Intermediate Rope Rescue

Technical Rescue
1601

Student Manual

STATE OF NEW YORK DEPARTMENT OF STATE
OFFICE OF FIRE PREVENTION AND CONTROL

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Welcome to the New York State Fire Training Program

Intermediate Rope Rescue

The Department of State recognizes that providing training for paid and volunteer firefighters and related officials is an important part of the services it makes available. Our Office of Fire Prevention and Control (OFPC) places a very high priority on training because we believe it is essential for the men and women of the fire and emergency services in New York State.

The Office of Fire Prevention and Control's programs include the most complete progression of training available today -- beginning with probationary firefighters and extending the full length of a firefighter's career with the fire service. While our training programs address specific fire and arson prevention and control issues, we also encourage expansion and improvement of local training facilities and programs in cooperation with fire companies, municipal corporations and districts.

Intermediate Rope Rescue provides information and skills to adequately perform basic vertical rope rescue techniques in an urban/suburban environment. While many of the techniques and skills taught in this program are applicable to the wilderness environment, this is not the intent of this program. The overall objective is to improve rescuer awareness of the safety concerns at rope rescue situations and to develop basic skills in rappelling and high-angle rescue systems.

Your comments and suggestions about this student manual, our training classes or any OFPC program are always welcome. Your input will help us build on our successes and make needed changes, when appropriate.

On behalf of the citizens you serve, we want you to know that your participation and commitment are greatly appreciated.

FIRE PREVENTION AND CONTROL
NEW YORK STATE

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Training Policy-Firefighter Safety Training Required by the Public Safety and Health Act

Date of Issue: 07/01/00

An evaluation of the Office of Fire Prevention and Control's Outreach Training Programs was conducted by the New York State Department of Labor to determine what course components meet the initial fifteen hour and annual eight hour safety training required for firefighters under the Public Employees Safety and Health Act. This listing provides the approved time for each subject area of the designated courses. Students completing the listed courses should receive credit as listed below:

Based on OSHA Safety Training Requirements
CFR 1910.156 & CFR 1910.134

COURSE #	COURSE TITLE	SUBJECT AREA	TIME
03	Fire Behavior and Arson Awareness	General Hazard Recognition	60 min.
06	Ladder Company Operations	General Hazard Recognition Fire Scene Safety Tool and Equipment Safety Total	30 min. 30 min. 30 min. 90 min.
23	Commanding the Initial Response	Fire Scene Safety	30 min.
24	Rescue Operations (until 10/21/00)	General Hazard Recognition Fire Scene Safety Protective Clothing Tool and Equipment Safety Total	30 min. 30 min. 15 min. 60 min. 135 min.
26	Apparatus Operator- Emergency Vehicle Operation	Response Safety Scene Safety Tools and Equipment Total	60 min. 30 min. 60 min. 150 min.
27	Mask Confidence	SCBA Recent Developments in Fire Safety Total	120 min. 60 min. 180 min.
29	Incident Command System	General Hazard Recognition Response Safety Fire Scene Safety Total	30 min. 15 min. 45 min. 90 min.

continued on reverse

35	Confined Space Awareness and Safety	General Hazard Recognition	15 min.
		Response Safety	15 min.
		Fire Scene Safety	45 min.
		Protective Clothing	30 min.
		SCBA	15 min.
		Total	120 min.
38	Water Supply Operations	General Hazard Recognition	15 min.
		Response Safety	30 min.
		Fire Scene Safety	45 min.
		Protective Clothing	15 min.
		Tool and Equipment Safety	30 min.
		Total	135 min.
45	Introduction to Fire Officer (effective 4/01/01)	General Hazard Recognition	30 min.
		Fire Station Safety	30 min.
		Response Safety	30 min.
		Scene Safety	60 min.
		Protective Clothing	30 min.
		Total	180 min.
47	Rescue Technician - Basic (effective 1/1/01)	General Hazard Recognition	30 min.
		Fire Scene Safety	30 min.
		Protective Clothing	15 min.
		Tool and Equipment Safety	60 min.
		Total	135 min.
78	Apparatus Operator - Pump (effective 1/1/01)	Response Safety	30 min.
		Fire Scene Safety	30 min.
		Tool and Equipment Safety	30 min.
		Total	90 min.
91	Basic Firefighter	Subject matter in Basic Firefighter exceeds both the fifteen-hour initial and the eight-hour annual refresher safety training requirements.	
92	Intermediate Firefighter	Subject matter in Intermediate Firefighter exceeds both the fifteen-hour initial and the eight-hour annual refresher safety training requirements.	
93	Advanced Firefighter	Subject matter in Advanced Firefighter meets the eight-hour annual refresher safety training requirement.	
80 81 82 83	Refresher Courses	To be determined at the local level after the content of the presentation has been evaluated.	

INTERMDIATE ROPE RESCUE

ACKNOWLEDGEMENTS

The preparation of this course was made possible through the assistance, cooperation and dedication of many people. The Department of State's Office of Fire Prevention and Control wishes to thank all of the following persons for the role they played in the development of this course.

Richard Browne
Captain
West Point Fire Department

Joseph DeFrancisco
County Fire Coordinator
Madison County

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State Fire Instructor
Delaware County

Table of Contents

Unit 1: Introduction to Intermediate Rope Rescue

Course Overview and Objectives

Course Overview

The Intermediate Rope Rescue course consists of eight lessons totaling thirty two hours. This course is designed to provide information and skills to adequately prepare you to perform basic vertical rope rescue techniques in an urban/suburban environment. While many of the techniques and skills taught in this program are applicable to the wilderness environment, this is not the intent of this program. As you progresses through the course, it will become apparent that our most important role in rescue is that of being responsible for rescuer safety. The overall objective of the Intermediate Rope Rescue course is to impart rescuer awareness of the safety concerns at rope rescue situations. Topics included are: safety orientation, risk assessment, equipment, basic rappelling, basic ascending, anchoring, belaying, mechanical advantage, patient packaging, incident management, skills evaluation and testing.

The Intermediate Rope Rescue course is part of a series of courses designed to develop and enhance your skills as a rescuer. These programs are delivered both in the field as well being taught as part of the residential offerings at the New York State Academy of Fire Science to allow you the opportunity to continue your education and training as a rescuer.

Because this course is intended to be the first in a series of advanced rope rescue training programs, it is expected that the student entering this program receive prior rope training which, as a minimum, shall consist of completion of the following course: Course #24 - Rescue Operations

After satisfactory completion of this course the student will be able to coordinate the use of rope and associated equipment to gain access to and extricate a patient(s) from peril above or below grade level to remove that person to a safe environment.

Because of the nature of the training, the student shall be required to adhere to the following requirements:

- Be physically capable of performing high angle tasks.
- Attend and participate in ALL lessons.
- Have required personal protective equipment including:
  - Helmet
  - Rappel gloves
  - Safety shoes or boots
  - Eye protection
  - Harness (NFPA 1983 compliant and in good shape – subject to instructor approval)

Course Objectives

While each unit has specific enableing objectives, the overall course objectives that each student is expected to be able to demonstrate are listed below. These objectives are considered to be, as a minimum, those which will display a minimal level of competancy in vertical rope rescue techniques. At the completion of this course the student, given the appropriate equipment, shall be able to:

1. Demonstrate safe practices for working around vertical drops.
2. Perform a risk assessment of different vertical accident situations and determine a safe strategy for Rescue or Recovery.
3. Demonstrate an understanding of ropes and other specialized equipment used in urban/suburban vertical rope rescue and the correct procedures for the use and maintenance of that equipment.
4. Demonstrate an understanding of anchors, their selection and construction.
5. Demonstrate the acceptable techniques for belaying one or more rescuers or patients.
6. Construct a mechanical advantage system for given rescue situations requiring various load capacities.
7. Demonstrate an understanding of low angle rope systems vs. high angle rope systems and the limitations of each.
8. Demonstrate proper patient packaging, handling, raising and lowering techniques.
9. Be able to perform self controlled descent and demonstrate its application for rescue purposes.
10. Perform a self rescue during a self controlled descent.
11. Construct a 3 prusik ascending rig and ascend a rope.

The 32 hour **Intermediate Rope Rescue** course consists of 8 units of instruction covering the following subjects:

UNIT 1 – Program Orientation
1.1 Introduction and Registration
1.2 Course Overview and Objective
1.3 Safety Orientation
1.4 Risk Assesment
1.5 Rescue Knots

UNIT 2 - Rappelling and Ascending
2.1 Rappel & Ascending Overview
2.2 Ascending & Rappel Practical Application
2.3 Breakdown and Equipment Inventory

UNIT 3 – Standards and Equipment Familiarization
3.1 NFPA 1983 & 1670 Overview
3.2 Equipment Overview/ PPE, Software & Hardware

UNIT 4 – Rope Rescue Systems
4.1 Introduction to Rope Rescue Systems
4.2 Anchoring
4.3 Belaying
4.4 Incident Management
4.5 Patient Packaging
4.6 High Angle Theory – Lowering
4.7 Mechanical Advantage

UNIT 5 – Practical Applications
5.1A-D Anchoring, Belaying, Mechanical Advantage & Patient Packaging Practical Application

UNIT 6 – High Angle Systems Practical Application
6.1 High Angle Systems Practical Application
6.2 Breakdown and Inventory

UNIT 7 – Course Review
7.1 Course Review

Unit 8 - Testing and Evaluation
8.1 Written Test
8.2 Practical Applications and Evaluations
8.3 Practical Skills Evaluation
8.4 Breakdown and Inventory
8.5 Course Evaluation and Graduation

Safety Orientation

Course Safety Objectives

Given the proper equipment the student shall:

- Identify, utilize and care for the personal protective equipment needed for rope rescue operations.
- Demonstrate an understanding of the safe use of the specialized rope and hardware used in rope rescue operations.
- Demonstrate procedures for performing "Pre-operational Checks" to identify and control hazards, making the rescue area safe.
- Demonstrate an understanding of the importance of redundancy in rope rescue systems and operations.

Safety Guidelines

The training in this program involves the use of specialized equipment and techniques to support human life. In order for this training to be effective, all students will participate in evolutions that may expose them to peril if proper and safe procedures are not adhered to. Although there may be alternative methods and equipment that may be used to accomplish vertical rope rescue, the methods being presented and used in this program are intended to provide the highest level of safety for all participants.

The following guidelines should always be followed during training as well when performing an actual rescue.

- ✓ Never step on the software (rope & webbing).
- ✓ Never throw or drop hardware.
- ✓ Always dress your knots.
- ✓ Always backup your knots.
- ✓ We belay all "Lives".
- ✓ Never hesitate to ask a question.
- ✓ Always ask "What if this part fails?"
- ✓ Touch check your systems.
- ✓ Always have a safety officer.
- ✓ Lock all carabiners.
- ✓ Use and follow clear, simple communications.
- ✓ Utilize the Incident Command System.
- ✓ Smoking is never permitted around equipment, on the rappel tower or around equipment at a rescue scene.
- ✓ Helmets with chin straps fastened are required on or around the rappel tower or rescue scene.
- ✓ Gloves will be worn whenever working with rope that is "under load".

Risk Assessment

Introduction

The primary function of rescue is to locate and extricate trapped victims as well as transferring the victims to a stable and safe area while providing basic life support. A secondary function is to restore the area to a safe condition, thus precluding additional rescue at the incident site. The purpose of this lesson is to assist in the proper assessment of an incident (or potential incident) so as to ensure a safe outcome.

Hazard and Risk Assessment

The components of a hazard and risk assessment include:

✓ Preplan Information

The first component of your pre-plan is the information obtained from a site survey. Sample items that should be included in the site survey are: terrain, anchors and accessibility.

The second component of your pre-plan is an analysis of past incidents. Examples include: Where have past incidents occurred? How have past incidents occurred (are they college students being places they shouldn't or are they stuck recreational climbers)? Also of consideration is the probability of survival. Have past incidents always been fatal because the drop is 200 feet?

The third component is an assessment of available resources. Included in this assessment should be in-house resources and available mutual aid. Mutual aid can take many forms in addition to fire departments including specialized rescue teams, individuals with special expertise or equipment etc.

The final component of your pre-plan should include the lessons you have learned and information obtained from training at the site. This can provide valuable information on conditions and situations you may encounter.

✓ Determination of Rescue verses Recovery.

Rescue involves the moving of victims to a safer environment. When it is unknown if a victim is alive, the operation should proceed as a rescue. Recovery is the removal of a body from a trapped location to a location where it can be examined and identified. It is unfortunate that there are times when we cannot tell with assurance that there is no possibility of rescue. The following list may help in understanding the decision process to be followed. This list is not intended to be exhaustive, and the student should be encouraged to add to the list based on his/her own knowledge and experience.

- Know victim is alive.
    - Can see or hear victim.
    - Report from a reliable source.
- High probability victim is alive.
    - No known toxic conditions.
    - Air space available.
    - Victim fell less than 25 feet onto a moderately soft surface.
- Low probability victim is alive.
    - Exposed to toxic or hazardous gases or highly probable exposures.
    - Minimal chance of air space remaining.
    - Victim fell 50 feet or more onto a moderately hard surface.

- Certain victim is dead.

  - Exposed to high concentration of toxic gases.
  - Trapped with no air voids (example: sand bank or farm grain silo).
  - Victim fell 100 feet or more onto a hard surface.
  - Body decapitated or dismembered

✓ Determination of Hazards

Hazards present at a scene may prohibit rescue of live victims. Hazard assessment of the scene may dictate whether incident is a patient rescue or a victim recovery. A size-up or scene survey to identify potential or existing hazards can assist decision-making process and must include the entire area. Typical general hazards present or potentially present include: unsafe ground or unsafe footing, inadequate anchors, improper equipment, potential for falling objects and potential for damage to equipment from the work environment

✓ Determination of Risk verses Benefit.

Another way of analyzing the "patient rescue" versus "victim recovery" issue is to weigh the risks versus the benefit. All rescue work involves some risk, but some operations are riskier than others.The following should be considered when calculating risk vs. benefit:

- Danger to rescuers
- Number of victims
- Are the victims salvageable?
- Capabilities of the department
- Anything overlooked?

Knots for Rope Rescue

Introduction

Knot tying is a skill. The knots learned in this lesson must be practiced by each individuual team member to ensure that they can tie any of the needed knots without mistake or delay. **All** team members must be able to tie **all** knots used by the team.

A rescue team should rely on a small selection of knots that do their jobs well. By standardizing the knots used, there will be fewer knots for the team members to learn. During a rescue, checking the knot is much easier since a particular knot will be expected at a given position. This lesson utilizes the most common name for a given knot although the same knot may be known by several names.

The knots for rope rescue which are used throughout this course are:

Figure eight family of knots
- Simple Figure of 8
- Figure of 8 on Bight
- Figure of 8 Follow Through Loop
- Figure of 8 Bend - Join 2 Ropes
- Double Loop Figure of 8 (with & without incorporated ring)

Other knots
- Double Fisherman
- Prusik Hitch
- Overhand Knot
- Safety Knot
- Munter Hitch
- Square Knot
- Clove Hitch
- Butterfly Knot & Double Loop Butterfly Knot
- BC Load Releasing Hitch

Webbing knots
- Water Knot
- Mariner's Knot

What Makes A Good Knot

Strength

Knot strength is a measure of how much the knot will weaken the rope. Bending weakens rope and knots are nothing more than tight bends. The following table of relative strengths shows the strength (Figure 1-1) of a rope with a particular knot in it and is given as a percentage of the strength of that rope without the knot.

Figure 1-1

Relative Strength Of Knots For Single Kernmantle Rope

	Strength in lbs.	Percent Lost
Bends		
Double Fisherman's Knot	8,440	21%
Figure 8 Bend (Flemish Bend)	8,640	19%
Loops		
Figure 8 Loop (with a bight)	8,560	20%
Figure 8 Loop (follow through)	8,640	19%
Double Figure 8 Loop	8,820	18%
Figure 9 Loop	9,760	9%
Inline Figure 8 Loop	8,000	25%
Butterfly Knot	8,000	25%
Bowline	7,180	33%
Overhand Loop (with a bight)	9,060	15%
Overhand Double Loop	7,900	26%
Rope With A Loop In It (*)		
Figure 8 Loop	6,960	35%
Inline Figure 8 Loop	6,280	41%
Butterfly Loop	7,360	31%
Knots In Web		
Water Knot	3,060	36%
Overhand Loop	3,120	35%
Figure 8 Loop (with a bight)	3,360	30%
Figure 8 Loop (follow through)	3,560	26%
Web Slings		
Water Knot-Single Loop	5,700	
Water Knot-Double Loop	12,920	
Water Knot-Triple Loop	22,860	

(*) *Rope pulled end to end*

Dressing a knot

Neatness counts when tying a knot. Making the rope run smoothly without any extra bends or twists is called "dressing" the knot. When you dress the knot, it is stronger and easier to check.

Securing a knot

Some knots, like the double fisherman and water knot, tend to be self-locking. Some knots, like the bowline, are not particularly secure and tend to loosen when loaded. Because of this, the bowline has been eliminated from the knot selection for rope rescue.

Rescue Knots

Knots are grouped according to what they do. The most common knot family is the Figure 8 family of knots. In webbing, knots based on the overhand family work best. These knots have been chosen for ease of use, minimal loss in strength and test results proving the reliability of the knot.

As part of this course, given 8' of rope of minimum 1/2-inch diameter, the student shall properly tie each of the following knots completing all operations in sequence without safety violations and with 100% accuracy.

Simple Figure of 8 (Figure 1-2)

This knot is the basis for the other figure 8 knots. It is also commonly used as a stopper knot.

Figure 1-2

Figure of 8 on Bight (Figure 1-3)

This is a strong knot and is less bulky than double loop figure 8.It is used primarily for anchor systems and for attaching single person loads on to the rope.

Figure 1-3

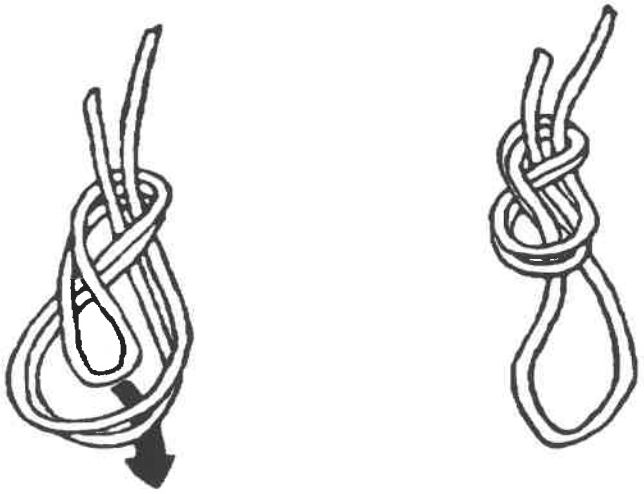


Figure of 8 Follow Through Loop (Figure 1-4)

This knot is used to tie around an anchor and tie into a harness when the loop in the rope cannot be put over or through to object (although we usually use a figure 8 on bight or double loop figure 8 with a carabiner).

Figure 1-4

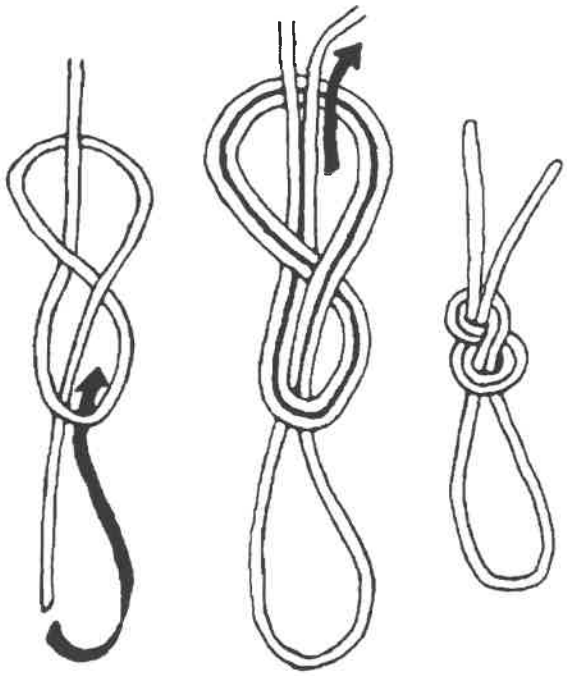
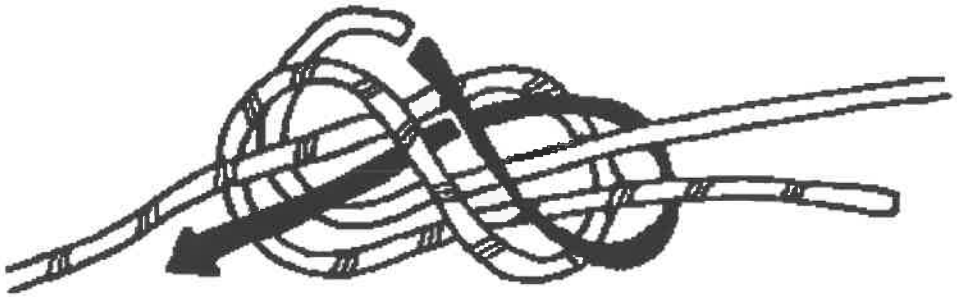


Figure of 8 Bend - Join 2 Ropes (Figure 1-5)

Used to join 2 ropes togeather.

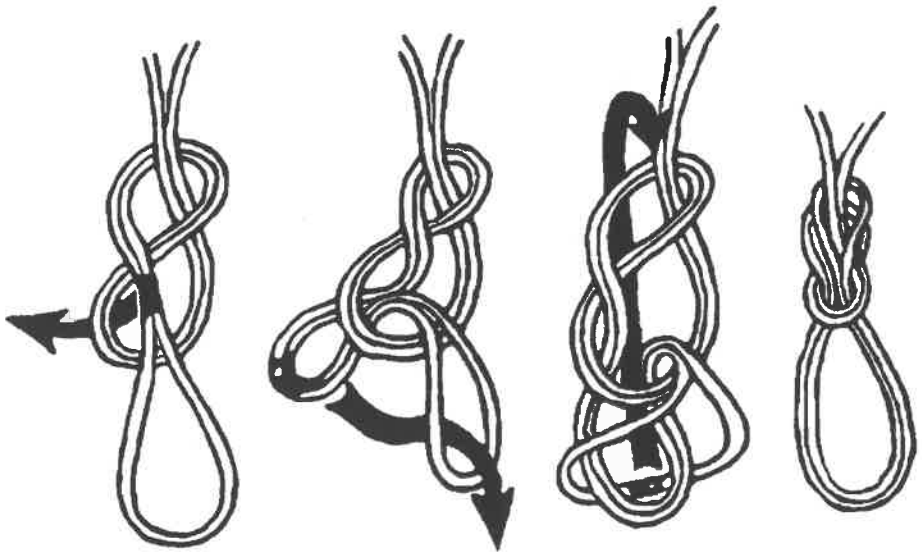
Figure 1-5



Double Loop Figure of 8 (Figure 1-6)

This is a strong knot and the double loop reduces wear and strength loss from the rope being bent around carabiner. It adjusts easily and is a versatile knot for anchor systems. It works well for anchor systems having two, three, or more points and the self-equalizing and omni-directional efficiency of the knot is increased when it is tied in rope rather than web. This knot can be tied in the end of the main line, or you can use a separate anchor rope. You can also have a ring incorporated for stretcher attachment.

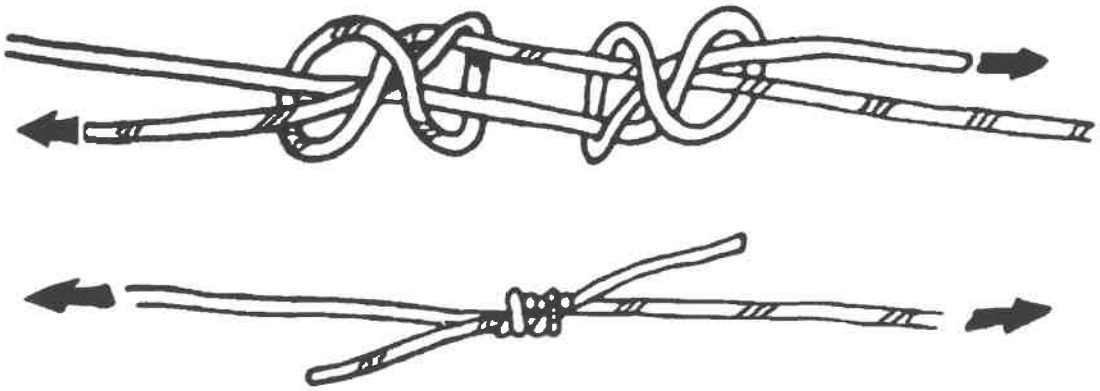
Figure 1-6



Double Fisherman Knot (Figure 1-7)

Used to connect two ropes or to make a rope into a loop. It is a strong, self-locking, very secure knot. This knot is primarily used with prusik cord in this course.

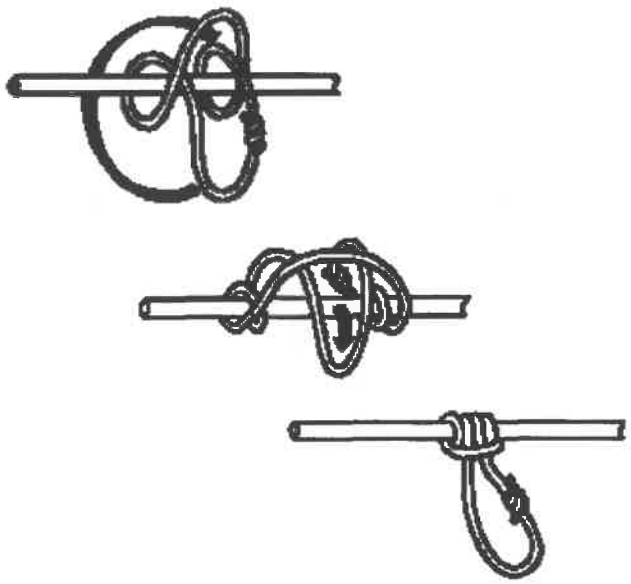
Figure 1-7



Prusik Hitch (Figure 1-8)

Used to secure a prusik loop to a rope. The knot holds when loaded but slides when loose. We use dual wraps for personal use and triple wrapped tandem lines for rigging and system use.

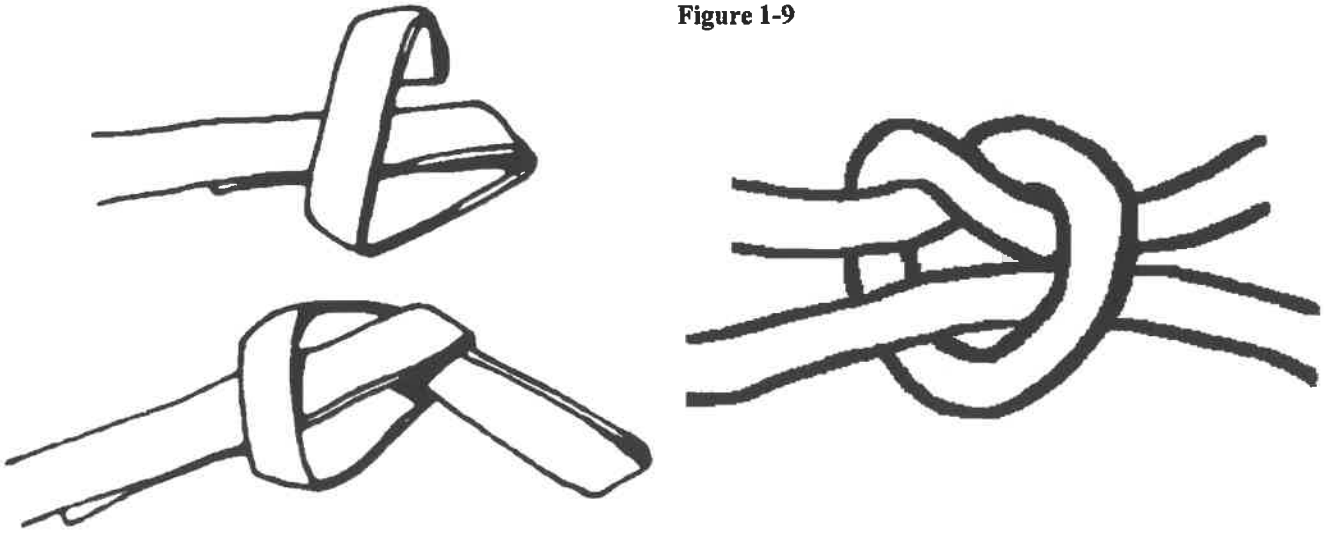
Figure 1-8



Overhand Knot (Figure 1-9)

Good choice for use with webbing. Is also used as back-up / safety knot with rope

Figure 1-9



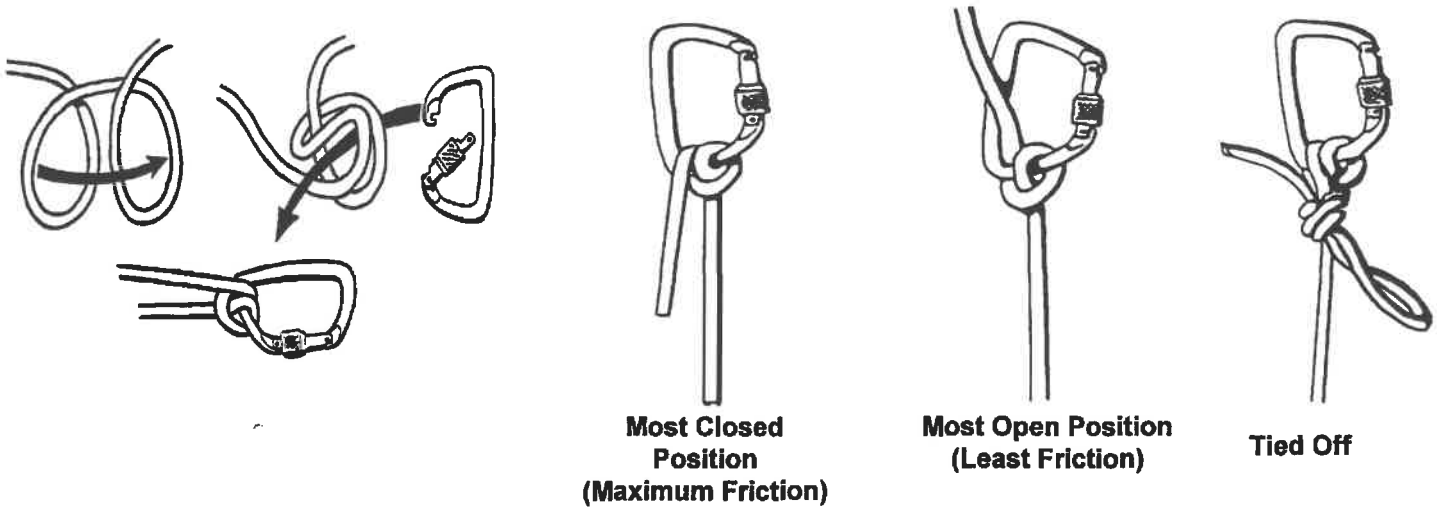
Safety Knot (Half Double Fisherman)

Used as a back-up/safety knot with rope.

Munter Hitch (Figure 1-10)

Used in place of a figure 8 plate or rack to belay a single person load.

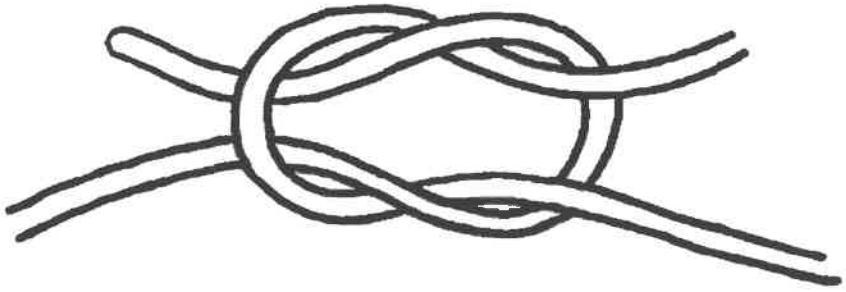
Figure 1-10



Square Knot (Figure 1-11)

Used in some victim packaging systems. MUST BE BACKED UP WITH A SAFETY KNOT.

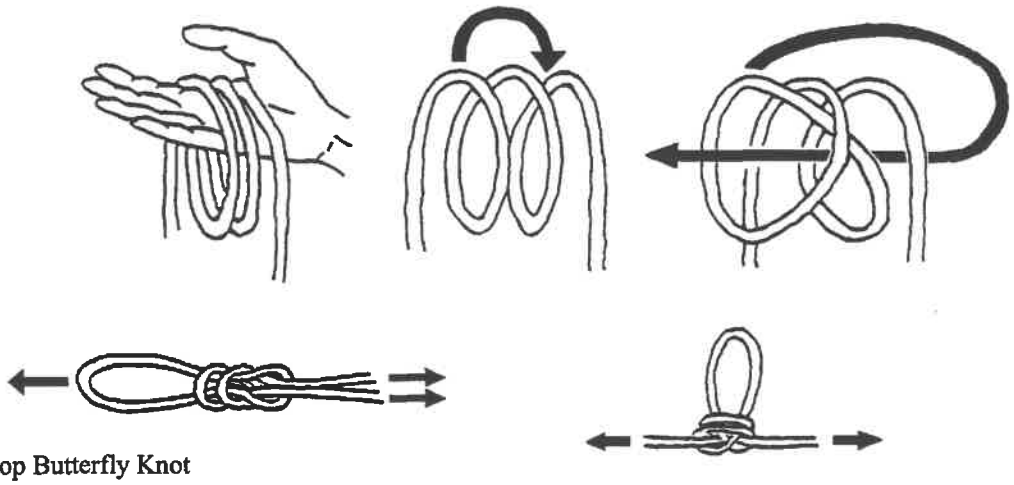
Figure 1-11



Butterfly Knot (Figure 1-12)

Used to create a loop in the middle of the rope. Often used for attachment of removal devices or victims to the rescue rope.

Figure 1-12



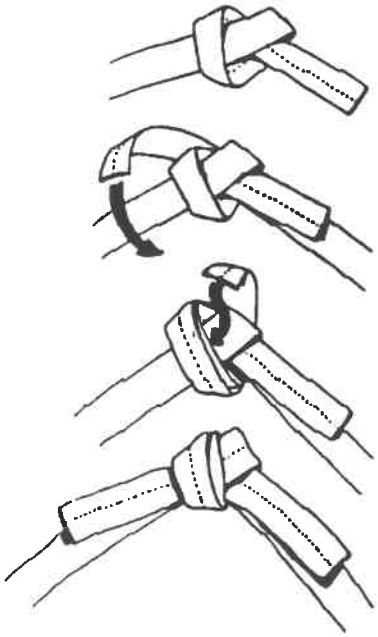
Double Loop Butterfly Knot

Used when the Butterfly Knot is utilized for system loads. Ties by adding an additional wrap and then pulling 2 loops through.

Water Knot (Figure 1-13)

Used with webbing. The knot is secured by tying an overhand safety knot on each side of the water knot unless you set the knot very tightly before use.

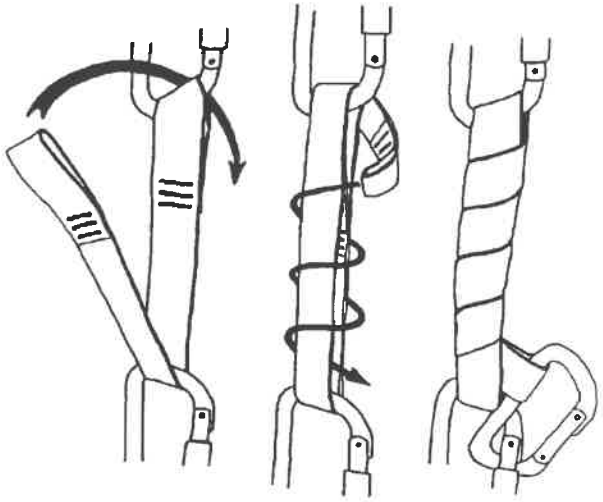
Figure 1-13



Mariners Knot (Figure 1-14)

Actually a knot system that can be releaded under load. It is primarily used to connect the brake to the anchor. If you need to release the brake while it is still under load, such as when it is holding a system, the Mariners' knot will free the brake. To untie the knot while it is under load, start by unclipping and removing the carabiner (the loose one) and push the loop back through the web, opposite of how you tied the knot. Start unwrapping the web carefully. As the web starts to slide, let the load transfer gently onto the lowering device or rope. This knot is not the preferred load release device in a high angle environment unless used in conjunction with a rated shock absorbing device.

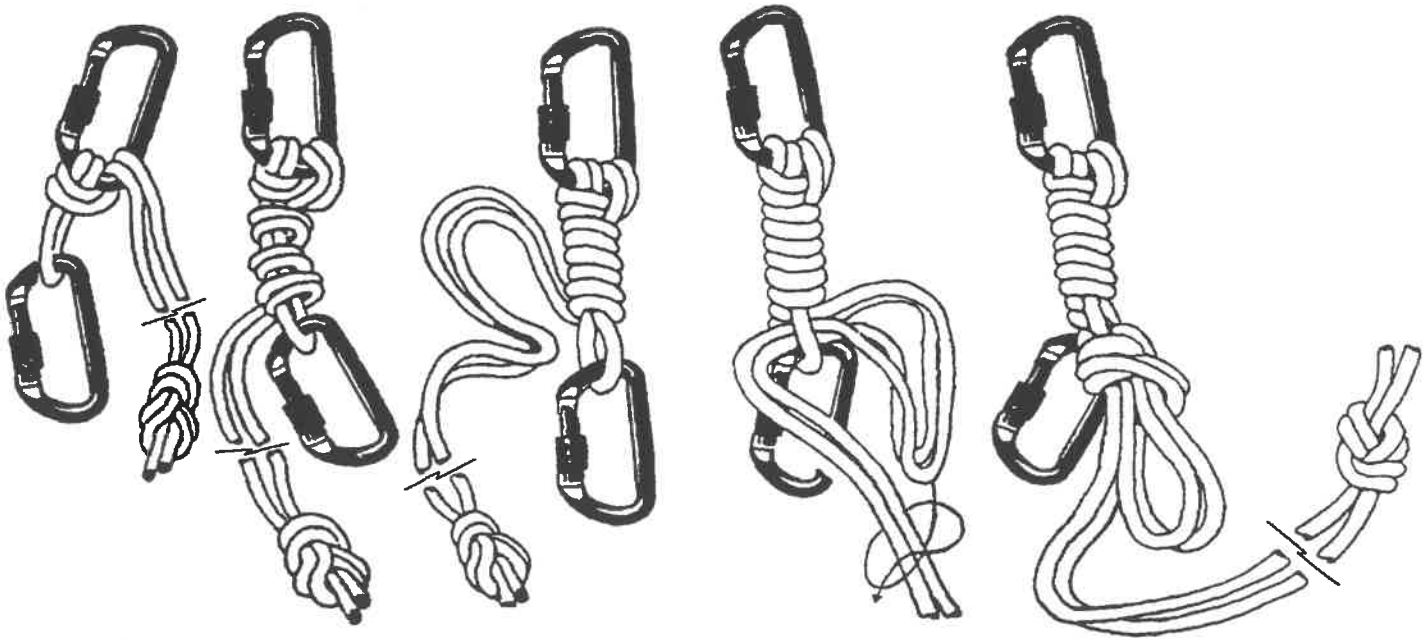
Figure 1-14



BC Load Releasing Hitch (Figure 1-15)

It is used in the tandem prusik belay system. Its major advantages include: it is stronger (better for high angle situations), greater shock absorbing capability as compared to the Mariners Knot and it has a longer release capability. The actual incorporation of this hitch will be covered more in depth during the belay lesson in unit 4.

Figure 1-15



Knot Practical Skills

Name:_____ Date: ____/____/____

Individual Knots:

Simple Figure of 8	Complete / Incomplete
Figure of 8 on Bight	Complete / Incomplete
Figure of 8 Follow Through Loop	Complete / Incomplete
Figure of 8 Bend - Join 2 Ropes	Complete / Incomplete
Double Loop Figure of 8	Complete / Incomplete
Double Fisherman	Complete / Incomplete
Prusik Hitch	Complete / Incomplete
Overhand Knot	Complete / Incomplete
Safety Knot (Half Dbl. Fisherman)	Complete / Incomplete
Munter Hitch	Complete / Incomplete
Square Knot	Complete / Incomplete
Butterfly Knot	Complete / Incomplete
Double Loop Butterfly Knot	Complete / Incomplete
Water Knot	Complete / Incomplete
Mariner's Knot	Complete / Incomplete
BC Load Releasing Hitch	Complete / Incomplete

Unit 2: Rappelling and Ascending

Rappel and Ascending Overview

Introduction to Rappeling

Descenders such as the Figure Eight and Brake Bar Rack are common braking devices used in rope rescue work. Both work by imparting friction to the rope to either brake the load directly or, as in a lowering system, brake the rope attached to the load.

In rescue work, the figure eight with ears (also referred to as a rescue eight) is the most common device used for personal rappelling. The brake bar rack is also widely used and is preferred by some because of its ability to be adjusted for friction while loaded.

This lesson will also discuss the need for rescuers to be able to rescue themselves if necessary as well as an overview of rescuer (also referred to as one person) based rescue techniques.

Figure Eight with Ears

Advantages & Disadvantages of the Figure Eight with ears

The advantages of the Figure Eight with ears is that it is simple to use, can be set up for different levels of friction, can be less expensive than the brake bar rack, is smaller size as compared to a rack (good for carrying & storage), and will not slip to form a girth hitch as will a standard figure 8.

The disadvantages of the Figure Eight with ears is that it imparts spin to rope (most noticeable over 150 – 200'), is height limited (more difficult to control over approx. 150 ft.) and cannot be adjusted for additional friction once "on line".

Rappelling with the Figure Eight with ears

Whenever possible, rappelling should be with a belay line. As such, attach a belay line as described later in this manual. Once attached to the belay line, initiate the belay cycle with the belay voice communications. The rappeller says "On Belay" and the belayer replies "Belay On". (This means that the belay line is now ready and attended.)

Rigging the figure eight with ears descender (Figure 2-1)

- ✓ Hold the figure eight descender with ears in your brake hand (your brake hand is usually your strongest hand, the right hand for most "right handers").
- ✓ Face the anchor with the rope running past you on the brake hand side.
- ✓ Grasp the rappel line near the anchor, take a bight of the rope in your guide hand.
- ✓ Slide the figure eight descender over the bight (hard over soft).
- ✓ Bring the bight up into the large opening in the descender, continue over the end of the small ring and across the waist of the descender.
- ✓ This process can be repeated if additional friction is needed (this procedure is known as double wrapping a figure eight).
- ✓ Attach the figure eight descender to the carabiner on the harness "D" ring and lock the carabiner.

Figure 2-1

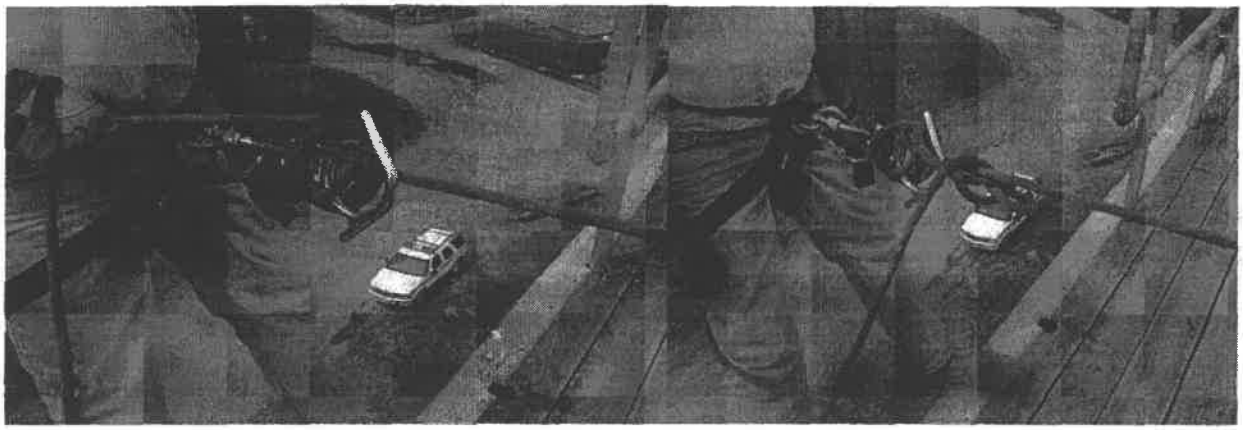
Rappelling

- ✓ Grasp the rope trailing from the figure eight descender in your dominant hand. This is the brake hand. This hand will always stay on the rope unless you are locked off.
- ✓ Grasp the rope above the figure eight descender in your remaining hand. This is the guide hand. This hand is used for balance, not support.
- ✓ Remove the slack between the figure eight descender and the anchor.
- ✓ Grasp the rope below the figure eight descender with your brake hand and pull it taut against your hip with the hand about 6 inches below the waist. (This position is used when stopping.The rope should be held away from the hip while rappelling to avoid abrading the harness).
- ✓ While still on a flat surface, lean back away from the anchor and let the line draw taut. Do a visual check of the rigging, carabiner, descender, gloves, etc.
- ✓ Begin walking backward, letting the rope slide slowly through the figure eight descender with the brake hand, while grasping the rope above the descender in your guide hand.
- ✓ Stop walking when you reach the edge. Lean back with your feet at about shoulder width with the knees relaxed and slightly bent and your instep at the wall edge.
- ✓ Continue to lean back into your rope until your body is approximately perpendicular to the wall. Begin your descent by taking slow and deliberate steps backward, releasing rope through the brake hand at a rate that will allow a gradual and controlled descent speed.
- ✓ Keep your body turned slightly toward your brake hand, looking down to pick a path for the descent.
- ✓ If you lose your footing while on rappel, grasp the rope in your brake hand tight against your hip to arrest your fall. Place your feet flat against the wall and rebalance yourself.

Locking off (Figure 2-2)

- ✓ It is possible to stop and secure oneself while rappelling at any point during a descent. By locking off the descent device, a rescuer can be suspended from the rope with both hands free to work at other tasks.
- ✓ The trick to a successful tie off is to be as fluid as possible while locking off rather than coming to a stop while descending and then trying to hold oneself in place and lock off at the same time.
- ✓ Anticipate the lock off procedure by grasping the eight plate near the point at which the plate is connected to your harness with a carabiner.
- ✓ Grasp the rope with your brake hand and allow the rope to travel through the eight plate until your brake hand is approximately a foot from the descender.
- ✓ Holding the rope taut with your brake hand, pull the rope in a sweeping arc from the rappel position, accross the front of your body, and over the top of the eight plate, trapping the rope between the front of the rappel line and the back of the eight plate.
- ✓ Continue the arc bringing the rope around the far ear of the eight plate.
- ✓ Repeat this procedure twice more, then tie a large overhand knot on a bight, around the base of the figure eight plate or around the rope above the eight plate.
- ✓ To unlock, reverse the process, using the "ear" for leverage if necessary. Keep the line in the brake hand taut so as to maintain control when the system is unlocked.

Figure 2-2



Brake Bar Rack

Advantages and Disadvantages of the Brake Bar Rack

Advantages of the Brake Bar Rack include: the amount of friction generated by the descender can be varied over a wide range, it allows the operator to reduce friction for long rappels with less twisting (as rappels become longer, around 200 feet or more, the Figure 8 has too much friction and the twist it puts in the rope becomes more of a problem), the rate of descent can be controlled by spread of the bars as well as by rope running through the brake hand of the operator, the bar will flop loose if rack is not rigged correctly, (angled bars may hold while you test rigging, then pop loose after you have committed yourself over the edge - care must be exercised.), the training groove on the first bar (or the first and third bars) will help to keep the rope in the center of the rack and the rack will accept two ropes, even if some of the bars have training grooves.

Disadvantages of the Brake Bar Rack include: it is somewhat more complex than the figure eight with ears, it takes a bit longer to put on the rope and it is somewhat bulkier and heavier.

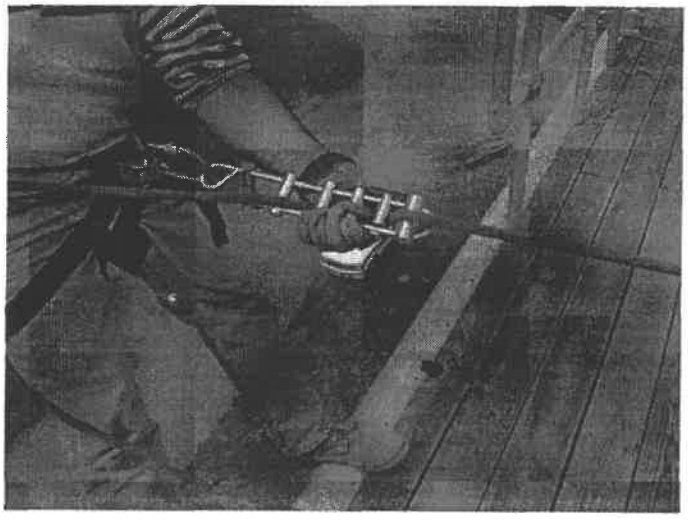
Rappelling with the Brake Bar Rack

Whenever possible, rappelling should be with a belay line. As such, attach a belay line as described later in this manual. Once attached to the belay line, initiate the belay cycle with the belay voice communications. The rappeller says "On Belay" and the belayer replies "Belay On". (This means that the belay line is now ready and attended.)

Rigging the brake bar rack (Figure 2-3)

- ✓ Clip the brake bar rack into the seat harness carabiner and lock the carabiner. If the carabiner is on a horizontal plane, attach the rack so the short leg faces down. If the carabiner is on a vertical plane, attach the rack so the short leg is on the brake hand side.
- ✓ Face the anchor with the rope running past you on the brake hand side.
- ✓ Disengage all bars on the rack except the top one.
- ✓ Pick up the rope with the brake hand and drape it on top of the top bar and then down between the two legs of the rack.
- ✓ Remove the slack between the rack and the anchor. Hold the rope down and away from you.
- ✓ With the other hand, swing the second bar up, snap into place and move it upwards toward the first bar, trapping the rope.
- ✓ Pull the rope up between the legs of the rack, pulling away from you so the second bar is snugged against the first bar.
- ✓ Repeat this process until all bars are locked into place.

Figure 2-3



Rappelling

- ✓ Grasp the rope trailing from the brake bar rack in your dominant hand. This is the brake hand. This hand will always stay on the rope unless you are locked off.
- ✓ Take the brake bar rack in your less dominant hand. This is the guide hand. The hand stays on the rack to control the spacing of the bars.

✓ Grasp the rope below the brake bar rack with your brake hand holding it in the same position as you would while rappelling with a figure eight.

> **NOTE* There are two ways that braking occurs while using a brake bar rack:**
>
> - With the brake hand, pull the rope away from the front of your body,towards the anchor. This is called the "quick stop".
> - With the guide hand, push the bottom bar, along with the other bars, toward the top of the rack. This is called the stop position (This is also a method of adding more friction without stopping).

✓ While still on a flat surface, lean back away from the anchor and make the line taut. Do a visual check of the rigging, carabiner, descender, gloves, etc.

✓ Begin walking backward, letting rope slowly through the brake bar rack with the brake hand, while holding the bars in a spread position using the fingers of your guide hand. If you do not move, remove one bar and try again. Remove a second bar if necessary.

✓ Stop walking when you reach the edge. Lean back with your feet at about shoulder width with the knees relaxed and slightly bent.

✓ When your body is approximately perpendicular to the wall, begin taking slow deliberate steps backwards, releasing rope through the brake hand at a rate that will allow a safe and controlled descent speed.

✓ Keep your body turned slightly towards your brake hand, looking down to pick a path for the descent.

✓ If the rappeller slips and falls, holding the rope in the brake hand tight against your hip will arrest your descent. Place your feet flat against the wall, rebalance yourself and resume your descent.

Locking off (Figure 2-4)

✓ With your brake hand, pull the rope toward the top of the rack. Add all of the bars to impart maximum friction.

✓ Pass the rope over the side of the rack by the guide hand so that the rope runs across the top bar between the curve of the rack and the rope coming from the anchor.

✓ Continue to move the rope in an arc towards the carabiner and, from the under side of the rack, pull the rope up between the two legs of the rack.

✓ Repeat the procedure while maintaining constant tension on the rope. Once you have gone "around the rack" at least twice, snug all of the bars together. The rack is now in the "stop" position.

✓ Form a large bight on the rope with your brake hand (with assistance from your guide hand if necessary) and, treating the bight as one rope, tie an overhand knot around the body of the rack or around the rope above the rack.

✓ To unlock the rack, reverse the above procedure. Make sure that no slack is allowed in the brake end of the rope.

Figure 2-4

Self Rescue

A technique for self rescue is critical knowledge for the rescuer (no rescuer wants to be in a position where he needs to be rescued). The most common need for self rescue involves objects becoming entangled in the rappel device.

There are two commonly employed techniques for performing self-rescue. The first method requires considerable upper body strength and a strong grip but has the advantage of requiring no additional equipment to perform. The second method is considerably less physically demanding but requires the availability of extra prusik loops.

Method 1

- ✓ When your downward progress has halted due to a jammed descent device, tangled ropes, or a stuck prusik, lock off the descender.
- ✓ Notify the belayer that you are "locking off"
- ✓ Sit back in your harness and cross one leg over the other at the knee. (if you are right handed you will want your right leg crossed over your left and vice versa)
- ✓ Wrap the rope trailing below your secured descent device twice around the upper foot and bring the tail end of the rope up above your descender in your upturned hand and hold it together with the rope above your descender. Squeeze the two ropes together with a death grip, straighten your leg and stand upright. This procedure will transfer your body weight from the stuck prusik or descender to your leg.
- ✓ Break loose the stuck prussik or clear your jammed descender and carefully bend your leg to transfer your weight back on to your descender.
- ✓ Unwrap the rope from around your foot, clean up any twists in your attachment points and carefully unlock your descent device.
- ✓ Call out to your belayer that you are once again "on rappel" and continue with your descent.

Method 2.

Recommended equipment for this evolution includes:

- 2 medium length prusiks
- 1 long prusik
- 1 paramedic shears
- 1 rigging knife with marlin spike

✓ Lock off on the rappel device. Notify the belayer that you are "Locking Off".

✓ Attach the long prusik to the rappel line above the rappel device. (Use a double wrap for a one person load.)

✓ Dress and set the prusik hitch

✓ Attach a second prusik cord from your harness to a point on the rope just below your large prusik to maintain at least 2 points of attachment to the rappell line.

✓ Place one foot into the prusik loop and step up to relieve the tension on the rappel device.

✓ Lock your knee and hold onto the rappel line above the rappel device with your free hand.

✓ Remove the entangled object from the rappel device and return to the rappel position.

✓ Remove the prusik from the rappel line and secure it.

✓ **NEVER** store the prusik around your neck.

✓ Notify the belay person that you are "On Rappel" and continue with the rappel.

Procedure if the object cannot be removed:

If the object cannot be removed by relieving tension on it, you may need to cut the object away from the rappel device.

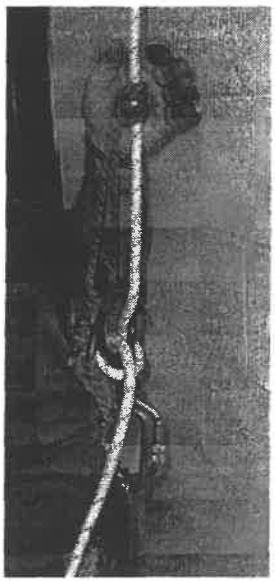
WARNING: This Option Should Be Done As A Last Resort.

Use paramedic shears or a seat belt cutter. This a very delicate procedure - take care not to damage the rappel or belay lines as well as the harness.

Single Line Technique (Figure 2-5)

Some organizations use single line technique for the medic line. The reason for this is that it reduces equipment and personnel needs. This method is accomplished by attaching a prusik hitch above the rappel device and the loop to the harness front "D" ring.

Figure 2-5



Rescuer based Rescue Techniques

NOTE: This segment is provided as an overview only. The actual training for this type of rescue will be provided in the "Advanced Rope Rescue" course.

Rescuer based rescue techniques provide well trained rescue teams with the option of employing team based rescue techniques. The rescuer must be highly skilled in rope rescue before attempting this type of rescue. A backup rescuer should be on standby in case the primary rescuer needs assistance.Rescuer EMS training must be to at least the DOT First Responder level.

The rescuer must be able to evaluate and treat the patient before moving the patient. Team based rescue techniques are the preferred method for rope rescue. Only when a team based rescue has been ruled out should the rescuer based rescue technique be considered.

Rescuer based rope rescue techniques may be considered when:

- There is a shortage of trained personnel on scene to perform a team based rescue.
- The terrain does not provide a suitable area to set up team based rescue systems.
- The situation does not allow time to perform a team based rescue.

Rescuer based rope rescue techniques should not be used when:

- The victim is uncooperative.
- The medical care required cannot be performed using the rescuer based rescue technique.
- A team based technique would be better suited for the rescue situation at hand.

Command Process

The following general rules should be followed when operating at a rope rescue incident. (See Unit 4 for more detailed information)

- ✓ Command - Establish the Incident Command System. The Incident Commander (IC) should designate a Technical Rescue Officer (TRO) as soon as possible. The command post should be set away from the rescue operation.

- ✓ Size Up - When the team arrives at the rescue site the TRO and team will begin a size up of the situation. The TRO will gather the team and solicit ideas for an action plan. Once the ideas have been presented the TRO will make a decision on what plan to use.

- ✓ Assignments - The TRO will now assign personnel to positions using the I.C. flow chart. The TRO will then brief the personnel on their assignments using the incident worksheet. The TRO will designate where each element of the system will be located. Personnel finishing their assignment should report to the TRO for reassignment.

- ✓ Staging - Once an equipment officer has been assigned, a tarp should be laid out and all equipment should be neatly arranged on the tarp. All equipment taken from the staging area and not utilized should be returned to the tarp.

- ✓ Rigging - The system should consist of three components, main line, belay line and patient packaging. The main line and belay line should be on separate bomb proof anchors. Personnel should now complete their assignments. Each person should check all components of their system to ensure proper rigging. The TRO and Safety Officer (or Assistant) (SO or ASO) should monitor the rescue scene for problems and provide correction as needed.

- ✓ System Inspection - When all systems have been completed, the TRO and the SO shall check all systems and components for proper rigging. Upon completion the TRO will pass control of the rescue operation to the SO.

- ✓ Rescue Operation - The SO begins by verbally checking all systems (belay, main line, and attendant). The SO uses standardized commands and whistle blasts to control the operation. The TRO will continue to monitor the rescue scene and systems for potential problems. The TRO will troubleshoot any problems should they occur. The SO will remain in control until the patient is removed from the rope.

- ✓ Post Incident Critique (PIC)- The TRO will conduct a PIC with the assistance of the SO. Discussion will be on what went well, what did not go so well, and what could we do to improve the operation.

- ✓ Termination - The SO will then pass control back to the TRO. The TRO will oversee the tear down, inspection, inventory and repacking of all rescue systems and equipment. The TRO is accountable for all personnel.

Commands for Rope Rescue Operations

Verbal Commands

The use of standard commands during rope rescue training and operations allows all personnel to operate in a safe and clear manner. The following verbal commands are used during rope rescue operations:

- ✓ "Down" (or Lower) - The command from the controller to lower the system. Repeat this command to increase speed.

- ✓ "Up" (or Haul or Raise) - The command from the controller to raise the system. Repeat this command to increase speed.

- ✓ "Slow" - This command is used with "Up" and "Down" commands as needed.

- ✓ "STOP" - A command anyone may use to stop a rescue operation at anytime. All personnel must stop immediately and listen for instructions.
- ✓ "STOP" Why STOP?" - A question from the controller to find out why the stop was called and what needs to happen to continue the operation.
- ✓ "Set" (or Brake) - A command by the controller during a raise, to the main line and the belay line, to set their systems.
- ✓ "Reset" - A command to the haul team by the controller, after the set command, to reset the hauling system. This command is repeated by the haul team leader once the hauling system is reset.
- ✓ "Belay Line Ready?" - A question from the controller to the belay to find out if the belay is ready.
- ✓ "Belay Line is Ready" - The belayers response to the controller that the belay station is ready.
- ✓ "Main Line Ready?" - A question from the controller to the main line to find out if the main line is ready.
- ✓ "Main Line is Ready" - The main lines response to the controller that the main line is ready.
- ✓ "Attendant Ready?" - A question from the controller to the attendant to find out if the attendant is ready. The controller always asks the attendants status last.
- ✓ "Attendant is Ready" - The attendants response to the controller that the attendant is ready.
- ✓ "Stand-By" - The response to the controller, or any other person, when they are not ready.
- ✓ "Prepare to Tension" - A command from the controller to the rescue team notifying them the system is ready.
- ✓ "Tension" - The attendant weights the system. Personnel check their systems.

Introduction to Ascending

There are circustances in rope rescues when the ability to climb a rope as part of a rescue evolution becomes essential. In the sport climbing arena, all techniques for ascending a rope have come to be referred to as "Prusiking"(NOTE: Techniques for ascending ropes will be covered in greater detail in the "Advanced Rope Rescue" course).

The most basic climbing technique is the three knot sit/stand method. It is important that novice rope rescue personnel recognize that climbing a rope is always a strenuous activity that requires considerable strength and agility.

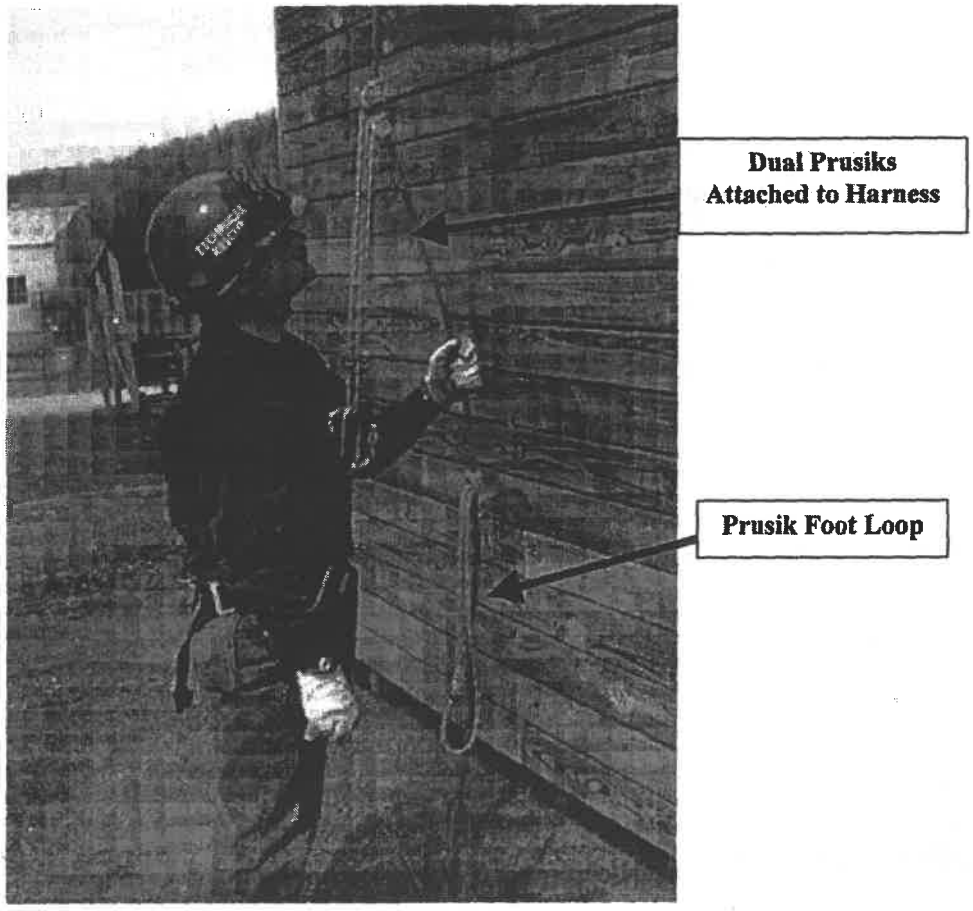
Rigging a 3-knot Prusiking System (Figure 2-6)

Because everyone is uniquely proportioned it is not possible to specify the exact length of prusik loops that will be required for a 3-knot prusik rig. However a reasonable compromise can be reached by equipping rescuers with 2 standard length prusik loops and one longer (8-9 foot) prusik loop, and a spare carabiner connected to his/her harness attachment point.

- ✓ Place one of the standard length prusiks on the line you are going to climb and pull it taut from the harness attachment point. The point on the rope where this top prusik attaches to the rope must always remain within the reach of the rescuer both while sitting in his/her harness and when standing in the foot sling.
- ✓ A second standard length prusik loop should be clipped into the second carabiner and is attached to the rope just below the top prusik. This prusik will become the second point of attachment to the rope and is essentially a belay in this version of the three knot rig.

- ✓ Attach the long prusik loop to the rope at a point about waist high.
- ✓ Once all three prusik loops are tied to the rope, dress them all and pull them tight.

Figure 2-6



Using a 3-Knot Rig to Ascend a Rope

- ✓ With one hand reach up the rope and use your body weight to pull the line taut. With your other hand slide the top knot as far up the rope as you are able. (Figure 2-7)
- ✓ Sit back in your harness so that your weight is supported by the top prusik loop.
- ✓ Reach down and slide the second "safety" prusik up the rope until it is just below the top prusik.
- ✓ Slide the bottom "foot loop" prusik as far up the rope as you are able. Bringing your knee towards your chest while maintaining a slight pressure on your foot loop will allow you to reach an efficient "step". (Figure 2-8)
- ✓ Grasp the top prusik knot, straighten your leg, and stand upright in your foot loop.
- ✓ While standing in your foot loop, move the top prusik knot as far up the rope as you can, then simply sit back in your harness and repeat steps 1-6 (Figure 2-9)

Figure 2-7

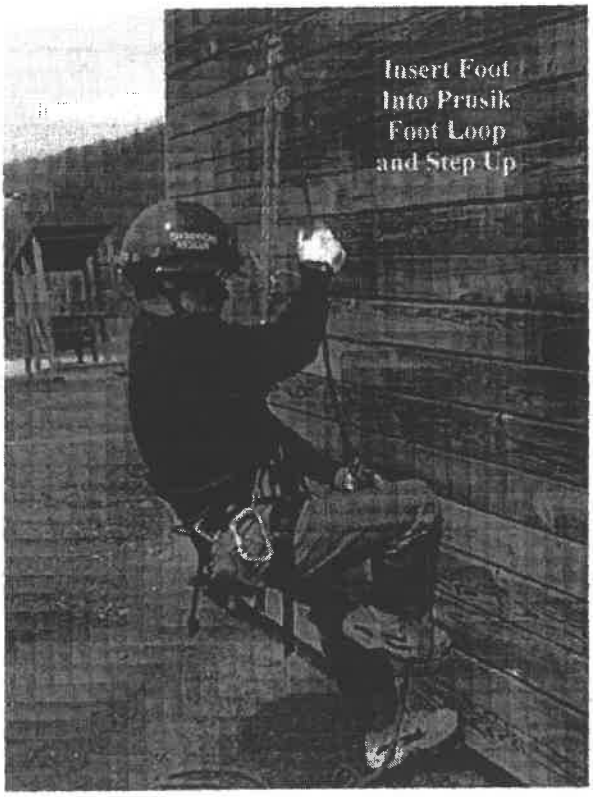


Figure 2-8

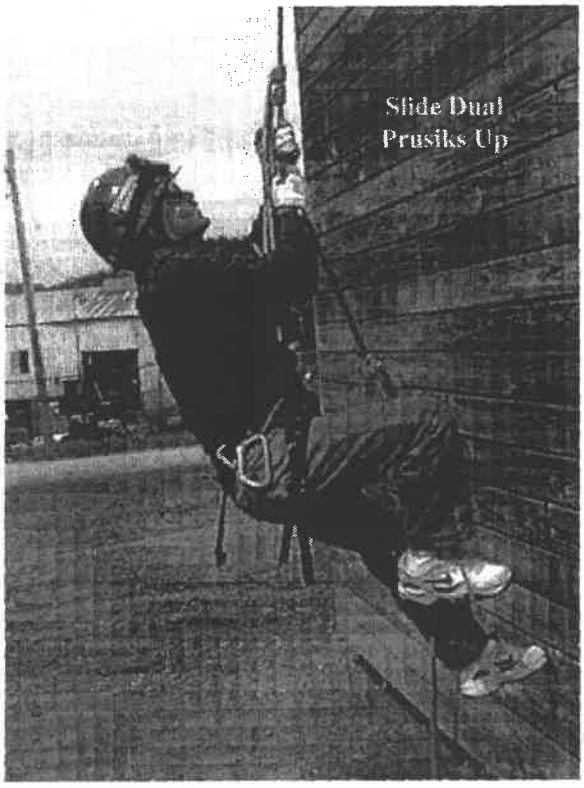
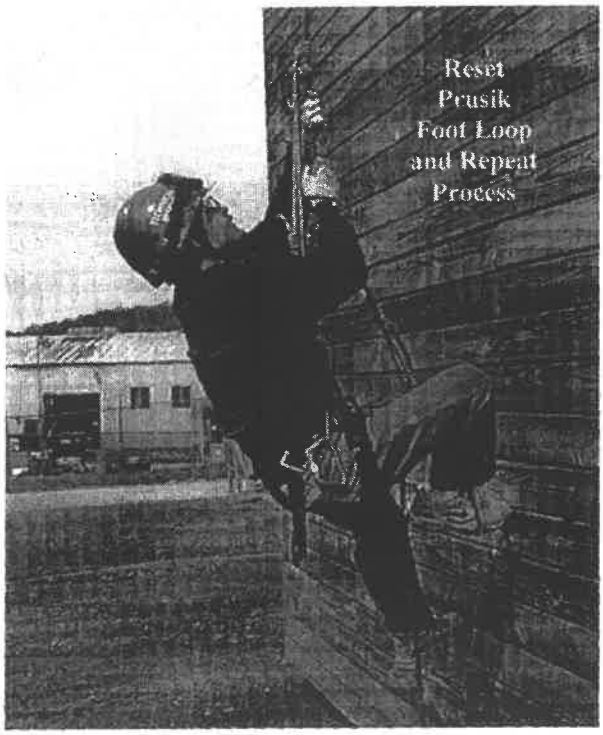


Figure 2-9



Unit 3: Standards and Equipment Familiarization

NFPA 1983 & 1670 Overview

NFPA 1670

NFPA 1670, "Standard on Operations and Training for Technical Rescue Incidents", was published in March of 1999. It is designed to assist organizations in developing a technical rescue capability in their community. It is commonly referred to as an "organizational standard" because the organization as a whole (as compared to individual members) must comply with the requirements of the standard. It is designed as a core + (plus) standard meaning that all specialties share a common set of needs and there was no point in repeating these for each individual specialty.

Standard Components

Core requirements for all specialties including:

- Medical care.
- Hazard analysis & risk assessment
- Incident response planning
- Equipment
- Safety
- Safety Officer
- Incident Management System
- Fitness

Specific requirements for the following specialties:

- Structural Collapse
- Rope Rescue
- Confined Space
- Vehicle & Machinery
- Water
- Dive
- Ice
- Surf
- Swift Water
- Wilderness Search & Rescue
- Trench & Excavation

This standard is also based on a 3 operational level system. These include: Awareness, Operations and Technician. Rope Rescue requirements are (in addition to the core requirements):

Awareness Level:

- ❖ Size up
- ❖ Resource identification
- ❖ Response system & scene management procedures
- ❖ Hazard recognition
- ❖ PPE needs

Operations Level – Awareness plus:

- ❖ Mechanical advantage systems
- ❖ Edge protection
- ❖ Anchor systems
- ❖ Belay systems
- ❖ Lowering system
- ❖ Low angle raising system
- ❖ Knots
- ❖ Patient packaging
- ❖ Ascending & descending
- ❖ Low angle litter tending

Technician Level – Operations plus:

- ❖ Load distributing anchor systems
- ❖ High-line systems
- ❖ High angle raising systems
- ❖ Knot passing
- ❖ High angle litter tending

NFPA 1983

The current version of NFPA 1983, "Standard on Fire Service Life Safety Rope and System Components" was published in 1995 and is the most widely used standard with regards to the construction, care and use of rope rescue equipment. This standard is divided into the following major segments:

- Certification
- Product labeling & information
- Design & construction requirements
- Performance requirements
- Testing requirements

The standard does not cover:

- Utility rope
- Rope and equipment for special rescue operations including: mountain rescue, cave rescue, water rescue. lead climbing operations and operations where personnel work above the anchor points or where the fall factor exceeds 0.25.

Major Standard Components

Certification

- Rope and components must be labeled and listed
- Certification organization must be independant from the manufacturer. (Certification shall include a follow-up inspection program with at least 2 random and unannounced visits per year).

Product labeling and information

Rope

Life safety rope shall be marked for its full length by insertion of a continuous identification tape. The information provided includes:

- Meets requirements for Life Safety Rope of NFPA 1983, 1995 edition.
- Certification Organizations label
- Name of manufacturer
- Year & quarter of manufacture
- (1 or 2) person rope (described further in a later part of this lesson).

Life safety rope will have a product label attached to each rope. The information provided includes:

- Number of person rope
- Maximum working load
- Minimum breaking strength
- Circumference and diameter
- Certifying organization's label
- Type of fiber
- Manufacturer, product ID and lot number
- Month & year of manufacture
- Country of manufacture
- Warnings as provided

Life safety rope designed to include electrical carrying capabilities shall also meet requirements of Class I, Division I, hazardous locations specified in ANSI/UL 913. Also, personal escape rope must meet most of the requirements for life safety rope.

Harnesses

Must have a label affixed stating

- Meets NFPA 1983, 1995 Edition
- Certification organizations label
- Name, product identification and lot or serial number of the manufacturer
- Month & year of manufacture
- Country of manufacture
- Warning as provided. (States waist, height or chest size as appropriate for the class of harness).

Belts

- Similar to the requirements for harnesses.

Auxiliary equipment

General requirements - A product label shall be affixed to all auxiliary equipment stating:

- Meets NFPA 1983, 1995 Edition
- Certifying organization's label
- Name, product identification and lot or serial number of the manufacturer
- Month & year of manufacture
- Country of manufacture
- Warning as provided.

Software - Label shall be sewn, stapled, riveted or otherwise permanently affixed.

Hardware - Required information shall be stamped, engraved or otherwise permanently marked. Shall also be marked "G" for general use or "P" for personal use.

User information

Life safety rope

Manufacturer shall provide to purchaser:

- Use criteria
- Inspection procedures
- Maintenance procedures
- Retirement criteria

Life safety rope may be reused if the following conditions are met:

- Rope has not been visually damaged.
- Rope has not been exposed to heat, direct flame impingment or abrasion.
- Rope has not been subjected to any impact load.
- Rope has not been exposed to materials that can deteriorate the rope.
- Rope passes inspection by a qualified person following the manufacturer's inspection procedures both before and after each use.

The rope must be removed from service and destroyed if it does not meet the requirements stated above.

Information on the use, care, inspection and maintenance of personal escape rope, harnesses, belts and auxiliary equipment must be provided as specified.

Design and construction requirements

Life safety rope

Class One Person - Maximum working load of at least **300 lbs.**

Class Two Person - Maximum working load of at least **600 lbs.**

Working load is calculated by dividing the new rope minimum breaking strength by a factor of 15. Rope shall be of block creel construction using virgin fibers.

Personal escape rope

Maximum working load of at least 300 lbs. Rope shall be of block creel construction using virgin fibers.Working load is calculated by dividing the new rope minimum breaking strength by a factor of 10.

Harnesses

Class I - Harness that fastens around the waist and around the thighs or buttocks. Designed to be used for emergency escape with one person load.

Class II - Harness that fastens around the waist and around the thighs or buttocks. Designed for rescue where two person loads may be encountered.

Class III. - Harness that fastens around the waist, around the thighs or buttocks and over the shoulders (may consist of one or more parts).. Designed for rescue where two person loads may be encountered and inverting may occur.

Belts

Defines the difference between a ladder belt , escape belt and a ladder/escape belt.

Auxiliary equipment

Defines "personal" vs. "general" use. Personal use is for equipment intended for the sole use of the rescuer and not where the equipment could be subjected to a two person load. General use is for equipment intended to be used where two person loads are anticipated.

Performance requirements

Life safety rope

- Minimum breaking strength - One person - 4500 lb - Two person - 9000 lb
- Minimum elongation - 15% @ 75% of the breaking strength.
- Maximum elongation - 45% @ 75% of the breaking strength.
- Size, weight and other requirements as specified.

Personal escape rope

- Minimum breaking strength - 3000 lb.
- Maximum elongation - 45% @ 75% of breaking strength.
- Size, weight and other requirements as specified.

Harnesses

- Shall be tested and perform as specified and show no visible signs of damage that will affect its function.
- Other requirements as specified.

Belts

- Shall be tested and perform as specified and show no visible signs of damage that will affect its function.
- Other requirements as specified.

Auxiliary equipment

- Carabiners and snap links
- Shall be tensile tested
  - ❖ Minimum breaking strength - major axis - gate closed - Personal use - 6000 lbs. - General use - 9000 lbs.
  - ❖ Minimum breaking strength - major axis - gate open - Personal use - 1650 lbs. - General use - 2400 lbs.
  - ❖ Minimum breaking strength - minor axis - Personal use - 1500 lbs. - General use - 2400 lbs.

- Ascending devices
  - ❖ Shall be tested and withstand a minimum load test of 1200 lbs. without permenant damage to the device or rope.
- Descent control devices
  - ❖ Personal use devices - Shall be tested and withstand a minimum load test of 1200 lbs. without permenant damage to the device or rope. - Shall withstand a minimum load test of 3000 lbs. without failure.
  - ❖ General use devices - Shall be tested and withstand a minimum load test of 1200 lbs. without permenant damage to the device or rope. - Shall withstand a minimum load test of 6000 lbs. without failure. Rope grab devices shall be considered general use devices and be tested and withstand a minimum load test of 2400 lbs. without permenant damage to the device or rope.
- Other auxiliary equipment.
  - ❖ Personal use - Minimum tensile strength of 1200 lbs. without permanent damage to the equipment or other associated equipment. Minimum tensile strength of 5000 lbs. without failure.
  - ❖ General use - Minimum tensile strength of 5000 lbs. without permanent damage to the equipment or other associated equipment. Minimum tensile strength of 8000 lbs. without failure.

Testing requirements - equipment shall be tested as follows:

- Life safety rope - Breaking and elongation testing
- Personal escape rope - Breaking and elongation testing
- Harnesses
  - ❖ Class I - Static test (upright) - Dynamic drop test
  - ❖ Class II - Static test (upright) - Static test (horizontal) - Dynamic drop test
  - ❖ Class III - Static test (upright) - Static test (head down) - Static test (horizontal) - Dynamic drop test
- Belts - Static test (upright) - Static test (horizontal) - Dynamic drop test
- Auxiliary equipment - Shall be tested for strength as specified as well as meet other requirements as necessary.

Equipment Overview – PPE, Software and Hardware

Personal Equipment

What you wear to the rescue is based on your personal experience as to what works and what does not. The terrain, weather, type of calls and duration all have an influence. Department standard operating procedures dictate what you wear or use for personal protection. As a minimum, the following equipment should be used:

- Helmets

Accepted safety practice in rescue work. Protects from falling debris, rocks and equipment. Types of helmets include: climbing helmets, fire service helmets and hard hat type helmets.

- Harnesses

Used as a quick clip-in point, for a belay or emergency rappel, as fall protection, as a work platform and as a means of transporting the victim.

  - ❖ Inspection of rescue harness. - It is the responsibility of the user to inspect the harness. Look for worn or broken stitching and rivets torn out of the holes. Check the material for damage from abrasion, cuts or chemicals. **If it does not look safe, do not use it!**

- Gloves

A rescuer's hands need protection from the rope, especially when rappelling, as well as from other hazards found in a rescue situation. Any durable leather glove will work, but we want to mention two specialty types of gloves. Depending on the type of work involved and the environment, heavy duty gloves with extra leather patches on the palms and light, tight-fitting deerskin glove with a double palm are typically used and recommended.

- Boots

The purpose of selecting an appropriate boot for rope rescue is to protect and support your feet as well as provide traction on poor surfaces. The typically recommended type is a moderately heavy mountaineering boot (the stiffness and narrow sole helps in climbing situations). It is important that the foot is well protected when carrying heavy loads like a stretcher. It must provide good support for the foot and ankle, the boot should fit well and the sole should provide good traction.

- Lighting at Emergency Scene

There are 4 primary types of lighting used at rope rescue incidents. These include:

  - ❖ Head lamp - Mounts to rescuer's helmet, usually provides adequate light and keeps the hands free.
  - ❖ Hand light with shoulder strap.
  - ❖ Vehicle lights.
  - ❖ Portable lights.

- Personal Items for Rope Rescue

Every rescuer should carry a certain amount of personal equipment that may prove very handy. Care needs to be taken to not "overload" yourself while trying to think of every possibility. Good judgement and experience is very useful in this area. As a minimum the rescuer should carry a pair of large utility scissors (sometimes called paramedic scissors) and extra Prusik rope. The prusik can be used as a self-belay on a rappel, adjustable tie-in to a safety line as an edge rope and as a short runner.

- Safety for Rope Rescue Personal Equipment

Inspect your equipment on a regular basis. Look at it carefully after you buy it or before you put it into service. When repacking your kit after a rescue or after washing your equipment, inspect it again. It is your life support equipment, so satisfy yourself that everything is the way you want it.

Rope Rescue Software

Rope rescue equipment referred to as software includes:

- ❖ Rope
- ❖ Prusik Cord
- ❖ Webbing
- ❖ Harnesses
- ❖ Other auxiliary equipment such as straps, etriers, runners, etc.

Rope

There are two types of rope commonly in use for rappeling or climbing:

- ❖ Static Kernmantle Rope - rope use for rescue
- ❖ Dynamic Kernmantle Rope - used by rock climbers and is designed for more stretch in case of a fall.

Its uses include: to raise, lower, traverse, provide safety, and constructing/rigging of mechanical advantage raising or lowering systems.

- Elements comprising a rope.

The primary fiber used in the manufacture of almost all Kernmantle rescue ropes is nylon in either braid-on-braid or three strand laid ropes. Different manufacturers use different types of nylon . The premier nylon is DuPont 707, Type 6,6. Other rope fibers available are polyester or polypropylene. A rescue rope can have different fibers in the core or center area than in its outer covering or sheath. Manila is no longer acceptable as a fiber in life rescue ropes.

- Rescue Rope Construction Techniques.

Braided rescue ropes have a braided core covered by a braided sheath. This is technically described as a kernmantle rope. Static kernmantle rope has little stretch (no more than 20% elongation at break). Approximately 75 % of the strength of the rope is in the core. It is made of parallel fibers and is the load bearing part of rope (the design of the core determines whether it is static or dynamic). The sheath provides 25% of the strength of the rope and its primary function is to protect the core. The percentage of load carried by the core of a kernmantle rope can vary from 70 to 90 percent depending on the braid of rope and its diameter (braid-on-braid ropes can have as low as 50 percent of load carried by core (the inner braid) and the rest carried by sheath).

The major advantages to using static kernmantle rope include: low stretch, good resistance to damaging dirt and grit, good resistance to abrasion and high tensile strength. Disadvantages include: not as easy to handle and tie knots in as some other rope types and it is not designed for severe shock loading.

Sample Breaking Strengths

Rope:

5/16" static kernmantle	4,270 lbs.
3/8" static kernmantle	5,900 lbs.
7/16" static kernmantle	7,800 lbs.
1/2" static kernmantle	10,000 lbs.
5/8" static kernmantle	12,700 lbs.

Prusik Cord

7mm prusik cord	2,992 lbs.
8mm prusik cord	3,630 lbs.
9mm prusik cord	3,670 lbs.

Webbing/Straps:

1" tubular spiral stitched	4,000 lbs.
Pick-off strap & stretcher strap	10,000 lbs. (buckle slips at 4,500 lbs.)
Anchor Strap	8,000 lbs.
Rescue runner	6,800 lbs. (breaking strength of loop 5,000 lbs.)

- Rescue Rope Strength.

The strength rating given for a rope is the load required to break the rope (called tensile breaking strength). The working load is less than breaking strength. We use a 15:1 ratio for safety and a person weight of 300 lbs. This means that a 1 person rope must be rated for at least 4,500 lbs. and a 2 person rope must be rated for at least 9,000 lbs. When constructing mechanical advantage systems care must be taken as they can generate great force. Exceeding the working load of a rope causes damage to some of the fibers and rope ages faster if it is abused. Also, the rope's ability to resist abrasion, water absorption, chemicals and sunlight become as important as pure strength.

- Abrasion Resistance

Study of mountaineering and caving accidents has shown that broken ropes are often the direct result of abrasion (such as rope being abraded over an edge or from the rope receiving an impact load while it is bent over an edge). The advantages of high resistance to abrasion include: the rope retains its strength longer and is safer. The use of edge pads and edge rollers will further increase safety and the rope life but it is never possible to eliminate all sources of wear.

- Elongation

This is referred to as stretch and exists in all ropes. It is measured as percentage of increase in rope length under a given load specification for rescue rope elongation (usually given for a load of 200 pounds)

- Size

American rope manufacturers typically use inches to state rope size while European manufacturers use millimeters. The following chart shows the rope size equivalents.

Inches	mm	Actual mm
1/4	6	6.35
9/32	7	7
5/16	8	7.94
11/32	9	9
3/8	10	9.53
7/16	11	11.11
1/2	12.5	12.70
9/16	14	14.29
5/8	16	15.88

Larger diameter ropes are stronger and easier to grip while providing a slower rappel. Smaller diameter ropes have lower weight, less bulk and fit a wider variety of rope rescue accessories.

- Length

The length of a coil of rescue rope is actually determined by department standard operating procedures. Rope is available in uncut spools of 300 and 600 foot lengths. Most rescue crews cut their rope into lengths of 150, 200 or 300 feet (depending on need).

- Knotability

Balance is needed between a knot being easy to tie and its ability to be untied after use. Rescue ropes are designed for a middle ground where knots can be set by hand, but do not tighten excessively under rescue loads. Soft, flexible ropes tie easily and knots can be set tight by hand. Unfortunately, knots become impossible to untie after loading. Stiff rope, on the other hand, is hard to work with and knots cannot be set tight by hand. There is a possibility of coming untied or slipping before the load has set them.

Webbing

Webbing is available in two types – flat or tubular. Sizes range from 1/2 inch up to 3 inches in width and are usually available in nylon or polyester. Tubular web, particularly one inch, is popular for rescue work. Heavy duty flat web comes in 2 and 3 inch widths, is stronger than one inch tubular, and is typically used for harness construction and various types of straps.

Nylon webbing is strong and is a light weight synthetic material. It is typically of a spiral weave - continuous strand wrapped around horizontal strands. As mentioned before, one inch tubular web is preferred by rescue teams and has a military specification rating of 4000 pounds. Its high abrasion resistance makes it excellent for tying anchors. The softness of webbing makes it more comfortable when used as a stretcher tie-in or an improvised harness as compared to rope

One word of caution is in order regarding webbing construction. If you can hold the web by the edges and flatten it to reveal a row of stitching holding the two layers together to make the web tubular, you have a problem. This type of web is considered unacceptable by a large number of rescue teams and should not be used.

- Length and care of webbing

Department SOPs determine the length of webbing used, although the recommended lengths are:

- ❖ 12' - 15' - for anchors
- ❖ 20' - 25' - for anchors and harnesses
- ❖ 30' - 35' for basket stretcher lacing

Care of webbing is the same as rope. It is recommend that different colors be used for different lengths. This provides for easy identification.

Prusik Rope / Prusik Loop

Prusik cord is of a polyester braid on braid construction. Sizes of 7 – 9 mm are typically used depending on application. 7mm is usually used for personal prusik, 8mm is used for system (braking) prusiks and 9mm is used in the construction of the BC load release hitch. It is very strong for its diameter and its softness allows it to hold well.

The diameter of prusik cord used as a rope grab should be not less than 1/3 but no more than 1/2 of the diameter of the rope it is to be used on. Length will be determined by application. Care and maintenance is the same as rope.

Anchors And Slings

A long run out from the anchor point to the system tie-in should be done with rescue rope. Attachments to rocks, trees, or vehicles can be done with one inch tubular webbing or straps. Sewn web or straps can make anchor setting faster, has a higher abrasion resistance for use as anchors, is less bulky to work with than rope and its softness and large surface area allows web to grip the anchor point (which prevents slipping).

Considerations In The Selection Of Rope And Web For Rescue

It will be your life on the line, not the manufacturer's, the salesman's, or your purchasing agent's. Read the advertisement carefully and ask questions. There are several good brands of rescue rope on the market. Depending on your rescue needs, a particular brand or type may have particular advantages over the others. Rope tests and results should be in compliance with NFPA 1983 "Standard on Fire Service Life Safety Rope and System Components".

The type of rope selected will be determined by need. Abrasion resistance, as an example, is very important to some organizations. Rope suffers abrasion in many different ways. Static kernmantle ropes perform better than other types of construction. Braided ropes and three strand ropes have their load bearing fibers exposed to abrasion causing the rope to lose strength faster . In general, the stiffer a kernmantle rope is, the greater the abrasion resistance. Also, the heavier sheaths on the American manufactured ropes give a better abrasion resistance than the European rescue/caving ropes.

What To Use

For rescue applications, American made, static kernmantle ropes are the best choice for nearly every rescue situation. It has a high strength core, is protected from abrasion by a sturdy sheath and has good knotability. The sheath also helps the rope resist effects of chemicals, dirt and sunlight. The rope tends to be stiffer but it holds up better under use. Knotability is a good balance between good handling characteristics and knots that set well but do not become impossible to untie.

The nylon fiber used by all manufacturers of kernmantle ropes made for rescue have high strength, high abrasion resistance and are relatively durable. Nylon has significantly better resistance to aging than manila ropes and allows even a static rope to still have enough give to withstand an impact load without failure. Polyester fiber is used occasionally for the sheath of the kernmantle rope

Although special rope rescue circumstances can require different ropes, if you are standardizing use static kernmantle rescue rope for everything. Knowing your rope's capabilities and limitations is still the key to safe use.

- Snow Rescue - wet and frozen ropes disappear in low visibility. Loads on rope in these incidents tend to be lower and surfaces that cause abrasion are usually buried under snow. Polyester braid-on-braid ropes are often used due to high strength and low water absorption

- River Rescue - Rope with polypropylene is recommended to be used only as a water rescue throwline, and never in rescue systems or rappels. If the rope is primarily used for rescue systems and only occasionally subjected to dunking, the strength and abrasion resistance of a rescue quality static kernmantle rope are required. If a nylon rope is left in the water long enough to get saturated, you could lose up to 15 percent of the strength. But the resulting strength may still be greater than a polypropylene rope.

  Rivers can generate surprisingly high forces and ropes are going to get wet. Nylon fibers absorb water and will eventually sink. Also, soaking will also cause some loss in strength. Rope with polypropylene will float although strength and abrasion resistance are not has high as desired. A compromise is to use rope with a polypropylene core with a nylon (or polyester) outside sheath This provides increased strength and abrasion resistance.

- Environmental Considerations - Polyester ropes offer the best resistance to chemicals, chemical atmospheres, and sunlight. Nylon is highly resistant and, in the case of alkalis it is better. Static kernmantle rescue ropes remain the best choice. All ropes should be stored away from exposure to UV light and contaminants.

Rope and Web Care

New Rope

Inspect rope carefully before placing it in service. Be sure to read the manufacturer's literature carefully and save it. Tape the ends of the rope to identify the coil (a product called **Whip-End Dip™** can be used to protect the tape or to color code the end of the rope). Write important data on the tape such as: date purchased, rope number, length in feet, rope diameter, owner and whether it is a lifeline or utility line. A rope does not need to be broken in but a new rope will be faster than one that has seen some use.

Rope Bags

The best way to store rescue ropes is in a rope bag. The bag protects rope from ultraviolet rays and contamination. Rope is stuffed into bag, not coiled, for ease of deployment. Data provided on outside of bag can include: rope length, diameter and ID number. Bags should be stored in a cool, dry place out of direct sunlight and be kept away from chemical atmospheres.

Rope Logs

Keeping track of the rope's history is one of the best ways to know whether the rope is in good condition or not. Start a rope log for each of your ropes and relevant data is to be recorded on a rope log. Log when the rope leaves the rescue vehicle and when it is back in. Note use made of the rope, any suspected damage, any shock loading incidents, any observed fraying and if the rope was hit by a rock or sharp object.

Inspection of Rescue Rope

There is no non-destructive test that will tell you how much strength your rope has lost. After each use, the rope shall be inspected before placing it back in service, even if there was no actual damage or misuse. The decision to retire a rope or to keep it in service relies on good judgment which comes only from experience in working with rope. The physical inspection must include checking the sheath for visible damage, such as necking down of the core (core shrinks at one spot). All inspections should be noted on the rope log.

When checking for sheath damage, what do you see and what do you feel? If damage looks like it came from impact or from abrasion over a sharp edge with a full load on the rope, retirement should be considered. If the rope feels like the core is missing or has an unusually soft spot compared to rest of the rope, damage may have occurred and retirement should be considered. Potential for rope damage includes: abrasion and sharp edges, dirt and glass, walking on the rope, caustics and ultra violet rays.

Maintenance of Rope

Rope inspections should be done both visually and physically. A visual inspection includes: sheath damage, rope core showing through the sheath as well as checking for dirt and contaminants. A physical inspection includes checking for soft spots in or necking down of the rope core.

- Washing - The best way to wash a rescue rope is with a product designed for use with rescue ropes or by using a mild soap. Chain the rope and put it in washing machine. Use caution on front loading washers that have a plastic window. The rope rubbing against the window can possible damage the rope by melting the nylon rope fibers.

  Rope can also be placed in a tub with the cleaner and agitated by hand This does not clean as well as a washing machine.Fabric softener can be added to help help keep rope fibers soft and provide a certain amount of lubrication between the fibers. After washing, air dry the rope by hanging it in a loose coil in the shade. Inspect the rope again when it is ready to go back into service.

Rope Classification

Rescue rope is normally the newest ropes in the best condition and are reserved for rescues only. Training rope are those ropes taken out of service only because it is being replaced by new rope. These ropes should still meet the requirements for a life support rope. Black taped ends is the color often used to designate training equipment.

When To Retire A Rope

Reasons for retiring a rope are: age, extensive use, damage or **suspected** damage (such as impact or shock load, visual damage to the software and situations such as the rope being smashed between a stretcher and a wall) as well as loss of faith.

Rope Rescue Hardware

Carabiners

A carabiner attaches pieces of equipment together such as joining ropes and anchors. They are also sometimes used as a friction device. They take the load on their long axis. The gate is not intended to take the load and are rated only with the gate closed and secured.

Carabiners are constructed of either steel or aluminum. Steel is used in rescue work because of its high strength. Aluminum should only be used for a one person load - never in systems. There are two types of carabiners available today, locking and non-locking. The locking type should be used in rescue applications. The pin lock type has a lock configuration that prevents the gate side from opening in a high force situation. It loses 10 - 20% of its strength when left unlocked. The machined lock type has a gate matching mechanism that holds the gate in line with the latch for alignment of the gate lock. It loses 50 - 90% of its strength when left unlocked. You should standardize on one type/kind for your department. The specifications for carabiners include a minimum breaking strength (NFPA - Major Axis - Gate Closed) :

- Personal use device - 6000 lbf.
- General use device - 9000 lbf.

Care and Maintenance of carabiner

Cautions with carabiners include:

- Do not drop or throw (a drop of more than 5 ft. – retire).
- Do not attach to hard edged metal anchor points if possible - can dent/or burr carabiner.
- Keep clean.
- Inspect for dents/burrs, rust, proper gate function, proper lock function and department markings.

Cleaning should be done by wiping clean with a cloth and using a small file or emery cloth for metal burr removal.

REMEMBER:

- Strength is from end to end - no side loading.
- Always lock the carabiner after attaching equipment.
- Do not hard link

Triangular Screwlink

Used where multiple direction loading is expected. These are less expensive than carabiners and, like carabiners, must always be locked. Care and maintenance of the triangular screwlink is the same as a carabiner.

Pulley

Pulleys are used for the following applications:

- ❖ Change of direction/directional pulley.
- ❖ Mechanical advantage pulley.
- ❖ Reduce friction over edge.
- ❖ Provide rope tension.

Pulleys are constructed of a metal sheave (wheel) mounted on a bearing or metal bushing and can be aluminum or steel bodied with a steel axis. A rescue pulley should have a minimum pulley diameter of four times the ropes diameter. For example: a 1/2" rope requires a 2" pulley. A 5/8" rope requires a 3" pulley. There are 2", 3" or 4" sizes available as standard. A 4" is much more efficient than 2" because the rope bends less and has less friction.

Minimum breaking strength (NFPA) for pulleys are:

- ❖ Personal use device - 1200 lbf minimum load test without permanent damage to device or rope, 5000 lbf minimum load test without failure.
- ❖ General use device - 5000 lbf minimum load test without permanent damage to device or rope, 8000 lbf minimum load test without failure.

Do not drop or throw pulleys and keep them clean. Pulleys should be inspected noting proper movement of cheeks and sheave. Any egg shaped attachment holes indicate the pulley has been over stressed. Check the tightness of nuts or bolts holding the pulley together. Wipe clean with cloth.

Remember to use the proper diameter rope for the size of the pulley (four times the rope diameter). Always back up high point directional pulleys. Use a steel pulley as a change of direction because the forces created may be compounded in this situation.

Figure Eight Plate / Figure Eight Plate with Ears

A figure eight plate can be constructed of high strength plate aluminum for low overall weight or can be all steel, which is more expensive, heavier but nearly impossible to wear out.

Figure Eight Plate Specifications:

- ❖ Typical breaking strength: Aluminum - 12,000 lbs., Steel - 45,000 lbs.
- ❖ Minimum breaking strength (NFPA):

  Personal use device: 1200 lbf minimum load test without permanent damage to device or rope. 3000 lbf minimum load test without failure.

  General use device: 1200 lbf minimum load test without permanent damage to device or rope. 6000 lbf minimum load test without failure.

The figure 8 plate is designed to create friction and is typically used for rappelling where the load is not expected to exceed one person. It is considered to be height limited because it imparts spin to the rope (most noticeable over 200 ft) and excessive weight, such as a long length of rope hanging below creating a lot of weight, will act as a brake not allowing movement.

Do not drop or throw a plate. Keep them clean and inspect regularly. Check for dents and/or burrs, cracks, sharp edges caused by rope wear and distortion of holes. Wipe with a cloth and use a small file or emery cloth for sharp edges or metal burrs. Dirty ropes cause accelerated wear of figure 8 plates. When a plate is worn to more than 1/3 the diameter of the original material it should be discarded.

Brake Bar Rack

A brake bar rack can be of aluminum or steel construction. Aluminum bars give a slower rappel but wear faster than steel. Racks work by generating friction based on the number of bars used and the space between the bars. The types available include 5 or 6 bar styles with a straight or twisted frame. The top bar is 1" in diameter and has a "training groove" which guides the rope. The second bar is 3/4" with a straight slot which allows the bar to fall out if improperly rigged. The 3rd - 6th bars are 3/4" with an angled slot which snaps in place.

As mentioned before, the brake bar rack works by generating friction. The amount of friction generated by the descender can be varied over a wide range. It allows the operator to reduce the friction for long rappels with less twisting. The rate of descent can be controlled by the spread of the bars as well as by rope running through the brake hand of the operator. Caution: angled bars may hold while you test the rigging, then pop loose after you have committed yourself over the edge. The training groove on first bar (or the first and third bars) will help to keep the rope in center of rack. Racks will accept two ropes, even if some of the bars have training grooves

Do not drop or throw a rack. Keep clean and inspect regularly for dents and/or burrs, cracks, wear of bars, integrity of the weld eye, tightness of the frame nut and distortion of the frame. Clean by wiping with a cloth and a small file or emery cloth can be used to remove sharp edges or metal burrs.

Ascent Devices

Ascent devices are an auxilliary equipment system component used as a friction or mechanical device to allow ascending a fixed line. They shall withstand a minimum test load of at least 1200 lbf without permanent damage to the device or rope.

The most common type of ascent device found in rope rescue is the cam (Gibbs) ascender. It is available in cast aluminum, forged aluminum and forged stainless steel and comes in sizes to accomadate 3/8 inch to 3/4 inch rope. They can be free running or spring loaded and consist of a sleeve, cam, pin and spring (for spring loaded types). The capacity of a cam ascender depends on construction. The typical breaking strength for a 1/2" size is:

- 2,550 lbs. - cast aluminum
- 5,000 lbs - forged aluminum
- 5,400 lbs - forged stainless

The use of any ascender as a pulling cam or braking cam should only be done in accordance with the manufacturers recommendations. As a pulling cam, it pulls the rope into motion. As a braking cam, it stops the rope from moving. To install on the line, remember that the arrow points toward the load. This should be double checked by pulling in the intended direction.

Do not drop or throw any ascender and keep them clean by wiping with a cloth. Inspect the cam ascender by looking for worn cam teeth, egg shaped holes for pin placement, cracks around the holes for pin placement and worn cord or chain holding the pin and cam to the sleeve. Keep the cam connected to the sleeve with the pin when stored. Make sure you check that the pin is through both sides of the sleeve during use.

Rope Grab Devices (MIO)

Rope Grab Devices (MIO) are an auxiliary equipment system component used to grasp a life safety rope for the purpose of supporting and catching single person loads. It can be used for ascending a fixed line. The specifications (NFPA) are that it shall withstand a minimum test load of at least 2400 lbf without permanant damage to the device or rope.

Edge Protection

Edge protection protects rope and webbing from abrasion and sharp edges. Rescuers can use covers, tarps, sleeves, old fire hose or edge roller devices. Edge rollers reduce friction caused by running rope over the edge. Rollers are typically constructed of aluminum. Rollers should be secured and anchored and a person should be in place to monitor the roller so that is stays in place. Mechanical edge protection devices should be kept clean and inspected for tightness of any nuts and/or bolts, worn rope contact points and that moving parts move smoothly.

Stretchers

The most widely used type of stretcher today is the wire basket (stokes basket) and the plastic basket. Other specialty stretcher types commonly in use include the SKED™, Res-Q-Mate™.

The wire basket stretcher consists of the following components: main frame, ribs, skids and chicken wire lining. The plastic basket stretcher consists of a main frame and plastic shell. Better stretchers have metal support ribs which provide better structural integrity.

When inspecting a wire basket, plastic stretchers and others, you should look for bends or cracks in the main frame, broken welds, torn or loose wire, broken or cracked shell or ultra violet ray deterioration of plastic units.

Unit 4: Rope Rescue Systems

Introduction to Rope Rescue Systems

The rope rescue system is divided into three basic components:

- Belay Line
- Main Line - Lowering and Raising Systems
- Attendant and Patient Packaging

Belay Line

To belay the two person load, we use the Tandem Prusik Belay (TPB). The Tandem Prusik Belay System consists of: a shock absorbing, load releasing hitch (LRH), two steel rescue carbiners, a short and long prusik and a prusik minding pulley. The TPB was chosen because of its ability to successfully arrest a falling two person load.

Main Line

The main line has two primary functions, lowering systems and raising systems. The main line must be adaptable to the changing needs of the rescue situation. It must also be able to change from a lowering to a raising system and back and forth as needed. The main line crew should be able to anticipate these changes before they are needed and be capable of changing these systems in a timely manner.

Attendant and Patient Packaging

The third part of the rope rescue system is attendant/patient packaging. The attendant is responsible for rigging his/her attachments to the belay and main lines, rigging the patient litter or harness, the attachments to the main and belay lines and for packaging the patient. The attendant should be highly skilled on rope and be competent at treating and managing the patients injuries.

Anchors

Anchors are defined as a stationary, hold fast to which rigging is attached. Anchors are a critical part of any rope system. Failure of an anchor can result in serious injury or death.

Terminology

Anchor is a generic term which refers to all of the hardware and software components that are combined to attach rope systems to immovable objects.

Anchor Point is the object that webbing or rope is tied into or around when constructing anchors. It could be a tree, bush, piton, fire truck, boulder, guardrail, etc.

Anchor Systems connect anchor points together to create a stronger anchor. The ultimate aim in constructing anchor systems is to create an anchor that is **self-equalizing** (designed so that all anchor points in a system share an equal percentage of the load forces) and **omni-directional** (designed so that the no matter what direction the load is pulled the forces on the anchor points remain relatively equal).

BFR is slang for a very large rock, but also includes big trees, fire trucks, water tanks, stairways and other large, well anchored objects. BFRs are said to be **bomb-proof** or capable of holding the load under any and all circumstances.

Back Ties use pretensioned ropes to extend an anchor point or a high point change of direction to a remote anchor point. Back tieing can also be used to back up the primary anchor.

Backed Up means that the anchor has a second, independent anchor also connected to the load. If one anchor should fail, the second would hold the load.

Bridles – rope or webbing used to extend anchor points that are not directly in line with the plumb point to the anchor system in order to make the anchor position more efficient.

Directionals reposition an anchor line to a better vantage point or move a line to reduce abrasion. Directionals typically employ pulleys or caribiners to pull moveable rope systems into a desired alignment.

Double Anchor Rule A fundamental operational guideline for all rope rescue situations is to **"back up all anchors"** this may involve the use of two independant anchors and or backing up a single bomb-proof anchor with the construction of redundant anchor systems for all live load applications.

Fixed Anchor Systems (also known as **directional, load sharing anchor systems)** distribute the load among several anchor points. Pulling the load in any direction other than perpendicular to the anchor points will place most or all of the load forces on one anchor point.

Omni-Directional means that the load forces at each anchor point are equalized regardless of shifts in the direction of pull from one side to the other.

Padding is used whenever possible. All sharp edges should be covered to protect the rope from abrasion.

Picket Holdfast Anchor is a series of stakes driven into the ground to form an anchor. This is used when other anchors are not available.

Primary Anchor is the first point back from the edge that the rope is connected to.

Secondary Anchor is another point that is in line with and behind the primary anchor. This anchor could be used as a backup.

Structural Anchors involve tying to large building components or integral parts of the building such as columns, steel stairs, welded steel handrails, etc.

Examples Of Anchor Points

Natural anchors are most frequently associated with "wildland" environments, but have urban applications also. You must check to make sure they are solid and estimate their holding ability based on their size and the condition of the soil. Examples of natural anchors include: trees, boulders and brush/root systems. Large bushes can be used, but almost always as part of a self-equalizing system.

When using natural anchors, tie the web as low to the base as possible. This reduces the leverage on the root system. Make sure the tree or bush is alive. Watch out for sharp edges and pad if necessary. Wet ground can reduce the holding power of both rocks and plants so be even more conservative after (or during) a storm.

Man made anchors include buildings, bridges and structural steel as well as vehicles. Building components commonly used as anchors include: window washer stanchions, steel trusses, doorways (deadman technique), windows (in one out another), interior furnishings, standpipes, stairwells, fire escapes and ladders.

When using vehicles be sure to tie to the axles – not the bumpers. Place the vehicle in park (standard transmission in reverse with parking brake set). Additionally, disable the vehicle from starting i.e. remove keys, post guard, etc.

In an urban environment, rescuers must be prepared to locate and/or rig man made anchors. Locating anchors might consist of pulling plaster walls, ceilings and/or ripping up floors to gain access to structural components. Rigging an anchor could also consist of placing a desk in a door opening lengthwise and attaching the system to the center of the desk or rigging a deadman or picket anchor. In any event, make certain that whatever you are wrapping is secure and that all sharp edges are padded.

Pickets as anchors

Pickets are primarily used in the wilderness environment. Their use is limited in the urban/suburban environment. They are primarily used as anchors for snow, sand or dirt conditions. A picket line can also provide a relatively solid anchor where nothing else will work. When constructing a picket system, three pickets are usually needed for an anchor point. (Figure 4-1)

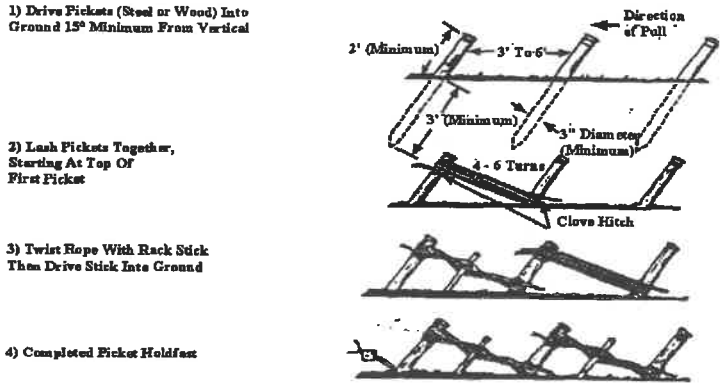


Figure 4-1

Selecting Anchors

The rescuer must give careful consideration to the selection of any anchor(s) to be used in a rescue system. Care must be taken to consider the following:

- ✓ Purpose of system.
- ✓ Amount of load.
- ✓ Direction of pull/loading.
- ✓ Strength of anchor.
- ✓ Mass of anchor.
- ✓ Contour of anchor.
- ✓ Location of anchor.

Double Anchor Rule

All life support lines should have two independent anchors or, if absolutely bomb proof, should have redundant hardware and software connections to the anchor point. Anchor points are often out of sight so any potential failure cannot be seen in time to be prevented. Anchors are normally backed up by tying to another anchor that is also capable of holding the expected load. An anchor is considered to be backed up if each anchor point can support the load.

The term "BFR" or "Bomb Proof" describes a totally 'failure proof' anchor. It should be used for both the main anchor and back up. Use a second piece of web or rope to back up the first in case a mistake is made in tying the knot or if something else causes a failure. (Figures 4-2 and 4-3)

Figure 4-2

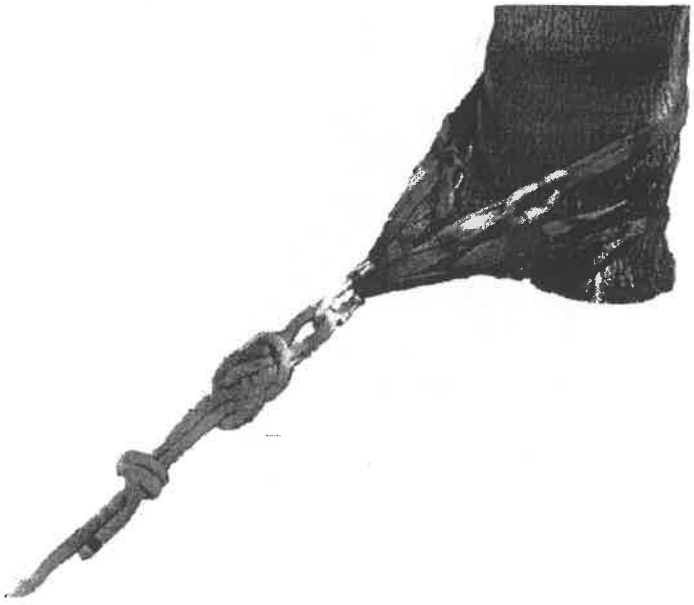


Figure 4-3

Anchor Strength

Think about what kind of loads the anchor will have to hold. A rappel usually has the weight of one person, but may turn into a pick-off situation and the weight of a second person will be added. A stretcher system for a vertical evacuation could have the weight of the victim plus two tenders, even if the original plan was for only one tender.

A rappel anchor set up to access the victim must be re-evaluated as a rescue anchor if it will be used for a stretcher system. Hauling systems generate higher loads than lowering systems due to the forces generated by the haul team. Putting all the considerations together, set the anchor to handle the highest expected load.

Most teams use web for tying anchor points. This is because it is light in weight, the wide surface area provides a good grip on anchor points and it offers high abrasion resistance. One inch tubular webbing should always be looped and doubled to insure necessary safety margins. Never use a girth hitch. To avoid the potential for side loading the carabiner used to attach a rope to an anchor sling, use one carabiner to make the web sling a continuous loop and use a second carabiner to connect the rope.

Wrapping the web too tightly around the anchor point can increase the load on the web. Watch the interior angles. If the angles become too large, the load on the web will be multiplied. Keep the web as close to the base of anchor point as possible (this maximizes the strength of the anchor). Finally, tie the web so it does not slip off the anchor object.

When setting up anchors, check the direction that the load will be pulling. (Figures 4-4 thru 4-8)) Make sure that the anchor point will handle the load in that direction. Check carefully for any looseness, cracking or other weak points before committing yourself to anchor. If the anchor point is not strong enough, you will need to combine several anchor points to make an anchor system. If tying a self-equalizing system, use rope. It \runs through carabiners more easily.

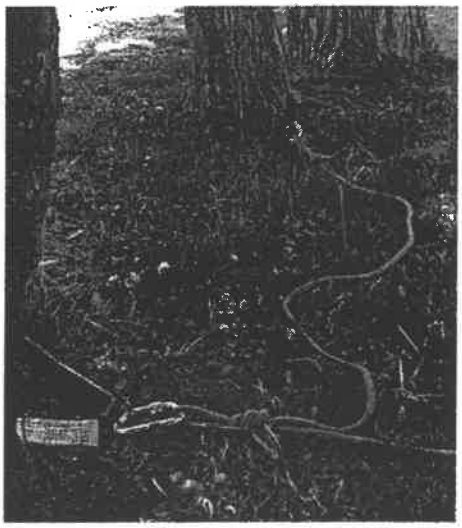


Figure 4-4

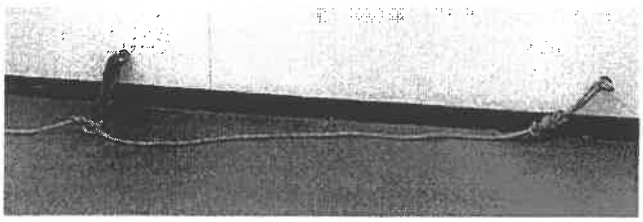


Figure 4-5

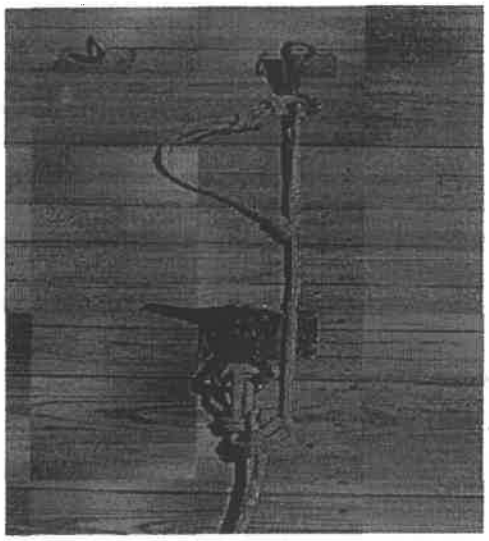


Figure 4-6

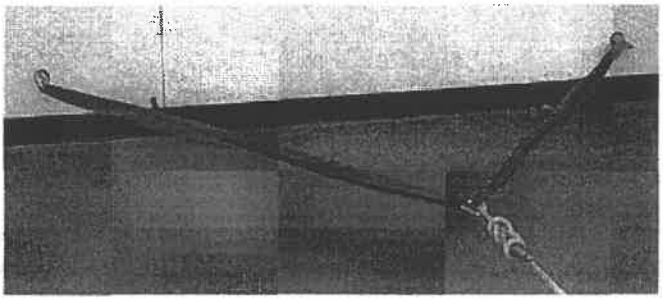
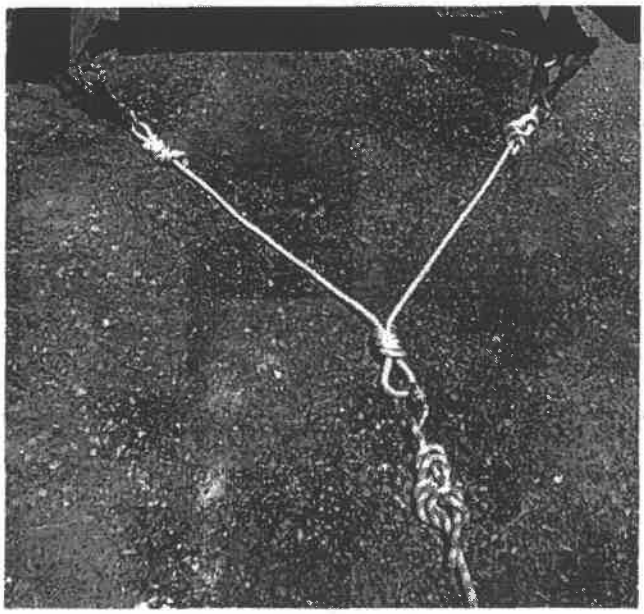


Figure 4-7



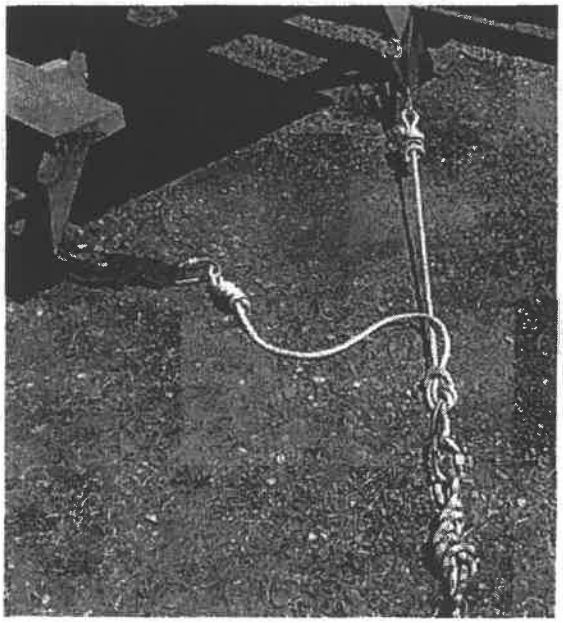


Figure 4-8

Wrap Three Pull Two Technique (Figure 4-9)

This technique is used for high weight or high force hauling evolutions. It is often employed in anchoring tracklines in highline systems. Anchors systems created with this technique have been tested to between 12,000 and 18,000lbf . To tie:

- ✓ Wrap three turns of the webbing around the anchor
- ✓ Tie the ends together using a water knot

- ✓ Pull two turns of the webbing out away from the anchor, centering the knot against the anchor point
- ✓ Make sure that the interieor angle of the webbing loops leaving the anchor point are less than 90 degrees

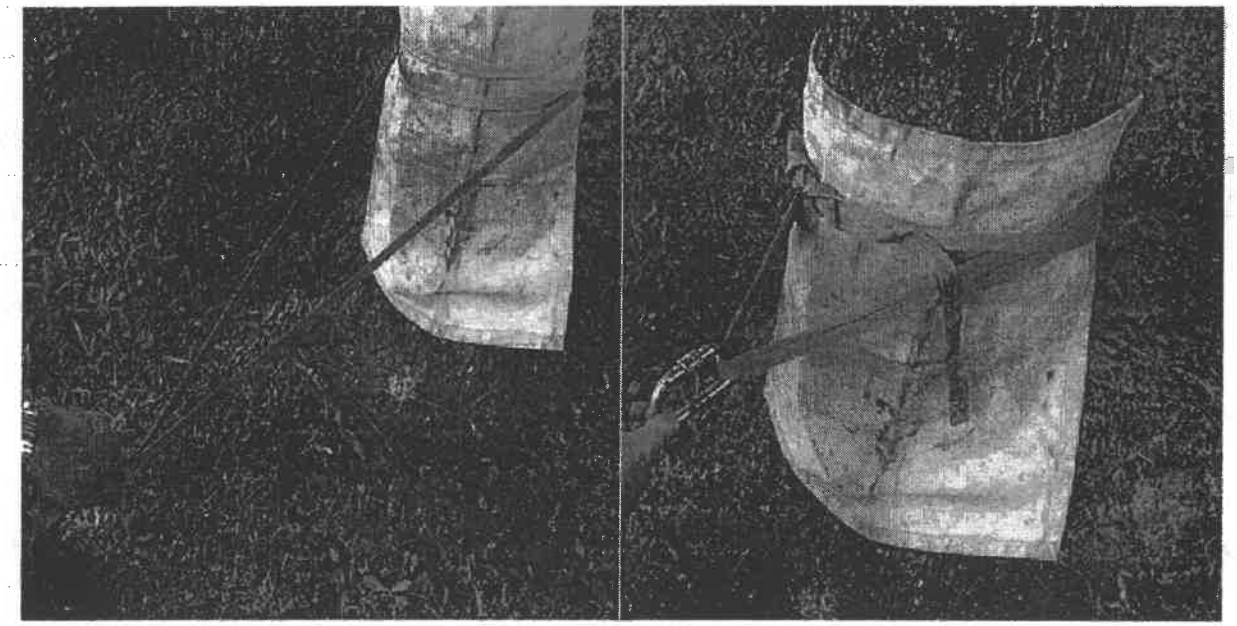


Figure 4-9

Tensionless Hitches (Figures 4-10 and 4-11)

Tensionless hitches are also referred to as "high strength tie offs". The anchor should be a minimum of 8-10 times the diameter of the rope. A tensionless hitch is constructed by wrapping successive turns of the rope around the anchor going up. Make sure that none of the turns cross over another. Secure the end of the rope with a carabiner connected to the line entering the anchor at the lowest point of the circumference. The coefficient of friction of the anchor point will determine the number of wraps in a tensionless hitch - the smoother the object the more wraps will be necessary.

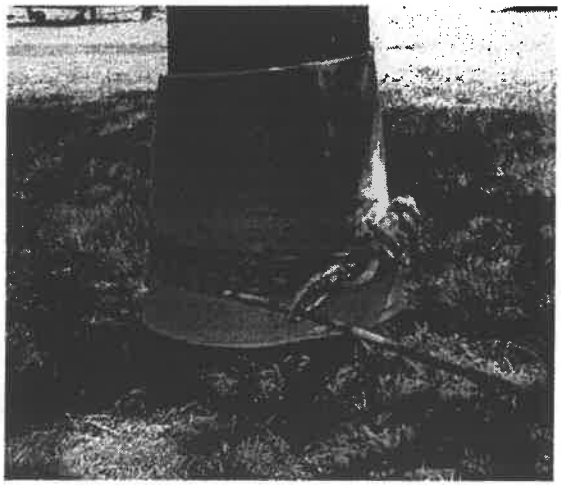


Figure 4-10

Figure 4-11

Anchor Systems

Anchor systems perform two functions, share or equalize the load on each of the anchor points used in the system and make the distribution of forces "omni-directional". (Figure 4-12) The load on individual anchor points still remain equal should the direction of pull change. In theory, a three point system should place 1/3 of the load on each of the three anchor points. (Figure 4-13) Rope drag and other friction in the system will prevent the load forces from being precisely equal in actual applications. Because the distribution of forces among anchor points happens automatically, the system is said to be "self equalizing".

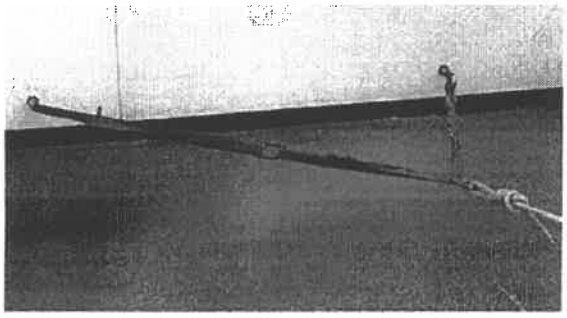


Figure 4-12

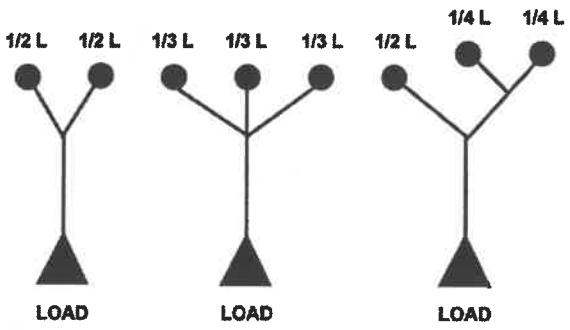


Figure 4-13

When You Need An Anchor System

You need an anchor system whenever you do not trust any one of the available individual anchor points to hold the entire load. Anchor Systems distribute the load so that when the direction of the load will be changing , such as in a pendulum across a cliff or snow field, the load will be distributed among the anchors. The omni-directional nature of an anchor system will keep the load even on the various anchor points.

When Not To Use An Anchor System

If a single anchor point will hold the load (is **bomb-proof**), the anchor point can be backed up to another anchor point or additional webbing slings and hardware can be used to make the connections redundant. If anchor slings are nearly the same length, there will be very little movement if the primary anchor point should fail. (Figure 4-14) The trade off to tieing directly to two anchor points is that the anchor becomes non-directional. Directional movement may cause the load to be shifted from one point to the other.

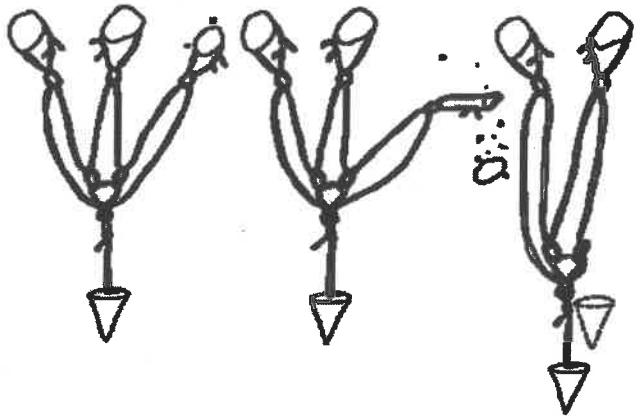


Figure 4-14

Multi-Point Anchor System

Muti-point anchor systems connect two or more anchor points together. They can be tied in the end of rope or, if necessary, with a separate rope. (Figure 4-15)

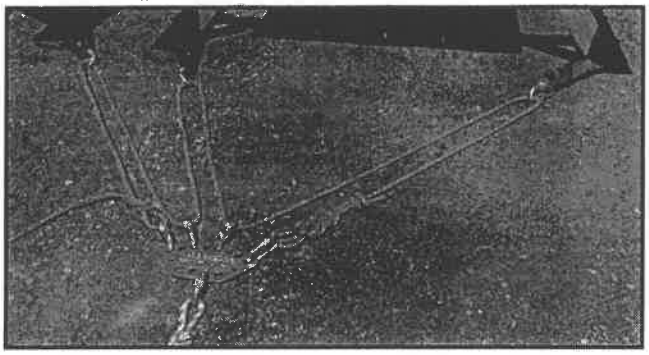


Figure 4-15

To construct a self equalizing system (Figure 4-16), use a Double Loop Figure 8 knot and adjust the knot so that one of the loops is very small and the other is no more than 3-4 feet in diameter. Use anchor extensions (bridles) from the anchor points to the loop if necessary. Care must be taken to insure that if any one of the anchor points in a self equalizing anchor system fails, the load will fall no more than one foot! Connect the large loop to the carabiners at anchor points or extensions. Connect the large loop to the small loop with additional carabiners.

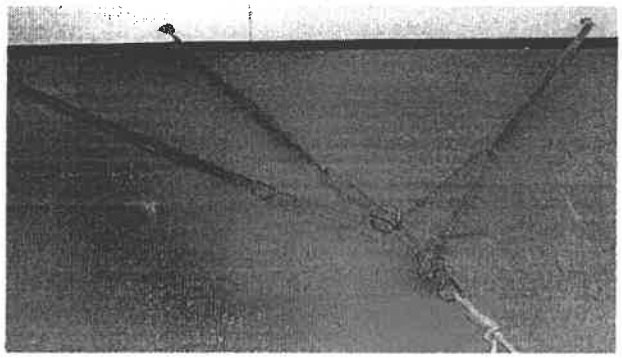


Figure 4-16

Tie a Double Loop Figure 8 to connect the hauling system to the anchor system if a seperate rope is used. (Figure 4-17) If the distance between anchor points is significant, anchors should be extended to a centralized rigging point (a rigging plate that can incoporate multiple attachment points is ideal for these situations). Anchor points are typically extended with rope or webbing and connect the rope ends to each anchor point that you are extending with any of the above listed techniques. Adjust the length of each rope to achieve a suitable focal point for the rope system attachment.

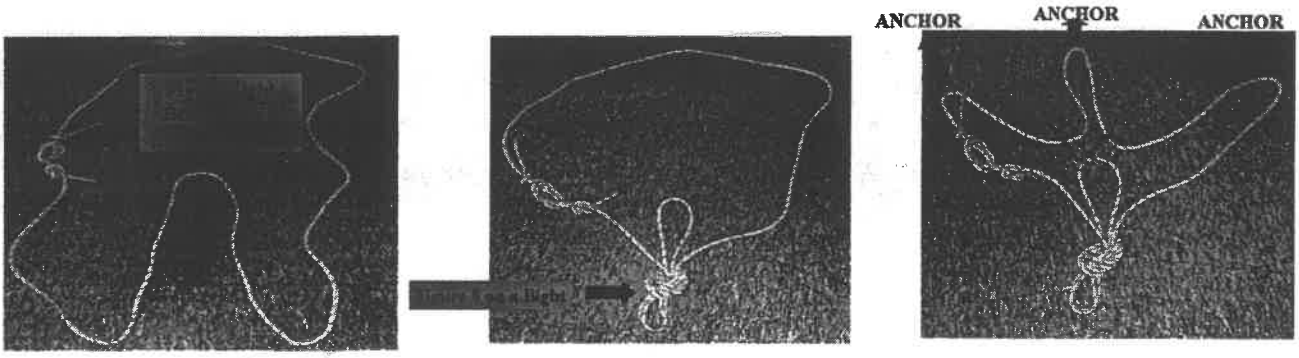


Figure 4-17

Fixed Anchor Systems

This anchor system provides a non-directional point of attachment for the rope system. This anchor system should utilize 1" tubular web. The web should be wrapped around the anchor in the same manner as the self equalizing anchor system and each end of the webbing loop is secured to its own anchor. Care should be taken to insure that the interior angle never exceeds 90 degrees. (Figure 4-18)

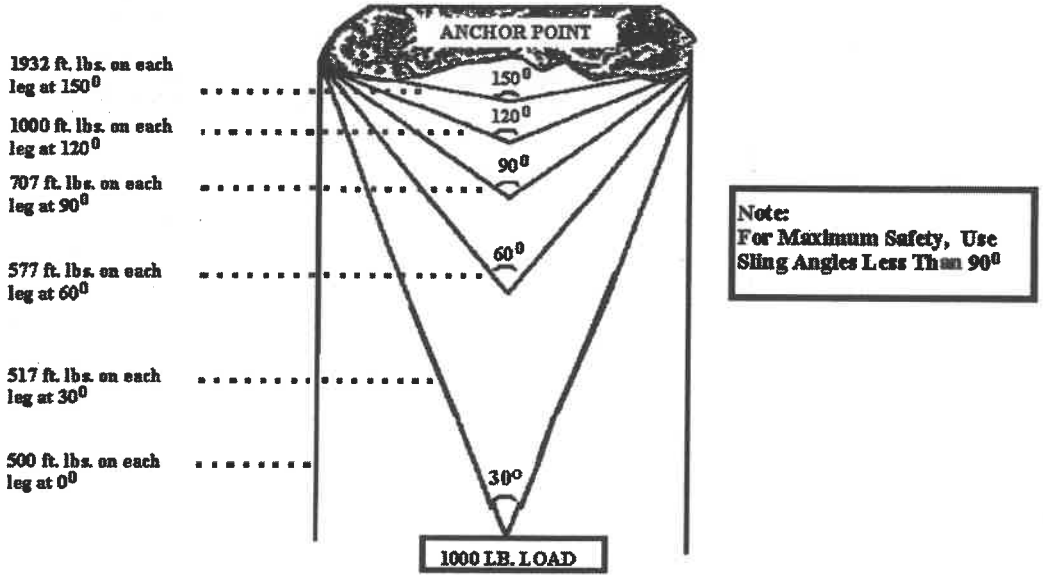


Figure 4-18

Back Ties

3:1 pretensioned back-ties are used to stabilize the main anchor or for supporting high directionals. Tie a rope from the main anchor or anchor that you are backing up to a remote secondary anchor and rig the rope through a 3:1 mechanical advantage system (z rig). Tension the rope and secure the ends with a prussik or half hitches.

Change of Directions

A change of direction (Figure 4-19) is used to make negotiation of the edge more manageable. Working to a natural plumb line keeps all the forces on the rope system in a single direction. This often makes rope management more efficient. When employing pulleys into change of directions care should be taken to use the strongest pulley available. For added safety, the pulley should be backed up with a carabiner.

High directionals can make negotiating the edge significantly easier and can be attached to structural elements, tree trunks, tripods, A-frames, gin poles, etc. The forces encountered when using high directionals can often exceed the safe main line tension. You must always be conscious of the consequences to your rope system should a high directional fail. To this end: NEVER RIG BELAY ROPES THROUGH CHANGE OF DIRECTIONS. Finally, the angle of deflection between the main anchor and rope leaving the change of direction pulley should never be less that 120 degrees.

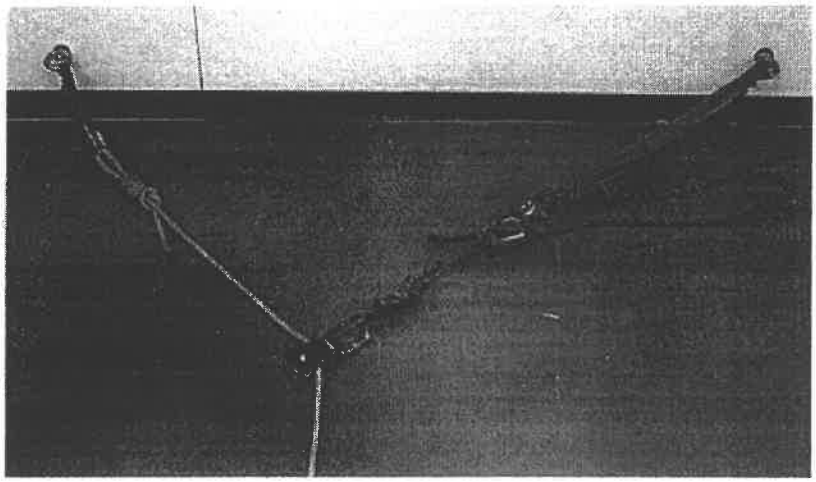


Figure 4-19

Belaying

Introduction

When performing a rope rescue it is recommended that the rescue team use a belay. To belay, by definition, is to secure a person at one end of the rope. A belay is also described as a safety or backup system used in the event the primary system fails.

In this lesson we will discuss belay conditions, single person belays and two person belays. These techniques will be used later in the course during practical exercises and applications on the training ground.

Belay Conditions

An **Independent Belay** is a totally separate tensionless rope that is managed by others. This is the preferred method of belay for rope rescue. This rope is attached to the harness of the rescuer and a separate anchor.

A **Conditional Belay** is a rope under tension from part or all of the load and is managed by another person. An example of this is a bottom belay and is not normally recommended for rescuers.

A **Conditional Self Belay** is a rope under tension from part or all of the load and is managed by the person needing it. An example of this is the use of a shunt or prusik attached to the rappel line (Single Line Technique). While this is not the primary method preferred for rescuers it provides an alternate method when a standard belay will not work or it creates a greater danger than the use of the conditional self belay will.

A **Self Belay** is a totally separate tensionless rope that is operated by the rescuer needing it. An example of this is the use of a shunt or prusik attached to a separate rope during a rappel and is not recommended for rescuers.

An **Auto Belay** is a self - activating belay that does not require a positive action to engage it. This term may be applied to the other four belays listed above as needed. An example would be the use of fall arrest devices.

Single Person Belay

Munter Hitch

The Munter Hitch provides an adequate belay for the single person load. The Munter Hitch should NEVER be used as a belay for more than 1 person. The belay may be performed close to or away from the hitch as necessary. The belay should be running over an edge (for friction) and not free hanging.

To perform an arrest, the ropes going into and out of the hitch are moved together for maximum friction. Slack must be kept to a minimum to prevent shock loading if a mainline failure occurs. Gloves must be worn to prevent injuries to the hands if an arrest occurs. The use of an extra large steel locking carabiner allows the hitch to move back and forth as rope is taken in and out. The munter hitch can be tied off by tying an overhand knot around the main line.

Commands for the single person belay.

The use of standard commands during rope rescue training and operations allows all personnel on the scene to operate in a safe and clear manner. The following commands are used in the operation of belay systems:

- "On Belay?" - The question asked by the person being belayed to the belayer.
- "Belay is on" - The response from the belayer that the belay is ready.

- "Tension" - A request from the person being belayed to the belayer to take up all of the slack and put tension on the rope.
- "Up Rope" - A request from the person being belayed to the belayer to remove slack from the rope.
- "Slack" - A request from the person being belayed to the belayer for extra rope.
- "Falling" - A command from the person being belayed to the belayer that the belay should be put into the arrest position immediately.
- "Rock" - A warning to all that an object has been dropped over the edge. **If someone yells rock - DON'T LOOK UP!**
- "Off Belay" - A response from the person being belayed to the belayer that the belay can be removed.
- "Belay is Off" - The response from the belayer that the belay has been removed.
- "On Rappel" - Notification to the rescue team that the rescuer is on the main line and ready to rappel.
- "Rappel Away" - The belayers response to the rescuer that the belay is ready.
- "Off Rappel" - Notification from the rescuer on rappel that the main line is clear.
- "Locking Off" - Notification from the rescuer to the belayer that he will be locking off with his rappel device. The belayer should respond "Belay is on".
- "Unlocking" - Notification from the rescuer to the belayer that he is unlocking his descent device and will be descending. The belayer should respond "Belay is on".
- "STOP" - A command anyone may use to stop an operation at any time. All personnel must stop immediately.

Two Person Belay

The Tandem Prusik Belay System (TPBS) is used to belay loads of two persons or more in a raising or lowering rescue operation. It may also be used for a single person load. The TPBS (as is true with all belays) should be on an anchor separate from the main line. The anchor should be able to withstand a shock load if the main line should fail. The TPBS was chosen based on testing that has shown that the TPBS is acceptable as a belay for a two person load. The two person load was stopped when dropped from 2.5 meters. This was the only system tested to do this.

The TPBS is constructed from the following components:

- Carabiners - one large locking steel and one extra large locking steel (the extra large carabiner is used with the double munter hitch on the load releasing hitch).
- Prusik Minding Pulley – this is used during the raising operation of the TPBS and is included in the system from the beginning for ease of operation.
- Tandem Prusiks - two constructed from 8mm low stretch accessory cord cut to 53 inches and 65 inches and then tied into a prusik loop with 1 1/4 inch tails. Each is then triple wrapped the same way around the belay line.

The components are then loaded onto the carabiner in the following order: long prusik, short prusik and prusik minding pulley. The B.C. Load Releasing Hitch is constructed of 33 feet of 9mm low stretch accessory cord.

The hitch provides shock absorbing capability as well as load releasing capability in case of accidental loading of the belay line. (Figures 4-20 and 4-21)

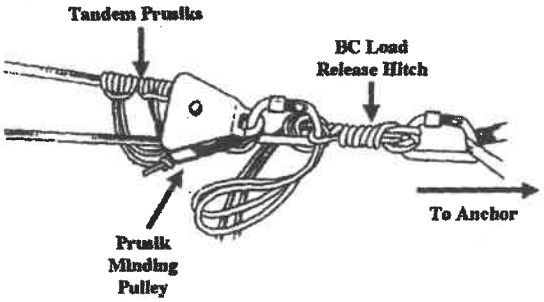


Figure 4-20

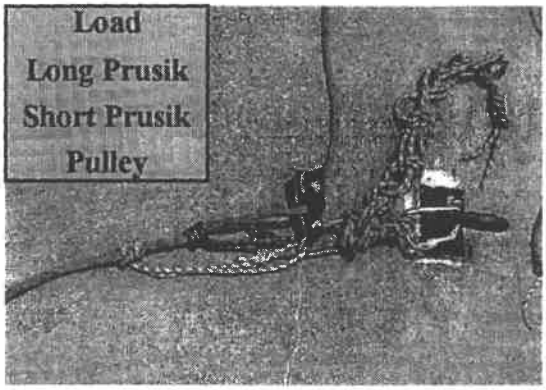


Figure 4-21

Tandem Prusik Belay System Operations

The belayer must monitor the main line station and use the main line operation as a reference. The rope must be laid out to ease feeding the rope through the belay, stacked so it feeds from the top and be within reach of the belayer.

The angle between the main line and the belay rope running out of the prussik hitches should be approximately 5 degrees (these two ropes need to be nearly parallel to one another to prevent the load from penduluming if the belay is utilized to prevent a fall). Prusiks must be held tight under the belay hand. Loose prusiks must be tightened immediately.

If the operation is stopped, the belayer must remove all slack from the belay line. A "Z" turn should be taken out before movement of the main line occurs. The weight of the rope in long raises sometimes requires an assistant to continually pull the slack out of the system ahead of the tandem prusik belay. On normal raising operations, the belayer hauls rope up through the prusik minding pulley. All slack should be removed from the rope to prevent shock load situations.

If a failure occurs, the prusik hitches will lock and catch the load. Whenever a mainline failure is caught by the belay line, the mainline (and replacement belay line) must be restablished while the belay line is holding the load. All system components must be carefully assessed for possible damage with an eye towards replacing any questionable hardware or software. Once the new mainline rigging and new belay line is in place and locked off, you will need to release the load release hitch gradually transfering the system load back on to the mainline.

Incident Management

Introduction

A technical rescue operation will run more effectively and safely when an Incident Command System (ICS) is utilized. By employing an incident command system to organize all rescue incidents, rescuers will gain the necessary confidence to organize even the most complex technical rescue incidents.

In this lesson we demonstrate ways in which the familiar model ICS plans (Figure 4-22) used to organize fire operations can be modified to manage a rope rescue incident. The techniques discussed in this lesson are continually reinforced during the practical applications of this course.

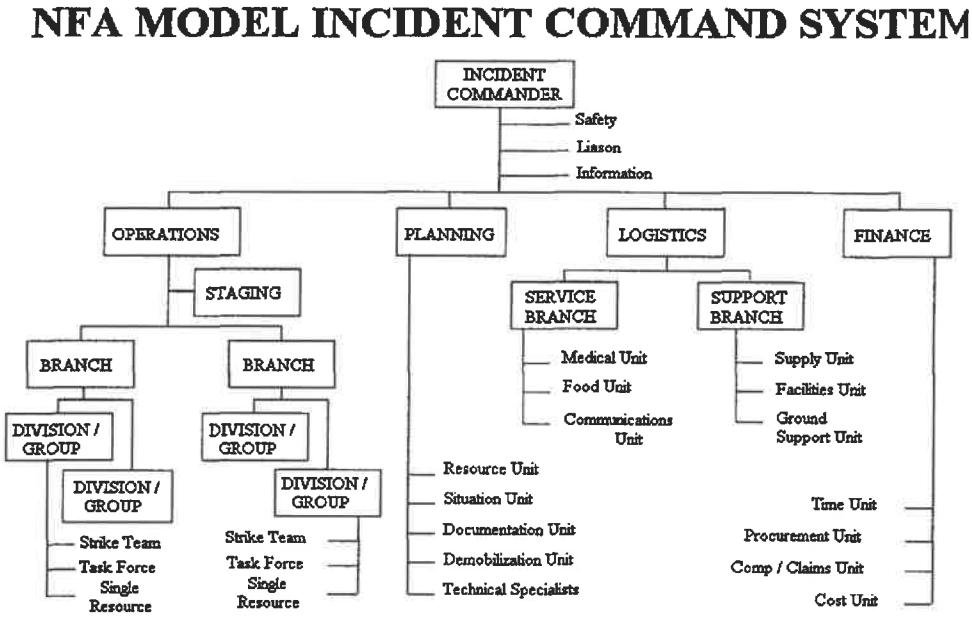


Figure 4-22

The Incident Command System

A rescue scene can be one of confusion if a command system is not established early in the incident. The command system must be versatile, adaptable to any type or size of emergency or incident, relatively familiar if it is going to be useable throughout the state and be expandable in a logical manner if changing conditions dictate. The majority of technical rescue operations will be most efficiently managed with a pared down version of the full blown ICS model. It will be the rare technical rescue incident that will require filling positions such as Planning; Logistics; Finance, etc. (Figures 4-23 and 4-24).

Full Command Structure

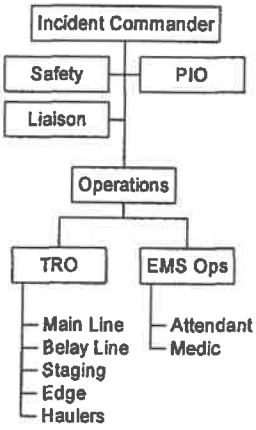


Figure 4-23

Short Crew

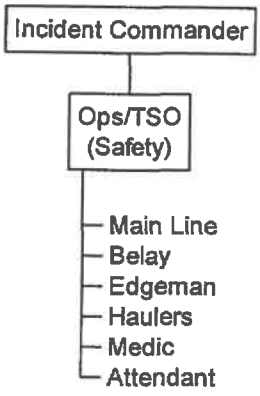


Figure 4-24

Span of Control

The ICS allows for a manageable span of control of people and resources. Utilizing an ICS takes much of the pressures off the Incident Commander. The **maximum** span of control is 7 (seven) persons while the **recommended** effective span of control of 5 to 1 allows for the most effective management. The system is set up so that the IC is only **communicating to and receiving information from** a maximum of five people, rather than the whole assignment of personnel at the scene. Individual managers of personnel and resources within ICS are also working within a manageable span of control.

ICS Positions for the Typical Rope Rescue Scenario

The **Incident Commander** (IC) or "command" is the individual responsible for the management of all incident operations. The IC does not need to be well versed in technical rope rescue, however he/she should be well versed in the ICS. The IC should be stationed at a command post remote from the incident. On large, complex, and or protracted incidents, the **I.C.** may delegate functional responsibilities by appointing an:

- Operations Officer (Operations)
- Planning Officer (Planning)
- Logistics Officer (Logistics)
- Finance Officer (Finance)

The IC also communicates directly with Command Staff:

- Public Information Officer (PIO)
- Safety Officer (Safety)
- Liaison Officer (Liaison)

The **Operations Officer** is responsible for direction and coordination of all tactical operations. On modest sized rescue incidents, Operations may fulfill the functions of a Technical Rescue Officer (TRO). At large scale rescues, Operations may designate a TRO. Operations also interfaces with the media and other appropriate agencies as necessary.

The **Safety Officer** (SO) is responsible for enforcing general safety rules and developing measures for ensuring personnel safety. This includes ensuring personnel working near the edge are tied off and checking for proper rigging. When manpower is limited the SO position may be combined with the TRO and/or Operations positions. The SO can bypass the chain of command when necessary to correct unsafe acts immediately.

The **Technical Rescue Officer** (TRO) or "Team Leader" is responsible for the rescue operation. This person is normally the most experienced rescue technician on the team and assumes the lead role in designing and setup of the necessary rescue systems. When the set-up is complete the TRO will check the entire system. The TRO is the liaison between the rescue site and the command post and designates "tactical" level positions in the ICS as needed.

The **Main Line** sets up main line anchors and systems for lowering and raising and operates the lowering and raising system. They are responsible for managing the change over when the main line is transitioned from a lowering system to a raising system.

The **Belay Line** sets up belay line anchors and the belay system. They operate the Tandem Prusik belay system and any other belaying that may be required.

The **Medic** initially descends or ascends to the patient and performs medical assessment and stabilization. If the victim is in a precarious position, the medic will apply a rescue harness if appropriate, secure the victim to the medic line, provide a belay if the victim is on his own line or otherwise secure the victim to prevent a further fall. Getting the necessary lines or systems in place to get the medic to the patient should be the first tactical priority. Medics should be trained to at least the CFR level and will usually be the team member most comfortable "on rope".

If a litter evacuation is necessary, the **Attendant** rigs the litter and patient packaging systems and is raised or lowered with the litter. He/she then packages the patient (usually with the assistance of the Medic), provides emergency medical care, and tends the litter. The Attendant should, as a minimum, be trained to the CFR level.

The **EMS Operations Officer** (MO) oversees the medical care of the victim/victims. The MO makes triage, treatment and transport decisions on multiple victim rescues, advises the Medic and Attendant on medical issues and provides advanced life support care for patients who have been removed to grade.

The **Equipment Staging Officer** (EO) position is especially useful if personnel resources allow. The EO assembles all available rescue equipment on a tarp in a neat organized manner. Once the equipment is organized the EO is available for reassignment.

The **Edgeman** is usually a member of the main line group. He/she maintains visual contact with the attendant and the litter from the edge and assists the attendant and litter over the edge. The edgeman must be secured to topside anchors for safety. This position plays a vital role in relaying communications between the medic and litter attendant and the TRO who is controlling the pace of lowers and raises.

Haulers are also usually members of main line group. They set-up and operate the hauling systems. A haul team leader is used to answer for the haul team and resets the hauling system. Untrained personnel may be used as haulers when manpower is limited.

Patient Packaging

Introduction

The proper securement and packaging of the victim serves two purposes: stabilization of injuries and providing methods for removing the victim to a safe area.

Backboard Securement

The need for full backboard securement with high and low angle litter basket techniques are very much related to each other. Medical considerations also play a role in the method used. Spinal immobilization and backboard securement for high angle transport are two different procedures. In most cases, both work "hand in hand". First follow the NYS DOH procedures and local protocol for "C"-Spine immobilization procedures. Backboards may have a different configurations. Using a backboard with runners underneath makes it easier to pass the straps through the holes.

Consider the following securement options:

- Strap Method
- Diamond Lash – This works well when straps are not available but is time consuming. This method is used for patient securement to the board - you will still need to diamond lash into the litter.
- Spider – These are a manufactured strap that is very quick, easy to use and effective. They are a rated and shielded seat belt type strap arrangement.

Victim Lashing – Steel Litter Basket

Depending on the injuries of the victim, their weight should be supported within the stretcher by one of the following methods:

- Foot support - Used where leg injuries are not present.
- Harness support (Figure 4-25) - This method is used when the victim has injuries to the lower extremities that prohibit the use of the foot support mentioned above. This method must be put on the victim prior to securement to the backboard. The harness is then secured to the backboard. This method is also used in conjunction with the foot tie in as a secondary attachment to the stretcher and also as an additional safety when attached directly to the belay line. Once the backboard is placed into the basket stretcher, the victim is secured into the stretcher by the use of a 30 - 35 foot piece of webbing. Use the following procedure (Figures 4-26 and 4-27):
  - ✓ Begin by finding the middle of the webbing. Make a girth hitch around the rail at the foot end of the basket. You now have two equal lengths of webbing.
  - ✓ If a foot wrap is to be used, pass the working ends up between the feet and proceed to make an ankle wrap. Otherwise proceed to the nearest upright cross member on the same side as the webbing.
  - ✓ After the ankle wrap, proceed to the nearest upright cross member of the basket on the same side of the corresponding ankle wrap.
  - ✓ Pass the webbing around the cross member and begin to cross it in a shoelace fashion to the other cross members until it ends up at the head of the basket. Never wrap the webbing over the top rail of the basket, instead, pass it around the upright cross members.

✓ From the head end of the basket, tighten each length of webbing securely and tie two clove hitches (or other acceptable method of securement) with each end of the webbing.

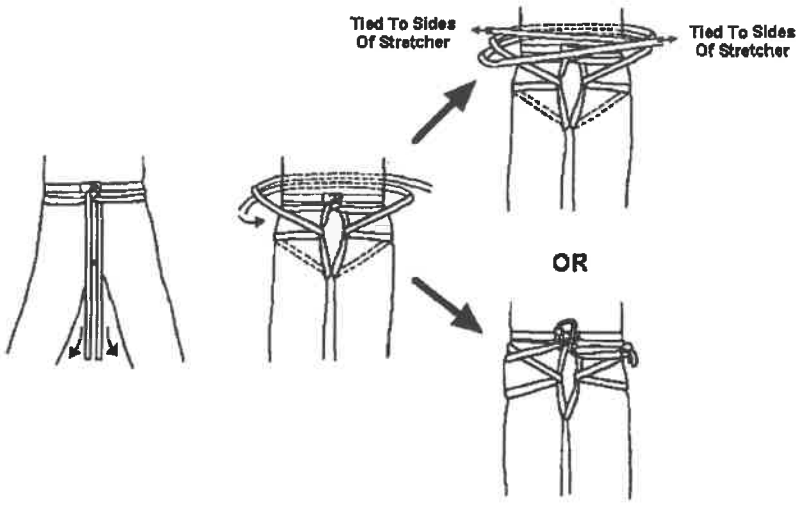


Figure 4-25

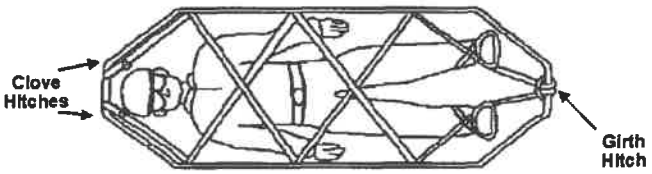


Figure 4-26

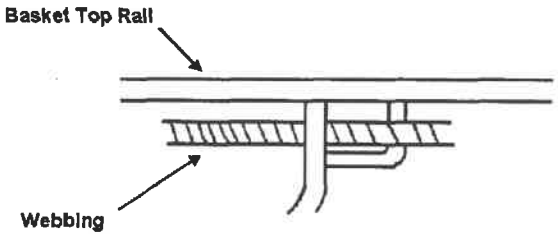


Figure 4-27

Some rope teams will girth hitch a number of pieces of webbing 15-20' in length at various spots on each side of the stokes basket, daisy chaining up the ends of each piece. This allows rescuers numerous options as to where lacing begins and ends thus accounting for the victim's injuries. A frost knot (an overhand knot tied in doubled loops of web) is used to create a loop at one end of the lacing crossties. The remaining end of the web is fed through the loop and secured with either an overhand knot or a "trucker's hitch"

Whatever specific method is used to fasten the victim to the stokes basket, the end result must be to avoid causing futher injury while at the same time insuring that the victim is SECURLY attached. There are many different types of steel baskets and in some cases the cross section of webbing near the head area may be too close to the neck. You may have to adjust the cross sections or skip a cross to remedy this problem.

Single Line Bridle – Horizontal (Figure 4-28)

Regardless of the method chosen, the head should be slightly higher than the feet (this is better for the patient). In all cases, a safety line should be considered.

- Commercial Bridle - Manufactured bridle that is very quick, easy to use and effective.
- Site Made Bridle – Constructed of rope only, rope with prusiks, anchor belts, pickoff straps or stretcher straps.

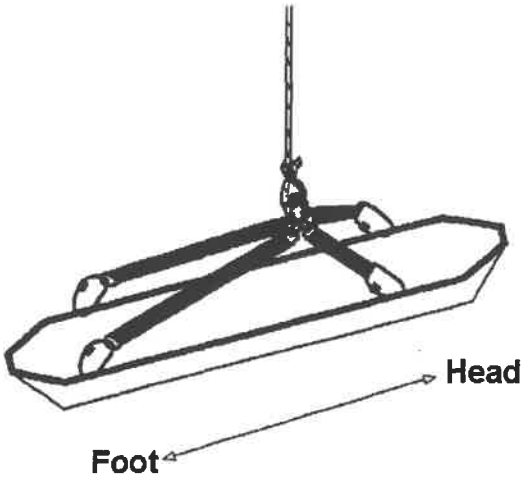


Figure 4-28

Vertical Bridal (Figure 4-29)

This method uses a 25 - 30 foot piece of static kernmantle rope (3/8" or greater). The bridle is constructed in the following way:

- ✓ Tie a double loop figure eight knot in the middle of the rope. This knot will serve as the attachment point to the lowering line. You can add rigging ring if available.
- ✓ Place the knot of the bridle rope at the head of the basket.
- ✓ Wrap each of the two legs of rope extending from the knot around the top rail several times.
- ✓ Continue to wrap the ropes around the railing, moving downward towards the feet. There should be one rope wrapped around the railing on either side of the basket and in between uprights.
- ✓ When the ropes have reached the approximate level of the patients knees, wrap the rope on each side around the railing at least twice.
- ✓ Bring the ropes together over the patients knees and tie them together with a square knot.
- ✓ Back the square knot up with an overhand safety knot on each loose end.

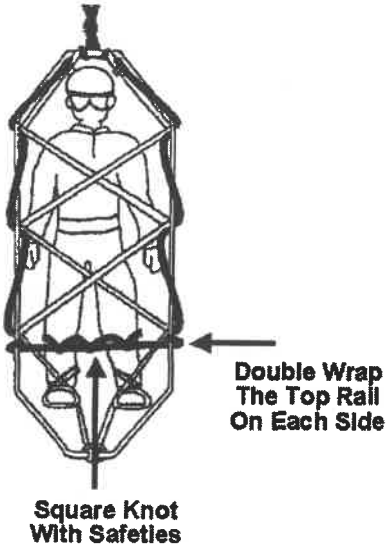


Figure 4-29

Adding an Attendant (Figures 4-30 and 4-31)

Adding an attendant to a litter basket is a common practice. It offers the patient assurance and also allows the attendant to provide medical attention if necessary. The attendant can also help move the litter around obstructions.

To accomplish adding an attendant, you may use rope, a sling, or a stretcher strap. The litter should already be over the edge and ready to be lowered. A belay line may be used to assist the attendant in getting into position. The attendant is attached in the following manner:

- ✓ Attach one end of the belt (or rope) to the main line knot with a carabiner (or rigging ring if used).
- ✓ Attach the other end of the belt to the attendants harness.
- ✓ The attendant should now clip into the belay line. This is accomplished by tying a double butterfly knot 3 - 4 feet from the bridle connection. This configuration allows two points of attachment on the same line (one for the litter and one for the attendant).
- ✓ The attendant can now cross over the litter and get into place.

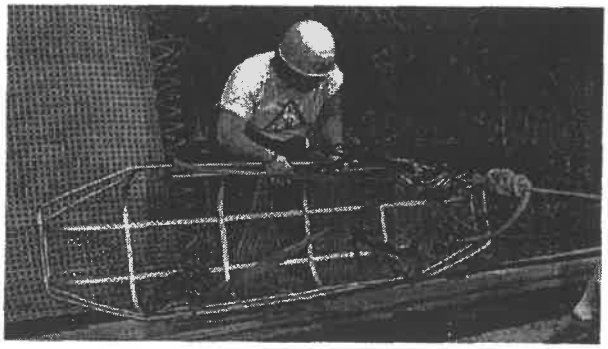


Figure 4-30

Figure 4-31

High Angle Theory - Lowering

Introduction.

In most high angle rope rescue situations, the safest and most appropriate method of gaining access to and removing the victim to a safe place is with the use of a lowering system. The purpose of a lowering system is to provide for the controlled descent of the rescuer, victim or both. This lesson will describe the three types of lowering systems in use. These are:

- Figure eight lowering system.
- Brake bar rack lowering system.
- Mechanical advantage lowering system.

Figure Eight Lowering System

This system is recommended for single person loads only. The main reason for this is the lack of ability to adequately control and adjust friction.

Brake Bar Rack Lowering System (Figure 4-32)

This system is recommended for single and two person loads. It provides for better control and adjustment of friction as compared to the figure eight lowering system. Both the standard rack and rigging rack may be used.

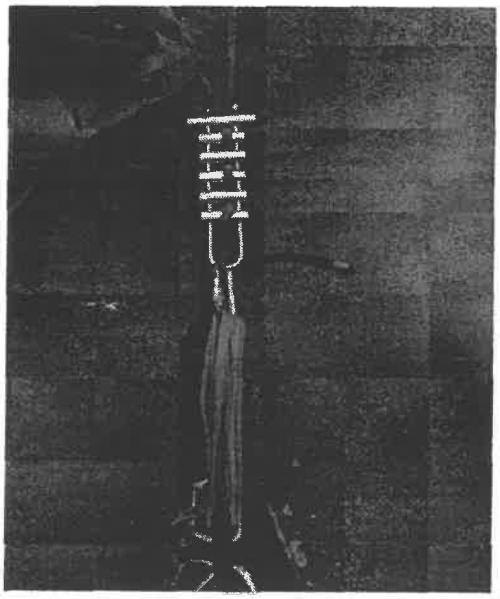


Figure 4-32

Mechanical Advantage Lowering System

This system is utilized where heavy loads are anticipated and a rack is not available.

Mechanical Advantage

Introduction

In many rescue situations that may be encountered, sheer strength may not be enough to move a victim, the rescuers or an object. In fact, this method may be one of the least safe methods available to us. Because of this, we use mechanical advantage systems that are designed specifically for rescue work. These systems provide the lifting or moving ability necessary, while at the same time giving us a great level of control and safety. The choice of equipment that is available for use is wide and a thorough understanding of this equipment and its limitations is very important.

Mechanical Advantage System Theory

Introduction to Levers

The purpose of levers is to move a load that is heavier than can be moved by manpower alone. Levers are used for pulling, hauling and raising. The rope and pulley systems we use are one type of lever.

- Class 1 - Gives the greatest mechanical advantage. The load is located at one end, the lifting force at the other end with the fulcrum located between the two. This method is best for lifting vertically. A pry bar is the most common example of this.

- Class 2 - Consists of a fulcrum at one end, a load in the middle and a force at the other end. This type of lever most useful for horizontal movement. The wheelbarrow is the most common example of this.

- Class 3 - The load is at one end, the fulcrum at the other end and the force in the middle. This is used when force may be sacrificed for distance. Examples include shovels and brooms.

Inclined Planes

Mechanical advantage is gained because the load raises vertically only a small portion of the distance it travels horizontally.

Types of Machines

By utilizing variations of the two types of simple machines, i.e. the lever & inclined plane, moving parts of other mechanical advantage devices can be constructed. Examples include: pulleys, screwjacks and cranks.

Pulley - Lever Systems (Figure 4-33)

A pulley, in its basic component, is a lever arranged so that a force can be applied steadily to a rope. A single fixed pulley is a lever of the first type. A single moveable pulley is a lever of the second type. In a pulley system, the MA is equal to the number of strands supporting the weight.

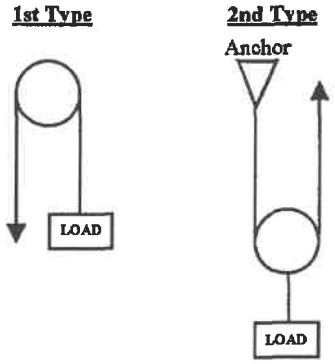


Figure 4-33

Differences with Hauling and Lifting Systems

Lifting Systems are a mechanical advantage system where the fall line originates from a fixed pulley. This type of system is used when the point of attachment is located above the rescuers. It does not utilize the full mechanical advantage potential of the system.

Hauling Systems are mechanical advantage systems where the fall line originates from a movable pulley. This type of system is used where the point of attachment is located either below or horizontal to the level of the rescuers. It provides for the most advantageous use of the system's mechanical advantage potential.

Calculating Mechanical Advantage and Determining the Length of Rope Necessary

- Determine weight to be lifted

The amount of force needed to lift an object is **theoretically** proportional to the mechanical advantage system used. Because of other forces such as friction, there will be a slight (in most cases) difference between theoretical and actual forces required.

An example of determining appropriate mechanical advantage: To lift a 200 pound object using a 1:1 mechanical advantage system, 200 pounds of force will be necessary. The use of a 4:1 system will require 50 pounds of force.

- Determine length of rope needed

The length of rope necessary is proportional to the mechanical advantage system used. An example of determining length of rope needed: A lift or run of 50 feet using a 1:1 system will require 50 feet of rope. The use of a 4:1 system will require 200 feet of rope. Remember, in order to lift the object 50 feet while using a 4:1 system, you will also have to pull 200 feet of rope through the system.

Because of the need for working slack and extra for stretch in vertical systems, the length of rope needed = (MA + 1) x (length of lift + 4). So, a lift or run of 50 feet with a 4:1 system requires 270 feet of rope. (4:1 + 1 = 5 times 54 feet = 270 feet of rope). Because of this, choose the minimum mechanical advantage system necessary. You can always add to it if necessary.

Constructing Mechanical Advantage Systems

A. Pulley Systems

The pulley system selected will depend on the amount of weight to be moved, the available personnel, the equipment available and the system configuration necessary for the particular site. Some mechanical advantage systems will be given 2 examples: a "simple" system and a "compound" system.

A rule of thumb in constructing systems that may help the students is that the terminal (knot) end of the rope will be at the load end of the odd (3:1, 5:1 etc.) systems. Even (2:1, 4:1 etc.) systems will have the terminal (knot) end of the rope at the anchor end of the system.

The mechanical advantage of a simple system is determined by counting the number of ropes supporting the load. (Figure 4-34)

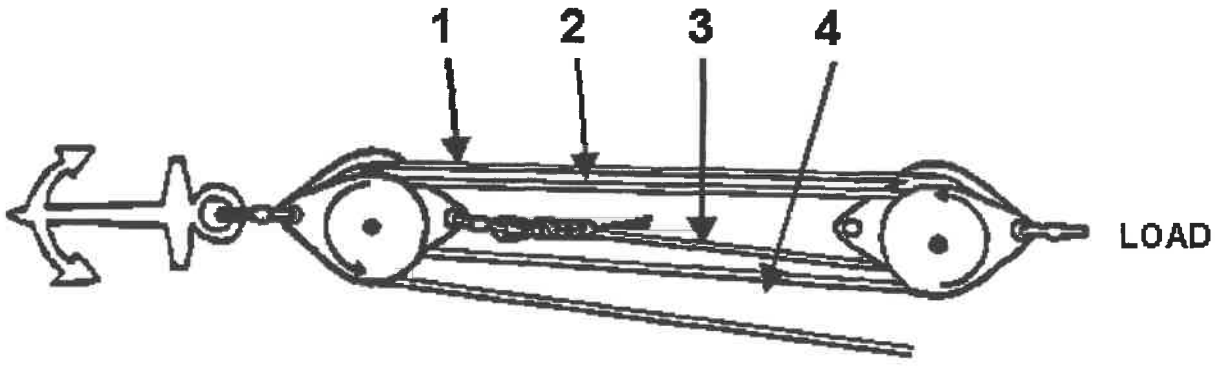


Figure 4-34

A compound system is made by using 2 or more systems together. When combining mechanical advantage systems, the numbers are multiplied. For example, if you pull a 3:1 system with a 2:1 system, the result would be 3 times 2, which is a 6:1 system.

One of the quickest ways to convert a lowering system to a raising system and back again is to use an **"add on system"** (Figure 4-35). This is a simple or compound mechanical advantage system that is attached to the main line.

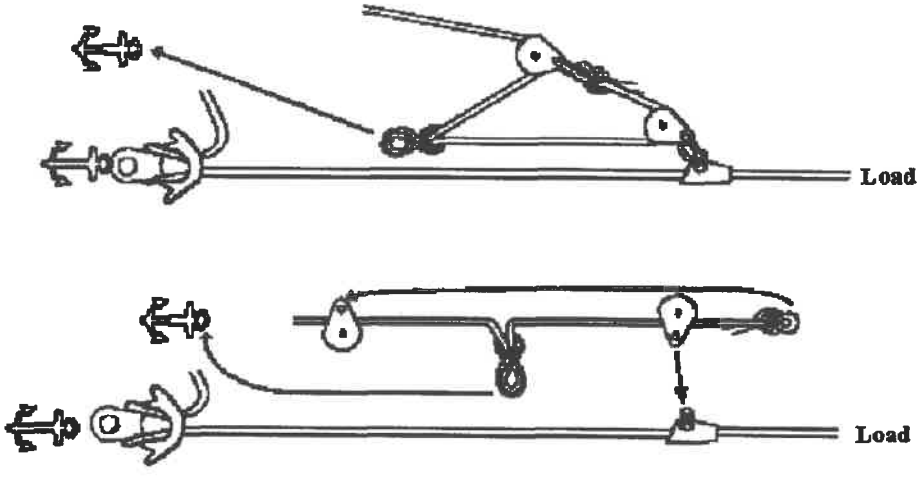


Figure 4-35

2:1 System – Simple (Figure 4-36)

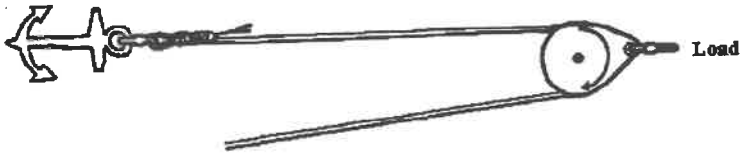


Figure 4-36

3:1 System - Example 1 (Figure 4-37)

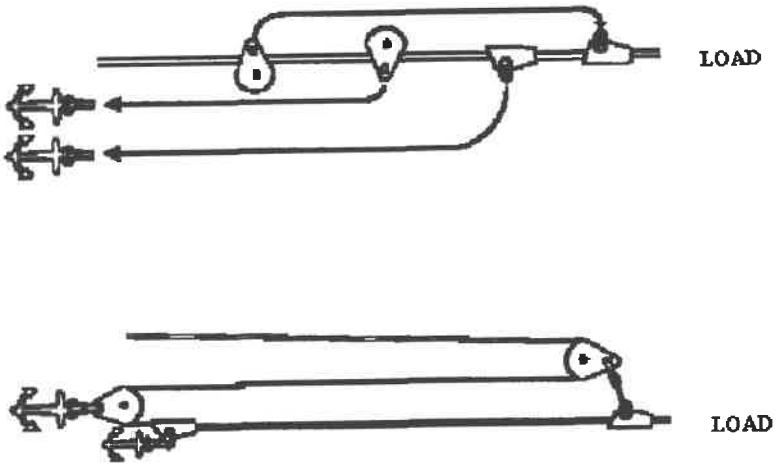


Figure 4-37

3:1 Simple - Example 2 (Figure 4-38)

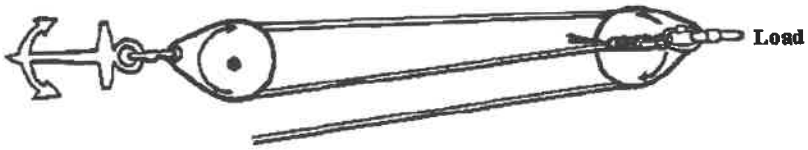


Figure 4-38

4:1 System – Simple (Figure 4-39)

Figure 4-39

4:1 System – Compound (Figure 4-40)

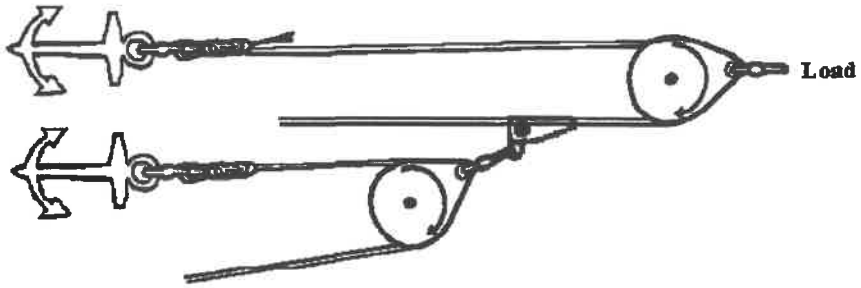


Figure 4-40

5:1 System – Simple (Figure 4-41)

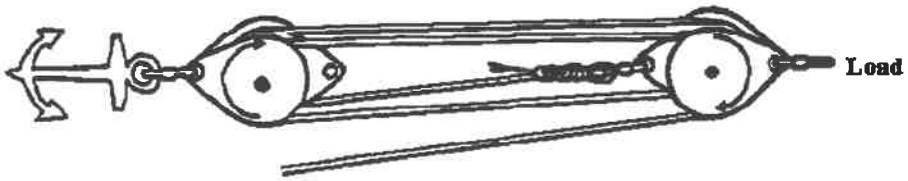


Figure 4-41

6:1 System – Compound (Figure 4-42)

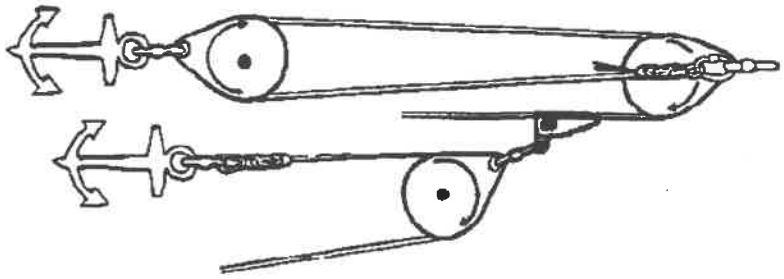


Figure 4-42

Methods of Attachment

System incorporation

The rope supporting the load is rigged with pulleys so as to construct the MA system out of it.

System added on

The MA system is constructed out of an independant rope and pulley. The independant MA system is attached to the support rope to raise the load. This is attached to the line to be raised by the use of a triple wrap 8mm prusik as a minimum.