Arcadia Fire Department Rope Rescue Manual

March 2017

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Rope Rescue Manual
Chapter 1
Rope Rescue Equipment

The fire service uses ropes in a variety of ways, as safety lines, to move equipment, to transport rescuers to victims and victims to safety, to secure unstable objects, to create mechanical advantage systems, etc. As you can see, the variety of use is left to the imagination of the user balanced by the limits of the material used.

Ropes, straps, webbing and webbing harnesses are called software. Carabiners, pulleys, rigging plates, brakes and ascenders are collectively called hardware. Together they are combined into many configurations to transport an item or a person safely from one location to another. Because of the myriad of different techniques that ropes and their associated hardware can be used to safely move an object, the Department has determined that a Rope Rescue Training Manual is necessary to define the way that its members should configure their systems so that some consistency can be achieved among its operational units. Where applicable, Minimum Breaking Strength (MBS) is noted on equipment listed in this chapter.

Rope Rescue Software

Rescue Rope

Before a rope system is designed, the user must understand the material he or she is working with. Rope may be made from the following: natural materials, cotton, hemp, manila, hair, silk or synthetic materials nylon, Kevlar, polyester, polypropylene, and spectra. Natural ropes begin to deteriorate from the date of manufacture. They are also more susceptible to harm from chemicals or exposure to the environment. For these reasons, natural fiber ropes are not to be used for rope rescue. Synthetic ropes have many advantages including; higher strength, greater length, lighter weight, and the materials used are less susceptible to environmental damage.

Rather than describe all the available types of synthetic rope, we will focus on the types of rope used by the Department.

Nylon Rescue Rope

Rescue Rope

An extremely low-stretch kernmantle rescue lifeline constructed of 100% high-tenacity polyester fiber. The polyester fibers do not absorb water, so there is no loss of strength or increase in weight if the rope gets wet. With less than 2% stretch at 300 lbf., Static-Pro is an excellent choice for high lines, long rappels, and many mechanical advantage haul systems. Polyester fiber ropes have better resistance to acids than nylon, which makes Static-Pro the preferred choice in acidic environments. Favored for its excellent hand, knotability and UV resistance, Static-Pro Lifelines come in solid colors with a single stripe to prevent confusion with CMC Lifeline and other solid color kernmantle ropes.

Static-Pro Lifeline Specifications
The following specifications apply to all diameters of CMC Static-Pro Lifeline:
Certification — UL Classified to NFPA 1983 Standard on Life Safety Rope and Equipment for Emergency Services, 2006 Edition.
Construction — Block creel, static kernmantle.
Fiber – 100% high-tenacity polyester.
Sheath — 32-strand braided, with half the strands having a left (Z) twist and the other half having a right (S) twist for a balanced, torque-free rope with maximum abrasion resistance.
Strength — NFPA General Use for 12.5 mm (1/2 in.)
Temperature — Melt point 480° F (249° C)

The Department uses low-stretch kernmantle rope because of its strength, durability, and flexibility characteristics. In rescue work, potential fall distances are relatively short (max 3.3ft (or 1m)) when the system used incorporates a tended Belay Line. Low-stretch ropes are the preferred type of rope for rescue work. Static ropes have an elongation of less than 6% at 10% of the rated minimum breaking strength. In practice, low-stretch ropes still have a significant amount of stretch that rescuers need to consider when rigging their systems.

The kernmantle weave is a technique that wraps most of the parallel nylon fibers in the core of the rope while the rest of the fibers are braided into the sheath. This technique is also known as block creel construction. The core of kernmantle rope contains 75-90% of the strength of the rope. The sheath contains 10-25% of the rope's strength. Rope manufacturers can manipulate the stretch characteristics of the rope by changing the tension and thickness of the braided fibers in the sheath.

Currently, the Department distributes its 12.7mm (1/2") rescue rope in a couple lengths: 600ft., 300 ft., 200 ft., 150 ft., and 20 ft.

Utility Rope

Most damage occurs to ropes during the movement of equipment at an incident. These ropes are typically used to hoist tools aloft on structure fire calls. Utility rope is to be used for moving equipment only.

Polypropylene Rope

The Department provides polypropylene rope for swiftwater rescue throw bags. This rope material will float and is very resistant to mechanical damage. Because polypropylene has less than half the strength of nylon rope and poor shock absorbing capability, ***polypropylene rope is to be used as water rescue throw line only. It should never be used in place of nylon kernmantle rescue rope.***

RIC Bag

The department's RIC Bag is standard throughout the Verdugo City's. There is 150' of rope with a single knot at 50', and two knots at 100'. PASS device, strobe, flashlight, cable cutters, trauma sheers, two carabineers, 60 minute SCBA cylinder, SCBA mask with second stage regulator, 36" transfer air line.

Prusik Cord

The Department currently uses 8 mm, type 6.6 nylon, low-stretch kernmantle rope for Prusiks. Prusiks are traditionally used in climbing as a self-rescue tool. They allow climbers to ascend the rope in case of a fall or other bind in the system. In rescue work, Prusiks are tied in loops and are typically used in three ways:

1. A **hauling** Prusik grabs the rope and pulls it in motion as part of a mechanical advantage system.
2. A **ratchet** Prusik holds the rope in place while a mechanical advantage system is reset.
3. Tandem Prusiks are used as an emergency system **brake** when attached to a Belay Line.

Prusik cord size is smaller in diameter than the rope it is attached to. 8mm Prusik cord works best with 12.7 (1/2”) rope. The difference between sizes of the Prusik cord and rope will affect the breaking, holding and releasing characteristics of the Prusiks’ attachment to the rope. Prusiks should slip a little on the rope before setting so that the knot will dissipate some of the frictional heat along the rope and absorb some of the shock on the rope system. Prusiks are cut in two lengths: 66” (long) and 56” (short). They are tied in either a two-wrap loop or three-wrap Prusik Hitch depending on the intended use of the Prusik.

Search Bags

The Department currently provides 65' of 8mm, type 6.6 nylon, (4662 lbs. strength) low-stretch kernmantle rope for its personal escape line drop bag. These bags have traditionally been used as utility line to raise and lower equipment on the fireground.

Because of their intended use as rescue rope, members should limit the use of these ropes as utility lines. This will limit the potential damage created from dirt, oil, and abrasion. Because of this potential for damage and the infrequency of rescue use, members should inspect these ropes after each use.

Care for rescue rope as if your life depends on it, because it does.

Rope Coloring Scheme

The current rope diameter and coloring scheme is as follows:

Yellow Rescue Rope	12.7 mm (1/2”)
Blue Rescue Rope	12.7 mm (1/2”)
Orange Rescue Rope	12.7 mm (1/2”)
Red Rescue Rope	12.7 mm (1/2”)
White Rescue Rope	12.7 mm (1/2”)
Red / Blue Prusik (short)	8 mm (3/8”)
Red / Sand Prusik (long)	8 mm (3/8”)
Tan Personal Escape Line	8 mm (3/8”)

Webbing

The Department uses one types of webbing for rope rescue, tubular. The most familiar type is tubular which is carried on all Department apparatus and comes in a 1” width. Flat webbing is typically used in harness and strap construction. Because of its shape, webbing loses little of its strength when bent around a carabiner or tied in a knot. 1” tubular webbing has a typical tensile strength of 4,000 lbf. (20 kN). 2” tubular webbing has a tensile strength of 7,000 lbf. Department webbing has the following coloring scheme:

Department webbing

Green	5' Webbing
Yellow	12' Webbing
Blue	15' Webbing
Orange	20' Webbing
Red	15’ Webbing (RIC, Personnel)

Webbing is used for harnesses, etrier’s, anchors, tethers, straps and any other use that requires distribution of rescue system loads over a wide area. Webbing is best suited for use as an anchor strap because webbing tends to hold its strength better than rope when bent sharply.

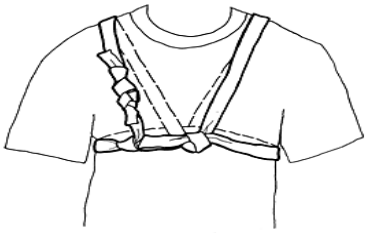
Harnesses

The Department utilizes the harnesses listed below as rescuer and victim harnesses.

Full Body Harness (Class 3)

This harness will serve as a single, all-risk rope rescue and technical rescue harness. They have upper, lower, front and rear attachment points.

Rescue Systems 1 Chest Harness



RS1 chest harness

The webbing chest harness in current use by the Department is the Rescue Systems 1 Chest Harness. It is tied from a 12 or 15' length of 1" webbing. Its intent is to keep a rescuer from inverting while being suspended from a rope system. The seat and chest combination will also distribute the force of a fall over a greater area of the body and ensure that the rescuer will end up in a semi-fowlers position after a fall.
(See Chapter 5 for steps on tying this harness.)

Seat and Chest Harness with a Connector Strap

Chest and Seat harness with a Connector Strap

These two harnesses are combined when working in a high-angle environment. If the rescuer cannot make these two harnesses touch one another when bent over, back injury may occur during a fall. A connector strap, made from a 5' webbing tied with an overhand bend facing out, can prevent this potential injury from occurring by creating a new connection point for the Main Line.
(See chapter 7 for details on rigging this harness.)

Swiss Seat Harness

The webbing seat harness in current use by the Department is the Swiss Seat. The Swiss Seat is tied with a 20' length of 1" webbing. This harness can restrict circulation in the rescuers legs and should be used in low-angle rope rescue and swiftwater rescue situations only. (See Chapter 5 for steps on tying this harness.)

Swiss seat harness

Manufactured seat harnesses are always preferable to the Swiss Seat because of the additional support and their ability to be adjusted to the user.

Hasty Harness

The Hasty harness is a webbing harness used for victim rescue. It is a pelvic harness that is tied from a 15' length of webbing. It is only to be used as a quick method of attaching a victim to a rope system for rapid rescue. It should not be chosen as a preferred method because of its limited means of security. (See Chapter 5 for steps on tying this harness.)

Hasty harness

Victim Pelvic Harness

This manufactured victim harness is designed for quick attachment to a victim, minimizing the contact time once the rescuer is with the victim during a Pick-off operation. It can also be used for the seat lashing when securing a victim into the Stokes litter. A piece of webbing would be Girth Hitched to the waist loop of the harness and secured to the Stokes litter the same way as the standard interior lashing is finished.

C.M.C. ProSeries Lifesaver Victim Harness

Victim Chest Harness

This chest harness turns the Lifesaver Victim Harness into a full-body evacuation harness for vertical lifts during confined space operations or wherever upper body support is needed. It's easy to attach to the patient under all conditions, and its padding provides added comfort.

C.M.C ProSeries Lifesaver Victim Chest Harness

Straps

Pick-Off Strap

The Pick-Off Strap is a section of flat 1-3/4" webbing with a D-Ring attached, used to connect the rescuer to a victim. This strap is used in situations where a victim is trapped in a location where a vertical rope rescue system must be used to make the rescue (a "pick-off"). The rescuer attaches the D-Ring of the Pick-Off Strap to the victims' harness, and the adjustable V-Ring to either the rope system above the rescuer or directly to the rescuer's harness with the victim secured below the rescuer. (See Chapter 12 for the techniques used with the Pick-Off Strap.)

Stretcher Strap

The Pick-Off Strap can also be used as a Stretcher Strap. It can be used in one of two ways. First, when used during a four rescuer, low-angle litter operation, it becomes the main attachment point for the side rescuers to the rigging plate. (See Chapter 10, Stokes Rigging for details) Second, it can be used to connect rescuers directly to the Stokes litter for a low-angle scree-evac. The strap is Girth Hitched around the top rail of the Stokes litter and the V-Ring is connected via carabiner to the front D-Ring of the rescuers' harness. Rescuers should raise the Stokes litter and adjust the straps to a satisfactory length before proceeding. This strap is not intended as a replacement to connecting into the rope system via the Stokes litter harness.

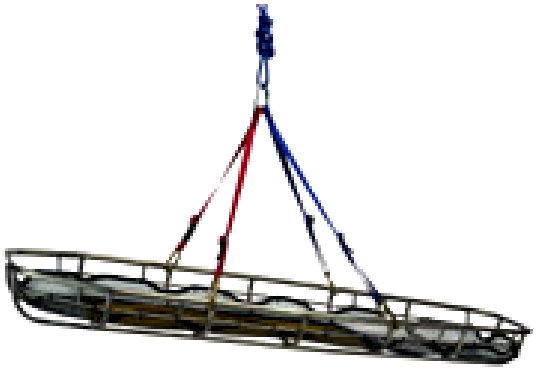
The idea is to redistribute the weight of the patient to the hips of the rescuers. In practice, rescuers need to travel slowly so that all can work together to balance the Stokes against the terrain. The more uneven the ground, the more difficult it is to use these straps.

Anchor Strap

Anchor straps are issued in 5' and 10' lengths. One end is taken through a tire or around an object and then a carabiner is connected to the two D-Rings facing towards the load. To protect the strap from a hot object (typically a brake drum), use a piece of fire hose around it for protection. **MBS 8,039 lbs.**

Stokes Litter Harnesses

These adjustable Stokes litter harnesses are designed for use in either the low- or high-angle environment. The legs are color coded for quick set-up. They include 4 X-Large carabiners for attachment to the Stokes litter frame. (See Chapter 10 on how to use these harnesses.)



Spreader Bar

The spreader bar is made from an anodized aluminum plate. It is designed to maintain a rescuer or victim in a near vertical position. It is typically used during entry into confined spaces in order to maintain a low profile position. Adjustable shoulder buckles allow the wearer to balance the lifting.

Rescue Hardware

Carabiners

Carabiners are metal connectors that connect rope rescue components together. The Department currently uses locking aluminum carabiners for rope rescue.

There are 4 basic parts of a carabiner:

- Gate
- Lock
- Hinge
- Spine

Department carabiners have the following minimum strength rating:

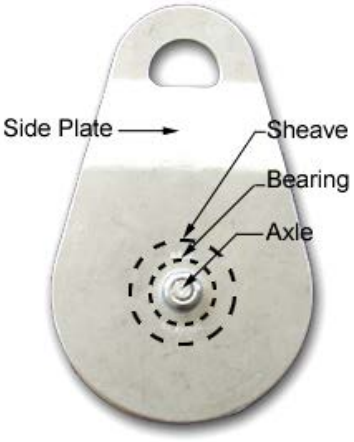
Aluminum	**11,424 lbs.**
Steel	**9,000 lbs.**

Carabiners are at their full strength when the gate is locked closed and the load is directed along the spine. If the carabiner is side-loaded or the gate is left unlocked, failure is much more likely.

A locked carabiner ***shall not*** be unlocked and opened when under load. Likewise, the lock should only be tightened when the system is not loaded. Tightening the lock while under load may prevent the gate from being opened when the load is taken off the system.

The gates of the carabiner should be turned away from the face of a cliff or building to prevent it from being rolled open. The gate should screw downward in order to prevent it from coming unlocked due to vibration.

Rescue Pulleys



In rope rescue, pulleys are used to:

- Change the direction of force on a running rope.
- Reduce rope friction.
- Create mechanical advantage for hauling systems.

Rescue pulleys are made of metal for maximum strength. The metal sheave should be the proper width for the diameter of rope being used. The pulley diameter should be four times the diameter of the rope for minimum loss of rope strength as the rope bends around the sheave.

The pulley's side plates must be moveable so they can be placed on the rope anywhere in the system. The axle should be firmly attached with rounded bolt heads to prevent damage to other rescue system components.

The bearing should be sealed so that it turns freely and will not be contaminated with dirt and debris.

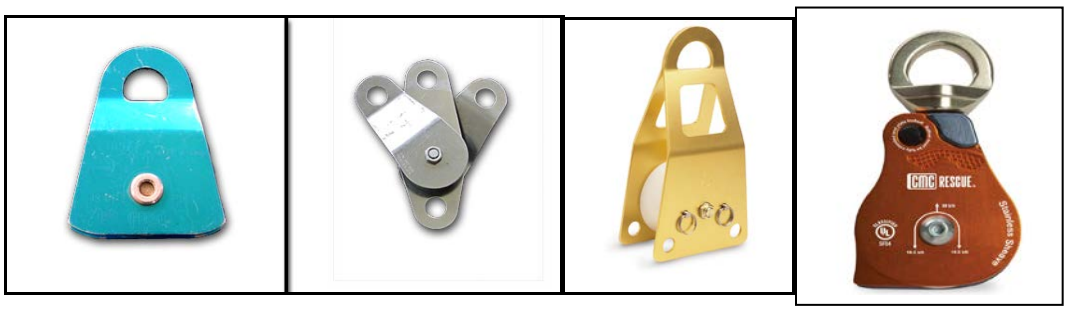
The Department carries 2" rescue pulleys. 4" pulleys are preferred in most rope system applications because of the reduced friction due to the more gradual bend in the rope around the sheave.

Specialized Pulleys

Prusik Minding Pulleys are designed to work with Prusiks to make a self-tending brake system for Belay Lines and ratchets for mechanical advantage pulley systems. **MBS 8,043 lbs.**

Double Sheave Pulleys are used for setting up parallel systems and for increasing mechanical advantage. **MBS 9,000 lbs.**

Knot Passing Pulleys have uses as a knot passing pulley and a means of creating a Tensionless Hitch. **MBS 9,000 lbs.**



Prusik-minding-pulley **Double-sheave pulley** **Kootenay carriage** **PMP Swivel Pulley**

Friction Devices

The Department utilizes three different types of friction devices.

Figure 8 Descenders with Ears

These are designed as descending/ rappelling devices. Figure 8 plates work by creating friction when the rope is wrapped around them. A bight of rope passes through the large ring to create friction, while the smaller ring is used as an attachment point to either a harness or an anchor. The ears are to prevent the rope from accidentally forming a Girth Hitch causing a jam that is difficult to unlock. Rescue 8 descenders are larger than recreational descenders allowing them to accept larger rope and dissipate heat, as well as making them easier to lock off.

While Figure 8 plates are easy to use, there are several problems associated with them:

- They twist any rope that goes through them.
- They are one-person devices with limited ability to hold heavier loads.
- Once attached to a system, friction cannot be increased to support a heavier load.

Figure 8 descenders are not to be used as a belay device on a safety line, and should only be used for one-person rappels, or for lowering one-person loads. In most cases, enough rope to reach the objective should be taken out of the bag, a Stopper Knot tied in the end of rope, and the end of the rope sent over. This will serve two purposes: it will keep twists out of the rescue rope, and it will leave the excess rope at the top, where it can be used to form a hauling system if needed. **MBS 45,000 lbs.**

Figure 8 Descender properly tied- off

Brake Bar Racks

Brake Bar Racks are friction devices designed for use on the Main Line for lowering systems or for rappelling. Reeving the rope over and under the bars creates friction; the more bars used, the greater the friction. Adjusting the distance between the reeved bars creates additional friction. The maximum friction is obtained by pushing the bars close together. Brake Bar Rack riggers should start off with four bars for a single-person load and six bars for a two-person load.

Parts of the Brake Bar Rack include:

- A steel frame, and retaining nuts
- One 1" top hyper-bar with two tie-off bars
- Five 1" U-shape bars

When reeving a Brake Bar Rack the rope should first contact the top bar. The rope should then pass under the next bar forcing the bar against the rack. The rope then passes over and under the rest of the bars. **MBS 30,000 lbs.**

During long lowers / rappels, a small amount of water can be applied to the top bar, to facilitate cooling of the bar.

Brake Bar Rack properly tied-off

F-4 Descent Device

Sterling Rope's innovative escape device gives firefighters an advanced, yet simple tool for emergency egress. It is engineered to allow easy horizontal movement. The auto-locking feature adds security and confidence for a hands free exit of a structure.
NOTICE: The F4 escape device is only certified with approved Sterling escape rope. **MBS 3,035 lbs**

F-4 Descent Device

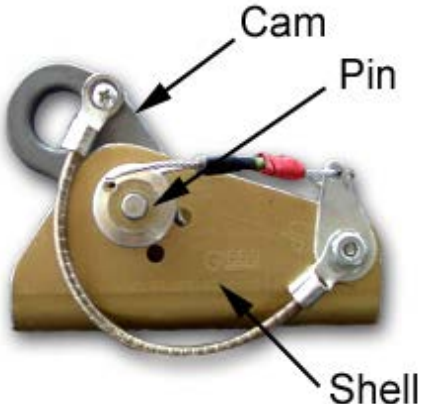
Rigging Plate

Rigging Plates, also called Anchor Plates, are used to gather equipment into a single focal point. They are stamped from sheet aluminum or stainless steel (not cast). Their strength ratings vary and are usually stamped on the equipment. **MBS 9,150 lbs.**

Steel O-Rings

Made from drop-forged alloy steel, O-Rings can be used as a gathering point for equipment. They are commonly used in Highline systems. The inside diameter is 3 inches. **MBS 5,000 lbs.**

Ascenders



Mechanical Gibbs Ascenders are designed to ascend a fixed rope. They are also used in conjunction with an Etrier on the attendant line in a vertical litter operation. (See Chapter 10)

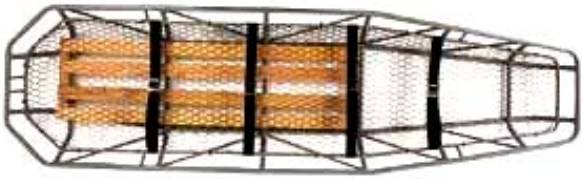
Under no circumstances should they be used as a braking cam on a Belay Line or a rope grab on a hauling line.

When subjected to the shock-load of a 1-meter fall, tests have shown that in 66% of the trials the ascender will either cut the rope completely, or strip the sheath when used as a braking cam.

Components of the Gibbs Ascender include shell, cam, and pin. Ensure that the pin is through both sides of the sleeve and locked before use. The arrow should be pointing to the direction of ascent. **MBS 2,550 and 5,000 lbs.**

Stokes Litter

The Stokes Litter is used to transport injured victims in a horizontal or a vertical position. It is used in low-angle scree evacuations as well as high-angle/ vertical evolutions. Backboards can be incorporated into the lashing of a victim in the Stokes Litter.



Stokes Litter Shield

The Stokes Litter Shield protects the patient's face, head, and neck from inclement weather, brush, dirt, falling rocks, and debris without compromising access to the head for monitoring or treatment. Quick-release straps allow the rescuer to load and maintain access to the patient while a raising or lowering system is attached to the stretcher. One is carried on Truck 105.

Stokes Litter Wheel

The Stokes Litter Wheel clamps onto the top rail of the Stokes litter. It uses an all-terrain tire that provides stability during the transport of a victim in a low-angle environment. A Stokes Litter Wheel is carried on USAR 106.

Tripod

THE ORIGINAL ARIZONA VORTEX
The Arizona Vortex is a fixed A-frame design artificial high directional rescue tripod with third rotating (easel type) leg. It can be used as a tripod, A-frame or gin pole. All structures, except the stainless steel tip in foot, are made from aircraft grade aluminum. All tubing is .25" (6.35 mm) wall thickness, all plate .5" (12.7 mm) thick. Wren Industries keeps on file a record of material chemical composition, and heat treatment certification, from the aluminum manufacturer. Pins for assembly are military style, positive lock. Double shear strength: 18,000 (8165 kg). The head configuration allows for attachment of pulles with carabiners. It does not include a head that allows direct attachment of the pulley with a pin attachment system. The direct attachment does not allow the pulley to rotate under the rigging head and can impart rotational torque to the head. This torque is transmitted to the legs of the tripod and, if the load and torque is great enough, can cause flexing of the legs.

- Short tripod configuration is 48" (1220 mm) tall with 41" (1041 mm) inside working clearance.
- Regular tripod configuration is 87" (2210 mm) tall with 80" (2032 mm) inside working clearance.
- Extra Tall tripod configuration is 127" (3226 mm) tall with 120" (3048 mm) inside working clearance. Note: Extra tall tripod requires optional two lower legs.
- Total weight approximately 65 lbs.,(30 kg.) Distributed between five duffel style bags for transport. See bottom of page for accessories

The Original Arizona Vortex Kit Includes

- Head w/ Carrying Bag (1 ea.)
- Upper Legs w/ Carrying Bag (3 ea.)
- Lower Legs w/ Carrying Bag (4 ea.)
- Flat Feet (3 ea.)
- Raptor Claw Feet (3 ea.)
- Assembly Pins w/ Bag (13 ea.)
- Instruction Manual (1 ea.)

It is located on USAR 106.

ARIZONA VORTEX (AZV)

The Arizona Vortex (AZV) was created from years of trial and error. Having worked with crude but functional lashed timber frames at Sedona-based Ropes That Rescue, Reed Thorne developed the AZV with the help of Rock Thompson at Rock Exotica. The AZ Vortex represents the essence of at-the-edge frames, which no standard multi-pod can match today.

The father of all portable artificial high directionals (AHDs), the AZV is a tripod, bipod and monopod in one all-inclusive kit. Its precision two-piece head can be rigged as a standard tripod or, in advanced applications, as an A-frame, a sideways A-frame, a gin pole or a multitude of other configurations. The tripod can be formed into an easel A-frame with adjustable leg lengths. The versatile third leg allows rescuers to set up an artificial high directional in virtually any urban, industrial or wilderness location. On A-frame and easel A-frame applications, pulleys can be attached using quick-pins directly into the Head Set without using carabiners, eliminating lost headspace and working clearance. This feature makes the AZV ideal for use with high lines and tracking line offsets. The extra attachment points also work well for rope access where several lines may be needed over the edge. Raptor and Flat feet sets are both included to provide secure footing options on varying terrain.

The AZV comes complete with:

- Head Set
- Head Set Pulley Wheel
- Head Pins (4)
- Head Backpack
- Inner Legs (3)
- Outer Legs (7)
- Leg Pins (11)
- Leg Bags w/ Shoulder Straps (3)
- Flat Feet (3)
- Raptor Feet (3)
- Foot Sleeves (2)
- Pin Bag
- Pin Flags (15)
- Hobble Straps (3)
- 8 mm Cord – 40 ft (12 m)
- Instruction Manual

Edge Protection

Edge protection is used to protect rope and webbing from abrasion and sharp edges. The edge protection used by the Department includes Edge Rollers, hose rollers, tarps and hose.

Edge Rollers are constructed of an aluminum frame and rollers. The eight tie-down holes can be used to anchor a safety line to them or to link the rollers together in series to provide protection on multiple sides.

All edge protection should be secured with a back-tie after being placed to prevent movement with the rope.

Rope Rescue Manual
Chapter 2
Equipment Care

Service Testing

All Department life safety rope and system components shall be inspected after each use or monthly. Engine company personnel in accordance with rope inspection procedures that follow in this text should conduct this procedure.

At this time it is unclear as to how long rescue rope and its system components retain their original rated strength capacities. The amount of use and the intensity of that use will be factors. Physical damage that compromises integrity is the primary reason for retiring this equipment. As more industry research is committed to evaluating rescue rope strength retention, we will be able to establish reliable criteria for the service life of this equipment. Regardless of the equipment's estimated service life, the most reliable method for evaluating rope rescue equipment is a visual and tactile inspection.

The current Department standard for the service life of rescue rope is ten years of service life.

Equipment Repair or Replacement

Any deficiencies in the equipment should be reported to your supervisor. If equipment must be placed out-of-service, red tag the iteam by department policie.

Damaged Prusiks

Inspection Procedures

Your safety and that of others depends on the proper care and use of your equipment. Carefully document the rope inspection after each use on the Rope Log.

Life Safety Rope

Assigned personnel should review all rope logs for the equipment on the apparatus. At the completion of the inspection make sure all conditions found and actions taken are properly noted in the log.

Personal Escape Line Drop Bags

Drop Bags represent a unique hazard to personnel. They are intended to be a single-use escape line. However, because of their convenience, Department personnel often use these lines to move equipment. In addition to following life-safety rope inspection guidelines, these ropes should be inspected weekly on B-day. They should be cleaned and inspected after each use.

Utility Rope

Utility rope does not have rope log. It should receive inspections weekly, request replacement when it is not suitable for its intended purpose.

Storage

All rope should be stored in a cool, dry place. Check the storage location on the apparatus to ensure the rope is in a bag and away from hydrocarbons, cleaning agents, moisture, extreme heat and out of direct sunlight.

B-Day Check (Weekly)

Check the condition of the rope labels on the ends of the rope and replace it if necessary. Check in-service date of the rope. If its service life exceeds the department standard, the rope shall be downgraded.

Department ropes **are assigned to each apparatus. Each rope has its own permanent number to facilitate tracking its use throughout its service life.**

Tactile Inspection

For equipment grading criteria check Appendix A at the end of this chapter.

Begin inspection of the rope from the top of the bag. Hold the rope end tightly in one hand and pull about 18" through the other hand.

Look and feel for:

- Reductions in the rope's original diameter (hour glass), bulges.
- Stiff sections, soft or hard spots. These all may indicate broken fibers in the rope's core.
- Cuts, chafed areas, broken filaments, evidence of extreme abrasions, exposed core, or any other signs of unusual wear.
- Signs of discoloration, burn marks or melted areas in the sheath, these may be signs of heat or chemical exposure.

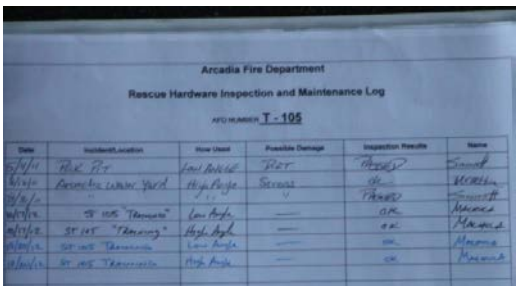
Continue this process for the full length of the rope. If any of the above conditions are noted, the rope shall be removed from service and a service inspection shall be requested.

Check the rope for overall cleanliness. If the rope requires washing utilize the washing procedures outlined in this document.

Reverse Rope in its Bag Quarterly

Reverse the rope whenever it is repacked in its bag. If the rope is not used often, this should be done at least every three months (quarterly). The action will permit even wearing and will assure a longer rope life.

Log each use in the rope log.



Indicate on the rope log the date, condition of the rope, a detailed accounting of its use, approximate load, training session or emergency and your name.

EXAMPLE: 02-02-14,
Rope T105, Main Line, Orange low-angle scree-evac ,
Four persons-approximately 700 lb. load.

When the rope log is full attach it to a new form to maintain a running document for the complete service life of the rope.

Rope/Software Washing Procedure:

- Rinse off muddy or excessively dirty rope/ webbing with a hose first. Scrub tough spots with a nylon bristle brush.
- When utilizing a washing machine, run the empty machine though a cycle with plain water to remove any harsh detergents.
- “Daisy-chain” (bird’s nest coil) the rope before washing.
- Wash the rope in cold water with 1/8 cup of Woolite per load. Do not exceed 200 ft. of rope per load. 1-ounce of Downey fabric softener can be used to replace the lubricant the rope loses during repeated use and washing. Rinse 3 times and hang dry.
- Hang the rope out of direct sunlight to dry; making sure it is completely dry before placing it in its bag for storage.
- For 600 ft. ropes, pour 1 capful of Woolite into a clean 55-gallon trash can and add water. Place rope into solution and agitate for several minutes. Remove rope and rinse thoroughly. Hang the rope to dry per directions above.
- Blood or other body fluids can be washed away with a 10% chlorine bleach solution.

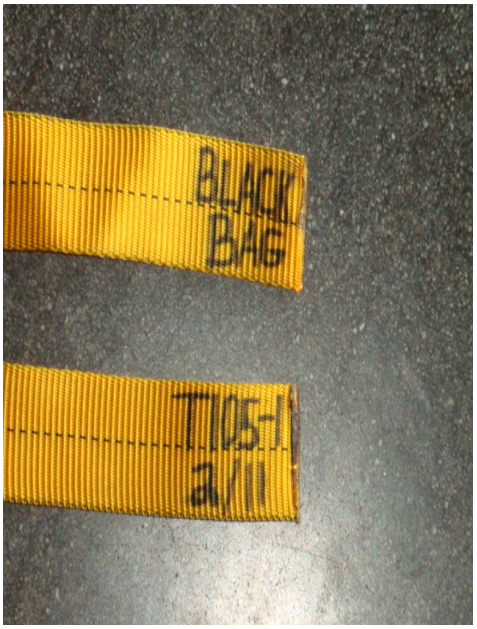
Webbing and Etriers

The inspection procedures and service guidelines are the same for webbing as they are for rope. Inspect the webbing end to end checking for any signs of damage, physical or chemical, and excessive wear. If any of the above conditions are noted, remove the webbing from service immediately and notify the US&R station. Etriers shall be inspected utilizing the webbing guidelines. Ensure all equipment is properly marked.

Use a similar technique to inspect webbing.

Marking Webbing

Mark the webbing with the appropriate marking pen. Only mark webbing within 3-inches of its end. All webbing is marked in the center with “C” on both sides of the webbing.



Webbing ends marked with service date and Engine assigned

Harnesses

Inspect harnesses for: cuts, cracks, tears or abrasions, undue stretching, overall deterioration, mildew, operational defects, heat damage, acid or other corrosion, defective or distorted snap-hooks, soft or hard spots. Check the stitching and thread for wear abrasion and deterioration. Equipment that is showing any defect shall be removed from service immediately. Ensure that all equipment is properly marked.

Class 3 Harness

Adjustable Straps

Pick-Off Straps shall be inspected for cuts, worn or frayed areas, broken fibers, soft or hard spots, or discolorations. Check the stitching for pulled threads, abrasions or breaks. If any of the above has been noted, retire the equipment immediately. Ensure that all equipment is properly marked.

Pick-Off Strap

Prusik Cord

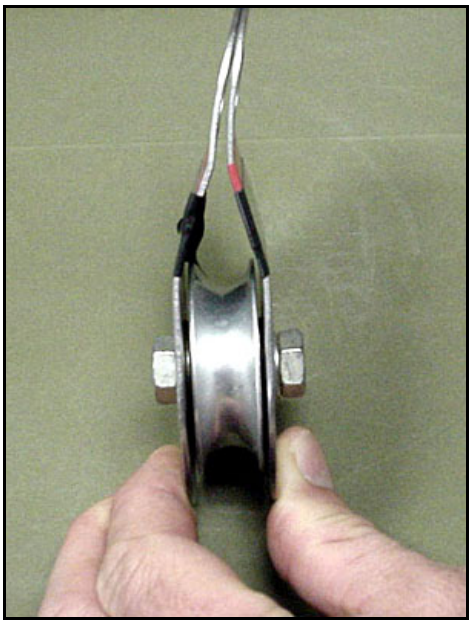
The inspection procedures and service guidelines are the same for Prusik cord as they are for rope. Inspect the cord end-to-end checking for any signs of damage, physical or chemical and excessive wear. Ensure it is properly marked with the appropriate marking tape, clean and the Double Overhand Bend is tied correctly.

Hardware Inspection

Rescue Pulleys and Anchor Plates

All rescue pulleys; edge rollers and Knot Passing Pulleys shall be inspected for surface damage, corrosion, or impairment of their mechanical function. Check that the wheels turn freely and that there are no burrs that may chaff rope or other software. Check for cleanliness, wash if necessary, and check the sealed bearings for free movement after washing.

Rigging plates shall be inspected for any signs of distortion, cracks, corrosion, sharp edges or wear. Ensure that all equipment is properly marked.



Damaged pulley

Carabiners

All carabiners shall be inspected for surface damage, corrosive wear, or impairment of its mechanical function. Inspect them for stress fractures. Rope motion wear should also be watched for; keeping the rope clean can slow this. Verify that the gate operates smoothly and will close completely and lock securely. If gates become stiff, clean the hinge and spring with a mild solvent (i.e. spray solvent) then lubricate with dry graphite. Make sure that they are properly marked with the appropriate marking tape.

Carabiner inspection

Brakes, Ascenders and Descenders

Figure 8 Plates

Figure 8 plates shall be inspected for stress fractures, wear, distortion, corrosion, gouges, sharp edges or rough areas that might abuse a rope. If any of these conditions are observed the Figure 8 shall be removed from service. Ensure that they are marked with the appropriate marking tape.

Damaged Figure 8 plate

Brake Bar Racks

Brake Bar Racks shall be inspected for surface damage, distortion, excessive friction wear and stress fractures. If individual brake bars show any signs listed above remove the damaged bar and replace with a new one. If the main rack frame shows any signs listed above remove the Brake Bar Rack from service. Ensure that they are properly marked.

Gibbs Ascenders

Gibbs Ascenders shall be inspected for any signs of distortion, cracks, corrosion, sharp edges or wear. Make sure the Ascender runs smoothly, replace the spring and cam if the operation is not smooth or the cam shows wear. Check the tightness of the screws. Verify that it is properly marked.

Damaged Gibbs Ascender cam

Appendix A: Life Safety Rope Grading Schedule Definitions

Use this section to assist you in judging the suitability of your rope for rescue work. On the last page there are some examples of damaged webbing. We do not rate webbing. It is either in-service or out-of-service.

Rope with a rating of “Excellent or Good “have no restrictions placed on them and are suitable for any department authorized operations where a “Life Safety Rope“ is required. Rope with a rating of “ Fair” shall be removed from line assigned apparatus. Rope given the rating of “Poor” shall be removed from service and not utilized for any purpose within the department, this rope shall be Red Tagged and placed out of service.

Excellent: Rope or software having the appearance of being new, without signs of wear, abrasion or soiled.

Good: Rope or software having the appearance of limited use with signs of minimal wear, minor abrasions to the outer jacket, and uniformity throughout, free of staining.

Fair: Rope or software having the appearance of moderate wear and abrasion throughout the outer jacket. Make notification to have equipment replaced.

Poor: Rope or software having the appearance of heavy wear, excessive abrasion, cuts or nicks that expose the core of the rope. Look for bulging, hour-glassing, hard spots, stiffness, discoloration, signs of heat damage or indications of chemical exposure. Remove the item from service immediately and request a replacement rope.

“Poor” Graded Rope Examples:

Rope with heavy wear or excessive abrasion.

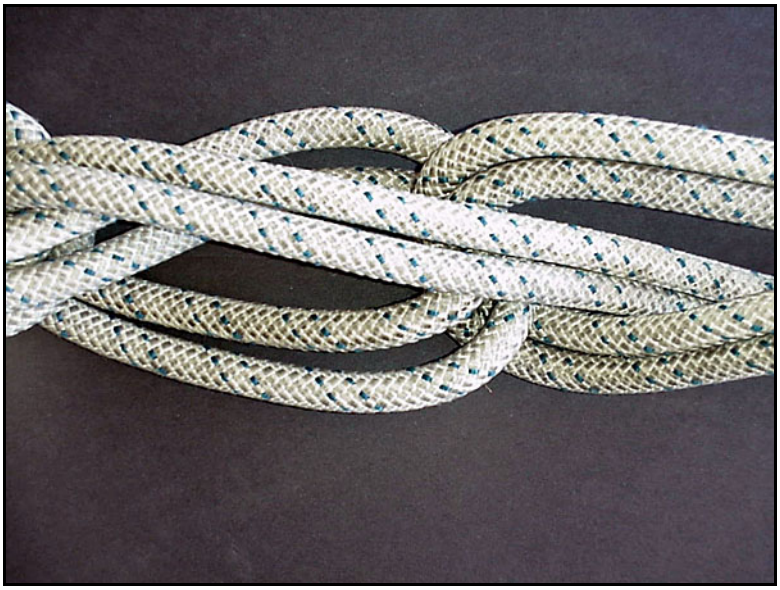
Note soft spots and oil marks in the upper right portion of the frame.

"Fair" Graded Rope Examples:

Moderate wear

Moderate wear. Note the oil spots

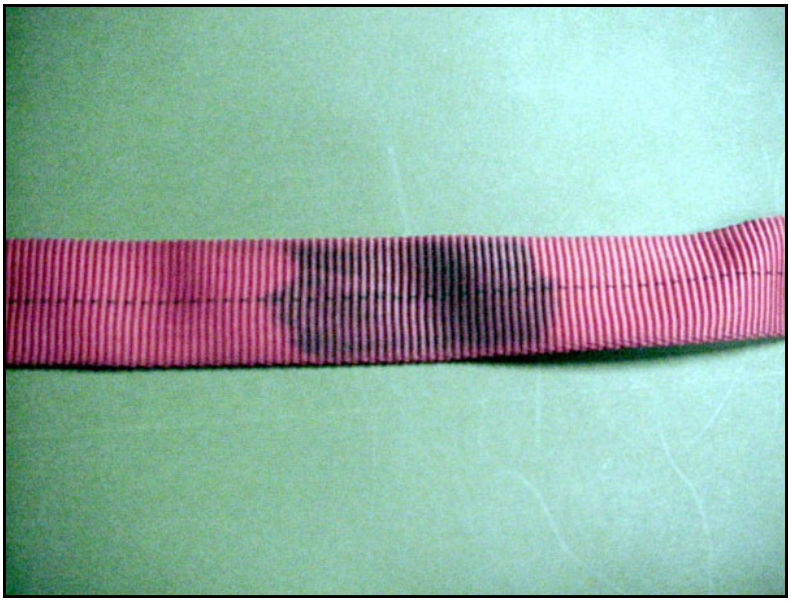
“Excellent” or “Good” Graded Rope Examples:



New rope.

Damaged Webbing Examples:

This webbing has cuts and abrasions



Markers degrade the webbing strength.

Rope Kit Inventories

Standard inventory for all **Engine Companies**:

1 KMIII LifeLine 200' of ½" Static Kernmantle Rope (Red)
1 KMIII LifeLine 200' of ½" Static Kernmantle Rope (Blue)
2 KMIII LifeLine 20' of ½" Static Kernmantle Rope (White/Blue)

Center Pouch –RPM-

1 CMC ProSeries Anchor Strap 5 Feet (M) (Blue)
1 CMC ProSeries Anchor Strap 10 Feet (XL) (Blue)
1 CMC Collection Plate (Blue)
2 CMC Rescue PMP Swivel Pulley 1 ½" (BRONZE / SLATE)
6 CMC ProSeries Aluminum Locking D Carabiner 49KN
1 CMC Marners Load Release Strap w/ SMC Purple Aluminum Carabiner
1 CMC Rescue Brake Rack
2 Prusiks 8.3mm Mammut Static Kernmantle 56" (Short)

Left Pouch

2 CMC ProSeries Edge Guards
11 CMC ProSeries Aluminum Locking D Carabiner 49KN

Right Pouch

1 CMC Marners Load Release Strap w/ SMC Purple Aluminum Carabiner
3 Prusiks 8.3mm Mammut Static Kernmantle 66" (Long)
3 Prusiks 8.3mm Mammut Static Kernmantle 56" (Short)
3 CMC Rescue PMP Swivel Pulley 1 ½" (BRONZE / SLATE)
1 CMC Steel Collection Ring
1 CMC Rescue Eight Descender
4 5 feet One-Inch Tubular Webbing (Green)
3 10 feet One-Inch Tubular Webbing (Yellow)
3 12 feet One-Inch Tubular Webbing (Blue)
3 20 feet One-Inch Tubular Webbing (Orange)

Pick-Off Bag

1 CMC PorSeries Lifesaver Victim Pelvic Harness (Blue Bag)
1 CMC PorSeries Lifesaver Victim Chest Harness (Red Bag)
1 CMC ProSeries Pick-Off Strap
3 CMC ProSeries Aluminum Locking D Carabiner 49KN
1 Non-Locking Aluminum Carabiner (Red)
2 Prusiks 8.3mm Mammut Static Kernmantle 66" (Long)

Harnesses

2 CMC ProTech Fire-Rescue Harness (L, XL)
1 CMC Radio Harness

Standard inventory for all **Truck Companies**:

1 KMIII LifeLine 200' of ½" Static Kernmantle Rope (Red)
1 KMIII LifeLine 200' of ½" Static Kernmantle Rope (Blue)
1 KMIII LifeLine 300' of ½" Static Kernmantle Rope (White)
1 KMIII LifeLine 300' of ½" Static Kernmantle Rope (Orange)
2 KMIII LifeLine 20' of ½" Static Kernmantle Rope (White)

Two Heavy Rescue Bags (Red and Black)

Center Pouch

9 CMC ProSeries Aluminum Locking D Carabiner 49KN
1 CMC Marners Load Release Strap w/ SMC Purple Aluminum Carabiner
3 Prusiks 8.3mm Mammut Static Kernmantle 66" (Long)
3 Prusiks 8.3mm Mammut Static Kernmantle 56" (Short)

Left Pouch

2 CMC ProSeries Edge Guards
3 CMC Rescue PMP Swivel Pulley 1 ½" (BRONZE / SLATE)
1 CMC ProSeries Anchor Strap 10 Feet (XL) (Blue)

Small Black Bag Inside

1 CMC Steel Collection Ring
1 CMC Rescue Eight Descender

Right Pouch

4 5 feet One-Inch Tubular Webbing (Green)
3 10 feet One-Inch Tubular Webbing (Yellow)
3 12 feet One-Inch Tubular Webbing (Blue)
3 20 feet One-Inch Tubular Webbing (Orange)

Harnesses Bag

3 CMC ProTech Fire-Rescue Harness (L, XL)
1 CMC Radio Harness

High Angle Bag

1 CMC Steel Collection Ring
9 CMC ProSeries Aluminum Locking D Carabiner 49KN
1 CMC ProSeries Variable Anchor Strap Pre-Rig
1 10' of ½" Static Kernmantle (Yellow)
3 Prusiks 8.3mm Mammut Static Kernmantle 66" (Long)
3 Prusiks 8.3mm Mammut Static Kernmantle 56" (Short)
3 20 feet One-Inch Tubular Webbing (Orange)

Low Angle Bag

14 CMC ProSeries Aluminum Locking D Carabiner 49KN
4 CMC ProSeries Stretcher Adjustable Stretcher Straps
1 CMC ProSeries Low-Angle Evacuation Stretcher Harness
1 CMC Collection Plate (Blue)
5 Prusiks 8.3mm Mammut Static Kernmantle 66" (Long)
3 20 feet One-Inch Tubular Webbing (Orange)

RPM Bag #1 and #2

1 CMC ProSeries Anchor Strap 5 Feet (M) (Blue)
1 CMC Collection Plate (Blue)
2 CMC Rescue PMP Swivel Pulley 1 ½" (BRONZE / SLATE)
6 CMC ProSeries Aluminum Locking D Carabiner 49KN
1 CMC Marners Load Release Strap w/ SMC Purple Aluminum Carabiner
1 CMC Rescue Brake Rack
2 Prusiks 8.3mm Mammut Static Kernmantle 66" (Long)
2 Prusiks 8.3mm Mammut Static Kernmantle 56" (Short)

Pick-Off Bag

1 CMC PorSeries Lifesaver Victim Pelvic Harness (Blue Bag)
1 CMC PorSeries Lifesaver Victim Chest Harness (Red Bag)
1 CMC ProSeries Pick-Off Strap
3 CMC ProSeries Aluminum Locking D Carabiner 49KN
1 Non-Locking Aluminum Carabiner (Red)
2 Prusiks 8.3mm Mammut Static Kernmantle 66" (Long)

Sked

1 Skedco Half-Sked Patient Drag (Orange)
1 Search Bag 150'
2 CMC Rescue Edge Pads 28"x34"

Utility Rope

2 100' Drop bags for Ladder Pipe Operations and Stokes Basket Operations

USAR Rope Kit Inventory

USAR 106 is currently certified as a State OES Heavy US&R Resource.

Water Rescue

1 100' 10mm Polypropylene Rope – Water rescue
1 50' 10mm Polypropylene Rope – Water rescue

Upgraded Rope Kits

In addition to the above standard inventories, several apparatus have had their Lifelines upgraded to 400' lengths due to areas of response that may require longer descents for victim access or technical rescue responsibilities. The following apparatus have been upgraded from 2 - 200' Lifelines to 2 - 400' Lifelines.

Rope Kit Organization

The initial priority in any rope rescue operation is to gain access to the patient(s) to make an assessment and determine further rescue needs. Upon arriving on scene, the primary focus is to establish anchors, rig the lowering system and send the first rescuer over-the-side as quickly and safely as possible. In an attempt to expedite this process, the following pre-rigging of the main and belay equipment is recommended.

Main Line Pre-Rigging

The Main Line Pre-Rigging includes the equipment to facilitate lowering/rappelling, changing-over to raise and the raising system. The intent is to have an easy-to-use, quick to set up, way to get the initial rescuer over-the-side.

The Main Line Pre-Rigging consists of a Collection Plate, Brake Bar Rack, Marners Load Release Strap with SMC Purple Aluminum Carabiner, 2 Prusik Minding Pulley 2", 3 short prusiks and 6 "G" general use carabiners.

The Brake Bar Rack is a friction device used for lowering or can be tied off when the Main Line is being rigged for a rappel.

The change over equipment consists of a Marners Load Release Strap and 1 short prusik. It is used to hold the load while changing from lowering to raising when the system is still supporting the weight of the rescuer(s) and/or patient. *This equipment can be omitted if the rescue team is in a safe location off the rope.*

The Change-of-Direction (CD) Pulley is a 2" prusik minding pulley used as a change of direction at the main anchor when the raising system is run between the main anchor and another anchor (typically another vehicle for over-the side operations). *This pulley can be omitted if there is enough distance to run the raising system from the main anchor to the edge.*

The 3:1 Z-system equipment consists of 2" swivel prusik minding pulley, and 2 short prusiks.They are intended to build the 3:1 Z-system for the raising operation.

Belay Line Pre-Rigging

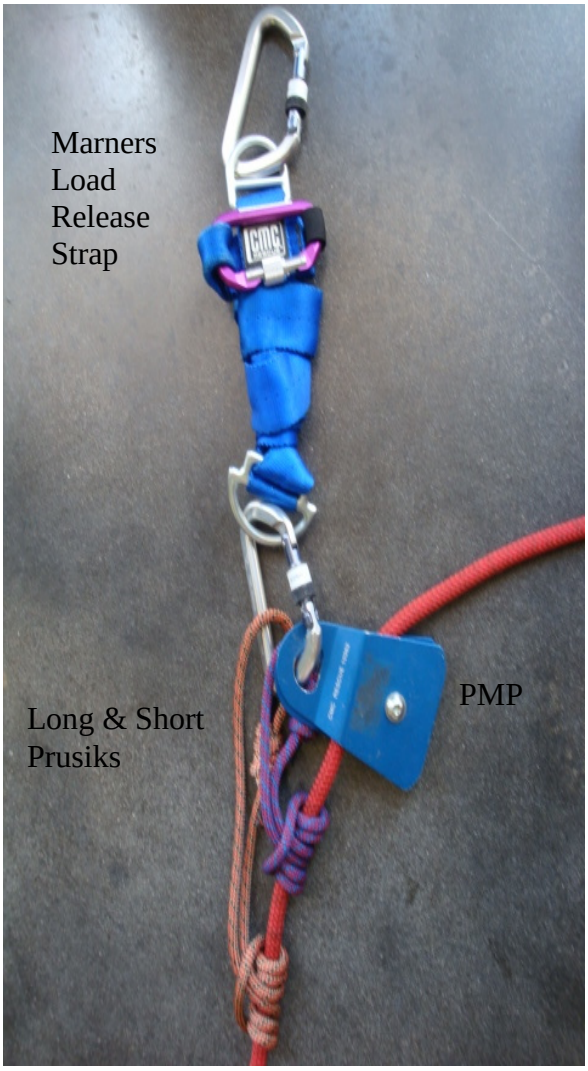
The intent of a Belay Line Pre-Rigging is the same as the Main Line Pre-Rigging, to have an easy-to-use, quick to set up, way to get the initial rescuer over-the-side when using a two rope system in a steep or high-angle environment. The Belay Line is also used whenever a victim is attached to the system.

The Belay Line Pre-Rigging, once set up, remains the same for lowering as well as for raising.

The rigging includes a CMC ProSeries Marners Load Release Strap with SMC Purple Aluminum Carabiner, one long and one short Prusik for a Tandem Prusik Belay and a Prusik Minding Pulley (PMP).

This design is often referred to as a Tandem Prusik Belay.

Notice the order of the equipment into the carabiner. Long, Short, and Pulley.



Stokes Litter Pre-Rigging

The purpose of pre-rigging equipment for the Stokes litter is to save time and simplify the rigging process.

The High Angle Bag Pre-rigging includes 1 Steel O-Ring, 9 “G” use carabiners, Variable Anchor Strap Pre-Rig, 10’ of ½” Static Kernmantle Rope, 3 long and 3 short Prusiks. 3 Orange 20’ webbings.

The Low Angle Bag Pre-rigging includes 1 Collection Plate, 14 “G” use carabiners, 4 Adjustable Stretcher Straps, 3 Low-Angle Evacuation Stretcher Harness (1 adjustable, 2 fixed length), 5 long Prusiks, and 3 20’ Orange webbing.

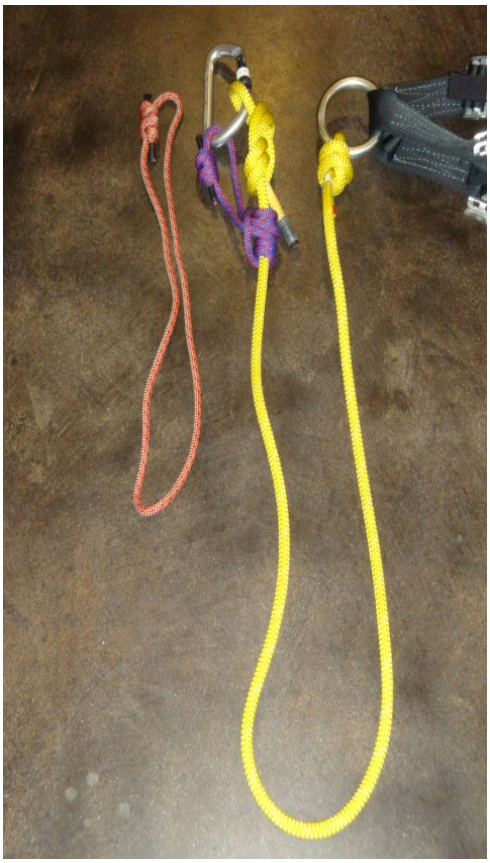
Barf Line

The addition of a pre-rigged Barf Line for use in a horizontal Stokes litter operation can assist the rescuer in tilting the litter if the patient is nauseated. It can also be used to adjust the Stokes Harnesses when traveling over terrain changes.

The Barf Line is built with a short utility line, two carabiners, one 2” pulley, and one prusik.

Tender Line

A rescuer’s Tender Line is added for position adjustment while lowering or raising durind a high-angle operations. The Tender Line is a 10’ length of rope with a Double Overhand on a Bight around the Steel O-Ring and a Figure 8 on a Bight. The Tender Line has 2 Three-Wrap Prusiks Hitches attached to the line. One Prusik is attached to the rescuer’s waist with the Figure Eight on a Bight. The other is used to help with adjustment if needed.



Chapter 5
Rope Rescue Knots

Knots are critical links in all rope systems. Rescue personnel must continually practice and develop knot-tying skills until they can tie knots properly in any emergency situation. An incorrect or improperly tied knot could result in sudden system failure. The knots used by the Department in its rope rescue systems are standardized and documented in this training manual section. All members should be able to easily identify these knots and safety-check their rope rescue systems.

Knot Terminology

See *Appendix A* at the end of this document.

Qualities Of A Good Rescue Knot

While there are many knots, good rescue knots should meet certain criteria. They should be:

- Easy to tie.
- Easy to identify to determine if it is tied correctly.
- Will not work loose on its own.
- Minimally reduces rope strength.
- Relatively easy to untie after loading.

All knots in a rope should be untied before storing. Knots left tied in a rope will decrease its strength over time.

All knots need to be dressed and set, which means that all the strands should run parallel and lie flat against each strand. This makes the knot stronger and easier to check for safety. Lastly, keep in mind that...

"A knot that looks bad probably is bad."

Department Knots

Figure 8 Knots

The family of Figure 8 Knots meets all of the criteria for a good rescue knot. These knots are popular within the rescue community because they are:

- Secure when tied correctly and unlikely to come apart with flexing and bending.
- Easy to identify and to see if they are tied correctly.
- Easy to learn.

Figure 8 Stopper Knot

The Figure 8 Stopper Knot, also known as the Figure 8, is used as the foundation knot for other knots in the family of Figure 8s. The knot is called a stopper-knot because it is used in the end of a rappel line to prevent someone from rappelling off the end of the line. It is also used to keep the end of a rope from accidentally running through the hardware in a rope system.

To Tie The Knot:

Step 1: Take the running end of the rope, create a bight, and cross it over itself.

Step 2: Continue with the running end and wrap it around the standing part of the rope and feed the running end through the bight.

Step 3: Pull tight.

Figure 8 on a Bight

A Figure 8 on a Bight is used to create an attachment point at the end of a rope. It is typically used to connect the end of a rope to an anchor point, a rescuer's harness, pulley systems, or a Stokes litter. The bight should be as small as possible when used in pulley systems and at Stokes connection points to help minimize its' impact on the rope system.

To Tie The Knot:

Step 1: Take the running end of the rope, create a bight, and cross it over itself.

Step 2: Continue with the running end and wrap it around the standing part of the rope.

Step 3: Feed the running end through the bight.

Step 4: Pull the bight tight through the knot.

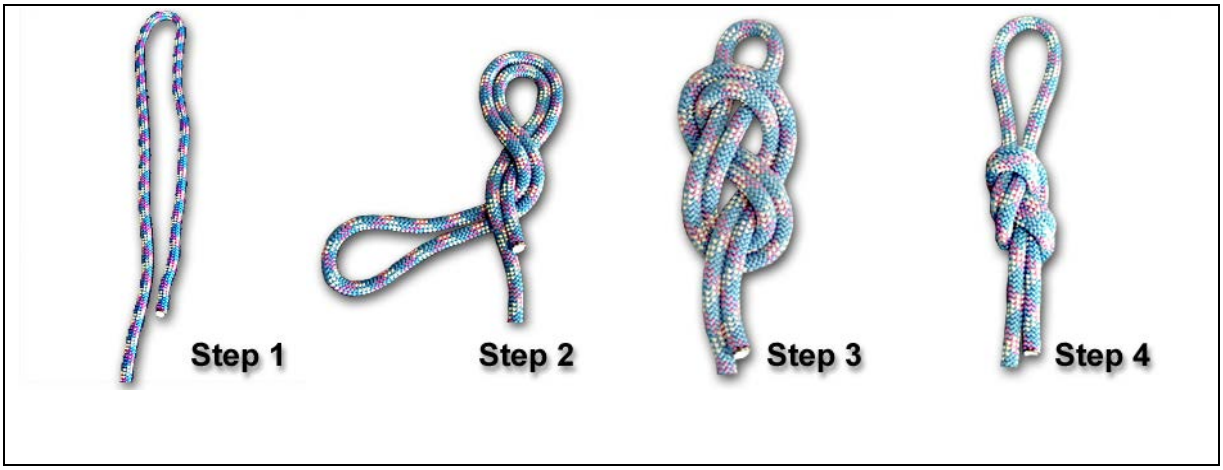


Figure 8 Follow-Through

This knot is used in place of the Figure 8 on a Bight when it is not possible to slip the loop over the intended object or clip it in with a carabiner. The Figure 8 Follow-Through allows the rescuer to tie directly into or around an object.

To Tie The Knot:

Step 1: Tie a Figure 8 Stopper Knot as previously demonstrated. Pass the working end of the rope in the reverse direction through the knot.

Step 2: Continue following the path of the original knot.

Step 3: Cinch the knot.

The result looks the same as a Figure 8 on a Bight.

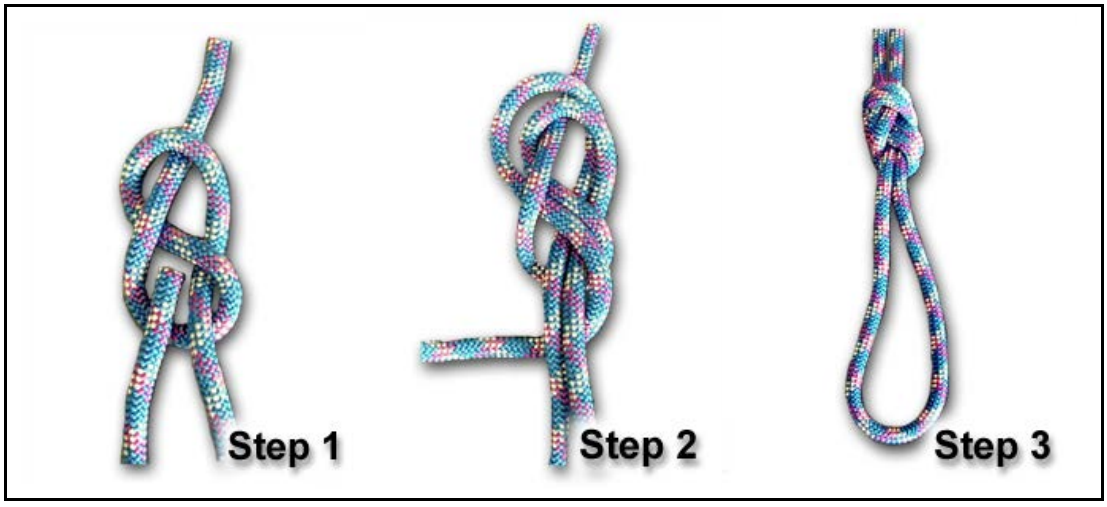


Figure 8 Bend

The Figure 8 Bend is used to join the ends of one rope or the ends of two ropes of the same diameter together. This knot is used to lengthen the amount of working rope in the system by attaching two ropes together, make a rope sling or multi-wrap anchor when the ends of the same rope are tied together.

To Tie The Knot:

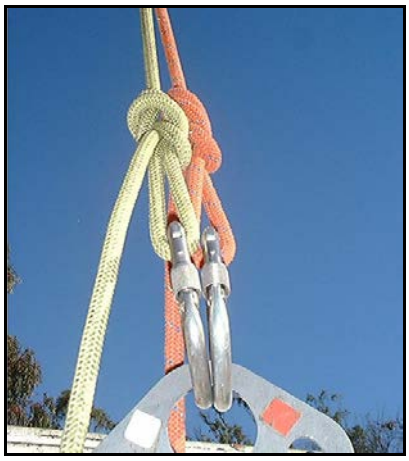
Step 1: Tie a Figure 8 with the end of one of the ropes.

Step 2: With an end of the other rope, trace the Figure 8 in the reverse direction.

Step 3: Pull the knot tight.

The Figure 8 Bend differs from the Figure 8 Follow-Through in that the ends of the ropes are facing in opposite directions with the Figure 8 Bend while the ends face the same direction in a Figure 8 Follow-Through.

In-Line Figure 8



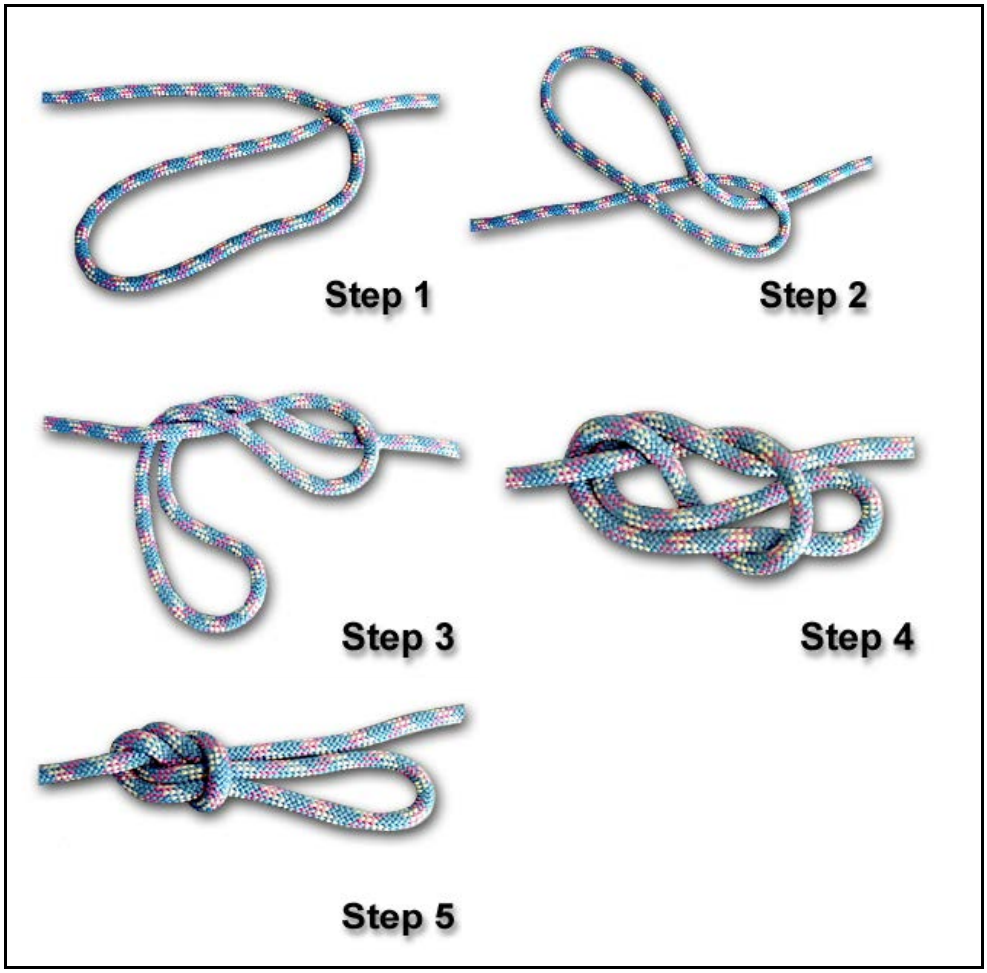
The In-Line Figure 8 is a directional knot that is tied in the middle of a rope. It is used to attach loads to the rope or to begin a Trucker's Hitch (not shown in this chapter). It is useful for tensioning guy lines when building a Ladder Gin or an A-Frame.

To Tie The Knot:

Step 1: Make a loop.

Steps 2-3: Take the bight of the loop and wrap it around the rope.

Steps 4-5: Feed the bight of rope back through itself and pull tight.



Bowline Knots

The Bowlines are another family of knots widely accepted throughout the rescue community. Some important differences between the Bowlines and the Figure 8s are that in the Bowline family:

- Every Bowline must be backed up with a safety (the Bowline on a Bight being the only exception).
- Bowlines' are easily adjustable.
- Bowlines' are easier to untie after loading the knot.

The safety knot, whether an Overhand or a Double Overhand, must be tight and securely set against the knot or hitch it is backing up.

Bowline

Rescue uses for the Bowline are similar to that of a Figure 8 on a Bight. It is easily adjustable and it is the preferred knot to use when connecting a Belay Line into a rescue harness (without carabiners).

To Tie The Knot:

Step 1: Make a loop in a rope and pass the running end through it.

Step 2: Wrap the end around the standing rope and back through the loop.

Step 3: Pull tight and add a safety knot.

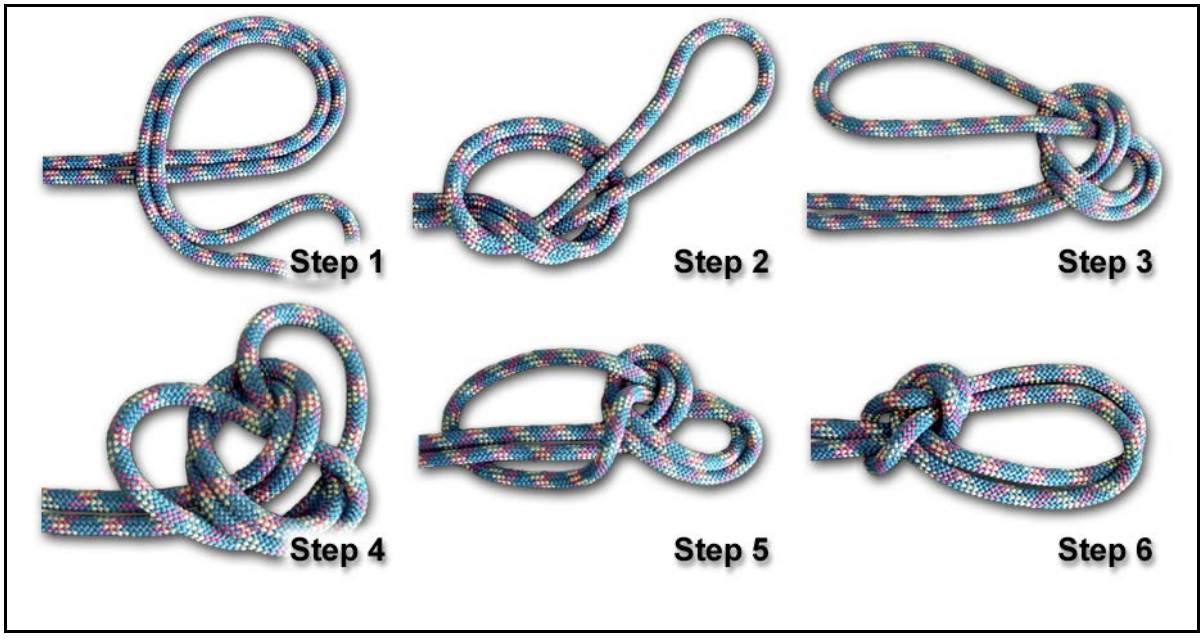
Bowline on a Bight

This knot is used to raise or lower tools and equipment. It is also used as a tied seat harness (as shown).

To Tie The Knot:

Steps 1-2: Take a bight of a rope and tie an Overhand.

Steps 3-6: Pass the loop back over the knot drawing the bight into a double loop.



In-Line Bowline

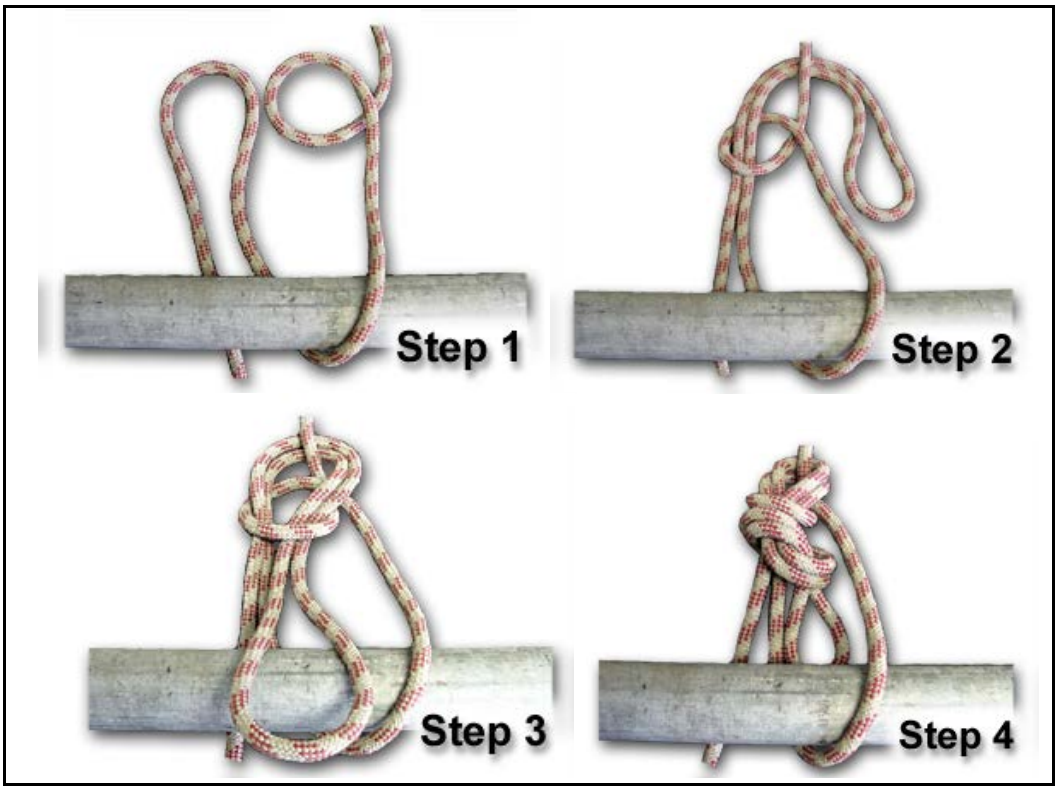
The In-line Bowline is used to raise or lower tools and equipment. It is a convenient way to attach equipment to the middle of a rope.

To Tie The Knot:

Step 1: Make a loop in the rope. Take a bight of a rope; create a loop (or wrap around an object).

Steps 2-3: Pass the bight through the loop and wrap it around the standing rope.

Step 4: Pull tight and add an Overhand Knot as a safety.



The Butterfly Knot

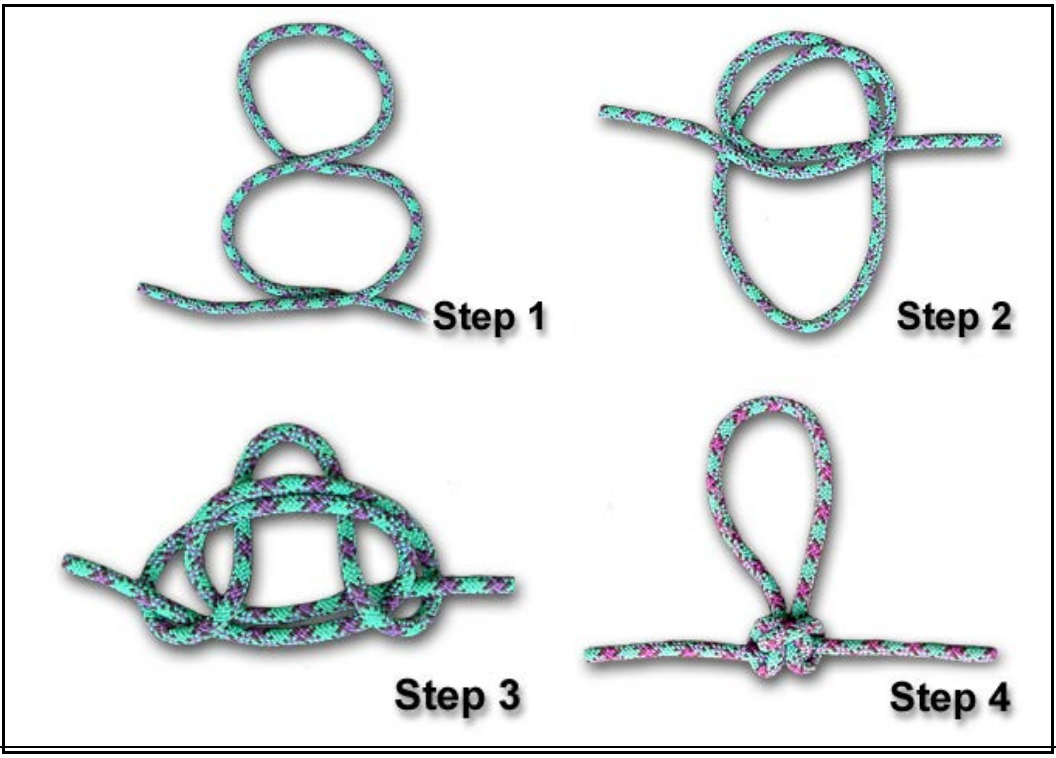
This knot is used to tie a loop in the middle of a rope when the end is carrying the load, or not available for use. The Butterfly Knot is a bi-directional knot, meaning a load can be applied in either direction of the rope.

To Tie The Knot:

Step 1: Take a bight of rope and twist it twice.

Step 2-3: Take the top bight and wrap it around the rope, passing it through the lower loop.

Step 4: Pull tight.



Half Hitch

Half Hitches are used to secure the working end of a rope or webbing. They are always used in pairs and usually follow a knot or round-turn around an object. Half Hitches can be formed either using the end of a rope, or with a bight of rope.

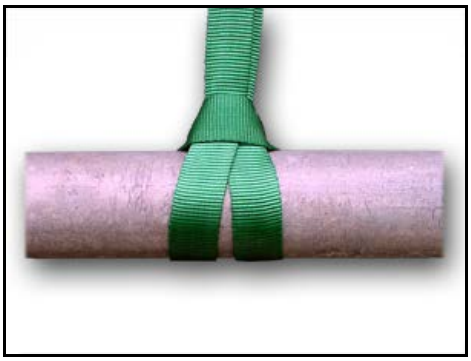
Girth Hitch

A Girth Hitch provides a quick means to attach a webbing sling around an anchor.

Note:

It is only to be used as a fall protection anchor in a lead climb application.

It is not to be used as an anchor sling for a rope rescue system since it is not rated for a two-person load.



Münter Hitch

A single Münter Hitch is used with a carabiner as emergency egress from a roof. It is used as part of the Radium Release Hitch. A double Münter Hitch is used as part of the BC Load Releasing Hitch.

Note:

A single Münter Hitch shall not be used by itself as a belay technique with rescue sized (2-person) loads.

Clove Hitch

The Clove Hitch is used to secure the working end of a rope or webbing around an object. Slack is removed from the standing part of the rope by pulling on the working end to cinch up the knot. The Clove Hitch should always be backed up with a safety knot (not shown).

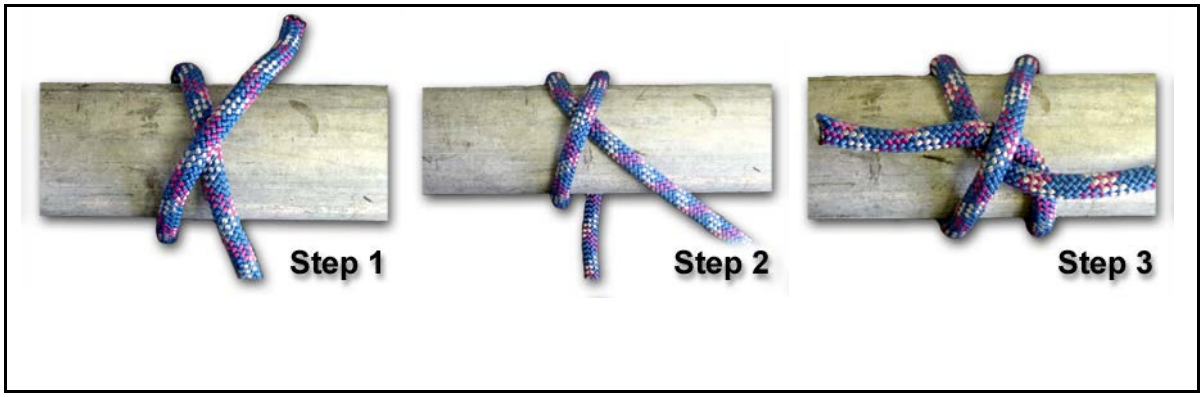
To Tie The Knot:

Step 1: Take the working end of the rope and wrap it around an object, creating an “X”.

Step 2: Continue circling the object with the working end of the rope until it is ready to complete the second wrap around the object.

Step 3: Pass the working end underneath the “X” you created in step one. This should capture the running end of the line within the hitch (as shown).

Note: This hitch is bi-directional. For the purposes of this lesson, we will assume the load is to the right.



Three-Wrap Prusik Hitch

The Three-Wrap Prusik Hitch is the method of attaching Prusik slings to a rope for:

- Hauling.
- Ratcheting a rope system.
- Breaking a system (Tandem Prusiks).

The Prusik slings come in short (56”) and long (66”) lengths.

To Tie The Knot:

Step 1: Hold the Prusik Loop near the Double Overhand Knot with the knot resting away from the apex of the bight.

Steps 2-4: Pass the Double Overhand Knot around the other rope and through the loop that is created three times.

Step 5: Pull tight. Make sure the Double Overhand Knot isn’t at the apex of the bight.


Step 1


Step 2


Step 3

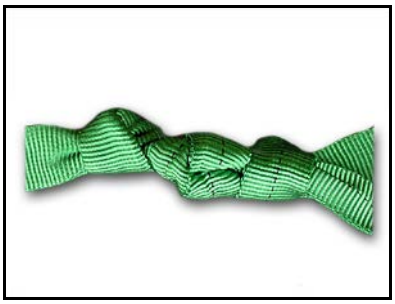

Step 4


Step 5

Square Bend (Square Knot)

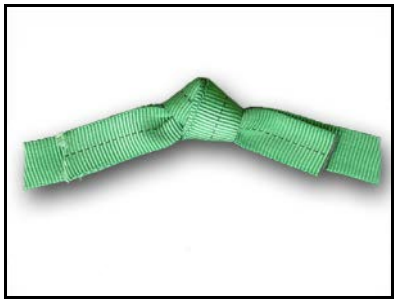
This knot is used to tie the ends of webbing together in the Swiss seat and the RS 1 chest harness.

This knot requires a safety knot and a safety check to ensure that it has not been tied improperly to form a rolling granny knot.



Overhand Bend (Water Knot)

The Overhand Bend is used to either attach two pieces of webbing together or the ends of a single webbing to form a sling.



Overhand

The Overhand Knot is the most basic of the knots. Its' primary use is as a safety knot.

To Tie The Knot:

Step 1: Take the running end of the rope and cross it over the standing end.

Step 2: Wrap once.

Step 3: Pull tight.

Overhand on a Bight

This knot is used to form a loop in a piece of webbing. Its typical use is to begin the RS 1 chest harness.

To Tie The Knot:

Step 1: Take a bight of rope or webbing.

Step 2: Wrap it over itself, creating a loop.

Step 3: Pass the bight through the loop and pull tight.

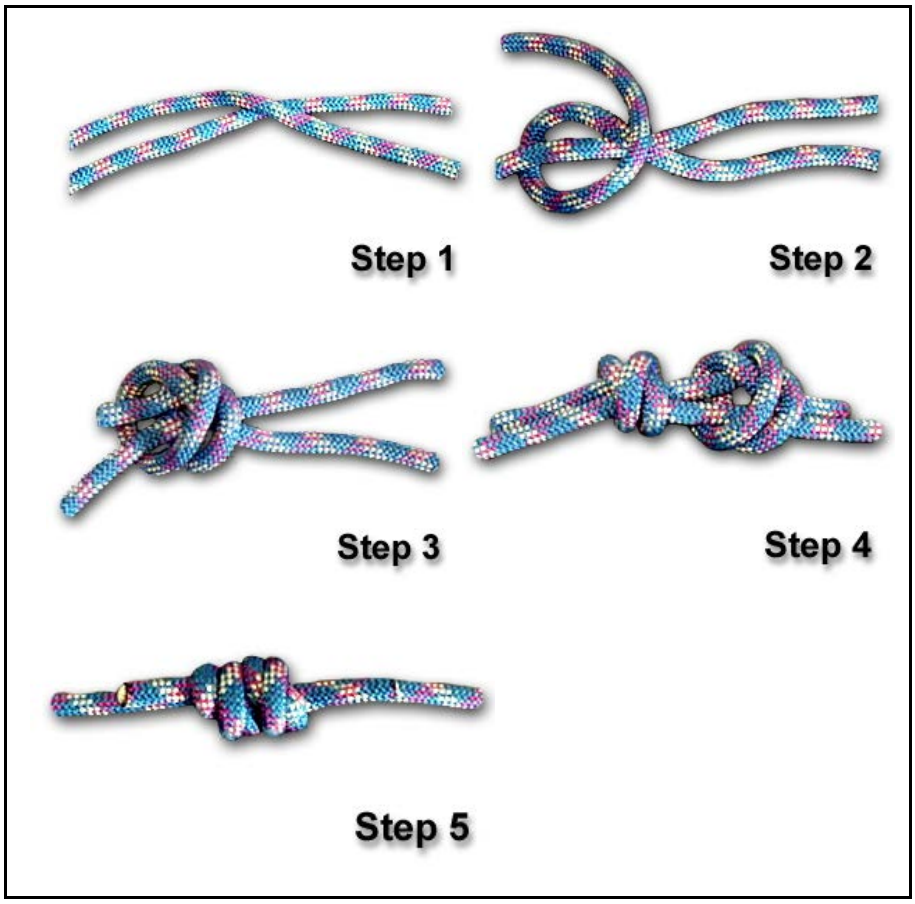
Double Overhand Bend (Double Fisherman)

This knot is used to make a Prusik sling. It may also be used to connect two different ropes (as long as they are the same diameter). It is a very secure, self-locking knot.

To Tie The Knot:

Steps 1-3: Take one end of a rope, cross over the other end of the rope and loop it over itself twice. Then pass the end through the loops creating a Double Overhand.

Steps 4-5: Repeat the action, exchanging the ropes and tying the second overhand in the opposite direction. Pull tight.



Hasty Seat Harness

The Hasty Seat Harness is a webbing harness used for victim rescue. It is a pelvic harness that is tied from a 15' webbing. It is only to be used as a quick method of attaching a victim to a rope system for rapid rescue. It should not be chosen as a preferred method as a rescuer harness because of its limited means of security.

To Tie The Harness:

Step 1: Take a 15' webbing and tie an Overhand Bend with the ends creating a webbing loop. Place the knot in the small of the victims back, while holding the webbing on either side of the victim.

Step 2: Pass your hands underneath the webbing to grab the loop that is created between the victim's legs.

Step 3: Pull the loop through as shown.

Step 4: Tie the bights of webbing in your hands in an Overhand Knot to secure (not shown).

Hasty Chest Harness

This harness is used when time is of the essence and onlyone victim harness can be secured.

To Tie The Harness:

Step 1: Tie a 12’ or 15’ piece of webbing, depending on the size of the victim, into sling using an Overhand Bend.

Step 2: Place the knot between the victim’s shoulder blades, then wrap the sling around the victim’s sides to the front forming a bight in each hand.

Step 3: Have the victim place one arm through the bight and the other arm over the opposite bight.

Step 4: Pass one bight through the other, then pass the other one through it forming a Locking Hitch.

Step 5: Cinch until snug, keeping the sling just under the armpits. Caution: Ensure the sling is not permitted to become slack or it will droop too low, which may cause internal injuries by squeezing the lower ribs if the victim is subject to a shock load while suspended in the harness.

Step 6: Secure with two Half Hitches.

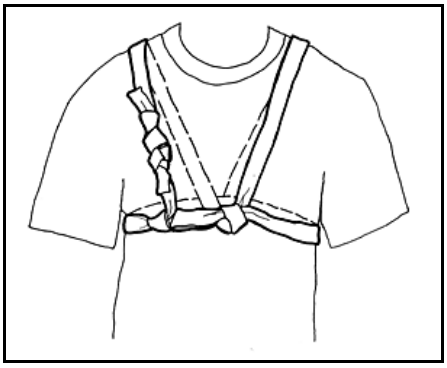
Step 7: Attach carabiner to the bight, then clip it to the single strand, bighting down and flipping up.

*** Firefighter must be able to form this harness on themselves as well as a victim.**

ATTENTION: Cal-OSHA regulation prohibits the use of improvised harnesses in lieu of commercial rescue or victim harnesses except when necessary to save a life. This means students are not to use this harness while being suspended in a rope rescue system during training.

Webbing Chest Harness (RS1 Chest Harness)

This harness is used in conjunction with a seat harness to form a full body harness suitable for high-angle rescue. This harness can be connected to the seat harness by a connector strap (typically a green webbing tied in a loop).

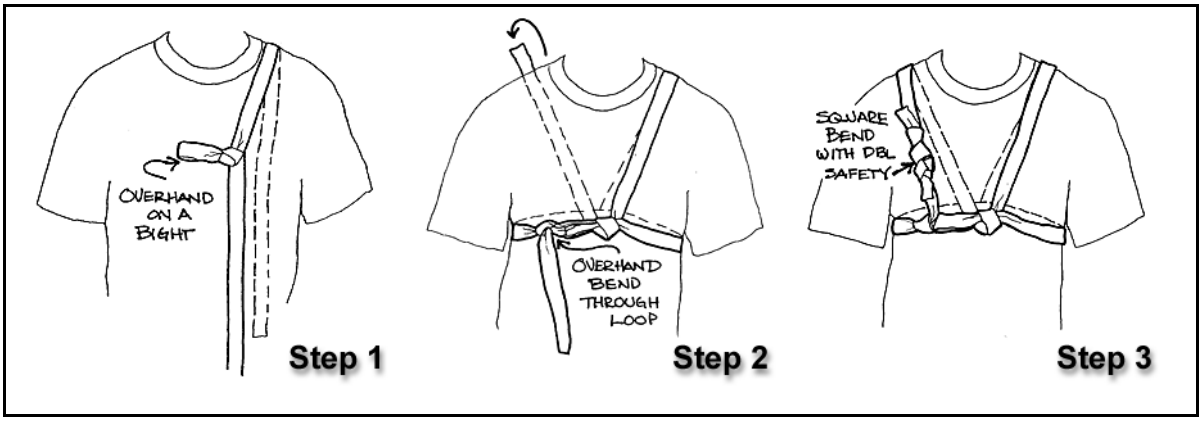


To Tie The Harness:

Step 1-2: Tie an Overhand on a Bight in the center of the webbing, drape over a shoulder and wrap one leg of webbing around the torso and terminate with an Overhand Bend.

Step 3: Take the other leg of webbing and weave it under the webbing between your shoulder blades and drape it over the opposite shoulder. Tie the harness off with a Square Bend and two Overhand safety knots.

Note: The new Rescue Systems 1 curriculum does not endorse tied webbing seat harnesses for high-angle rescue. The Department has provided manufactured seat harnesses that are to be used for these rescue situations. Therefore this harness is optional, it can be combined with a manufactured seat harness and connector strap for high-angle rescues, or may be used when necessary during low-angle rescues.



Swiss Seat

This harness is tied with a 20' section of 1" webbing and is used as a low-angle rescue seat harness. This harness is also used as a rescuer safety harness for swiftwater rescues.

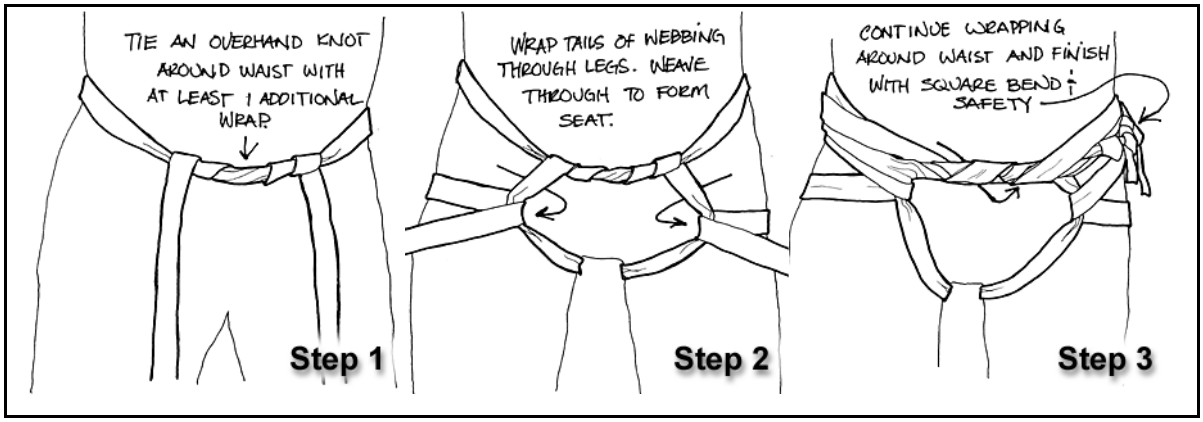
To Tie The Harness:

Step 1: Tie an Overhand Knot with at least two wraps at belt buckle as shown.

Step 2: Take the webbing tails and wrap them behind your legs and pass them beneath the webbing by your crotch to form the seat harness.

Step 3: Tie the harness off to the side with a Square Bend and two Overhand safety knots.

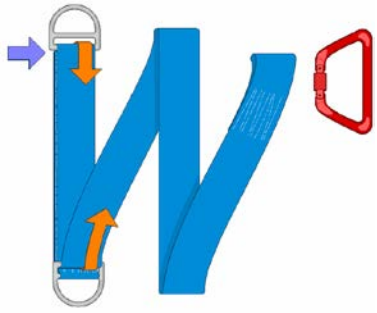
Note: The new Rescue Systems 1 curriculum does not endorse tied webbing seat harnesses for high-angle rescue. The Department has provided manufactured Class 3 harnesses that are to be used for these rescue situations.



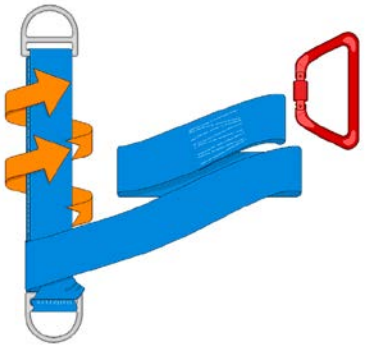
Mariner's Load Release Strap

Our Load Release Strap makes sizing and tying a load-releasing hitch fast and easy. Constructed from the same high-strength web and hardware as our Anchor Straps, the larger D-ring on the load end has enough space for multiple carabiners. The wide web and multiple wraps provide a high degree of control during release.The strap now comes assembled with purple carabiner.

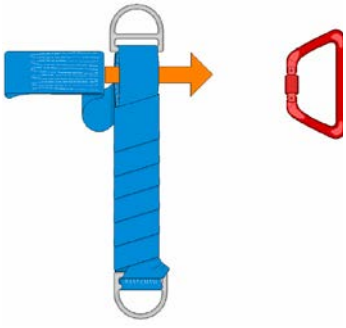
Set up:



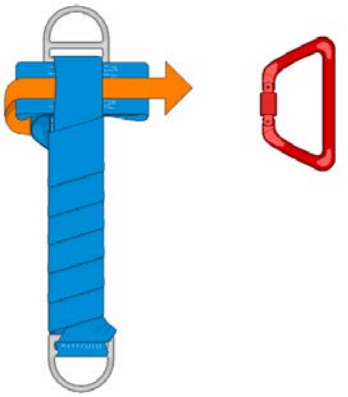
Step 1. Pull the end of the strap until the floating D-ring is close to the end of the stitched section of the webbing.



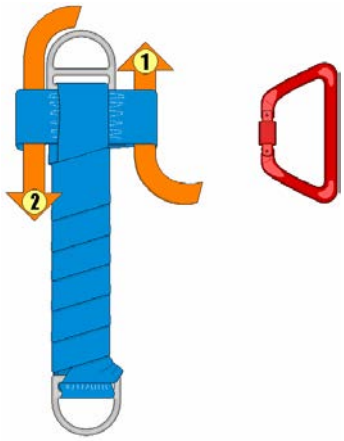
Step 2. Wrap the webbing around itself until about 8" of webbing is left.



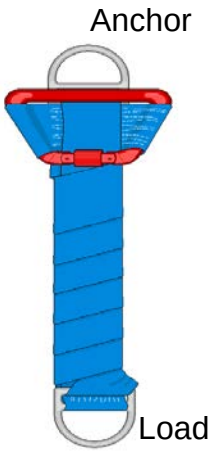
Step 3. Form a bight near the stitched section at the end



Step 4. Pass the bight through the strap



Step 5. Connect the bight and the stitched loop together with a carabiner.



Step 6. Finished LRD.

Appendix A: Knot Terminology

Some knots have more than one name associated with them. For example, a Double Overhand Bend and a Double Fisherman's Knot refer to the same knot. Both the descriptive name and any common slang names for knots will be included in this text. The following terminology should be used as they apply to Department rope rescue operations:

- The ***running end*** of a rope is the straight part that is to be used for work such as hoisting, pulling, or belaying.
- The ***working end*** (also known as the loose end or bitter end) of a rope is the part used in forming a knot.
- The ***standing part*** of a rope is between the working end and the running end.
- A ***knot*** is a rope or webbing that is intertwined.
- A ***bend*** is two rope or webbing ends connected together.
- A ***hitch*** is a rope or webbing around an object (if the object is removed the hitch will fall apart).
- A ***bight*** is formed by simply bending the rope back on itself while keeping the sides parallel.
- A ***loop*** is made by crossing one side of a bight over the standing part so that the rope crosses itself.
- A ***round turn*** is made by continuing to cross one side of a loop all the way around to form a circle with the ends of the rope parallel as in a bight.

Arcadia Fire Department

Knots, Hitches, Harnesses Manipulative Evaluation

Trainee Name: _____ **Date:** _____ **Trainee Signature** _____

Performance: *Identify and tie all knots, hitches, and don harness.*
All tails must be a minimum of 2" in length and a maximum of 4" in length.

Standard: *80% accuracy. Any score below 80% is not passing. Pass 21 out of 27 knots.*

KNOTS	POINTS POSSIBLE	POINTS EARNED	REASON FOR DEDUCTION *(circle all that apply)*
Figure Eight Stopper	4		□ Wrong Knot □No knot □Tail(s) short / long
Figure Eight on a Bight	4		□ Wrong Knot □No knot □Tail(s) short / long □Gain small / large
Figure Eight Follow Through	4		□ Wrong Knot □No knot □Tail(s) short / long □Gain small / large
Figure Eight Bend	4		□ Wrong Knot □No knot □Tail(s) short / long
In-line Figure Eight (both directions)	4		□ Wrong Knot □No knot □Wrong direction
Bowline with Safety	4		□ Wrong Knot □No knot □Tail(s) short / long □No Safety □Gain small / large
Bowline on a Bight	4		□ Wrong Knot □No knot □Gain small / large
In-line Bowline with Safety	4		□ Wrong Knot □No knot □No Safety □Wrong Direction(s)
Half Hitch	4		□ Wrong Knot □No knot
Girth Hitch Single with Webbing	4		□ Wrong Knot □No knot □Tail(s) short / long
Clove Hitch with Safety- End & In-Line	4		□ Wrong Knot □No knot □Tail(s) short / long □No Safety □Wrong Direction
Prusik Hitch Three Wrap	4		□ Wrong □Loose
Butterfly Knot	4		□ Wrong Knot □No knot
Square Knot Bend with Safety-Rope&Webbing	4		□ Wrong Knot □No knot □Tail(s) short / long □No Safety
Overhand Knot/Stopper	4		□ Wrong Knot □No knot □Tail(s) short / long
Overhand Bend with Rope &Webbing	4		□ Wrong Knot □No knot □Tail(s) short / long
Overhand on a Bight with Webbing	4		□ Wrong Knot □No knot □Gain small / large □Tail(s) short / long
Double Overhand Bend	4		□ Wrong Knot □No knot □Tail(s) short / long
Hasty Seat Harness (1 minute)	4		□ Wrong □No knot □ Loose □No square knot □Above waistline
Hasty Chest Harness (1 minute)	4		□ Wrong □Loose □Low on ribs □ No double larks foot □ No Safety
RS1 Chest Harness	4		□ Wrong □Loose □Low on ribs □No square knot □Tail(s) short
Swiss Seat	4		□ Wrong □Loose □No knot □No square knot □Above waistline
Three Bight Anchor	4		□ Wrong □Loose
Wrap 3 Pull 2 Anchor	4		□ Wrong □Loose
Don Engine Class 3 Harness	4		□ Wrong □Loose
Don Victim Chest / Pelvic Harness	4		□ Wrong □Loose
Mariner's Load Release Strap	4		□ Wrong □Loose □Wrong Direction □Wrong Amount Wraps
Total Points	**100**		

Total Points Deducted _____ **Total Points Earned** _____ **Percentage** _____ **Evaluator Signature**_____

Chapter 6
Anchors & Anchor Systems

Anchors are a basic part of every rope rescue system. In most cases, anchors are single, stationary objects or a group of stationary objects to which we attach a load. In most situations, contact points on a fire engine are used as “bombproof” anchors. Bombproof means that there is absolutely no question that the anchor will hold all predicted rescue loads and loads associated with a fall (10 X rescue load). Selecting the proper anchor for an application takes skill, experience, an understanding of the forces involved, and practice.

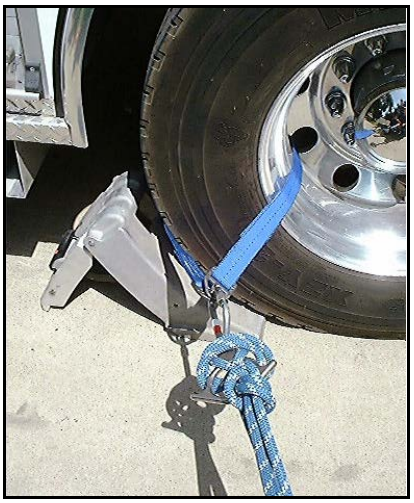
Anchors can be either natural or manmade. Natural anchors are large trees, big rocks, etc. Manmade anchors are structural elements of a building, expansion bolts embedded in rock or concrete, picket systems or vehicles. When selecting the anchor for your rescue system, a variety of factors affect that decision:

- Location of the ‘fall line’ (What direction is the load going to come from?).
- Slope of the terrain.
- Purpose of the rescue system (static or dynamic loading).
- Estimated strength of the object.
- Main anchor HIGH, Belay anchor LOW.

When using natural anchors, different factors come into play. When considering a tree, its size, health, root structure, loose bark, and location are concerns. When considering boulders, not only is the size important, but also what type of surface the rock is in and its overall stability. Care should be taken to add rope protection around sharp edges. When the strength of an anchor is questionable, a load-sharing or back-tie system may be needed.

Anchors on Apparatus

Obvious hazards on vehicles include sharp surfaces, hot brakes, and "locking-out" the vehicle. On smaller vehicles, back-tying (see page 8) might be necessary if the anchor is intended for highline operations. Back-tying might also be necessary when vehicles are loaded from the side instead of along the length of the vehicle, or if the road surface is icy or on gravel.



Apparatus anchor. Note the wheel is chocked.

When using a vehicle for an anchor:

- Connect to the frame, axle or other solid structural member.
- Turn the engine off.
- "Lock-out" the vehicle by setting the brake, chocking the wheels and removing the keys.
- Communicate to incident personnel that the vehicle cannot be moved during the rescue.

Directional Anchors

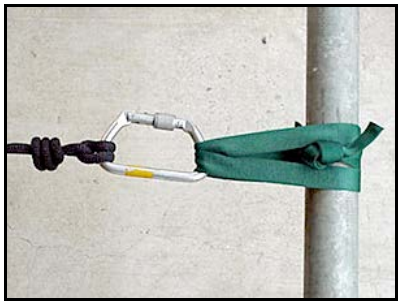
Anchors that can withstand a pull from one direction only are considered directional anchors. These anchors can withstand a pull of 15º to either side of their direction of pull, without weakening the anchor. Two or more directional anchors can be incorporated together to form a single focal point (shown), adding strength and flexibility. Picket systems and back-tied anchors are directional anchors.

Directional anchors

Non-Directional Anchors

Anchors that are considered bombproof in any direction of pull are referred to as non-directional anchors.

Wrap-3, Pull-2 Anchor (Multi-Loop)


Wrap-3, Pull-2 = 8,800 lbs.

A Wrap-Three, Pull-Two anchor is the preferred method to secure webbing (or rope) to any anchor. In this method, webbing is wrapped three times around an anchor and then tied using an Overhand Bend. Grab two of the strands and pull the knot towards the load side of the anchor. More than three wraps are permissible, but a minimum of two loops must be pulled when using webbing to remain within the 10:1 SSSF.

The angle between the two loops of webbing shall be less than 90º to prevent overstressing the webbing.

Single Loop


Single Loop = 5,280 lbs.

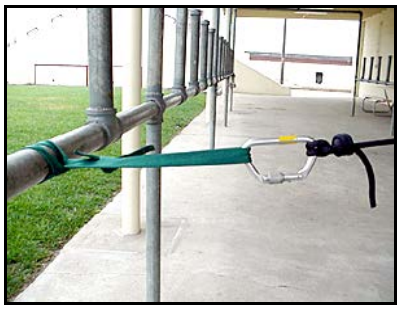
To make a Single Loop anchor point, pass a piece of webbing or rope around an anchor, and then join the two ends with an Overhand Bend if webbing is used, or a Double Overhand Bend if rope is used. A Single Loop anchor point made out of webbing should ***only*** be used for edge lines, anchoring edge rollers, or single person loads, *but not a rescue (2 person) load.* The more shallow the angle between the two strands of webbing, the stronger the anchor. A Single Loop anchor made from rope can be used as an anchor point, but a Figure 8 on a Bight should be tied into the loop to serve as an attachment point.

Three-Bight


Three-Bight = 8,800 lbs.

A Three-Bight is created by tying a sling with webbing or rope, passing one end of the loop around an anchor, and then bringing both ends together with a carabiner or tying them together with a Figure 8 on a Bight. Care must be taken to keep a maximum of a 90º interior angle, and to not side load the carabiner. The Anchor Strap uses this concept. If the interior angle of the rope gets close or exceeds 90º, tie a Figure 8 on a Bight to eliminate the side loading of the connecting carabiner.

Girth Hitch


Girth Hitch = <5,000 lbs.

A Girth Hitch provides a quick means to attach a webbing sling around an anchor. It is the least acceptable method of attachment and should not be used for Main or Belay Line connection to anchors. There is a good chance of overstressing the webbing where it crosses over itself when rescue sized loads are applied. Girth Hitches may be used for edge protection lines, and lead-climbing applications.

Tensionless Hitch


Tensionless Hitch = 100% strength of the rope

Used when the full, non-knotted strength of the rope is required. The rope is wrapped a minimum of *four* times around an anchor that is at least *eight* times the diameter of the rope. The end of the rope is connected to the working end with either a knot or carabiner. This is primarily used in Highline applications but is also used in swiftwater rescue as the upstream knot in a Tension Diagonal.

A Knot Passing Pulley may also be used to create the Tensionless Hitch by acting as the object that the rope is wrapped around. Use a steel carabiner and suitable multi-wrap sling to complete the anchor system.

Tensionless Hitch made with a Knot Passing Pulley.

Anchor Systems

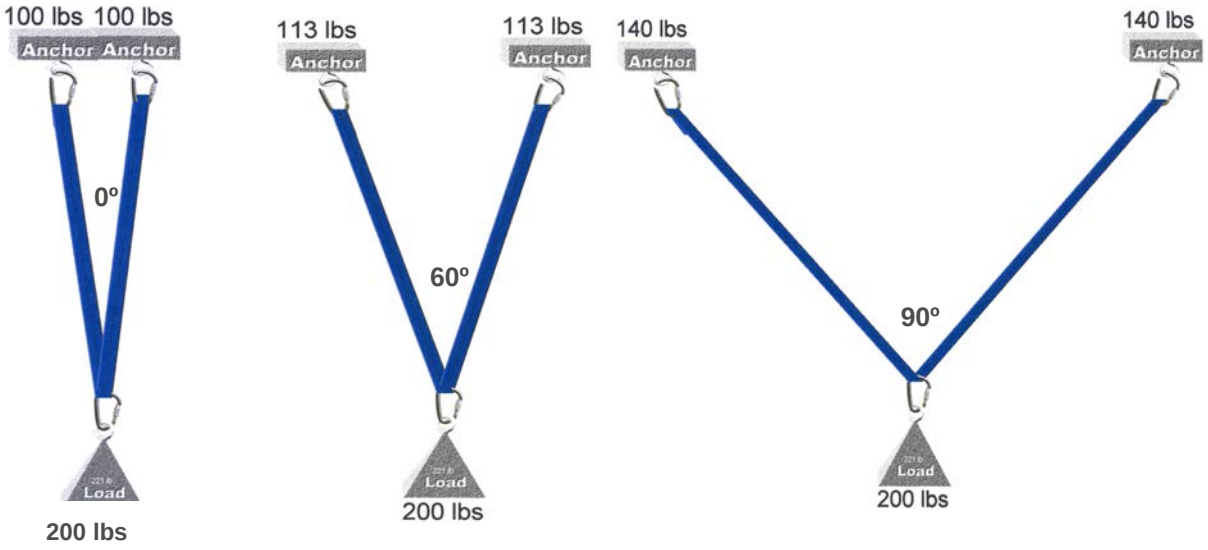
An anchor system is the rope, webbing and hardware necessary to attach a load to its anchor. Anchor systems may combine two or more anchors and anchor points to form a single focal point. Any combination of the previous anchors and anchor points can be used, taking into consideration the critical factors listed previously. Each system should be designed to be able to withstand the maximum force anticipated. In order to safely employ these systems, the two basic concepts of critical angles and fall line should be understood.

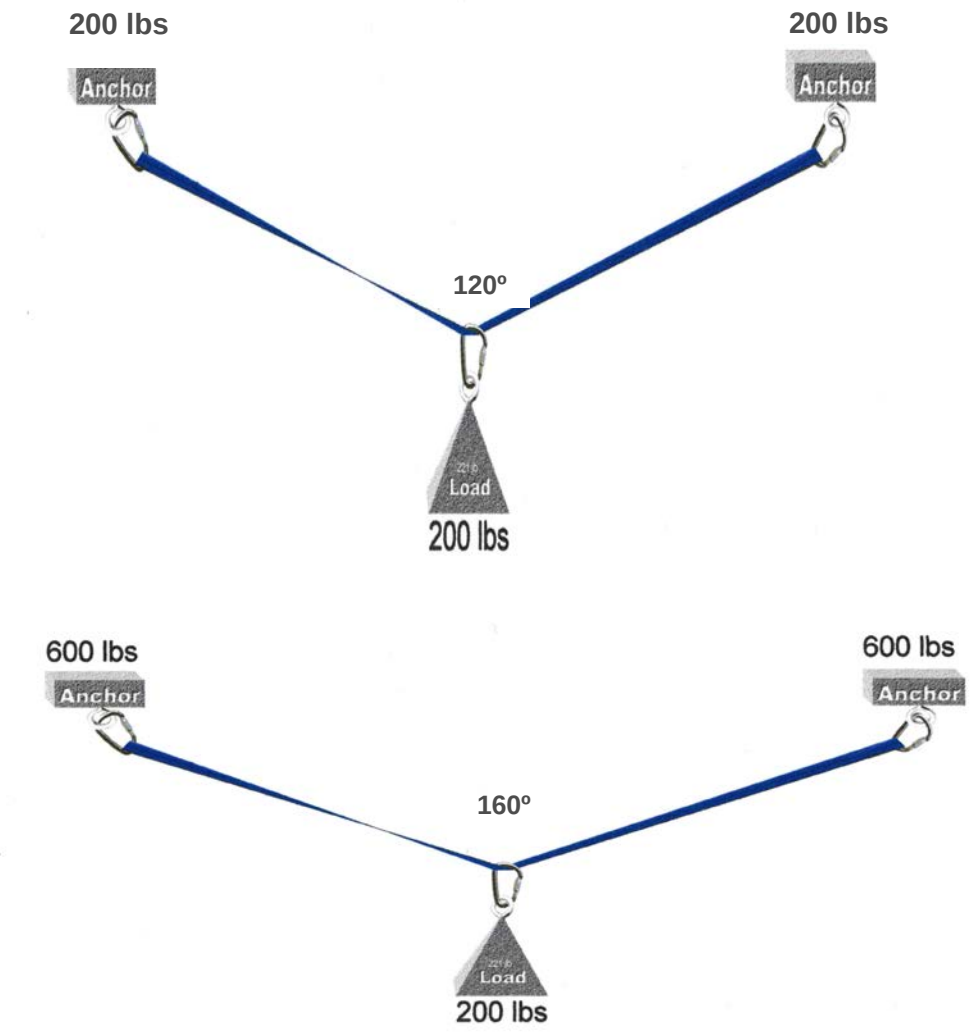
Multiple anchor systems used for a High Line system.

Critical Angles

Critical Angles are the angles within a rope system that directly affect the forces applied to the system components and its anchors. When force is applied midline to a rope, a type of leverage occurs at both ends of the rope and the anchors to which they are attached. If two anchors were next to each other, a 200 lb. weight was hung midline on a rope that was attached to both, and the interior angle was 0º, each anchor would see 100lbf or 50% of the load. With a 120º angle created in the middle of the rope, each anchor would see 200lbf or 100%. The force on the anchors will continue to increase with the angle to 52:1 at a theoretical 180º of angle. (See diagram)

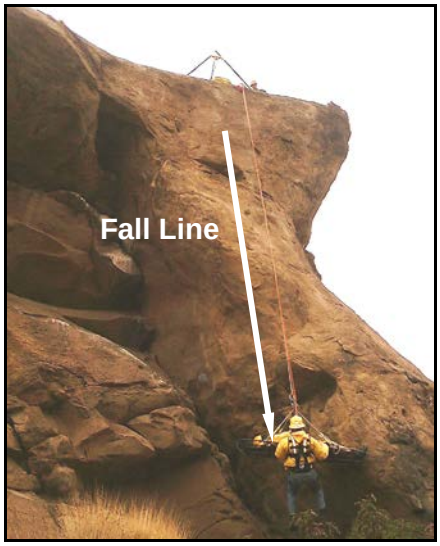
Considering these facts, the maximum allowable angle is considered to be 90º. It is also known as the field angle. At this angle, less than the total force of the rescue load is seen at each anchor.



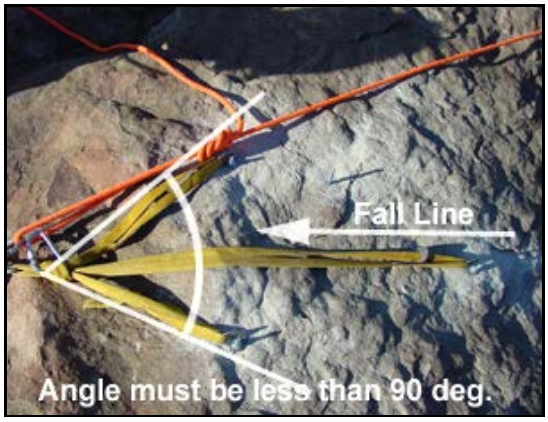


Fall Line

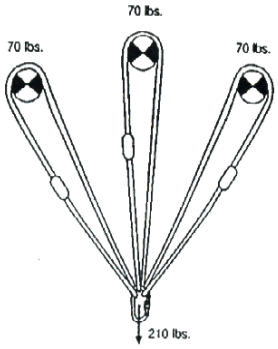
The fall line is that imaginary vertical path which a load (the rescuer and possibly the patient) would travel downward if influenced only by gravity. All anchors or focal points should be rigged with consideration given to the fall line. Minimal deviation from this line is desired in order to prevent a pendulum effect on the rescuer.

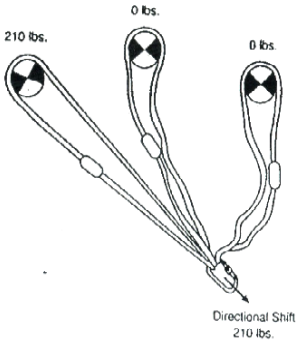


Load-Distributing Anchor

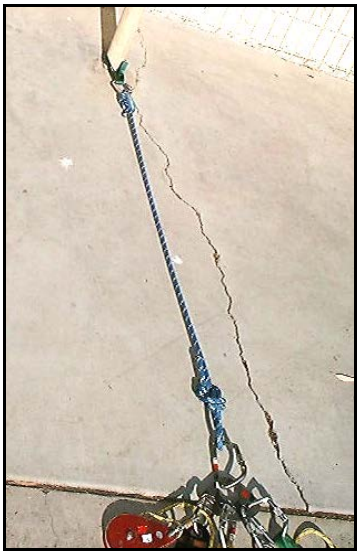


A load-distributing anchor is a collection of anchors that shares the load between them. It is used when a bombproof anchor is not available in-line with the fall line or proximal to the rescue work area. The critical angle between the anchors webbing should be at maximum 90º (see diagram). The anchor points must be gathered so that they share the load equally, retain strength in their direction of pull, and collect at a focal point in the fall line. The Main or Belay system will attach to this focal point. If the collection point moves to one side, the anchors will not share the load equally as originally planned and anchor system failure may result.





Floating Focal Points



Also known as collection points and floating anchor points, floating focal points are needed when there are large distances between the anchor(s) and operational area, or there are no existing anchors in line with the fall line. Because rope stretches, a Pre-Tension Front-Tie should be incorporated into the system. If this is not possible, then multiple wraps of rope between the anchor and floating focal point will help minimize the stretch in the rope under load.

Pre-Tension Front-Tie

A Pre-Tension Front-Tie is a method used to take the stretch out of the anchor rope in a floating focal point system. An anchor in front of the floating focal point is used to apply a 3:1 force to the focal point. The pre-tension anchor should be as close to the fall line as possible without interfering with the Main or Belay system. Before loading the main anchor system, the 3:1 should again be tightened to account for rope stretch.

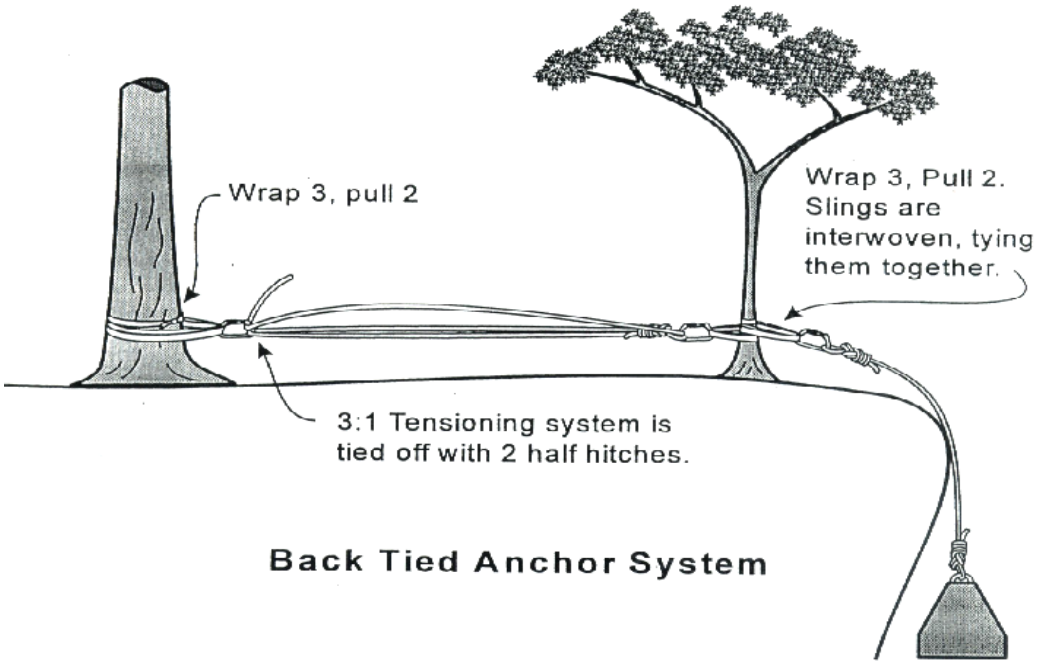
Directional anchor systems such a Gin Poles and A-Frames are secured using this method.

Pre-Tensioned Back-Tied Anchor

Reinforcing a marginal anchor by connecting it to another anchor using a 3:1 mechanical advantage system in the opposite direction of the load is referred to as pre-tensioned back-tying. This is done when only a marginal anchor is available in the desired operational area. Key points to remember are:

- The rear anchor is bombproof, or the two shall combine to create a bombproof anchor.
- The anchors are no more than 15º off the fall line.
- Interweave the back-tie and the initial anchors.
- Account for rope stretch by re-tensioning the back-tie when appropriate.

It is important to remember that the front marginal anchor is now a Directional anchor, with only a 15º allowance off the direction of the back-tie. The complete system is known as a linear anchor system.



Back Tied Anchor System

Site-Built Anchors

When manmade or natural anchors are in scarce supply, it is possible to create your own anchors with material on the fire engine and material found at the scene.

Picket Systems

Picket systems are limited by the stability of the soil they are driven into. Pickets are made of 1” steel rods cut to 4’ lengths and ground to a dull point at one end. Pickets should be driven 2/3rds of the length into the soil at a 15º angle opposite the load. Add additional pickets 3’ apart in line with the intended load. (**Fig. 1**)

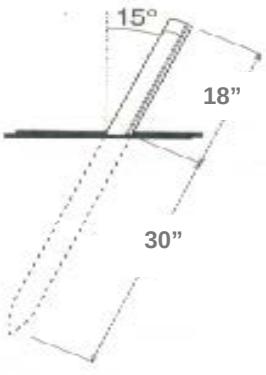


Figure 1: Picket

Spanish Windlass

The Spanish Windlass is tied beginning with a clove hitch or one round turn with two Half Hitches at the base of the rear picket. Wrap the lashing material between the bottom of the rear picket and the top of the picket in front three to six times and then finish the knot with another Clove Hitch or round turn with two Half Hitches. Use a small stick or other device to insert into the wraps and twist the windlass. Tension the windlass only until the forward picket starts to move. Then back off a turn and a half and secure the stick. This action will tension the windlass sufficiently to share the load between each picket.

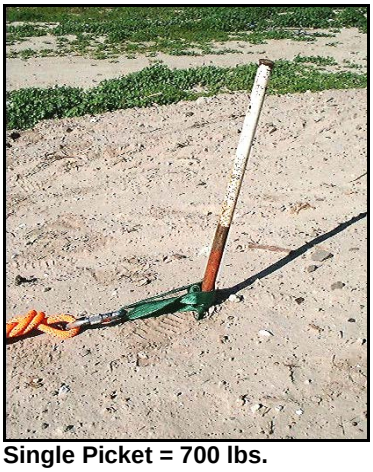
Tie another Spanish Windlass between the other pickets. This will complete a 1:1:1 picket system with an anchor capacity of approximately 5,000 lbf. (Suitable for a Main Line system anchor.)

Note: *The addition of webbing lashed between the bases of the first two pickets has shown a significant increase in the strength of the picket system.*

Picket Capacities

Soil type, moisture content and compactness all affect the holding strength of picket anchors. Below some capacity specifics are listed. Picket capacity is for loamy soil of average compactness.

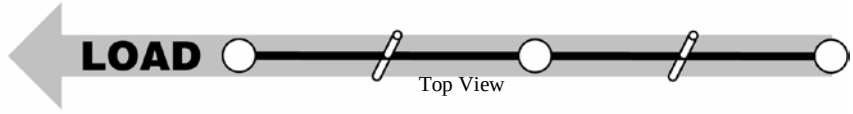
- A single picket can hold up to 700 lbs. force.
- Two pickets set in a line and lashed together, 1:1 can hold up to 1,400 lbs. of force.
- Three pickets set in a line and lashed together, 1:1:1 can hold up to 5,000 lbs. of force.
- A 3:2:1 combination can hold up to 5,000 lbs. of force.
- Clay and gravel reduce picket capacities by 10%.
- River clay and sand can reduce picket capacities by 50%.



Single Picket = 700 lbs.

1:1 Picket System = 1,400 lbs.

1:1:1 Picket System = 5,000 lbs.

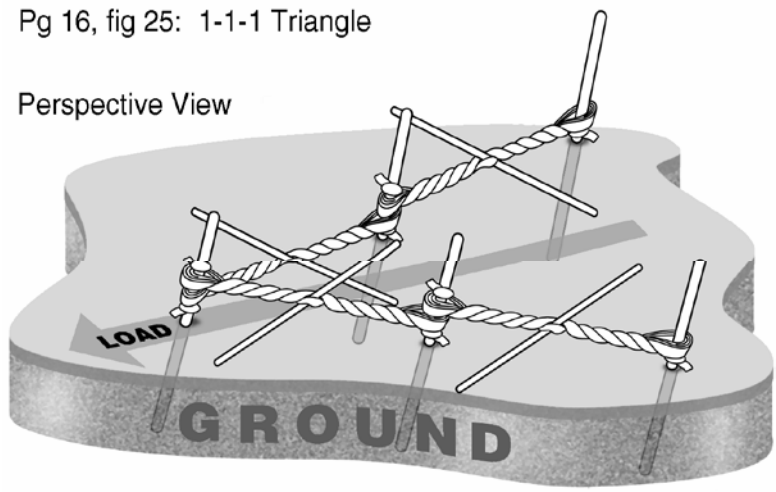


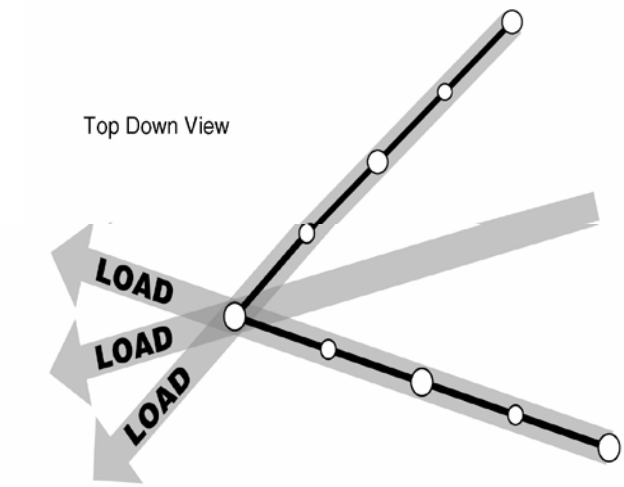
Top View

• Rope Minimum of two wraps (a 20-foot length should be adequate)

• Webbing Minimum of four wraps (two 20-foot lengths of webbing tied together should be adequate)

• Some teams will have 36- to 40-foot lengths of webbing prebagged for windlass material. It is common to see orange or a nonstandard color of webbing for this purpose.

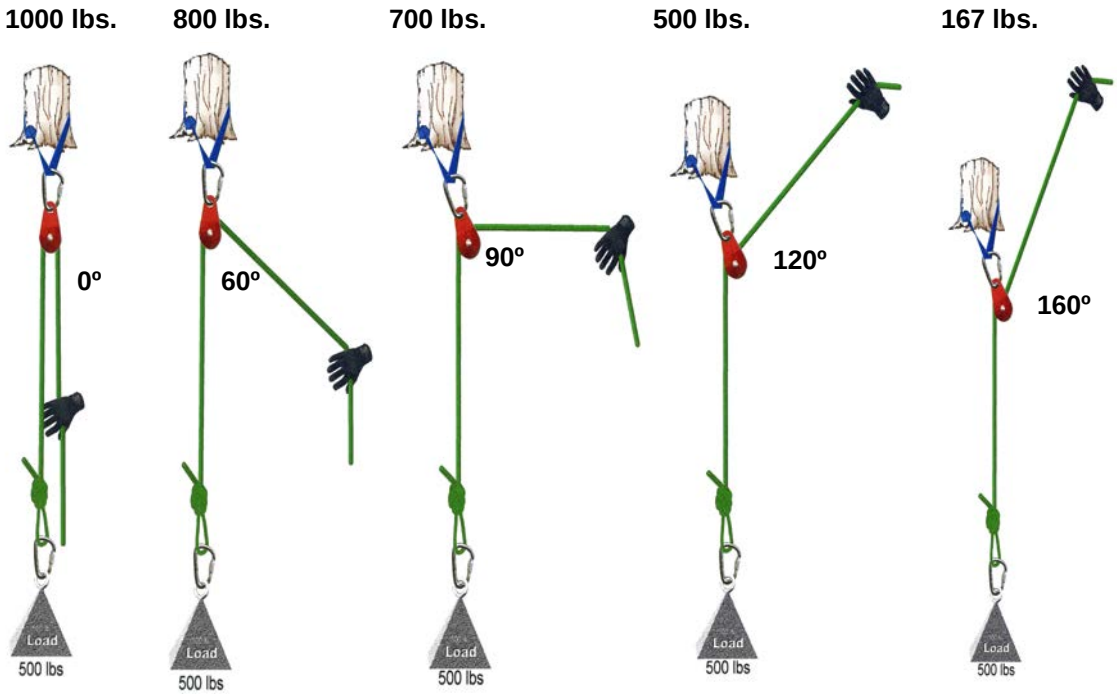




- Shown with windlass material tensioned and set.
- Note directions of load. This offers more flexibility in load changes than the 1:1:1 inline windlass

Vector Forces on Anchors

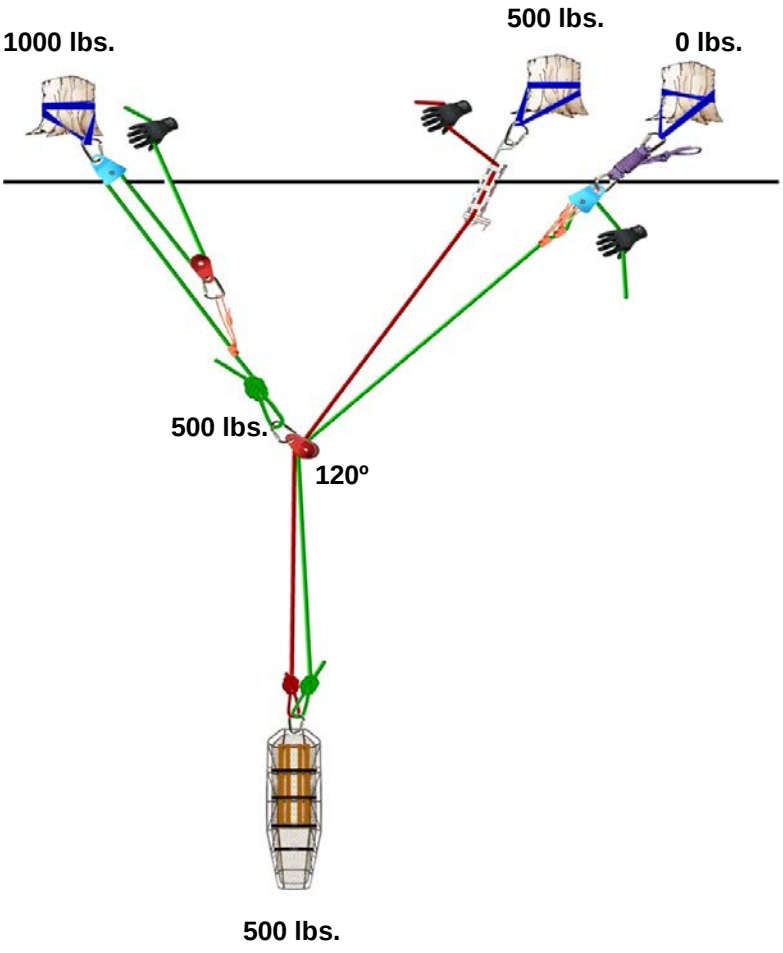
When selecting anchors for rope rescue systems, consideration must be given to the forces that will be applied to those anchors. Different anchors in the system may see different forces depending upon where it is in the system and the angles of the rope that are created as the rope enters and exits the equipment attached to it. Using the same diagrams shown earlier for multi-point anchor systems and the relation between the forces applied to those anchors as a result of the interior angles created, a relation can be built to determine the forces applied to other anchors throughout the system. Once the load (weight of the rescuers, victim and all equipment) has been calculated, the vector forces can be determined. This is what ultimately allows the rigging team to determine if the anchors are strong enough to support the load.



The following example shows a raising system with a single rescuer and one victim in a Stokes litter. Their total weight is estimated at 500 pounds. A Deflection Line (See Chapter 15 for details) is used to add an additional change of direction anchor for demonstration.

Note the forces applied to the different anchors in the system based upon the angles of the rope as it relates to that anchor. Also consider the direction of pull the anchor will see when the load is pulled into motion. This is particularly important when building directional anchors.

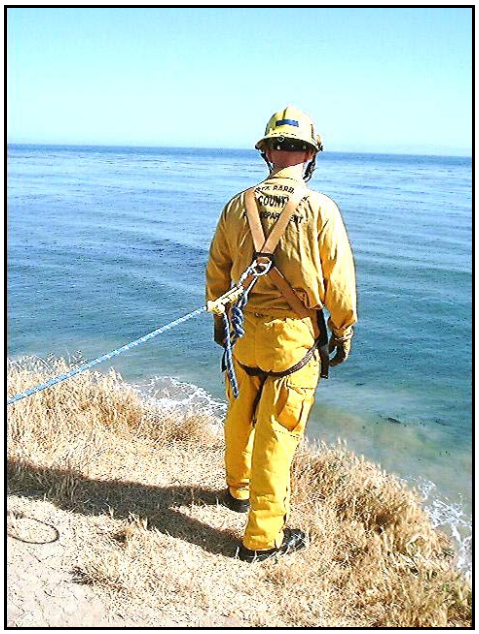
Finally, the peak force, also known a momentary force for this example, is slightly higher than the constant force shown in this diagram. This momentary force is seen whenever a system is first pulled into motion, as in the beginning of a haul, or again after each reset.



Edge Lines

An edge line is a utility line tied to an anchor on one end and secured to the harness of the edge person. A Three-Wrap Prusik Hitch is attached to the edge line near the edge person and acts as the main attachment to their harness. This allows adjustability as the edge person moves around. The Prusik should be set to prevent the edge person from falling over the edge.

Edge line connected to Class 2 Harness



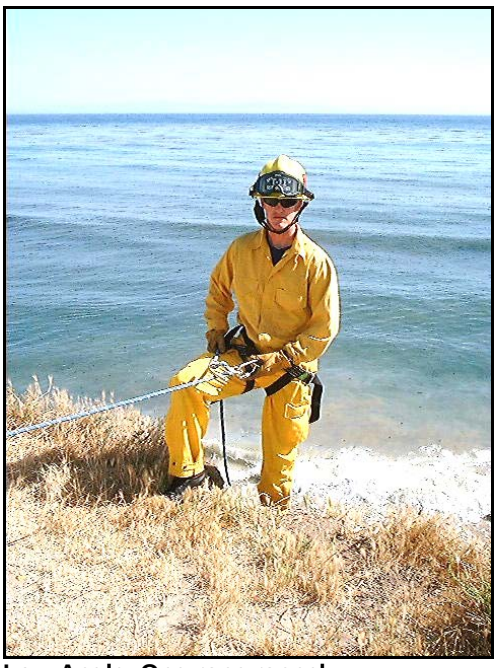
Edge line connected to Fall Protection Harness

Chapter 7
Main Line Systems

The initial priority in any rope rescue operation is to gain access to the patient(s) to make an assessment and determine further rescue needs. There are two primary ways to gain access to the patient, to rappel or be lowered. This chapter will look at both techniques. After arriving on scene, the decision of which technique to use should be made based on the individual incident.

Low-Angle Rappelling for Patient Access

To make access to a patient in a low-angle area, a single rope rappel is acceptable. The friction device can be either tended from the top, or by the rescuer. If tended by the rescuer, enough rope should be removed from the rope bag to make access to the patient, with a Figure 8 Stopper Knot tied in the end. The rope is secured to the anchor, leaving the rope bag with excess rope at the top. This 1) keeps the twists out of the rope if using a Figure 8 plate and 2) leaves excess rope in the operational area, where it can be used as an additional line to lower the rescuer if needed, or to set up the mechanical advantage system to raise the rescuer and patient.



Low-Angle -One-rope rappel

Reeving Friction Devices

There are two common friction devices used in rope rescue, the Figure 8 Plate and the Brake Bar Rack. Either device can be used for lowering or rappelling a single-person load. The Brake Bar Rack ***shall*** be used when managing a ***two-person load***.

Figure 8 Plate

The standard reeve for the Figure 8 Plate with Ears is:

Step 1: Pass a bight of rope through the large hole of the plate.

Step 2: Pass it back down and over the smaller hole.

Step 3: Clip the smaller hole into either the main anchor or the D-Ring on the rescuer's harness with a carabiner.

To Lock-Off:

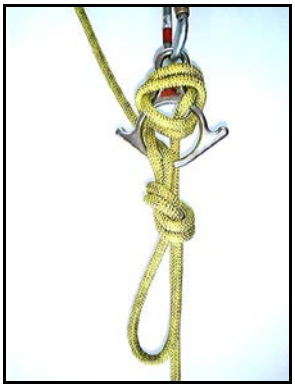
Step 1: Pass the rope between the rope and the top of the Figure 8 Plate. Pull down hard to secure.

Step 2: Trace the rope around the Figure 8 Plate once more to "back-up" the first pass. It is now locked off.

Step 3: To secure the lock off, begin to trace the rope around a third time, but pass a bight of rope up through the large hole of the Figure 8 Plate (about 2') and tie an Overhand Knot around the standing part of the rope.

Step 1: Figure 8 Secured

Step 2: Figure 8 Locked off



Step 3: Figure 8 Tied-off

Brake Bar Rack

Reeving the Brake Bar Rack

Step 1: Attach the Brake Bar Rack to anchor carabiner when used in lowering operations (Shown). Attach the Rack to carabiner on rescuer's harness when used in rappelling operations. Clip into the base of the Rack. Lock carabiner.

Step 2: Lay rope over top bar.

Step 3: Push a bight of rope down through the Rack.

Step 4: Pull up on the rope bringing the first bar up and clipping into the rack. ***(Note: The first U-shaped bar facing up)***

Step 5: Push another bight of rope down through the Rack.

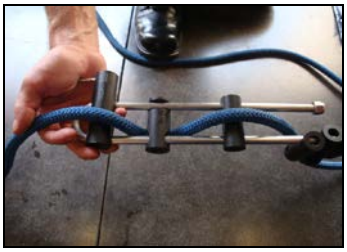
Step 6: Pull up on the rope bringing fourth bar up and clipping into the Rack.

When adding a second rescuer/victim to the system, the following steps should be added.

Step 7: Push a third bight of rope down through the Rack.

Step 8: Pull up on rope bringing sixth bar up and clipping into the Rack.

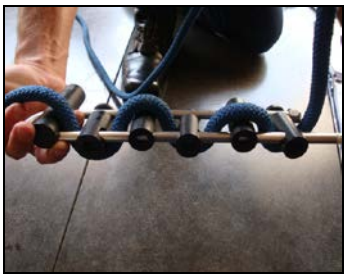
Step 1



Step 2

Step 3

Step 4



Step 5

Step 6

Once the rescuer is at the patient, the Rack should be locked off.

- If used for rappel, this enables the rescuer to work hands-free.
- If used for lowering, this enables the rigging team to change-over to a raising system.

To Lock-Off:

Step 1: Pull the rope towards the load with the brake hand. (*This increases friction by pushing all the bars together*.)

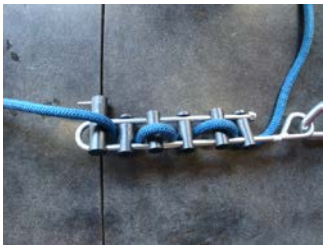
Step 2: Hook the rope over the tie-off (hyper bar) and pull back. (*Do not cross over the rack diagonally when trying-off.)*

Step 3: Hook the (hyper bar) again for the second time.

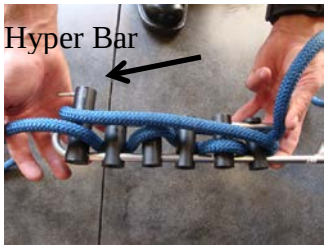
Step 4: Pull the bight up towards the load.

Step 5: Tie an Overhand Knot around the Brake Bar or standing part of the rope.

Step 6: Pull the Overhand Knot tight and set against the top of the rack. *(This prevents any slipping of the knot or movement of the load.)*



Step 1

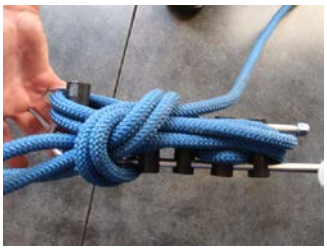


Step 2

Step 3

Step 4

Step 5



Step 6

Lowering Systems

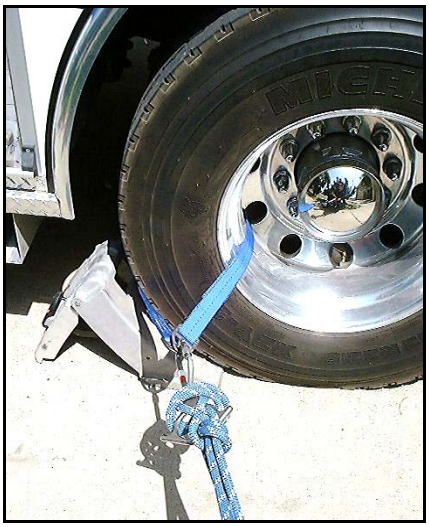
Operational level lowering systems include patient access rappel, low-angle scree-evac, and Flying Stokes. Pick-Offs and other vertical stokes techniques are considered Technical level capabilities and will be covered in another chapter.

The question of whether to be lowered vs. rappel is a common debate. Most often, it is safer and more practical to be lowered. This is for several reasons. First, it allows the rescuer to be lowered “hands-free” to perform a victim Pick-off without having to tie-off a Figure 8 Plate or Brake Bar Rack first. The rescuer would then have to rappel with the addition of a victim, doubling the load, or if being raised back up, the extra rope would drag behind, potentially getting caught and stopping the system. Second, the change-over from a lowering system to a raising system is easier since only the necessary amount of rope is lowered over the side. This gives the rigging team more rope to work with when building the raising system.

Main Line System - Lowering Operations

The Main Line should be attached to a high anchor point, when the anchor is considered bombproof, in order to minimize edge trauma to both the system and to the rescuer. A Brake Bar Rack or a Figure 8 Plate is used to lower a single rescuer down to a patient to perform a medical evaluation. For a rescue load (2 or more people), a Brake Bar Rack shall be used as the friction device because of the greater friction control it affords the team.

One/Two person load



Single person load (option). Note the wheel chock under the tire to secure the vehicle.

Main Line Attachment Points

Single Rescuer- The location of attachment for the Main Line depends upon the type of rescue being performed.

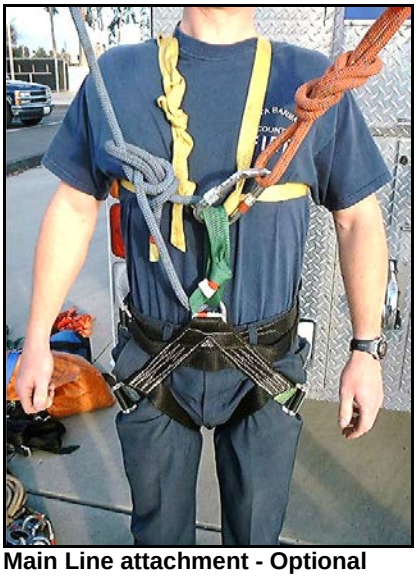
For low-angle rescues and vertical 'wall' rescues, the Main Line should be attached to the D-Ring located on the seat portion of a harness when being lowered.

Main Line attachment - Lowering

Main Line attachment – Rappel

When rappelling, a Figure 8 Plate or Brake Bar Rack is reeved and attached to the seat harness D-Ring.

Once a rescuer is secured in both chest and seat harness, the two harnesses should be able to touch when the rescuer is bent over. If not, a connector strap should be added (green webbing in adjoining picture). This strap becomes the new attachment point for the Main Line during high-angle operations. Ensure the knot on the connector strap is facing out. This allows the strap to self-adjust when loaded.



Main Line attachment - Optional

Rappel Systems

Rappelling is an important function in rope rescue. In most operations, it is better to lower rescuers to a patient. However, there are times when a rescuer needs to rappel to access the site. Rappelling is a dangerous activity, so it must be performed under controlled conditions. Rappelling in the rescue environment requires a slow, controlled walk down the terrain. A slow, steady descent is much easier on rope system equipment and reduces heat build up caused by friction devices that can damage nylon rope.

The start of a rappel is usually the most difficult, especially when starting at the same elevation as the anchor system. Once the rescuer has been attached to the Main Line (and Belay Line if used) and a safety check of the entire system has been completed, the rescuer can approach the edge.

The proper body position for a rappel is to stand with the feet slightly wider than shoulder width apart and knees bent. The rescuer should lean back until the body is nearly perpendicular to the terrain. This allows any stretch in the rope to be taken out. The control hand is best placed along side the hip. By loosening the grip of the control hand, the rescuer begins the descent. This grip is what regulates the speed of the descent.

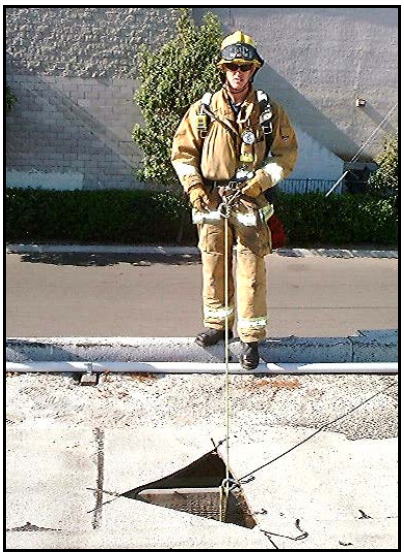

Rappel position

A common tendency is to remain in a vertical position, which tends to cause the rescuer's feet to slip down the wall or cliff. Lean back and let the rope take the weight, forcing the feet against the wall. If the rescuer should encounter an undercut terrain (or ledge) feature, keep the feet in contact with the terrain until gravity pulls the feet away. Once on the ground, do a deep knee bend to gain enough slack to disconnect from the system.

A fast, bounding rappel has no place in rope rescue and may lead to abrasion or system failure from the aggressive sawing action over rough terrain.

Emergency Escape Line (Options)

In the event an emergency escape must be performed from a roof and it is impossible to make access to establish ladders already in place, the Department has provided Emergency Escape Line Drop Bags to perform an emergency rappel. The bags are set up with a pre-tied and pre-reeved F4 Descent Device with two carabiners for quick attachment and deployment. The following options are listed and based on individual preferences.

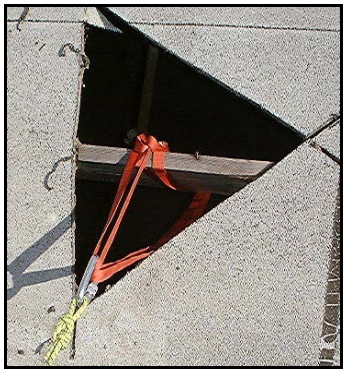


Selecting an Anchor

1. Wrap a suitable anchor on the roof (i.e. HVAC unit)
2. Cut an inspection hole to expose a structural member that can then be used as an anchor.

Securing the anchor

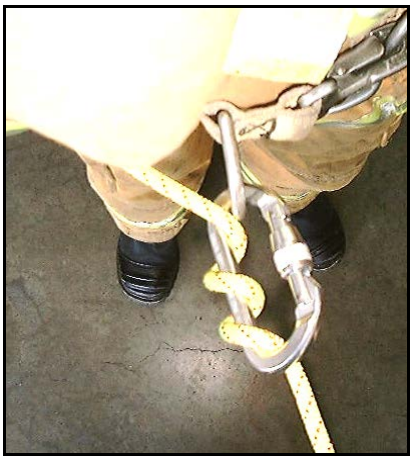
1. Use a 15’ webbing to make a Three-Bight anchor sling.
2. Using only the end of the rope, build a Tensionless Hitch.



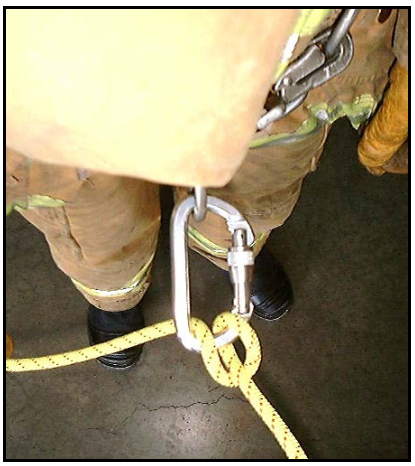
Reeving the Friction Devices (Options)

1. Use the included F4 Descent Device (Pre-reeved) and connect to the D-Ring of the escape belt with the included carabiner.

2. (Excludes the F4 Descent Device) Wrap the rope 3 times around the spine of the carabiner and connect to the D-Ring of the turnout coat.



3. (Excludes the F4 Descent Device) Wrap a Munter Hitch around the carabiner and connect to the D-Ring of the turnout coat.



Chapter 8
Belay Systems

Rope Rescue System Belay

A Belay Line, also known as a safety line is a back-up system to the main-line system. It is intended to protect the rescuer and victim from injury in case of Main Line failure. The Belay system shall be designed to withstand a substantial shock force. Most rope rescue professionals feel that the Belay system should be designed to absorb a shock load from a 1-meter fall with 3-meters of rope in service with a rescue load (600lbs). This condition is frequently found at an edge transition with a victim in a Stokes litter and one attendant. Careful attention must be paid to the Belay Line when a load is on the main system in order to keep the fall distance as short as possible.

Slopes, Ropes, and Risk Assessment

The decision whether a Belay Line is needed is based on factors such as slope of terrain, weather, type of terrain (loose shale, multiple boulders/uneven footing), equipment deployed or if a victim is attached to the system.

In most situations, the slope of the terrain will determine the need for a Belay Line. If most of the rescuer's weight is on their legs and not on the Main Line, then a Belay Line is probably not needed for gaining victim access. But if the Main Line is supporting a greater portion of the rescuers weight, or if the footing is unstable, then a Belay Line should be added to the system.

The exception to both of these rules is that a Belay Line will always be used on a patient.

The following is a risk assessment evaluation tool:

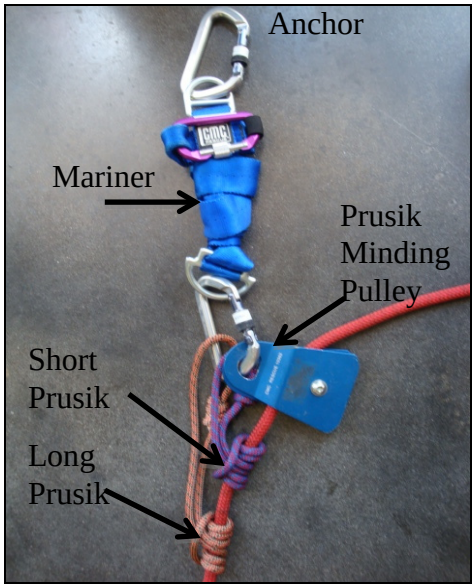
Slope	Risk	Rope
0-15 degrees (flat)	Minimal	0-1 rope
15-40 degrees (low-angle)	Low	0-1 on the low end
		1-2 on the upper end
40-60 degrees (steep angle)	High	2 ropes
60+ degrees (vertical)	Extreme	2 ropes

Two Rope Systems with a Safety Belay

This system employs a Belay rope separate from the Main Line to provide safety to the rescuer. It is attached to its own anchor point, and the Belay Line remains tensionless unless it is activated during a fall or Main Line failure.

The components for the Belay system are an anchor point, a Mariner's Load Releases Strap, 8mm Tandem Prusiks, a Prusik minding pulley and a 12.7mm(1/2 inch) low-stretch kernmantle rope.

The order of attachment for the Tandem Prusiks and Prusik minding pulley onto the Mariner's Load Releases Strap carabiner is long Prusik, short Prusik, then Prusik minding pulley. This order is commonly referred to as LSP (Long, Short, Pulley). This allows the short Prusik to be closer to the spine of the carabiner, as it will see the initial load if the Belay Line is activated.



Belay line

The Belay Line shall be rigged to have a path of travel closest to the ground and shall be slightly slack. It should only be attached to a high point if the high point is bombproof. Ladder A-Frames, Tripods or Ladder Gins are not considered acceptable for purposes of a high anchor point for a Belay Line. When used with these devices, the Belay Line shall be kept as close to the ground as possible, providing the shortest distance between the anchor and the rescue team.

Belay Line Attachment Points

Single Rescuer

The end of the Belay Line should be attached to the chest D-Ring of the Class 3 harness . It should not be attached to the rear D- Ring of a Class 3 harness, as it makes self-rescue extremely difficult, as well as applying immense forces to the rescuer if the Main Line fails.


Belay attachment

A Bowline or Figure 8 on a Bight can be used with carabiners to attach the Belay Line to the rescuer. A Bowline or Figure 8 Follow-Through can be used to secure the Belay Line if no carabiners are available. A Bowline is preferred due to its adjustability, however it must have a Double Overhand backup knot to secure it. If a Bowline is used, start by passing it down through the chest harness and then the D-Ring attachment on the front of the seat harness. This will ensure the knot is loaded correctly.

Horizontal Stokes

The Belay Line is attached to the rigging plate by using either a Long-tail Bowline, Interlocking Long- tail Bowline, In-Line Figure 8 or Butterfly Knot. Enough line should be left after the connection to allow for a 6’ tail, after a Bowline or Figure 8 on a Bight have been tied in it. The attendant will attach this tail to either his connector strap carabiner, or both his seat and chest harness. The Main Line tail shall be attached to the patient.


Belay (Orange rope) attachment for horizontal Stokes

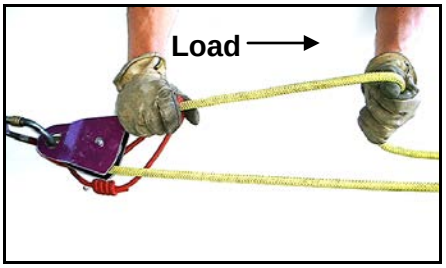
Vertical Stokes

The Belay Line should be attached the same as it is for a horizontal Stokes operation. (See above) However, the Stokes litter is attached using a 5’ green webbing that has been attached to the head of the Stokes or Low Angle Pre-Rigging and connected to the rigging plate.

Belay Technique

The use of proper technique when tending the Belay Line is critical. The person assigned to tend the Belay Line is called the Belayer. This person must be able to keep up with the pace in which the rescuer is either being lowered or is rappelling. If they are having difficulty doing so, the Belayer must communicate with the Main Line attendant or rescuer to slow down. Otherwise, the Belayer may inadvertently have the Tandem Prusiks grab the load and stop the rope from moving.

During lowering operations, the Belayer must feel resistance while paying out the rope. This will minimize the chance of too much rope being paid out. Allowing too much slack in the Belay Line can greatly extend the fall distance and increase the chance of serious injury to the rescuer in the event of a Main Line failure.



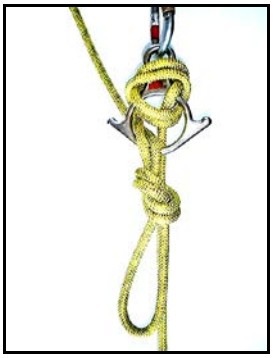
Proper Belay hand placement

During raising operations, slack must be taken up by pulling the rope through the Prusik minding pulley, which tends the Tandem Prusiks as the load is raised.
In the event the Tandem Prusiks grab the rope, the load comes to a stop. It cannot move until the Prusiks are released. A Radium Release Hitch placed between the anchor and the Tandem Prusiks is used to release the Prusiks. The Radium serves two purposes. First, it allows the Tandem Prusiks to be released in the event of Main Line failure or if the Prusiks inadvertently become jammed during a lowering operation. If the Main Line fails, a new Main Line would be placed into service. The Radium Release Hitch would then be used to lower the load back onto the Main Line.

The second purpose of the Radium Release Hitch is that it will absorb some of the shock force generated as it stretches out during the arrest of a fall.

To use the Mariner's Load Releases Strap to release stuck Prusiks:

Step1: Lock off the Main Line. This prevents more slack from being introduced in the Main Line.



Step 1

Step 2: Unclip the SMC Purple Carabiner. Pull the loop to unraval the wraps.

Step 2

Step 3: Extend the Mariners Load Release Strap until the load is transferred back onto the Main Line.

Step 3

Step 4: Rewrap the Mariners Load Release Strap. Simply secure the MLRS with a minuim of 6 wraps. The MLRS does need to be rewraped before continueing the operation.

Step 4

Step 5: Continue descent.

Chapter 9
Mechanical Advantage Systems

Pulley Systems

A combination of fixed and moving pulleys in a rope system creates a mechanical advantage that allows a rescuer to lift a load that normally would be too heavy for them. The trade off to mechanical advantage is while it takes less force to move the load; the force must be applied over a greater distance. This therefore increases the time it takes to move the load.

There are three types of pulley systems: simple, compound and complex. Each has its positive points and its negative points. A well-trained crew will choose a pulley system according to the advantages it has for the situation they are applying it to and the amount of resources available to them.

Simple Systems

Simple pulley systems consist of a rope tied at either the anchor or the load, passing alternately between the pulleys on the anchor (stationary or change-of-direction pulleys) and the pulleys on the load (traveling or mechanical advantage pulleys). All the pulleys on the load side travel at the same speed and all the pulleys at the anchor remain stationary. The tension in the rope remains the same throughout the pulley system.

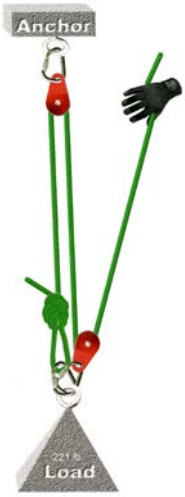
Some simple principles that apply to simple pulley systems are:

- If the tied end of the rope is at the load, the IMA (Ideal Mechanical Advantage) will be odd (i.e. 3:1, 5:1).
- If the tied end of the rope is at the anchor, the IMA will be even.
- The number of pulleys required to build a simple system is the IMA minus one (i.e., a 3:1 IMA simple system will take 2 pulleys to build).
- The IMA of a simple system can be determined by counting the ropes under tension between the anchor and the load.

Simple Systems

1:1 Simple System

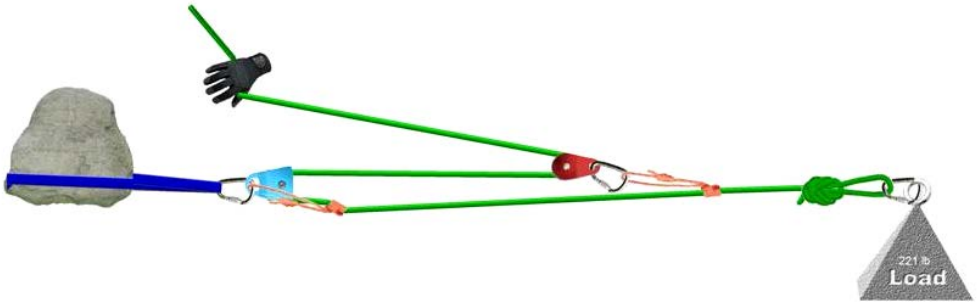
2:1 Simple System



3:1 Simple System

4:1 Simple System

5:1 Simple system



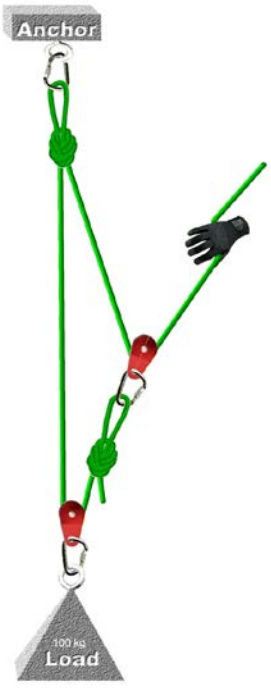
3:1 Z-System

Compound Systems

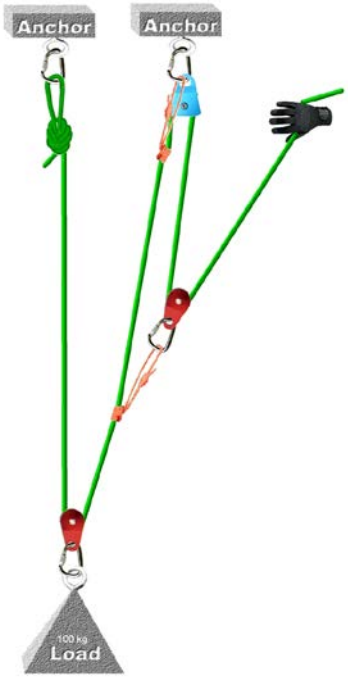
Compound systems are one simple system pulling on another simple system. The traveling pulleys of one of the simple systems will travel towards the anchor at a different rate than the other simple system. The advantage of compound systems over simple systems is that you can create a greater mechanical advantage with fewer pulleys in the system, resulting in less overall friction loss for the same IMA.

Some principles that apply to compound pulley systems are:

- The IMA of a compound pulley system is determined by multiplying the IMA of each simple pulley system together. For example, a 3:1 simple pulling on a 2:1 simple would be 3 x 2 or a 6:1 IMA compound pulley system.
- To limit the amount of resets needed to bring the load to the top, the higher MA system should pull upon the lower MA system, i.e. 3:1 should pull on a 2:1. This way, the systems will collapse more evenly.
- Longer throw distances per reset are achieved by positioning the anchor pulley(s) of the last simple pulley system (system closest to the haulers), far enough back from the anchor pulleys of the first system, to allow both systems to collapse at the same time.



4:1 Compound System (2:1 pulling on a 2:1)



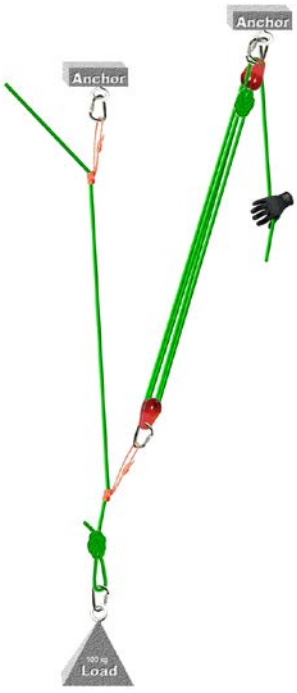
6:1 Compound System (3:1 pulling on a 2:1)

Piggyback Systems

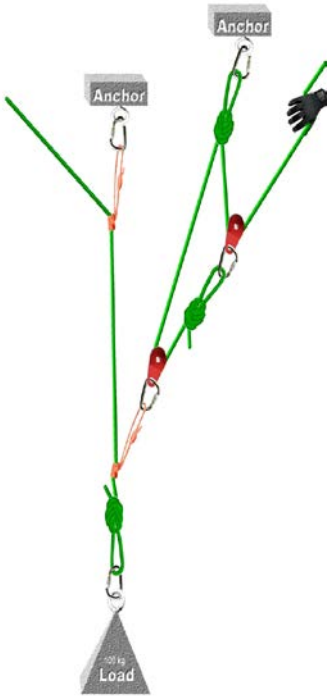
Piggyback systems, commonly referred to as Pig-Rigs, are mechanical advantage systems built with a separate rope and attached or “piggybacked” onto a main system. They are typically used as raising systems when there is not enough rope left to build a mechanical advantage system out of the Main Line when rescues are located at distances equal to the length of our ropes. They are also used to pass knots in a system when ropes are tied together to gain access to the location of a rescue.

A Piggyback system can be any mechanical advantage system needed to perform the function. Build the system with the least amount of mechanical advantage need to do the job. This maintains maximum efficiency in the system.

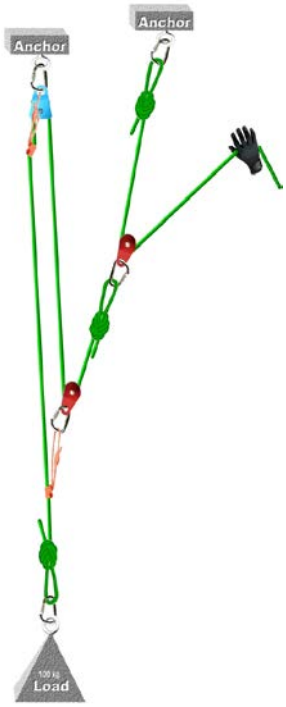
Three common Piggyback systems are the 4:1 simple, built with double pulleys, the 4:1 compound, built with 2 single pulleys and the 6:1 compound built by adding a 2:1 Piggyback to a 3:1 Z-Rig.



4:1 Compound Piggyback with Double pulleys



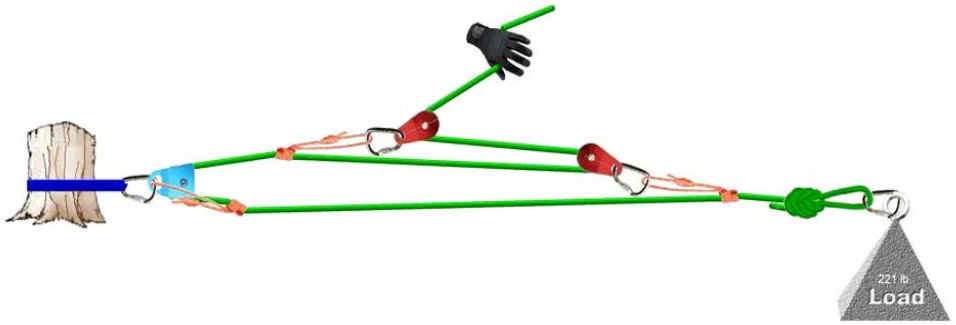
4:1 Compound Piggyback with Single pulleys



6:1 Compound - 2:1 Piggy-back attached to a 3:1 Z-Rig

Complex Systems

These systems are characterized by being neither simple nor compound. Complex pulley systems are rarely used in rescue work. The exception is a 5:1 Complex system.



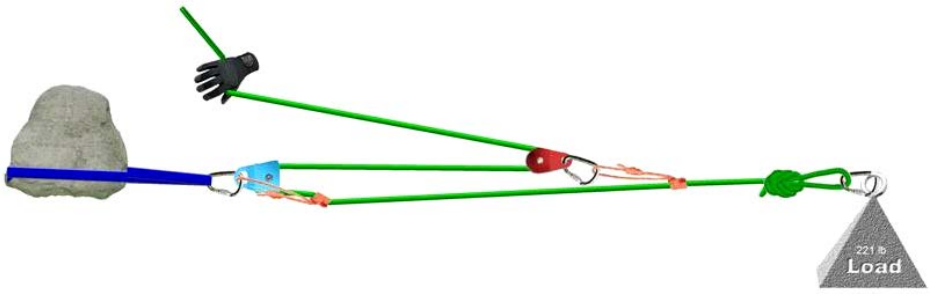
5:1 Complex System

Increasing Mechanical Advantage

The most often-used mechanical advantage system is a simple 3:1. It is typically referred to as a Z-System or Z-Rig due to its appearance resembling the letter Z. This is usually enough mechanical advantage to raise a rescue load. When more rescuers are added to the load more mechanical advantage may be required.

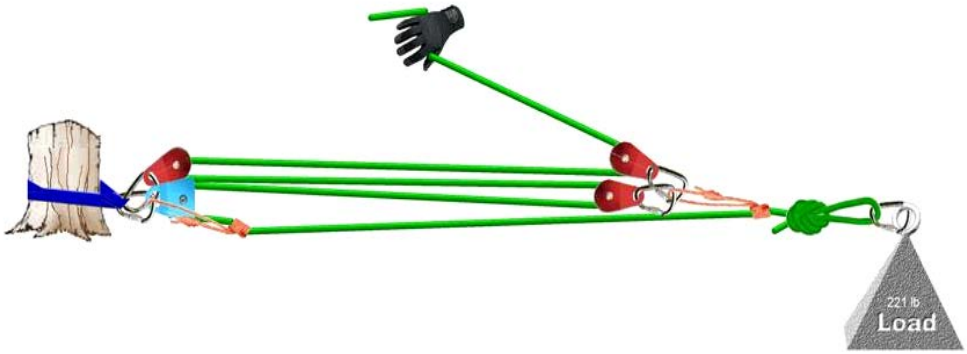
One option is to add personnel to the haul team to apply more force. However, more personnel can also be more difficult to manage and control.

When adding mechanical advantage, the goal should be to make the change quickly with the least amount of equipment.



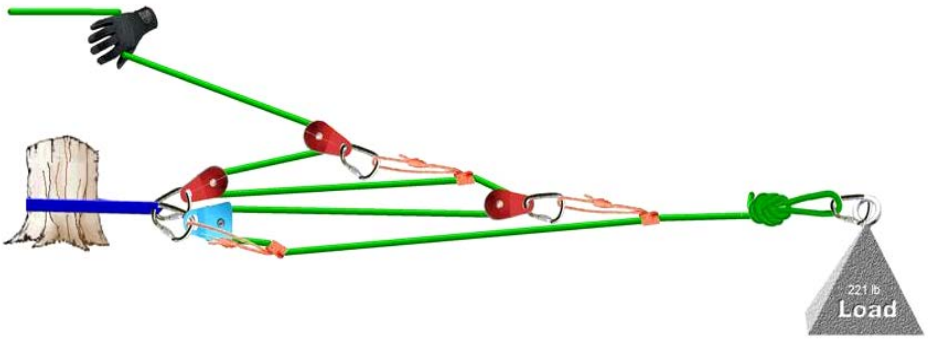
3:1 Simple System / Z-System

The 3:1 Z-system can be quickly changed to a simple 5:1 system by adding two pulleys and two carabiners.



5:1 Simple System

When this is still not enough mechanical advantage, adding one Prusik can quickly make a compound 9:1. (Simple 3:1 pulling on a simple 3:1) This system is rarely needed.



9:1 Compound System

Building a 4:1 Simple System with Double Sheeve Pulleys

The use of double sheeve pulleys allows the rigging team to build a simple 4:1 (or 5:1) mechanical advantage system with less equipment. This system can be used vertically as a ladder rig, as in a Ladder A-Frame system, or horizontally as a piggyback system for hauling. If the knotted end within this system is closest to the anchor it is calculated as a 4:1 mechanical advantage. If it is turned over and the knotted end within the system is closest to the load, it is calculated as a 5:1.

How To Rig A 4:1 With Double Pulleys:

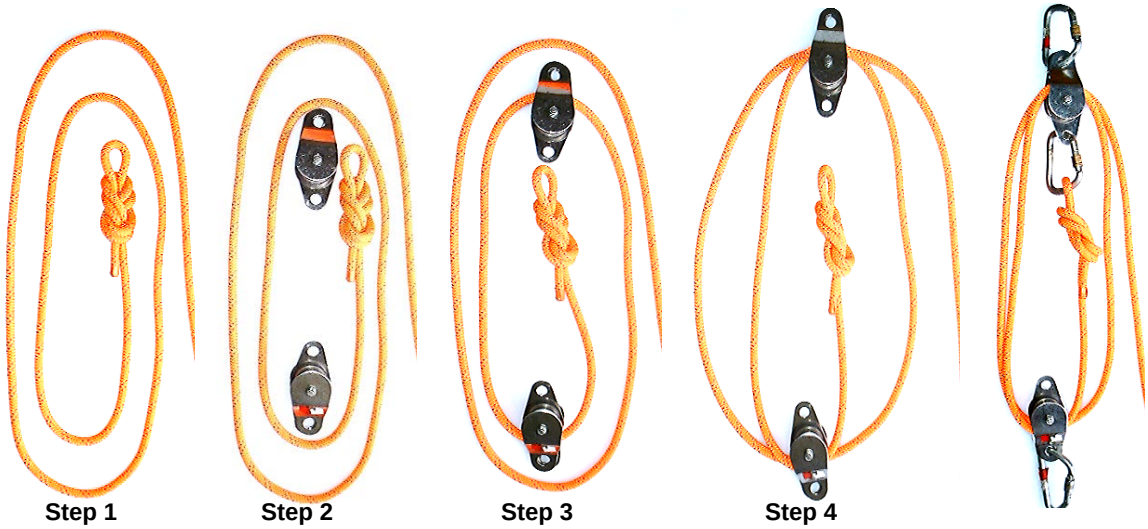
Step 1: Tie a Figure 8 on a Bight in the end of the rope. Make two small round turns around the Figure 8 on the ground.

Step 2: Place the two Double Pulleys flat on their side paltes inside the smallest loop with the beckets facing each other.

Step 3: Reeve the smalerl loop into the top sheeve of each Double Pulley.

Step 4: Reeve the larger loop into the bottom sheeve of each Double Pulley.

Step 5: Clip a carabiner to each pulley to secure the ropes. A third carabiner is used to connect the Figure 8 on a Bight to the closest pulley's becket.



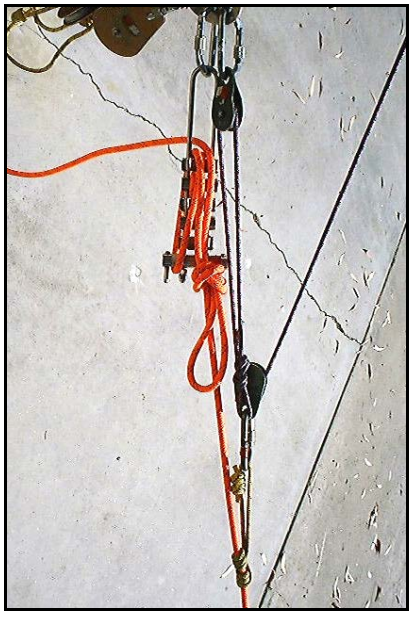
Step 1 **Step 2** **Step 3** **Step 4** **Step 5**

Jigger Systems

A Jigger system is a mechanical advantage system used for single person load adjustments. It is to be managed by one person as the hauler. It can be used to piggyback onto a Main Line during a lowering operation when the rescuer wants to be brought back up only a few feet to adjust themselves over terrain changes. It is also commonly used when tending a Stokes litter during high-angle operations. During Litter Scoop Pick-Off operations the rescuer can lower the foot of the Stokes litter when approaching the victim, then ratchet the jigger back up when the victim is secured. When tending the Stokes litter in a vertical position, the rescuer uses a Jigger as a main attachment to the system and uses the Jigger to raise them up when using Litter Bridal Bypass techniques.

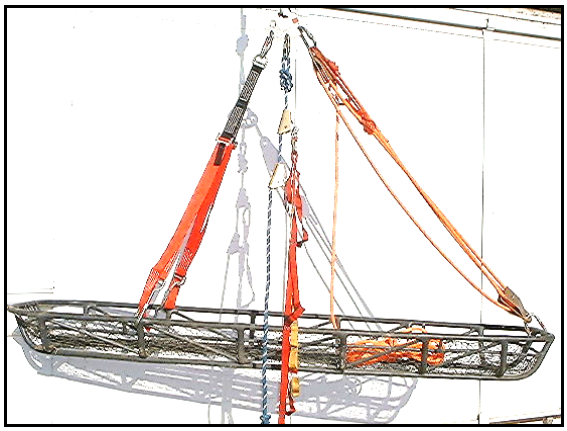
It can be built with two single pulleys to create a 2:1 or 3:1MA. It can be built with two double pulleys to create a 4:1 or 5:1 MA. This latter configuration is more common when used to tend a Stokes litter in a high-angle operation. It is typically built with smaller diameter rope. A 10-meter (33') section of 8 mm cord like the ones used for the Radium Release Hitch makes an ideal rope to use. A 5 mm Ratchet Prusik is used when resets are desired, like when it is used by a Stokes tender during high-angle operations.

For Main Line Adjustments



The Jigger is used as a short, temporary haul system. Rather than changing an entire system from lowering to raising, then back to lowering to allow a rescuer to make a position adjustment, the Jigger can accomplish the same function. One end is anchored to the Main rigging plate and the other is attached to the Main Line with a Three-Wrap Prusik Hitch. One person begins to pull up on the Jigger until the rescuer has made the position change. Then the Jigger system is eased back out until the load is transferred back to the Brake Bar Rack. The Jigger is then removed from the system.

For Litter Scoop Pick-Off
When used for a Litter Scoop Pick-Off operation, one end of the Jigger is attached to the Stokes rigging plate and the other is attached to the foot of the Stokes litter.

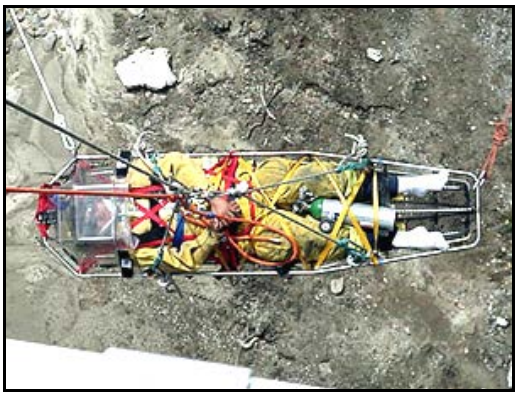


As the rescuer approaches the victim, the Jigger is extended to lower the foot end of the Stokes litter to prepare to “scoop” the victim.

Once the victim has been “scooped”, the Jigger is ratcheted back up until the Stokes litter is in a horizontal position. The system is either lowered to ground or raised back up.

Chapter 10
Stokes Rigging

Stokes Litter Basket

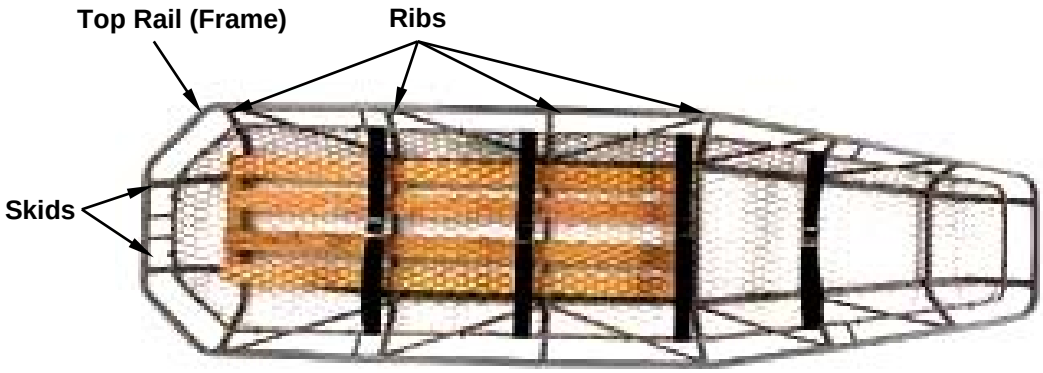


A Stokes litter basket is used to transport injured patients in a horizontal or a vertical environment. At the *Operations* level of NFPA 1670, it is used in low-angle scree-evacuations.

At the *Technician* level of NFPA 1670 its uses include; high-angle operations, vertical wall pick-offs, highline evolutions, vertical confined space evacuations, and guiding line evolutions.

This chapter will cover the rigging of the Stokes litter for both a low-angle scree-evac and high-angle operations. It will also cover the rescuer connection points into these systems.

Stokes Litter Components



Low-Angle Scree-Evac Stokes Rigging

The low-angle litter rigging can be rigged for a three or four rescuer carry. The number of litter tenders depends on the victim's weight and available personnel. It is not recommended to have more than four litter tenders at one time due to limited space along the litter sides.

When possible, the Stokes litter should be rigged before it is sent over the side. This allows the litter tenders to focus on victim packaging without the addition of litter rigging once they are with the victim. Additional rescuers can also connect themselves into the system prior to being lowered.

System Attachment For Stokes Litter

Step 1: Attach outside straps to the cross bar with Larks Foot.

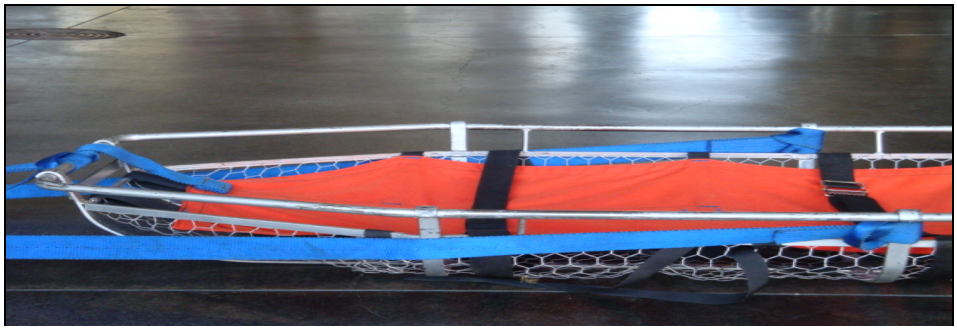
Step 2: Attach outside straps to the cross bar on the other side with a Larks Foot.

Step 3: Attach the adjustable strap around the horizonal tubing in the center of the head section with Larks Foot.

Step 4: Attach all straps to a carabiner on the collection plate.

Step 5: Adjust the adjustable strap to match the outside straps.

Stokes Litter Sling



Three Litter Tenders

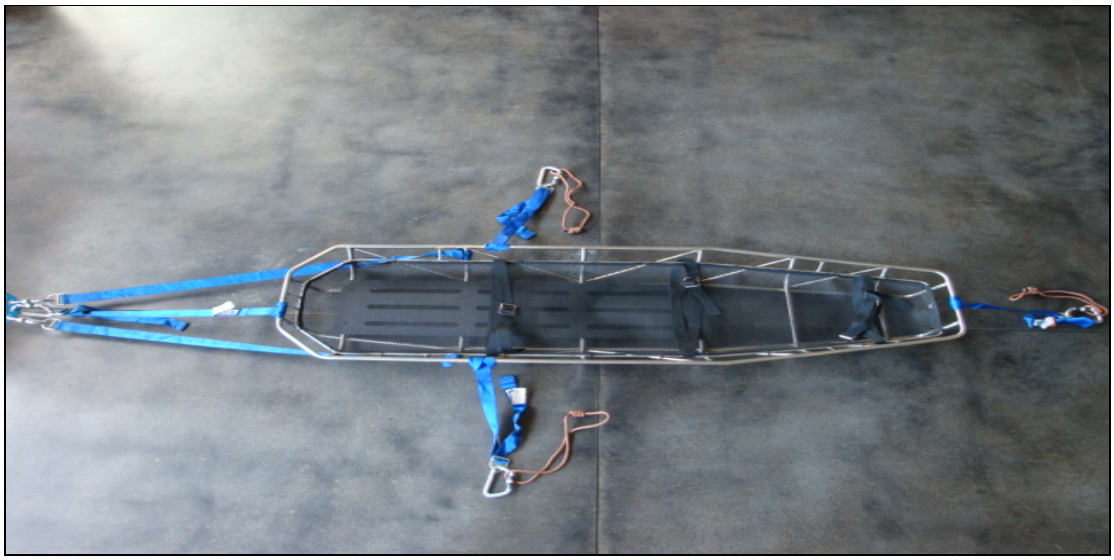
The three litter tender operation consists of an initial rescuer sent over for victim evaluation and two additional rescuers sent down with the litter and additional equipment for victim treatment and packaging. This is the ideal number of rescuers for most low-angle operations. This rigging can be accomplished with the equipment stored in the Stokes litter pre-rigging bag.

Step 1: Both the Main and Belay Lines are tied with an in-line knot, terminated with a Figure 8 on a Bight, (Long Tail Bowline.) Leave approximately 8 feet for the main and 12 feet of rope between the Long Tail Bowline and the Figure 8 on a Bight in the end of the rope.

Step 2: Connect the Low Angle Evacuation Stretcher Harness to the Stokes and attach it to the collection plate with carabiners.

Step 3: Connect the Stretcher Adjustable Straps to the Stokes top rail. These attachment to the rescues wait for the three rescuers positioned on either side of the litter and at the foot end. Use carabiners to connect to their seat harnesses.

Step 4: The Belay Line needs three, Three-Wrap Prusik Hitchs. These will be the secondary attchments point for the rescuers. Attch the Three-Wrap Prusik Hich with a carabiner to the rescuers chest attachment point.



Four Litter Tenders

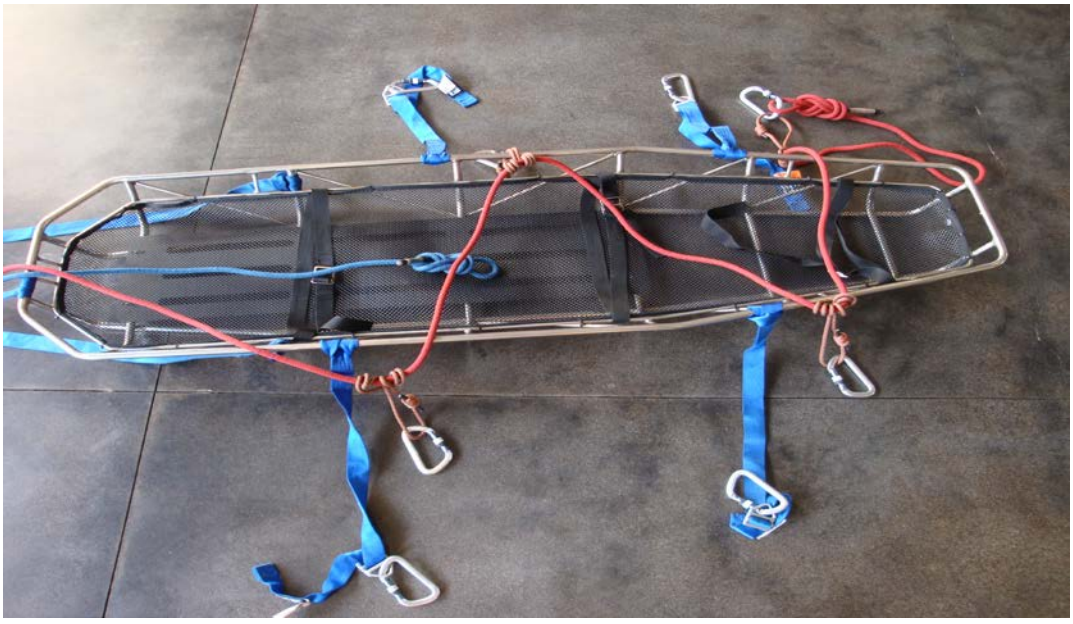
Step 1: Both the Main and Belay Lines are tied with an in-line knot, terminated with a Figure 8 on a Bight, (Long Tail Bowline.) Leave approximately 8 feet for the main and 12 feet of rope between the Long Tail Bowline and the Figure 8 on a Bight in the end of the rope.

Step 2: Connect the Low Angle Evacuation Stretcher Harness to the Stokes and attach it to the collection plate with carabiners.

Step 3: Connect the Stretcher Adjustable Straps to the Stokes top rail. These attachment to the rescues wait for the three rescuers positioned on either side of the litter and at the foot end. Use carabiners to connect to their seat harnesses.

Step 4: The Belay Line needs four, Three-Wrap Prusik Hitchs. These will be the secondary attchments point for the rescuers. Attch the Three-Wrap Prusik Hich with a carabiner to the rescuers chest attachment point.

Step 5: Repeat Step 4 for the left side.



High-Angle Stokes Rigging

In the high-angle environment, the Stokes Litter can be rigged in either a horizontal or vertical position. The Stokes can be rigged with or without an attendant (rescuer) in either position. This rigging is constructed before the litter is put into operation so the rescuer can focus on patient care and packaging.

The Stokes Litter Pre-rig bag includes the equipment needed to connect the Stokes litter to the Main and Belay Lines for either a low-angle scree-evac or high-angle vertical or horizontal operation.

See Chapter 4, Rope Kit Organization for the Stokes Litter Pre-rig bag inventory.

A Main and Belay Line shall be used whenever a victim is attached to the system.

High-Angle Stokes Rigging

Main and Belay Attachment

Although there are many ways to attach the Stokes litter and rescuer to the Main and Belay Line, in order to standardize the system attachment, the following connections will be the Department standard.

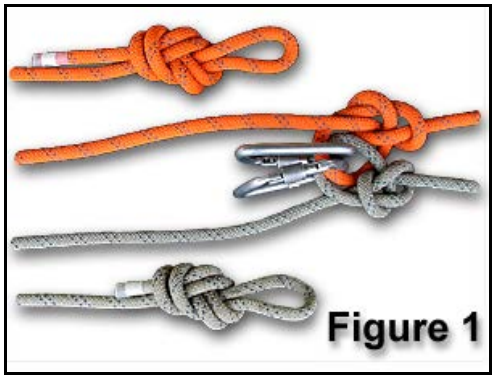


Figure 1

Step 1: Both the Main and Belay Lines are tied with an in-line knot, terminated with a Figure 8 on a Bight. **Figure 1**(*Long-tail Bowlines (shown)*

Step 2: Leave approximately 6' - 10' of rope between the in-line knot and the Figure 8 on a Bight in the end of the rope.

Both rescuer and victim must have <u>two</u> points of attachment to the system to maintain the appropriate safety factor.

Step 3: Connect the in-line knots to the Steel O-ring with two carabiners.

Step 4: The end of the Main Line is attached to the victim's harness or interior pelvic lashing.

Step 5: Attach a Three-Wrap Prusik Hitch to the Main and Belay Line.

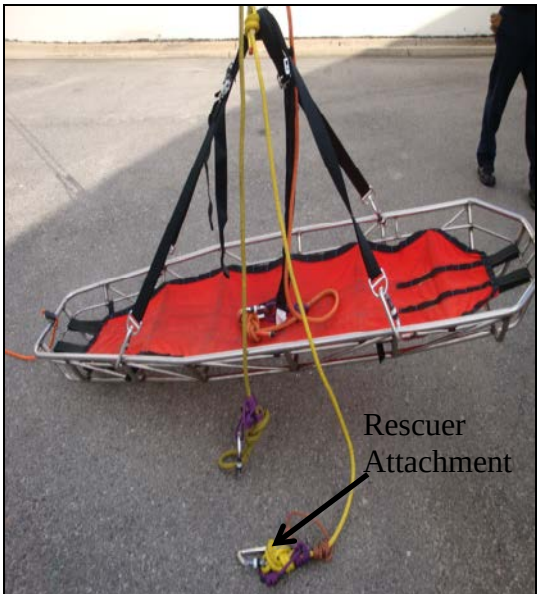
Step 5: The end of the Belay Line is attached to the rescuer and continues to serve as the rescuer's Belay Line.

Note: *If no rescuer is tending the Stokes, the Belay Line is also attached to the victim's harness or interior pelvic lashing.*


Main and Belay attached to rigging plate

Tender Line

When a rescuer is tending the Stokes litter, an additional Tender line is attached. The Tender line provides a main attachment point for the rescuer and is also designed to allow for position adjustment during lowering or raising operations.



The Tender Line is a 10’ length of rope with a Double Overhand Knot at the Steel O-ring and a Figure 8 on a Bight at the bottom end. Two Three-Wrap Prusik Hitches are attached to the line. The higher Three-Wrap Prusik Hitch is connected to the Rescuer’s seat harness D-ring. The lower Three-Wrap Prusik Hitch to adjust position, the rescuer.

If no adjustment is anticipated, this line can be omitted. For a second point of attachment, attach a Three-Wrap Prusik Hitch to the Main Line and connect to the rescuer’s harness with a carabiner.

Tender line

Barf Line (Optional)

A pre-rigged Barf Line can be used in a horizontal Stokes operation to assist the rescuer in tilting the litter of a nauseated patient. The Stokes litter should be positioned with the head of the litter on the rescuer's ***right side***. This places the victim in a left lateral position when vomiting and reduces the chances of aspiration. Clear the victim's airway before returning the litter to a supine position.

Step 1: Tie a Figure 8 on a Bight on the end of a short utility rope.

Step 2: Connect this knot to the litter with a carabiner.

Step 3: Run the rope through a carabiner or pulley (shown) attached to the rigging plate Steel O-ring. *This acts as a fulcrum when tilting the Stokes litter.*

Step 4: A Three-Wrap Prusik Hitch is tied near the other end of the rope.

Barf Line

Step 5: A Figure 8 Follow-Through is tied through the Prusik Hitch to form an adjustable foot loop for the rescuer. *When connected, the rescuer steps into the adjustable foot loop, causing the litter to tilt towards them.*

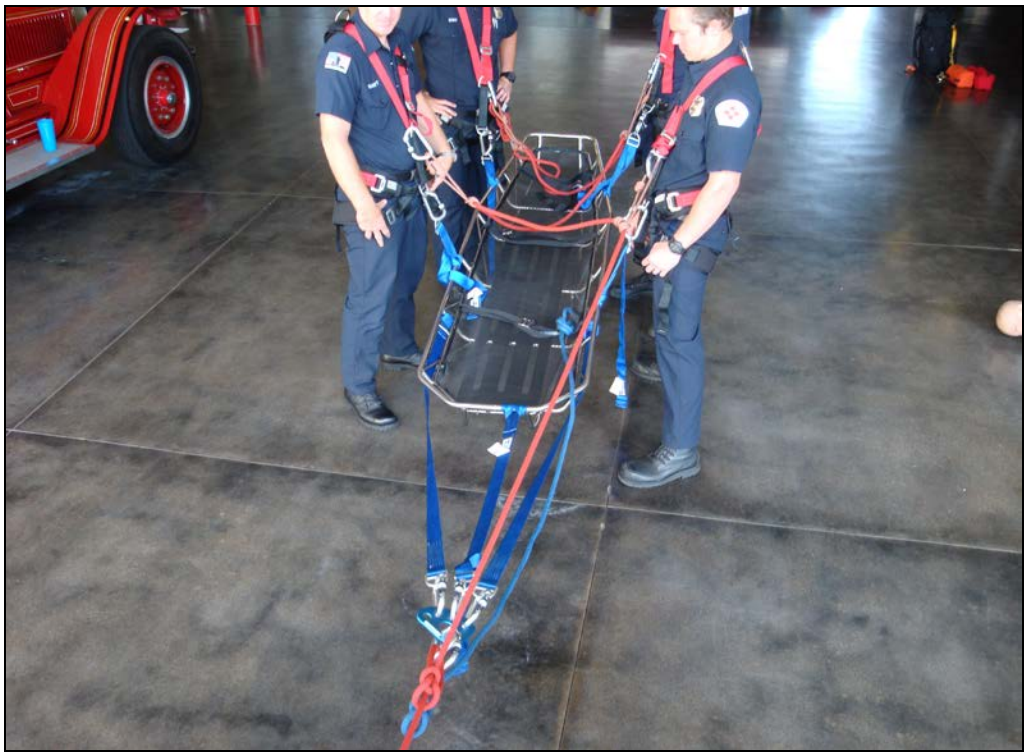
If the Stokes litter harnesses need adjusting during an operation due to terrain changes, the Barf line can be used to de-tension the individual harness line.

Step 1: The rescuer removes the carabiner attached to the litter, and re-attaches it close to the harness line that needs adjustment.

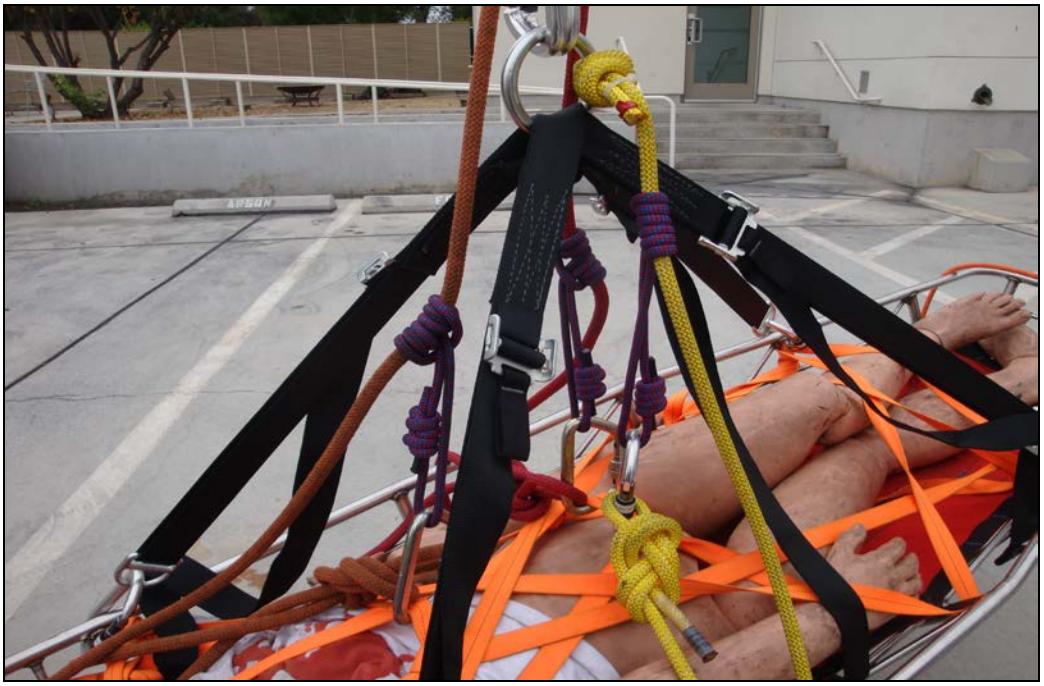
Step 2: Follow the same procedure for tilting the litter as above.

Step 3: Adjust the Stokes harness up or down depending on what is needed.

3 Litter Tenders – Stokes Stretcher Straps (Blue), Belay Line (Red) and Main Line (Blue)



4 Litter Tenders – Stokes Stretcher Straps (Blue), Belay Line (Red) and Main Line (Blue)



Horizontal Stokes Rigging with out a Rescuer

Horizontal Stokes Rigging with a Rescuer

Horizontal Stokes Rigging with a Rescuer

Suspension Trauma

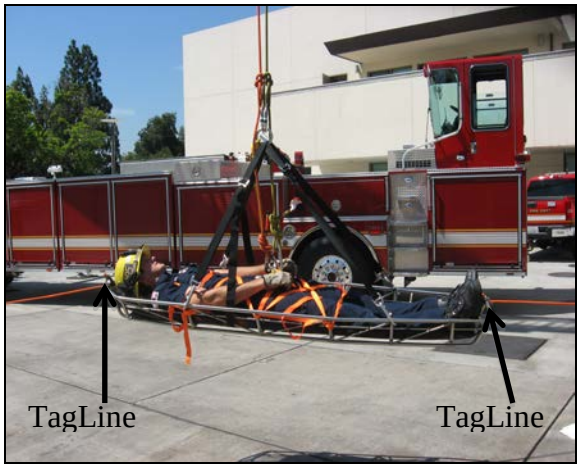
Vertical positioning of the rescuer or victim should be considered as a last resort choice. Being suspended in this position for only a few minutes can have severe medical complications including unconsciousness or death. This is due to the body position being held in a totally vertical position decreasing blood flow return to the heart from the lower extremities. However, there are times when this is the only option for rescue. All personnel should practice correct harness application to prevent this from occurring.

Tender Line as Main Attachment

Horizontal Stokes rigging with a Rescuer

Taglines

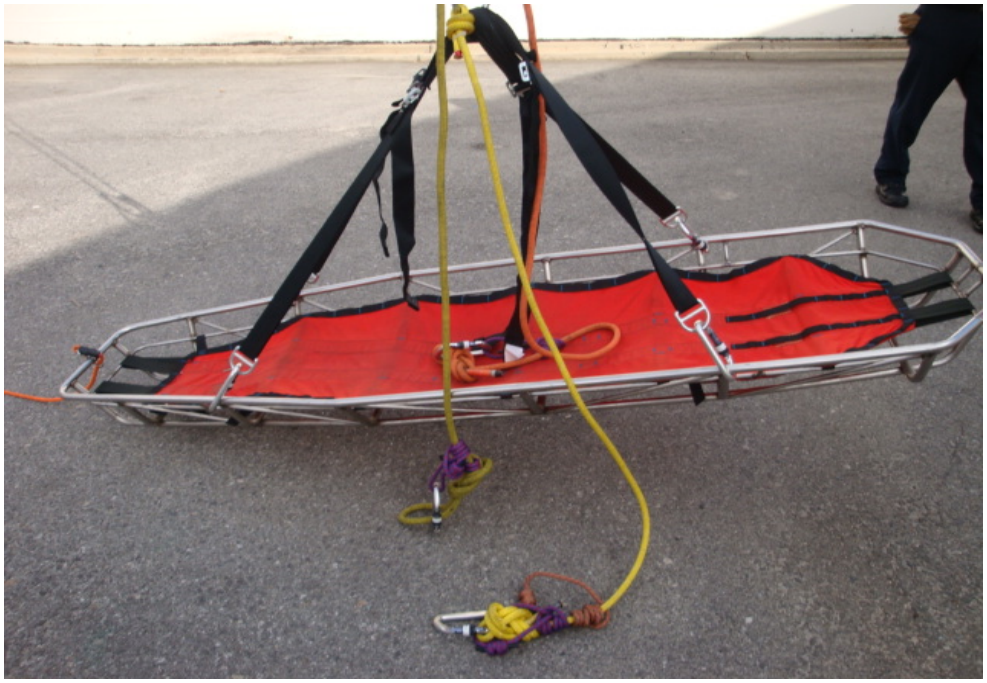
When the Stokes is unattended or attended and positioned horizontally, a 200' Lifeline attached to each end of the Stokes guides and stabilizes the litter during movement. They can also be used to keep a Stokes away from the terrain to avoid getting caught as it travels.



Taglines attached to Horizontal Stokes litter

When the Stokes is unattended and positioned vertically, a 200' Lifeline attached to the foot end of the Stokes will guide and stabilize the litter during movement. They can also be used to keep a Stokes away from the terrain to avoid getting caught as it travels.


Tagline attached to Vertictal Stokes litter



Horizontal Stokes rigging with and without Attendant

Vertical Stokes rigging without Attendant

Chapter 11
Patient Packaging

Victim Lashings For Stokes Litters

Victim lashing is usually the most time consuming part of the rescue. Unlike the rigging of the entire rescue system, victim lashing is usually performed by one or two rescuers, many times in difficult areas. In order to expedite this, the lashing should be kept to the minimum needed for that particular rescue while still maintaining safety. Also, refresher training is a must, as this skill is easily lost.

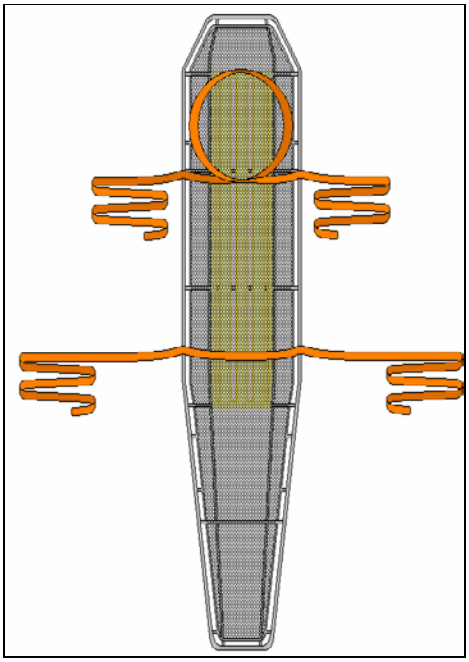
In the lesson below, the pelvic, chest and external lashing are shown separately. Each victim lashing should be tailored to a particular rescue situation. For example, on the ordinary low-angle scree-evac, a pelvic harness and exterior lashing may be all that is necessary. This would include scree-evacs, trench rescue and ladder rescues utilizing the Stokes litter.

For a high-angle Stokes lift, all three lashings should be used together to ensure the patient doesn't move within the litter during rescue.

How To Lash A Patient Into The Stokes Litter

Preparation

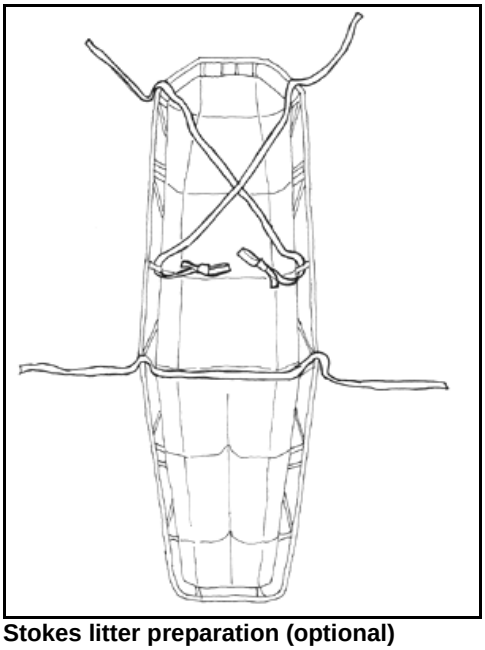
Prepare the chest lashing by forming an 18” loop in the middle of a 20’ webbing and lay it in the litter so that the top of the loop is where the top of the victims head will be. Prepare the pelvic lashing by draping an additional 20’ webbing across the middle of the Stokes litter as shown.



Stokes litter preparation

Preparation (optional)

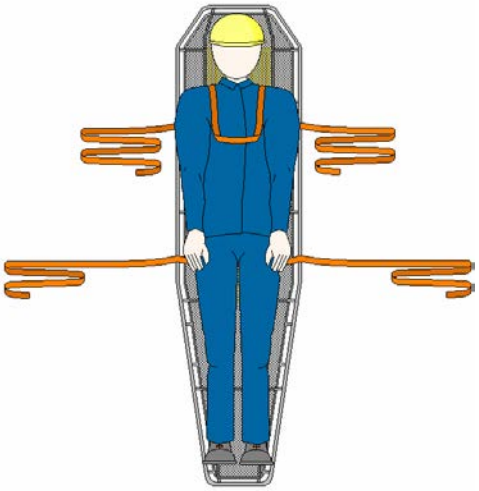
Prepare the chest lashing by crossing two 20’ webbings with an Overhand on a Bight tied in each. Prepare the pelvic lashing by draping an additional 20’ webbing across the middle of the Stokes as shown.



Stokes litter preparation (optional)

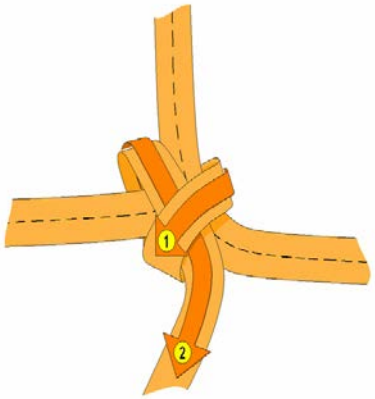
Interior Lashing

Chest Lashing



The chest lashing is necessary when the possibility exists that the Stokes litter could be tipped with the patients' head down. The lashing is designed to keep the patient from sliding toward the head of the litter.

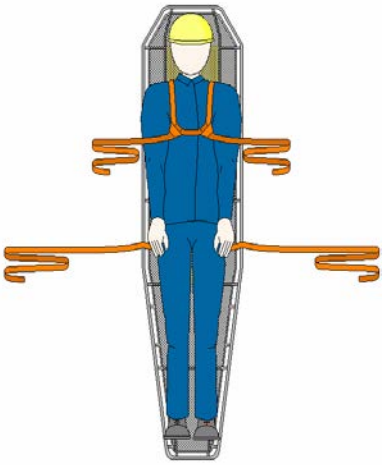
To Tie The Chest Lashing



Step 1: Form an 18" loop in the middle of a 20' webbing and lay it in the litter so that the top of the loop is where the top of the victim's head will be.

Step 2: Place the victim in the Stokes litter.

Step 3: Pass the loop over the victim's head to the nipple line.



Step 4: Wrap the webbing ends under each arm and pass through the loop at the chest.

Step 5: Remove slack ensuring crossed webbing at the victim's shoulder blades does not ride up on the neck.

Step 6: Tie an Overhand Knot in the webbing around the loop at the point it passes over the nipples on each side.

Step 7: Tie a round turn and two Half Hitches at the ends of the webbing around a rib below the victim's waist where the rib meets the main frame.

Pelvic Lashing

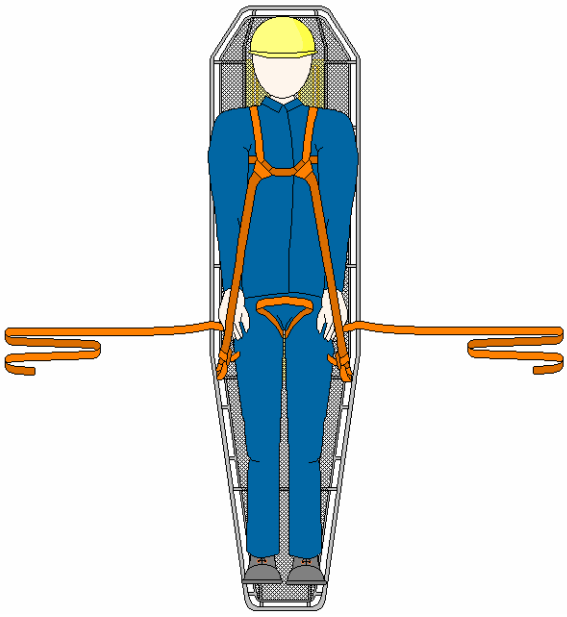
The pelvic lashing keeps the victim from sliding downward when secured in the Stokes litter. It is combined with the external lashing for low-angle scree-evac operations. It is combined with a chest lashing to complete the interior lashing and exterior lashing for high-angle operations.

To Tie The Pelvic Lashing:

Step 1: Pull midpoint of the webbing between legs up to victim's waist creating a 6" triangle.

Step 2: Pass ends of webbing around thighs and through triangle pulling up towards shoulders to remove slack.

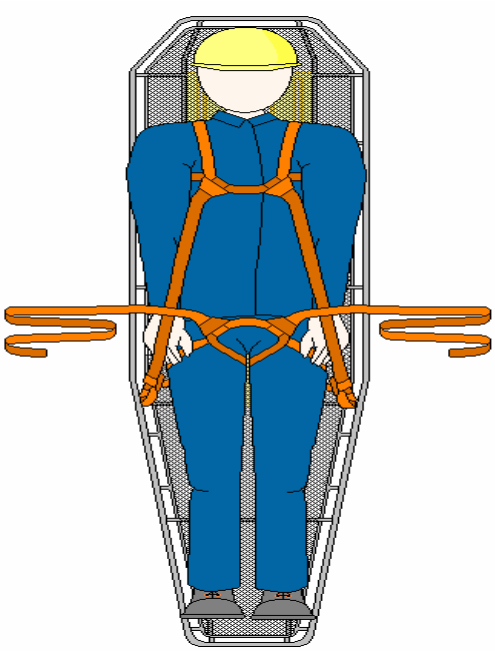
Step 3: Tie an overhand knot in the webbing on each side at the point it passes through the triangle.



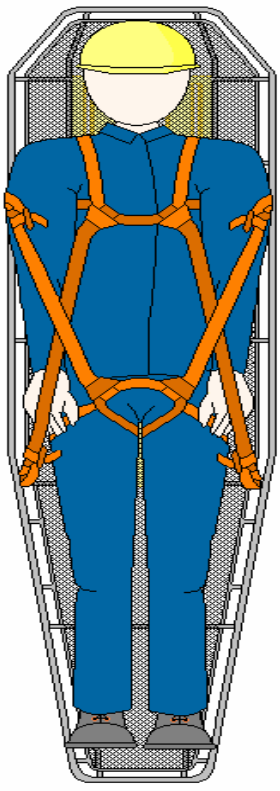
Interior pelvic lashing

To Tie The Pelvic Lashing Continue:

Step 4: Tie a round turn and two half hitches at the ends of the webbing around a rib near the victim's shoulders where the ribs meets the main frame.



Step 5: Keep even tension between the two ends of webbing when trying the knots.



Alternative Chest Lashing

This optional method has been used in the past and taught in previous versions of Rescue Systems 1. It requires two pieces of webbing for the chest harness. It is equally as secure as the current chest lashing and is designed to prevent the victim from sliding up towards the head during a high-angle operation. See Preparation (optional) in this chapter for diagram on how to prepare the Stokes litter chest lashing.

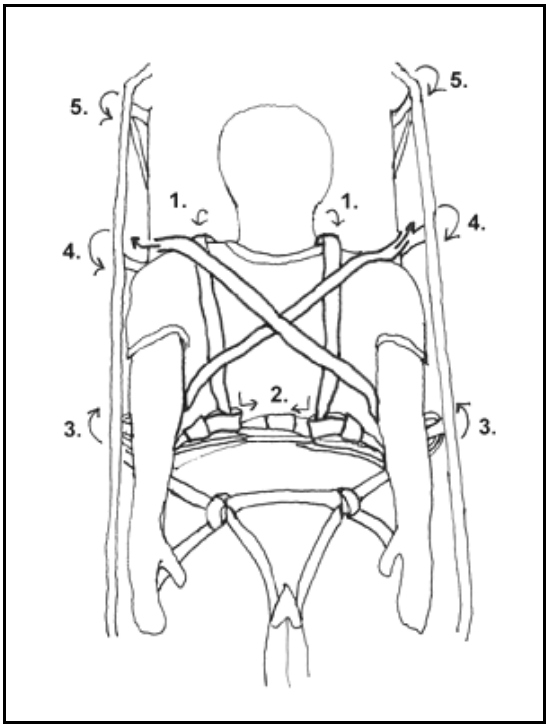
To Tie The Chest Lashing

Step 1: Bring the top of the webbing 'X' over the patient's shoulders.

Step 2: Feed the webbing through the pre-tied loops.

Step 3: Pull snug. (Evenly on each side) Then pass the webbing around the nearest vertical frame member below the Stokes rail.

Step 4: Cross the patient's chest and terminate each side of the lashing at points #4 or #5 with one round turn and two Half Hitches.

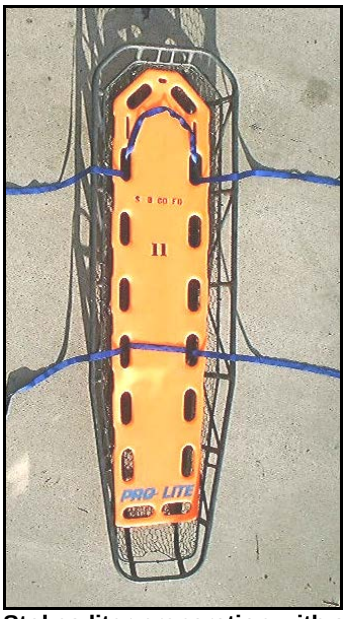


Alternate Chest Lashing

Interior Lashing with a Backboard

Preparation

Using a 20’ webbing, prepare the chest lashing by forming a complete loop around the backboard with the tails exiting the handholds at the level of the victim’s shoulders.



Stokes liter preparation with a Backboard

Step 1: Begin by passing one end down through the handhold, then beneath the backboard.

Step 2: Pull the end up through the handhold on the opposite side.

Step 3: Come back over the board and down through the first handhold again.

Step 4: Pull the end up through the handhold on the opposite side again. Even out the tails.

Repeat the same procedure at the level of the victim’s waist with an additional 20’ webbing for the pelvic lashing.
Before placing the victim on the backboard, pull slack in the both of the loops lying on the top of the backboard.

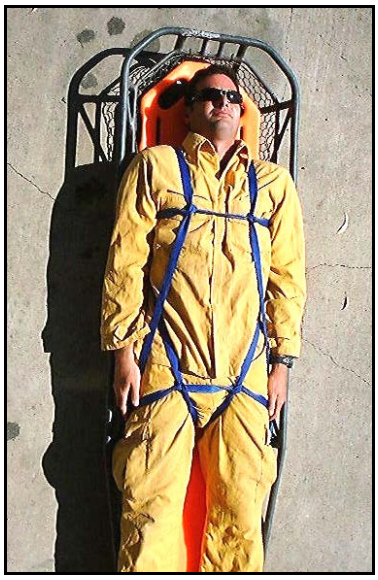
To Tie The Chest Lashing

Refer to the Chest Lashing procedure on page 4 of this chapter.

To Tie The Pelvic Lashing

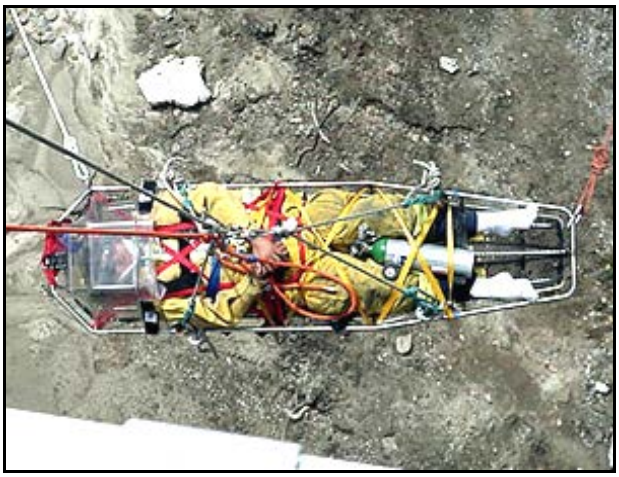
Refer to the Pelvic Lashing procedure on page 3 of this chapter.

Note: The tie-off of all lashings remains attached to the Stokes litter, incorporating the backboard and Stokes together.



Exterior Lashing

One or two rescuers usually perform external lashing. In the picture shown, the victim is secured by all three lashings. The external lashing's primary function is to keep the victim within the confines of the Stokes litter.



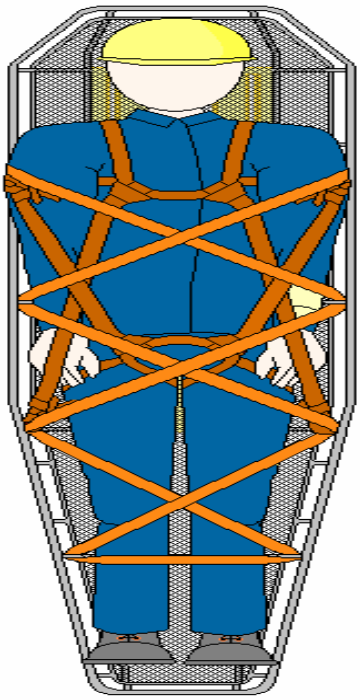
To Tie The Exterior Lashing:

Step 1: Lay a section of 20' webbing across the victim's legs, locating the midpoint of the webbing between the knees of the victim.

Step 2: Working simultaneously with a partner, weave the webbing through the Stokes litter as shown using the vertical supports as pivot points.

Step 3: Tie-off one side with one round-turn and two Half Hitches.

Step 4: Working backwards, pull the slack through the lashing, until the other end of the webbing is reached.



Exterior Lashing

Step 5: Tie-off the other side with the same knot. Ensure the webbing is snug over the patient without constricting vital functions or aggravating injuries.

Chapter 12
Low-Angle Operations

Low-Angle Scree-Evac

Very often in low-angle rescues the terrain isn't steep enough to warrant a full rappel line but minor assistance may be needed to stabilize rescuers as they walk down a slope. The use of rescue rope as a hand line in these situations is also acceptable. The objective is to quickly and safely get rescuers to the victims. Training, experience and common sense will dictate what system, if any, needs to be utilized in a scree-evac. If rescuers can safely walk down, then do so. In most cases though, a rope system will be needed to bring the packaged patient in the Stokes back up the incline, even in low-angle scree-evac situations.

While rescuer judgment will decide what will and will not be used, a few rules must be followed:

- The patient must have a Belay Line (2 rope system).
- Four persons max, including patient, on a slope of 45º or less.

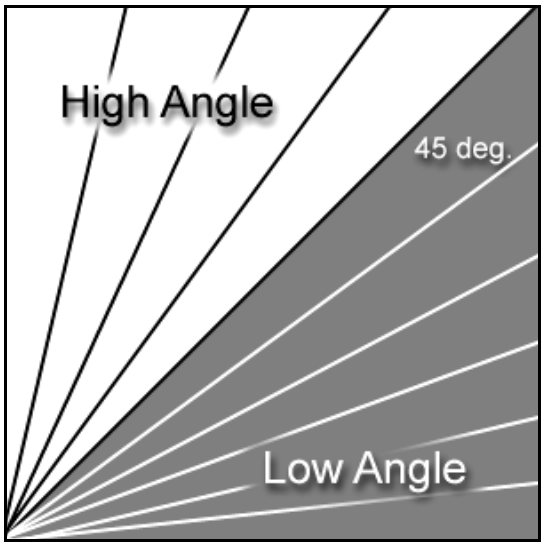
The following are reminders that will make the rescue fast, efficient, and easier on both the rescuers and patient:

- Rig the Main Line on a bombproof, high directional anchor if possible to ease the angle of the edge transition.
- In a three rescuer Stokes evolution, place the tallest/heaviest attendant at the rear of the Stokes.
- Let the system pull you up the slope; lean back against the rope system.

The reason for rigging the Main Line on a high anchor is to avoid the Stokes litter, rescuers, and victim from being pulled into the ground as they try and clear the edge. If the Main Line must be anchored low, use two edge men to lift (vector) the Main Line as the Stokes litter and attendants traverse the edge. After the rescue team is over the side, lower the line into its edge protection slowly. Reverse the process when the attendant(s) return with the victim.

A tall/heavy attendant on the rear of the Stokes acts as a counterweight when they lean back, relieving some of the stress on the other attendants. With all attendants leaning back, the rope system takes the load, as opposed to trying to carry the Stokes litter up the slope.

Low-Angle / High-Angle



In this text, and in Department operations, low-angle rope rescues are those rescues where most of the system load remains on the ground (less than a 45º angle, 0º is level ground). High-angle rope rescues are those rescues where most of the system load rests on the rope system (steeper than 45º angle).

While in the field, use the following question to assist in determining whether to use a Belay Line in a low-angle environment:

If, while mid-slope, you fell, what would happen?

If you fell without sliding down any farther, you are in a low-angle environment. A single rope may be used for patient access.

If you fell and continued sliding down the hill, a Belay Line should be added at the beginning of the operation before descent.

***Remember*: A Belay Line (second rope) *shall always* be used whenever a patient is attached to the system.**

Low-Angle Operations for a Non-Ambulatory Victim

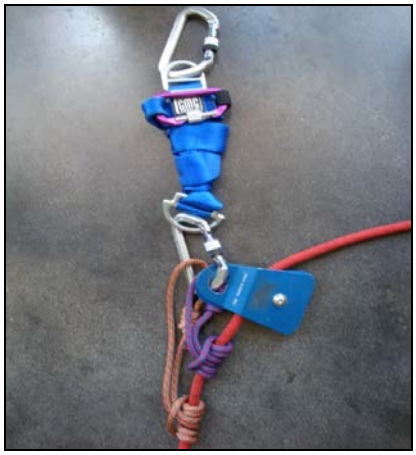
Step 1: **Locate anchor(s) near the point of departure.** See Chapter 6 for information on anchors.

Step 2: **Attach an anchor sling for the Main Line and one for the Belay Line.** See Chapter 6 for information on anchor systems.

Step 3: **Connect the Main Line Pre-rigging to the main anchor.** See Chapter 4 for information on Main Line pre-rigging systems.

Step 4: **Reeve the Main Line through the Brake Bar Rack.** If *rappelling*, leave min. 50’ at the main anchor (for raising system later), lock off the Brake Bar Rack, send the remaining rope down with the rescuer. If *lowering*, a Main Line attendant must tend the Brake Bar Rack during the operation. See Chapter 8 for information on reeving friction devices.

Step 5: **Connect the Belay Pre-rigging to the belay anchor.** See Chapter 4 for information on Belay Line pre-rigging systems.



Step 6: **Package rescuer:**

- Don Class 3 harness.
- Attach Main Line to Rescuer's waist and Belay Line to rescuer's chest on the harness.

Step 7: **Perform safety checks.** Check each component of the system (i.e. knots tied correctly, carabiners locked, etc.), beginning at the anchors and finishing at the rescuer.

Step 8: **Lower the rescuer *or* rappel down the slope to the victim.** Rescuer may disconnect from the system if in a safe location. If not, rescuer remains tied to the system.

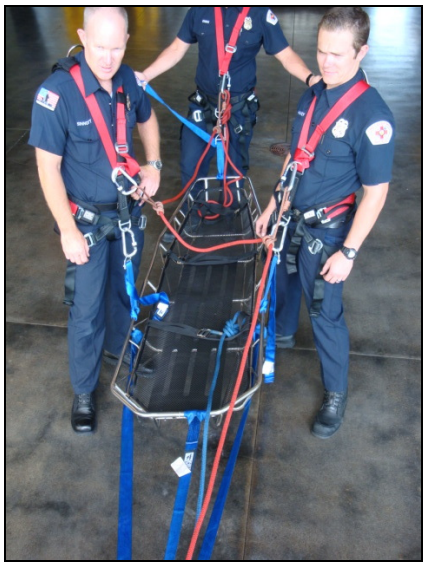
Step 9: **Lock off the lowering system.** See Chapter 7 for information on locking off friction devices.

Step 10: **Rescuer assesses victim status.** Determine number of victims and further rescue needs. Rescuer requests additional personnel and equipment.

Step 11a: Pull up Main and Belay Lines if rescuer is disconnected.

Step 11b: Establish a second Main and Belay Line if rescuer cannot disconnect from original system.

Step 12: Rig system with additional personnel and Stokes litter. See Chapter 13 for information on low-angle Stokes rigging.

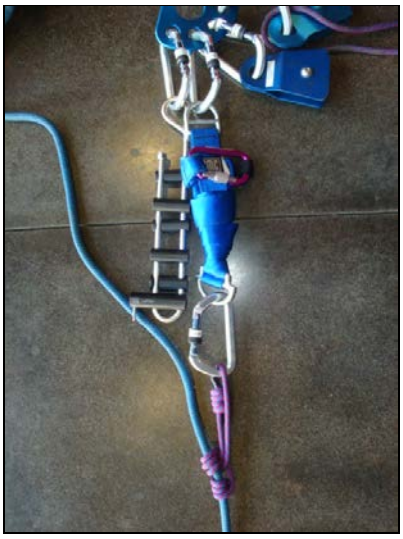


Step 13: Lower additional personnel and Stokes litter to victim. This step can be done as part of an initial 3 or 4 person lowering system. However, patient access with one rescuer should not be delayed for this additional rigging.

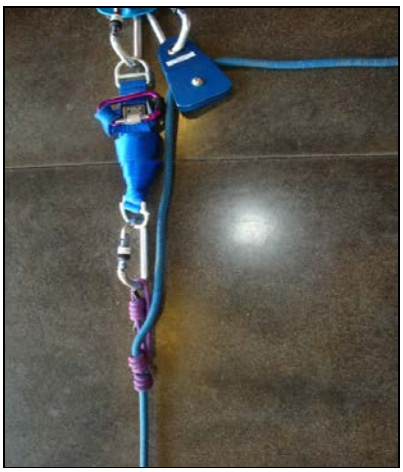
Step 14: Package the victim. See Chapter 12 for information on patient packaging.

Step 15: **Change the lowering system over to a raising system by capturing the Main Line with a Prusik.** Use the change-over equipment attached to the Main line collection plate. Attach a three-wrap Prusik Hitch onto the Main Line. Use the Mariners Load Release Strap to extend around the Brake Bar Rack and connect to Prusik Hitch with the carabiner.

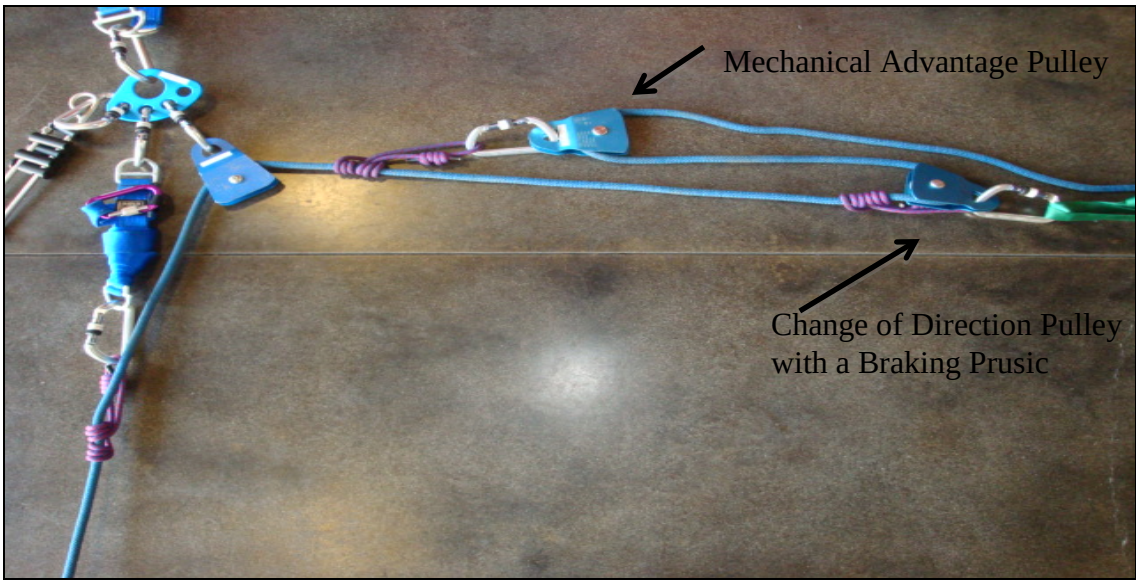
Step 16: **Untie and remove the Brake Bar Rack from the system.**



Step 17: **Reeve a Change-of-Direction Pulley onto the Main Line at the main anchor.** This step can be omitted if the distance between the main anchor and the point of departure (edge) is sufficient to build the raising system.

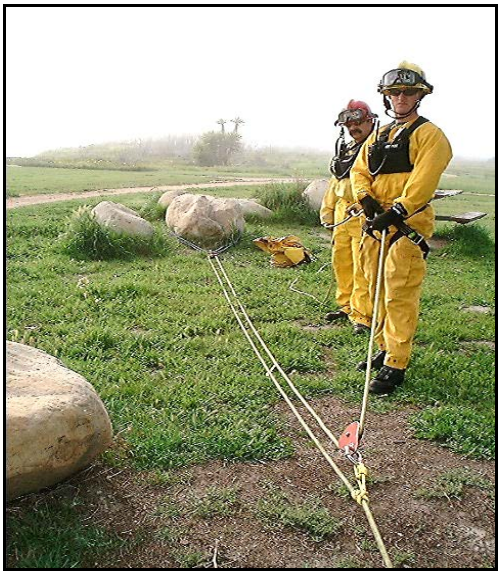


Step 18: **Use the 3:1 Z-rig equipment to build a raising system.** This equipment is pre-connected to the Main Line collection plate. Use a single Three-Wrap Prusik Hitch, carabiner and Prusik minding pulley at the next anchor point (Connect this equipment directly to the main anchor if omitting step 17). Use the other Prusik, carabiner and pulley as the mechanical advantage pulley to build the Z-system.

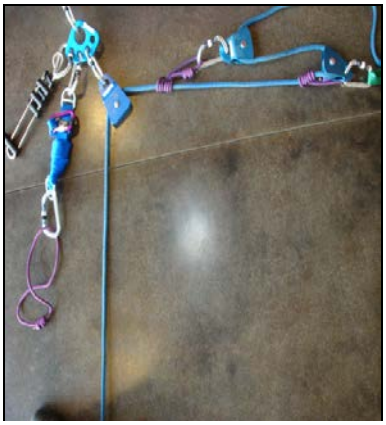


Step 19: **Perform safety checks.** *This should be done anytime a significant change has occurred in the system (i.e. change-over).*

Step 20: **Begin raising the rescuers and victim up with the rescuers assisting the victim.** The haul team should walk back with the rope until the 3:1 Z-system is fully collapsed. Ensure the Prusik Brake is set. Extend the 3:1 Z-system out as far as possible. Continue to haul.



Step 21: Remove the Change-over Prusik as it becomes slack when the haul team begins to pull up on the rope. The haul team pauses after pulling up the first few feet of rope of the system. Once the Prusik is removed, the haul team continues to raise the system.



Step 22: Keep tension on the Belay Line by pulling the rope through the Prusik minding pulley at an angle that allows the pulley to tend the Tandem Prusiks.

Step 23: Continue raising until the rescue team is brought to the top.

Low-Angle Operations for an Ambulatory Victim

Step 1: **Locate anchor(s) near the point of departure.** See Chapter 6 for information on anchors.

Step 2: **Attach an anchor sling for the Main Line and one for the Belay Line.** See Chapter 6 for information on anchor systems.

Step 3: **Connect the Main Line Pre-rigging to the main anchor.** See Chapter 4 for information on Main Line pre-rigging systems.

Step 4: **Reeve the Main Line through the Brake Bar Rack for a lowering operation.** A Main Line attendant must tend the Brake Bar Rack during the operation. See Chapter 8 for information on reeving friction devices.

Step 5: **Connect the Belay Pre-rigging to the belay anchor.** See Chapter 6 for information on Belay Line pre-rigging systems.

Step 6: **Package rescuer:**

- Don Class 3 harness.
- Attach Main Line to Rescuer's waist and Belay Line to rescuer's chest on the harness.
- Attach a Three-Wrap Prusik Hitch to the Main Line and one to the Belay Line. Set the Prusiks about 3' from the rescuer.
- Attach the Victim Pick-Off bag and Cest harness to Rescuer.

Step 7: **Perform safety checks.** Check each component of the system (i.e. knots tied correctly, carabiners locked, etc.), beginning at the anchors and finishing at the rescuer.

Step 8: **Lower rescuer down until rescuer is slightly below the victim.** Rescuer should stay to one side of victim while being lowered in case loose debris is knocked loose. Rescuer should approach the victim with caution, encouraging the victim not to move.

Step 9: **Lock off the lowering system.** See Chapter 7 for information on locking off friction devices.

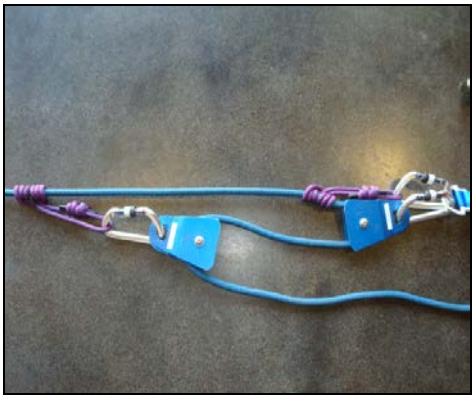
Step 10: **Package the victim.**

- Apply the Victim Pelvic Harness and Victim Chest Harness.
- Attach a Three-Wrap Prusik Hitch from the Main Line to victims waist and one from the Belay Line to victims chest. Set the Prusiks about 3' from the victim.
- Lock the carabiner.

Step 11: **If needed pull the loose end of the Pick-Off Strap to adjust the victim's position until the victim is set above the rescuer.** This allows the rescuer to control the victim's movement.

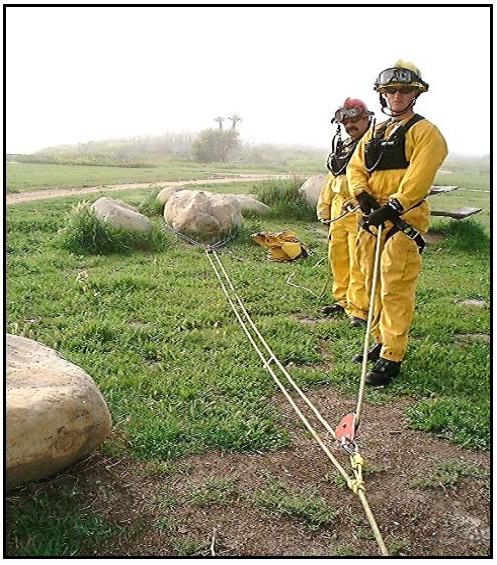
Step 12: Prepare to continue descent or change-over for a raising operation. *It is typically safer to continue lowering down if there is a safe location and access to get out at the bottom, since less time is usually spent on the system. However this may not be possible. Therefore, it may be required to raise the rescuer and victim back up.*

Step 12a: Reeve a Change-of-Direction Pulley onto the Main Line at the Load Release Strap. If the distance between the main anchor and the point of departure (edge) is sufficient to build the raising system.



Step 13: Perform safety checks. *This should be done anytime a significant change has occurred in the system (i.e. change-over).*

Step 14: Lower or raise the rescuer and victim to a safe location.



Rope Rescue Systems Safety Check

Each rope rescue system must be safety checked prior to operation. A safety check includes:

- All anchor components
- All Belay system components
- All Main Line components
- Rescuer/victim packaging

The safety check includes the following operations:

- A visual scan looking for properly tied knots and bends.
- Physically confirming all carabiners are properly aligned and locked by squeezing the gate.
- Touching each knot as you look at it, and turning it over to inspect it.

The safety check ensures that all parts of the system are properly assembled, tied, and secured. A member of the crew who has not constructed the component being checked performs the safety check.

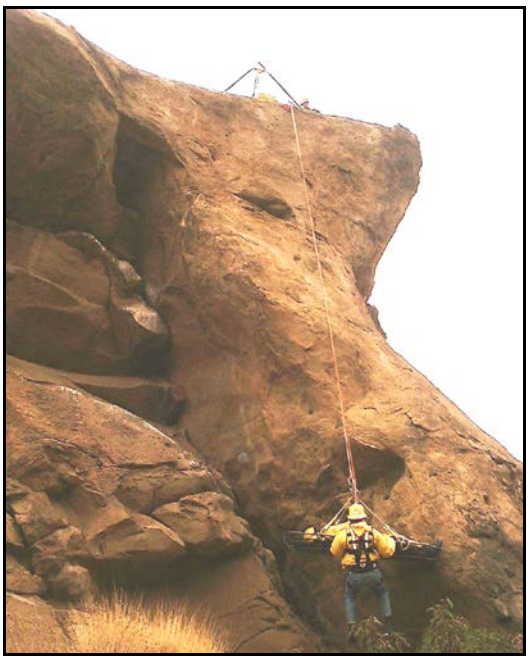
Additional Rigging considerations:

- Make knots small and neat.
- Keep the system organized and clean.
- Use edge protection whenever possible.
- Pre-tension and adjust the system before operating it.

Chapter 13
High-Angle Operations

High-Angle Operations

When working in a high-angle environment careful consideration must be given to the rigging and safety checks preformed prior to the system being put into operation. Many reference guides consider 40º - 60º slopes as steep angle and 60º and steeper as high-angle. However, with any slope over 45º, 100% of the load is supported by the rope system. Therefore, for the purposes of this manual and Department operations, high-angle is considered any slope steeper than 45º.



Due to this dependency on the rope system, redundancy is built into the system wherever necessary to improve rescuer and victim safety. This includes a Belay line which acts as a safety line in the event of a Main line failure.

***Remember*: A Belay Line (second rope) *shall always* be used whenever a patient is attached to the system.**

High-Angle Operations for a Non- Ambulatory Victim

Step 1: **Locate anchor(s) near the point of departure.** See Chapter 6 for information on anchors.

Step 2: **Attach an anchor sling for the Main Line and one for the Belay Line.** See Chapter 6 for information on anchor systems.

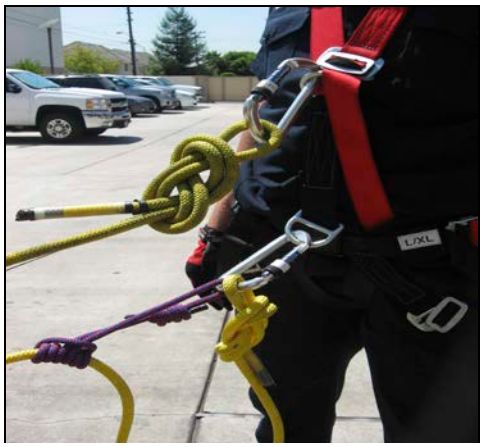
Step 3: **Connect the Main Line Pre-rigging to the main anchor.** See Chapter 4 for information on Main Line pre-rigging systems.

Step 4: **Reeve the Main Line through the Brake Bar Rack.** A Main Line attendant must tend the Brake Bar Rack during the operation. See Chapter 7 for information on reeving friction devices.

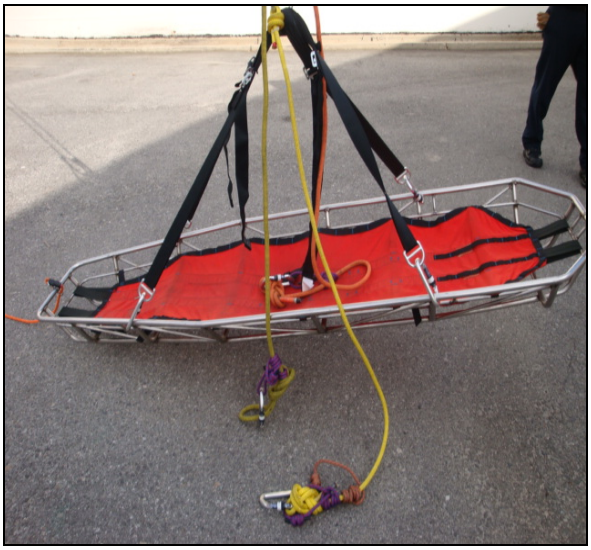
Step 5: **Connect the Belay Pre-rigging to the belay anchor.** See Chapter 4 for information on Belay Line pre-rigging systems.

Step 6: **Package rescuer:**

- Don Class 3 harness.
- Attach Tender Line to rescuer's seat harness.
- Attach Belay Line to rescuer's chest and harness.



Step 7: **Rig the Stokes litter for a high-angle operation with an attendant.** See Chapter 10 for information on high-angle rigging with an attendant.



Step 8: **Perform safety**

checks. Check each component of the system (i.e. knots tied correctly, carabiners locked, etc.), beginning at the anchors and finishing at the rescuer.

Step 9: **Lower the rescuer down to the victim.** Rescuer may disconnect from the system if in a safe location. If not, rescuer remains tied to the system.

Step 10: **Lock off the lowering system.** See Chapter 7 for information on locking off friction devices.

Step 11: **Rescuer assesses victim status.** Determine number of victims and further rescue needs. Rescuer requests additional personnel and equipment if needed.

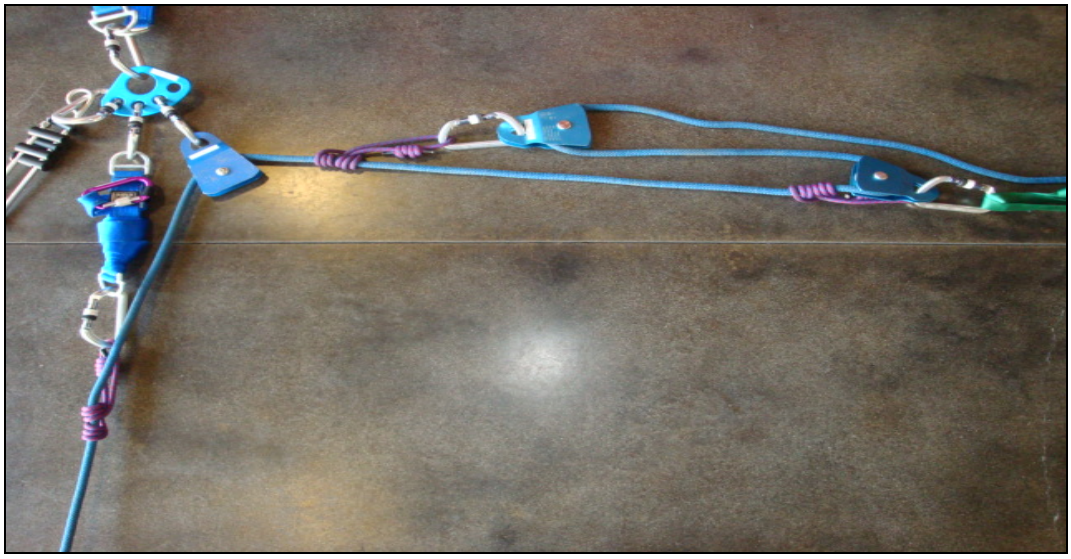
Step 12: Package the victim. See Chapter 12 for information on patient packaging.

Step 13: Change the lowering system over to a raising system by capturing the Main Line with a Prusik. Use the change over equipment attached to the Main Line rigging plate. Attach a Three-Wrap Prusik Hitch onto the Main Line. Use the doubled-looped 5' webbing to extend around the Brake Bar Rack and connect to Prusik Hitch with the carabiner.

Step 14: Untie and remove the Brake Bar Rack from the system.

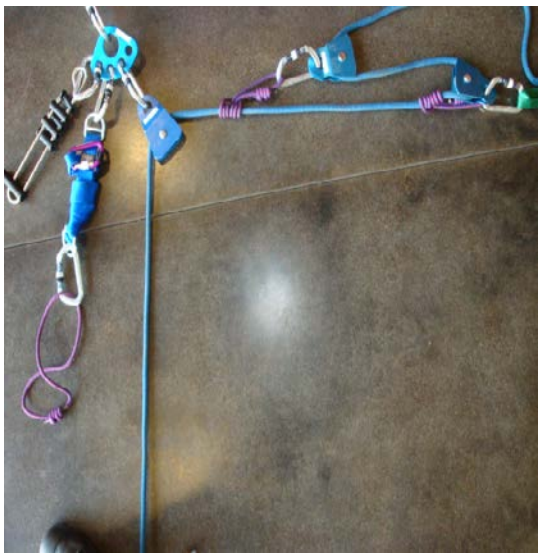
Step 15: Reeve a Change-of-Direction Pulley onto the Main Line at the main anchor. This step can be omitted if the distance between the main anchor and the point of departure (edge) is sufficient to build the raising system.

Step 16: Use the 3:1 Z-rig equipment to build a raising system. This equipment is pre-connected to the Main Line rigging plate. Use a single Three-Wrap Prusik Hitch, carabiner and Prusik minding pulley at the next anchor point (Connect this equipment directly to the main anchor if omitting step 15). Use the other Prusik, carabiner and pulley as the mechanical advantage pulley to build the Z-system.

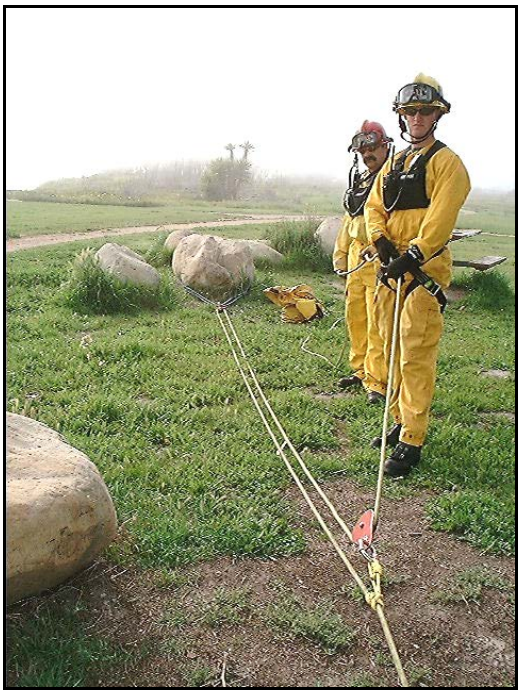


Step 17: Perform safety checks. *This should be done anytime a significant change has occurred in the system (i.e. change-over).*

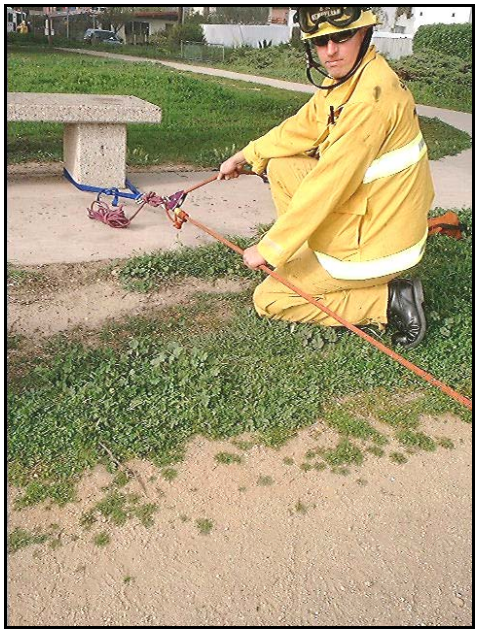
Step 18: Remove the Change-over Prusik as it becomes slack when the haul team begins to pull up on the rope. The haul team pauses after pulling up the first few feet of rope of the system. Once the Prusik is removed, the haul team continues to raise the system.



Step 18: **Begin raising the rescuer and victim up with the rescuer tending the Stokes.** The haul team should walk back with the rope until the 3:1 Z-system is fully collapsed. Ensure the Ratchet Prusik is set. Extend the 3:1 Z-system out as far as possible. Continue to haul until the rescue team is brought to the top.



Step 20: **Keep tension on the Belay Line by pulling the rope through the Prusik minding pulley at an angle that allows the pulley to tend the Tandem Prusiks.**



High-Angle Pick-Off of an Ambulatory Victim - Lowering

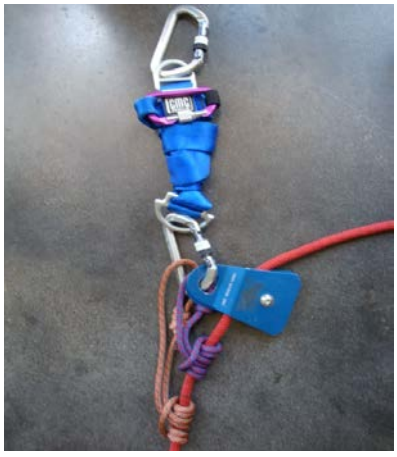
Step 1: **Locate anchor(s) near the point of departure.** See Chapter 6 for information on anchors.

Step 2: **Attach an anchor sling for the Main Line and one for the Belay Line.** See Chapter 6 for information on anchor systems.

Step 3: **Connect the Main Line Pre-rigging to the main anchor.** See Chapter 4 for information on main line pre-rigging systems.

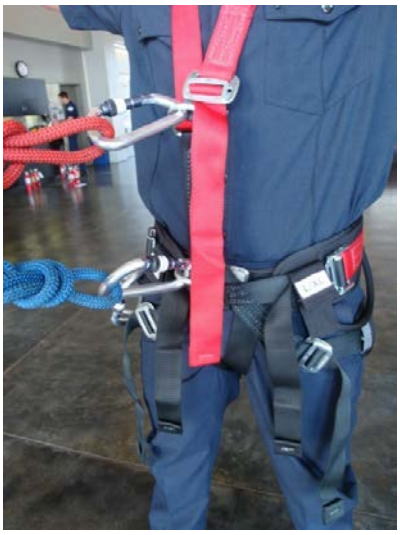
Step 4: **Reeve the Main Line through the Brake Bar Rack for a lowering operation.** A Main Line attendant must tend the Brake Bar Rack during the operation. See Chapter 7 for information on reeving friction devices.

Step 5: **Connect the Belay Pre-rigging to the belay anchor.** See Chapter 4 for information on Belay Line pre-rigging systems.



Step 6: **Rescuer packaging:**

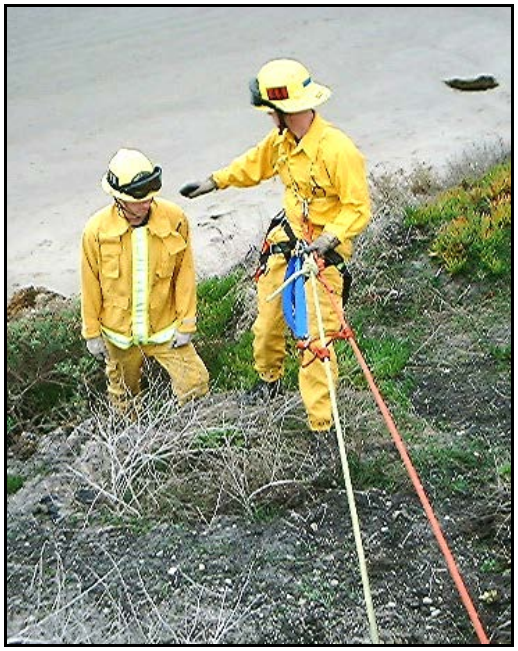
- Don a Class III harness.
- Attach Main Line to rescuer's waist connection.
- Attach Belay Line to rescuer's chest connection.
- Attach a Three-Wrap Prusik Hitch to the Main Line and one to the Belay Line. Set the prusiks about 3' from the rescuer.
- Each Three-Wrap Prusik Hitch gets it's own carabineer.
- Attach the Victim Chest Harness to Belay Three-Wrap Prusik Hitches carabineer.
- Do not lock these carabiner. It will allow a quicker attachment to the victim's Chest and Seat harness.



Engine Co. Rescuer Packaging

Step 7: **Perform safety checks.** Check each component of the system (i.e. knots tied correctly, carabiners locked, etc.), beginning at the anchors and finishing at the rescuer.

Step 8: **Lower rescuer down until rescuer is slightly below the victim.** Rescuer should stay to one side of victim while being lowered in case loose debris is knocked loose. Rescuer should approach the victim with caution, encouraging the victim not to move.



Step 9: **Lock off the lowering system.** See Chapter 7 for information on locking off friction devices.

Step 10: Package the victim.

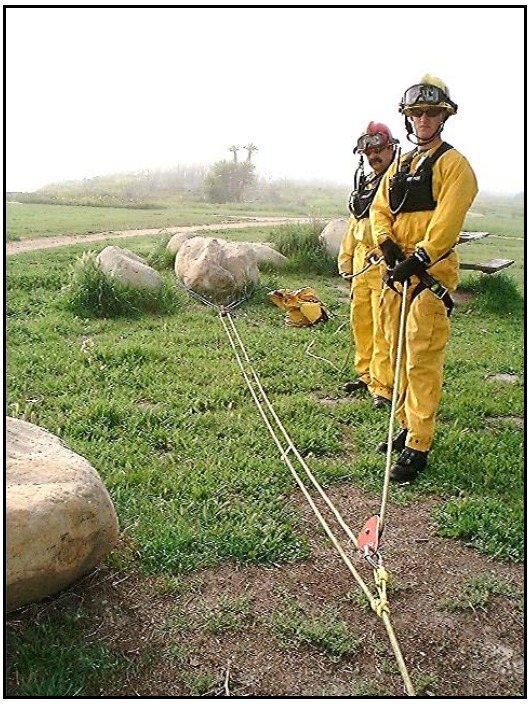
- Apply the hasty harness or victim harness.
- Remove the D-Ring end of the Pick-off Strap from the rescuer's harness and connect it to the victim's harness.
- Lock the carabiner.

Step 11: Pull the loose end of the Pick-off Strap to adjust the victim's position until the victim is set above the rescuer. This allows the rescuer to control the victim's movement.

Step 12: Prepare to continue descent or change-over for a raising operation. *It is typically safer to continue lowering down if there is a safe location and access to get out at the bottom, since less time is usually spent on the system. However this may not be possible. Therefore, it may require the rescuer and victim be raised back up.*

Step 13: Perform safety checks. *This should be done anytime a significant change has occurred in the system (i.e. change-over).*

Step 14: Lower or raise the rescuer and victim to a safe location.



High-Angle Pick-Off of an Ambulatory Victim - Rappel

The procedure for performing a Rappel Pick-Off operation is the same as the procedure for a Lowering Pick-Off operation with the following exceptions:

1) It is assumed that the rescuer will continue on a descent to the ground below after the victim has been secured to the system.

2) The rescuer will lowered using a Brake Bar Rack since they will likely need to add friction once the victim's weight is added to the system.

3) The victim will be secured to the Main and Belay Line via the Pick-Off Bag and Chest Harness. They will be attached to a fixed position on the Main Line and Belay Line and continue the lowering operation

Rope Rescue Systems Safety Check

Each rope rescue system must be safety checked prior to operation. A safety check includes:

- All anchor components
- All Belay systems components
- All Main Line components
- Rescuer/victim packaging

The safety check includes the following operations:

- A visual scan looking for properly tied knots and bends.
- Physically confirming all carabiners are properly aligned and locked by squeezing the gate.
- Touching each knot as you look at it, and turning it over to inspect it.

The safety check ensures that all parts of the system are properly assembled, tied, and secured. A member of the crew who has not constructed the component being checked performs the safety check.

Chapter 14
Aerial Ladder Operations

Overview

Aerial apparatus can be used in rope rescue to facilitate difficult or technically challenging operations. There are three basic rigging options when using an aerial ladder. First the aerial can be used as a High Directional Anchor (HDA), providing a change of direction for over-the-side operations to facilitate an easier edge transition. In the second operation, the aerial is used similar to a crane. Static lines are rigged from the tip of the aerial to the Stokes litter and the aerial is operated as if it were a crane. The third operation, called the Flying Stokes, the aerial ladder is used for gaining access to victims in difficult locations. This operation involves rigging a Main and Belay Line over the aerial ladder rungs and tying them off. They can be put into service as a lowering system in the event the aerial ladder tip cannot reach the ground due to limited space. A combination of any of the three evolutions may also be used.

It is important to keep in mind the tip load of the Aerial apparatus that is being used. This tip load ***should never*** be exceeded. The tip load of Truck 105 is rated at 500 pounds at all angles and in all directions when used for rescue purposes. There is a 3:1 safety factor built into this tip load rating.

Flying Stokes

The Flying Stokes operation is a vertical stokes operation where the patient is packaged in a Stokes then lifted and transported by an aerial ladder to a point where transport personnel can access them safely. A key safety consideration is to limit the weight of the load. Therefore only fly an attendant if absolutely necessary.

Rigging the Flying Stokes

Spot Apparatus

Step 1: Spot the aerial apparatus into working position.

Step 2: Retrieve Rope Rescue Pulley. Insert Rope Rescue Pulley on tip of ladder.

Retrieve two Ladder Pipe Rope Bags use later for Tag Lines.

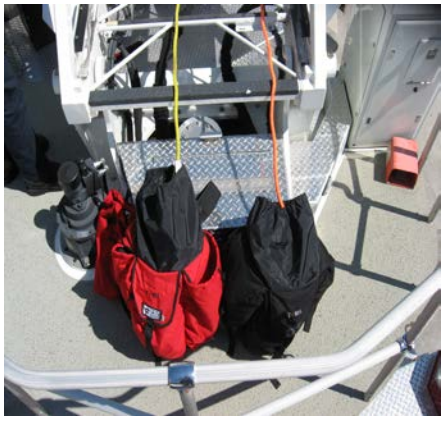
Secure the Rope Rescue Pulley with the attached safety pin.

Step 3: Rotate and extend the aerial for attachment of ropes. Extend ladeder to 60' and 0°.

Step 4: Retrieve RPM Bags #1, #2, Black, Red 300' Rope Rescue Bags, High Angle Bag, and Harnesses Bag from the Truck Rope Compartment.

Step 5: Retrieve Stokes Basket from Truck Compartment.

Step 6: Bring RPM Bags #1, #2, Black, Red 300' Rope Rescue Bags to the turntable of the Ladder.



Step 7: Standing on the turntable with Two 300’ ropes tie a Figure 8 on a Bight in the ends of the ropes.

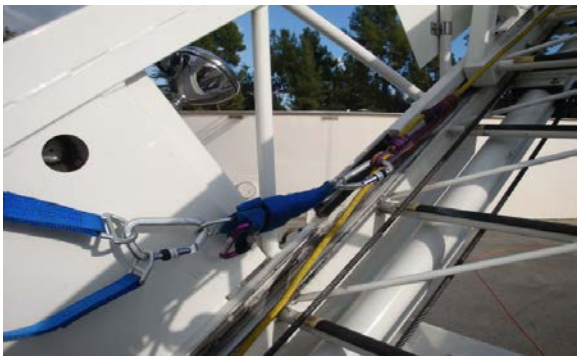
Step 8: Leaving the two rope bags on the turntable, walk the ends of the ropes and knots across the ladder. Insert the ropes into the Rope Rescue Pulley. Ensure that there is about 10’ of rope on the ground.

Step 9: Hold Main and Belay Line while Aerial is elevated to 40° and staying at 60’ extended.

Step 10: Attach two 5’ anchor slings to the top of ladder hand rail at the base of the ladder. (One for the Main Line and one for the Belay Line.)

Step 11: Attach one carabiner and Brake Bar Rack to the 5’ webbing anchor slings. Wrap the sling around the ladder hand rail as shown.

Step 12: Attach Belay Line pre-rigging to the second 5’ webbing anchor sling.



Step 13: Once Aerial is at 40° Reeve one rope through the Brake Bar Rack.

Lock off the rope in the Brake Bar Rack.

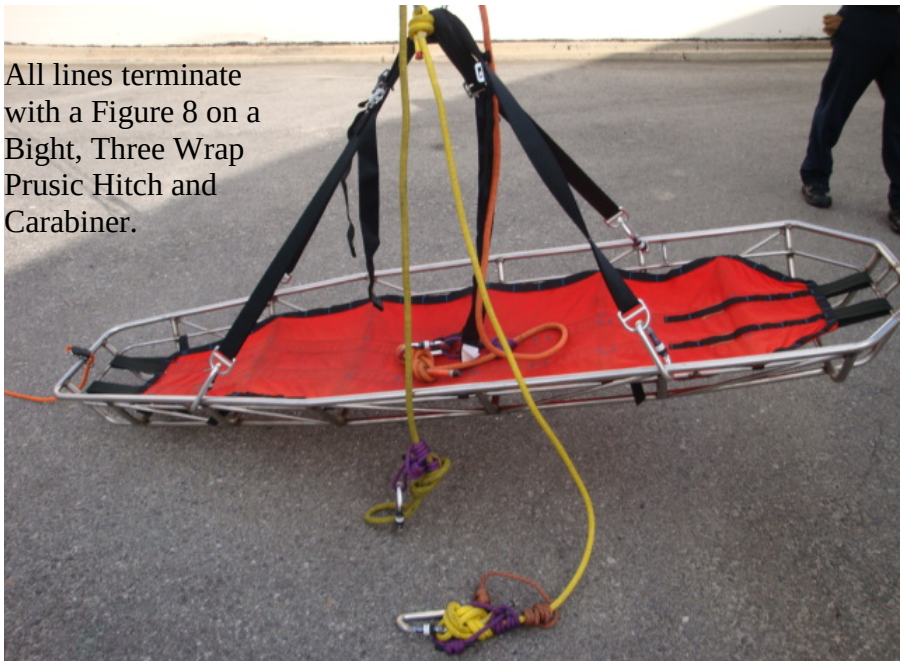
Step 14: Connect the Belay Line Pre-rigging (Tandem Prusiks) to the Belay Line. Place a 5' Green Webbing Sling using a Larks Foot around the top of the ladder hand rail securing the end into the carabiner.

Step 15: Both the Main Line and Belay Line are now secured.

Stokes Litter Rigging

Step 1: Attach the Stokes Litter Pre-rigging to the Main and Belay Lines. Pre-connected to the Collection Ring should be the Stokes harnesses set up for horizontal attachment to the Stokes litter. The Long Tail Bowline should be 6'-8' long.

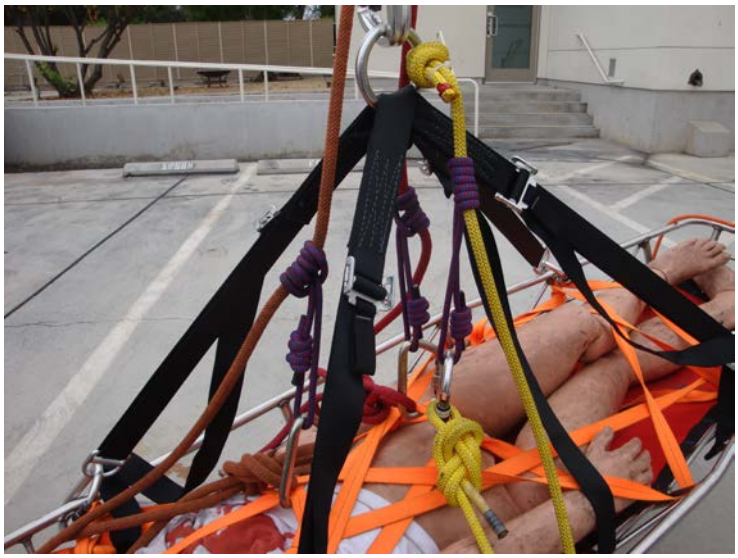
Step 2: Connect the Stokes litter and lock all carabiners.



Step 3: Attach 100' Lifeline Ladder Pipe Rope Bags to each end of the Stokes litter with either a carabiner, Figure 8 Follow-Though or securing around he Stokes back onto it self. These lines serve as Taglines when the litter is suspended in the air. They are tended from the ground.

Step 4a: If the Stokes litter is attended, connect the Tender Line to the attendants waist. This line will serve as the rescuer's primary attachment point to the system. This will also allow for rescuer adjustment.

Step 4b: If the Stokes litter is without an attended, connect the Tender Line to the victim's waist lashing. This line will serve as the victim's primary attachment point to the system. Connect the Main Line to the victim's waist lashing. Connect the Belay Line to the victim's chest lashing.



***All lines end with a Figure 8 on a Bight and Three Wrap Prusic Hitch.**