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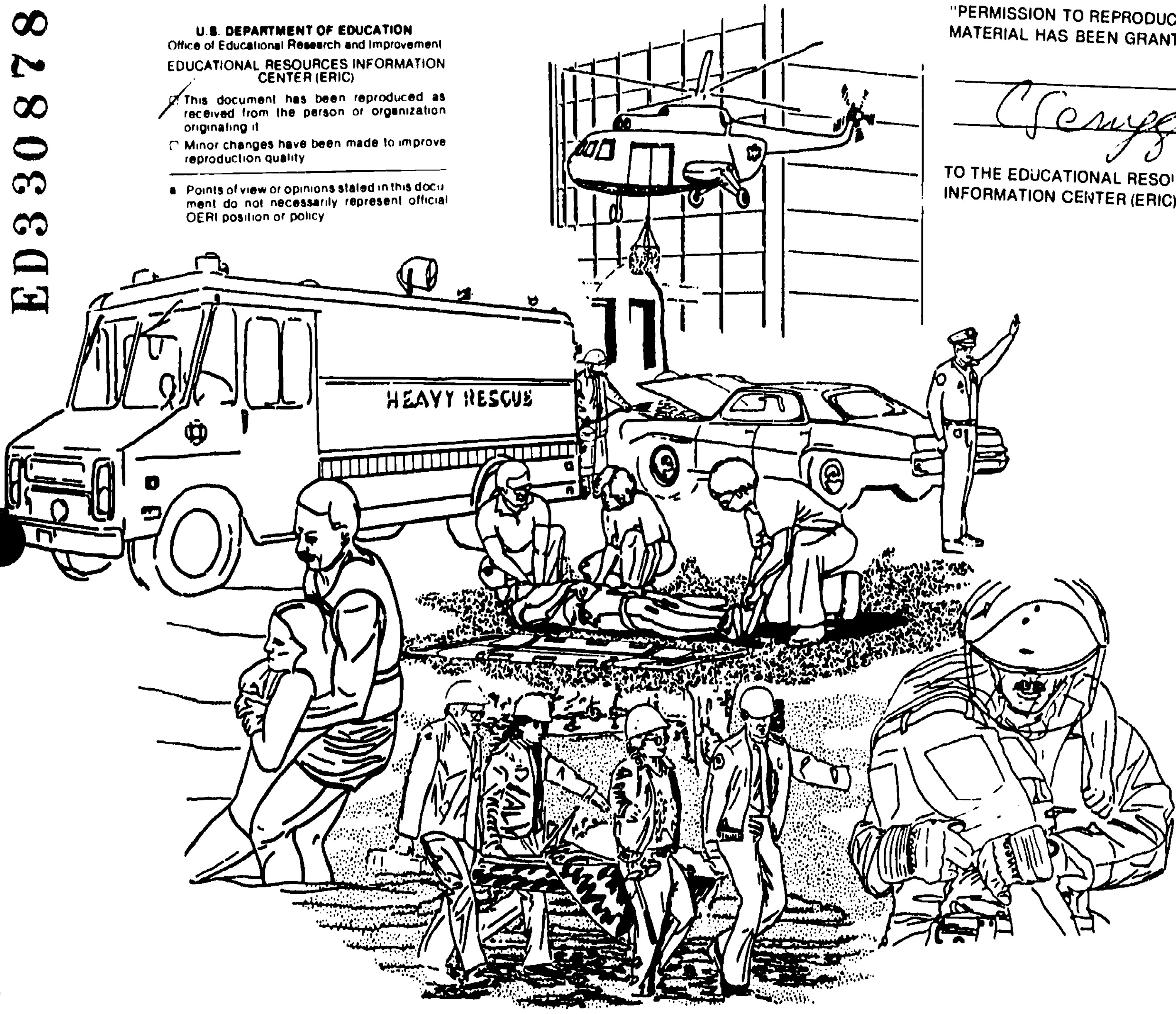
ABSTRACT

This learner manual for rescuers covers the current techniques or practices required in the rescue service. The fourth of 10 modules contains 8 chapters: (1) construction and characteristics of rescue rope; (2) knots, bends, and hitches; (3) critical angles; (4) raising systems; (5) rigging; (6) using the brake-bar rack for rope rescue; (7) rope rescue techniques; and (8) aerial ladder and aerial platform rescue. Key points, an introduction, and conclusion accompany substantive material in each chapter. (NLA)

RESCUE MANUAL



MODULE 4

Construction and Characteristics of Rescue Rope
Knots, Bends, and Hitches
Critical Angles
Raising Systems
Rigging
Using the Brake-Bar Rack for Rope Rescue
Rope Rescue Techniques
Aerial Ladder and Aerial Platform Rescue

INSTRUCTIONAL MATERIALS LABORATORY
THE OHIO STATE UNIVERSITY
COLUMBUS, OHIO 43210

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College of Education
Columbus, Ohio 43210

Rescue operations may subject both rescuer and victim to the possibility of injury or death. Rescuers must understand the nature and effect of each rescue technique, and practice techniques regularly, using this text to enhance their learning. The materials and information presented here are intended only as a learning aid, and are no substitute for training. Expert opinions, recommendations, and guidelines change as research and experience refine procedures. This text includes the most up-to-date information from rescuers working in the field.

Specialized procedures require demonstration and training by subject-matter experts. It is not likely that a rescuer will become proficient in all rescue operations. Most rescuers develop proficiency in only a few areas but may be familiar with several others.

This text suggests procedures and explains how to do them. The techniques given are guidelines only. Each department should incorporate its own procedures and address local needs.

RESCUE MANUAL

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ACKNOWLEDGMENT

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Using the Brake-Bar Rack for Rope Rescue
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FOREWORD

The intent of this manual for rescuers is to provide the latest instructional content and serve as an up-to-date, comprehensive source of information covering the current techniques or practices required in the rescue service. To help in this endeavor, an instructor's manual has been developed to be used in conjunction with this learner's manual. The manual has been produced in a series of modules to facilitate future revisions more rapidly and cost effectively.

The instructor's manual follows the key points identified in the text. Chapters have been included in the text which exceed those printed in any other resource. These include managing and operating the emergency vehicle, rope rescue techniques, industrial rescue, farm accident rescue, and various water emergency procedures, among others.

That the rescue profession is a dangerous and challenging career is a recognized fact. It is our hope that this text will help the rescuer meet the challenges of the rescue service in a safe and professional manner.

Tom Hindes
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PREFACE

The Ohio State University Instructional Materials Laboratory has played a major role in the training of public safety personnel through the development of text materials for many years. Due to the advances in the rescue techniques, it became apparent that the existing text was obsolete. Upon the advice of many knowlegeable people in the rescue service, the Instructional Materials Laboratory initiated the development of a new text that would be easily updated, and address the needs of the rescuer. To this end, an editorial review board representing a broad spectrum of individuals in the various phases of the research profession was convened to determine what topics this text should address. The culmination of this effort is the Rescue Manual. It is hoped that this text will be useful to not only the new rescuer but will serve as a reference source for the experienced rescuer.

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MODULE 4

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MODULE CONTENTS

The 1989 Rescue Manual has been grouped into ten modules in accordance with the recommendations from the Rescue Editorial Board.

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CONSTRUCTION AND CHARACTERISTICS OF RESCUE ROPE

KEY POINTS

- **The different types of materials used for rope construction**
- **The different types of construction used for rope and the disadvantages and advantages of each**

INTRODUCTION

It is the application for which a rope is to be used that determines the materials and construction methods used in rope manufacturing. Rescue rope differs greatly from the rope used for industrial, mountaineering, or marine applications. Because lives depend on rescue operations, it is vitally important that the rescuer choose the proper equipment, including the proper kind of rope for rescue operations.

Rope Fibers

Rope can be made of either natural or synthetic fibers. Ropes made from natural fibers such as manila, hemp, and cotton, should not be used in a rescue system (see Figure 1). These types of rope deteriorate rapidly, have low strength, and have little ability to absorb shock loads. Any natural fiber ropes presently in use in a rescue service must be destroyed or downgraded to utility status. These types of ropes should be used only for noncritical applica,tions, such as hauling equipment or crowd control.

Nomex, Kevlar, and even fiberglass have been used for rope construction. Special characteristics are imparted by each of these materials; however, none of them has proven suitable for use in rescue operations.

Figure 1. Manila Rope

Synthetic fiber ropes, such as nylon, polyester, and polyolefin, are less susceptible to deterioration from moisture and chemical exposure, are much stronger, and have a higher resistance to abrasion. Unlike natural fibers, which are very short, synthetic fibers are continuous throughout the length of the rope. This makes the rope much stronger so that a smaller diameter can be used safely.

Of all fibers, nylon is by far the most recommended and used material in the manufacturing of rescue ropes. It possesses great strength and abrasion resistance, and withstands most forms of chemical and environmental degradation.

Nylon fibers can lose 10-15% of their strength when wet, but regain their full strength upon drying. Nylon's ability to absorb shock loads is excellent. However, it cannot withstand certain strong acids or bleaches, so extra caution must be taken when using nylon ropes in industrial rescue operations or those involving hazardous materials.

Polyesters such as dacron are very strong even when wet, and are highly resistant to decomposition caused by exposure to sunlight (ultraviolet rays). Because of its relatively low ability to absorb shock loads, polyester rope is probably better used as marine or sailing line than as a rescue rope.

Polyolefin ropes (polypropylene and polyethylene) float, and are therefore good throwlines and can be useful in other water rescue applications. Electricity can be conducted along the surface of the rope through the water, oils, and dirt on the rope; however, the polyolefin rope itself does not conduct electricity. These ropes can also standup extremely well to chemical agents. These characteristics make "poly" ropes the best choice for dealing with electrical hazards and for rescue operations in which hazardous materials are involved. However, because of their low melting point and poor abrasion resistance, poly ropes are not appropriate for most rescue situations.

Construction

The three most common methods of building rope from its basic fibers are laid (twisted), braided (plaited), and kernmantle (core-and-sheath).

Laid rope is generally undesirable for rescue purposes because of its high stretchability and, due to its construction with twisted strands, it has a tendency to spin when under load (see Figure 2). It also shows poor abrasion resistance because each of the fibers is exposed to the surface at some point along the length of the rope. Most natural fiber ropes are constructed using this method.

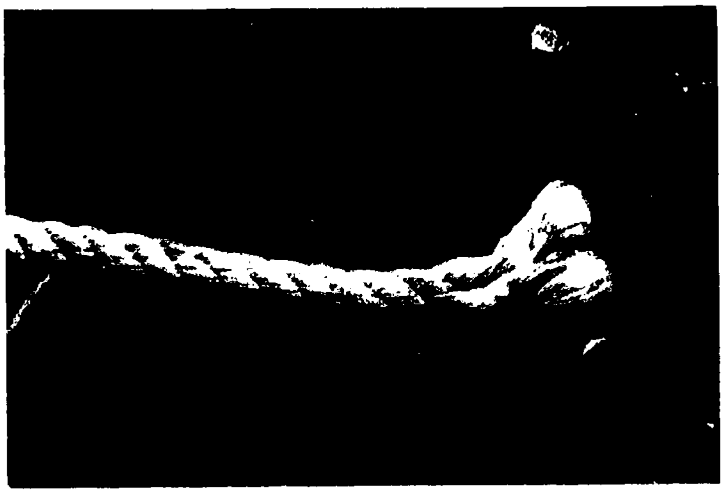


Figure 2. Laid Rope

Braided rope does not tend to have kink and spin like laid rope but still has low abrasion resistance because most fibers are exposed to the surface (see Figure 3). Many marine lines (ropes) are of this soft type of construction.

Figure 3. Braided Rope

Kernmantle rope is made by weaving a protective sheath (the mantle) over bundles of load-bearing core fibers (the kern). There are two types of kernmantle rope: dynamic and static (see Figure 4). The difference between them is the configuration of the core fibers. In dynamic kernmantle, the core fibers are spiraled into cords which make this type of rope very stretchy allowing 40-60% elongation. Static kernmantle, on the other hand, has nearly parallel core fibers and is a very low-stretch rope with less than 20% elongation.

Figure 4. Kernmantle Rope

Dynamic kernmantle rope is used by climbers because of its capacity to absorb shock. The stretchiness is essential in situations where high "fall factors" are encountered. The only time this type of rope is recommended for rescue is when "lead climbing" is necessary, that is, when the rescuer must climb above the point where the rope is anchored or belayed (fall factor >1). In these cases, a "running belay" system would also be used.

Static kernmantle rope made of nylon is the most popular type of rope for most rescue applications. It has high strength, high abrasion resistance, and does not spin under load. The core fibers carry from 70-90% of the load, so that severe abrasion to the sheath will not significantly weaken the rope, and the rope maintains a wide margin of safety.

CHARACTERISTICS

Size and Strength

The necessary size or diameter of a rescue rope is determined by the weight that the rope will be expected to hold, the weight of the rope itself, and the characteristics of any hardware (pulleys, ascenders, etc.) that will be used. In choosing rope, rescuers must remember that many types of hardware are not made to accommodate ropes larger than 1/2 inch in diameter and larger hardware may cost two to three times more.

To date, the only standards for rescue rope specifications are those written in NFPA 1983 (*Fire Service Life Safety Rope, Harness, and Hardware,* 1985 edition) (see Figure 5). These standards are based on size and strength considerations. A one-person load is considered to be 300 pounds. The accepted safety factor is 15:1. Therefore, to safely hold a two-person load (victim and rescuer), a rescue rope with 9000 pounds tensile strength should be used. These standards include a safety margin that takes into consideration the reduction in strength due to bends, knots, and pulleys, and wear to the rope.

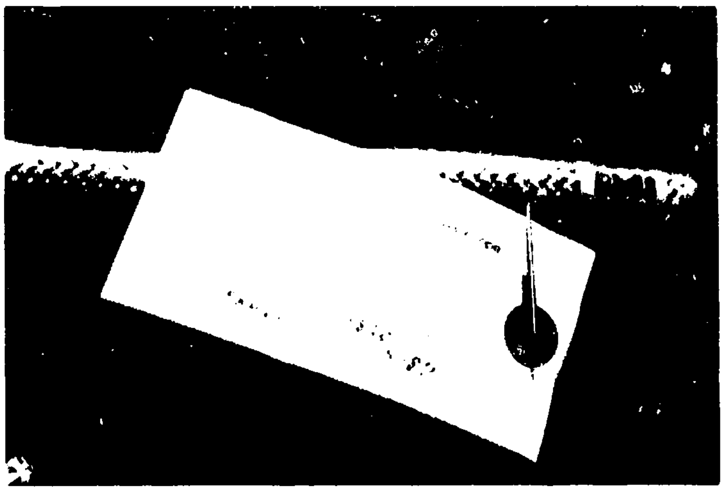


Figure 5. Rope Identification Tag

Flexibility

A good rescue rope should be flexible so that it handles well (has "knotability"). An extremely stiff rope will provide the most abrasion resistance, but may be very difficult to tie a knot in or stuff into a rope storage bag. Conversely, in a very soft, flexible rope knots may be easily set by hand, but may be impossible to untie after being under load.

Color

Modern synthetic rescue ropes are available in many colors. Undyed ropes are less expensive, but cost is not the only factor to be considered. Some rescue personnel use colored rope for purposes of identification. During a rescue scenario, it is very helpful to have colors that contrast with the background, making it easier to see the rope. Having different colored rope also simplifies identification when multiple systems are in use. Additionally, damage to the sheath may be seen easily if the white core fibers show through a contrasting sheath color.

Dyed nylon rope is slightly weaker than natural white nylon rope. This problem is minimized if the dying process involves coloring the yarn after it has been manufactured (surface dying) as opposed to chemically mixing the dye with the raw nylon (extrusion dying).

Length

The lengths of ropes carried for rescue purposes should be determined by local needs. Departments in an area that has very tall structures or long drops (high-rise buildings, antenna towers, cliffs, mines, etc.) will need longer ropes than departments in areas that do not have these characteristics. For general rescue use most rescuers seem to favor rope lengths of 150 to 200 feet. These lengths are generally easy to store, carry, and deploy.

CONCLUSION

There are many factors to consider when choosing ropes for use in rescue service. As with any other type of rescue equipment, rope must be purchased to deal with local hazards and potential rescue problems. Only a survey of local needs will determine what specifications are best. In all decisions about equipment, the safety of both the victim and the rescuer is of primary importance. No rescue rope is safe unless the user has had the training necessary to use it correctly.

KNOTS, BENDS, AND HITCHES

KEY POINTS

- **Care of a rope**
- **Knots used in rope rescue**
- **The safety knot**
- **Types of knots, bends, and hitches**

INTRODUCTION

Ropes are used for a variety of rescue activities in the public safety service business. Many improvisations and rigs require the incorporation of rope knots, bends, or hitches to effectively perform a safe rescue. Rope dedicated to rescue procedures must receive proper care for maximum use and reliability.

CARE OF ROPE

Inspection

Inspection of a rope is critical when the rope is to be used for a life-support system in rescue operations. Rope should be inspected after each use and at regular intervals during periods of nonuse. Maintain an accurate record of the inspection and use of each rope (see Figure 6). There is no definite rule regarding when to retire a rope; however, some general criteria can be followed. Several things to observe in the rope include the following:

1. Dirt in the fibers of the rope
2. Cut fibers
3. Excessive wear or abrasion of the fibers
4. Deterioration of the fibers from chemical contact
5. Serious impressions (hour-glass shapes, diameter changes, or puffy or mashy areas)
6. Shock-loaded ropes

Dirt in Fibers

Keep all rope as clean as possible to avoid damage caused by dirt particles cutting into the fibers. This can be done by avoiding any unnecessary dragging of the rope through dirt or mud, and by cleaning a rope when it gets muddy. Also, never walk or stand on a rope. Natural fiber rope can be brushed with a stiff fiber broom and synthetic fiber rope can be washed with a solution of mild soap and water.

The two most common methods to wash a rope are with a front-loading washing machine or with a special rope-washer machine. If the rope is washed in a regular washing machine, place it in a porous bag such as a laundry bag or pillow case to prevent damage from the washer's drum. Several types of special rope-washer machines are available; most resemble a small hose washer. Always follow the manufacturer's instructions when using the machine. Ropes should never be force-dried in a clothes dryer or a hose dryer; they must be air dried.

Cut Fibers

In a laid or braided rope, all of the fibers in the rope are exposed to the surface at some point. Cut fibers on the outer surface in a laid or braided rope are more critical than in a kernmantle rope. When cut fibers are found in a laid or braided rope, the rope should be taken out of service.

Excessive Wear

Excessive wear on a rope is hard to define; however, if a rope has not been subjected to extreme conditions. certain criteria can be applied. In a laid rope, if the twist can no longer be easily seen or felt, retire the rope. In kernmantle rope when the sheath has been worn through to where the core can be seen, or if suspicious bumps or dents can be felt in the core fibers within the sheath, retire the rope.

Chemical Deterioration

Different materials used in rope construction are sensitive to different chemicals. To preserve the strength of a rope, avoid all unnecessary contact with gasoline, bleaches, battery acid, or other harsh chemical. It is impossible to determine exactly when to retire a rope; however, if the rope cannot be trusted, retire it.

Record of Rope Use

Identification Number________________ Identification Marking________________

Purchase date________Purchased From________Manufacturer________Date of Mfg________

Brand__________Fiber Content__________Color__________Construction__________

Length____________Diameter____________Date Placed in Service____________

DATE USED	LOCATION OF USE	TYPE OF USE	ROPE CONDITION AND EXPOSURE	DATE INSPECTED	INSPECTOR	COMMENTS

Figure 6. Card for Recording Rope Use

Serious Impressions

Hour-glass shapes or diameter changes due to overloading may indicate possible ccre failures. Puffy or mashy areas on ropes also indicate possible internal failures.

Shock-loading

If a rope has been overloaded or shock-loaded greater than a fall factor of .78 it should be taken out of service.

STORING ROPE

The best way to store a rope is in a rope bag (see Figure 7). This allows the rope to be thrown out straight without tangling and protects it from damage while in storage. The bag also provides an easy method to carry the rope. To place the rope in the bag, open the bag, place one end of the rope in the bottom and insert the remainder of the rope. There is no need to try to coil or stack the rope; simply feed it into the bag. When finished leave a small portion of the rope's end outside the bag so it can be grasped by the rescuer when preparing to throw.

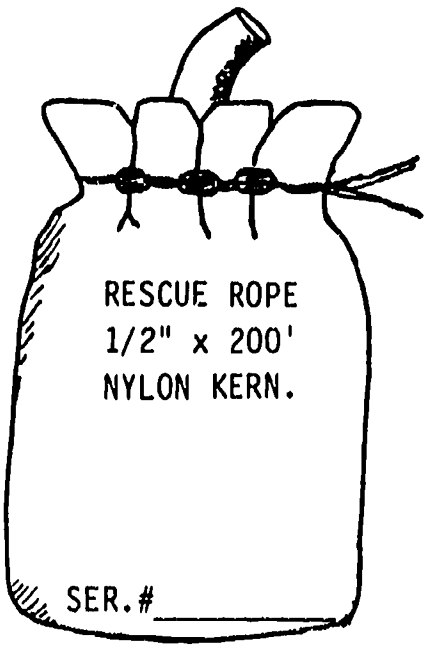


Figure 7. Rope Bag

Knots Used in Rope Rescue

Rescuers must have a working knowledge of knots to be proficient in rescue work. Hundreds of knots have been developed; however, only a few selected knots are necessary for rescue operations. It is better to know a few knots well than to know a little information about a lot of knots.

Selecting the proper knot is especially important when dealing with life-threatening rescues. Most knots have a distinctive shape or arrangement which makes them easy to identify when checking and double-checking a rescue system. Ideally, a knot should be:

- Easy to tie and easy to remember
- Strong and secure for safety
- Easy to untie to facilitate a quick system change during a rescue

A knot is not finished and ready to use until it has been properly dressed and set. A knot has been **dressed** when all parts of the knot have been arranged or aligned in proper position. Failure to dress a knot can result in a significant loss of strength.

Tightening the parts of the knot in the correct manner is referred to as setting the knot. Setting the knot prevents slippage within the knot and makes it functional.

THE SAFETY KNOT

Many rescue ropes made from synthetic fibers are slipperier than the natural-fiber ropes making a safety knot a necessity. Knots tied in the end of a rope should always be backed up with a safety knot. This is necessary to ensure the safety of the main knot when a rope is used in a life-threatening rescue.

The safety knot can be tied by using either an overhand knot (see Figure 8) or half of a double Fisherman's knot (see Figure 9). The safety knot must be snugged up against the main knot once it is dressed and set.

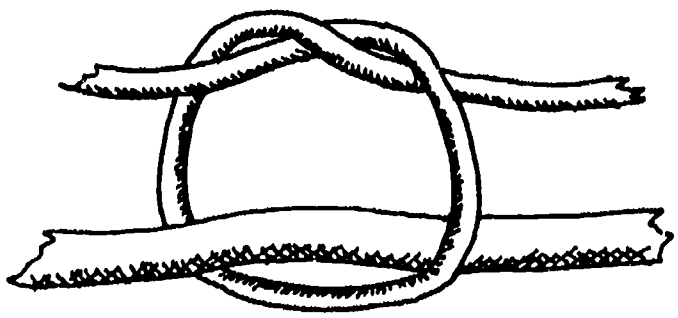


Figure 8. Overhand Knot Used as a Safety Knot

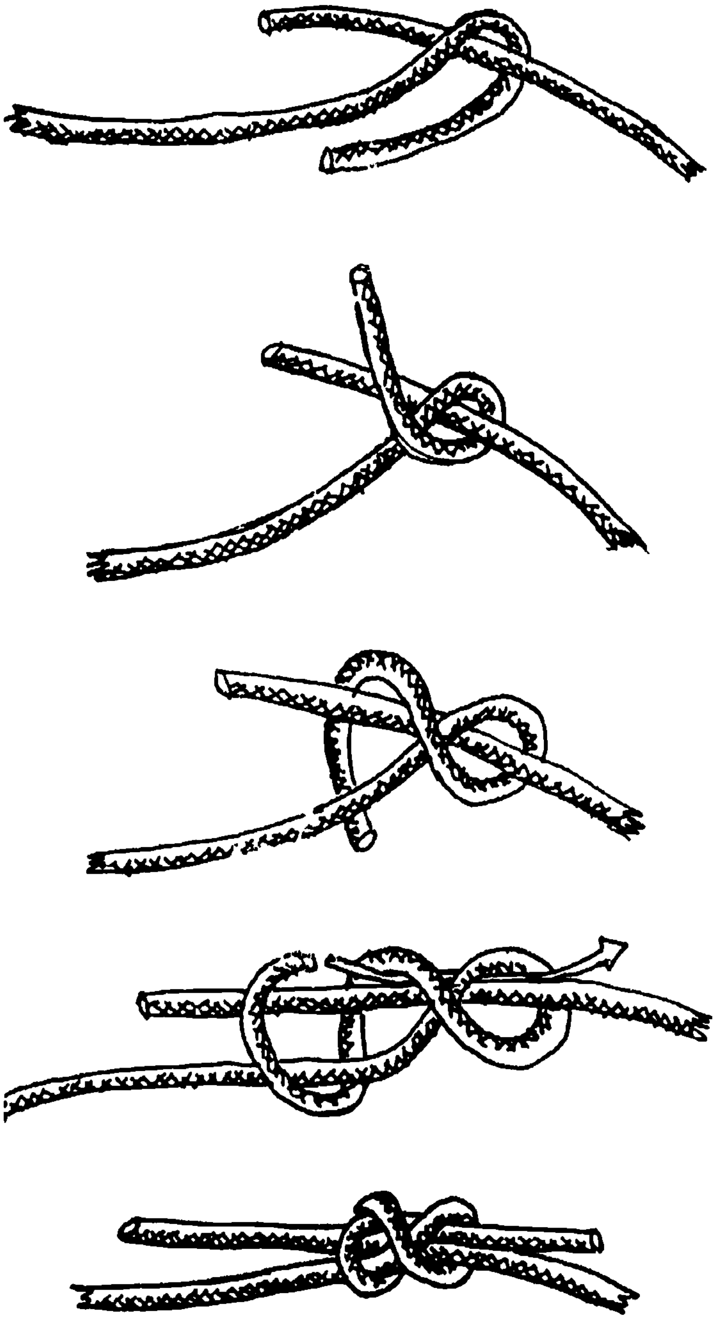


Figure 9. Half of a Double Fisherman's Knot Used as a Safety Knot

TYPES OF KNOTS, BENDS, AND HITCHES

Bowline Knot

The bowline knot is a loop knot with many uses. Several methods can be used to tie this knot (see Figures 10 and 11). The finished knot is correctly tied when the end of the rope is inside the loop. The end must also be secured with a safety knot (see Figure 12).

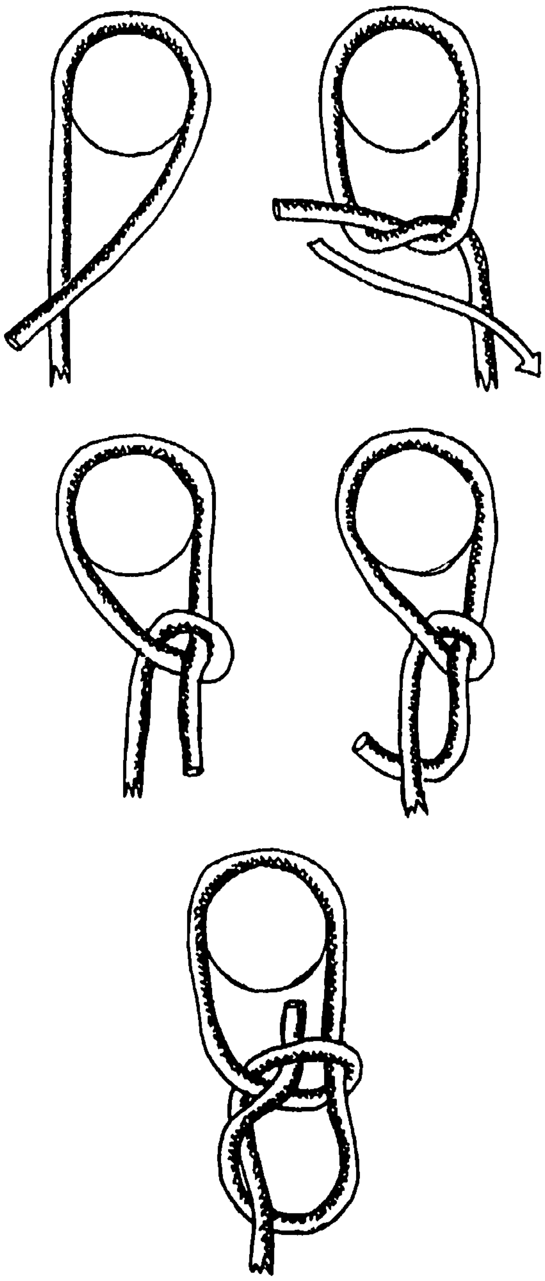


Figure 10. Bowline Around an Object

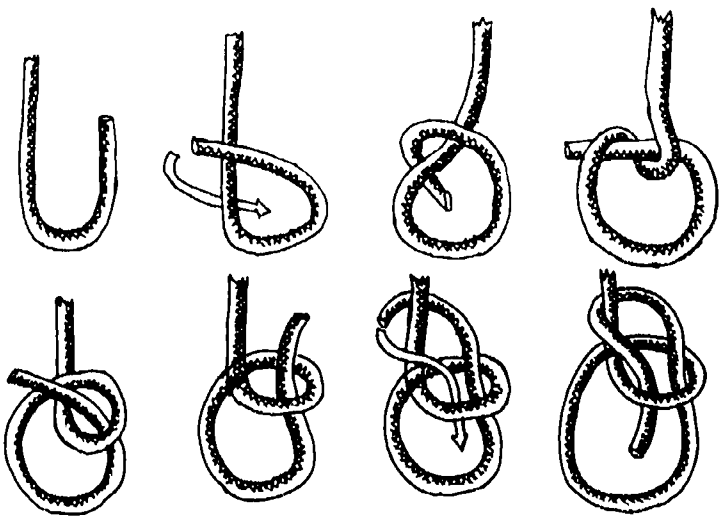


Figure 11. Free-Standing Bowline

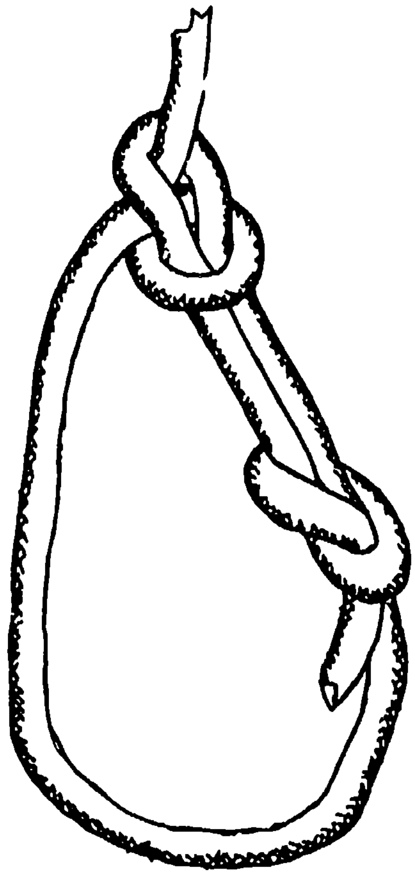


Figure 12. Bowline with a Safety Knot

Bowline on a Bight Knot

A bowline knot on a bight provides two fixed loops when the knot is finished (see Figure 13). Adjust the loops to the correct size prior to dressing and

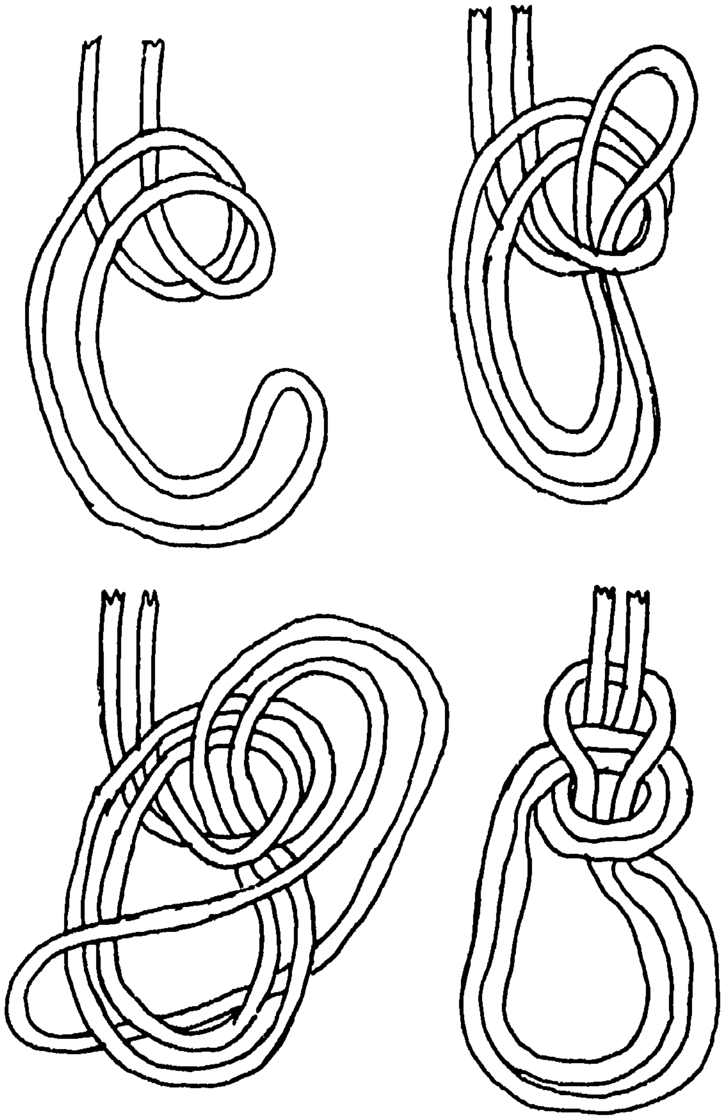


Figure 13. Bowline on a Bight

Figure Eight Knot

The figure-eight knot which is the basis of a family of rescue knots, is a simple, strong knot that is easily identifiable (see Figure 14). Figure-eight knots can be used in many rescue applications.

When rappelling, the rescuer should tie a figure-eight near the end of the rope when the possibility exists that a rappel rope may not reach all the way to the bottom of the drop. This prevents the rescuer from inadvertently rappelling off the end of the rope.

Figure-Eight Bend

A figure-eight bend is used to tie together the ends of two ropes that are the same diameter (see Figure 15). Because of the knot's wide bends, it can be easily untied once it is loaded (see Figure 16). Always secure the ends with safety knots (see Figure 17).

Figure-Eight Loop (Figure-Eight on a Bight)

The figure-eight loop is stronger than a bowline knot and can be used when a single fixed loop is needed. The figure-eight loop can be tied on a bight at the end of a rope or at midline (see Figure 18).

The follow-through method can be used when it is necessary to secure the rope around an object (see Figure 19).

Double Figure-Eight on a Bight

This double figure-eight on a bight knot is formed from a figure-eight loop (see Figure 20) and provides two fixed loops when completed (see Figure 21). It can be used in a multi-point anchor system or for improved load distribution when the rope passes around a tight radius such as a carabiner.

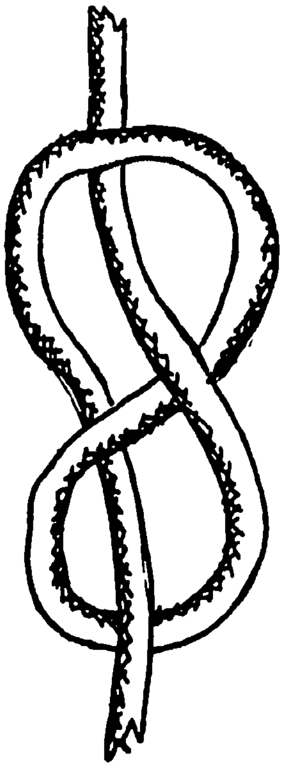


Figure 14. Figure-eight Knot

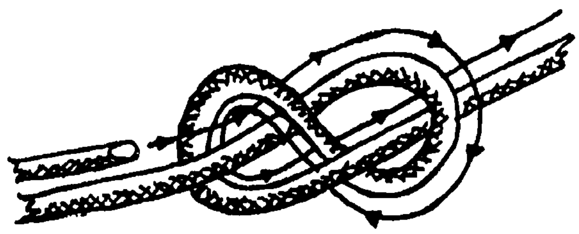


Figure 15. Tying the Figure-eight Bend

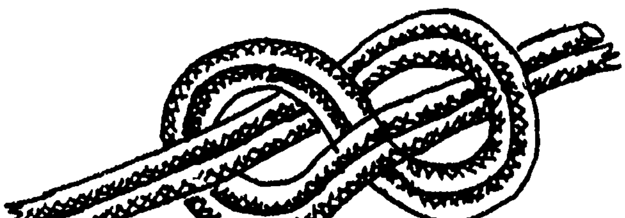


Figure 16. Completed Figure-eight Bend

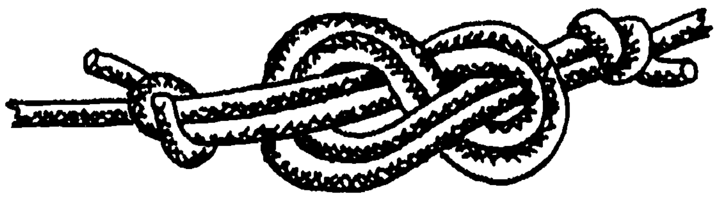


Figure 17. Figure-eight Bend with Safeties

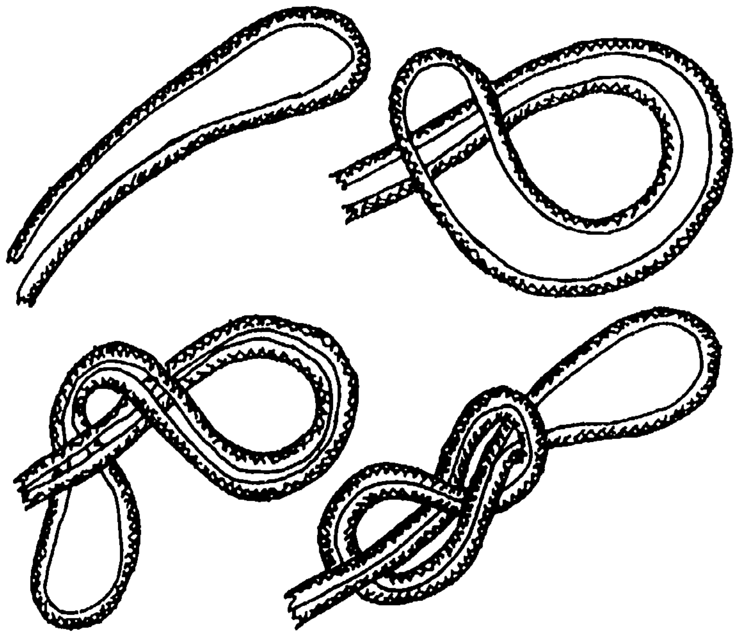
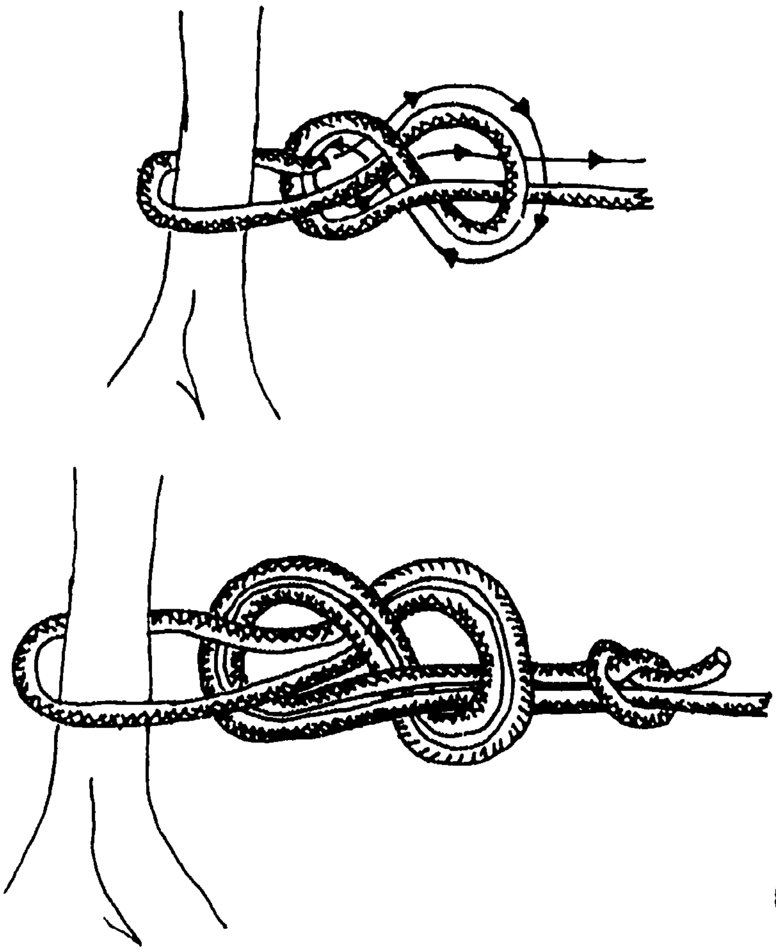


Figure 18. Figure-eight Loop on a Bight



Figur 19. Figure-eight Loop Around an Object

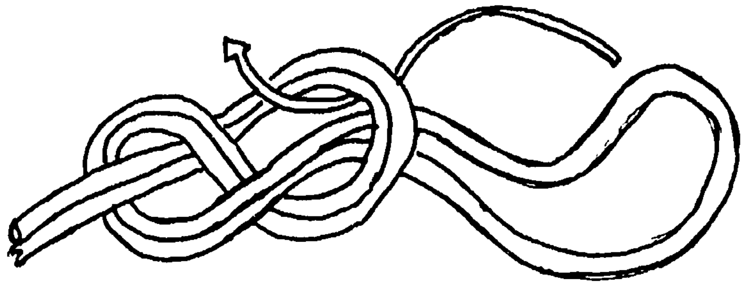


Figure 20. Figure-eight Loop

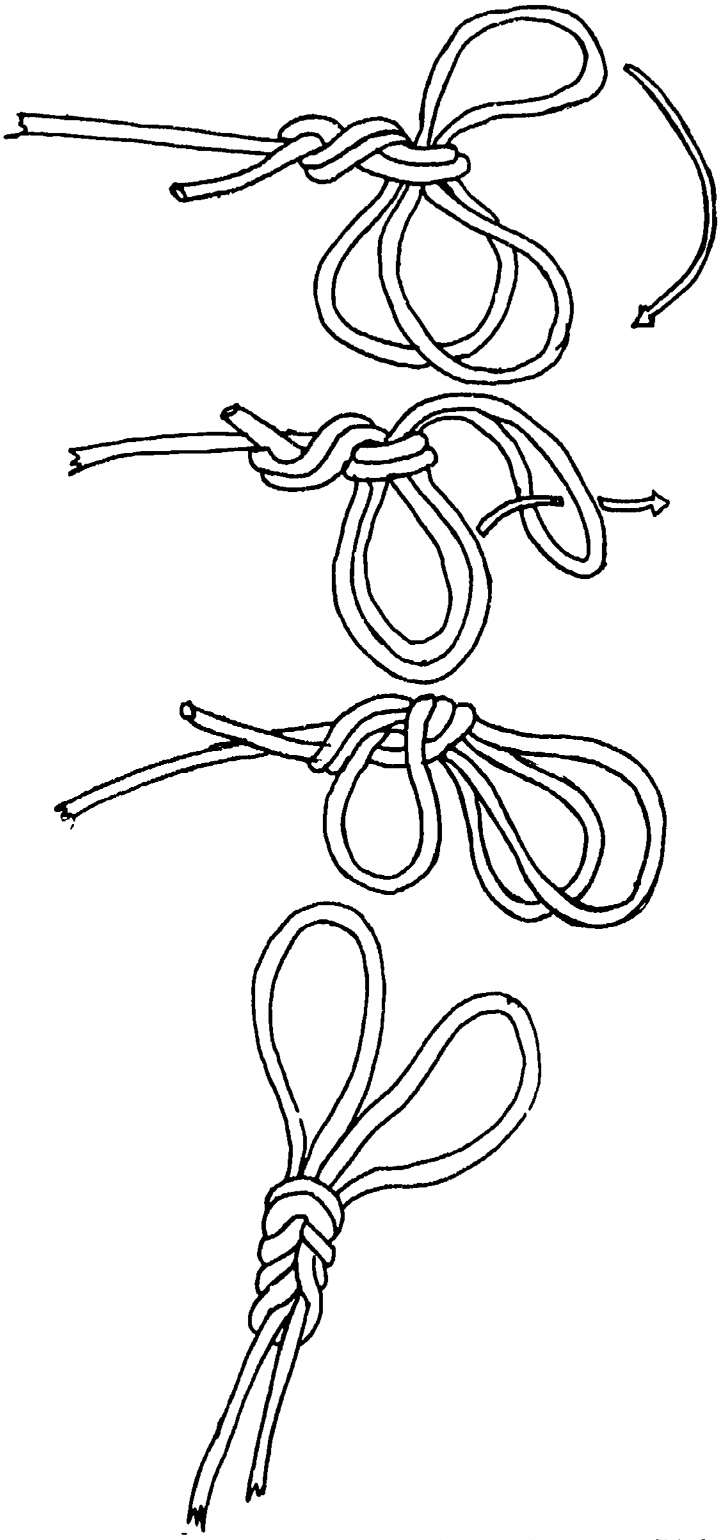


Figure 21. Completed Double Figure-eight on a Bight

Double Fisherman's Knot

The double fisherman's knot is a safe, compact knot that is often used for tying the ends of two ropes together (see Figure 22). It can be used even if the two ropes are of different diameters. The main drawback of the double fisherman's knot is that it is difficult to untie after being heavily loaded.

This knot is most commonly used in rescue operations to tie an accessory cord into the Prusik loops. Using half of a double fisherman's knot makes an excellent safety knot.

Prusik Knot

A Prusik knot is used on a rope when a rescuer is climbing. It grabs and holds the rope when tension is applied, but will slide freely up or down the rope when the tension is slackened. Prusiks can also be used in rescue when rigging a mechanical-advantage raising system where a ratchet-like movement is required.

A three-wrap Prusik knot is recommended for use in many rescue systems. This knot must be dressed and set carefully to be functional. When using a double fisherman's knot always be sure that the knot is away from the point where the load will be attached to the Prusik loop (see Figure 23).

Water Knot (Overhand Follow-Through)

The water knot is the best knot to use for tying together the ends of webbing used for a sling or an anchor (see Figure 24). Be sure to leave at least two inches of rope on each end after the knot has been dressed and set.

Water knots are difficult to untie after heavy loading.

Clove-Hitch Knot

This clove-hitch knot has many uses in rescue rigging. It is fast to use since it is easy to tie and untie. A clove-hitch will hold tight when tensioned, but can be easily adjusted when slackened (see Figure 25). When used in life-threatening rescue, the end of the rope must be tied off and secured so that slipping cannot occur.

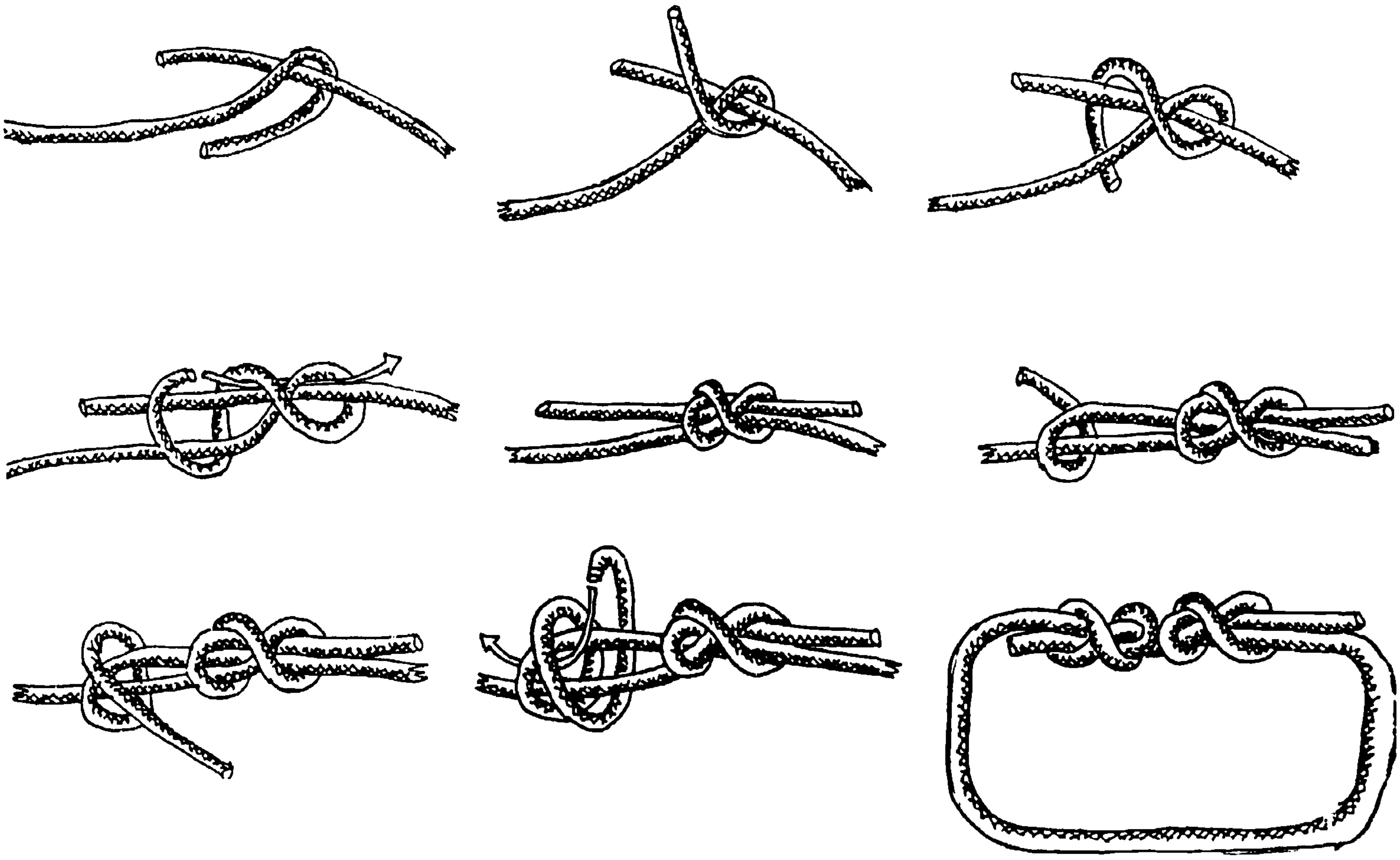


Figure 22. Double Fisherman's Knot

Figure 23. Three-wrap Prusik Knot Including Completed Prusik Knot with a Double Fisherman's Knot

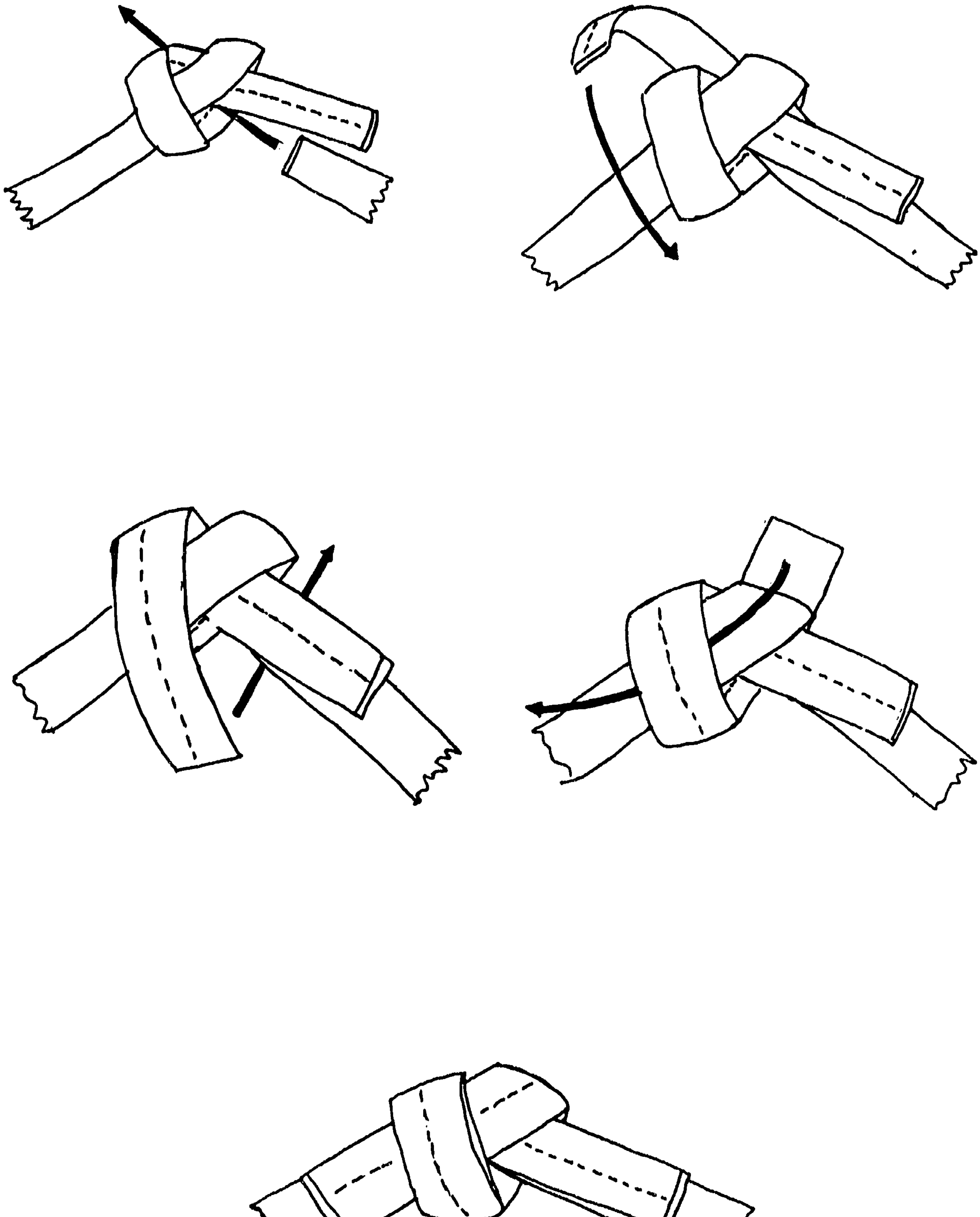
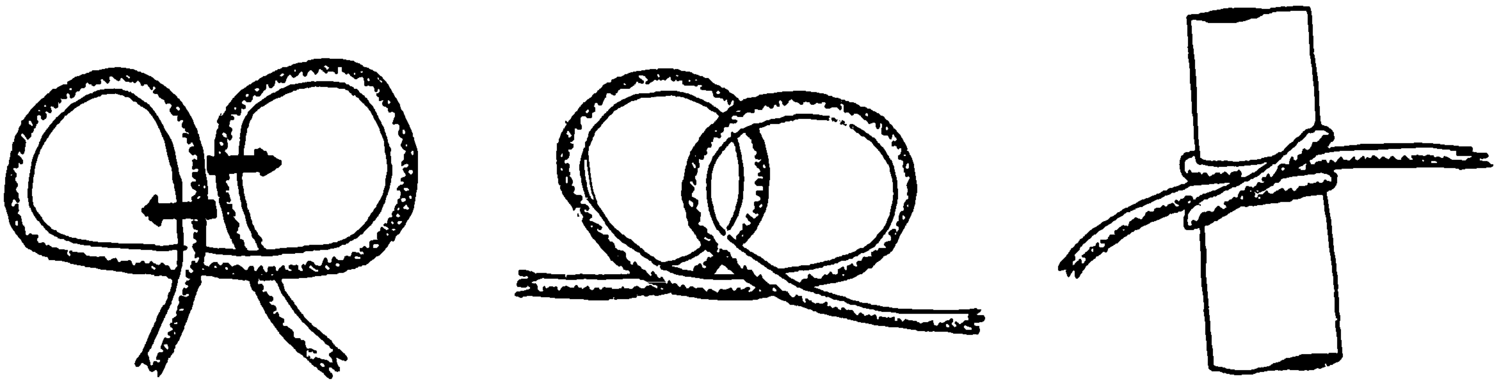
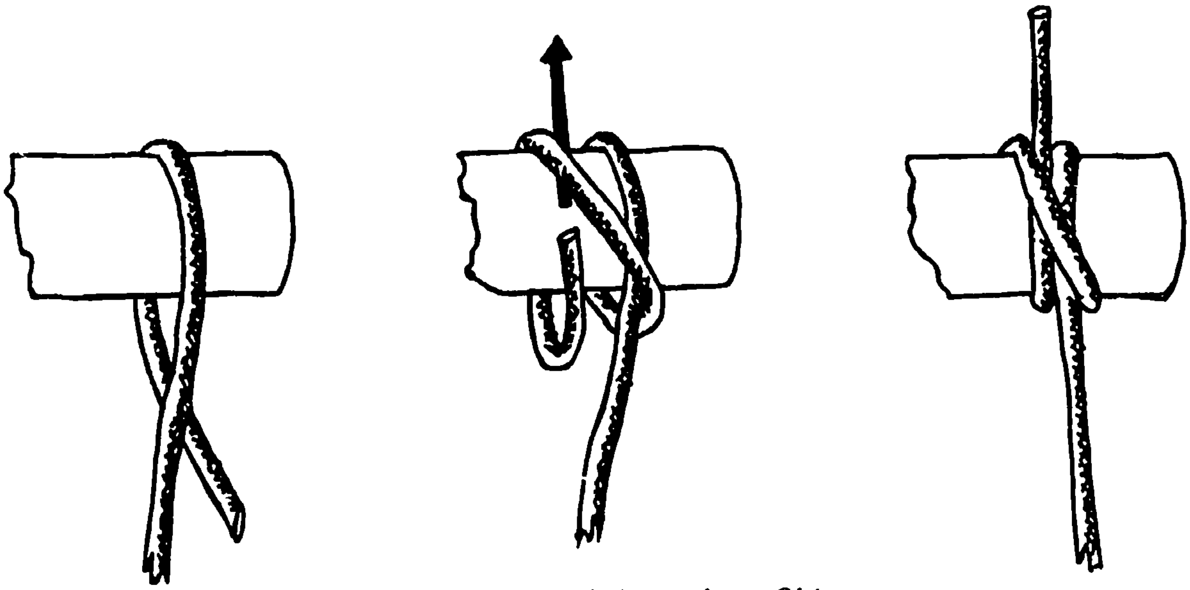


Figure 24. Water Knot



Clove Hitch to be Placed Around an Object.



Clove Hitch Tied Around an Object

Figure 25. Two Methods of Tying a Clove Hitch.

CONCLUSION

To become knowledgeable about the use of rope knots, bends, and hitches, the rescuer must learn the basic procedures from someone who is proficient in knots and their applications. It is also necessary to practice tying each type of knot, bend, or hitch to check its effectiveness and security. Tying knots is not a skill that can be learned on the job.

CRITICAL ANGLES

KEY POINTS

- **The importance of considering critical angles**
- **Examples of critical angles encountered in rope rescue operations**

INTRODUCTION

"It is possible to rig a rope in such a way that the tension on the rope and the anchor points is greater than the load applied."

This quote about vertical caving refers to one of the most misunderstood concepts in rope rescue operations: dealing with the critical angles. Improper angles can amplify the weight of a load many times. When a system is symmetric (that is having angle A, B, and C equal) the tension with in the three parts is equal, (see Figure 26).

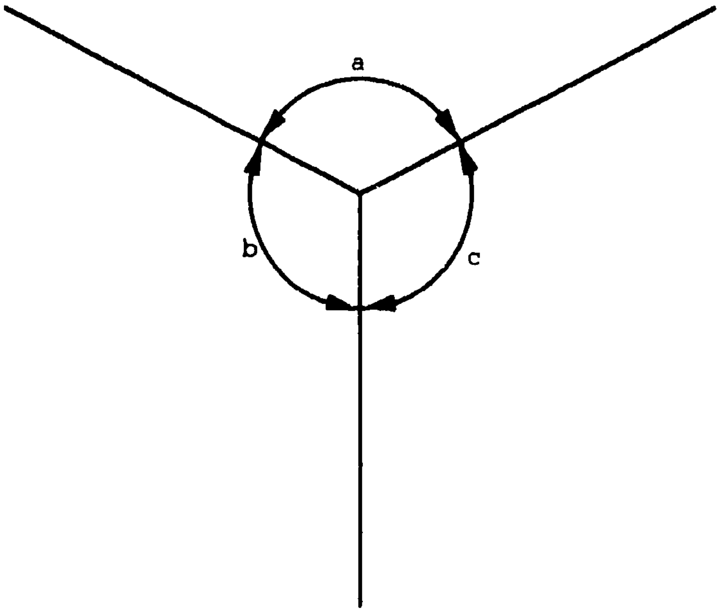


Figure 26. Symmetrical System

In Figure 27, angle A is 120 degrees, which is often referred to as the maximum safe value.

If tension is applied to the system so angle A exceeds 120 degrees the weight or load will be multiplied (see Figure 28).

If angle A is less than 120 degrees the tension on the anchors and the rope together will be less than the weight of the applied load (see Figure 29).

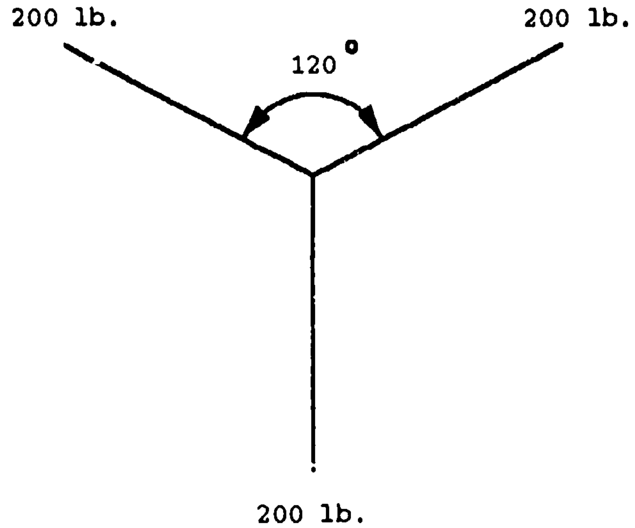


Figure 27. Maximum Safe Valve

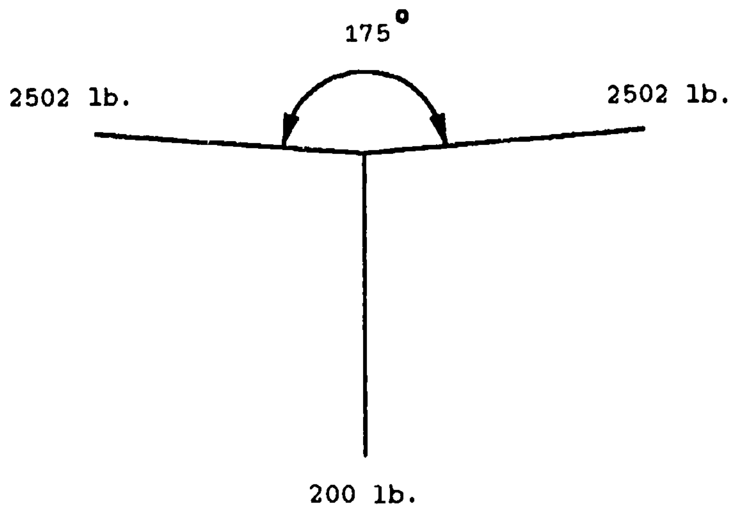


Figure 28. Angle Greater Than 120°

Critical angles are a source of load amplification that is commonly overlooked where systems have failed from over-tensioning. The rule of critical angles can apply many places within a rope rescue system, not just in a Tyrolean or high line, but in anchor systems as well (see Figures 30 and 31).

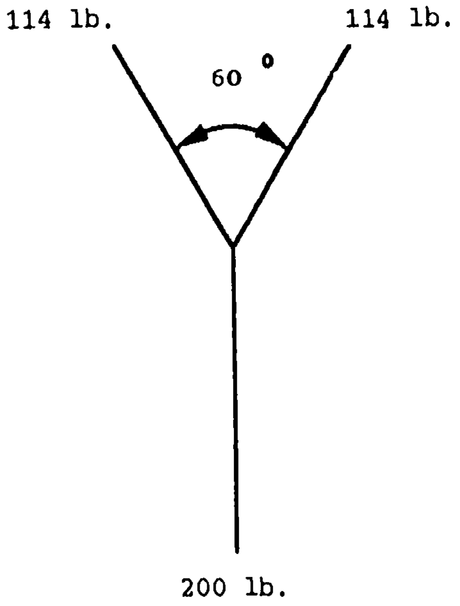


Figure 29. Angle Less Than 120°

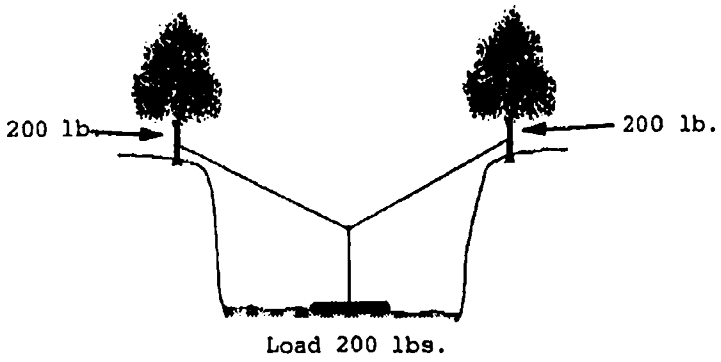


Figure 30. Tyrolean or High-line System

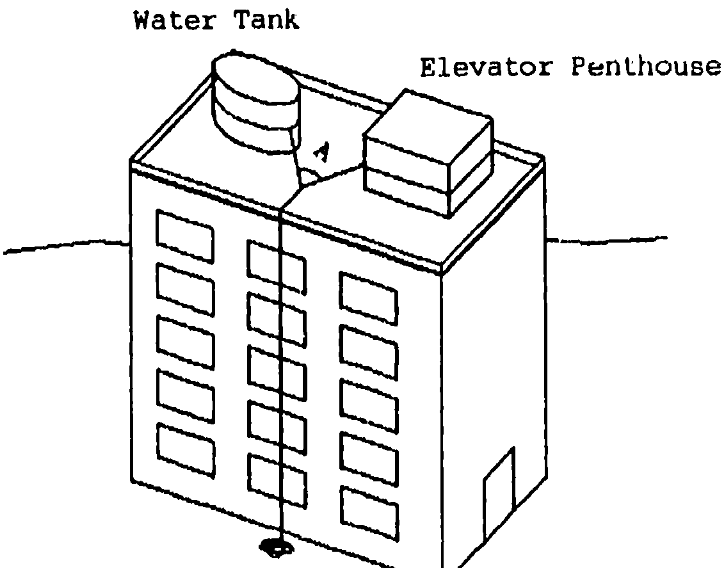


Figure 31. Anchored System

In addition to the angles marked with the letter A, there are other areas where the rule of critical angles applies. Ti. re could be critical angles and load amplification at the point anchored around an object such as a round water cooling tank or the elevator-penthouse as shown in Figure 32.

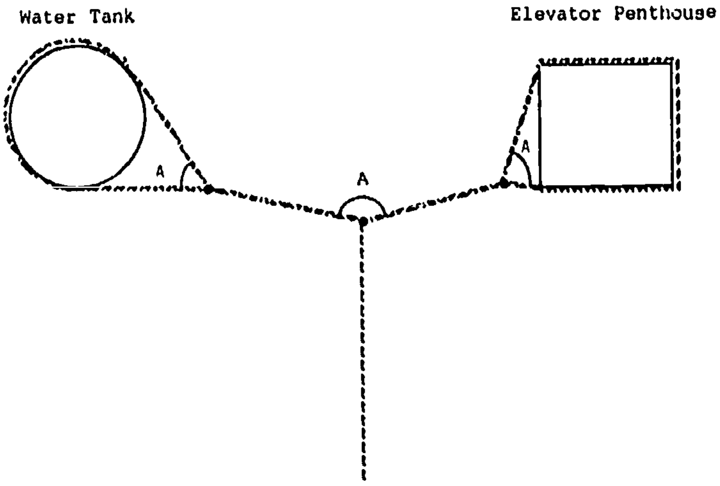


Figure 32. Other Critical Angles may be Found at the Anchor Points

Forces may also be greater than expected in a situation such as that shown in Figures 33 and 34.

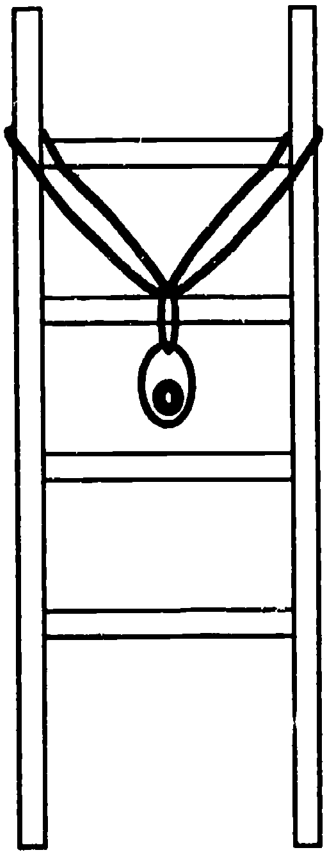


Figure 33. Pulley-Hanging on a Ladder. Calculate the Angle

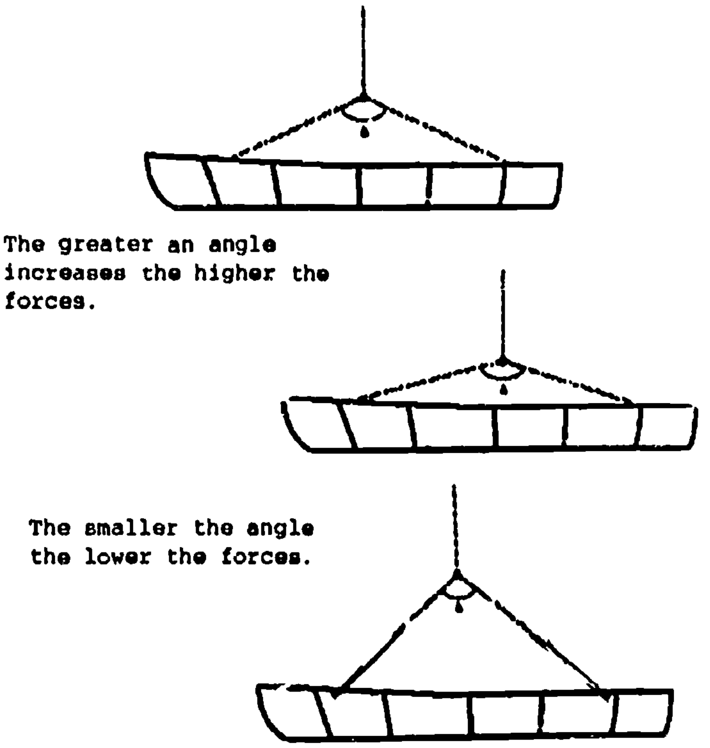


Figure 34. Rescue Baskets with Varying Angles. Calculate the Angle

Since the pulley (see Figure 35) is just changing direction, the pull required to lift the 500 lbs. is theoretically over 500 lbs. The resulting force placed on the beam is then doubled to more than 1,000 lbs. As this example shows, critical angles are extremely important and must be considered in any rescue operation that involves the use of rope.

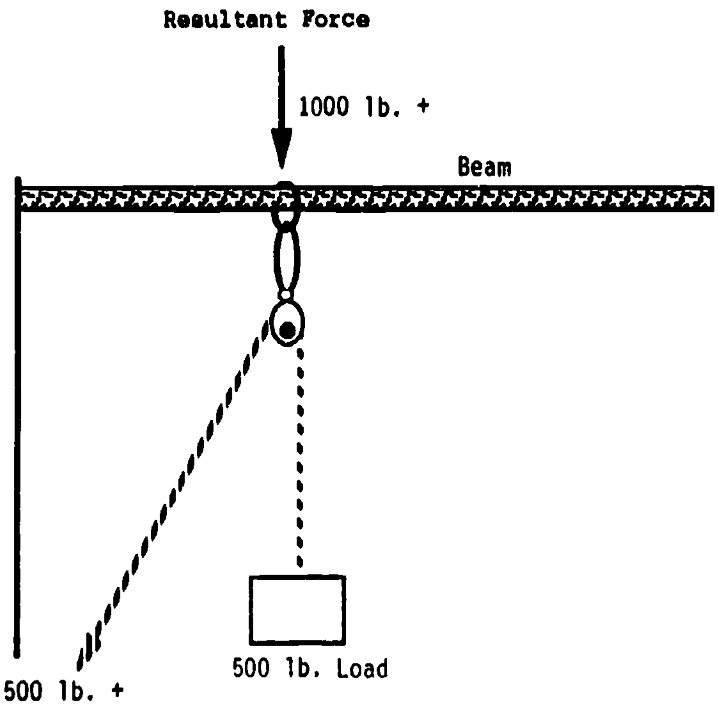


Figure 35. Example of Load Amplification

BELAY SYSTEMS

In the United States, the term belay refers to being able to stop or to catch a person from falling during a rappel; however, in Europe to belay means to anchor, or refers to a piece of fall protection.

Belay can be performed in several ways. On long drops due to the increased weight of the descending rope a person descends with less friction than normal. The belayer is required to pull hard on the rope to stop the descent, especially if the rapeller loses control completely. Rappels must be done slowly, maintaining control at all times. The preferred method is to use a bottom belay which is practical to use for short-to-moderate distance rappels.

Top Belay System

The top belay system is a good application for the beginner to learn rappelling. The belay system will utilize a separate rope anchored at the top system. The rope is then attached to the rappeller using either the small end of an eight ring as a sticht plate or a Munter hitch for the top belay system (see Figures 36 and 37). As shown in Figure

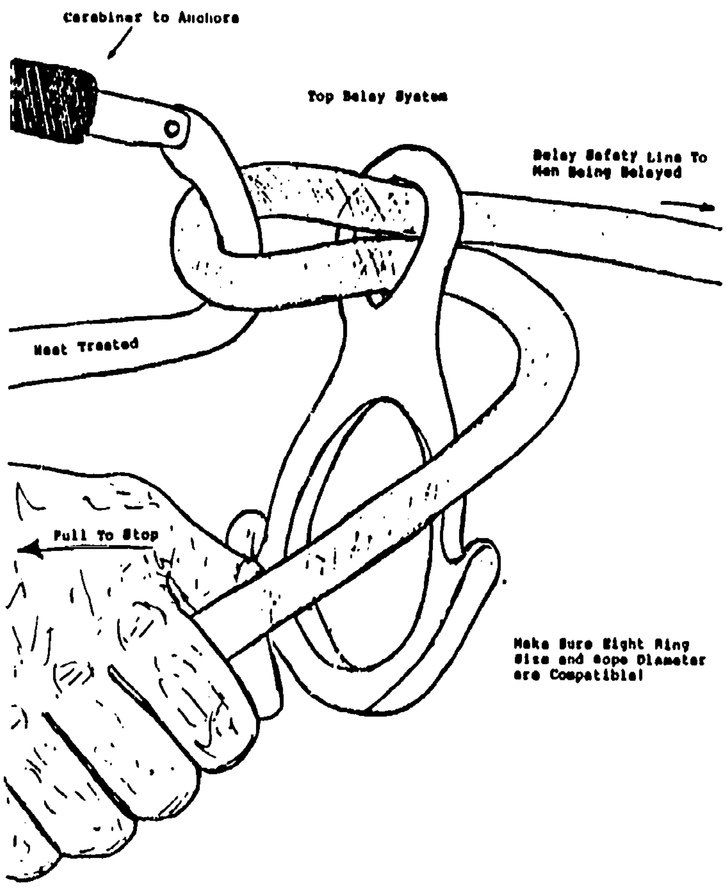


Figure 36. Small End of an Eight-ring Used as a Sticht Plate

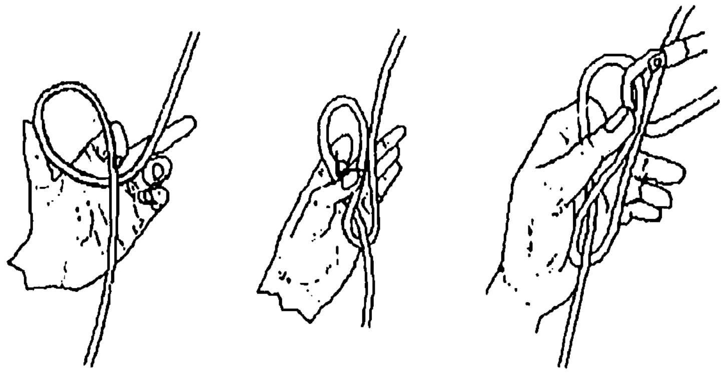


Figure 37. Tying a Munter Hitch

38 the rope is in position to travel through the belay system. In Figure 39 the belayer is showing the position to stop a descent. Figure 40 shows the eight ring used as a sticht plate in a completed system. The Munter hitch has been successfully utilized to catch a two-person load. If a rappeller loses tota' control, or becomes unconscious, the belayer must

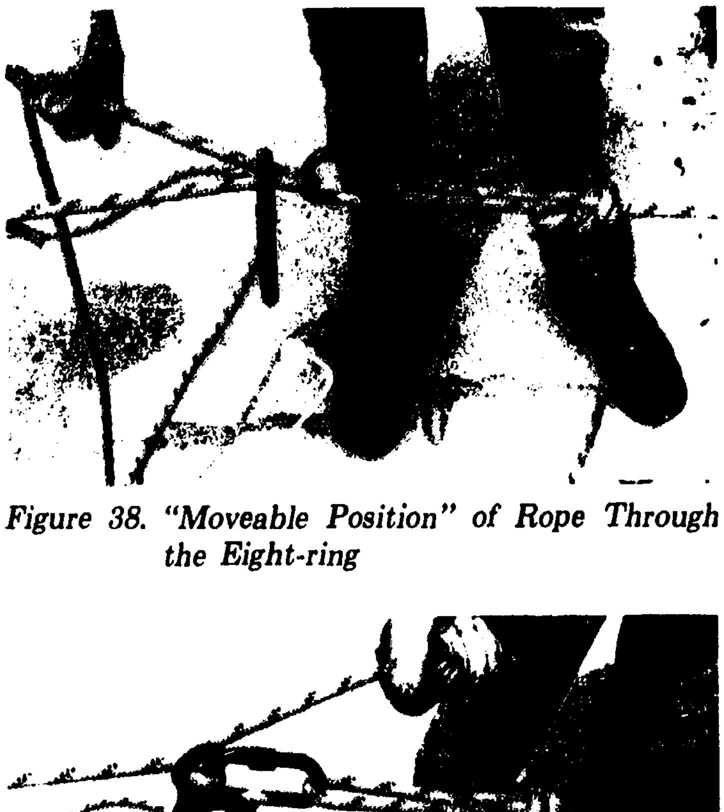


Figure 38. "Moveable Position" of Rope Through the Eight-ring

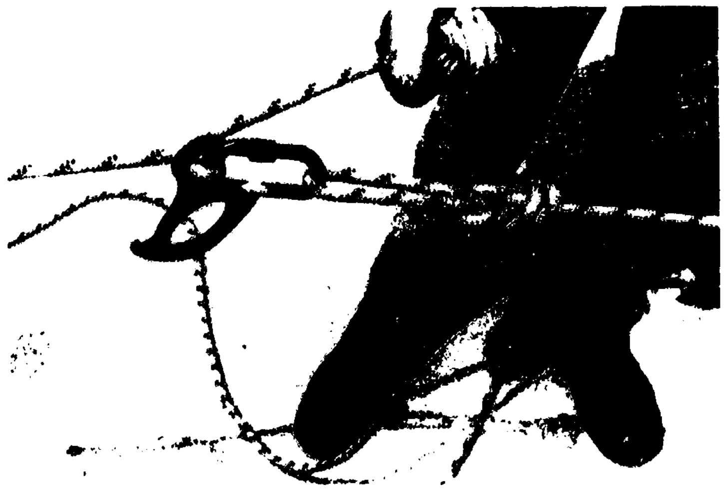


Figure 39. Position to Stop a Descent

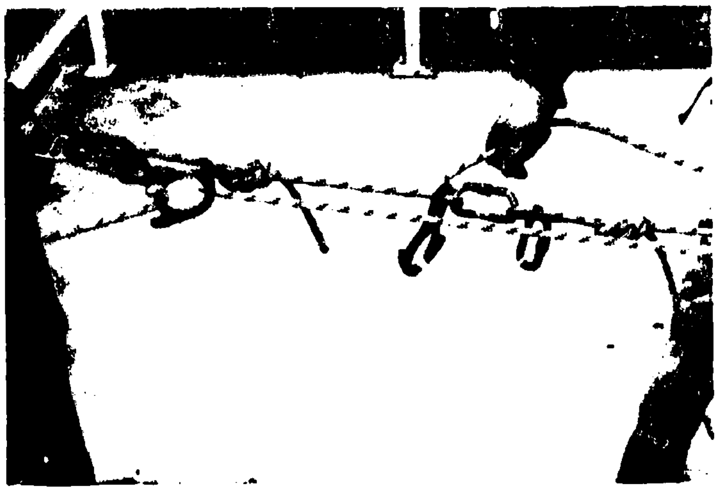


Figure 40. Eight-ring as a Sticht Plate in a Completed System

take control of the descent. The belayer may, based on the circumstance, decide to stop the descent or continue lowering to a safe position.

A disadvantage of the top belay when rappeling on an eight-ring is that when a person is on a free-air hang where there is no wall to walk down, the eight-ring causes the person descending to spin, wrapping the belay rope around the main line. This can stop the descent causing the rappelling rescuer to become stuck on the belay system. Also, in the top belay system, the pendulum effect happens if the two anchor ropes are spaced more than 1′ to 2′ apart when the belay system is activated.

Even if there is a wall on which to walk, the rescuer may become off balance causing an injury. A disadvantage with the top belay system is that on longer drops, the belayer positioned at the top cannot tell if the rope is being pulled by the person on rappel, or if the rope weight is pulling the belay rope.

With an increased drop distance, it is difficult to see what is going on with the rappeller. If too much rope is let out, a large loop of belay rope can end up dangling underneath the person on rappel. Thus presenting a dangerous situation to the rappeller if a limb or the neck becomes entangled.

Another danger with the top belay is the possibility of the belay rope on the top belay system, traveling over an edge causing rocks, tree limbs, or debris to fall on the rescuer.

Bottom Belay System

This system requires a belayer to stand at the bottom of the drop and hold onto the rope on which the rescuer is descending (see Figure 41). If the

Figure 41. Position of Bottom Belayer

Figure 42. Bottom Belayer Stopping a Descent

individual on the descending rope loses control, the belayer can use his or her body weight to pull on the rope to increase the friction on the rappeller's descending device, thus slowing or stopping the descent (see Figure 42).

The bottom belay system works well with either an eight-ring or a brake bar rack. On long drops, a bottom belay is difficult to manage, since it is hard to see the person who is descending a rope because of the distance. It is hard to gauge how fast the person is moving.

A disadvantage of the bottom belay is that the belayer is located in a hazardous zone (the fall zone). In a cave pit or on a cliff, there is danger of rocks falling and striking the belayer. In a building or tower rescue, there is a danger of lose objects falling. If the belayer moves out of the fall zone and has to stop a rappeller who is out of control, the halt will cause the rappeller to pendulum causing him or her to swing back or even stop; however, as soon as the person starts to swing, the rope will slacken slightly and downward travel will resume.

Self-Belay Systems

A self-belay is often used for a long drop. The self-belay is a system whereby the person on rappel does not have to do anything to activate the system. If the rappeller becomes unconscious, the device automatically stops the descent. The self-belay is necessary when a person is rappelling in an area where there is a high probability of falling rock, or on an extremely long drop where fear itself could cause unconsciousness. Several devices are available to use for a self-belay system (see Figures 43 and 44).

The belay system used must be of adequate strength for the amount of weight encountered. Hip

Figure 43. Self-Belay Using a Petzl Shunt

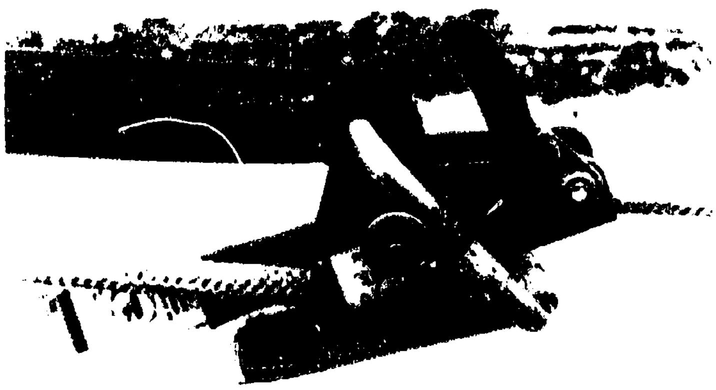


Figure 44. Self-Belay. Gibbs Ascender Rigged as a Spelean Shunt

or body belays and eight-rings rigged in rappel mode techniques are inappropriate to use with a two-person load. Evaluate what type belay is needed for the load conditions encountered before beginning to assemble the system. When using a top belay system, slack must be kept out of the system. If a two-person load goes out of control and 3' - 4' of slack is in a belay system, it is nearly impossible to stop. A Munter hitch has been successfully used to catch a two-person load.

RAISING SYSTEMS

KEY POINTS

- **Important concepts of a raising system**
- **Mechanical-advantage raising systems**
- **Hauling commands**
- **Raising and belay systems**

INTRODUCTION

When performing rope rescue, lowering systems are easier to set up and operate than raising systems. However, sometimes it is necessary to establish a raising system to haul a victim or rescuer up out of a utility hole (manhole), up a roadside embankment, or out of some other situation. More personnel, equipment, and time are required to overcome the force of gravity such as raising an object, than are required to establish and operate a system for lowering an object. Rescuers must be aware that there is a greater danger of overloading all the components of a raising system than there is with a lowering system.

Many rescue departments have power winches, cranes, or tow trucks available at an emergency scene; however, these devices should never be used to haul a human being. If a stretcher or part of a victim's body becomes caught on an obstruction, such as a rock or a tree limb, the machines cannot feel the resistance and can cause serious damage. The power of a ten-ton winch can tear apart a Stokes litter during a lift before any indication of trouble is noted. Even if the operator reacts quickly and turns off the winch, the wind-down time of the machine can cause an overtension of the rescue system to the point of failure. Crane hooks or winches may be used as fixed anchor points, but only 'people power' should be used in a rope-rescue system.

Straight-Pull Raising System

The simplest and fastest rope raising system is a straight pull, with the full weight of the load on the rope itself. However, this procedure may require many rescuers and is difficult to manage if space or personnel is limited. A large group of rescuers may be slow to respond to the "stop" or "haul slow" commands. Also, a slip can cause the load to drop.

To set up a straight-pull raising system, establish a strong anchor point and attach a Gibbs ascender or Prusik as a safety. This will prevent the load from dropping and also hold the load when haulers reset for another pull (see Figure 45).

Mechanical-Advantage Raising Systems

When a straight pull is not practical, pulleys can be used to rig a mechanical-advantage raising system. A mechanical-advantage raising system reduces the effort required to move a load and uses fewer people for the task. The following explanations and illustrations address the various mechanical-advantage raising systems that can be used.

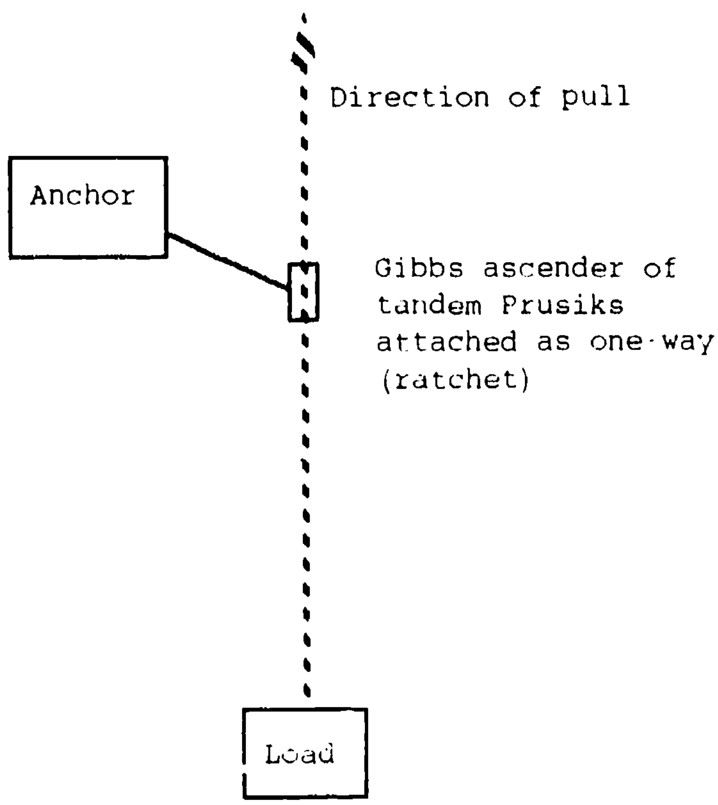


Figure 45. 1:1 Straight Pull

A 2:1 mechanical-advantage can be gained by attaching a pulley directly to the load on a single rope or using a Gibbs ascender or Prusiks from a separate line (see Figures 46-A and 46-B). This system may prove to be sufficient for a single-person load if enough people are available to pull.

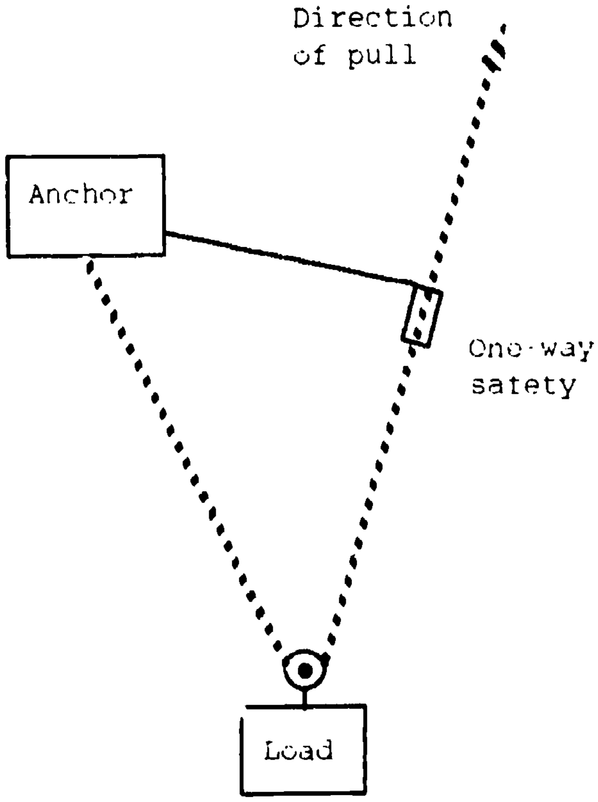


Figure 46-A. 2:1 Mechanical-Advantage Svstem (Pulley Attached Directly to the Load)

A 3:1 mechanical-advantage system, or "Z-rig", is better than the 2:1 system because it reduces the effort even more and can be set up just as quickly using only a single line (see Figure 47). The Z-rig is probably the most popular raising system used in rope rescue operations.

Many rescuers prefer to use a 4:1 mechanical-advantage system, or "piggyback," using the same hardware as a Z-rig. It is rigged by stacking a 2:1 system onto another 2:1 system (see Figure 48). This compound arrangement is easier to rig using two separate ropes, although an experienced rescuer should be able to utilize a single line.

A 6:1 system can be made in the same manner as the 4:1 system by stacking a 2:1 system onto a Z-rig (see Figure 49). Rig the 2:1 system by using a separate line.

A 9:1 compound system is easier and faster to set up than a 6:1 system; it is done by stacking two Z-rigs together (see Figure 50).

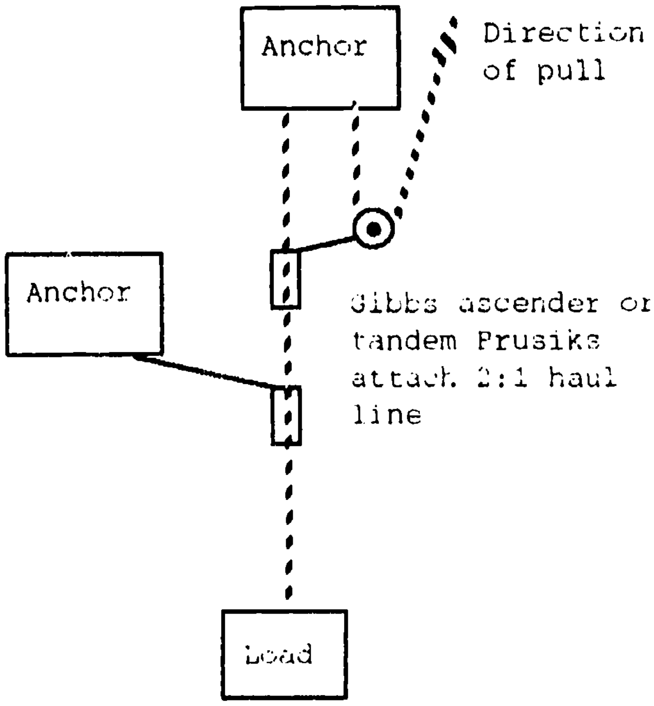


Figure 46-B. 2:1 Mechanical-Advantage System (Safety Placed in Front of Haul System)

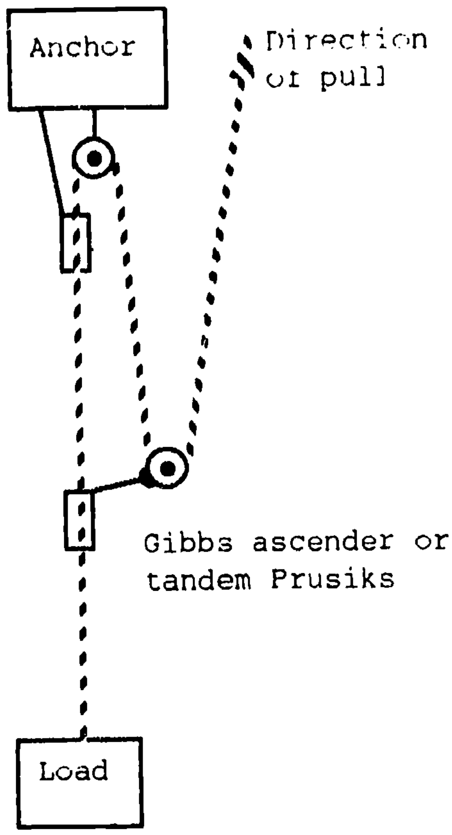


Figure 47. 3:1 Z-Rig System

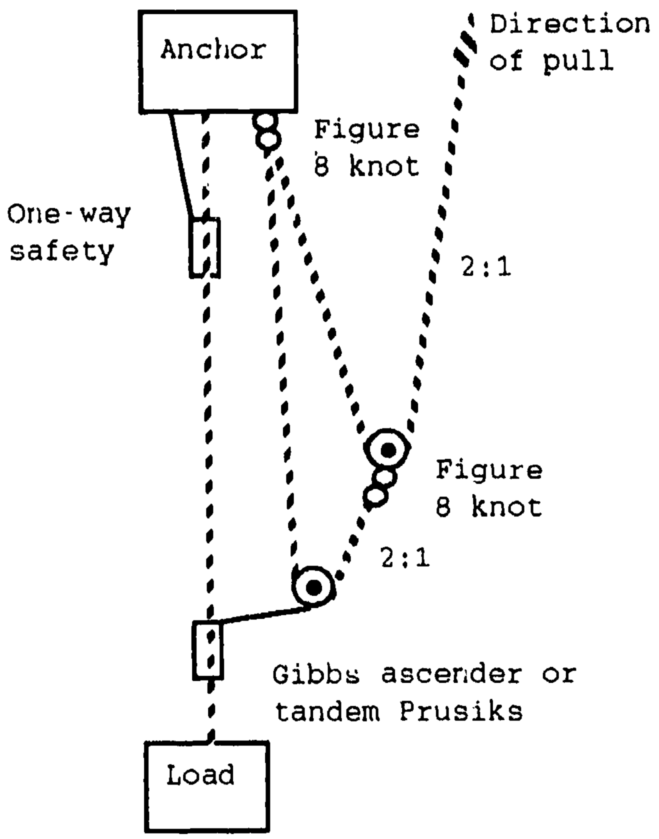


Figure 48. 4:1 Piggyback System

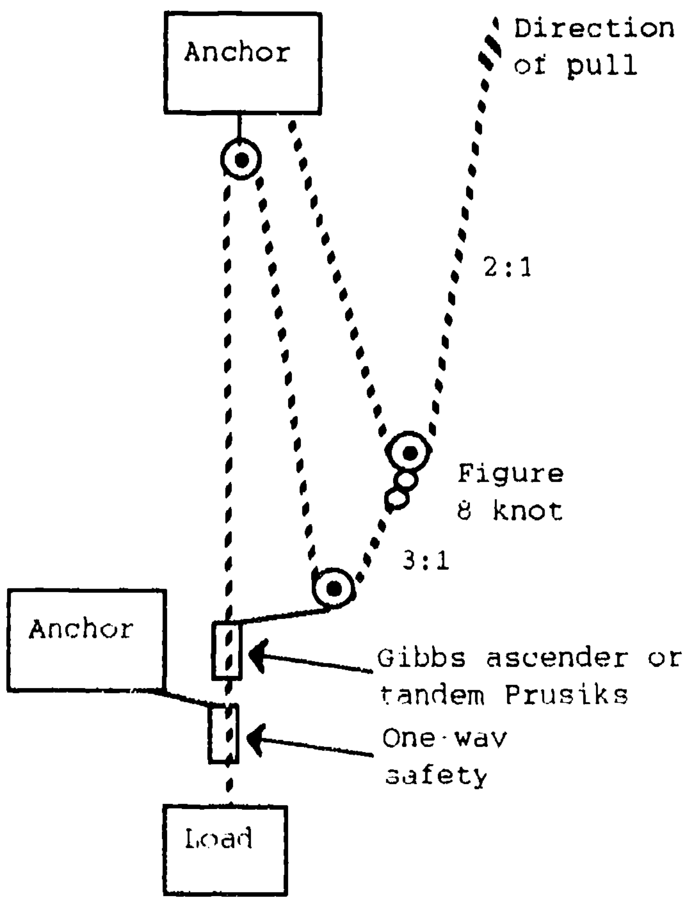


Figure 49. 6:1 Mechanical-Advantage System

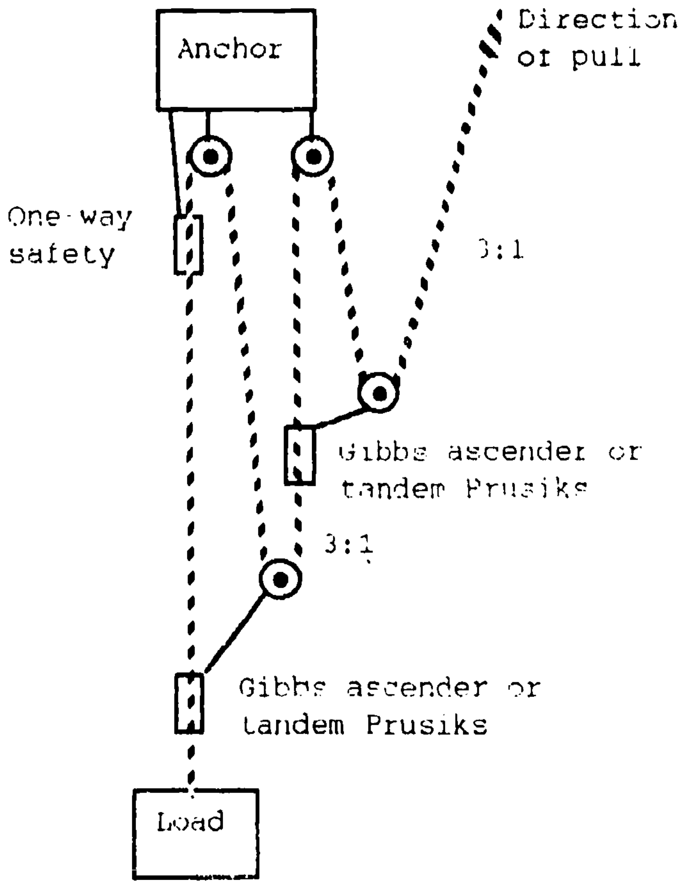


Figure 50. 9:1 Compound System

Special Consideration

The following considerations must be noted when rigging raising systems:

The mechanical-advantage of the systems listed is only theoretical; the practical mechanical advantage is always less due to added friction from the pulleys. Larger diameter pulleys cause less friction than smaller ones. Three" or four" diameter pulleys are recommended.

When determining the mechanical advantage of a system, remember that the traveling pulleys (the ones attached toward the load) increase the mechanical advantage; the fixed pulleys (the ones attached to the anchors) only cause a change of direction.

Compound systems can be extended to extreme ratios, but the theoretical advantage gained is outweighed by the added friction of the pulleys. Increased mechanical advantage causes decreased sensitivity in the system, which can easily lead to a severe overload and failure. Rig systems with just enough mechanical advantage to get the job done. Before rigging a system, the incident commander should consider: the weight of the load, the amount of equipment, the number of rescuers, the amount of space, and the time available.

The greater the mechanical advantage, the more rope must be pulled through the system. For example, in a 3:1 system, three feet of rope must be hauled for each foot the load travels.

Always place the ratchet cam or safety in front of the haul system (see Figure 46-B). If this is not possible, place it near the main anchor just in front of the first pulley (see Figure 47). It must be anchored securely so that it can hold the entire weight of the load in the event the raising system fails. One rescuer must be assigned to function as a tender throughout the entire raising operation.

With any raising system, always use a separate belay line, properly anchored, with a raising system. The rescuers must not allow any slack in the belay system during a haul.

Anchors must be bombproof. Be sure to pad all edges and abrasion points.

Raising and belay systems must be carefully monitored during the rescue operation. Safety and backup systems should be anticipated and prerigged when possible.

Changing Direction

Sometimes it is necessary to change the direction of travel of a raising or lowering system. The rescue team must know how to do this safely and quickly, even while the system is under load. Changeovers must be done in such a way that the load is always held securely.

To change a lowering system to a raising system, lock off the belay and attach a mechanical-advantage system to the load line. The descender can then be removed from the load line. Unlock the belay and proceed with the haul.

Changing from a raising system to a lowering system is easier if the ratchet cam or safety is attached to the main line; use a load-releasing hitch such as a Mariner's knot (see Figure 51). To change over, set the safety on the haul system and lock off the belay. Remove the mechanical-advantage system from the main line, then attach and lock off the descender. Release the Mariner's knot to transfer the load from the safety to the descender. Unlock the descender and the belay; prepare to lower.

Raising a load a long distance may require tying ropes together for extra length. The rescue team will then have to deal with passing knots through the raising and belay systems. Special knot-passing pulleys can be purchased. Remember to change only one line at a time so that the load is always secure. If possible, tie the knots so they do not reach both systems at the same time.

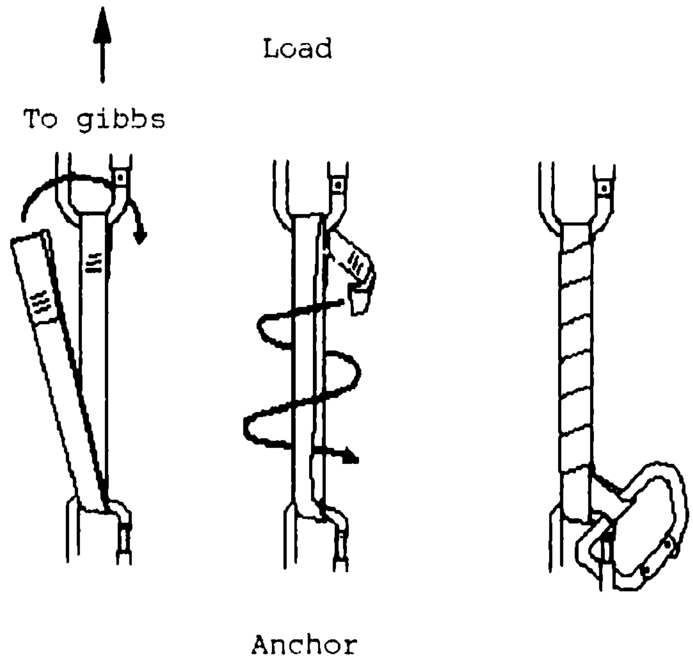


Figure 51. Mariner's Knot

Rescuers should train to perform changeovers and knot passes in the same sequence every time. This will allow less margin for error or lost time.

Each rescuer must be familiar with the commands and signals used. Good communication among all the rescuers is essential to the safety and success of the operation.

Standard raising system commands include the following:

"Haul." Haulers pull steadily and smoothly to raise the load. The safety tender should keep all slack out of the ratchet cam system.

"Set." Haulers stop pulling and release just enough tension for the safety tender to set the ratchet cam.

"Slack." Haulers reset the raising system to gain maximum travel with each pull.

"Tension." Haulers stop moving, but continue to hold tension on the raising system until another command is given.

CONCLUSION

When operating a raising system, it is very important for the rescue team to be well organized. The incident commander should assign specific duties to each rescuer for hauling, belaying, and tending to the ratchet cam. Coordination and communication are the key factors in a safe, efficient Mechanical-advantage raising system.

RIGGING

KEY POINTS

- **Using deadmans and pickets**
- **Using block-and-tackle appliances**
- **Below-grade rescue rigging**
- **Above-grade rescue rigging**

INTRODUCTION

Rescuers are called for a variety of incidents, frequently a victim must be raised from a confined space (a trench or silo), or lowered from a high elevation (a building top or hillside). Often an aerial apparatus is used to assist in the rescue; however, in some locations it may not be possible to use an aerial apparatus. In such incidents, rescuers may have to rig a device on site to assist in rescue operations.

Use of Deadmans and Pickets

Deadmans and pickets are used when tie-off points for lifelines are unavailable. This may be in an open field or at a point on a high wall.

A deadman is a timber or pipe buried horizontally in a trench, at a right angle to a pull (see Figure 52). The deadman must be strong enough for the required pull. Dig the trench so that it is just large enough to bury the timber or pipe. The less the soil is disturbed, the better the weight-bearing surface. It is possible for a deadman that is properly set and connected to guys to bear a weight-load up to five tons.

Pickets are suitable for use as holdfasts in ordinary soil for pulls up to a weight-load of two tons. Drive two pickets into the ground 3′ apart at a fifteen degree angle pointing away from the pull, and approximately two-thirds of their length. Attach a fifty-foot piece of 1/2″ rope at its center to the front of the picket (see Figure 53). Wrap the rope together around both pickets and attach with a clove hitch.

Place a third picket between the loops of rope and rotate causing the ropes to tighten. When maximum tension is achieved, drive the third picket into the ground. Place a short sling around the front picket and attach it to the rope with a carabiner (see Figure 54).

NOTE: Use only static kernmantle rope for rigging procedures.

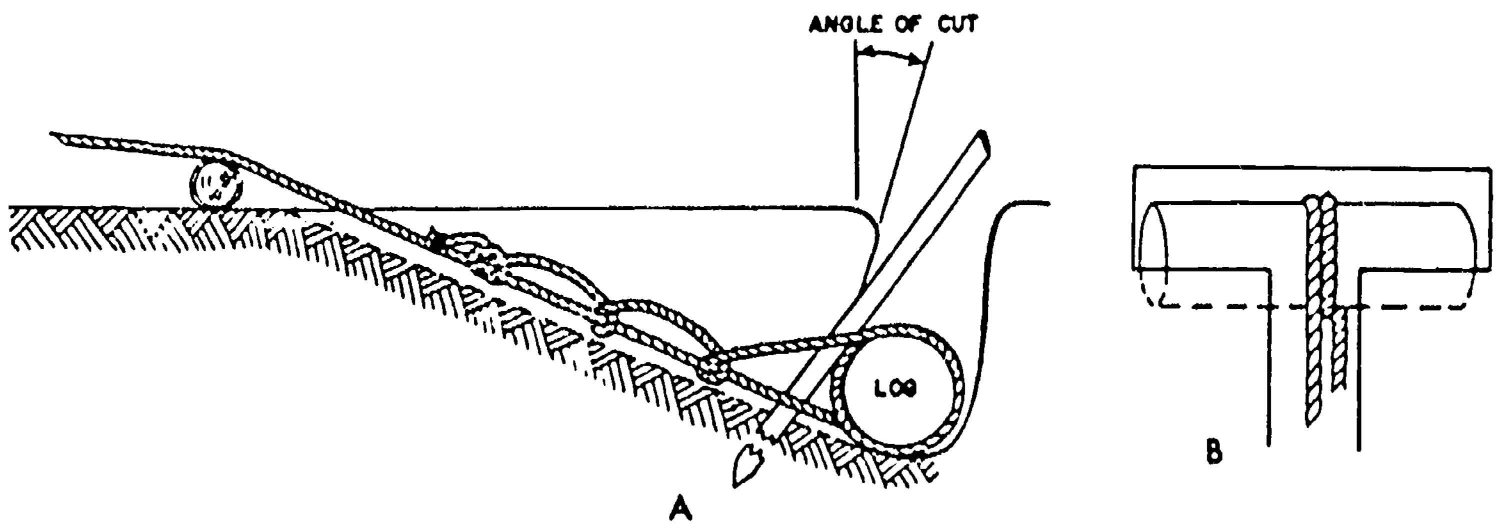


Figure 52. Deadman Holdfast

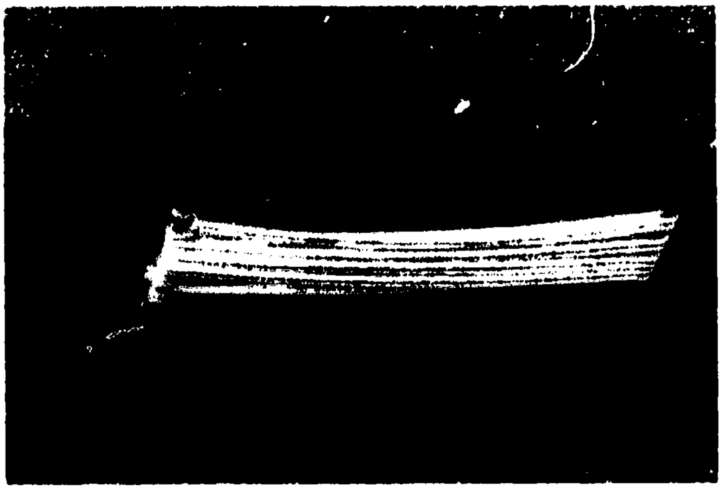


Figure 53. Picket

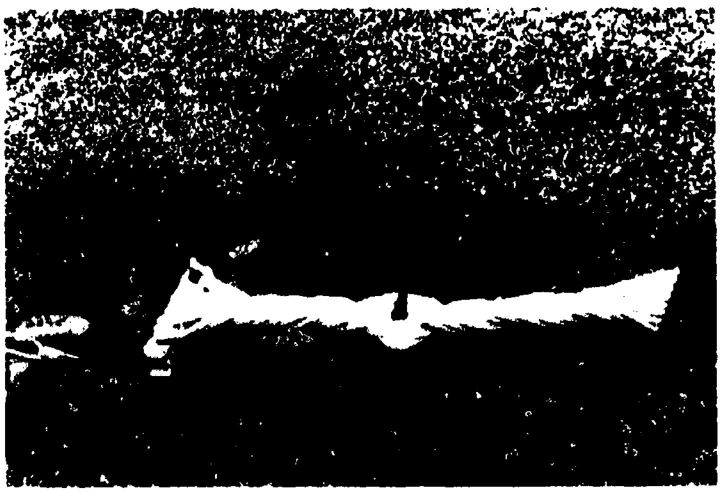


Figure 54. Completed Picket with a Sling and Carabiner

Block and Tackle Appliances

Block and tackles are used in rescue work to provide a mechanical advantage when raising or moving a heavy object. A block is named by the number of sheaves or pulleys it contains. Use only blocks made from aluminum. Never use blocks made of wood to raise a victim. All blocks must be OSHA approved.

The number of sheaves used determines the power gain or the mechanical advantage the block will provide. The number of ropes between the sheaves compared to the haul-line determines the ratio. For example, when using two double-sheave blocks, there are four ropes between the pulleys, which equals a 4:1 mechanical advantage. This means that the force applied to the haul-line will lift four times the weight.

The length of the rope needed to use a block and tackle will determine the lifting ability of the block and tackle. To determine the length of rope needed, count the number of sheaves in the two blocks and add one for the hauling line. This number multiplied by the length of pull of the block and tackle will determine the minimum length of rope needed. For example, a 4:1 system used to raise an object ten feet will require a fifty-foot length of rope.

"Chock-a-block" is a term used with block and tackle applications. It refers to the position in which both blocks are pulled together as tightly as possible.

The twisting of the rope in a block and tackle is hard to prevent and can present a problem. A twist in the rope exerts unnecessary stress on the rope. The force required to lift a load is nearly doubled if the rope has just one complete twist. The best way to prevent twisting is by reeving the block and tackle.

To reeve a block and tackle, place the blocks at right angles to each other, about three feet apart. When reeving the blocks, the rope should remain on the same side of both blocks (see Figure 55). Start the rope at the block that will be placed on the anchor point. When the rope is on the top right of the block, bring it to the top right of the other block. When finished, the ropes will be aligned in a parallel position and should run in opposite directions.

BELOW-GRADE RESCUE RIGGING

If a victim is located over a high wall, on a hillside, in a confined space, or in an underground hole or sewer line, use a gin pole or an A-frame to perform the rescue.

Free-Standing Gin Pole

A gin pole may be used with pickets in a free-standing position in an open area. A twenty-four foot extension ladder is required for this procedure. Establish four pickets as close as possible at a right angle to the victim's location (see Figure 56). Extend the ladder to the appropriate height and lay it on the ground with the fly toward the victim. Use two lifelines. Form the center of each lifeline into a bight. Attach the bight to the top beam of the ladder using a split-clove hitch over both beams at the top rung or a ladder hitch on each beam (see Figures 57 and 58).

When using a split-clove hitch, leave the bights long and connect them together with a carabiner to

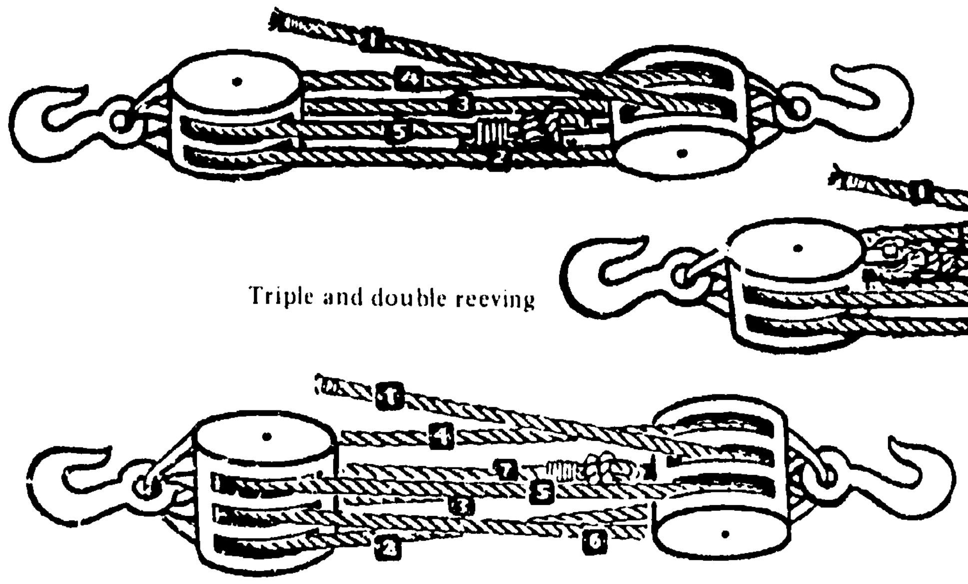


Figure 55. Block and Tackle Reeving

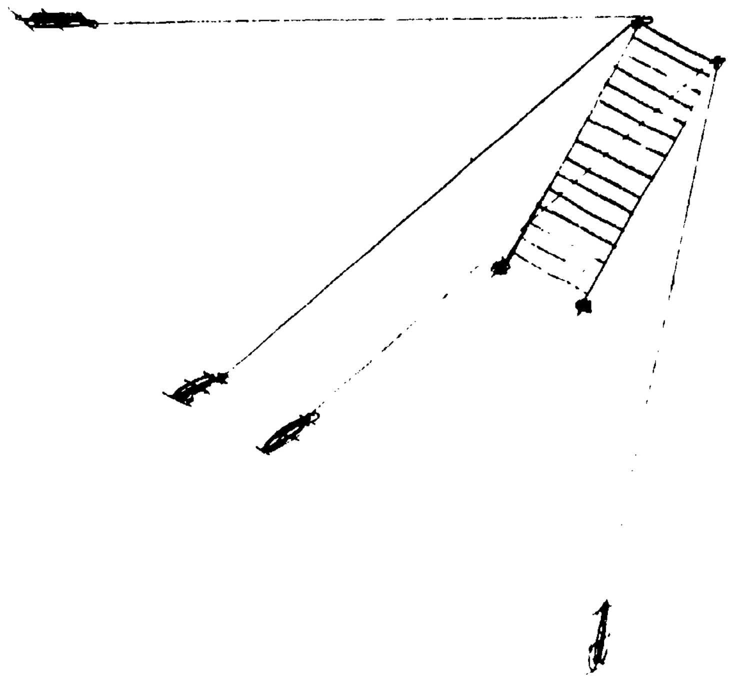


Figure 56. Placement of Pickets

Figure 57. Split Clove-Hitch

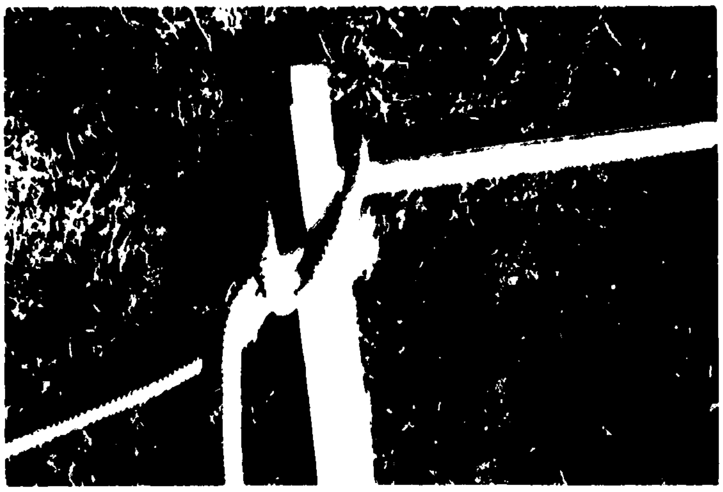


Figure 58. Ladder Hitch

form a sling for the lifeline. If a ladder hitch is used, place two slings on the second rung and beam and attach a carabiner. Attach a sling and single pulley to the beam at the bottom rung. Next, attach a block and tackle to the top sling and thread the haul-line through the bottom pulley. Thread a lifeline through both pulleys and attach it to an approved hauling system.

The bottom change-of-direction pulley is used to assure that the hauling force is in line with the ladder and to help seat the ladder. If a rescuer is to be lowered from a gin pole, substitute a descent device for one of the pulleys.

When the rigging is complete, dig two small holes into the ground to seat the beams of the ladder. Position a rescuer on each of the four ropes and raise the ladder to an upright position. Place the base legs in the holes. Drive a metal stake into the ground next to each beam and attach it to the beam with circular lashing (see Figure 59).

Figure 59. Extension Ladder Secured

Lower the ladder into position and secure the ropes to the pickets. If it is necessary to ratchet the gin pole or move the gin pole back and forth over a hillside, place a "Z-rig" or some other hauling system at each rear picket. This allows the rescuers to move the gin pole over the victim and back again. This may be especially useful when rescuing a person from a high wall or a hillside.

Using a Gin Pole on a Fire Engine

If it is possible to get a fire engine to the victim's location, a gin pole may be rigged off the rear end of the engine. Position the engine in close proximity to the rescue site. Rig the gin pole as explained earlier. Place a 4″ × 4″ × 36″ piece of cribbing on the tailboard of the engine and place the butt of a ladder against the cribbing (see Figure 60). Raise and position the ladder at approximately a 60° angle (see Figure 61). Secure the two guy ropes in position as close to a right angle to the ladder as possible.

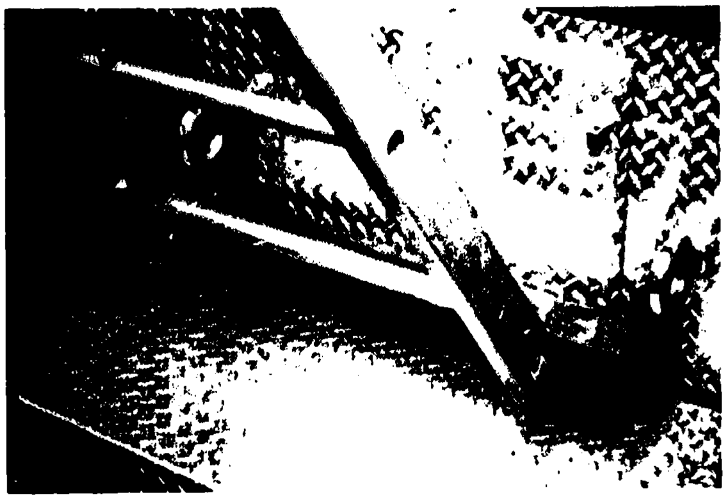


Figure 60. Placement of the Ladder on the Tailboard of an Engine

Figure 61. Ladder Raised and in Position

Place the support ropes over the hose bed and bring them down to the steamer connections of the pump. Secure with clove hitches (see Figure 62). Back the engine into position to effect the rescue. Care must be taken so that the weight of the engine will not jeopardize the rescue attempt.

A-Frame Rigging

An A-frame is very useful in a below-grade rescue operation, especially over a utility entry or a well. To construct an A-frame, disassemble a 24′ extension ladder and lash the two top ends of the sections together at the top rung with a 50′ piece of 1/2″

Figure 62. Support Ropes Secured to the Steamer Connections

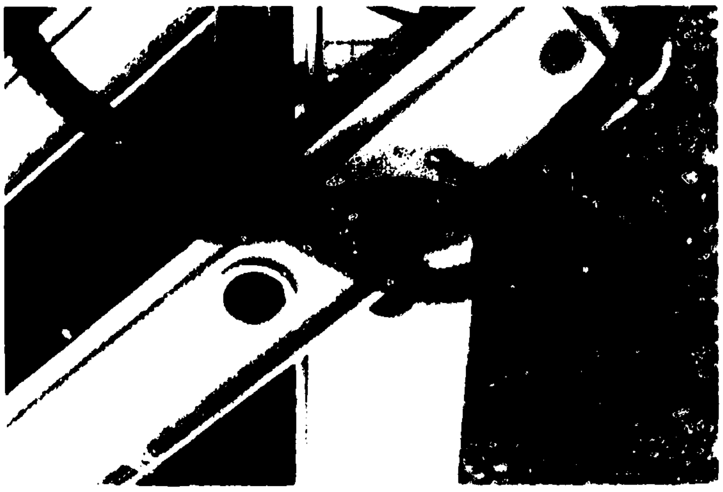


Figure 64. Attaching a Lifeline

rope. Tie a split-clove hitch on the beam and circular lashing around the length of the top rung (see Figure 63). Complete the tying with a split-clove hitch on the opposite side beam.

Figure 63. Lashing Ladder Sections Together to Make an A-Frame

Attach a lifeline at its center to both beams, using a split-clove hitch around the beam at the top rung (see Figure 64). Leave a loop of rope between the two ladders so a figure-eight knot can be tied in the center (see Figure 65). Then use a split-clove hitch to tie the lifeline to the opposite beams.

Attach a block and tackle or other hauling or descending device to the figure-eight knot.

Next, if possible, attach a change-in-direction pulley to the beam at the bottom rung of one ladder. Raise the A-frame into position and dig four holes

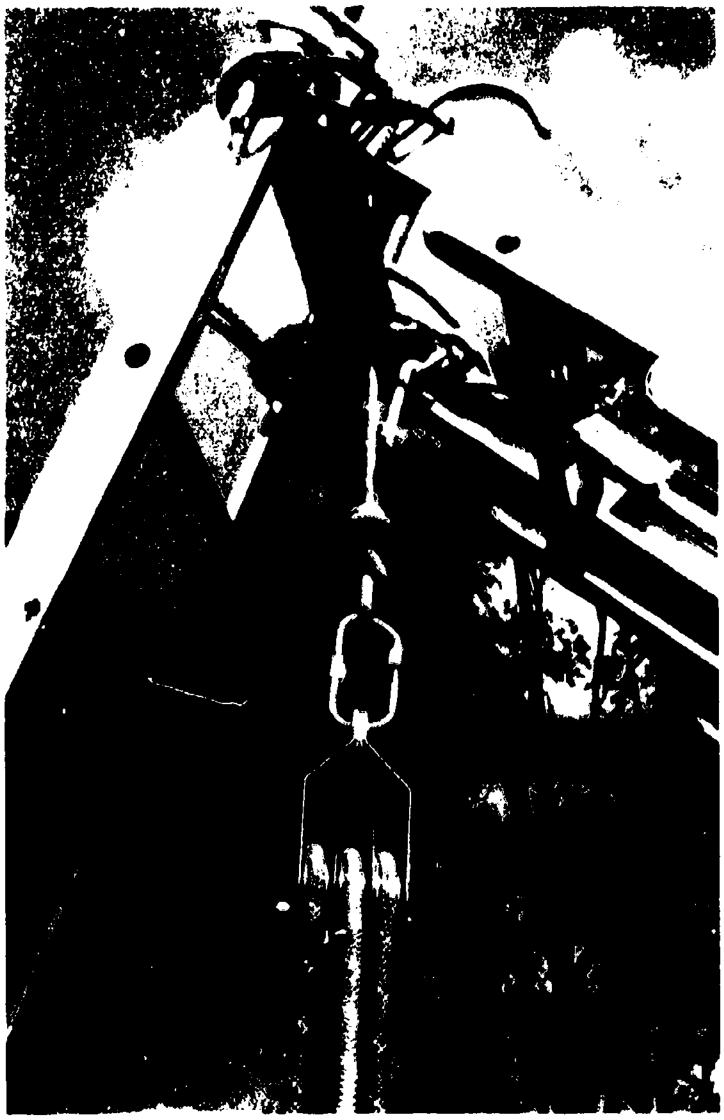


Figure 65. Figure-eight Tied in Center

into the ground so that the beam can sit in the A-frame. Drive stakes at each beam and lash the stakes to the beams (see Figure 66). If it is not possible to drive stakes into the ground (i.e., if there is concrete footing), lash the beams together with short sections of rope to prevent the legs from spreading apart (see Figure 67). Tie the guy lines to pickets and position a rescuer to monitor the guy lines.

Figure 66. Securing the Bottom Beams of the A-Frame

ABOVE-GRADE RESCUE RIGGING

The Ladder Hinge

A ladder hinge apparatus may be used to remove a victim from a roof or the upper story of a building. It can also be used to remove a victim from an accident involving heavy equipment.

Figure 67. Another Method of Securing the A-Frame

NOTE: The ladder hinge is limited to the height of the ground ladder being used.

To remove a victim, place a ground ladder under the window or roof. Position the butt of the ladder against the building. Use two lifelines and draw a bight in the center of each rope. Attach the ropes to the beam at the top rung with a split-clove hitch, and to the ladder hitch. Use one end of each rope as a guy line and use the other ends as lowering ropes. Hoist the ropes to the victim's position. Using a flat raise, raise the ladder and position it two rungs above the victim's level. Control the guy lines during this raise.

Once the ladder is in position, place the victim in a Stokes basket and use a sling and carabiner to attach the basket to the second rung of the ladder. Tie a figure-eight knot in each support line and attach each line to the foot of the Stokes basket. Leave enough slack so that none of the tension is taken up between the knot and the ladder.

Attach the support ropes to descending devices and lower the victim to the ground. Use the guy lines to keep the ladder in a vertical position. Carefully controlling the descent, lower the victim in a horizontal position (see Figure 68).

The Leaning Tower

To lower a victim from a second- or third-story window, use a leaning tower. Position a ladder above the window and check the angle of the ladder for safety. Drive stakes into the ground and set the beams into holes in the ground. Then, use 1/2" rope to lash the beams to the stakes with circular lashing. Using slings, attach a single pulley to the beam at the rung above the window.

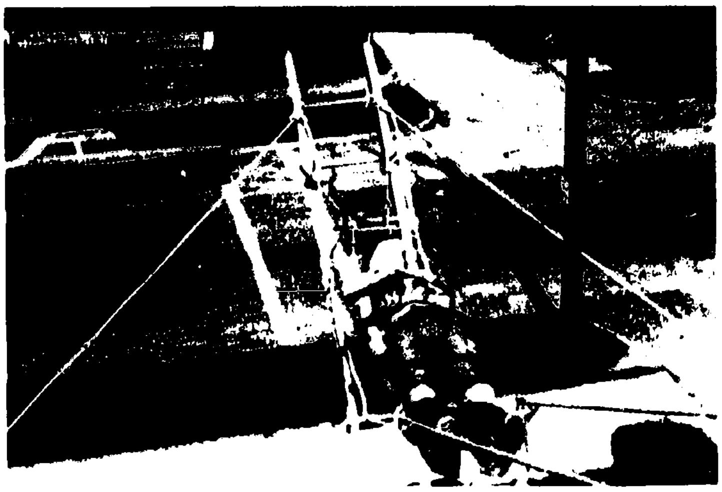


Figure 68. Lowering the Victim

Position a second pulley or descent device on the beam at the bottom rung with a lifeline threaded through the pulleys and attached to the victim in a Stokes basket or body harness. Tie a guy line to the victim and lower the victim to the ground, using the guy rope to keep the victim away from the wall.

CONCLUSION

As with many other rescue operations, rigging requires training and practice. Rigging is an art that must be learned. Any rescuer who will be participating in rigging operations must become actively involved in a serious training program with a qualified instructor.

USING A BRAKE-BAR RACK FOR ROPE RESCUE

KEY POINTS

- **The structure of a brake-bar rack**
- **Preparation and assembly of the brake-bar rack**
- **Rappelling with the brake-bar rack**
- **Safety concerns**
- **Using the brake-bar rack for rescue**

INTRODUCTION

Techniques and devices used in rappel procedures range from a simple body wrap requiring no extra equipment through using equipment such as the venerable brake bar or carabiner rigging, onto very complicated improvised systems. Traditional rappel systems are limited, in that once the rescuer is engaged in the rappel procedure, there is no way to increase or decrease friction on the rope that determines the rappeller's rate of descent.

The inability to change the amount of friction is a critical factor on a longer drop (longer than 100 feet) because of the weight of the rope below the rappeller. Using a constant friction device, the rappeller may barely be able to move at the top of a long drop and end up moving so fast he or she is completely out of control near the bottom. The longer the drop, the more pronounced this effect becomes.

During a rappel, the inability to vary friction also causes a problem if weight is added or subtracted such as when it is necessary for a rappeller to aid a victim who is in trouble. A device suitable for a normally equipped person may not be adequate for the same person carrying extra ropes or rescue equipment. Such a situation requires a device such as a brake-bar rack that allows the rappeller to vary the friction on a rope. The friction can be varied without detaching the device from the rope.

In addition to providing variable friction, the brake-bar rack can be securely locked off, leaving the rappeller's hands free to tend to a rescue litter and an occupant, or rigging vertical gear. Once properly set up, the brake-bar rack is easy to manipulate and can be operated by fingertip pressure. The rack's flexibility and ease of operation compensates for its slightly greater weight and bulk, and for the fact that it is slower to rig than some other options, such as the figure-eight descender.

THE BRAKE-BAR RACK

The brake-bar rack is a steel bar bent into a U with attached brake bars that move freely up and down. It can be attached to the seat harness or another anchor. The rack style may differ slightly with each manufacturer; however, most brake-bar racks have the following parts.

The rack frame (the shaft without the brake bars) is made of 3/8″ diameter stainless steel bent into U-shape with one short leg (see Figure 69). Most racks are 14 inches long and designed to be used with six brake bars. A shorter version, 10-12 inches long, uses five brake bars, is lighter in weight, and takes up less space; however, the six-bar rack has greater versatility. The short leg of the rack has a

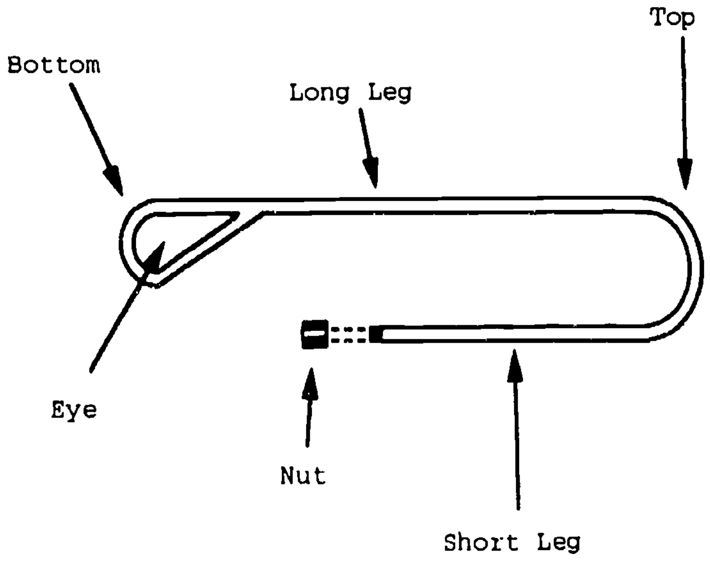


Figure 69. Rack Frame

threaded section for the nut that keeps the bars on the rack. This may be a self-locking nut with nylon in the grooves of the last few threads, or two standard, nonlocking nuts.

The longer leg has an **eye** through which a carabiner can be clipped to attach the rack to a seat harness when rappelling, or to an anchor when lowering. The center of this eye is at the center of the curve at the bottom of the rack.

The construction of the eye is critical. Some manufacturers secure the eye by wrapping the bar in a circle at least one-and-a-half times (see Figure 70), wrapping the tail of the bar around the shaft (see Figure 71), or by applying a weld (see Figure 72). The weld is the strongest method.

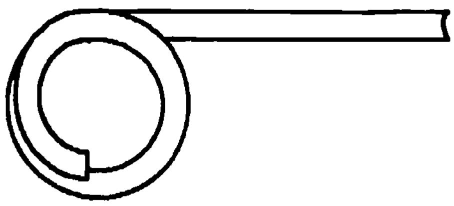


Figure 70. Securing the eye by a double wrap around into circles

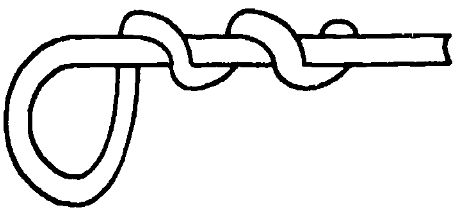


Figure 71. Securing the eye by wrapping the "tail" around the shaft

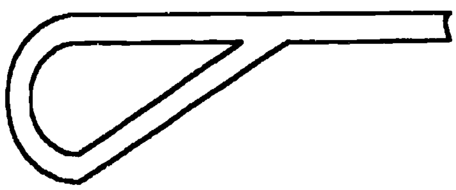


Figure 72. Securing the eye by welding it to the shaft

When under stress, eyes secured by wrapping the bar in a circle or wrapping the tail around the shaft may begin to unwind; however, correctly welded eyes can withstand more than 10,000 pounds during tensile tests. When purchasing a rack with a welded eye, be sure that the weld has been individually inspected either by X-ray or with a dye-penetrant.

The entire rappel rack is a frame. The term **rack** refers to the entire device including the 3″ cylindrical brake bars not just a bare frame.

Bars may be made of solid aluminum or steel. The choice of bar used depends upon the weight encountered and conditions expected. Aluminum bars are lighter and less expensive than steel; however, steel is more resistant to wear and allows a faster rappel. The steel bar may be preferred when making a short drop or using muddy ropes, and may be the best choice for lightweight rappellers.

The use of steel and aluminum bars may be mixed. For example, a lightweight rappeller doing a long drop may want to use steel for the top one or two bars and aluminum for the remainder. If a rappeller is used to using aluminum bars and switches to steel bars, it is important to be careful on the first rappel, especially if the rope is new.

Standard brake bars are 3/4″ in diameter. A 1″ diameter aluminum bar is also available for use as the top bar. The top bar is designed to absorb the extra heat and wear received by the top bar. Some bars have a machined groove on the front, which helps keep the rope centered on the bar. If the top bar has no training groove, file a shallow groove in the middle of the top of one or two bars (see Figure 73) to keep the rope running down the center.

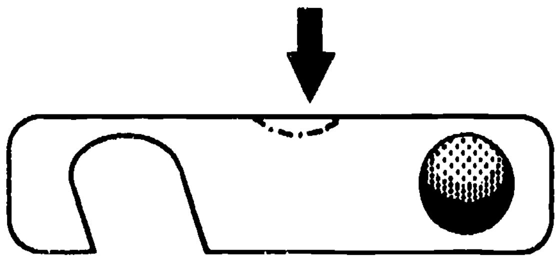


Figure 73. Placement for shallow groove to be filed into top bar(s) for better rope guidance

Preparation and Assembly

Quality control for the manufacture of vertical gear is excellent, but every new rack should be carefully examined by the user. The sides should be smooth, parallel, and in the same plane. Slight problems may be corrected by bending the frame with the hands into the proper shape. If a rack is out of alignment or visible defects can be seen, return it to the manufacturer.

Threading a Bar

As the rope is passed over and under successive bars, a friction is created to control the rappeller's rate of descent. One end of each bar has an angled or straight slot, which is open on one side (see Figures 74 and 75). The angled slot allows the other end of the bar to be easily slipped onto or off the rack

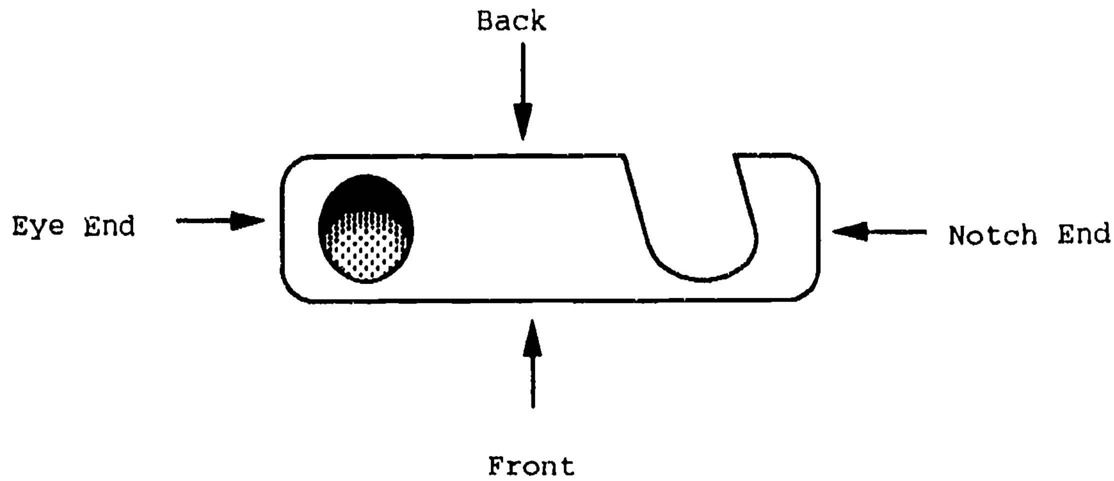


Figure 74. Standard Brake Bar (or Angled Slot)

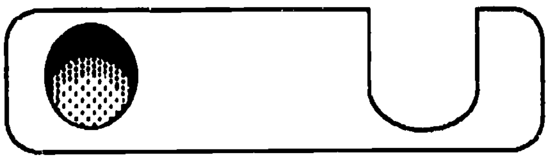


Figure 75. Straight Slot Brake Bar

when the two legs of the rack are pinched together. The straight slot bar sometimes called the stupid bar, will stay in the correct position only when the rope is threaded correctly.

It is very important that the rope be threaded so that it touches the side of the bar opposite the open slot (see Figure 76). This side is referred to as the front and the side with the open slot as the back. Threading in this manner ensures that the force of the rope when under tension helps keep the bar on the rack rather than forcing it off.

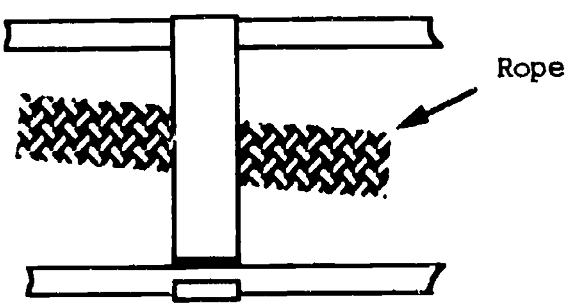


Figure 76. Segment of rappel rack showing the rope correctly placed, touching the front side of bar (the side opposite the notch opening)

If the straight slot or stupid bar is used, use only as the second bar down from the top on a rack. If the rapeller begins to lace up the rope from the wrong side of the bars, it can be easily noticed. Using a straight-slot bar below the second position from the top can be dangerous. It may swing or fall out of place when adding or subtracting bars while in rappel. Using angled slot bars in the third through sixth positions will prevent a problem.

It may be necessary to smooth a rack with fine emery cloth and steel wool. To do this, remove the bars from the rack. Examine the eyes of the bars and, if necessary, smooth these with a round file and emery cloth. No rough edges on the rack or bars to abrade the rope can be left on the rack. The bars must slide freely on the frame when it is held by the eye and tilted up and down.

How the Rack Rides

Attach the rack to the seat carabiner so that (assuming the carabiner lies flat against the body) the rack will ride with the long leg up. After handling the rack a few times, the rappeller knows that each time a bar is engaged or disengaged it will be necessary to switch the rope to the opposite side of the rack to keep the rope in the same position relative to the bottom bar. Switching sides is difficult unless the short leg of the rack is on the bottom, pointing toward the ground.

Placement of the Bars

Thread the eyes onto the long or short leg, as shown in Figure 77. It is best to place them on the long side, allowing the engaged bars to be further spread apart. If necessary, a disengaged bar may be moved completely out of the way.

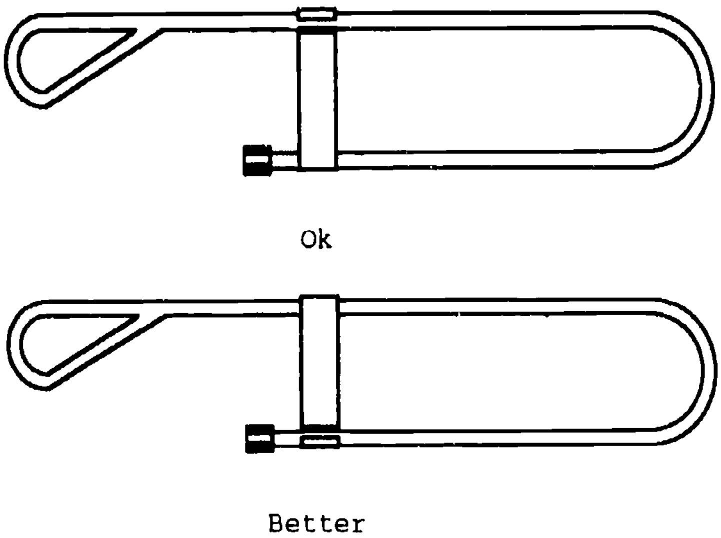


Figure 77. Alternative method to thread a bar onto a rack frame, with eye on the long leg

Number of Bars Used

For most applications use six bars. For a lightweight person (120 pounds or less) not carrying extra gear, five bars may be sufficient. Remember, more friction is needed when carrying long ropes or additional gear, or when using a rack for a rescue operation. Using six bars, the rappeller can spread the bars to decrease friction and still maintain the safety of having four or five bars engaged at all times. A heavy person carrying heavy gear will need to use six bars at all times. Inexperienced rappellers sometimes assume that short drops require fewer bars. The same number bars are needed for short drops as for long drops.

Types of Bars Used

Rappellers who prefer extra friction may use the larger aluminum bar as a top bar. The straight slot bar, which is held in place by the rope, helps prevent lacing the rope in backwards, is placed as a second bar only. Put remaining bars into place once the second bar is secured.

Setting up the Rack

Put the lowest bar on the rack first. Slide it around the bend and clip it in place. Remember the slot on this bar must face in the direction of the preferred control hand. Put the next bar on the rack with the slot facing the other hand. Continue alternating the bars up to the top bar. If a 1″ diameter top bar is used, place it on the rack last. The following examples illustrate the rack setup procedures (see Figures 78 and 79).

The rack shown in Figure 78, with the sixth bar engaged, would work for a normal-size, left-handed person or for a right-handed person who prefers to control the rack with the left hand.

Once the bars are in place, replace the nut securely. If it is the self-locking type, use a wrench to turn it a full turn past finger tight. If it is not, screw a second nut tightly against the first one to lock it in place.

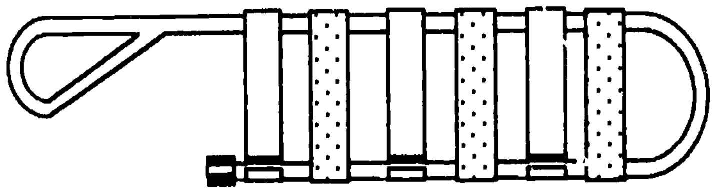


Figure 78. Rack setup for a large right-handed rappeller. Six bars

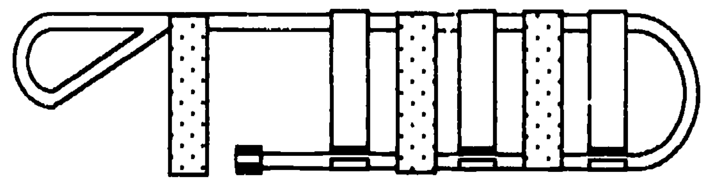


Figure 79. Rack setup for a small right-handed rappeller usually with five bars or less

ATTACHING A RACK TO A ROPE

Placement of Free End of the Rope

Placement of the free end of the rope is a matter of the preference of the rappeller. Most people control the free end of the rope with their preferred hand (right, if right-handed, left, if left-handed) and cradle the rack with the other hand. Set up the rack so that the rope is placed so it comes off the bottom bar on the preferred side when all bars are engaged.

Threading the Rope

Before threading the rope make sure it is correctly anchored and that the proper edge protection is in place to protect the rope. Prepare to rig-in by disengaging all bars except the top one. This is done by sliding the bars one at a time toward the bottom of the rack. By pinching the short leg of the rack toward the long leg, the slotted ends of the bars can be easily slipped off the rack with the thumb or fingertips.

When at a safe distance from the lip of the drop, turn away from the drop so the standing anchored end of the rope is in front of you with the rope passing at the side on the same side as the front of the top bar, then behind you and over the lip. Next, pick up the rope.

At this point, weave the rope through the bars, between the two sides of the rack, by clipping in the bars on alternate sides of the rope. To make it easier, pull up enough rope to give a little slack. It is important to remember that if the rope is very long and dropped, its weight applied suddenly to the partially rigged-in rack can throw the rappeller off balance. The rappeller must be far enough from the lip of the drop that the fall will not be harmful.

Next, pass the rope between the legs of the rack so that it touches the front and bottom of the top bar. **DO NOT** pass it between the top bar and the bend of the rack; this will pinch the rope, causing the rack to wear excessively. With the rope on the side of the rack opposite from where it started, clip the second bar in place and slide it up. This pinches the rope between the top and second bars. Next, bring the rope back toward the side where it was started. Clip in the third bar below the rope and slide it upward. Continue this procedure until all bars are engaged (see Figure 80).

If the rack is set up properly, the rope, when held in the preferred control hand, will be coming from beneath the bottom, (or lowest engaged) bar.

After some practice, a rappeller can prejudge the amount of friction that will be needed for the various drops. It is wise to clip all the bars in place when doing a longer drop. However, it is always necessary to **start with at least one bar more than you think will be needed.** It is far better to have too much friction at the top of a drop than to have too little. The first few drops practiced with a rack should be short ones using all bars.

The number of bars needed depends on the following factors:

1. **The weight of the rappeller.** The heavier the rappeller, the more bars needed.
2. **The weight of the gear.** More gear weight will require more bars.
3. **The length of the drop.** Longer drops require fewer bars at the top of the drop.
4. **The character of the drop.** Free rappels, when the feet are not touching a wall and all of the rappeller's weight is on the rope, will allow the rappeller to move faster than those done against a wall. More bars are needed for a free rappel.

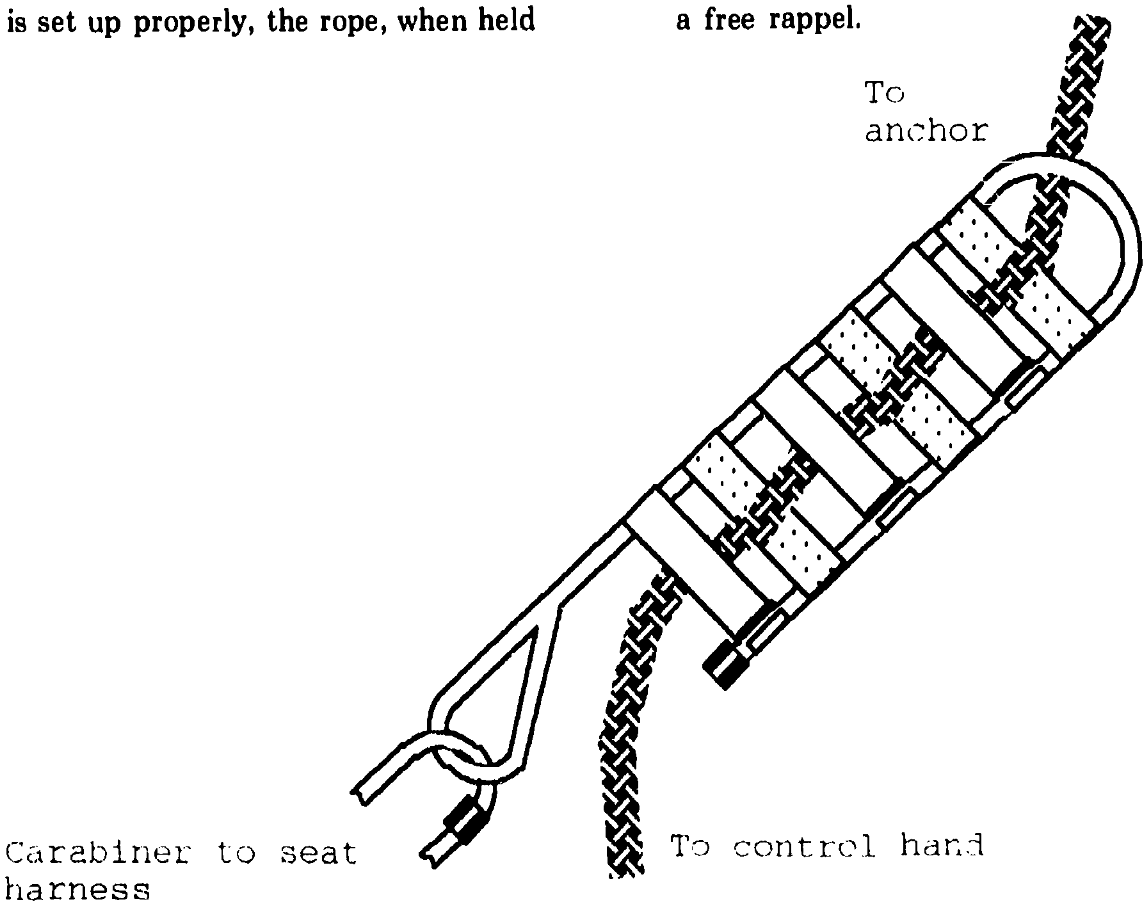


Figure 80. Rappel rack ready for descent

5. **The bar material.** A rappel on a rack with steel bars will go faster than one done on a rack made with aluminum bars.
6. **The type of rope.** Some designs of rope give faster rappels than others, and ropes of the same design may even differ slightly among themselves. The slicker the rope, the faster the rappel.
7. **The condition of the rope.** Significant factors include the following:
   a. **Age** - New rope allows a faster rappel than older rope.
   b. **Cleanliness** - Clean rope allows a faster rappel. Dirt or mud on the rope slows a rappel considerably.
   c. **Wetness** - A dry rope allows a faster rappel than a wet rope; however, a rappel through water may be faster because water lubricates the rope/bar contact.
   d. **The size of the rope** - The smaller the diameter of the rope, the faster the rappel.

RAPPELLING

Before proceeding with a rappel **double check the rig** to make sure the seat carabiner is locked and the rope is threaded on the correct side of each bar. This check is very important and must not be omitted. Excitement, fatigue, or a distraction can cause even an experienced person to rig in backward if not cautious.

When rappelling, wear gloves with leather palms to protect the hands. The friction of the rope against a bare hand can burn the skin. Also, the rack can get too hot to touch with bare fingers.

Stance and Position

The rappelling stance with the rack in place is the same as with other devices. Whether the rope drops between the legs or to one side is a matter of personal preference. The following description is based on the rope dropping to the side.

Hold the free end of the rope in the control hand slightly below the hip. The other hand is then free to move bars up and down, engage or disengage them, and maintain the spacing between the lower bars. This hand is referred to as the cradling hand, because it is usually held with the thumb on the upper leg of the rack and the fingers curved around the lower leg. It should always be on or near the rack.

Friction

If the rappel is a free drop, wait until the body is hanging free to adjust the bars on the rack. The point at which the body is hanging free is the point at which the maximum friction will be needed.

Friction can be adjusted on a rappel rack by changing the number of bars engaged or by changing the distance between the bars. The second step is a fine tuning of the first. On shorter drops, just changing the distance between the bars will probably adjust the friction. Friction can also be adjusted, by tightening the grip of the control hand or changing the position of the control hand in relation to the body.

Adding or Subtracting Bars

The procedure for adding or subtracting bars has been discussed earlier. The process is the same when rappelling with one exception. When ready to engage or disengage a bar, raise the rope above the bar being changed, thus jamming the remaining bars toward the top of the rack. It is not as easy to change bars when actually hanging on the rope as when at the top before beginning a rappel. This is due to the weight of the rope below which p[illegible] some tension on the rack and tends to keep the bars engaged.

Do not wait to add another bar until the last minute when all the engaged bars must be jammed up tight to keep the descent from going too fast. There will be a moment while changing bars when the tension will be less. It is possible to lose control at this point if you have waited too long.

An alternative to completely disengaging the bar is to switch hands and use the cradling hand to hold the bottom bar at the appropriate place for the friction needed. If the rappel is too fast after taking the rope off the bottom bar, push the bottom bar back up against the rope to slow the rappel.

Never take both hands off the rope unless the rack is locked off. When changing from right to left, move the rope to the left side with the right hand, grab the rope with the left hand, and then let go with the right hand, moving it up to cradle the rack.

Next, begin spreading the bars again, until the right amount of friction is achieved. The principle is simple: the closer together the bars, the tighter the bends in the rope, the greater the surface contact between the rope and bars, and the greater the friction. To slow down the rappel, move the bars together with the cradling hand. Remember, if there is a lot of rope below the rappeller, it is harder to move the bars.

Stopping

There are five methods for stopping a rappel. Each depends on adding enough friction to overcome the weight of the body and the gear. The first and simplest method is to use the control hand. Simply grip the rope tighter. This adds more weight to the rope passing through the rack and increases the rope/bar friction. The added pressure on the rope will stop the decent. If this is not sufficient, pull the rope tightly against the hip. This method adds friction in the same manner. When wearing a nylon seat harness, make sure that the rope does not ride across the harness; the friction can cause glazing or fusing, or can even burn through the harness.

A second method is to use the cradling hand to jam all the bars tightly against the top of the rack. The cradling hand is then kept around the rack below the bars to keep them from working down (see Figure 81).

A third method of stopping is to simply raise the rope in the control hand above the rack. This will jam the bars together bringing the rappeller to a quick stop. This is a very effective stopping method that can be used when the rappel is becoming uncontrollable.

A fourth way to add friction is by using the body. Place one leg down and swing it around the free end of the rope so that the rope is wrapped around the leg. In a free drop the efficiency of the leg wrap can be increased by holding the leg out perpendicular to the body.

These methods are useful for short-term stops. They require the rappeller to keep the hands in the normal position on the rack and the rope, through the rappel.

A Soft-lock is shown in Figures 82 and 83.

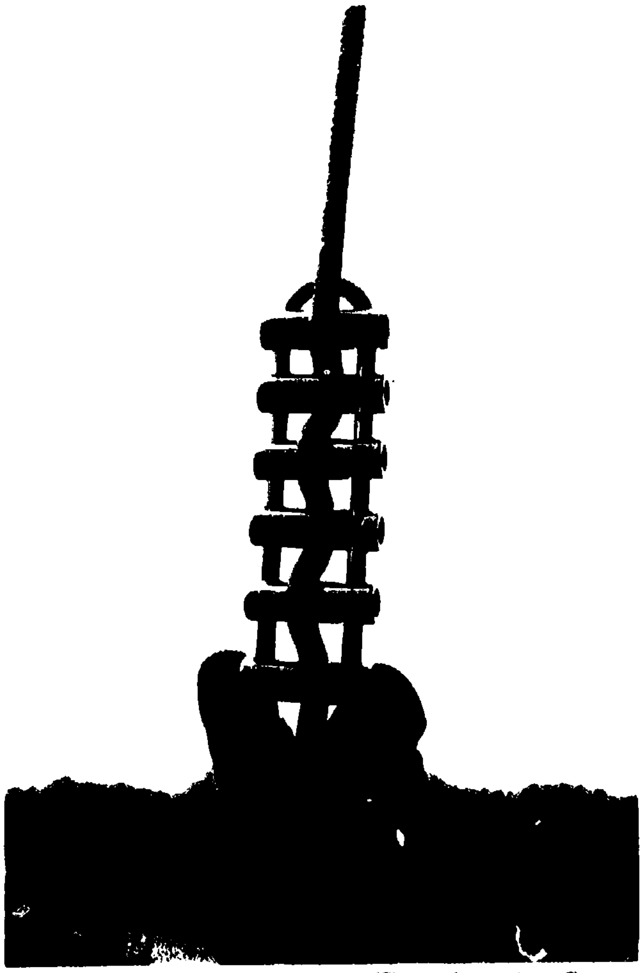


Figure 81. Brake-Bars Held Together for Stopping

Figure 82. Preparing for a Soft Lock-Off

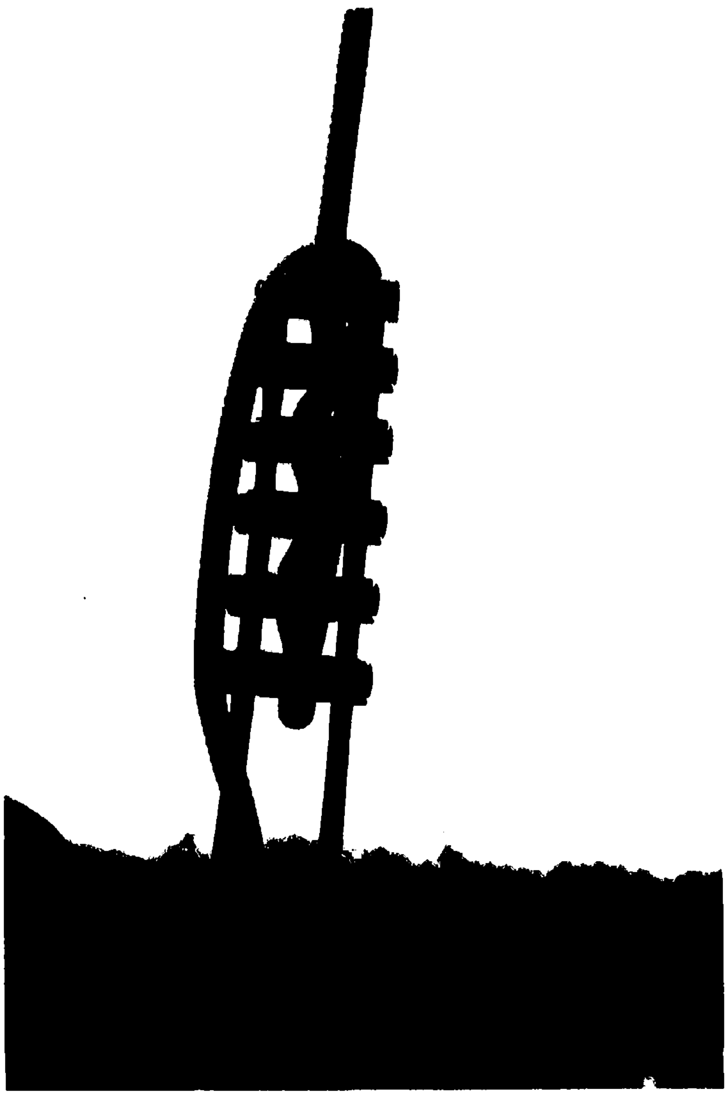


Figure 83. Rope in Soft Lock-Off Position

To stop for a longer period of time or if it is necessary to free both hands, lock off and tie off the rack (as shown in Figures 84, 85, and 86). To do this, jam the bars together at the top and bring the rope in the control hand toward the top of the rack. Slip it between th~ bend of the rack and the standing portion of the rope. If the top bar is a regular size, the rope can be firmly nestled by pinching it between the rack and the standing rope. If the top bar is too large to make the tie-off secure, then tie the rope.

To continue rappelling, reverse the procedure. Remember, to avoid awkward shifting, firmly grasp the rope as it is unlocked. Keep the bars jammed together until the control hand has been returned to its normal position.

Getting off the Rack

When the bottom of the drop is reached bend or sit down and pull more rope through the rack; then stand up to get enough slack so that the bars can be disengaged. If the drop is especially long, it may be necessary to pull the rope through the top of the rack to get enough slack. Use caution, the rack may be hot enough to glaze the rope or burn the hands. Be sure to remove all bars from the rack and get out of a rockfall zone before signaling "Off Rope" or "Off Rappel".

A bottom belay is a must, especially for training sessions. Position someone at the bottom of the rappel, out of the rockfall zone and in a hip-belay stance. If the rappeller loses control, the bottom belayer can simply put his or her body weight on the rope to add tension to the rope, creating more friction on the rack, and slowing or stopping the descent.

SAFETY CONCERNS

Hair and Clothing

When using a rack on a rappel, always secure the hair and clothing preferably tuck it into a helmet. Do not wear loose clothing, tuck the shirt in firmly. If clothing becomes caught in the rack and a free hand is needed to untangle it, lock off the rack and attach an ascender **above** the rack to use as a safety to seat the harness. Carefully slack the rope in the rack and remove the tangled clothing. Cut the offending m terial only as a last resort. Be careful. Rope under tension is easily cut and may split if the knifeblade even touches it. If a knife must be used, work with the cutting edge pointed away from the rope.

Heat Buildup

On a long drop, heat may build up in the rack, causing it to burn the skin or glaze the rope. When on a long drop, move at a reasonable speed and do not stop once the rack gets hot. It is possible to carry wa'er to pour onto the rack to cool it; however, this should not be necessary.

Rope Length

Always tie a good knot in the end of the rope before using it for rappelling. If the rope is too short, this knot will keep the rappeller from rappelling off the end of it since the knot will not pass through the rack.

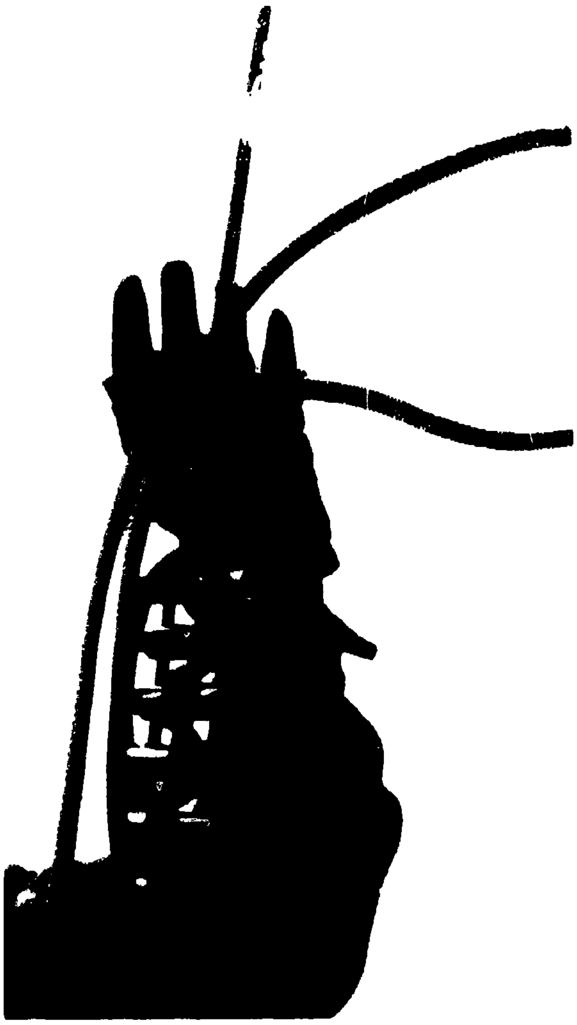


Figure 84.

Figure 85.

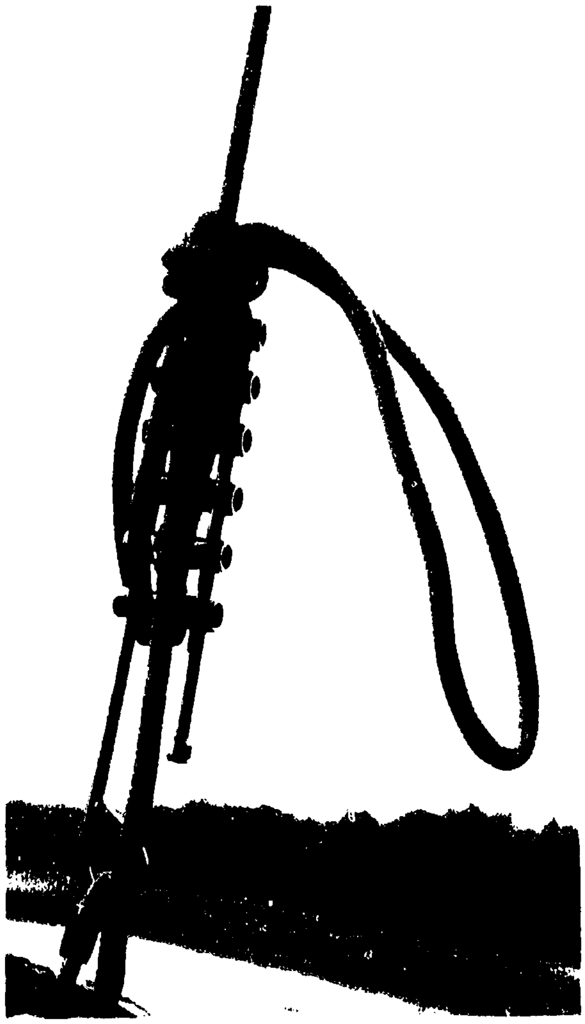


Figure 86.

Figures 84 thru 86. Locking Off and Tying Off the Rack

Care of the Rack

Keep the rack clean. Replace aluminum bars when they are worn one-third of the way through. If the bars do not provide enough friction or they feel insecure, replace them. Replace steel bars before they are worn halfway through. Holes in the steel can create sharp edges that can cut rope.

Check the alignment of the rack occasionally. The easiest way to do this is to engage all of the bars with no rope in the rack and tilt the rack up and down to see if the bars slide freely. If the rack has been dropped or received a sharp impact, it should be inspected by a metallurgist.

USING THE BRAKE-BAR RACK FOR RESCUE

Increasingly, rescue groups are finding that the strength and controllability that make the rack attractive for rappelling also make it an excellent braking device for lowering people and litters. The principles of creating friction are the same, but using a rack for lowering is different from basic rappelling.

There are some different techniques used and these techniques should be taught only by a qualified instructor. There use must be practiced before attempting an actual rescue operation.

Anchoring

One of the most important considerations when lowering rescue personnel or a victim is to have strong anchors for the rack. Some rescuers are satisfied with the single "bombproof" anchor for the rack, while others, insist on multiple anchors or self-equalizing anchors.

Anchor the rack high enough off the ground so that the bars can be easily added or removed. Place it far enough from the edge so that it will not interfere with the rescuers or litter attendants going over the edge, yet close enough so that the brake-person can see and hear the signals.

Once the rack has been attached through its eye to a strong anchor, thread a rope through it and attach it to the object or person to be lowered. Lay the rope out behind the rack so that it can run smoothly.

Fixed Brake Lowering

A very essential person called the brakeperson, must stand between the rack and anchors, and control the rate of the drop by controlling the friction of the rack on the rope. The brake-person should wear gloves to help control the friction, and stay close to the rack at all times in a stable position to lesson the danger of falling.

A rope tangle feeding into the brake system can jam, creating a major problem. If enough people are available, it is helpful to have a rope handler feeding the rope to the brakeperson.

The most difficult part of the entire rappel with a rack is going over the edge. Friction through the rack will seem excessive until the person or the stretcher is over the edge. Only when the full weight is on the system will the brakeperson know how much friction is needed. Remember, on a long drop the rope will add significant weight.

An edge tender is essential when a stretcher is taken over the edge to make sure that the rope stays on the pad or edge roller. The edge tender must be securely tied to an anchor. If the brakeperson must be far back from the edge and unable to see the person or stretcher being lowered or hear the commands, the edge tender can relay information. Several pictures of fixed brakes are shown in Figures 87 thru 90.

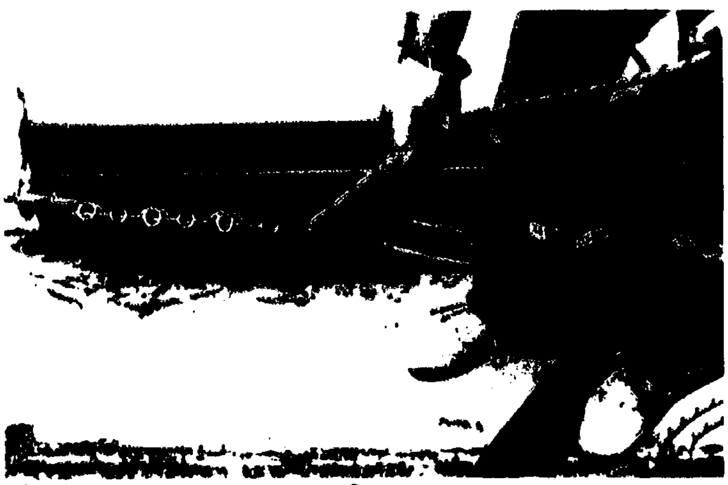


Figure 87. Fixed Brake Lower

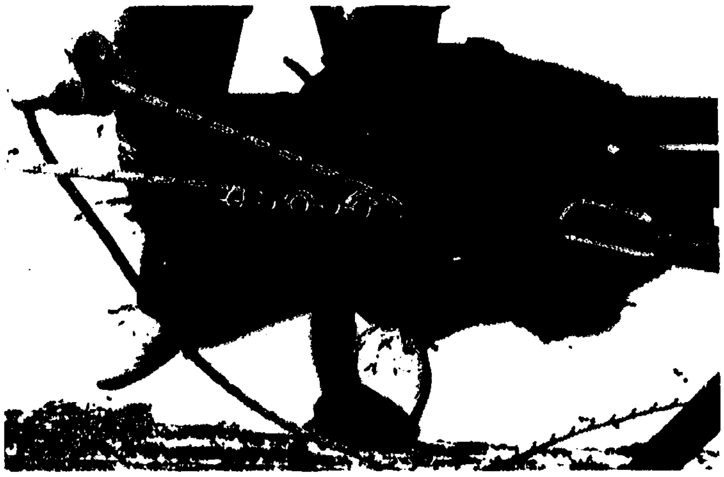


Figure 88. Fixed Brake Lower Stop

Figure 89. Fixed Brake Lowering System in Soft Lock Position

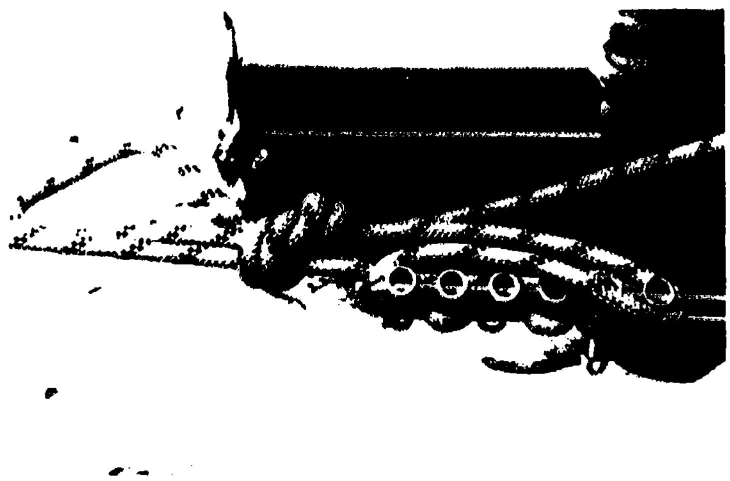


Figure 90. Fixed Brake Lowering System Locked Off and Tied Off

Calls and Signals

Since the brakeperson may not be able to see the rescuers, crisp and clear communications between the brakeperson and the rescuers is necessary. A limited number of clear, distinct signals should be agreed upon before rescue operations begin.

The most commonly used signals are "down slow", "down fast" and "stop". Signals are given by one person only, usually the rescuer on the rope or the litter attendant. However, signals may be relayed by the edge tender.

Additional commands: "stop, stop, why stop?" may be used by the litter attendant when the lowering has stopped with no command from the litter attendant. This can happen if the brakeperson is still feeding out line, and the rope is jammed in a crack. Unless this situation is remedied quickly, all the rope might be suddenly freed, causing severe shock loading.

Lowering the Litter

Some rescue groups prefer to lower a litter with two litter-attendants, while others prefer to use only one. This is determined by protocal and the training that the rescuers have received. When lowering with two attendants, two ropes are usually run through the braking system and attached to the litter (see Figures 91 and 92). The weight of the two attendants helps keep the litter horizontal.

Using two racks controlled by two rescuers may lead to difficulty in keeping the ropes going through at the same rate, and a problem keeping the litter in a horizontal position (see Figure 93). Running both ropes through one rack managed by a single brakeperson allows better control.

Since the head end of the person in a litter is heavier than the foot end, there will be greater weight on one rope and a tendency for the litter to become unbalanced. A couple of ways can be used by the brakeperson to overcome this difficulty. First, the brakeperson must grasp both lines in a two-rope lower with the control hand and keep them together in the brake rack. This will keep the litter even and help prevent the ropes from getting crossed in the device.

If lowering is still uneven, the brakeperson should use both hands and hold the slower-moving line away from the lower bar to reduce friction on that line. When lowering with one rope, there should be a separate belay from a separate anchor, run by a separate belayer. The lowering line and belay line must be kept apart so that they do not tangle or run across one another and cause heat friction or melting.

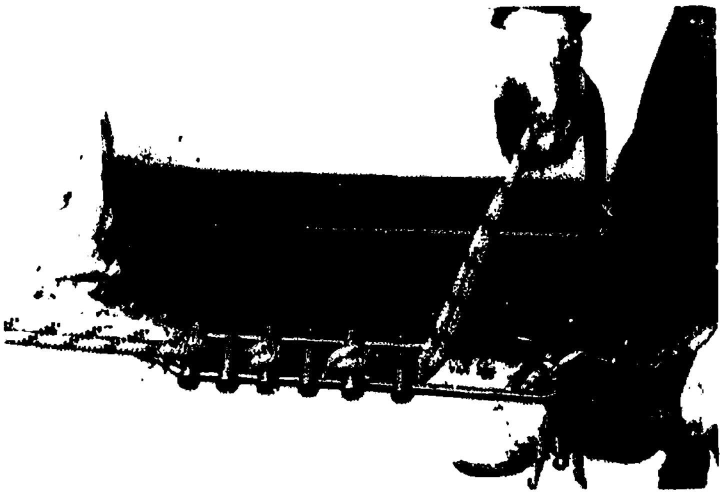


Figure 91. Fixed Brake Lower Using One Rack and Two Ropes

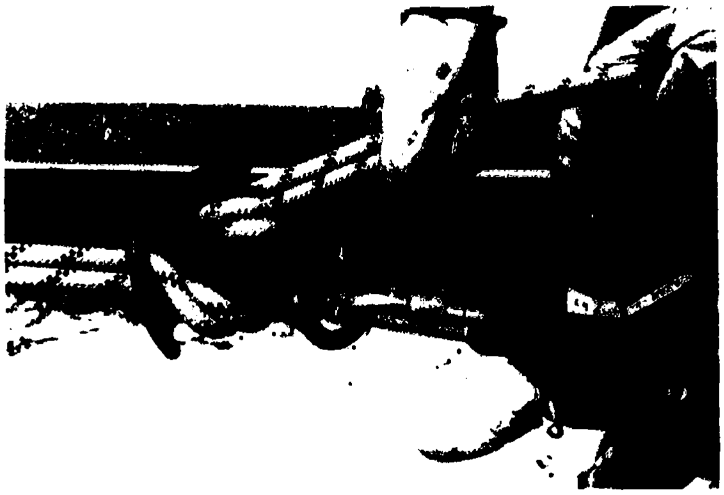


Figure 92. Fixed Brake Lower Using Two Ropes and an Eight-ring

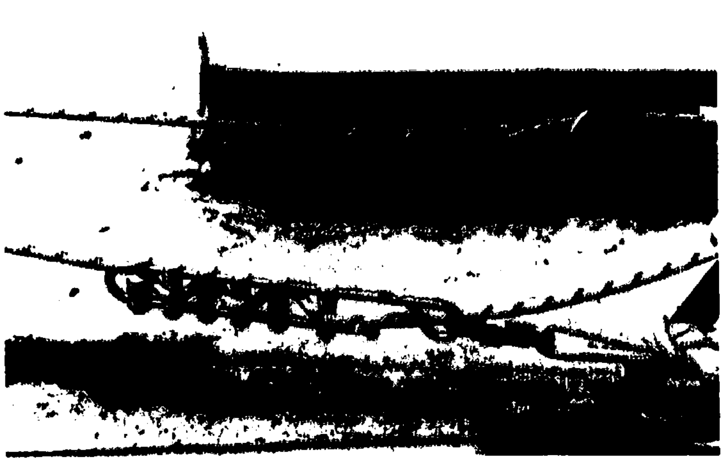


Figure 93. Fixed Brake Lowering Using One Rack on Each Rope

CONCLUSION

Like all rescue procedures, rappel operations require extreme caution. Training and practice are needed to become skillful in the use of the brake-bar rack. Onlv rescuers who have practiced and who maintain these skills are qualified to use the brake-bar rack in rescue operations.

ROPE RESCUE TECHNIQUES

KEY POINTS

- **Introduction to rope rescue techniques**
- **Locking off and tying off an eight-ring**
- **Backing over an edge**
- **Controlling a descent**
- **Stopping a rappel**
- **Self-rescue techniques**
- **One-on-one rescue techniques**
- **Descending using a single rope**
- **Using an eight-ring for a pick-off**
- **The Prusik knot**
- **The Petzl-shunt belay**
- **The Gibbs ascender**
- **Ascending techniques**
- **Changeover techniques**

INTRODUCTION

Before rescuers move a victim in distress using a rope system it is important that the rescuers involved in the procedure have a thorough background in rescue rope systems and the tools and equipment used. Rescuers must also understand the function of special devices, the tensile strengths of all equipment, the load amplifiers, critical angles, and rope construction. To execute a successful rope rescue, rescuers must also know the correct techniques to use during the rescue procedures. With training, practice, and experience, rescuers can safely rescue a victim via a rope system.

Written text can only provide information about rope rescue techniques that have been successful. Many hours of training and practice are required to master the vertical techniques that rescuers need to use in today's high-rise society. To rescuers, a **high rise** is any elevated structure such as a building, a smokestack, a tower, a silo, or similar structure.

Vertical rescue techniques may be required above or below ground, and may involve lift procedures in high-rise buildings, sewer systems, confined spaces, caves, or pits.

Fortunately, there is not a daily need for a one-on-one rope rescue; however, one-on-one rescue procedures are necessary when a worker such as a painter or window cleaner working from a swinging-stage scaffold or pick becomes stranded. A motorized scaffold or pick is usually suspended from two steel cables with a motor attached to each end of the scaffold to propel the apparatus up or down the cables. Most motorized scaffolds require two people to operate, one on each end.

If a switch on this apparatus malfunctions, it can cause the scaffold to continue to climb on one end while the other end remains stationary. Thus, the scaffold tips and the workers fall, leaving them suspended by their safety harnesses. Another rescue situation may be caused by a cable failure that leaves the entire apparatus dangling by one end with two workers dangling from safety lines, hanging in their harnesses.

The simplest way to retrieve the victims is to climb to a higher level and retrieve them to a safe place. To execute this type of rescue, adequate anchors must be selected, and a rescue rope must be secured to the anchors. Next, set a roller or pad to protect the rope on the edge of the structure. Then lower the rope down to the ground to a bottom belayer and proceed to rappel down to the victim.

PREPARATION FOR A RESCUE

Locking off and Tying off an Eight-ring

The following method can be used to lock off and tie off an eight-ring, whether on a single or double rope.

1. Remove an eight-ring from the harness. Hold the eight-ring in front of you with the small end toward your body (see Figure 94).

Figure 94. Position Eight-ring

2. Stand facing the anchor points. If right-handed, stand with the rope to your right side (see Figure 95); if left-handed, stand with the rope to your left side. Next, reach down and pick up the rope, and form a bight in the rope with the down side of the bight facing the down side of the rope.

Figure 95. Form a Bight

3. Lay the eight-ring over the bight, bringing it up through the large hole; then pull the bight over and under the small end of the eight-ring to the back side (see Figures 96 and 97). Next,

Figure 96. Place Bight Through the Large Hole of the Eight-ring

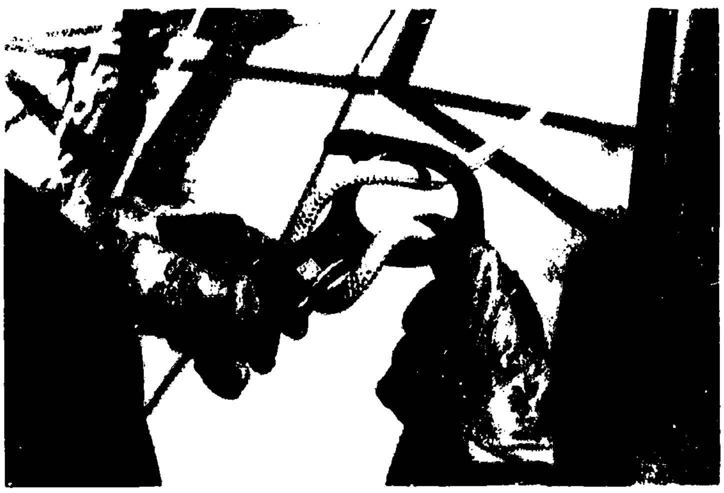


Figure 97. Bight is Pulled Over then Under the Small End of the Eight-ring

attach the eight-ring to the carabiner and harness (see Figure 98).

Checking the System

Take precaution at this point to double-check the system. Start with yourself. As a rescuer, you are a part of the system. Do the following mental check.

1. Am I mentally and physically up to this task?
2. Is my harness on correctly and buckled or tied properly?
3. Are the carabiners (also referred to as "biners") properly attached to the harness?

Figure 98. Eight-ring Attached to a Carabiner

4. Is the descending device attached? Is the gate locked?
5. Is the device properly rigged?
6. Is the rope properly rigged?
7. Will the rope be protected from sharp edges and rub points?
8. Are the anchors strong enough and securely locked up?

Once you are confident that everything in the system has been double-checked, complete a final check (see Figure 98). This time check the rig from a different perspective. It is possible to spot a mistake or problem that was overlooked when preparing the original rig or that someone else may have failed to recognize.

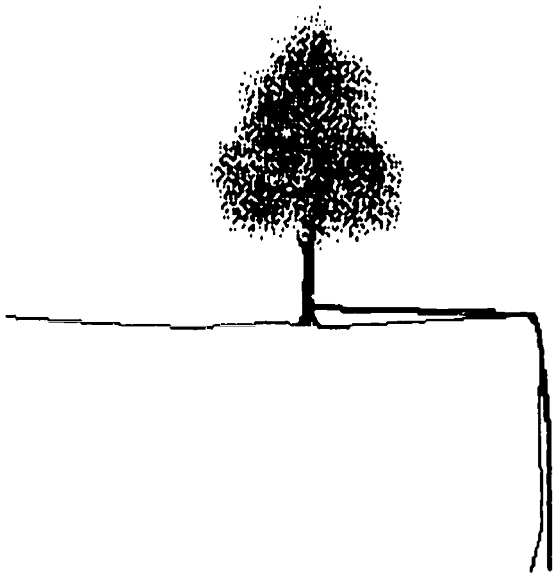


Figure 99. Easy Edge

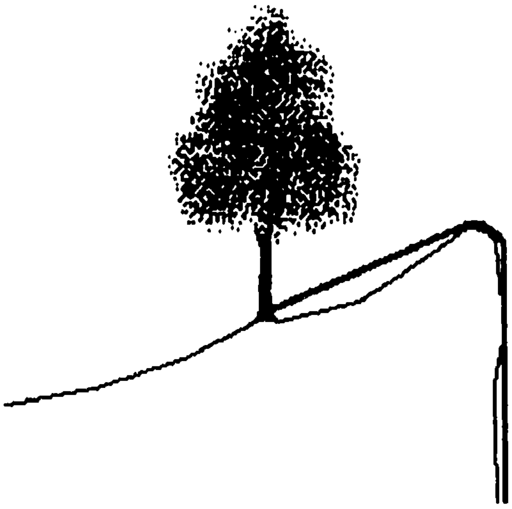


Figure 100. Bad Edge

DESCENT

Backing Over an Edge

Backing over an edge may seem simple, but this task can be very complex. Several factors affect the way this procedure is performed.

First, check the position of the anchor in relation to the edge. An edge that is at the same elevation as the anchor or lower than the anchor is usually easy to negotiate (see Figure 99). However, edges that are higher than the anchor may become tricky (see Figure 100). The rescuer may decide to belly over an edge of this type rather than to stand and back over it.

Other considerations to check when negotiating an edge are the length of rope used between the anchor and the edge, and the elongation of that rope. A rope that has a lot of stretch or one that is anchored a long distance from the edge will make negotiating an edge more difficult.

Before approaching the edge, check to see if a belay person is in place. Yell the signal "On belay" and wait for the return signal "Belay on". As you back to the edge, some pull will be placed on the rope (see Figure 101). This will help pull the stretch out of the rope before getting on the edge.

When rescuers (especially beginners) become white-knuckled, they tend to look down. When yelling "On belay," just glance to be sure that a belay is there, do not stare or focus on the ground.

Keep your feet about shoulder-width apart and position yourself with the edge under the arches of the feet (see Figure 102). Next, take three quick steps down the wall (see Figure 103). Try to keep the legs perpendicular to the wall while descending. If your feet tend to slide down and out from the body, they are placed too low (see Figure 104).

Figure 101. Pulling Stretch Out of Rope

Figure 103. Three Quick Steps Down the Wall

Figure 102. Position to Begin Belay

Figure 104. Feet Placed too Low

The feet must be moved down the wall quickly or the buttocks will keep dropping until the feet hit the wall, leaving the body hanging upside down (see Figure 105).

Figure 105. Caused by Feet Moving too Slow

Descending

One technique for descending is to use a single rope and a descending device (a brake-bar rack). Always rig more bars than needed for this type of rescue. When the rope is secured, carefully back over the edge of the structure and begin the rappel. Once on rappel, you can tell how much friction is needed to maintain control. It may be necessary to remove a bar or two to regulate the friction, then continue to descend.

Controlling a Descent

To control a descent or rappel, keep your brake hand away from the eight-ring and clear of the body. Keep a firm grip on the rope with the thumb side of the hand nearest the eight-ring. **Never let go with the brake hand.** If you feel the need for more control, bring the nonbrake hand over and grasp the rope between the eight-ring and the brake hand (see Figure 106). Do not press the rope under the buttocks or on the tail bone. This will increase the friction, but nylon rubbing over nylon generates high heat thus increasing the chance of melting through the harness in places where the melting cannot be seen (see Figure 107).

Figure 106. Using the Nonbrake Hand to Control a Descent

Figure 107. Imporper Position of Break-Hand for Rappelling

The question "How fast should a person rappel?" always arises. Slowly!! Walk down the wall. Hot-dogging invites disaster. When performing rescue procedures there is no reason to rappel head first or use excessive speed.

Belaying

The Prusik Knot. One of the first methods of self-belay was to use the Prusik knot. It works satisfactorily provided that the person rappelling is not intentionally seeing how fast he or she can descend. When nylon rubs nylon, a high heat is generated.

It is possible that when on an intense rappel, the rescuer trailing the Prusik knot in the nonbrake hand just above the descender, with the accessory cord attached to the seat harness, enough heat is generated to severely damage or melt the Prusik. If control is maintained the Prusik will not melt.
CAUTION: Hot-dogging can cause a rappeller to get into trouble. Control must be maintained. One manufacturer of Prusik cord has designed a polyester or dacron sheath cord with the thought that polyester on nylon would not melt as easily as nylon on nylon.

Although not recommended for self-belay, a Prusik is better than no belay at all. The main thing to remember when using the Prusik as a self-belay is that unlocking the Prusik when the body weight is on it is a simple technique but does require practice. To unlock the Prusik, keep the brake hand on the rope, then cross one leg over the other or bring one foot up to the knee. Then, using the nonbrake hand, reach down and grab the standing rope and wrap the foot three times with the main line used for the rappel. Next, bring the left hand above the descender to the Prusik knot with the downward side or trailing rope still in this hand and wrapped around the foot.

Now, stand in the foot loop. This removes tension and slackens the Prusik knot on which the rescuer is hanging, thus permitting the release of the knot and the freedom to slide it downward toward the descender. Maintain a firm grip with the brake hand so as to not slide downward and reload the Prusik while unwrapping the foot.

If a second person is attached to the rappeller, or the rappeller is doing a traveling-brake lower, then using a Prusik knot is extremely difficult, if not impossible to unload, it is hard to get the rescuer's body weight and the victim's body weight off the cord and the knot to descend on downward. When rappelling with a victim, use the bottom or a top belay technique.

Petzl Shunt. The Petzl shunt device is lightly constructed and designed for mountain climbing. The Petzl shunt is designed for a one-person load and should not be used to rappel with a second person or litter attached. The Petzl shunt is easy to unlock once it is loaded, unless it is hard-shock loaded with a two person load, then it can fail. A 600 lb. load can easily produce forces of 1200 to 1400 lbs. which may cause the device to fail. The Petzl shunt is designed for self-belay on either a single-rope or a double-rope system. When using a double-rope system, both ropes must be the **same diameter and rigged with the same amount of tension.** The shunt has an attachment point to fasten to a chest harness or the webbing can be looped behind the chest harness down to the seat harness. Located on the back of the Petzl shunt is a small hole to which a small piece of accessory cord or string is attached to form a loop approximately twelve inches long.

A problem with this technique occurs if the rappeller becomes frightened and panics. A rappeller may clamp down on the device keeping it open for free traveling and the rappeller ends up riding the rope all the way to the ground. Do not hold the device. Hold the string with the finger and thumb of the nonbrake hand, and trail the device down the rope just above the descending device.

If the rappeller panics and loses control, he or she will likely release the string and reach for the device itself. A fraction of a second is all that is necessary to activate the belay causing it to lock up. As soon as the person releases the string and reaches for the rope or the shunt, he or she attempts to grab the rope above the descender with both hands. This provides a fraction of a second for the string to slacken, which allows the shunt to grab the rope and lock up the descent. To continue the rappel, the rappeller can yank hard on the string, causing the shunt to release.

The Spelean Shunt. Many cave rescuers use a self-belay technique called the Spelean shunt. This apparatus is an oval carabiner looped through the eye on the Gibbs ascender and over the shell of the ascender. A piece of webbing strung through the eye of the ascender is attached to the body harness in the same manner as with the Petzl shunt. The carabiner provides a release handle, since once the ascender is loaded with body weight, it is extremely difficult to unload and get back on to rappel without additional leverage. The oval carabiner can be used as a handle or bar on the side of the ascender to make a release mechanism. A Spelean shunt is best rigged with a spring-loaded Gibbs ascender that cannot travel freely down the rope.

This technique is called the Spelean shunt. Attach a small piece of accessory cord either to that bar or to the oval carabiner. If the rappeller panics and reaches for the rope or the ascender, the piece of cord will slacken and permit the device to grab the rope and stop the downward fall. Many cavers use a free-running Gibbs for the Spelean shunt.

The Spelean shunt, using the Gibbs ascender, should not be used as a belay device with a two-person load. The Gibbs ascender can damage the rope sheath and strip the sheath completely off the rope when loaded with a weight of 1700 to 1800 lbs. On a traveling-brake rappel with a victim, it is necessary to have a bottom belay with the belayer paying close attention.

Top and Bottom Belay. Good communication between the rescuer and the belayer is a must. If there are problems such as loose dirt, rocks, or debris falling from the traveling rope of a top belay, then use a bottom belay. When using a top belay with a traveling load, the two-person load should be the second choice. The third choice for a belay is to use a skilled rescuer who is not dependent on a belay and is able to maintain control regardless of the height of the rappel.

Stopping a Rappel

Once you have descended to the desired work level, stop the rappel. This is accomplished by squeezing the rope in the brake hand so it cannot slide through the hand (see Figure 108). When moving in on a victim, such as a rock climber who is stuck on an edge, or a victim hanging out the window of a burning high-rise, stop the rappel at a safe distance to either side, so the victim cannot pounce on you and cause both of you to fall. Once you are locked off and tied off, move over to the victim. The victim cannot knock you off the rope once you are locked and tied off.

Figure 108. Stopping a Rappel

Locking Off

1. To lock off after stopping the rappel, reach between the device and the body with the non-brake hand and grip the rope above the brake hand. If you are right-handed, use the left hand as the nonbrake hand. It now becomes the temporary brake hand. Place your brake hand on the standing rope above the eight-ring (see Figure 109).
2. It will be necessary to coordinate three simultaneous moves into one smooth motion. Pull the body weight up sightly with the brake hand. While pushing up with the feet, bring the rope up and over the top of the eight-ring. Pinch it between the eight-ring and the standing rope with a firm tug down to the left side of the eight-ring (see Figure 110). Keep the temporary brake hand on the rope (as shown in Figure

Figure 109. Preparing to Lock Off

Figure 110. Position of Hands for Locking Off

Figure 111. Completed Soft Lock

111) next to the eight-ring, and open the grip between the index finger and thumb (see Figure 112).

3. Remove the hand from the standing rope, and reach below and grab approximately four feet of rope. Make a bight and lay it across the nonbrake hand into the finger and thumb (see Figure 113).
4. Reach around in front of the eight-ring with the right hand, bringing the bight around the front of the eight-ring with the brake hand (see Figure 114), then into the chest (see Figure 115) and down under all the ropes and the left arm (see Figure 116). Push the bight upward

Figure 112. Opening Finger and Thumb

Figure 113. Position of the Bight

Figure 114. Going From a Soft Lock to a Tie-off

Figure 115. Bring the Bight Around to the Chest

Figure 116. The Bight is Positioned Under all Ropes and Under the Left Arm

through the hole at the backside of the non-brake hand where the knuckles protrude (see Figure 1:7).

Figure 117. Push the Bight Upward Through at the Nonbrake Hand

5. While working the left hand out of this knot (see Figure 118), pull the slack out of the overhand knot that has just been formed around the base of the eight-ring. Tighten or set the knot by pulling on one rope at a time.

Figure 118. Working the Left Hand Out of the Knot

Follow this procedure closely to secure the body. **Be sure to check the carabiner gate** since pulling rope across the carabiner may have unscrewed the gate (see Figure 119). Do not tighten the gate tight, but make sure it can be opened. At this point you have both hands free and can move in close to the victim.

Figure 119. Checking the Gate of the Carabiner

Before untying, grip the rope where it comes out of the eight-ring with the left or temporary brake hand (see Figure 120). Untie the safety knot **using the right hand only** (see Figure 121). After the safety knot is untied, keep the left hand in place

Figure 120. Preparing to Untie

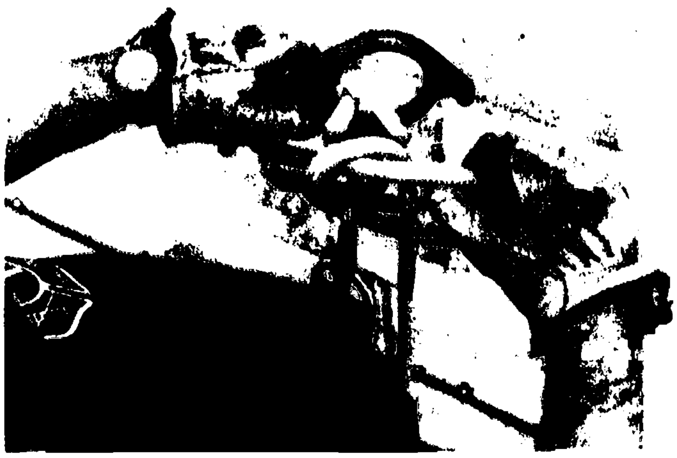


Figure 121. Untying the Safety Knot

as a temporary brake and check the biner (see Figure 122). Next grip the rope in the right hand with the thumb side of the hand toward the eight-ring. Then remove the left hand to unlock (see Figure 123). Lift the rope over the eight-ring and yank down toward the right side (see Figures 124 and 125). This will put the rappeller on rappel again.

These instructions must be followed precisely. This procedure will work on a double or single rope, and on all types of eight-rings, with or without ears, round or square. Figures 126 through 132 show locking off and tying off with double ropes.

Figure 123. Left Hand is Removed to Unlock

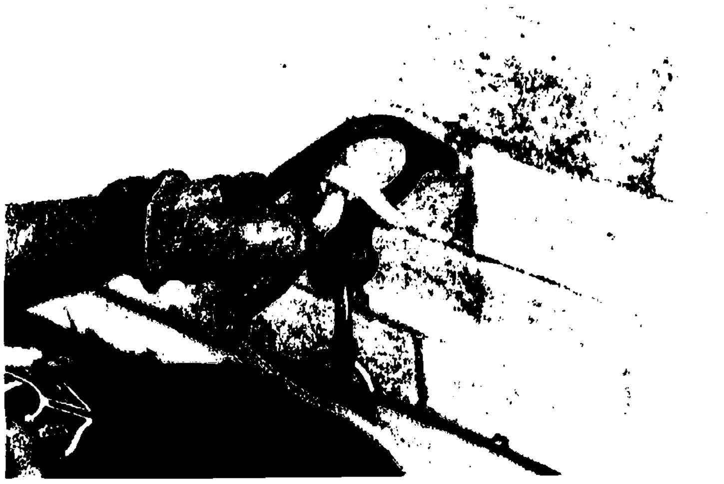


Figure 122. Left Hand Used as a Tempo ary Brake

Figure 124. Preparing to Lift the Rope Over the Eight-ring

Figure 125. On Rappel Again

BEST COPY AVAILABLE

Figure 126.

Figure 127.

Figure 128.

Figures 126 thru 132. Locking Off and Tying Off With Double Ropes

Figure 129.

Figure 130.

Figure 131.

Figure 132.

Figures 126 thru 132. Locking Off and Tying Off With Double Ropes

REMOVING THE VICTIM

Once the victim is reached, stop the rappel and add all the bars to the rack. Stop in a position so that the victim's armpits are just above the rescuer's thighs. Next, lock off, and tie off. Once the rack is locked off and tied off, use a pick-off strap and daisy chain to attach the victim to the descending device (see Figure 133). After the victim is attached to the rescuer's descending device, lift the victim's weight off the rope-grab device from which he or she is hanging.

If the victim's weight is about the same or slightly less than that of the rescuer, attach a Prusik knot on the victim's rope directly above the victim. Next, hang a carabiner in the Prusik knot. Attach a piece of accessory cord with a small loop tied in one end to the victim, and run the cord up through the carabiner and then down, leaving a loop large enough to insert a foot at the free end (see Figures 134 and 135). If the victim weighs less than the rescuer, it may be possible to lift the victim while the rescuer

Figure 133. Securing the Victim to the Rescuer

Figure 134. Prusik Knot, Carabiner, and Accessory Cord with Victim Loop and Rescuer's Foot Loop Assembled

Figure 135. Accessory Cord Attached to Victim

Figure 136. Standing in Foot Loop Preparing to Lift a Victim who is Lighter Than the Rescuer

is standing in the loop (see Figure 136). However, if the victim weighs nearly as much as or more than the rescuer, there will be no mechanical advantage, and it will be strictly a one-to-one system. Even a victim who weighs more than the rescuer can be lifted. Simply reach down, grab the victim by the harness, and lift with the arms while standing with one foot in the loop (see Figure 137).

Figure 137. Lifting a Heavier Victim by the Harness and Using the Foot Loop

Figure 138. Unpinning the Victim's Rope-Grab

As soon as the victim is in position so that there is slack on his or her rope-grab device, unpin the rope-grab device and detach it from the victim's rope (see Figures 138 and 139). After completing this step, slowly lift your body weight off of the foot loop (see Figure 140), and back onto your seat harness. This will lower the victim slightly, applying weight onto the pick-off strap and daisy chain connected to the victim.

Once the victim's weight is on the pick-off strap and daisy chain, position the victim between the rescuer's legs with the victim's armpits resting on the rescuer's thighs. This is possible if the victim has a front attachment point harness.

Figure 139. Detaching the Victim's Rope

Figure 140. Rescuer Lifting his Body Weight off the Foot Loop

Figure 141. Untying

If a rear attachment point harness is used, it might be better to have the victim hanging slightly below the rescuer. Before untying and unlocking, check to make sure a bottom belayer is in place ready to proceed, and knows that you are going to untie and unlock the device to start the descent (see Figures 141 and 142).

Figure 142. Unlocking

A slow, steady descent helps control the heat buildup in the descending device. Use the nonbrake hand to spread the bars to lessen the friction or to push the bars together to increase the friction (see Figure 143). This descent in which the victim is attached to the rescuer, is referred to as a **traveling-brake lower.**

Figure 143. Nonbrake Hand Controlling the Descent

When the Victim Outweighs the Rescuer

If a victim outweighs the rescuer, rig two double-sheave pullies, making a small four-to-one mechanical-advantage system. Clip the four-to-one system into the Prusik hanging directly above the victim and attach the other end to the victim's harness. This gives the rescuer the mechanical advantage necessary to lift the victim.

Another method that can be used is to rappel down to the victim with a second rope to be attached to the victim's harness. A topside crew can then haul the victim up to safety without having to unpin or detach the victim's rope-grab device from his or her rope. Also, the victim may be hauled up approximately 1′ to slack the device so the rescuer on rappel can detach the rope-grab device and the topside crew can do a fixed-brake lower and lower the victim to the ground.

When rescuing a victim suspended outside a building do not attempt to break out a window at any height. There is a possibility of the glass cutting the victim's rope or injuring persons below.

With practice, a rescuer using either the one-on-one rescue system or the four-to-one mechanical advantage system can complete a rope-grab in two to three minutes. Once the rescuer has reached the victim, the one-on-one pickoff technique is effective and requires only a minimal amount of equipment and workforce.

Using a Litter to Lower a Victim

Depending upon the emergency situation, a suspended victim may not be in a body harness, but in a belt that can crush the ribs or cause lower-spinal damage. Belts can restrict breathing and become quite painful to the suspended victim.

If the victim has been suspended for a long period of time or a back injury is suspected, it may be necessary to use a litter. This should be attached to the rescuer's rack for the descent. It is not difficult to litter-package a person hanging in midair. Use an adjustable litter spider to get the victim into the litter. Tighten the adjustments to level the litter. One end or side of the litter can be dropped if an airway problem develops.

To lower the litter and yourself to the victim, use a traveling-brake lower. With the assistance of another rescuer who is rappelling on a separate line, litter-package the victim to get his or her body weight out of the harness or belt and onto the litter.

An advantage of the adjustable litter spider is the ability to maintain airway management. If the patient vomits, drop one side of the litter by pulling down on the spider Prusiks nearest the rescuer to position the patient on his or her side.

To lift the litter back to level, attach a cord (commonly called the "barf line") to the litter-side rail nearest the rescuer, and loop it through a carabiner clipped into the main spider carabiner using the foot loop in the free end. Stand with one foot in the foot loop, lift the siderail with your hands, and slide the spider to adjust the Prusiks and level the litter.

A "barf line" used on a nonadjustable litter spider must be attached to the litter siderail away from the rescuer. The rescuer must stand in the foot loop, grab the siderail, and lift with both hands and one foot to flip the litter on its side.

Using an Eight-ring for a Pick-off

Another technique used to do a pick-off is to use an eight-ring. When rappelling on a single rope, it is necessary to double-wrap the eight-ring or use two ropes for the descent to increase the friction. This procedure acts like a double-wrapped single rope. It is extremely difficult to unlock the eight-ring once the victim's weight is hanging from the rescuer. The heat buildup on the device can also be a problem. If the rescue involves a long drop, use a brake-bar rack.

Once the rescuer rappels to the victim, cutting the victim's rope is not recommended. This procedure creates a shock-load to the entire rope system. If a rescuer uses a knife in the presence of a person who is scared and suspended in air experiencing a lot of pain, a scuffle can occur, causing the victim or rescuer to accidentally cut the rescue rope.

CHANGEOVER TECHNIQUES

Changing from Rappelling to Ascending

A rope rescuer must be able to change from ascending to rappelling, or from rappelling to ascending. To change from a rappel to an ascent stop the rappel, attach a top ascender and allow the body weight to rest on the top ascender, then attach a knee and a foot cam.

Leave the rope slack at the knee and foot cams so enough slack remains to allow the climber to remove the descending device from the rope and complete the changeover.

Changing from a rappel to an ascent can be useful when rappelling into a deep pit. When you reach the figure-eight knot tied in the end of the rope, and realize the rope is several hundred feet short with no additional rope available, there is only one thing to do; transfer from rappel to ascend, and climb out of the pit.

Changing from Ascending to Rappelling

It takes more practice to change from ascending to rappelling than rappelling to ascending. First, it is necessary to stop the ascent and hang from the top ascender with a top safety above the roller as in the rope-walker system. This positions the climber hanging so that he or she is suspended from the top safety.

Next, unpin the roller and reach down and detach the right foot cam. Then open the knee cam and pull up enough rope to rig a descender. This leaves the climber hanging from the top safety but backed up by the knee cam.

When using an eight-ring, attach it to the harness and work the slack rope down through the eight-ring so that the eight-ring is pointing up the rope. Next, stand on the left foot to slack the top safety ascender, and detach the top safety or the top ascender from the rope.

Next, set a brake hand beneath the descender. Lower the body into a seated position, bring the left leg up over the right knee, and unpin the knee cam. The changeover is now completed and the rappel can begin. This procedure sounds simple; however, it does require practice.

Changeover Using a Petzl or Spelean Shunt

When using a Petzl or Spelean shunt for a top safety, hang from the shunt, unpin the chest roller, release and detach the knee cam, rig the descending device, and set a brakehand under the descending device.

Next, pull the slack out of the descender so it is pointed up the rope and remove the slack between the shunt and the descender. Reach down and unpin the foot cam and, with the brake hand in place, reach up with the nonbrake hand and yank hard on the shunt to release it.

Changeover Using a Gibbs Ascender

It is more difficult to do a changeover using a rack and a rope-walker system with a Gibbs or handled ascender as the top safety above the roller. It is necessary to totally stop the ascent, hang from the top safety, and remove the chest roller and knee cam. Next, pull slack rope up through the foot cam and rig the rack into place. Be sure to pull enough slack through to lock off the rack. The rack should end up pointed up the rope.

Locking the rack off as weight is applied on the right foot tips the rack downward and outward, and away from the body. This allows you to slack the top safety, so that it can be detached from the rope. Next, position the brake-hand and reach down and disconnect the foot cam, and then unlock the descender. The changeover is now completed and the rappel can begin.

Safety Precautions for Changeover Evolutions

Changeover evolutions must be practiced for proficiency. It is easy to forget what to unpin first and end up with all the equipment jammed together. When practicing, use an additional belay rope with no slack.

ASCENDING TECHNIQUES

Many people think rope rescue involves descending techniques only; however, technical rope rescue and vertical rope rescue require the rescuer to know not only descending, but ascending techniques as well.

Ascending techniques require a rescuer to be physically attached to a rope. Prior to using today's ascending procedures, ascending rescuers used hand-over-hand climbing and hanging onto knots for assistance. This technique resulted in many fatalities. A margin of safety is provided to the ascending rappeller with the addition of Prusik knots attached to a rope. If the rappeller gets tired and needs to rest it is possible to let go of the rope and hang safely on the Prusik knots.

Today's classic ascending system has one Prusik attached to a chest or seat harness that is then looped behind the chest harness. A second Prusik is attached to the left foot and extended slightly above the knee. A third Prusik is attached on the right foot slightly below the knee. This method is a traditional system. The rig is inexpensive and provides a great deal of safety.

Mechanical Ascenders

Another way to climb a rope is to use a mechanical ascender. A mechanical ascender (except for the Gibbs type) is a toothed ascending device which actually digs into the sheath of the rope to provide the rappeller a hold. A mechanical ascender should be used only with kernmantle rope. Various mechanical ascenders available include the Gibbs ascenders, Jumars, the Petzl, the Clogs, and the CMI's.

The Petzl shunt was designed for self-belaying not ascending; however, it does not have teeth and will work as an ascender in some situations. The Gibbs ascender is one of the strongest types of mechanical ascenders. It is so strong it can damage a rope when 1800 to 2000 lbs. of force is applied in a shock-load situation. Some tooth ascenders have been found to damage a rope with a shock-load as minimal as 1100 to 1200 lbs.

Do not use handled descenders in a mechanical-advantage system when dealing with a two-person load such as in a one-way safety in a system, or as a belay for a one-person load that could be shock-loaded. Any amount of slack in a belay rope that has been shock-loaded will cause the rope to be destroyed.

Rope-Walker Ascending System

Other systems can be used to attach ascenders. A system referred to as the rope-walker system can be rigged by attaching one ascender to the right foot, one in a stirrup positioned at the left knee for the left foot, and one on the right shoulder.

Next, attach a bungie or shock cord to the knee cam, draw it up over the right shoulder, and attach it to the back of the climber. The shock cord will pull the left knee cam up the rope every time the left leg is lifted.

This system allows a person to move quickly up a rope without using the hands. The leg muscles provide the power to climb a rope while the arms are used for balance when ascending.

Chest Roller. The shoulder cam has been replaced with a chest roller. The chest roller provides little or no friction, and no grip; however, it does allow a climber to speed up the system, keep the spinal column in a straighter line, and keep the body vertical. Keeping the body vertical allows the climber to keep the feet driving downward directly under the buttocks thus forcing the individual to move upward. Pushing out with the feet in front of the body is a waste of energy and not as effective as pushing downward under the body.

The Frog Ascending System

The frog ascending system is one where an ascender is attached to the climber's harness between the chest harness and seat harness. A second ascender is attached to the feet of the climber with an accessory cord or with webbing. The frog system position allows the climber to use a sit-stand movement similar to an inch-worm motion. As the climber stands, the chest ascender is slid as high as possible. Next, bend the legs moving into a seated position and hanging from the chest harness. This slackens the cords to the feet and permits the climber to lift the foot ascender up the rope with the hands. Repeat the sit-stand procedure to continue the ascent. The frog system is slower to use than the rope-walker system.

SPECIAL SITUATIONS

Using an Eight-ring for Self-Rescue

The first eight-rings designed did not have ears, so if a rescuer bellied over a lip or slacked the rope while standing on a ledge it was possible to have the rope ride up and over the top of the eight-ring and form a girth hitch (see Figure 144) or cinch knot. Once a rescuer is in such a situation it is possible to be stuck in this position until the body weight is taken off the eight-ring. However, it is very easy to correct this situation by tying a 6′ or 8′ length of accessory cord into a continuous loop with a double fisherman's knot using the following procedure.

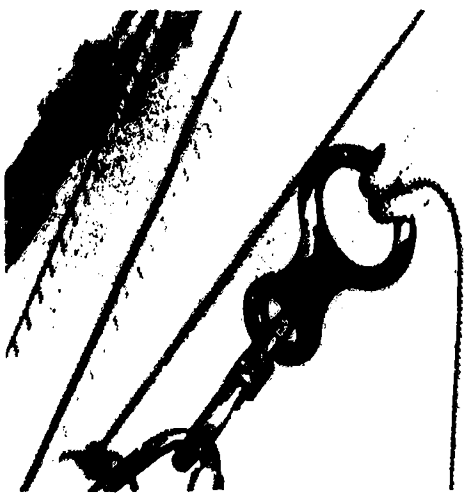


Figure 144. Girth Hitch

1. Use the free hand to remove the accessory cord from over the shoulder. **Do not let go with the brake hand!**
2. Hold the cord by the double fisherman's knot and lay it against the standing rope above the eight-ring (see Figure 145). Next, spiral the knot around the standing line, wrapping it three times through itself (see Figure 146). This is called a Prusik knot.

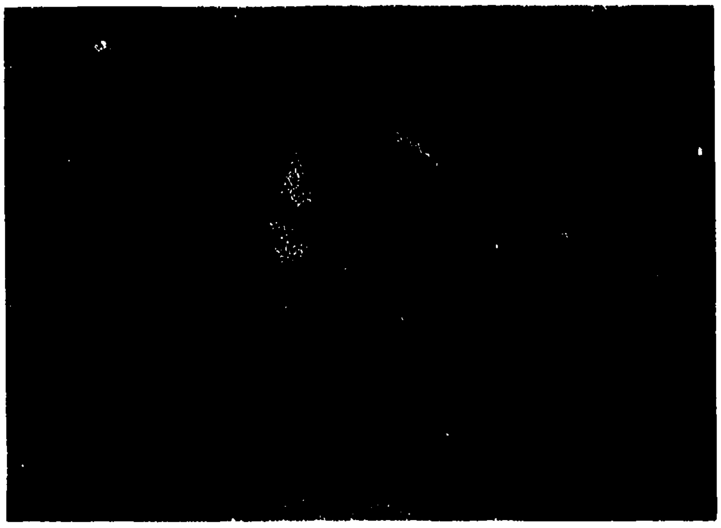


Figure 145. Accessory Cord Positioned Against the Standing Line

Figure 146. Cord Wrapped Three Times Through Itself

3. Pull the fisherman's knot to tighten the Prusik knot. Always pull one side of the double fisherman's knot more than the other. This prevents the fisherman's from forming right at the end of the loop (see Figure 147).
4. Dress and set the knot (see Figure 148). Slide the Prusik knot up or down the standing rope to just a few inches above the eight-ring. It is now possible to stand in the loop to slack the tension on the eight-ring and remove the girth hitch or other offending objects (see Figure 149).


Figure 147. Tighten the Prusik Knot

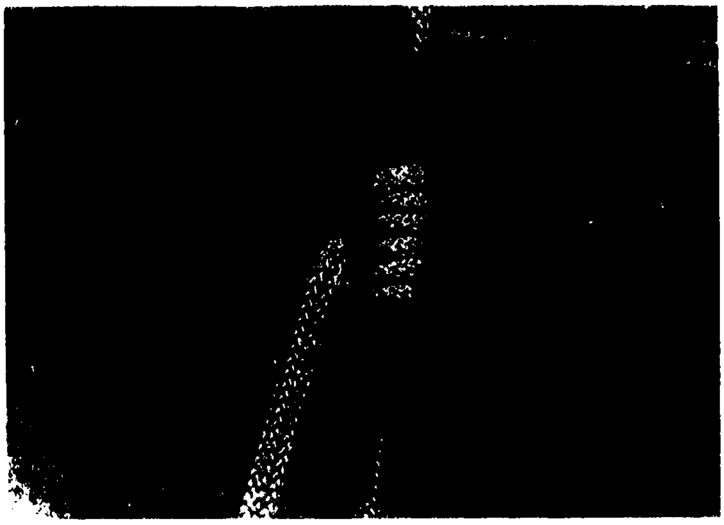


Figure 148. Prusik Knot Set and Dressed


Figure 149. Standing in Loop

While this procedure is being done, it is important to keep the brake hand in place at all times (see Figure 150). This means that the self-rescue must be completed using one hand only.


Figure 150. Brake Hand Kept in Place

5. Next, clear the jammed descending device, load the body weight onto the eight-ring, retrieve the accessory cord, and proceed with the rappel procedure.

Eight-rings and other descending devices will gobble anything nearby. If a rescuer leans against the device while rappelling, hair, a beard, a glove, or clothing can be pulled into the eight-ring and tangled to a point that downward travel is stopped. For this reason it is best to keep the brake hand clear of the eight-ring and let the rope slide through it rather than allowing the brake hand to travel with the rope up to the eight-ring. Then, slide the hand back down the rope and allow it to ride back up to the eight-ring. If the rope is not fed in this manner, there is a risk of catching a glove in the device and injuring the hand.

RECOVERING FROM A PARTIAL FALL

An ascending system must be constructed so that the climber cannot fall. If any portion of an ascending system fails, the climber must be protected from falling upside down. If the top cam or chest roller fails, the climber ends up hanging by the heels.

This position is awkward and one from which it is difficult to recover. The most physically fit person usually gets only one chance to recover from a double-heel hang. To recover from a double-heel hang, cut one foot free, allowing one leg free to use as a balance beam. Swing the free leg until momentum is gained to pendulum the upper body back into a vertical position. This is a difficult and dangerous maneuver. Do not practice this procedure.

To prevent this situation attach an accessory cord from the seat harness to the knee cam. If the top roller fails, the climber ends up hanging on his or her back or slightly inverted, but not completely upside down. Many climbers attach a top safety in lieu of the accessory cord from the seat harness to the knee cam.

Dropping a Rope to a Suspended Victim

If a rescue situation occurs where descending to the victim is out of the question or where it is not necessary to send a rescuer to the victim, lower a rope with a locking carabiner attached in the end to the victim. Then rig a mechanical-advantage system at the top lifting point to allow rescuers to haul the victim safely to the top. If a victim is unconscious or cannot reach a rear attachment point, it is necessary to send one person down to the victim to attach the system.

Rappelling Past a Knot

Rappelling past a knot can be done with a single Prusik; however, two Prusiks are preferred. When you are rappelling down and come to a knot, stop the descent with the descender about a foot above the knot; do not jam the knot in the descender. Rig a Prusik, wrap it three times through itself around the rope above the descender, and attach it to the harness. Next, shove the Prusik up as high as possible and derig the descender from the rope.

Attach both Prusiks above the knot so that one backs up the other. Derig the descender, rerig it just below the knot, do a foot wrap, stand up to slack the Prusiks, retrieve the Prusiks, and transfer the body weight onto the descender. Do not jam a Prusik into the knot. Retrieve the Prusiks, and proceed to rappel. This procedure is useful if a rescuer finds that a rappel rope is too short or if two rappel ropes have to be tied together.

Ascending Past a Knot

Ascending up a rope past a knot is a simple procedure. When using a modified rope-walker system, ascend to the knot and remove the top safety. Place the top safety above the knot and unpin the chest roller, ascend up the rope, and reattach it to the rope above the knot. As the knee cam reaches the knot, detach it, and reattach it above the knot. The same procedure can be used with the foot cam. When using the original Gibbs, three-cam, rope-walker system, it is helpful to use another safety or a Prusik. Ascend the rope until the shoulder cam is a couple of inches below the knot, attach the Prusik or a separate ascender above the knot, and connect to the seat harness.

Next, detach the shoulder cam, ascend approximately twelve inches, and reattach the shoulder cam. Use the same procedure to move the foot and knee cams.

This technique is used to pass a fixed intermediate belay, such as a bolt, or when transferring from one rope to another while ascending. When a rope is dropped over an edge, the edge is referred to as the lip. To clear the lip while ascending, it is helpful to have an extra handled ascender to attach to the rope above the lip. Attach it to the rope just past the lip or roller. The chest roller can then be unpinned. The same procedure can be used with the Gibbs cam rope-walker system. Preattach a handled ascender with a piece of webbing or accessory cord to the harness.

Ascending can be useful in some rescue situations when it is impossible to rappel down to a victim, or is necessary to climb from a lower point up to a victim. Practice is required to become proficient in the technique.

Ascending While Carrying a Victim

If two climbers have ascended or rappelled and one becomes injured, it may be necessary for a climber to ascend while carrying the other person. To execute such a rescue, rig a pulley or locking carabiner and a Gibbs ascender onto the victim's harness. Take the tail of the victim's ascending rope and loop it down through the rigged Gibbs ascender to act as a one-way safety and then through the pulley. Next, attach the tail of the rope to your own seat harness. While climbing, you will be working at a two-to-one mechanical advantage. This means that you will be lifting half of the victim's weight during the ascent and that as you ascend the first twenty feet of rope, the victim will be lifted approximately ten feet.

Next, hanging from the top safety, place a second pulley and Prusik on the rope. Remove the hauling rope from the rescuer's harness and place it through the pulley. Unpin the knee cam and transfer it to the rope coming out of the pulley. Unpin the foot cam and attach to the rope below the knee cam.

Use your legs to pull the victim up while climbing in place to this level. During this phase of the rescue, you will be operating at a three-to-one mechanical advantage. Next, rerig the foot or knee cam on the standing rope that is being ascended, and attach the end of the rope back to the seat harness. The victim will hang on his or her safety until you climb to where the victim's weight is felt on the rope. Repeat the procedure until the victim is at your level. Once again, use your legs to pull the victim up the rope. Each time you repeat this procedure an additional length of rope is available to pull the victim up the rope. The first twenty feet of this climb is the most difficult.

Rescuing a Victim From Inside a Furnace

One of the worst one-on-one rescue situations occurs when a victim is trapped inside a furnace. Many power companies have 300′ high furnaces with a pick (motorized scaffold) hanging inside a furnace making it impossible for a rescuer to rappel down from above to a victim. Often this type of furnace has a small inspection port (4″ or less diameter) at the top through which a rescue rope can be lowered to the bottom of the furnace.

In this situation, the rescuer must enter from the bottom of the furnace, ascend to the victim, transfer from a change-over to rappel, and remove the victim from his or her safety line. This technique requires a minimum of three people, one rescuer, one belayer, and one rigger. If a rescue department has a highly-trained rope rescue team, additional help may be available.

Many cavers feel that if the rappeller has the attachment looped behind the chest harness and down to the seat harness, and becomes unconscious, the body will start to lean or pitch backwards, thus activating the cam of the Gibbs ascender and stopping the fall.

But if the rappeller is sitting in an upright position and becomes unconscious, he or she will free fall. The force of gravity is equal on all parts of the body. It is unlikely that the body will pitch backwards unless he or she is already backwards or hits something to force the body back.

The spring-loaded Gibbs, which cannot freely travel up and down the rope, should be rigged with a Spelean shunt. Pressure must be applied to the trailing spring to keep the device or the cam open while a rescuer is on rappel. The instant the spring or accessory cord is released, the spring in the Gibbs ascender activates (rather than depending upon the body to lean backward to activate the device.)

CONCLUSION

Rope rescue techniques appear to involve simple tasks but require an extensive knowledge of the tools and equipment used. Along with this knowledge, any rescuer who engages in rope rescue procedures must have training taught by an accomplished rope rescuer with recognized expertise. To enhance their training rescuers must continually practice the techniques to be used. There is no replacement for training and practice.

AERIAL LADDER AND AERIAL PLATFORM RESCUE

KEY POINTS

- **The importance of preparing the victim before the lift**
- **How to use the backboard in an aerial lift procedure**

INTRODUCTION

An aerial rescue presents a situation that brings together two units of the public safety service; the emergency medical team and the fire fighting department. Cooperation and good communication among all personnel involved are essential factors for the safety of the victims and the rescuers.

Preplanning is helpful in all rescue procedures. It is especially helpful to know of an access route to hazardous terrain for a rescue that may involve a cliff, a valley, or a river. In cases where a victim cannot be safely retrieved from a low place or taken down from a high area, an aerial ladder may be the appropriate tool to be used to execute a safe rescue.

PREPARING FOR THE RESCUE

Preparing the Victim

Before any rescue procedure can be initiated, an emergency medical team must get to the stranded victim. This situation presents another rescue operation where preplanning and improvisation are essential. The medical team's responsibility is to take care of the physical needs of the victim before preparing for rescue and transport. If the victim's condition permits, it is advisable to take the time to obtain the best equipment available for the rescue. Position the equipment to properly execute a safe, successful rescue.

Preparing the Backboard and Related Equipment

Before proceeding with the rescue, prepare the backboard and necessary equipment. Use the following steps to prepare the equipment.

1. Straps may be put on the backboard before or after the victim is placed on the board.
2. Attach a foot rest to the backboard.
3. Place the two web belts through the handholds on the sides of the backboard by passing the belts down through the handholds on one side, continuing under the backboard and up through the handholds on the other side of the board.
4. Place a cravat through the two slots at the head of the backboard, going down through one slot, continuing under the board, and up through the other slot.

Placing the Victim on the Backboard

Follow the steps when placing a victim on a backboard. Patient should be packaged as shown in Patient Care and Handling Techniques.

1. A blanket should be placed on the backboard.
2. Place the victim on the blanket, covering the victim's arms and legs with the sides of the blanket.
3. Strap the victim on the backboard, keeping the victim's feet against the footrest.
4. Place the first strap around the backboard and the victim just above the knees.
5. Place the second strap around the board and across the victim's hip region.
6. Place the third strap around the board and the victim's chest, and fasten just below the shoulders.
7. Reassure the victim that everything possible is being done to execute a safe rescue. Procedures need to be explained to the victim. This will help calm the victim and reduce the chance of panic.
8. Place a cervical collar around the victim's neck. Using a cravat at the head, tie the victim's head to the backboard covering the eyes with the cravat. The knot on the cravat should be placed to one side of the head. If the victim's head does not line up with the slots, it may be necessary to use two cravats to tie the head.

9. Using a second cravat, tie the victim's feet to the footrest. Place the middle of the cravat over the ankles, then take the ends of the cravat under the ankles and up between the legs. Continue taking the ends down between the victim's feet and under the footrest against the footrest pins. Tie off under the footrest. If the victim has injuries to one or both legs, use an alternative method of tying the victim's feet.

PREPARING THE AERIAL LADDER AND RELATED EQUIPMENT

The fire fighting team will need to use the following steps when preparing the aerial ladder equipment for a rescue operation.

1. With the aid of a second fire fighter, position the aerial ladder so that it will extend directly over the victim.
2. Observe all obstacles such as wires, trees, or objects suspended in the air.
3. Place a hose roller on the top rungs of the fly section of the ladder. Secure the hose roller to the ladder.
4. Place one end of an approved life-saving rope over the hose roller. Using a slip knot, tie off the end of the rope to the top rung of the ladder. Leave a tail of rope long enough for the rescuer to reach.
5. Next, run the life-saving rope down the center of the aerial and lay the remaining line on the turntable or the ground. If the rescuer is unable to reach the end of the rope after the aerial is raised, it may be necessary for someone to climb to the top of the aerial and drop the rope over the hose roller to the fire fighter.
6. Raise the ladder to desired location. Do not lock the pawls.

PREPARING TO LIFT

Use the following procedures when preparing to lift a victim using a backboard and/or rescue basket. When using either device, attach four straps with D-rings with two at the foot-end and two at the head of the device. Position the D-rings as follows:

1. Bring the four "D" rings together with the two from the foot between the two from the head.
2. Pull on the tail of the rope from the hose roller to untie the slip knot.
3. Thread the rope through the "D" rings twice and tie using the appropriate knot (see the rope rescue techniques chapter). Leave a five to six foot tail of rope to use as a safety knot after tying the knot.
4. Pull the slack rope toward the turntable, take two turns around the top trunnion bar, then tie a clove hitch and safety knot around the bottom brace bar. This method of tying will allow the rescuer to safely loosen the clove hitch if necessary to readjust the length of rope. All aerials/platforms may not have a trunnion bar and/or a brace bar but whatever the rope is secured to must rotate with the turntable. If the rope is secured to something other than a part of the turntable the rope may break when the aerial is rotated.
5. Next, raise the victim two or three feet and check the knots.
6. Tie the two smaller ropes to the backboard, one at each end, on the same side toward the aerial.
7. Drop the two smaller ropes to the rescuers below to be used to stabilize and guide the backboard.

THE RESCUE

Moving the Victim

Use the following steps when moving the victim.

1. Use the standard hand signals, the radio, or the ladder intercom to direct and communicate during the rescue. If it is a roof rescue, one person on the roof should direct the movement of the aerial ladder until the victim is clear of all obstacles.
2. Raising and lowering a victim in a straight verticle line may necessitate alternating the controls (raise/lower or extend/retract). Using two controls simultaneously is confusing and may not be recommended by the vehicle manufacturer. The power is reduced for each operation when two controls are used at the same time.
3. Once the victim is clear of all obstacles, the ground person should direct the movement of the aerial ladder until the rescue is completed.

4. Aerial rotation is done by using a hand crank except when using a ladder with an electrically-operated backup system. (The operation must be smooth; without quick starting and stopping motions.)
5. When the victim is at ground level, place the backboard with the victim strapped in place on a stretcher for transport. Various high- or low-level emergency situations may require variation from this basic procedure.

AERIAL BACKBOARD RESCUE WITH A BASKET STRETCHER

Most rescuers carry a basket stretcher or a rescue basket as a standard piece of equipment. When this stretcher is used, place a blanket under the victim to facilitate moving the victim from the stretcher. Implement the following procedures if this stretcher is used in lieu of a backboard when performing an aerial backboard rescue. The basic rescue procedure will be the same.

1. If the condition of the victim is such that the backboard is **NOT** needed, place the victim directly into the basket on a blanket.
2. Then, strap the victim into the basket using the normal procedure. Small victims may need to be wedged under the restraining straps by using blankets, pillows or other materials that will not injure the victim.
3. When the victim is ready to be raised, fasten the hoisting ring and straps into place. Pretie the hoisting straps to the hoisting ring and leave a length of the strap ends necessary for fastening. To fasten these straps, hold the hoisting ring over the stretcher. Fasten the end of one strap to the top or head-end frame hand-holds on the side of the stretcher. Do not use the hand-holds on the oblique part of the head of the stretcher.
4. Next, fasten the other end of the strap to the second set of frame hand-holds from the foot of the device, on the side of the stretcher. Do the same with the strap on the other side of the stretcher. Fasten each strap on the same side of the basket or diagonally so that the basket can be tilted in case the victim's physical condition is such that the person's head or feet must be elevated. Fasten the four strap ends in such a way that little or no twist is in the straps. If there is a need to hoist with the stretcher in a vertical position, loosen the knots and re-adjust the strap lengths so that the straps can be fastened to both the top or head end frame hand-holds and the hand-holds on the oblique part of the head of the stretcher.

Low Places

When performing a rescue from a low place, ropes may be attached to the backboard or rescue basket using the aerial as an arm for lifting, and a hose roller to reduce the friction on the ropes.

LIMITATIONS

High limits. The height from which a victim can be removed is limited to the maximum extension of the aerial ladder.

Low limits. The depth is also the maximum extension of the ladder unless a supplemental hoisting mechanism is used. When using a hauling system the depth of rescue is limited to the amount of rope or cable used for the system. For example, a wrecker with a cable and wench or a long length of rope attached to a vehicle that can drive away with the hoisting rope going through the aerial (used as a pivot point) to lift the victim. In these operations, use the aerial to position the rope or cable directly over the victim and the pivot point of attachment for the change-of-direction. (See chapter on rope rescue techniques.)

AERIAL PLATFORM

Another method for removing a victim from a high or low place is to use the aerial platform.

High Places

When performing a rescue from a high place using the aerial platform, secure the backboard or rescue basket across the top rails of the platform. This method allows a rescuer to provide constant attention to the victim's needs.

Low Places

In a low place, once the victim has been secured to the backboard or rescue basket, place the platform directly above the victim. Drop a life-saving rope to the rescuers below. Tie the backboard or rescue basket to the rope the same as it was in the aerial rescue. Using a bowline, tie the other end of the rope to the underside of the platform. Tie a guy line to both ends of the backboard or rescue basket to be used by the rescuers positioned at ground level to guide the victim being lifted from the low place.

COMMUNICATIONS

It is essential that continuous communication is maintained between the point where the victim is prepared for evacuation and the operator of the aerial platform.

Use of Walkie Talkies

Portable radios such as walkie-talkies are valuable for communicating but a backup system should be available. A suggested set of hand signals is shown in.

Position the person in charge of communicating the hand signals given to the aerial operator in a location where a clear visual contact can be maintained simultaneously with the victim and the aerial operator. Isolate this person from any others who may unknowingly give an inappropriate signal.

OTHER CONSIDERATIONS

1. The use of a Stokes basket is preferred to using a backboard if the victim's condition permits.
2. The use of static Kernmantle rope is preferred to using manilla hemp rope.
3. The use of a 100′ aerial ladder is preferred to the using a 65′ aerial ladder.
4. The use of an aerial platform is preferred to the using an aerial ladder.
5. If a victim must be removed from a high or low place at a construction site and a crane is on site, it may be better to use this piece of equipment and its operator in lieu of an aerial ladder or platform. This decision must be made by the incident commander.