

**Tempe Fire Department Policies and Procedures**  
**High Angle Rescue**  
**208.04**  
**Rev 4-21-05**

**PURPOSE**

This procedure outlines the techniques used by the Tempe Fire Department for rescue on high or steep angles.

**PROCEDURE**

Personal equipment used in rescue operations should include helmet and gloves, for obvious reasons. Climbing type shoes are best in rocky terrain. A knife or scissors should be carried in case ropes have to be cut in an emergency. When the decision has been made to cut, do so carefully as a sharp edge will sever a loaded rope quite easily.

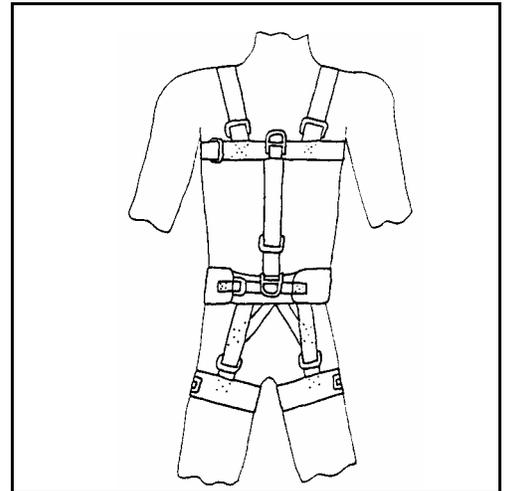
**HARNESSES**

Rappelling and rescue is done using various types of harnesses:

- Class 1 - around the waist (ladder belt).
- Class 2 - around the waist and buttocks (swiss seat).
- Class 3 - around the waist, buttocks, and shoulders (carried on ladder companies).

The swiss seat is a Class 2 harness. It is tied using a 17'- 20' 1" nylon webbing strap. Place the strap around your back at the top of the hips. With the ends in front of you make one side a foot longer, depending on whether you are right or left-handed. This will determine on which side you tie the final knot. Using the long end as the running end, tie an overhand knot around your waist (Figure 1).

Take another wrap next to the first one (Figure 2).



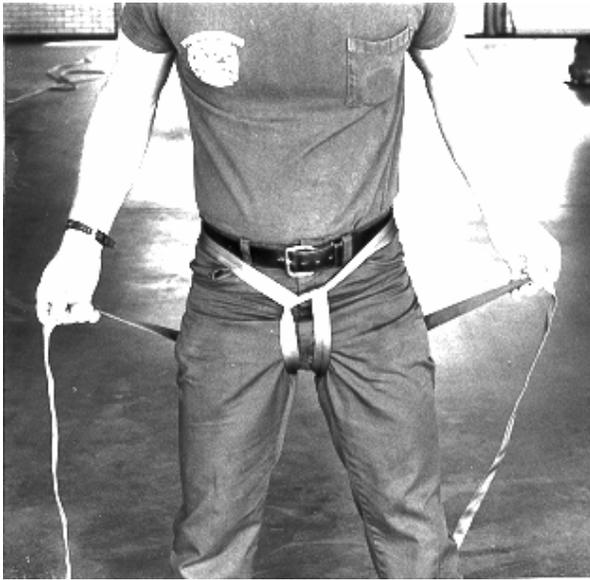
**Class 3 Harness**



**Figure 1**



**Figure 2**



**Figure 3**

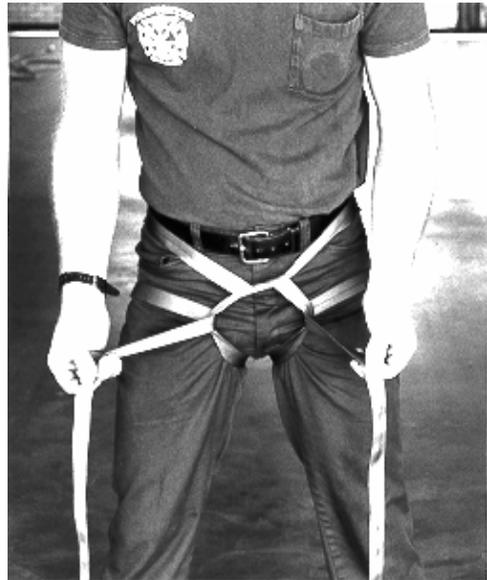
Keeping the webbing tight, place the ends down, between your legs. Bring the webbing through your crotch and around the back of your thighs (Figure 3).

Pull tight and cross the ends behind your back,



**Figure 5**

around the hips, and towards the front (Figure 5).



**Figure 4**

Bring the webbing around your hips and underneath the crotch straps (Figure 4).

Pass the longer end around the front and tie an



**Figure 6**

overhand knot at the side (Figure 6).



**Figure 7**

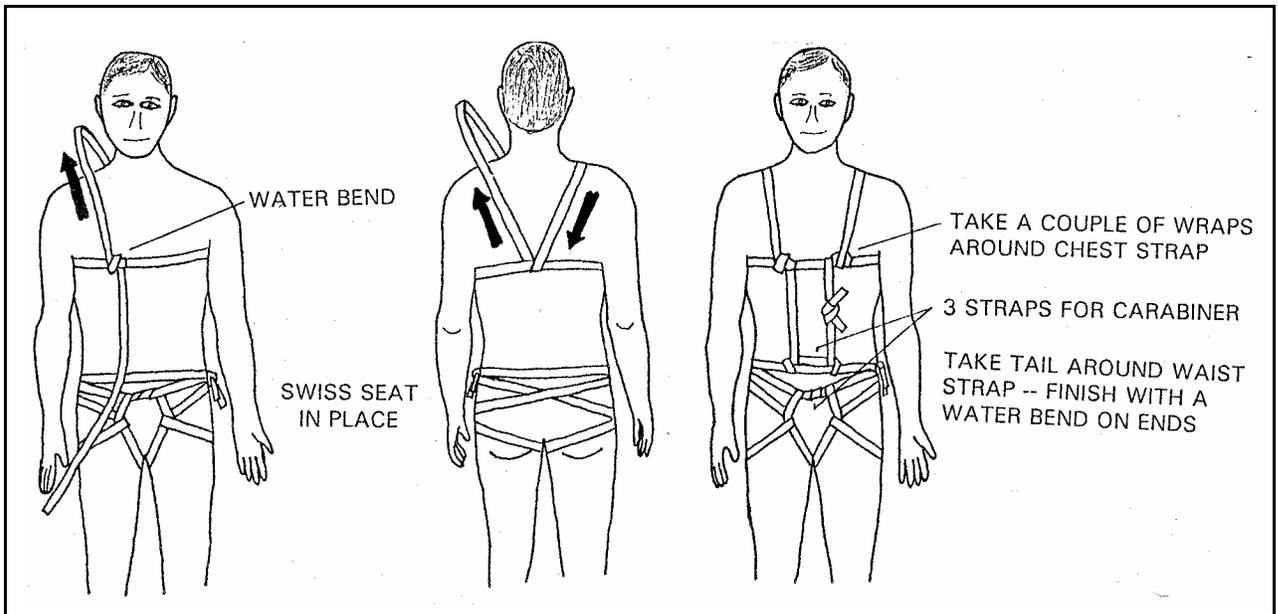
Tie another overhand knot the opposite direction, forming a square not (Figure 7).



**Figure 8**

Tie an overhand safety on each side of the square knot with the tails. Tuck any extra tail under the leg straps (Figure 8).

The addition of a shoulder harness (see drawing) makes the swiss seat a Class 3 harness.



**Shoulder Harness**

## TICKNOR HARNESS

The Ticknor harness is a Class 3 harness used in rescue. It is tied on a person using a 17' - 20' length of 1" nylon webbing and a carabiner. It can be tied on a person standing or supine in 20-30 seconds.

Place the center of the webbing across the person's back and adjust upward into the armpits. Tie an overhand knot across the chest. Then tie a bow over the first overhand knot, forming a square knot with two loops (Figure 9), similar to tying your shoes.



**Figure 9**

Place a carabiner through both loops of the bow with the hook side at the top and front (Figure 10).



**Figure 10**

Take the tail on the left and run it around the left leg lateral and posterior while holding the strap inside the thigh with the opposite hand (Figure 11).



**Figure 11**

Pass the tail under the strap at the thigh and using your thumb at the hip and holding the tail with the other hand, snug the strap into the crotch (Figure 12). Repeat the procedure for the right leg.

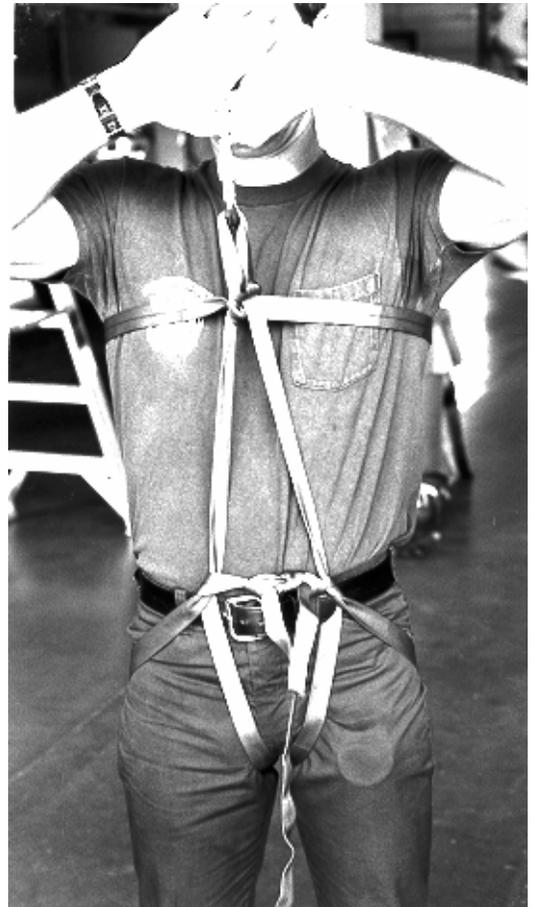


**Figure 12**

Then pull the tails snug and tie them in a square knot across the abdomen with safeties on each side of the square knot (Figures 13 & 14).



**Figure 13**



**Figure 14**

Even an unconscious person will hoist upright with the Ticknor harness (Figure 15).



**Figure 15**

### **BUTTERFLY HARNESS**

The butterfly harness can be applied to a person in a



couple of seconds. It could be used to secure a jumper or steady a person climbing down a ladder. If a person is suspended from a butterfly harness, they could turn upside down. For normal rescue use the Ticknor harness or hasty hitch, which are types of Class 3 harnesses.



**Figure 17**

Roll most of the strap in loops in your right hand (Figure 17).



**Figure 18**

Pass the loops around the victim's back at waist level and grab the strap with your left hand so that the top of the strap is across the small of the back and the bottom hangs just above the back of the knees (Figure 18).

Cross the ends you are holding forming a type of diamond shape (Figure 19).



**Figure 19**



**Figure 20**

Hold both ends in one hand and with the other hand reach through the diamond and grab the strap behind the knees (Figure 20).

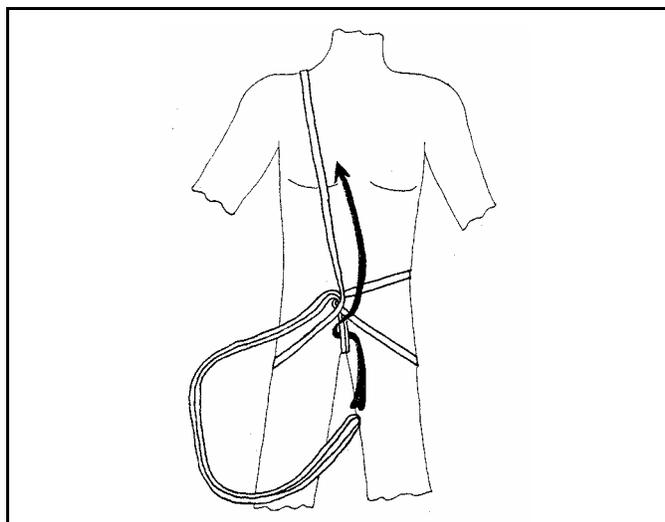


**Figure 21**

Then pull the knee strap toward you and release the other straps. The harness will tighten around the victim's pelvis (Figure 21).

### **HASTY HITCH**

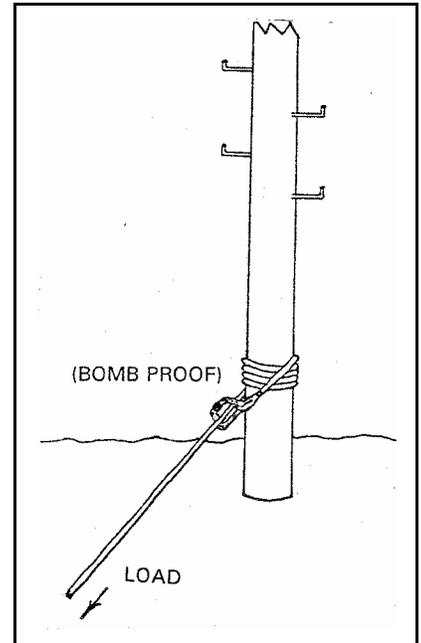
The "hasty hitch" is a form of the butterfly that places the waist strap across the back and over one shoulder. The extra line is half-hitched around the points where the lines come together. The looped end is half-hitched at the chest around the strap coming over the shoulder. This is the hoisting point.



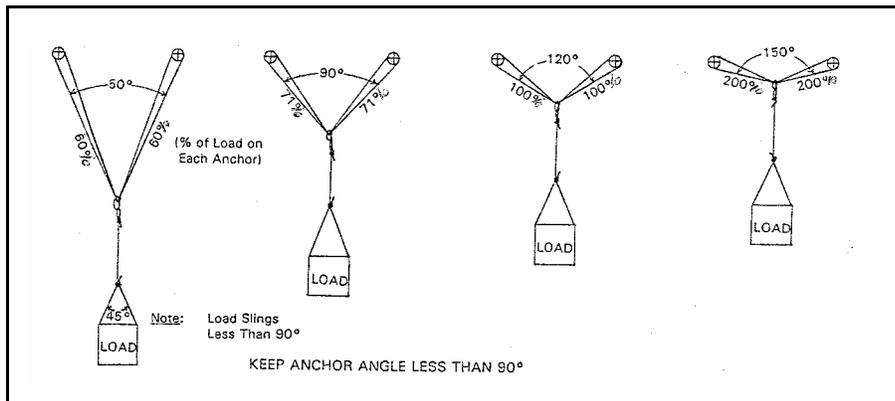
**Hasty Hitch**

## ANCHORS

The lines used in rescue must be firmly attached to a solid object, thus the term anchor. A single object that is very stable (palm tree or telephone pole) would be considered a "bomb proof" anchor. The anchor should be as strong or stronger than the rope used (9000 lbs. +). When attaching an anchor at two or three points, level ample slack. More force is exerted on the anchor points and ropes when the anchor ropes are not slack with an angle of less than  $90^\circ$ . (Refer to drawings)



**Tensionless Anchor**  
No reduction in rope strength

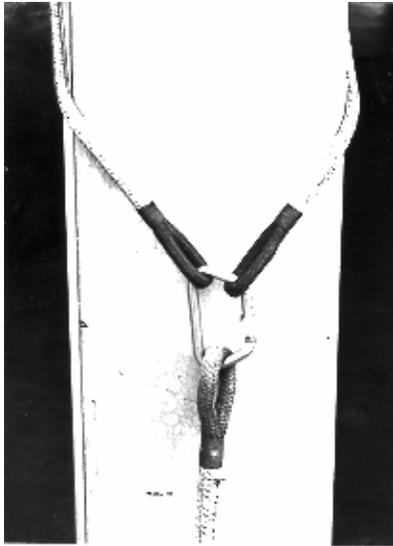


**Effects of Angles on Anchors/Loads**

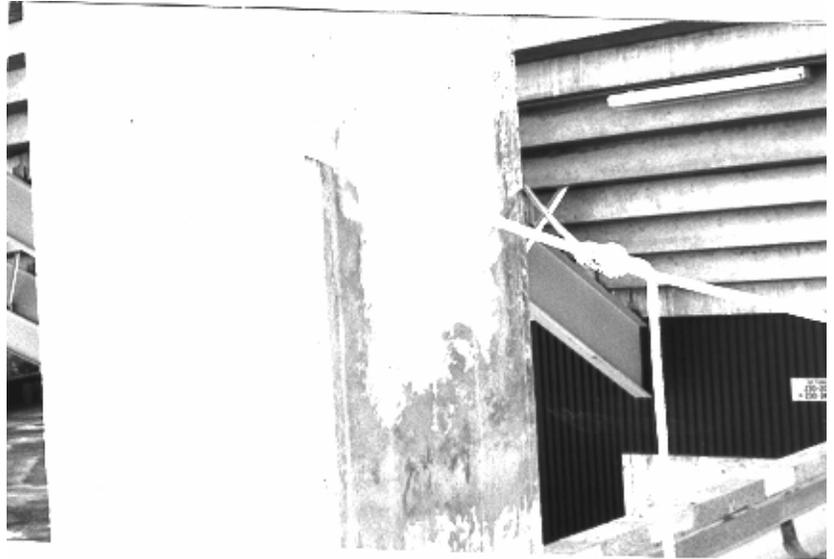
Shown in Figure 22 is a lifeline anchored using a 10' anchor rope with an eyesplice at each end. The sling anchors are used in the same fashion.

An anchored line using a figure 8 follow through around an object is depicted in Figure 23.

If the anchor is marginal use a self-equalizing or load distributing anchor with a two or three-point attachment.

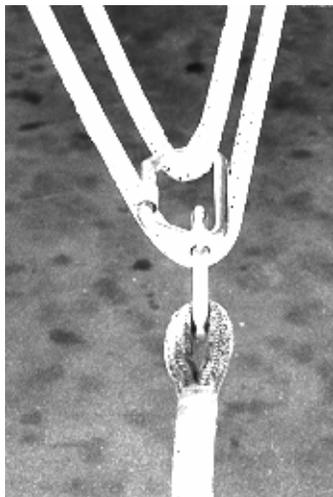


**Figure 22**

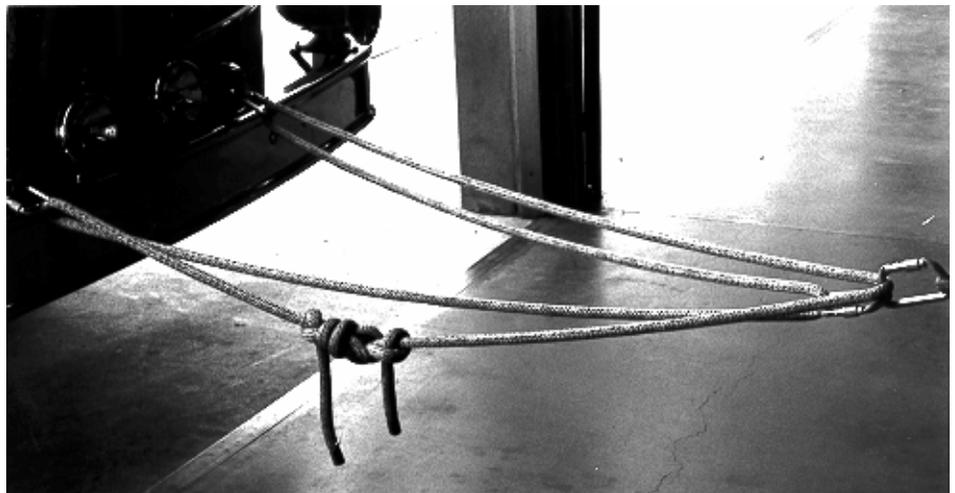


**Figure 23**

Again, leave slack. Anchor rope show is a two-point attachment looped and tied with a follow through figure 8 splice with safety half-hitches (Figures 24 and 25). With a half twist in the center loop, one carabiner can be used.



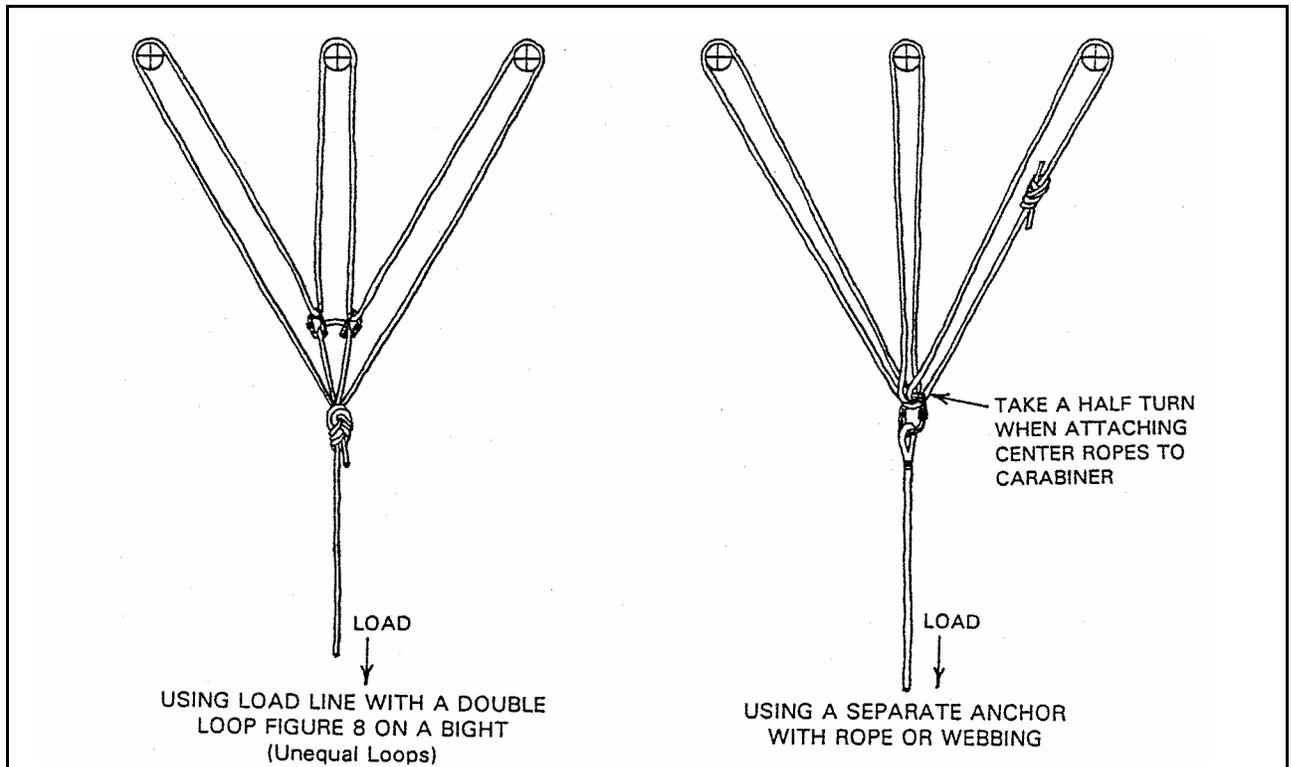
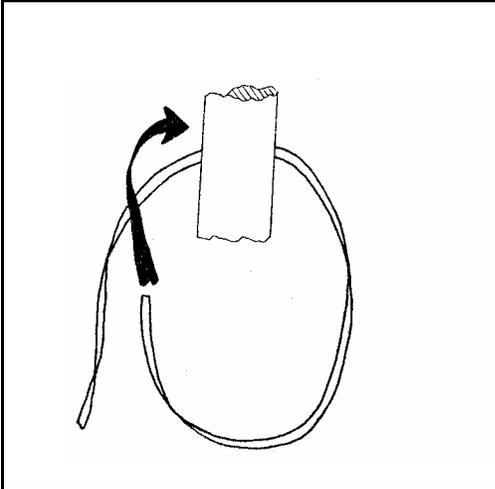
**Figure 24**



**Figure 25**

Using webbing, this anchor will not slip up and down and has about 12,000 lb. rating including loop strength .

If extra strength or safety is needed, two carabiners may be used in anchor systems instead of one. Place them side-

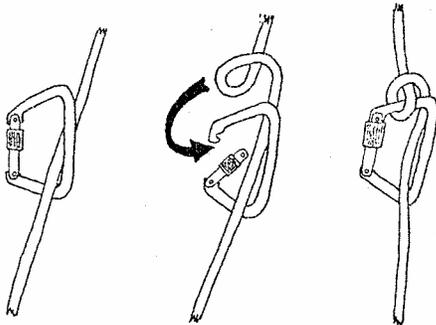


**Three-Point Load-Distributing Anchors**

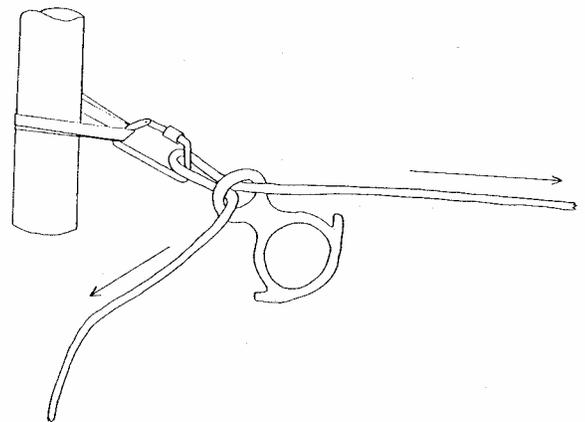
by-side with gates opposing. An anchored figure-8 is used as a friction device to lower a load. If the load is multi-person, a 6 bar rappel rack is used. If the load is in sight the person can turn around and face the load while still maintaining control of the lowering operation. If out of sight then commands must be relayed. Realize if hoisting is going to be necessary that equipment should be near the anchor point to build a hoisting system on the lifeline (Figure 26).

## BELAY SYSTEMS

The end of the figure 8 plate can be used for belaying single person loads (see drawing). When lowering the people in a high or steep angle setting a top belay should be used in case there is a failure of the lifeline. A simple friction hitch that can be used in belay is the "munter hitch" it may also be used to control descent (see drawing).



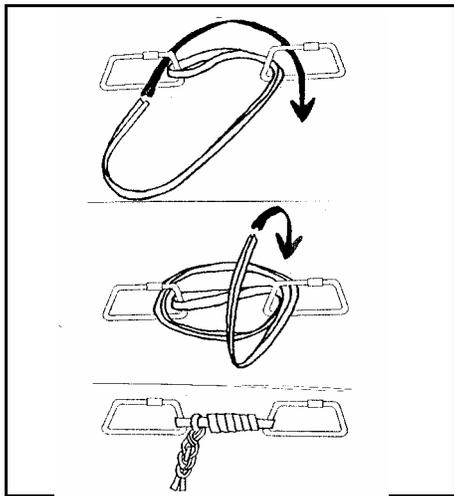
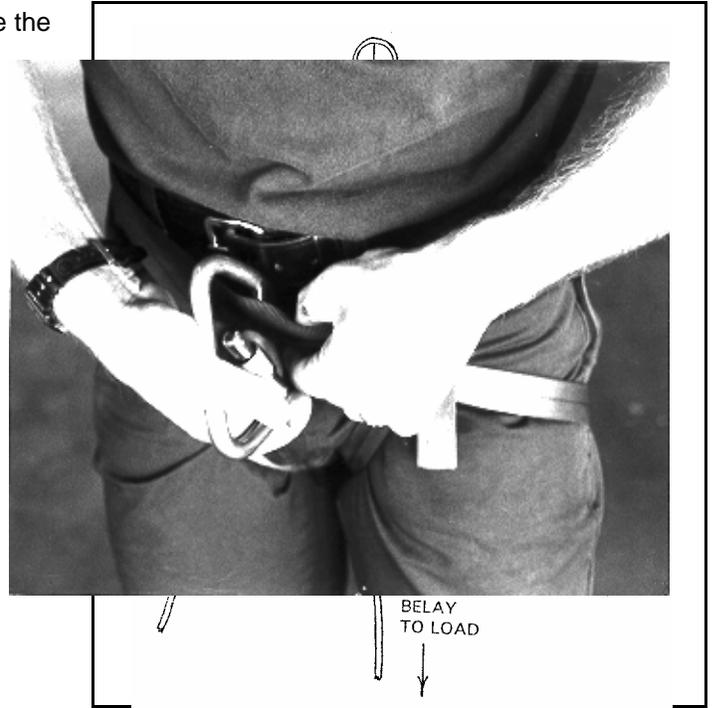
**Munter Hitch**



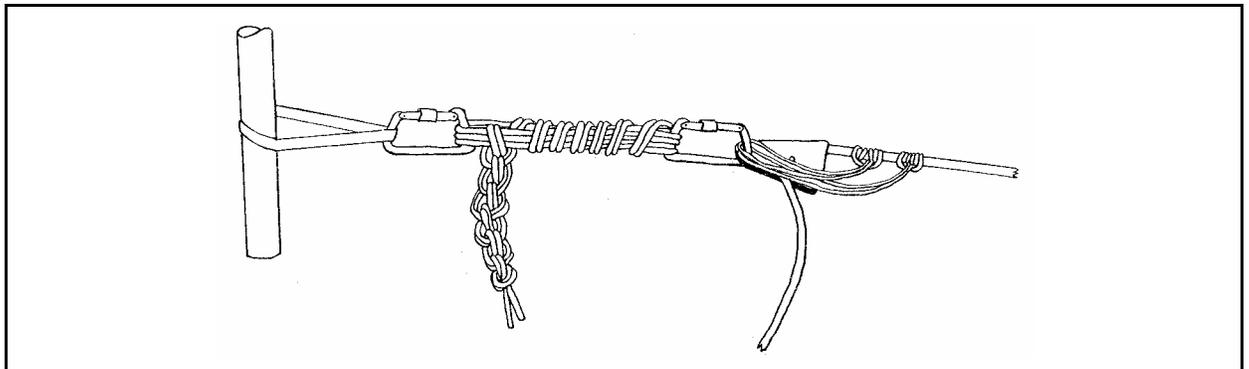
**Figure 8 Belay**

For multi-person loads the tandem prusik belay system must be used. This system uses a load-releasing hitch in the anchor (see drawing). This hitch can absorb a significant shock and if the prusiks in the system become locked you can lower the load a few inches by slowly twisting the wraps in the opposite direction. Otherwise the lifeline will have to have a hoisting system incorporated to raise the load to release the prusiks in the belay line.

Use a 20'- 30' piece of webbing. After looping one carabiner with the center of the webbing folded in half and then wrapping both as shown, wrap the connecting webbing 6 times, pull the tail through the center of the wrapped loops, and daisy chain the tails.



**Load Releasing Hitch With Webbing**

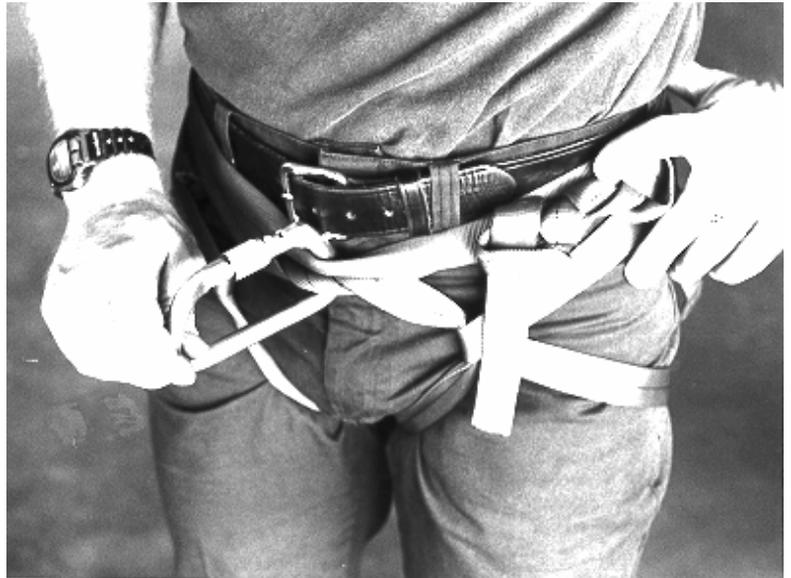


**Load Releasing Hitch with Tandem Prusik Belay using 9mm cord**

## RAPPELLING

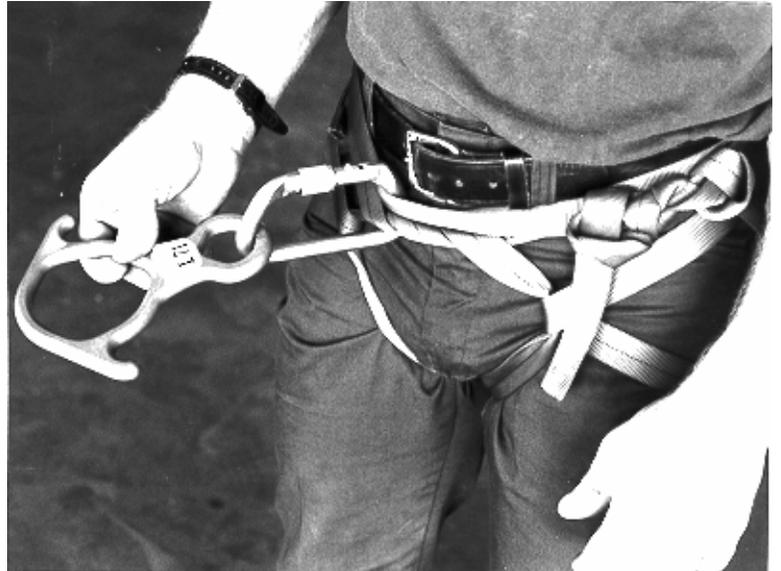
The figure-8 descender must be attached to the swiss seat or harness. Open a carabiner and place the hook end toward yourself and down around both waist straps and the shoulder harness strap, if used or to the waist ring on a Class 3 harness (Figure 27).

Rotate the carabiner so that the locking device is on top with the hook end away from you. This enables quick release from the rope at the completion of rappel (Figure 28).



**Figure 28**

The figure-8 can now be hooked into the carabiner. The lifeline must be attached to the figure-eight descender (Figure 29).



**Figure 29**

Hold the figure-8 by the small loop in your left hand. Place the lifeline across the large loop towards yourself in the direction of descent and push the line through the loop with your right thumb (Figure 30).



**Figure 30**

Grasp the figure-8 with your right hand at the large loop. With your left hand pull the line through the large loop and around the small loop, forming a wrap (Figures 31 & 31). The 8 plate can be wrapped from the bottom also with the same friction results. However, the above method is easier to tie off.



Figure 31



Figure 32

After the lifeline is attached to the person rappelling and the carabiner is locked in the closed position, the right hand is placed on the descending portion of the lifeline. This hand never leaves the line and stays in the same position next to the hip once your weight is on the line. To brake, tighten your grip and turn your right hand

toward your back, under your hip. The left hand is on the line above the figure-8 for stability (Figure 33).

After you are in a comfortable, seated position, with your feet against the wall, descent is made by releasing some tension in your right hand. You can just walk down and with experience jump away from the wall to descend or over ledges, windows, etc. Whenever possible a belay person will be stationed at the base of the lifeline. The rappeller will call "on rope" when he is attached to the lifeline. At the command "on belay" or in an uncontrolled descent, the belay man will exert tension on the lifeline. When the line is pulled tight, descent will stop. "Off belay" is the command to release the tension.

## **TOP BELAY**

A second rope or belay line should be attached to any person "going over the edge" in steep or high angle situations. This line is attached to an anchor with a friction device or a munter hitch on a carabiner for safety if the life line should fail. This rope is manned by the belay person. One exception to a two-line operation is a stokes basket/aerial ladder operation where the 5/8" lifeline is used with the rope passing over rollers or blocks with no danger of being severed. This operation is covered later in this chapter. The 5/8" Lifestron rope has an average strength of 18,300 lbs. This is the rope used in the photographs depicted here. With a 90 to 1 safety factor, no top belay was used. There may be instances where a top belay is not used. In such cases, the safety factor of rope strength to load and any chance of rope damage must be considered.

## RAPPELLING OVER A PARAPET WALL

After securing an anchor, attach the lifeline to the anchor rope (Figure 34).

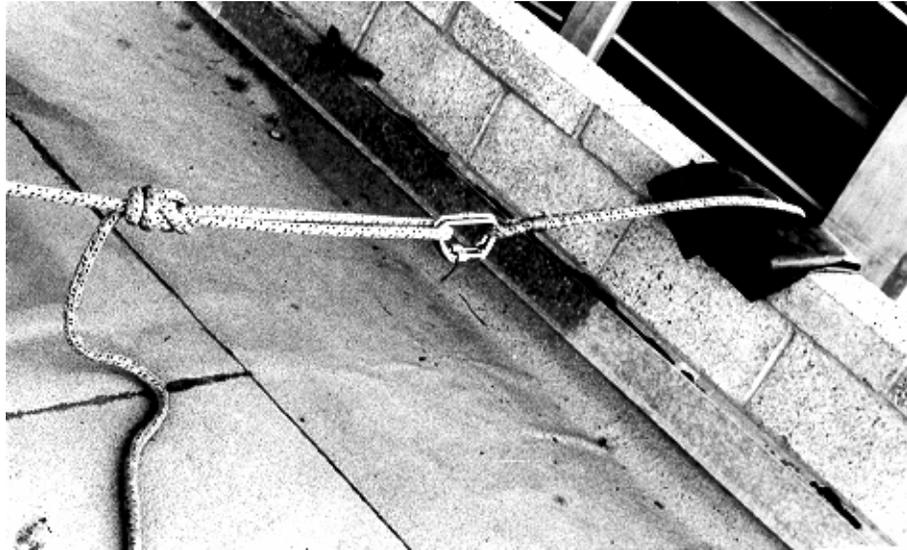


Figure 34

Always pad the line any time it must go over a sharp corner (Figure 35). A hose roller works well to round out a sharp corner.



**Figure 35**

Attach yourself to the lifeline. Call "on rope" for the belay man. Get your hands in position and straddle the wall (Figure 36).



**Figure 36**

Put your chest down over the figure-8 and grip the wall with your left hand and ease over, all the while holding tension on the lifeline with your right hand (Figure 37 & 38). Use care to keep your left hand out from under the line.



**Figure 37**



**Figure 38**

Use your knees against the wall to get in position (Figure 39). With practice you can step off directly to your feet.



Get in the rappel position with your feet against the wall (Figure 40). You are now ready to descend. Some may contend that standing on the parapet is the correct way to start this rappel. The above method is easier and safer.



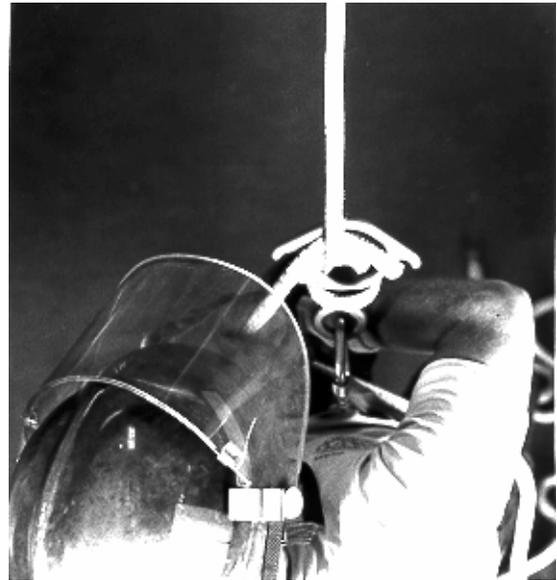
Figure 40

#### **TYING OFF**

If during the descent the rescuer needs both hands free then he must tie off. Bring your left hand down and grip the wrap on the figure-8 (Figure 41).

Keeping tension on the line, bring your right hand around and wrap between the Figure-8 and the lifeline (Figures 42 & 43).

Take a second wrap on top of the first (Figure 44 & 45).



**Figure 45**



**Figure 42**



**Figure 43**

To finish the tie off, bring the line through the figure-8, forming a loop (Figure 46). Then half-hitch around the ascending line (Figure 47). While tied off you can move your body to a horizontal position and use both hands. When untying, it may take both hands to pop the wraps loose. Keep hold of the line. If during high angle operations an object is dropped or falls, the warning shouted is "rock".

**ONE-ON-ONE RESCUE (Mid-face Pickoff)**

One-on-one rescue is where the rescuer and victim both descend down the lifeline together. Use a top belay that insures that if the main line should fail, both rescuer and victim are still attached to the belay line. Tie the Ticknor or hasty hitch harness on the victim (Figure 48).



Figure 44



Figure 46



Figure 47



Figure 48



**Figure 49**

Take a double wrap on your figure-8 and lock in (Figure 49).



**Figure 50**

Lock the victim's carabiner into the figure-8 with your own on the left side (Figure 50).

Have the victim straddle the wall (or window sill) at your left while you get into the rappelling position (Figure 51).



**Figure 51**

The descending rope in your right hand must be held to the side of the Figure-8 when using the double wrap with the right elbow close to the body in order to keep the wrap with the right elbow close to the body in order to control the wraps. (Figure 52).

Ease the victim's weight on the line and get into rappel position. The added weight is easily controlled with the double wrap. Now just walk down the wall (Figures 53 & 54).

For a mid-face pick off, take the belay line down with you and then attach it to the victim. This will be your belay line also.

Attach yourself with an in line figure 8 or butterfly knot. Then make sure you and the victim are securely attached from his harness to your figure 8 plate. A webbing sling can be used. If the victim has no harness, you will have to tie a Ticknor or hasty hitch on them.

The recommended friction device for multi-person loads is the rappel rack.

### **BELAYING A PERSON WITH HARNESS**

This technique can be used to rescue people from heights without using the one-on-one rescue. With a



**Figure 55**



**Figure 53**



**Figure 54**

few lengths of webbing and figure-8's, several people can be lowered in a short time. After a few descents the webbing and figure-8's can be hoisted back up to the starting point using the lifeline in place.

Attach the persons harness to a lifeline with a figure-8 (Figure 55).

With a belay man in position at the bottom of the line, announce "on rope" and help the person over the edge. If person is conscious, tell them to leave their hands off of the rope. The person can now be lowered at the control of the belay man (Figure 56).



**Figure 56**

## ASCENDING

Ascending (climbing) a rope can be done by the use of ascenders, such as the Gibb's, or by prusiks. A set of 3 prusiks (6mm) designed for ascent and self rescue are called prousals.

After tying off, attach your harness above your figure 8 plate with the short prusik using 2 wraps (Figure 57).

Attach the two long prusiks just below the short one (2 wraps) and put your feet in the preformed loops (Figure 58).

By standing in the loops; you can release the tension from your figure 8 plate and remove it from the line. Move the small prusik up the line as far as you can and transfer your weight from your feet to your harness via the short prusik. Now bend your knees and move the long prusiks up the line as far as you can and repeat the process (Figure 59).

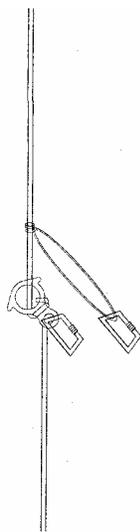


Figure 57

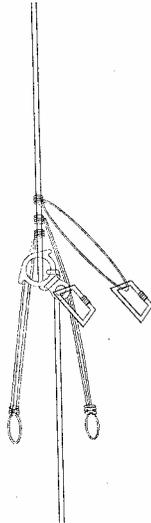


Figure 58

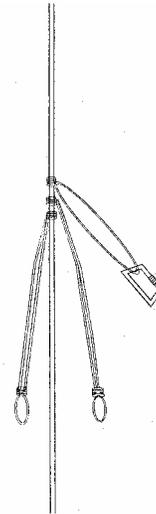


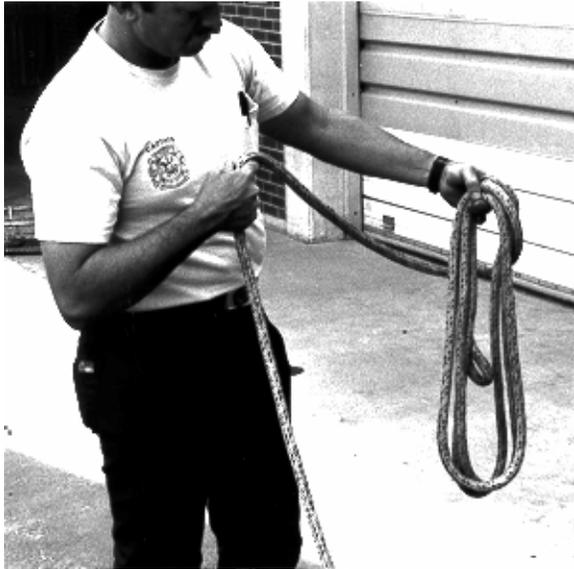
Figure 59

## **THROWING A ROPE**

This technique is used to get a rope, either safety or lifeline, from below to an upper floor, roof, etc. Roll enough rope in coils to reach the objective (Figure 60).



**Figure 60**



**Figure 61**

Take a wrap at the top of the coils close to the hand holding them (your left if you are right-handed). (Figure 61).



**Figure 62**

Push the standing end of the rope through the center of the coils forming a loop from which the coils now hang ( Figure 62).



**Figure 63**

Roll a few more coils with the loop at the top. Hold the standing end in one hand and the coils in your throwing hand. (Figure 63).  
Throw the coils in a sideways motion. The rope will play out on its way to the objective (Figure 64).



**Figure 64**

## STEEP ANGLE

Rescues not in the high angle environment may be low, moderate, or steep angle.

Low and Moderate angle (up to 40 degree grade) may not need the use of ropes. The stokes basket is carried by 4 to 6 bearers. However, ropes may be needed in rough terrain. Long carries can be made easier by attaching your personal strap to the basket, and passing it behind your carrying arm, over the opposite shoulder, and pulling down on it with the opposite hand. This will help distribute the load across your upper body. Extra men can also trail behind the procession and move up and relieve the back positions on the stokes, with all bearers moving forward one position and the leaders falling back to trail. This rotates the bearers without stopping.

When the angle of the terrain is 54 to 60 degrees, it is considered steep angle. This requires special techniques. Attendants are used verses bearers. Each attendant will use a class 3 harness and be attached to the stokes basket. One on each side and one at the rear, for a minimum of three attendants. This will always be a two line operation.

The descent system incorporates a 6 bar rappel rack for the main line and a tandem prusik belay with a load releasing hitch. With 3 attendants and the victim, this will be at least a 4 person load (Figure 65).

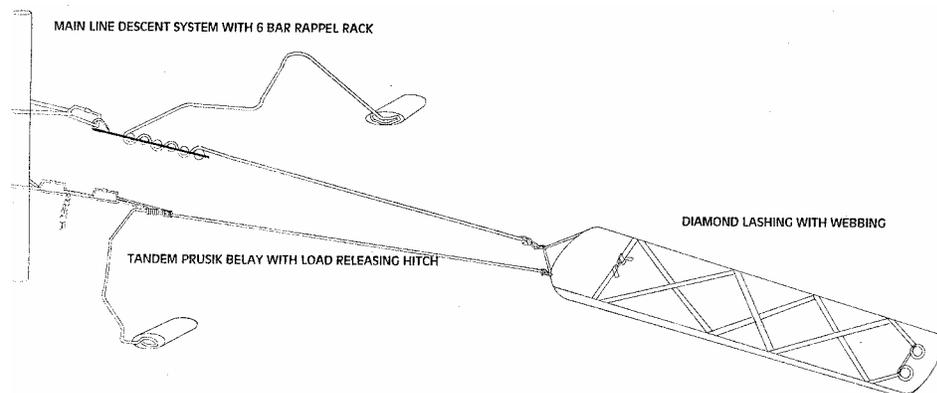


Figure 65

The ascent or hoisting system can incorporate different mechanical advantage systems. A 5/1 complex is shown. A tandem prusik belay with a load releasing hitch is used in conjunction with a prusik minding pulley. When the MA system needs to be reset, the belay man also needs to set the tandem prusiks (Figure 66).

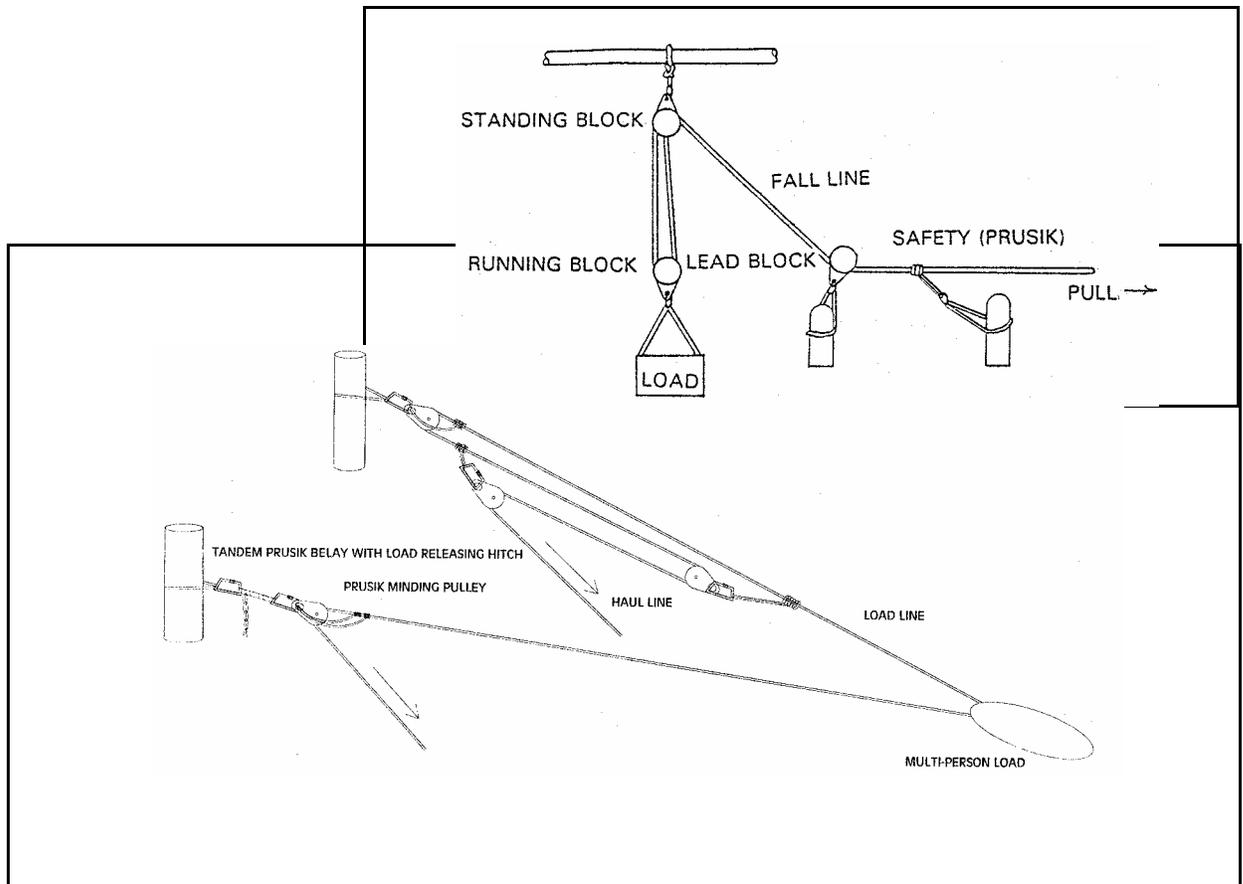


Figure 66

## HOISTING SYSTEMS

By using a combination of blocks, anchors, and rope, several different types of hoisting arrangements are possible. By using several blocks in the system a mechanical advantage can be gained. Lead blocks or any pulley used to just change the direction of pull give no mechanical advantage. Lead blocks are used to allow force to be applied to the fall line from a good position. When pulling on the fall line to raise a load, have enough men to do the job and use a steady pull. Always use a safety in your system that will hold the load while you reset your rigging or change positions. One man will be stationed at the safety. The safety is also called a

ratchet. If a ratchet prusik is used it can be anchored at the standing block.

When using a mechanical advantage the length of rope passing through the system compared to the height the load is raised is the same ratio as the advantage. Example: In a 2/1 system, 2' of rope will pass through the system to raise the load 1'. If the load weighs 100 lbs. it takes 50 lbs. of force applied to the fall line to lift it. This can be expressed mathematically as:

$$\text{Force X Distance Moved} = \text{Weight X Distance Raised}$$

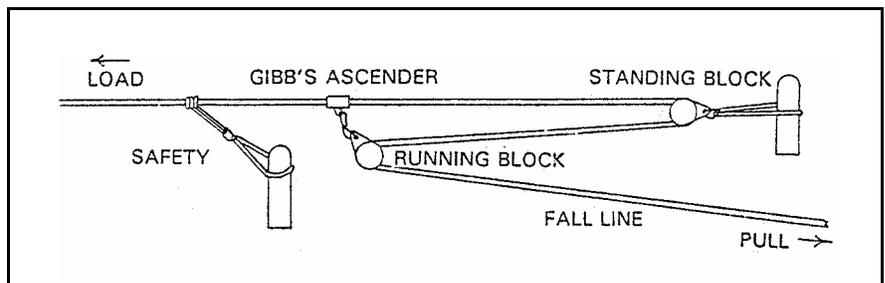
To determine the mechanical advantage (MA) remember:

If the rope starts at the anchor the system is even.

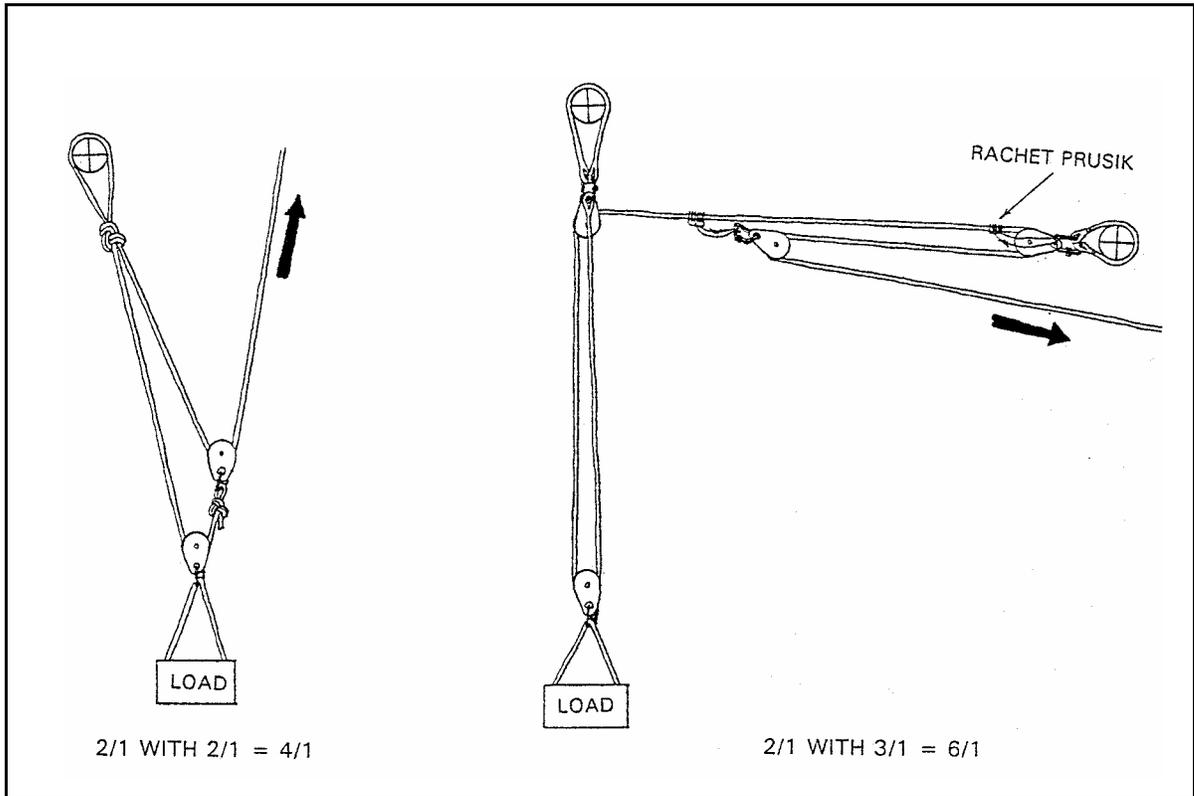
If the rope starts at the load the system is odd.

For simple systems count the pulleys and add 1. Don't count the pulleys used for a change of direction.

Safeties are always system prusiks. Gibbs ascenders may be used in the system, but not as a ratchet or safety. The line used in these systems is a minimum of 1/2".



**Z Rig 3/1 Advantage System**



**Compound Mechanical Advantage Systems**

Use a lead block so that your fall line pull is to the best advantage.

A compound system uses two or more MA's together. The product of the systems gives the total MA.

A complex system integrates systems for advantages equal to compound systems with fewer pulleys. However, a greater advantage, regardless of the system, means more rope moved through the system and a slower raise, which will mean more resets of the system.

The method for lowering a stokes basket smoothly on blocks is depicted in 67 & 68. There is not mechanical advantage here. The fall line is attached to an anchored figure-8 for a friction control device. (No belay shown).



Figure 67

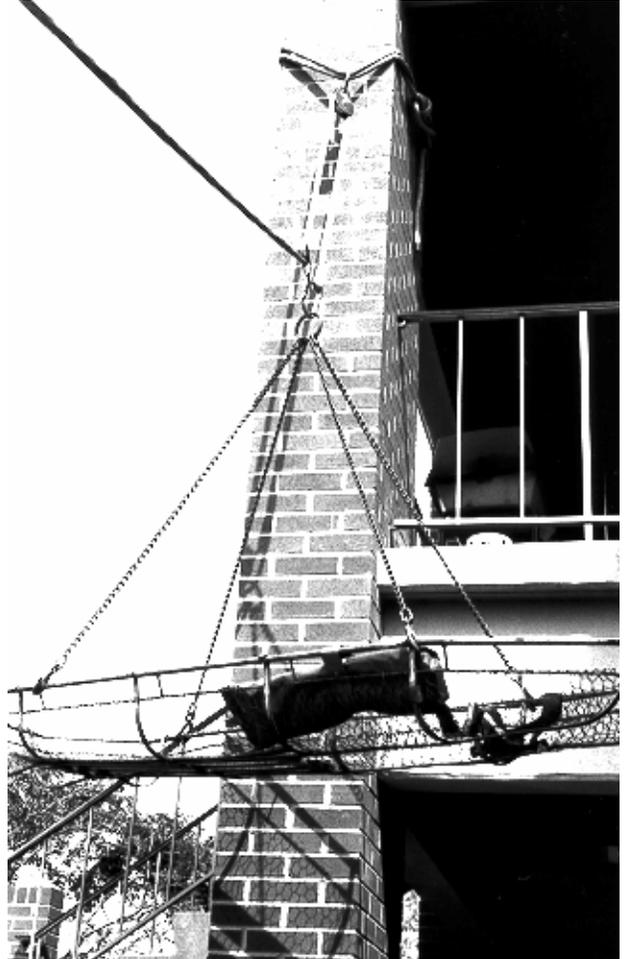
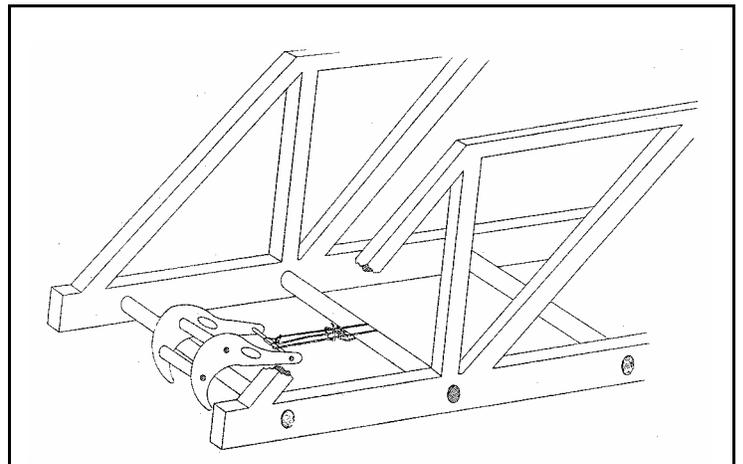


Figure 68

### STOKES BASKET RESCUE USING AERIAL LADDER

The 5/8" lifeline is passed up through the trough of the aerial and over a hose/rope roller attached to the last rung of the fly section. A carabiner is attached to the eyesplice to attach to the stokes bridle. Another method on the LTI is to pass the line over the second rung (Figure 69) where a notch has been cut out of the rubber sleeve. Then through a block anchored to the first rung with an anchor strap by wraps (as shown) or a clove hitch with a

half-hitch safety. This method cannot be used on the E-One, as the rungs are ribbed and will damage the rope.



**Rope Roller Attached to Aerial**



The line at the turntable is attached to a figure-8 anchored to a rung with a carabiner clear of the extending mechanism. In this configuration the line can be adjusted easily for length. The stokes basket can also be lowered using the figure-8 as a friction device. With one man in the stokes basket the engineer at the turntable can easily handle the lowering using the single wrap on the figure-8. If an attendant is attached to the hoisting point of the stokes basket (using his own system) then a double wrap should be used on the figure-8. This is an option; if room permits the stokes basket can be lowered with the aerial controls. (Figure 70)



Figure 70

When the adjustments in length of the line are complete and all maneuvering of the stokes basket can be made with the aerial controls, then the line is tied off at the figure-8 (Figure 71).

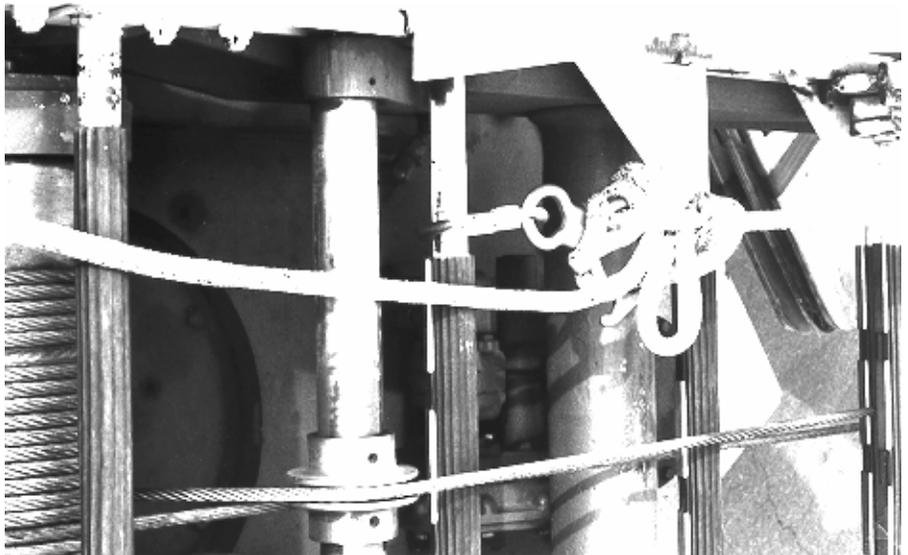


Figure 71

Stokes basket attached to lifeline and ready to lift from a roof (Figure 72).

Stokes basket suspended from aerial ladder that has been rotated from the roof over the touch down spot (Figure 73). The stokes basket can now be lowered using the aerial controls or the figure-8 friction device at the turntable. NOTE: A guy (tag) line is not shown in the photos, but should be in place to steady the stokes basket during the maneuvering sequence.

If an attendant is required for the victim in the stokes basket, he can lock into the carabiner where the stokes harness attaches to the lifeline. A double carabiner should be used at the attachment point. He would use his own system consisting of: carabiners, a short lifeline, and Class 3 harness. He will be suspended to the side of the stokes basket with his waist at the basket level. He should have no weight on the stokes basket. A safety belay can be attached above the connecting point by using a prusik on the lifeline and attaching it to your harness.

All beaners should be in the gate down position so that gravity will keep the screw closed.

With advances in Technical Rescue and procedures, the following changes are made in the Stokes Basket Rescue.

- The pulley attached at the end will be on a 4 point load sharing anchor that uses the 2 end rungs and both beams.
- The rope roller will be attached to the 3<sup>rd</sup> rung.
- A rack will replace the figure 8 for the friction device at the base of the aerial.
- The main line will go up through and over the rope roller and through the pulley, and can be the 5/8" Lifestron, or 1/2" kernmantle.
- A 1/2" kernmantle belay line will be used that is attached to a separate rung at the base using tandem prusiks. This belay will go up the trough, and over the roller to the stokes basket.
- No attendant will be used for this rescue.
- The load placed on the ladder will be figured at twice the weight of the stokes basket and victim.

The rigging and operation of this procedure is depicted in the Ladder Company Operations policy, 202.02.

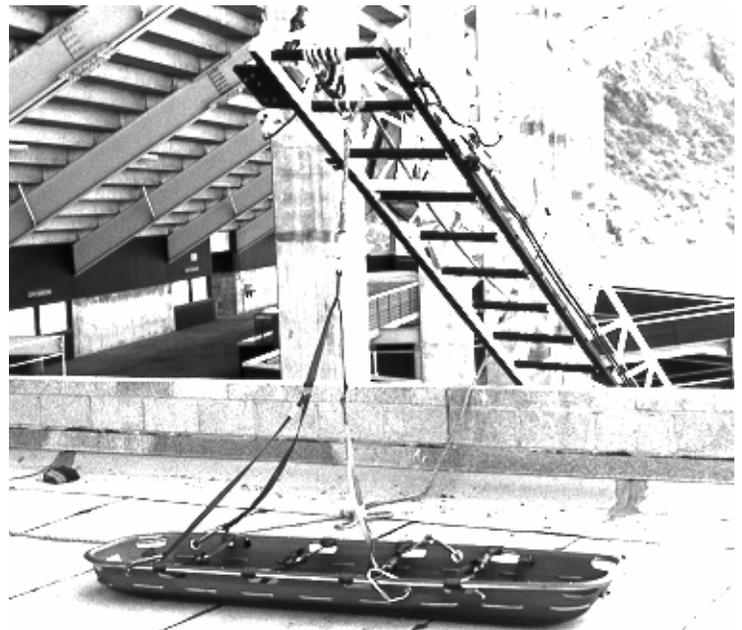


Figure 72

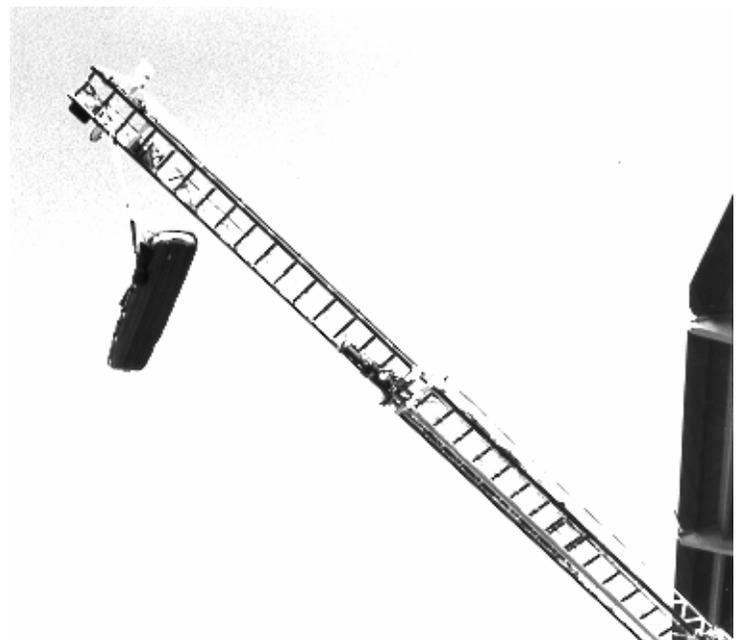


Figure 73

## GLOSSARY OF TERMS

*Anchor* - Term for attaching life or hoisting lines, blocks, and safety lines to a solid, stable object using ropes and carabiners.

*Beaner* - Carabiner.

*Belay* - Method of controlling or stopping a descent of a person on a lifeline by another person, located at the base of the lifeline or by a second line from the top. Commands are: "On/Off Belay".

*Block* - Pulley.

*Butterfly Harness* - Fast rescue harness around the pelvis using 17' length of 1" nylon webbing tied in a loop. May be modified to a hasty hitch by placing waist over one shoulder.

*Carabiner* - Metal locking device for connecting ropes, stokes baskets, figure-8 descenders, etc.

*Complex System* - Integrated mechanical advantage system that can give the same advantage as compound systems with fewer pulleys. Calculating advantage is done differently than in simple systems.

*Compound System* - A series of systems using mechanical advantage to a greater degree.

*Fall Line* - The line where the pull is generated on a hoisting device. Also the path a weighted rope would take in high angle conditions.

*Figure 8 (8 plate)* - Friction device used to descend. Also a knot used in anchors and splicing.

*Gibb's Ascender* - Device that moves one way on a rope.

*Hasty Hitch* - A form of the butterfly harness that uses one shoulder as well as the pelvis. A Class 3 harness.

*Life Line* - Rope used for rescuer or victim.

*Mechanical Advantage* - Differential of force obtained by using blocks in different configurations. Force X Distance - Weight X Distance.

*Munter Hitch* - A friction hitch around a carabiner, usually used in belaying.

*On Rope* - Term used by person descending on lifeline to inform belay man that he is connected.

*Prusik* - Small diameter rope tied in a loop that works as an ascender.

*Rappel* - To descend on a lifeline by use of a life seat, carabiner, and a figure 8. harness using a descent device, usually a figure 8 plate or rappel rack.

*Rappel Rack (6 bar)* - An adjustable friction descent device that can be used in systems or to rappel.

*Ratchet* - The safety ascender in a hoisting system.

*Rigging Plate* - A stainless steel plate with several holes used to attach several items to one anchor point.

*Safety* - Half-Hitch or overhand knot used to secure another knot. Also a locking device on the load line when hoisting. i.e., a ratchet prusik. A belay can be referred to as a safety line.

*Simple System* - A basic mechanical advantage system; i.e., 2/1 and 3/1 Z-rig.

*Swiss Seat* - A seat harness tied with 17' - 20' of 1" nylon webbing. A Class 2 harness.

*Ticknor Harness* - Rescue harness tied on the victim with 17' - 20' of 1" nylon webbing using a carabiner at the hoisting point. A Class 3 harness.

*Up/Down Victim* - Command for direction of hoist with a victim in stokes basket or harness.

*Water Knot (bend)* - Non-slip knot using a trace overhand knot used to tie webbing together.

*Z Rig* - A hoisting assembly using blocks, Gibb's ascender, and prusiks that gives 3/1 mechanical advantage. A simple system.