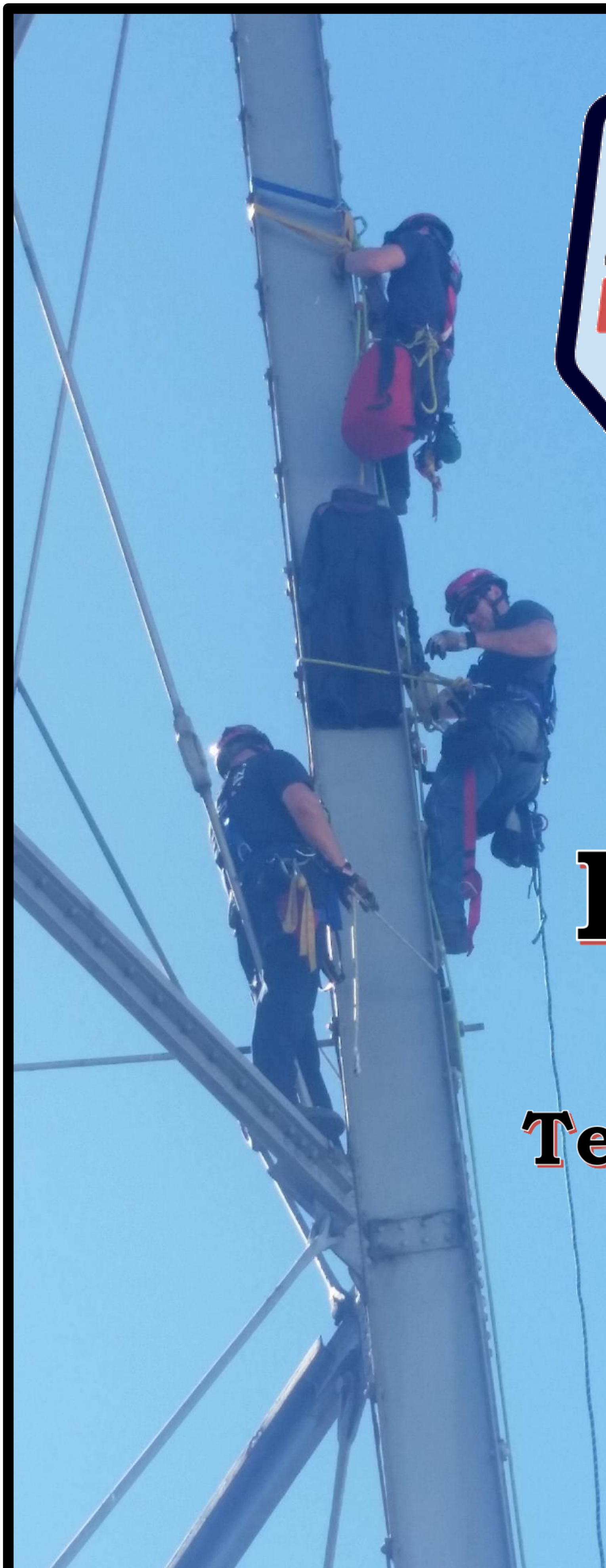

EST. 2018

KING COUNTY

TECHNICAL RESCUE

# ROPE RESCUE

## Technician Level

Revision 2019-4

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# Table of Contents

This manual represents a collaborative effort by Zone 1 and Zone 3 to establish, train and employ a common practice when performing Technical Rope Rescue.

It is recognized that isolationism regarding fire service operations, ultimately limits the level of service we can provide our public. It is our responsibility to evolve with our changing environments. This manual is an aggressive effort to provide an enhanced level of service to our public by having operational practices that are seamless between bordering agencies.

As we evaluated systems to use as our foundation, we decided to build upon the “Technical Rescue Handbook”, published by The U.S. Department of the Interior, National Park Service. In addition, contributions from both Zone 1 and Zone 3 rope rescue manuals became a compilation of “Best Common Practice”.

Therefore, its appropriate to acknowledge those individuals that produced the National Park Service Handbook, as well as, those individuals (alphabetically) whose efforts and contributions produced both Zone 1 and Zone 3, rope rescue manuals

Brian Gilbert - Northshore
Bryan Rozewski - Puget Sound Fire
Charles Dow – North highline Fire
Chris Martin – Kirkland Fire
Christian Dubois – South King Fire
Don Sanderson - Redmond
Drew Erickson - Puget Sound Fire
Greg Lewis - Maple Valley Fire
Jason Herman – Valley Regional Fire Authority
Jay Fischer - Shoreline
Jeff Greene - Puget Sound Fire
Jim Ochs - Renton RFA
Kyle Felmley – Woodinville Fire
Lando.Alvarado - Valley Regional Fire
Authority Macaleb Fitzgerald – Bellevue Fire
Mark Anderson - Kirkland
Mark Freymuth - Redmond
Rich Rathvon - Shoreline
Roger Anderson, North Highline Fire
Ryan Rodenberg – Enumclaw Fire
Sabine Arnold - Shoreline
Will Aho - Renton RFA


This manual serves as only a guide and is intended to provide convenient reference for the student. It is the responsibility of the user of this manual to obtain proper training, education, and guidance in the use and application of rope rescue.

This manual is designed to accompany certified instruction in a field setting as part of a Rope Rescue program. The authors caution the reader that attempts to utilize the techniques described herein without a certified instructor may present significant hazards!

This manual is not a standalone text. Throughout this course please keep in mind that the skills presented are one way of accomplishing an objective not the only way!

NFPA 1670- Standard on Operations and Training for Technical Rescue Incidents- addresses technical search and rescue standards for fire service agencies in rescues involving rope rescue, structural collapse, confined space, vehicle search and rescue, water search and rescue, wilderness search and rescue, trench and excavation search and rescue, machinery search and rescue, cave, mine and tunnel search and rescue, and helicopter search and rescue.

Identifies three different levels of operational capability for rescue organizations;

Awareness Level- minimum capability of organizations that provide response to technical search and rescue incidents.

Operations Level- capability of organizations to respond to technical search and rescue incidents and to identify hazards, use equipment, and apply limited techniques specified in this standard to support and participate in technical search and rescue incidents.

Technician Level - capability of organizations to respond to technical search and rescue incidents and to identify hazards, use equipment, and apply advanced techniques specified in this standard necessary to coordinate, perform, and supervise technical search and rescue incidents.

NFPA 1983- Standard on Fire Service Life Safety Rope and System Components

The standard applies to the performance, testing and certification of *"new life safety rope, escape rope, water rescue throwlines, life safety harnesses, belts, manufacturer-supplied eye terminations, moderate elongation laid life safety rope, belay devices and auxiliary equipment."* NFPA 1983 is explicitly a standard for manufacturers as opposed to a usage document for rescuers.

NOTE: Unfortunately, technical rescue personnel have developed numerous misconceptions regarding the intent of NFPA 1983, particularly with the interpretation of earlier versions of the document.

These flawed misconceptions include;

- Only metal connectors and components constructed of steel.

  Components may be constructed of ferrous metal, stainless steel, aluminum, brass, copper or zinc.
- Only single use of a rope for emergencies is permitted prior to disposal.

  Incorrect- such a requirement was included in the 1990 edition; however, it is was removed from the standard in 1995.
- A 15:1 safety factor is required in rope rescue.

  This became misapplied from an earlier version of NFPA 1983, when the NFPA committee was developing a performance requirement for a general-use life safety rope and starting with a 600 lbf design load picked a multiple of fifteen to get 9,000 lbf requirement

NFPA 1983 EQUIPMENT LABELING DESIGNATIONS:

There are three designations for manufacturers to utilize in labeling rescue component equipment as "Meets NFPA 1983 (2012 ed.)," which include;

GENERAL USE, labeled "G". Heavier components providing a higher margin of safety, which might be chosen by an organization based upon their operational capabilities

TECHNICAL USE, labeled "T". Lighter components with a lower breaking strength which might be chosen as acceptable by an organization with highly trained personnel capable of conducting complex rescue operations.

Note: Equipment is in use that is marked "P" (Personal) or "L" (Light), which were the designations in previous editions of NFPA 1983.

ESCAPE USE, labeled "E". Employed for immediate self-rescue or bailout by firefighters.

# SAFETY CONSIDERATIONS

Remember your priorities for operational safety:

1. You are number ONE!
2. Your fellow rescuers are your SECOND concern.
3. The subject is your THIRD priority.

We also have an operational responsibility to protect bystanders at the scene.

Safety is always of paramount importance. IF YOU SEE SOMETHING YOU THINK IS UNSAFE STOP THE OPERATION! ANYONE CAN STOP THE OPERATION! PLEASE REMEMBER, IT TAKES A TECHNICAL SAFETY OFFICER TO PROCEED.
WHEN A HELMET IS REQUIRED, ALWAYS WEAR IT WITH THE CHIN STRAP SECURED.
PERFORM A SAFETY CHECK ON ALL SYSTEMS BEFORE USING THEM, ESPECIALLY THE ANCHORS!

*Remember that no one is infallible and that includes you! The worst- case scenario is having a rescuer injured, resulting in two patients. Don't create an incident within an incident.*

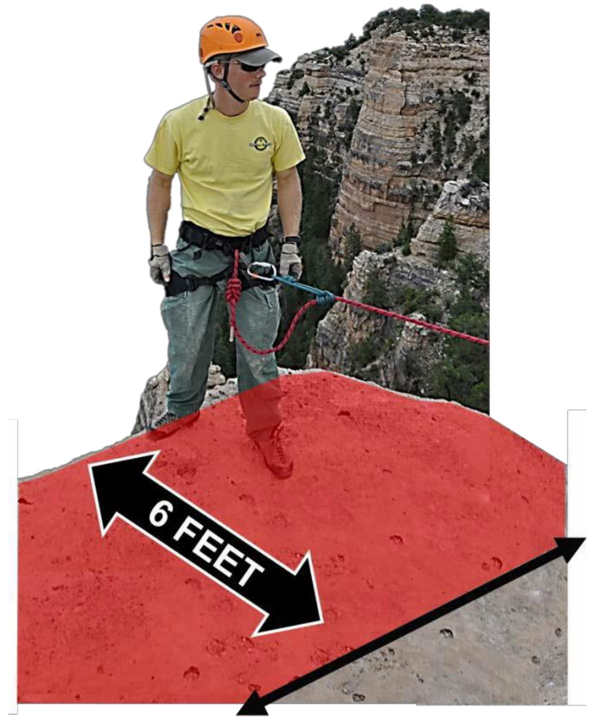
IMPORTANT SAFETY REMINDERS

“Slow is smooth... smooth is fast.”

This mantra from military marksmanship emphasizes that rushing in a reckless manner is much riskier than slow careful and deliberate actions. By being well organized a rescue team can breed efficiency in their emergency response efforts. A disciplined team communicates effectively, and they accomplish their tasks without rushing or yelling. Team members know what to do and are trained to the level of competency.

- Speed- Do not rush! Maintain a sense of *"controlled urgency."*
- Proficiency- Use well-trained, competent rescuers for the core of the team.
- Safety Checks- Do a thorough visual and tactile (look, touch and talk) rigging safety check prior to use of a system. Recheck equipment during use, since carabiners can unlock, or rigging can become misaligned.
- Redundancy- Create a system with backups.
- Communication- Use standard terminology.
- PPE- Aggressively employ appropriate PPE for all incident hazards, environments and tasks (e.g. gloves, footwear, helmet, harness, hearing protection, high visibility clothing, safety glasses, sunscreen, personal flotation device etc.

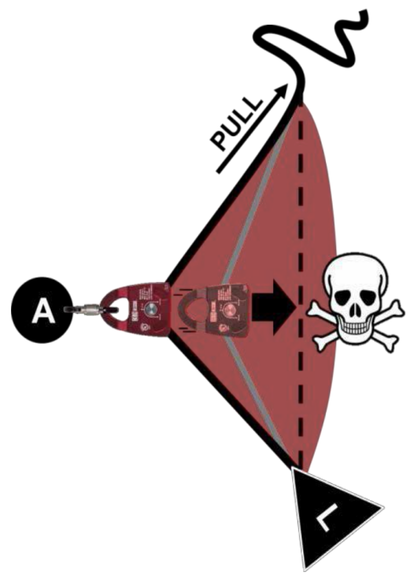
## EDGE SAFETY




Establish a marked hazard (exclusion) zone at the edge of a cliff or hazardous drop. This setback distance is a minimum of six feet and is established to prevent an individual from tripping near the edge and being unable to stop themselves. A site with a downward incline, rolling or stair-stepped edge may require that this hazard zone be established much further back. All personnel entering this hazard zone must be secured by a safety line which restricts their travel to the edge of the drop. Secure all equipment positioned inside this area (e.g. artificial high directional tripod) with a tether or safety line. Minimize the number of personnel working near an edge, since they have the potential to generate rockfall below.

### THE VECTOR ZONE

**Recoil or Snapback Hazard**




When a tensioned rope breaks or a component forming a rope bight fails, the energy within the rope will cause it to recoil back in unpredictable directions with great force, resulting in possible injury to persons in the path. Avoid having personnel standing or working in the potential path of a rope bight under tension.

*Avoid standing inside a bight of rope (vector zone) under tension, such as inside of a pulley system.*

# PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment (PPE) refers to such items as helmets, eyewear, specialized clothing, footwear, gloves.

Class II harness, also referred to as a seat harness is typically worn in recreational climbing. It relies on a snug fit around the waste to capture the pelvis during an inverted fall arrest.

Class III- Full Body Harness. Per the WAC, Class III harnesses must be used when the potential to become inverted exists.

## OTHER PERSONAL EQUIPMENT

- Trauma scissors - A sharp knife around tensioned ropes is dangerous.
- Headlamp- A durable and compact headlamp should always be carried.
- Radio Chest Harness- Avoid stuffing a radio in a pant or coat pocket, it’s likely to be dropped.
- Hearing Protection- To be employed when working around helicopters.

## WHAT NEEDS TO BE ON YOUR PERSONAL HARNESS?

Keep the equipment on your harness organized and avoid having any gear suspended on your harness that hangs down below mid-thigh, it’s likely to become entangled in vegetation, or you may inadvertently step your foot through a looped Purcell and trip.

- Purcell Prusiks, set (neatly coiled, bundled with rubber bands or in a stuff sack)
- Additional set of Tandem Prusiks
- Leather gloves, supple and well-fitting
- Cutting tool (preferably trauma scissors)
- Locking carabiners (half dozen is plenty)
- Webbing runner

# DEFINITIONS

***ACCESSORY CORD***: Cordage in sizes smaller than the main line, typically 8mm. There is a wide variety available in static & dynamic, sheath composition and thickness.

***ANCHOR***: An object to secure a rope system to. An anchor may be manmade or natural. Pad any edges to protect the webbing or rope. Always keep in mind the thought that "your system is only as good as your weakest link".

***ANCHORING PLATE***: A tool used to gather multiple anchor points or multiple pieces of hardware. Also known as Gathering Plate or Bear Paw.

***ASCENDER***: A device used to grip a rope, which is then used to ascend. This maybe a mechanical device or soft material such as a Prusik. In this class we will be using Purcell Prusiks because a mechanical ascender can damage or destroy a rope when shock loaded.

***AZTEK***: (Set of Fours) One end of this kit is used as a Personal Mechanical Advantage system in either a 4:1 or 5:1 MA. The other end can be used for a personal travel restraint system. Other uses include but are not limited to, Litter scoop jiggers, tensioned tie backs, pick off attachments, and dynamic high directional.

***BELAY***: To protect a person with a rope. Sometimes referred to as a safety.

***BELAY LINE***: A back-up system to protect the mainline in case of failure. It also assists in the event the mainline jams up. This system is totally separate from the main line and should be on a separate anchor.

***BELAYER***: Operator of the belay system. The belayer provides a back-up system, able to catch a fall. The belayer must be mentally prepared to catch a fall at any time during the operation.

***BRAKE BAR RACK***: A variable friction device used for lowering and/or rappelling, sometimes referred to as a rappel rack. Two ropes can be run through the larger models, side-by-side. Friction is adjusted by adding or subtracting bars and by squeezing the bars together.

***CARABINER*** (‘biner): Carabiners are metal objects in oval or D shape with a gate to allow a rope to be installed or removed without untying the rope. They come in a wide variety of shapes, metals, and strength ratings. All have a gate, long axis, and short axis. The D shape is stronger than oval because it puts most of the load along the spine instead of loading across the gate area. Locking carabiners come with a knurled rotating knob, which locks the gate closed. Older models are prone to jamming when locked under load. They must be re-loaded to be unlocked. Carabiners of more recent design have non-jamming gates.

***CATASTROPHIC FAILURE***: Failure of the system. The equipment, or anchor system failed, causing the load to drop. The most common cause of catastrophic failure is the human element not properly using the equipment. Technical rescue requires education, regular training, teamwork, and extreme attention to detail.

***CHANGE OVER****:* The act of changing a system from a lowering operation to a hauling operation. It can be done under tension or slacked and usually requires the same operation for the belay line.

***DESCENDER***: Any device used for rappel. A device that creates friction such as, figure eight devices or brake racks.

***DYNAMIC ROPE***: A rope designed to stretch and reduce the impact on a fall

***EDGE PROTECTION***: Something placed over the edge to protect the rope and assist its movement. This may be a roller or canvas.

***EDGE PERSON*** *(OR TENDER):* The person that works at the edge during rescue operations. They assist with the litter or help communicate between rescuer and hauling team. The Edge attendant may have to go over the edge to assist with litter edge transition.

***FALL FACTOR****:* Rope length in use divided by fall distance equals Fall factor. A fall of 1 or greater will likely result in serious injury or death.

***EIGHT PLATE***: A personal rappel tool resembling a sea anchor. They come in various sizes and materials. The ears assist in tying off and in avoiding an unintentional lock-off. The figure-eight descender is widely used in rescue as a personal rappel tool. They have minimal friction adjustment ability and friction cannot be easily changed once they are loaded. Figure-eight descenders put twists and kinks in the rope and are NOT to be used for rappel-based pick offs. They are also intended for a single person load only.

***FRICTION***: The resistance of an object to the medium through which or on which it is traveling. In rope rescue, friction on the rope occurs in relation to other equipment and the environment. Generally speaking, friction is our friend when lowering a load, and our enemy when raising.

***GIBB'S CAM***: An ascending device used to form an attachment point to the rope. Gibb's cams work in the same way as toothed ascenders but with one major difference. The cam has dull teeth as opposed to sharp teeth. Gibb's cams are pull tested to 1,000 pounds. Gibb's cams come in various sizes and materials. They can be spring loaded or free running. NOT to be used within Zone One.

***GUIDING LINE***: A rope used to deviate a load from a direct "fall line" during a raise or lower.

***HARDWARE***: Metallic tools used in technical rescue (carabiner, brake racks, pulleys etc.). Types of metals in use include cast iron, cold rolled steel, extruded aluminum, cast aluminum, titanium, zircon, and heat-treated steel.

***HAUL PRUSIK***: A system Prusik used as a grab to attach a pulley to when using a mechanical advantage.

***HAUL TEAM***: A team assigned to pull on the load.

***HIGH ANGLE***: Refers to an environment in which the load is predominately supported by the rope rescue system. At this angle you are employing a mainline and belay line**.**

***KERNMANTLE***: A method of rope construction composed of a core (kern) surrounded by a sheath (mantle). The core accounts for approximately 75% of the strength and the sheath 25%. Can be either static or dynamic.

***KILO NEWTON***: A measure of force. One Kilo Newton (KN) equals 224 pounds of force.

***KNOT PASS****:* The act of moving a knot (on either a main line or belay line) past a device in that line, such as a change of direction pulley, brake bar rack or any other piece of critical hard or software. This is commonly done under a live load.

***LEAD CLIMBING****:* The process in which a rescuer must climb in an upward, downward, or horizontal direction to access an injured or stranded civilian. During a lead climb, the rescuer is either self-belayed or belayed by a person qualified to do so. Scenarios that may require lead climbing includes cranes, power or communication towers, bridge girders, industrial settings, or even in trees not accessible by other means.

***LOAD RELEASE HITCH***: An assembly of two carabineers and 33' of accessory cord tied with a Munter hitch, typically used to introduce slack in a belay system to unlock tensioned prusiks. The Radium Release Hitch is a version of the Load Release Hitch.

***LOW ANGLE***: Refers to an environment in which the load is predominately supported by itself and not the rope rescue system. (e.g., flat land or mild sloping surface). Where the angle of the slope, and the exposures to hazards for the rescuers and patient are low. For low angle rescues, litter attendants can literally walk the litter with patient up the hill. A belay line may be incorporated and, on some occasions, a 2:1 mechanical advantage to overcome minor obstacles and slope variations.

***MAIN LITTER ATTACHMENT POINT***: The ring, carabineer, or screw link where the main and belay line attach to the litter; the gathering point.

***MAIN LINE***: The primary load carrying rope in the system.

***MECHANICAL ADVANTAGE***: This is the ratio between a given load and the force required to move it.

***MUNTER HITCH***: A friction hitch used for belay. A munter-hitch belay is only good for a 1 person load.

***NYLON***: The primary software material used in technical rescue. Nylon is strong, durable, does not mildew, and comes in many forms for many uses. Nylon is damaged by ultraviolet light and hard surfaces. While strong, nylon products must be treated with care.

***PERSONAL PRUSIK***: Used for personal fall protection, can be double wrapped. Usually made from 6mm or 7mm nylon cord. Found on AZTEK, and edge kits. May be used for Ascending and back up purposes. ( single person loads only)

***PIGGYBACK SYSTEMS***: This is a separate mechanical advantage system attached to an existing mainline system.

***POLYESTER***: Polyester ropes have very low stretch making them excellent for guying applications. They are excellent in both chemical and ultraviolet resistance.

***PRE-RIG***: A system of rope or webbing, usually with a gathering point to attach a rope system to a litter. Sometimes referred to as a spider or bridle.

***PRUSIK***: A device used to form an attachment point to the rope. The Prusik hitch is a software interface point of attachment, which will lock in either direction. Prusik loops (being a diameter of 60-80% of the main line) will normally fail before they damage the rope. System Prusiks shall be a minimum of 8mm in diameter when using 12.5mm rope.

***PULLEYS***: Pulleys are used to redirect the forces or for mechanical advantage. They are made of various materials and utilize either sealed ball (90-95% efficient) or oilite (85-90% efficient) bearings. The wheel should be steel, and the side plates should swing open. Pulley diameter should be four times that of the rope to be used to maximize efficiency and less damaging to the rope, i.e. 1/2" rope = 2" pulley or larger.

***PURCELL PRUSIK***: A personal Prusik system designed for many uses but mainly used in ascending and attaching to a rope system. These are adjustable.

***RATCHET PRUSIK***: or progress capture prusik, used in a haul system to hold the load when resetting the pulley system. This Prusik should be placed at the last anchor pulley nearest the load.

***RESCUE LOAD***: This is the total weight which is supported by the rope. According to NFPA this is 600 lbs. or 270 kgs. (this includes rescuer, victim and equipment).

***RESCUE ROPE***: Rescue rope has a “two person” 600 pounds or 270 kilogram working load capacity. It usually is ½” or 12.7 mm in diameter, in order to meet NFPA 1983 rescue rope standards. Rope should have an ultimate tensile strength of at least 9000 pounds or greater. Rope used for both main and belay lines shall be low stretch kernmantle.

***RESULTANT FORCE****:* A resultant force is the single force which represents the vector sum of two or more forces.

***REQUISITE KNOWLEDGE****:* Student verbally explains a basic understanding of theory or concept, this may be shown through a series of questions and answers

***REQUISITE SKILL***: Student demonstrates a skill or technique through a manipulative exercise

***ROPE CARE***: New ropes should be inspected for flaws before use and washed to remove any soap products used during manufacture. Ropes should be stored in rope bags or coiled and hung on wooden pegs in a cool, dry place. They should be inspected and washed after every use. Each rope will have tip tags identifying this itself. Each rope shall have a log indicating purchase date, date put into service, and use.

***ROPE INSPECTION***: Visually inspect the sheath for damage and look for signs of the core showing through. Start at one end and feel for kinks in the core. Bend the rope back and forth between thumb and finger while working your way up the rope.

***ROPE MARKING***: Mark only the tips of your rope, never mark the middle. The product "Whip-end Dip" is useful for marking the tips of software. The primary ingredient is poly vinyl chloride (PVC) and will not harm nylon. However, there is a solvent used to keep the PVC in liquid form. The solvent harms nylon.

***ROPE WASHING***: There are several accepted methods for washing a rope. The simplest method is to fill a bathtub with cool water and flake your rope into the tub. A new toilet plunger purchased and tagged for ropes makes a nice agitator. Do not use chemicals such as detergent or Downey Softener, since their only purpose is beautification or to make the rope more pliable. An alternative is to use a commercial rope washer. The rope washer is designed to fit on the end of a hose. The rope is pulled up stream against the flow of water. The rope can be run through the rope washer as many times as needed to remove surface dirt.

***SIT HARNESS***: A commercially sewn harness designed to fit the user and keep them in an upright position. Technical rescue harnesses differ from sport models by having a lower point of attachment, often by use of a large D ring. We recommend that you wash your harness using the bathtub method and inspect the stitching on a regular basis.

***SOFTWARE***: Non-metallic rescue equipment. Edge pads, rope bags, equipment packs, sit and chest harnesses, foot stirrups, rope, webbing, etc.

***SOFT INTERFACE***: Utilizing software at high-load points. A current trend within the rescue community. Examples: Tandem Prusiks and Guide's Rappel Back-up.

***STATIC ROPE***: Low stretch. Low energy absorbing capability. In order to provide high load carrying ability, our rescue ropes are of static construction. Static rope, while strong, has little ability to absorb the forces of a fall. It's like working with steel cable. Static ropes should not be used for climbing.

***STEEL RINGS, RESCUE RATED***: The use of large steel rings has become popular in technical rescue. They are most often used as the main litter gathering point. In physics the round shape is not designed to be pulled in opposite directions. The fact that these particular rings carry a very high breaking strength (40,000 lbs) means that they have been over-engineered. We have incorporated these tools into our litter rigging.

***SYSTEM PRUSIK***: Made from 8mm cord in lengths of 54'' and 65''. Any system Prusik used on a main or belay line shall be triple wrapped.

***TANDEM PRUSIK BELAY***: This is the traditional method of belay throughout the fire service, It is made up of two Prusiks, one approximately 135 cm long and the other approximately 165 cm long.

***TOWER RIG:*** A tower rig is a means for the rescuer to be self-belayed and allows the rescuer to move rapidly to access a patient while being protected from a fall. Most Tower Rigs are purchased from a commercial manufacturer and consist of two large carabiners or locking "claws" on two short lanyards terminating at a shock absorbing component.

***VECTOR***: A force applied to a system in order to control the initial movement of a load. An edge person may apply a vector to the system while assisting the litter over the edge.

***WEAK LINK***: The point most likely to fail. Identification of the weak link in a system requires intimate knowledge of the equipment. It also requires the ability to identify all critical angles in the system and limit them to 90 degrees or less. In technical rescue, we must be able to see each individual piece of the puzzle while maintaining a view of the overall system.

***WEBBING***: There are many types of nylon webbing. We use one-inch tubular spiral weave and flat webbing. The advantage to spiral weave is, if the webbing is damaged, it will not unravel. Unfortunately, many manufacturers are discontinuing the spiral weave process and are now making tubular by taking 2-inch webbing, folding it in half, and stitching one side. Tubular webbing comes only in solid colors, rated at 4000#. Flat weave is rated at 6000#.

***WHISTLE TEST***: The whistle test is a way to confirm that your operation is as safe as possible. When performing the whistle test, in theory if everyone let go of what they are holding onto when they hear the whistle blow…what happen to the load? Your answer should be…NOTHING! It stopped where it was.

***Z-RIG***: A common name for a 3:1 simple pulley system.

# ROLES AND RESPONSIBILTIES

## Rescue Group Supervisor (RGS):

- Reports directly to the on-scene Incident Commander.
- Is responsible for direct supervision of the rescue team operations. (1670)
- Determines RESCUE or RECOVERY mode. Performs a continuous hazard analysis and risk assessment.
- Provides passport accountability and maintains an ongoing awareness of the location and condition of all members. (1500)
- Provides and maintains safety and scene security. (1500) ⊔ Makes key assignments of personnel:
    - *Technical Safety Officer*
    - *Rigging Team Leader*
    - *Entry Team Leader*
    - *Support Team Leader*
    - *Back-Up Team (as required)*
- Determines an action plan, communicates the plan, and ensures that the plan is adhered to.
- Develops a back-up contingency plan. (1500)
- Ensures that the appropriate PPE is utilized and equipment to provide protection from those hazards to which personnel are exposed or could be exposed is provided. (1670)
- Initiates, maintains, and controls incident communications. (1500)
- Ensures that medical care at a minimum level of basic life support (BLS) is provided. (1670) ⊔ Conducts pre-entry briefing with the entry team.
- Ensures that all rope systems have been safety checked by the Technical Safety Officer and Rigging Team Leader prior to operation.
- The RGS is the only person at a rope rescue incident who can initiate motion of the rope system or restart the rope system if stopped or re-set. The RGS may delegate this function to the Entry Team Leader.)

## Technical Safety Officer (TSO):

- Reports directly to the Rescue Group Leader.
- Performs a continuous hazard analysis and risk assessment.
- Provides direction with respect to the overall safety of personnel. (1670) □ Ensures scene security.
- Ensures that the appropriate PPE is utilized and equipment to provide protection from those hazards to which personnel are exposed or could be exposed is provided.
- (1670) Ensures passport accountability and maintains an ongoing awareness of the
- location and condition of all members. (1500)
- Is aware of and approves the action plan and ensures that the plan is adhered to. Is aware of and approves the back-up contingency plan.
- Ensures that medical care at a minimum level of basic life support (BLS) is provided. (1670) □ Is present at the pre-entry briefing with the entry team.
- Ensures that all rope systems have been safety checked by the Rigging Team Leader then double-checked prior to operation by the TSO.
- Ensures that the Entry Team has been safety checked by the Entry Team Leader then double-checked by the TSO prior to deployment.
- Ensure that the Entry Team is properly equipped, properly secured, and all equipment and medical supplies necessary for the treatment and packaging of the patient(s) is present and secured.

## Rigging Team Leader:

- Reports directly to the Rescue Group Supervisor.
- Assists the RGS in determining:
- The type of rope system(s) to be utilized.
- The location from which the rope system(s) are to be based from.
- Selecting the location and type of the anchor point(s).
- Responsible for direct supervision and safety of personnel assigned to the Rigging Team. (Main Line and Belay Line Team).
- Understands the action plan and communicates the plan to personnel assigned to the Rigging Team.
- Responsible for the engineering, construction, and operation of all rope-based systems utilized during the operation. This responsibility includes "visualizing" the integrity of the rope system(s) in motion, and its effect or potential effect to all personnel who depend on the rope system(s) for their safety as well as to personnel working on or around the rope system(s).
- Determines a contingency plan prior to the initial operation of the rope system(s) that addresses the utilization of additional rope systems in case of an emergency. This plan shall be worked out in advance with the RGL and approved by the TSO.
- Ensures that all rope systems have been safety checked then double checked by the TSO prior to operation.

## Entry Team Leader (ETL):

- Reports directly to the Rescue Group Leader.
- Responsible for direct supervision and safety of all personnel on the Entry Team and Backup Team.
- Understands the action plan and communicates the plan to personnel assigned to the Entry Team and Backup Team.
- Responsible for ensuring that all personnel on the Entry Team and Backup Team (if utilized) have proper PPE and have the ability to communicate with the Entry Team Leader or RGL.
- Responsible for ensuring that the Entry Team is properly secured to the rope system(s) prior to deployment.
- Ensures that any necessary PPE and/or medical equipment necessary for the patient is available and properly secured prior to deployment.
- Maintains an ongoing awareness of the location and condition of all Entry Team members.
- Ensures that the Entry Teams PPE and their attachment to the rope system has been safety checked and approved by the TSO prior to deployment.
- The properly secured Entry Team Leader should position himself/herself in such a manner as to have continuous line of sight (if at all possible) with the Entry Team as well as with the Main and Belay Line Teams to facilitate communicating the starting, stopping, re-setting, and speed of the rope systems.
- The Entry Team Leader (or RGS) is the only person at a rope rescue incident who can initiate motion of the rope system or restart the rope system if stopped or re-set.
- The RGS may elect to perform the duties of Entry Team Leader in addition to the role of RGS. This may occur on a simplistic rope rescue evolution or in the event that a sufficient number of rope rescue based, technician level personnel are not available to support all positions that require the presence of technician level personnel.

## Support Team Leader:

- Reports directly to the Rescue Group Supervisor.
- Responsible for direct supervision and safety of all personnel on the Support Team.
- Responsible for completing assignments given by the RGS that supports the overall technical rescue incident. These assignments may include but are not limited to:
- Providing scene security
- Removing brush, trees, or any obstacles that may hinder the rope systems.
- Securing utilities.
- Setting up an equipment staging area.
- Acquiring equipment from apparatus necessary to support the technical rescue incident.
- Providing edge protection as required.
- Provide staffing for the Haul Team.

# COMMUNICATIONS

During emergency rescues it is imperative to communicate in a clear, concise, and specific manner. For example, does “right” or “left” mean as you face the cliff or as you face away from it? On a cliff face, directions are oriented to a climber or rescuer facing the rock. Therefore, to the right of the rescuer would be face right, and to the left of the rescuer, face left. In river and stream operations, river right is on the rescuer’s right as they face downstream, and river left is on the left facing downstream.

Reduce the command vocabulary to as few words as possible and to use only words that are clear and concise. The only word for “stop” is “Stop!” It should never be substituted; “whoa,” for example, could easily be mistaken for “slow,” or even worse, for “go.” Again, any team member can say “Stop!” Only the team leader will give the command to proceed.

## COMMON COMMANDS: (To use during this course)

“DOWN”………………………………………… command to lower from controller.
“DOWN SLOW” …………………………..…….command for a slow and easy descent.
“DOWN DOWN DOWN”……………………..command to increase speed of descent.
“UP” ……………………………………………command to raise from controller.
“UP SLOW”……………..……………………command for a slow and easy raise.
“UP UP UP”..................................................command to increase speed of raise.
“STOP!”...................................................... command to stop from anyone.
“WHY STOP?”............................................question from controller to determine problem.
“BELAY READY?”…………………………   question if Belay is ready to take a load.
“BELAY READY!”..…………………….……..response to confirm ready if loaded.
“MAIN-LINE READY?” …………………...... question if Mainline is ready to move the load.
“MAIN-LINE READY!”……………….………response to confirm Mainline is ready to move.
“ATTENDANT READY?”……………….……question if attendant is ready for the system to move.
“ATTENDANT READY!”……….……………response by attendant to confirms ready.
“STAND-BY”…………………….…………….response by any system piece requiring more time
“SET”...........................................................set systems and prepare for reset or change over.
“RESET”……………………………….…....after system is set, haul systems are reset for raising.
“RACK TIGHT”………………………………command to remove all slack in the Main Line DCD
……………………………………………………SCARAB: wrap the rope around ALL four horns.
……………………………………………………MPD: engage the secondary friction post.

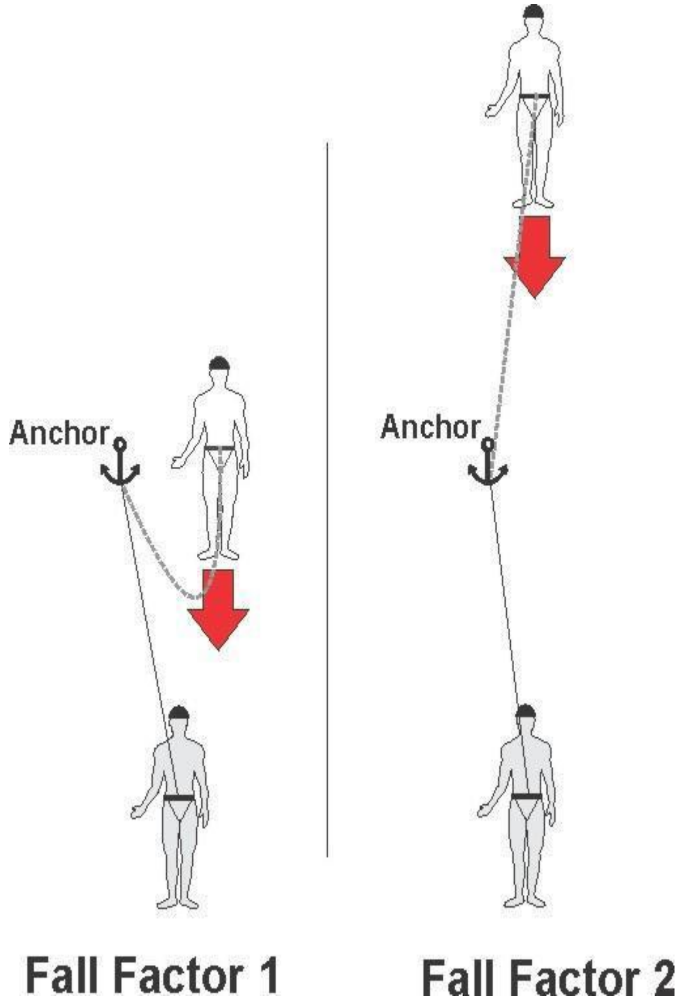
## WHISTLE COMMANDS

| | | | |
|---|---|---|---|
| One long blast | “STOP” | Four short blasts | “OFF ROPE” The rope is free |
| Two short blasts | “UP” | Continuous | HELP-TROUBLE-ALERT |
| Three short blasts | “DOWN” | | |

## FALL FACTORS AND DYNAMIC FORCES

The forces generated during fall arrests are referred to as *shock forces*.

For systems involving climbing/high stretch ropes, forces on the system will increase in a linear manner with acceleration from longer falls,
however this does not hold true for low-stretch ropes. *Fall factor* is a measure of fall severity. A knotted low-stretch rope can fail from a tension below its rated strength by the dynamic forces of a falling mass, which puts too much stress on the rope too quickly. The potential for a "dynamic event" occurring in the worst-case situation (i.e. 1m drop on 3m of rope with rescue-sized load) underscores the need to build a system stronger than the intended maximum rescue load.




Fall factor is calculated from the length of the fall divided by rope available for energy absorption. Typically, a factor 2 fall is the highest encountered in a climbing situation, where the rescuer lead climbs above the belayer. This might involve falling 20 feet (6 meters) with 10 feet (3 meters) of rope available for energy absorption. A fall factor 2 on low-stretch rope generates enough force to cause injury or death.

Keeping this principle in mind, one of the potential scenarios for generating the highest shock forces is during an edge transition, either down over or up to, with a rescue-sized load and with little rope in service. The National Fire Protection Association (NFPA) Standard- NFPA1983, which is utilized by the fire service, states; *"when fall factors of greater than 0.25 are anticipated, such as are possible in lead climbing, dynamic ropes specifically designed for climbing should be considered."*

Once More! *"for the purposes of this document fall factors greater than 0.25 generate unacceptable impact loads."*

# ROPES, WEBBING AND KNOTS

Figure Eight On A Bight

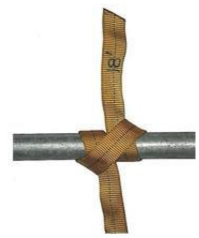
**TERMINOLOGY**

- KNOT - when a strand of material is tied to itself (e.g. Figure 8)
  (“knot”, is a general term for all knots, bends, and hitches.)
- BEND - when two or more strands of are tied to each other. (e.g. Flemish)
- HITCH - when a strand or strands is tied around another object.
- BIGHT - a 180° turn, U-shaped bend in a strand of rope.
- LOOP - a 360° turn in a strand of rope.

Figure Eight (Flemish) Bend

**KNOT DEFINITIONS**

BACK-UP KNOT: A knot used to back-up the main load-bearing knot. Back-up knots should be nestled against the main knot to limit shock-load. Typically, a double overhand is used as a back-up.



Clove Hitch

BOWLINE KNOT: A knot used throughout the fire service. The advantage of this knot is that it is easy to untie after being loaded, which is why a back-up knot is required. The Yosemite finish is preferred. The variations that will be used in this class consist of long tail, interwoven and the interlocking long tail.

Round Turn

DOUBLE OVERHAND BEND: Also known as a double fisherman’s knot. Used to join two ends of rope together, commonly used for joining the ends of Prusik loops.

DOUBLE OVERHAND KNOT: Preferred back-up knot.

Round Turn with a Half Hitch

DIRECTIONAL EIGHT OR IN-LINE EIGHT: This knot is used for re-directing a rope. Used for tensioning or securing a system. The directional knot enables the rope to stay inline while securing the load.

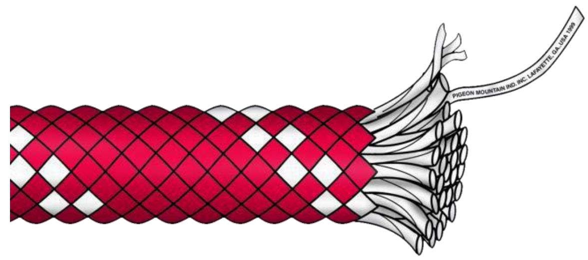
FIGURE EIGHT FOLLOW THROUGH: Used extensively in rope rescue. This knot is used to tie around an object.

FIGURE EIGHT ON A BIGHT: Used to tie a loop in the end of a rope.

Round Turn with Two Half Hitches

## KERNMANTLE ROPE

Kernmantle rope construction is a braided style in which the kern, a high strength inner core, is covered by the mantle, an outer braided sheath. The core supports the major portion of the load; and may be of parallel, braided or twisted strands. The sheath serves primarily to protect the core and also supports a portion of the load.



**Static Rope:** Manufactured by cavers beginning in 1966 (BlueWater) for the purpose of rappelling and ascending ropes that had little stretch and did not spin in comparison to laid rope construction. A static rope may have a stretch of about 2% with a 300lb load but it will have a maximum elongation of 6% at 10% of its minimum breaking strength. Static rope is the most common classification of rope employed by rope rescue teams.

**A static rope should not be used when a leader fall is possible.**

**Low-Stretch Kernmantle Ropes:** A rope with an elongation greater than 6% and less than 10% at 10% of its minimum breaking strength. The core fibers are parallel for minimum elongation. Low-stretch rope should not be used when a leader fall is possible.

**Dynamic**: High stretch rope that is primarily used for lead climbing and can stretch up to 60% of its breaking load. Due to its stretching properties this type of rope should not be used for Rescue loads.

**ROPE DIAMETER:** The fire service routinely employs STATIC 12.5 mm (1/2 inch), which is required by NFPA 1983 to have minimum breaking strength of 40 kN (9,000 lbf).

**ROPE LENGTH:** Rescue teams typically develop preferred lengths locally based upon their operating area. Although there is no industry standard, common working rope lengths by rescue teams include 150, 200, 300 and 600 ft (46, 61, 91 and 183 m). Longer lengths are employed; however transport to remote incident sites becomes problematic. Teams will cut short 50 ft (15.2 m) sections as “anchor ropes” to assist with topside rigging applications, including edge lines, back-ties, and anchor point extensions. Recreational climbing or incidents that require dynamic rope typically employ dynamic ropes ranging in length from 30 to 80 m (98-262 ft) long, with the most common length being 60m (195 ft).

Rope should be stuffed in a protective bag for easy deployment and protection from elements and abrasion. They should be stored in a cool dry place that is well ventilated and away from harmful chemicals and solvents. Storage in direct sunlight should always be avoided due to synthetic fibers deteriorating under ultraviolet light.

Life Safety Rope
We generally use ½'' diameter kernmantle and meet NFPA 1983 standards as well as having the following minimum information affixed to both ends of the rope:

- An identifier that matches the rope to its bag
- Rope Length
- Date the rope was placed in service
- "A" and "B" designator on each end
- Whether the rope is Dynamic

A Rope log shall be kept for the duration of the service life. Specifics of the rope log shall include at a minimum:

- The Manufacturer
- Lot Number
- Date manufactured and date placed in service
- Color of rope
- Diameter and length
- Static or Dynamic
- Minimum breaking strength
- History of rope
- Inspection Information
- Inspectors name and date
- Proper care, use, inspection, and maintenance shall follow the manufacturer's recommendations. All life safety rope shall be inspected after purchase and prior to being placed in service, after each use and at least semi- annually.

## WEBBING

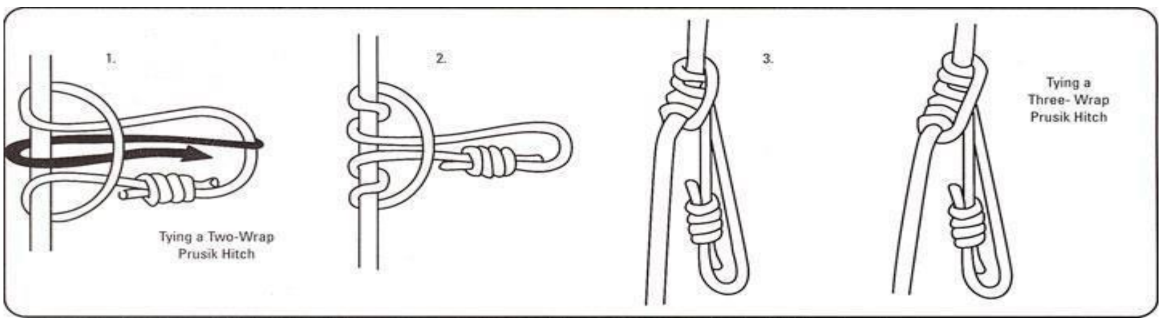
Tubular webbing which is easier to tie and is more commonly used in rescue. There are two types of tubular webbing. They are edge stitched formed from flat webbing folded and stitched together or spiral weave formed by weaving the tube as a unit.


1'' nylon tubular webbing: minimum breaking strength 4000lbs

Lengths

- Green 5 feet
- Yellow 12 feet
- Blue 15 feet
- Red 20 feet
- Black 25 feet

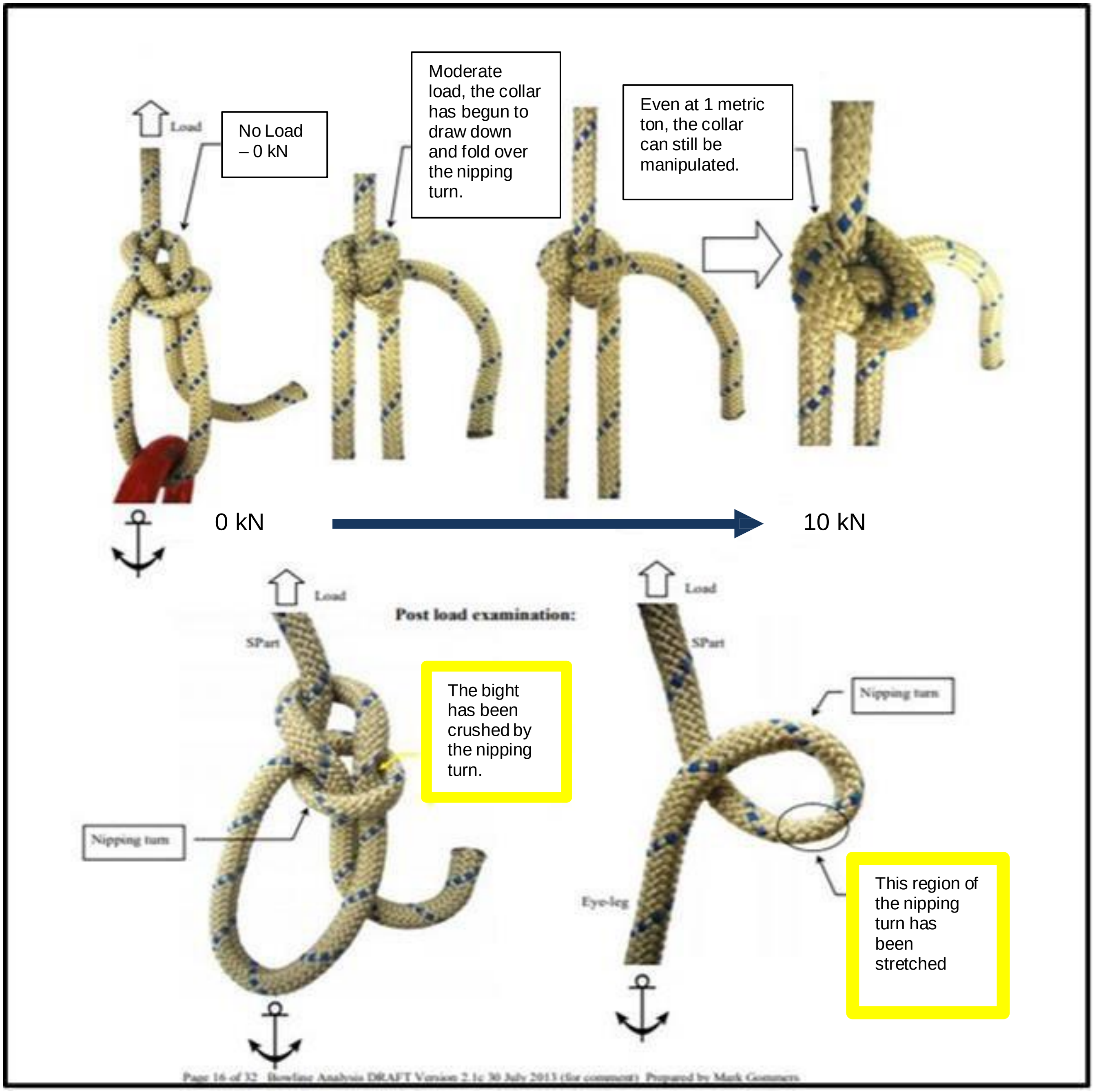
PRUSIK CORD




- 8mm low stretch Static kernmantle with a breaking strength of 2875 lbs (may also vary depending on manufacturer).
- Common lengths to form a "Match Set" are 54'' (untied) for the short and 65'' (untied) for the long.
- When tied using a double overhand knot, tails must protrude a minimum 2'.
- Prusik sheath material may not be compatible with other manufacturer's rope, thorough testing must be done to determine whether the prusik will perform as designed when using different manufactured ropes.
- Prusik cord utilized for a Radium Release Hitch is commonly cut at 33'
- Prusik cord utilized in a system receives above average wear and should be inspected after each use and semi- annually.
- Sewn Prusik loops will have the same minimum breaking strength (2875).The double overhand knot is replaced by the manufacturers sewing process  Rope logs should be kept on these types of prusiks.

# KNOTS

Factors that make certain knots or ties superior to others includes the ability of the knot to remain tied, the ease of untying and the relative strength. As a general rule, *a knot in rope reduces the strength of the rope by one third.* (A knot in tubular webbing decreases the strength by at least 45%). This is due to sharp bends in the rope created by the knot. The strength of the knot will be affected by the sharpness of these bends and the angle at which the rope leaves the knot. NOTE: Additional knots in a line do not decrease rope strength by another third.



## FIGURE 8’s

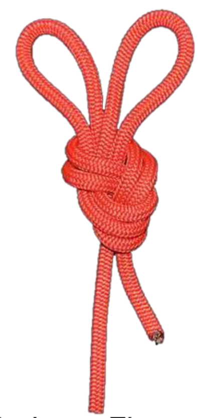
| | | |
|---|---|---|
|  Overhand Knot |  Figure Eight Knot |  Figure Eight On A Bight |
|  Figure Eight Follow Through |  Figure Eight (Flemish) Bend |  Double Loop Figure Eight |

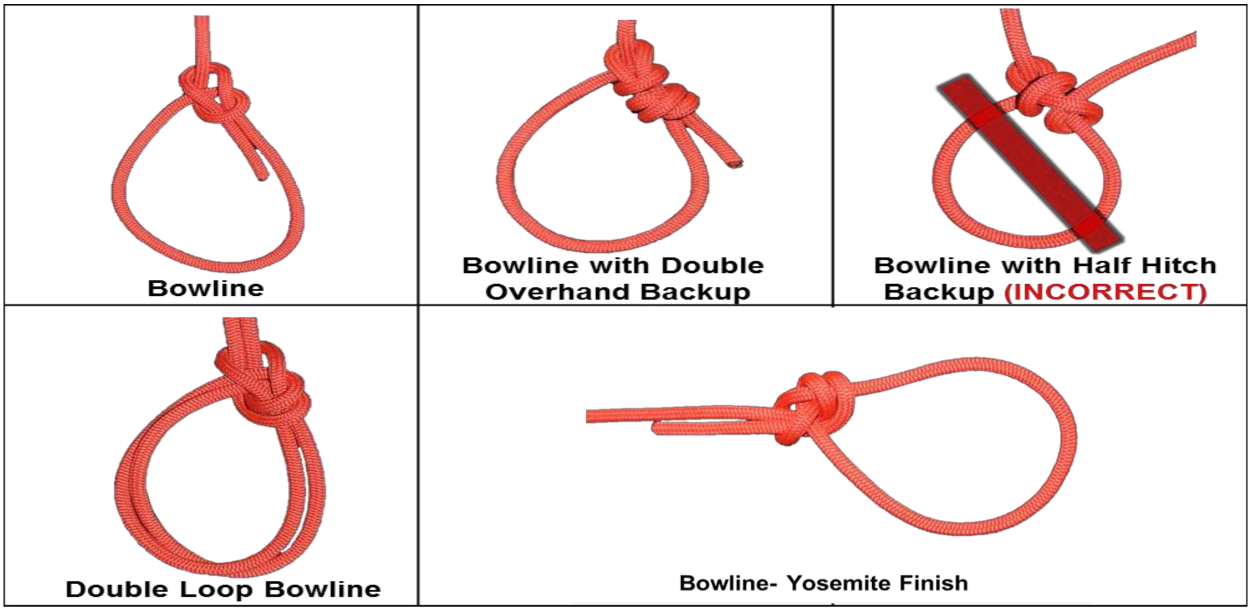
Figure 8 Knot- Forms a stopper knot that can be easily untied.

Figure 8 On A Bight- A bight at the terminus of a rope which can be attached to an anchor.

Figure 8 Follow Through “Bend” - Useful for joining two rope ends together.

Double Loop Figure 8 - Two bights at the terminus of a rope for rigging, which can be identically sized or different depending on rigging requirements.

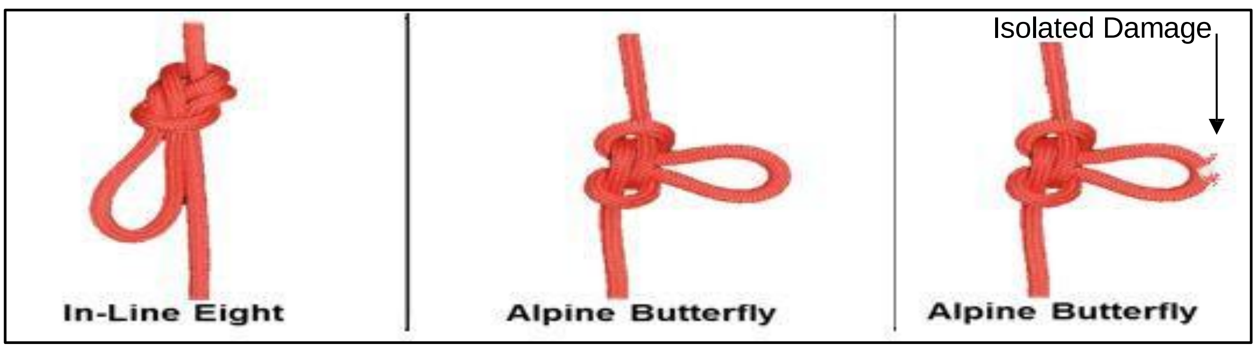
## THE BOWLINE-




**The Bowline**

Although the Bowline is an efficient knot, it can work itself loose under repeated loading, therefore it is essential to tie a backup knot to secure the tail. **It is recommended that a Double Overhand Knot be used for this backup application due to instances of a single Overhand Knot coming loose**. An advantage of the bowline is that it is easier to untie after being tensioned.

**In-Line Knots**




**In Line Figure 8** - Creates a load-bearing loop in the middle of a rope which can take a load in one direction only.

**Alpine Butterfly** is used to form a fixed loop in the middle of a rope. It can be tied without access to either of the ropes ends. It handles multi-directional loading well and has a symmetrical shape which makes it easy to inspect.

**Isolating a damaged section of rope during an operation can be accomplished by incorporating the damaged section into an inline knot such as, an In-Line 8 or Alpine Butterfly.**

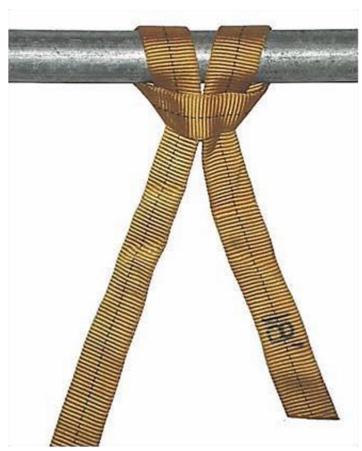
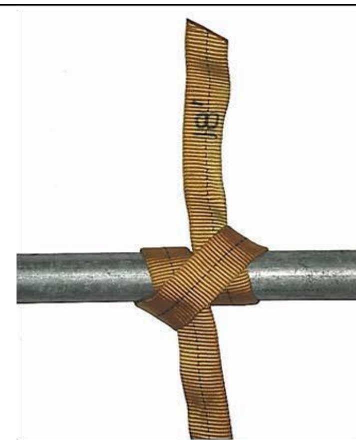
## BENDS

**Double Fisherman's Bend**. The Double Overhand Bend is a bend used to join two lengths of rope. The knot is formed by tying a Double Overhand Knot, with each end around the opposite line's standing part.

**Double Fisherman's Bend**

**Water Knot** (aka, Tape Knot, Ring Bend, Grass Knot, or Overhand Follow- Through) is used for joining two ends of webbing together to construct a sling. It is tied by forming an Overhand Knot in one end and then following it with the other end, feeding in the opposite direction. The knot should be "set" by tightening it with under tension prior to use.

**HITCHES**

| | | |
|---|---|---|
|  **Ring Bend (Water Knot)** |  **Girth Hitch** |  **Clove Hitch** |
|  **Munter Hitch** |  **Double Munter Hitch** |  **Prusik Hitch (3 wrap)** |

## HITCHES

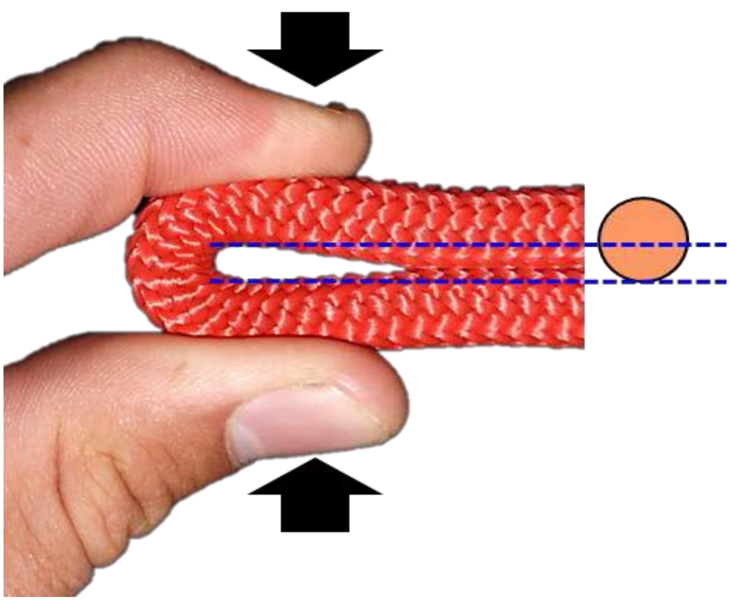
**Clove Hitch**. A Clove Hitch is two successive Half Hitches around an object. This knot is particularly useful where the length of the running end needs to be adjustable.

**Girth Hitch.** The Girth Hitch (Cow Hitch) is a tie used to attach a rope to an object, which is comprised of a pair of Half Hitches tied in opposing directions, as compared to the Clove Hitch in which the Half Hitches are tied in the same direction.

**Münter Hitch** (AKA- Italian Hitch, [MB Mezzo Barcaiolo] The Munter Hitch may be used for belaying or lowering in an emergency although, it provides limited holding power. It is also known as HMS, the abbreviation for the German term Halbmastwurfsicherung, meaning half Clove Hitch Belay.

**Prusik Hitch** (three wraps for rescue load applications, which forms six coils). The hitch is formed by applying it to a host rope.

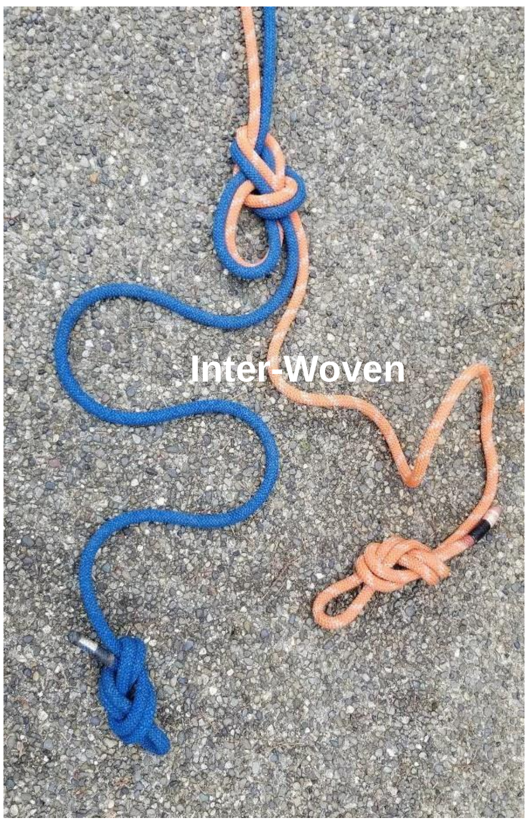
Note: To ensure that Prusik cord moves and grips properly, the diameter relationship between the standing line and the Prusik loop cord diameter should follow the general rule of 60-80% ratio. Not all manufactured Prusik cord behaves in the same manner and any new cord should be tested prior to actual field use. Be careful not to employ Prusik cord that is too stiff. Check the Prusik Hitches prior to the belay being put into service, to be certain they will grab! Use a "pinch test" for optimal cordage, that when pinched between two fingers in a bight will leave a gap 1/2 the diameter of the material. A secure Prusik loop is formed by joining the ends of the cordage with a Double Fisherman's Bend.



# Inter-LOCKING and Inter-WOVEN Longtail Knots

Typically applied with a Bowline however, this could be applied to a Inline Figure Eight as well.

Inter-locking Long-Tail Bowlines- used to interconnect the main line and belay line an initial Bowline is tied with a small loop and extra-long tail. The other rope is tied through the loop of the bowline in the first line. The connection point of the Bowlines is a redundant attachment point for a rescue load and the long tails become secondary attachment points for the rescuer and subject.


Inter-woven Long-Tail Bowlines- used to interconnect the main line and belay line. The knot is tied with both lines together as if it were one line. A couple advantages are that only one knot instead of two are tied, saving time. Also, once the knot is interwoven the long tails lose any need to be differentiated between a main and a belay. They become neither and both. Interwoven Bowlines appear to perform better in pull testing for ring loading. A disadvantage is that some may find it cumbersome to tie. Also, both lines are needed to tie, implying that rigging may be delayed if waiting for one of the lines to be brought to you.

## Both methods are acceptable.

## STRENGTH OF KNOTS

In 2016 Thomas Evans of SAR3 presented at the International Technical Rescue Symposium. His research was a data mining compilation of 1440 knot strength tests from 114 sources. Below is the combined data from those results.

| Knot | Low % | Median % | High % |
|---|---|---|---|
| Bowline | 41.8 | 56.3 | 70.7 |
| Figure 8 On a Bight | 64.8 | 75.6 | 86.3 |
| Inline 8 | 62.5 | 68.6 | 74.7 |
| Alpine Butterfly | 60.7 | 70.7 | 80.6 |
| Scaffold Knot | 68.5 | 74.9 | 81.3 |
| Double Fisherman | 73.5 | 76.9 | 80.3 |
| Figure 8 Bend (Flemish) | 56.8 | 68.8 | 80.7 |

The Table below was collected from the CMC Rope Rescue Manual 4th ED 2013.

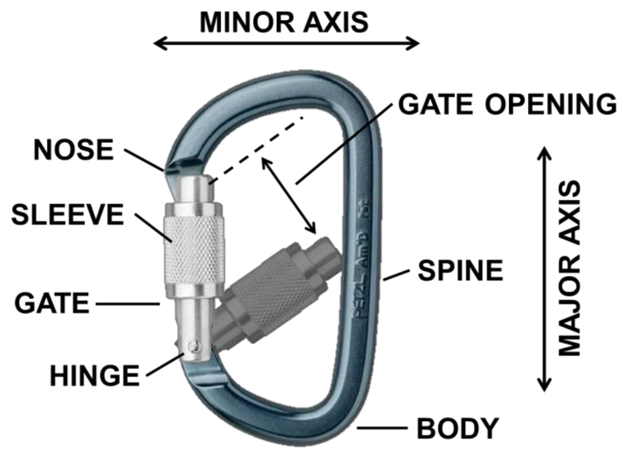
| Knot | % |
|---|---|
| No Knot at All | 100 |
| High Strength Tie-Off | 100 |
| Figure 8 | 77 |
| Alpine Butterfly | 75 |
| Scaffold Knot | 69 |
| Double Overhand Bend (Double Fisherman’s | 68 |
| Bowline | 67 |
| Figure 8 Bend | 51 |
| Water Knot (in webbing) | 64 |
| | |
| *James A. Frank, 2013 CMC Rope Rescue Manual* | |

*Note: Values will vary with rope type and are based upon static pull testing, not dynamic loading.*

Field Rule: A general belief is that a knot will reduce rope strength by one third (33%) and webbing strength by 45%

# EQUIPMENT AND HARDWARE

## CARABINERS




Metal connectors with spring loaded gates, which are used to attach components in rigging. The name is derived from "Karabinerhaken", which is German for "spring hook."
Rescue applications require carabiners to be stronger than the more lightweight designs used in recreational climbing. They are constructed of aluminum, alloy steel and stainless steel. Steel carabiners are stronger, more durable against wear, but also much heavier than aluminum carabiners. The specific parts of a carabiner include the body, spine, gate, nose, hinge and sleeve. The major axis of a carabiner refers to an orientation end-to-end along the spine, while the minor axis refers to an alignment across the carabiner side-to-side

LOCKING STYLES

Non-locking- Used in limited applications during rescue operations for <u>non-life-safety loads</u>, which include securing edge protection and securing equipment to a harness or a litter.

Screw Lock- features a threaded sleeve that must be manually screwed open or closed in order to release the gate. They have fewer moving parts than spring-loaded mechanisms, are less prone to malfunctioning due to contamination or component fatigue. They are more time-consuming to operate than twist-lock.

Auto-Locking (Twist Lock)- Have a security sleeve which must be manually rotated to disengage with a spring-loaded collar that automatically springs closed upon release. Manufacturers offer some proprietary auto-locking design mechanisms including Petzl Ball-Lock and Triact-Lock, ISC Supersafe and Quadlock, Omega Pacific Quik-Lok and Rock Exotica ORCA 3-stage auto-locking system. It is important to recognize that dirt, ice, or other contamination can inhibit the auto locking mechanism and prevent it from functioning properly.

NFPA Standard 1983 (2017) Fire Service Life Safety Rope and Equipment defines two classes of rescue carabiners; technical use (T rating) and general use (G rating).

| Major Axis | | Minor Axis: | Gate Open Major |
|---|---|---|---|
| "T"- Technical Use | 27 kN (6,069 lbf) | 7 kN (1,574 lbf) | 7 kN (1,574 lbf) |
| "G"- General Use | 40 kN (8,992 lbf) | 11kN (2,473 lbf) | 11kN (2,473 lbf) |

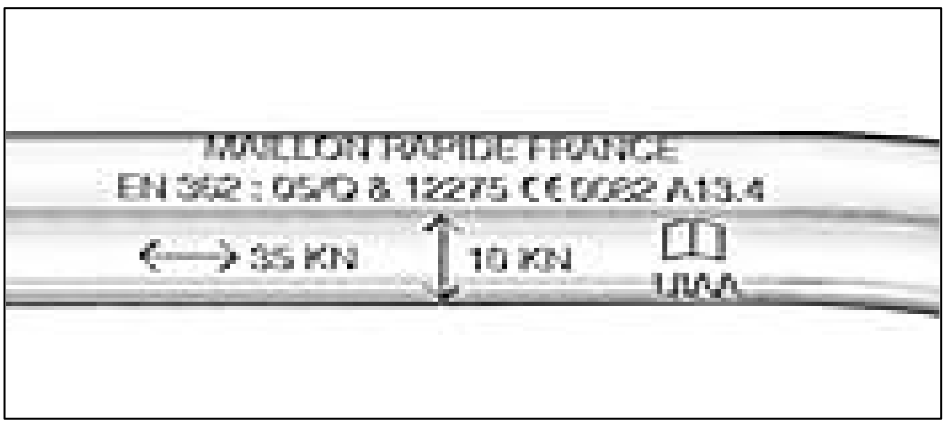
## SCREW LINKS


Screw links provide a compact, lightweight alternative to carabiners for a semi-permanent attachment. Maillon Rapide (translates quick link), produced in France by the manufacturing firm Péguet, have become the industry standard for highly secure life-safety load connections in rescue.

**Inferior screw links are commonly sold in hardware stores, which should not be employed for rescue applications**.

The most common screw link shapes employed for rescue include oval, demi-round (D-shape) and delta (triangular). Maillon Rapide links, which are marked with the brand name, are constructed of zinc plated steel, stainless steel, and zicral (aluminum and zinc alloy). Do not exceed the working load limit (WLL) engraved in kg on the screw link.The screw link gate requires numerous revolutions to close securely. For semi- permanent connections, it may be tightened with a wrench for security. They are designed to handle multi-directional loading applications.

Minimum breaking strength for all shapes certified for climbing and mountaineering applications (CE EN 362 and EN 12275) in the closed and locked position; major axis 25 kN and minor axis 10 kN.



## RESCUE PULLEYS


A rescue pulley has rotating side plates and is constructed with a sheave (wheel) mounted on a bearing or bushing. Pulleys constructed with sealed bearings are superior and more efficient in handling rescue loads than those containing bushings. When using a pulley as a directional, keep in mind that the force on the pulley anchor may be twice the force on the rope!

The tread diameter of the pulley sheave, where the rope lays, is important to note. For efficiency, the optimum rescue pulley size would be a tread diameter of at least three times the diameter of the rope being used on it. Some manufacturers will state the outside diameter (OD), which could be misleading. Pay attention to the tread diameter which relates directly to performance.

<table>
<tr>
<td>

Prusik-Minding Pulley. CMC Rescue ProSeries® Pulley with side plates shaped to tend Prusik Hitches.</td>
<td>

Double Sheave Pulley. Rock Exotica Omni-Block Swivel Pulley. Design allows opening the side plate while clipped to an anchor and has becket attachment point at the base.</td>
<td>

Rock Exotica Kootenay Ultra. Specialized pulley with wide sheave to permit knot passing or serve as travelling carriage in a highline system.</td>
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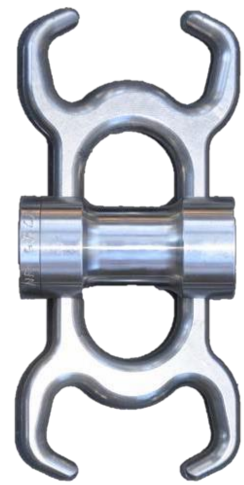
</table>

Knot Passing Pulley- The wide sheave The Kootenay Ultra by Rock Exotica permits knot passing and has a locking sheave to create a high strength tie-off. It is also purpose-designed for highlines as there are separate connection holes for taglines and hoist-lines, with a sheave that is wide enough to run over multiple track-ropes.

# DESCENT CONTROL DEVICES

## SCARAB®

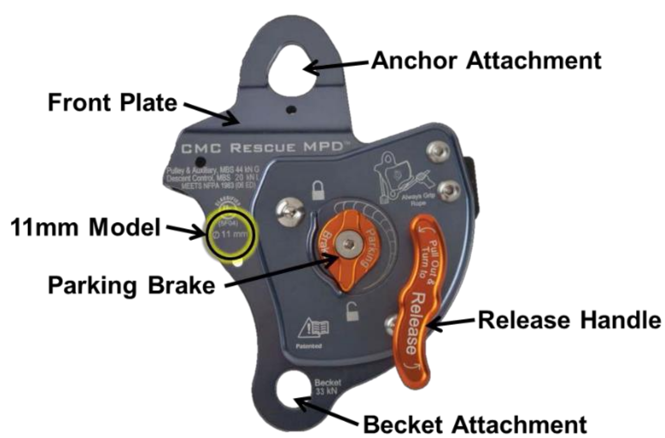
The Scarab® is a compact variable friction descent control device (DCD) developed by Rick Lipke, Conterra Technical Systems, which does not twist the rope during use. In comparison to the rappel rack, the Scarab provides a very compact rescue DCD. A rope can be attached to the device without unclipping the device from the anchor and variable friction is accomplished by adding or removing wraps of individual horns on the frame. The Scarab easily manages lowering of a 600 lb. rescue load and the basic “boat cleat” style of the frame permits easy lock off during an operation. The device is available in stainless steel or titanium models. Scarab FR is manufactured from stainless steel and works with 9mm to 13 mm rope. Weight 385g (13.8 oz). Scarab TI is machined from solid Titanium and operates with 6mm to 11 mm rope. Weight 185g (6.6 oz). The Scarab model SFR-1 is certified to NFPA 1983 General Use for 12.5mm rope.



According to Conterra, the frame and crossbar’s strength is greater than 40kN (8,992 lbf). However, during destructive testing nylon ropes would fail at the nose of the Scarab close to their knotted strength. When pulling a 12.7mm (1/2 inch) rescue rope on a locked off Scarab, the rope broke a t about 27kN (6,070 lbf), which easily exceeds the 22kN (4,946 lbf) strength rating that NFPA calls out for to rate class “G” for a DCD.

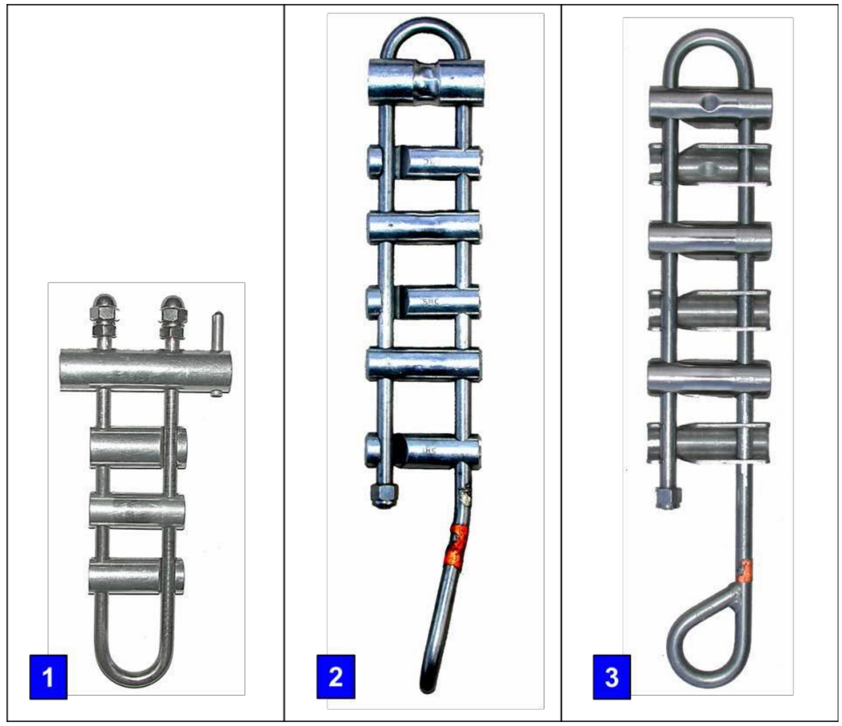
## CMC RESCUE MPD™ (MULTI-PURPOSE DEVICE)

MPD™ (Multi- Purpose Device) is manufactured by Rock Exotica and sold exclusively by CMC Rescue. This device serves as high-efficiency pulley, DCD and a belay device that permits immediately switching from lowering to raising without any change in hardware. The MPD pulley has an integral rope-grab mechanism allowing it to be used as a lowering device on the main line or for belaying on a belay line systems. The MPD allows for a quick change from lowering to a raising system without switching out hardware. There are 2 sizes. Be certain to use rope meeting the diameter requirements of the device. Additionally, wet, icy or muddy ropes could affect the proper function of the device, and additional friction may need to be applied by the operator.



## RAPPEL RACKS

Invented by John Cole in 1966 to allow variable friction during a descent. A very popular device among cavers and a very efficient tool for rescue loads. The rappel rack does not twist the rope during use as it applies friction in an "in-line" fashion. Two rappel rack styles include the standard inverted "J". shape (open style), which has attachment eye along one of the legs of the inverted "U" frame. The second popular style is the closed rack, which is also "U" shaped, but the base of the "U" serves as the attachment point




The amount of friction can be easily adjusted during use and the device dissipates heat well.

**Always have a minimum of four bars in the system. Start with all bars incorporated and reduce the number of bars after getting past the edge.**

## Figure Eight

Although once a very popular friction device in technical rescue, the Figure Eight ("Rescue Eight") has lost its acceptance as a rescue DCD with the development of much more versatile and appropriate appliances. It is shown here for comparison only and is no longer considered a recommended tool for rope rescue. This classic friction device is an efficient personal descender, however it does not provide the necessary utility required to handle a rescue load. The device is loaded by feeding a bight of rope through the large hole and looped down around the outside of the smallend till it rests on the "neck" of the Figure Eight. The bottom small hole is clipped to the rescuer or anchor. The "rescue eight" design (Figure 49) incorporates protruding ears, which prevent the rope from sliding up to the top of the device and forming a Girth Hitch during a rappel, which immediately stops further descent. A very significant drawback of the Figure Eight is that it twists the rope during use. Although the Figure Eight can be double wrapped during setup to increase friction, it however cannot be varied during an operation, which limits its overall usefulness.

## Petzl I'D "L"

The Petzl I'D (Industrial Descender) is a self-braking descender/braking device. Descent is controlled by pulling on the control handle while keeping hold of the rope with the opposite hand. The I'D handle has a range of positions that include stop for work positioning, descent and panic stop. Petzl manufacturers the I'D S and I'D L models. The "S" is rated for "Technical Use" while the "L", shown is rated as "General Use".

- Multi-function handle allows the user to unlock the rope with the handle and control the descent with your brake hand on the free end of the rope. It allows you to move more easily on horizontal or inclined terrain. You can position yourself without having to tie off the device.
- Anti-panic function activates if the user pulls too hard on the handle: it brakes and stops the descent automatically
- Anti-error catch to reduce the risk of an accident due to incorrect installation of the device on the rope.
- Lowers heavy loads up to 272 kg (only for expert users; consult the Instructions for Use for the device at www.petzl.com)
- Min. rope diameter: 11,5 mm
- Max. rope diameter: 13 mm
- NFPA 1983 General Use,

# BELAY DEVICES

## 540°™ RESCUE BELAY


The 540 Rescue Belay was designed by Kirk Mauthner of Basecamp Innovations Ltd. and is manufactured by Traverse Rescue. This self-locking device is capable of holding a falling rescue load quickly, while limiting the peak force applied to the rope. The device has a symmetrical internal design which permits bi-directional loading. A built-in release lever releases the tension on the belay rope, which eliminates the need for a release hitch.

**It is available in Small (GREEN) for ropes, 10.6 – 11.5 mm. and Large (BLUE) for ropes, 11.5 – 13mm.**

## RIGGING PLATES

The focal point of anchor system can be kept organized with the use of a rigging plate. This simplifies multiple tasks or connections occurring at a single location and helps to keep lines orderly. Numerous sizes of rigging plates are now commercially available, providing numerous connection point configuration to meet different needs.  Rig plates are tested and rated between two holes. Do not exceed the safe working load of a single hole with rigging. Shifting equipment, particularly when tension is released and then reestablished, creates the potential for a rigging plate to lever against a carabiner, causing failure. Be aware of this hazardous scenario and keep a watchful eye on all rigging during use.


Rigging Plates. 1.) Petzl Paw S (small) 2.) Rock Exotica PentaPlate 3.) Rock Exotica   UFO (Universal Focusing Object)

## RESCUE LITTER

Rescue litters, which are also referred to as stretchers. The classic Stokes Stretcher was the forerunner appliance which led to the evolution of basket style litters used in technical rescue within North America. The original “Stokes Splint Stretcher” was developed and patented by Dr. Charles F. Stokes,fourteenth Surgeon General of the Navy, in 1905.  As a surgeon and medical officer on a hospital ship, Dr. Stokes relied on his experience to develop the litter design. There are now, several variations of the litter. These are specs from a particular stainless- s t e e l CMC litter to provide just a general idea of specifications.

- Vertical MBS: 30.2 (kN)
- Horizontal MBS: 14.1 (kN)
- Weight: 31 lb (14.1 kg)
- Load Rating: 11 kN (2,473 lbf)

## MISCELLANEOUS

**The AZTEK** is first and foremost, a personal travel restraint that utilizes various lengths typically between 30 and 50 feet of 9mm as the main support mechanism.

The AZTEK addresses energy absorption through the use of a shock absorber. This shock absorber is a purcell fashioned from 8 feet of 6mm accessory cord hitched to the 9mm rope. By employing a unique five wrap, 3 over 2, prusik at all the connecting and adjustments points, it was found to have effective energy absorption. The second basic tool of the AZTEK is a pre-rigged 5:1 pulley system or *"Set of 4's" (SOFs)*, a fitting nickname given to us from the lineman industry. This 5:1 pulley system uses two mini double sheave pulleys rigged on 9mm rope at the opposite end from the travel restraint system.

**Mechanical Ascenders**- For long ascents mechanical ascenders outperform Prusiks. Handled ascenders are designed to be easily attached to and removed from a fixed rope, providing an efficient personal rope ascending tool. Mechanical ascenders are rated by manufacturers only for one-person loads.

**Bypass Lanyards** – A versatile piece of fall protection equipment for "Leading" on structures such as towers. The double tie off lanyard, also known as the Y-lanyard. The Y-lanyard attaches two lanyard legs to a shock absorber, which is recommended as to limit the force of a fall to 8kn. Fall factors of .25 are considered unacceptable. They can also allow rescuers to move horizontally from one area to another while being continuously attached.

**Evacuation Triangle**- The Petzl Bermude or Pitagor are evacuation triangles, used when the subject will be suspended rather than climbing. They can be rapidly secured around a subject for a pick-off situation. The Pitagor model has shoulder straps, which prevent the device from dropping down around a subject's ankles when not supported under tension. The three connection rings should be joined together with a wide (HMS style) locking carabiner and for proper balance should be positioned just above a line between the subject's armpits. Weight (Pitagor) 1.29 kg (2.84 lbs)

## MANUFACTURER BREAKING STRENGTHS OF RESCUE EQUIPMENT

*Note: All strength ratings shown reflect ideal conditions with new products. Remember that rope, cordage and webbing loose significant strength when wet or rigged with knots.*

| ITEM | kN | Force pounds |
|---|---|---|
| CORDAGE/ROPE: | | |
| 4 mm Accessory Cord (PMI) | 3.8 kN | 854 lbf |
| 5 mm Accessory Cord (PMI) | 5.8 kN | 1,304 lbf |
| 5.9 mm PowerCORD (Technora core) (Sterling Rope) | 19 kN | 4,271 lbf |
| 6 mm Accessory Cord (PMI) | 7.5 kN | 1,686 lbf |
| 7 mm Prusik Cord (PMI) | 10.7 kN | 2,405 lbf |
| 8 mm Prusik Cord (PMI) | 13.4 kN | 3,012 lbf |
| 11 mm Static Nylon Rope (PMI Pro Classic Max-Wear) | 28.6 kN | 6,430 lbf |
| 11mm HTP (High Tenacity Polyester) (Sterling) | 30.5 kN | 6,856 lbf |

| | | |
|---|---|---|
| WEBBING: | | |
| 1 inch Mil-Spec Tubular Webbing (PMI) | 18 kN | 4,000 lbf |
| 1 inch Type 18 Woven Flat Webbing (PMI) | 27 kN | 6,000 lbf |
| Climb Spec Webbing, 15mm (9/16") (BlueWater) | 10.2 kN | 2,300 lbf |
| Spectra TM Sewn Titan Sling, 13mm (1/2") (BlueWater) | 27 kN | 6,069 lbf |

| | | |
|---|---|---|
| HARDWARE: | | |
| Petzl Minder (Prusik-Minding) Pulley (P60A) (97% efficiency) | 36 kN | 8,093 lbf |
| Rock Exotica 2.0 Prusik Minding Pulley | 36 kN | 8,093 lbf |
| Rock Exotica Omni-Block 2.0 Pulley | 36 kN | 8,093 lbf |
| Traverse Rescue 50 TM Rescue Belay | 40 kN | 8,992 lbf |
| CMC MPD | 44 kN | 9,891 lbf |
| Conterra Scarab *(rope breaks at 27kN)* | 40kN | 8,992 lbf |
| CMI Mini Hyper Rack | 62 kN | 14,000 lbf |
| SMC Figure Eight with Ears, NFPA128701 | 32kN | 7,194 lbf |
| Petzl Delta Triangular Screw-Link, 10 mm (P11) | 25 kN | 5,620 lbf |

*Source: Manufacturer websites*

# EQUIPMENT CARE AND RETIREMENT

Proper storage and general treatment will greatly extend the useful service life of all rescue equipment. Keep in mind that life safety equipment is designed to keep you safe. Develop a strong discipline of good housekeeping and storage of all equipment in a response-ready state.

Store equipment in a well-ventilated area out of direct sunlight, to avoid the possibility of degradation from ultra-violet exposure. Do not store near corrosive substances or acids (vehicle battery acid). Avoid storing equipment in a damp place where mold can develop (damp closets, bags and waterproof containers with moisture inside).

The following recommendation regarding retirement timeframes is made by Petzl, regarding the lifetime of their equipment; “The maximum lifetime is up to ten years from the date of manufacture for plastic and textile products. The lifetime is indefinite for metal products. Warning: An unusual event may require you to retire a product after only one use. This may involve the type and intensity of use, or the environment in which it is used: aggressive environments, sharp edges, extreme temperatures, chemicals.”

When determining the age of equipment, recognize that manufacturers who meet EN (CE) requirements, mark the year of production and lot number on an item in some manner. Etched marking indicates this carabiner was manufactured in 2010.  Marking arrangements vary between manufacturers.

**RETIRE GEAR WHEN NECESSARY, INCLUDING**:

- Over ten years old and made of plastic or textiles
- When subjected to a major fall or impact force
- When it fails to pass an inspection
- If the reliability of the equipment is in question
- The usage history is unknown (e.g. not marked, missing rope log, etc.)
- Obsolete design due to changes in standards, technique, or equipment compatibility
- Destroy any retired equipment to prevent further use in a life safety application
- Check all carabiner surfaces regularly for cracks, sharp edges, corrosion, burrs or excessive wear. Hairline cracks can result in significantly reduced carabiner strength.
- Check carabiners gates to make certain they open and close quickly and easily. Be sure all gates, as well as any locking mechanisms, close freely and properly. Retire any carabiner, if the gate does not function properly, or is out of alignment.
- Carabiners that have been dropped a significant distance should be retired. A dropped carabiner can suffer significant damage yet still appear visually intact. When in doubt, remove it from service.

**CARABINER CLEANING**

- Clean gates by blowing dust and dirt from the hinge area.
- For a sticky gate, wash in warm soapy water, rinse thoroughly, and allow to dry.
- Lubricate carabiners with a general purpose lubricating oil (e.g. 3-IN-ONE®) or Teflon based (PTFE) lubricant (e.g. Tri-Flow®) around the hinge area, the spring hole and the locking mechanism. Wipe off excess lubricant.
- Do not use WD-40 as it can dry out the hinge and spring, accelerating aging.
- Do not use graphite based lubricants, which promotes corrosion in aluminum.
- Remove any sharp burrs that can damage rope, sand them using fine grit sandpaper. Do not file carabiners to remove a burr.
- Clean and lube carabiners after contact with saltwater or salt air.

**HELMET CARE AND CLEANING**

- Manufactures oppose numerous decals or paint, due to the possible degradation.
- Do not compress a helmet inside a pack
- Do not sit on a helmet.
- Clean a helmet with household soap and rinse with water.
- Do not use solvents, stain removers, degreasers, etc. that are not compatible with polycarbonate, polystyrene, or nylon, and can degrade the helmet.
- Shell of ABS helmets can be cleaned with a cloth moistened with rubbing alcohol.

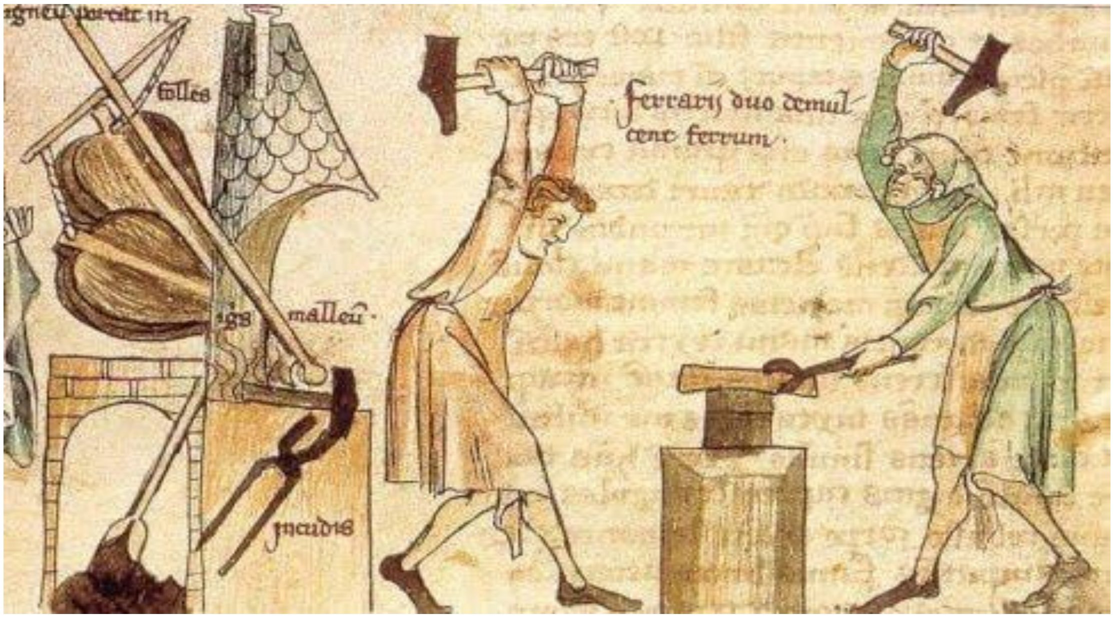
## HARNESS CARE AND CLEANING

- Inspect the stitching and condition of the straps on a clean textile product.
- After use in a salty environment (seaside), rinse with fresh water.
- Wash a harness in lukewarm soapy water, then rinse thoroughly with fresh water.
- Use a small brush to remove stubborn spots (oily dirt or mud).
- Clean in washer on delicate setting (max 86°F or 30°C), without spin cycle.
- Wash in a cloth bag to avoid damaging machine drum from metal harness parts.
- Use only household face or body soap (Do not use laundry detergent). Solvents, stain removers, or degreasers are incompatible and can degrade nylon.
- Hang harness on a line to dry

## ROPE CARE AND CLEANING

- Do not walk or stand on ropes.
- Aggressively protect ropes from edge abrasion, by using rope protectors and rollers.
- Avoid descending too fast on a rope as this heat the sheath and accelerates wear.
- Rapid descents can cause a rappel device to heat up (446°F or 230 °C) and melt nylon rope fibers.
- Store ropes uncoiled in a bag to protect them from dirt.
- Keep rope away from contact with sharp objects.
- Keep your ropes clean. A rope's condition can have an impact on the wear of other gear. For example, a muddy rope can inhibit the proper function of an ascender. A wet, sandy rope can cause premature wear of ascenders, descenders and carabiners.
- Use a hot knife to get a neat, clean cut.
- Mark each rope end with in-service date, diameter, and rope length.
- Use labels or adhesive tape to record information and protect the label with a heat- shrink tubing (WARNING: do not exceed 176°F or 80 °C).
- After use in a salty environment, rinse with fresh water.
- Wash ropes in lukewarm soapy water (ph neutral, 86°F or 30°C maximum), and rinse thoroughly with water.
- Clean in washer on a delicate setting (max 86°F or 30°C), without spin cycle.
- Use only household face or body soap (Do not use laundry detergent).
- Solvents, stain removers, or degreasers are incompatible and can degrade nylon.
- Hang to air dry.

## MARKING EQUIPMENT



**Use of a metal stamp or punch for identification is unacceptable.**

- However, you can use an electric engraving pen (depth less than 0.1 mm) on the frame, next to the serial number.

- You can also mark your metal equipment with a small amount of paint (paint pen or "metal writing" paint). Warning: do not dip your equipment in paint. Apply a small, thin marking of paint, not too thick. Avoid marking any working areas which would immediately cause the marking to worn off.

- The marks must be made on a part of the body where there is no rubbing against another device, or rope. The marks must not hide the original marking (serial number, standards, etc.) This type of marking is prohibited on plastic pieces, as the chemical agents in paints can weaken the structure of

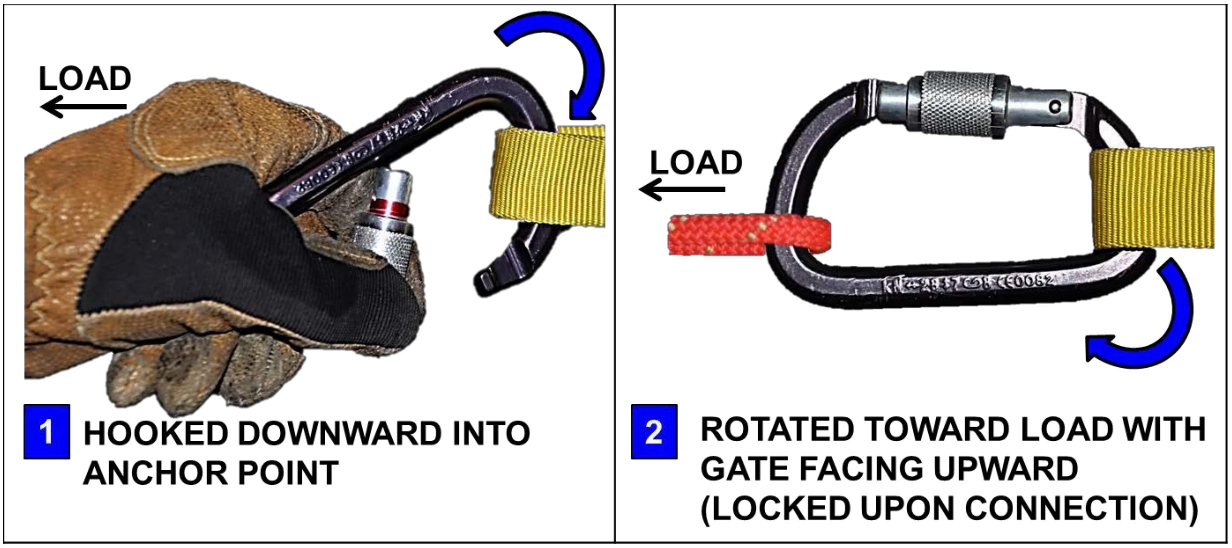
- You can use adhesive tape on the areas where the rope does not run.

*See appendix for various department color coding chart

# GENERAL RIGGING CONSIDERATIONS

Orientation of Carabiners in Rigging

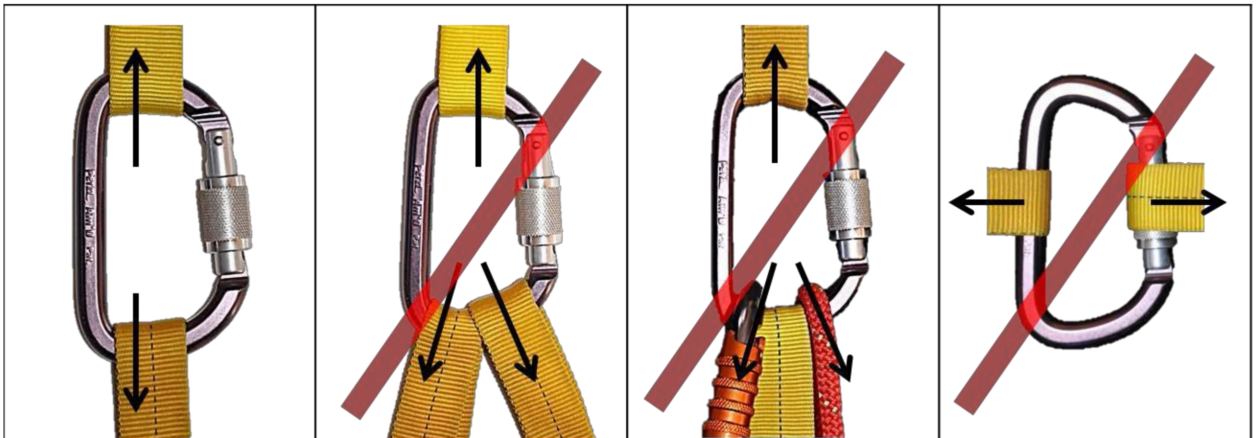
Consistently orienting carabiners in the same manner during rigging provides efficiency and reliability for a secure connection point. A recommended practice is to hook a carabiner into a connection point in a downward motion and rotate the body around so that the gate is facing upward with the nose of the gate oriented away from the connection point. This procedure places the spine against the ground and keeps the gate accessible for rigging and visual inspection.




NOTE: Be cautious that this manner of rigging, when untensioned and then tensioned again with a suspended carabiner, can promote diagonal rigging of the carabiner, resulting in 50-60% strength loss. In such cases, rotation of the heavier gate downward can be appropriate, however it should be away from terrain.

## CARABINER RIGGING

- For safety at a critical rig point, consider using one locking carabiner or two non- locking carabiners that are placed with their gates opposite and opposed.
- Tension along the major axis of a carabiner- be aware to prevent the primary force going onto or across the minor axis (cross-gate forces).
- Tension carabiners along the spine and avoid three-way loading of carabiners. A three-way load across the major axis results in approximately the same strength reduction as tying a knot in a rope, which is a 1/3 loss in strength. A three-way loading across the minor axis can result in up to an 80% loss in strength. Finally, diagonal tensioning a carabiner results in about a 50- 60% loss in strength.
- Keep straps, lanyards, and other carabiners away from the gate.
- A carabiner's gate-open strength is usually less than half of its gate-closed strength.
- Remember locking carabiners can unlock themselves! Recheck them during use.
- Do not allow the rope to run against the locking sleeve of a locking carabiner.
- Do not over tighten a locking carabiner while it is loaded. After the tension is released it will be difficult to unlock. To unlock such a "stuck" carabiner it may be necessary to re-tension it in order to loosen the gate.
- Avoid linking carabiners in a “chain.”
- Avoid rigging a carabiner over a sharp edge.



| **GOOD-**<br>**Long Axis Loading** | **POOR-**<br>**Three-Way Loading** | **POOR-**<br>**Three-Way Loading** | **POOR-**<br>**Cross Gate Loading** |
|---|---|---|---|

**Do not open a loaded carabiner supporting a life safety load in a rescue system.**

Think about your actions and the possible consequences. This could create a pathway for a catastrophic accident.

## OTHER RIGGING

Nylon quickly moving across stationary nylon generates tremendous friction that results in heat.

This heat can quickly melt through a piece of nylon in a short amount of time resulting in failure of the stationary component. Avoid rigging in a manner that permits nylon components to rub against one another. Introduce a carabiner or other intermediate rigging component to separate the nylon items.

## SAFETY INSPECTIONS

Once a rigging task is completed by a rescuer, it should be completely inspected by a safety officer or another rescuer. Newly constructed rigging or a system that has been re-rigged, needs to have a safety inspection completed. All rescuers receive a safety inspection prior to entering the hazard zone at an exposed edge. This disciplined process provides a redundancy for safety, which can catch natural rigging errors that do occur.

Inspections are conducted in a systematic manner, such as from head-to-toe or anchor point to rescue load If a person is interrupted during a safety inspection, the distraction could lead to an omission. Start the inspection of a system over to ensure thoroughness for complete safety. For

thoroughness, the actual safety inspection should involve three distinct actions by the inspector, including looking, touching and talking.

- LOOK- Visually inspect all rigging; Rigging meets acceptable techniques. Knots are correctly tied and dressed. Carabiners are locked. Buckles are secure. PPE is being completely employed. Housekeeping of all rigging has been addressed.

- TOUCH- Physically touch and trace the rigging; Squeeze carabiners to verify security with a “press check.” Pull on harnesses. Pull on anchor points and systems for confirmation.

- TALK- Verbally talk (even if it is only to yourself) about what you are inspecting; State what you observe and what you are looking for. Ask questions of the rigger.

# ANCHOR SYSTEMS

**GUIDELINES FOR ANCHOR SYSTEM CONSTRUCTION:**

Technical rescue employs anchor points rigged together into an anchor system. Constructing a rescue anchor system does not require an engineering degree, however a solid understanding of sound anchor rigging concepts is essential to be a competent rescuer. Upon arriving at a rescue scene, the following considerations for team leaders are useful to assist in maintaining efficient scene management.

In the Fire service we typically use single point anchors. They must be "Solid" all by themselves.

Rocks, Bollards, Columns, Beams, Cars, Trees, etc.….

- Whatever is used it must be bombproof beyond doubt.
- Check edges where webbing or rope will be up against and confirm no sharp edges that could damage the nylon under great loads.
- Cars can slide if on ice or loose gravel.
- Rocks can roll.
- Trees can break or topple over especially if under wind or snow load. Is it live? Is it in good soil? Is the soil saturated? Are the roots exposed?

**ANCHOR CONSTRUCTION DEFINITIONS:**

**ANCHOR POINT**- Single connection point (e.g. tree, boulder, camming device, etc.).

**ANCHOR SYSTEM**- Multiple anchor points rigged together creating redundant system.

**DEVIATION**- Redirects the natural fall line of the rope on the rock face. A deviation point may or may not to be subjected to the same force as the primary rig point.

**DIRECTIONAL**- Rigging technique to change the natural line of a rope with a carabiner or pulley attached to an alternative anchor.

**FOCAL POINT**- A location, floating or fixed, where all rigging is directed for anchor points. This concept disciplines rescuers to construct rigging which joins together at an efficient point, rather than unwittingly resorting to wherever the knot that joins all anchor points ends up due to the length of material used; the latter can result in an awkward spot to manage rope handling tasks.

**ANCHOR SELECTION**

Where do you need to go?

- Select an efficient fall line in order to reach the victim.
- Don't fall into the trap of rappelling directly down on top of fallen subject (non- pickoff situation) in a manner that might cause rockfall injury. Generally, a descent adjacent to the patient's location makes more sense. Packaging the patient can occur at their resting point and then the litter can be traversed to the raising or lowering system.
- Lowering route selection should avoid additional hazardous terrain if possible.
- Is a *deviation* pulley required to redirect the fall line of the rope?
- What rescue tasks need to be accomplished (e.g. edge management, lowering, raising or a traverse)?

Where should the anchor "focal point" be located?

- Raising the focal point off the ground increases efficiency of belayer/attendant.
- Is a floating focal point necessary?
- Does the focal point require pretensioned back-ties or front-ties?
- Focal point prevents extension of an anchor point in a load-sharing anchor system.

What anchor points should be used?

- Pad anchor points with sharp edges.
- Evaluate the integrity of the anchor points being utilized.
- Anchor point should not be hot to the touch or expose the rope to Haz-Mat.
- Seek system-wide redundancy, which can require use of more than one anchor point. Avoid overreliance on a single feature or placement of one piece of artificial protection (e.g. bolt or camming device).
- Attach at the base of an "anchor point" to prevent a leverage situation.

What directionals are available if needed?

- A directional may be needed for the use of certain anchor points.
- Is an artificial high directional needed at the edge?
- Rig the focal point high to take advantage of any natural high directional (e.g. stair- stepped edge) and allow for more efficient edge management with a litter.

**EARNEST'R- RESCUE ANCHOR ACRONYM**

Rescue anchor system construction requires addressing a few important considerations. Rigging for Rescue modified a similar acronym over to EARNEST'R.

**E** - Equalized– Anchor systems should be constructed so that each anchor point carries an equal amount of the load.

**A**- Angle/Alignment

**R** - Redundant– Anchor systems should consist of multiple components in case one or more components fail.

**NE** - No Extension– Anchors should be built so that if one or more of the components fail the remaining components won't be shock loaded S - Strong (or Solid)– Select anchor points that are capable of holding the load.

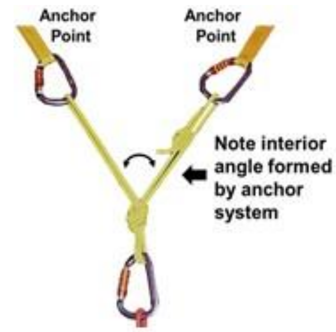
**T** - Timely– Anchor systems should be as timely

as possible without giving up any of the other qualities.

**R** – Rigid– When possible, slack is removed from the anchor system through pre- tensioning.

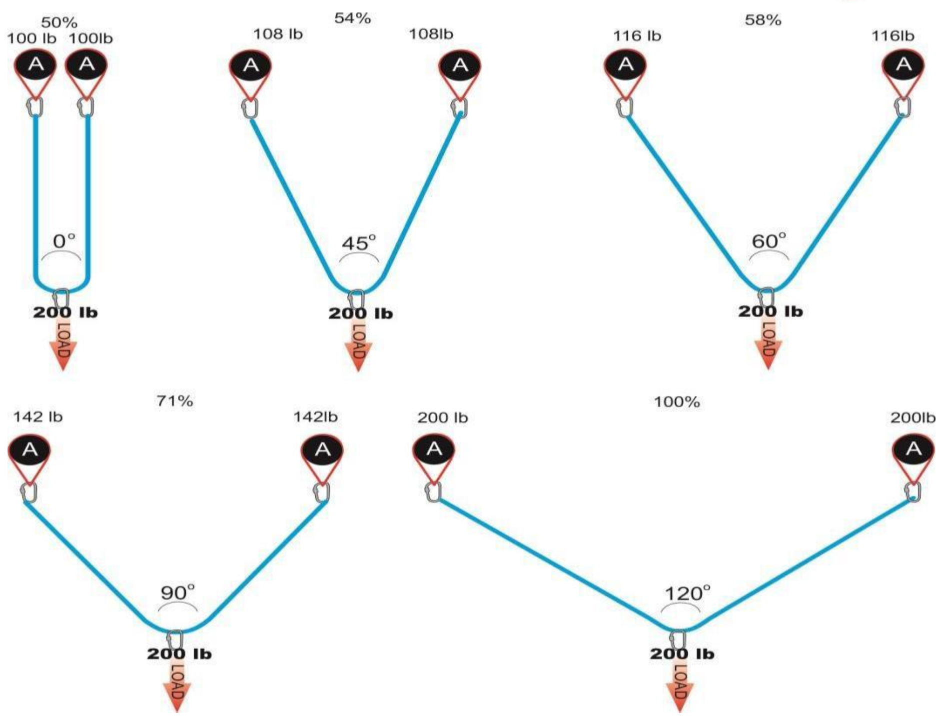
**LOCATING ANCHOR FOCAL POINTS**

During the initial size-up of a rescue incident, determine the focal point locations for both rope systems (main line and belay line). Using mental projection to predict how ropes lines will run when they are set up will assist in avoiding a rigging nightmare. Take a moment to carefully strategize at the outset, which will pay off in the long run in not having to de-rig later because of a poor selection. The focal points should be situated far enough from the edge to allow for construction of a haul system (if required), which does not place the haul team inside the hazard zone. A constricted location at the top of a cliff can be employed with the use of a change of direction that still permits the focal points to have some distance from the edge. Ultimately, both focal points need to be situated outside the hazard zone. There are advantages to having the focal points of both ropes side by side. Communication between the two rope systems is far better and each rope operator can more easily monitor what the other rope system is doing. On-the-job detection and correction of technique is far better.

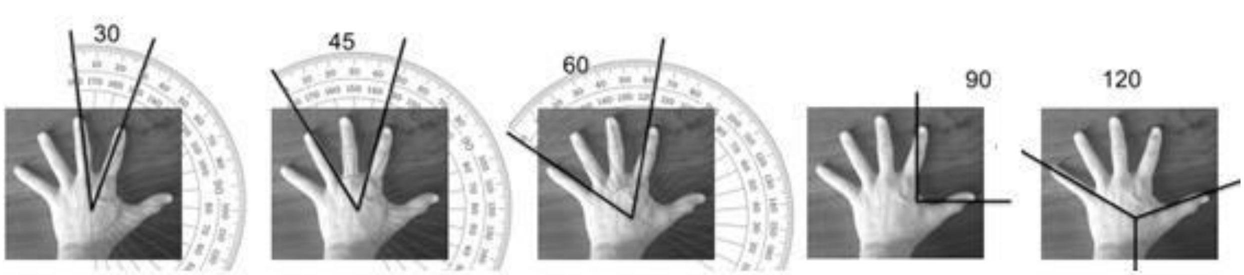



## CRITICAL ANGLE IN ANCHOR SYSTEMS

The connection of two or more anchor points and a load is placed upon it forms a critical angle. This interior angle can act as a force multiplier. As the angle increases, the force directed along each anchor leg is increased. At 120°, the force on each anchor leg is equal to the load. Beyond this point, such as a tensioned highline system, the force applied to each leg of the anchor rapidly increases.




### ROUGH ESTIMATE OF ANGLES




**Anchor Forces 200 Lb Load**

| Angle | % of Load at Anchor | Actual Load at Anchor |
|---|---|---|
| 0° | 50 | 100 |
| 60° | 58 | 115 |
| 90° | 71 | 141 |
| 120° | 100 | 200 |
| 150° | 193 | 386 |

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## One-Inch Webbing Anchors: Minimum Breaking Strength of Common Configurations

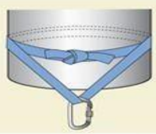
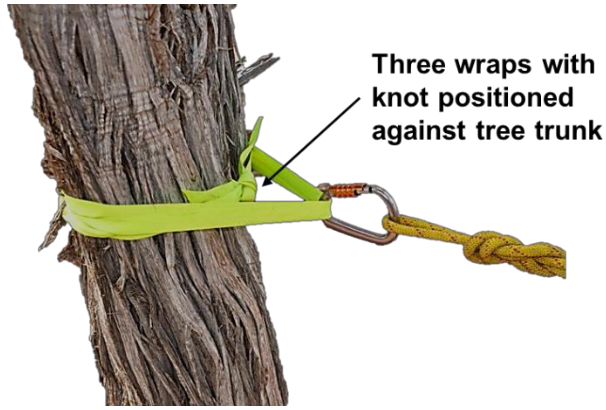
| | | Tubular Web lbf (kN) | Flat Web lbf (kN) |
|---|---|---|---|
| Web Strength |  | 4,340 (19.31) | 6,000 (26.00) |
| Girth Hitch |  | 4,799 (21.35) | 8,776 (39.04) |
| Single Loop (90° Internal Angle) |  | 4,832 (21.50) | 6,130 (27.27) |
| Wrap 2, Pull 1 (90° Internal Angle) |  | 5,510 (24.51) | 8,098 (36.02) |
| Redundant Double Loop (90° Internal Angle) |  | 7,777 (34.59) | 10,786 (47.98) |
| Wrap 3, Pull 2 (90° Internal Angle) |  | 7,899 (35.14) | 10,507 (46.74) |
| Basket (90° Internal Angle) |  | 8,464 (37.65) | 12,989 (57.78) |
| Double Loop (90° Internal Angle) |  | 8,716 (38.77) | 10,538 (46.88) |
| Redundant Wrap 2, Pull 1 (90° Internal Angle) |  | 9,700 (43.15) | 11,458 (50.97) |

Figure 8-7: MBS of Common Configurations

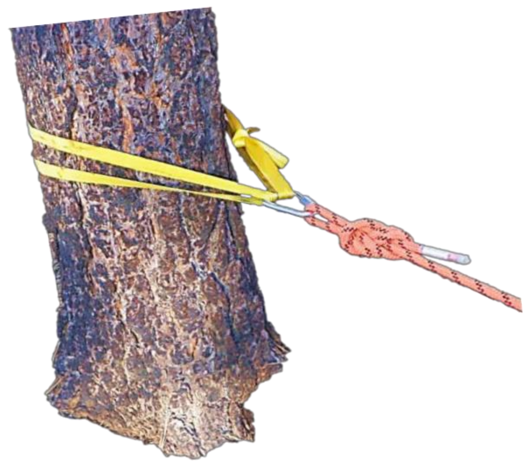
## Wrap 3 Pull 2   ( 7,899 lbs)




Provides Friction around the object so, it may stay when tensioned or unweighted.
Probably the best anchor if you expect movement from the carabiner as in a change of direction, because the carabiner is free to slide on the nylon and the friction will help keep the anchor webbing in its place.

Drawbacks:
Takes a little longer to build.

*Reminder –  the TSO is expecting that the knot will be facing the load!!*



## 3-Bight aka Basket   ( 8,464 lbs)

Fast.
Pretty Strong.

Drawbacks:
Not the best for directional or change of directions as the carabiner is unable to slide so the webbing may rub against the object as it pendulums from being loaded, relaxed, loaded etc.…

Reminder - Subject to tri-loading if not out far enough, even at 90 Degrees.

## Dou bl e  L o op  ak a  Wr a p  2  P ul l  2    ( 8,716 lbs)

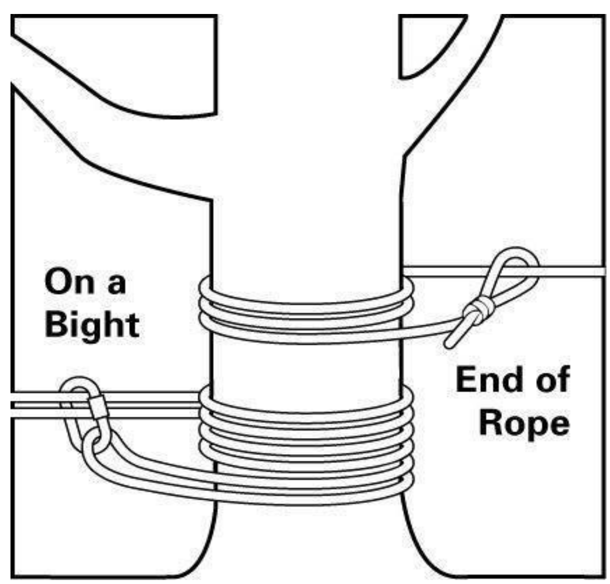
Strongest of the three.
Pretty Quick to tie.
A pretty good knot if you expect movement from the carabiner as in a change of direction because, the carabiner is free to slide on the nylon.

Drawbacks:
Provides no friction around the object so, it will most likely slide down when unweighted. Not ideal.

**HIGH STRENGTH TIE-OFF**:

The high strength tie-off, which is also referred to as a Tensionless Hitch, is a method of attaching a line to an anchor point, which provides for most of the original rope strength to still be available. The end of the line is wrapped at least three times around the anchor point and then finally attached back to the main line at a 90° angle. The number of wraps is dependent upon the anchor point and the amount of friction provided by the surface. Canvas wrapped around a tree trunk can be used to protect the bark from damage and the line can be protected in this manner from sap on the tree. This was formerly referred to as a tensionless anchor.





**CMC Anchor Strap**

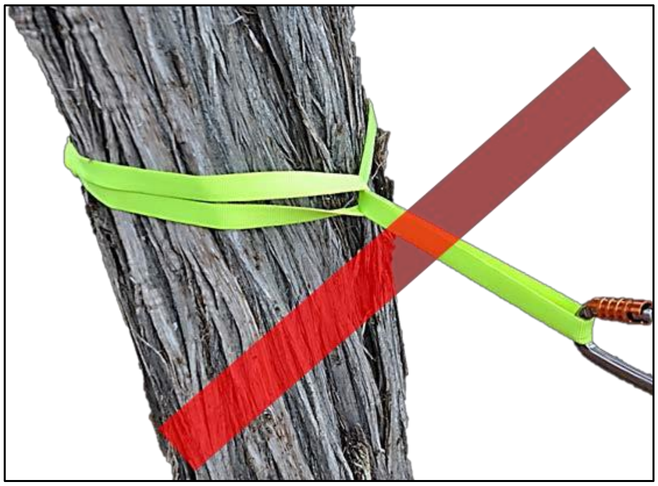
Basket (U) Configuration:  85 kN (19,108 lbf)

**Reminder - Subject to tri-loading if not out far enough, even at 90 Degrees.**

End-to-End Configuration:  46 kN (10,341 lbf)

Choker Configuration:  48 kN (10,790 lbf)

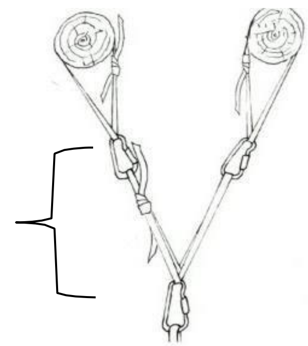
It is recommended that a Girth Hitch or a tied single loop of webbing be avoided as an attachment to an anchor point, due to the significantly weaker rated strength



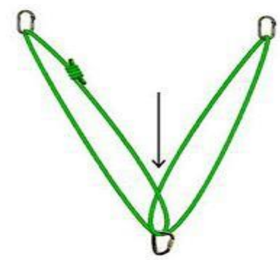
# LOAD DISTRIBUTING ANCHOR

**Load distributing anchor systems** are designed to tie two or more anchors together to distribute the weight of the load evenly between the anchors. If there is a shift in direction of the load, or a failure of one of the anchor points, the load will be redistributed among the remaining anchor points.

Load distributing anchor systems must be tied in a manner that keeps the actual "load distributing" system itself, small in size. This is accomplished by extending from each anchor point to the small load distributing system (green webbing). If a leg were to fail, the load will drop the length of the slack in the collapsed leg creating a large dynamic force that will impact the remaining anchor points. By keeping the size of the load distributing portion as small as possible you can minimize the impact caused by the collapsed leg. Keep all interior angles in a load distributing system less than 90 degrees.



A twist MUST be made for the carabiner to be clipped through. If a leg were to fail, the carabiner would remain captured in the loop.



# LOAD SHARING ANCHOR

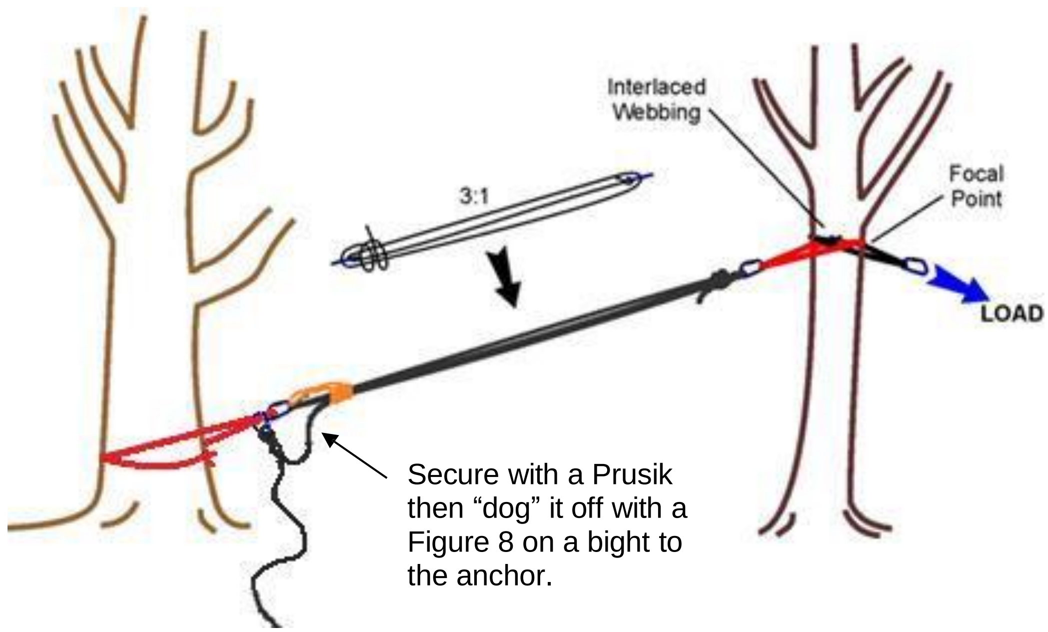
**Load sharing anchor systems** are designed to tie two or more anchors together to distribute the weight of the load between the anchors. Due to the nature of how load sharing anchors are rigged, the load will only be equalized when the load remains inline with the shared anchors. Any shift in the direction that the load applies to the anchors can result in the entire weight of the load shifting to one of the anchors only.

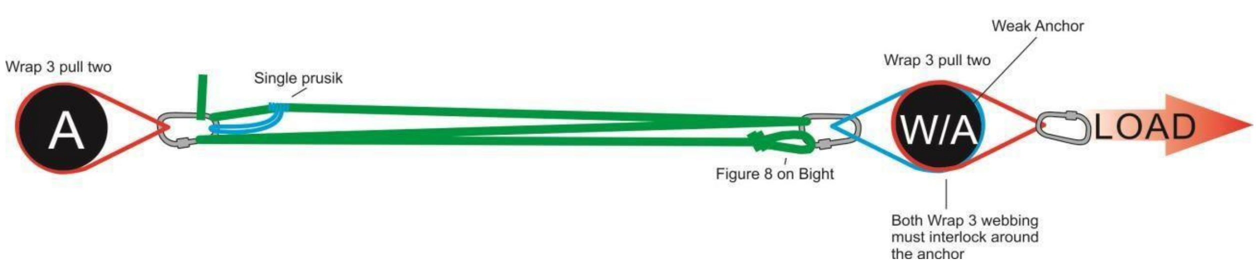
A load sharing anchor system distributes the load between two or more anchor points, but not precisely evenly. The key distinction from a load-distributing anchor is that the legs of the anchor system are a fixed length and will not adjust once rigged. This distinction makes it a superior technique for rigging rescue anchor systems, because it provides for no extension of the focal point in the event one leg (single point) fails, thereby reducing the potential for a shock force to be generated within the anchor system.

The load-sharing anchor system or "cordelette" is easily constructed with a ten-meter (33 feet) length of 8 mm cord. It may also be constructed with nylon webbing. Once all anchor points are clipped in and the load is distributed evenly, the middle of the load-sharing anchor is tied off with a Figure Eight Knot or Overhand Knot.

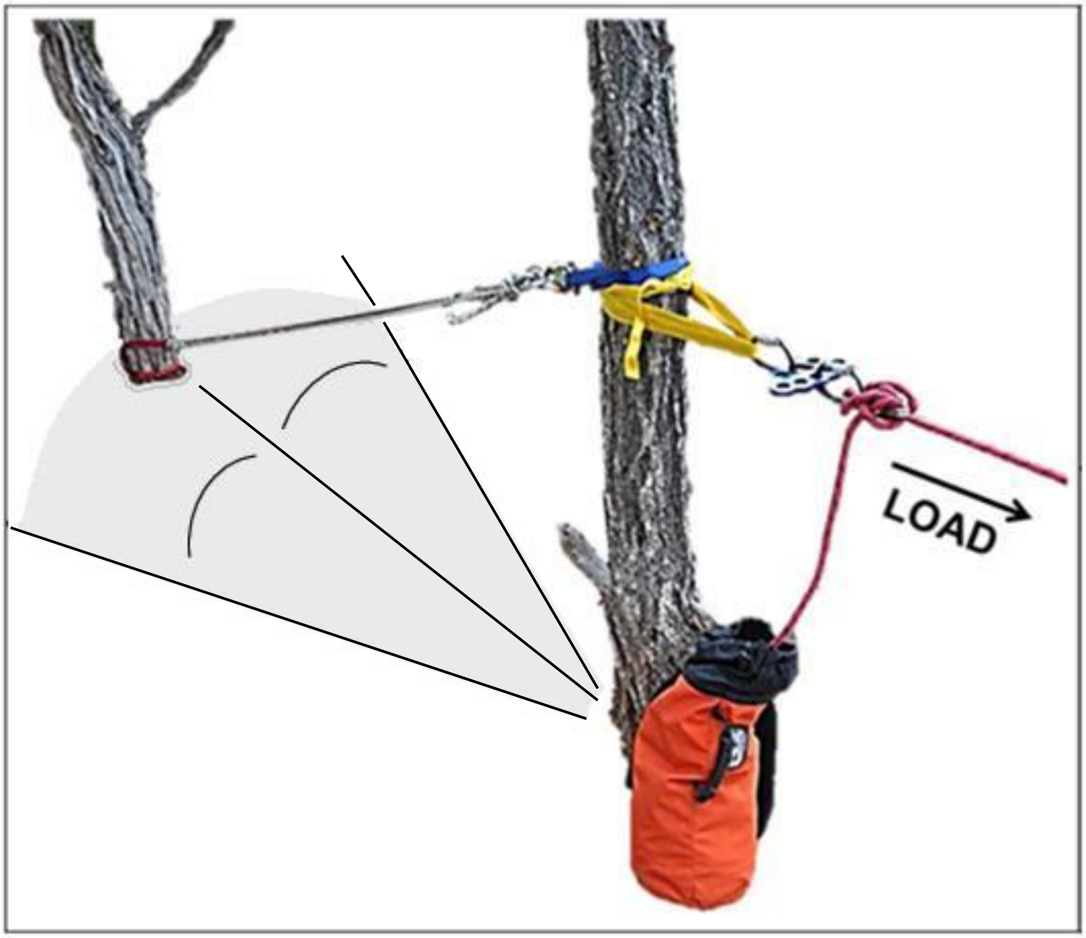
## PRETENSIONED BACK-TIE

The purpose of a pretensioned back-tie, constructed to back up an anchor point, serves to prevent movement in the main anchor and provide for redundancy in the anchor system. The webbing wraps of the focal point need to be interwoven with at least one wrap of the webbing connecting to the back-tie connection in order to have integrity with the back-tie anchor point. If the objective is to create a solid rigid link between the focal point and the rear anchor point, then a three stranded back-tie is used. When properly tensioned it creates a 3:1 mechanical advantage system between the front and rear anchor points using carabiners instead of pulleys. If the line is constructed with one end starting at the rear anchor, then the tie will be finished at the front anchor leaving the remaining line to be flaked nearby and available for the edge if needed.



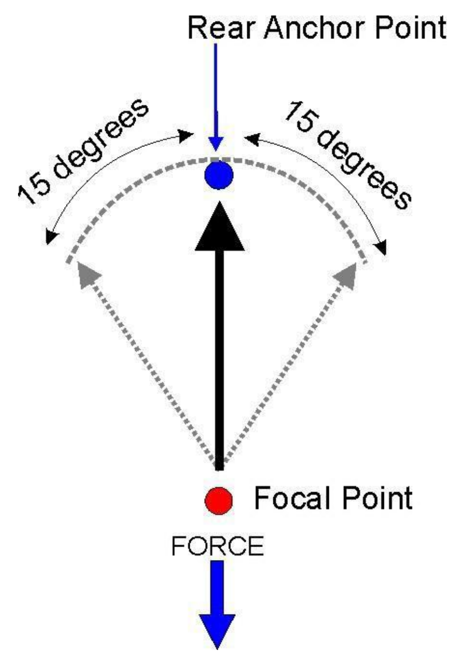




To tension the back-tie the 3:1 hauling system is pulled tight by at least two people. After the bundle of strands is sufficiently tight, push sideways on the rigging to "vector" it for additional tensioning in order to get any remaining stretch out of the rope. Finish with a prusik to lock it off then, “dogged” to the anchor. A variation eliminates the prusik, if not available, with two half hitches.

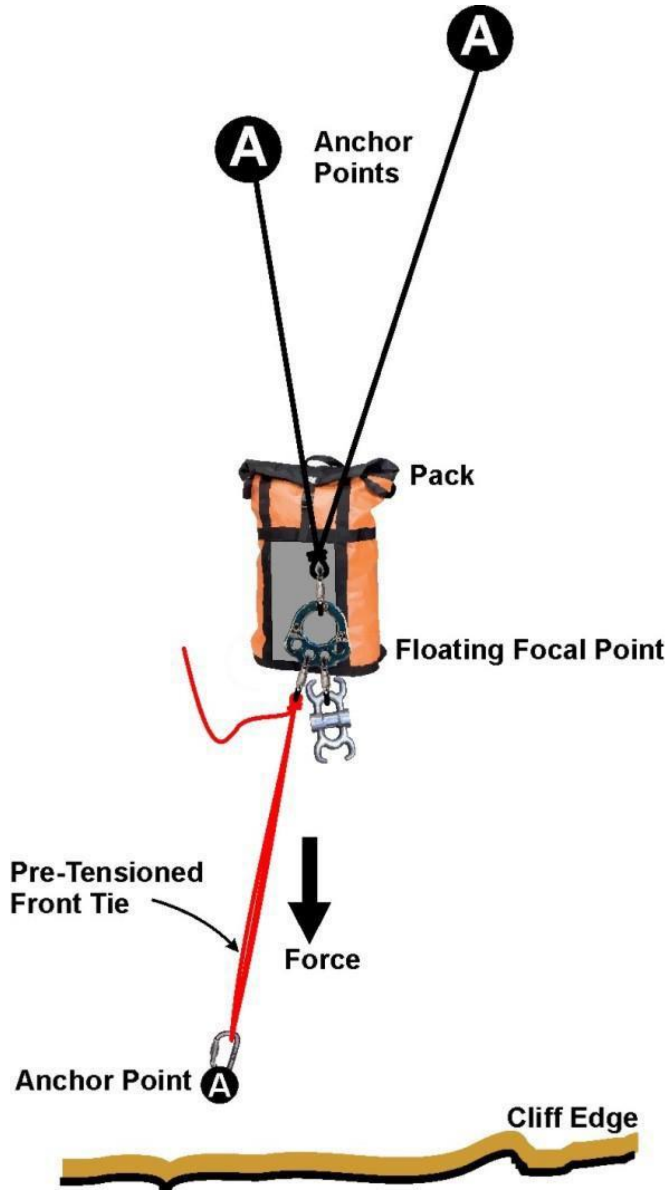



The alignment of the front and rear anchor points need to be within 15° either side of in-line to the fall line (30° total width) If the angle of offset is greater than 15° out of alignment, then employ two pretensioned back- ties to balance the offset forces. This creates a separate back-tie on either side of the horizontal alignment line.

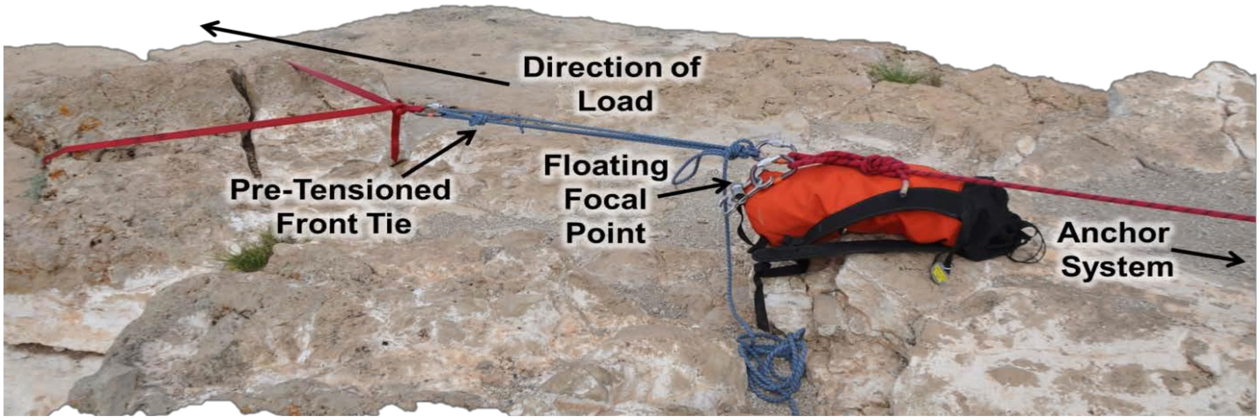
Two pretensioned back-ties can be constructed with a single rope if the distances are not too great, by starting at the focal point and splitting the rope to use half the line rearward on each back-tie.



## PRE-TENSIONED - **FRONT TIE**




A pre-tensioned front tie is employed when anchor points have been extended a significant distance to a focal point, where substantial slack can be generated when the anchor system is not tensioned. To "pre- tension" and remove the slack from the system, a front tie is constructed that is simply strong enough to apply tension to the focal point. This is not a life safety load and a much weaker anchor point and smaller cordage can accomplish this task if required. The front tie tends to pull the focal point down into the dirt at ground level, which is a poor location to manage a rescue load. Placing an object, such a pack, under the focal point allows it to float and creates a much better working environment for rescuers.



## NATURAL ANCHORS

Natural anchors include trees and boulders, referred o as “BFT” and “BFR” (Big friendly trees and rocks). Make certain to pad sharp edges and protect ropes from sap with canvas. When considering the use of a single anchor point evaluate it for the potential to fail. Question strength and integrity of boulders lying on slabs or partially buried in soil. Many trees appear sturdy, but in reality, have shallow root systems.

Below is the result of research performed by PNW local SAR, John Morton and presented to international technical rescue symposium. According to Mr. Morton’s paper the acceptable diameter could range from 6”-10”. To keep it simple, let’s say that tree anchor – Main, Belay or, Directional must be at least 10” in diameter, about the size of your helmet.

CAUTION: CONSIDER WIND AND SNOW LOADING, SOIL, HEALTH OF TREE AND ROOT SYSTEM.

**Trees smaller than helmet-sized (28 in circumference) may be used as rescue anchors by following these criteria.**

**If in doubt about anchor integrity, use other material or back up anchors as appropriate.**

- ☑ Tree is living & structurally sound
- ☑ Tree has vertical trunk, including base
- ☑ Rooted in normal soil (not sand or gravel), without voids
- ☑ Tree has symmetrical base at ground level

**Measure circumference around tree @ 2 ft above ground (incl for**

**Ratings based on ANCHOR @ 2 ft and HIGH-D @ 7 ft**

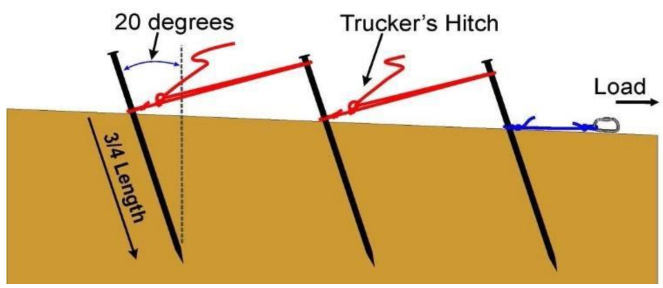
**Wind rating data applies *[location description defining region familiar to rescue team].***

**Applies from Mmm-20xx through Mmm-20xx**

| Identify tree species, or use largest Circumference | Minimum Circumference for ANCHOR | Approx Dia. for ANCHOR | Minimum Circumference for HIGH-D | Approx Dia. for HIGH-D |
|---|---|---|---|---|
| W.Red_Cedar or UNKNOWN species | >24in | 8 | >32in | 10 |
| Ponderosa_Pine | >24in | ↓ | >30in | ↓ |
| Bigleaf_Maple | >23in | ↓ | >30in | ↓ |
| W.Hemlock | >23in | ↓ | >29in | ↓ |
| Engelmann_Spruce | >22in | ↓ | >28in | ↓ |
| Red_Alder | >22in | ↓ | >28in | ↓ |
| Smooth_Hickory | >21in | ↓ | >27in | ↓ |
| Water_Oak | >21in | ↓ | >26in | ↓ |
| Loblolly_Pine | >21in | ↓ | >26in | ↓ |
| Douglas_Fir | >20in | ↓ | >26in | ↓ |
| Quake_Aspen | >18in | ↓ | >22in | ↓ |
| White_Ash | >18in | ↓ | >22in | ↓ |

# PICKETS

Pickets are utilized in soil where no rocks or other natural anchors are available. Although very dependable, a picket system is only as strong as the soil conditions allow. In light, dry soils it may pull out very easily and not support a rescue load, while an anchor rigged in heavy, dense soil may have a large safety factor for a normal rescue load. Soil moisture content and compactness will affect the holding power. An understanding the existing soil conditions is essential to achieving a safe working load when utilizing picket systems. Pickets must employ quality steel stakes as opposed to steel rebar which can bend. Ideal material is 1 in diameter rolled steel pointed at one end. Utilize eye protection and gloves when pounding steel stakes. Minimum length of 3-foot metal stake with 3/4 of the length driven into the ground. Common configuration is three pickets oriented in a straight line away from the direction of the load, each picket is spaced one picket length away from the other. Pickets should be driven into the ground at a 20° angle away from the load. Lash top of front picket to the base of rear picket. Tension picket cordage using a Trucker's Hitch or a Spanish Windlass. Spanish Windlass is constructed by placing a smaller stake between the multiple strands of connecting cordage and twisting to create tension. The smaller stake is then driven in the ground to secure it.

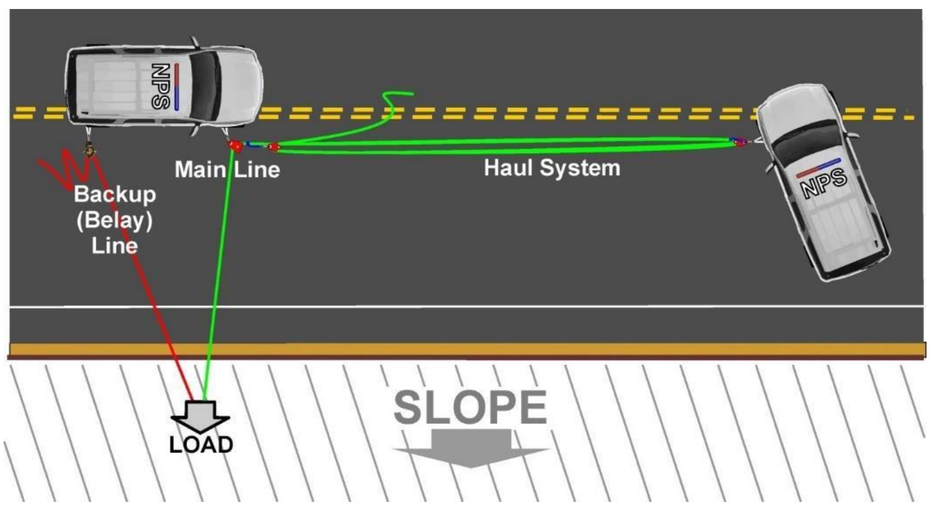



Picket anchor system constructed with a set of SMC Rescue StayK.

## VEHICLE ANCHORS

Vehicles can be utilized very effectively as anchor points. They can be placed in a position that is advantageous to the rescue rigging at a scene. Depending upon the size of the vehicle or application, rigging may be performed at the end of the vehicle (long axis) or to the side (short axis). Consider that the weight of the vehicle being utilized in relation to the surface it is sitting upon must provide sufficient friction to prevent the vehicle from sliding once a rescue load is applied. The frame and axle provide the most reliable points for connection points. Some considerations include keeping ropes away from hot (exhaust) or greasy parts. When rigging to wheels, avoid entangling nearby brake lines. Check the mounting bolts and connection points of hooks or brackets to ensure tightness and a lack of unsafe corrosion.

Some examples of vehicle anchor points. L to R. Open hook which requires constant tension to prevent detachment, welded bracket with connection point and attachment directly to a wheel rim (avoiding brake lines) at a right angle.




Example of vehicles positioned for rigging placement as anchors in a slope rescue.

When employing vehicles as anchors, set the brake and chock the wheels, particularly when the direction of pull will be in the long axis. To prevent accidental movement of the vehicle by an operator, remove and secure the vehicle ignition keys.

## DIRECTIONALS

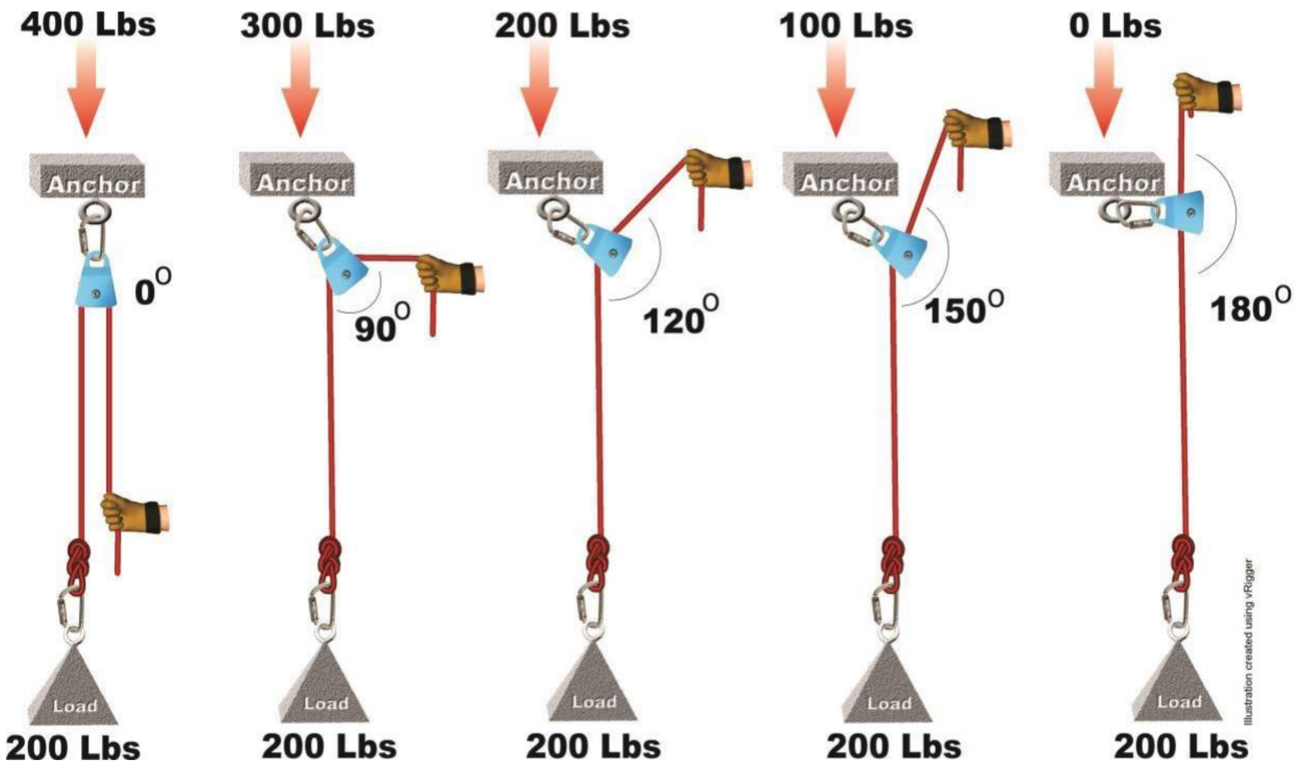
Forces placed on change of direction pulleys or directional pulleys often compound the force on the pulley and its associated anchor or anchor system. This force is usually greater than we would expect on the basis of the weight of the load. The force on the pulley is a function of the interior angle of the lines feeding into and out of the pulley.

A directional provides a means of redirecting the path of a rope under tension. This may be necessary to avoid contact with vegetation or a large rock, as well as providing better alignment at a cliff edge.

A pulley rigged on a fixed tether to a separate anchor point does not permit adjustment if the distance has been improperly estimated.

Constructing a directional with a tether that is adjustable by means of a jigger or adjustable hitch allows greater flexibility permitting the pulley to be placed in the proper point of alignment. Both the main and belay can be directed for alignment with a double-sheave directional pulley.

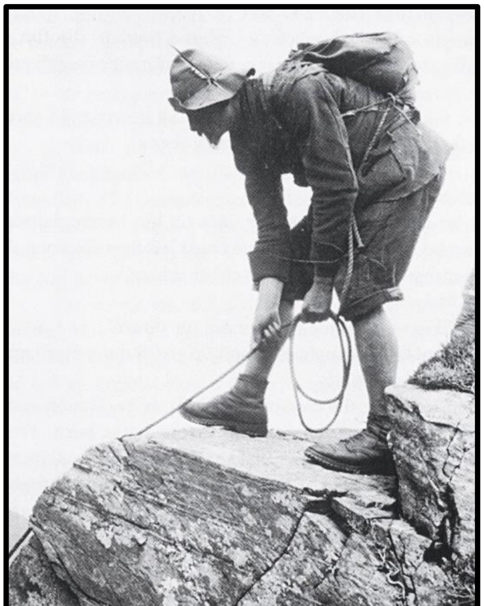
## DIRECTIONALS AND CRITICAL ANGLES




### Change of Direction Anchor Forces 200 Lb Load

| Angle | % of Load at Anchor | Actual Load at Anchor |
|---|---|---|
| 0° | 200 | 400 |
| 90° | 141 | 282 |
| 120° | 100 | 200 |
| 150° | 52 | 104 |
| 180° | 0 | 0 |

# BELAYING TECHNIQUES



*The term "belay" is derived from the old English word "belecgan". The original meaning is to surround an object with things. Later, surrounding an object with things became a way to secure them. The earliest surviving sense of the word is from the Dutch "beleggen", used in the early 1500's, is the nautical one of "to coil a rope around a cleat or pin to secure it".*

**Per the WAC and NFPA**, in rescue work a separate belay line is employed when ascending or descending. There are limited exceptions that may dictate deviation from the use of a separate belay line. Rescuers need to practice good sound judgment in deciding what is warranted.

Single rope technique (SRT) means the rope completely supports the load and there is not a separate rope as a belay. In rope rescue, the standard practice is to employ a separate belay for safety. That being understood, there are a few situations where single rope technique may be employed. These include a solo rescuer taking immediate action to reach a stranded subject in danger, rescue team travelling past a slot canyon or pour-off that requires rappelling and pulling the rope, and helicopter hoist or short-haul operations. SRT is commonly predicated by the likelihood and consequences of a mainline failure.

### BELAY TERMINOLOGY

Independent Belay-In two rope systems, it is a separate rope managed by someone other than the attendant.

**Self-Belay** Protection provided by the rescuer themselves moving their connection point along a fixed rope. (e.g. Prusik or autoblock).

**Conditional Belay**- Fall protection is provided through the use of a rope, that is already under tension from part or all of the load, to hold the load should failure occur in some other part of the system (e.g. mirrored rope system, bottom belay on rappel).

**Auto Belay**- A positive auto locking device (deadman) that does not require a positive action to engage it (e.g. Tandem Prusik Belay)
*-adapted from Belay Definitions, originally prepared by Arnör Larson, Rigging For Rescue.*

Currently the most consistently reliable techniques for belaying a rescue load are;

540°™ Rescue Belay

Tandem Prusik Belay Technique

## TANDEM PRUSIK BELAY

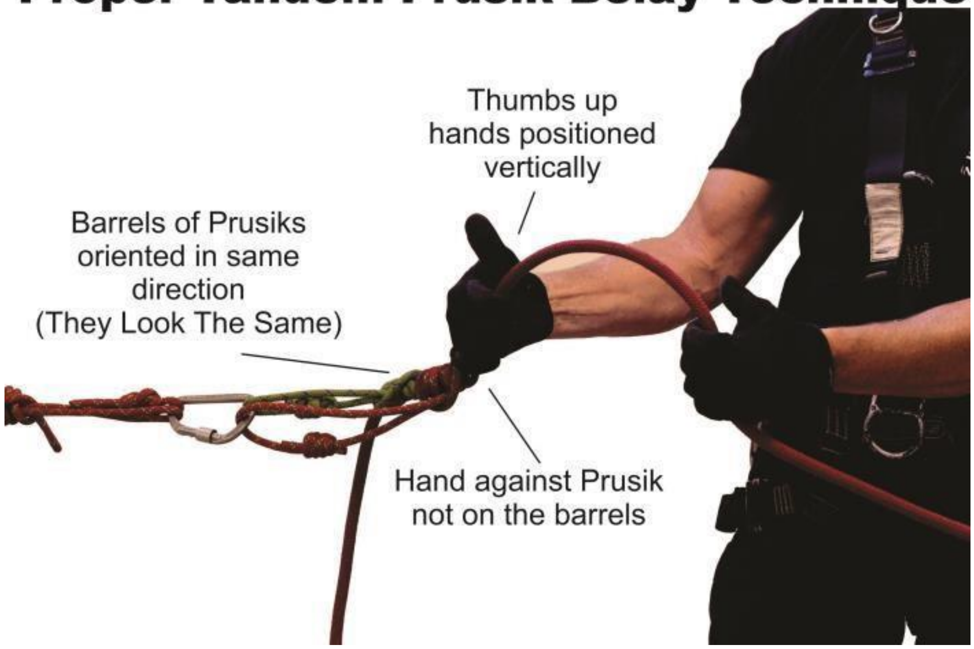
The Tandem Prusik Belay was developed as a field practical alternative in order to provide a reliable rescue load belay technique. During the tests, the Prusik Hitches typically "settled in" with a slipping clutch effect and glazed the host rope. If they did slip, they melted slightly before holding the fall, but left the belay line intact. This technique utilizes two triple-wrapped Prusik Hitches attached between the belay anchor and the belay rope.

The short Prusik of the pair will typically be the first one to catch and the longer one is available for redundancy in addition to providing better heat dissipation in the event of a sudden shock force being applied. The Tandem Prusik Belay consistently held falls of one meter on three meters of rope without damage to the main line and almost no damage to the prusik.

Prusik Hitches need to be monitored throughout an operation and requires constant attention by the belayer to keep the Prusiks snug but free-running. A mini 4:1 unit must be present at the "MAIN LINE" station as the tool of choice to resolve a stuck set of Prusiks on the belay line.

Another important note is that we no longer utilize a prusik minding pulley to belay a package up. It was an item of convenience. It was observed to have led to complacency in the belayer leading to several near miss situations.

**Proper Tandem Prusik Belay Technique**




On a lowering, the belayer should hold both hitches BEHIND one hand and pull out some slack in the belay rope with the other hand as they attempt to "feel the load". As the load takes the slack, the back hand remains perpendicular and stationary. The other hand rotates and slides back to pull another bight of slack. The Prusiks should be held (with fingers open in event belay activation) perpendicular to the plane of the belay line, which provides greater chance for the Prusik Hitches to grab, as opposed to an in-line position. The belayer also coordinates their actions through the Edge Manager and slows down the movement if needed.

## Considerations for Belay

- Have a plan for releasing tension back onto the Main Line if the belay is activated.
- Have an assistant assigned with you, if able, for rope management and relief.
- Be an ATTENTIVE belayer. Do not leave belay system unattended.
- Do not wrap thumb around belay line when using a Tandem Prusik belay.
- Maintain a twist of the wrist, ( S ), when belaying with tandem Prusiks to ensure some slack (less than 1 meter), in the belay line.
- Belayer should build their belay system at a height and position so that they can operate it comfortably, efficiently and safely.
- Prusiks are not foolproof. They must be constantly properly tended. Verify they have not become too loose and will work in their intended manner of function.
- NEVER use metal cammed ascenders in any part of a belay system for rescue loads.
- NEVER let go of the rope with either hand. When you need to move your hands, slide them along the rope instead. In the event of main line failure, the belayer lets go.

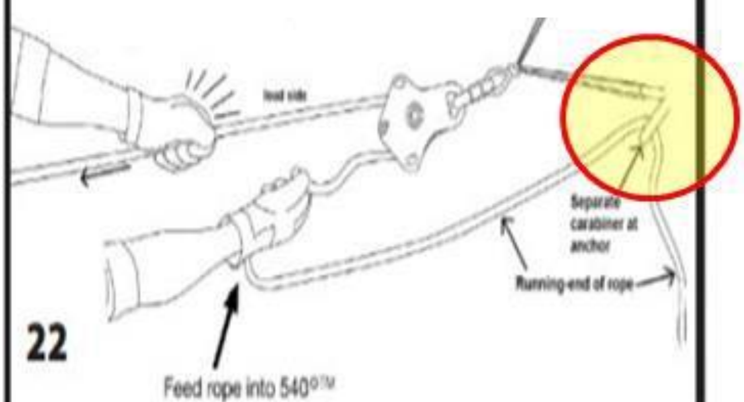
## The 540°™ Rescue Belay

**To load the 540º** ™ Rescue Belay, remove the front plate by depressing the push-pin. Wrap the rope around the obround (defined as form of a flattened cylinder with the sides parallel and the ends hemispherical) pulley one- and-a-half (11/2) times, or 540 degrees Since the 540º is symmetrical and bi-directional in design, the wraps may start from either side of the pulley. Ensure that the 11/2 wraps are divided by the rope guide pins, located on each side of the pulley. The device will not work if only half of a wrap is placed over the pulley. Replace the front plate and confirm that the push-pin balls have completely seated correctly in their locked position. Also ensure that both the running end (free or loose end) and standing part (load-side rope) are in- between the two stationary wedges and exiting below the pulley. The keeper cord connecting the front and back plates must be in-between the two ropes exiting the device. Use a locking carabiner to attach the 540º to an anchor system.

**Belaying with the 540°**™ Rescue Belay

Self-Locking will occur with sudden drops. It is important to understand that a “slow” fall on a supple rope will require resistance being applied to the running end of the rope in order to ensure locking. Self-locking for “slow-falls” can be improved by clipping the running end of the belay rope through a separate carabiner attached to the anchor, behind the 540°™. Do not belay a load using the Release Lever to manage the feed, as this may prevent rope-locking if the load were to suddenly drop. While lowering or raising, feed the rope straight into the 540º™, in order to prevent accidental locking of the device. This is especially important with wet, dirty, muddy, fuzzy or stiff ropes. While lowering with a gloved hand, provide resistance to the standing part (load-side and with the other hand, simultaneously feed the running end of the rope into the device (During a raising, do not attempt to pull the belay line through the device with both hands hauling on the running end opposite of the loaded side. This will only result in a lock-up of the device. While raising, with each hand on separate strands, pull up on the standing part and feed it into the device, while pulling out the running end with the opposite hand.

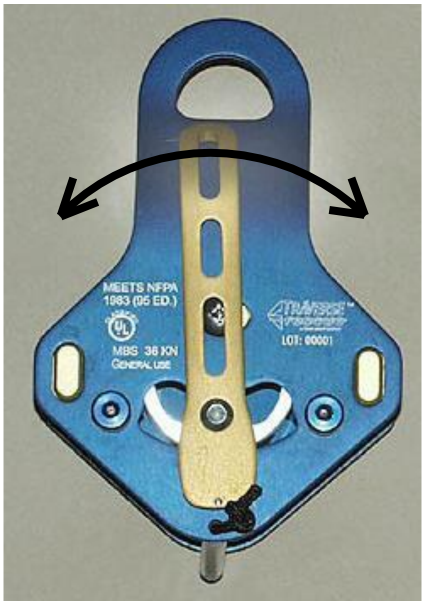
From the product manual, a carabiner must be added on the “brake hand” side to assist with the whistle test during “slow” fall scenarios.



**To Lock Off the Belay Manually**

In a situation where the belayer needs to manually lock off the 540º™, it is accomplished by firmly holding the running end and with the opposite hand sharply tugging on the standing part. Additional security can be achieved by tying a bight of the running end off around the around the standing part with a Half Hitch and an Overhand Knot. This should be done anytime the device will be left unattended.

**Releasing a Locked Belay**




If the belay rope is only lightly locked, then a quick reversing of the direction of rope feed can return the pulley to its neutral, or centered position. If this cannot be accomplished, first confirm the main line is locked off. Using the release lever, slowly transfer tension back to the main line. If the 540º catches a rescue-sized load and receives significant shock force, the rope within the device may “stiffen” during fall arrest. Initially releasing the device handle may be more problematic. Traverse Rescue recommends threading a webbing sling through the top of the Release Handle to make pulling easier. Once the load is released remove the webbing.

## RAPPELLING

## RAPPELLING IS DANGEROUS!

**The following are important safety considerations relating to rappelling**;

*Hans Dulfer -1910*

*The Dulfersitz. A rappelling technique developed over a 100 years ago which is rarely practiced today except for the extremely nostalgic, or those that dropped all their equipment.*

- Verify the rope reaches the target
- Double check your harness, carabiners, and all rigging prior to going over the edge
- Check that carabiners are locked and not cross loaded
- NEVER LET GO OF YOUR BRAKE HAND!
- Keep hair and clothing away from the descending device.
- Avoid dislodging rocks with the rope.
- Do not bounce during a rappel- dangerously shocks the rappel anchor.
- Descend slowly and avoid excessive heat buildup.
- You must be Safety Checked by another Tech whom did not participate in your rigging.
- A BELAY MUST BE USED. This could be a self-belay with a prusik on a second belay line or if the "agency having jurisdiction" permits, a Single Rope Technique for emergency access, the prusik would then be attached to the rappel line.

Begin rappelling with more friction then reduce as necessary. More friction will be required towards the bottom of a long rappel as the weight of the rope below you decrease. Proper stance involves leaning back perpendicular to the rock with feet spread and legs straight but flexible.

This photo is from the pages of the CMC Rope Rescue Manual, 4th Edition. We have found that edge transitions where the anchor is at waist level or lower are very difficult when transitioned as depicted. We have seen this technique result in injuries during training.


Figure 19-2: Different Start Positions

To negotiate a sharp roof edge, **SIT DOWN** slowly rotate into position while keeping the rappel line under tension. This is preferred to dropping over a sharp lip in an unstable manner to avoid "edge trauma". The hand on the rope below the DCD is the "brake hand" and remains in place on the rope at all times unless your DCD has been properly locked off.

## THE SCARAB

### RAPPELLING

IMPROPER LOADING: The rope should be wrapped in a bight back around the crossbar. Failure to follow the sequence shown below would provide very little friction and could result in injury or death.


Proper threading sequence of a rope into the Scarab is shown here.

Additional friction is created by continuing to thread underneath the Scarab in diagonal path to the opposite side where the horn is captured. This should be adequate for a 200 kg (441 lbs) mass. Finally, additional friction to manage a heavy rescue load of 280 kg (617 lbs) can be achieved by tracing the rope through the one remaining empty horn.

## TYING-OFF WITH THE SCARAB

For an extended stop, you may lock off a Scarab by wrapping all four hyper-horns, then place a bight with a twist over a forward horn.

This is a “Soft Lock” and is appropriate for all non-emergency situations. You can now let go of the rope.

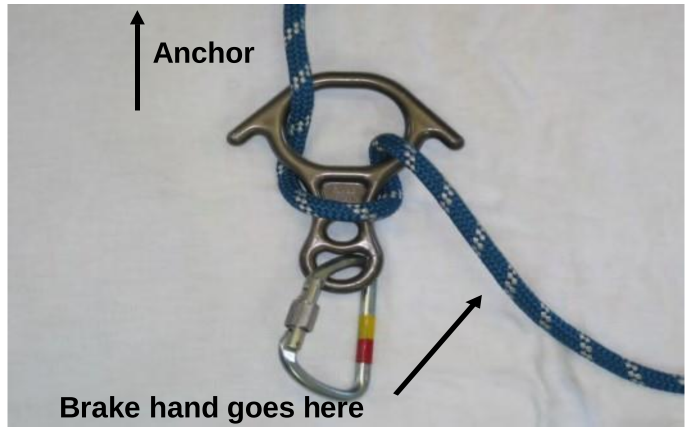
For extended stops during emergency operations or when your attention is focused elsewhere, a “Hard Lock” is required.

After completing the soft lock continue the rope around the horn and tie an overhand around the main line.

# FIGURE – 8 - DCD

Normal rappelling configuration

For single person rappelling only!




Wrap around 8-Plate and under ears then "pop" it under the anchor side rope.

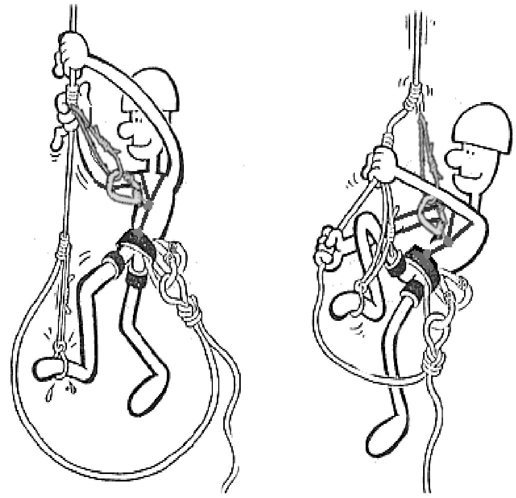
Repeat the wrap around and "pop". Total 2x.


Take a bight and bring it through the large hole and finish with an overhand.

# ASCENDING

There are many types of ascenders available, but these are the most common:

- Friction Hitches (Purcell Prusik System)
- Closed Ascenders (e.g. Gibbs or Rock Exotica Rescucender)
- Handled Ascenders (e.g. Petzl, CMI, Clog, and ISC)



TWO POINTS OF CONTACT

An ascending system should have *"two points of contact at or above the waist"*

These may include:

- Separate top belay
- Prusik backup

Ascending rope with a Purcell Prusik:


Attach a Purcell Prusik to the main line either directly or with a mechanical ascender.

Attach a long prusik to the main line, either directly or with a mechanical ascender above the Purcell Prusik.

Clip the long prusik into your harness's collection point with a carabiner. Slide the long prusik attached to your harness up the rope until snug, then sit back into your harness.

Stand into the Purcell Prusik relieving the tension to your harness, and slide the long prusik attached to your harness up the rope until snug. Sit back into the harness.

Slide the Purcell Prusik up the rope and again stand into it allowing you to slide the long prusik further up the rope.

Alternate sliding the Purcell Prusik and long prusik up the rope by placing your weight onto one or the other thus allowing the non-tensioned member to slide freely up the rope.

The rescuer shall be outfitted in proper PPE and safety checked prior to ascending the rope.

**ASCENDING TIPS:**

If ascending a fixed rope that is rigged with intermediate connection points off the rope to the rock or other obstacles, it will require the rescuer to remove the top ascender and replace above the obstacle. The process is then repeated with the lower ascender. Two points of contact can be maintained with the rope, through the use of a QAS or tying in short.

**ASCENDING CHANGE-OVERS:**

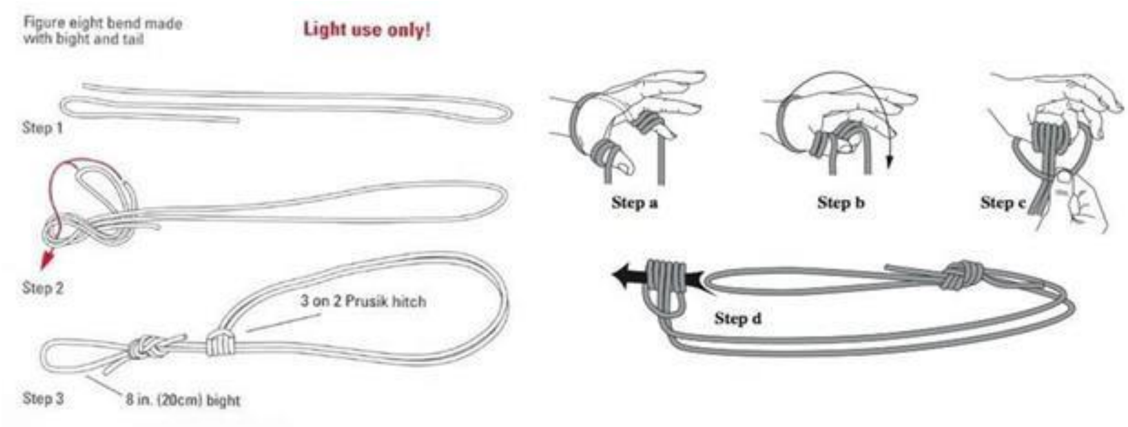
Changing over from ascending to rappelling, while part way up a rope, requires that the rescuer follow a logical sequence of steps to ensure personal safety. Maintain two points of attachment during this changeover process. A knotted bight achieved by tying in short, can be used for a point of security in lieu of one of the ascenders. During a changeover do not open any attachment carabiner to the harness while it is supporting a load. Use separate attachment carabiners for ascending and rappelling components.

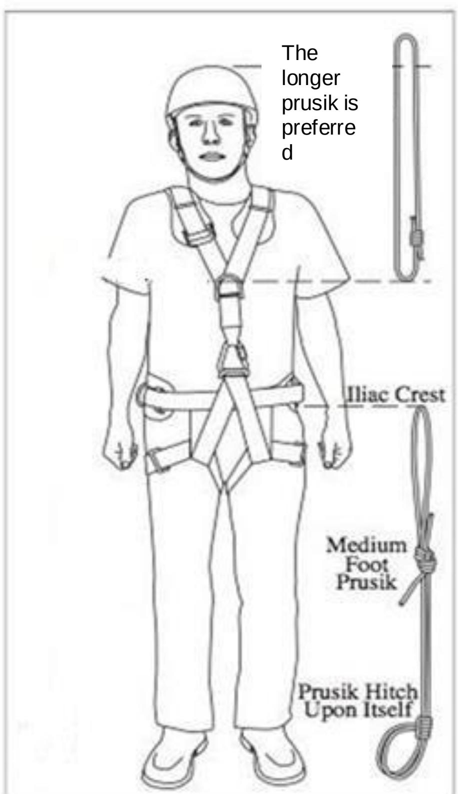
The steps for conducting an ascending to descending changeover include;

- Position upper ascender to nearly full extension
- Ensure additional secure attachment (e.g. separate belay, tie in short or QAS)
- Remove lower ascender
- Attach DCD to the fixed rope below the upper ascender
- Tension the DCD to the harness and lock off with a secure tie
- Remove the upper ascender
- If attachment includes tying in short, release this connection from harness
- Release lock off on DCD and initiate rappel.

## BUILDING YOUR ASCENDING PURCELLS

The traditional Purcell Prusik Ascending System does not meet the requirement for two points of attachment. For this reason, a belay line is needed. If a separate belay is not possible and a single rope technique (SRT) is utilized then, a second attachment point must be added to your harness and prusiked onto the rope.

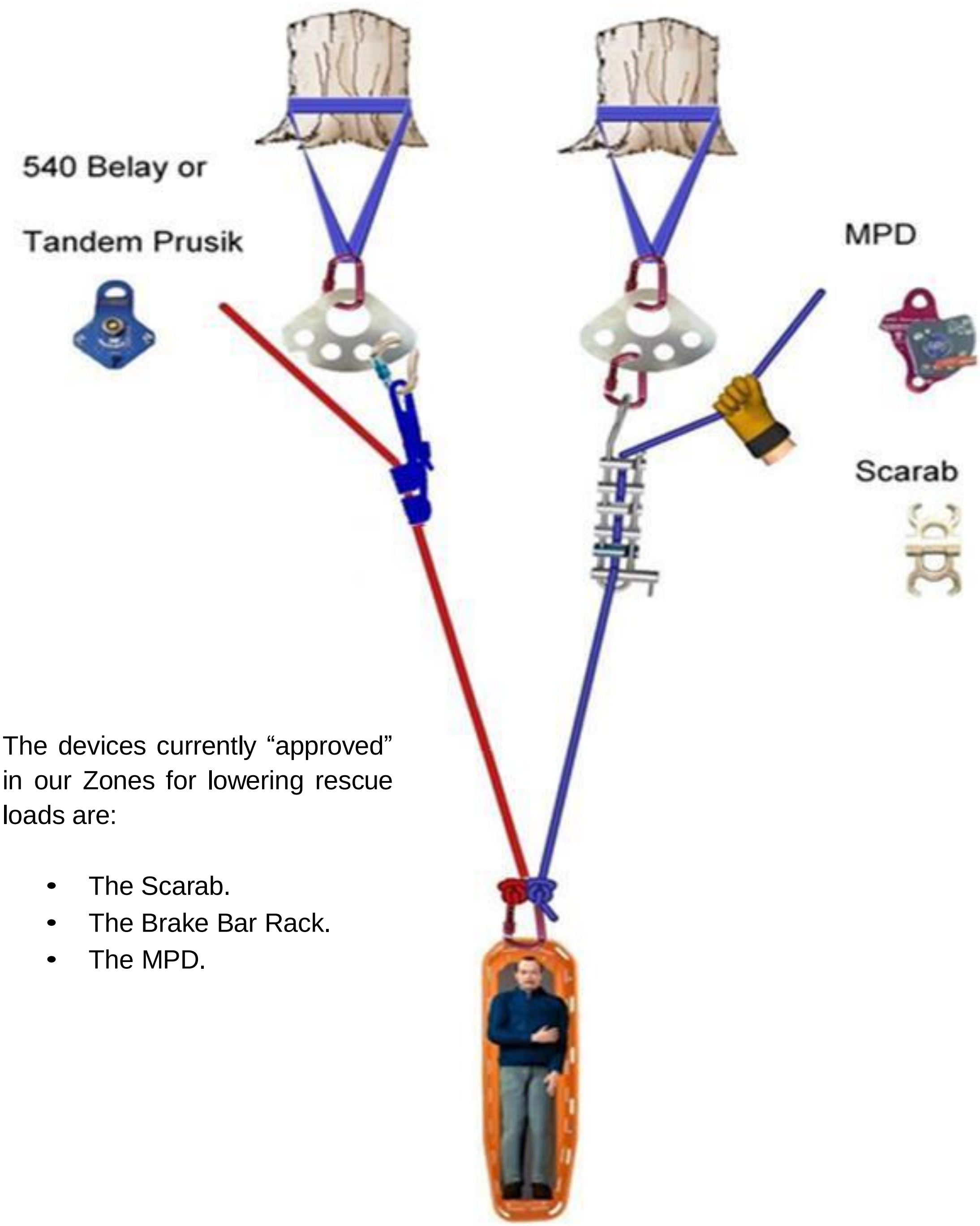



**Purcell Prusik Loop** is an adjustable loop suitable for making the components of the Purcell Prusik System and an adjustable tether.- The Purcell Prusik System is standard personal protective equipment for many rescue personnel operating in technical Search and Rescue settings.

**Uses:** This system is utilized for a wide range of applications including: adjustable attendant/patient tethers, load releases/transfers, or friction hitches/rope grabs.

# LOWERING




The devices currently "approved" in our Zones for lowering rescue loads are:

- The Scarab.
- The Brake Bar Rack.
- The MPD.

# THE SCARAB:

## LOWERING

Begin each lowering evolution with all four cleats engaged. Once loaded, cleats may be taken off to facilitate a smooth and controlled operation.

“Main Line ready” is defined as:

- Safety Check is complete.
- All the slack is out of the system.
- All four cleats are engaged.
- Brake hand has control of the rope.
- You are ready to take the load the instant you reply that you are ready.

Soft Tie and Hard Ties are identical to rappelling

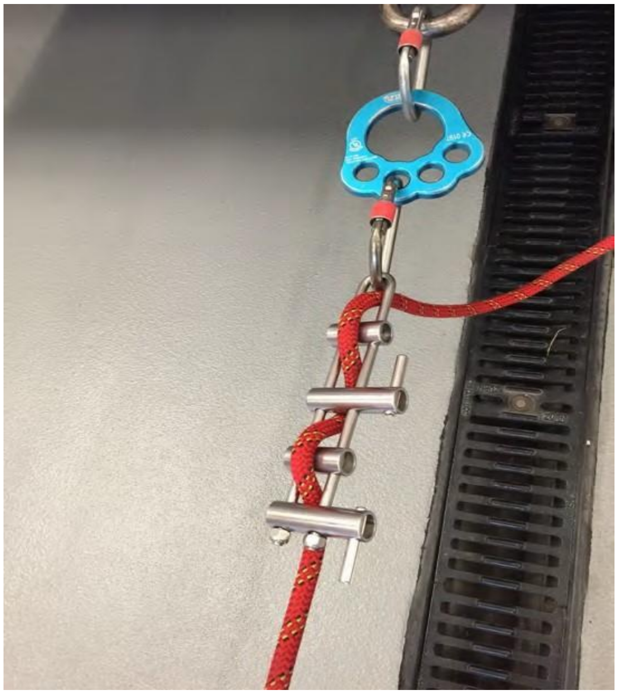
For an extended stop, lock off a Scarab by wrapping all four hyper-horns, then place a bight with a twist over a forward horn. This is a “Soft Lock”.

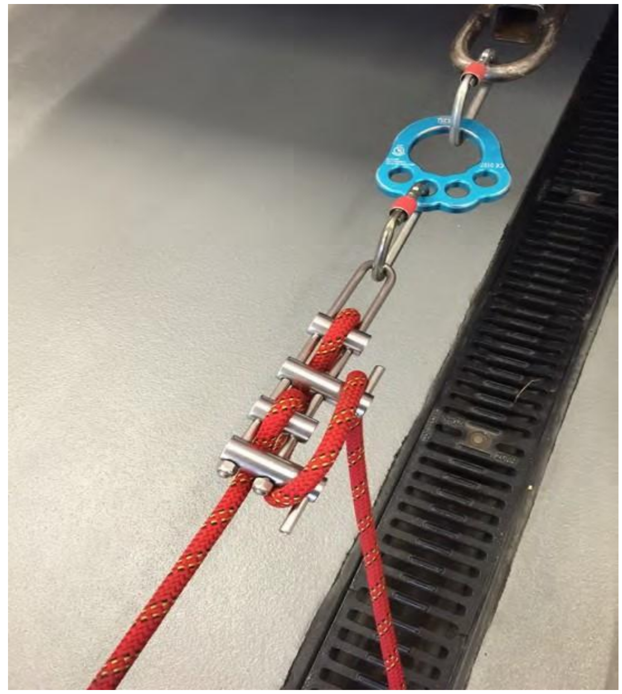
For extending stops or when your attention is focused elsewhere, or the system must be left unattended a “Hard Lock” is required.

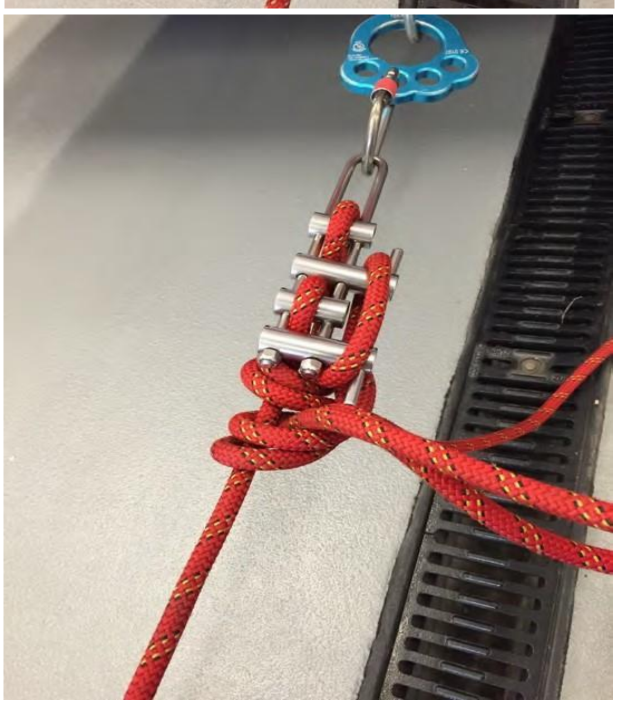
After completing the soft lock continue the rope around the horn and tie an overhand around the main line.

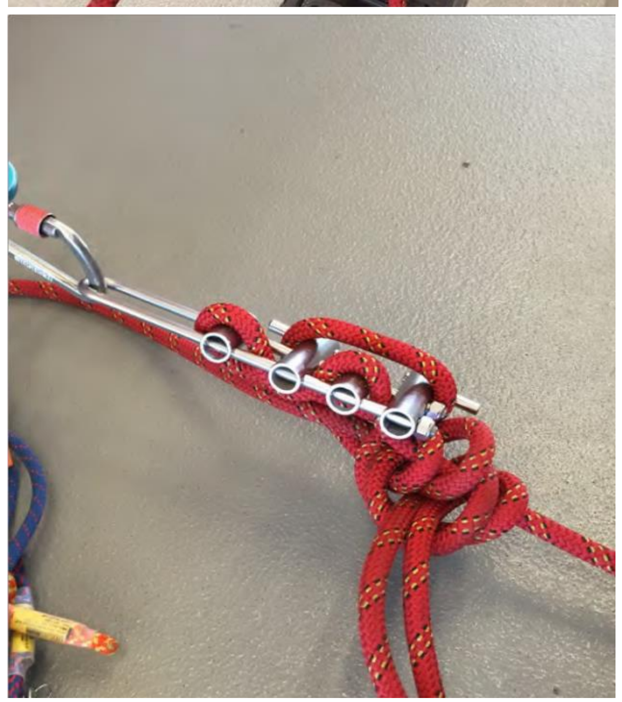
## THE BRAKE BAR RACK:

The amount of friction can be easily adjusted during use and the device dissipates heat well. **Always have a minimum of FOUR - 4 - bars in the system**. Start with all bars incorporated and reduce the number of bars after getting past the edge rope to ensure it activates as intended.









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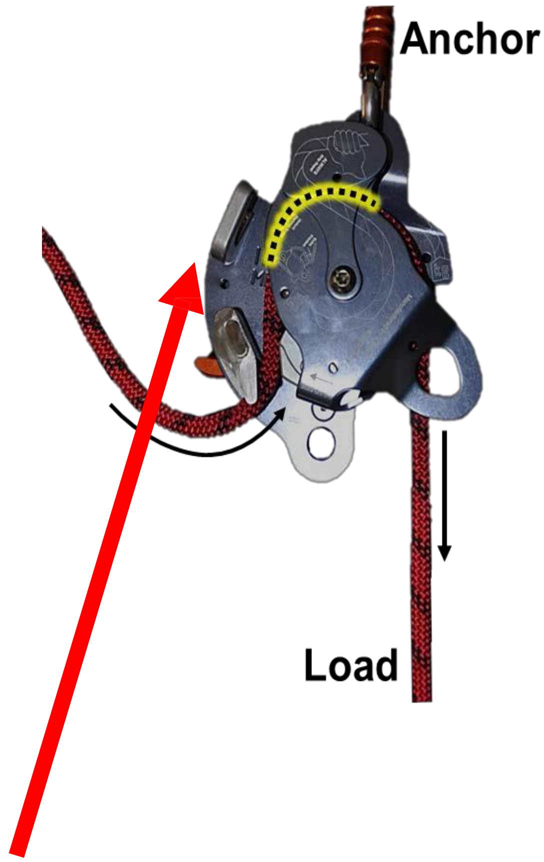
## MPD

**Prior to any use of the MPD, perform a safety check with the Parking Brake unlocked and tug on the load end of the rope.**

### OPERATING THE MPD



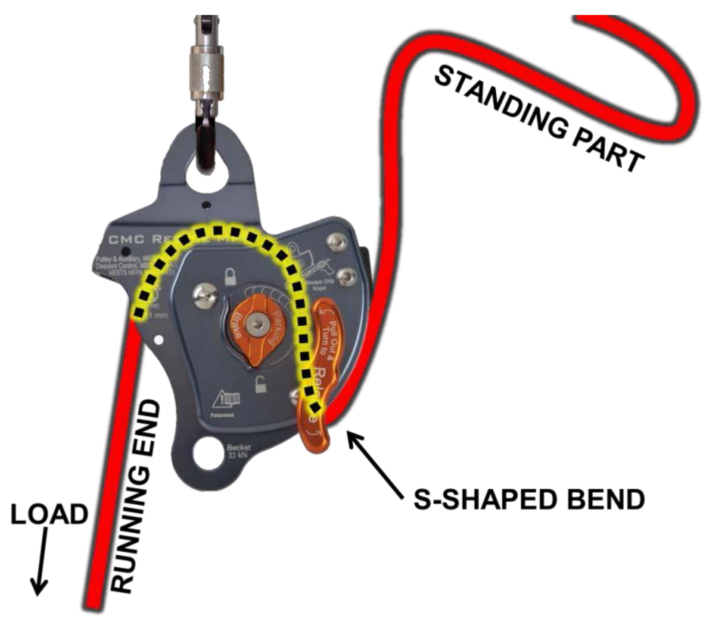

Firmly grip the rope tail entering the back side of the MPD and apply friction over the Fixed Brake V-Groove, bringing the running end of the rope back toward the anchor in an S-shaped bend.

The release handle is used to rotate the internal moving brake off the rope, which permits rope movement through the MPD to lower a load or release tension.

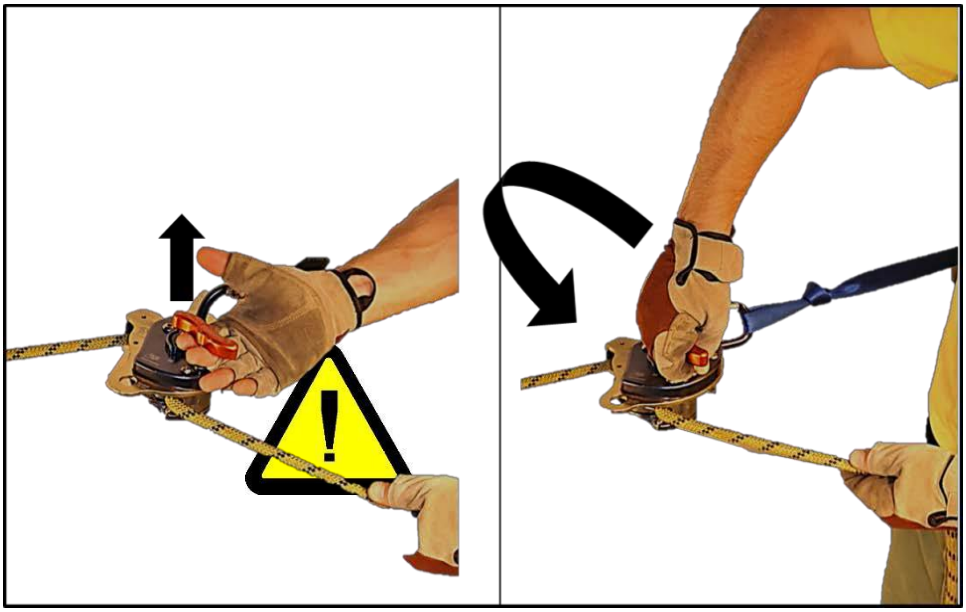
The manufacturer specifically advises that the **Release Handle be fully turned counterclockwise in order to completely unseat the moving brake** from rope and control primarily maintained with the friction of the rope applied through the Fixed Brake V-Grove on the back side.

For heavier loads, maximum friction is achieved by using the Secondary Friction Post. To stop lowering and lock the rope in place, disengage the Release Handle.

The lowering speed is controlled by the friction applied to the V- Groove. Initially start with the running end of the rope held back toward the anchor in an aggressive s-shaped bend in order to maximize the range of available friction. Friction is reduced by changing the entry angle of the rope into the MPD and moving it forward.



Activating the Release Handle of the MPD with a lift and a turning counterclockwise.



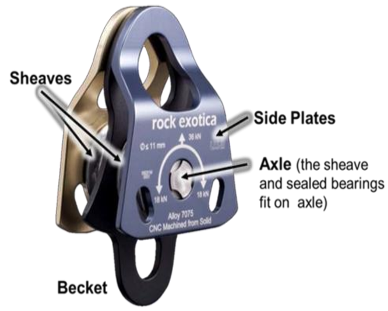
To maintain control during a lowering, always maintain an s-shaped bend in the rope. Do not permit the entry angle of rope feeding into the MPD to be less that 90° to the load end.

Locking the MPD off

When a loaded MPD is left unattended, secure the device with a tie-off at the device with an overhand knot around the load end of the rope.

# MECHANICAL ADVANTAGE AND PULLEY SYSTEMS

**PULLEY SYSTEMS**




*The origin of the pulley system is unknown. It is thought that by 1500 BC, people in Mesopotamia were using rope pulleys. The overall configuration of a pulley has remained unchanged for thousands of years. The first documented use of compound pulleys in the block and tackle system is that of Archimedes.*

The mechanical advantage of a pulley system is calculated as the ratio of the load in comparison to the amount of force required to move the load. If a pulley system employs a 1 kN force to move a 2kN mass, then the mechanical advantage is calculated as 2:1. Mechanical advantage is gained at the expense of endurance. Even though less force is required, it must be employed over a greater distance


Pulley efficiency is reduced as a result of friction loss and other factors, such as bending and unbending of the rope. The measure of pulley efficiency is calculated by the output force coming out of a pulley over the input force going into a pulley, which is expressed as a percent. As an example, if a 95N force is required on one side of a pulley to hold a 100N load, then the efficiency of the pulley is calculated to be 95% (95/100). 90-95% is the typical efficiency of a rescue pulley.

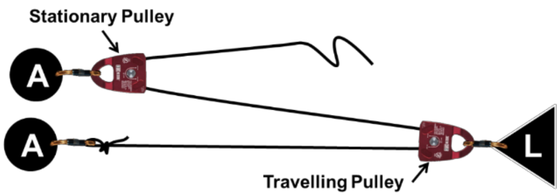
Pulleys are force magnifiers! When the two weighted legs of the rope passing through a pulley are maintained in a parallel configuration, the forces brought to bear on the pulley's point of attachment are doubled! Important for change of direction anchors!

**Ideal Mechanical Advantage** (IMA)- estimated mechanical advantage without taking into consideration any friction loss in the system. When we refer to a pulley system as 3:1, 5:1, 9:1 and so forth, we are referring to the IMA.

**Theoretical Mechanical Advantage** (TMA)- refers to the mechanical advantage that has some calculation of efficiency losses, however it not measured.

**Actual Mechanical Advantage** (AMA)- measured mechanical advantage that will be actually experienced or observed when friction loss is taken into account.

Within a pulley system, travelling pulleys move toward the anchor when the system is being pulled on to move a load. The pulleys which remain fixed and do not move when a pulley system is being pulled upon are known as stationary (standing) pulleys. As a pulley system is employed to move a load it will collapse to the point where one or more travelling pulleys will make contact with a stationary pulley. The pulley system is then re-expanded, through a "reset", to the original size or throw distance, so that hauling may continue.




Simple pulley system. Simple 2:1 MA with change of direction

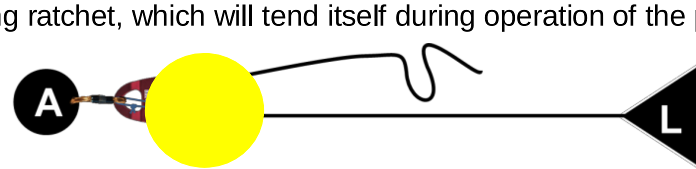
**PULLEY SYSTEM RIGGING:**

Prusiks are utilized as haul and ratchet rope connections since they can handle shock forces without catastrophically failing a line.

Do not use a mechanical ascender in a pulley system in place of a haul or ratchet Prusik.

Haul Prusik- the Prusik closest to the load which serves to attach the pulley system to the main line going to the load (e.g. Prusik initially extended to achieve maximum throw distance). This Prusik can also serve as a force governor for the whole system, the canary-in-the-coalmine so to speak. Tests indicate that an 8 mm, 3-wrap Prusik, on a 1/2" rescue rope may begin to slip at between 7 and 9.5 kN (1,575- 2,125 lb.). For this reason, it is wise to task someone with keeping a watchful eye on that Prusik and instruct them to call a halt at the first sign of slippage. Remember: keep an eye on that lead Prusik!


Ratchet Prusik- also referred to as a *progress capture device* (PCD), the ratchet Prusik within a pulley system works in conjunction with a pulley to advance it up a line during movement of a load. A ratchet Prusik holds tension on the line during a reset, preventing it from going backward, so that progress is not lost. A ratchet Prusik used in conjunction with a Prusik minding pulley creates a self-minding ratchet, which will tend itself during operation of the pulley system.



## PULLEY SYSTEM CLASSIFICATIONS.

### SIMPLE PULLEY SYSTEM

All pulleys on the load side (known as travelling pulleys) move toward the anchor at the same speed. All pulleys at the anchor remain stationary and tension in the rope is constant throughout the pulley system.

In a simple pulley system, when the rope end terminates and is attached at the anchor, then the TMA will result in an even number (e.g. 2:1, 4:1, 6:1, etc.). When the rope end terminates and is attached at the load, then the resulting TMA will be an odd number (e.g. 3:1, 5:1, etc.).

### COMPOUND PULLEY SYSTEM

Compound pulley systems are identified as one simple pulley system acting on another simple pulley system. Travelling pulleys in the system move towards the anchor at different speeds. Compound pulleys systems are useful because they can provide greater mechanical advantage than simple systems for the same number of pulleys.

The TMA of a compound pulley system is calculated by multiplying the individual TMA of each simple pulley system together. A simple 2:1 pulling on a simple 3:1, results in a compound pulley system with 6:1TMA.

To achieve the highest MA with the least number of pulleys requires constructing a compounded system of a 2:1 simple pulley system acting on a 2:1 simple pulley system, acting on a 2:1 and so forth. As each pulley is added to such a system, the mechanical advantage increases exponentially (e.g. 2:1, 4:1, 8:1, 16:1, 32:1, etc.).

### COMPLEX PULLEY SYSTEM

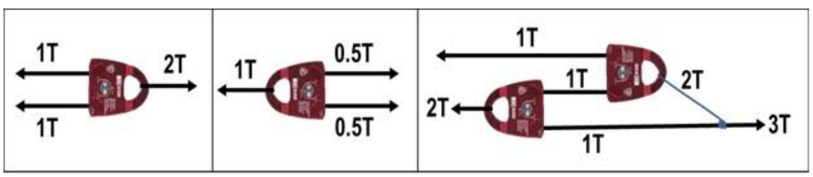
Complex pulley systems do not meet the definition of either a simple or compound system; rather they involve more variables in rigging. Complex pulley systems can have pulleys moving toward the load and the anchor at the same time (Figure 178). With some rare exceptions, complex pulley systems are employed less frequently within rescue. Fortunately, the same objective can be achieved with simple or compound systems which are easier for rescuers to understand and rig.

## CALCULATING MECHANICAL ADVANTAGE

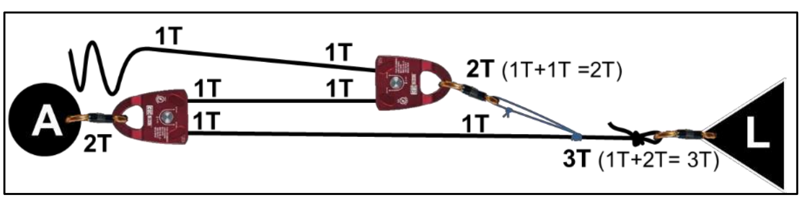
Mechanical advantage in a pulley system is achieved by increasing the number of times an initial input force applied upon the load. The input force is the tension applied by pulling on the system and it is expressed as one unit of tension. Understanding how this one unit is transferred through a pulley system permits calculating the TMA, which is referred to as the "T-Method" (Tension Method).

By assigning one unit of tension (T) to where the pull is applied to the system, then following the path of the rope through the pulley system to the load itself, the TMA can be determined by keeping track of how that initial unit of tension is distributed throughout the system. Simply compare the amount of tension that is applied to the load with the input unit of tension.

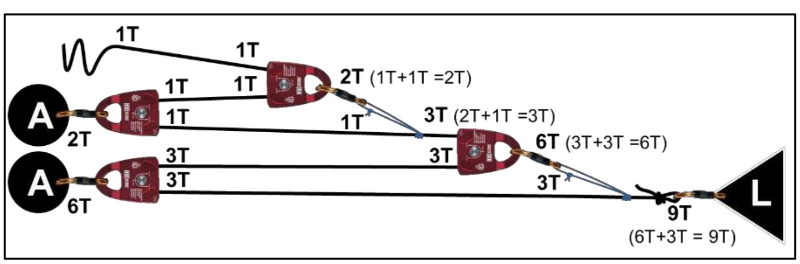
Understand that wherever a junction occurs with the ropes of the pulley system, such as one rope acting on another or one rope acts upon more than one rope, then the tension on one side of the junction must be equal to the tension on the other side of the junction. Additionally, on each side of the junction, the tension must be distributed appropriately (not always equally) to each rope. As an example, if a rope having one unit of tension makes a 180° change of direction through a pulley (considered a junction), then whatever that pulley is connected to receives two units of tension. In other words, two ropes each having a tension of one (two total units of tension) are acting on and opposed by what the pulley is connected to.




T Method Examples




Simple 3:1 Pulley System illustrating T-method




Compound 9:1 Pulley System illustrating T-method

# Mechanical Advantage Systems

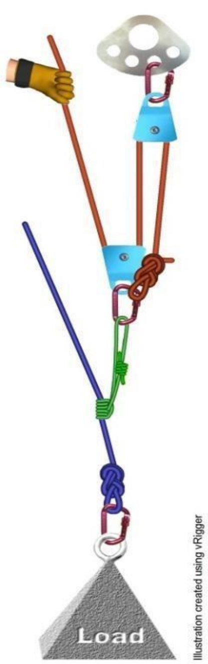
2:1


2:1 MPD



3:1 MPD

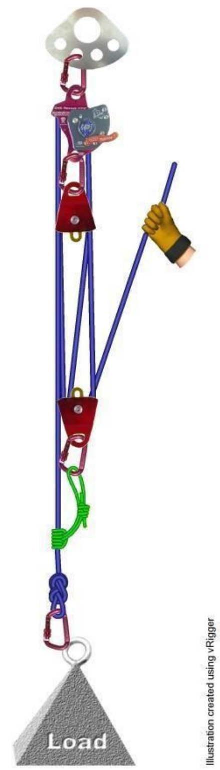

3:1 Piggyback




4:1 (Simple) Double Sheave Pulley

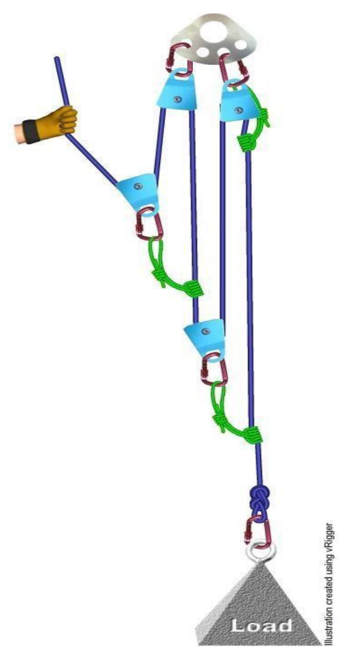


5:1 MPD




5:1 Complex


5:1 Complex MPD

**HAUL FACTOR**

Caution must be used when selecting an MA system, the chance of overloading a system or one of its components are increased as the MA increases.

A rule of thumb to keep forces within our safety factor is to take the number of haul team members times the ratio of the MA system i.e (5 members X 3:1) 5 X 3 = 15.

**The goal is to keep the sum of this equation between 12 -18.**

This goal is merely a guiding principle that can be adjusted based on environmental conditions, soil traction, haul path obstacles, vegetation, weather or, a slippery rope due to water or mud.

If you exceed this number, it must be a calculated decision and not an unwitting oversight. It is possible to deliver so much force that the haul team would never feel the rescuers stuck leg explode in an exposed root system.

As a general guideline, the average person can provide 209 Newtons (46 lbs) of gripping ability per hand (combination of grip strength and coefficient of friction of the item being gripped).
on a rope. This is useful to know in planning a raising system and determining how many haulers will be needed. By simply rounding off to 50 lbs of force (222 Newtons) per hauler and multiplying by the mechanical advantage of the pulley system, the theoretical output (not accounting for friction loss) of the pulley system can be determined.

A common error is pulling too hard and too fast, which is very dangerous since the load can be jammed in a crevice or injure rescuers on the line. The goal is to generate a smooth raising effort on the line. Avoid a "heave-ho" pull on the haul system. This can cause the litter to bounce and create excess abrasion on the main line. If a heave-ho is occurring increase the mechanical advantage or increase the number of haulers.

Have a single person giving the commands and restrict all excess verbal bantering among topside personnel.

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# CHANGEOVER TECHNIQUE- RESCUE LOAD

**LOWERING TO RAISING**

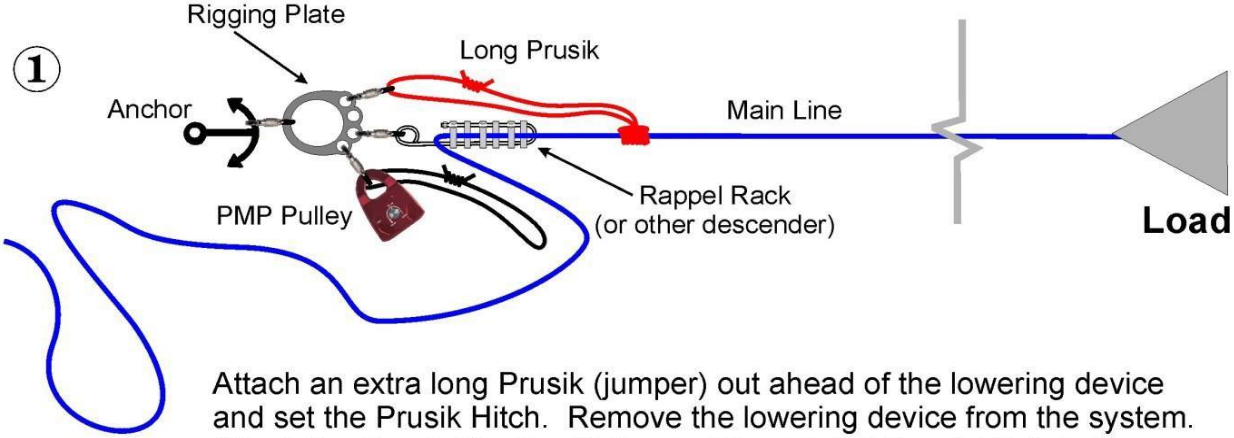
Conducting a changeover from lowering to raising involves transferring tension off the DCD. This can be accomplished through the use of an extended long Prusik, referred to as a "jumper," which bypasses the DCD. The attendant calls for a "stop" and communicates "rig for raise." The DCD is manually held at full stop without a tie-off. The Jumper is rigged on the line and attached to the rigging plate at focal point. The attendant is advised to "prepare for settling." The main line is lowered out, which transfers tension to the Jumper. As additional rope is fed through the DCD, the device becomes slackened and can be removed from the system. Once the rope is released from the lowering device, the pulley system is constructed for the raise. As the raise is initiated, the Jumper is removed, while the raising operation continues.

**RAISING TO LOWERING**

During a raising operation the load can be quickly lowered back down a short distance by the haul team simply letting out on the main line with the ratchet on the haul system held open, so it does not set. Although less commonly employed during a rescue, a complete changeover from a raising to lowering operation is accomplished through another transfer of tension maneuver. When a "stop" is called on the raising operation, a Jumper, with a LRH attaching it to the rigging plate, is rigged on the tensioned line in front of the Ratchet Prusik Hitch with enough distance to rig the DCD after the line is slackened. The attendant is advised to "prepare for settling," as the haul system is lowered back out while the ratchet is manually held open. This allows the tension to settle on to the Jumper. This will permit the haul system to be slackened and removed. The DCD is rigged to the slackened line behind the Jumper and tied off. The LRH is then let out to transfer tension over to the descender.

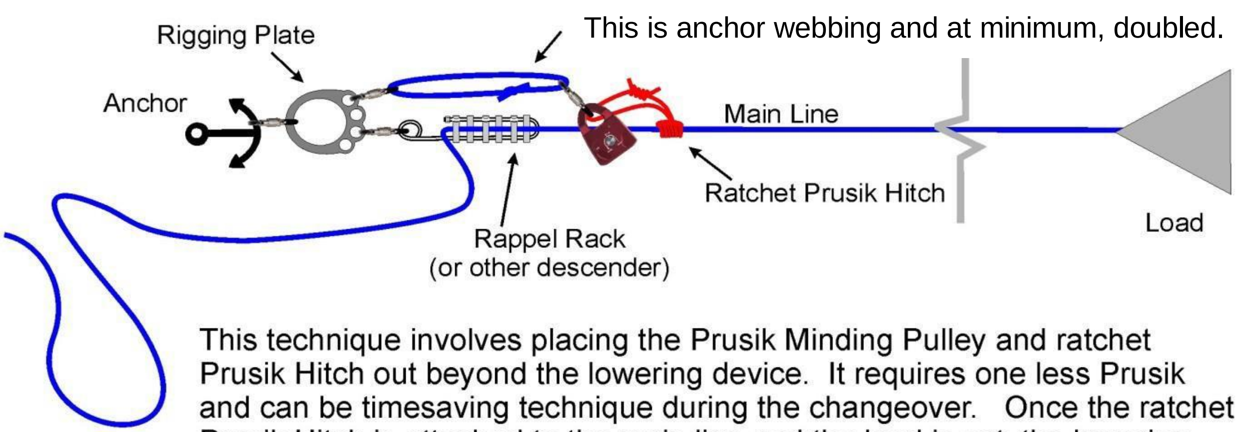
Note: The use of a CMC MPD™ preconfigures a lowering or raising system for an immediate changeover without having to complete the steps shown above.

# CHANGEOVER TECHNIQUE (LOWERING TO RAISING)




Attach an extra long Prusik (jumper) out ahead of the lowering device and set the Prusik Hitch. Remove the lowering device from the system. Attach the Prusik Minding Pulley and the ratchet Prusik Hitch to the main line. Finish constructing the remainder of the haul system. During the initial part of the raise, remove the extra long Prusik from the system. Continue the raising operation. Employ a rigging plate at the anchor focal point to keep the rigging organized and increase efficiency.

## ② ALTERNATE METHOD (from Arnor Larson)




This technique involves placing the Prusik Minding Pulley and ratchet Prusik Hitch out beyond the lowering device. It requires one less Prusik and can be timesaving technique during the changeover. Once the ratchet Prusik Hitch is attached to the main line and the load is set, the lowering device can then be removed from the system. Finish constructing the hauling system and begin the raise. If the Prusik Minding Pulley and ratchet Prusik Hitch are attached during the lowering to expedite the changeover, make certain that they are tended as rope is being feed out.

## KNOT PASSING – DURING LOWER

1. Attach an Aztek (AZ) and system Prusik.

Use a single Prusik Hitch (3 wrap, 8 mm) out beyond the DCD (approximately one foot) which is attached to the running end of the AZ. The AZ is then attached to the same anchor as the DCD. DO NOT construct a separate anchor. This Prusik Hitch will need to be minded during the lowering.

2. Allow the AZ to take the tension.

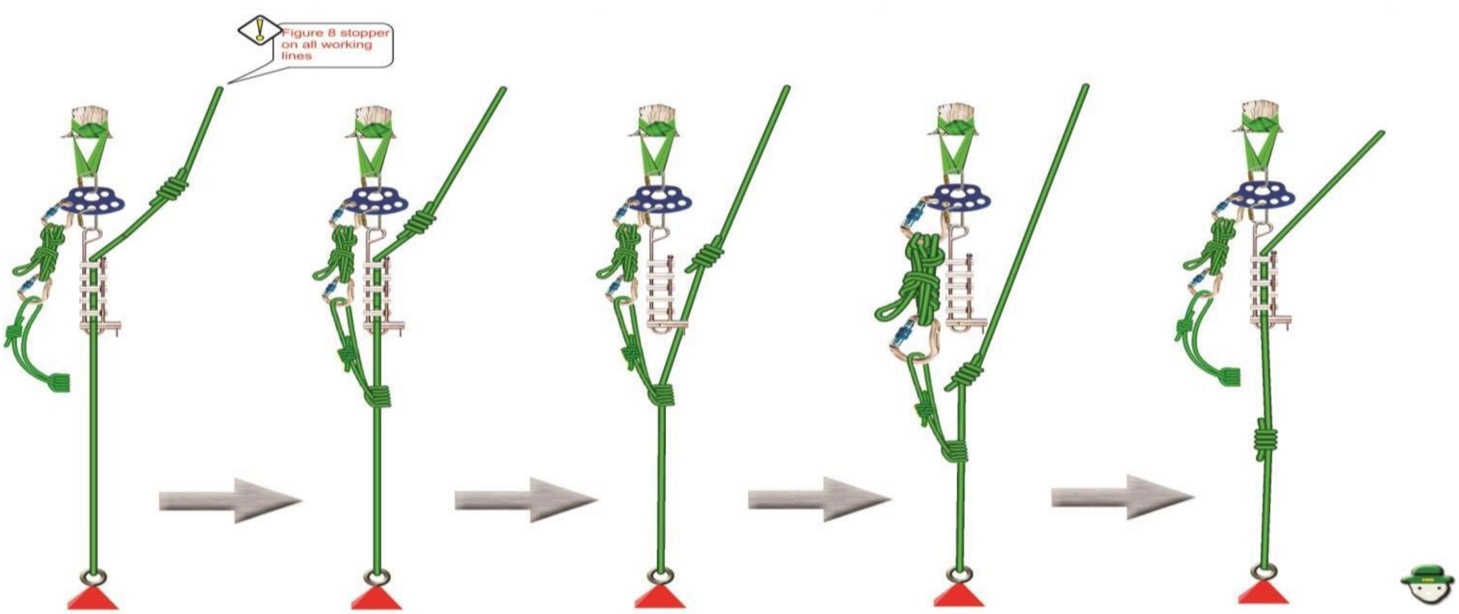
At the point where the incoming bend (knot in the main line) is about 12 to 16 inches away from the DCD, let the minded Prusik Hitch grab the rope by pushing it away from the anchor down the rope. At this point BOTH the DCD and the Prusik Hitch will have tension on them. Allow total slack onto the friction device and angle the rope between the Prusik Hitch and the DCD away from the AZ. The tension is now on the AZ.

3. Move the DCD beyond the knot, reattach and lock off.

The rope will slide through the DCD and become slack. Remove the DCD completely and replace it onto the other side of the knot to be passed. Make sure the knot is as close as possible to the top of the DCD. The DCD operator should lock-off the DCD, ready to receive tension again.

4. Lower the load with the AZ until tension is on the DCD. An assistant uses the AZ to gently lower the load (extended out) back onto the readied DCD. As this happens, tension will again be on each system.

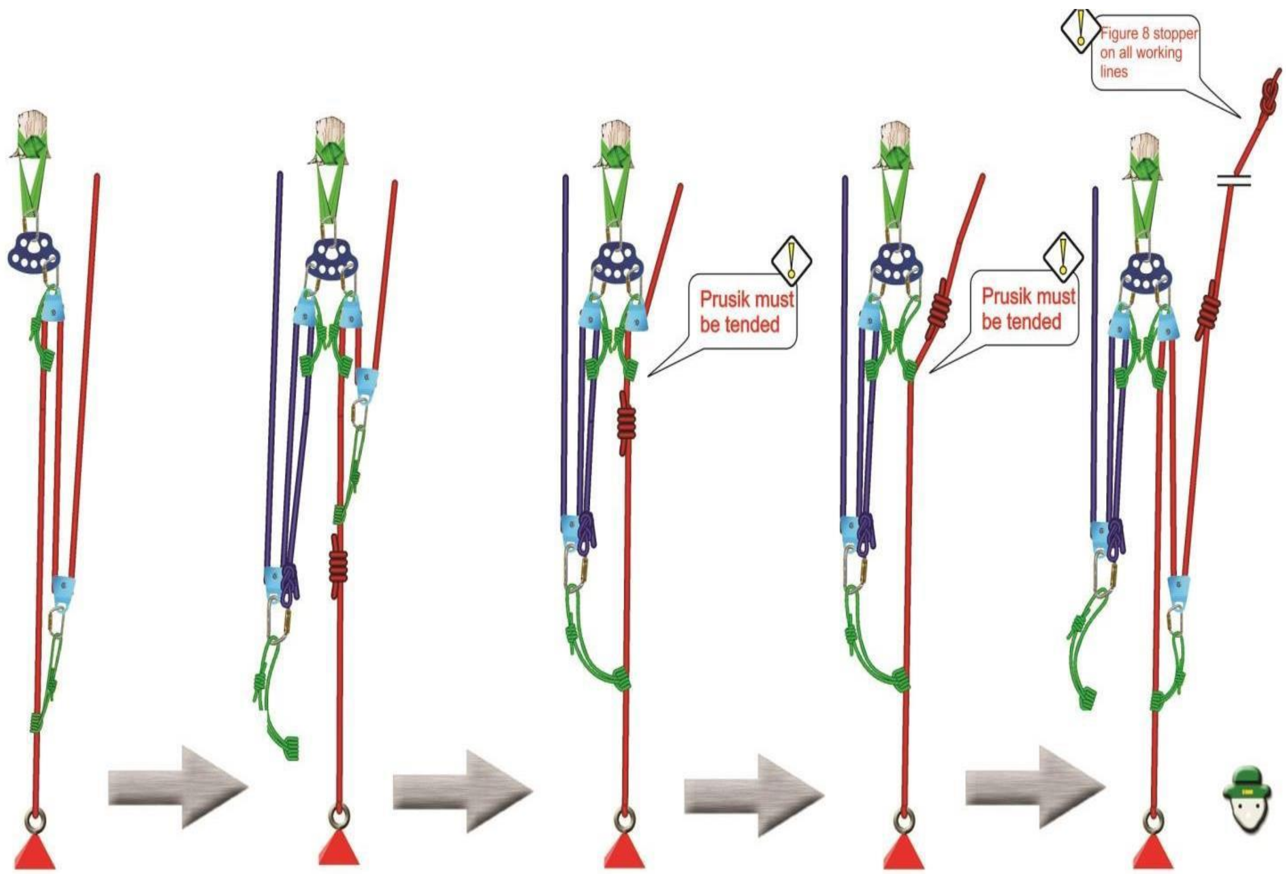
5. Remove AZ and system Prusik Hitch.



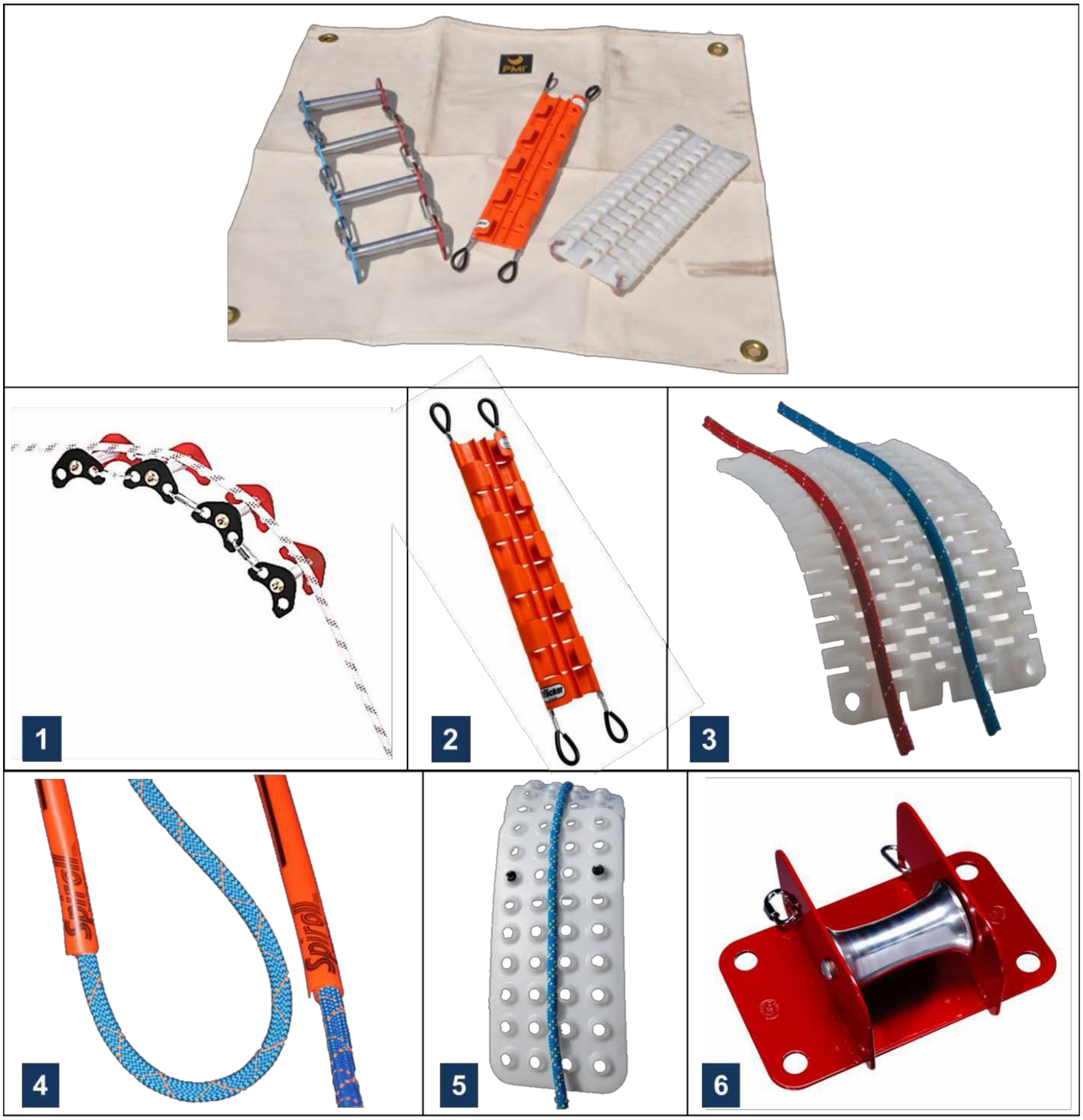
## KNOT PASSING - DURING RAISING

Attach a "ganged" or "pigged" hauling system like a "set of 4's", extended out passed the bend, to the main line. These permits hauling of the main line and the knot until it is well above and out of the way of the primary hauling system. With adequate anchors and additional equipment this may be a more efficient technique.

You may continue the raise incorporating the pigged system however, the Main Line progress-capture prusik will require a dedicated person to mind it. You may also consider rebuilding your system and remove the pigged system all together.

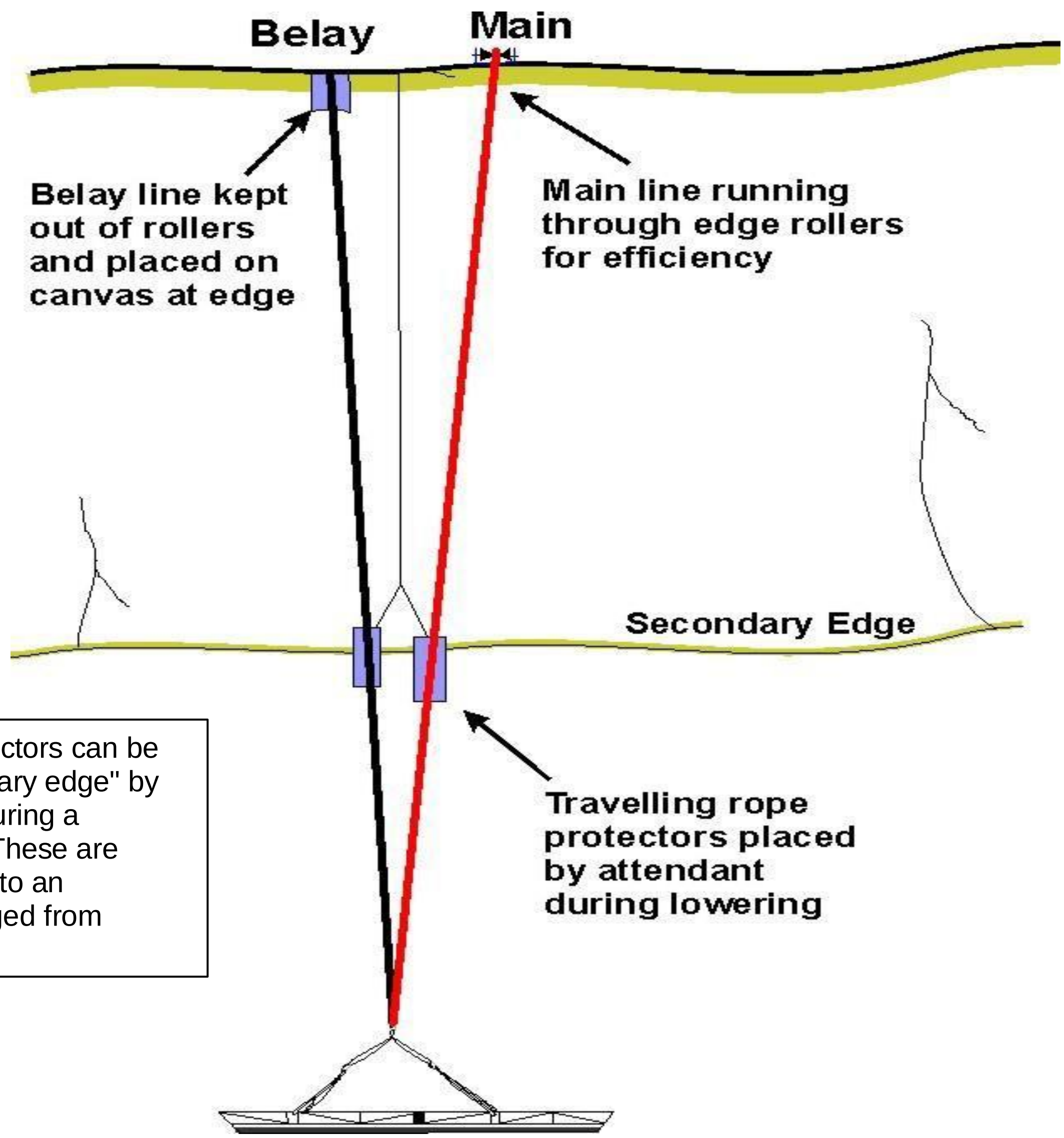


# EDGE PROTECTION



Using canvas padding or edge rollers are the most common techniques to protect a rope running over a sharp edge. This is a crucial task, since protecting the rope on sharp edge is essential to prevent rope damage or failure. Edge rollers provide greater efficiency during a raising operation; however, they are heavier and bulkier than many other related products. A directional may be used to keep the ropes from encountering the edge. Using a rock hammer to dull an edge may also be employed if considered appropriate for the site. Tie-in edge rollers and pads or Prusik them to a separate line so they are secure and adjustable.

RIGGING NOTE: In settings employing a dedicated main line and a dedicated belay line, the main line should be placed directly on edge rollers, while the belay line is left out of edge rollers. This is to utilize friction in the event the belay is activated. Edge rollers can cause the belay device to actually receive higher peak forces. Friction at the edge reduces these forces. On a sharp edge use padding for the belay line




Travelling rope protectors can be placed on a "secondary edge" by the litter attendant during a lowering operation. These are most easily secured to an independent line rigged from above.

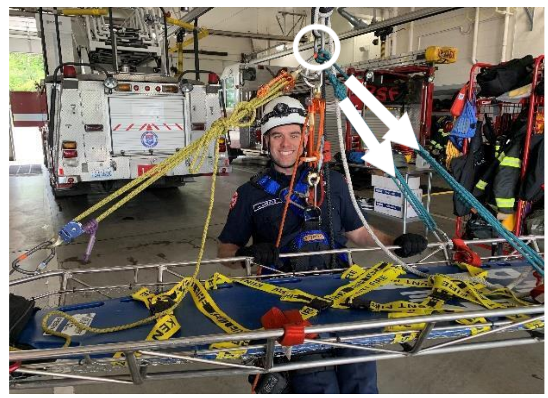
# UNIVERSAL RESCUE LOAD ATTACHMENT

The Hudson Rig

The Hudson Rig consists of a steel O-ring rated to 44.5 KN ,( depending on the manufacture), with two Purcells girth hitched to the ring. Purcells are made from 8mm cord cut to 160” long.

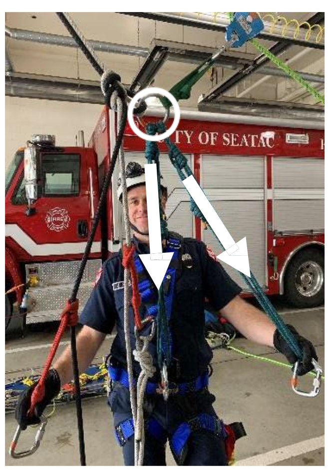
It has been decided that this will be the substructure for all rescuer/patient attachments to the main and belay, with the exception of rappel pick-offs. The purpose is to create a standard configuration across applications.

The Technician should be able to improvise, if needed, to achieve the same general configuration and strength



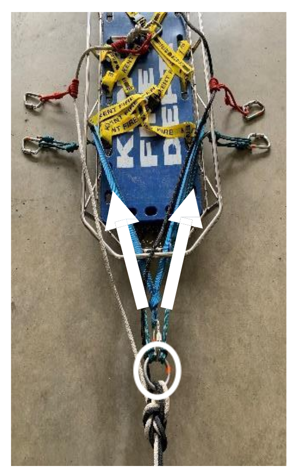
Vertical Litter

Team Based Pick-Offs



Guiding Line Pick-Offs

Guiding Line Litter



Low/High Angle Litter

# HIGH ANGLE RESCUE

High Angle as defined in NFPA 1670:

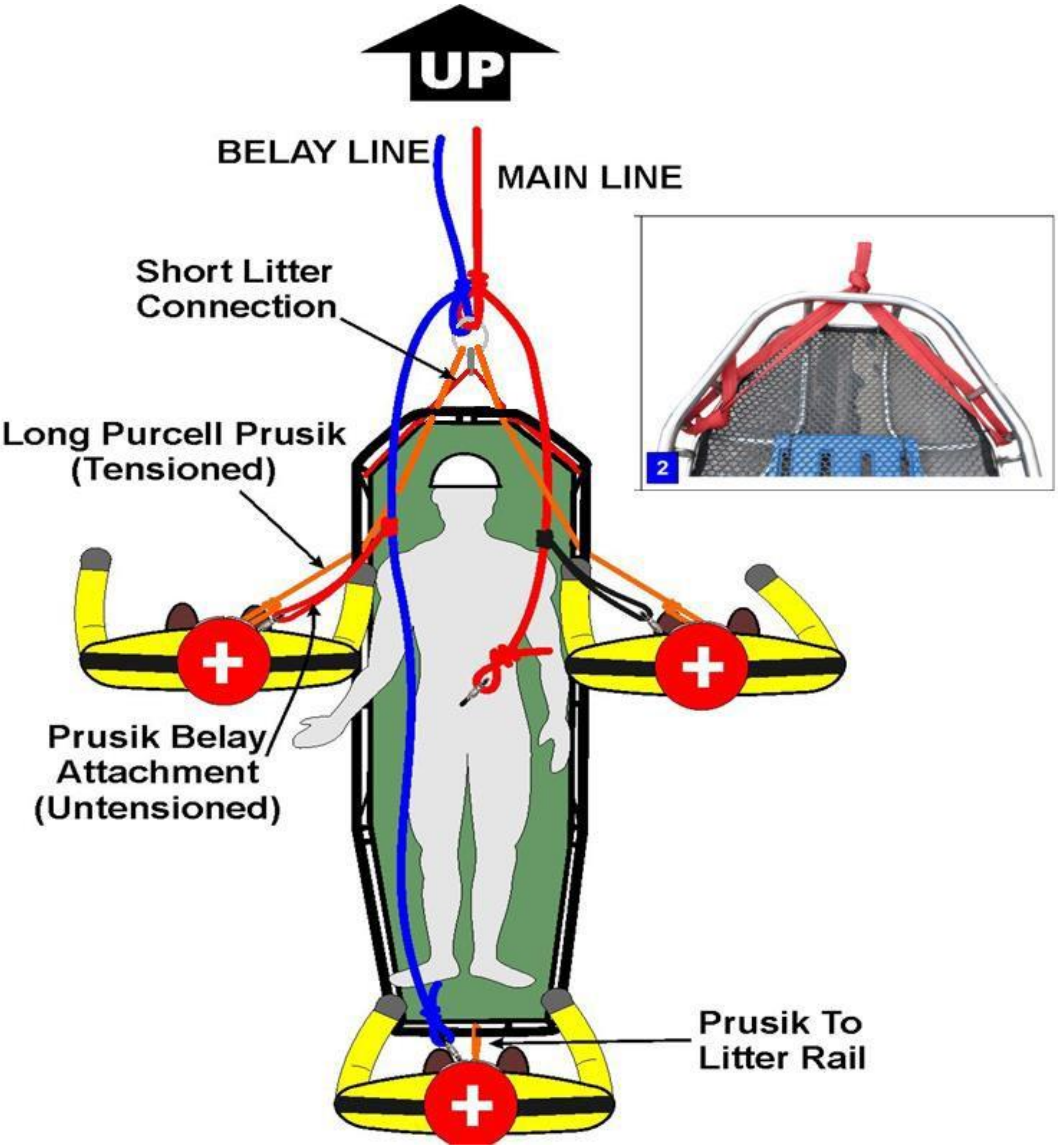
*“Refers to an environment in which the load is predominately supported by the rope rescue system.”*

On steep slopes employ both a main line and belay line combination. Systems for steep angle rescues can generate significant forces with the combined weight of several attendants plus the patient. Remember that the attendants are standing on their feet and not suspended, so not all their mass is placed on the rope system. Despite this, recognize what could happen in the event of catastrophic failure. Tether the litter bearer’s harness to the main and belay with an adjustable Purcell Prusik to each line. Litter bearer's lean back, placing the load on their harness. A low-gain connection to interlocking long-tailed bowlines, by shortening the litter tether. In the steeper terrain using only three bearers as shown for more efficient transport and reduces the force placed on the system.

**STEEP ANGLE SYSTEM FORCES- By Kirk Mauthner**

While static forces on a steep slope may be higher than say, a 2 kN, two-person load in vertical terrain (e.g. a four-person, 360 kg load at 45 degrees will produce a rope tension of about 2.5 kN), we need to keep in mind that the relative worst case event in this environment will not produce the same potential peak force as can a 1m drop on 3m of rope with a 200 kg mass (this can produce a peak force of about 8-12 kN whereas on a steep slope, the peak force is generally 2-2.5x the static force, or about 5-6+ kN, or about half of what an edge transition force can produce). This is where the concept of static safety factors is quite misguided and that is why engineers don’t generally use “static” safety factors. Engineers compare highest anticipated load (static or dynamic) to material yield or breaking strengths, and the target is to achieve a 1.5- 2:1 safety factor. However, the North American culture of SSSF would require rescuers to build a steep slope rescue system that produces a static force of 2.5 kN with a strength of 25 kN, with the ironic reality that this heavier initial static force cannot produce the same magnitude of peak force as a two-person load on a poor edge transition. Enter the concept of Force Limiting Systems (slipping clutch) (that truly limit the force between 6-12 kN) with a requirement of rigging to 20+ kN strength; this approach covers for all worst-case events in rescue work.

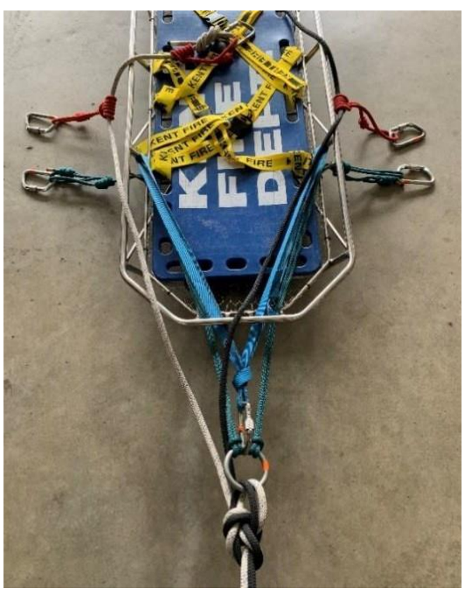
# HIGH ANGLE LITTER RIGGING



# HIGH ANGLE LITTER RIGGING


It is preferred to pass the attachment point of the litter to the second or third post as it is believed this will move the pivot point aft and help lift the head.

A piece of webbing may be secured to the litter and placed behind the neck and on the shoulders to assist with the load.



# LOW ANGLE LITTER RIGGING

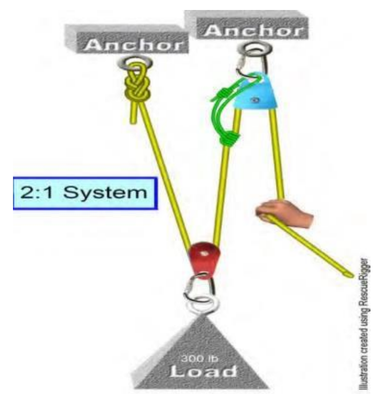
**LOW ANGLE RESCUE**

Low Angle as defined in NFPA 1670:

*"Refers to an environment in which the load is predominately supported by itself and not the rope rescue system. (e.g., flat land or mild sloping surface). "*

These types of environments require moving the patient in a litter over low angle and/or rugged terrain. The decision to incorporate a mainline and a belay, or just a main line, or just a belay will be determined by evaluating the potential consequences. Ask yourself, "What are the consequences if there was a failure in a single rope system?" Let's call this "The consequence-based decision process"

Some Low Angle considerations:




- Use of belay line only or a 2:1 with a progress capture prusik only may be appropriate
- If the decision is made to (in any way shape or form) attach attendants to the liter or system, a mainline and a belay line should be used.
- Assign ONE attendant to be the Lead. Only the Lead calls signals.
- Attendants may find it helpful to use webbing loops as "across-the-shoulders" straps to distribute the weight of the patient.
- Keep your systems as simple as possible.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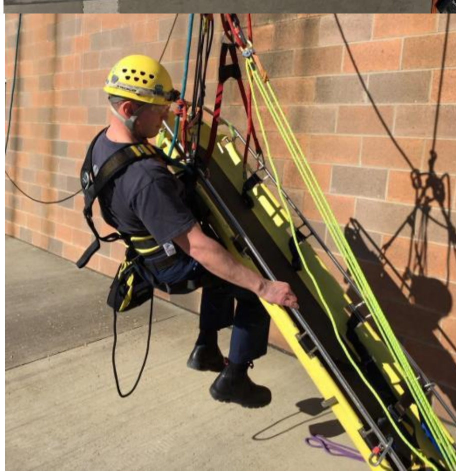
# VERTICAL AND SUSPENDED RESCUE RIGGING

Vertical litter rigging can be accomplished many ways with several different types of manufactured bridle systems or pre-constructed rope bridles. Regardless of the system being used, bridles should have the ability to adjust at the feet for proper patient positioning. All rope or webbing should be rated, inspected, and constructed using proper knots, and connection points.

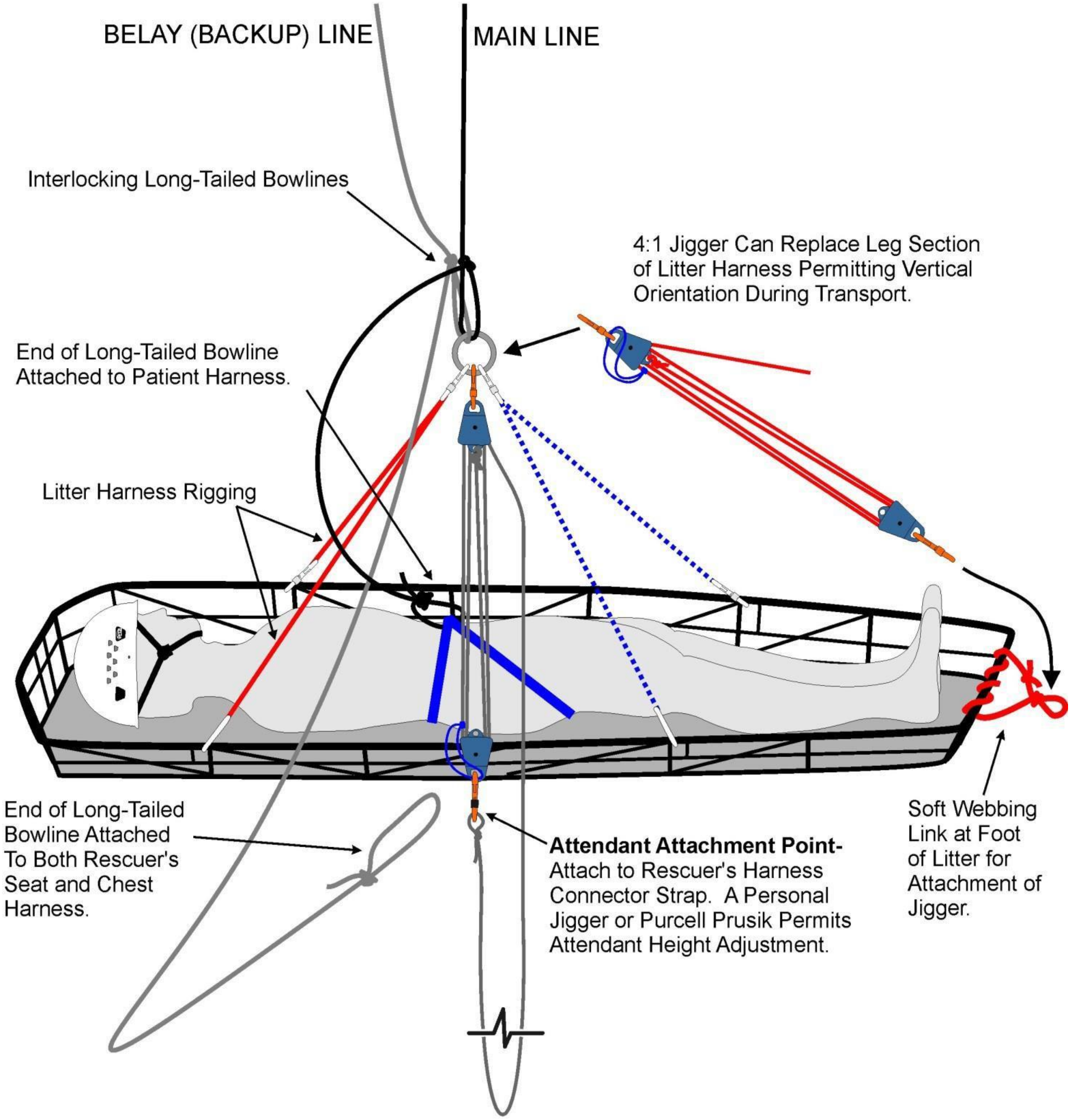
Following the two points of contact rule, both the patient and attendant must be attached to the rope system with long tails of the Main line and Belay Line).

Another preferred item included in the system is for the attendant to travel vertically between the litter and the collection point. This is usually accomplished with a “Set of Fours” (AZTEK) that serves as the attendants second point of attachment. An Etrier is sometimes used for a soft step to aid in vertical movement.



*Alternative to the Hudson Rig*

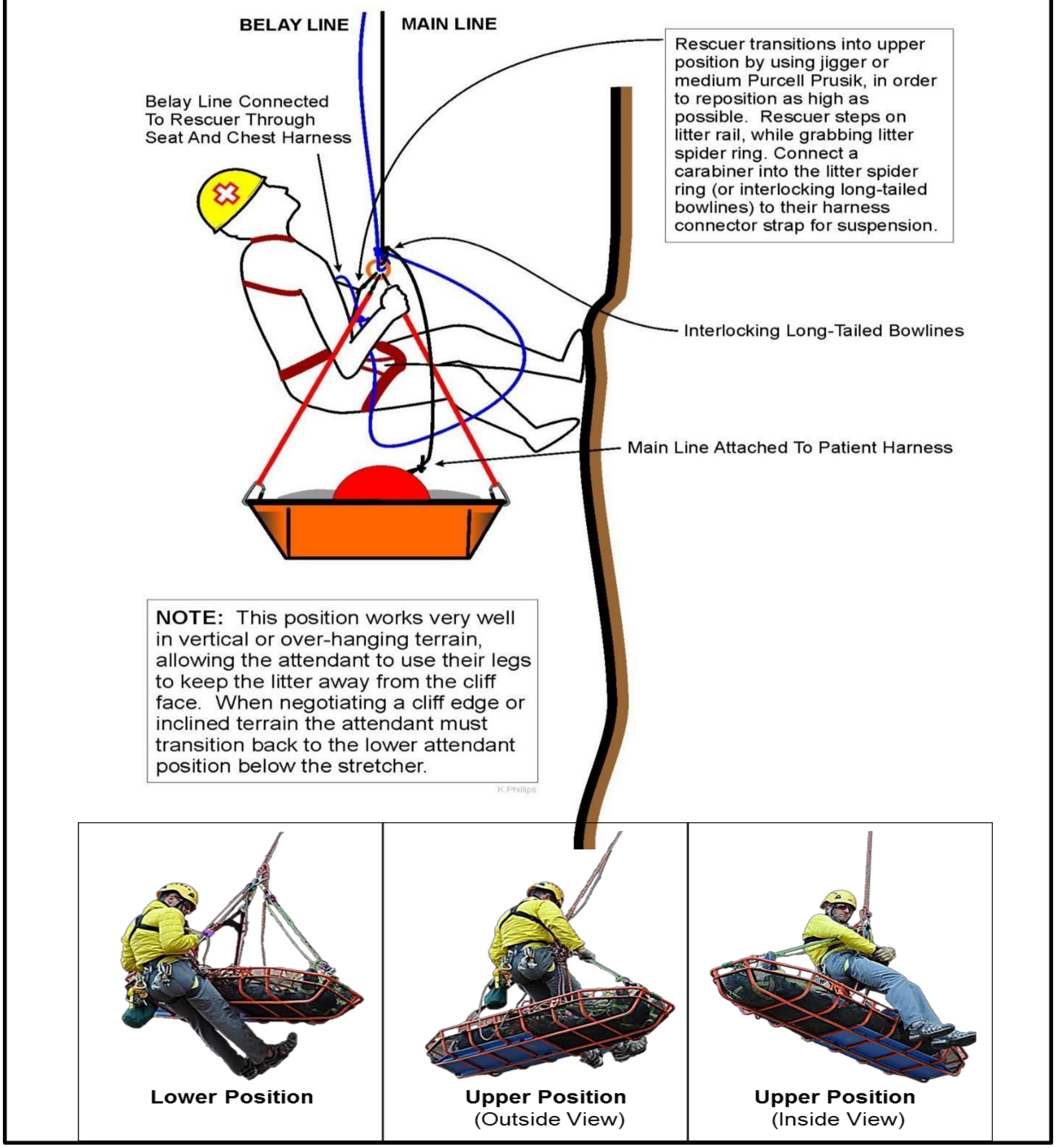
# VERTICAL LITTER RIGGING




**EMS NOTE: For a patient with a compromised or unstable airway, who is not intubated, it is much safer to package the patient on their side, rather than attempt to roll the litter on its side with a "barf strap" if they vomit.**

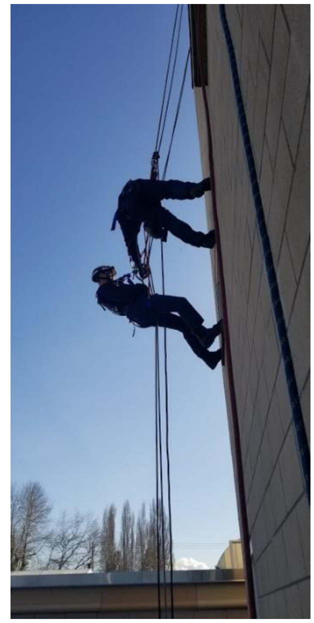
K.Phillips

# UPPER ATTENDANT VARIATION




Litter rigging schematic for raising/lowering operation

## PICK-OFFS



A pick-off technique is employed to rescue a stranded subject with minor injuries which does not require the use of a litter. The preferred method, if resources permit, is to have the primary rescuer lowered from above. This avoids over-tasking the rescuer and permits a simple changeover to a raise, if required. Consider selecting a descent path for the rescuer which will not generate rockfall on the subject. If necessary, the rescuer must remember to bring a pick-off harness and helmet for the stranded subject(s).

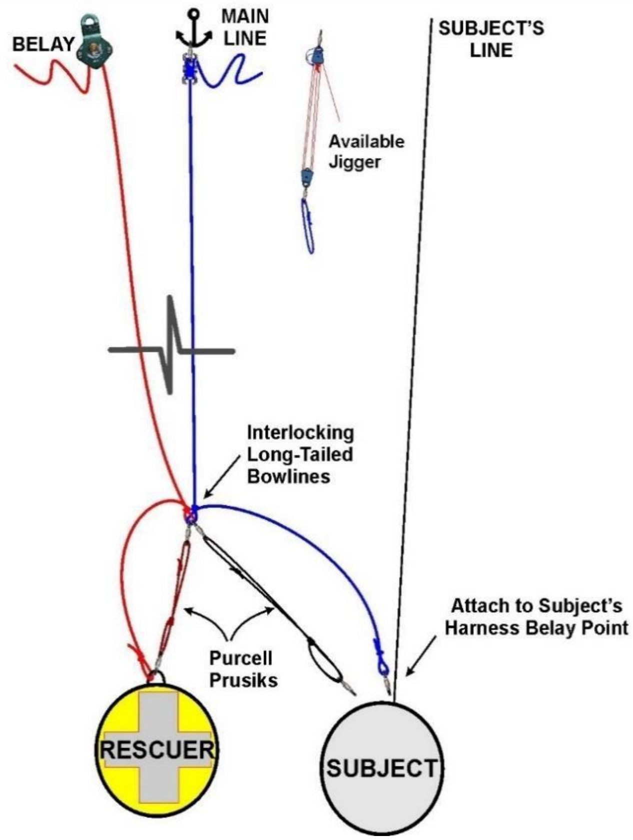
Cutting the subject's line during a pick-off could result in a shock load to the rescue system. Raising the load on to the rescue system is more controlled, and a safer way of transferring the load.

Industrial workers commonly attach their fall protection to the "dorsal", however, this point is not used by rescue technicians. Being suspended from the dorsal, concentrates weight to the inside portion of the leg loop. This can restrict blood return from the Femoral Vein. Not only extremely uncomfortable, it may lead to a life-threatening condition known as "suspension trauma"

**SUSPENSION TRAUMA**

1. Fall arrested by harness.
2. Legs suspended, blood flow is impeded by leg straps and gravity.
3. Blood collects in large muscles.
4. Blood return to the heart declines.
5. Danger plus pain causes the heart rate to increase.
6. Heart pumping action is reduced because of decrease blood return.
7. More blood collects in legs.
8. Body reflex reduces heart rate and blood pressure drops.
9. Blood flow to brain falls.
10. Loss of consciousness.
11. Blood flow to brain continues to fall.
12. Brain damage.
13. Eventual death.

# TEAM BASED PICK-OFF





### TEAM BASED PICK-OFF

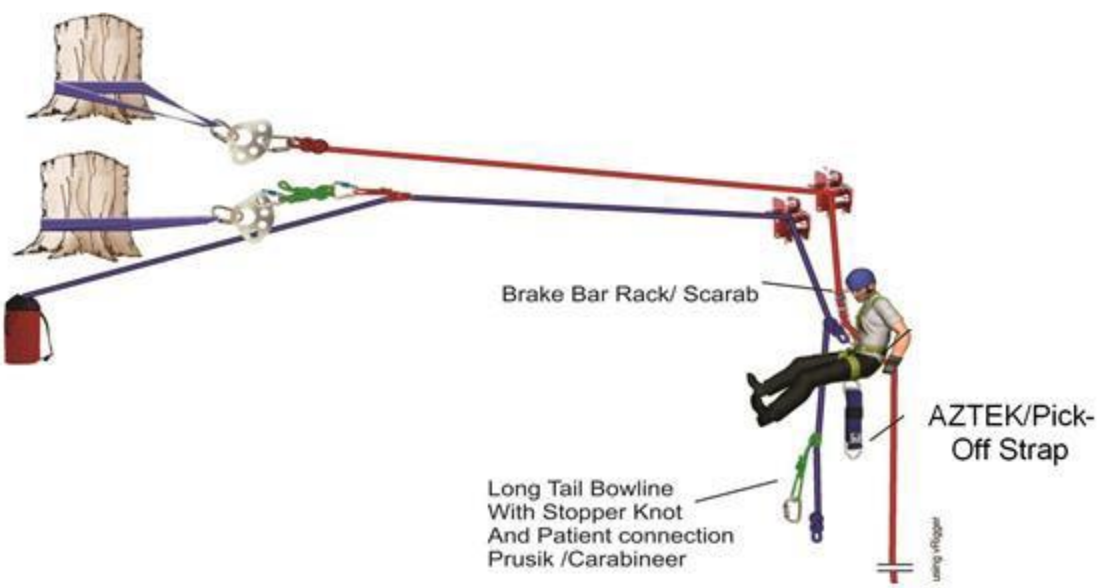
The Team Based Pick-Off is described here with some adaptations from the method originally developed by Arnör Larson. The working ends of the main line and belay line are joined together with long-tailed bowlines. The rescuer uses a Purcell Prusik, which is attached at the junction, as well as the tail of the belay line as their connection points. Another Purcell Prusik and the tail of the main line are retained by the rescuer to connect to the subject's harness. The rescuer is lowered down to the subject and calls a stop at the first opportunity the rescuer can clip the Long Tail from the Belay Line to the subject's harness. The Subject Purcell Prusik is attached to the subject's harness as the primary attachment point.

## RAPPELLING PICK-OFF

A Rappelling Pick-Off involves the rescuer on the face directly controlling their descent and managing a two-person load A minimum of two rescuers rig a fixed main line and belay line. One rescuer serves as belayer and the other prepares to rappel to the subject. The rescuer attaches their DCD to a mini rigging plate OR Delta Link. A lifting device like an AZETEK, is also attached to the mini rigging plate/Delta Link, which will become the primary tether to the subject. The Delta Link is attached to the harness via an extension sling. This permits the AZTEK to have greater distance to collapse the set of 4's..

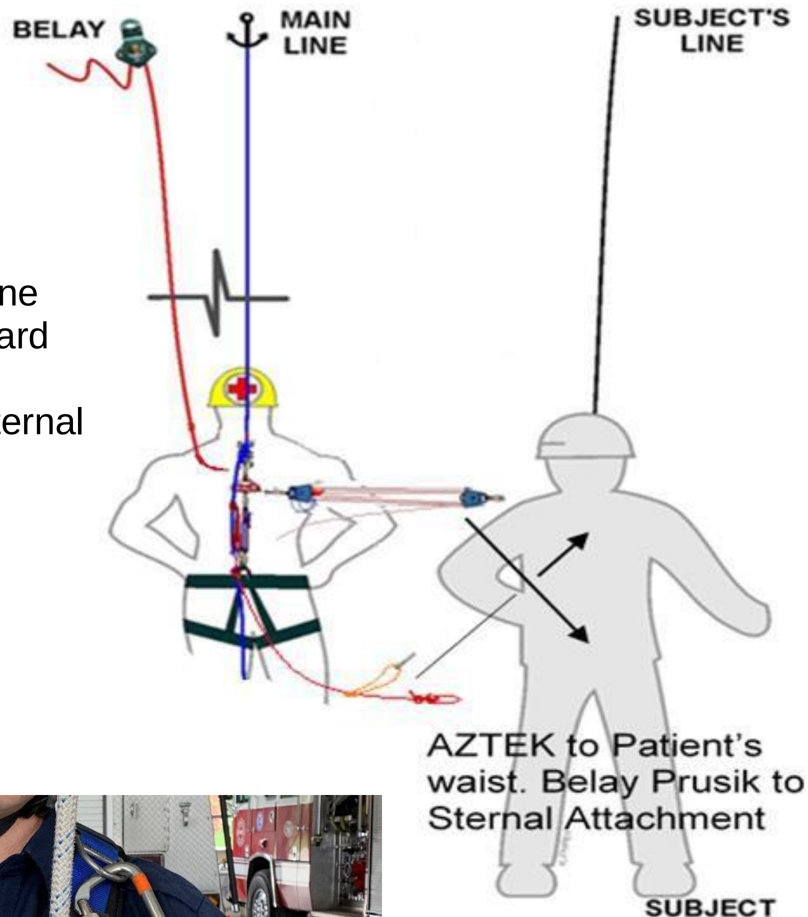
A long tail off the rescuer's belay will become a secondary attachment to the subject. Once attached to the subject, slack can be removed with a prusik on the long tail.

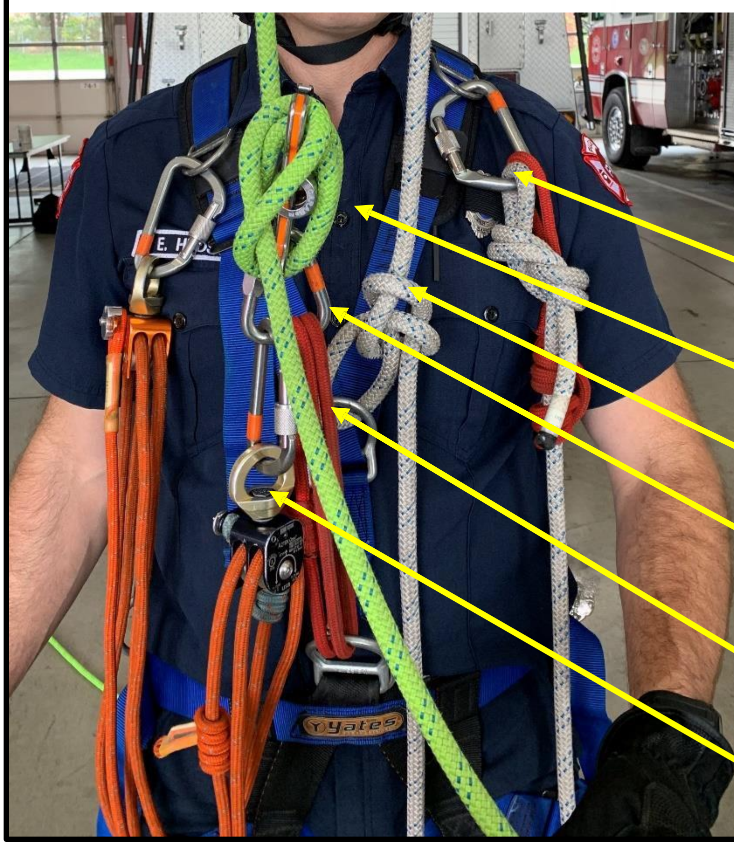
The rescuer rappels to just above the subject but within reach of the patient's waist or harness. The Belay Prusik is immediately attached to the subject's harness. <u>If the subject is not wearing a harness, a rescue chest or cinch is secured immediately to the patient</u>. An improvised or commercially sewn pick-off harness is then placed on the subject. A secondary connection is made from the rescuer's Lift Device to the subject's harness. The subject is removed from their original line if one is present. This procedure can be accomplished with the use of a 2:1 pick-off strap or personal AZTEK. Following the transfer of the subject to the rescue system, the rescuer rappels to the ground with the subject.

# RAPPELLING PICK-OFF

The Belay Line Should be Hard Tied to the Rescuer's Sternal Attachment



Subject's Belay

Descent Control Device (DCD)
SCARAB

Rescuer's Belay

Hardware to allow
Multi-directional loading
Tri Link, Rigging Plate…

Extension Sling

AZTEK – Main Attachment for Subject

# GUIDING LINE TECHNIQUE

A guiding line provides a very effective method for avoiding obstacles at the base of a cliff during a raise or lower. The guiding line is more than a "tag line," which would simply attach beneath a litter to permit personnel below to provide tension and deflect the litter's path. The guiding line provides an independent ropeway for a guiding pulley, which is linked to the litter, to move along as a managed directional.

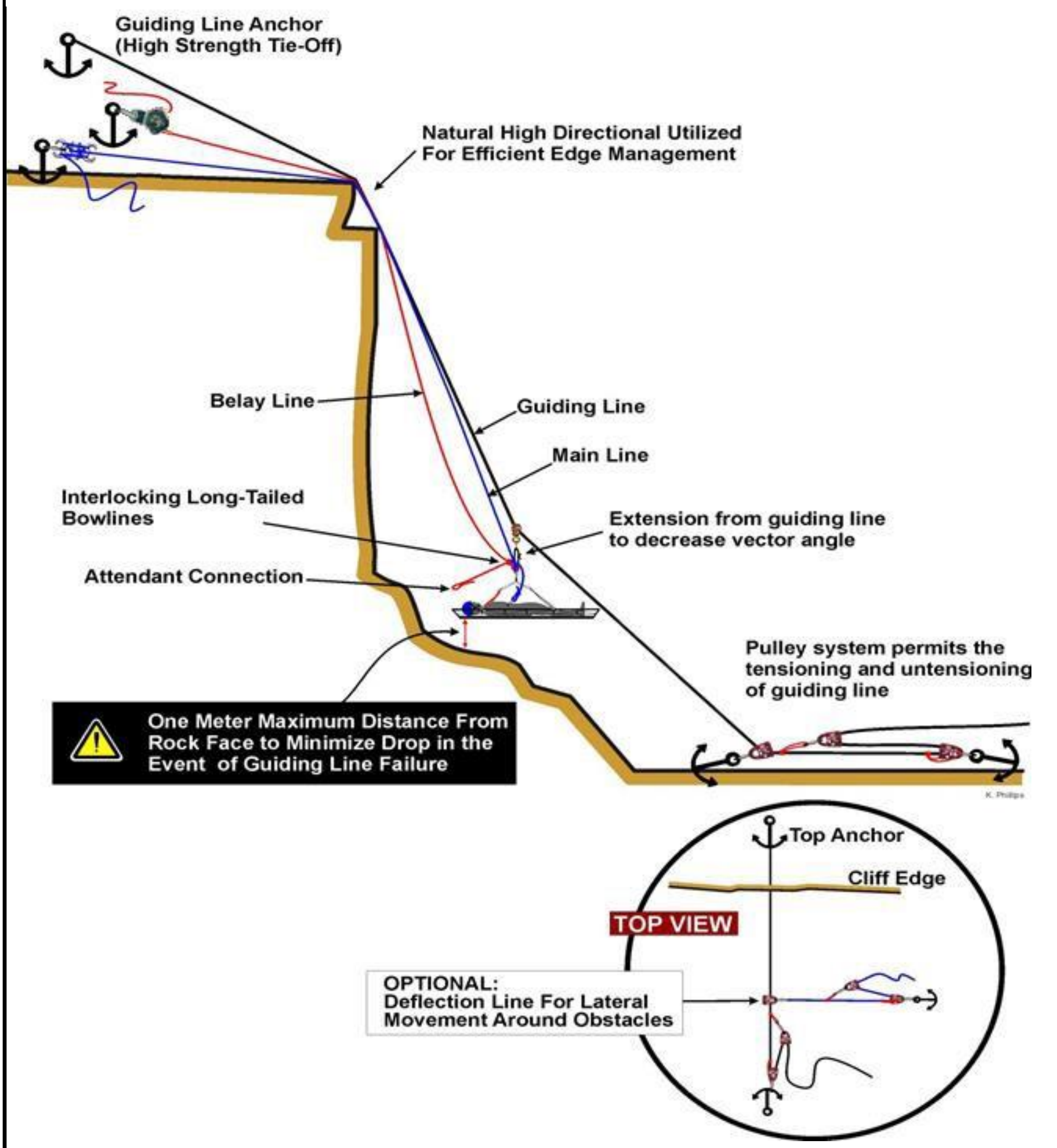
This technique can be viewed as a "low-tech highline", but it is important to understand that it is not designed to suspend loads a significant distance in the air. During transport with a guiding line the load should not be more than one meter away from the face or slope. This permits a very short pendulum into the face if the guiding line fails. If there exists a significant potential for injury due to the height that the load is suspended, then another technique should be employed. When operating a guiding line in sloping terrain where the rescuer can safely walk, such as a talus field, then it is only necessary to have the patient and litter suspended on the guiding line.

The main and backup lines are joined to a litter harness with interlocking long-tailed bowlines. The adjustment of the guiding line is performed with a simple MA pulley system at the bottom end to tension or un-tension as necessary.

The addition of a ground level directional pulley in front of the pulley system will permit horizontal control of the pulley system.

| GUIDING LINE COMMUNICATIONS | |
|---|---|
| Main Line: | "Main Line Up"<br>"Main Line Down" |
| Guiding Line: | "Guiding Line- Take In" *(Tension Guiding Line)*<br>"Guiding Line- Let Out" *(Slacken Guiding Line)* |

# GUIDING LINE RIGGING

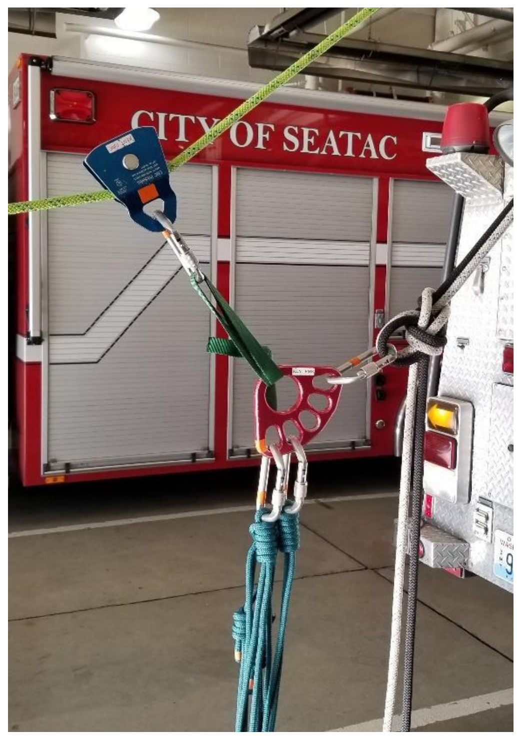


# GUIDING LINE RIGGING

<u>GUIDING LINE RIGGING</u>

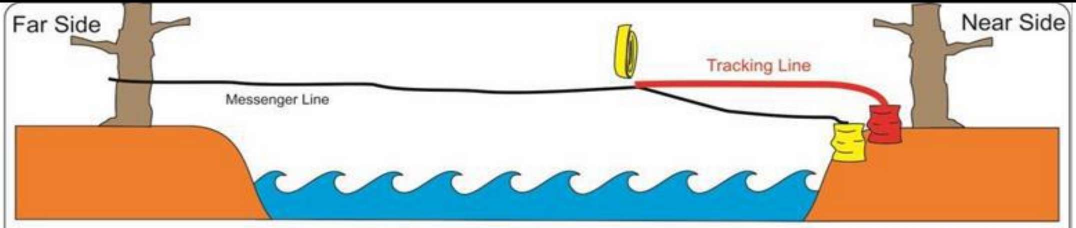


You may replace the “soft connection” with a swivel.

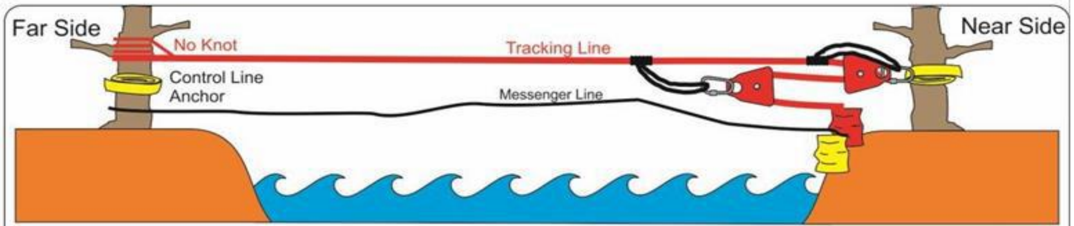



Alternative rigging without a Hudson Rig

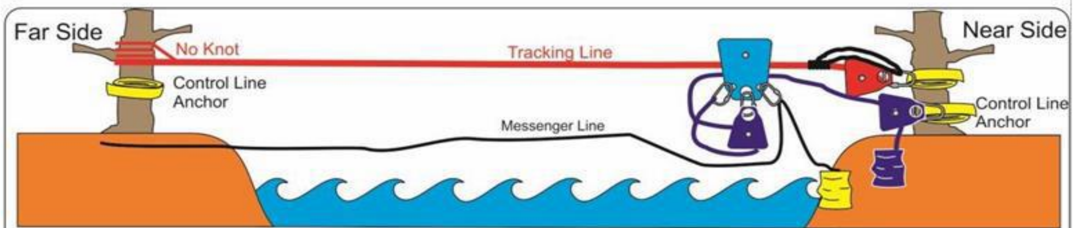
# BOAT CONTROL LINE



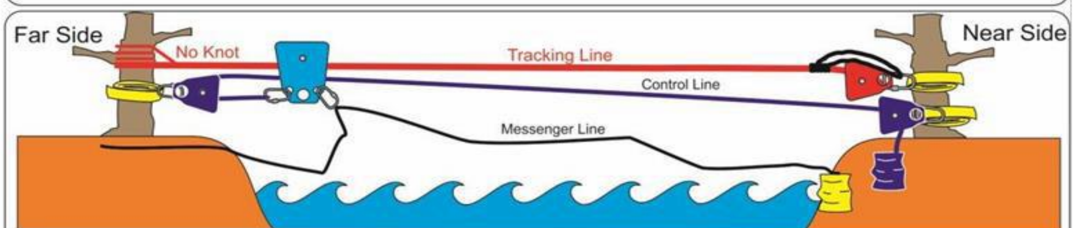

Deploy **Messenger Line** via Line Gun, Swimmer, or Throw. Pull ½ " Tracking line across with anchor webbing or anchor strap. NOTE: Webbing can also be swam across if applicable.



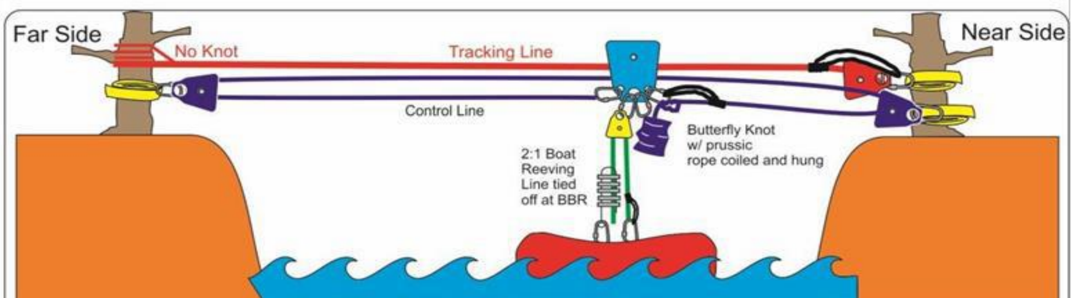

No Knot the Far side Tracking line and tension Near Side with appropriate MA. Assemble a control line anchor on Far Side. NOTE: leave messenger line tied off for future use.




Assemble Near Side Control Line Anchor with pulley. Attach Kootenay Carriage with 3 carabineers and a pulley. Attach messenger line. Reeve Control line through anchor pulley and Kootenay Pulley, then through middle pulley, terminating at last carabineer. NOTE: MA and Tracking Line rope bag omitted for clarity.




Haul Kootenay to Far Side, remove middle pulley and carabineer and attach to Control Line anchor




Haul Kootenay to Near Side, remove messenger line, pull control line hand tight and add prussic. Terminate control line with a butterfly knot and hang the remaining rope in bag. Add boat reeving line. 2:1 with brake bar rack at boat for descent control.

# PATIENT PACKAGING

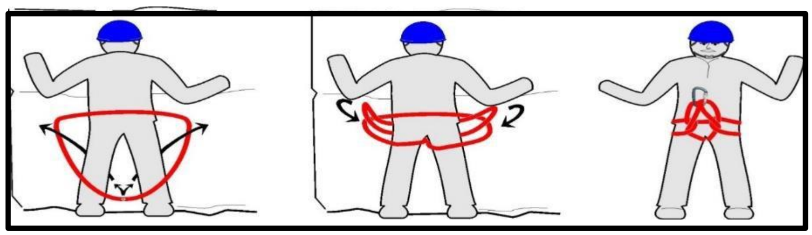
**VICTIM HARNESSES**

A victim (subject) harness should be capable of being donned without requiring the individual to step into the harness. Improvised harnesses are useful for stabilizing a stranded subject and are easily tied with webbing, however they do require proficiency. General comfort is sacrificed, when fully suspended in an improvised harness.

The FEMA harness: 20' of red webbing. It is secured with a square knot and two overhands.

**PICK-OFF HASTY HARNESS**

This technique provides an effective means for securing a subject in exposed terrain without having them move. It is also useful on a supine patient in a litter without excessive manipulation or movement.



## LITTER PATIENT PACKAGING.

**SAFETY**

- Patient(s) must be internally lashed to protect them from ejection out of the ends of the litter. They must also be externally lashed to prevent them from moving within the litter.
- All carabiners should have gates opening down and toward the "inside" of the litter basket. Ensure carabiners are properly loaded and will not torque or side load.
- Never tie patient lashing around top rail of the litter: Always weave webbing between uprights of the stokes or to internal areas of plastic stretchers.

**STEPS TO PATIENT PACKAGING:**

1. Stabilize the patient before loading;
2. Head/eye/face protection
3. Sit harness (for steep & high angle, maybe considered during Low angle)
4. C-collar, backboard, bandaging, splinting
5. Prepare the litter to receive the patient
6. Load the patient
7. Lash the patient into the litter securely
8. Internal lashing (two 12-foot yellow webbings)
9. External lashing (If litter is not equipped with seatbelt type external lashing us a 25-foot black webbing to establish external lashing)

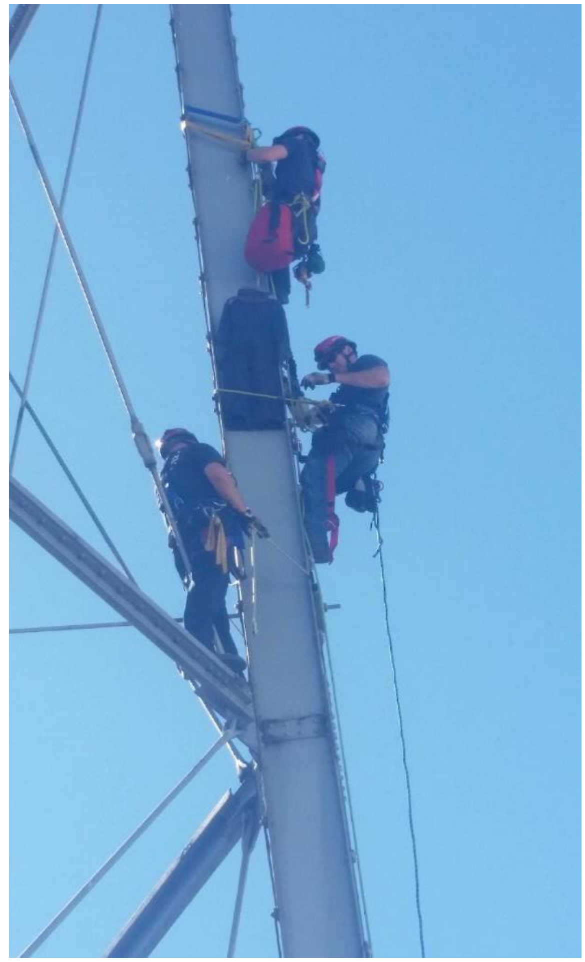
# INTERNAL LASHING


NOTE: In a LOW ANGLE environment internal lashing is all that be needed to keep the patient from sliding out.

# EXTERNAL LASHING

## ARTIFICIAL HIGH DIRECTIONALS, HIGHLINES, TOWERS

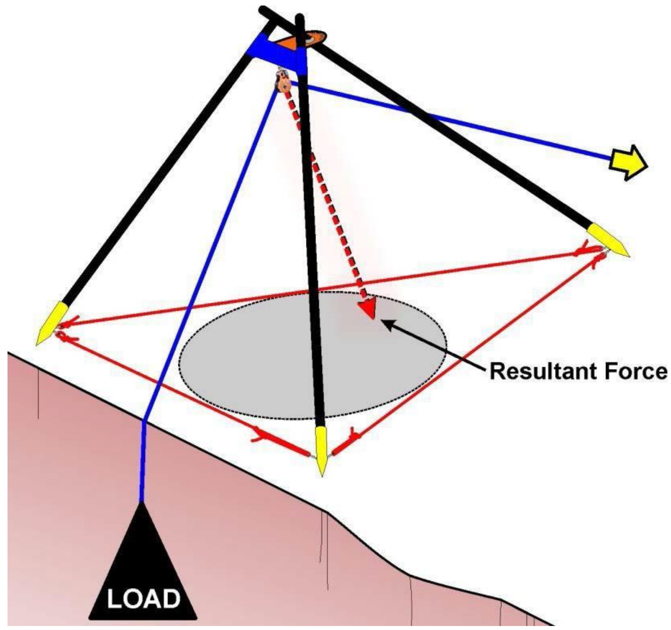
These represent rigging that requires an unforgiving comprehension of the hazards associated with either the environment or the physics. They are included in this manual as an introduction however, Technicians should be formally trained before exposing themselves or others to these potentially life-threatening risks.



## ARTIFICIAL HIGH DIRECTIONALS,

Negotiating a sharp cliff edge with a loaded litter is dramatically easier for the attendant and can be less traumatic on the patient when the main line is directed up through a high point near the edge. This facilitates a much smother edge transition and eliminates the “edge trauma” a patient might experience if a litter is pulled up over a sharp cliff edge. A natural rock stair-step or a well-placed tree with the attachment of a directional pulley could provide rescuers with an easy solution. However, lacking such a natural rigging opportunity an artificial high directional (AHD) can be engineered with a quad- pod, tripod, A-frame or gin pole configuration, which are constructed respectively with either four legs, three legs, two legs or a single leg.

A commonly employed high directional tripod has an elevated center of gravity, however when a load is properly applied in a downward manner the compression forces stabilize it in place. When a rope, threaded through a pulley at the top of an AHD, is tensioned with a load at one end and secured at the other end, there is a "resultant" force vector created by the interior angle of the rope at the pulley. This can be visualized by projecting an imaginary line from where the base of the pulley is pointing.



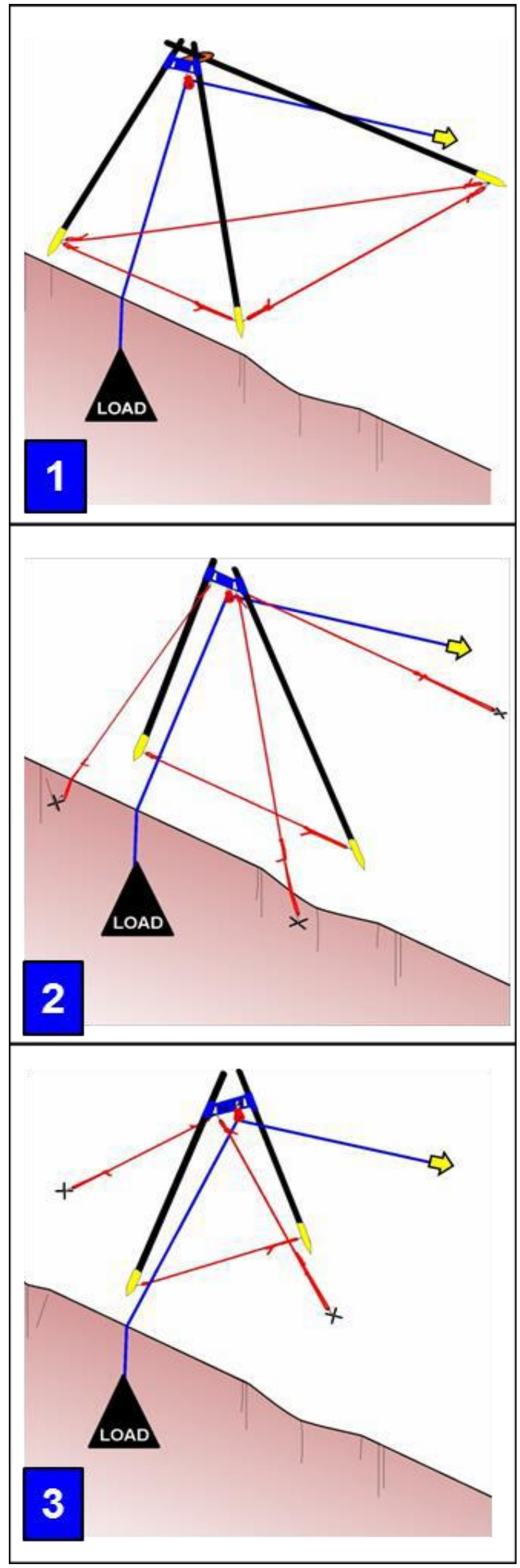

Resultant force vector. Created by a rope running through a directional pulley on an artificial high directional (shown in tripod configuration).

A resultant located well inside the footprint of a tripod stabilizes it in place. However, when the resultant force vector for the main line is located outside of the tripod base, the device will become unstable and tend to want topple in the direction of this force. The goal in rigging a tripod is to have the resultant force as close to the center of the three legs as possible.

An artificial high directional, if not properly rigged with guy lines or having adequately stabilized legs, will topple over in a catastrophic manner. It is crucial to understand the forces generated in specific situations and configurations.

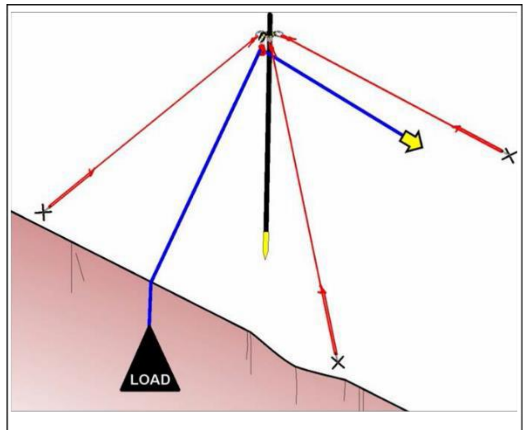
Two legged and mono-pole AHD configurations are inherently unstable requiring guy lines to counteract the tipping forces. A resultant force vector that is not in straight compression upon the legs results in additional loading on guy lines, which could cause it to fail. Varying guy line configurations are used to provide proper stabilization of different AHD designs. An easel A-frame with a properly positioned resultant force located in the center of the three legs is sufficiently stable to not require additional guying. Using the guy lines, an A-frame configuration should be leaned toward the edge, creating a resultant force, once the load is applied, that directly bisects the line between the legs. This results in balancing the load on the legs.

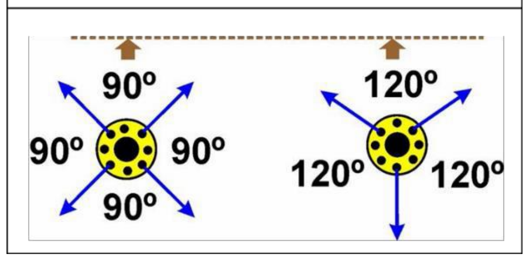
A Sideways A-frame configuration employs guy lines from both sides, thus alleviating the necessity for an anchor point at or over the edge as required by a traditional A-frame set-up. A gin (jin) pole is a mono- pod arrangement and inherently the most unstable arrangement for an AHD, thereby requiring numerous tensioned guy lines to keep it vertically secure for use. A gin pole can be suitably secured with a minimum of three guy lines rigged with exactly 120° spacing between each. When sufficient anchors are available, construct four guy lines with 90° spacing between each line. Secure the bottom end of the gin pole in a natural depression and, when feasible, anchor it to prevent movement. Tilting the gin pole, like an A-frame, toward the edge will keep the resultant force vector down and in-line with the pole.




The main line is rigged directly through a directional pulley at the top of an AHD. It is highly recommended to elevate the back-up line also through a high directional during edge transitions, otherwise any "failure" of the main system is guaranteed to result in the maximum fall distance. The AHD backup line is ideally suspended at waist height of the attendant, initially during the initial edge transition, and then once the load is safely below the edge, with the attendant in the proper plumb line and in control of the load, the backup line can be moved to a lower position lowered close to ground level once the attendant is well below the cliff edge. This can be accomplished by running the belay line through a pulley suspended from the head of the AHD on an adjustable jigger that is managed by the edge attendant. This approach of also elevating the back-up rope is excellent risk management of some of the more likely factors that can affect the fall of the load during edge transitions sudden overfeeding of the main line, causing a sudden drop of the load).

The AZ Vortex is promoted as a “multi- pod” because of its ability to be rigged as a standard tripod, easel A-frame, sideways A-frame or a Gin Pole. Adjustable leg lengths allow it to be adapted to uneven and challenging terrain at a cliff edge. The Head Set of the AZ Vortex has numerous attachment points to rig pulleys or attach guy lines. Guy lines are intended to be attached to the triangular holes in the head. Raptor feet (spiked) and flat feet are sold with the AZ Vortex to provide a secure footingin different terrain or structural locations.




With both sets of feet the entire unit weighs 33 kg (72 lbs). The rated breaking strength is 36 kN (8,093 lbf) and it is NFPA 1983 certified for General Use as well as CE certified to 0120 (EN 795 B) Standard.

The AZ Vortex is most efficiently assembled a short distance from a cliff edge and then moved into place. In the easel A-frame configuration, the AZ Vortex is awkward to maneuver in to place, requiring a well-coordinated movement with one person handling each leg. All AHDs need to be belayed on an adjustable tether in order to prevent it from toppling over the cliff edge during installation. This tether is left in place during the operation providing an effective safety line. Once the device is properly positioned, the feet are secured or hobble straps are rigged between the legs. When the top of the AZ Vortex is subjected to a downward compression, the wide arrangement of the legs causes them to be forced apart. The legs therefore must be physically stabilized by either anchoring the feet to the surface or alternatively hobbling the legs with separate straps or cordage. Only two legs per hobble strap are rigged together, since three legs encircled with a single hobble tie could still permit two legs to spread. Moderate tension is applied to the hobbles so that the straps are snug but not excessive tension causing the legs to flex. The hobble straps are rigged low to the ground to prevent a possible tripping hazard.

## THE HIGHLINE EVOLUTION.

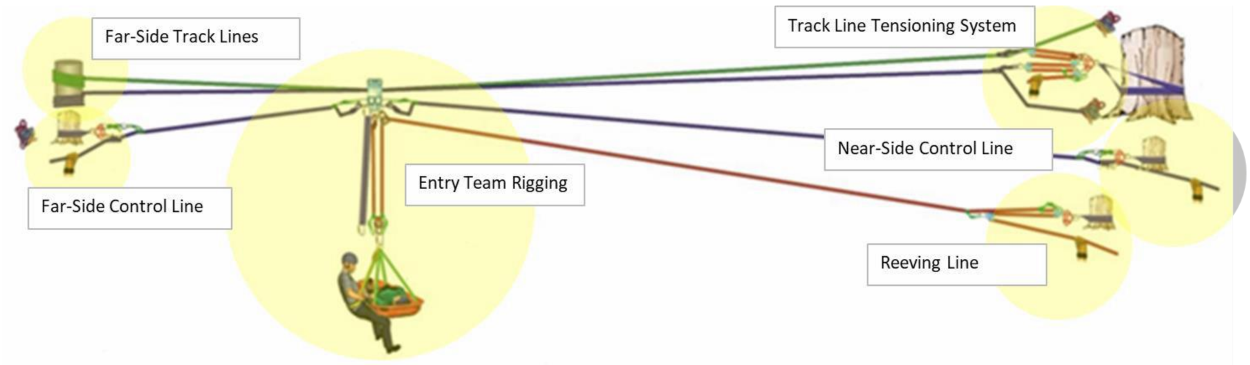
Highline systems are rope systems that allow movement of a rescuer and/or litter along a horizontal or angled plane, and may also be designed to facilitate vertical movement of the rescuer and/or litter from any position upon that horizontal or angled plane.

Highline systems are considered the most complex of rope systems as they typically require more equipment and personnel involvement to assemble and operate then any other rope system. Due to the combination of a highline rope system being personnel and equipment heavy, along with the total dependency of the safety of the rescuer on the highline system, the highest degree of scrutiny of the assembly and operation of the system in its entirety is required.

The successful operation of a highline system is dependent upon the coordination of personnel, equipment and the components that comprise highline systems all working together under the direction of the Rescue Group Leader and his/her staff.

The set up and operation of a horizontally oriented Highline system involves personnel, equipment, and tasks performed from each “end” of the Highline system. To simplify the identification for these two locations, the terminology “near side”, and “far side” are utilized. The “near side” designator is applied to the location in which operations are based and the rescuer and/or litter is deployed from. The “far side” operation is where the Highline is extended to and typically involves fewer personnel and equipment. On Highline systems that angle to the ground from an anchored location above, the terminology “top” and “bottom” are used.

Highline System Assignments




As RGS, the responsibility of managing a highline operation can seem very daunting and test the skills of any technician. Like a factory assembly-line, it helps to break it down and assign specific, individual tasks that when completed and assembled, produce a highly functioning machine.

It is important to delegate and assign positions as quickly as possible. Then support those positions with the needed personnel.

1. Rigging Team Leader.
2. Entry Team Leader.
3. Tech Safety Officer.

The following tasks can be separated out and teams assigned to them.

1. Far Side
2. Entry Team.
3. Track Line.
4. Control Line.
5. Reeving Line.

Once you identify the location of the system, Far Side may need some extra time to get in position. Give them their task, location and objective (TLO). They will need to build a system for a control line that will perform raising, lowering, and belaying operations. They will also secure the track lines once the messenger line is shot over. Get them on their way as soon as you can.

It is important to "stay-in-your-lane" regarding the task you were assigned. If you believe a tech is struggling, inform the Rigging Team Leader so they can provide additional clarity, assign someone to assist, or replace them.

REMEMBER, ANYONE WHO SEES DANGER OR AN IMMEDIATE
SAFETY CONCERN MUST STOP THE OPERATION!!

**Track Line(s):**

The Track Line is the rope(s) that the load is suspended from and determines the path of the litter or rescuer. Track Lines can be single or doubled and may be oriented horizontally or angled up or down. The effective practical span of Track Lines should not exceed 300'. A load suspended from a horizontal Track Line can adversely impact the anchors that support the Track Line two ways. First, wide critical angles amplify the loads effect to the anchors and second, movement of the load on the Track Line can cause fluctuations of several hundred pounds at the anchor points. Because of these factors, the highest degree of scrutiny must be given in regard to the stability of the anchors being utilized for the Track Line. To help minimize the impact of wide critical angles, the Track Lines need only be tensioned sufficiently for the load to safely clear all obstacles. Due to the high loading that Highline systems subject to the Track Line anchors, a maximum of two persons (rescuer and patient), shall be allowed to be suspended from the Track Lines.

**Single Track Lines:**

The use of a single Track Line is frequently utilized when the Track Line angles steeply to the ground from its anchored position above, commonly referred to as a "Sloping Track Line". Due to the steep orientation of the Track Line, the load is mostly captured by the Control Lines therefore removing the necessity of doubling the Track Line. When a Track Line is set up for this type of operation, the use of multiple Control Lines (Main and Belay) is recommended to prevent the possibility of an uncontrolled descent of the load.

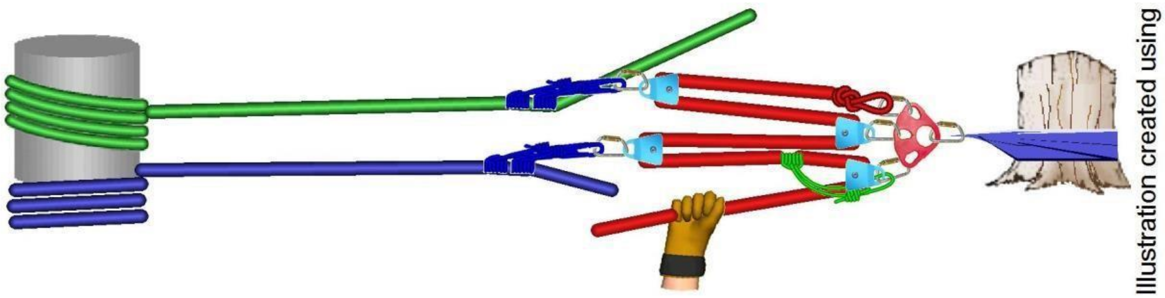
**Double Track Lines:**

The highest degree of safety for a Track Line system is reached when two Track Lines are utilized. Multiple Track Lines when tensioned equally splits the weight of the load between the two lines thus minimizing the impact that the load imparts onto the ropes. Multiple Track Lines can be anchored expeditiously and most effectively from one "bombproof" anchor. The utilization of separate anchors for each Track Line for the purpose of backing up each other is not typically necessary as the Control Lines can be designed to capture the load in case of a Track Line failure (See "Control Lines" below). If separate anchors for each Track Line are utilized, the location of each anchor should be aligned in reasonable proximity to allow both Track Lines to break over the edge along the same plane and right next to each other. In order to allow the load being applied on the Track Lines to be evenly distributed between the two lines, both of the Track Lines should be from the same manufacturer, be of similar construction and length, and be tensioned equally (see "Anchoring and tensioning of Track Lines" below).

**Anchoring and tensioning of Track Lines:**

The far side Track Line is anchored with full strength tie offs to minimize equipment usage and most importantly, to help reduce rope strength reduction from knot application such as when an anchor is connected to with a Figure 8 on a Bight. (The Figure 8 on a Bight has a knot efficiency of 80% to 85%, thus reducing the 9000 lb breaking strength of ½" life line by 1350 to 1800 lbs.) Once the Track Lines are properly tensioned, the near side Track Lines are each held in place by tandem Triple Wrapped Prusiks.

The two Triple Wrapped Prusiks that hold tension on the Track Lines also act as a suedo dynamometer as the Prusiks will begin to "slip" at around 1500 lbs of force. Tensioning of the Track Lines can be accomplished by applying a 2:1 TMA (theoretical mechanical advantage) to each of the Track Lines with a single tensioning rope in the following manner:




1. The end of the tensioning rope is secured to the tensioning ropes anchor and its anchor plate with a Figure 8 on a Bight.

2. The tensioning rope is brought up to the first Track Line and connects to the first Track Line through a pulley attached to the Track Line with a Triple Wrapped Prusik.

3. The tensioning line is pulled back towards its anchor plate where it passes through a second pulley attached to the anchor plate, then is pulled back towards the second Track Line.

4. The tensioning line is connected to the second Track Line by a third pulley attached to the second Track Line with a Triple Wrapped Prusik, exactly like the connection to the first Track Line.

5. Tension the Track Lines and secure the tensioning line.

Track Line tension may be adjusted as necessary while in operation. Coordination of a Track Line adjustment must be carefully orchestrated by the Rescue Group Leader with all safeties in place that will allow passing of a "whistle test" once the operation commences Tensioning system for Track Lines.

**Control Lines:**

Control Lines allow the rescuer and/or litter to be moved along the Track Lines. Since a horizontally oriented Track Line is not excessively tensioned, a sag in the Track Line occurs as the load approaches the center of the span. Due to this sag, the Control Lines function as a lowering operation from one side down to the center of the span (called the near side Control Line), and a raising operation from the center of the span up to the far side anchor (called the far side Control Line). When Control Lines move a load past mid span and back, the near side lowering operation will have to be converted to a raise to bring the load back up to the near side. Conversely, if the load passes mid span, the "far side" raising operation will have to be converted to a lower to support a belay of the load back to mid span. The lowering side of the Control Line is set up the same as a "Main Line Lower" by using a Brake Bar Rack with the addition of Tandem Prusiks on a Load Release Hitch placed ahead of the rack towards the load. The raising side of the Control Line can be set up the same as a "Main Line Raise" by using a 3:1 TMA configured from the Control Line, or more expeditiously by using a Pig-Rig attached to the Control Line. A set of Tandem Prusiks are also utilized in this system, as detailed next. In addition to the role of moving the load along the Track Lines, the Control Lines also may serve as a backup safety in case of a Track Line failure. In order to function as a backup safety for the Track Lines, the Control Lines must adhere to the following:

1. The Control Lines must have anchors separate of the Track Line anchors. (To account for a Track Line anchor failure).

2. The depth of the span must be sufficient enough for the Control Lines to capture the load prior to the load "bottoming out". (The capture distance of the Control Line is approximately equal to 1/5 the span).

3. Tandem Prusiks are employed to the control line after the DCD and will act as the belay on the "lowering" side. An AZTEK or set of 4's will need to be available to disengage the prusiks if activated. On the far side "raising" Control Line, Tandem Prusiks will be positioned at the change of direction pulley when the far side Control Line is set up like a 3:1 TMA "Main Line Raise" (see "Main and Belay Line Systems" section).

The Control Lines may be suspended from the Track Lines by Girth Hitching Prusiks called “festoons”, around the Control Lines at about 30’ intervals, then making attachment to the Track Lines with a carabiner. A single Control Line may be utilized in place of separate near and far side Control Lines but will only work if the single Control Line is longer than twice the span. With the exception of an obvious “bombproof” anchor, the anchors utilized for the Control Lines should be separate to that of the Track Lines. This separation from the Track Line anchor’s is especially relevant if you are depending on the Control Line to back up a Track Line failure. (Failure of the Track Line system occurs most frequently due to failure of its anchor, not to the Track Line itself). The connection of the Control Lines to the rescue carriage is detailed below under “Rescue Carriage”.

**Rescue Carriage:**

The carriage that moves the rescuer and/or litter along the Track Lines must have a sheave diameter and width suitable to accommodate multiple Track Lines. Pulleys that meet this is need are knot passing pulleys and the Kootenay Carriage. The design of the Kootenay Carriage includes one larger hole that can accommodate up to three carabiners suitable for attaching the Reeving Line, and a hard tie for the rescuer while moved along the Track Lines, as well as two additional smaller holes for the attachment of the Control Lines. A knot passing pulley used for a rescue carriage may have an anchor plate attached to its single hole to provide the additional connection points for the Control, Reeving Lines, and rescuer attachment during transport.

A single Triple Wrapped Prusik (sometimes referred to as a “soft interface”) is placed onto each Control Line located where the Control Line connects to the carriage that the rescuer and/or litter is suspended from. The Control Line is allowed to “droop” at this connection point, with the Triple Wrapped Prusik taking all of the tension that the lower or raise systems on the Control Line imparts. The Triple Wrapped Prusik acts as a dynamometer and gives all personnel a visual confirmation if excessive forces are being applied to the Control Line, as the Prusik will begin to slip at around 1500 lbs of force.

If a single Control Line is utilized, the connection to the carriage may be accomplished by two inline Figure 8’s with two single Prusiks added to act as the dynamometer.

Reeving Line: The Reeving Line allows vertical movement of the rescuer and/or litter at any position along the Track Lines. The Reeving Line is operated from the near or top side position. Lowering of the rescuer and/or litter is accomplished by a brake bar rack with the addition of a single Prusik attached to a Load Release Hitch connected on the load side of the brake bar rack. The addition of the LRH and Prusik allows the system to pass the "whistle test" during operation and allows change over from a lowering system to raising system. The raising system may be formed from a 3:1 TMA on the Reeving Line, or more expeditiously with a Pig-Rig attached to the Reeving Line. The single Prusik and LRH utilized for the lowering operation is left in place during the raising operation to allow passing of a whistle test as well as securing the load during a reset of the hauling system.

**Attachment of a litter on a Reeving Line:**

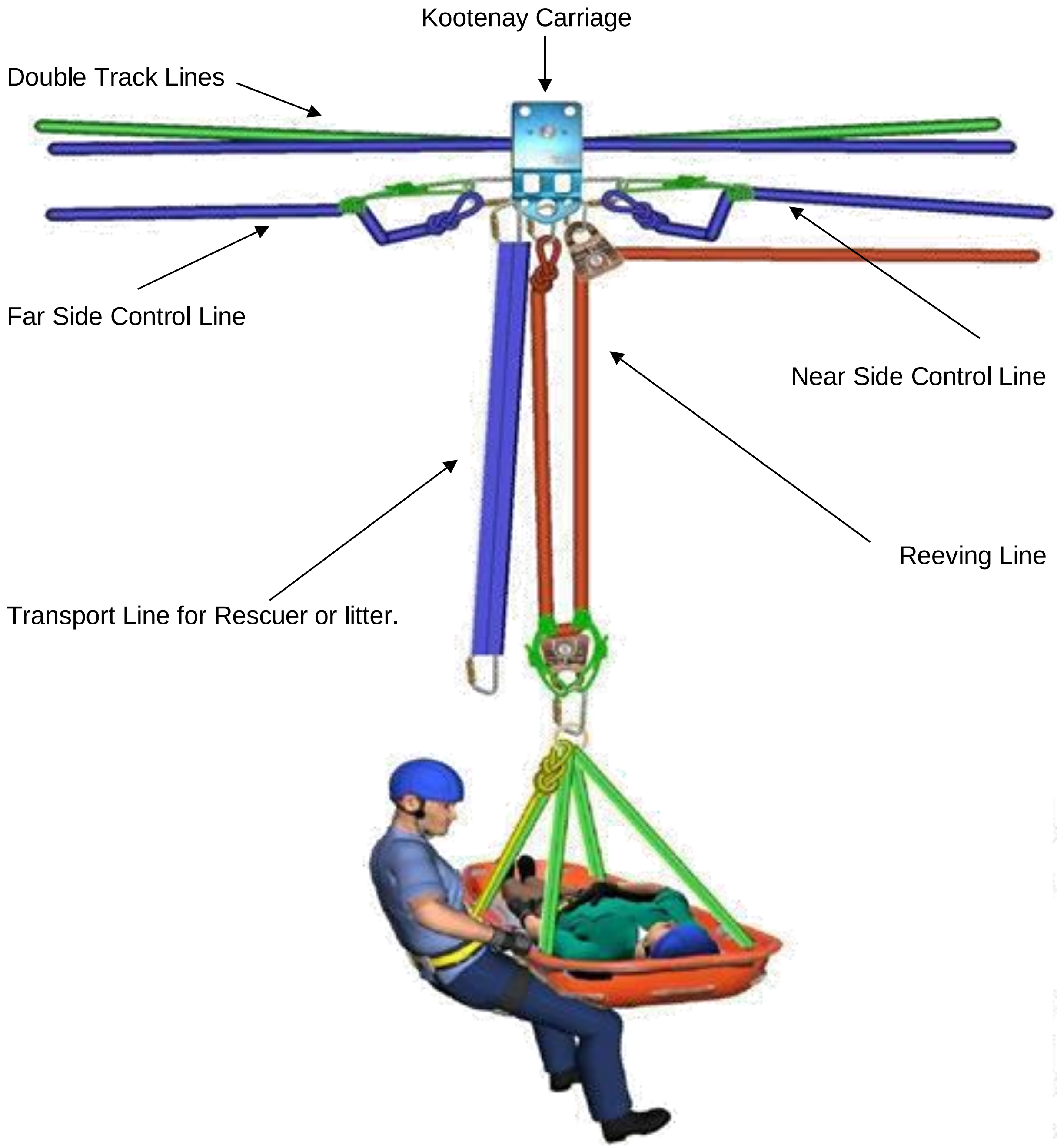
The attachment of the litter, Tender, and patient onto a Reeving Line is accomplished the same as outlined above under Two Rope Systems. The exception to this is that there is only the one Reeving Line in place of the Main and Belay Line set up. The Reeving Line connects to the "O" ring on the litter harness with either a Longtail Bowline or an inline Figure 8 with the tail connecting to the Tenders harness. The patient is connected to the Reeving Line with a Purcell Prusik or webbing and a Prusik.

**Example of a tactical set up sequence for a horizontal Highline**:
Determine the location of the Highline and select suitable anchors. Due to the high loads that horizontal Highlines impart on anchors, the Track Line anchor must be “bombproof”. Determine the means of getting the ropes across to the far side. If a messenger line is utilized propelled by a line throwing gun, ensure the safety of all personnel prior to deployment. If multiple Track Lines are utilized, three rope ends will need to be hauled across by the far side personnel (two Track Lines and the far side Control Line). If hangers are going to be utilized to support the far side Control Line, they may also be sent across with the three ropes. Secure appropriate anchors for the near and far side Track Lines. The Far side Track Lines will be secured by full strength tie offs. The near side Track Lines are held in place each with tandem Triple Wrapped Prusiks after tensioning. The tensioning system is rigged on the near side (see “Anchoring and tensioning of Track Lines” above for details).

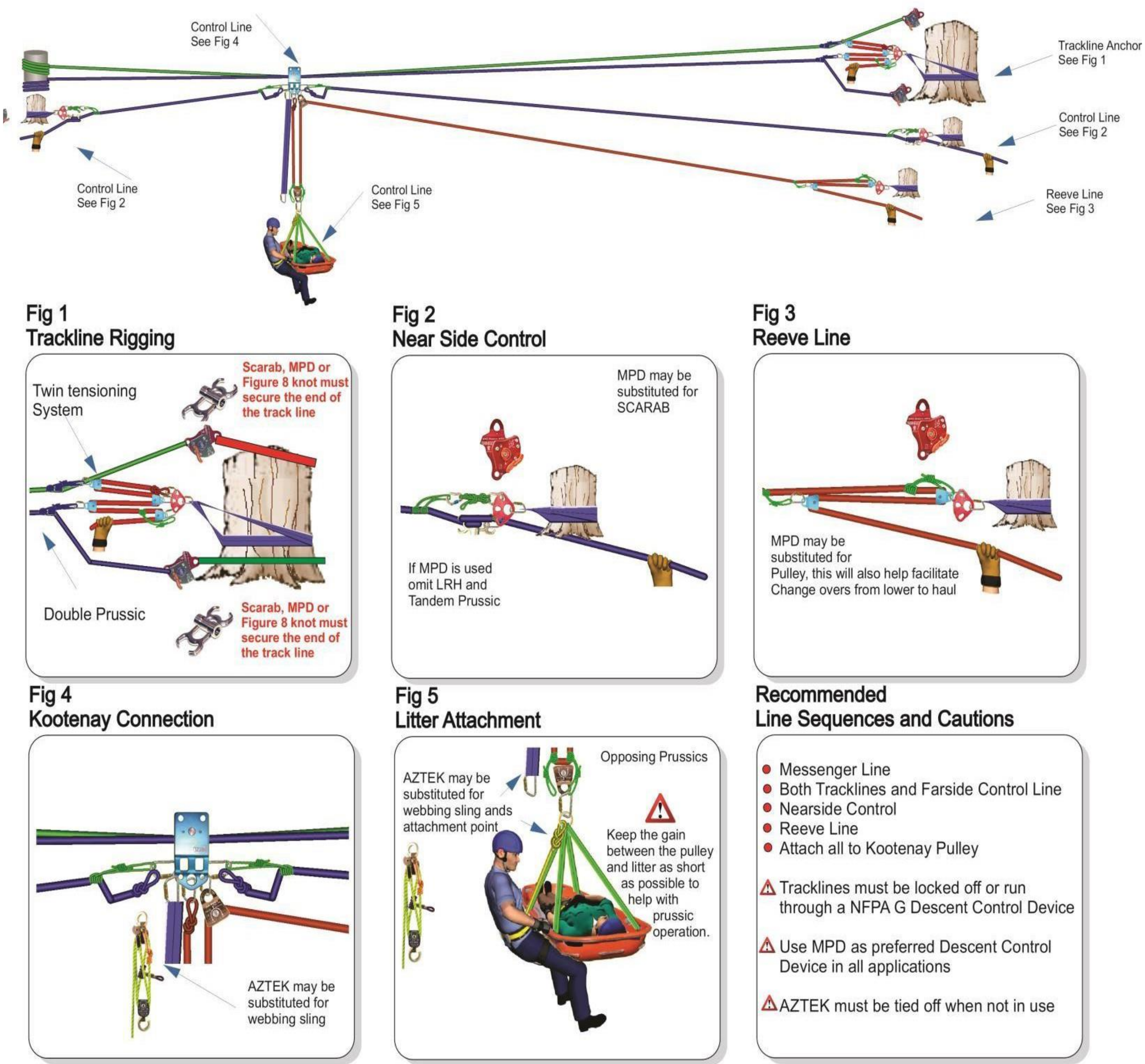
Pre-tensioning is provided by one person operating the 2:1. Final tensioning may be adjusted so that the weight of the rescuer, litter, and patient clears all obstacles. The Control Lines anchors for the near and far side must be separate to that of the Track Lines if the Control Lines are to function as a backup in case of Track Line failure. Using the same anchor for both the Track Line and Control Line may be utilized only if the anchors are positively “bombproof” and suitable multiple “bombproof” anchors are not present.

The near side control line is set up the same as a “Main Line Lower” with a SCARAB and tandem Triple Wrapped Prusiks on the load side of the rope. The far side Control Line is set up the same as a “Main Line Raise” with the addition of tandem Prusiks. The tandem Prusiks capture the load in case of a Track Line failure, and also allows passing of a whistle test. The rescue carriage is set onto the Track lines. The near and far side Control Lines are connected to the carriage side holes with a Figure 8 on a Bight into a carabiner. A single Triple Wrapped Prusik is added to the connection to act as a visible dynamometer via a “droop” in the Control Line at the carriage connection. If a single Control Line is utilized for both sides, two inline Figure 8’s may be utilized with two Triple Wrapped Prusiks added for the above reason. (Note; if a single Control Line is utilized, it must be longer than twice the span). A pulley is connected with a carabiner to the carriage for a change of direction to the rescuer and/or litter if a Reeving Line is utilized. During transport along the Track Lines via the Control Lines, the rescuer and litter are tied directly to the carriage with a piece of webbing. Protection while lowering the Reeving line is provided by a Triple Wrapped Prusik attached to the Reeving line on both sides of the pulley at the collection point of the rescue package. Once the rescuer is positioned along the Track Line at a location where the lowering operation will commence, the Reeving Line will have to perform a short raise to allow the rescuer to disconnect himself/herself from the transport webbing. Once the rescuer has secured the patient, and the rescuer and patient are raised with the Reeving Line up to the carriage, the rescuer shall reconnect the transport webbing prior to the Control Lines moving the carriage.

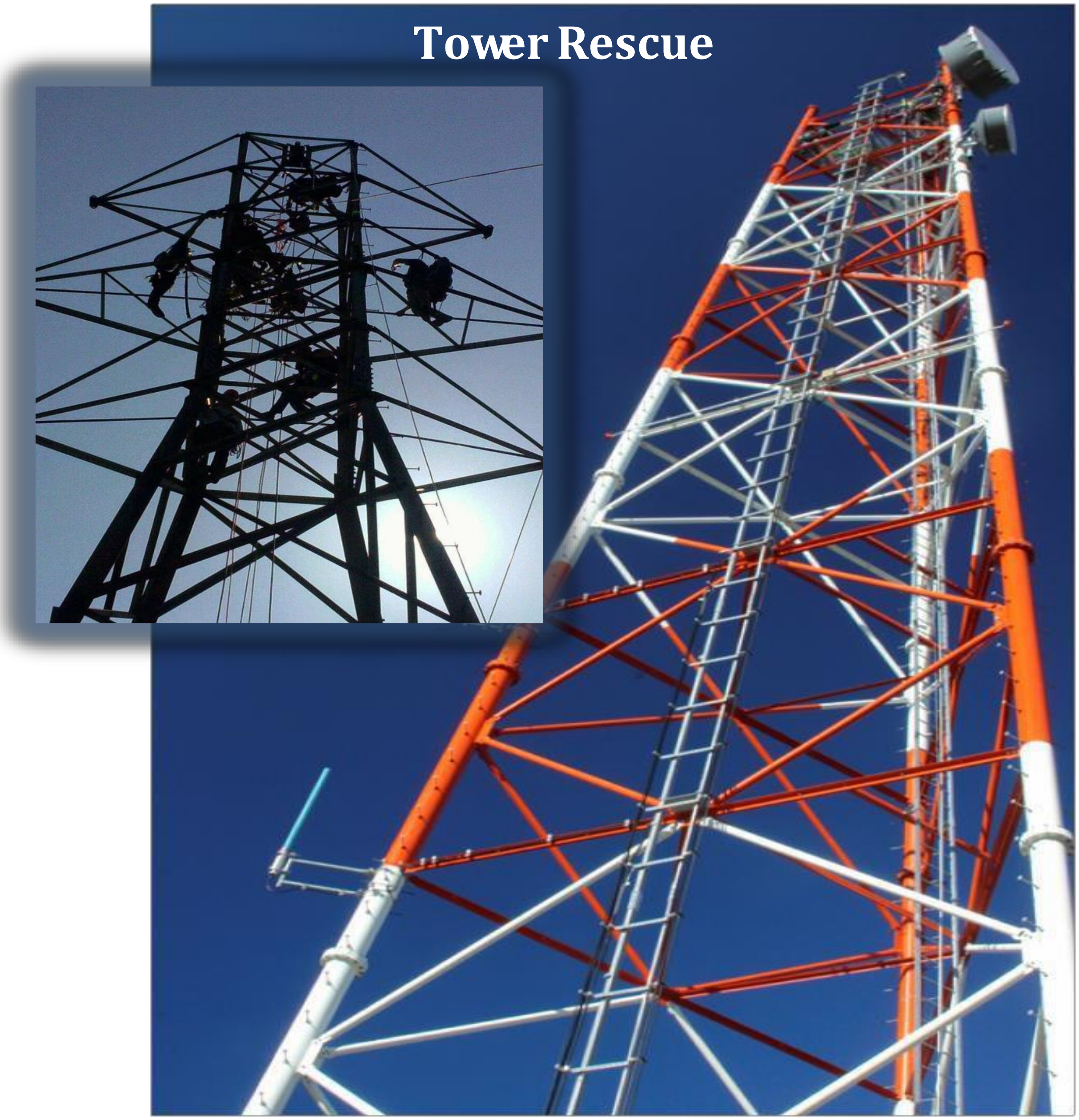
**Highline System components**:



This drawing depicts a critical angle that is UNACCEPTABLE and DANGEROUS – it was done so that that the drawing would fit into this format.
Remember 120 Degrees produces equilibrium. 150 Degrees transfers approx. twice the load to the system.



# Tower Rescue



With the advent of elevated transmission towers to the recent surge in communications infrastructure, towers and other elevated structures are now commonplace from urban skylines to sparsely populated wind turbine farms. With the increase in the number of accessible elevated structures comes an increase in the potential *and* actual cases of falls, injury, death, and professional rescue. Lineman and other access technicians have been and will continue to rescue their own given a rescue type scenario. Many private companies mandate specific rope rescue and self-rescue training for their employees, which means we don't get called to their emergency. Like many other rescue disciplines, tower rescue is a specialized ever evolving skill with techniques, evolutions, and equipment designed around tower rescue.

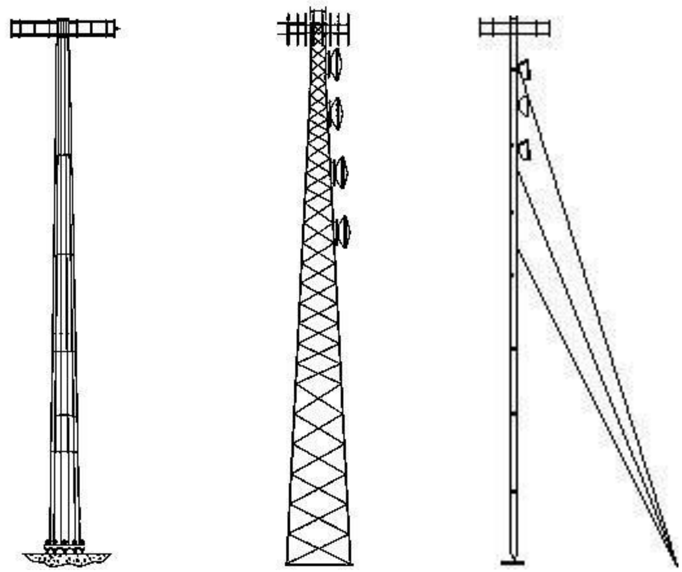
**Tower Types:**

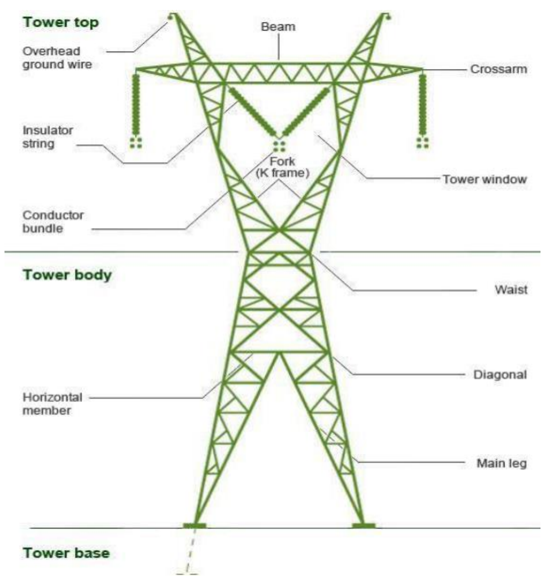
Monopole

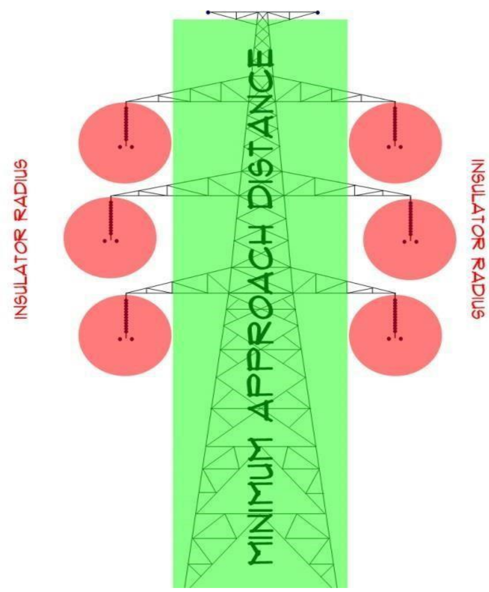
- Self-Supporting
- Guyed
- Other (water tower, etc)

**Uses:**

- Utility Poles
- Electrical Transmission Lines
- Cell Towers
- Tower Cranes
- Bridges
- Water Towers
- Other elevated structures




**Transmission Towers:**

One of the most common types of towers and usually support high voltage transmission lines. There are many different designs and heights depending on the surrounding topography and distance between towers. Most are made out of angle iron of various gauge steel and connected via bolts and or rivets. This type of construction is cheap easy to erect and designed to flex. BE PREPARED FOR TOWER MOVEMENT WHEN CLIMBING! Lattice type construction provides for an anchor rich environment and usually has foot pegs or a permanently installed fall protection travel wire made of 3/16 to 5/8 wire rope. These towers are not easily de-energized or powered down due to the vast amount of infrastructure they support, so accessing these towers must be done within the minimum approach distance and with extreme caution.

## TERMINOLOGY

**Transverse view**- viewing the tower from the front or back usually parallel or under the transmission lines.

**Longitudinal view-** viewing the tower from the side or profile, usually perpendicular to the transmission lines.

**Tangent Angle Tower-** A transmission tower that is at the apex of turn in the transmission lines run

**Dead End Tower-** A transmission tower that all lines terminate at

**Arm-** a lattice structure built out from the main body of the transmission tower to hold the insulators which support the transmission lines.

**Insulators-** Bell shaped, nonconductive plates usually made of porcelain to insulate high voltage wires and prevent the energizing of the tower.

**Minimum Approach Distance-(MAD)** A safe zone for access and working, usually created by measuring the length of the insulator and its associated radius. Most if not all pre-installed fall protection or foot peg paths should fall within the MAD

**Fixed Brake-** A fixed brake is a friction device that is located at a stationary anchor to lower a victim or rescuer. A fixed brake can be utilized in a structure-based or ground-based rescue. It all depends on the location of the fixed brake relevant to the tower. Some examples of fixed brakes are brake bar rack, CMC MPD and Petzl ID.

**Dynamic Fixed Brake-** A brake as described above, only with the ability to move under load. Usually with a Set of Fours, AZTEK, or other mechanical advantage system behind the brake.

# APPENDIX

**Zone 3 Minimum Equipment list- (2016 revision)**

For 2016 there will no longer be a “Main” and “belay” bag. This is not intended to reduce the number of bags, (the main and belay bag will become two identical bags) just allow them to be used for either task.

8- Locking steel carabiners
4- Prussik minding pulleys (PMP)
1- Brake Bar Rack (BBR) - To be phased out in 2017
1- Hudson Rig Assembly.
1- Anchor Plate
1- Anchor Strap

3- SCARAB’s
4- Long Prusiks
4- Short Prusiks
33’ of 8mm cord
1- Pick-off Strap
1- Victim harness
1- Soft edge protection

**Webbing**

1- Black – 25’
2- Red – 20’
2- Blue – 15’
2- Yellow – 12’
2- Green – 5’

**Additional Recommended Equipment:**

The following equipment is in addition to the minimum equipment list (MEL) above, but it will be used extensively in training evolutions in 2016 and will most likely be moved to the MEL in 2017

1- CMC MPD
1-Traverse 540 belay device
1-Petzl ASAP- lock w/ Absorbica 1-
Petzl ID
1-AZTEK (Arizona Technician Edge Kits) - per rescue apparatus

- Recommend the CMC version because it comes pre-rigged and “G” rated
- Also, a spare pin should be purchased with each one and zip tied to the unit so that each pulley/ prussik has a dedicated pin.

**Optional Tower/ Access Kit:**

Bypass Lanyards (Lobster claws)
Work positioning lanyards (Buck straps)- may be purchased or self-made

| Equipment Color Coding by Department | | | | |
|---|---|---|---|---|
| Valley Regional | RED | | Tukwila Fire | BLUE |
| South King Fire | RED / WHITE | | Burien Fire | RED/WHITE/BLUE |
| Puget Sound Fire | ORANGE | | North Highline | RED / WHITE |
| Mtn View Fire | YELLOW | | Enumclaw Fire | YELLOW |
| Renton Reg Fire | RED / BLUE | | | |

**<u>Zone 1 Minimum Equipment list</u>**

## GENERAL EQUIPMENT

1” tubular webbing<br>
Black - 25’ length<br>
Red - 20’ length<br>
Blue - 15’ length<br>
Yellow - 12’ length<br>
Green - 5’ length

Tandem Prusik set

Anchor strap

Rescue bypass lanyard aka cowtails

Handled ascender with foot stirrup

Lightweight locking “D” carabiner rated @ 9,000 lbs.

Standard locking “D” carabiner rated @ 9,000lbs.

Steel rescue pulley

Double-sheave steel pulley with becket

Aluminum Prusik minding pulley aka PMP

Edge roller

Paw, collection plate

Knot passing pulley..Kootenay carriage

Handled ascender with foot stirrup & daisy Anchor plate aka rigging plate, Bear

Brake rack with hyper bar

| Equipment Color Coding by Department | | | |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

| NFPA 1983- Selected Equipment Performance Requirements | | |
|---|---|---|
| | "T"- Technical Use | "G"- General Use |
| Carabiners | Major axis (gate closed): 27 kN (6,069 lbf) MBS | Major axis (gate closed): 40 kN (8,992 lbf) MBS |
| | Gate open major axis: 7 kN (1,574 lbf) MBS | Gate open major axis: 11kN (2,473 lbf) MBS |
| | Minor axis: 7 kN (1,574 lbf) MBS | Minor axis: 11kN (2,473 lbf) MBS |
| Life Safety Rope | 20 kN (4,496 lbf) MBS. Minimum 1% elongation at 10% breaking strength | 40 kN (8,992 lbf) MBS. Minimum 1% elongation at 10% breaking strength |
| | diameter range: ≥9.5 mm (3/8 in) to < 12.5mm (1/2 in) | diameter range: >11 mm (7/16 in) to ≤ 16 mm (5/8 in) |
| Descent Control Device | 13.5 kN (3,034 lbf) | 22 kN (4,946 lbf) MBS |
| Multiple Configuration Straps *(e.g. basket, choker and end-to-end straps)* | 32 kN (7,194 lbf) in basket configuration | 45 kN (10,120 lbf) in basket configuration |
| End-to-End Straps *(e.g. pick-off, load-releasing and vertical lifting straps)* | 20 kN (4,500 lbf) | 27 kN (6,070 lbf) |
| Pulleys | 22 kN (4,946 lbf) MBS | 36 kN (8,093 lbf) MBS |
| Portable Anchor Devices | 22 kN (4,946 lbf) MBS | 36 kN (8,093 lbf) MBS |

- NFPA 1983 Equipment Definitions:
- CLASS II Harness- Fastens around waist and buttocks. Designed for rescue with a design load of 2.67 kN (600 lbf)
- CLASS III Harness- Fastens around the waist, around thighs or under buttocks, and over shoulders. Designed for rescue with a design load of 2.67 kN (600 lbf).
- Belt- Fastens only around the waist as a positioning device.

| FORCE: A Newton is the force required to accelerate one kilogram, one meter per second. 1,000 Newtons or 1 kilonewton (1 kN) is the force required to accelerate 1,000 kilograms, one meter per second. | |
|---|---|
| 1 kN | 225 lbf (pounds-force) |

MATERIAL STRENGTHS

| Material | nknotted Strength | | Knot Strength | Knotted Strength | |
|---|---|---|---|---|---|
| | kN | lbf | 30% | kN | lbf |
| 6 mm accessory cord | 7 kN | 1,573 lbf | 30% | 5 kN | 1,124 lbf |
| 7 mm accessory cord | 10 kN | 2,248 lbf | 30% | 6 kN | 1,349 lbf |
| 8 mm accessory cord | 14 kN | 3,147 lbf | 30% | 10 kN | 2,248 lbf |
| 9mm accessory cord | 16 kN | 3,597 lbf | 30% | 11 kN | 2,473 lbf |
| 11mm nylon rope | 28 kN | 6,294 lbf | 30% | 20 kN | 4,496 lbf |
| 1 inch (25 mm) tubular webbing | 18 kN | 4,046 lbf | 45% | 10 kN | 2,248 lbf |

COLOR CODE- STANDARD LENGTHS FOR WEBBING

| Webbing Color | Meters | Feet |
|---|---|---|
| Green | 1.5 m | 5 ft |
| Yellow | 3.5 m | 12 ft |
| Blue | 4.5 m | 15 ft |
| Red | 6 m | 20 ft |
| Black | 7.5 m | 25 ft |

TANDEM PRUSIK PAIRS:

8MM Cord cut to 1.35 m (53 inches) and 1.65-1.70 m (65 inches). Tied with 25-30 mm (Min 2” inch) tails.

PURCELL PRUSIK

8MM Cord Cut to 160”

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# Request for Best Practice Review

(Technical Rope Rescue BPR Form)

Date Submitted: Importance: ☐ Urgent / Safety ☐ Routine

Name:

Agency:

Email:

Level of Training ☐ Awareness ☐ Operations ☐ Technician

What would you like to have reviewed? ☐ Equipment ☐ Techniques ☐ Training ☐ Safety

| Item or Topic to Review | |
|---|---|

| As detailed as possible, describe what you propose and why this should be incorporated: |
|---|
| |

| What could be potential challenges in implementing your proposal? |
|---|
| |

Submit this form to a representative of the instructor group. You may expect the following communication:

- You will be contacted by email to let you know when it has been received by the group.
- You will be contacted if there are additional questions.
- You will be informed at the conclusion regarding the review.

The review process may take a few months unless, indicated as “Urgent”. It will be thoroughly discussed by the instructor group and if appropriate, practiced before a conclusion is made.

Thank you for your commitment toward improving our rescue practices.