



## CHAPTER 9 - ROPE RESCUE EQUIPMENT AND KNOTS

The purpose of this chapter is to provide an overview of the equipment used in rope rescue and the knots used by SAR#3.

Equipment currently in use may vary slightly from the description, graphic, and specification listed in this chapter because equipment is purchased from various vendors.

### **DEFINITIONS**

#### **Bight**

A turn in a rope which does not cross itself. Basically an open loop. See Figure 9-1.

#### **Half-Hitch**

A loop in a rope which turns around a shaft or piece of rope, so as to lock itself. Figure 9-42 shows two Half-Hitches.

#### **Hardware**

Hardware refers to metal equipment used in rope rescue such as carabiners, Rescue 8 Descenders, and anchor plates. SAR#3 uses primarily hardware made out of aluminum for its lightness.

#### **Kernmantle**

Type of rope that has a core (*kern*) and a sheath (*mantle*). This is the type of rope used in rescue and climbing ropes. The core is the primary load bearing part of the rope. The sheath provides protection and holds the cores.

#### **Kilonewton**

A Kilonewton (kN) is a measure of force. Rescue and climbing equipment use Kilonewton to measure the kind of forces the gear can withstand. A kilonewton is equal to 225 pounds.

#### **Loop**

A turn in a rope which crosses over itself. See Figure 9-2.

#### **Running End**

The free end of the rope that is not attached to any other rope or system. Also known as the bitter end. See Figure 9-3.



## Software

Software refers to the soft equipment used in rope rescue such as ropes, webbing, and Prusiks. Software is generally made out of nylon.

## Standing Part

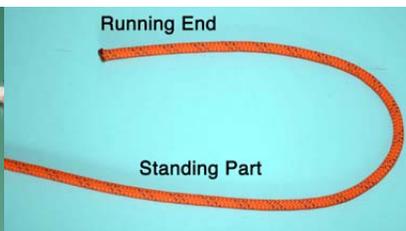
The fastened part or the whole rope other than the running end. See Figure 9-3.



**Figure 9-1: Bight**



**Figure 9-2: Loop**



**Figure 9-3: Rope Parts**

## GENERAL RULES FOR GOVERNING ROPE WORK

Rope rescue equipment is used as a personal life support and for rescue operations. Although the equipment is sturdy and can handle the stresses of a rescue operation, care must be taken during an operation and in storing the equipment.

1. Never walk on a rope. Stepping on a rope is a cardinal sin, usually calling for prompt and uncouth comments. Stepping on a rope will needlessly cause small particles of dirt and rock to be pushed into the rope fibers, causing internal wear that is extremely difficult to detect.
2. Do not allow the rope to run over sharp or rough edges, especially if it is loaded.
3. Never expose rope to any chemicals such as gasoline, thinners, oil, road flares, etc. This includes storing ropes in automobile trunks with oily rags or where fumes may accumulate.
4. Store rope in a clean, dry, cool area whenever possible, and never store rope wet. Store the rope in a protective storage bag. This provides protection for the rope as well as assuring that the rope should not tangle when it is needed.
5. Examine the rope periodically during use, and immediately after it has held a fall or been hit by falling objects. Any suspect rope shall be noted and removed from active use until it can be inspected by the team equipment officer. If a rope is at all suspect it should be retired. If puffs of inner fiber are visible along the rope, retire it immediately. During use a Butterfly Knot can be used to temporarily isolate a damaged rope section.
6. Do not leave the rope stretched or under tension for extended lengths of time. Remove all knots before storing the rope.



7. During an operation the rope will undoubtedly be dragged against rock faces, through dirt, and over brush. Sharp edges could easily cut the best line if the conditions are correct and the rope is under tension. Whenever possible minimize the rope's exposure to sharp edges through the use of padding for static lines. Smooth surface protection or edge rollers should be utilized for moving lines of raising or lowering systems. Especially pad the area of the rope near the edge of a cliff when rappelling.
8. After each use of a rope it should be logged in the team rope log in the rescue room.
9. Do not drop hardware. Any hardware drop from a significant height onto a hard surface should be removed from the system.
10. If hardware is resting on a hard surface or may bounce on a hard surface during the normal course of the operation, the area should be padded or the hardware moved.
11. Keep hardware out of the dirt. If the hardware must be close to the dirt use a tarp or other protection to keep the hardware clean. Put hardware not in use either on one's harness, clipped to the anchor, or in the equipment cache.

### Washing and Drying of Ropes

Team ropes that have been used either for an operation or training should be cleaned upon returning to Station 10. The rope should be cleaned using the rope washer. While feeding the rope through the rope washer the rope should be inspected for any defects. The rope should be coiled and hung to dry completely in the rescue garage.

Personal sections of 9 mm rope can be washed at home in an automatic washer. Larger sections of 11 mm or larger rope should be cleaned using a large commercial machine. Double-up and chain stitch the rope, and use a nylon safe detergent such as Woolite™. Set the machine for "gentle action", warm wash and cool rinse. Rinse twice if any soap is left on the rope.

The preferred method of drying is to hang the rope in a cool, shady place, however, it can be placed in a dryer on the "cool" or "air dry" setting. Keeping a rope clean is vital for safety and maximum rope life.

### Storage of Ropes and Webbing

Rescue ropes are stored in the truck in rope bags. The bag allow the ropes to be carried into the field and deployed without kinks in the rope. Rope bags allow more control in dropping of the rope down a cliff to avoid hitting the victim. A rescuer may rappel with the rope bag attached to the harness to completely avoiding dropping the rope onto the victim or if there is heavy brush that may snag the rope.

Rope bags have a hole at the bottom of the bag. This is to prevent the rope and bag separating when the rope is deployed. When putting a rope into the bag a stopper knot is placed in the rope about four feet before the end of the rope. The rope is push through the hole from the



**Figure 9-4: Stuffing a Rope**



inside and another stopper knot is tied at the end of the rope on the outside. This way the rope will stay with the bag and the rope will not be pulled out from bottom.

When putting the rope into the bag, also known as stuffing, the rope is pushed into the bag in line. Do not grab a hand full of rope and shove it into bag. That may cause the rope to jam in the bag. Figure 9-4 shows a common way of feeding the rope through a carabiner attached to a harness to stuff a rope.

An alternative way of storing and transporting is to chain it. This is generally done when a rope bag is unavailable. While sitting down on the ground with knees apart, wrap the rope around the knees about five turns. Then start chaining the rope around the turns until the end of the rope. See Figure 9-5.



**Figure 9-5: Chaining a Rope**

Webbing is chained. See Figure 9-6. The key to successful chaining of webbing is that when the webbing is unchained there are no knots at the end. For long longer lengths of webbing the webbing can be folded into quarters to make the final chained webbing shorter.



**Figure 9-6: Chained Webbing**

Climbing rope kept in SAR#3 trucks are kept in rope bags. But generally climbing ropes are coiled using traditional climbing techniques.

### **Rope and Webbing Identification**

Each rope placed into service is identified at each end with a label. The label indicates the length of the rope, the year the rope was placed into service, and the rope sequence number.

Webbing is identified on ends with the length of the piece and the month and year it was placed in service. Personal webbing should also be identified with the member's name. Webbing should be discarded after the current years of service limitation.

## **ROPES AND WEBBING**

Ropes used in mountain rescue serve a three-fold purpose:

1. As an aid in mountaineering



2. As an aid in victim evacuation
3. In a safety system.

### Static Rope Specifications

Static rope, also known as low-stretch rope, is the primary rope used for rope rescue. Static rope has a maximum elongation less than 6% at a load at 10% of the rope's minimum breaking strength.

SAR#3 uses static rope made by various manufactures. The information in Table 9-1 is for the current New England Ropes in use. The specifications from other manufactures are similar. The breaking strength in Table 9-2 uses 3 sigma statistical method for reporting minimum breaking strength that provides a 99.87% certainty of the result.

The primary ropes used by SAR#3 are 200 feet in length, 1/2 inch in diameter, and kept in rope bags. Other ropes available are 7/16-inch, 200-foot, 300-foot, and 400-foot ropes. Current personal rope issued is 3/8-inch, 100-foot ropes.

Knots, bends, and other factors will reduce the strength of the rope.

Model	New England KM III Static Kernmantle Rescue Rope
Construction	Block creel, static kernmantle construction
Fiber	The core is 100% nylon and the sheath is 100% polyester
Sheath	Braided polyester jacket, 32 carrier, two over-two under construction with half of the strands having a Z-twist and half having a S-twist
Temperature	Melt point 480° F (248° C)

**Table 9-1: Static Rope Specifications**

Diameter in (mm)	Breaking Strength lb (kN)	Weight lb/100 ft
3/8 (9.5)	5,000 (24)	4.7
7/16 (11.0)	7,000 (31)	5.4
1/2 (12.5)	9,900 (44)	7.0
5/8 (16.0)	11,900 (53)	10.2

**Table 9-2: Static Rope Breaking Strength and Weight by Diameter**

### Climbing Rope Specification

Climbing rope, also known as dynamic rope or high-stretch rope, is used in climbing situations where the rope would stretch and absorb the energy of a fall. SAR#3 uses 11 mm (7/16 in) climbing rope with a length of 50 m (165 ft). The breaking strength of the rope is 5,000 lb (22 kN) with elongation at 176 lb of 6.7 %.



Climbing rope is rated in dynamic falls. SAR#3 climbing ropes are rated at 9-11 falls.

### Webbing Specification

Webbing can be used for anchors, tie-ins, and emergency harnesses. Webbing is flat or tubular and comes from 1/2 in up to 3 in. SAR#3 uses 1-inch tubular webbing with a breaking strength of 4,000 lb (17 kN). The length of the webbing can vary depending on use. The length should be marked on the end of the webbing. Fire departments use a standard color-coding (See Table 9-4) to indicate the length of the webbing used in rescue systems. Table 9-3 lists the color-coding for the length of webbing used by SAR#3 though this is not a hard rule.

System Pack	Green	5 ft
System Pack	Yellow	12 ft
System Pack	Blue	15 ft
System Pack	Red	20 ft
Personal	Orange	20 ft

**Table 9-3: SAR#3 Webbing Color-Coding**

Green	5 ft
Yellow	12 ft
Blue	15 ft
Orange	20 ft

**Table 9-4: Fire Department Webbing Color-Coding**

### Prusik Cord and Utility Cord Specification

Prusik cord is primary used for Prusik hitches and load release hitches. Utility cord is used for a cordelette. Prusik cord uses kernmantle construction. Table 9-5 shows the use of Prusik cord currently in use by SAR#3 and its specifications. Colors may vary as new stock is obtained.

Use	Typical Color	Length In	Diameter mm	Breaking Strength lb (kN)
Tandem Prusik - short	Yellow / Brown	53	7	2,875 (12)
Tandem Prusik - long	Blue / Brown	65	7	2,875 (12)
Load Release Hitch	Blue	180	8-9	2,875 (12)
Cordelette	Blue	240	8-9	2,875 (12)

**Table 9-5: Prusik Cord Use and Specifications**

## HARDWARE

Because SAR#3 is a wilderness SAR team and needs to carry its gear into the backcountry the hardware the team uses is primarily made out of aluminum alloy rather than heavier steel.

### ATC (a.k.a. Black Diamond Air Traffic Controller)

The ATC is used as a personal belaying device. It can be used for rappelling or as a climbing belay device. The ATC should never be used in any rescue systems. An ATC is shown in Figure 9-7.



Figure 9-7:  
ATC

### Carabiners (a.k.a. Biners)

Carabiners are used as a link. There are three basic types of carabiners as shown in Figure 9-8.



Figure 9-8: Types of Carabiners

1. Locking carabiners use a locking nut to lock the gate. They are generally “D” shaped. Rescue systems use locking carabiners exclusively. Figure 9-9 shows the parts of a locking carabiner.
2. Non-locking carabiners are used by climbers because they are very quick to connect and disconnect from the rope. Non-locking carabiners come in the traditional oval shape or specific shapes for specialized applications. Non-locking carabiners are used in pairs. Figure 9-10 shows the correct “opposite and opposed” use when used in pairs. There are very few non-load bearing uses of non-locking carabiners in rescue systems such as in a “keeper” for a load releasing hitch.

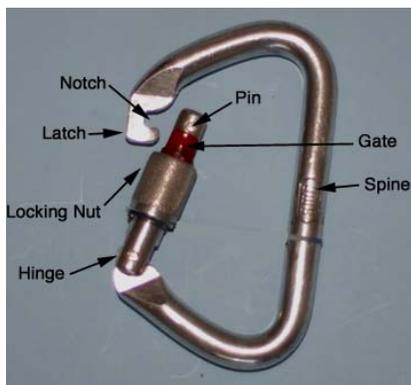


Figure 9-9: Parts of a  
Carabiner



Figure 9-10: Non-locking Carabiner  
"Opposite and Opposed"



- Auto-locking carabiners have an automatic locking mechanism. These carabiners are for personal use where quick access and locking of a carabiner is necessary such as rappelling from a helicopter.

The standard size carabiners that SAR#3 uses are classified to NFPA 1983-Light Use. Table 9-6 shows the strength of carabiners.

Size	Breaking Strength lbs. (kN)
Standard	6,069 (27)
Large	7,643 (34)

**Table 9-6: Locking Carabiner Strength**

The purpose of the locking nut is to prevent the gate from being open. The locking nut does not need to be tightened completely. During an operation a carabiner will flex as the load increases and decreases. If the locking nut is too tight it is possible that the nut becomes impossible to loosen when the load is released.

The load on a carabiner should always be down the spine and not across the carabiner which is known as “cross loading”. Carabiners in use should be checked periodically to make sure that they have not shifted and become cross loaded. A carabiner should not be located at the edge where it will be loaded on the edge. The carabiner should be relocated by adjusting the anchor.

The best way to use a carabiner is the “bite down and twist” method as shown in Figure 9-11 that allows easy access to the gate.



Bite the opening of the gate down on the anchor point



Twist carabiner so that gate opening is easily accessed

**Figure 9-11: Carabiner Bite Down and Twist**

### Rescue 8 Descender (a.k.a. Figure 8)

The Rescue 8 descender is a friction device used for rappelling and lowering systems. The “ears” of the Rescue 8 Descender helps prevent the rope creating a girth hitch around the device and make it easier to lock off. Figure 9-12 shows the correct threading of a rope through the Rescue 8 Descender. The rope is fed through the bottom of the Rescue 8. A disadvantage of the Rescue 8 Descender is that it will twist the rope as it goes through.

Additional friction can be gained by adding an additional wrap on the Rescue 8 descender.

### Brake Bar Rack Descender (a.k.a. Rappel Rack)

The Brake Bar Rack Descender is an alternative friction device for rappelling and lowering. Unlike the Rescue 8 Descender the Brake Bar Rack does not twist the rope. Figure 9-13 shows the threading of the Brake Bar Rack. The amount of friction can be adjusted by adding or subtracting the number of bars. The amount of friction can also be adjusted by adjusting the spacing between the bars. A major disadvantage of the Brake Bar Rack is that it can be completely removed from the rope without unclipping the attaching carabiner.



**Figure 9-12: Rescue 8 Descender**



**Figure 9-13: Brake Bar Rack**

### Anchor Plate (a.k.a. Brenner Plate, Rigging Plate, Paw Plate)

Anchor plates help organize the rigging of a system at the anchor collection point. SAR#3 uses a standard four-hole aluminum plate as shown in Figure 9-14.

The “Brenner Plate” is named after ex-SAR#3 team member David Brenner who designed the anchor plate.



**Figure 9-14: Anchor Plate**

### Pulleys

Pulleys are used to change the direction of moving ropes and to build mechanical advantage systems. The bearing of pulleys are either sealed ball bearing or oilite bushing. SAR#3 uses four types of pulleys as shown in Figure 9-15.



Standard round-bottom pulleys used for general use.



Double pulleys used for mechanical advantage systems.



Prusik-minding pulleys used to help maintain Prusiks in systems.



Knot passing pulleys allow knots to pass through easily.

**Figure 9-15: Types of Pulleys**

### Mechanical Ascenders

Mechanical ascenders are used to ascend ropes. Mechanical ascenders may not be used in a rescue system. The two makes used by SAR#3 are Gibbs and Petzl Rescucender. Handled ascenders such as those made by Jumar or Petzl are used in climbing. See Figure 9-16.



Gibbs Ascender



Petzl Rescucender



Handled Ascender

**Figure 9-16: Mechanical Ascenders**

### ROPE PROTECTION

All software including rope and webbing must be protected from sharp edges and abrasion that may damage or cut. There are many ways to provide this protection. Figure 9-17 shows three of the types of edge protection used by SAR#3. The protection must be secured so that it stays in the needed location and does not fall.

Soft items such as packs and jackets can also be used for rope protection. These are best used in non-moving rope situations such as for sharp edges on an anchors. Care should be used when using these items on moving rope that there is no metal or plastic parts or connectors that will damage the rope.

Rope protection should also be used to prevent the rope from cutting into the dirt on a slope.



**Figure 9-17: Types of Edge Protection**

### **Edge Guards (a.k.a. Rope Condom)**

Edge Guards are either 18- or 24-inches in length, surrounds the rope or webbing and closes with hook-and-loop strip.

### **Ultra-Pro**

Ultra-Pro is a flexible nylon pad with multiple grooves to guide multiple ropes.

### **Edge Rollers**

Edge rollers greatly reduces the friction of a moving rope over an edge protection. Disadvantage is they are heavy and bulky to carry into the field.

## **KNOTS**

Basically, a knot is a configuration in one or more ropes, which is used:

1. to create a stop,
2. to tie the ends of two ropes together,
3. to tie the end of a rope to an object or creating a loop,
4. to tie the middle of a rope to an object, and
5. create a friction knot.



Reliability, ease of tying, and experience are the criteria in selecting the few basic knots presented herein. Although a great many more knots exist, many are unsuitable for rescue usage. Further study beyond the limited scope of this manual is recommended. Some knots are known by different names. The knot's alternative names are listed with the predominate SAR#3 name.

The knots used must be learned well enough so that each knot can be tied correctly the first time, even under adverse conditions. Knots should be inspected frequently when subjected to long use and bad weather, especially since knots tied on nylon rope tend to slip due to the smoothness of the fibers. To counter this, all knots shall be tied off with an overhand knot unless otherwise noted. Neatness counts in knot tying. The knot should be dressed eliminating any extra bends or twists. This makes the knot stronger and easier to check.

Remember, the success of every rescue operation can be dependent upon the reliability of each knot.

Note that for clarity the safety overhand knot may not be shown in the figures.

## Basic Knots

### *Overhand Knot*

The Overhand Knot the simplest knot to tie. It's used as a temporary stop on an unlashd rope or to supply a better handhold for climbing a single line. The Overhand Knot is also used as a safety knot to secure the free ends of the rope in most other knots. See Figure 9-18.



**Figure 9-18:  
Overhand Knot**

### *Figure of Eight (a.k.a. Stopper Knot, Simple Figure Eight)*

The Figure of Eight is used on the ends of ropes to prevent them from slipping through a pulley, descending device, or rope bag. It is bulkier than the Overhand Knot, but forms more gentle turns in the rope. See Figure 9-19



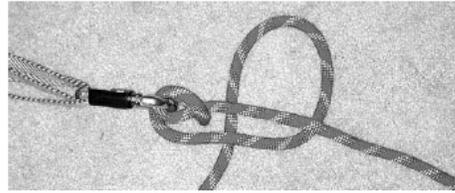
**Figure 9-19: Figure  
of Eight**

### *Mule Knot (a.k.a. Munter Mule, Releasable Knot)*

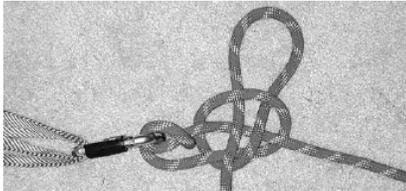
The Mule Knot is used to lock-off a Munter Hitch, Brake Bar Rack, or an ATC. Figure 9-20 shows locking off a Munter Hitch.



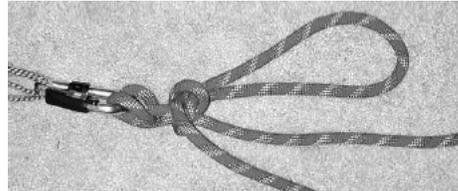
Hold the load on the Munter Hitch tightly during entire process and do not let go of the breaking hand, even for an instant.



Make a loop of rope exactly as shown.



Pass a bight of rope through this loop as shown, creating an overhand slip knot.



While ensuring that the load will not suddenly drop, tighten the overhand slip knot that was just made.



With the bight of rope exiting the slip knot above, tie an overhand knot around the loaded line.  
Clip a carabiner through the overhand knot back to the carabiner or to the loaded line.

**Figure 9-20: Mule Knot**

## Knots for Connecting Two Ropes Together

### *Square Knot (a.k.a. Reefers Knot)*

The Square Knot is used to tie the ends of equal diameter rope together. It should not be used for life support applications where tension varies considerably. This is typically used for utility connections or for securing bandages for splints etc. See Figure 9-21.

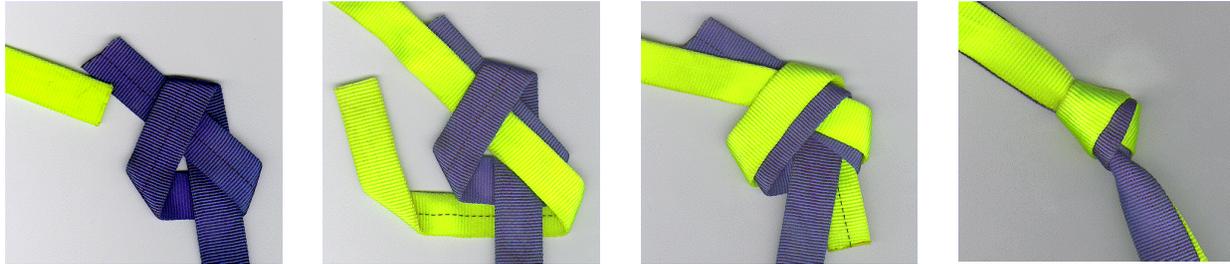


**Figure 9-21: Square Knot**



***Water Knot (a.k.a. Overhand Follow Through, Ring Bend)***

The Water Knot is used for tying the ends of flat or tubular webbing together. It is feasible to use this knot to join rope together, however, since a Figure Eight Bend is superior, it will be used for joining rope. Safety knots are not required to finish off the knot but it is imperative that the tails are at least 3 inches long. See Figure 9-22.



**Figure 9-22: Water Knot**

***Figure Eight Bend (a.k.a. Flemish Bend)***

Figure Eight Bend is the primary knot used to tie ropes of equal diameter together. See Figure 9-23.



**Figure 9-23: Figure Eight Bend**

***Double Fisherman (a.k.a. Grapevine Knot, Double Overhand Bend, Tape Knot)***

The Double Fisherman is used to tie together two ropes of either equal or unequal diameter, or to make a Prusik loop. Once loaded, it's difficult to untie which makes this an inferior knot with respect to the Figure Eight Bend for joining ropes for systems operations. Safety knots are not required to finish off the knot. However there should be at least one inch of tail on both sides of the knot. See Figure 9-24.



Using one end of rope, tie a double Overhand Knot around the other end of rope



Now flip the rope over and once again tie a double Overhand Knot around the other end of rope  
Notice in step 1 that the end of rope with a blue circle on it is on the right side, and when the rope is flipped over then the end of rope with a blue circle is now on the left side. It works best if the knot in step 1 is tightened before flipping the rope over to tie the second knot, but the first knot was left un-tightened in step 2 just for the sake of clarity.



After tightening the two knots, pull them together and they should stack nicely next to each other

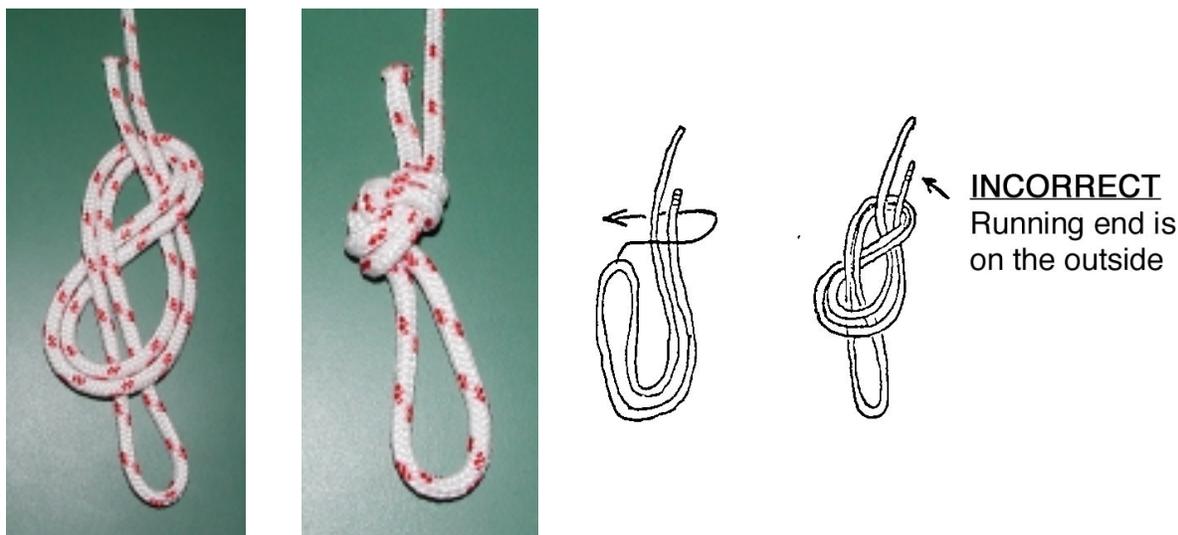
**Figure 9-24: Double Fisherman**

### **Knots Used to Create a Loop**

#### ***Figure of Eight on a Bight (a.k.a. Figure Eight Loop, Flemish Loop)***

The Figure of Eight on a Bight is used to make a loop at the end or in the middle of a rope. It's easier to tie than a Butterfly Knot and is stronger than a bowline. It can be used as an anchor knot or in any system used by this team. Both ends of the rope leaving the knot should be in the same direction when the knot is loaded. Make sure to dress the knot properly so that all of the strands of rope are parallel to each other and do not cross over each other. See Figure 9-25.

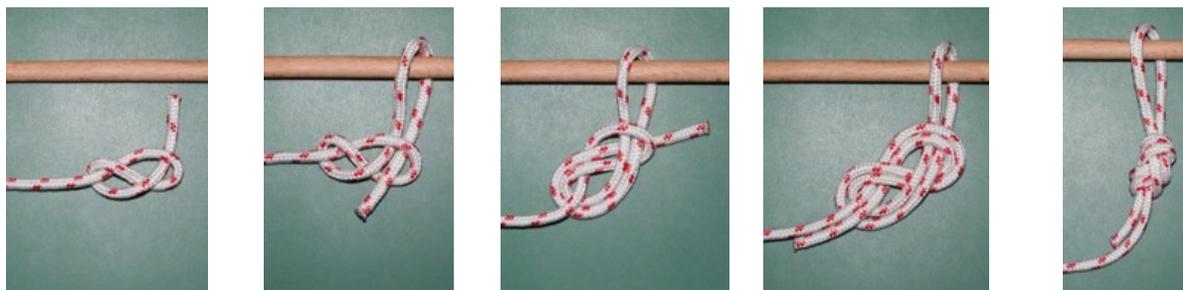
Note that it is possible to tie this knot incorrectly, thus reducing its strength by 8 - 10 percent.



**Figure 9-25: Figure of Eight on a Bight**

***Figure of Eight Follow Through (a.k.a. Rethreaded Figure-Eight Loop)***

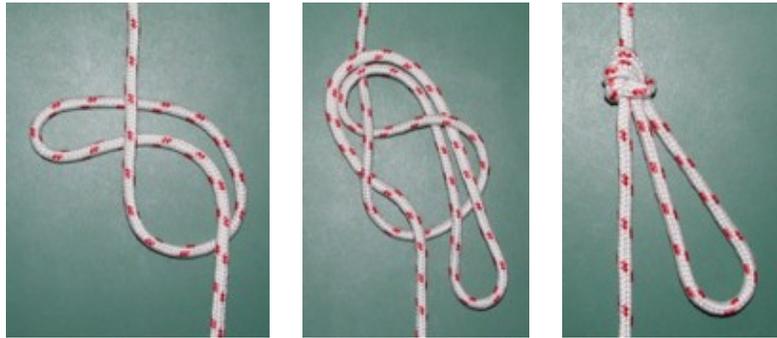
The Figure of Eight Follow Through is used where a Figure Eight on a Bight cannot be used such as around a tree. It's also used to tie the end of a climbing rope in a sit harness. To use this knot to secure a sit harness into a climbing line, first tie the Figure of Eight, pass the running end through the harness attachment, then complete the Figure of Eight Follow Through. This provides the most secure harness tie in for climbing applications. See Figure 9-26.



**Figure 9-26: Figure 8 Follow Through**

***Inline Figure Eight (a.k.a. Directional Figure-Eight Knot)***

The Inline Figure Eight is used when the knot and the end of the rope will be loaded at the same time such as a collection point. The Inline Figure Eight should not be used as a middleman knot. A safety knot is not required to finish off the knot. See Figure 9-27.



**Figure 9-27: Inline Figure Eight**

### ***Bowline***

The Bowline can be used to secure an end man on a belay, or used as an anchor knot. It's easy to tie, but must be tied off to insure it won't loosen when the rope is slack. When looping a rope around a boulder or a tree to create an anchor, the Bowline knot should be utilized. Note that it is possible to tie this knot incorrectly by having the running on the outside of the loop, thus reducing its strength by one-half. See Figure 9-28.



**Figure 9-28: Bowline**

### ***Bowline on a Bight (a.k.a. Double Loop Bowline)***

The Bowline on a Bight is a very useful anchor knot. It can be used with offset sized loops to form a self-equalizing anchor. This may also be used to secure the middle of the rope when both ends of the rope are required for the system being used. Be careful when tying this knot as it can easily be tied into a slip knot. See Figure 9-29.



**Figure 9-29: Bowline on a Bight**

***Bowline on a Coil***

The Bowline on a Coil is used to secure a climber into a climbing line when the climber is not wearing a climbing harness. This technique has the advantage that there is nothing to fail between the climbing rope and the climber as is the case when tying into a climbing harness. Falling on this knot is more irritating than falling in a sit harness. The knot should be tied snugly around the smallest section of the abdomen. This knot should be used to attach a belay when rappelling or ascending. See Figure 9-30.



Starting position. The coil that makes up the major loops would be around your waist.

Before setting

Set and secured. Note that the backup knot goes around all of the loops.

**Figure 9-30: Bowline on a Coil**

**Middleman Knots**

There are two middleman knots authorized for use by SAR#3. The knots are interchangeable but the rescuer should be familiar with both knots so they can identify both as safe and accepted knots. This is used to tie a loop in the middle of a rope or to isolate a damaged section. When loaded the two ends of the rope leaving the knot are to be in opposite directions. The loop of the knot may be loaded in any direction including 90 degrees with respect to the rope.



A safety knot is not required to finish off middleman knots.

### Butterfly Knot (a.k.a. Alpine Butterfly Knot)

The Butterfly Knot is the primary middleman knot used by SAR#3. Figure 9-31 show the traditional SAR#3 technique. Figure 9-32 shows an alternative technique to tie the Butterfly Knot.

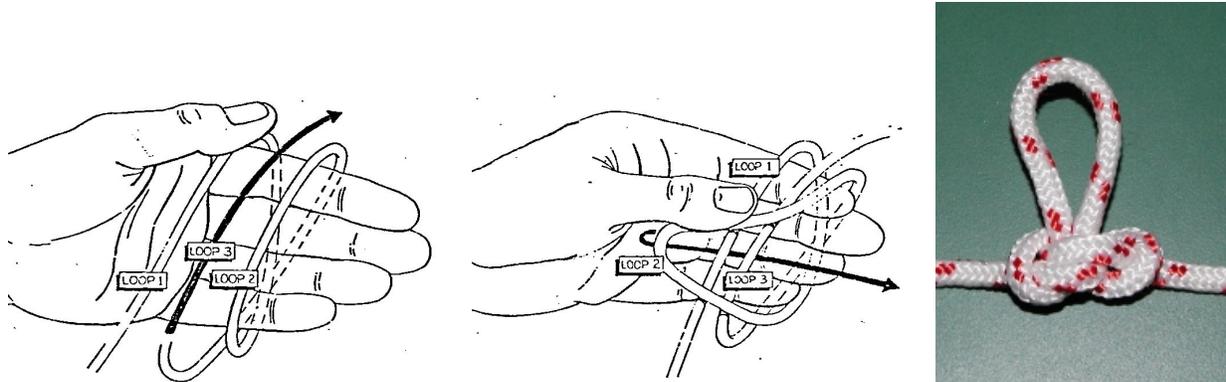
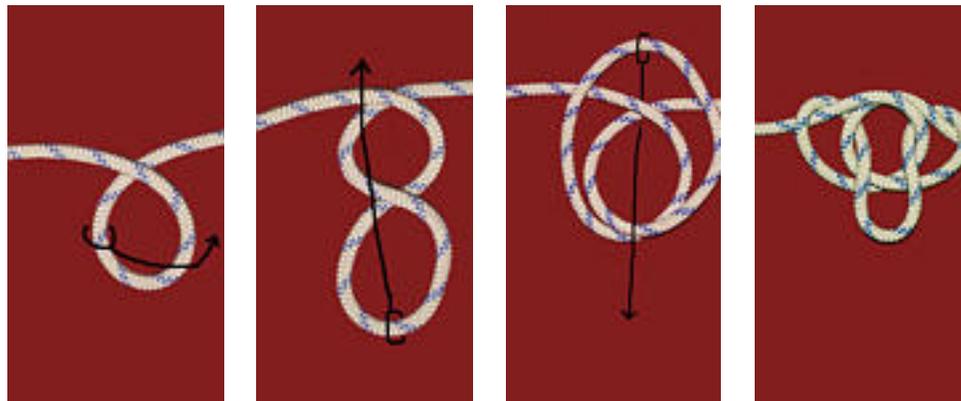


Figure 9-31: Butterfly Knot



Grab the main line and turn once to form a loop (shown). Turn again to form a second loop.

Fold the second loop over the first.

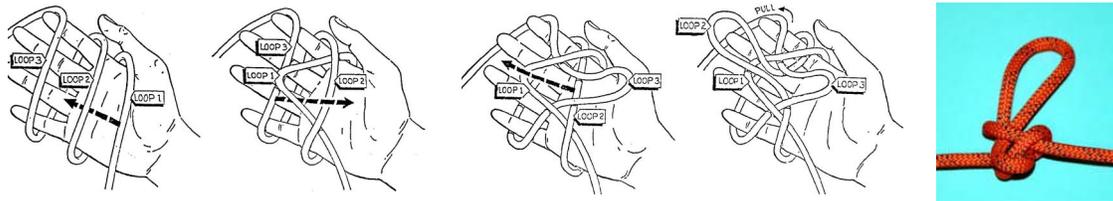
Pass the second loop around the main line and through the first loop.

The completed alpine butterfly before setting.

Figure 9-32: Alternative Butterfly Knot Tie

### Ballatine Bowline (a.k.a. Wireman's Knot)

The Ballatine Bowline is an authorized middleman knot used by SAR#3 and used by senior team members. The Butterfly Knot is the preferred as it is the middleman's knot used most in SAR and mountaineering applications. See Figure 9-33.



**Figure 9-33: Ballatine Bowline**

## Hitches

### *Prusik Hitch (a.k.a. incorrectly Prussik Hitch)*

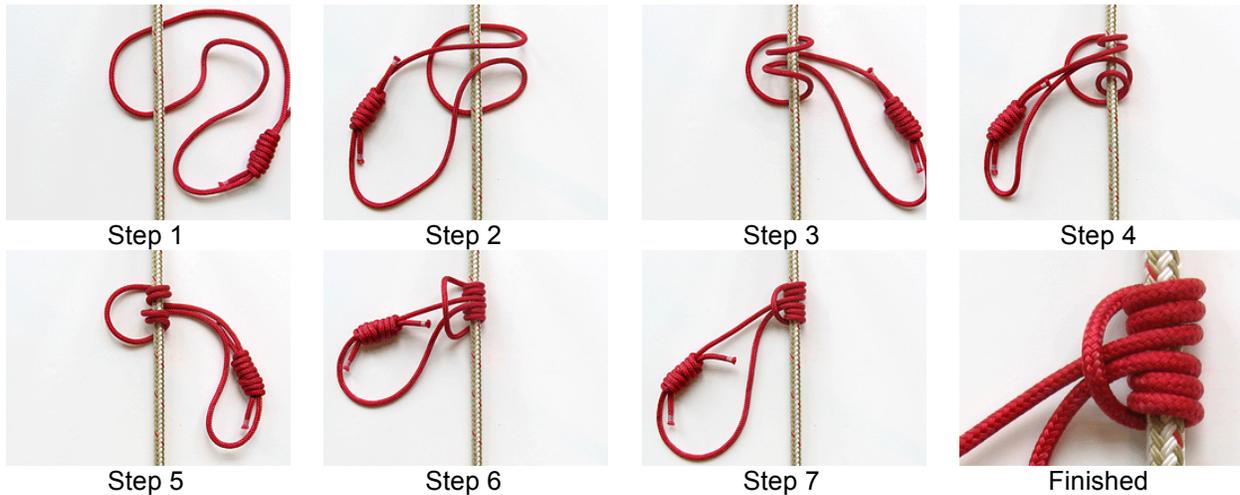
The Prusik Hitch is a friction brake knot used as a safety device in tandem Prusik belay, rappelling, litter evacuation, or ascending a rope. It grips the climbing line securely when under tension, but slips when pressure is released. The Prusik is considered a "soft" ascender since the rope being ascended is not being impinged by a "hard" metallic device. Prusiks need to be at least 2 - 3 mm less in diameter than the rope being wrapped to provide a good grip. Smaller wraps grip better, with the tradeoff of providing a lower breaking strength, and if too small possibly being difficult to unlock.

Prusiks used on the team should be comprised of 7 mm line, which is issued by the team equipment officer. The Prusik must be attached to a larger diameter rope to work properly. Extreme care should be used when using the Prusiks to not allow the Prusik to move quickly with tension on the system line as this can cause a large amount of heat which would both damage the Prusik and the ascending line. There have been reports of Prusiks knots that have burnt through main lines. See Figure 9-34.

A three-wrap Prusik may be used to increase the amount of resistance generated by the Prusik. Three-wrap Prusiks are required in all system applications of the Prusik. The triple wrapped Prusik is somewhat easier to move when tension is released due to the size of the wraps.

The Prusik Hitch should be placed so that the connecting Double Fisherman's Knot does not interfere with an attached carabiner.

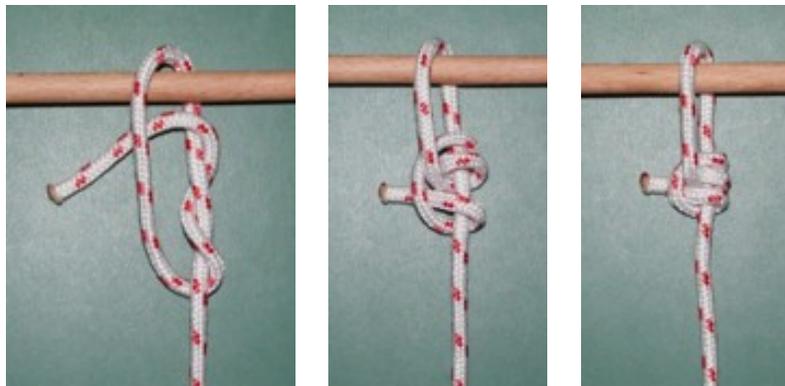
The Prusik Hitch was developed in 1931 by Dr. Karl Prusik.



**Figure 9-34: Prusik Hitch**

***Taut Line Hitch (a.k.a. Midshipman's Hitch)***

The Taut Line Hitch is a utility knot commonly used by Boy Scouts to tension guy ropes to stabilize tent poles. This is used to adjust the edge protection location used in system operations. See Figure 9-35.



**Figure 9-35: Taut Line Hitch**

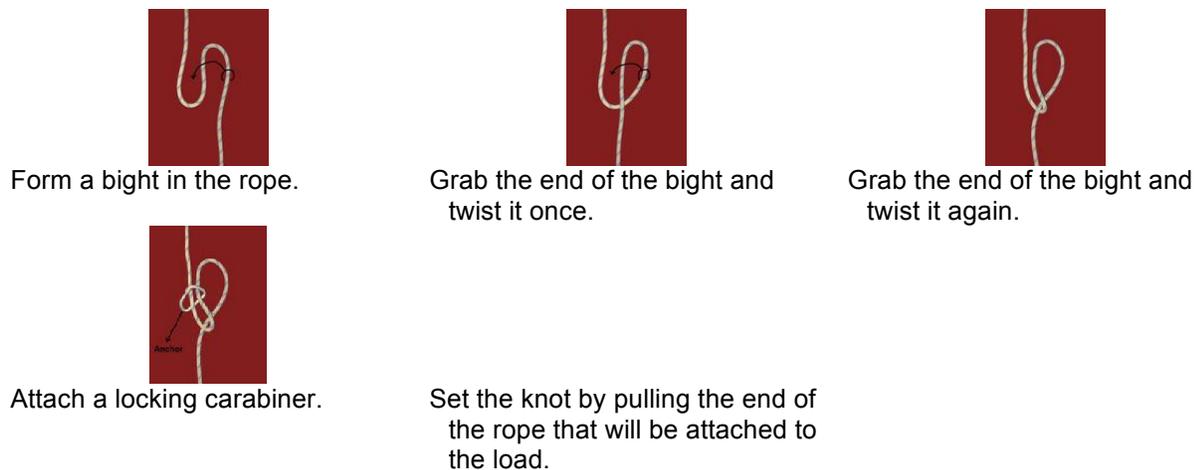
***Munter Hitch (a.k.a. Italian Hitch)***

The Munter Hitch can be used as an emergency belay or friction knot when there are no other mechanical devices available. To use the Munter Hitch as a belay, tie the Munter Hitch around an object. Releasing tension on the abrading rope sections allows the rope to move freely. Increasing the tension prevents the rope from moving. In an emergency the object used could be a carabiner, an ice axe, or even a tree. See Figure 9-36. An alternative method for tying the Munter Hitch is shown in Figure 9-37.

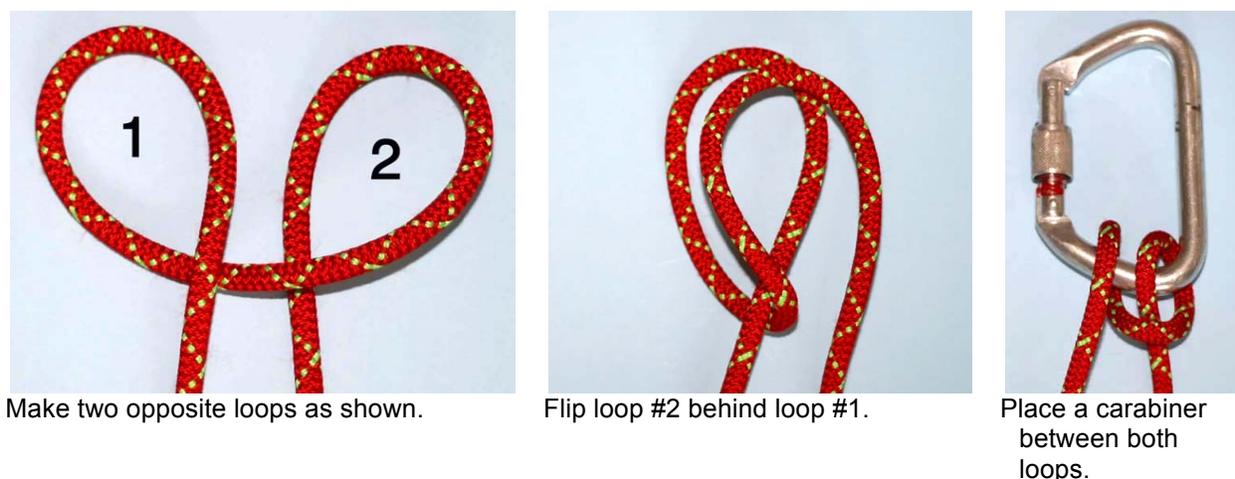
The Munter Hitch on a bight is used as part of a load release hitch.



The Munter Hitch is named after Werner Munter (born 1941 in Lohnstorf, Switzerland), a Swiss mountain guide.



**Figure 9-36: Munter Hitch**

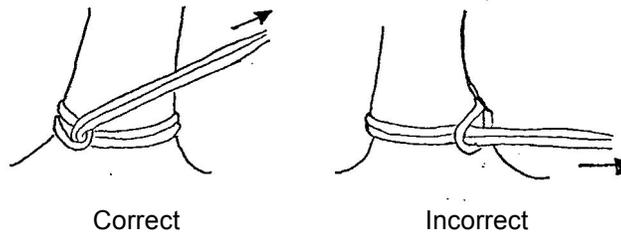


**Figure 9-37: Munter Hitch - Alternative Tie**

### ***Girth Hitch***

The Girth Hitch is a good single person anchor hitch, especially with webbing. The Girth Hitch should not be used in a rescue system as a sole anchor point. A Girth Hitch is acceptable as an anchor for a point of an equalized anchor, but the Wrap-3-Pull-2 is the most appropriate.

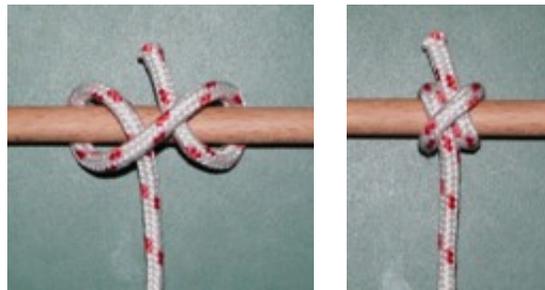
Be sure it locks back on itself. The Girth Hitch is usually tied with a climbing runner or a section of webbing. The rescuer should verify that the Water Knot or sewn connection of the runner is not against the object to which the Girth Hitch is being tied. See Figure 9-38.



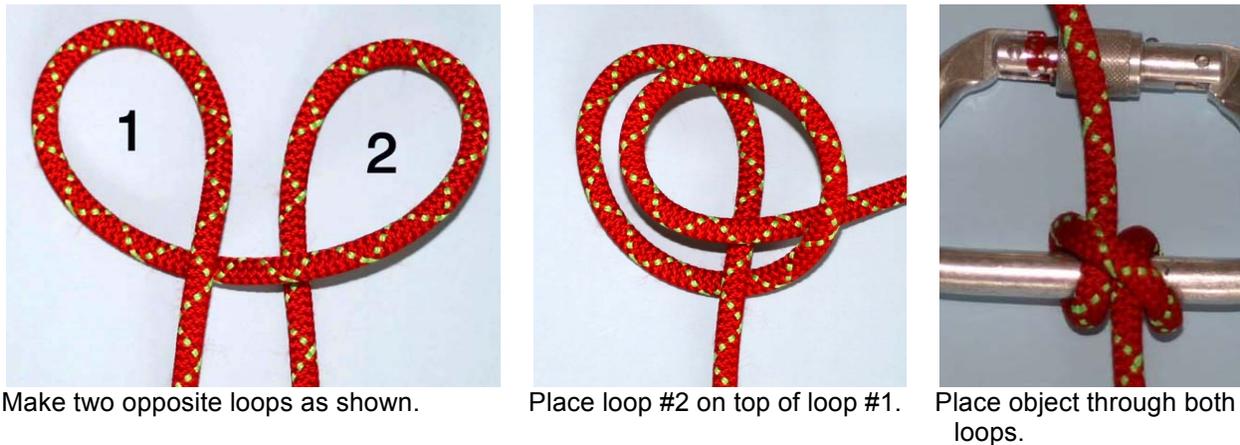
**Figure 9-38: Girth Hitch**

### *Clove Hitch*

The Clove Hitch works well for wrapping a litter or for tying a patient into a litter. Figure 9-39. An alternative way of tying the Clove Hitch is shown in Figure 9-40



**Figure 9-39: Clove Hitch**



**Figure 9-40: Clove Hitch - Alternative Tie**

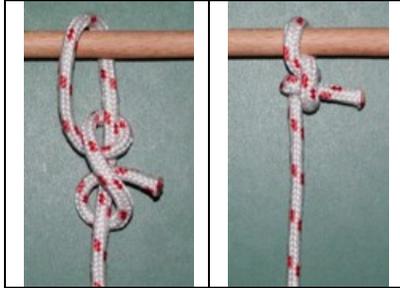
### *Two Half Hitches*

Two Half Hitches works well when the end of the length of rope or web needs to be tied off while keeping tension on it, such as when tying a patient into a stretcher. See Figure 9-42.



### *Trucker's Hitch*

The Trucker's Hitch creates a makeshift 3:1 mechanical advantage system to tension webbing. This hitch is useful in patient tie-in. The Trucker's Hitch is finished with two half hitches. See Figure 9-41.



**Figure 9-42: Two Half Hitches**



**Figure 9-41: Trucker's Hitch**

### **Load Release Knots**

A load release knot is used in raising systems. Its purpose of a load release knot is that it can be untied while under load and gently transfer the load or lower the load a short distance. Load release knots can also act as a shock absorber.

#### *Load Release Hitch (a.k.a. LRH, BC LRH, British Columbia LRH, LR Hitch)*

The Load Release Hitch is the primary load release knot used by SAR#3. It uses 15 feet of 8 or 9 mm Prusik cord, two locking carabiners, and one non-locking carabiner (a locking carabiner is acceptable). This hitch should not be confused with the "Radium" load release hitch which is tied differently.

See Figure 9-43 for how to create a Load Release Hitch.



Tie the cord with a Double Fisherman's Knot. Place the two locking carabiners approximately 5-6 inches apart. Clip one locking carabiner through cord at the middle of cord at the opposite end from the Double Fisherman's Knot. This will be the load side carabiner.



Tie a Munter Hitch on a bight on the second carabiner. This will be the anchor side carabiner.



Make 5 or 6 fraps around the hitch. Push the end of the cord through the hitch.



Chain the remaining cord. Clip the non-locking carabiner to the end of the cord and to the anchor side locking carabiner.

**Figure 9-43: Load Releasing Hitch**

### *Mariner's Knot*

Mariner's Knot can be improvised using a short runner or a 5 ft section of webbing, two locking carabiners, and one non-locking carabiner (a locking carabiner is acceptable).

See Figure 9-44 for how to create a Mariner's Knot.



Tie the webbing with a Water Knot. Place the two locking carabiners approximately 5-6 inches apart. Clip one locking carabiner through the webbing. This will be the anchor side carabiner. Feed the webbing through the second locking carabiner. This will be the load side carabiner.



Feed the webbing through the first carabiner.



Continue feeding the webbing through both carabiners until there is about 12 inches of webbing left coming out of the load side carabiner.



Frapp the remainder of the webbing tightly at least three times. Push the end of the webbing through the wrapping. Clip the non-locking carabiner to the end of the webbing and to the anchor side locking carabiner.

**Figure 9-44: Mariner's Knot**

## Improved Harnesses

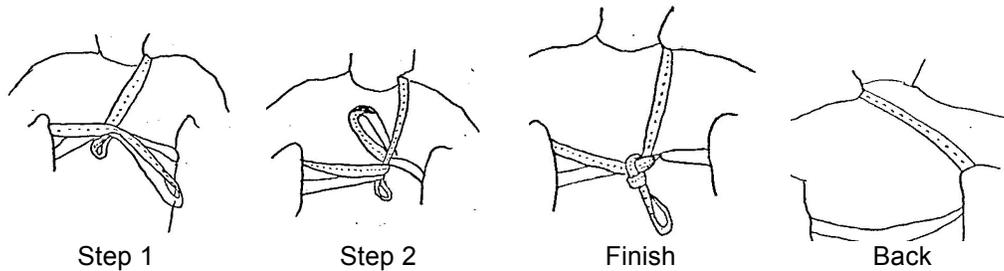
There are times when a manufactured harness is not available or a victim needs a harness for evacuation such as a cliff hanger situation. A rescuer may need to use an improvised sit harness if they are caught in the field with only minimal gear and a rappel is required.

Chest harnesses are useful for ascending and climbing. If a fall occurs during a climb the chest harness will help prevent the climber from inverting on the belay rope.

Improved harnesses do not provide the same level of protection as a manufactured rescue harness. The improvised harness should be snug and checked often.

### ***Parisian Baudrier (a.k.a. French Baudrier, Pronounced: Bo-Dree-A)***

The Parisian Baudrier is a quick improvised chest harness. A piece of webbing approximately 8 ft can be used. The webbing is tied into a loop that is adjusted to the rescuer. The Parisian Baudrier is tied off using a modified Overhand Knot. See Figure 9-45.



**Figure 9-45: Parisian Baudrier**

***FD Chest Harness (a.k.a. Fire Department Chest Harness)***

This chest harness uses 12 – 15 feet section of webbing depending on the size of the rescuer. See Figure 9-46.



**Figure 9-46: FD Chest Harness**

***Hasty Chest Harness***

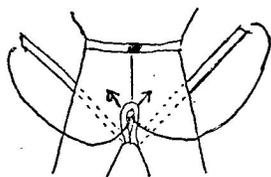
A Hasty Chest Harness can be quickly attached to the rescuer or subject without having to tie knots, using a double runner. Take the runner and cross behind the back, place the arms through each of the two loops. Two single runners may be used instead. Girth Hitch the two runners together placing the hitch in the back.

***Swiss Seat (a.k.a. Hasty Harness)***

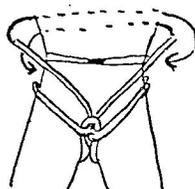
A Swiss Seat is used as a sit harness. A 20 – 25 feet section of webbing is required for a Swiss seat. See Figure 9-47.



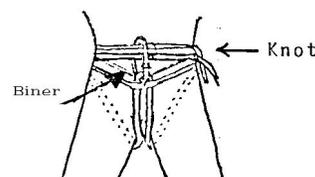
The Swiss Seat must be tight around the waist. To help keep the seat tight on the waist wrap crossing just before the last wrap, tie a Overhand Knot to help keep waist snug while tying Water Knot finish.



Using a untied section of webbing, feed the a point about two feet of the middle of the webbing through the legs from behind. Run the two ends from around the back to the front.



Feed the two end through the loop between the legs and pull back in the opposite direction. Continue to wrap the two ends tightly around the waist until there is not enough to go around another time.



Tie the two ends of the webbing using a Water Knot on the side of the body. Clip a carabiner through the loop through the leg and around all waist wraps. This carabiner will be the harness attachment point.

**Figure 9-47: Swiss Seat**

***Diaper (a.k.a. Hasty Harness)***

A diaper is used as a sit harness. A 12 – 15 feet section of webbing pre-tied into a loop with a Water Knot is used. The length of the webbing should be adjusted so that the harness is a snug fit for the user. The loop of webbing is pulled between the legs and from both sides from the back. A carabiner is clipped into all three points of the webbing in the front. This carabiner will be the harness attachment point.

This harness is quicker to put in an emergency situation. The diaper is not as secure as the Swiss Seat and should not be the primary harness for either the rescuer or victim even for a patient tie-in. See Figure 9-48.



**Figure 9-48: Diaper**