CHAPTER X

RESCUE TECHNIQUES

In recent years there has been quite a lot of research and development of new ropes and equipment, not only for sport but for fire/rescue service. The trend has been toward lighter and stronger rope and equipment. In years past, larger diameter ropes were used in rescue, primarily for two reasons: (1) tensile strength, and (2) good gripping surface. This was because it was usually done without the aid of braking devices. The modern day ropes are small in diameter, high in tensile strength, made of low stretch nylon, normally having a hard slick finish, making it difficult to hold without the aid of friction. In many areas rescuers are finding that they have to perform with less manpower. This also brings on a need for different and additional equipment.

Rescue skills and techniques have changed very little over the years, and should not change much in the coming years. We will continue to use our basic skills with "state-of-the-art" equipment. The development of newer and lighter equipment is making rescue operations easier and safer. Each of us must learn the basic skills well and be able to adapt to the particular emergency at hand.

This chapter will acquaint you with some of this rope and equipment. Some of the proven rescue skills and techniques will be illustrated and described. All of the skills and techniques described in previous chapters can be accomplished with the rope and equipment shown in this chapter. Only the basic use of rope and hardware will be shown. The variations that can be accomplished from these basic skills are limited only to the creativity of the rescuer. It is recommended that the rescuer have a thorough knowledge of their equipment and basic skills.

It is of utmost importance when purchasing equipment, that it be purchased for its intended use. If it is to be used for sport, weight may be a factor. If it is to be used for industrial or municipal rescue, strength and durability may override the weight factor. The old saying "a chain is only as strong as its weakest link" cannot be overlooked in rescue operations. The equipment shown on the following pages is not necessarily an endorsement of that product.

A. TYPES OF ROPE

1. GOLDLINE - This is a three (3) strand hard lay constructed rope. It is 7/16" diameter with an average tensile strength of 6200 lbs. It is used for rappelling, but is not as widely used now as in the past because of better design of rappel ropes.

2. STATIC KERNMANTLE - Kernmantle means: kern (core) and mantle (sheath). This rope is designed with a braided sheath over a continuous stranded core. Static means it has a low stretch factor, So we have a rope that is high abrasion resistant, low stretch, no spin, high strength and easy handling. This rope is designed for:
   a. Rappelling
   b. Standing line climbing
   c. Rescue (lowers, raises and hauling)

   It is not a dynamic rope and should not be used as a belay line in rock and mountain climbing. Remember, it has a low stretch factor and should not be subjected to a dynamic load (sudden load such as a person falling when climbing and the rope stopping the fall).

3. DYNAMIC KERNMANTLE - This rope is used for rock and mountain climbing, and is mentioned only for identification purpose. It is designed to stretch when loaded. Consult manufacturer for specifications.

B. STRENGTH OF STATIC KERNMANTLE ROPE - The strength of rope is governed by its size, its condition, and by the care with which it is used. Rope is made to a standard set of specifications and when new, has a stated "breaking strength" or "tensile strength". When purchasing rope of any size, you should always know the "tensile strength". When using rope for rescue you should not exceed the "safe working load", which is one-fifteenth (1/15) of the tensile strength. The SWL accounts for age, wear, knots and sudden jerks on the rope. (See Fig. 86 on page 94)
STATIC KERNMANTLE
ROPE SPECIFICATIONS*

<table>
<thead>
<tr>
<th>Size</th>
<th>Tensile Strength</th>
<th>SWL (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches</td>
<td>(mm)</td>
<td></td>
</tr>
<tr>
<td>5/16</td>
<td>(8)</td>
<td>4,800</td>
</tr>
<tr>
<td>3/8</td>
<td>(10)</td>
<td>5,800</td>
</tr>
<tr>
<td>7/16</td>
<td>(11.1)</td>
<td>6,800</td>
</tr>
<tr>
<td>1/2</td>
<td>(12.5)</td>
<td>9,000</td>
</tr>
<tr>
<td>5/8</td>
<td>(16)</td>
<td>13,000</td>
</tr>
</tbody>
</table>

Figure 86
Note: SWL is figured at 15:1. The above specifications are an average and may differ from one manufacturer to another. 3/8" and 7/16" is a one person rope. 1/2" and 5/8" is a two person rope.

STATIC KERNMANTLE
ACCESSORY CORD SPECIFICATIONS*

<table>
<thead>
<tr>
<th>Size</th>
<th>Tensile Strength</th>
<th>SWL (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6mm</td>
<td>2170</td>
<td>145</td>
</tr>
<tr>
<td>7mm</td>
<td>3550</td>
<td>235</td>
</tr>
</tbody>
</table>

Figure 87
Note: There seems to be a great difference in some of the tensile strength of same size accessory cord. It is recommended (by this author) that you use accessory cord with a minimum tensile strength of at least 3000 lbs. when used in rescue. SWL above is figured at 15:1

C. CARE OF ROPE - The care of rope has already been covered in Chapter 1.

D. KNOTS - As previously stated, a good knot must hold without slipping. It not only should be easy to tie, but easy to untie once it has been used. The rescuer should have a thorough knowledge of the basic knots used in rescue. They should not only know how to tie, but should recognize and check knots that have been tied by others. Knots can be disguised or "camouflaged" by overhand safety knots. Figure 88-B shows the bowline with an overhand safety. The overhand safety makes it a little harder to recognize the bowline. Figure 88-A shows the bowline with the running end seized to the standing part of the rope with a small piece of cord (or string) and with tape.
1. **Two-Wrap Prusik**
   The prusik is tied with a small rope sling (accessory cord) around a larger diameter rope. The two-wrap prusik is tied by passing around the larger rope two (2) times, and forming a double girth hitch. See Fig. 89. The prusik will slide up and down the larger rope with no tension on the sling, but will grip or hold when tension is applied to the sling. The prusik is used for ascending fixed lines, safety when rappelling, attaching slings for safeties, and on "Z" rigs. You will find many uses for the prusik.

2. **Three-Wrap Prusik**
   The three-wrap prusik is tied in the same manner as the two-wrap, except you make three wraps on the larger rope with the sling. The three-wrap is much stronger, and will hold about one-half again more than the two-wrap before slipping. (See Fig. 90)
3. Figure of "8" Loop
   Used to form a single loop in a rope. Can be hard to untie when heavy tension has been applied. To tie, double the rope, hold the standing part in the left hand, pass the running end over the top of the standing part forming a loop. Pass the running end under and around the standing part. Next, pass the running end down through the loop you have formed. Draw the running end tight, the knot should resemble the figure "8" with a loop. (See Fig. 91) This knot can be tied in the end or any part of the rope.

4. Butterfly
   The butterfly also forms a single loop. It too has a tendency to jam when heavy tension is applied. The butterfly like the figure "8" loop is used when you need anchor points to set up "Z" rigs for lowers, raises or hauling systems. To tie the butterfly see Fig. 92.

5. Double Fisherman
   This knot is used for joining the ends of rope together to make a sling. It is a jam knot; the more pressure exerted on it, the tighter the knot. It is very strong and hard to untie, and should not be used in lines that have to be untied. This knot is formed by tying two double overhands, each around the opposite standing part. When drawn taut, the double overhand jams against each other. (See Fig. 93)

6. Water Knot
   This knot is very good for joining the ends of flat webbing to make a sling or seat. To tie; tie an overhand knot in one end of the webbing, then with the opposite end, trace back through the overhand knot formed. This knot will also jam and be difficult to untie. (See Fig. 94)

7. Square Knot
   The only place this knot is used in this text is tying the Inverted Swiss Seat. To tie; hold the two ends in opposite hands, take the end in the right hand and lay it over and bring all the way around the rope in the left hand. Then take the end in the left hand, lay it over and bring it all the way around the rope in the right hand. Dress it down and you have the square knot. (See Fig. 95)
8. Inverted Swiss Seat
Using a 14’ - 16’ piece of 1” x 1/8” soft tubular nylon webbing or a piece of rope of adequate size and strength to tie a seat or harness for rappelling when a pre-made harness is not available.

a. Double your webbing or rope and pass the double end between your legs, from back to front. When doubled, the piece in the left hand should be about 12 to 18 inches longer than the one in the right hand. (See Fig. 96-A)

b. Bring the two ends around your hips and pass each end through the double end. (See Fig. 96-B)

c. Pull each end back to the same side it came from and pass each end around the body. (See Fig. 96-C and 96-D)

d. Finish off on the left side of the body with a square knot. With each end of the webbing or rope, tie an overhand knot (safety knot) on each side of the square knot. (See Fig. 96-E) If you have loose ends, tuck them in your pocket to get them out of the way.

Note: If you plan to rappel left handed, finish the Inverted Swiss Seat on the right side, and the longer piece of webbing should be in the right hand at the beginning.
E. CARABINERS

These are metal "snap-links" that are used to connect equipment and rescuers to an object or to each other. They are important items in rescue equipment and should be used with care. They must be used properly to prevent failure. They are designed for longitudinal loading and the gates are the weakest point. Sideways loading can cause failure. Carabiners can be purchased in two shapes - (1) oval and (2) D-shaped. Oval shaped ones are easier to use in some situations, but D-shaped ones are stronger since the force of pull is away from the gate. Carabiners come in several sizes and construction. Again, equipment should be purchased for an intended need. Sport climbers probably would use standard size aluminum because they are light weight. Fire/rescue services probably would prefer the larger carabiners made of steel. The standard size is shown in Fig. 97. The oval carabiner shown has a non-locking gate, others shown have a locking gate. The standard size carabiner can be purchased in high strength aluminum or steel. The average tensile strength will be approximately 4500 lbs to 5800 lbs. These figures can vary with materials and manufacturer.

The large and extra-large carabiners were developed primarily for fire/rescue services. They are large enough to fit over litter rails and ladder rungs. They come with locking and non-locking gates in aluminum or steel. Average tensile strength will be approximately 9,000 to 16,000 lbs. These figures will vary according to the material, the finish of the material and the manufacturer. (See Fig. 98)

F. DESCENDERS

All descenders use friction in someway. The devices can be used for rappelling, lowering litters, and equipment. They differ from one another by the amount of control the user has over the friction, how much friction they give, strength of the device and whether or not you can vary the friction once weight has been applied. Some things that should be pre-determined before purchasing descenders are:

Will they be used for sport or rescue?
Will they be used to lower people and equipment?
What amount of control (friction) will be needed for your operations according to the availability of manpower?

1. Brake Bar Rack

Brake bar racks or rappel racks are designed for controlled rappelling. They allow the user to adjust the amount of friction while in use. These racks are constructed of stainless steel with a welded eye or by continuing the wrap around the circle or by wrapping the tail around the shaft to form the eye. The eye is used to anchor the rack to a seat harness or other anchors by use of a carabiner. The rack is a very useful tool for lowering equipment or litters. Friction can be added or
or taken away while being used. Racks are available in two sizes, five (5) or six (6) brake bars. Bars are constructed of steel or aluminum. (See Fig. 99 on page 101) Steel is more durable but offers less friction. A recommended set-up of bars for a rack is listed below and shown in Fig. 100.

1st - top bar with a trimmig groove
2nd - straight slotted bar (straight slot will help prevent rigging backwards)
3rd - 6th angled slotted bars (aluminum or steel)

Caution should be used in attaching the rope (descending rope) to the rack, to prevent rigging it backwards. (See Fig. 101 on page 102) Straight slotted bars will help prevent this (only the 2nd bar needs to be straight slotted). Although the rack is bulkier and slightly heavier than some other devices, ease of operation and its flexibility over-ride this. Large diameter rope and even double ropes can be used.

2. FIGURE "8" (See Fig. 102 on page 102)
The figure "8" is very strong and easy to use, but it is difficult to vary the friction. They are constructed in different sizes and materials. Figure "8's" can be used for rappelling, lowering persons or equipment. The smaller aluminum ones are generally preferred for sport and the larger steel or aluminum are used for rescue.

a. Standard figure "8" without 'ears' can be used for rappelling and belaying. It will handle double 11mm rope. It is preferred by rock climbers and for sport climbing.

b. Large figure "8" with 'ears' made of steel or aluminum is made for larger diameter rope to be used in rescue. The 'ears' help prevent the rope from sliding around the top and forming a girth hitch.
G. ASCENDERS

Ascenders are used as a replacement of prusik knots for climbing up a fixed rope, but can be used in other applications, such as, personal safeties and in hauling systems. As with other equipment, know your intended need before purchasing. All modern day ascenders work on the principle of using a cam to make it run in one direction on the rope. Ascenders that use teeth on the cam to grip the rope should have only one person’s body weight on it at one time. For ascent, at least two ascenders are required and on long ascents, three are recommended. (See Figure 103 on page 103)

There are several brands on the market that do the same job. They are different in design and construction. Because of time and space only one ascender will be shown in this text. This is in no way intended to take away from the qualities of other ascenders.

When using hauling systems that could stress equipment, Gibbs ascenders may be preferred. They are of simple design and press the rope instead of gripping with teeth. Heavier loads can be pulled without damage to the rope sheath. The Gibbs ascender must be taken apart to put on, or take off a rope. This is more time consuming, but insures that it will not come off the rope unexpectedly. Each Gibbs is pull-tested to 1000 lbs. They can be rigged in various methods for mechanical prusiks and are excellent tools for equipment hauling and rescue litter raising or lowering. Figure 103 shows the Gibbs taken apart, assembled and attached to a rope. Figure 105-A on page 104 shows the Gibbs being used to ascend a rope. Figure 105-B on page 104 shows prusik slings being used to ascend a rope.
H. PULLEYS

Pulleys have three specific purposes when used in rescue operations. (1) To reduce friction and cause the rope to run smoothly; (2) To change direction of pull; and (3) to gain a mechanical advantage. When using pulleys they should be compatible to your rope, and all other equipment being used. For rescue operations it is recommended that you use pulleys with metal wheels, side-plates and bearings. Pulleys (wheels) should be a minimum of four (4) times larger than the rope used. Smaller ratios than this could reduce the strength of rope because of sharper bends. Pulleys can be purchased in standard duty and heavy duty. Heavy duty models will handle up to 5/8" rope and are designed for heavy loads. Standard duty pulleys will handle up to 1/2" rope. (See Fig. 104)

I. RAPPELLING

In rescue operations, occasions may arise that require rescuers to descend steep or vertical slopes. With proper equipment, a slow and deliberate rappel may be the best method. Mountain climbing and rock climbing have become very popular sports. Also, hiking in mountain terrain and caving has become very popular. With increase of activity, we have seen an increase in accidents. We find that accidents also occur in industrial plants that may involve people being injured or falling into tanks or open vessels. Rappelling may be a quick and safe way to reach these victims.
Ascending A Fixed Rope With A Gibbs Ascender
Figure 105-A

Ascending A Fixed Rope With A Prusik Sling
Figure 105-B

104
CAUTION

It is of utmost importance that rappelling be done in a controlled condition. Be sure the rope and equipment are designed and constructed for their intended use. In training (and emergencies when possible) be sure that the person rappelling has a belayer, all knots are checked, rappel rope is attached to the descending device properly, you have a solid anchor, and the rappel is made with two ropes (or double rope). Single rope rappel can be and is frequently done, but a double rope is safer and easier to belay. When the above cautions are not followed, people get seriously injured and some have been killed because of mistakes. Even very experienced persons follow these cautions.

Rescue workers should be thoroughly familiar with rappelling techniques, equipment and terminology.

1. TERMINOLOGY

a. Rappelling - a technique for descending a rope on a steep or vertical slope or incline.

b. Belay - a technique for securing a safety line on a person for climbing or rappelling, to prevent that person from falling. This can be accomplished by tying a bowline (snug fit) around the chest of the person rappelling, and tying a munter hitch to a large carabiner that is anchored securely. (See Fig 106)
The rope is fed through the figure “8” during the rappel, but can be used to brake a fall at any time if needed. When belaying below the person on rappel, it is accomplished by applying tension on the rappel ropes to prevent a fall. Single rope rappel, pull downward on the rappel rope. (See Fig. 107-A) Double rope rappel, separate the ropes and apply downward tension. (See Fig. 107-B) Belay on double ropes can also be accomplished using the same technique as on a single rope.

Caution: It is important that the belayer observe and pay very close attention at all times to prevent a fall. Distraction could be fatal.

2. RAPPELLING COMMANDS OR CALLS

a. **On rappel** - Command given by person beginning a rappel. This call requires an answer before you begin a rappel.
b. **Rappel on** - or - **On belay** - Given by the person on belay to notify the person on rappel it is safe to begin. Does not require an answer.
c. **Off rappel** - Command given at end of rappel. Does not require an answer but the next person should not begin to rappel until he has received this call.
d. **Up rope** - A command to notify the belayer to take up the rope. Requires no answer.
e. **Slack** - A command to notify the belayer to let out rope. Belayer should let out only a small amount at a time. Requires no answer.
f. **Falling** - A warning call given by the climber or person on rappel that he/she is falling or a fall is eminent. Requires no answer, just a safe belay catch.
3. TECHNIQUE FOR RAPPELLING

a. Anchor the rappelling ropes with a round-turn and two-half-hitches, and seize the running end to the standing part. (See Fig. 108) If necessary use more than one anchor.

Round turn and two-half-hitches
Figure 108

b. Make an inverted swiss seat or use a pre-made seat harness. See illustrations previously shown.

c. Attach carabiner to seat. (See Fig. 109-A and 109-B on page 108)

d. Attach carabiner to the rappel rope. (See Fig. 110-A, 110-B, and 110-C on page 109)

Note: Rappelling with only carabiners is not recommended if you have other descending devices. The reason for this recommendation is: (1) You have better control with a Figure "8" or Brake Bar Rack, and (2) You have less chance to make mistakes in rigging the descender.

e. Attach the Figure "8" descender to the rappel rope. (See Fig. 111-A and 111-B on page 110)

d. Rappelling should be accomplished by:

(1) Hand in front for balance.

(2) Hand at rear for control of descent. (See Fig. 112-A on page 111)

(3) Feet spread apart, touching surface if not a free rappel. (See Fig. 112-B on page 111)

(4) Descent should be slow, walking down side of building, incline, etc. with ropes sliding through hand at rear for control. (See Fig. 113 A & B on page 112)

(5) To stop and lock-in on rappel to free both hands, bring ropes around your body from behind, pull ropes between the figure "8" and the rappel rope. (See Fig. 113-B) You will have to exert a hard pull on the ropes to unlock. A half-hitch tied on the rappel rope above the figure "8" will give additional security. (See Fig. 113-C on page 112)
Figure 109-A

Figure 109-B
NOTE: **CAUTION:** This is a repeat caution, but cannot be over-stated. Be sure all knots are checked by another person, descending device properly attached, sound anchor and properly belayed. Rappel should be on double ropes if possible, for additional safety.
J. HAULING SYSTEMS OR "Z" RIGS

When rescue operations require raising litters or heavy loads, we either need a lot of manpower or be able to gain a mechanical advantage. The use of block and tackle has been covered in a previous chapter. Conventional block and tackle surely has a place in rescue operations and will continue to be an important tool. The techniques that will be described and illustrated on the following pages will broaden the rescuer’s skills and expand on the various jobs that can be accomplished. These techniques not only will give you more mechanical advantage, but will do it with less rope (length) than conventional block and tackle. It is a known fact, the greater the mechanical advantage the more rope that has to be hauled to raise the load a given distance. It is important to remember that when using hauling systems, the mechanical advantage gained can reduce the rescuer’s sensitivity to the load, and over-stressing the rope and anchor can occur. Therefore it is important that systems be monitored carefully and back-up safety be used, particularly in lifting operations.

Note: When anchoring ropes to pulleys, it should be accomplished with the use of carabiners, not tied directly to the pulley. This will prevent the ropes from being cut. This is not shown in the illustrations.

1. BASIC HAULING/LIFTING SYSTEMS

a. Change of direction. (See Fig. 114) This is adequate when you have light loads and adequate manpower. Note that pulleys are stationary, thus it is a 1:1 system, no mechanical advantage.

![Diagram of basic hauling/lifting system](image)

1:1 MA
Figure 114

b. A Two-to-One (2:1). This is the simplest of the systems giving a mechanical advantage. Here we have a pulley moving or traveling with the load, giving us a 2:1. By using a prusik knot or a ratchet cam (such as a Gibbs ascender) as shown, when the pull is released, the load goes on the ratchet cam. (See Fig. 115-A and 115-B on page 114) A person may have to be stationed at the ratchet cam or prusik hitch to assure proper operation.
G. Three-to-One (3:1). This system requires an additional pulley or pulleys and will require additional rope to lift a given distance. Figures 116-A and 116-B on page 115 shows two techniques for achieving the 3:1 mechanical advantage. The Gibbs or prusik at the fixed pulley holds the load when the rescuers stop pulling. The Gibbs or prusik on the load line is attached to the moving pulley to assist in lifting. You now have three ropes traveling in the same direction as the load, giving a 3:1. A simple system is to reeve a single pulley to a double pulley to get the same results.

NOTE: It must be remembered that to get a mechanical advantage with these systems, the ropes must remain in "Z's", and pulleys have to be moving with the load. Stationary pulleys only give us a change of direction, no mechanical advantage.

2. ADDITIONAL MECHANICAL ADVANTAGE
To gain mechanical advantage greater than 3:1, the system already described may be ganged. That is to combine two or more systems together. When the systems are ganged or combined we multiply their total theoretical lifting advantage. Example: A 2:1 system combined with a 2:1, forms a 4:1 system. A 3:1 combined to a 2:1 forms a 6:1 system. A 3:1 combined to a 3:1, forms a 9:1 system, and so on.

NOTE: Using conventional block and tackle, you can get more than a 3:1 by adding more sheaves or pulleys in the system.

a. Four-to-One (4:1). Combining two 2:1 systems. (See Fig. 117 on page 116)
b. Six-to-One (6:1). Combining a 2:1 to a 3:1 system. (See Fig. 118 on page 116)
c. Nine-to-One (6:1). Combining a 3:1 to a 3:1 system. (See Fig. 119 on page 117)
3:1 MA
Figure 116-A

3:1 MA
Figure 116-B
4:1 MA
Figure 117

6:1 MA
Figure 118
K. LOWERS FROM HEIGHTS USING DESCENDERS

1. Vertical Lowers-Stokes Basket

   a. Fig. 120-A on page 118 shows a vertical lower, using a Figure "8" descender, with the Figure "8" anchored on the upper level. This method of rescue would be employed when you have adequate room for man-power, solid anchor and a safe environment on or in the upper level. The stokes would be blanketed and lashed as previously described. The tag line and lowering line would be attached as described in a previous chapter. The lowering line would be attached to the Figure "8", and the lower be made in a safe and controlled fashion. **CAUTION:** It is recommended that at least two (2) rescuers control the descent, even though only one (1) might be needed. This is nothing more than good "common safety sense".
Lower With A Figure of Eight Descender
Figure 120-A

Vertical Lower With A Figure of Eight Descender
Figure 120-B
b. Fig. 121-A shows the same lower (vertical) using the brake-bar-rack. Less effort is required to control descend but rigging is slower.
c. Fig. 122-A shows a vertical lower, but manpower is controlling descent from the ground level. This method can be used when the environment that the injured person is in, limits the number of rescuers you can have in that area. It may be limited space, health hazards or any number of reasons. Notice that you will have to have an anchor point above the opening you are lowering from, and that the rope will have to be at least two (2) times longer than the distance to be lowered. You will also need a pulley or carabiner in the anchor above for a change of direction. A carabiner can be used, but it will create friction and more stress on the rope, therefore, more damage to the rope.
d. Fig. 123-A shows a horizontal lower with a descender in the upper level. All lashings, guy lines and lowering lines are tied in their normal manner, already shown in a previous chapter.

Horizontal Lower With Figure Eight Descender On Upper Level
Figure 123-A

Horizontal Lower With Figure Eight Descender On Upper Level
(Cats Paw Or Butterfly)
Figure 123-B
e. Fig. 124-A shows a horizontal lower with the descender at the ground level.

NOTE: Rescuers can employ the use of descenders on any lower, regardless of what other equipment is used. The purpose of a descender is to create friction and reduce the load. Descenders will make the job easier and safer on Ladder Hinges, Lowers using Jib Arms, Ladder-Derrick, Leaning Ladders, and Life Basket/Double Bowline. A round turn on a pipe (or any smooth surface, unheated) will accomplish the same job. The whole idea is the utilization of friction (with minimum of rope damage) for safety and less physical exertion to lower rescue personnel, litters, and equipment.

When litters, rescue personnel and/or equipment must be raised, rescuers should employ the use of pulleys. This can be accomplished with conventional block and tackle or the pulleys shown in this chapter. The amount of mechanical advantage needed should be determined by the weight to be lifted, and the manpower available for the lift. Remember, to gain mechanical advantage, we must have pulleys traveling with the load.
I. TELPHER LINE/TRAVERSE LINE/TYROLEAN

All three serve the same purpose, and accomplish the same job. What it is called, depends on what circle you travel in. The most common term used in municipal/industrial rescue is "Telpher Line".

A telpher line is nothing more than a suspension system by which you can transport a load off the ground along with a static line. It is a useful technique for crossing streams, gorges or other such difficult terrain. In municipal rescue, it can be used from roof tops, windows or other high elevations to transport litters or people. In industrial rescue, particularly petro/chemical refineries, it may be used to remove an injured worker from pipe racks, tops of vessels and other areas. The telpher line is a versatile rescue technique, limited only by the users rescue skills and ability to innovate.

1. Line Tension
   The tension on the static line (telpher line) may be much greater than the load it is supporting.
   The most extreme case being a horizontal traverse with the load at midpoint. Fig. 125 shows deflection or sag in the line due to the load. Deflection is an important consideration when rigging telpher lines.

   ![Deflection in a horizontal line](image)

2. Pretensioning
   The pretensioning of the telpher line is generally done by using a mechanical advantage system such as already described. Because the stresses are very high on the ropes, some precautions are very important. Care must be used to prevent over-tensioning the rope by mechanical advantage. When the line is pretensioned, it should be loaded by pushing sideways on the line, or by using rescuers body weight to stretch the rope. Once it is stretched, tension can be re-applied. This will help reduce sag or deflection in the line. When rigging telpher lines, the rope should be three (3) feet or more from the surface you are working (roof top, ground and etc.). This will allow clearance for the litter to pass over the edge, when the load is on the line.

123
In some cases "A" Frames will have to be rigged for proper height. (See Fig. 126) Be sure "A" frames are set back from the edge to allow room for loading and unloading. If "A" frames are used, be sure they are stabilized with adequate guy lines to prevent falling when loaded.

Rescuers normally think of Telpher Lines as being rigged with tension, and then being loaded with litters or whatever is to be transferred. There may be occasions where you need to rig the Telpher in a "slack" position, load with a litter, and then apply tension. This application not only provides a traverse, but it actually lifts. In other words with this application, you can lift, traverse, and then lower. Example: Out of a ravine or gorge, off of a pipe rack, tops of tanks or other vessels.

NOTE: Telpher lines can be used for many rescue problems. It is a dramatic and exciting rescue technique. Due to high stress on rope and equipment, caution is of utmost importance. These high stresses are caused by: tension applied on telpher with a hauling system; distance the telpher spans (causing more deflection); and the load to be traversed. SAFETY CANNOT BE OVER EMPHASIZED. FAILURE OF EQUIPMENT, ANCHORS, OR A LACK OF RESCUE SKILLS CAN BE DEADLY. DO NOT OVER TENSION WITH HAULING SYSTEMS.

M. PORTABLE DAVIT

1. Occasions may arise when rescuers need an anchor to place a pulley or other pieces of hardware, and there may not be any in that location. This situation will probably occur in industrial areas much more than in municipal areas. In refineries and process plants there are many areas that a rescue has to be made with no overhead structure to anchor to. These areas would be protected with handrails. If vertical lowers are to be made, this creates no problem. But, if you need to make a horizontal lower, problems could arise. A very safe and simple method is to employ the use of a portable davit. See Fig. 127-A and 127-B for a drawing of a portable davit. This particular size seems to work very well, but you may need to make some changes for your particular need. I do not feel that less than schedule 80 pipe should be used. All welds should be thoroughly checked (preferably X-rayed), remember that this is to be used as a life saving piece of equipment and will be subjected to high stress. This davit can be made at any good machine/welding shop, and will prove to be a very versatile piece of equipment.
2. USE OF PORTABLE DAVIT
a. Using body cords - make at least two lashings around the base (the 2" pipe) of the davit and substantial anchor point. (See Fig. 128-A on page 126) This would probably be a hand rail, preferably in a corner at the strongest point. These lashings are put on in the following manner.

(1) Begin with a clove hitch around the pipe and anchor

(2) Marry ends

(3) Proceed to lash by making round turns (tightly) until most of the rope is used (each turn on top of the other, do not cross rope)

(4) Finish lashing with clove hitch

Note: Minimum of two lashings (one at top of hand rail and one at bottom). More than two can be used if needed. The davit should ALWAYS be given additional support (and safetied) by securing an aft guy line. (See Figure 128-B on page 126) If hand rails seem unstable, do not use. You will have to make these judgment decisions at each location when the emergency or training exercise arises.

b. Once the base is lashed, the top part of the davit is placed in the base. (See Figure 128-B on page 126) The top will rotate 360 degrees, allowing the davit to be turned in over the stokes for rigging. Once the stokes has been attached, it can be rotated to the outside for lowering. (See Figure 128-C on page 126) Lowering can be accomplished from the same level, other levels or from the ground. ALWAYS go to the base of the davit with a change of direction pulley. This will reduce the stress applied at the top. A snatch sling (See Figure 68 on page 77) can be used on the bottom lashing of the davit for this change of direction pulley. (See Figure 128-A on page 126) Proper size-up is important; and the more you use the portable davit, the more you learn about it, making for easier use each time.
N. ADDITIONAL KNOTS, HITCHES AND SLINGS

The following knots, hitches and slings will be useful and will give you additional skills that you will find very beneficial in your rescue efforts.

1. Munter Hitch
   A munter hitch is used for belaying a person on rappel, or climbing. It is a running knot that slips around a carabiner and creates a friction against itself. (See Figure 129-A and 129-B for tying)

   ![Munter Hitch](image1)
   Muenter Hitch
   Figure 129-A

   ![Munter Hitch](image2)
   Munter Hitch
   Figure 129-B

You must use a large carabiner with the munter hitch to prevent jamming. When belaying a person, you must not take your hands off the rope. Pull slack with one hand and hold the rope with the other hand to prevent a fall. Remember this hitch will run or slip through the carabiner in either direction.
2. Tensionless Hitch

This is used as an anchor knot. It reduces stress on the rope and equipment. To tie:

a. Take several turns on the upright (or other suitable anchor) with the rope. Small diameter anchor points will require more than larger ones. A minimum of three (3) turns should be used on any anchor. Do not cross the rope when making the turns. The turns should spiral up if the anchor is above the load.

b. Tie a figure "8" on a bight, or a bowline in the running end of the rope. Clip a locking carabiner in the loop formed by the knot.

c. Clip the carabiner across the standing part of the rope at the bottom of the spiral. Do not have a sharp angle where the carabiner is clipped across the standing part of the rope. (See Figure 130)

Tensionless Hitch
Figure 130
3. Basket Hitch
This is used for anchoring friction devices, carabiners, and change of direction pulleys. It is especially useful when attaching to a vertical anchor and you want to prevent it from slipping up or down. This also makes a stronger anchor than a girth hitch (or choker) or just passing the sling around your anchor point. It can be tied when using webbing without loops. (See Fig. 131-A and 131-B) The webbing is tied with a water knot and overhand safeties. It can be placed around your anchor point with endless slings (pre-made) or slings with pre-made loops in the ends. See Figures 132, 133 and 134 for constructing one, two and three point anchoring systems.
Horizontal Lower with Butterfly in Belay Line
Figure 135

Horizontal Lower with Butterfly in Belay Line Taped To Side of Basket
Figure 136
4. Slings for Horizontal Raises or Lowers Using a Stokes Basket

To tie a sling for a horizontal raise or lower for a stokes basket, use 7/16" x 25' nylon kernmantle rope (larger diameter and longer rope may be used).

a. Using two (2) pieces of rope, tie a butterfly knot near the center of both pieces of rope (one knot) This will leave you four (4) pieces of rope to tie to the stokes.

b. Place the butterfly knot over the casualty's navel. (See Figure 137)

c. Using the four (4) pieces of rope coming out of the butterfly knot, tie a locking-split-clove hitch (and an overhand safety) to the out-side up-right at the shoulder area "D" and at the foot area "D". By using the "out-side" up-right, if you have structural failure where you attach the sling, it will not change the casualty's horizontal position.

d. A figure "8" loop can be used for the horizontal sling in place of the butterfly.

e. Your lowering (or haul) line is attached directly to the loops formed by the butterfly or figure "8", using the appropriate knot, carabiner or pulley.
O. LOAD RELEASING HITCH

The load releasing hitch is used to transfer a hauling system to a lowering system without raising the stokes (or load) to release the gibbs or prusiks. It was developed by Arnor Larson in the late 70's for use in British Columbia rescue work. To make the load releasing hitch use a 20-25' 3/8" static kernmantle rope (body cord), and two large carabiners.

1. To begin the load releasing hitch take the two ends and tie the ends together with a Figure "8" knot. (See Fig. 142-A on page 134)

2. Make a loop with the bight in the rope crossing over the two ropes and then coming back (or over) itself where the rope is trapped forming a Munter Hitch. (See Fig. 142-B on page 134)

3. Clip a large steel carabiner across the four lines of rope. (See Fig. 142-C on page 134)

4. While holding up by the carabiner, clip another large steel carabiner into the bight. (See Fig. 142-D on page 135)

5. Pull on the standing part of the ropes until the two carabiners touch. (See Fig. 142-E on page 135)

6. Now pull on the carabiner that is in the bight until the Munter Hitch rotates. Pull only enough to set the Munter Hitch. Once you pull on that carabiner, dress up the hitch. (See Fig. 142-F on page 135)

7. Make three tight wraps, starting at either the front or back. (See Fig. 142-G on page 135)

8. After completing the three wraps, tuck a portion of the double rope through the bight. (See Fig. 142-H on page 135)

9. Pull enough rope to tie an overhand knot taking the 4 ropes over the 2 ropes and up through the middle to form the overhand. (See Fig. 142-I on page 135)

The carabiner with the Munter Hitch is usually attached to the anchor and the bight is attached to the load. To release the hitch, untie the overhand knot, while holding one hand tightly over the three wraps. Pull the rope out of the bight, and carefully un-wrap. Once you have control of the ropes coming off the hitch, you can lower (and transfer the load to the friction device) by feeding the ropes toward the Munter Hitch.

NOTE: Do not release until you have installed a friction device.