

Rope for Ordinary Vessel Use

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Although a number of “high performance” ropes are now being used in certain demanding applications like trawling and the towing industry, most vessel owners don’t need—and can’t afford—the latest high-tech cordage. Instead, they use lines, rigging, and anchor rode made of one or more of the three common and relatively inexpensive rope materials.

Rope can be made in several ways and of various materials, and can have different characteristics that are suitable for a range of applications. To work effectively and safely, it is important to select the right kind of rope, use it correctly, and take reasonable care of it.

Materials

Each of the common rope materials has its own characteristics, some of which are strength, elasticity, specific gravity (which determines whether or not it floats), propensity for water absorption, and resistance to abrasion and to damage from UV (sunlight), chemicals, high temperatures, and rot or mildew. An additional characteristic called “hand” is a subjective assessment of a rope’s feel and ease of handling. New materials come along from time to time, but 90% commercial fishing and recreational boats is made from the following three materials.

1. Nylon. First introduced by DuPont in 1938, nylon probably is still the most common kind of rope used in the marine industries, and with good reason. It is strong; highly resistant to most chemicals, mildew and UV deterioration; and highly resistant to abrasion. It has high elasticity and will stretch 10-15% under normal working loads and 40% as the load approaches breaking strength. This elasticity makes it highly desirable for use as anchor rode, for towing and for dock lines, as the stretch absorbs shock. Nylon rope can be made fairly soft and easy to handle. Its specific gravity of 1.14 means it sinks. Nylon absorbs water—it shrinks and hardens, and loses 10-15% of its strength when wet.

2. Polyester. Also known by the brand name Dacron, polyester is a little more expensive than nylon but has slightly better UV and abrasion resistance. It has 40% less elasticity (stretch) than nylon, does not lose strength when wet, has similar strength and resistance to mildew and chemicals, doesn’t absorb water or shrink, and has specific gravity of 1.38. Like nylon, it can be made into a smooth, soft rope that holds knots well. Also like nylon, it can be made in a variety of colors. But coloring weakens rope slightly and increases its cost substantially, so other than on yachts white is most common.

Marine overlay finishes are available to treat both nylon and polyester to reduce strength loss and improve abrasion resistance.

It is difficult to distinguish nylon from polyester by appearance or feel. Burning nylon fibers give off white smoke and leave a yellow bead; polyester gives off black smoke and makes a black bead. Short of laboratory testing, the only way to tell one from another is to read the markings on the spool.

3. Polypropylene. It’s the cheap, lightweight rope with the plastic feel that is usually yellow but comes in a variety of colors. It has limited usefulness on boats because it has less strength and, although it is resistant to chemicals and mildew, it is more susceptible to abrasion and UV damage than nylon and polyester. Most polypropylene rope is “slippery” when new and doesn’t hold knots well, and when it ages it becomes prickly to the touch. It is more elastic than polyester but less than nylon. It doesn’t absorb water or lose strength when wet. With a specific gravity of 0.91 it floats, which is an advantage in some applications.

Cordage manufacturers offer many combination-fiber ropes. This includes combinations of polypropylene with polyethylene, and polyester with polypropylene. The resulting materials resist abrasion and

UV damage, and provide a good “hand” and knot holding, while remaining strong and light enough to float.

Rope Construction

Nearly every kind of rope is constructed of the same components—hundreds of very fine fibers are bunched and twisted into yarns, dozens of which in turn are combined into strands. How those strands are arranged determines the rope’s construction.

Twisted or cable-laid rope consists usually of three strands, twisted in a clockwise (“right-hand lay”) direction. The yarns in each strand are twisted counterclockwise, and the fibers in the yarns are clockwise; this alternate reversing of direction balances the rope. Twisted rope is the standard, utilitarian construction for thousands of uses. It is generally the least expensive type of rope (for any given material), and is the easiest to splice. Its chief disadvantage is that under extreme tension it will partially unravel and may impart a twist to the items that it connects, so it’s sometimes necessary to use swivels at either end. If subjected to great tension that is subsequently released, it has a tendency to form *hockles*. That is, one or more strands will form loops inside the lay of the rope. Hockles weaken the rope and require that it be cut off or discarded. Another disadvantage in some applications is that it usually must be coiled when not in use and only coils in one direction.

Twisted three-strand rope can be made in a three-stage process, which produces a very soft, limp rope, or a four-stage process which makes it firmer. The manufacturing process can be adjusted to produce “soft lay” rope which will drop in a pile, “medium lay” rope, or “hard lay” rope, which is so stiff that it is difficult to handle but has the property of being self-coiling as it comes off a gear hauler. Self-coiling crab rope is hard lay.

Braided rope comes in several types. **Plaited** rope consists of eight strands woven together like braided hair, without a core

or hollow. Twelve-strand braid (sometimes called *round plait*) is a relatively new construction that has the attributes of double braid but with somewhat less strength.

Single braid (or **hollow braid**) have strands woven together in an alternate pattern, similar to a maypole, to form a sort of tube with a hollow core. The hollow tube can also be filled with fibers for extra strength or to make the rope more firmly round. Single braid is extremely easy to splice (even easier than twisted) and some single braids have trade names that include phrases like "Quick Splice."

Double braid ropes have a braided sheath or outer shell covering a braided, twisted, or even parallel fiber core, which may be of a different material than the shell. Double braids tend to be the most expensive because of the complexity of construction and because of their special attributes. A tough outer shell, usually of polyester, can make the rope quite abrasion resistant and any abrasion damage will be obvious before core damage occurs. The surface is relatively smooth and has soft "hand." The core can be made of special materials, like aramids (Kevlar, Technora, Twaron) or high modulus polyethylene (Dyneema or Spectra) for great strength, with other materials for buoyancy, or even can be leaded to make it sink. Most gillnet cork and lead lines are double braid.

Braided ropes are torque-free and generally are stronger than cable-laid for the same material and diameter, and have a little less stretch. All braided rope has the advantage (for some applications) of lacking a directional "set," so it doesn't need to be coiled and it can't form hockles.

Rope Strength

A great deal has been written about rope strength, almost none of which is of any use to boat operators, for two reasons. One is that strength is usually expressed in pounds of breaking strength (or working load) and rarely does anyone working around a boat actually know the weight equivalents of the loads put on rope. More important, breaking strength and working load are expressed as static loads, while working boats are constantly in motion and their dynamic loads or shock loads are much greater than static loads, and essentially impossible to calculate accurately.

Manufacturers load test each model and size (diameter) of rope in laboratory conditions to determine how many pounds of load

is required to break it. The industry trade association Cordage Institute expresses it as *Minimum Breaking Strength* (MBS), although individual manufacturers use other terms. *Maximum Working Load* (MWL), called *Working Load Limit* by the Cordage Institute, is calculated by dividing by a safety factor, called *Design Factor* (DF), which varies from 5 to 12, depending on the type of load. A DF of 5 is acceptable when the rope is used in a modest dynamic mode, which means that a line with a 10,000 lb MBS can be used to lift about 2,000 lb.

The problem is that as more motion is added the DF increases, and in most cases you can't calculate dynamic load. The dynamic load can easily be two to three times greater than static load, and the DF can only be based on your assessment of the conditions of use and the degree of risk to yourself and crew.

Remember that rope strength is diminished by several factors. One is overall rope condition, including the effects of chafe and abrasion, stress caused by previous use, degradation by sunlight or chemical exposure, and heat. Friction on a capstan that temporarily heats fiber temperature to 250° F, for example, will reduce by half the strength of some polypropylenes.

Another factor is how the rope is used. Strength is diminished by bends imposed by sheaves or other equipment, and by knots and splices. Sheave block (pulley) diameter should be at least six and preferably ten times the rope diameter for cable-laid rope, and eight times for braided rope, and the bending radius for fixed terminations should be at least three times the rope diameter. Well-executed splices reduce strength by 10%, and some common knots by 30 to 50%.

Sudden application of load is harder on rope than gradual application. Polyester rope can be pre-stretched to remove some elasticity by slowly applying and holding tension for a period of time and then gradually releasing it, prior to working the rope.

Rope that is properly coiled or *faked* (laid out in figure-eights) will retain more strength than if it is stowed in a way that creates sharp bends and kinks. Three-strand twisted rope should be coiled in a clockwise direction, and uncoiled counterclockwise. Braided rope should be faked on deck or hung vertically in figure-eights. When first put into use, rope that comes in a coil should be pulled out from the inside of the coil, and rope that comes on a spool should

be unwound from the top side of the spool as it lies in a horizontal position, rotating on a spindle.

Always keep in mind that nylon and other high-stretch ropes are extremely dangerous if they or any of the items they connect either break or pull out. The snap-back from a highly stressed nylon line can slam dogs or shackles right through cabin walls, sweep stovepipes and antennas from wheelhouse roofs, and severely injure crewmembers. The danger zone of a nylon line is a 90 degree arc centered on the line itself at its attachment point on the boat.

Rope Maintenance

Rope strength and durability depend on periodic inspection and a level of maintenance. High performance racing sailboat crews routinely inspect halyards, sheets, and other working lines every few hours, looking for evidence of chafe. Workboat crews should do so at least every few weeks, and more often if conditions warrant. It is easy to take up an arm's length of rope at critical points and hold it up to sight along it to look for chafe, cuts, broken strands, and other deformation such as bulging or flattened spots, glazed or burned spots, and discoloration that would indicate wear or deterioration. Any time a line has cut strands, obvious chafe, or a decrease of 10% in overall diameter, the damaged part should be cut off, or the whole thing replaced. Lines, such as anchor rodes, that suffer most of their damage at one end should be cut back or reversed end for end at least annually and more frequently as conditions dictate.

Obviously, chafe protection is critical for the life of any line aboard a boat. It is important to keep various kinds of chafing gear handy, including rags that can be wrapped temporarily around a chafe point, and split garden or fire hose that can be secured around a line with wire ties, twine, or hose clamps. Careful inspection should be given to sheaves, rollers, chocks, and other points where burrs or corrosion could chafe the lines that pass over or through them.

Dirt causes internal abrasion of fibers, as will rust scale or powder from metal corrosion, and even salt crystals. Rust (iron oxide) weakens and destroys nylon. Rope should be washed with freshwater occasionally but, unless it is necessary to remove oil or grease, don't use detergents. Manufacturers coat the fibers with a preservative/lubricant to reduce friction within the strands when the rope is working, and detergents can re-

move the coating. Marine overlay finishes are available that restore water- and abrasion resistance to rope fibers.

Rope must be kept clean of solvents, acids and alkalies, either as fluids or fumes.

Despite their relative resistance to UV, rot, and mildew, rope stored for long periods of time should be kept off the floor in a cool, dry, well-ventilated location out of direct exposure to sunlight. ◆

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