

KING COUNTY ZONE ONE ROPE RESCUE RIGGING



ROPE TECHNICIAN COURSE

TABLE OF CONTENTS

LESSON PLAN	2
PREPARATION	3
INTRODUCTION	3
SAFETY	4
DEFINITIONS	5
ROPES/KNOTS	12
EQUIPMENT	21
ANCHORS	27
MECHANICAL ADVANTAGE	32
RAPPELLING & ASCENDING	46
BELAY	55
MAIN LINE SYSTEMS	69
-- Lower	70
-- Raise	72
ROPE SYSTEMS	73
-- Patient Packaging	74
-- Low Angle	77
-- Steep Angle	84
-- High Angle	91
• Single Point Litter Lower	93
• Pick-off - Lowered & Rappel Based	101
TOWER RESCUE	108
APPENDIX	112
-- Guiding Line	113
-- Main Line Change-Overs	114
-- Knot Passing	120
REFERENCES	125
-- NFPA 1670	
-- NFPA 1006	
-- WAC	

ROPE RIGGING FOR RESCUE

LESSON PLAN

<u>TOPIC:</u>	Rope Rescue
<u>MANDATE:</u>	WAC / NFPA standard
<u>LEVEL:</u>	Technician
<u>TIME:</u>	40 hrs.
<u>BEHAVIORAL OBJECTIVES:</u>	At the completion of this course, each student
Given:	sufficient hardware and software, and clear objectives shall meet
Performance:	by completing each exercise accurately & safely to meet
Standards:	Identified in: NFPA 1670, 1006,1500, 1561, 1983 WAC 296-305-5005 & 296-305-02019
<u>REFERENCES:</u>	NFPA, WAC
<u>MATERIALS NEEDED:</u>	8 - 300' Section of ½" low stretch rope (kernmantel), minimum of 30 carabiners, minimum of 6 brake racks, 10 ea. Webbing size, 6 LRH, 8 sets of Prusiks (8 long & 8 small), personal Purcell Prusiks, 3 stokes pre-rigs, PPE for each student. Easel with paper, ICS chart, student manuals.

PREPARATION

Due to new construction, which consists of taller buildings in urban centers and increased demands in rural areas, the fire service is challenged to perform rescues involving High & Low angle scenarios. Although we have had these types of scenarios before and have muscled our way through them, we are faced with new safety standards established and driven because of injuries that have occurred to fellow firefighters.

The purpose of this class is to prepare our members for these types of rescues and to establish a solid foundation that can be built upon.

This class has been developed by Zone One rope technicians to provide standardization throughout our Zone, thereby improving our working relationships between departments and providing our communities with the highest skills possible.

During the development of this manual, rescuer and victim safety was the primary focus. You will be reminded, reminded, and reminded to check, check and recheck your systems before putting them to use.

Good luck and remember “**ABOVE ALL DO NO HARM.**”

COURSE INTRODUCTION

This course was developed keeping in mind that there are many different ways to rig systems, or as we have been reminded since very small “many ways to skin a cat.” Of all the Technical Rescue disciplines, rope rescue is the most controversial because of the many ways and thoughts of what works “best.”

The committee members that developed this manual have many years of experience in rope rescue as instructors. The question we asked ourselves was, “How do we put a class together that meets our student’s needs but yet is condensed to what we feel are the core requirements of most rope rescue teams?” More importantly, we wish to help the departments who have different concepts or ideas work together effectively and efficiently.

This course is the result of hard work and many hours of putting together text and pictures showing what the Zone One standard is. While each department reserves the right to have subtle differences, you should be able to work with each other without any trouble. The systems shown in this manual are safe, easy to construct and subscribe to the K.I.S.S principal. We hope that you find it so. Let’s get started!

1st Edition contributors: Mark Anderson - Kirkland, Sabine Arnold - Shoreline, Jay Fischer - Shoreline, Mark Freymuth - Redmond, Rich Rathvon - Shoreline

2nd Edition contributors: Mark Anderson - Kirkland, Brian Gilbert - Northshore, Chris Martin - Kirkland, Don Sanderson - Redmond

SAFETY

Being part of a technical rescue class is sometimes unsafe - heck sometimes it's dangerous. To maximize your team's exposure you have to perform each task as in real life. You can only do so much on the white board. As children we were taught to do things right the first time, well this is the case in any technical rescue. If it's not done right the first time there is rarely another chance to perform. We need to practice SAFETY immediately...on day one! The following rules will apply throughout this course:

IF YOU SEE SOMETHING YOU THINK IS UNSAFE **STOP** THE OPERATION! ANYONE CAN STOP THE OPERATION, PLEASE REMEMBER IT TAKES AN INSTRUCTOR TO PROCEED.

WHEN A HELMET IS REQUIRED, ALWAYS WEAR IT WITH THE CHIN STRAP SECURED. YOU CAN LOOK COOL WHEN YOUR STATION IS IDLE.

PERFORM A 3-POINT CHECK ON ALL SYSTEMS BEFORE USING THEM, ESPECIALLY THE ANCHORS!

“The question of which knot is the strongest in a given application is subject to debate. There are many publications with conflicting statistics caused by variations in testing procedures. In the real world, knot failure is most often attributed to poor knot tying.” – Don Sanderson

WHEN WORKING IN OR AROUND HIGH ANGLE OPERATIONS, BE AWARE OF THE DROP ZONE.

SIDEBAR DISCUSSIONS SHALL NOT BE HELD!!! LISTEN WHEN THE INSTRUCTOR IS SHARING THEIR THOUGHTS AND IF YOU NEED TO CHAT, KEEP YOUR DISCUSSION TO THE SUBJECT AT HAND.

WHEN WORKING WITHIN 5 FEET OF ANY EDGE YOU SHALL BE TIED OFF.

WHEN DORNING YOUR HARNESS, BACK IT UP WITH AN OVERHAND AND/OR DOUBLE BACK THROUGH THE BUCKLE.

DO NOT THROW EQUIPMENT!

NO SHOW BOATING!!!

OTHER THAN THAT...HAVE FUN!!!!

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, Bear Paw.

ASCENDER: A device used to grip a rope, which is then used to ascend. This may be 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.

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. This is the primary tool used in technical rescue for lowering loads or performing a rappel based pick-off. 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): The primary tool used to assemble the system. 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.

CRITICAL ANGLE: An interior angle of 90 degrees should not be exceeded. As the interior angle, or also known as the field angle, approaches 180 degrees, the forces on the system are multiplied.

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

DYNAMIC: High stretch and shock-load absorbing.

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.

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: Loss of efficiency within the system (*contributes to global warming!*)

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: Generally referred to as a slope that exceeds an angle of 60 degrees. At this angle you are still using a mainline and belay line but you are usually only using one litter attendant to attend to and manipulate the litter and patient package.

HIGH STRETCH ROPE: A rope used to lessen the forces created in a fall situation. This type of rope is not used for rescue situations but should be considered for lead climbing situations. A high stretch rope may be referred to as a dynamic rope.

HELMET: Used to protect the head from dain bramage. There should be a Fastex quick release buckle and a four-point suspension system. You should be able to mount an electric headlamp without drilling holes.

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 225 pounds of force.

LOAD RELEASE HITCH: A method of decreasing the forces on the system by slacking the system or releasing the load at a pre-arranged point. We will use the Radium Release Hitch as the Zone One standard.

LOW ANGLE: Where the angle of the slope, and the exposures to hazards for the rescuers and patient are low. For low angle rescues, litter attendants are able to literally walk the litter with patient up the hill. At a minimum a belay line is incorporated and on some occasions a 2:1 mechanical advantage to overcome minor obstacles and slope variations.

MAIN LITTER ATTACHMENT POINT: The ring, carabiner, 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. Not recommended for use in Zone One. **See Tandem Prusik Belay.**

NFPA: **National Fire Protection Association** establishes safety standards, including life safety equipment standards for firefighters. This also includes equipment standards for rope rescue.

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. Also known as Perlon.

PERSONAL PRUSIK: Used for personal fall protection, can be double wrapped. Usually made from 6mm or 7mm nylon cord.

PIGGYBACK SYSTEMS: This is a pulley system attached to an existing mainline system.

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.

PRUSIK WRENCH: A method of unjamming locked carabiners by placing a girth hitch made with accessory cord around the knurled gate screw for added leverage. This method distributes the forces around the gate as opposed to squeezing it with a pair of pliers.

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.

RADIUM RELEASE HITCH: Standard release hitch within Zone One. Made by taking 10 meters of 8mm cord and tying a 3:1, finishing with a munter hitch.

RATCHET 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 must be 1/2" or 12.7 mm in diameter, in order to meet NFPA 1983 rescue rope standards. It must have an ultimate tensile strength of at least 9000 pounds. This allows for a 15:1 safety factor. The 15:1 meets NFPA's requirements for lifelines. (600 lbs x 15 = 9000 lbs). Rope used for both main and belay lines shall be low stretch kernmantle.

ROCK EXOTICA RESCUCENDER: A device used to form an attachment point to the rope. The Rock Exotica Rescucender is similar in shape to the Gibb's cam. The shell contains a hollowed-out area adjacent to the cam in order to give the rope a place to go instead of being squeezed flat against the shell. The Rescucender is designed to slip before damaging the rope. **Not to be used in lieu of a tandem Prusik belay.**

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 should have tip tags identifying this particular rope. A rope log shall be kept on all ropes indicating purchase date, when it was put into service, standing time and running time.

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. If you feel a bad spot, move back down the rope and close your eyes. Try to find the spot by feel alone. When in doubt, cut the rope at the bad spot. It is better to have two short ropes than one injured rescuer.

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. Selecting a harness should include hanging in it for a period of time before purchase. 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: 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#) means that they have been over-engineered. We have incorporated these tools into our litter rigging.

STEEL TOOLS: Steel will stretch a fair amount before failure unless heat-treated. Steel is heavier, stronger, and less brittle than aluminum.

STEEP ANGLE: An angle where it becomes impractical or inappropriate to just carry the litter and patient up the hill. Or where the need for a mechanical advantage system exceeds the capabilities of a 2:1 system. At this angle it would require a main line and a belay line with three litter attendants.

SYSTEM PRUSIK: Made from 8mm cord in lengths of 135 cm and 165 cm. Any system Prusik used on a main or belay line shall be triple wrapped.

TANDEM PRUSIK BELAY: This is the belay system of choice for rescue loads. It is made up of two Prusiks, one approximately 135 cm long and the other approximately 165 cm long.

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 have 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.

COMMON COMMANDS: (To use during this course)

“DOWN” command to lower from controller.

“DOWN EASY” command to slow the descent.

“DOWN DOWN DOWN” command to increase speed of descent.

“UP” command to raise from controller.

“UP EASY” command to slow the raise.

“UP UP UP” command to increase speed of raise.

“STOP” Command to stop from anyone.

“STOP! WHY STOP?” question from controller to determine problem.

“SET” Command by controller to set systems and prepare for reset or change over.

“RESET” After system is set, mechanical haul systems are reset for additional raising.

“BELAY READY?” “MAINLINE READY?” Controller asks if the system is ready, ready to move the load.

“BELAY READY” “MAIN LINE READY” Belay and Main line operators confirm they are ready to move, to lower or raise.

“ATTENDANT READY?” Controller asks attendant if he is ready for the system to move.

“ATTENDANT READY” Attendant confirms that he is ready.