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Rope Inspection and Retirement

ROPE LIFE FACTORS AND DAMAGE ASSESSMENT

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

The use of rope for any purpose subjects it to friction, bending and tension. All rope hardware, sheaves, rollers, capstans, cleats, as well as knots are, in varying degrees, damaging to the rope. It is important to understand that rope is a moving, working, strength member and even under the most ideal conditions will lose strength during use in any application. Maximizing the safety of rope performance is directly related to how strength loss is managed and making sure ropes are retired from service before they can create a dangerous situation. Ropes are serious working tools and used properly will give consistent and reliable service. The cost of replacing a rope is extremely small when compared to the physical damage or personnel injury a worn out rope can cause.

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1. SELECTION

Select the rignt rope for the job in the first place.

Selecting a rope involves evaluating a combination of factors. Some of these factors are straightforward like comparing rope specifications. Others are less qualitative like a preference for a specific color or how a rope feels in your hand. Cutting corners, reducing application factors, 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 out-last a smaller rope because of the greater surface wear distribution. By the same token, a stronger rope will out-last a weaker one because it will be used at a lower percentage of its break strength with less chance of over stressing.

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.

ELONGATION: It is well accepted that ropes with lower elongation under load will give you better load control, which is a big help at complicated job sites. However, a rope with lower elongation that is shock loaded can fail without warning even though it appears to be in good shape. Low elongating ropes should be selected with the highest possible strength. 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. A loose or mushy rope will almost always have higher break strengths than a similar rope that is firm and holds its shape because the fibers are in a straighter line, which improves strength but compromises durability.

CONSTRUCTION AND ABRASION: Rope construction plays an important role in resistance to normal wear and abrasion. Braided ropes have a basically round, smooth construction that tends to flatten out somewhat on a bearing surface. This distributes the wear over a much greater area, as opposed to the crowns of a 3-strand or, to a lesser degree, on an 8-strand rope. All ropes should be protected against sharp and abrasive surfaces. Wire ropes tend to score and gouge chocks and bitts creating cutting edges that can damage synthetic ropes. Weld beads on repaired capstans, fairleads, etc. are equally damaging unless dressed down smoothly.

2. USAGE

Use rope properly: do not abuse or shock load it. Observe recommended usage factors for bending and work loads. Keep ropes clean and eliminate abrasion whenever possible.

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%. 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.

BENDING: Any sharp bend in a rope under load decreases its strength substantially and may cause premature damage and failure. Sheave diameters on rotating sheave blocks should be 10 times the rope diameter for twisted ropes and 8 times the rope diameter for braided ropes. The diameter on fixed pin terminations should be at least 3 times the rope diameter (i.e. the bending radius for 1/2" ropes should be 1-1/2").

KNOTS: While it is true that a knot reduces rope strength, it is also true that a knot is a convenient way to accomplish rope attachment. The strength loss is a result of the tight bends that occur in the knot. With some knots, ropes can lose up to 50% of their strength. It is vital that the reduction in strength by the use of knots be taken into account when determining the size and strength of a rope to be used in an application. To avoid knot strength reduction, it is recommended that a rope be spliced according to the manufacturer's instructions. Splice terminations are used in all our ropes to determine new and unused tensile strengths. Therefore, whenever possible, spliced terminations should be used to maximize the rope strength for new and used ropes.

ROPE STORAGE: Keep your ropes as clean and dry as possible and store them in a coil away from heat sources.

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 work load range.

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 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 abrasion, glossy or glazed areas, inconsistent diameter, discoloration, and inconsistencies in texture and stiffness.

UNDERSTANDING THE ROPE DESIGN/CONSTRUCTION: It is first important to understand the design of the specific rope in use. Most ropes are designed to have features specifically tailored to their application. These features can lead to misconceptions during visual inspections. When a rope has a braided cover, it is only possible to visually inspect the cover (which, at best, carries only 50% of the load). Rope designs utilizing HMPE fibers will show initial rapid abrasion until the rope has a fuzzy appearance — *this appearance actually acts as a protective layer.*

DETERMINING THE AVERAGE CONDITION OF THE ROPE: The average condition of a rope can be an important factor in determining the rope's retirement. To determine the average condition, walk the entire length of the rope and document its overall condition. Many ropes can be classified by the total amount of overall wear and cleanliness.

Inspection

fig. 1 New rope

fig. 2 Used rope

fig. 3 Severely abraded rope

ABRASION:

When the rope is first put into service the outer filaments of the rope will quickly fuzz up *(fig. 2)*. 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 *(fig. 3)*, excessive abrasion is taking place and strength is being lost. As a general rule for single braid 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 3-strand ropes, 10% or more wear is accepted as the retirement point.

LOCATE AREAS DEVIATING FROM AVERAGE:

Many times a rope will have areas that are routinely used around a bit, through a chock, or buried on the winch drum. These areas typically have different wear patterns than the average condition of the rope. Pay close attention to these areas in the future and frequently examine them for rapid changes in appearance.

Look closely at both the inner and outer fibers. When either is worn the rope is obviously

fig. 4 Inspect for internal abrasion

fig. 5 Inspect for internal abrasion

fig. 6 Compare surface yarns with internal yarns

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.

Internal abrasion can be determined by pulling one strand away from the others and looking for powdered or broken fiber filaments *(fig. 4 and fig. 5)*.

To determine the extent of outer fiber damage from abrasion, a single yarn in all abraded areas should be examined. The diameter of the abraded yarn should then be compared to a portion of the same yarn or an adjacent yarn of the same type that has been protected by the strand crossover area and is free from abrasion damage. *(fig. 6)*.

It should be noted that comparing diameters of the yarns does not give an accurate measure of the retained strength. Since the strength should depend on the cross-sectional area of the yarn, a diameter difference alone will underestimate the true abrasion reduction. If the diameter of the abraded yarn is 1/2 the diameter of the internal yarn, the strength of the abraded yarn is nearly 1/4 that of the internal yarn.

Determining the extent of fiber loss due to abrasion can be difficult. Since all the strands are twisted, the outer fibers, which are the most prone to abrasion damage, rotate through the rope's length. Therefore on a single strand, the fibers that have been abraded on one pick, are not necessarily the fibers being abraded on the next. However, over a long distance, a single yarn could have the majority of fiber loss due to abrasion.

GLOSSY OR GLAZED AREAS:

Glossing or glazing can occur from two different mechanisms. The most common and relatively benign form of glossing or glazing on a rope is generally caused by compression *(fig.7)*, which typically occurs when the rope is wound on the winch drum, around bits, or through chocks or staples. This form of glossing can be determined on 8- and 12-strand products by compressing the rope length wise forming a "bird cage" *(fig.8)*. After numerous "bird cage" cycles the glossy region will become more pliable and begin to resemble normal rope. If the glazed section remains hardened, this could be a sign of heat damage. Heat damaged rope typically has 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.

fig. 7 Compressed areas

fig. 8 Bird cage

INCONSISTENT 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.

DISCOLORATION:

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

INCONSISTENCY IN TEXTURE AND STIFFNESS:

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.

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

Fiber Type	Critical Temp.	Melting Temp.
POLYPROPYLENE	250° F	330° F
HMPE	150° F	300° F
TECHNORA	520° F	930° F*
NYLON	325° F	425–490° F
POLYESTER	350° F	480–500° F

*Charring point

CHARING POINT:

High temperatures can be achieved when surging rope on a capstan or drum end, checking ropes on bitts, and 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 a steam line or any other hot surfaces. 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.

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