Wire Rope Basics - Physical Properties

The basic characteristics of wire rope.
How do you choose the wire rope that's best suited for your job? Following are the most common characteristics to be considered when selecting a rope for an application.

Strength. Wire rope strength is usually measured in tons of 2,000 lbs. In published material, wire rope strength is shown as minimum breaking force or nominal (catalog) strength. These refer to calculated strength figures that have been accepted by the wire rope industry.

When placed under tension on a test device, a new rope should break at a figure equal to - or higher than - the minimum breaking force shown for that rope. Certain standards allow for an acceptance strength that is 97.5% of the nominal strength to allow for testing variables.

The published values apply to new, unused rope. A rope should never operate at - or near - the minimum breaking force. During its useful life, a rope loses strength gradually due to natural causes such as surface wear and metal fatigue.

Fatigue resistance. Fatigue resistance involves metal fatigue of the wires that make up a rope. To have high fatigue resistance, wires must be capable of bending repeatedly under stress - for example, a rope passing over a sheave.

Increased fatigue resistance is achieved in a rope design by using a large number of wires. It involves both the basic metallurgy and the diameters of wires.

In general, a rope made of many wires will have greater fatigue resistance than a same-size rope made of fewer, larger wires because smaller wires have greater ability to bend as the rope passes over sheaves or around drums. To overcome the effects of fatigue, ropes must never bend over sheaves or drums with a diameter so small as to bend wires excessively. There are precise recommendations for sheave and drum sizes to properly accommodate all sizes and types of ropes.

Every rope is subject to metal fatigue from bending stress while in operation, and therefore the rope's strength gradually diminishes as the rope is used.

Crushing resistance. Crushing is the effect of external pressure on a rope, which damages it by distorting the cross-section shape of the rope, its strands or core - or all three.

Crushing resistance therefore is a rope's ability to withstand or resist external forces, and is a term generally used to express comparison between ropes. When a rope is damaged by crushing, the wires, strands and core are prevented from moving and adjusting normally during operation.

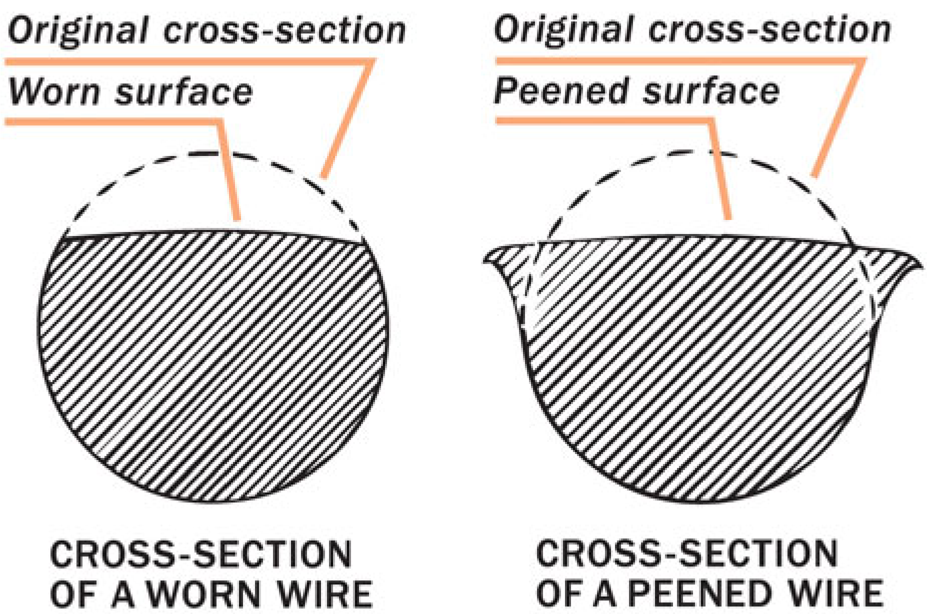
In general, IWRC ropes are more crush resistant than fiber core ropes. Regular lay ropes are more crush resistant than lang lay ropes. Six strand ropes have greater crush resistance than 8 strand ropes or 19 strand ropes. Flex-X® ropes are more resistant than standard round-strand ropes.

Resistance to metal loss and deformation. Metal loss refers to the actual wearing away of metal from the outer wires of a rope, and metal deformation is the changing of the shape of outer wires of a rope.

In general, resistance to metal loss by abrasion (usually called "abrasion resistance") refers to a rope's ability to withstand metal being worn away along its exterior. This reduces strength of a rope.

The most common form of metal deformation is generally called "peening" - since outside wires of a peened rope appear to have been "hammered" along their exposed surface.

Peening usually occurs on drums, caused by rope-to-rope contact during spooling of the rope on the drum. It may also occur on sheaves. Peening causes metal fatigue, which in turn may cause wire failure. The hammering - which causes the metal of the wire to flow into a new shape - realigns the grain structure of the metal, thereby affecting its fatigue resistance. The out-of-round shape also impairs wire movement when the rope bends.



Resistance to rotation. When a load is placed on a rope, torque is created within the rope as wires and strands try to straighten out. This is normal and the rope is designed to operate with this load-induced torque. However, this torque can cause loads to rotate. Load-induced torque can be reduced by specially designed rotation resistant ropes.

In standard 6 and 8 strand ropes, the torques produced by the outer strands and the IWRC is in the same direction and add together. In rotation resistant ropes, the lay of the outer strands is in the opposite direction to the lay of the inner strands, thus the torques produced are in opposite directions and the torques subtract from each other.

Depending upon your application, other wire rope characteristics such as stability, bendability or reserve strength may need to be considered.

Design Factors
The design factor is defined as the ratio of the minimum breaking force of a wire rope to the total load it is expected to carry.

Use of design factors provides rope installations with reasonable assurance of adequate capacity for the work to be done throughout a rope's service life. Considerations in establishing design factors include the type of service (operating speed, rough treatment, sudden loading changes, for example), design of equipment and consequences of failure.

In most applications, the selection of a rope based on the proper design factor has been made by the equipment manufacturer. In an application where a different rope is to be used, or in a new application, check government and industry regulations for the required design factor. Different rope types on the same application may have different design factor requirements.

How to use design factors
Standards and regulations require that design factors be applied to the rope's minimum breaking force to determine the maximum working load. To determine the maximum working load for which an operating rope may be used, divide the rope's minimum breaking force by the required design factor. This is the rope's maximum working load. There may be other limiting factors in an application that make the maximum load the equipment can handle less than the rope's maximum working load. NOTE: The rated capacity of a wire rope sling incorporates both a design factor and a splicing or attachment efficiency.

Remember, an installation is only at the prescribed design factor when the rope is new. As a rope is used, it loses strength and literally is "used up."

Stretch
Wire Rope is an elastic member, it stretches or elongates under load. This stretch derives from two sources:

1. constructional, and
2. elastic

In actuality, there may be a third source of stretch - a result of the rope rotating on its own axis. The unlaying of the rope strands brings about such elongation, which may occur either as a result of using a swivel, or from the effect of a free-turning load.

- **Constructional Stretch:** When a load is applied to wire rope, the helically-laid wires and strands act in a constricting manner thereby compressing the core and bringing all the rope elements into closer contact. The result is a slight reduction in diameter and an accompanying lengthening of the rope.
  Constructional stretch is influenced by the following factors:
  1. Type of core (fiber or steel)
  2. Rope construction
  3. Length of lay
  4. Material

  Ropes with wire strand core (WSC) or independent wire rope core (IWRC) have less constructional stretch than those with fiber core (FC). The reason for this is the fact that the steel cannot compress as much as the fiber core.

  Usually, constructional stretch will cease at an early stage in the rope's life. However, some fiber core ropes, if lightly loaded (as in the case of elevator ropes), may display a degree of constructional stretch over a considerable portion of their life.

A definite value for determining construction stretch cannot be assigned since it is influenced by several factors. The following table gives some idea of approximate stretch as a percentage of rope length under load.

Rope Construction	Approximate Total Constructional Stretch
6 strand FC	1/2% - 3/4%
6 strand IWRC	1/4% - 1/2%
8 strand FC	3/4%-1%
8 strand IWRC	1/2% - 3/4%

- **Elastic Stretch:** Elastic stretch results from recoverable deformation of the metal itself. Here again, a quantity cannot be precisely calculated. However, the following equation can provide a reasonable approximation.

$$\frac{\text{Changes in load (lb)} \times \text{Length (ft)}}{\text{Area (inches}^2\text{)} \times \text{modulus of Elasticity (psi)}}$$

Rotation-resistant Ropes

Rotation-resistant ropes are available in two general classifications:

1. Single layer - consisting of a single layer of three or four strands. Typically the strands support one another without a core member.
2. Multilayer strand (multistrand) - consisting of two or more strand layers closed in opposing directions. Torsional forces generated by each layer of the rope counteract one another to minimize rotation. The multistrand classification includes ropes with between eight and twenty outer strands.