Knots for Arboriculture

Vtio
victorian
tree industry
organisation

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INTRODUCTION

Good knowledge of knots and knot tying is essential for the climbing arborist. Although it is possible to 'muddle through' with just a handful of basic knots, using the wrong knot for a particular application can be awkward and hard to untie at best, and flat-out lethal at worst.

This document attempts to provide some foundations for understanding the different sorts of rope used in arboriculture; their construction and intended use. In addition, a large range of knots commonly used by climbing arborists are presented and described, and their particular strengths and weaknesses categorised. A simple photographic guide to tying each knot is also included.

As discussed below, "*You must be sure of tying your knots correctly, and the best way to learn them is through repetition. You can then identify the knot through recognition. If you cannot recognise the knot you have tied then you probably have not tied it correctly or as intended. Make sure it is* <u>*always*</u> *tied correctly*."

In other words, as with any unfamiliar technique, it is important to practice on or near the ground until you are completely confident, before using a knot for life-support or for rigging.

1 ROPES FOR ARBORICULTURE

Man has used rope in one form or another since the earliest days. In fact, the use of creepers or vines as climbing aids arguably pre-dates any other form of tool, taking us back to a time before the species learned to walk upright or make fire.

In the arboricultural industry ropes are used primarily for safety and rigging. To utilise the correct ropes the tree worker or arborist should know the different types and how to correctly use and care for the ropes available.

Knowing the types of ropes available allows you to select the best rope for the job to be undertaken. Important considerations are:

- Strength
- Elasticity(Elongation)
- Weight
- Maintenance

DEFINITION OF ROPE:

A rope is a length of fibres, twisted or braided together to improve strength for pulling and connecting. It has tensile strength but is too flexible to provide compressive strength (i.e. it can be used for pulling, not pushing). Rope is thicker and stronger than similarly constructed cord, line, string or twine.[1]

NATURAL FIBRES:

Natural fibre rope such as Manila, Sisal, Coir and Hemp/Flax are very rarely used in modern arboriculture and should be avoided. They tend to be very inconsistent with breaking strains and SWL (Safe Working Loads) and tend to break down in the elements too quickly to be trustworthy for prolonged use.

SYNTHETIC FIBRES:

Polyester is very close to nylon in strength when a steady force is applied. However, unlike nylon, polyester stretches very little (roughly 38% extension) and therefore cannot absorb shock loads as well. It is as equally resistant as nylon to moisture and chemicals, but is superior in resistance to abrasion and sunlight.

In arboriculture polyester represents by far the largest percentage of ropes we use as it has the right durability, elongation and strength requirements for our day to day industry requirements.

SYNTHETIC FIBRES (Continued)

Nylon is the strongest of all ropes in common use (excluding hi-tech fibres). When stretched it has a 'memory' for returning to its original length. For this reason it is best for absorbing shock loads, as is the case when lifting or towing. Nylon lasts 4-5 times longer than natural fibres because it has good abrasion resistance and is not damaged by oil or most chemicals. Like manila, nylon has good resistance to ultraviolet deterioration from sunlight, referred to as "U.V. stability". It can have around 48% ultimate extension, and a melting point close to 250°C.

In Arboriculture Nylon ropes are generally used for specialist rigging jobs to try to reduce the impact of shock loading. For most day to day tree work Nylon ropes tend to be a little too stretchy, this is however dependant on the rope's construction.

Polypropylene (Poly), because of its light weight, is one of the few ropes that float. For this reason, it is very popular for pool markers and water sports. Poly is affected by sunlight deterioration, more so than any other synthetic or natural fibre rope, but its life can be extended by storing it away from direct sunlight. Poly begins to weaken and melt at 150°F, the lowest melting point of all synthetic ropes (excluding Hi-tech fibres). It is not as strong as nylon or polyester with 38% extension but it is 2-3 times stronger than manila. Because poly is less expensive than other fibres, it is the most popular all-purpose rope for the average consumer.

In Arboriculture Poly ropes are generally used for rough rigging work where if the ropes are damaged it is of little concern.

HI-TECH FIBRES:

In recent years developments with synthetic fibres such as Kevlar, Spectra / Dyneema, Technora, Vectran and selected others have lead to the development and production of Hi-Performance - Hi-Tech ropes. These synthetic fibres are used by leading rope manufacturers for the possible replacement of conventional steel wire rope because of the weight to strength ratio. High performance ropes are used in marine, oilfield, offshore, shipping, mooring, construction, aerospace applications and arboricultural climbing and rigging operations.

Kevlar is a synthetic fibre primarily used in ropes for high heat resistance, low elasticity and high strength.

Technora is a synthetic fibre primarily used in ropes for high strength and low elasticity. Good abrasion resistance and high resistance to heat. Ideal for Prussik cords and harness bridges etc.

Spectra - HMWPE **-** A high molecular weight polyethylene fibre. A synthetic fibre which is one of the world's strongest yarns. It provides very high strength to its weight ratio, low moisture absorption and has excellent abrasion resistance, but a low resistance to heat. Excellent for winch lines due to its low elongation. Low elongation results in a poor ability to handle shock loading.

Dyneema - UHMWPE – An ultra high molecular weight polyethylene fibre. A synthetic fibre providing high abrasion resistance, very low elongation, highest strength to weight ratio of any fibre, approximately twice the strength of steel wire of the same diameter. Excellent flex fatigue resistance but a low resistance to heat.

ROPE CONSTRUCTION TYPES

There are two broad types of rope: braided rope and twisted rope, each of which has very different characteristics. In order to optimize a rope's performance and safety, it is important to select the correct rope construction for a given application.

Twisted Ropes are made by twisting bundles of individual yarns together to form 3 strands, which are then themselves twisted together to form the rope. As the successive bundles of fibre are twisted together, the direction of the twisting is alternated so that the torque resulting from twisting in one direction is balanced against the torque resulting from twisting in the other direction. This counteracts the tendency of the three strands to unwind. These ropes can be recognized by their spiral shape. Some larger ropes may be made up of more than three strands.

Twisted ropes are typically less expensive than braided ropes, because the manufacturing process is faster. Twisted ropes can be easily spliced, however, despite the balancing of torque achieved by alternating the direction of twist; these ropes retain some torque, and therefore have a tendency to kink up, and to rotate under load.

Braided Ropes come in various braiding patterns, but always consist of bundles of fibre which are formed into 'strands' and then interlaced by passing each strand over and under other strands. This structure creates a round rope as opposed to the spiral shape of twisted ropes. This round shape makes them well suited for use with hardware such as pulleys, winches and rope grabs. Generally speaking, braided ropes are inherently torque free and non-rotating. Braiding is a relatively slow process, so ropes made in this fashion tend to be more costly than twisted ropes.

When braiding ropes, there are a number of variables the manufacturer can use to alter characteristics such as strength, elongation, flexibility, and durability. The following is a brief description of some of the more common types of braided ropes.

Solid or Sash Braid ropes are formed by braiding strands of fibre in a reasonably complicated pattern, with or without a filler core in the centre of the rope. Solid braid ropes tend to maintain their round shape, and therefore work exceptionally well in pulleys and sheaves. They tend to have high elongation but are generally less strong than other braided constructions.

Diamond Braid ropes are used extensively in arboriculture as climbing lines and cheaper rigging lines. They are formed by rotating half the strands of fibre in one direction, while the other half rotate in the other direction crossing alternately over and under each other. Diamond braid ropes tend to be flatter than some of the other constructions. Often a filler is put in the core of the rope to make it rounder and firmer or to build it up to a desired size. Diamond braid ropes tend to have moderate strength.

Double Braid ropes are used extensively in arboriculture as high quality rigging lines and some modern light weight climbing lines. They are made by braiding one rope over the top of another, so you actually have a rope within a rope. The inner rope and outer rope are generally designed to share the load fairly evenly. These ropes tend to be very flexible, strong and easy to handle. Eyes can be spliced into the ends of these ropes. Double Braid ropes are very popular in boating and marine applications. However, caution must be exercised where double braid ropes are run over pulleys, through hardware or in any situation where the outer rope may slide along on the inner rope and bunch up. This condition, often called "milking", will cause dramatic loss of strength by causing the entire load to go onto the inner rope, because the sheath is bunched up and therefore not under the same tension as the inner rope.

Kernmantle ropes are also used in arboriculture as climbing lines and specialist access lines. They are made by braiding a cover (mantle) over a core (kern). The core may be made of filaments of fibre lying essentially parallel inside the rope or it may be twisted into little bundles much like miniature twisted ropes. In some cases it will be made of small braided ropes. Kernmantle ropes are always designed so that the inner core is taking most, if not all of the load. The outer cover serves primarily to protect the fibres of the inner core. If ‘milking’ occurs on these ropes, it does not generally affect strength very much because the rope is designed so that the inner core is the load bearing member. These ropes are very strong and durable, and can be made to have very low elongation. Since the load bearing fibres are inside the protective outer cover, they are well protected from abrasion, dirt and ultra violet rays. All other forms of rope have the load bearing fibres exposed, resulting in faster deterioration.

Kernmantle ropes are often categorized as either ***static*** meaning having very little stretch or ***dynamic*** meaning they have more stretch. These terms are however, relative since all ropes have some stretch. Kernmantle ropes have their origins in mountain climbing where the higher stretch versions are used to absorb energy if the climber falls. The low stretch versions are used in rappelling, rescue, and in most industrial safety applications where they are favoured because of their inherent toughness and the efficiency with which rope grabs work on them. They tend to be more expensive than other ropes because they are normally made from very high quality fibres and have stringent requirements for care in manufacturing, particularly where they are designed for use in life critical applications. Most of the higher initial cost is offset by their durability and because one can normally select a smaller kernmantle rope for any given application.

STANDARDS FOR STRENGTH AND USAGE

NEW ROPE TENSILE STRENGTHS

New rope tensile strengths are based on tests of new and unused rope of standard construction in accordance with manufacturer's Standard Test Methods. It can be expected that strengths will decrease as soon as a rope is put into use. Because of the wide range of rope use, changes in rope conditions, exposure to the many factors affecting rope behavior, and the possibility of risk to life and property, it is impossible to cover all aspects of rope applications or to make blanket recommendations as to working loads.

WORKING LOAD

Working loads are for rope in good condition with appropriate splices, in noncritical applications and under normal service conditions. Working loads are based on a percentage of the approximate breaking strength of new and unused rope of current manufacture. For our arborist rope products, when used under normal conditions, the working load percentage is 20% of published strengths for rigging lines and 10% for climbing. Normal working loads do not cover dynamic conditions such as shock loads or sustained loads, nor do they cover where life, limb or valuable property are involved. In these cases a lower working load must be used.

A higher working load may be selected only with expert knowledge of conditions and professional estimates of risk, if the rope has been inspected and found to be in good condition, and if the rope has not been subject to dynamic loading (such as sudden drops, snubs or pick-ups), excessive use, elevated temperatures, or extended periods under load.

NORMAL WORKING LOADS

Normal working loads are not applicable when rope has been subject to dynamic loading. Whenever a load is picked up, stopped, moved or swung there is an increased force due to dynamic loading. The more rapidly or suddenly such actions occur, the greater the increase will be. In extreme cases, the force put on the rope may be two, three, or even more times the normal load involved. Examples could be ropes used as a tow line, picking up a load on a slack line, or using rope to stop a falling object. Dynamic effects are greater on a low elongation rope such as polyester than on a high elongation rope such as nylon, and greater on a short rope than on a long one. Therefore, in all such applications normal working loads as given do not apply, for more information see page 24.

ROPE INSPECTION

Avoid using rope that shows signs of aging and wear. If in doubt, destroy the used rope. No type of visual inspection can be guaranteed to accurately and precisely determine the actual residual strength. When the fibers show wear in any given area, the rope should be re-spliced, downgraded, or replaced. Check the line regularly for frayed strands and broken yarns. Pulled strands should be re-threaded into the rope if possible. A pulled strand can snag on a foreign object during rope operation. Both outer and inner rope fibers contribute to the strength of the rope. When either is worn, the rope is naturally weakened. Open the strands of the rope and look for powdered fiber, which is one sign of internal wear. A heavily used rope will often become compacted or hard, which indicates reduced strength. The rope should be discarded if this condition exists.

AVOID OVERHEATING

Heat can seriously affect the strength of synthetic ropes. The temperatures at which 50 percent strength loss can occur are: Polypropylene 250° F, Nylon 350° F, Polyester 350° F. When using rope where the temperature exceeds these levels (or if it is too hot to hold), consult the manufacturer for recommendations as to the size and type of rope for the proposed continuous heat exposure conditions. When using ropes on a capstan or winch, care should be exercised to avoid surging while the capstan or winch head is rotating.The friction from this slippage causes localized overheating that can melt or fuse synthetic fibers, resulting in severe loss of tensile strength.

STORAGE

All rope should be stored clean, dry, out of direct sunlight, and away from extreme heat. It should be kept off the floor on racks to provide ventilation underneath. Never store rope on a concrete or dirt floor, and under no circumstances should cordage and acid or alkalies be kept in the same vicinity. Some synthetic rope (in particular polypropylene or polyethylene) may be severely weakened by prolonged exposure to ultraviolet (UV) rays unless specifically stabilized and/or pigmented to increase UV resistance. UV degradation is indicated by discoloration and the presence of splinters and slivers on the surface of the rope.

DYNAMIC LOADING

For dynamic loading applications involving severe exposure conditions, or for recommendations on special applications, consult the manufacturer. For more information see page 24.

DANGER TO PERSONNEL

Persons should be warned against the serious danger of standing in line with a rope under tension. Should the rope part, it may recoil with considerable force. In all cases where any such risks are present, or if there is any question about the loads involved or the condition of use, the working load should be substantially reduced and the rope properly inspected before every use.

AVOID ABRASIVE CONDITIONS

All rope will be severely damaged if subjected to rough surfaces or sharp edges. Chocks, bitts, winches, drums and other surfaces must be kept in good condition and free of burrs and rust. Pulleys must be free to rotate and should be of proper size to avoid excessive wear.

SPLICING AND KNOTS

Splices should be used instead of knots whenever possible because knots can decrease rope strength up to 50%. When splices are used, always use the manufacturer's recommended splicing procedures. When knots are used, be sure to take into consideration the knot's corresponding reduction to the rope strength and adjust your working load accordingly. For more information please see the Knots and Rigging section, pages 13 thru 14.

WINCHING LINES

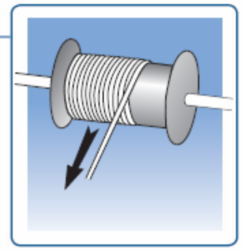
Braided rope can develop a twist when constantly used on a winch. This makes handling more difficult; the rope should be relaxed and rotated in the opposite direction to remove a twist. To avoid this condition, the direction of turns over the winch should be alternated regularly.

AVOID CHEMICAL EXPOSURE

Rope is subject to damage by chemicals. Consult the manufacturer for specific chemical exposure, such as solvents, acids, and alkalies. Consult the manufacturer for recommendations when a rope will be used where chemical exposure (either fumes or actual contact) can occur.

REMOVING ROPE FROM REEL OR COIL

Synthetic fiber ropes are normally shipped on reels for maximum protection while in transit. The rope should be removed from the reel by pulling it off the top while the reel is free to rotate. This can be accomplished by passing a pipe through the center of the reel and jacking it up until the reel is free from the ground. Rope should never be taken from a reel lying on its side. If the rope is supplied on a coil, it should always be uncoiled from the inside so that the first turn comes off the bottom in a counter-clockwise direction.



ROPE STORAGE

FIGURE 8

Great care must be taken in the stowage and proper coiling of braided ropes.

Braided ropes have no built-in twist and are far more resistant to kinking, than three-strand ropes. Even if kinks do develop they do not develop further into hockles.

The best method for making up braided rope is in figure-eight fashion. The rope should not be hand coiled in either direction as this merely puts turn into the line, which may develop into kinks when paying-out. Remember that there is no turn or twist in the line to begin with, so do not produce it by coiling.

COILING – TWISTED ROPES

Three-strand ropes should be coiled in a clockwise direction (or in the direction of the lay of the rope) and uncoiled in a counter-clockwise direction to avoid kinks.

BAGGING

Bagging is the most common method of storing braided or twisted climbing lines. The rope is allowed to fall into its natural position without deliberate direction.

AVOID KINKING AND HOCKLING

The continuous use of a line on one side of a winch or windlass is a common abuse that can render a line useless in a comparatively short time. Repeated hauling of a line over a winch in a counterclockwise direction will extend the lay of the rope and simultaneously shorten the twist of each strand. As this action continues, kinks (or hockles) will develop. Once these hockles appear, they cannot be removed and the rope is permanently damaged at the point of hockling.

If, on the other hand, the line is continuously hauled over a winch in a clockwise direction, the rope lay is shortened and the rope becomes stiff and will kink readily.

To avoid detrimental conditions, the direction of turns over the winch should be alternated regularly. Clockwise turns are recommended for the initial use of a new line. If this practice is observed, the original rope balance will be maintained and the lines will have a much longer useful life.

Excessive turns can cause kinking in any rope but hockles can occur only in the basic "twisted" ropes (three-strand, four-strand and cable-laid).

Braided and plaited ropes cannot be hockled; their inter-locking strand construction prevents the unlaying. Strands run in both directions creating a torque-free balance thus eliminating any inherent tendency toward twist or rotation. Swivels can be used safely but are seldom necessary. One word of caution here: when marrying a braided line to a twisted line (and also to wire rope) the twisted line can impart its twist to the braided line if the ropes are married without a swivel in between.

A braided or plaited rope, being torque-free, can have twist induced by constant working on winches and capstans. If a twist develops, it can easily be removed by "counter-rotating" when the rope is relaxed.

A hockled rope.

This page courtesy of Samson Cordage

ROPE LIFE FACTORS

There are basically three steps to consider in providing the longest possible service life for ropes, the safest conditions and long range economy: Selection, Usage, and Retirement.

1 SELECTION: SELECT THE RIGHT ROPE FOR THE JOB IN THE FIRST PLACE:

Selecting a rope involves evaluating a combination of factors. Some of these factors are straight forward like comparing rope specifications. Others are less quantitative like a preference for a specific color or how a rope feels in your hand. Cutting corners, reducing sizes or strengths on an initial purchase creates unnecessary replacements, potentially dangerous conditions and increases long term costs. Fiber and construction being equal, a larger rope will outlast a smaller rope, because of the greater surface wear distribution. By the same token, a stronger rope will outlast a weaker one, because it will be used at a lower percentage of its break strength with less chance of over stressing.

Consider the opinion of professional climbers who may have more experience as to how well a rope performs. Consider also the reputation of the rope manufacturer. Are they involved with and supportive of the arborist industry? Do they stand behind their products with consistent quality and reliable service? Buying unproven ropes because they are a little less expensive is false economy and can lead to disaster.

STRENGTH

When given a choice between ropes, select the strongest of any given size. A load of 200 pounds represents 2% of the strength of a rope with a breaking strength of 10,000 pounds. The same load represents 4% of the strength of a rope that has a breaking strength of 5,000 pounds. The weaker rope is having to work harder and as a result will have to be retired sooner. Braided ropes are stronger than twisted ropes that are the same size and fiber type.

ELONGATION

It is well accepted that ropes with lower elongation under load will give you better load control, a big help at complicated job sites. However, ropes with lower elongation that are shock loaded, like a lowering line, can fail without warning even though it appears to be in good shape. Low elongating ropes should be selected with the highest possible strength. Both twisted ropes and braided ropes are suitable for rigging. Twisted rope has lower strength and more stretch. Braided rope has higher strength and lower stretch.

FIRMNESS

Select ropes that are firm and round and hold their shape during use. Soft or mushy ropes will snag easily and abrade quickly causing accelerated strength loss. Because the fibers are in a straighter line, which improves strength but compromises durability, loose or mushy rope will almost always have higher break strengths than a similar rope that is firm and holds its shape.

2 USAGE: USE ROPE PROPERLY: OBSERVE RECOMMENDED SAFETY FACTORS. KEEP ROPES CLEAN AND AVOID SHOCK LOADS WHENEVER POSSIBLE.

Proper use of your ropes, maintaining them, and staying within recommended working loads will allow you to get the most from your rope investment. Working loads are calculated to maximize safety and extend the working life of both climbing and rigging lines. Dirt and grit embedded in the fibers can also significantly shorten rope life. Keep them clean, bagged and properly stored when not in use.

WORKING LOADS

Working loads are the loads that a rope is subjected to in everyday activity. They are normally expressed as a percentage of new rope strength and should not exceed 20% for rigging lines and 10% for climbing lines. A point to remember is that a rope may be severely overloaded or shock loaded in use without breaking. However, damage and strength loss may have occurred without any visible indication. The next time the rope is used under normal working loads the acquired weakness can cause it to break. Do not blame the rope, it was simply overloaded and failed from what is known as fatigue.

RECOMMENDED WORKLOAD LIMIT
(expressed as a percent of new rope strength)

Rope Used	Braided	Twisted
Climbing Line	10%	10%
Rigging Line	20%	20%

SHOCK LOADS

Shock loads are simply a sudden change in tension – from a state of relaxation or low load to one of high load. Any sudden load that exceeds the work load by more than 10% is considered a shock load. The further an object falls, the greater the impact. Synthetic fibers have a memory and retain the effects of being overloaded or shock loaded and can fail at a later time, even though loaded within the normal working load range.

This page courtesy of Samson Cordage

Sheeve diameters on rotating sheave blocks

Twisted Rope = 10 times the rope diameter

Braided Rope = 8 times the rope diameter

Fixed PIN Termination Diameter

The diameter on fixed pin termination should be at least 3 times the diameter – i.e., the bending radius for 1/2" rope should be 1-1/2"

KNOTS AND HITCHES

While it is true that a knot reduces rope strength, it is also true that a knot is a convenient way to attach a rope to tree limbs and other ropes. The strength loss is a result of the tight bends that occur in the knot. With some knots, ropes can loose up to 50% of their strength, which is part of the reason the work load limit should not exceed 20% of the rope strength.

ROPE STORAGE

Keep your ropes as clean and dry as possible and store them away from heat sources. Many climbers keep their ropes in special rope bags, which keep them clean and makes them easy to identify at the job site.

3 RETIREMENT: RETIRE ROPE FROM USE WHEN IT HAS REACHED ITS DISCARD POINT

One of the most frequently asked questions is "When should I retire my rope?" The most obvious answer is before it breaks. But, without a thorough understanding of how to inspect it and without knowing the load history, you are left making an educated guess. Unfortunately, there are no definitive rules nor industry guidelines to establish when a rope should be retired because there are so many variables that affect rope strength. Factors like load history, bending radius, abrasion, chemical exposure or some combination of those factors, make retirement decisions difficult. Inspecting your rope should be a continuous process of observation before, during and after each use. In synthetic fiber ropes the amount of strength loss due to abrasion and/or flexing is directly related to the amount of broken fiber in the rope's cross section. After each use, look and feel along every inch of the rope length inspecting for damage as listed below.

ABRASION

When the rope is first put into service, the outer filaments of the rope will quickly fuzz up. This is the result of these filaments breaking and this roughened surface actually forms a protective cushion and shield for the fibers underneath. This condition should stabilize, not progress. If the surface roughness increases, excessive abrasion is taking place and strength is being lost. As a general rule for braided ropes, when there is 25% or more wear from abrasion the rope should be retired from service. In other words, if 25% or more of the fiber is broken or worn away the rope should be removed from service. With three-strand ropes, 10% or more wear is accepted as the retirement point.

Look closely at both the inner and outer fibers. When either is worn the rope is obviously weakened. Open the strands and look for powdered fiber, which is one sign of internal wear. Estimate the internal wear to estimate total fiber abrasion. If total fiber loss is 20%, then it is safe to assume that the rope has lost 20% of its strength as a result of abrasion.

GLOSSY OR GLAZED AREAS

Glossy or glazed areas are signs of heat damage with more strength loss than the amount of melted fiber indicates. Fibers adjacent to the melted areas are probably damaged from excessive heat even though they appear normal. It is reasonable to assume that the melted fiber has damaged an equal amount of adjacent unmelted fiber.

DISCOLORATION

With use, all ropes get dirty. Be on the lookout for areas of discoloration that could be caused by chemical contamination. Determine the cause of the discoloration and replace the rope if it is brittle or stiff.

INCONSISTANT DIAMETER

Inspect for flat areas, bumps or lumps. This can indicate core or internal damage from overloading or shock loads and is usually sufficient reason to replace the rope.

INCONSISTANT TEXTURE/STIFFNESS

Inconsistant texture or stiff areas can indicate excessive dirt or grit embedded in the rope or shock load damage and is usually reason to replace the rope.

TEMPERATURE

When using rope, friction can be your best friend or worst enemy if it is not managed properly. By definition, friction creates heat, the greater the friction, the greater the heat buildup. Heat is an enemy to synthetic fiber and elevated temperatures can drastically reduce the strength and/or cause rope melt-through.

High temperatures can be achieved when surging rope on a capstan, checking ropes on a cable, or running over stuck or non-rolling sheaves or rollers. Each rope's construction and fiber type will yield a different coefficient of friction (reluctance to slip) in a new and used state. It is important to understand the operational demands and ensure the size, rope construction and fiber type be taken into account to minimize heat buildup.

Never let ropes under tension rub together or move relative to one another. Enough heat to melt the fibers can buildup and cause the rope to fail as quickly as if it had been cut with a knife.

Always be aware of areas of heat buildup and take steps to minimize it; under no circumstances let any rope come in contact with an exhaust muffler or any other hot object.The strength of a used rope can be determined by testing, but the rope is destroyed in the process so the ability to determine the retirement point before it fails in service is essential. That ability is based on a combination of education in rope use and construction along with good judgment and experience. Remember, you almost always get what you pay for in the form of performance and reliability.

The critical and melting temperatures for synthetic fibers are listed below:

TEMPERATURES	Critical	Melting
Dyneema®	150° F	297° F
Manila	180° F	350° F*
Polypropylene	250° F	330° F
Nylon	350° F	460° F
Polyester	350° F	480° F
Technora	450° F	900° F*

**While the term "melting" does not apply to these fibers, they do undergo extreme degradation at these temperatures: Technora and Manila char.*

ROPE INSPECTION AND RETIREMENT CONT.

ROPE INSPECTION CHECK LIST

Condition Discard Point

1. Original rope bulk reduced by abrasion:

- Double braid* cover by 50% ✓
- Twelve-strand braid by 25% ✓
- Eight-strand plait by 25% ✓
- Three-strand by 10% ✓

2. Fiber strands cut:

- Double braid* by three or more adjacent strands cut ✓
- Twelve-strand braid by two or more adjacent strands cut ✓
- Eight-strand plait by one or more adjacent strands cut ✓
- Three-strand by one or more adjacent strands cut ✓

**Refers to double braids that have both core and cover strength members.*

3. Diameter inconsistency:

- Localized diameter reduction ✓
- Flat areas ✓
- Lumps and bumps in rope ✓

4. Glossy or glazed fiber:

- Localized or extended areas ✓

5. Inconsistency of texture:

- Localized or extended areas of stiffness ✓

6. Discoloration:

- Localized or extended areas caused by chemical contamination ✓

This page courtesy of Samson Cordage

ORIGINAL BULK NEW ROPE

VOLUME REDUCTION

Rope displaying 25% strand volume reduction from abrasion – rope should be retired from service.

Note: Amount of volume reduction that indicates retirement depends on rope construction. Refer to "check list" at left.

PULLED STRAND

Rope displays a snagged strand. If the strand can be worked back into the rope, no need to retire. If not, this indicates a retirement point.

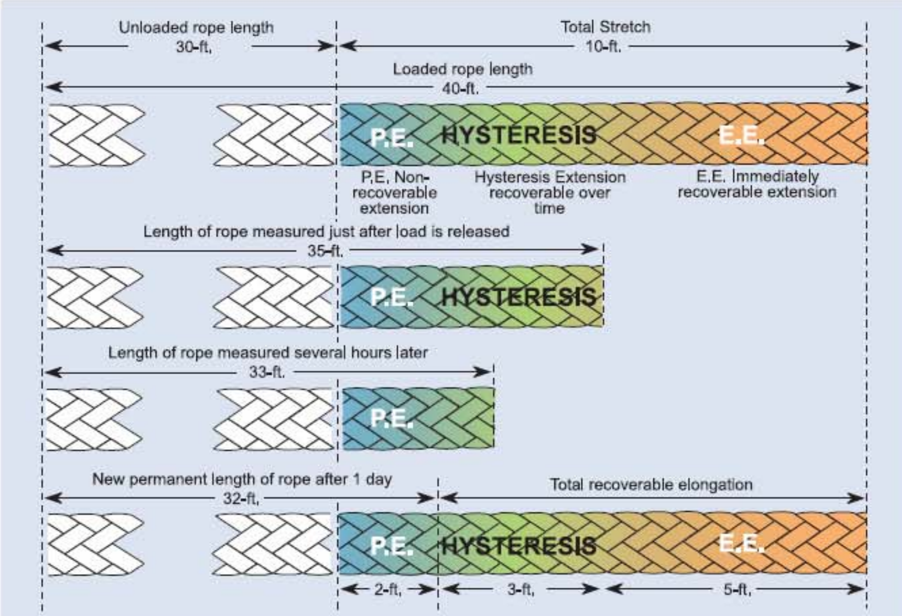
CUT STRANDS

Rope displays two adjacent cut strands. This rope should either be retired or the cut section should be removed. If possible, re-splice.

Note: Number of cut strands that indicate retirement depends on rope construction. See "check list" at left.

MELTING OR GLAZING

Damage depicted below caused by excessive heat, which melted and fused the fibers. This area will be extremely stiff. Unlike fiber compression, melting damage cannot be mitigated by flexing the rope. Melted areas must be cut out and rope respliced or the rope must be retired.



In order to establish definitions involving stretch in ropes, it is necessary to review the terms utilized to define the basic components of stretch.

ELONGATION DATA

Elastic Elongation (E.E.): Refers to the portion of stretch or extension of a rope that is immediately recoverable after the load on the rope is released. This recoverable tendency is a primary result of the fiber (or fibers) used as opposed to the rope construction. Each type of synthetic fiber inherently displays a unique degree of elasticity. Relatively, HMPE fiber has an extremely low elasticity compared to nylon fiber.

Hysteresis: Refers to a recoverable portion of stretch or extension over a period of time after a load is released. In measuring elastic recovery it is the recovery that occurs immediately when a load is removed. But thereafter, a remaining small percentage of elastic recovery will occur slowly and gradually over a period of hours or days. This retardation in recovery is measured on a length/time scale and is known as hysteresis or recovery over time.

Permanent Extension (P.E.) After Relaxed: That portion of extension which, due to constructional deformation (compacting of braid and helical changes) and some plastic deformation of the fibers, prevent the rope returning the original length.

Permanent Extension (P.E.) While Working: The amount of extension that exists when stress is removed but no time is given for hysteresis recovery. It includes the nonrecoverable and hysteresis extension as one value and represents any increase in length of a rope in a constant working situation such as during repeated surges in towing or other similar cyclical operations.

The percentage of Permanent Extension over the working load range is generally in order of four to six percent for braided ropes and two to three times as much for plaited – but will vary slightly with different fibers and rope constructions. In some applications, such as sub-surface mooring or devices that demand precise depth location and measurement, allowances must be made for this factor.

Cold Flow (Creep): Fiber deformation (elongation) due to molecular slippage under a constant static loading situation. Fibers that have this inherent characteristic will display extremely lower or negligible creep if minor fluctuations occur in the rate and or frequency of load levels.

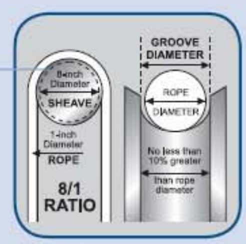
BENDING RADIUS

Any sharp bend in a rope under load decreases its strength substantially and may cause premature damage or failure. Many rope users are surprised to learn that a simple overhand knot (a series of sharp bends) reduces rope strength by almost 50%. In sizing the radius of bitts and fairleads for best performance the following guidelines are offered: Where a rope bends more than 10 degrees around its bitts or, for that matter, is bending across any surface, the diameter of that surface should not be less than 3 times the diameter of the rope. Another way of saying it is that the diameter of the surface should be at least 3 times the rope diameter. A 4 to 1 ratio (or larger) would be better yet as durability of the rope increases substantially as the diameter of the surface over which it is worked increases.

SHEAVE DIAMETER AND SIZES

Sheave Diameters Should Be:

- **Twisted/Plaited = 10 times rope diameter**
- **Braided = 8 times rope diameter**

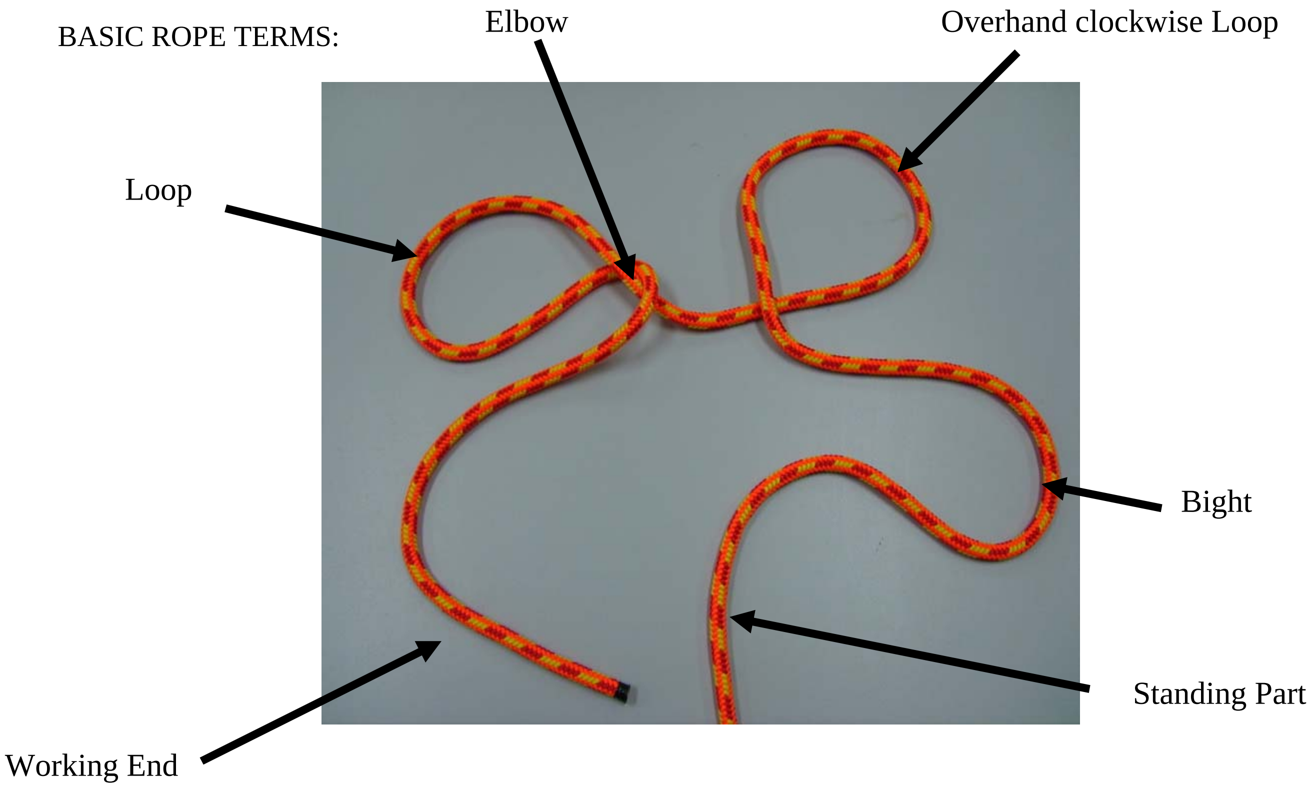


To assure maximum efficiency and safety, sheaves for braided ropes should be no less than eight (8) times rope diameter. Although an 8:1 ratio is preferred, 4:1 is widely accepted within the arborist industry. The sheave groove diameter should be no less than 10% greater than the rope diameter. The sheave groove should be round in shape. Sheaves with "V" shaped grooves should be avoided, as they tend to pinch and damage the rope through excessive friction and crushing of the rope fibers. Sheave surfaces should be kept smooth and free of burrs and gouges. Bearings should be maintained to ensure smooth rotation of sheaves.

This page courtesy of Samson Cordage

2 KNOTS FOR ARBORICULTURE

BASIC ROPE TERMS:



THE PARTS OF ROPE:

To tie and apply the knots in this document, first ensure you have grasped the basic terms referring to the respective parts and configurations of rope. Once you have familiarized yourself with these terms, you will be able to easily identify which part of a rope is being used at a particular stage of tying a knot.

The **working end** is the end that you are using to tie the knots; the **running end** is the end you are not tying with. You may still be using the running end in climbing/rigging situations.

The rope in between the two ends is the **standing part**. There are other various loops and turns which are made in the rope to help form knots and these may be called a **bight**, a **loop,** an **elbow,** or an **uncrossed loop**. A **turn** is where the rope loops around an object. See picture above for these terms and parts.

THE RULES OF KNOT TYING:

An arborist must know a range of knots and their application for different situations. Arborists must know how to choose the appropriate knot for a given situation, how to tie the correct knot and also untie the chosen knot. Importantly we must know how the knot will perform under load and not under load; also what other knots could be used to substitute for the selected knot.

Knots can be the best way to attach a rope to another object although the compromise is that the knot will weaken the strength of the rope. Different knots will weaken the rope by different amounts, but allow for a **loss of rope strength** by as much as **60%**. When calculating the **Safe Working Load: (S.W.L.),** of a rope with knots, factor this percentage into your calculations.

The tying of knots is broken up into three parts, these are as follows:

1. **T** = Tie — to tie the knot
2. **D** = Dress — to align all of the parts of the knot
3. **S** = Set — to tighten the knot ready for use.

You must be sure of tying your knots correctly, and the best way to learn them is through repetition. You can then identify the knot through recognition. If you cannot recognise the knot you have tied then you probably have not tied it correctly or as intended.

Make sure it is *always* tied correctly.

Also make sure you leave enough tail of rope beyond the end of a knot: as a general rule of thumb you should leave a tail roughly eight times the rope diameter, for example if you are tying a knot using 12.5mm (1/2 inch) rope you should leave a tail no shorter than 10cm (4 inches) long. The only exception to this rule is if you are tying a permanent knot such as a Double Fisherman's Bend (knot #6) and you either stitch or whip the ends to the body of the rope.

3 KNOTS ILLUSTRATED

BASIC KNOTS

1. **Bowline:** Also known as the Standing Bowline, Bolin or Bowling Knot. Possibly the best knot you could know, commonly known as the (King of Knots) because it is arguably the most versatile knot with numerous variations. When tied correctly as pictured below you will notice the ‘Working End’ of the rope finishing on the inside of the loop.

Uses: As an end line attachment knot in many rigging situations.

Pluses: The best thing about a Bowline knot is that even under extreme loading it remains easy to untie.

Minuses: The downside to this is that if it is not kept under constant tension it has a tendency to creep, distort and even unravel. For this reason the Bowline on its own or (Standing Bowline) is ***NOT*** acceptable as a Lifeline Attachment Knot; however there are acceptable variations listed bellow, refer to knots # 17 - #18.

2. Clove Hitch: Also known as the Waterman's Knot.

Uses: Second only to the Bowline (knot #1) in versatility. Commonly used as an end line attachment knot in many rigging situations such as attaching limbs to be lowered (must be Backed Up in this situation). It is also the best way to send items up to a climber that do not have a karabiner attached, such as a drink bottle, hand saw, etc.

Pluses: Very Quick and easy to tie, with practice it is able to be tied with one hand. Can be tied midline.

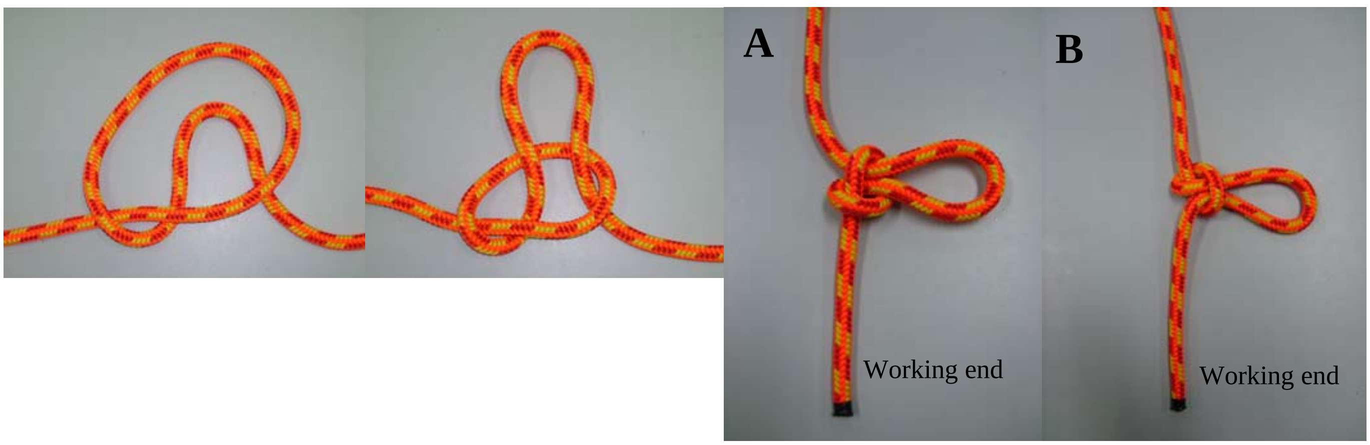
Minuses: If used as an end line attachment knot (NOT suitable for climbing) it must be backed up with a minimum of two half hitches to stop this hitch from potentially rolling out. The bigger the object it is tied to the easier it is for this hitch to role out. As easy as it is to tie it is just as easy to tie wrong, there is not much difference between the Clove Hitch, Girth Hitch (knot #4) and the Munters Hitch (knot #15).

3. **Marline Spike Hitch:** Picture (A) is also known as the Slip knot, or Slipped Overhand knot. Picture (B) is also known as a Simple Noose or Noose. The difference is if you pull on the ‘working end’ of (A) it tightens the loop, whereas if you pull on the ‘working end’ of (B) it pulls the loop through undoing the knot.

Uses: Most commonly used to clip equipment in to pass up to a climber (A) or can be tied underneath a Prussik knot as a backup to stop it from slipping (B), once tied a karabiner needs to be placed in the loop and clipped back onto the ‘working end’ to stop the loop slipping through if used in a climbing situation.

Pluses: Very quick and easy to tie and even easier to undo, it can also be tied midline.

Minuses: Easy to confuse knots A and B. If knot (B) is used to pass up a heavy object such as a chain saw it has the potential to pull the loop through and the saw fall to the ground. Whereas if knot (A) is used to back up a Prussik knot and the Prussik slips it will push the loop through undoing it with potentially fatal consequences.



4. Girth Hitch:

Uses: Mostly used in conjunction with the English Prussik (knot # 20) to stop the bottom of the loop moving around on the karabiner.

Pluses: As stated above it stops the loop moving around on the karabiner which significantly reduces the possibility of nose loading or gate loading the karabiner. It can be tied either with a loop or midline.

Minuses: Makes slipping the loop on and off a karabiner a fraction slower.

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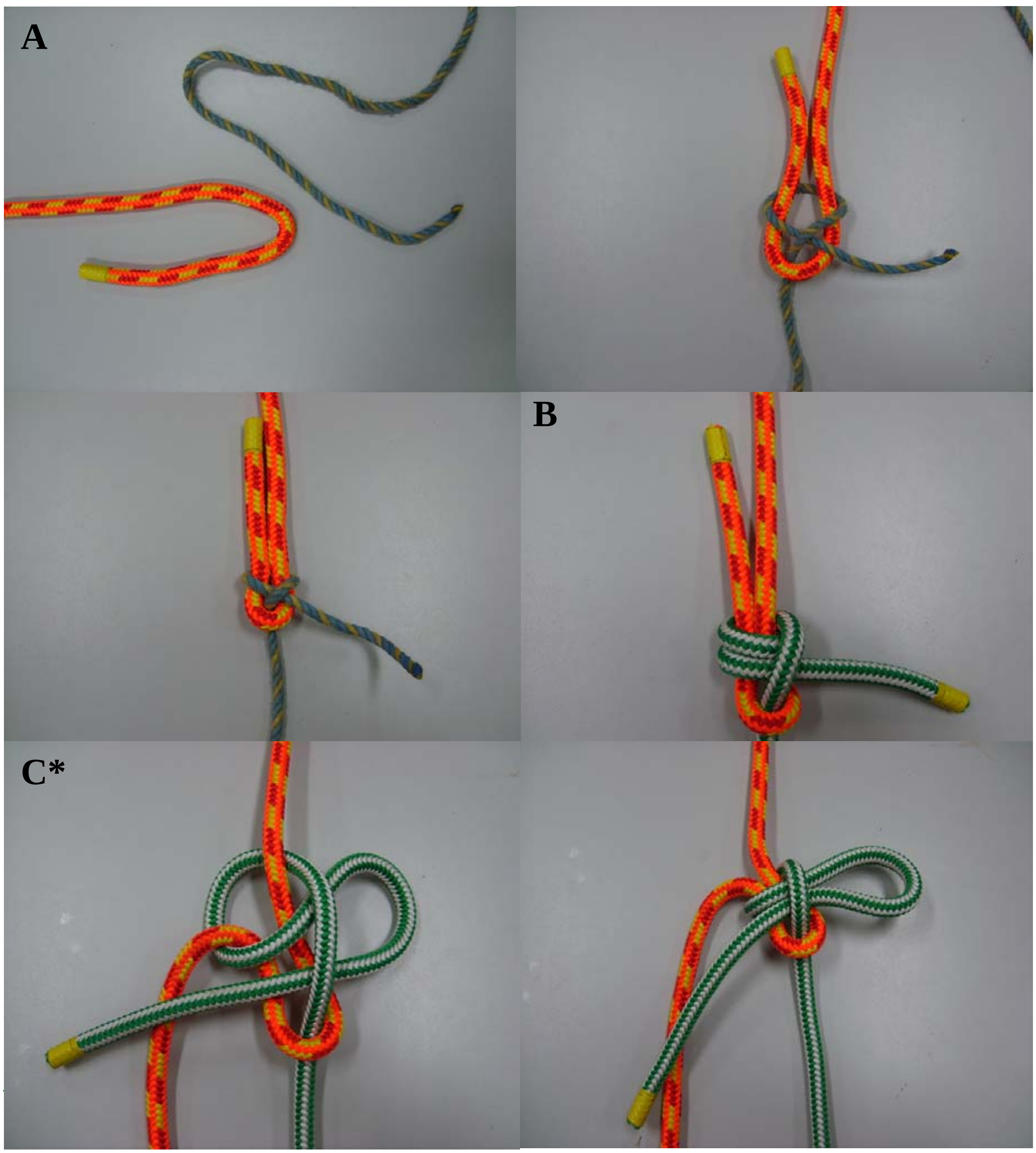
ROPE JOINING KNOTS:

5. Sheet Bend: Sheet Bend (A), Dbl. Sheet Bend (B), Slipped Sheet Bend or Quick Hitch (C*).

Uses: The Sheet Bend is one of the few knots that are effective for joining two ropes of different sizes and types. Make sure the smaller rope is the one tucked under its own 'standing part'. This knot has limited uses in Arboriculture, and is certainly *NOT* intended to be used in a life support situation. Its best use is to pass a rope up to a climber and version (C the Quick Hitch*) is best for this. For a more secure version use version (B the Double Sheet Bend).Use in light non critical rigging situations only.

Pluses: Easy to tie and untie even when loaded, can be tied midline.

Minuses: Not for life support or big loads. It reduces rope strength and has a tendency to slip.

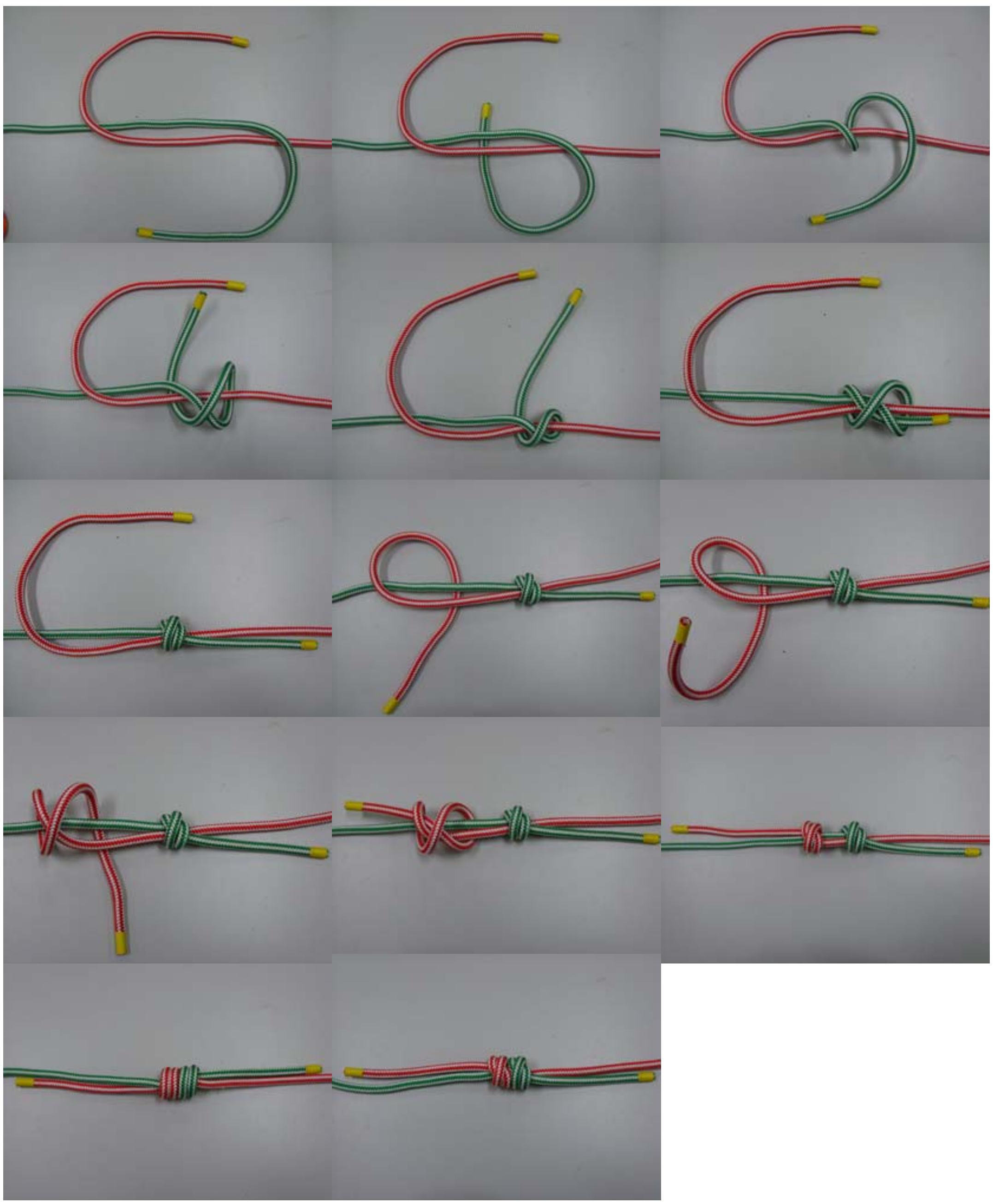


6. Double Fisherman's Knot: Also known as the Grapevine Knot.

Uses: For joining ropes together. It is most commonly used for making Prussik loops such as for the English Prussik (knot #20)

Pluses: Very secure life support knot for joining ropes together.

Minuses: Once loaded it can be very difficult to untie and is most commonly used in a permanent situation. Some modern heat resistant rope fibres are very slippery and can creep slowly so it is advisable to 'whip' or stitch the tail of the knot to the standing part of the rope once loaded.



7. Figure-Eight Bend: Also known as a Flemish Bend.

Uses: For joining ropes together in life support or heavy load situations.

Pluses: Very secure knot for joining ropes together. Easy to add additional backup if desired.

Minuses: A time consuming knot to tie that takes practice to 'dress' correctly. A relatively bulky knot that has a tendency to work tight over time.

HITCHES:

8. **Running Bowline:** Simply tie a bowline (knot #1) around its own 'standing part'.

Uses: A very useful knot for many rigging and climbing situations. In rigging this knot allows you to rig branches from a distance and is the preferred hitch used to pull a tree over. This hitch can also be used to set anchor slings for Pulley blocks, lowering devices and even belay devices. It also works well to isolate the trunk or limb as an anchor for SRT ascent (Single Rope climbing Technique). Important: if using for climbing the bowline needs to be backed up, refer to knots #17 – #18.

Pluses: As stated above this knot allows you to rig branches from a distance, simply throw the end of the rope over the desired limb, take the working end, tie a Standing Bowline (knot #1) around the 'standing part' of the rope and pull snug up to the branch. As per knot #1 even under extreme loading it remains easy to untie.

Minuses: The downside to this is that if it is not kept under constant tension it has a tendency to creep, distort, and even unravel. For this reason the Bowline on its own or (Standing Bowline) is ***NOT*** acceptable as a Lifeline Attachment Knot; however there are acceptable variations listed bellow, refer to knots # 17 - #18.

9. Timber Hitch:

Uses: The Timber Hitch is used for attaching an anchor sling to the trees trunk/branch to attach a lowering device, pulleys etc for rigging. It is important to have at least four wraps around the 'standing part' of the hitch and they need to be wrapped at least one-third around the circumference of the object. A stopper knot can also be added to the loose end.

Pluses: This is a very easy knot to tie and is very secure under load, it is also very easy to untie and does not jam. The timber Hitch also uses minimal rope.

Minuses: Not to be used for life support. This hitch is very susceptible to direction change and it is important to load the hitch vertically or ninety degrees (90°) to the bight, instead of horizontally (not to be used for pulling trees over). If the hitch slips sideways the wraps could bunch up severely compromising its hold on the object. Placing a Half Hitch below the Timber Hitch will reduce this.

10. Cows Hitch:

Uses: The Cows Hitch is used for attaching an anchor sling to the tree's trunk or branch to attach a lowering device, pulleys etc for rigging, and belay devices for climbing.

Pluses: More secure than the Timber Hitch and can be used for anchoring slings in climbing situations. Less susceptible to the issues of sideway or change of direction when loaded (care still needs to be taken to avoid this). Still easy to undo when loaded.

Minuses: This hitch requires a lot of rope because it has to travel around the trunk twice. Can slip with sideways movement depending on which way it is tied but less of a concern than with the Timber Hitch.

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MIDLINE KNOTS

11. Alpine Butterfly: Also known as the Butterfly Knot, Harness Loop, Single Lineman's Loop, Lineman's Loop or Artillery Man's Hitch. This knot can be confusing at first to tie so attached are two completely different ways to tie the same knot.

Uses: This knot makes an ideal midline/inline anchor point. It is also ideal for reducing rope spread around a limb for the secured foot lock technique, simply place the tail end of your access line through the loop of the Butterfly Knot (keep the loop small) and run it up under the limb.

Pluses: Very secure midline knot that is reasonably easy to undo when loaded. Both ends exit the knot in the direction of pull. It is visually easy to see if the knot has been 'tied, dressed, and set' correctly.

Minuses: This knot can be a little confusing at first to tie.

STOPPER KNOTS:

12. Double-Overhand Knot: Also known as Double-Fisherman's Stopper Knot, Blood Knot or Multiple-Overhand Knot.

Uses: End of climbing line stopper knot.

Pluses: Easily tied very secure stopper knot.

Minuses: Relatively bulky knot that can be difficult to untie if loaded, practice is required to correctly 'dress' this knot.

13. Figure-Eight Knot:

Uses: Stopper knot for use at end of Blake's Hitch etc, not recommended for end of life line.

Pluses: Very easy to tie and untie even when loaded.

Minuses: Has a tendency to undo itself if left unattended.

CLIMBING ESSENTIALS:

14. Closed Climbing System: Start by tying a Bowline Knot (Knot #1) leaving approximately 1.5m of tail after the knot with the working end of your climbing line. Using the remaining 1.5m of tail, tie a Blake's Hitch (Knot #21) around the running side of your climbing line leaving a comfortable length to advance the hitch between the two knots. Finish the system by tying a Figure-Eight Knot (Knot #13) as an all important stopper knot in the remaining tail. Now simply clip the Bowline Knot loop into your karabiner and you are ready to climb. It is acceptable to tie the Bowline directly into the 'D' rings of your harness.

Uses: Not commonly used as a climbing system as it requires re-tying every time the rope is set over a new fork. This configuration is normally reserved for a backup system or emergency system in the event you may have damaged/dropped your Prussik or you may simply need a second re-direct system using the other end of your climbing line. For these reasons a system like this is a must know for all climbers.

Pluses: Very simple system that requires only your climbing line. The Blake's Hitch runs quite smoothly.

Minuses: If used regularly the friction and heat generated by running rope on rope damages the end of your climbing line meaning your rope will get shorter every time you cut the damaged section off. Also the system needs to be completely undone and re-tied every time you wish to change limbs resulting in a potentially labour intensive slow climb.

15. Munters Hitch*: Italian Hitch, or Crossing knot.

Uses: This hitch is a must know for all climbers. It can be used to descend with, to belay a climber with and to even use in light lowering applications. It is important to note that a large pear shaped locking karabiner be used with this hitch to enable the two directional hitch to invert when switching from lowering a load to raising a load.

Pluses: Very easy to tie and untie, always available and easy to remember. It also runs quite smoothly.

Minuses: Tends to twist the rope.

LIFELINE ATTACHMENT KNOTS

16. **Figure-Eight Loop:** One extra turn of the loop gives you an even more secure Figure-Nine knot favoured by cave explorers and yet another turn gives you the Figure-Ten knot favoured by Police and Fire rescue services.

Uses: A life line Attachment knot, very popular amongst beginners but still an old favourite for many experienced professionals.

Pluses: Very secure lifeline attachment knot and very simple to tie in principle, however:

Minuses: A well ordered Figure-Eight Loop requires practice. The Figure-Eight Loop can be difficult to untie once loaded.

17. Double Bowline:

Uses: This variation of the Bowline makes an ideal lifeline attachment knot.

Pluses: The Double Bowline remains easy to untie and with the addition of the second loop it significantly reduces the Standing Bowlines (knot #1) tendency to creep, distort, or unravel.

Minuses: It takes some 'dressing' to properly align all parts of the knot otherwise clipping into the wrong loop is possible and potentially deadly.

18. Bowline with Yosemite-Tie Off:

Uses: This variation of the Bowline also makes an ideal lifeline attachment knot when tied correctly.

Pluses: As with the Standing Bowline (knot #1) the Bowline with the Yosemite-Tie Off remains easy to untie however by passing the 'Working End' around and back through the 'Bight' significantly reduces the Standing Bowlines tendency to creep, distort or unravel. It also places the working end parallel with the standing part of the rope and out of the way of the loop. This knot makes a good Lifeline Attachment Knot.

Minuses: Much care must be taken to 'tie' and 'dress' this knot correctly to reduce the possibility of clipping into the wrong part of this knot.

19. Double Fisherman's Loop: also known as the Poacher's knot. One more turn of the 'working end' gives you a Triple Fisherman's Loop.

Uses: A lifeline attachment knot or end terminations for the accessory cord of your advanced Prussik Hitch such as the Swabian (knot #22), Distel (knot #23) or VT (French Prussik) (knot #24).

Pluses: A secure easy to tie lifeline attachment knot that chokes up tight on to a karabiner making a very compact knot that is extremely easy to untie once the karabiner has been removed.

Minuses: can be difficult to untie if tied onto an object that can't be removed first from the loop. The tail has a tendency to creep if tied with some rope types such as heat resistant Prussik cord.

CLIMBING FRICTION HITCHES

20. Prussik Knot: also known as the English Prussik.

Uses: This climber's friction hitch is very popular amongst beginners but is still an old favourite for many experienced professionals. It is traditionally tied to form a loop and also has many rigging applications. As a general rule four – six parts of the cord need to encircle the climbing line, depending on rope types and application.

Pluses: Easy to tie, easy to use and very safe; simply add another wrap if it slips when loaded. One of the very few Prussik hitches that functions in both directions

Minuses: Because it is generally tied using a loop whose length is set for ease of ascent using the body thrust method it can be out of reach to adjust whilst branch walking. Tends to bind quite tightly on the climbing line and may need regular 'dressing' for smooth operation depending on the two rope types used.

21. Blake's Hitch:

Uses: Climbers friction hitch, a favoured among American climbers. As a general rule four or more parts of the cord need to encircle the climbing line, depending on rope types.

Pluses: The length the hitch sits away from the climber is easily adjustable allowing the hitch to be always in reach. Does not bind on the climbing line, and is easy to add a 'Micro Pulley' bellow the hitch for a 'Fairlead'. Can be tied using the end of your climbing line as a closed climbing system (knot #14) or with a split tail (a piece of rope approximately 1.5m long normally with an eye spliced in one end).

Minuses: Normally works best using the same diameter rope as the climbing line resulting in quite a bulky knot. Heat and friction build-up causes damage to the part of rope used to tie the hitch if descended on too fast.

22. Swabian Prussik Hitch: Also known as the Swaybish Prussik or the Asymmetrical Prussik. This hitch is a variation or advancement on the English Prussik (knot #20). As a general rule five or more parts of the cord need to encircle the climbing line, depending on rope types.

Uses: Generally used as a climbing hitch but has many rigging applications as well. As a climbing hitch it can be tied with a 'Micro Pulley' on the climbing line bellow the hitch (as pictured in knot #24) this is commonly referred to as an advanced climbing system and the Swabian Prussik is normally the entry level Prussik for such a system

Pluses: Releases the climbing line easier than the English Prussik. When tied as an advanced climbing system it is kept very short making it always easy to reach.

Minuses: It can't be tied using a loop; regular 'dressing' is required while climbing to maintain smooth action. This friction hitch only operates in one direction.

23. Distel Prussik Hitch: This hitch is a variation or advancement on the Swabian Prussik (knot #22). It is effectively a clove hitch (knot #2) with a minimum of three extra turns in the upper part, depending on rope types.

Uses: As with the Swabian this hitch is generally used as a climbing hitch but has many rigging applications as well. As a climbing hitch it is commonly used as an advanced climbing system. A very short version of this hitch with a 'Micro Pulley' is favoured as a flipline adjuster also.

Pluses: Releases the climbing line easier than the English Prussik and the Swabian Prussik for an even smother climb. When tied as an advanced climbing system it is also kept very short making it always easy to reach.

Minuses: It also can not be tied using a loop, and regular 'dressing' is required whilst climbing due to the bottom wrap tendency to work up making the hitch tight to advance. To maintain smooth action, the bottom wrap needs to be kept apart from the top wraps to work smoothly. This friction hitch generally only operates in one direction however if more wraps are added to the bottom of the knot it can be both directional.

24. Valdotain Tresse: Also known as French Prussik, Valdotain Braid or VT Prussik.

Uses: This hitch is also generally used as a climbing hitch especially in climbing competitions but has many rigging applications as well.

Pluses: Very fast and very smooth. Works well on almost any rope type. Releases the rope and 'fairleads' the climbing line very well. Very simple to tie and the addition or subtraction of wraps or braids drastically changes its performance. It is one of the very few Prussik hitches that holds securely on a rope that is already under load. Can be tied using a loop, this variation is called a Machard Tresse (MT Prussik).

Minuses: Very fast! Too fast for beginners. '***The French Prussik is an unforgiving knot that has short comings with potentially fatal consequences.*** *The primary shortcoming is that it sometimes fails to grab the rope if not tied exactly right. This typically occurs when not enough wraps and braids are taken with the cord. The length, diameter, and pliability of the cord also strongly influence how the hitch will perform. As with all knots, the French Prussik must not be integrated into a climbing system until the climber has mastered tying and operating it while on the ground.' (The Tree Climber's Companion, Jepson, p.84)* This friction hitch only operates in one direction.

25. Klemheist Knot:

Uses: Most commonly used as a Prussik belay for double rope footlocking technique. As a general rule six to eight parts of the cord need to encircle the climbing line, depending on rope types. Most commonly tied with a loop of cord.

Pluses: Fastest and easiest of all Prussik knots to tie. Very easy to advance when not loaded.

Minuses: Tends to bind very tightly when loaded and needs loosening off to run smoothly again. This friction hitch only operates in one direction.

TUBE TAPE”

Tube tape is a useful accessory used to create continuous loops and slings, often used as a redirect for the climbing line, as a foot sling to gain purchase in a tree, or even in rigging as light weight anchor or speed-line strops.

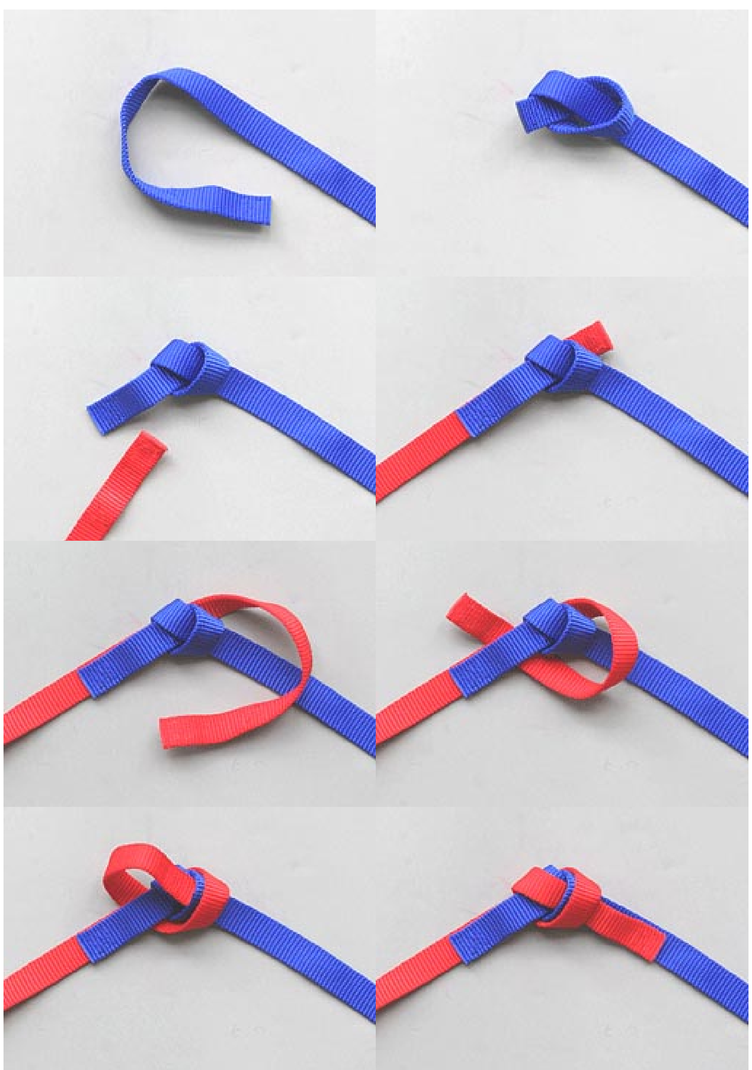
The tube tape is a hollow tube constructed from nylon fibres and range from 12mm – 50mm in diameter. It has high strength, low elongation and low cost. Average tensile strength in 25mm tube tape is 2200kgs.

26. The Water Knot: Also known as the Tape knot. Leave a minimum of 8cm (3 inches) of tail once tied.

Uses: The most common knot used to join webbing slings together or to form an endless loop.

Pluses: Very easy to tie.

Minuses: Has a tendency to creep and can eventually come undone if not regularly inspected. Very difficult to untie when loaded.



27. Beer Knot:

Uses: Another knot for joining tube tape together or tying endless slings. Insert at least 25-30cm (10-12 inches) of tape into itself before centralising and tightening the overhand knot in place.

Pluses: Much more secure knot than the Water knot and still very easy to tie. This knot retains 80% of the original strength of the webbing and is neater and more compact than the Water Knot.

Minuses: Can be difficult to undo when loaded and can be time consuming to tie.

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www.yalecordage.com info@yalecordage.com

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Wikipedia

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