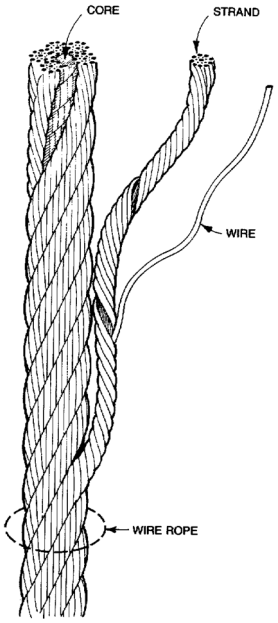
WIRE ROPE

General Information

Terminology & Properties

Terminology

With precise, moving parts, designed and manufactured to bear definite relationship to one another, **Wire Rope** can be a complex mechanism.



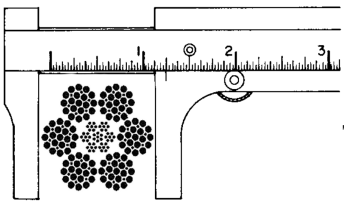
Wire rope is generally composed of wires, strands and the core (See Fig.). The wires are helically laid together in a precise geometric pattern to form the strand. The strands helically laid about the core to form the wire rope. The process of positioning the strands about the core is called “closing”. The process of positioning the wires within the strand is called “stranding”.

Wire rope varies:

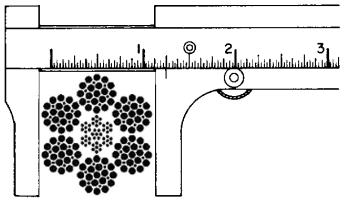
- By Diameter
- The grade of steel utilized
- The direction of stranding and closing
- The finish on the wire (Bright, Galvanized, etc.)
- The core material

Each variation changes the performance characteristics of the wire rope.

The first differentiation of wire rope is by diameter. The diameter is measured at the diameter of the circle formed by the extreme outer dimensions of the strands. (See Fig.). New wire rope is manufactured to an oversized diameter of approximately 2-1/2%. This allows for the normal reduction of diameter experienced when a new rope is placed under load because of constructional stretch.



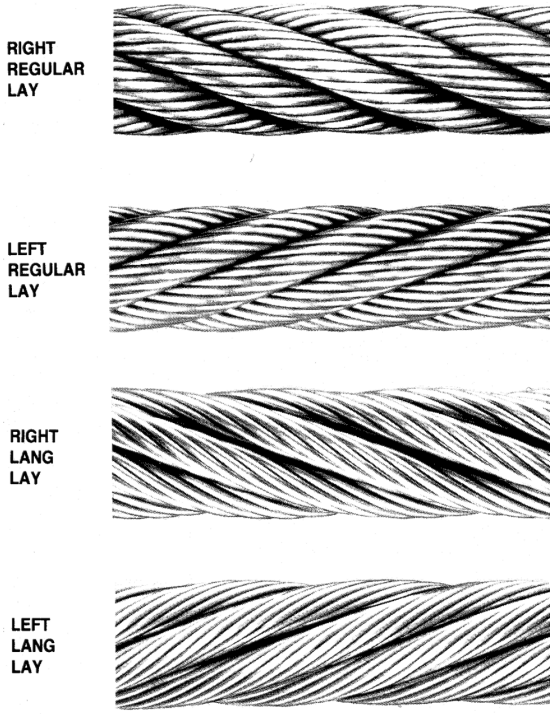
The RIGHT Way



The WRONG Way

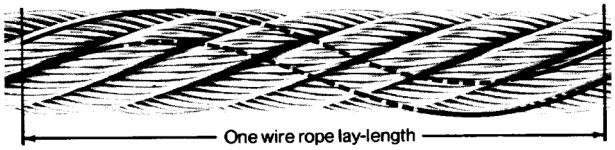
CAUTION: At NO time should the measured diameter be less than the nominal diameter of the wire rope.

The grade of steel (or other material) utilized in the construction of the wire rope has a major influence upon the ultimate break strength. Generally most steel wire rope today is at **Improved Plow Steel Grade or IPS.** In recent years **Extra Improved Plow Steel (EIPS)** wire rope has gained in popularity and is approximately 10% stronger than IPS. Manufacturers have begun producing limited constructions of Extra Extra Improved Plow Steel (EEIPS), which is 10% higher than EIPS grade. Some special constructions exceed EEIPS grade.



The “Lay” of the wire rope (the direction of stranding and closing) directly affects the operating properties. In **Regular Lay** wire rope, the direction of the wires are twisted in an opposite direction than the direction of the strands. Regular Lay may be **Right Regular Lay** or **Left Regular Lay** depending upon the direction of the strands. (See Fig.).

In Lang Lay wire ropes the direction of the wires are twisted in the same direction as the strands. Lang Lay may be **Right Lang Lay** or **Left Lang Lay** depending upon the direction of the strands. The wires of a regular wire rope seem to travel parallel and along the length of the rope while those of a lang lay rope appear to travel around the rope.

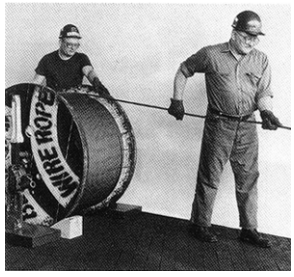


"LAY" AS A UNIT OF MEASURE

In addition, the **Lay Length,** the length of the rope necessary for one strand to travel completely around the rope (See Fig.) may be varied slightly by manufacturer.

Most wire rope has a **Bright, self-colored finish** and a coating of lubricant. However, many wire ropes are galvanized, stainless steel, or plastic/vinyl/urethane coated.

Most wire ropes are supplied with either a fiber or steel core. The core's primary function is to support the wire strands of the rope, maintaining the corrective relative positions during the operating life. Fiber Cores are composed of natural **Vegetable Fiber Core (VFC -** sisal, etc.) or **Synthetic Fiber Core (PFC-** polypropylene, etc.) which have been formed into yarns and twisted into strands. Steel cores may be **Independent Wire Rope Core (IWRC)** or **Wire Strand Core (WSC).** These steel cores provide more support than fiber cores to the outer strands during the rope's operating life. Steel cores resist crushing, are more resistant to heat, reduce the amount of stretch, and increase the strength of the rope.



The Right Way

Unreeling & Uncoiling

The Right Way to Unreel. To unreel wire rope from a heavy reel, place a shaft through the center and jack up the reel far enough to clear the floor and revolve easily. One person holds the end of the rope and walks a straight line away from the reel, taking the wire rope off the top of the reel. A second person regulates the speed of the turning reel by holding a wood block against the flange as a brake, taking care to keep slack from developing on the reel, as this can easily cause a kink in the rope. Lightweight reels can be properly unreeled using a vertical shaft; the same care should be taken to keep the rope taut.

The Wrong Way to Unreel. If a reel of wire rope is laid on its flange with it's axis vertical to the floor and the rope unreeled by throwing off the turns, spirals will occur and kinks are likely to form in the rope. Wire rope always should be handled in a way that neither twists nor unlays it. If handled in a careless manner, reverse bends and kinks can easily occur.

The Right Way

The Right Way to Uncoil. There is only one way to uncoil wire rope. One person must hold the end of the rope while a second person rolls the coil along the floor, backing away. The rope is allowed to uncoil naturally with the lay, without spiraling or twisting. Always uncoil wire rope as shown.

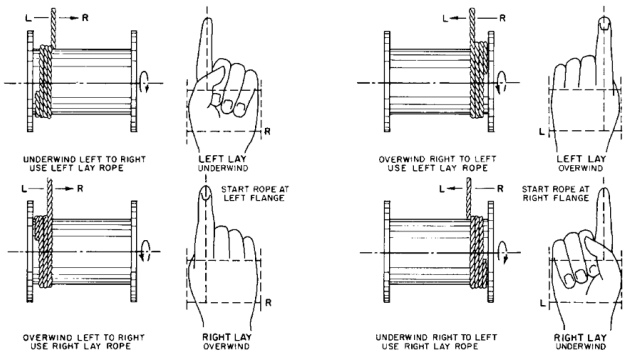
The Wrong Way to Uncoil. If a coil of wire rope is laid flat on the floor and uncoiled by pulling it straight off, spirals will occur and kinking is likely. Torsions are put into the rope by every loop that is pulled off, and the rope becomes twisted and unmanageable. Also, wire rope cannot be uncoiled like hemp rope. Pulling one end through the middle of the coil will only result in kinking.

Kinks

Great stress has been placed on the care that should be taken to avoid kinks in wire rope. Kinks are places where the rope has been unintentionally bent to a permanent set. This happens where loops are pulled through by tension on the rope until the diameter of the loop is only a few inches. They are also caused by bending a rope around a sheave having too severe a radius. Wires in the strands at the kink are **permanently damaged** and will not give normal service, even after apparent "restraightening."

Drum Winding. When wire rope is wound onto a sheave or drum, it should bend in the manner in which it was originally wound. This will avoid causing a reverse bend in the rope. Always wind wire rope from the top of the one reel onto the top of the other. Also acceptable, but less so, is re-reeling from the bottom of one reel to the bottom of another. Re-reeling may also be done with reels having their shafts vertical, but extreme care must be taken to ensure that the rope always remains taut. It should never be allowed to drop below the lower flange on the reel. A reel resting on the floor with its axis horizontal may also be rolled along the floor to unreel the rope.

Wire rope should be attached at the correct location on a flat or smooth-faced drum, so that the rope will spool evenly, with the turns lying snugly against each other in even layers. If wire rope is wound on a smooth-face drum in the wrong direction, the turns in the first layer of rope will tend to spread apart on the drum. This results in the second layer of rope wedging between the open coils, crushing and flattening the rope as successive layers are spooled.



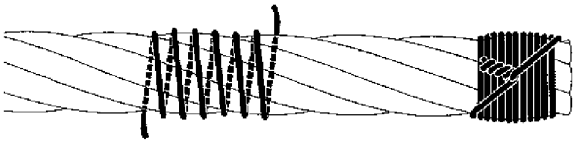
A simple method of determining how a wire rope should be started on a drum is shown in the above diagram. The observer stands behind the drum, with the rope coming towards him. Using the right hand for right-lay wire rope, and the left hand for left lay wire rope, the clenched fist denotes the drum, the extended index finger the oncoming rope.

Seizing Wire Rope

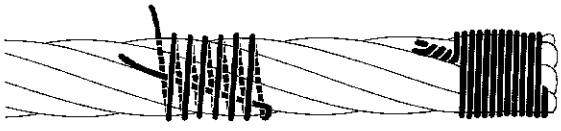
Proper seizing and cutting operations are not difficult to perform, and they ensure that the wire rope will meet the user's performance expectations. Proper seizings must be applied on both sides of the place where the cut is to be made. In a wire rope, carelessly or inadequately seized ends may become distorted and flattened, and the strands may loosen. Subsequently, when the rope is operated, there may be an uneven distribution of loads to the strands; a condition that will significantly shorten the life of the rope.

Either of the following seizing methods is acceptable. Method No. 1 is usually used on wire ropes over one inch in diameter. Method No. 2 applies to ropes one inch and under.

Method No. 1



Method No. 2



Method No. 1: Place one end of the seizing wire in the valley between two strands. Then turn its long end at right angles to the rope and closely and tightly wind the wire back over itself and the rope until the proper length of seizing has been applied. Twist the two ends of the wire together, and by alternately pulling and twisting, draw the seizing tight.

Method No. 2: Twist the two ends of the seizing wire together, alternately twisting and pulling until the proper tightness is achieved.

The Seizing Wire. The seizing wire should be soft or annealed wire or strand. Seizing wire diameter and the length of the seize will depend on the diameter of the wire rope. The length of the seizing should never be less than the diameter of the rope being seized.

Proper end seizing while cutting and installing, particularly on rotation- resistant ropes, is critical. Failure to adhere to simple precautionary measures may cause core slippage and loose strands, resulting in serious rope damage. Refer to the table for established guidelines. If core protrusion occurs beyond the outer strands, or core retraction within the outer strands, cut the rope flush to allow for proper seizing of both the core and outer strands.

In the absence of proper seizing wire or tools, the use of sufficiently- sized hose clamps is acceptable.

Rope Design	End Preparation
All standard preformed wire rope 6x26 Reverse Lay 6-Pac, 6-Pac RV, Flex-X, Endurance Dyform® 6 & 8/8PI	Single Seizing
All standard non-preformed wire rope 19x7 & 8x19 Class Rotation Resistant SFP19, Endurance Dyform® 18/18PI, Endurance Constructex®, Triple-PAC, Endurance 35x7®, Endurance 34LR/PI/MAX®	Double Seizing (Fused Ends Recommended)
SFP 35	Double Seizing **AND** Fused Ends

Installation

The majority of wire rope problems occurring during operation actually begin during installation, when the rope is at greatest risk of being damaged. Proper installation procedures are vital in the protection and performance of wire rope products.

- Provide Proper Storage- Avoid damage and moisture
- Check the Rope Diameter Prior to Installation
- Use Proper Unreeling/Uncoiling Procedures
- Keep the Wraps Tight
- Treat Rotation-Resistant Ropes with Extra Care
- Secure the Ends Before Cutting
- Use a Wire Mesh Grip or Chinese Finger (to Prevent Torque from the old rope transferring to the new rope)
- Always Perform a Break-In Procedure to Maximize Service Life
- Avoid Slack in the Rope
- Slowly Lift or Release the Load
- **Use the Wire Rope ONLY for the Job it was Intended**.

Wire Rope Definitions

Ropes

Spiral Rope: An assembly of two or more layers of shaped and/or round wires laid helically over a center, usually a single round wire. There are three categories of spiral rope, i.e. spiral strand, half locked coil and full-locked coil.
Spiral Strand: An assembly of two or more layers of round wires laid helically over a center, usually a single round wire.
Half-locked coil Rope: A spiral rope type having an outer layer of wires containing alternate half lock and round wires.
Full-locked Coil Rope: A spiral rope having an outer layer of full lock wires.
Stranded Rope: An assembly of several strands laid helically in one or more layers around a core or center. There are three categories of stranded rope, i.e. single layer, multi-layer and parallel-closed.
Single Layer Rope: Stranded rope consisting of one layer of strands laid helically over a core.

Note: Stranded ropes consisting of three of four outer strands may, or may not, have a core. Some three and four strand single layer ropes are designed to generate torque levels equivalent to those generated by Rotation-Resistant ropes.

Rotation-Resistant rope: Stranded rope designed to generate reduced levels of torque and rotation when loaded and comprising an assembly of two or more layers of strands laid helically around the center, the direction of lay of the outers strands being opposite to that of the underlying layer.
Rotation-Resistant rope: category 1:
Stranded rope constructed in such a manner that it displays little or no tendency to rotate, or, if guided, transmits little or no torque, has at least fifteen outer strands and comprising an assembly of at least three layers of strands laid helically over a center in two or three operations, the direction of lay of the outer strands being opposite to that of the underlying layer.
Rotation-Resistant rope: category 2:
Stranded rope constructed in such a manner that it has significant resistance to rotation, has at least ten out strands and comprising an assembly of two or more layers of strands laid helically over a centre in two or three operations, the direction of lay of the outer strands being opposite to that of the underlying layer.
Rotation-Resistant rope: category 3:
Stranded rope constructed in such a manner that it has limited resistance to rotation, has no more than nine outer strands and comprising an assembly of two layers of strands laid helically over a center in two operations, the direction of lay of the outer strands being opposite to that of the underlying layer.
Compacted Strand Rope: Rope in which the outer strands, prior to closing of the rope, are subjected to a compacting process such as drawing, rolling or swaging.
Compacted Swaged Rope: Rope which is subjected to a compacting process after closing, thus reducing its diameter.
Plastic (Solid Polymer) Filled Rope: Rope in which the free internal spaces are filled with a solid polymer. The polymer extends to, or slightly beyond, the outer circumference of the rope.
Cushioned Rope: Stranded rope in which the inner layers, inner strands or core strands are covered with solid polymers or fibers to form a cushion between adjacent strands or layers of strands.
Cushion Core Rope: Stranded rope in which the core is covered (coated) or filled and covered (coated) with a solid polymer.
Solid Polymer Covered Rope: Rope which is covered (coated) with a solid polymer.
Solid Polymer Covered and Filled Rope: Rope which is covered (coated) and filled with a solid polymer.
Rope Grade (Rr): A number corresponding to a wire tensile strength grade on which the minimum breaking force of a rope is calculated.

Note: It does not imply that the actual tensile strength grades of the wires in a rope are necessarily the same as the rope grade.

Preformed Rope: Stranded rope in which the wires in the strands and the strands in the rope have their internal stresses reduced resulting in a rope in which, after removal of any serving, the wires and the strands will not spring out of the rope formation.

Note: Rotation Resistant stranded ropes should be regarded as non-performed rope even though the strands may have been partially (lightly) preformed during the closing process.

Rope Class: A grouping of rope constructions where the number of outer strands and the number of wires and how they are laid up are within defined limits, resulting in ropes within the class having similar strength and rotational properties.
Rope Construction: System which denotes the arrangement of the strands and wires within a rope, e.g. 6x19S; 6x36WS; 18x7; 34x7.
Cable-laid Rope: An assembly of several (usually six) single layer stranded ropes (referred to as unit ropes) laid helically over a core (usually a seventh single layer stranded rope).
Braided Rope: An assembly of several round strands braided in pairs.
Electro-mechanical Rope: A stranded or spiral containing electrical conductors.

Strand and Rope Lays

Lay direction of strand: The direction right (z) or left (s) corresponding to the direction of lay of the outer layer of wires in relation to the longitudinal axis of the strand.
Lay direction of rope: The direction right (Z) or left (S) corresponding to the direction of lay of the outer strands in relation to the longitudinal axis of a stranded rope or the direction of lay of the outer wires in relation to the longitudinal axis of a spiral rope.
Regular Lay: Stranded rope in which the direction of lay of the wires in the outer strands is in the opposite direction to

the lay of the outer strands in the rope. Right Regular Lay is designated zZ and Left Regular Lay is designated zS.

Note: This type of lay is sometimes referred to as 'ordinary' lay.

Lang Lay: Stranded rope in which the direction of lay of the wires in the outer strands is the same as that of the outer strands in the rope. Right Lang Lay is designated zZ and Left Lang lay is designated sS.

Alternate Lay: Stranded rope in which the lay of the outer strands is alternatively Lang's lay and regular lay. Right hand alternate lay is designated AZ and left hand alternate lay is designated AS.

Contra-Lay: Rope in which at least one layer of wires in a spiral rope or one layer of strands in a stranded rope is laid in the opposite direction to the other layer(s) of wire or strands respectively.

Note: Contra-lay is only possible in spiral ropes having more than one layer of wires in, multi-layer stranded ropes.

Rope Lay Length (Stranded Rope): That distance parallel to the axis of the rope in which the outer strands make one complete turn (or helix) about the axis of the rope.

Cores

Core: Central element, usually of fiber or steel, of a single layer stranded rope, around which are laid helically the outer strands of a stranded rope or the outer unit ropes of a cable-laid rope.

Fiber core: Core made from either natural (e.g. hemp, sisal) or synthetic fibers (e.g. polypropylene) and designated by its diameter and runnage.

Steel Core: Core produced either as an independent wire rope (e.g. 7x7) or wire strand (e.g. 1x7).

Solid polymer core: Core produced as a single element of solid polymer having a round or grooved shaped. It may also contain internal elements of wire or fiber.

Insert: Element of fiber or solid polymer so positioned as to separate adjacent strands or wires in the same or overlying layers and fill, or partly fill, some of the interstices in the rope.

Rope Characteristics and Properties

Fill factor: The ratio between the sum of the nominal cross-sectional areas of all the load bearing wires in the rope and the circumscribed area of the rope based on its nominal diameter.

Spinning loss factor: The ratio between the calculated minimum breaking force of the rope and the calculated minimum aggregate breaking force of the rope.

Minimum breaking force (T min): Specified value, in tons or kN, below which the measured breaking force is not allowed to fall in a prescribed test.

Rope torque: Value, usually expressed in ft pounds or N.m, resulting from either test or calculation, relating to the torque generated when both ends of the rope are fixed and the rope is subjected to tensile loading.

Rope turn: Value, usually expressed in degrees per foot/meter, resulting from either test or calculation, relating to the amount of rotation when one end of the rope is free to rotate and the rope is subjected to tensile loading.

Initial extension: Amount of extension which is attributed to the initial bedding down of the wires within the strands and the strands within the rope due to tensile loading.

Note: This is sometimes referred to as constructional stretch.

Elastic extension: Amount of extension which follows Hooke's Law within certain limits due to application of a tensile load.

Permanent rope extension: Non-elastic extension.