformity, should be learned by all ASCC members, as described, Idiosyncratic coiling methods are not discouraged as long as they do not damage the rope or make it difficult for another person to unravel.

Coiling provides an excellent opportunity for inspecting and cleaning the ropes, and one should develop the habit of doing so every time the rope is coiled. With practice, it takes no extra time to run the hand over the entire rope, brushing off dirt, and feeling for cuts and the variations in thickness which indicate internal damage.

a) Speed Coiling. The descendent coil to do, and the best suited to throwing the rope, is the speed coil: the rope is simply folded back and forth across the hand in a series of large loops, as shown in Figure 3.1.
6) Mountainer's Coil. For the mountainer coil, the rescuer kneels and wraps the rope from boot to knee. See figure 3.2.

![Figure 3.1. Speed Coil.](image)

![Figure 3.2. Mountainer's Coil.](image)

c) Lap coil. For the lap coil, the rescuer wraps the rope from knee to knee while he sits with his feet together. See figure 3.3. The lap coil is especially well suited to people with short legs whose mountainer's
coils are too small for other people to carry. It has the disadvantage, however, that the person making the coil must sit, perhaps on wet ground.

d) Ty'ing off a Coil. A coiled rope will come apart and become tangled unless it is properly tied off. Dismantling stretchers are discouraged since it is easy to tangle a rope by undoing its tieoff improperly. The accepted method is shown in figure 3.4. First, one end of the rope is folded back on itself to make a loop. Then, the other end is wrapped around the coil and the loop, starting at the open end, continuing five or six
turn out then being passed through the loop. Finally, the front end is pulled to cinch up the loop and hold everything firmly in place.

3) Throwing.

Several points should be observed when throwing the rope:

a) To avoid the embarrassment of throwing the rope away, (or throwing himself away), the receiver must secure himself and his end of the rope before throwing.

b) The call "Rope!" is always used to warn those below that a rope is coming down. Responses to this call must be heard. The end of a thrown rope snaps like a whip and can deliver a surprisingly forceful blow. It can also dislodge rocks onto the people below; it can also dislodge people.
c) The rope should be speed coiled before throwing since other coils are more likely to tangle.
d) The speed coiled rope is thrown hand-over-hand, at the chosen target.

4) Carrying

A coiled rope can be conveniently carried slung over one shoulder and across the body to the opposite hip. Putting the trelleff just behind the shoulder helps to keep the coils from hiding down and getting in the way.

If part of the rope is in use, the excess coils must not be carried across the body, but should be carried hanging straight down from the shoulder. This precaution avoids the danger of strangulation should the rope suddenly be loaded.

B) KNOTS

When a straight rope is loaded, all its fibers share equally in supporting the applied tension.
If, on the other hand, the rope is loaded while bent over some object, such as a carabiner, the fibers on the outside of the curve will support a greater strain than those on the inside and, consequently, the bent rope can withstand less tension than the straight one.

Although this phenomenon is of concern whenever it occurs, it is particularly problematic in knots. The presence of a knot substantially weakens the rope in which it is tied since in the knot, the rope bends on itself. In fact, the weakest point in a well-designed rope system is usually a knot. The fraction of a rope's straight strength remaining after a particular knot has been tied is called the efficiency of the knot—a figure typically in the 40% to 60% range.

Now the efficiency of any given kind of knot will be greatest if a knot is tied in such a way that the most heavily stressed parts make the largest radii.
of curvature in the knot. This condition can frequently be achieved by pressing the standing part of the rope into the outer contour of the knot and bringing the running part out of the middle*.

A knot so tied is said to be "properly contoured." Contouring and neatness add materially to the strength of knots, but also the discipline required to properly contour knots helps to prevent tying errors. In the view of the conscientious mountain rescuer, a knot is not correctly tied unless it is neat and properly contoured.

A particularly annoying quirk of knots in nylon rope is that they untie themselves with amazing ease at the most inappropriate moments. They can be effectively discouraged from this behavior, however,

* The "standing part" is the part of the rope the end of which is inaccessible to the person tying the knot. Ordinarily it will be locked. The "running part" is the end that is manipulated in tying the knot. Ordinarily it will be unloaded.
by tying the "tail", or "left over running" part, back to a standing part of the rope with an overhand knot. No knot should be considered complete until the tail is tied off.

The essential mountain rescue knots are discussed below. Each of them has peculiar properties making it useful for certain kinds of applications. The knots shown make an incomplete list of all knots useful in mountain rescue, but they will accommodate most needs. Additional knots can be found in the references listed in Chapter I.

1) Bowline

The bowline is surely the single most versatile and important knot in mountaineering and mountain rescue. It is used to put a non-slip, fairly high efficiency loop

* The half-hitch (half-gripper) is recommended by some as being even more secure than an overhand. This is doubtless true, but overhands are entirely adequate and easier to tie. The half-hitches recommended by others are nearly ineffective.
in the end of a rope. There are other knotes with this same function, but the bowline enjoys the great virtue of being very easy to tie! With practice, it can be tied in the dark, one handed and while wearing mittens. The bowline (and its derivatives) also have a distinctive appearance which makes it easy to check visually.

![Diagram of a bowline](image)

Figure 3.5 Bowline.

The bowline is illustrated in Figure 3.5. Note that the tail comes out on the inside of the loop. If the running part passes the opposite direction around the standing part after passing through the bight, the knot is called a "left bowled" bowline and is weaker than a "right bowled" bowline. If
two kights are taken, the bent is called a "high strength" bowline, and is slightly more efficient than the regular bowline. The tail is tied off to the adjacent loop strand.

2) Bowline-on-a-Coil 

The bowline-on-a-coil is essentially the same as a regular bowline except that it has more loops and, therefore, more settling area. It is much preferred to the plain bowline for waist loops and for anchors to trees.

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![Diagram](image)

Figure 3.6. Bowline-on-a-Coil

The bowline-on-a-coil is illustrated in figure 3.6. Any number of loops can be
used, but these are not in adequate for most applications. Note that all the loops pass through the eye of the hight.

The tie-off may be made to one or all of the loop strands, but tying to only one is probably better.

3) Figure - 8 Loop

The figure - 8 loop puts a strong, fairly jam-resistant loop in the middle of end of a rope. It is somewhat more efficient than the bowline, but harder to tie — especially when the end must be passed around or through something. Proper

drawing:

Figure 3.7. Figure - 8 Loop.
require care. The figure-8 loop is useful for putting a loop in the middle of a rope, but it tends to jam when the two standing parts are located collinearly, that is, all in one line with the loop in the middle. The butterfly is preferred in that case. The figure-8 loop is shown in figure 3.7.

4) Butterfly Knot

The butterfly is used to put a loop in the middle of a rope when the standing parts may be located collinearly. It is excellent for tying in to the middle of a rope or even for tying out a damaged spot in the rope. It is shown in figure 3.8.

Figure 3.8. Butterfly.
5) Water Knot (very kind, overhead kind)

The water knot is used for joining ropes or webbing. It is fairly easy to
untie, even after being loaded, but if it
is not carefully tightened before use, it
is particularly prone to slipping, especially
when wet. The water knot is illustrated
using webbing, in figure 3.9.

![Figure 3.9 Water knot.]

6) Grapevine Knot (barrel knot)

Like the water knot, the grapevine knot
is used for joining ropes or webbing. It
is completely immune to slipping, however,
and, in fact, is usually considered permanent.
It is, therefore, very useful for making
slings and runners and it outside need not
be tied off. It is shown in figure 3.10.

![Diagram of a knot](image)

**Figure 3.10. Guanakin knot.**

7) Prusik Knot

The prusik is a ratchet knot: when pulled by the knot, it slides; when pulled by the loop, it locks. It is useful in belaying and ascending systems, and also for belay backups in certain situations. The thinner the prusik sling rope size, the better the knot works, with 6 mm being about the maximum practical size of nylon for use on 11 mm nylon rope. Of course, thinner rope means a weaker system. Many cavers have found, however, that 7/16 inch polypropylene holds well on 11 mm rope and is very strong. The knot is illustrated...
in figure 3.11.

1. (Cath Paw)

2.

Figure 3.11. Prawik knot.

8) Headless Knot

The headless knot is a prusik substitute for use with webbing. It is used when a strong knot is necessary, such as in a bitter hauling system, but polyprop is not available. Although the headless has great holding power and works with one-inch webbing on 11 mm rope, it is directional and jams more easily than the prusik. It is illustrated in figure 3.12.
9) Tautline Hitch

The tautline hitch is a retold knot similar to the prusik, but tied with an end rather than a loop of rope. Although useful in anchorage (see section III D3) the tautline hitch should not be used as a major load-carrying component in a rope system. It's adjustable and excellent for tent lines, tying equipment to pack frames and can-top carriers and for tying patients in stretchers. The tautline hitch is illustrated in figure 3.13. Note that it is directional.
C) SEAT HARNESS

The seat harness is a critical item of personal equipment, and before selecting one, the mountain rescuer should carefully consider his options. Although the final decision will depend on very personal considerations, several points should be kept in mind when choosing a seat.

First, of course, the seat must be safe. This means that it must be strong enough not to break in a fall and that it must effectively transfer the load to some reasonably durable portion of the individual's anatomy. The waist and the male genitalia do not fall into that category; consequently, the traditional swami belt and the venerable
Swiss seat are unacceptable. A second difficulty with the Swiss seat is that it is fairly easy to end up hanging by one knee from the seat, or even to fall out of it entirely. The Swiss belt severely impairs breathing and inevitably causes asphyxiation within a few minutes. A good seat will rely on a pair of leg loops to transfer most of the load to the legs and will use waist loops mainly for stability.

Another design feature considered important by many is that the seat should not fail completely if it is cut. The "ASRC Seat" was designed with the aim that it would not fail completely even if cut in two places.

A second major consideration in selecting a seat harness is that it must be comfortable both to wear and to hang from. Wide webbing is greatly advantageous in this respect, although many people consider one inch webbing to be adequate for most work. The seat should fit snugly enough not to
fall down around the wearer's knees, but should be loose enough not to restrict motion or impede circulation. It should also be convenient to put on and take off.

The UIAA requires that, for approval, a climbing harness must automatically support an unconscious climber in an upright position. Without the addition of a chest harness, no seat harness will meet this requirement, but in recent work it is neither necessary nor particularly desirable. Nevertheless, the seat should be designed in such a way that the wearer can easily get himself and keep himself in an upright position. Occasionally, however, he will want to voluntarily invert, and that maneuver is impossible when wearing a chest harness.

1) Commercial Seat Harnesses

The commercial seat harnesses supplied by reputable manufacturers are all quite
safe and effective. Research and experience both indicate that sewn seams and joints are very strong and that the buckles used do not slip under load. The main disadvantages of commercial seats are their expense and considerable bulk.

2) The ASRC Seat

The ASRC seat is a tried webbing harness with the virtue that it may be cut in any two places without failing completely. The seat is made from about five meters (more or less, depending on the size of the user and the number of waist wraps desired) of one inch tubular webbing.

The seat is prepared as shown in figure 3.14 and is worn as shown in figure 3.15.

For rappelling and tying in to a litter, a locking carabiner may be clipped around all the waist loops and the short section between the leg loops. When tying in to the end of a rope, tie the rope directly to the harness with a small bowline; do not tie in to the carabiner or else loading may result (cf. fig. 2.8).
Figure 3.14. Construction of the ASRE Seat

Figure 3.15. Use of the ASRE Seat
3) A Simple Tied Seat

A simple, but quite effective, tied seat can be made from a single piece of one inch (or larger) tubular webbing about five metres long and tied as shown in Figure 3.10. This seat is as comfortable and strong as one made from one inch webbing, can be, but unlike the DSR seat, it does not enjoy the virtue of holding its shape up after having been cut. Still, it has the advantages of simplicity, easy adjustability, and the fact that when the webbing is not in use as a seat it is available for other purposes.

![Figure 3.10. Simple tied seat hanger.](image-url)
The locking cambrake is for rappelling, tying in to a ladder and similar uses; it is not for tying in to the end of a rope. When tying in to a rope, use a small bowline around both horizontal sections of the seat. This will preclude the danger of cross-loading the locker in a fall (cf. fig. 2.8).

D) ANCHORAGE

The setting of strong and reliable anchors is a complex and subtle art which cannot be fully treated in this manual. All mountain rescue personnel should have, however, an understanding of the fundamental principles of anchorage, and should be able to competently rig the anchors discussed here.

Any anchor must be strong enough to withstand the load anticipated for it, and it must be reliable enough that minor disturbances, such as load variation, will not cause it to fail. The object being anchored to must be sound and secure; all materials must be in good condition; the anchor must be properly designed, and
knot must be properly tied and carabiner properly positioned. Finally, the anchor must be properly used and frequently checked.

Selecting a solid object to anchor to is almost invariably the most difficult and uncertain part of setting an anchor. Boulder and rock outcroppings may seem obvious candidates for bombproof anchors, but they are often fraught with subtle instabilities detectable only to experienced eyes. When the rock is solid, and the boulder heavy and well-planted, rock anchors are very strong, but still, rock is abrasive and hard on rope. Sharp edges (even dull edges!) can and do cut ropes, usually just when they are needed most. Such situations are to be avoided, of course, but when the rope must run over surfaces that can damage it, the rope should be padded with whatever is available. Rubber or cloth work nicely, or so articles of clothing, blanket and pieces of asphalt. Swatches of canvas or carpeting are ideal.
Trees, when they are available, are often preferable to rocks as anchorages sites, mainly because it is easier to pick a solid tree than a solid rock. Nevertheless, trees used for anchorages must be selected with care. Ideally, the tree should be healthy, well-rooted and more than about 10 cm in diameter — larger if the anchor is placed more than half a meter off the ground. Good judgment will allow for some flexibility in these principles, but one should think twice about dead trees, and be wary of the proverbial "tree rooted in solid rock." Frequently, such a tree is barely rooted at all. Conifers often will secrete sap which is difficult to remove from equipment. Given a choice, take the deciduous tree over the conifer.

Inevitably, the mountain rescuer will sometimes be faced with a situation in which the need for an anchor cannot be escaped and yet non-bombproof placement
can be found. It is vastly tempting at the moment of crisis to make do with an inferior anchor, comforting oneself with the illusion of safety. But gravity cannot be deluded; neither does it forgive mistakes. If you need an anchor, you need an anchor; nothing less will do. The author's purpose is to forcibly thwart the will of gravity, not to persuade you to do something you would not do otherwise. As the old climbers used to say, "Beware the psychological pitfall."

When no bomb-proof placement is at hand, one must be constructed, sometimes elaborately, by backing up available sites, linking together weak sites, or running long extensions to distant, but solid, sites further uphill. However, the anchor is constructed, the finished product must be assessed rationally and objectively. Wishful thinking will not hold an inferior anchor together.

1) Runners

A runner is a piece of rope or webbing (usually manila) tied in a loop with a water knot or grapevine
knot. A runner long enough to fall to the waist when slung across the shoulder is called a single length runner; one twice that long is called a double length runner, and so forth. Very short runners are sometimes called "hero loops."

The simplest application of a runner is simply to hang it over a rock outcropping and clip on a carabiner (see figure 3.17). Made with new one-inch tubular webbing such an anchor has a strength of nearly 2000 kg if the angle is small. The strength drops rapidly as increases: for , the strength is 71% of that for , for 120°, it is only 50%. The strength

Figure 3.17. Runner
will also be degraded by sharp edges on the rock which could cut or abrade the runner. This kind of anchor is unreliable if upward pulls can occur.

To use the runner on an object (such as a tree) which cannot have things hung over it, two schemes are used: the girth hitch and the doubled runner (see figure 3.18).

![Girth Hitch and Doubled Runner](image)

The doubled runner is approximately twice as strong as a single runner, but may be unreliable if it can slip up or down or if the carabiners can become over-loaded.
The girth hitch has the advantage of being very reliable but it is not as strong as the doubled runner, although it is fully as strong as a single runner with $\theta = 0$. When made with 11mm rope, the girth hitch is a superior anchor.

The best knots for tying in to a cableliner are the bowline and the figure-8 loop.

2) Tree wrap anchors

The end of a rope can easily be tied around a tree using a bowline or a bowline-in-a-coil, but a stronger anchor can be made by using a tree wrap as shown in figure 3.19. This anchor is nearly 100%...

![Diagram of tree wrap anchor]

Figure 3.19. Tree wrap anchor.
efficient since all the tension in the rope is taken up by friction around the tree and there are no loose, small radium bands. An added advantage is that the tree wrap can be rigged or de-rigged while the rope is taut (e.g., when rigging a tyrolean traverse).

On occasions when the tail is too long to conveniently tie a tautline hitch, or when the center of the rope is to be anchored, the rope can be wrapped double and tied off with two half hitches, the loop being clipped to the standing parts with a carabiner (see figure 3.20).

Figure 3.20. Tree wrap anchor in the middle of a rope.
IV. BELAYING

In mountaineering, rock climbing, and caveing, the terms "belay" and "belaying" are usually used only to denote the technique of using a rope to protect a climber in the event of a fall. In mountain rescue, however, the terms take on a somewhat broader meaning, referring not only to protection but also to the use of the rope in aiding the latter team to ascend or descend steep slopes safely and smoothly. The simpler breaking and hauling systems used in mountain rescue belays are described in Chapter II. This chapter discusses the techniques employed by the belayer in managing the belay rope and supporting heavy loads, and it also treats the procedures followed in using any type of belay. The complete set of belaying a climber is more subtle and complex than the treatment here resolves, however, and the references cited in Chapter I should be consulted for more complete information on that subject.
It is very important in setting up and using a belay that the mountain rescue view it as an integrated system consisting of many individual components, each of which must function properly and in concert with the rest of the system. I'm thinking of this as relatively easy to do since the systems are simple and usually involve only two people. In mountain rescue, however, the belay system will usually include several people with specific functions, and these people must work together smoothly if the belay is to be effective. Not only must the mechanical parts of the system be bombproof, but the sense of teamwork among the members of the rope team must be equally as rugged. This chapter concentrates on individual skills, but it should be borne in mind that the procedures and techniques treated are often used in the larger contexts discussed in subsequent chapters.

Belay systems are typically not highly redundant: the failure of any one of several vital components will precipitate a
catastrophic failure of the entire system. Consequently, sound materials, sound technique, sound judgement, and close attention to detail are all essential to the operation of a safe belay. Although exceptional circumstances will frequently call for extraordinary procedures, the use of the standardized techniques and procedures described in this manual will help to minimize errors and enhance teamwork.

A) THE BELAY STANCE

When choosing and establishing his belay stance, the belayer's primary consideration is that tension in the rope must not pull him off balance or out of position. Mechanical brakes and belay devices present few problems in this regard since the belayer himself is not subject to the forces in the belay system. But frequently circumstances call for the simplicity and superior control of the traditional hip belay, a method which is considerably less secure than using mechanical aids. In any
case, once an appropriate method has been chosen, the following three points should be considered to guarantee the belayer's security:

1) Aiming insecure: that tension on the rope will come from a single known direction, allowing the belayer to be prepared for it. Belays must always be aimed. If the belay does not have a naturally well-defined aim, an anchor must be placed to provide one.

2) If the belayer will hold considerable force himself, he must be tied in securely. Tie-ins are nearly always necessary for belaying climbers, and certainly when the belayer is in an exposed position, but tie-ins are seldom necessary when using tree wrap belay or mechanical brakes. In doubtful circumstances, of course, a tie-in should always be used. It should be as short as possible to minimize problems with stretching and it should be directly in
line with the aim (see figure 4.1).

3) The stance itself should be chosen carefully. Good footing is important in both seated and standing belays. A small hollow to sit in, or a stomp on rock to sit behind will substantially increase the security of a seated belay. Since the belayer may be in position for a long time, a reasonably comfortable stance should be chosen. The belay stance should not be placed in a precarious position in order to get a view of the climber on better terms; this is not necessary. If voice communication is a problem, someone can be suitably placed to relay calls — by radio, if necessary. The belayer should directly face the aim. The rope passes across the belayer's hips (not his waist or thighs) above the tie-in if the aim is below the belayer, or below the tie-in if the aim is above the belayer.

\[\text{Insert from page 4}\]
B) TECHNIQUE

The belay is function in the belay system is to control the tension and length of rope in the system, to brake the descending litter and to hold the rope during a fall. The use of mechanical brakes is treated in section II - this section is devoted mainly to the chip belay, since it is the prototype of other methods such as the Münter hitch or the belay plate.

When the belay is employed strictly for protection, there should be no slack in the system, but there should be no tension either. When the belay is used for leading
or braking, the tension will, of course, depend upon the weight of the load, the angle of the terrain and the strenuous friction in the system. It can range from nearly zero to as much as 600 kg continuously with peak loads instantaneously above 2000 kg.

The belayer must be quite attentive and sensitive to the changing demands of the load in order to run a smooth belay.

The loads mentioned above cannot be borne directly by the belayer, of course, but are offered to indicate the magnitude and type of force the system itself must be capable of holding. Even after modification by tree wraps or friction devices, however, the continuous loads applied directly to the belayer can run as high as 100 kg, and instantaneous loads due to falls can exceed 1000 kg. Since the forces exerted on the belayer during a fall are so large, and since falls often occur suddenly and without warning, it is very important that manipulation of the rope not
interfere with the belayer's constant readiness to catch a fall. Leather-palmed gloves or mittens are essentially both to protect the belayer's hands and to provide friction on the rope.

The belayer's two hands are identified as the "feeling hand," which holds the rope going to the load and senses the tension of the belay, and the "breaking hand," which holds the rope going to the stock and, in conjunction with friction around the belayer's hips or through a mechanical device, provide the breaking force to hold a loaded rope.

To prevent the breaking hands being pulled around behind the belayer's back, he keeps his elbows close to his body and does not allow them to pass behind his hips. *

While the belay is on, the breaking hand must never leave the rope. This principle

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* When practicing, the student of belaying might imagine that he is inside a narrow box with one wall at his back and two others separated just widely enough to accommodate his shoulders.
cannot be overemphasized. With the breaking hand off the rope, the belayer is essentially non-existent; the rope moves too quickly and too forcefully during a fall for one to even hope to regrasp it. The maneuvers described below are designed to provide the belayer with full control over the rope while never relaxing his breaking hand or relaxing his vigilance for falls. They should be mastered with either hand as breaking hand.

1) Catching a fall. Whenever the rope is heavily loaded (as during a fall), the breaking hand quickly moves under the opposite thigh so as to maximize the amount of rope friction around the belayer’s hips. Hang on!

2) Up-rope. The maneuver used to decrease the length of rope in the system is called “up-rope.” It is carried out in three distinct steps, each of which is executed on one foot.
of a smooth diatonic rhythm. * The steps are illustrated and described in figure 4.2. The kicking hand may be thrust between the legs into the fall position at any time during the procedure. The kicking hand never leaves the rope.

![Diagram of rope jumping steps]

**Figure 4.2. Up-ropes.**

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* When learning to up-ropes, counting out loud, "one, two, three; one, two, three," or singing a waltz helps to maintain a good rhythm.
3) Slack. The belaying maneuver used to increase the length of rope in the system is called "slack." The tension in the belay is usually enough that the belayer can simply pay out rope without removing either knot, or center the reticule which has been used to draw rope into the system. However, the belayer never forces a climber to pull his own slack; the climber has enough of a problem overcoming friction in the rest of the system without having to pull rope around the belayer too. When a climber or belayer calls for slack and it is not clear how much he wants, the belayer slackens about one meter. If more is needed, it will be requested.

C) BELAY DEVICES

The principal advantage of the hip belay is its inherent simplicity -- a great virtue -- but...

* Note that when belaying a climber, the call for slack is "Slack," but when lowering a ladder the call is either "Down Slow" or "Down Fast." See IV - D - 2.
occasions will frequently arise when simplicity is not sufficient. When the belay load is greater than the belayer's strength, or the stance is unavoidably precarious, artificial belay devices make possible a safe and effective, if more complex, belay.

1) The Münster Hitch. Figure 4.3 shows a method of tying the belay line to a carabiner which can be securely anchored independently of the belayer himself. The knot is called a Münster Hitch. With no tension on the

Figure 4.3 a. Tying a Münster Hitch.

braking hand, the feeling hand can pull slowly through the belay fairly easily, but in a fall,
the breaking hand puts tension on the rope
by pulling forward as in figure 4.3, tightening the hitch.

1. Fall configuration
2. Up-roped configuration

Figure 4.3b. Using the Müntin hitch.

During up-roping, the feeling hand
relieves tension on the hitch and the
breaking hand pulls forward (against the
anchor) to draw rope through the bine.
As shown in figure 4.3, this causes the
hitch to invert. If a fall should occur,
the knot will reverse and the breaking hand
is in position to tighten the hitch and
catch the fall.

The Müntin hitch technique is easy to
master, requires no special equipment and
is effective enough to have been designated the
standard belay techniques of the UIAA.

2) The Belay Plate. Belay plates, such as the Stretched-Slewed Belay plate and the MSR chain links enjoy considerable popularity among climbers and canoes, mainly because they work more smoothly than the Munter Hitch and require less effort to move the rope. However, an item of special equipment is required which must be readily available when needed.

The belay plate is illustrated in figure 4.4. Up-rake and slack are

Figure 4.4. The Belay Plate
easily accomplished in the usual way. In a fall the rope snaps into a straight line and draws the plate and biner tightly together. This provides enough friction to support a hard fall.

The main difficulty with the baby plate is that it tends to either sway away from the biner or lodge too closely for easy up-roping and climbing. The first problem is solved by the use of a short cord to keep the plate close to the biner. Some models solve the second problem with a large spring which properly spaces the plate and the biner when there is no tension and which compresses under load.

D) PROCEDURES AND CALLS

If the belayer is to be responsive to the needs of the climber or litter captain, fast, accurate, and succinct communication between them is imperative. Under the difficult conditions which prevail in the
field, this communication is provided by a set of standard shouted signals or "calls." These calls are part of a rigid procedural framework which is designed to ensure that both the belayer and the climber or little captain always know the status of the belayer. Since this communication is entirely aural, noise and confusion are a direct threat to the success of the operation and to the safety of the rescuer and the patient. Unnecessary noise in the vicinity of a belay is therefore intolerable. When there is difficulty in hearing calls, a rescuer should be placed as a relay.

A glossary of belaying calls with their associated procedural contexts is given below. Underlining indicates that, when heard, the call should be repeated back, or "echoed," as an acknowledgment. Note that most calls occur in pairs: a statement and a response, or in the case of verification calls, a call from each end of the belay indicating
its status. The only exceptions are READY SWITCH, ROCK and FALLING, which require not answers but immediate action.

BELAYING CALLS

1) Readiness Calls,
   a) ON BELAY is given by the climber on litter captain; It indicates his readiness to the belayer; it is not a question.

   b) BELAY ON is given by the belayer to indicate his readiness to the climber on litter captain; it is not a question.

The belay is not operational until both (a) and (b) have been called. However, the belayer assumes the belay to be operational from his call of BELAY ON. The calls may be given in either order depending upon who is ready first.

   c) OFF BELAY is given by the climber or litter captain when the belay
is no longer required.

d) Belay Off is the belayer's acknowledgement of OFF BELAY.

The belay is not terminated until both (c) and (d) have been called. The belayer may withhold BELAY OFF until he is satisfied that the climber or litter is indeed secure.

2) Procedural Calls.

a) CLIMBING is used by the climber to indicate that he is about to begin moving. It is redundant, but very useful nevertheless. It is not used by the litter captain.

b) CLIMB AWAY is the belayer's acknowledgement of CLIMBING.

c) UP ROPE is used by the climber or litter captain to indicate that there is unwanted slack in the
belay. It is also used by the litter captain in place of CLIMBING or to request tension on a haul line.

d) SLACK is used by the climber or litter captain to request slack in the belay. If it is not clear to the belayer how much slack is needed, he gives about a meter. The climber or litter captain can always request more if he needs it.

e) TENSION is a climber's request for a rope assist. It is usually not considered sporting in recreational climbing, and in practice the mountain rescuer should not get in the habit of counting on it.

f) PRELOAD is given by the litter captain just before loading the rope before beginning a technical descent. The belayer stops the rope and the
litter team needs it to get the stretch out before beginning their descent.

g) **Down slow** is the litter captain's request for a slow descent.

h) **Down fast** is the litter captain's request for a fast descent. "Slow" and "fast" in this context are relative to the terrain.

i) **Stop** is the litter captain's request for a stop. It is also used by the belayer to indicate that he is stopping the descent because he is out of rope.

j) **Ready, switch** is used by the belayer in the "Brute Force Hauling System" to reverse the high and low groups of the haul team.
3) Warning Calls
   a) ROCK: Something is falling! Shield the patient! Take cover!

   b) FALLING: Catch me! Used by the climber or litter captain whenever appropriate. The belayer must not count on hearing this call before a fall.

   c) HALF WAY is used by the belayer to warn that half the rope has been used up.

   d) TWO-0H is used by the belayer to indicate that not much rope is left in the system and the next available belay site should be taken. This call derives from the old mountaineering signal which originally meant "20 feet of rope left," but in rescue work, "not much rope" is a relative quantity which depends upon terrain and the
availability of good being stance.
In straightforward circumstances,
10 meters is a good rule of thumb.
V. LITTER BEARING

Moving a litter patient over mountain terrain requires extraordinary teamwork and several special techniques. This chapter and the one which follows deal with the special techniques that litter bearing in rough terrain requires. This chapter covers general principles and terrain not requiring the use of ropes -- non-technical terrain -- while chapter VI covers the techniques of moving litter on terrain steep enough to require a rope -- semi-technical terrain. Vertical evacuation techniques are beyond the present scope of this manual. The interested reader should consult the references listed in chapter VI.

Although several different kinds of litters can be used in mountain rescue, the single most popular and versatile is the Stokes Basket Stretch*, and all of the techniques treated here assume the Stokes is being used. Nevertheless, of necessity, the

* The Stokes Basket is described in section VI-B.
mountain rescuer will occasionally find himself using other stretcher types, and he should therefore be familiar with their peculiarities. The two other types most frequently encountered are the Army (or D-Ring) Stretcher and the Neils-Robertson Stretcher. Most of the techniques used on the Stokes are easily applied to other types, but practice with the other types is necessary to enhance teamwork and keep the patients ride smooth and secure.

The importance of teamwork cannot be overstated. A rapid, smooth, secure ride directly affects the patient's progress, but speed and smoothness cannot be achieved unless all members of the team work together skillfully and conscientiously.

Rigging the Army Stretcher for semi-technical use is described in section III-B.
A) THE LITTER TEAM

The basic litter team consists of six litter bearers, three on a side. On steep, semi-technical terrain, however, only four litter bearers need be used, and only three should be used when hauling the litter uphill. (These situations are described in chapter III). The positions on the litter are denoted by "right front," "left middle," etc. where "front" means in the direction of travel and does not refer to the orientation of the patient.

The leader of the litter team is the litter captain, who is whichever litter bearer is in the left front ("driver's seat") position. As litter bearers rotate and the direction of travel changes, any litter bearer might be called upon to become litter captain.

At his discretion, the Medic may or may not serve as a litter bearer. In general, however, he will want to be free to attend the patient, manage medical
equipment, and keep records.

A "seventh man" at one end of the litter is frequently helpful.

Additional team members should

assemble themselves ahead of the litter, 

ready to rotate in. They should

occupy themselves cleaning trail (as 
necessary) carrying excess equipment 

and resting for the exhausting work of 

carrying the litter. When these

additional litter bearers are 

included, the smallest complete team 

consists of nine people. This number 
is adequate to execute all non-technical 

and semi-technical even techniques.

In general, however, fifteen litter bearers 
is not too few.

2) LITTER HANDLING

The requirement of a smooth ride for the 

patient demands that the mechanics of litter 

handling be standardized and thoroughly practiced.
1) Lifting:
   a) The litter bearers arrange themselves two at the patient's head, two at his waist and two at his knees. It helps to evenly distribute the load if each pain is matched in height. Each litter bearer kneels on one knee as close to the basket as possible, facing in with both hands on the wall.

b) The litter captain surveys the team and says, "Ready, (pause) Lift." Litter bearers must firmly should indicate so during the pause. Counting ("one, two, three, Lift") is unnecessary and is not used.

c) Litter bearers lift the litter, keeping their backs straight and pulling out rather than up. This technique not only promotes smoothness in the maneuver, it helps prevent strained backs. The litter bearer keeps his butt down and raises with his legs rather than his back muscles.
d) Once up, all litter bearers must strive to maintain a slight back-up attitude on the litter.

2) Moving the litter

a) Litter carriers: "Forward."

b) Litter bearers walk out of step, keeping their arms bent. Once in motion, each litter bearer need keep only one hand on the rail. A distant from 5.5 feet.

c) A smooth ride is essential. The litter must be kept level on land up.

d) Forward litter bearers call out obstacles on their sides (e.g., "Rock on the right.")

e) Much of the strain of carrying a litter can be relieved through the use of load straps, as shown in figure 5.1. Load straps.
give a rouging ride to the patient, however, and should be used only when the medic judges that the increase in litter bearer efficiency

![Figure 5.1. Litter Straps](image)

is worth the cost of a rougher ride. The strap is run across the shoulders and is held by the straight outside arm. Litter straps must not be tied to the litter bearer.

3) To stop, the litter bearer calls, "Stop."

4) Lowering

   a) The litter bearer faces in, both hooks on the rail.
b) The litter captain checks under the litter for projections which might hurt the patient.

c) Litter captain: "Ready, (pane) down." The litter is lowered using the reverse of the lifting technique.

d) Once down, the litter must be propped into a comfortable attitude for the patient.

c) NON-TECHNICAL EVACUATIONS

Non-technical terrain is level enough or smooth enough that a belay is not necessary. On non-technical terrain, a falling litter bearer poses no threat to the safety of the patient, the rest of the litter team, or to himself.

1) Rotation

During long evacs, litter bearers may be relieved by the procedure of
rotation, described in figures 5.2 through 5.5. As was mentioned above, team members not actually carrying the litter should walk ahead of the litter. The two closest to the litter are designated relief bearers and should not get more than about ten meters ahead of the litter. When the litter captain (LC) decides a rotation is in order, he initiates the procedure described below. The two relief bearers are rotated in and the litter captain and right front bearer are rotated out. The process is repeated as necessary to keep the litter team reasonably fresh. The entire procedure is carried out with the litter in motion.

[Diagram of rotation process]

Figure 5.2. Litter Captain (LC): "Ready to rotate." Relief bearers stand off the trail.
Figure 5.3. The litter piece between the relief bearers.

Figure 5.4. The relief bearers group to basket at the rear. At this point the left rear (LR) one of the relief bearers calls, "Rotate," the only time someone other than the litter captain gives a command. The basket is passed back and the two front bearers peel off.

Figure 5.5. The new relief bearers cross the trail and move off forward. When they rotate both in they will have exchanged sides on the litter.
2) **Laddering**

Laddering is a procedure for carrying the litter over (or through) obstacles which cannot simply be stepped over. It is described in figures 5.6 through 5.12. An important principle is that while laddering we are supporting the litter with our feet.

![Obstacle Diagram](image)

**Figure 5.6.** The litter is brought as close to the obstacle as possible before the litter captain calls, "Stop. Ready to ladder." The middle bearers reach back to accept the rear load. They do not step back.

![Ladder Diagram](image)

**Figure 5.7.** The two rear bearers peel off and go to the front of the litter. Note that there is now a new litter captain. The new litter captain calls "Ladder" and the basket is passed forward.
Figure 5.8. Again, the latter captain calls, "Ready to lode,", and the rear below peel off.

Figure 5.9. The rear kapers proceed to the front, the rear latter capture calls "Huddle," and the basket is pressed forward.

Figure 5.10. "Ready to lode." Peel off.

Figure 5.11. "Lodge." Peel basket forward.
Figure 5.12. The litter captain calls "Forward," and the litter is again underway. The procedure may be repeated as many times as is necessary, of course, to cross a wider obstacle than the one shown in the figures.

3) Toesailing

A variation on the laddering technique useful for climbing short steep pitches is "toesailing." The head end of the litter is in the slope while the rear litter bearers move up. The procedure is illustrated in figures 5.13 through 5.15.
Figure 5.13. "Ready to ladder." Rear beacon peal off.

Figure 5.14. "Ladder." Pose the latter up. Don't jerk!

Figure 5.15. The process is repeated as many times as is necessary.
VI. SEMI-TECHNICAL EVACUATIONS

Semi-technical terrain is rugged enough or steep enough that it is difficult or dangerous to move the litter without a belay, but not so steep or exposed that individual rescuers need be belayed. In descending, the belay might more strictly be termed a braking system since it is used to control the descent of the litter, and in ascending, the belay sometimes takes the form of a rudimentary hauling system. Nevertheless, the term “belay” persists where it is not confusing.

A) THE EVAC TEAM

In semi-technical terrain, the standard evac team comprises nine members, usually arranged as a litter team of six and a rope team of three. On steep slopes, however, when much of the weight of the litter is supported by the rope, some variations are used.
Descending, only four are needed on the bucket, and reducing the team to this size gives a lighter load on the delay and also better visibility for the litter bearers. The two extra team members can be well employed carrying equipment (which is particularly annoying on steep slopes). Ascending, using the "Brute Force Hauling System" (described in VI-C-5), the litter can be managed by only three, with the other six on the rope team. When the angle is steep enough that a reduced litter team can be used, the litter bearers tie in to the bucket.

Extra rescuers should be deployed well off the fall line of the litter so as to avoid kicking rocks onto the litter team or catching the rocks inevitably knocked loose by the litter team.

It possible the Rescue Specialist should avoid litter bearing and rope hauling duties and concentrate instead on planning the route and directing the work.
B) LITTER RIGGING

The Stokes Basket Stretcher is ideally ideal for most mountain rescue applications. It is strong, stiff, reasonably lightweight and provides excellent stability and protection for the patient. The even techniques described in this chapter have been designed with the Stokes basket in mind, but they are easily adaptable to other types of litters. In particular, a short description of rigging adaptations for the Army stretcher is included in section II-B-4.

The Stokes litter is illustrated in figure 6.1 along with its rigging.

1) The Yoke

The yoke is a loop of 11mm rope permanently attached to the head rail of the litter with rope as shown to minimize slippage of the butt wood. The yoke used is a locking type and should never be removed. For
storage and transportation, the gokh lines may be clipped to a sturt.

The belay rope is clipped to the gokh lines with a figure-8 loop.

2) Patient Tie-Ins

There are three patient tie-ins permanently attached to the sturt: two for the patient's body, and one for his feet. All are of 9/16, 3/4, or 1 inch tubular webbing, 5 meters long, and tied to the knee sturt with one knott loops, one on one side and two on the other. For storage and
transportation, they may be run to the
forward strut and back a few times
and tied off with half hitches. They
are also very useful for securing
equipment in the litter.

Figure 6.2 illustrates the basic
patient tie-in scheme. Each tie-in starts
at the knee strut, passes directly across to
the opposite strut, diagonally up to the
next strut, straight across to the opposite
side and so forth. The patient is then
"laced" securely into the basket. The
tie-in ends are tied to the head strut
with half-hitch knots so that they can
be easily adjusted. To avoid abrasion
of the webbing, tie-ins are never run over
the litter rail, but always to the struts
instead.

A detail of the foot tie-in scheme
is shown in Figure 6.3. The tie-in
begins at the knee rail, crosses diagonally over
the shin and under the opposite foot. It then
ascends to the knee rail and repeats for the
other foot. The tie-in then proceeds directly down to the foot strap, across both ankles, but passing under the leg divider, and finally draws off at the ankle strap with a tautline hitch.

In actual practice, of course, this basic patient packaging scheme will be

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**Figure 6.2. Patient Packaging**

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**Figure 6.3. Detail of Foot Tie-in**
varied to suit the patient's injuries. For example, crutch straps made from well polished cotton may be used to prevent a patient with leg injuries from sliding down in the basket.

3) Litter Beamer Tie-In

A litter beamer tie-in is an item of personal equipment that we should stock. It is a 6mm rope loop approximately 50 cm long. When snapped between a litter strut and the litter beamer's seat harness, it supports the litter beamer's weight on steep slopes. See figure 6.4. The tie-in can be shortened by doubling one or both strands. If a carabiner is not available, the tie-in can be girth hitched to the litter.

Figure 6.4. Litter Beamer Tie-In.
4) Army Stretch Riggimg

Although it is not nearly as good as the Stokes basket, the Army (D-Ring) Stretchr may be effectively used for semi-technical rescue. Riggimg is illustrated in figures 6.5 and 6.6.

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Figure 6.5. Army Stretch Riggimg

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Figure 6.6. Detail of Riggimg
The patient tie-ins are made from 15 meters (each) of 7/16, 3/4, or 1 inch tubular webbing. The center of each piece is tied to the hinge of the stretcher with a cloth paw and then each half is tied to a stretcher handle with a clove hitch. This arrangement prevents the stretcher from accidentally collapsing. It must be tight to be effective.

Instead of using a yoke, the Korea rope is tied directly to the head and of the litter with a bowline. The loop of the bowline passes through two D-rings (which keep the load), and quick hitches are placed around the handles for stability. Of course, if the litter is to be left permanently rigged, a yoke could be attached in the same fashion, but such an arrangement would be somewhat cumbersome for storage and non-technical use.

The patient is secured to the stretcher as shown in figure 6.7. Usually there
Figure 6.7. Patient Packaging with Air Army Stretcher will be considerable excess foot tie-in. The reason the foot tie-in is made so long is that by making the two ends of the litter symmetrical there is no danger of loading the patient backwards. Also, plenty of webbing is available if the patient's injuries demand modification of the tie-in scheme.
C) BELAYS

Belay methods for semi-technical areas fall into three categories:

a) Tree-wrap belays, which are used both to protect the ascending belayer to break the descending belitter.

b) Mechanical brakes, which are used on descents too steep for tree wraps to provide adequate protection, or when no trees are available.

c) The Brut Force Handling System, which is on aid used for steep descents.

Because of their low stretch, high strength, and excellent handling characteristics, 11mm Bluewater or PM1 carving rope is preferred for belayer belaying, but Goldline or kernmantle climbing ropes are also useful.

1) The Tree-Wrap Belay

Sufficient friction for most routes can be had by belaying to a tree, as illustrated in figure 6.8, but if the belayer feels the need for a tie-in, the
Tree-wrap should be abandoned in favor of a mechanical belay. The tree must meet all the requirements for an anchor, but in addition, the belayer should select as large a tree as possible, since larger trees will give him better control. A tree diameter of 35 to 50 cm is probably ideal. Also, hardwoods are to be preferred over conifers, since conifers secrete sap that is very difficult to clean off the rope.

Figure 6.8 illustrates tree-wrap belay configurations for an ascending litter; in a descent, the rope handler (RH) is employed.
elsewhere. His purpose on the ascent is to relieve rope friction around the tree as the belayer (B) supplies up-rope. On the descent, this function is unnecessary since the system is under constant tension and the belayer only slides, using the tree to provide braking friction.

The belayer assumes a standing big-knee stance about 1 1/2 metres from the tree, and keeps the rope as close to the ground as possible. In a fall, if the belayer is in the basic stance, he will sometimes find that he must move rapidly (that is, dive desperately) into the maximum friction stance. Placing himself a metre and a half from the tree gives him enough rope that he will not be pulled into the tree before he gets enough friction to stop the fall, but also keeps reasonably small the distance he must move to get to the maximum friction stance.

The rope is kept low on the tree so simply to make it easier for the belayer to step across.

In the basic stance, the rope handler positions himself a metre or so below the tree.
and provides the force to pull the rope uphill. He must also keep the rope around the tree just slack enough that the belayer can up rope easily, but no more. When the litter team can move up the slope rapidly, the rope handler feeds rope at the belayer's maximum up-rope rate, but no faster: it is up to the litter captain not to overrun the belay. The rope handler must watch both the litter and the belayer since it is he who controls the rate of ascent. He must pull rope as fast as the litter needs it pulled, but no faster than the belayer can up rope.

In a fall, the rope handler must get out of the belayer's way in case he needs to go to the maximum friction stance. The reason the rope handler stays close enough to the tree that he would be in the belayer's way is simply that if he gets too far below the tree he cannot effectively relieve friction around it.

In the maximum friction stance, the rope handler crouches on the uphill side of the tree; this
is the only effective position. It is also quite hazardous since, in a fall, his fingers could get caught between the rope and the tree. The ropehandler must therefore handle the rope carefully, keep a good bit of slack around the tree (this also helps the belayer), and stay alert for a fall. In a fall he must drop the rope immediately!

Fortunately, the maximum friction stance is rarely used anymore. Usually, when the slope is steep enough or treacherous enough, the basic stance with the potential for moving rapidly into the maximum friction stance is adequate. From the Basic Force Bending system is necessary. Nevertheless, occasions arise where the maximum friction tree-wrap belay is the best choice. It is safe if everyone respects its hazards and the ropehandler stays on his toes.

2) Mechanical Belay

During descents over treacherous terrain or over terrain on which tree-wrap belays provide inadequate
security, mechanical brakes are necessary. The standard brake for this use is the figure-8 descender riggged with a locking biner and a runner made from 9 or 11 mm rope or 1 inch tubular webbing. This rigging is illustrated in figure 6.9. The kind

![Figure 6.9: The Figure-8 Descender](image)

of anchor used will depend mainly upon what is available, but in any event, the anchor must be bombproof. The basic brake configuration of figure 6.9 is most frequently used, but on steep slopes it quite often will provide inadequate friction. The maximum friction configuration, however, is nearly always easy to use and provides enough friction
and range of control for vertical descents. Although no firm rules can be stated, it is usually advisable to reduce the litter team to four when the terrain is steep enough to warrant the maximum friction brake. For extremely steep or vertical slopes, the litter team should even be reduced to two. The idea is to keep the litter team as small (and light) as possible while still providing enough manpower to properly control the basket. As the angle increases, more of the weight of the litter is taken by the rope and fewer people are needed to control it.

The heat handling capacity of the figure-8 brakes is sufficient for most evens, but there is no great margin of safety. The belayer must constantly monitor the brake temperature with his un gloved feeling hand, and if it gets too hot to touch, slow the descent and cool the brake with snow or water. Normally, excessive heating indicates too fast a speed, and therefore can be avoided.
There are two different techniques for handling the figure-8 brake. In the more commonly used of these, the belayer adopts a hip belay stance (possibly tied in), and simply uses the brake for extra friction. Often, however, it is more convenient not to use a hip belay but to rely entirely on the friction of the figure-8. The belayer holds the rope in his hand and releases it to reduce friction or pull it toward the anchor to increase friction. This second method is particularly effective with the maximum friction brake. The decision to use a particular technique on a particular occasion depends largely on experience and, to some extent, personal preference.

In addition to the figure-8 brake, several of the brakes described in Section II-1 are useful alternatives. By far the best of these is the caring vappel rack. It is exceedingly strong and provides an unsurpassed range of control, but is heavy and somewhat complex (although skilled canoes rig racks with..
marvelous dexterity). For routine work, the rack is inferior to the figure-8, but for very steep or vertical routes of any length it is nearly ideal. One particular advantage in such circumstances is that the rack can accommodate a double rope (and even brake each independently), whereas a single figure-8 in the maximum friction configuration cannot.

The six-rover (Yosemite) brake is effective, although cumbersome, and has the advantage that it requires no special equipment. The carbine wrap brake (made with a strong bircher) is simpler and provides good control, but its best springing capacity is low and consequently it must be used with great care.

Brake bar chains should be avoided. Although they provide good control, all the force in the belay falls on a single (usually oval) carbine, which is not strong enough to be relied upon to support a ladder team.
3) EVALUATION PROCEDURES

The key to a successful event is teamwork. The procedures which have evolved for the conduct of semi-technical rescue have proved to be very successful in promoting rapid, efficient and smooth transportation of the patient, but they work properly only if the team members are individually skilled and thoroughly drilled and disciplined to follow them and to work together. Semi-tech does not require high-powered mountain climbing skills, but since it requires precise coordination among the nine team members, it is still not easy. If you want to get your patient off the mountain speedily and comfortably, you must concentrate, communicate and cooperate.

Although the Field Team Leader always retains overall responsibility for the operation of his Field Team during a semi-tech event, the Rescue Specialist assumes the leadership function bearing directly on the technical aspects of transporting the patient. He selects the mode of travel, assigns duties on the rescue team, selects appropriate equipment, and
generally supervises the ongoing operation. He must pay particular attention to matters of safety.

Even when the Rescue Specialist must supervise several rescue teams at once, there is no particular leader in charge of each team. The litter captain manages the litter team, the belayer manages the rope team, and it is up to these two -- whoever they may be at any moment -- to keep the litter moving smoothly.

1) Descent Procedure

The deployment of the rescue team for a descent is illustrated in figure 6.10. The tree-wrap belay is shown, but the same procedure is applicable when a mechanical brake is used instead.

The belayer (B) controls the rate of descent of the litter according to the request of the litter captain (L). (See section V-1 for an explanation of the calls used.) As the litter descends, the downhill ropemover (DR) counts
the route and watches for potential belay sites. The uphill ropehandler (UR) acts as “safety net” and keeps the rope clean and relays calls as necessary. When the belayer calls “Two-O,” the downhill ropehandler indicates his choice of belay site to the litter captain who then steps the litter just below it. Once the litter is down, the litter captain calls, “Off Belay,” the belayer answers, “Belay Off,” drops his belay stance and clears the rope from around the tree. Immediately, the downhill ropehandler takes up the belay at the new site and when ready calls “Belay On.” Meanwhile, the former belayer is descending to assume the uphill ropehandler position and the former uphill ropehandler has already taken up his new station as downhill ropehandler. As soon as the litter team is ready (frequently the medical will want to check the patient while the litter is off belay), the litter captain calls, “On Belay” and raises the litter. Before resuming the descent the litter captain usually calls for a final oral to stretch...
out the rope and avoid a jerky start.

The rotation procedure just described is diagrammed in figure 6.11. A useful mnemonic is "roll downhill." If the three rope team positions are visualized,

![Descent Rotation Diagram]

Figure 6.11. Descent Rotation.

the belayer in highest, the uphill rope holder in the middle, and the downhill rope holder in lowest. During the rotation, each member drops to the next lowest slot except the downhill rope holder, who rotates back to the top as belayer.

The litter may resume its descent as soon as the new belayer is ready. This
takes only a few seconds. The old belayer (now the uphill ropemaster) will have to hustle to catch the moving belay, but he should swing wide to avoid kicking rocks on those below.

If mechanical brakes are being used and member of the rope team should have his own rig. However, if only two rigs are available, the escourt can still run smoothly if the old belayer remembers to give his rig to the new downhill ropemaster during each rotation.

2) Ascent Procedure

The deployment of the escourt team for an ascent is illustrated in figure 6.12. While the latter team struggles up the hill as best it can, the belayer (B) and the downhill ropemaster (DR) work the belay. The uphill ropemaster scouts the route uphill, carrying the end of the rope with him. He should keep in mind that, since he is trailing the rope, whenever he goes, the latter must go also.
Figure 6.12. Semi-Technical Ascent.

When the litter arrives at the belay point, the litter captain (LC) calls for a stop, lowers the litter and calls, "Off Belay." The belayer answers, "Belay Off," drops his stance and clears the rope from around the tree. The uphill rope handler, meanwhile, has heard these calls (they must be loud enough for him to hear), has chosen his belay site, and now establishes a new belay. As soon as he is ready, he calls "Belay On." The litter captain, when his team is also ready, calls, "On Belay," raises the litter and starts up.
The old belayer rotates into the downhill ropehandler position, while the old downhill ropehandler rotates into the uphill ropehandler spot. The rotation scheme is diagrammed in figure 6.13. The mnemonic is "Roll uphill."

Figure 6.13. Ascent Rotation

A strong belayer can restart the ascent within a few seconds of the stop by belaying without a ropehandler. This is tiring, however, so the former belayer should heave up to the new stance to relieve tree friction as soon as he can. Nevertheless, the tree moving
up should swing wide to avoid kicking
rocks on the litter team.

If a fourth person is available to serve
on the rope team, the efficiency of the
descent procedure can be enhanced considerably.
The four rope team members form two pairs,
each consisting of a belayer and a rope handler.
As one pair belays, the other carries the
rope uphill to the next station. Using this
modification, the belayer need never be
unassisted.

3) The brute force hauling system

When the slope is too steep or unstable
for the litter team to ascend under its
own power, the litter team is reduced
to three (two at the shoulders and one at the
foot), and the hauling system shown in figure
6.14 is used to forcibly raise the litter
team up the pitch. Usually, the litter bearer
will want to tie in to the litter.

The rope team divides itself into two
groups (three per group is usually adequate), and
each member ties in to the rope with a prusik knot on his litter team tie-in.

Figure 6.14. The brute force hauling system.

The highest person on the low group is the belayer, since he can most easily judge the distance between groups and can be most easily heard by all of the rope team. The belayer exchanges the usual calls with the litter captain, the litter team lifts and pulls, and, on "Up Rope," the low group hooks prusiks and descends, hauling up the litter. After 20 or 30 metres, the belayer
calls, "Ready, Switch," and the high group holds prusiks and descends while the low group unlocks and hand-over-hand up the rope. Just before the two groups collide, the belayer calls again, "Ready, Switch," and the procedure is reversed so the high group is climbing and the low group is descending. The cycle continues until the litter captain calls "Ship." On this command, the entire rope team stops and locks prusiks until the litter is off belay. The anchors are then cleaned and the rope team moves up to the next belay site.

During the ascent, the litter team's primary concern is providing the patient a smooth ride. This usually means that the litter bear cannot assist the rope team in raising the litter, and in fact, will usually need to lean into their tucks, thus increasing the load on the belay. A six-member rope team can supply enough force to raise a litter team under these conditions, but it is prudent to put light people on the litter team and heavy ones on the rope team,
VII. SOME COMMON TECHNICAL PROCEDURES

A) THE Z HAULING SYSTEM

A 3:1 mechanical advantage can be achieved on a haul line by the use of the Z System, illustrated in Figure 7.1. The Z is very useful for raising litters, tightening Tyrolean Transaxes, and hauling equipment.

![Diagram of Z Hauling System]

Figure 7.1. The Z Hauling System

The following points should be observed when using the Z:

1) Although the system's mechanical advantage is 3:1, its efficiency is reduced considerably.
by friction of the rope running over blocks and the carabiners in the system. Using pulleys on the carabiners reduces friction substantially. Consequently, any means available for reducing friction of the rope against the rock is worth the effort. Running the rope over an idler轴 or through a freely suspended belay is a great help. These measures also protect the rope from abrasion.

2) For heavy loads (such as litters), big strength ratchet knots, such as Prusiks with 7/16 in. polyprop or drawsheet knots with 1 in. tubular webbing, must be used. Mechanical ascenders must not be used for heavy people.

3) As the rope is pulled, the distance between the two prusiks will, of course, decrease. The 2 must not be allowed to straighten, however, or the mechanical advantage will be lost. The purpose of prusik #2 is to hold the system tight while prusik #1 is slid back out for another pull. Prusik #2 must not be permitted to slip through the anchor belay.
5) Sometimes it is necessary to add hauling force to a rope which is already in tension and cannot be bent into the configuration shown in figure 7.1. In such a case, a Z system made from another rope can be added on, as shown in figure 7.2. This

![Diagram of Snap-On Z Hauling System]

configuration is sometimes called a "snap-on Z," as opposed to the configuration of figure 7.1, which is called a "conversion Z."
2) THE ZIP LINE

The Zip line is a quick method of transferring equipment (but not people) from the top of a cliff or steep slope to the bottom. A double rope is rigged from an anchor at the top to two people (or one person and another anchor) at the bottom. See figure 7.3. The equipment to be

![Diagram of Zip line]

Figure 7.3. The Zip line.

transferred is clipped to both ropes and allowed to slide down. The rescuers at the bottom can control the rate of descent of the gear by separating the rope
ends to show it, or bringing the rope ends together to let it drop more freely. It is usually necessary to let the load slide freely at first and then slow it near the bottom.

C) THE TYROLEAN TRAVERSE

A Tyrolean Traverse is a rope stretched tightly between two anchors and reaching across a difficult or dangerous obstacle such as a stream or deep ravine. The traverse is used to quickly and safely transfer people, litters and equipment across the impedance.

1) Rigging

Unless the rope can be thrown to someone already on the far side of the impedance, one person must cross in order to rig the traverse. First, however, he loops the rope around the anchor on the near side and then carries the two ends across. Once on the far side he takes an anchor, ties one rope directly to it and rig the other in a Z System, which he then uses to tighten the traverse as much as he can. An example of
a typical arrangement is shown in figure 7.4. It is highly desirable to rig the traverse to slope gently downward if possible. This makes crossing much easier.

![Diagram of a typical arrangement for a traverse](image)

**Figure 7.4. Rigging a Pyrolean Traverse.**

When the traverse is tight, package #1 is removed and the free end of the rope is tied in to the leading system anchor (or tree-wrapped to a tree) to back up package #2. Since package #1 must bear half the load of the traverse, a high-strength ratchet knot (package in 7/16 in polyprop or beaded knot in 1/2 in tube) must be used there, if the traverse will carry a litter.
The doubled rope scheme is used mainly to make the traverses retrievable once everyone is across. Single rope traverses are perfectly safe, and frequently necessary.

2) Traversing
   a) Equipment

   Equipment is simply clipped to the traverses and hauled or lowered by a tag line as shown in figure 7.5.

   ![Diagram of traversing equipment](image)

   Figure 7.5. Traversing equipment on the Tyrolean Traverse.

   b) People

   The individual rescuer clips to the traverse as shown in figure 7.6. The extra carabiner makes it easier to get on and off the traverse, and also protects the seat locker.
from overheating and melting the seat. Gloves prevent rope burns and protect the hands when they (inevitably) get pinched in the rigging.

After mounting the traverse, the rescuer calls, "On Traverse" before starting across; he calls, "Off Traverse" when he has dismounted on the far side. An etrier at each end of the traverse facilitates the somewhat awkward process of mounting and dismounting a high traverse.

*Unclad uphill traverses are always unpleasant and become impossible at surprisingly low angles. Standard practice.

*Traversing slowly is a better guarantee! Take it easy.
technique, however, is easily adapted to negotiating uphill traverses — and even makes the process bearable.

c) Litters

The litter can be clipped to the traverse using four runners, or better yet, a pair of spindles, as shown in figure 7.7. The litter is hauled across the traverse by a tag line tied to both runners and running to both ends of the traverse. Pulleys are seldom really necessary.

![Diagram of litter rigging](image)

Figure 7.7. Rigging a litter to the Tyrolean Traverse.

If the medic wishes to ride along with the litter, he clips in in the usual way.
or he may hang from one of the
litter bridges by his litter bearer
tie-in.

1) Rappelling

Rappelling is a rapid and convenient means
of using a rope to descend steep terrain.
The rope runs from an anchor at the top
of the pitch to the bottom, and the rescuer,
by one of several methods, uses the rope to
control his descent. When used cautiously
and with close attention to the details of
rigging and techniques, a rappel is quite
safe and efficient; used carelessly, it
is exceedingly dangerous.

1) Rappel Rigging

A bottom-retrievable rappel can
consist quite simply of a rope doubled and run around
a tree or other secure anchor as in figure 7.8.
A single-rope rappel (not bottom-retrievable) can
be rigged by tying the upper end of the rope
to any suitable anchor. (See figure 7.8.) In
either case, the anchor must be strong enough to withstand at least four times the weight of the user. Furthermore, the anchor must be checked frequently during use since under the intermittent stresses of rappelling, knots loosen and anchors become misadjusted. Anchors such as tree-wraps and girth-hitched runners, which are resistant to these unhealthy maladies, are, of course, preferred, but cannot always be rigged.

When the rappel is to be rigged from a fixed piton or a bolt, or when a runner and a descending ring can be sacrificed, a bottom-retrievable rappel using a single rope can
Chief spelling

be rigged using a "reefschnur," or
retaining line. The end of the rappel
rope is passed through the anchor ring and
a stopper knot, such as a figure-8, is
tied to keep it from slipping back out.
To the knot, a reefschnur made of light
rope or p-cord is tied and run down the pitch
parallel to the rappel rope. When the rappel is
no longer needed, the rescuer at the bottom
simply pull on the reefschnur to retrieve the
rope. The anchor is left behind.
In absolutely desperate circumstances, when
the rescuer must use a single-rope bottom-
retrievable rappel and he does not have the
materials for a reefschnur, he can use the
"cut sheepshank" technique. The rope is
anchored in the usual way, but just below
the anchor, the rescuer ties a three-strand
sheepshank and cuts (!!) the non-load-bearing
"strands." (See figure 7-9.) Being very careful to
keep constant tension on the rope, so as not to
allow the sheepshank to fall apart, the rescuer
rappels. Once off rappel, a sharp stroke of the
rope from the bottom causes the sheepshank
to disintegrate and the rescuer retrieves his rope. Again, this is a desperate technique.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{cut_sheepshank.png}
\caption{The Cut Sheepshank.}
\end{figure}

Whatever anchor or rigging system is chosen, the roper must be placed where the inevitable motion of the rope will not dislodge rocks or cause dangerous abrasion. The abrasion problem is particularly severe: many a roper has been surprised by the rapidity with which abrasion can part a roper rope or first sheeplag locked across even a dull rock lip. Side-to-side motion can often be avoided, but it is not the only culprit. Up-and-down motion caused by the rope stretching and relaxing is just as important and cannot be completely eliminated. When the rope must run
over an abrasive rock formation, the
danger can only be relieved
by careful padding as described in section
III - 7 - 7.

Ordinarily, one has no difficulty
insuring that the rappel rope actually
reaches the bottom of the pitch, and it
is important to see that it does. Whenever
any doubt exists -- and sometimes such
"blind rappels" are necessary -- a knot is
tied in the end of the rope and the first
person down goes prepared to prusik back
up. The knot is to prevent him from accidentally
rappelling off the end of the rope -- a
maneuver which is considered exceedingly poor form.

2) Rappel Technique

The basic technique of rappelling consists in
the recipe: attaching some kind of braking device
between the rope and his seat
harness, and then walking backward down the
pitch using the friction of the brake for
control. Rappel brakes are discussed in
section II - ?

It is possible, however, to rappel without mechanical braking device. Two rappel methods, the "sulfenity" and the "arm rappel," which rely upon direct friction of the rope on the user's body, are discussed in sections 3 and 4 below. The arm rappel is quite different from the others, but the "sulfenity" utilizes essentially the same technique as the "mechanically-braked" methods.

Proper rappelling form is illustrated in figure 7.10. The uphill hand is called the "balance hand," and generally serves no function except as an aid to balance. Consequently, it may be removed from the rope whenever the rescuer needs a free hand. The downhill hand is called the "breaking hand," and serves to control the braking force, and thus the rate of descent. Under most circumstances, it is best to have the thumb of the breaking hand point downhill, and that of the balance hand point uphill, although many find it convenient, when using a high friction brake (such as a rock), to reverse the breaking hand.
Some people prefer to run the rope through theotch, since that configuration allows recovery to the sufficiency in the event of a brake failure; others prefer to run the rope over the hip.

The attitude of the body is important. The shins are kept roughly perpendicular to the rock in order to minimize friction against the feet; the knees are slightly bent, and the back is straight. The temptation to try to stand vertically should not be yielded to except under unusual conditions. The rescuer looks down over the shoulder of the braking hand—not between his knees. These points are mainly important to keep good control over the rappel, but also they help keep equipment, clothing and hair from fouling the brake.

On a free rappel, that is, on an overhanging face with the feet out of contact, the body position will be more upright, relieving stress on the balance hand.

All movements in rappel should be slow, deliberate and smooth. A jerky rappel
puts unnecessarily high stresses on the system, loosens the anchor, abrades the rope, and knocks down rocks. A foot rappel can overload the brake to the point of melting the rope, and it increases the risk of missed steps and loss of control. A "bounding" rappel is the worst combination of jerkiness and speed, and is an invitation to disaster. A useful technique is to take one step at a time, always leading with the foot on the breaking hand side. This motion produces a smooth, graceful rappel -- the key to long life.

Getting started is usually the hardest part of a rappel because the rescuer must negotiate a dip at the edge of the cliff while the anchor is still too low for the rope to provide much stability or upward support. (See figure 7. a). Getting started can usually be facilitated by spreading the legs wide apart and squatting on the edge as low as possible before stepping down. In more difficult cases one can try sitting on the edge and then slithering off sideways. In extreme cases it is necessary
climb over the edge and take up the rappel below. Jumping off is extremely dangerous.

Should the rescuer need to stop partway down a rappel and attend to some business or other, he can tie off the rappel rope to completely support himself and then free his hands. There are several methods for accomplishing this end. Some methods for the figure-8 descendeur and the rappel brake are described along with these brakes in section II-5. Any mechanical brake can be tied off by tying two half hitches on the looped rope with a loop of the free end and clipping a biner from the loop to the looped line, but this tie-off can be difficult to undo. Some people like
to tie by passing a punch loop to the rope and then clipping to it, but that scheme can be very difficult to get out of if the tension on the punch loop cannot be relieved. Also, if the loop is too long, the knot can get out of reach.

All of these methods have their uses, but the simplest tie-off for a momentary stop is just to stop the rope around one leg several times and throw the free end over one shoulder.

3) The Dulfersity Rappel

The most elementary rappel system is the dulfersity, or "hotseat" rappel. It's main attraction is its simplicity: since the entire breaking force is obtained through friction between the rope and the rescuers body, the dulfersity requires no special equipment. For the same reason, it also serves nicely to very directly impress upon the novice the magnitude of the forces and the quantity of energy involved in a rappel. It demands good technique.
The Dufresneity rappel is executed in essentially the same manner as mechanically backed rappels, except that the rope is passed around the body as shown in Figure 7.11. The configuration shown is that usually preferred by right-handers, but each individual must decide for himself which hand to use for the breaking hand and which to use for balance.

When rappelling with the Dufresneity, the rescuer should take care to keep the rope out of his crotch, and instead keep it running on the upper part of his thigh -- a somewhat more durable spot. He must also be
particularly careful to keep his back straight, especially during a free rappel. Once that over, it is very difficult to straighten up again.

4) The Arm Rappel

The arm rappel, like the duffiness, is simple to implement and requires no special equipment but is only suitable for gentle slopes. It is especially useful on easy slopes more treacherous by unstable footing, while its advantage over the duffiness is that it provides a more appropriate amount of friction as well as being easier to use and much more comfortable.

The arm rappel is illustrated in figure 7.12. The rescuer steps up to the rope backwards, reaches over and takes one turn around each arm. He then walks sideways down the slope.

![Back View](image)

Figure 7.12. The Arm Rappel
5) Rappel Safety

Safety is of preeminent concern throughout mountain renewed, of course, but it becomes particularly problematic in the matter of rappelling. The trouble is not that rappelling is intrinsically dangerous, but rather that its supposed spectacle tempts the unwary into a risky endeavor -- and gravity does not forgive mistakes. Except, perhaps, in the view of the novice, a carefully executed rappel is not particularly spectacular or exciting. For a sensible person, the rush of adrenaline that accompanies the realization that one is hanging over the Great Abyss by a few threads of nylon soon gives way to a practical determination to keep control. Maintaining that control is, of course, the key to long life; consequently, the proficient mountainer, climber, or mountain rescue pilot himself, not in skillful descent by death-defying leaps and bounds, but rather in the craftsmanship be demonstrated in assembling and executing a smooth and secure rappel. As the saying goes, "If rappelling is fun, you're doing something wrong."
In addition to the safety precautions already mentioned, a few other important points are listed below:

a) Always wear gloves or mittens, even when using a high-friction brake. Gloves give the hands some resistance to being pinched, and offer the chance of recovery to a dulness if should the brake fail.

b) Tuck in shirt tails, roll or button long sleeves, and tie long hair back out of the way. Clothing and long hair can easily get caught in a brake, jamming the rappel and discomfiting the user.

c) Always belay beginners, and always honor anyone's request for a belay.* A rappel can always be belayed in the usual way with a separate rope, but a rappel using a mechanical brake can also be belayed from the bottom. In the event of a fall, the belayer quickly pulls the slack out of the rope and then applies his own weight to it. The tension thus created will clamp the brake.

* Footnote on p. 7-24.5/2
c) Use the call "On Rappel" when beginning a descent to warn those below of the danger of falling rock and to warn them not to tamper with the rappel rope. Use the call "Off Rappel" after getting completely free of the rope to announce that it is again available.

e) Visually recheck the system -- anchor, rope passing, brake configuration, locker sleeve and seat knots -- just before starting the rappel. There are few opportunities to correct defects once the descent is begun.

f) Set an example of caution and craftsmanship for all those who watch.

E) Prusik

Prusik is the technique of ascending a fixed rope by means of ratchet knots (classically, the prusik knot) or mechanical ascenders. It makes possible the easy and convenient
ascent of steep faces which would otherwise be difficult or impossible to climb.

The art of pursuing is very highly developed, particularly among vertical climbers, and many elegant methods have been devised to satisfy personal preference and the demands of special circumstances. For the sake of simplicity, however, only one very elementary method, the Texas Y, will be presented here.

The reader interested in pursuing the subject further should consult the references listed in Chapter 5.

1) The Texas Y Rig

The Texas Y is simple, safe, reasonably efficient and can be used with either knots or mechanicalAscendentes. The rig is illustrated in Figure 7.13.

The prusik slings themselves are ordinarily made of 5 mm nylon rope. Larger diameters do not hold reliably and smaller diameters have doubtful strength. Many vertical climbers, however, find that larger diameter (3/8 inch, or even 7/16 inch) polypropylene prusik slings
Figure 7.13. The Texas Y Prusik Rig.

Hold very well, even on wet rope. Normally, the knots are prusiks, but if webbing must be used for prusik slings, healden knots should be used instead. Mechanical ascenders used in place of knots increase the efficiency of the rig greatly.

The chest loop is tied to the seat through the chest-seat connector so that the rescuer
is comfortable when supported only by the chest 
bust.

The name of the rig derives from the 
configuration of rope connecting the feet 
to the foot knot. Ordinarily, the "Y" passes 
through a binder clipped to the seat, but, in 
a pinch, it can simply pass under the 
seat webbing. Some people even prefer 
that configuration; the nylon on nylon friction 
problem not being severe. The foot loops 
should be snug figure-8 loops. Some people 
prefers to girth hitch around the instep 
to keep the loop from coming off, but this 
restricts circulation and can be dangerous 
in the winter. Passing the leg ropes around 
the calves (to the outside first) is sufficient 
to keep the feet in their loops.

Although the safety jumper is not essential 
to the operation of the rig, it is an important 
safety feature. Without it, should the chest knot 
fail, the rescuer might end up in a very 
ungraceful upside down squat. With it, he 
can be spared this indignity. Similarly, the
simultaneously raise the chest knot as high as it will go. Again hang from the chest knot and repeat the procedure. Several cycles may be necessary to stretch the rope and actually get off the ground. To rest, simply straighten the legs and hang from both knots.

Spinning is often a problem, particularly with twisted lay ropes. It can be prevented by keeping the toes on the rock, but under an overhang there is not much help for it. Spreading the arms and legs will slow the spin, but not stop it.

Getting over the lip of an overhang is accomplished mainly by brute force. With both knots as high as possible under the lip, stand in the foot slings and with one hand pry the rope away from the rock while raising the chest knot with the other. It isn't easy. Gloves help. Exploit any available foot holds to their fullest advantage.

If this approach fails, tie a third

pursuit sling above the lip and hang from it while moving the other two knots over the edge. Tumans and similar ascenders that
The chest-seat connector may seem a nicely useful only in making the rig more comfortable, but without it, should the foot knot fail, the chest loop would soon prevent respiration -- another unseemly embarrassment.

The whole rig must be adjusted to suit the individual user. The chest knot should be high, but not out of reach when fully extended. The chest-seat connector should be just long enough that the chest loop and seat comfortably show the back when the legs are flexed. The carabiner at the junction of the "Y" should be just barely above the seat when the legs are extended and the foot knot should slide to just below the chest knot when the legs are moderately flexed. The safety jumper should come taut at the same time.

2) Technique

Starting with both knots as high as they will go, hang from the chest knot, raise the feet and slide the foot knot up under the chest knot. Then, stand up (locking the foot knot) and
can be operated with one hand, can simply be unclipped from below the edge and clipped back on above.

3) Prusik Safety

Prusiking is quite safe, but, as with all climbing techniques, small errors lead to large consequences. Some particular points to be watched follow.

a) Observe all the same anchorage precautions with prusicking as with rappelling.

b) Tie the prusik knots properly and neatly and keep them neat on each new set. A distorted prusik will slip.

c) 7 mm is the largest prusik sling which is reliable on 11 mm rope; 5 mm is the largest on 9 mm rope.

d) Prusik knots and ascenders frequently slip on wet, icy, or muddy ropes. If
pruiking on a slippery rope is the only means of escape from a desperate situation, try a multi-turn bowline knot; otherwise, go around.

e) Pruiking on a doubled rope works well, but watch the knots carefully: they tend to distort easily.