

Chapter 2: Rope Rescue Equipment

Scope: This chapter services as an introduction to rope rescue equipment.

Terminal Learning Objective (TLO): At the end of this chapter, the student will be aware of the equipment included in the two general categories of rope rescue equipment: software and hardware.

Enabling Learning Objectives (ELO):

1. Describe the components, use/misuse, types, construction, size/dimension, and inspection/maintenance for a kernmantle rescue rope, prusik loop, webbing, load-releasing device, commercial harness, carabiner, brake bar rack, figure eight plate with ears, rescue pulley, mechanical grab device, anchor plate, and edge protection

Equipment is divided into two general categories: software and hardware. Software includes rope, webbing, prusik loops, and commercial harnesses. Hardware includes carabiners, pulleys, anchor plates, descent control devices, and mechanical rope grabs. It is not the intent to promote any one manufacturer's equipment. Throughout this chapter, there will be references made to specific brands of equipment and their instructions for use. Your agency may possess or purchase different brands of similar equipment. It is up to you and your agency to follow the manufacturer's instructions for each piece of equipment.

The minimum breaking strengths provided in this manual are evaluated in laboratory conditions. Other factors, including how various pieces of equipment interface, their age, condition, and past use will affect the actual breaking strengths of life safety rope and equipment.

Kernmantle Rescue Rope

Components

- Kern = Core.
 - Continuous parallel fibers throughout the length of the rope.
- Mantle = Sheath.
 - Braided jacket.
 - Half of the strands have a left twist.
 - The other half has a right twist.
 - Eliminates twist when loaded.
 - Protects kern (core).
 - 10% - 25% of the rope's strength.

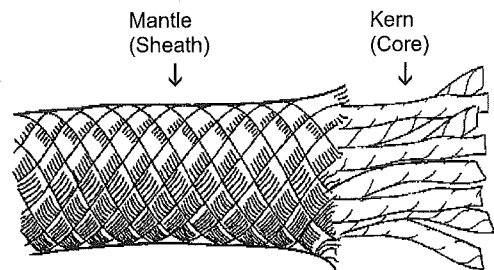


Figure 2-1: Kernmantle Rope

Use

- Primary tool for raising and lowering rescuers, equipment, and victims.
- Protects rescuers and victims as they move and work in elevated positions where a fall could cause injury or death.
- Used to create mechanical advantage systems.

Remember This Is Life Safety Rope! Treat It As If Your Life Depends On It!

Misuse

- Running the rope over sharp edges.
- Exposing the rope to excessive contamination from dirt and debris.
- Exposing the rope to excessive heat.
- Pulling or lifting vehicles.

Types

- High stretch (dynamic).
 - Greater than 10% stretch at 440 pounds force (1.95 kN).
 - May stretch to 60% at breaking strength.
 - Recreational climbing rope.
- Low stretch.
 - Has slightly more elongation than traditional static ropes.
 - Between 6% and 10% elongation at 10% of minimum breaking strength.
- Static.
 - Has slightly less elongation than low stretch ropes built to the same standard.
 - Less elongation prevents loss of system efficiency from rope stretch.
 - Preferred choice of the fire and technical rescue service.
 - ½" nylon kernmantle.
 - Most static kernmantle ropes have a thicker, tighter sheath than dynamic kernmantle ropes.
 - Provides additional protection to the kern (core) from abrasion and debris.
 - Less than 10% elongation at 10% of minimum breaking strength.

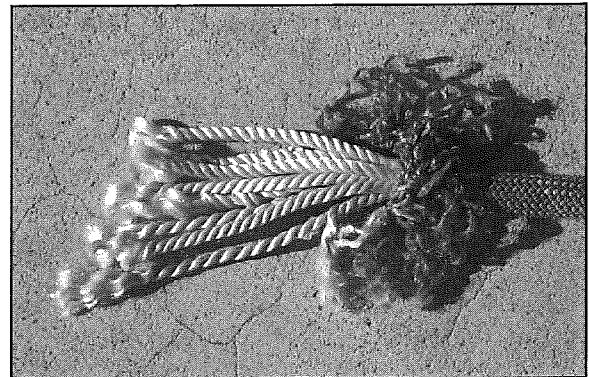


Figure 2-2: Dynamic Rope Core and Sheath

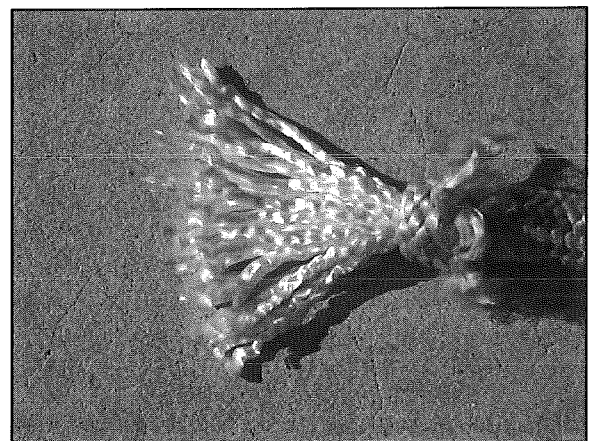


Figure 2-3: Static Rope Core and Sheath

Construction

- Only a few specially manufactured ropes meet the strength requirement.
- Kernmantle = core and sheath.
- Nylon (synthetic) is the most common.
 - Lighter.
 - Stronger.
 - More resistant to decay than natural fibers.
 - Loses 15% of its rated strength when wet, but quickly regains that loss when dried.

Size/Dimension

- ½" is most common.
- NFPA 1983 Standard on Fire Service Life Safety Rope and System Components compliant:
 - Two-person load (general use).
 - Minimum breaking strength of 40 kN (8,992 LBF).

Inspection/Maintenance

- Follow manufacturer's recommendations.
- Visual inspection.
 - Discoloration that could be from chemical contamination and/or sun exposure.
 - Burn marks from excessive friction and heat buildup.
 - Excess wear and abrasion of the sheath material.
 - Unusual wear.
 - Cuts.
 - Exposed core material.
- Physical inspection.
 - Soft spots.
 - Kinks.
 - Unusual bulges.
 - Inconsistent textures and flexibility.
 - Unequal diameter or thickness.
 - Excess contamination from dirt and debris.
 - Any of these could indicate damage to the core of the rope and may require taking a rope out of service.
 - If in doubt, take the rope out of service.

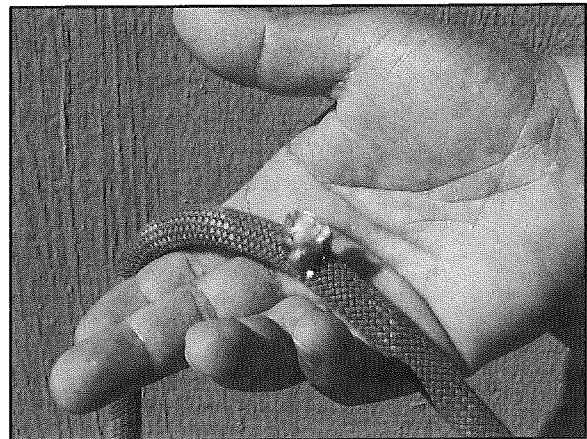


Figure 2-4: Visual Inspection

- Care and storage.
 - Stuffed into the rope bag for ease of deployment.
 - Do not coil.
 - Rope bag keeps the rope clean and protects it from ultra violet rays.
- Cleaning.
 - Keep clean of mud and dirt; can act as a sharp abrasive if allowed to work its way into the core of the rope.
 - Wash in a standard front-loading washing machine (should be placed in a dive bag or coiled), by hand in an open tub, or commercial rope washer.
 - Use cold water.
 - Do not use strong detergents.
 - May cause damage to the rope.
 - Ensure the rope is completely air dried before storing in a rope bag.
 - To avoid mildew and mold.
 - Do not dry in direct sunlight.
- Retiring/removing from service.
 - Excessive sheath wear.
 - More than half of the outer sheath yarns are broken in one pique.
 - After severe shock force from a fall or when stressed with a load beyond what it was designed to hold.
 - Contaminated by chemicals.
 - Worn out from use or age.
 - Inspection exposes an obvious fault or damage.
 - Usage cannot be accounted for.
 - The maximum life span for a lifeline is 10 years regardless of use per American Standards for Testing and Measures (ASTM) Standard F-1740.
 - Most rope manufacturers and rescue teams use a 5-year standard.
- Rope log.
 - Used for recording the usage of each rope and must be maintained.
 - Recorded information.
 - Purchase date.
 - Manufacturer.
 - Size.
 - Length.

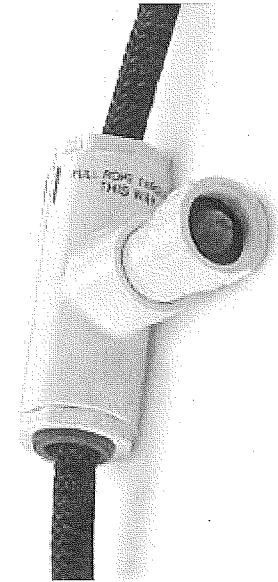


Figure 2-5: Rope Washer

- Whether it is high stretch (dynamic) or low stretch (static).
- Whether it is lifeline or utility grade rope (how the rope was used).
- Any unusual loading.
- Whether a fall was caught.
- Whether any object fell onto the rope.
- What materials (i.e., sand, glass, gasoline, etc.) the rope was in contact with.
- Washings.

<u>Rope Number</u> <u>Bag Color</u>
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Rope Use Log

(THIS ROPE MEETS NFPA STANDARDS FOR LIFE LINE USE)

Color:	Type:	Length:	Diameter:
Manufacturer:	Model:	Lot#	Strength:
Manufacturer Date (5 Year Life):		In Service Date	Page #

Show any cuts, abrasions, soft spots or frayed ends in the line to a Company Officer before bagging it

Date	Incident # and location or training location	How Used or Maintained	# of Uses	Type of Load	Observations	Print Name

Prusik Loop

Components

- Kernmantle (same as rope).

Use

- Haul cam/prusik.
 - Pulls the rope into motion.
- Ratchet cam/prusik.
 - Prevents the rope from moving out.
 - Tended by a pulley.
- Braking cam/prusik.
 - Prevents the rope from moving out.
 - Tended by a person.

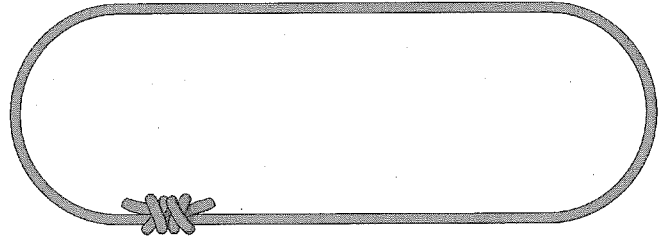


Figure 2-6: Prusik Loop

Misuse

- Same as rope.

Types

- Same as low stretch kernmantle.

Construction

- Double overhand bend is the preferred knot to form a prusik loop.

Size/Dimension

- 8mm for use on 1/2" rope.
- Length.
 - Variable depending on prusik minding pulley manufacturer.
 - Short prusik.
 - Should extend approximately 1" from pulley after being tied and set.
 - Long prusik.
 - Should extend 3"-4" beyond the short prusik.
 - Must extend in front of the descent control device after being set and formed.

Inspection/Maintenance

- Inspection (same as rope).
- Care and storage (same as rope).
- Cleaning (same as rope).
- Retiring/removing from service (same as rope).

Webbing

Components

- Varies, depending upon type of construction.

Use

- Build anchor slings.
- Build harnesses.
- Lashing.
- Load-releasing device.

Misuse

- Same as rope.

Types

- Flat
 - Constructed of a single layer or material.
 - Example: Seatbelt webbing.
 - Material is stiffer than tubular webbing.
- Shuttle loom (tubular webbing).
 - Has a continuous spiral of the fiber to form the webbing
 - Edge will not have a seam.
 - Due to manufacturing costs, shuttle loom is becoming more difficult to find.
- Needle loom (tubular webbing).
 - Formed by folding flat webbing lengthwise and stitching the two edges together.
 - Becoming the industry standard.

Construction

- Nylon.
- Strong, lightweight, synthetic material.

Size/Dimension

- Width.
 - 1" is the most common in rope rescue.
- Length.
 - Green = 5 feet
 - Yellow = 12 feet
 - Blue = 15 feet
 - Orange = 20 feet
- Strength.

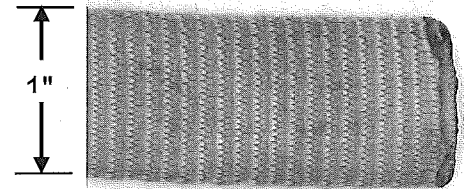


Figure 2-7: Flat Construction

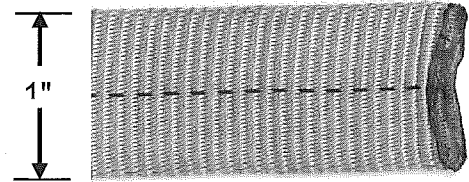


Figure 2-8: Shuttle Loom Construction

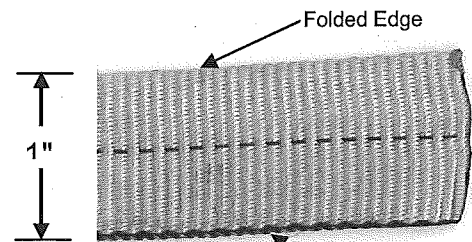


Figure 2-9:
Needle Loom Construction

- 1" tubular nylon – 4,000 lbs.
- 1" solid (flat) nylon – 6,000 lbs.

Inspection/Maintenance

- Inspection (same as rope).
- Care and storage.
 - Commonly stored in the pocket of the rope bag.
 - Daisy-chained or doubled over and tied for organization.
- Cleaning (same as rope).
- Retiring/removing from service.
 - Same as rope, plus when weave is broken and/or the material is contaminated with petroleum products or other caustic chemicals.

Load-releasing Device

Components

- Premanufactured flat webbing with D-ring at one end, a sewn loop at the other end, and a floating position D-ring in the middle of the webbing.
- One general use carabiner to attach the webbing into itself.

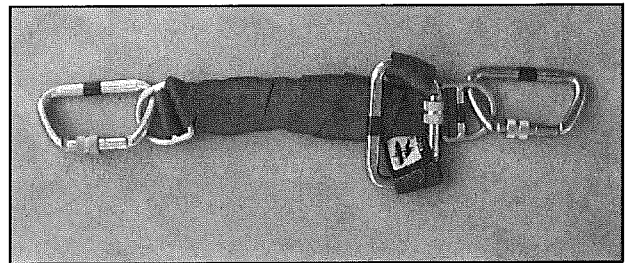


Figure 2-10: Assembled Load-releasing Device

Use

- Two primary purposes.
 - Transfer the load from the belay/safety line back to the main line.
 - If the belay/safety line tandem prusiks become loaded.
 - Has some shock absorbing capacity.
 - Can be used for changing over from a raising system to a lowering system or from a lowering system to a raising system.

Misuse

- Releasing the device without being certain that the load can be successfully transferred to another system.
- Attach backwards.
- Attaching the load-releasing strap carabiner to the anchor or load.

Types

- Manufactured strap (webbing).
- This course utilizes the manufactured strap design.
- Preassembled rope or accessory cord with carabiner.

Construction

- Webbing strap (flat nylon).
- D-ring.
- Floating D-ring.

Size/Dimension

- Webbing.
 - 1 $\frac{3}{4}$ " wide.
 - 55" long.
 - Minimum breaking strength of 45 kN (10,120 LBF).

Inspection/Maintenance

- Inspection.
 - Same as rope, plus:
 - Buckle D-rings for cracks and elongation.
 - Webbing and stitching for fraying and excessive wear.
- Care and storage.
 - Same as rope plus do not drop or throw.
- Cleaning.
 - Do not put in a washing machine.
 - Follow manufacturer's instructions.
- Retiring/removing from service.
 - Weave is broken through.
 - Material is contaminated with petroleum products or other caustic chemicals.
 - D-rings are cracked or elongated.

Commercial Harness

Components

- Manufactured harness with or without padding.
- D-ring attachment in front.
- Adjustable waist and leg straps.
- Optional gear loops.

Use

- Attach rescuer or victim to a rope system.

Misuse

- Not adjusted properly.
- Not following manufacturer's recommendations for use, care, and maintenance.
- Suspension syndrome, due to hanging in harness instead of sitting in harness.

Types

- Class I.
 - Harness that fastens around the waist, thighs, or under buttocks.
 - Designed to be used for emergency escapes with one-person loads.
- Class II.
 - Harness that fastens around the waist and thighs or under buttocks.
 - Designed for rescue where two-person loads can be encountered.
- Class III.
 - Harness that fastens around the waist, thighs, or under the buttocks and over the shoulders.
 - Can be a one- or two-piece model depending upon manufacturer.
 - Designed for rescue where two-person loads can be encountered.
- Victim harness.
 - Harness that attaches quickly and securely around the waist and thighs or under buttocks no matter where or how the victim is positioned.
 - The design allows the harness to be put on without the victim having to step into the harness.

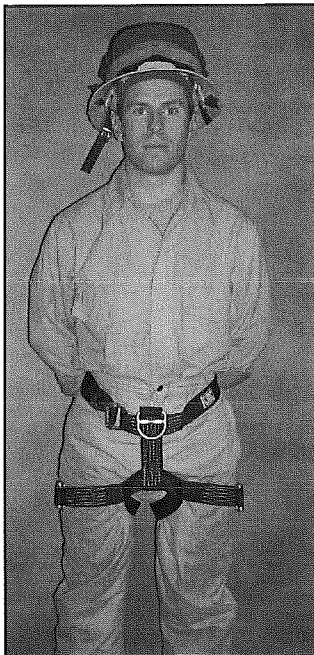


Figure 2-11: Class II Harness

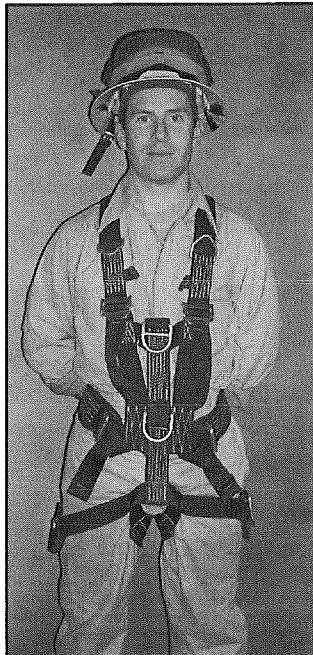


Figure 2-12: Class III Harness

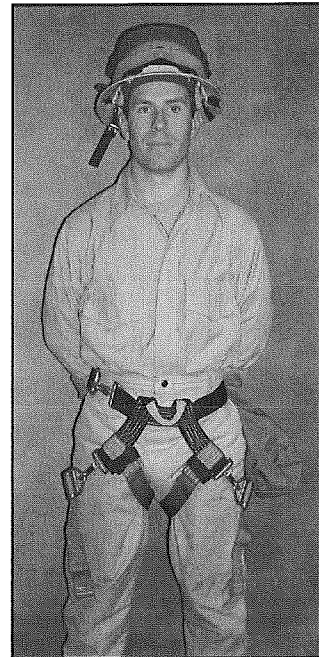


Figure 2-13: Victim Harness

Construction

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

Size/Dimension

- Varies depending upon manufacturer.

Inspection/Maintenance

- Inspection.
 - Same as load release device, plus pay particular attention to frayed stitching.
- Care and storage.
 - Same as rope, plus:
 - Do not drop or throw.
 - Follow manufacturer's instructions.
- Cleaning.
 - Hand wash; do not put in a washing machine.
- Retiring/removing from service.
 - When subjected to shock loads, fall loads, or abuse outside of normal limits.
- The fall protection industry recommends a service life for a harness or belt of 2-3 years.
 - The fall protection industry recommends a shelf life of 7 years.

Carabiner

Components

- Spine.
- Lock.
- Gate.
- Hinge.

Use

- Load-bearing metal connectors that link the elements of the rescue system.
- Create friction.

Misuse

- Side loading.
- Using a carabiner as a brake bar.
- Dropping or throwing.
- Locking nut after loading system.
- Unlocking when under load.

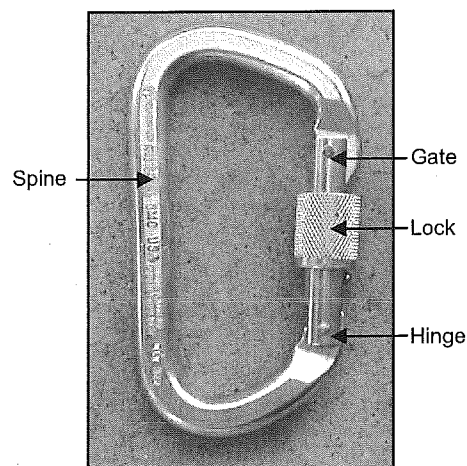


Figure 2-14: Components

Types

- Oval.
- D-shape.
- Modified D.
- Nonlocking.
- Locking.
- Auto locking.

Construction

- Steel or aluminum.
- NFPA 1983 Standard on Fire Service Life Safety Rope and System Components "General Use" compliant.
 - Major axis breaking strength.
 - Gate closed of at least 40 kN (8,992 LBF).

Size/Dimension

- Varies depending upon use.
- Rescue use/applications require NFPA 1983 Standard on Fire Service Life Safety Rope and System Components general use compliance.

Inspection/Maintenance

- Inspection.
 - Dents.
 - Burrs.
 - Rust/corrosion.
 - Cracks and gouges.
 - Proper gate and lock function.
- Care and storage.
 - Remove burrs and sharp edges with small file or emery cloth.
- Cleaning.
 - Clean with water and wipe dry with cloth.
- Retiring/removing from service.
 - Deformed.
 - Gate fails to lock or sticks.
 - Cracked or gouged.
 - Dropped from head height.

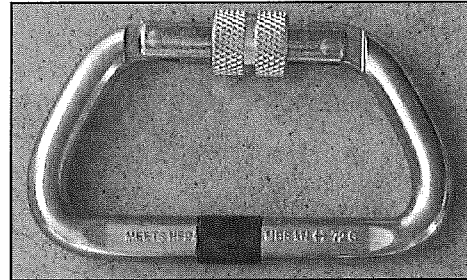


Figure 2-15: Locking D

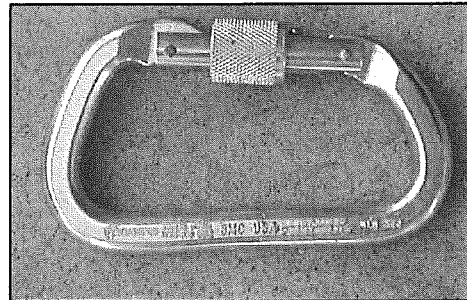


Figure 2-16: Locking Modified D

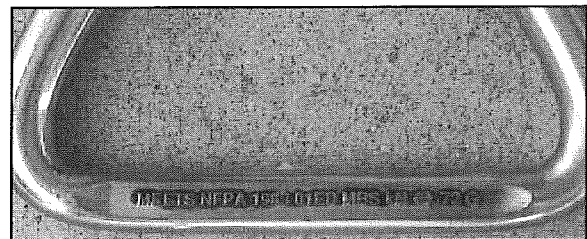


Figure 2-17: NFPA Label

Brake Bar Rack

Components

- An inverted U-shaped frame with a welded eye at one end and a nut on the other.
- A series of bars with a hole in one end enabling the bars to slide along the long side of the frame.

Use

- Create friction.
 - Rappel.
 - Lower.
- Advantages.
 - Adjustable friction.
 - Without interruption to lowering or rappel.
 - Does not twist rope.
- Disadvantages.
 - Complex to reeve.
 - Can be side-loaded.
 - Length can create difficulties at low point of departure.

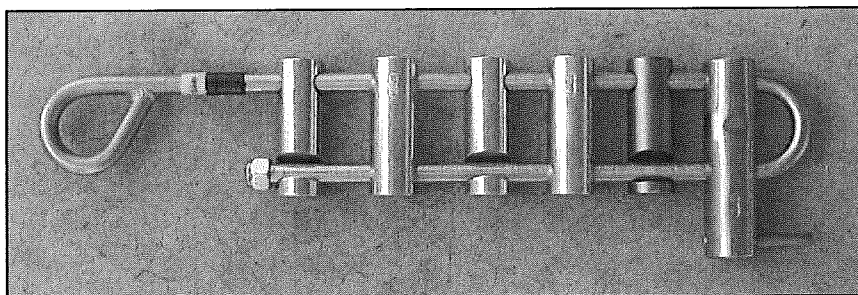


Figure 2-18: Brake Bar Rack with Tie-off Bar

Misuse

- Rigging the rope onto the bars the wrong way.

Types

- Standard racks with and without a "tie-off bar."
 - Racks with 90° twist of eye.
- U-shaped racks.

Construction

- NFPA 1983 Standard on Fire Service Life Safety Rope and System Components compliant.
 - Minimum breaking strength of 22 kN (4,946 LBF).
- Steel rack.
- Aluminum bars.
 - Advantages.
 - Provides more friction.
 - Lightweight.
 - Disadvantages.

- Streaks rope.
- Steel bars.
 - Advantages.
 - No streaking of rope.
 - Disadvantages.
 - Provides less friction.
 - Heavier than aluminum.

Size/Dimension

- Varies, depending upon use and manufacturer.

Inspection/Maintenance

- Inspection.
 - Secure nut.
 - Bent rack.
 - Worn bars.
 - Cracks.
 - Burrs and/or sharp edges.
- Care and storage.
 - Remove burrs and sharp edges with small file or emery cloth.
- Cleaning.
 - Wipe clean with cloth.
- Retiring/removing from service.
 - Deformed or cracked.
 - When 15% or more of the original diameter of aluminum bars is worn away.
 - Dropped from more than head height.

Figure Eight Plate with Ears

Components

- Small ring (lower one) for clipping into a seat harness with a carabiner.
- Large ring (top one) through which rope passes to create friction.
- "Ears" or projections fabricated into the large ring.

Use

- Create friction.
 - Rappel.

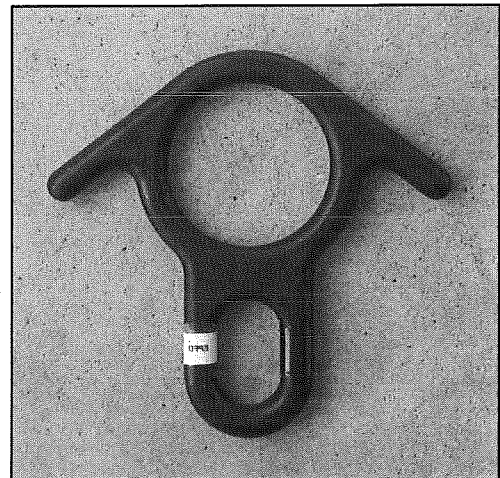


Figure 2-19: Figure Eight Plate with Ears

- Lower.
- Advantages.
 - Easy to reeve.
- Disadvantage.
 - Limited friction.
 - Once loaded, cannot add more friction to the device.

Misuse

- Using improper sized descender for the diameter of the rope being used.
- Used to gather equipment.

Types

- Conventional (without ears).
- Descender with ears.

Construction

- NFPA 1983 Standard on Fire Service Life Safety Rope and System Components compliant.
 - Minimum breaking strength of 22 kN (4,946 LBF).
- Aluminum.
- Steel.

Size/Dimension

- Varies, depending upon use and manufacturer.

Inspection/Maintenance

- Inspection.
 - Dents.
 - Cracks.
 - Sharp edges caused by rope wear.
 - Grooves caused by rope wear.
- Care and storage.
 - Remove burrs and sharp edges with small file or emery cloth.
 - Avoid dirty ropes.
 - Cause accelerated wear.
- Cleaning.
 - Wipe clean with cloth.
- Retiring/removing from service.
 - Deformed.
 - When 15% or more of the original diameter of aluminum bars is worn away.
 - Cracked.
 - Dropped from more than head height.

Rescue Pulley

Components

- Axle.
- Bearing.
- Sheave.
- Side plates or cheeks.

Use

- Change of direction.
- Mechanical advantage.
- Reduce friction.
- Tend prusiks (prusik minding pulley).

Misuse

- Side loading.
- Oversized/undersized rope.
- Attached with only one (1) side plate.
- Using wire/cable on rope pulley.

Types

- Light use (NFPA 1983 Standard on Fire Service Life Safety Rope and System Components).
- General use (NFPA 1983 Standard on Fire Service Life Safety Rope and System Components).
 - Prusik minding pulley.
 - Round pulley.
 - Confined space rescue.
 - Industrial/cable.

Construction

- Aluminum.
- Steel.
- Sealed ball bearing.
- Oilite® bronze bushing.
- NFPA 1983 Standard on Fire Service Life Safety Rope and System Components compliant.
 - Minimum breaking strength of 36 kN (8,093 LBF).

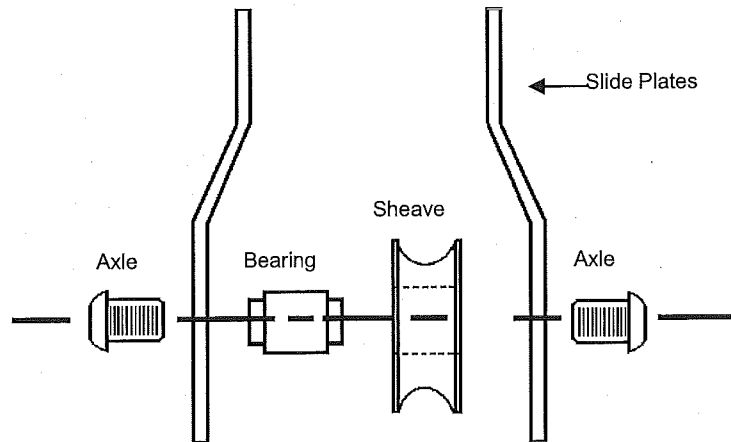


Figure 2-20: Rescue Pulley Components

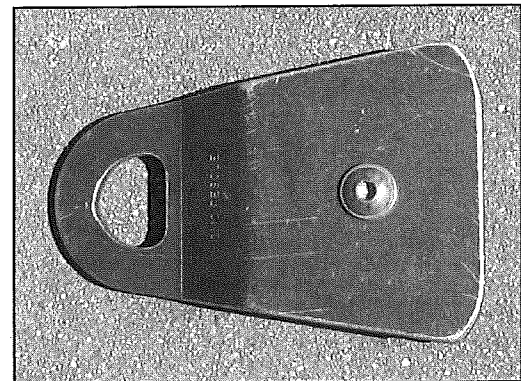


Figure 2-21: Prusik Minding Pulley

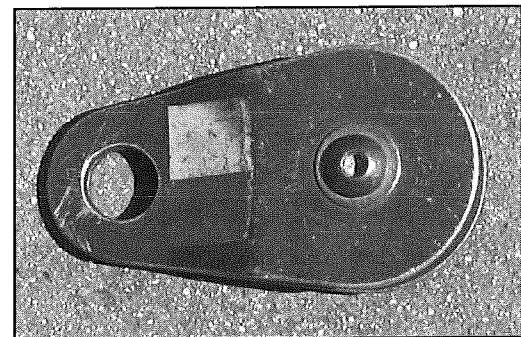


Figure 2-22: Round Pulley

Size/Dimension

- Determined by sheave diameter.
 - 1½" to 4".

Inspection/Maintenance

- Inspection.
 - Proper movement of side plates and sheave.
 - Egg shaped attachment hole, which indicates if the pulley has been over stressed.
 - Tightness of nuts and/or bolts on end of axle.
- Care and storage.
 - Remove burrs and sharp edges with small file or emery cloth.
 - Do not lubricate bearings or bushings.
- Cleaning.
 - Clean with water and wipe dry with cloth.
- Retiring/removing from service.
 - Cracked side plates.
 - Frozen pulley sheaves.

Mechanical Grab Device

Components

- Shell.
- Cam.
- Pin.

Use

- Ascender.
- Haul cam.

Misuse

- Used as belay/safety brake.
- Placed on rope incorrectly.

Types

- Varies depending upon manufacturer.

Construction

- Aluminum or steel.
- Model specific to rope diameter.
- Strength per manufacturer.

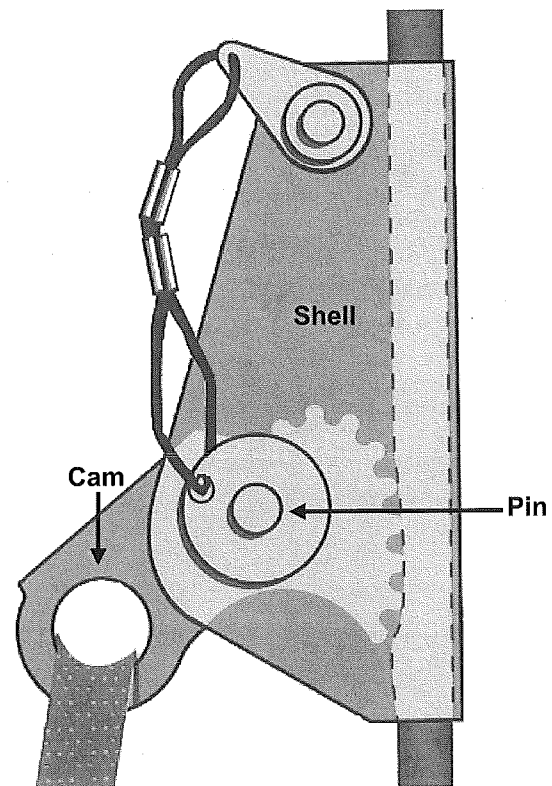


Figure 2-23: Ascender

Size/Dimension

- Varies, depending upon manufacturer.

Inspection/Maintenance

- Inspection.
 - Worn cam teeth.
 - Egg shaped holes for pin placement.
 - Cracks around holes for pin placement.
 - Worn cord, cable, or chain holding pin and cam to sleeve.
- Care and storage.
 - Store with components assembled.
- Cleaning.
 - Clean with water and wipe dry with cloth.
- Retiring/removing from service.
 - Sleeve or cam is cracked.
 - Sleeve is deformed.
 - Holes in the sleeve are worn enough to allow the pin to slip out.
 - Spring or other material holding cam and pin to sleeve is broken.
 - Dropped from more than head height.

Anchor Plate

Components

- Large opening for anchor point attachment.
- Multiple smaller openings for system hardware attachment.

Use

- Help organize anchor and system component rigging.

Misuse

- Using one side of the plate for both anchor system and component system rigging.

Types

- Attachment openings vary depending upon manufacturer.

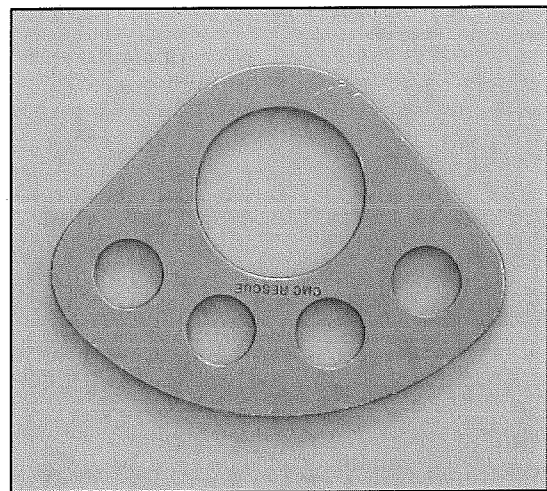


Figure 2-24: Anchor Plate



LOW ANGLE ROPE RESCUE OPERATIONAL



Construction

- Stamped or machined out of billet sheet aluminum.
- Stainless steel.
- NFPA Standard on Fire Service Life Safety Rope and System Components general use minimums.
 - Tensile strength of at least 36 kN (8,093 LBF).

Size/Dimension

- Varies, depending upon manufacturer.

Inspection/Maintenance

- Inspection.
 - Cracks.
 - Deformation.
 - Burrs.
- Care and storage.
 - Remove burrs and sharp edges with small file or emery cloth.
- Cleaning.
 - Clean with water and wipe dry with cloth.
- Retiring/removing from service.
 - Cracked.
 - Deformed.
 - Dropped from more than head height.

Edge Protection

Components

- Varies depending upon manufactured type and construction.

Use

- Protects rope and other system software from abrasion and sharp edges.

Misuse

- Not secured at departure edge.

Types

- Edge roller.
- Edge guard.

Construction

- Edge roller.
 - Aluminum wheels and frame.
 - Frames connect together in series.
- Edge guard.
 - Canvas.
 - Fire hose.
 - Plastic.

Size/Dimension

- Varies, depending on type and manufacturer.

Inspection/Maintenance

- Edge roller inspection.
 - Tightness of any nuts and/or bolts.
 - Wear on rope contact points.
 - Moving parts should move smoothly.
- Edge guard inspection.
 - Excessive wear.
- Care and storage.
 - Per manufacturer's recommendations.
- Cleaning.
 - Clean with water and wipe dry with cloth.
- Retiring/removing from service.
 - Edge roller.
 - Rollers are bent, stuck, or otherwise broken, including bent or broken frame.
 - Edge guard.
 - Material worn through at rope contact points.

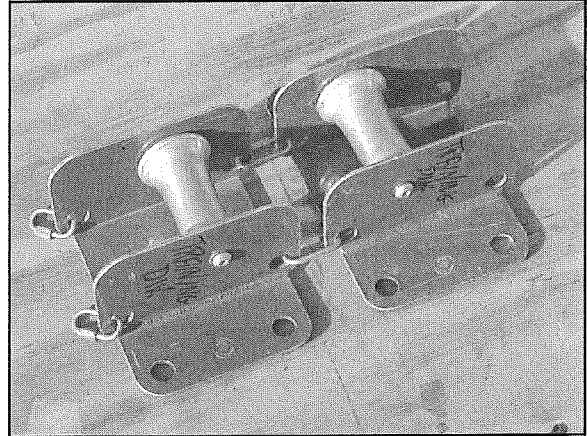


Figure 2-25: Edge Roller



Figure 2-26: Edge Guard