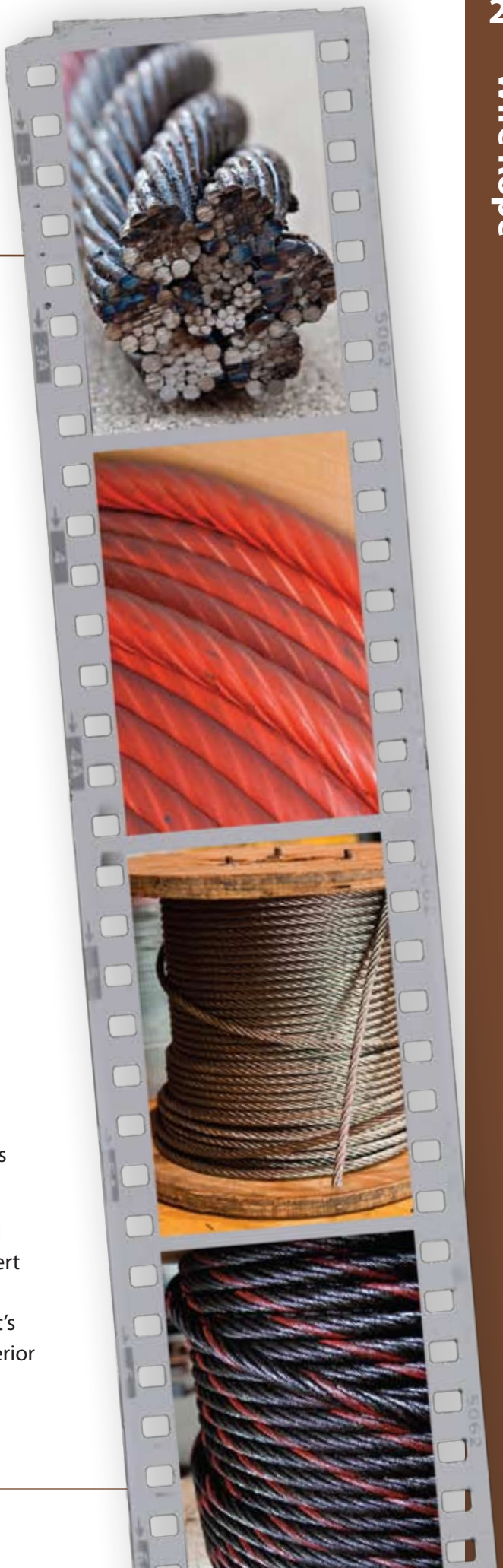
Wire Rope



Wire rope is one of the most basic components of rigging. Much of modern rigging design would not be possible without this strong, versatile, and relatively inexpensive product. Broadly, wire rope consists of nothing more than multiple strands of metal wire laid or twisted into a helix.

Yarbrough Cable stocks wire rope inventory from 1/16 inch through 4-1/2 inch diameter. By splicing eyes into the ends of wire ropes and/or installing spelter, swaged, or wedge sockets, or other end terminations, basic wire rope can be transformed into an almost infinite variety of rigging products and assemblies.

Wire Rope History

The first wire ropes were fashioned from wrought iron wires, but today steel is the main material used. Wire rope evolved from iron and steel chains. Many early chains experienced catastrophic failure because of flaws in the iron and steel bars used to fashion individual chain links. Wire rope was developed in part to address this problem. As opposed to a chain where a flaw that results in a break in any one link severs the chain, a flaw that causes a break in one or two individual wires of a wire rope is not critical. This is because the remaining wires readily take up the load. Friction between individual wires and strands, as a consequence of their helical twist, further compensates for flaws in the materials comprising the rope.

Modern wire rope was invented by the German mining engineer Wilhelm Albert, between 1831 and 1834. Albert developed his wire ropes for use in mining in the Harz Mountains in Clausthal, Lower Saxony, Germany. Albert's wire rope was quickly accepted because it proved superior to ropes made of hemp or to metal chains.

In America, the German immigrant and engineer John A. Roebling began producing wire rope on his Pennsylvania farm in 1841. This early work along with Roebling's innovations in the design, materials, and manufacture of wire rope, formed the basis for his success in suspension bridge building. In 1867 John Roebling began design work on the Brooklyn Bridge. His son, Washington Roebling, and wife, Emily Warren Roebling, completed its construction in 1883. The Brooklyn Bridge remains an enduring monument to the significance of wire rope development as well as its continued usefulness in engineering and construction.

Wire Rope Basics

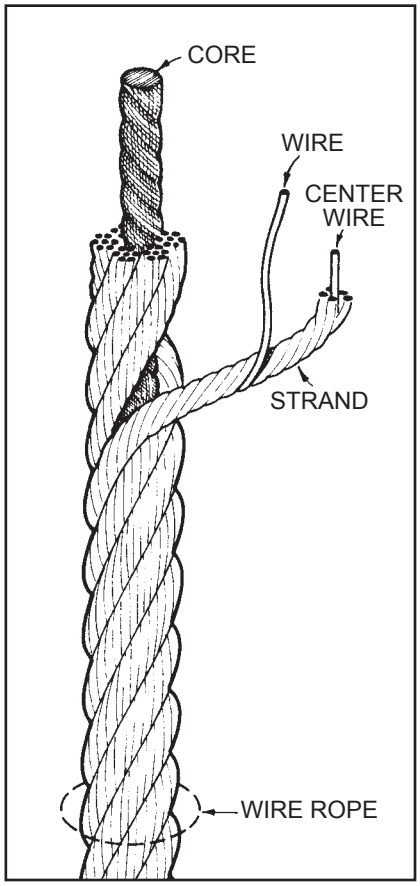
Wire rope consists of 3 basic components. While few in number, these vary in both complexity and configuration so as to produce ropes for specific purposes or with specific characteristics. These are the three basic components of a standard wire rope design:

- Wires that form a strand
- Multi-wire strands laid helically around a core
- The core

Materials for Wire

Wire for wire rope is made in several materials and types. These include steel, iron, stainless steel, monel, and bronze. By far, the most widely used material for wire rope is high-carbon steel. Steel for wire rope is available in a variety of grades, each of which has slightly different properties for strength, elongation, and other characteristics. Wire rope manufacturers select the steel grade that is most appropriate for the requirements of the finished product.

As seen from the pedestrian walkway, the wire rope supports of the Brooklyn Bridge form a distinctive spider web pattern.



The three basic components of a typical wire rope.

Grades of Steel for Wire Rope

Grades of steel used for wire rope are shown in the table below. These steel grade names originated at the earliest stages of wire rope development and have been retained as names for the grades of steel for rope. The plow steel strength curve forms the basis for calculating the strengths of all steel rope wires. The tensile strength (psi) of any steel wire grade is not constant; it varies with the diameter and is highest in the smallest wires.

Virtually all wire rope manufactured in North America and Western Europe is made with EIP steel. Wire rope imported from Asia is made with both IPS and EIP steel. Wire rope made with EEIP steel is rarely available as a stock item and usually requires a special order. Minimum mill run quantities in the range of 10,000 feet often apply to wire rope special orders.

The most common finish for steel wire is *bright* or uncoated; i.e. bare steel. To resist corrosion, steel wires may also be *galvanized*; i.e. zinc coated. *Drawn galvanized* wire has the same strength as bright wire, but wire *galvanized at finished size*—also known as *final finish* or *hot dipped galvanized*—is usually 10% lower in strength.

Stainless Steel

Stainless steel, also known as inox steel or inox from the French word *inoxydable*, is defined as a steel alloy with a minimum of 10.5% chromium content by mass. Stainless steel does not stain, corrode, or rust as easily as ordinary steel, but it is not stain-proof. It is also called corrosion-resistant steel or CRES when the alloy type and grade are not detailed. There are different grades and surface finishes of stainless steel to suit the environment the alloy must endure. Stainless steel is used when both the properties of steel and resistance to corrosion are required.

Stainless steel differs from carbon steel by the amount of chromium present. Unprotected carbon steel rusts readily when exposed to air and moisture. This iron oxide film (the rust) is active and accelerates corrosion by forming more iron oxide. Stainless steel contains sufficient chromium to form a passive film of chromium oxide, which prevents further

Grades of Steel for Wire Rope

Steel Grade Name	Tensile Strength in psi †	Approximate Metric Equivalent †
Traction Steel (TS)	170,000 to 190,000 psi	1240 MPa
Mild Plow Steel (MPS)	200,000 to 225,000 psi	1470 MPa
Plow Steel (PS)	195,000 to 258,000 psi	1570 MPa
Improved Plow Steel (IPS)	220,000 to 300,000 psi	1770 MPa
Extra Improved Plow Steel (EIPS or EIP or XIP)	245,000 to 340,000 psi	1960 MPa
Extra Extra Improved Plow Steel (EEIPS or EEIP or XXIP)	280,000 to 390,000 psi	2160 MPa

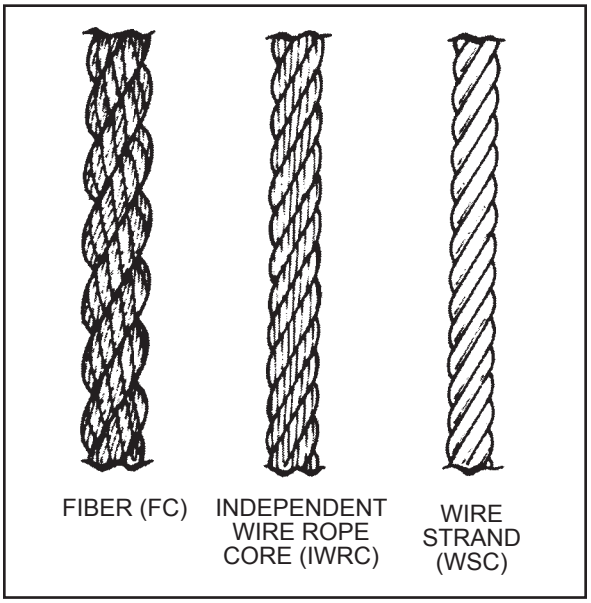
⚠ † Do not confuse tensile strength of the steel used to make a wire rope with the strength of the finished rope itself. The strength of any wire rope is based on both the tensile strength of the steel used to make the rope, and the size and construction of the rope.

surface corrosion and blocks corrosion from spreading into the metal's internal structure.

There are different types of stainless steel alloys. When nickel is added, for instance, the austenite structure of iron is stabilized. Austenitic, or 300 series, stainless steels make up over 70% of total stainless steel production and are the stainless alloys most often used in wire rope. They contain a maximum of 0.15% carbon, a minimum of 16% chromium, and sufficient nickel and/or manganese to retain an austenitic structure at all temperatures from the cryogenic region to the melting point of the alloy. Typical stainless alloys used for wire rope are types 304 and 316.

Type 304 (also known as 18-8) is the basic stainless steel alloy and is an austenitic steel possessing a minimum of 18% chromium and 8% nickel, combined with a maximum of 0.08% carbon. It is a nonmagnetic steel in which the 18% minimum chromium content provides corrosion and oxidation resistance.

Type 316 is for use in severe environments that require a higher level of resistance to corrosion than Type 304 can offer. Type 316 is an austenitic, nonmagnetic stainless steel like Type 304. The carbon content is held to 0.08% maximum, while the nickel content is increased slightly. What distinguishes Type 316 from Type 304 is the addition of molybdenum up to a maximum of 3%. Molybdenum increases the corrosion resistance of this chromium-nickel alloy to withstand attack by many industrial chemicals and solvents, and, in particular, inhibits pitting caused by chlorides.



The three basic wire rope cores

Wire Strands

Strands in a wire rope are made up of two or more wires, laid in any one of many specific geometric arrangements. Steel wires may also be combined with other materials such as natural or synthetic fibers to form strands. It is conceivable that a strand may be made up of any number of wires, or that a rope may have any number of strands.

Wire Rope Core

The core is the foundation of a wire rope. It is made of materials that will provide proper support for the strands under normal bending and loading conditions. Core materials include fibers (natural or synthetic) or steel. A steel core may consist either of a strand or an independent wire rope, i.e. a smaller diameter wire rope with its own separate construction of wires, strands, and core. The three most common core designations are fiber core (FC), independent wire rope core (IWRC), and wire strand core (WSC). Catalog descriptions of wire rope always include these abbreviations to identify the core type.

Characteristics to Consider when Selecting a Wire Rope

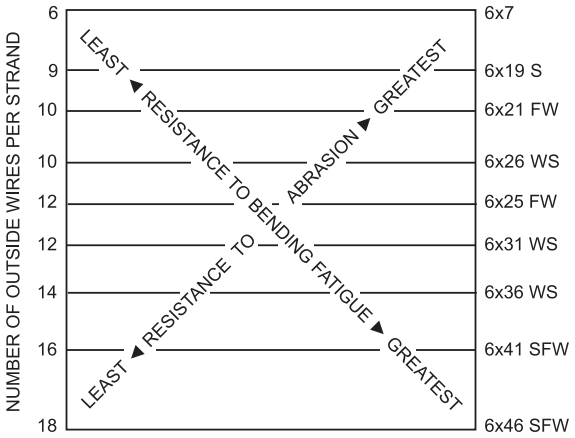
Major characteristics to consider when selecting a wire rope for a given application are shown in the table on the next page. This should not be considered a definitive list of all wire rope characteristics—many other characteristics of wire rope exist and may be important depending on the application at hand.

Wire Rope Characteristics

Attribute	Description
Strength of the rope	Strength of a wire rope is determined by the size (diameter) of the rope, the grade of steel used for the wire, and the rope construction; e.g. IWRC ropes are stronger than wire strand core or fiber core ropes.
Abrasion resistance of the rope	Abrasion is frictional surface wear on the wires of a wire rope. Abrasion can be caused by dragging the rope through or over abrasive materials (sand, gravel, etc.) as when ropes are used in mining and quarrying applications. Abrasion also occurs when rope travels over winch drums and sheaves. The effects of abrasion can be minimized by selecting a rope with larger wires.
Resistance of the rope to bending fatigue	Bending fatigue occurs when wire rope is subjected to bending around a sheave or drum. When selecting a wire rope for an application where bending fatigue is the principal cause of deterioration, it is important to select a rope containing small wires. In addition, one should avoid bending a rope around a sheave or drum that is smaller than 26 times the rope diameter; e.g. a 1-inch diameter rope should be used with sheaves or drums that are at least 26 inches in diameter.
Corrosion resistance of the steel used for the rope	Wire ropes deteriorate from the effects of corrosion when they are in contact with any corrosive agent. Corrosive agents include acids, alkalis, salts, fresh water, oxygen, etc. Corrosion may be minimized or eliminated by selecting a wire rope with corrosion resistant properties. Galvanized ropes have a zinc coating on the rope wires which resists attack by many corrosive agents. Stainless steel ropes are made with steel that has corrosion resistant metals in the steel itself. Galvanized steel and stainless steel wires in plastic coated and plastic filled ropes are covered by a plastic jacket that resists attack by many corrosive agents.
Resistance of the rope to rotation	All steel wire ropes will turn or rotate when a load is applied to the rope while one end is fixed and the other end is free. The degree to which a rope generates rotation will increase as the applied load increases and as the height of the lift increases. Select a rope with a construction specifically designed to minimize rotation when rope rotation is a factor.
Resistance of the rope to crushing	Wire rope may be crushed by 1) its own pressure against a sheave, 2) improperly sized sheave grooves, and 3) multiple layers of rope on a winch drum. The pressure of rope against a sheave is determined by the sheave diameter and the load. The pressure of rope on a drum is influenced by the support of the drum grooves, if any. Smooth drums have a more adverse effect than those that are grooved. Multiple layer winding is also a cause of crushing, even when done in an orderly manner. Irregular or scramble winding is a greater cause of crushing. In each of these cases, reducing the load will ease the condition. If this is not feasible, offending sheaves may be replaced with sheaves of larger diameter. Unsuitable drums and/or winding conditions may be corrected. The rope itself may also be replaced with a rope that has greater resistance to crushing; e.g. a fiber core rope may be replaced with a steel core rope. Regular lay ropes are better able to resist crushing than lang lay ropes.

Abrasion Resistance versus Bending Fatigue

Of all the characteristics in the table on the preceding page, the two facts that govern most decisions as to the selection of a wire rope are abrasion resistance and resistance to bending fatigue. Striking a proper balance with respect to these two characteristics demands careful consideration of the application at hand. A graphic presentation of this comparison of qualities, between the most widely used rope constructions, is given by means of the X-chart.



Known as the X-chart in the wire rope industry, this chart illustrates the inverse relationship between abrasion resistance and resistance to bending fatigue in commonly used wire rope constructions.

Referring to this chart when selecting a rope, the mid-point (at the X) comes closest to an even balance between abrasion resistance and resistance to bending fatigue. Reading up or down along either leg of the X, the inverse relationship becomes more apparent as one quality improves and the other declines.

Wire Rope Construction

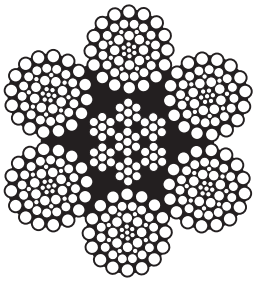
The design arrangement of the component parts of a wire rope is called the construction. To date, nearly 100 different constructions have been manufactured.

Wires and Strands

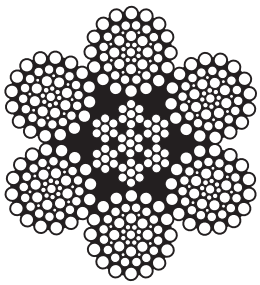
Construction of wire rope is designated first by the number of strands and then by the number of wires in a strand; therefore a 6x7 rope has six strands with seven wires per strand; 6x19 has 6 strands with 19 wires per strand; 8x19 has eight strands with 19 wires per strand, etc. When wire rope contains wires of different sizes, the construction is usually designated by name as well as by number.

Confusion arises from the fact that some of the wire rope construction designations have also become classifications. That is, ropes may be said to be 6x19 *class*, which includes ropes that are indeed 6x19, but also 6x21, 6x25, and 6x26. See the accompanying diagrams for illustrations of common wire rope classifications and some individual constructions within the classes. When class can also be a construction—as in the case of 6x19—it is not unusual for the word *true* to precede 6x19 in cases where 6x19 is used to describe the actual construction of a rope, instead of its class. This is the case where other constructions are also classifications; e.g. 6x61.

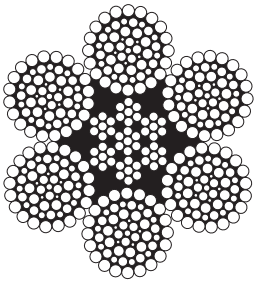
6 x 61 Classification



6 x 55 (2 Operation)
Filler Wire Seale
IWRC

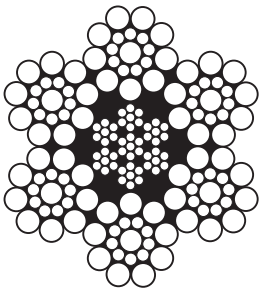


6 x 57
Seale Filler Wire
Seale IWRC

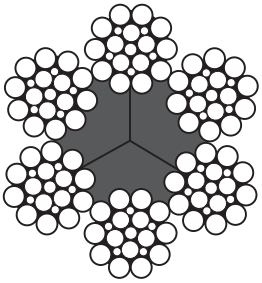


6 x 61 Filler Wire
Warrington Seale
IWRC

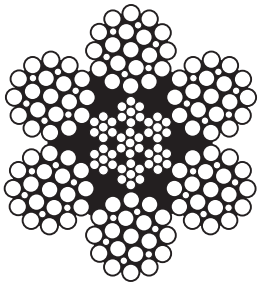
6 x 19 Classification



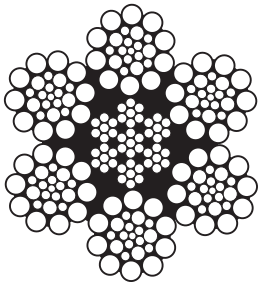
6 x 19 Seale
IWRC



6 x 21 Filler Wire
IWRC



6 x 25 Filler Wire
IWRC



6 x 26 Filler
Warrington Seale
IWRC

Cross sections of commonly used wire rope constructions.

Lay of Wires and Strands

In addition to designations that describe the number of wires and strands in a rope, there are designations that describe how the wires and strands are laid to form the rope. Collectively, these designations are referred to as the *lay*. As illustrated in the following image, there are five (5) common lays for wire rope.

Of all the types of wire rope in current use, *right regular lay* (RRL) is found in the widest range of applications. Many equipment applications use *right lang lay* (RLL) or *left lang lay* (LLL)

A comparison of typical wire rope lays: a) right regular lay, b) left regular lay, c) right lang lay, d) left lang lay, e) right alternate lay.

Common Wire Rope Lays

Lay	Description
Right hand lay – ropes **A** and **C**	Strands laid into rope to the *right*, in a manner similar to threading in a right-hand bolt.
Left hand lay – ropes **B** and **D**	Strands laid into rope to the *left*, in a manner similar to threading in a left-hand bolt.
Regular lay – ropes **A** and **B**	Wires in the strands are laid *opposite to the direction* of the strand lay in the rope. This results in the *wires being parallel* to the axis of the rope.
Lang lay – ropes **C** and **D**	Wires in the strands are laid in the *same direction* as the strand lay in the rope. This results in the *wires being at an angle* to the axis of the rope.
Alternate lay – rope **E**	Strands of alternating regular and lang lay.

ropes. At present, *left lay* rope is infrequently used. *Alternate lay* rope is only used for special applications.

Advantages and Disadvantages of Lang Lay Rope

Lang lay ropes are said to yield longer life when bent over sheaves and drums. This is because the wires follow the lay of the rope strands so bending a lang lay rope results in less axial bending of the outer wires. Lang lay ropes are also said to be more resistant to abrasion. Again, this is because the wires follow the lay of the rope strands and thus present more surface area for wear. Broadly, both claims are true, though with some reservations.

Specifically, lang lay rope has two important limitations. First, if either end is not fixed, it will rotate severely when under load. Second, lang lay rope is less able to withstand crushing forces on a drum or sheave, especially if these forces are magnified by poor drum winding conditions. Thus, lang lay rope should not be operated without being secured at both ends, nor should it be operated over minimum-sized sheaves or drums under great loads.

Putting it all Together – Specifying a Wire Rope

When specifying wire rope, one combines all the foregoing characteristics into a single description that includes the size, class and construction, steel grade, core, and lay. See the table below for some common examples.

Often, the lay designation is omitted entirely from a rope description, in which case the lay is understood to be RRL. Sometimes, the lay designation is only described as left or right, in which case the type is understood to be regular. Similarly, steel grade is often omitted, in which case the grade is usually understood to be XIP.

Specifying a Wire Rope

Single Description	Extended Description
5/8 in. 6x25 XIP IWRC RRL	5/8 inch diameter rope with 6 strands of 25 wires each, made from extra improved plow steel with an independent wire rope core in right regular lay
3/8 in. 6x19 IPS FC RRL	3/8 inch diameter rope with 6 strands of 15 to 26 wires each, made from improved plow steel with a fiber core in right regular lay
3/4 in. true 6x19 XIP IWRC LLL	3/4 in. diameter rope with 6 strands of 19 wires each, made from extra improved plow steel with an independent wire rope core in left lang lay
1-1/4 in. 6x41 XXIP IWRC RLL	1-1/4 inch diameter rope with 6 strands of 41 wires each, made from extra extra improved plow steel with an independent wire rope core in right lang lay

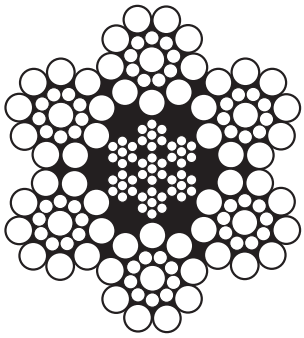
Common Wire Rope Constructions and Applications

There are many different wire rope classifications and each one is unique in its application and construction. The following pages outline the characteristics, uses, and special considerations of some of the more commonly used wire rope constructions.

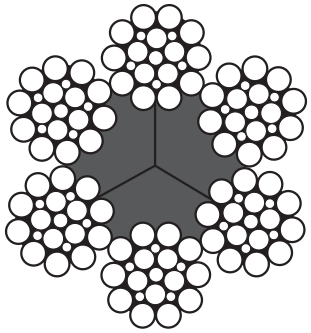
6x19 Classification

Ropes in the 6x19 classification will have 6 strands with 15 to 26 wires per strand. Common ropes in this classification include 6x19, 6x21, 6x25, and 6x26.

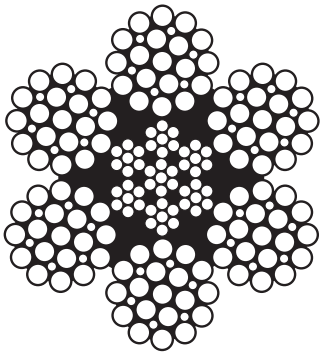
6x19 Characteristics	6x19 ropes are the stiffest and strongest construction of the types of wire ropes suitable for general pulling and hoisting purposes. These ropes also have the largest wires of common wire rope constructions.
Uses	When made of ungalvanized steel wire, this rope is principally used when great strength and abrasion resistance are required, particularly on derricks and dredges. When made of galvanized steel wire, 6x19 ropes may be used for standing rigging, guys, boat slings, topping lift pendants for booms, running rigging (7/16 inch and under), and wheel rope (7/16 inch and under).
Special Considerations	Sheaves and drums for this construction and classification should be larger than those for other more flexible types.



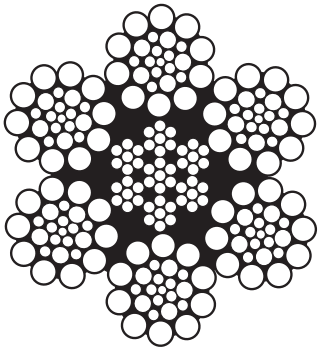
6 x 19 Seale



6 x 21 Filler Wire FC



6 x 25 Filler Wire IWRC

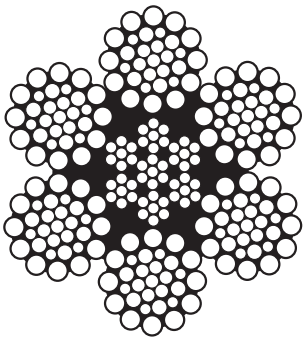


6 x 26 Warrington Seale IWRC

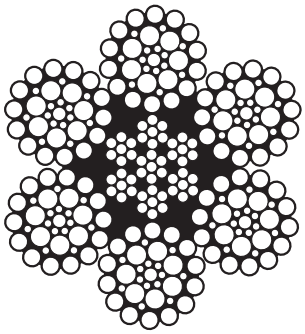
6x36 Classification

Ropes in the 6x36 classification will have 6 strands with 27 to 49 wires per strand. Common ropes in this classification include 6x31, 6x36, 6x41, 6x46, and 6x49.

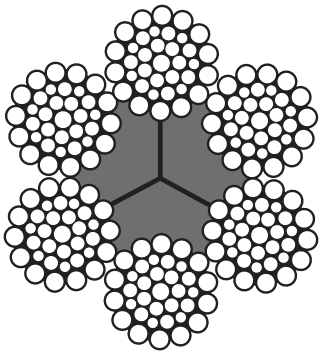
6x36 Characteristics	6x36 ropes are very flexible and are suitable for cranes and similar hoisting machinery. These ropes also have smaller wires than 6x19 constructions. They have good reserve strength, however, because a little more than 50 percent of the wires and consequently more than 50 percent of the strength are in the inner layers of the strand protected from abrasion.
Uses	When made of ungalvanized steel wire, this rope is principally used in applications where flexibility is the key requirement, particularly in cranes and similar machinery where sheaves and drums may be smaller than desirable and where bending conditions are unusually severe. Hoisting ropes larger than 1/2 inch in diameter are usually of this type. When made of galvanized steel wire, 6x36 ropes may be used for steering gear, transmission rope, hawsers (when great strength is required), relieving tackle, towing hawsers, bridles (large and small), tiller ropes, torpedo slings, and slings for general hoisting.
Special Considerations	The wires in 6x36 class ropes are smaller than in 6x19 ropes, and consequently will not stand as much abrasive wear.



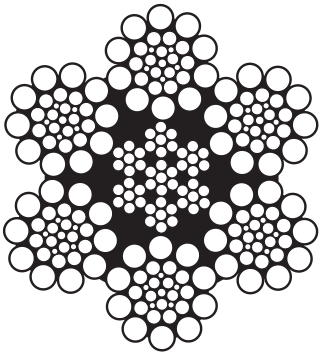
6 x 31 Warrington Scale IWRC



6 x 36 Seale Filler Wire IWRC



6 x 36 Warrington Scale FC

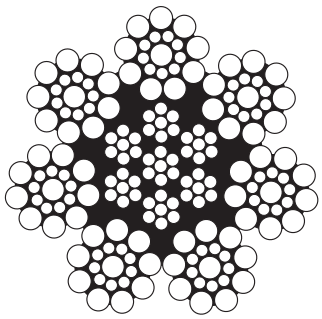


6 x 31 Filler Wire Seale IWRC

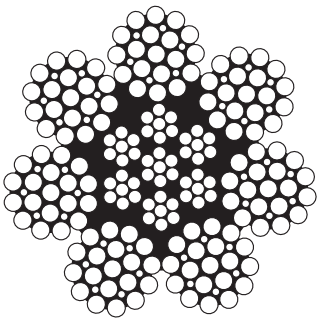
7x7 and 7x19 Galvanized and Stainless Steel Aircraft Cable

Aircraft cable is a common industry term for special strength small diameter wire rope originally designed for aeronautical applications. Its original use was as "flying wires" to brace and tension the wings of early multi-wing aircraft (i.e. biplanes and triplanes). Because of its special strength characteristic, the standard steel strength designations (IPS, XIP, etc.) do not apply to aircraft cable. All aircraft cable is wire strand core.

Aircraft Cable Characteristics	7x7 and 7x19 aircraft cable is a flexible and inexpensive utility cable used on winches, guy lines, and numerous other commercial, industrial, and marine applications. It is available in sizes from 1/16 inch to 3/8 inch diameter. For corrosion resistance, aircraft cable is available with a zinc coating (galvanized) or in 304 or 316 alloy stainless steel. Galvanized aircraft cable is also available with a flexible, PVC, or nylon cover to extend the cable's life by protecting wires from abrasion, dirt, grit, and moisture, sealing in lubrication, and reducing wear on sheaves and pulleys. The PVC cover also protects hands, clothes, and other materials with which the cable is in contact.
Uses	Aircraft cable is commonly used on light-duty vehicle winches, as guy lines, messenger lines, barrier cables, and cable railings, and for a wide range of utility applications in marine, industrial, and commercial applications.
Special Considerations	The wires in 7x7 constructions are larger diameter and less flexible than those in 7x19 constructions. 7x7 constructions should be avoided when bending is necessary, such as over small sheaves and drums. The wires in 7x19 constructions are smaller diameter than those in 7x7 constructions. Smaller diameter wires are less abrasion resistant and thus 7x19 constructions should be avoided when abrasion is a factor, as in applications where the cable is in continuous contact with abrasive materials or surfaces.



7 x 19 Seale
IWRC

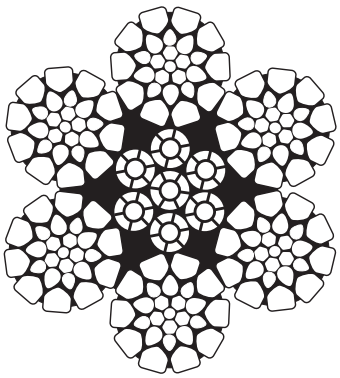


7 x 25 Filler Wire
IWRC

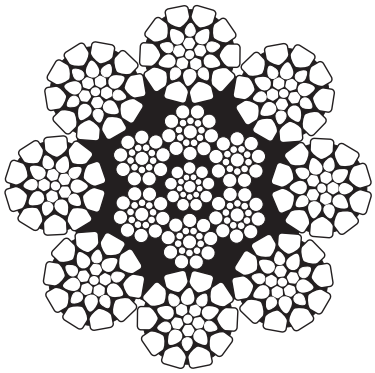
Compacted Strand Wire Rope

Compacted strand wire rope is wire rope manufactured from strands which have been reduced in diameter either in the stranding operation or in a separate operation after stranding, prior to the closing of the rope. There are various known methods for compacting: drawing the strand through a compacting die, roller reduction, and rotary swaging are several examples. Regardless of the process, uniform flattening of all wires in a strand is achieved.

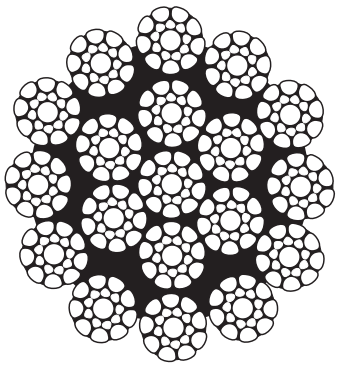
Compacted Strand Wire Rope Characteristics	In compacted strand wire rope, the wires are compacted or reduced in diameter either in the stranding operation or in a separate operation after stranding, prior to the final closing of the rope. This compression gives the strands higher tensile strength. The compacting process flattens the surface of the outer wires and reforms internal wires of the strand to increase the density of the strand. The result is a smoother bearing surface at the strand crowns, greater wear resistance, and an increase in minimum breaking force over round strand rope of the same diameter and classification.
Uses	Compacted strand wire rope is used in applications requiring increased strength in smaller diameters. The rope is also used in applications with sheaves and drums such as those involving cranes, diving systems, commercial fishing, etc.
Special Considerations	It is difficult to inspect any diameter reduction of compacted strand wire rope that might be associated with wear because of the rope's initial flattened appearance. Also, some deterioration in the rope's mechanical properties over time has been noted.



6 x 26 Warrington Seale Compacted Strand IWRC



8 x 26 Warrington Seale Compacted Strand IWRC

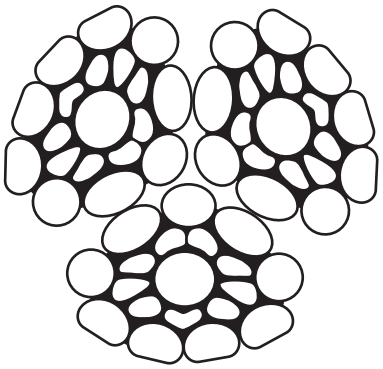


19 x 19 Seale Compacted Strand

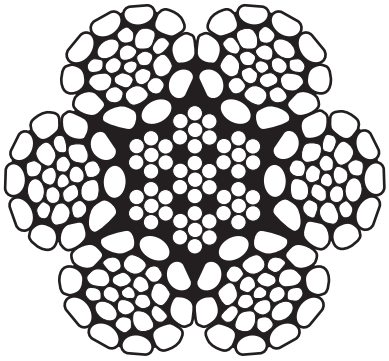
Swaged Wire Rope

Swaged wire rope is wire rope that has been reduced in diameter following the closing of the rope. Rotary swaging is the most common process employed to compact a rope, although other processes may be used. In general, the process of swaging after the closing of the rope results in flattening mostly the outer rope wires, though some compacting of inner wires is achieved.

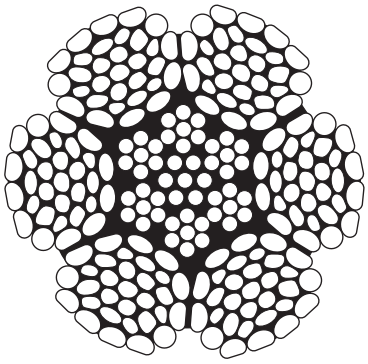
Swaged Wire Rope Characteristics	Swaged wire rope is compacted or reduced in diameter in a separate operation after the final closing of the rope. The wires and strands of the rope are flattened to produce a relatively smooth and wear-resistant outer surface. Compacted ropes generally have good wear resistance, crush resistance, and high strength.
Uses	Swaged rope is most useful in applications where abrasion is an issue, including mining, quarrying, logging, etc.
Special Considerations	Swaged wire rope may not have bending fatigue resistance that is equivalent to standard or compacted strand wire ropes, especially at small bending ratios. Swaged wire rope is also extremely stiff and may therefore be difficult to handle in limited space environments.



3 x 19 Seale Compacted (Swaged)



6 x 26 Warrington Seale Compacted (Swaged) IWRC

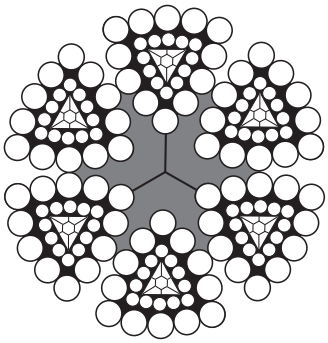


6 x 31 Warrington Seale Compacted (Swaged) IWRC

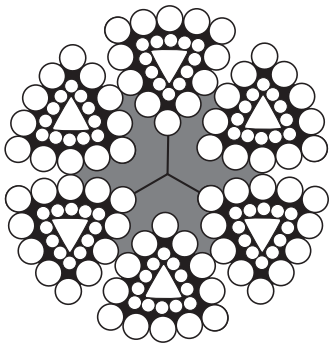
Flattened (Triangular) Strand Wire Rope

Triangular strand wire ropes are comprised of one or more layers of wire formed around a triangular shaped center. The triangular strand shape provides a high strength rope with high metallic area, which is exceptionally resistant to crushing forces.

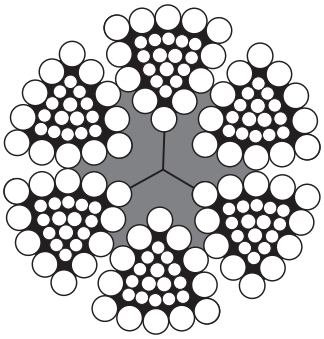
Flattened (Triangular) Strand Wire Rope Characteristics	Each strand of a flattened strand wire rope is comprised of a layer or layers of wire around a triangular shaped center. The center consists of either a triangular shaped wire element, or wires in a triangular configuration. The triangular strand shape provides a high strength rope with high metallic area, which is resistant to crushing. Abrasion resistance is enhanced by an increased bearing surface, in comparison to round strand ropes.
Uses	Flattened strand wire rope is used when the load is heavy and the operation speed is slow, when a crush resistant rope is required, or when adequate diameter sheaves and drums are used.
Special Considerations	Undersize sheaves should be avoided with triangular strand rope as the rope can exhibit poor bending fatigue resistance. Sheaves for use with the rope should in fact be somewhat oversized to minimize bending fatigue.



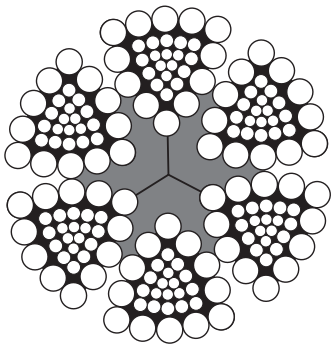
6 x 31 Style V Flattened Strand (Brangle Center) FC



6 x 25 Style B Flattened Strand (Solid Center Wire) FC



6 x 27 Style H Flattened Strand (3 Wire Center) FC

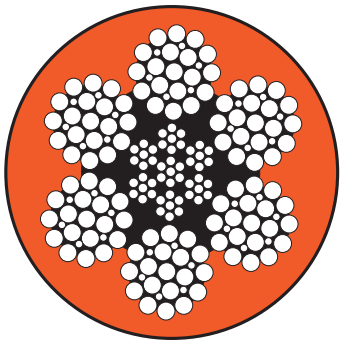


6 x 30 Style G Flattened Strand (Plaited Center)

Plastic Coated Wire Rope

Plastic coatings are often applied to the exterior of wire rope. The most common coatings are vinyl, nylon, polyethylene, PVC, or Teflon®. Coating type is typically selected based on the requirements of the application, such as UV resistance, chemical resistance, abrasion resistance, color availability, etc. Coatings protect both the rope and the user.

Plastic Coated Wire Rope Characteristics	Various wire rope constructions are available with a plastic coating applied to the exterior of the rope. Small diameter galvanized and stainless steel wire ropes with plastic coating are common. The plastic coating can provide protection against abrasion, dirt, grit, and moisture, and in some cases reduce wear of the rope and other rigging components. Coatings can also seal in lubrication.
Uses	Plastic coated ropes are typically not used as operating ropes, but mostly as standing or stationary ropes. Plastic coated ropes are also used in some corrosive environments as well as in applications where there is a need to protect sensitive surfaces from contact with the rope.
Special Considerations	Plastic coated ropes can be difficult to inspect and are more costly than uncoated wire ropes. Plastic coatings will trap any corrosive agents that penetrate the coating, either at unsealed ends or through longitudinal breaks. Many plastic coatings are not UV resistant and will quickly deteriorate in outdoor installations when exposed to solar radiation for extended periods. The plastic coating must be removed prior to installing any and all fittings.

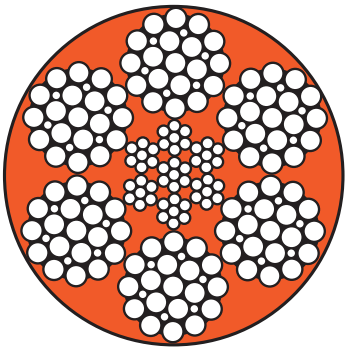


Plastic Coated Wire Rope

Plastic Filled Wire Rope

Plastic filled wire rope differs from plastic coated wire rope in that such ropes have plastic extruded into the internal spaces between the wires. The plastic filling typically extends to, or slightly beyond, the outer circumference of the rope, and it provides protection similar to that of a covering while also reducing internal rope wear.

Plastic Filled Wire Rope Characteristics	Plastic filled wire ropes are wire ropes in which internal spaces are filled with a matrix of plastic. The plastic extends to, or slightly beyond, the outer circumference of the rope. Plastic filling may improve bending fatigue life by reducing internal and external wear. The plastic may also protect the rope from contact with corrosive agents.
Uses	Plastic filled wire ropes are used in many demanding applications and require special handling and inspection techniques. The plastic filling in these ropes provides enhanced support for wires and strands when the rope is reeved over sheaves or wound on drums. Plastic filled ropes are also found in corrosive environments where the plastic may provide protection from corrosive agents.
Special Considerations	The outer layer of plastic on these ropes must be removed prior to installing any and all fittings including swaged or spelter sockets, wire rope clips, wedge sockets, etc.

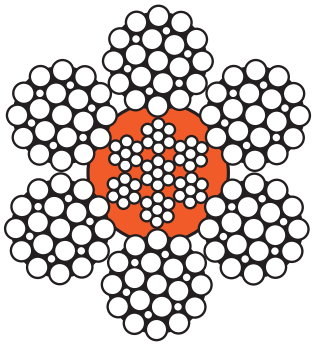


Plastic Filled Wire Rope

Plastic Coated and/or Plastic Filled IWRC Wire Rope

Plastic coated and/or plastic filled IWRC wire rope is a rope which incorporates a plastic cover or filling on or in the rope core, as opposed to the entire rope being plastic coated or filled. The benefits of this treatment are the same as for a plastic coating or filling on the entire rope, with the exception that the benefits apply mostly to the rope core.

Plastic Coated and/or Plastic Filled IWRC Wire Rope Characteristics	Plastic coated and/or plastic filled IWRC wire rope is wire rope which incorporates a plastic coated or plastic filled IWRC. That is, the *core* of the rope, and *only the core of the rope*, has either a plastic coating, is plastic filled, or is both plastic coated and plastic filled.The plastic coating or plastic filling reduces internal wear, seals lubrication in the rope core, and may increase overall rope life and bending fatigue life. Plastic coatings and fillings for rope cores serve as a cushion between outer wires and the core, and as such, can minimize internal rope damage.
Uses	Wire rope with a plastic coated or plastic filled independent wire rope core is well-suited for applications where the rope is reeved over sheaves or wound on drums. This rope provides improved resistance to crushing and bending fatigue. Corrosion of the core wires is minimized and thus, these ropes may deliver improved service life in corrosive and outdoor environments.
Special Considerations	Plastic coated and/or plastic filled IWRC wire rope may not be suitable for attachment of some end fittings such as swage or spelter sockets. Load tests may need to be done when end fittings are attached to these rope types. Additional expense of plastic coatings and fillings may be an issue in some applications.



Plastic Coated and Filled IWRC Wire Rope

High Performance Wire Rope

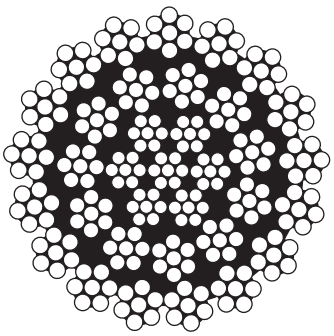
The past several decades have seen the development of a number of specialty wire ropes with enhanced performance characteristics for specific applications. In general, such ropes are lumped together under the heading *high performance rope*. Particular care should be exercised when selecting a high performance rope; good performance in some areas may have been sacrificed to achieve enhanced performance in other areas.

Rotation Resistant Wire Rope

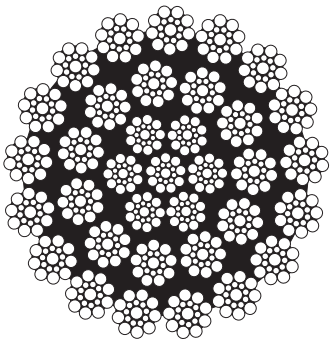
The most common group of high performance ropes are rotation resistant ropes. Rotation resistant ropes are a special category (class) of wire rope designed to resist the tendency to spin or rotate under load. In general, these ropes are used as single-part lines, or in situations where operating conditions require a rope that will resist cabling (twisting together) in a multi-part system. Special considerations apply to the handling, installation, and use of rotation resistant ropes. Attention should be given to these factors as well as to the advantages and disadvantages of rotation resistant ropes as they apply to the application at hand.

Categories of Rotation Resistant Rope

Category 1	Stranded rope constructed such that it displays *little or no tendency to rotate*, or if guided, transmits little or no torque.
Category 1 Construction	Category 1 rope has *at least 15 outer strands* and comprises an assembly of at least 3 layers of strands laid helically over a center in two operations. The direction of lay of the outer strands is opposite to that of the underlying layer.

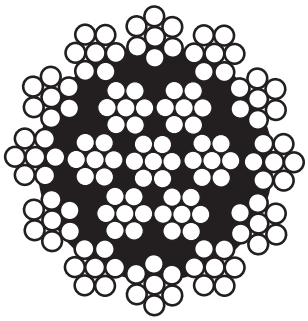


35 x 7

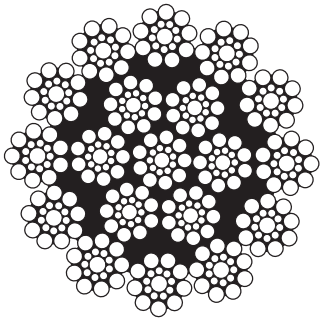


35 x 19

Category 2	Stranded rope constructed such that it has significant resistance to rotation.
Category 2 Construction	Category 2 rope has at least 10 outer strands and comprises an assembly of 2 or more layers of strands laid helically over a center in two or three operations. The direction of lay of the outer strands is opposite to that of the underlying layer.

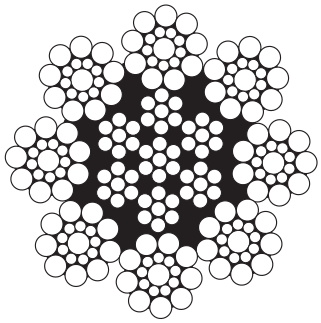


19 x 7

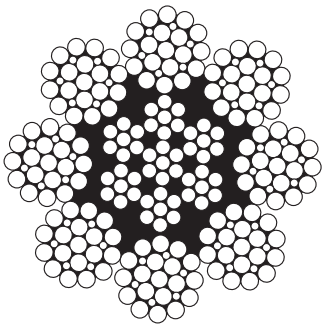


19 x 19 Seale

Category 3	Stranded rope constructed such that it has limited resistance to rotation.
Category 3 Construction	Category 3 rope has no more than 9 outer strands and comprises an assembly of 2 layers of strands laid helically over a center in two operations. The direction of lay of the outer strands is opposite to that of the underlying layer.



8x19 Seale
IWRC



8x25 Filler Wire
IWRC

The crossover points between strand layers in rotation resistant rope are points of high stress concentration. Relative motion of the strand at these points results in accelerated deterioration of the internal components of the rope. Because of this characteristic of rotation resistant rope construction, care must be taken to avoid high loads with small diameter sheaves.

Many rotation resistant ropes are only partially preformed, and some are non-preformed. Ends of the rope should thus be seized tightly, welded, or brazed to prevent lay disturbances of the outer strands or core. Care must be taken to avoid introducing twist into the rope during handling and installation.

The above is a brief discussion of rotation resistant rope. A complete discussion of the characteristics, advantages, and disadvantages of rotation resistant rope is beyond the scope of this catalog. Consult your Yarbrough Cable representative for further information regarding the use and application of rotation resistant wire rope.

Ordering Wire Rope and Aircraft Cable from Yarbrough

Yarbrough Cable stocks aircraft cable in sizes ranging from 1/16 inch diameter to 3/8 inch diameter, and wire rope in sizes ranging from1/4 inch diameter to 4-1/2 inch diameter. Most common constructions and sizes are in stock for immediate delivery. The tables on the following pages provide specifications for the common ropes and cables in Yarbrough's inventory. A wide range of special purpose wire ropes not shown here is also available through Yarbrough. Contact a Yarbrough rigging professional to discuss your specific wire rope requirements.

Aircraft Cable

Aircraft cable is available from 1/16 inch through 3/8 inch diameter. All aircraft cable is wire strand core.

Minimum Strength (lbs.) and Weight of Aircraft Cable †

Size	Weight lbs. / 100 ft.		Galvanized		Stainless Steel	
	7x7	7x19	7x7	7x19	7x7	7x19
ø 1/16 in.	0.75	0.75	480	480	480	480
ø 3/32 in.	1.6	1.7	920	1000	920	920
ø 1/8 in.	2.8	2.9	1700	2000	1700	1760
ø 3/16 in.	6.2	6.5	3700	4200	3700	3700
ø 1/4 in.	10.6	11.0	6100	7000	6100	6400
ø 5/16 in.	16.7	17.3	9200	9800	9000	9000
ø 3/8 in.	23.6	24.3	13100	14400	12000	12000

† All strengths approximate | For new aircraft cable or aircraft cable in new, unused condition

Working Load Limit (lbs.) and Weight of Aircraft Cable; 5:1 Design Factor †

Size	Weight lbs. / 100 ft.		Galvanized		Stainless Steel	
	7x7	7x19	7x7	7x19	7x7	7x19
ø 1/16 in.	0.75	0.75	96	96	96	96
ø 3/32 in.	1.6	1.7	184	200	184	184
ø 1/8 in.	2.8	2.9	340	400	340	352
ø 3/16 in.	6.2	6.5	740	840	740	740
ø 1/4 in.	10.6	11.0	1220	1400	1220	1280
ø 5/16 in.	16.7	17.3	1840	1960	1800	1800
ø 3/8 in.	23.6	24.3	2620	2880	2400	2400

† All strengths approximate | For new aircraft cable or aircraft cable in new, unused condition

Common 6-strand Wire Rope

Yarbrough stocks common 6-strand wire rope from1/4 inch through 4-1/2 inch diameter. Order by specifying size, class and construction, steel grade, core, and lay; e.g. 7/8 in. 6x25 XIP, IWRC, RRL.

See *Putting it all Together – Specifying a Wire Rope*. [page 33]

See tables for strength and working load limit for 6-strand wire rope on the following pages.

Minimum Strength (U.S. tons) and Weight of Common 6-Strand IWRC Wire Rope †

Size	Lbs./ft.	IPS (1770 MPa)		EIP (1960 MPa)			EEIP (2160 MPa)	
		6x19	6x36	6x19	6x36	6x61	6x19	6x36
ø 1/4 in.	0.12	2.94	2.94	3.4	3.4	—	—	3.74
ø 5/16 in.	0.18	4.58	4.58	5.27	5.27	—	—	5.8
ø 3/8 in.	0.26	6.56	6.56	7.55	7.55	—	—	8.3
ø 7/16 in.	0.35	8.89	8.89	10.2	10.2	—	11.2	11.2
ø 1/2 in.	0.46	11.5	11.5	13.3	13.3	—	14.6	14.6
ø 9/16 in.	0.59	14.5	14.5	13.2	16.8	—	18.5	18.5
ø 5/8 in.	0.72	17.7	17.9	20.6	20.6	—	22.7	22.7
ø 3/4 in.	1.04	25.6	25.6	29.4	29.4	—	32.4	32.4
ø 7/8 in.	1.42	34.6	34.6	39.8	39.8	—	43.8	43.8
ø 1 in.	1.85	44.9	44.9	51.7	51.7	49.1	56.9	56.9
ø 1-1/8 in.	2.34	56.5	56.5	65	65	61.9	71.5	71.5
ø 1-1/4 in.	2.89	69.4	69.4	79.9	79.9	76.1	87.9	87.9
ø 1-3/8 in.	3.5	83.5	83.5	96	96	91.7	106	106
ø 1-1/2 in.	4.16	98.9	98.9	114	114	109	125	125
ø 1-5/8 in.	4.88	115	115	132	132	127	146	146
ø 1-3/4 in.	5.67	133	133	153	153	146	169	169
ø 1-7/8 in.	6.5	152	152	174	174	168	192	192
ø 2 in.	7.39	172	172	198	198	190	217	217
ø 2-1/8 in.	8.35	192	192	221	221	214	243	244
ø 2-1/4 in.	9.36	215	215	247	247	239	272	282
ø 2-3/8 in.	10.4	239	239	274	274	264	302	302
ø 2-1/2 in.	11.6	262	262	302	302	292	—	332
ø 2-5/8 in.	12.8	288	288	331	331	321	364	364
ø 2-3/4 in.	14.0	314	314	361	361	350	397	397
ø 2-7/8 in.	15.3	—	341	—	392	382	—	432
ø 3 in.	16.6	—	370	—	425	414	—	468
ø 3-1/8 in.	18	—	399	—	458	—	—	504
ø 3-1/4 in.	19.5	—	429	—	492	483	—	543
ø 3-3/8 in.	21	—	459	—	529	518	—	582
ø 3-1/2 in.	22.7	—	491	—	564	555	—	621
ø 3-5/8 in.	24.3	—	523	—	602	592	—	663
ø 3-3/4 in.	26	—	557	—	641	632	—	705
ø 3-7/8 in.	27.7	—	—	—	680	669	—	—
ø 4 in.	29.6	—	—	—	720	713	—	—
ø 4-1/8 in.	31.4	—	—	—	761	753	—	—
ø 4-1/4 in.	33.4	—	—	—	803	799	—	—
ø 4-3/8 in.	35.4	—	—	—	846	846	—	—
ø 4-1/2 in.	37.4	—	—	—	889	888	—	—

† All strengths approximate | For new wire rope or wire rope in new, unused condition

Working Load Limit (U.S. tons) and Weight of Common 6-strand IWRC Wire Rope; 5:1 Design Factor †

Size	Lbs./ft.	IPS (1770 MPa)		EIP (1960 MPa)			EEIP (2160 MPa)	
		6x19	6x36	6x19	6x36	6x61	6x19	6x36
ø 1/4 in.	0.12	0.59	0.59	0.68	0.68	—	—	0.75
ø 5/16 in.	0.18	0.92	0.92	1.05	1.05	—	—	1.16
ø 3/8 in.	0.26	1.31	1.31	1.51	1.51	—	—	1.66
ø 7/16 in.	0.35	1.78	1.78	2.04	2.04	—	2.24	2.24
ø 1/2 in.	0.46	2.30	2.30	2.66	2.66	—	2.92	2.92
ø 9/16 in.	0.59	2.90	2.90	2.64	2.64	—	3.70	3.70
ø 5/8 in.	0.72	3.58	3.58	4.12	4.12	—	4.54	4.54
ø 3/4 in.	1.04	5.12	5.12	5.88	5.88	—	6.48	6.48
ø 7/8 in.	1.42	6.92	6.92	7.96	7.96	—	8.76	8.76
ø 1 in.	1.85	8.98	8.98	10.3	10.3	9.8	11.4	11.4
ø 1-1/8 in.	2.34	11.3	11.3	13	13	12.4	14.3	14.3
ø 1-1/4 in.	2.89	13.9	13.9	16	16	15.2	17.6	17.6
ø 1-3/8 in.	3.5	16.7	16.7	19.2	19.2	18.3	21.2	21.2
ø 1-1/2 in.	4.16	98.9	98.9	22.8	22.8	21.8	25	25
ø 1-5/8 in.	4.88	23	23	26.4	26.4	25.4	29.2	29.2
ø 1-3/4 in.	5.67	26.6	26.6	30.6	30.6	29.2	33.8	33.8
ø 1-7/8 in.	6.5	30.4	30.4	34.8	34.8	33.6	38.4	38.4
ø 2 in.	7.39	34.4	34.4	39.6	39.6	38	43.4	43.4
ø 2-1/8 in.	8.35	38.4	38.4	44.2	44.2	42.8	48.6	48.8
ø 2-1/4 in.	9.36	43	43	49.4	49.4	47.8	54.4	56.4
ø 2-3/8 in.	10.4	47.8	47.8	54.8	54.8	52.8	60.4	60.4
ø 2-1/2 in.	11.6	52.4	52.4	60.4	60.4	58.4	—	66.4
ø 2-5/8 in.	12.8	57.6	57.6	66.2	66.2	64.2	72.8	72.8
ø 2-3/4 in.	14.0	62.8	62.8	72.2	72.2	70	79.4	79.4
ø 2-7/8 in.	15.3		68.2	—	78.4	76.4	—	86.4
ø 3 in.	16.6		74	—	85	82.8	—	93.6
ø 3-1/8 in.	18		79.8	—	91.6	—	—	100.8
ø 3-1/4 in.	19.5		85.8	—	98.4	96.6	—	108.6
ø 3-3/8 in.	21		91.8	—	105.8	103.6	—	116.4
ø 3-1/2 in.	22.7		98.2	—	112.8	111	—	124.2
ø 3-5/8 in.	24.3		104.6	—	120.4	118.4	—	132.6
ø 3-3/4 in.	26		557	—	128.2	126.4	—	141
ø 3-7/8 in.	27.7		—	—	136	133.8	—	—
ø 4 in.	29.6		—	—	144	142.6	—	—
ø 4-1/8 in.	31.4		—	—	152	150.6	—	—
ø 4-1/4 in.	33.4		—	—	160.6	159.8	—	—
ø 4-3/8 in.	35.4		—	—	169.2	169.2	—	—
ø 4-1/2 in.	37.4		—	—	177.8	177.6	—	—

† All strengths approximate | For new wire rope or wire rope in new, unused condition

Rotation Resistant Wire Rope

Rotation resistant wire ropes are designed to resist the tendency to spin or rotate under load. These ropes are used either as single part lines or in situations where operating conditions require a rope that will resist block rotation in a multipart system. Choice of a particular rotation resistant wire rope involves careful consideration of the specification of the equipment on which the rope is to be used as well as various other factors. As a result, there are literally dozens of rotation resistant wire ropes available. Generally though, all rotation resistant ropes fall into one of the following three categories:

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 (15) outer stands** and comprises an assembly of at least three 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.

Category 2 - Stranded rope constructed in such a manner that it has **significant resistance to rotation, has at least ten (10) outer strands,** and comprises an assembly of two or more 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.

Category 3 - Stranded rope constructed in such a manner that it has **limited resistance to rotation, has no more than nine (9) outer strands,** and comprises an assembly of two or more 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.

⚠ In rotation resistant ropes, the crossover points between strand layers are points of high stress concentration. Relative motion of the strands at these points results in accelerated deterioration of the internal components of the rope. Because of this characteristic of rotation resistant construction, care must be taken to **avoid high loads with small diameter sheaves, and to insure that the rope is properly maintained with respect to lubrication**.

When your application calls for a rotation resistant rope, contact our trained rigging professionals. Our relationships with all the major wire rope manufacturers allow us to work with you to select the best rotation resistant rope for your application.

Minimum Strength (U.S. tons) and Weight of 8x19 IWRC Rotation Resistant Wire Rope †

For Working Load Limit (WLL) at standard 5:1 design factor, divide minimum strength by 5

Size	Lb. per ft.	IPS (1770 MPa)	EIP (1960 MPa)
		8x19 IWRC	18x7 IWRC
ø 1/2 in.	0.47	10.1	11.6
ø 9/16 in.	0.60	12.8	14.7
ø 5/8 in.	0.73	15.7	18.1
ø 3/4 in.	1.06	22.5	25.9
ø 7/8 in.	1.44	30.5	35.0
ø 1 in.	1.88	39.6	45.5
ø 1-1/8 in.	2.39	49.8	57.3
ø 1-1/4 in.	2.94	61.3	70.5
ø 1-3/8 in.	3.56	73.8	84.9
ø 1-1/2 in.	4.24	87.3	100.0

† All strengths approximate | For new wire rope or wire rope in new, unused condition
8x19 IWRC rope is typically used in low lift height environments.

Minimum Strength (U.S. tons) and Weight of 18x7 WSC Rotation Resistant Wire Rope †

For Working Load Limit (WLL) at standard 5:1 design factor, divide minimum strength by 5

Size	Lb. per ft.	IPS (1770 MPa)	EIP (1960 MPa)
		18x7 WSC	18x7 WSC
ø 1/2 in.	0.43	9.85	10.8
ø 9/16 in.	0.55	12.4	13.6
ø 5/8 in.	0.68	15.3	16.8
ø 3/4 in.	0.97	21.8	24.0
ø 7/8 in.	1.32	29.5	32.5
ø 1 in.	1.73	38.3	42.2
ø 1-1/8 in.	2.19	48.2	53.1
ø 1-1/4 in.	2.70	59.2	65.1
ø 1-3/8 in.	3.27	71.3	78.4
ø 1-1/2 in.	3.89	84.4	92.8

† All strengths approximate | For new wire rope or wire rope in new, unused condition
18x7 WSC rope is typically used in medium lift height environments.

Compacted and Swaged Wire Rope

Compacted wire ropes are ropes that have been reduced in diameter by compression during the manufacturing process. Two types of compacted wire rope are available from Yarbrough Cable: 1) compacted strand and 2) swaged wire rope. The difference between these two ropes is the way they are compacted during the manufacturing process.

In compacted strand rope, individual strands are compressed *before the strands are woven into a finished rope.*

In swaged rope, the entire rope is compressed *after the strands are woven into a finished rope.*

Compacted Strand Wire Rope	Compacted strand rope has a smoother bearing surface at strand crowns and significantly greater strength than a round strand rope of the same diameter and class. Compacted strand ropes also have longer bend fatigue life, excellent resistance to crushing, and—because of the rope's smooth surface—reduced sheave wear.
Swaged Wire Rope	Compacted (swaged) wire rope has a smooth outer surface which delivers greater abrasion resistance and slightly higher strength than round strand rope of the same diameter and class. However, bending fatigue life may be reduced by the compacting process.

Minimum Strength (U.S. tons) and Weight of 6x19 and 6x36 IWRC Swaged Wire Rope †

For Working Load Limit (WLL) at standard 5:1 design factor, divide minimum strength by 5

Size	Lb. per ft.	6x19 and 6x36 IWRC EIP
ø 1/2 in.	0.55	15.5
ø 9/16 in.	0.70	19.6
ø 5/8 in.	0.87	24.2
ø 3/4 in.	1.25	32.9
ø 7/8 in.	1.70	47.4
ø 1 in.	2.22	62.0
ø 1-1/8 in.	2.80	73.5
ø 1-1/4 in.	3.40	90.0
ø 1-3/8 in.	4.20	106
ø 1-1/2 in.	5.00	130

† All strengths approximate | For new wire rope or wire rope in new, unused condition

Minimum Strength (U.S. tons) and Weight of 6x19 & 6x36 IWRC Compacted Strand Wire Rope †

For Working Load Limit (WLL) at standard 5:1 design factor, divide minimum strength by 5

Size	Lb. per ft.	6x19 and 6x36 IWRC
ø 3/8 in.	0.31 lb./ft.	8.3
ø 7/16 in.	0.39 lb./ft.	11.2
ø 1/2 in.	0.49 lb./ft.	14.6
ø 9/16 in.	0.63 lb./ft.	18.5
ø 5/8 in.	0.78 lb./ft.	22.7
ø 3/4 in.	1.13 lb./ft.	32.4
ø 7/8 in.	1.54 lb./ft.	43.8
ø 1 in.	2.00 lb./ft.	56.9
ø 1-1/8 in.	2.54 lb./ft.	71.5
ø 1-1/4 in.	3.14 lb./ft.	87.9
ø 1-3/8 in.	3.80 lb./ft.	106
ø 1-1/2 in.	4.50 lb./ft.	125
ø 1-5/8 in.	5.27 lb./ft.	146
ø 1-3/4 in.	6.12 lb./ft.	169
ø 1-7/8 in.	7.02 lb./ft.	192
ø 2 in.	7.98 lb./ft.	217

† All strengths approximate | For new wire rope or wire rope in new, unused condition