Designation: A 1023/A 1023M – 07

Standard Specification for Stranded Carbon Steel Wire Ropes for General Purposes[1]

This standard is issued under the fixed designation A 1023/A 1023M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers the general requirements for the more common types of stranded steel wire ropes. Included in this specification are wire ropes in various grades and constructions from ¼ in. (6 mm) to 2⅜ in. (60 mm) manufactured from uncoated or metallic coated wire. Also included are cord products from 1⁄32 in. (0.8 mm) to ⅜ in. (10 mm) manufactured from metallic coated wire. For specific applications, additional or alternative requirements may apply.

1.2 The values stated in either inch-pounds or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 931 Test Method for Tension Testing of Wire Ropes and Strand

A 1007 Specification for Carbon Steel Wire for Wire Rope

2.2 *ISO Standards:*[3]

ISO 2232 Round Drawn Wire for General-Purpose Non-alloy Steel Wire Ropes

ISO 3108 Steel Wire Ropes for General Purposes—Determination of Actual Breaking

3. Terminology

Description of Terms Specific to this Specification

3.1 *inserts, n*—fiber or solid polymer so positioned as to separate adjacent strands or wires in the same or overlying layers or to fill interstices of the rope.

3.2 *Lubrication*:

3.2.1 *impregnating compound, n*—material used in the manufacture of natural fiber cores, covers, or inserts for the purpose of providing protection against rotting and decay of the fiber material.

3.2.2 *preservation compound, n*—material, usually containing some form of blocking agent, applied during, after, or both during and after manufacture of the rope to fiber inserts, fillers, and coverings for the purpose of providing protection against corrosion.

3.2.3 *rope lubricant, n*—general term used to signify material applied during the manufacture of a strand, core, or rope for the purpose of reducing internal friction, providing protection against corrosion, or both.

3.3 *rope cores, n*—central element, usually of fiber or steel (but may be a combination of both), of a round rope around which are laid helically the strands of a stranded rope or the unit ropes of a cable-laid rope (Fig. 1).

3.3.1 *fiber core (FC), n*—an element made from either natural or synthetic fibers.

3.3.2 *solid polymer core, n*—a single element of solid polymer material that is either cylindrical or shaped (grooved). It may also include an element or elements of wire or fiber.

3.3.3 *steel core, n*—a stranded rope (IWRC), or a round strand (WSC) construction. The round strand or the stranded rope core or its outer strands, or both, may also be covered or filled with either fiber or solid polymer. Steel cores are normally made as a separate independent element, the exception being rope with a stranded rope core closed parallel with the outer strands.

3.4 *strand, n*—an element of rope normally consisting of an assembly of wires of appropriate shape and dimensions laid helically in one or more layers around a center. The center may consist of one round or shaped wire, of several round wires forming a built-up center, or of fiber or some other material. If multiple wires are used in a strand center, they may be counted as one wire.

3.4.1 *Cross-Section Shape*:

3.4.1.1 *compacted strand, n*—a strand that has been subjected to a compacting process such as drawing, rolling, or swaging (Fig. 2).

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.03 on Steel Rod and Wire.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from International Organization for Standardization (ISO), 1 rue de Varembé, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

***A Summary of Changes section appears at the end of this standard.**

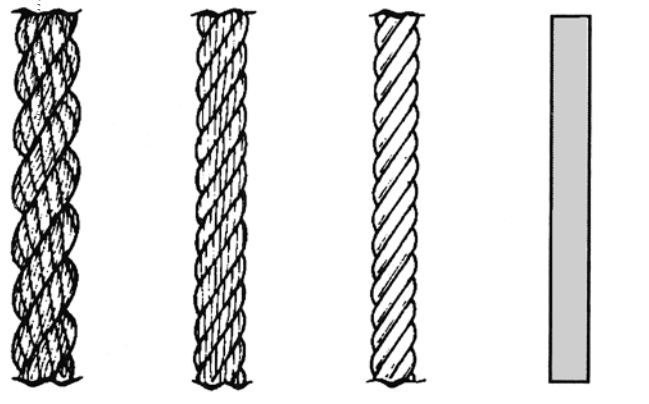


FIG. 1 Examples of Cores

3.4.1.2 *round strand, n*—strand having a perpendicular cross-section that is approximately the shape of a circle (Fig. 3).

3.4.1.3 *triangular strand, n*—strand having a perpendicular cross-section that is approximately the shape of a triangle (formerly referred to as flattened strand) (Fig. 4).

(a) Style B—Solid center wire

(b) Style G—3×2 or 3×2+3F center

(c) Style H—3 or 3+3F center

(d) Style V—1×7 center

3.4.2 *strand lay direction, n*—the direction right (z) or left (s) corresponding to the direction of lay of the outer wires in relation to the longitudinal axis of the strand (Fig. 5).

3.4.3 *Type and Constructions*:

3.4.3.1 *multiple operation lay, n*—construction containing at least two layers of wires in which successive layers are laid in more than one operation, with different lay lengths. There are two basic types of multiple operation strand:

(a) compound lay, n—strand that contains a minimum of three layers of wires where a minimum of one layer is laid in a separate operation, but in the same direction, over a parallel lay center.

(b) cross-lay, n—strand in which the wires are laid in the same direction. The wires of superimposed wire layers cross one another and make point contact.

3.4.3.2 *parallel lay, n*—strand that contains at least two layers of wires, all of which are laid in one operation (in the same direction). The lay length of all the wire layers is equal, and the wires of any two superimposed layers are parallel to each other, resulting in linear contact. There are four types of parallel lay constructions:

(a) combined, adj—describes a parallel lay construction having three or more layers laid in one operation and formed from a combination of the above, for example, Warrington-Seale construction (Fig. 6a).

(b) filler (F), adj—describes a construction having outer layer containing twice the number of wires than the inner layer, with filler wires laid in the interstices between the layers. Filler wires are designated with the letter "F" (Fig. 6b).

(c) Seale (S), adj—describes a construction having same number of wires in each layer, for example, 9-9-1 (Fig. 6c).

(d) Warrington (W), adj—describes a construction having outer (Warrington) layer containing alternately large and small wires and twice the number of wires as the inner layer. Warrington layers are designated by listing the number of large and small wires with a + sign in between and bracketing ( ) the layer, for example, (6+6) (Fig. 6d).

NOTE 1—Strand construction is designated by listing the number of wires, beginning with the outer wires, with each layer separated by a hyphen.

3.4.3.3 *single lay, n*—strand that contains only one layer of wires.

3.5 *stranded wire rope, n*—an assembly of strands laid helically in one or more layers around a core. Exceptions are stranded wire ropes consisting of three or four outer strands that may or may not be laid around a core. Elements of stranded wire rope are shown in Fig. 7.

3.6 *Wires*:

3.6.1 *finish and quality of coating, n*—the condition of the surface finish of the wire, that is, uncoated or metallic coated (zinc or zinc alloy).

3.6.1.1 *metallic coated wire, n*—carbon steel wire that has a metallic coating.

(a) drawn-galvanized wire, n—coated carbon steel wire with a zinc coating applied prior to the final wire drawing operation, that is, galvanized in process.

(b) drawn-Zn5/Al-MM wire, n—coated carbon steel wire with a zinc-aluminum alloy (mischmetal) coating applied prior to the final wire drawing operation.

(c) final-coated Zn5/Al-MM wire, n—coated carbon steel wire with a zinc-aluminum alloy (mischmetal) coating applied after the final wire drawing operation.

(d) final-galvanized wire, n—coated carbon steel wire with a zinc coating applied after the final wire drawing operation, that is, galvanized at finished size.

3.6.1.2 *uncoated wire, n*—carbon steel wire that does not have a metallic coating. Commonly referred to as bright wire.

3.6.2 *Function*:

3.6.2.1 *filler wires, n*—comparatively small wires used in certain constructions of parallel lay ropes to create the necessary number of interstices for supporting the next layer of covering wires.

3.6.2.2 *load-bearing wires (main wires), n*—those wires in a rope that are considered as contributing toward the breaking force of the rope.

3.6.2.3 *non-load-bearing wires, n*—those wires in a rope that are considered as not contributing toward the breaking force of the rope.

3.6.2.4 *seizing (serving) wires or strands, n*—single wires or strands used for making a close-wound helical serving to retain the elements of a rope in their assembled position.

3.6.3 *layer of wires, n*—an assembly of wires having one pitch diameter. The exception is a Warrington layer comprising large and small wires where the smaller wires are positioned on a larger pitch circle than the larger wires. The first layer of wires is that which is laid over the strand center. Filler wires do not constitute a separate layer.

3.6.4 *Position*:

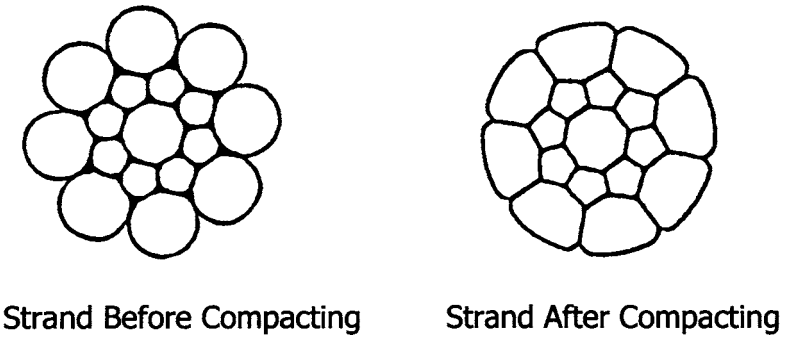


FIG. 2 Compacted Round Strand–Before and After

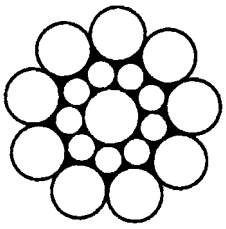


FIG. 3 Round Strand

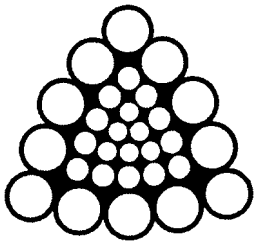


FIG. 4 Triangular Strand

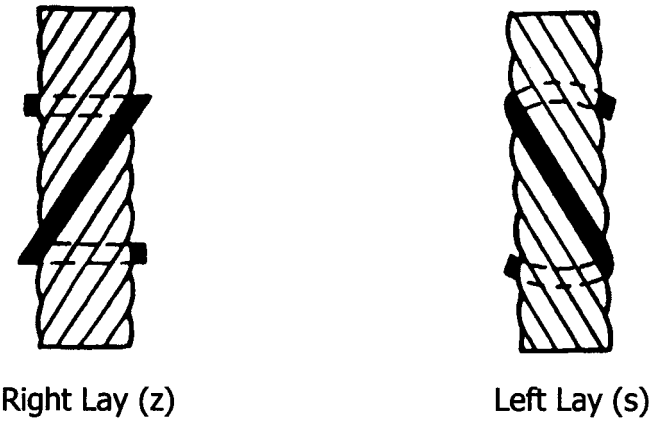


FIG. 5 Lay Direction of Strands for Stranded Ropes

3.6.4.1 *center wires, n*—wires positioned at the center of a strand of a stranded rope.

3.6.4.2 *core wires, n*—all wires comprising the core of a stranded rope.

3.6.4.3 *inner wires, n*—all wires except center, filler, core, and outer wires in a stranded rope.

3.6.4.4 *outer wires, n*—all wires in the outer layer of the outer strands of a stranded rope.

Dimensional Characteristics

3.7 *Diameter of Rope*:

3.7.1 *diameter of plastic-coated rope, n*—the diameter that circumscribes the overall rope cross-section including the cover followed by the diameter, which circumscribes the underlying rope (for example, ¾ × ⅝ in.).

3.7.2 *diameter of round rope, n*—the diameter (*d*) that circumscribes the rope cross-section. Diameter is expressed in inches or millimeters (Fig. 8).

3.8 *Lay Length*:

3.8.1 *rope lay length, n*—that distance measured parallel to the longitudinal rope axis in which the outer strands of a stranded rope or the component ropes of a cable-laid rope make one complete turn (or helix) about the axis of the rope (Fig. 9).

3.8.2 *strand lay length, n*—that distance measured parallel to the longitudinal strand axis, in which the wire in the strand makes one complete turn (or helix) about the axis of the strand. The lay length of a strand is that corresponding to the outer layers of wires (Fig. 9).

Manufacture (Rope)

3.9 *Preformation*:

3.9.1 *non-preformed rope, n*—rope in which the wires and strands in the rope will, after removal of any seizing (serving), spring out of the rope formation.

3.9.2 *preformed rope, n*—rope in which the wires and strands in the rope will not, after removal of any seizing (serving), spring out of the rope formation.

3.10 *prestretching, n*—the name given to a process that results in the removal of a limited amount of constructional stretch.

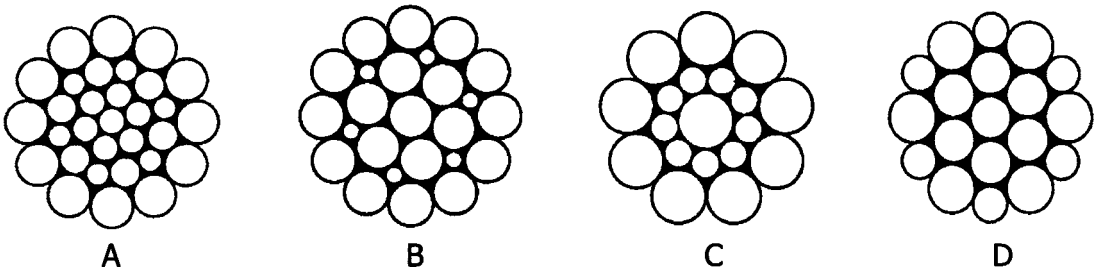
Mechanical Properties

3.11 *Rope*:

3.11.1 *actual (measured) breaking force, n*—breaking force obtained using the prescribed test method in Test Method A 931 or ISO 3108.

3.11.2 *calculated breaking force, n*—value of breaking force obtained from the sum of the measured breaking forces of the wires in the rope, before rope making, multiplied by the measured spinning loss factor as determined by the rope manufacturer's design.

3.11.3 *measured spinning loss factor, n*—ratio between the measured breaking force of the rope and the sum of the measured breaking forces of the wires, before rope making.



A—Example of Combined Parallel Lay ex. 31WS, 12-(6+6)-6-1
B—Filler Construction ex. 25F, 12-6F-6-1
C—Seale Construction ex. 19S, 9-9-1
D—Warrington Construction ex. 19W, (6+6)-6-1

FIG. 6 Parallel Lay Constructions

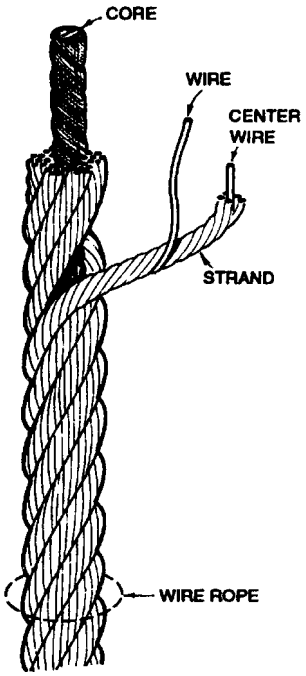


FIG. 7 Elements of Stranded Wire Rope

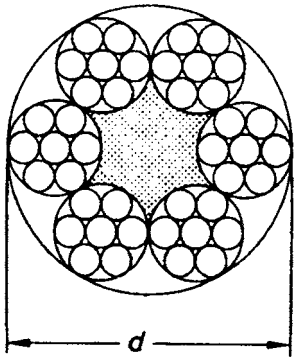


FIG. 8 Diameter of Round Rope

3.11.4 *minimum breaking force, n*—specified value that the actual (measured) breaking force must meet or exceed in a prescribed test.

3.12 *Rope Stretch (Extension)*:

3.12.1 *constructional stretch (extension), n*—amount of extension that is attributed to the initial bedding down of wires within the strands and the strands within the rope due to loading. Initial extension cannot be determined by calculation.

3.12.2 *elastic stretch (extension), n*—amount of recoverable extension that follows Hooke's law within certain limits due to application of a load.

3.12.3 *permanent stretch (extension), n*—non-elastic extension.

3.13 *Wire*:

3.13.1 *torsions, n*—a measure of wire ductility normally expressed as the number of 360° revolutions that a wire can withstand before breakage occurs, using a prescribed test method. Torsion requirements are based on the wire diameter and either the wire level, as specified in Specification A 1007, or the tensile strength grade, as specified in ISO 2232.

3.13.2 *wire tensile strength, n*—ratio between the maximum force obtained in a tensile test and the nominal cross-sectional area of the test piece. Requirements for wire tensile strength are determined by either the wire level, as specified in Specification A 1007, or by the tensile strength grade, as specified in ISO 2232.

3.13.2.1 *tensile strength grade, n*—a level of requirement for tensile strength based on the SI system of units. It is designated by a value according to the lower limit of tensile strength and is used when specifying wire. Values are expressed in N/mm^2 (for example, 1960).

3.13.2.2 *wire level, n*—a level of requirement for tensile strength based on the inch-pound system of units (for example, Level 3).

Terminology Relating to Ropes

3.14 *Rope Classification and Construction*:

3.14.1 *rope classification, n*—a grouping of ropes of similar characteristics on the basis of, for stranded ropes, the number of strands and their shape, the number of strand layers, the number of wires in one strand, the number of outer wires in one strand, and the number of wire layers in one strand. For classification details, refer to Table 2.

3.14.2 *rope construction, n*—detail and arrangement of the various elements of the rope, taking into account the number of strands, and the number of wires in the strand. For construction details, refer to Tables 9–34.

3.14.3 *Discussion*—Rope construction is designated by listing the number of outer strands followed by the number of

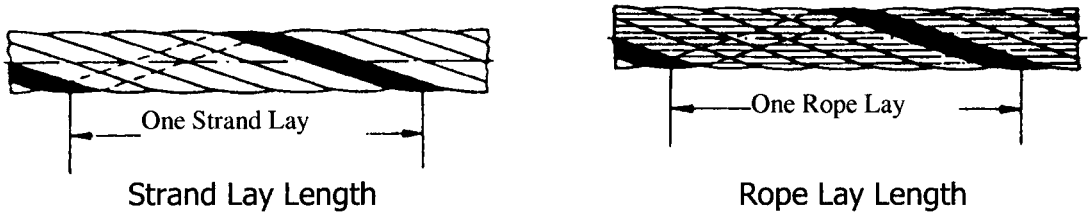


FIG. 9 Lay Lengths

TABLE 1 Wire Tensile Strength Grades or Levels for Given Rope Grades

Rope Grade	Wire Tensile Strength Grade or Level	
	Minimum	Maximum
IPS	Level 2 / 1570	Level 4 / 1960
EIP	Level 3 / 1770	Level 5 / 2160
EEIP	Level 4 / 1960	Level 5 / 2160
1770	1570 / Level 2	1960 / Level 4
1960	1770 / Level 3	2160 / Level 5
2160	1960 / Level 4	2160 / Level 5

TABLE 2 Classification

Classification	Table		Diameter (in.)	Diameter (mm)
	SC	FC		
6×7	9	10	¼ –1½	6–36
6×19	11	12	¼ –2⅜	6–60
6×36	13	14	¼ –2⅜	6–60
7×19	15		¼ –2⅜	6–60
7×36	16		¼ –2⅜	6–60
8×19	17		¼ –2⅜	6–60
8×36	18		¼ –2⅜	8–60
8×19 SR	19		½ –1½	12–38
19×7	20		¼ –1½	6–36
34×7	21		¼ –1⅝	8–40
35×7	22		⅜ –1⅝	8–40
6×12		23	5⁄16 –1	8–25
6×24		24	⅜ –2	9.5–51
6×25 TS	25	26	½ –2⅜	12–60
6×19 CS	27		⅜ –2¼	10–56
6×36 CS	28		⅜ –2¼	10–56
6×19 SW	29		½ –1½	12–38
6×36 SW	30		½ –1½	12–38
19×7 CS	31		¼ –1	6–24
19×19	32		⅜ –1⅝	10–40
35×7 CS	33		7⁄16 –1⅝	10–40
3×7 CORD	34		1⁄32	0.8
7×7 CORD	34		3⁄64 –⅜	1.2–9.5
7×19 CORD	34		1⁄16 –⅜	1.6–9.5

Designation key:
SR = spin resistant
TS = triangular strand
CS = compacted strand
SW = swaged rope
CORD = small diameter specialty wire rope
SC = steel core
FC = fiber core

TABLE 3 Weight of Coating for Final-Galvanized or Final-Coated Zn-5Al-MM Rope Wire

Diameter of Wire		Minimum Weight of Coating	
in.	mm	oz/ft^2	kg/m^2
0.025 to 0.047 incl	0.64 to 1.19 incl	0.20	0.06
over 0.047 to 0.054 incl	over 1.19 to 1.37 incl	0.40	0.12
over 0.054 to 0.063 incl	over 1.37 to 1.60 incl	0.50	0.15
over 0.063 to 0.079 incl	over 1.60 to 2.01 incl	0.60	0.18
over 0.079 to 0.092 incl	over 2.01 to 2.34 incl	0.70	0.21
over 0.092 to 0.192 incl	over 2.34 to 4.88 incl	0.80	0.24

TABLE 4 Weight of Coating for Drawn-Galvanized or Drawn Zn-5Al-MM Rope Wire

Diameter of Wire		Minimum Weight of Coating	
in.	mm	oz/ft^2	kg/m^2
0.0045 to 0.010 incl	0.11 to 0.25 incl	0.03	0.009
Over 0.010 to 0.017 incl	Over 0.25 to 0.43 incl	0.05	0.015
over 0.017 to 0.028 incl	over 0.43 to 0.71 incl	0.10	0.03
over 0.028 to 0.060 incl	over 0.71 to 1.52 incl	0.20	0.06
over 0.060 to 0.090 incl	over 1.52 to 2.29 incl	0.30	0.09
over 0.090 to 0.140 incl	over 2.29 to 3.56 incl	0.40	0.12

TABLE 5 Tolerances on Rope Diameter (Stranded Rope) (Inch-Pound Units)

Nominal Rope Diameter (*d*), in.	Diameter Tolerancesas a Percentage of Nominal Diameter
thru ⅛	-0, +8 %
over ⅛ thru 3⁄16	-0, +7 %
over 3⁄16 thru 5⁄16	-0, +6 %
over 5⁄16 and larger[A]	-0, +5 %

[A] 6×12 and 6×24 classifications -0, +7 % (Tables 24 and 25)

TABLE 6 Tolerances on Rope Diameter (Stranded Rope) (SI Units)

Nominal Rope Diameter (*d*), mm	Diameter Tolerances as a Percentage of Nominal Diameter
from 2 to <4	-0, +8 %
from 4 to <6	-0, +7 %
from 6 to <8	-0, +6 %
8 and greater	-0, +5 %

wires in each strand and the designation for the type of construction, for example, 6×25F. The "×" symbol is read as "by."

3.15 *rope grade, n*—a level of requirement for breaking force that is designated either by a number (for example, 1770, 1960) or a series of letters (for example, IPS, EIP). See 6.3. Rope grade does not imply that the actual tensile strength of the wires in the rope is necessarily of this grade.

3.16 *Rope Lay*:

3.16.1 *lay direction of rope, n*—the direction right (Z) or left (S) corresponding to the direction of lay of the outer strands in a stranded rope or the unit ropes in a cable laid rope in relation to the longitudinal axis of the rope.

3.16.2 *Lay Types*:

3.16.2.1 *alternate lay, adj*—describes stranded rope in which the type of lay of the outer strands is alternately regular (ordinary) lay followed by lang lay such that half of the outer strands are regular (ordinary) lay and the other half are lang lay. The lay direction of the rope will be either right (AZ) or

TABLE 7 Permissible Differences in Rope Diameter (Inch-Pound Units)

Nominal Rope Diameter (*d*), in.	Percentage Allowable Difference (%)
⅛ and smaller	7
over ⅛ thru 3⁄16	6
over 3⁄16 thru 5⁄16	5
over 5⁄16 and larger	4

TABLE 8 Permissible Differences in Rope Diameter (SI Units)

Nominal Rope Diameter (d), mm	Percentage Allowable Difference (%)
from 2 to <4	7
from 4 to <6	6
from 6 to <8	5
8 and greater	4

left (AS). Alternate lay can also be supplied with two lang lay strands followed by one regular (ordinary) lay strand in a repeating pattern.

3.16.2.2 *contra-lay, adj*—describes rope in which at least one layer of strands is laid in the opposite direction to the other layers.

3.16.2.3 *lang lay, adj*—describes stranded rope in which the direction of lay of the wires in the outer strands is the same direction as that of the outer wires in the rope (Fig. 10).

3.16.2.4 *regular (ordinary), adj*—describes 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.

3.16.3 *Discussion*—The lower case letter denotes strand direction; the upper case letter denotes rope direction.

3.17 *Rope Types*:

3.17.1 *cable-laid rope, n*—an assembly of several (usually six) round stranded ropes laid helically over a core (usually a seventh rope). Requirements for cable-laid rope are not covered in this standard.

3.17.2 Ropes incorporating filling and covering materials:

3.17.2.1 *cushioned rope, n*—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 overlying layers.

3.17.2.2 *plastic-coated core rope, n*—rope in which the core is covered, or filled and covered, with a solid polymer.

3.17.2.3 *plastic-coated rope, n*—rope in which the exterior surface is coated (covered) with a solid polymer.

3.17.2.4 *plastic-filled rope, n*—rope in which the free spaces up to the diameter of the rope are filled with a solid polymer.

3.17.3 *rotation-resistant rope, n*—stranded ropes 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 a center, the direction of lay of the outer strands being opposite to that of the underlying layer. There are three categories of rotation-resistant rope:

3.17.3.1 *category 1, adj*—describes 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 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.

3.17.3.2 *category 2, adj*—stranded rope constructed in such a manner that it has significant resistance to rotation, has at least ten outer strands, and comprises an assembly of two or more layers of strands laid helically over a center in two or

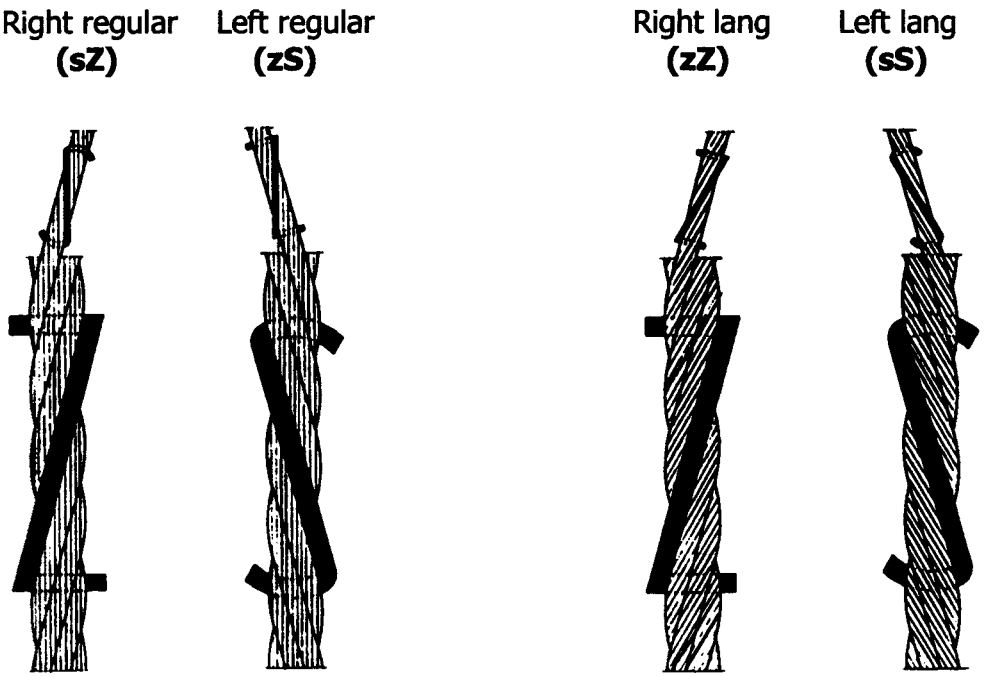


FIG. 10 Regular (Ordinary Lay) and Lang Lay

three operations, the direction of lay of the outer strands being opposite to that of the underlying layer.

3.17.3.3 *category 3, adj*—stranded rope constructed in such a manner that it has limited resistance to rotation, has no more than nine outer strands, and comprises 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.

3.17.4 *Discussion*—Rotation resistant ropes have previously been referred to as multi-strand and non-rotating ropes.

3.17.5 *Discussion*—Ropes having three or four strands can also be designed to exhibit rotational resistant properties.

3.17.6 *Stranded Rope Types*:

3.17.6.1 *compacted strand rope, n*—rope in which the strands, prior to closing of the rope, are subjected to a compacting process such as drawing, rolling, or swaging.

3.17.6.2 *multi-layer, adj*—describes an assembly of two or more layers of strands laid helically around a core, the direction of the lay of the outer strands being opposite (that is, contra-lay) to that of the underlying layer.

3.17.6.3 *single layer, adj*—describes rope consisting of one layer of strands laid helically around a core.

3.17.6.4 *swaged (compacted) rope, n*—rope that is subjected to a compacting process after closing the rope, thus reducing its diameter.

Values

3.18 *actual (measured) value, n*—value derived from direct measurement in a prescribed manner.

3.19 *maximum value, n*—specified value that an actual value must not exceed.

3.20 *minimum value, n*—specified value that an actual value must meet or exceed.

3.21 *nominal value, n*—the conventional value by which a physical characteristic is designated.

4. Ordering Information

4.1 It is the responsibility of the purchaser to specify all requirements that are necessary for material ordered under this specification. Such requirements may include, but are not limited to, the following:

Item	Examples	
	inch-pound	SI
Length	500 ft	175 m
Size (diameter)	¾ in.	16 mm
Rope classification or construction (if known)	6×36	6×36
Preformed or non-preformed	Preformed	Preformed
Lay direction and type	Right regular	sZ
Wire finish (uncoated or metallic coated and type)	uncoated	drawn-galvanized
Rope Grade	EIP	1960
Core Type	FC (fiber)	SC
Applicable specification	ASTM A 1023	ASTM A 1023
Special requirements		
Termination of rope ends		
Special length tolerance		
Type of certificate		
Special packaging and identification		
Lubrication, other than as noted in 4.3		
Prestretching		

4.2 *Certification of Conformance and Test*:

4.2.1 A certificate of conformance and test shall confirm compliance with this standard. It shall contain the following information items:

4.2.1.1 Certificate number,

4.2.1.2 Purchaser's name and address,

4.2.1.3 Purchaser's order number,

4.2.1.4 Rope supplier's name and address,

4.2.1.5 Supplier's order number,

4.2.1.6 Number traceable to manufacturer's production length,

4.2.1.7 Nominal length(s) of rope,

4.2.1.8 Rope designation (nominal diameter, construction and core, lay and grade), and

4.2.1.9 Minimum breaking force in tons (short tons) or kilonewtons.

4.2.2 *Tests on Wires and Rope*—If wire tests are required, indicate if the wire samples are taken before the rope fabrication or if they are taken from a completed rope. The following additional information can be supplied under agreement between purchaser and supplier. These items shall be completed as agreed between the supplier and the purchaser.

4.2.2.1 Quality system registration number of the rope manufacturer, if applicable;

4.2.2.2 Approximate mass in lb/ft (kg/m);

4.2.2.3 Wire standard used;

4.2.2.4 Number of wires tested;

4.2.2.5 Nominal dimensions of wire;

4.2.2.6 Measured dimensions of wire;

4.2.2.7 Breaking force of wire;

4.2.2.8 Tensile strength of wire;

4.2.2.9 Number of torsions completed (and test length);

4.2.2.10 Mass of zinc (or zinc alloy);

4.2.2.11 Actual (measured) diameter of rope; and

4.2.2.12 Actual (measured) breaking force of rope.

4.2.3 *Additional Information and Certification*:

4.2.3.1 Space for additional information, and

4.2.3.2 Space for certification with provision for certifying the foregoing, name and position held, signature, and date.

5. Material

5.1 *Wire*—The wires used in rope making shall comply with the appropriate requirements of Specification A 1007 or ISO 2232. The manufacturer, subject to the limits in Table 1, shall determine the tensile strength grade so that the minimum breaking force of the rope is achieved.

5.1.1 Wire tensile limitations in Table 1 do not apply to center, filler, and core wires.

5.1.2 Wire tensile limitations do not apply to compacted ropes, or compacted strand ropes.

5.1.3 The manufacturer shall have the option to adopt a single wire level or tensile strength grade throughout the rope, or decide on a combination of wire levels or tensile strength grades.

5.1.4 Wire diameters shall be selected by the manufacturer in accordance with applicable wire rope design requirements.

5.2 *Core*—Cores of stranded ropes shall normally be either steel or fiber composition.

5.2.1 *Fiber Core*—All fiber cores shall be natural fiber (for example, sisal), polypropylene, or other suitable synthetic fiber.

The cores shall be of uniform hardness, effectively supporting the strands. Natural fiber cores shall be treated with an impregnating compound free from acid. Fiber cores larger than 5/32-in. (4-mm) diameter shall be doubly closed.

5.2.2 *Steel Core*—Steel main cores shall be either an independent wire rope (IWRC) or a wire strand (WSC). Steel cores of single layer ropes larger than 7/16-in. (12-mm) diameter shall be independent wire ropes (IWRC), unless specified otherwise. Steel cores shall be lubricated. Cores closed in one operation (parallel lay) with the outer strands of the rope may be specified by agreement between the supplier and the purchaser.

5.3 *Lubricant*—All wire rope, unless otherwise specified, shall be lubricated and impregnated in the manufacturing process with a suitable lubricant selected by the manufacturer. Stranding lubricants used for fiber core ropes shall be compatible with the impregnating compound of the fiber core.

6. Rope Properties and Tolerances

6.1 *Classification*—The rope classification shall be specified by the purchaser and shall normally be one of those covered in Table 2 although other classifications and constructions are available by agreement between the supplier and purchaser.

NOTE 2—Where only the rope classification is specified by the purchaser, the manufacturer shall determine the construction.

6.2 *Rope Core*—Steel core (SC) shall be supplied unless otherwise specified. The manufacturer shall determine core construction. Cores with inserts or solid polymer cores are subject to agreement between the supplier and purchaser.

6.3 *Rope Grade*—The rope grade shall be one of the following although other grades are available by agreement between the supplier and purchaser.

6.3.1 The listed rope grades for the following inch-pound units are shown in the indicated tables:

6.3.1.1 *IPS*—Tables 10–21, Tables 24–27

6.3.1.2 *EIP*—Tables 10–21, Tables 26–33

6.3.1.3 *EEIP*—Tables 12–20, Tables 26–29, Tables 32 and 33

6.3.2 Rope Grades for the following SI units are shown in the indicated tables:

6.3.2.1 *1770*—Table 10–19, Tables 21–23

6.3.2.2 *1960*—Tables 10–19, Tables 21–23, Tables 28 and 29, Tables 32–34

6.3.2.3 *2160*—Tables 12–19, Table 23, Tables 28 and 29, Tables 32–34

6.4 *Wire Finish*—Unless otherwise specified, wire ropes will be furnished with uncoated wires. For wire ropes requested with metallic coated wires, the wires shall be galvanized unless otherwise specified by the purchaser.

6.4.1 *Final-Galvanized Rope*—All outer wires shall be supplied as final-galvanized. Inner, filler, and center wires shall be supplied as final-galvanized or drawn-galvanized. Minimum weight of coating for galvanized wire shall be as specified in Tables 3 and 4.

6.4.1.1 Final-galvanized rope shall be supplied with minimum breaking forces 10 % lower than those listed in Tables 9–34, except for Table 21 and Table 22.

6.4.1.2 *Final-Coated Zn-5Al-MM*—Wires of final-coated Zn-5Al-MM may be substituted for final-galvanized wire at the option of the manufacturer. Minimum weight of coating shall be as specified in Table 3.

6.4.2 *Drawn-Galvanized (Zinc Coated) Rope*—All the wires shall be galvanized (zinc coated), including those of any steel core. Minimum weight of coating shall be as specified in Table 4.

6.4.2.1 Drawn galvanized rope shall be supplied with minimum breaking forces no less than those listed in Tables 9–34.

6.4.2.2 *Drawn-Zn-5Al-MM*—Wires of drawn-Zn–5Al-MM may be substituted for drawn-galvanized wire at the option of the manufacturer. Minimum weight of coating shall be as specified in Table 4.

6.5 *Direction and Type of Rope Lay*—The direction and type of rope lay shall be as specified by the purchaser and shall be one of the following:

Right regular (ordinary) lay (sZ)
Left regular (ordinary) lay (zS)
Right lang lay (zZ)
Left lang lay (sS)
Right alternate lay (AZ)
Left alternate lay (AS)

Right regular (ordinary) lay will be supplied for six, seven, and eight-strand constructions unless otherwise specified by the purchaser.

6.6 *Dimensions*:

6.6.1 *Rope Diameter*—The nominal diameter shall be as specified by the purchaser and shall be the dimension by which the rope is designated.

6.6.1.1 *Tolerance on Rope Diameter*—When measured in accordance with 8.6.1, the actual diameter shall not vary from the nominal diameter by more than the tolerances specified in Table 5 or Table 6. For small diameter specialty cord with diameters from 1/32 in. (0.8 mm) to 3/8 in. (10 mm) inclusive, diameter tolerances shall be as specified in Table 9.

6.6.1.2 *Permissible Differences in Diameter*—The difference between any two of the four measurements taken in accordance with 8.6.1, and expressed as a percentage of the nominal diameter, shall not exceed the values given in Table 7 or Table 8.

6.6.2 *Lay Length*:

6.6.2.1 For single layer ropes of 6×7 class, the lay length of the finish rope shall not exceed 8 times the nominal rope diameter.

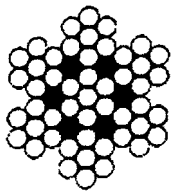
6.6.2.2 For other single layer ropes with round strands, except for 3 or 4 strand ropes, and multi-layer ropes with round or shaped strands, the length of lay of the finished rope shall not exceed 7.25 times the nominal rope diameter.

6.6.2.3 For single layer ropes with shaped strands, for example, flattened (triangular) strand, the length of lay of the finished rope shall not exceed 10 times the nominal rope diameter.

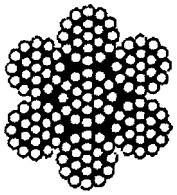
6.7 *Mechanical Properties*:

6.7.1 *Breaking Force*—Values for minimum breaking force for the more common classes of rope are specified in Tables 9–34 of this standard.

TABLE 9 Classification 7×7 and 7×19 Small Diameter (Galvanized) Specialty Cord

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
 7×7	Strands[A]	7	Wires	7 or 19
	Outer Strands	6	Outer Wires	6 or 12
	Layer of Strands	2	Layer of Wires	1 or 2
	Wires in Rope[A] (excluding core strand)	42 or 114		

Typical Examples		Number of Outer Wires	
Rope	Strand	Total	Per Strand
3×7	1–6	18	6
7×7	1–6	36	6
7×19	1–6/12	72	12


7×19

Diameter		Approx. Mass				Minimum Breaking Force[A]				Diameter Range	
		7×7		7×19		7×7		7×19		Min.	Max.
in.	mm	lb/100 ft	kg/30.5 m	lb/100 ft	kg/30.5 m	lbs	kN	lbs	kN	in.	in.
1/32[A]	0.79	0.16	0.07			110	0.49			0.031	0.037
3/64	1.19	0.42	0.19			270	1.2			0.047	0.055
1/16	1.59	0.75	0.34	0.75	0.34	480	2.1	480	2.1	0.063	0.073
5/64	1.98	1.1	0.50			650	2.9			0.078	0.089
3/32	2.38	1.6	0.73	1.7	0.77	920	4.1	1000	4.4	0.094	0.106
7/64	2.78	2.2	1.0			1260	5.6			0.109	0.122
1/8	3.18	2.8	1.3	2.9	1.3	1700	7.6	2000	8.9	0.125	0.139
5/32	3.97	4.3	2.0	4.5	2.0	2600	11.6	2800	12.5	0.156	0.172
3/16	4.76	6.2	2.8	6.5	3.0	3700	16.5	4200	18.7	0.188	0.206
7/32	5.56	8.3	3.8	8.6	3.9	4800	21.4	5600	24.9	0.219	0.237
1/4	6.35	10.6	4.8	11.0	5.0	6100	27.1	7000	31.1	0.250	0.268
9/32	7.14	13.4	6.1	13.9	6.3	7600	33.8	8000	35.6	0.281	0.301
5/16	7.94	16.7	7.6	17.3	7.9	9200	40.9	9800	43.6	0.313	0.335
11/32	8.73	20.1	9.1	20.7	9.4	11 100	49.4	12 500	55.6	0.344	0.368
3/8	9.53	23.6	10.7	24.3	11.0	13 100	58.3	14 400	64.1	0.375	0.401

[A] 1/32 construction is 3×7.

6.7.1.1 The minimum breaking force for other classes and constructions not covered by the tables, shall be agreed upon by the manufacturer and the purchaser.

6.7.1.2 Wire ropes with minimum breaking forces less than those allowed in this specification may be accepted by prior agreement between the supplier and purchaser and shall be regarded as beyond the scope of this specification.

6.7.2 *Mass*—The (approximate) nominal rope mass shall be as given in Tables 9–34 or as specified by the manufacturer.

6.7.3 *Length*—The actual length of rope supplied, expressed in feet or meters, shall be the specified length subject to the following limits of tolerance:

(a) Up to and including 1300 ft (400 m): +5.0 % of specified length,

(b) Over 1300 ft up to 3280 ft (400 m to 1000 m): +66 ft (20 m), and

(c) Over 3280 ft (1000 m): +2.0 % of specified length.

NOTE 3—The rope shall be measured under no load. Ropes required with more restrictive length tolerance shall be agreed upon by the supplier and purchaser.

7. Rope Workmanship and Finish

7.1 *Strand*:

7.1.1 Strand wires shall be tight and uniform. All the wire layers in a strand shall have the same direction of lay. The lay lengths of corresponding wire layers in strands of the same size shall be uniform.

7.1.2 Center wires and fiber centers of strands shall be of a size to provide sufficient support to enable the covering wires to be evenly laid.

7.2 *Rope*—The rope shall be uniformly made and the strands shall lie tightly on the core or the underlying strands.

7.2.1 The core of a stranded rope, except for swaged (compacted) ropes, shall be designed so that in a new rope under no load there is clearance between the outer strands.

7.2.2 Rope ends that have no end fittings shall be so secured as to maintain the integrity of the rope and prevent its unraveling.

7.3 *Wire Joints*:

7.3.1 Wires over 0.015 in. (0.4 mm) in diameter shall have their ends joined by soldering, brazing, or welding.

7.3.2 Wires up to and including 0.015 in. (0.4 mm) diameter may be joined by soldering, brazing, welding, twisting, or by ends being simply inserted into the strand's formation.

7.3.3 The minimum distance between joints in a strand shall be 18 times the nominal rope diameter.

7.4 *Preformation*—Stranded ropes shall be preformed unless otherwise specified, except that multi-layer ropes, including rotation-resistant and low-rotation ropes, may be non-preformed.

7.5 *Prestretching*—Stranded ropes are not prestretched unless otherwise specified. When specified, ropes may be prestretched using either a process of static or dynamic loading. Prestretch loads shall not exceed 55 % of the minimum breaking force for the rope.

NOTE 4—Example of static prestretching practice: Rope is subjected to three cycles of tensile loading to 40 % of the ropes minimum breaking force for 5 min, returning to 5 % of the minimum breaking force between cycles. After the last cycle, the tensile load is completely released.

8. Testing and Compliance

General

8.1 Wire ropes manufactured in accordance with this specification shall be capable of meeting all the appropriate requirements as specified in 8.2. The manufacturer shall be able to demonstrate compliance with this specification by either:

8.1.1 Testing each production length in accordance with 8.2, or

8.1.2 Operating a quality assurance system that includes a sampling program that meets the following requirements as a minimum:

8.1.2.1 For each size and grade of a given rope construction, the manufacturer shall present evidence from testing, if requested by the purchaser, of a minimum of three production lengths representing the current design. The purpose of these tests is to assure the manufacturer's ability to produce a rope that conforms to the minimum requirements as defined in this specification. Periodic acceptance tests are successfully completed on a sample taken from a minimum of every twentieth production length.

8.1.2.2 Manufacturers complying with all requirements of 8.1.2 may use calculated breaking force to verify compliance with requirements for an individual production length not included in sample testing.

8.2 Any change in design requires that the tests specified in 8.1.2 be repeated on the modified rope. However, if the same design, apart from the wire tensile grades, is used for ropes of a lower grade than the one which has successfully passed the tests specified in 8.1.2, it shall not be necessary to repeat the tests on the lower grade rope(s).

8.3 For the purposes of this specification, a production length is regarded as that length of rope manufactured in one continuous operation from one loading of the closing machine comprising strands, each of which has been produced in one continuous operation on the stranding machine. A production length may comprise one or more reels of rope.

NOTE 5—Examples of quality assurance systems are API Q1, ANSI/ASQC Q9002 and ISO 9002.

Acceptance Tests

8.4 *Test Piece*—When required by 8.1, one test piece shall be taken from each production length.

8.5 *Test Verification*—When requested, the manufacturer shall allow the purchaser or his representative the opportunity to witness acceptance tests (when these are performed), or to examine test records, to verify compliance with this specification. Test lengths required by the purchaser should be ordered as additional lengths.

8.6 *Rope*:

8.6.1 *Diameter*—Measurements for diameter shall be taken on a straight portion of the rope without tension, at two positions spaced at least three feet (or one meter) apart, and at each position two diameters at right angles shall be measured. The average of these four measurements shall be within the tolerances given in Tables 5 and 6 of this specification. The

permissible differences between any two individual diameter measurements are given in Tables 7 and 8.

NOTE 6—In case of dispute concerning oversize diameter, the rope shall be measured under a tension not exceeding 20 % of the minimum breaking force. If the measurements from this test are within the specified tolerances, the rope shall be deemed to be within the specified size.

8.6.2 *Breaking Force*—When measured in accordance with the method specified in Test Method A 931 or ISO 3108, the actual (measured) breaking force obtained shall be equal to or greater than the minimum breaking force required by this specification. If the minimum breaking force is not achieved, up to three additional tests shall be permitted. At least one of the additional tests shall achieve the minimum breaking force specified. Tables 9–34 show the minimum breaking forces of the more common classes, sizes, and grades of ropes:

8.6.2.1 Minimum breaking forces listed apply to uncoated or drawn-galvanized ropes.

8.6.2.2 Minimum breaking forces for final-galvanized ropes are 10 % lower than values listed, except for Tables 21 and 22.

8.6.2.3 Minimum breaking force values for IPS, EIP and EEIP are given in short tons of 2000 pounds.

8.7 *Rope Wires*:

8.7.1 *General*—Wires shall be tested for diameter, tensile strength, torsions, and, where applicable, metallic coating in accordance with the methods in Specification A 1007 or ISO 2232. The manufacturer shall have the option to test wires either before or after fabrication of the rope.

NOTE 7—After fabrication wire testing is not applicable to compacted strand ropes or swaged (compacted) ropes.

8.7.2 *Sampling*—All main wires from the equivalent of one complete strand of each layer, strand diameter and strand construction, including steel rope core, shall be tested. If there are more than eight strands of one diameter in one layer, then two strands of that diameter shall be tested.

8.7.3 For the purpose of evaluating the test results, the rope manufacturer shall record the nominal diameters and tensile grades of the wires.

8.7.3.1 The sample selected shall be of sufficient length to allow for retest.

8.7.3.2 The wires shall be selected at random.

8.7.3.3 Filler wires and center wires shall be excluded from this test.

8.7.4 *Levels of Acceptance*:

8.7.4.1 *Wire before Fabrication*—Wire samples tested before fabrication shall meet the requirements for the size and grade (level) specified by the supplier and as found in the appropriate wire specification.

8.7.4.2 *Wire after Fabrication*—For each requirement, a maximum of 5 % of wires tested is permitted to lie outside the values specified, rounded to the nearest whole number of wires. Failure of the same wire to satisfy more than one requirement shall be considered as a single failure.

(a) Diameter—The diameter of 5 % of the wires may exceed, by up to 50 %, the specified tolerance for the nominal diameter.

(b) Tensile Strength—When tested in accordance with the requirements of Specification A 1007, the measured values shall be within the tolerance specified with an additional tolerance of 7000 psi (50 N/mm^2) below the minimum value. The measured value of wire diameters less than 0.020 in. (0.5 mm) shall be greater than the minimum values specified in the appropriate wire specification.

(c) Torsion—When tested in accordance with the requirements of Specification A 1007, the measured values of wires of 0.020 in. (0.5 mm) diameter and greater shall be at least 85 % of the values specified, rounded down to the next whole number. The measured value of wire diameters less than 0.020 in. (0.5 mm) shall be greater than the minimum values specified.

9. Packaging and Identification

9.1 *Packaging*—Unless otherwise specified by the purchaser, ropes shall be supplied in coils or on reels at the discretion of the manufacturer.

9.2 *Identification*—Each package of rope shall be legibly identified with the following information, as a minimum:

9.2.1 Rope supplier and address,

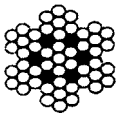
9.2.2 Rope length and description, and

9.2.3 Number traceable to manufacturer's production length.

10. Keywords

10.1 aircraft cable; cable; steel cable; steel rope; utility cable; wire rope

TABLE 10 Classification 6×7 Steel Core

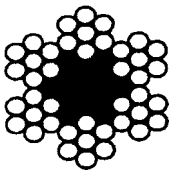
Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	6	Wires	5 to 9
	Outer Strands	6	Outer Wires	4 to 8
	Layer of Strands	1	Layer of Wires	1
	Wires in Rope	30 to 54		
	Typical Examples		Number of Outer Wires	
6×7 SC	Rope 6×7	Strand 1–6	Total 36	Per Strand 6

Diameter		Approx. Mass		Minimum Breaking Force[A]				Diameter Range	
				IPS	1770	EIP	1960	Min.	Max.
in.	mm	lb/ft	kg/m	Tons	kN	Tons	kN	in.	in.
	6	0.10	0.144		22.9		25.3	0.236	0.250
¼		0.11	0.161	2.84		3.12		0.250	0.265
	7	0.13	0.196		31.1		34.5	0.276	0.292
5/16		0.17	0.252	4.41		4.85		0.313	0.331
	8	0.17	0.256		40.7		45.0	0.315	0.331
	9	0.22	0.324		51.5		57.0	0.354	0.372
⅜		0.24	0.363	6.30		6.93		0.375	0.394
	10	0.27	0.400		63.5		70.4	0.394	0.413
	11	0.33	0.484		76.9		85.1	0.433	0.455
7/16		0.33	0.494	8.52		9.37		0.438	0.459
	12	0.39	0.576		91.5		101	0.472	0.496
½		0.43	0.645	11.1		12.2		0.500	0.525
	13	0.45	0.676		107		119	0.512	0.537
	14	0.53	0.784		125		138	0.551	0.579
9/16		0.55	0.817	14.0		15.4		0.563	0.591
⅝		0.68	1.008	17.1		18.8		0.625	0.656
	16	0.69	1.024		163		180	0.630	0.661
	18	0.87	1.296		206		228	0.709	0.744
	19	0.97	1.444		229		254	0.748	0.785
¾		0.98	1.452	24.4		26.8		0.750	0.788
	20	1.08	1.600		254		281	0.787	0.827
	22	1.30	1.936		308		341	0.866	0.909
⅞		1.33	1.976	33.0		36.3		0.875	0.919
	24	1.55	2.304		366		405	0.945	0.992
1		1.73	2.581	42.7		47.0		1.000	1.050
	26	1.82	2.704		430		476	1.024	1.075
	28	2.11	3.136		498		552	1.102	1.157
1⅛		2.19	3.266	53.5		58.9		1.125	1.181
1¼		2.71	4.032	65.6		72.2		1.250	1.313
	32	2.75	4.096		651		721	1.260	1.323
1⅜		3.28	4.879	78.6		86.5		1.375	1.444
	36	3.48	5.184		824		912	1.417	1.488
1½		3.90	5.806	92.7		102		1.500	1.575

[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 11 Classification 6×7 Fiber Core

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	6	Wires	5 to 9
	Outer Strands	6	Outer Wires	4 to 8
	Layer of Strands	1	Layer of Wires	1
	Wires in Rope	30 to 54		

Typical Examples		Number of Outer Wires	
Rope	Strand	Total	Per Strand
6×7	1–6	36	6

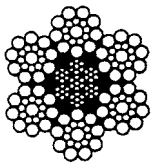
6×7 FC

Diameter		Approx. Mass		Minimum Breaking Force[A]				Diameter Range	
				IPS	1770	EIP	1960	Min.	Max.
in.	mm	lb/ft	kg/m	Tons	kN	Tons	kN	in.	in.
	6	0.08	0.124		21.2		23.4	0.236	0.248
¼		0.09	0.139	2.64		2.90		0.250	0.263
	7	0.11	0.169		28.8		31.9	0.276	0.289
5⁄16		0.15	0.217	4.10		4.51		0.313	0.328
	8	0.15	0.221		37.6		41.6	0.315	0.331
	9	0.19	0.279		47.6		52.7	0.354	0.372
⅜		0.21	0.313	5.86		6.45		0.375	0.394
	10	0.23	0.345		58.8		65.1	0.394	0.413
	11	0.28	0.417		71.1		78.7	0.433	0.455
7⁄16		0.29	0.426	7.93		8.72		0.438	0.459
	12	0.33	0.497		84.6		93.7	0.472	0.496
½		0.37	0.556	10.3		11.3		0.500	0.525
	13	0.39	0.583		99.3		110	0.512	0.537
	14	0.45	0.676		115		128	0.551	0.579
9⁄16		0.47	0.704	13.0		14.3		0.563	0.591
⅝		0.58	0.869	15.9				0.625	0.656
	16	0.59	0.883		150		167	0.630	0.661
	18	0.75	1.118		190		211	0.709	0.744
	19	0.84	1.245		212		235	0.748	0.785
¾		0.84	1.252	22.7		25.0		0.750	0.788
	20	0.93	1.380		235		260	0.787	0.827
	22	1.12	1.670		284		315	0.866	0.909
⅞		1.15	1.704	30.7		33.8		0.875	0.919
	24	1.34	1.987		338		375	0.945	0.992
1		1.50	2.226	39.7		43.7		1.000	1.050
	26	1.57	2.332		397		440	1.024	1.075
	28	1.82	2.705		461		510	1.102	1.157
1⅛		1.89	2.817	49.8		54.8		1.125	1.181
1¼		2.34	3.478	61.0		67.1		1.250	1.313
	32	2.37	3.533		602		666	1.260	1.323
1⅜		2.83	4.208	73.1		80.4		1.375	1.444
	36	3.00	4.471		762		843	1.417	1.488
1½		3.37	5.008	86.2		94.8		1.500	1.575

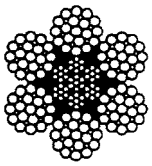
[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 12 Classification 6×19 Steel Core

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	6	Wires	15 to 26
	Outer Strands	6	Outer Wires	7 to 12
	Layer of Strands	1	Layer of Wires	2 to 3
	Wires in Rope	90 to 156		

6×19 Seale IWRC



6×25 filler wire IWRC

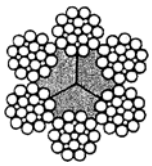
Typical Examples		Number of Outer Wires	
Rope	Strand	Total	Per Strand
6×19S	1–9–9	54	9
6×21F	1–5–5F–10	60	10
6×26WS	1–5–(5+5)–10	60	10
6×19W	1–6–(6+6)	72	12
6×25F	1–6–6F–12	72	12

Diameter		Approx. Mass		Minimum Breaking Force[A]						Diameter Range	
				IPS	1770	EIP	1960	EEIP	2160	Min.	Max.
in.	mm	lb/ft	kg/m	Tons	kN	Tons	kN	Tons	kN	in.	in.
	6	0.10	0.153		22.7		25.1		27.7	0.236	0.250
¼		0.12	0.172	2.94		3.40				0.250	0.265
	7	0.14	0.209		30.9		34.2		37.7	0.276	0.292
5/16		0.18	0.268	4.58		5.27				0.313	0.331
	8	0.18	0.273		40.3		44.7		49.2	0.315	0.331
	9	0.23	0.345		51.0		56.5		62.3	0.354	0.372
⅜		0.26	0.386	6.56		7.55		8.30		0.375	0.394
	10	0.29	0.426		63.0		69.8		76.9	0.394	0.413
	11	0.35	0.515		76.2		84.4		93.0	0.433	0.455
7/16		0.35	0.526	8.89		10.2		11.2		0.438	0.459
	12	0.41	0.613		90.7		100		111	0.472	0.496
½		0.46	0.687	11.5		13.3		14.6		0.500	0.525
	13	0.48	0.720		106		118		130	0.512	0.537
	14	0.56	0.835		124		137		151	0.551	0.579
9/16		0.58	0.870	14.5		16.8		18.5		0.563	0.591
⅝		0.72	1.074	17.7		20.6		22.7		0.625	0.656
	16	0.73	1.091		161		179		197	0.630	0.661
	18	0.93	1.380		204		226		249	0.709	0.744
	19	1.03	1.538		227		252		278	0.748	0.785
¾		1.04	1.546	25.6		29.4		32.4		0.750	0.788
	20	1.15	1.704		252		279		308	0.787	0.827
	22	1.39	2.062		305		338		372	0.866	0.909
⅞		1.41	2.104	34.6		39.8		43.8		0.875	0.919
	24	1.65	2.454		363		402		443	0.945	0.992
1		1.85	2.748	44.9		51.7		56.9		1.000	1.050
	26	1.94	2.880		426		472		520	1.024	1.075
	28	2.24	3.340		494		547		603	1.102	1.157
1⅛		2.34	3.478	56.5		65.0		71.5		1.125	1.181
1¼		2.89	4.294	69.4		79.9		87.9		1.250	1.313
	32	2.93	4.362		645		715		787	1.260	1.323
1⅜		3.49	5.196	83.5		96.0		106		1.375	1.444
	36	3.71	5.521		817		904		997	1.417	1.488
1½		4.16	6.184	98.9		114		125		1.500	1.575
	40	4.58	6.816		1008		1116		1230	1.575	1.654
1⅝		4.88	7.257	115		132		146		1.625	1.706
	44	5.54	8.247		1220		1351		1489	1.732	1.819
1¾		5.66	8.417	133		153		169		1.750	1.838
1⅞		6.49	9.662	152		174		192		1.875	1.969
	48	6.60	9.815		1452		1608		1772	1.890	1.984
2		7.39	10.994	172		198		217		2.000	2.100
	52	7.74	11.519		1704		1887		2079	2.047	2.150
2⅛		8.34	12.411	192		221		243		2.125	2.231
	56	8.98	13.359		1976		2188		2411	2.205	2.315
2¼		9.35	13.914	215		247		272		2.250	2.363
	60	10.31	15.336		2268		2512		2768	2.362	2.480
2⅜		10.42	15.503	239		274		301		2.375	2.494

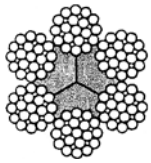
[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 13 Classification 6×19 Fiber Core

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	6	Wires	15 to 26
	Outer Strands	6	Outer Wires	7 to 12
	Layer of Strands	1	Layer of Wires	2 to 3
	Wires in Rope	90 to 156		
6×21 fiber wire FC				

Typical Examples		Number of Outer Wires	
Rope	Strand	Total	Per Strand
6×19S	1–9–9	54	9
6×21F	1–5–5F–10	60	10
6×26WS	1–5–(5+5)–10	60	10
6×19W	1–6–(6+6)	72	12
6×25F	1–6–6F–12	72	12



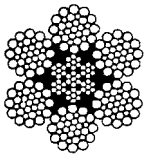
6×25 fiber wire FC

Diameter		Approx. Mass		Minimum Breaking Force[A]						Diameter Range	
				IPS	1770	EIP	1960	EEIP	2160	Min.	Max.
in.	mm	lb/ft	kg/m	Tons	kN	Tons	kN	Tons	kN	in.	in.
	6	0.09	0.140		21.0		23.3		25.7	0.236	0.250
¼		0.11	0.156	2.74		3.01				0.250	0.265
	7	0.13	0.190		28.6		31.7		34.9	0.276	0.292
5⁄16		0.16	0.244	4.26		4.69				0.313	0.331
	8	0.17	0.248		37.4		41.4		45.6	0.315	0.331
	9	0.21	0.314		47.3		52.4		57.7	0.354	0.372
⅜		0.24	0.352	6.10		6.71		7.38		0.375	0.394
	10	0.26	0.388		58.4		64.7		71.3	0.394	0.413
	11	0.32	0.469		70.7		78.3		86.2	0.433	0.455
7⁄16		0.32	0.479	8.27		9.10		10.0		0.438	0.459
	12	0.38	0.559		84.1		93.1		103	0.472	0.496
½		0.42	0.626	10.7		11.8		12.9		0.500	0.525
	13	0.44	0.656		98.7		109		120	0.512	0.537
	14	0.51	0.760		114		127		140	0.551	0.579
9⁄16		0.53	0.792	13.5		14.9		16.3		0.563	0.591
⅝		0.66	0.978	16.7		18.4		20.2		0.625	0.656
	16	0.67	0.993		150		166		182	0.630	0.661
	18	0.84	1.257		189		210		231	0.709	0.744
	19	0.94	1.401		211		233		257	0.748	0.785
¾		0.95	1.408	23.8		26.2		28.8		0.750	0.788
	20	1.04	1.552		234		259		285	0.787	0.827
	22	1.26	1.878		283		313		345	0.866	0.909
⅞		1.29	1.917	32.2		35.4		39.0		0.875	0.919
	24	1.50	2.235		336		373		411	0.945	0.992
1		1.68	2.503	41.8		46.0		50.6		1.000	1.050
	26	1.76	2.623		395		437		482	1.024	1.075
	28	2.04	3.042		458		507		559	1.102	1.157
1⅛		2.13	3.168	52.6		57.9		63.6		1.125	1.181
1¼		2.63	3.911	64.6		71.1		78.2		1.250	1.313
	32	2.67	3.973		598		662		730	1.260	1.323
1⅜		3.18	4.733	77.7		85.5		94.0		1.375	1.444
	36	3.38	5.028		757		838		924	1.417	1.488
1½		3.78	5.632	92.0		101		111		1.500	1.575
	40	4.17	6.208		935		1035		1140	1.575	1.654
1⅝		4.44	6.610	107		118		129		1.625	1.706
	44	5.05	7.512		1131		1252		1380	1.732	1.819
1¾		5.15	7.666	124		136		150		1.750	1.838
1⅞		5.91	8.800	141		155		171		1.875	1.969
	48	6.01	8.940		1346		1490		1642	1.890	1.984
2		6.73	10.013	160		176		194		2.000	2.100
	52	7.05	10.492		1579		1749		1927	2.047	2.150
2⅛		7.60	11.304	179		197		217		2.125	2.231
	56	8.18	12.168		1832		2028		2235	2.205	2.315
2¼		8.52	12.673	200		220		242		2.250	2.363
	60	9.39	13.968		2103		2328		2566	2.362	2.480
2⅜		9.49	14.120	222		244		269		2.375	2.494

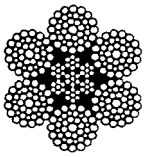
[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 14 Classification 6×36 Steel Core

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
 6×31 Warrington Seale IWRC	Strands	6	Wires	27 to 49
	Outer Strands	6	Outer Wires	12 to 18
	Layer of Strands	1	Layer of Wires	3 to 4
	Wires in Rope (excluding steel core)	156 to 276		

Typical Examples		Number of Outer Wires	
Rope	Strand	Total	Per Strand
6×31WS	1–6–(6+6)–12	72	12
6×36WS	1–7–(7+7)–14	84	14
6×41WS	1–8–(8+8)–16	96	16
6×41SF	1–8–8–8F–16	96	16
6×49SWS	1–8–8–(8+8)–16	96	16
6×46WS	1–9–(9+9)–18	108	18

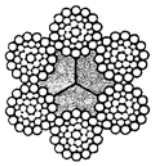

6×41 Warrington Seale IWRC

Diameter		Approx. Mass		Minimum Breaking Force[A]						Diameter Range	
				IPS	1770	EIP	1960	EEIP	2160	Min.	Max.
in.	mm	lb/ft	kg/m	Tons	kN	Tons	kN	Tons	kN	in.	in.
	6	0.10	0.153		22.7		25.1		27.7	0.236	0.250
¼		0.12	0.172	2.94		3.40				0.250	0.265
	7	0.14	0.209		30.9		34.2		37.7	0.276	0.292
5/16		0.18	0.268	4.58		5.27				0.313	0.331
	8	0.18	0.273		40.3		44.7		49.2	0.315	0.331
	9	0.23	0.345		51.0		56.5		62.3	0.354	0.372
⅜		0.26	0.386	6.56		7.55		8.30		0.375	0.394
	10	0.29	0.426		63.0		69.8		76.9	0.394	0.413
	11	0.35	0.515		76.2		84.4		93.0	0.433	0.455
7/16		0.35	0.526	8.89		10.2		11.2		0.438	0.459
	12	0.41	0.613		90.7		100		111	0.472	0.496
½		0.46	0.687	11.5		13.3		14.6		0.500	0.525
	13	0.48	0.720		106		118		130	0.512	0.537
	14	0.56	0.835		124		137		151	0.551	0.579
9/16		0.58	0.870	14.5		16.8		18.5		0.563	0.591
⅝		0.72	1.074	17.7		20.6		22.7		0.625	0.656
	16	0.73	1.091		161		179		197	0.630	0.661
	18	0.93	1.380		204		226		249	0.709	0.744
	19	1.03	1.538		227		252		278	0.748	0.785
¾		1.04	1.546	25.6		29.4		32.4		0.750	0.788
	20	1.15	1.704		252		279		308	0.787	0.827
	22	1.39	2.062		305		338		372	0.866	0.909
⅞		1.41	2.104	34.6		39.8		43.8		0.875	0.919
	24	1.65	2.454		363		402		443	0.945	0.992
1		1.85	2.748	44.9		51.7		56.9		1.000	1.050
	26	1.94	2.880		426		472		520	1.024	1.075
	28	2.24	3.340		494		547		603	1.102	1.157
1⅛		2.34	3.478	56.5		65.0		71.5		1.125	1.181
1¼		2.89	4.294	69.4		79.9		87.9		1.250	1.313
	32	2.93	4.362		645		715		787	1.260	1.323
1⅜		3.49	5.196	83.5		96.0		106		1.375	1.444
	36	3.71	5.521		817		904		997	1.417	1.488
1½		4.16	6.184	98.9		114		125		1.500	1.575
	40	4.58	6.816		1008		1116		1230	1.575	1.654
1⅝		4.88	7.257	115		132		146		1.625	1.706
	44	5.54	8.247		1220		1351		1489	1.732	1.819
1¾		5.66	8.417	133		153		169		1.750	1.838
1⅞		6.49	9.662	152		174		192		1.875	1.969
	48	6.60	9.815		1452		1608		1772	1.890	1.984
2		7.39	10.994	172		198		217		2.000	2.100
	52	7.74	11.519		1704		1887		2079	2.047	2.150
2⅛		8.34	12.411	192		221		243		2.125	2.231
	56	8.98	13.359		1976		2188		2411	2.205	2.315
2¼		9.35	13.914	215		247		272		2.250	2.363
	60	10.31	15.336		2268		2512		2768	2.362	2.480
2⅜		10.42	15.503	239		274		301		2.375	2.494

[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 15 Classification 6×36 Fiber Core

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	6	Wires	27 to 49
	Outer Strands	6	Outer Wires	12 to 18
	Layer of Strands	1	Layer of Wires	3 to 4
	Wires in Rope	156 to 276		

6×36
Warrington Seale
FC

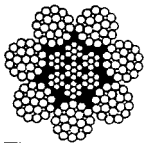
Typical Examples		Number of Outer Wires	
Rope	Strand	Total	Per Strand
6×31WS	1–6–(6+6)–12	72	12
6×36WS	1–7–(7+7)–14	84	14
6×41WS	1–8–(8+8)–16	96	16
6×41SF	1–8–8–8F–16	96	16
6×49SWS	1–8–8–(8+8)–16	96	16
6×46WS	1–9–(9+9)–18	108	18

Diameter		Approx. Mass		Minimum Breaking Force[A]						Diameter Range	
				IPS	1770	EIP	1960	EEIP	2160	Min.	Max.
in.	mm	lb/ft	kg/m	Tons	kN	Tons	kN	Tons	kN	in.	in.
	6	0.09	0.140		21.0		23.3		25.7	0.236	0.250
¼		0.11	0.156	2.74		3.01				0.250	0.265
	7	0.13	0.190		28.6		31.7		34.9	0.276	0.292
5⁄16		0.16	0.244	4.26		4.69				0.313	0.331
	8	0.17	0.248		37.4		41.4		45.6	0.315	0.331
	9	0.21	0.314		47.3		52.4		57.7	0.354	0.372
⅜		0.24	0.352	6.10		6.71		7.38		0.375	0.394
	10	0.26	0.388		58.4		64.7		71.3	0.394	0.413
	11	0.32	0.469		70.7		78.3		86.2	0.433	0.455
7⁄16		0.32	0.479	8.27		9.10		10.0		0.438	0.459
	12	0.38	0.559		84.1		93.1		103	0.472	0.496
½		0.42	0.626	10.7		11.8		12.9		0.500	0.525
	13	0.44	0.656		98.7		109		120	0.512	0.537
	14	0.51	0.760		114		127		140	0.551	0.579
9⁄16		0.53	0.792	13.5		14.9		16.3		0.563	0.591
⅝		0.66	0.978	16.7		18.4		20.2		0.625	0.656
	16	0.67	0.993		150		166		182	0.630	0.661
	18	0.84	1.257		189		210		231	0.709	0.744
	19	0.94	1.401		211		233		257	0.748	0.785
¾		0.95	1.408	23.8		26.2		28.8		0.750	0.788
	20	1.04	1.552		234		259		285	0.787	0.827
	22	1.26	1.878		283		313		345	0.866	0.909
⅞		1.29	1.917	32.2		35.4		39.0		0.875	0.919
	24	1.50	2.235		336		373		411	0.945	0.992
1		1.68	2.503	41.8		46.0		50.6		1.000	1.050
	26	1.76	2.623		395		437		482	1.024	1.075
	28	2.04	3.042		458		507		559	1.102	1.157
1⅛		2.13	3.168	52.6		57.9		63.6		1.125	1.181
1¼		2.63	3.911	64.6		71.1		78.2		1.250	1.313
	32	2.67	3.973		598		662		730	1.260	1.323
1⅜		3.18	4.733	77.7		85.5		94.0		1.375	1.444
	36	3.38	5.028		757		838		924	1.417	1.488
1½		3.78	5.632	92.0		101		111		1.500	1.575
	40	4.17	6.208		935		1035		1140	1.575	1.654
1⅝		4.44	6.610	107		118		129		1.625	1.706
	44	5.05	7.512		1131		1252		1380	1.732	1.819
1¾		5.15	7.666	124		136		150		1.750	1.838
1⅞		5.91	8.800	141		155		171		1.875	1.969
	48	6.01	8.940		1346		1490		1642	1.890	1.984
2		6.73	10.013	160		176		194		2.000	2.100
	52	7.05	10.492		1579		1749		1927	2.047	2.150
2⅛		7.60	11.304	179		197		217		2.125	2.231
	56	8.18	12.168		1832		2028		2235	2.205	2.315
2¼		8.52	12.673	200		220		242		2.250	2.363
	60	9.39	13.968		2103		2328		2566	2.362	2.480
2⅜		9.49	14.120	222		244		269		2.375	2.494

[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 16 Classification 7×19 Steel Core

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	7	Wires	15 to 26
	Outer Strands	7	Outer Wires	7 to 12
	Layer of Strands	1	Layer of Wires	2 to 3
	Wires in Rope	105 to 182		

7×25
filler wire
IWRC

Typical Examples		Number of Outer Wires	
Rope	Strand	Total	Per Strand
7×19S	1–9–9	63	9
7×21F	1–5–5F–10	70	10
7×26WS	1–5–(5+5)–10	70	10
7×19W	1–6–(6+6)	84	12
7×25F	1–6–6F–12	84	12

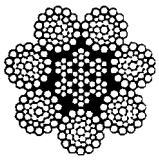
Diameter		Approx. Mass		Minimum Breaking Force[A]						Diameter Range	
				IPS	1770	EIP	1960	EEIP	2160	Min.	Max.
in.	mm	lb/ft	kg/m	Tons	kN	Tons	kN	Tons	kN	in.	in.
	6	0.11	0.157		22.7		25.1		27.7	0.236	0.250
¼		0.12	0.176	2.94		3.40				0.250	0.265
	7	0.14	0.214		30.9		34.2		37.7	0.276	0.292
5/16		0.19	0.275	4.58		5.27				0.313	0.331
	8	0.19	0.280		40.3		44.7		49.2	0.315	0.331
	9	0.24	0.354		51.0		56.5		62.3	0.354	0.372
⅜		0.27	0.396	6.56		7.55		8.30		0.375	0.394
	10	0.29	0.437		63.0		69.8		76.9	0.394	0.413
	11	0.36	0.529		76.2		84.4		93.0	0.433	0.455
7/16		0.36	0.540	8.89		10.2		11.2		0.438	0.459
	12	0.42	0.629		90.7		100		111	0.472	0.496
½		0.47	0.705	11.5		13.3		14.6		0.500	0.525
	13	0.50	0.739		106		118		130	0.512	0.537
	14	0.58	0.857		124		137		151	0.551	0.579
9/16		0.60	0.892	14.5		16.8		18.5		0.563	0.591
⅝		0.74	1.101	17.7		20.6		22.7		0.625	0.656
	16	0.75	1.119		161		179		197	0.630	0.661
	18	0.95	1.416		204		226		249	0.709	0.744
	19	1.06	1.578		227		252		278	0.748	0.785
¾		1.07	1.586	25.6		29.4		32.4		0.750	0.788
	20	1.17	1.748		252		279		308	0.787	0.827
	22	1.42	2.115		305		338		372	0.866	0.909
⅞		1.45	2.159	34.6		39.8		43.8		0.875	0.919
	24	1.69	2.517		363		402		443	0.945	0.992
1		1.89	2.819	44.9		51.7		56.9		1.000	1.050
	26	1.99	2.954		426		472		520	1.024	1.075
	28	2.30	3.426		494		547		603	1.102	1.157
1⅛		2.40	3.568	56.5		65.0		71.5		1.125	1.181
1¼		2.96	4.405	69.4		79.9		87.9		1.250	1.313
	32	3.01	4.475		645		715		787	1.260	1.323
1⅜		3.58	5.330	83.5		96.0		106		1.375	1.444
	36	3.81	5.664		817		904		997	1.417	1.488
1½		4.26	6.344	98.9		114		125		1.500	1.575
	40	4.70	6.992		1008		1116		1230	1.575	1.654
1⅝		5.00	7.445	115		132		146		1.625	1.706
	44	5.69	8.460		1220		1351		1489	1.732	1.819
1¾		5.80	8.634	133		153		169		1.750	1.838
1⅞		6.66	9.912	152		174		192		1.875	1.969
	48	6.77	10.068		1452		1608		1772	1.890	1.984
2		7.58	11.277	172		198		217		2.000	2.100
	52	7.94	11.816		1704		1887		2079	2.047	2.150
2⅛		8.56	12.731	192		221		243		2.125	2.231
	56	9.21	13.704		1976		2188		2411	2.205	2.315
2¼		9.59	14.273	215		247		272		2.250	2.363
	60	10.57	15.732		2268		2512		2768	2.362	2.480
2⅜		10.69	15.903	239		274		301		2.375	2.494

[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 17 Classification 7×36 Steel Core

Cross Section Examples



7×36
Warrington Seale
IWRC

Construction of Rope		Construction of Strand	
Item	Quantity	Item	Quantity
Strands	7	Wires	27 to 49
Outer Strands	7	Outer Wires	12 to 18
Layer of Strands	1	Layer of Wires	3 to 4
Wires in Rope	189 to 343		

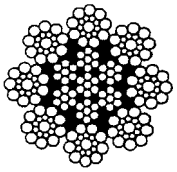
Typical Examples		Number of Outer Wires	
Rope	Strand	Total	Per Strand
7×31WS	1–6–(6+6)–12	84	12
7×36WS	1–7–(7+7)–14	98	14
7×41WS	1–8–(8+8)–16	112	16
7×41SF	1–8–8–8F–16	112	16
7×49SWS	1–8–8–(8+8)–16	112	16
7×46WS	1–9–(9+9)–18	126	18

Diameter		Approx. Mass		Minimum Breaking Force[A]						Diameter Range	
				IPS	1770	EIP	1960	EEIP	2160	Min.	Max.
in.	mm	lb/ft	kg/m	Tons	kN	Tons	kN	Tons	kN	in.	in.
	6	0.11	0.157		22.7		25.1		27.7	0.236	0.250
¼		0.12	0.176	2.94		3.40				0.250	0.265
	7	0.14	0.214		30.9		34.2		37.7	0.276	0.292
5⁄16		0.19	0.275	4.58		5.27				0.313	0.331
	8	0.19	0.280		40.3		44.7		49.2	0.315	0.331
	9	0.24	0.354		51.0		56.5		62.3	0.354	0.372
3⁄8		0.27	0.396	6.56		7.55		8.30		0.375	0.394
	10	0.29	0.437		63.0		69.8		76.9	0.394	0.413
	11	0.36	0.529		76.2		84.4		93.0	0.433	0.455
7⁄16		0.36	0.540	8.89		10.2		11.2		0.438	0.459
	12	0.42	0.629		90.7		100		111	0.472	0.496
½		0.47	0.705	11.5		13.3		14.6		0.500	0.525
	13	0.50	0.739		106		118		130	0.512	0.537
	14	0.58	0.857		124		137		151	0.551	0.579
9⁄16		0.60	0.892	14.5		16.8		18.5		0.563	0.591
5⁄8		0.74	1.101	17.7		20.6		22.7		0.625	0.656
	16	0.75	1.119		161		179		197	0.630	0.661
	18	0.95	1.416		204		226		249	0.709	0.744
	19	1.06	1.578		227		252		278	0.748	0.785
¾		1.07	1.586	25.6		29.4		32.4		0.750	0.788
	20	1.17	1.748		252		279		308	0.787	0.827
	22	1.42	2.115		305		338		372	0.866	0.909
7⁄8		1.45	2.159	34.6		39.8		43.8		0.875	0.919
	24	1.69	2.517		363		402		443	0.945	0.992
1		1.89	2.819	44.9		51.7		56.9		1.000	1.050
	26	1.99	2.954		426		472		520	1.024	1.075
	28	2.30	3.426		494		547		603	1.102	1.157
1⅛		2.40	3.568	56.5		65.0		71.5		1.125	1.181
1¼		2.96	4.405	69.4		79.9		87.9		1.250	1.313
	32	3.01	4.475		645		715		787	1.260	1.323
1⅜		3.58	5.330	83.5		96.0		106		1.375	1.444
	36	3.81	5.664		817		904		997	1.417	1.488
1½		4.26	6.344	98.9		114		125		1.500	1.575
	40	4.70	6.992		1008		1116		1230	1.575	1.654
1⅝		5.00	7.445	115		132		146		1.625	1.706
	44	5.69	8.460		1220		1351		1489	1.732	1.819
1¾		5.80	8.634	133		153		169		1.750	1.838
1⅞		6.66	9.912	152		174		192		1.875	1.969
	48	6.77	10.068		1452		1608		1772	1.890	1.984
2		7.58	11.277	172		198		217		2.000	2.100
	52	7.94	11.816		1704		1887		2079	2.047	2.150
2⅛		8.56	12.731	192		221		243		2.125	2.231
	56	9.21	13.704		1976		2188		2411	2.205	2.315
2¼		9.59	14.273	215		247		272		2.250	2.363
	60	10.57	15.732		2268		2512		2768	2.362	2.480
2⅜		10.69	15.903	239		274		301		2.375	2.494

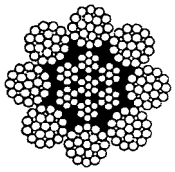
[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 18 Classification 8×19 Steel Core

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
 6×19 Seale IWRC	Strands	8	Wires	15 to 26
	Outer Strands	8	Outer Wires	7 to 12
	Layer of Strands	1	Layer of Wires	2 to 3
	Wires in Rope (excluding steel core)	120 to 232		

Typical Examples		Number of Outer Wires	
Rope	Strand	Total	Per Strand
8×19S	1–9–9	72	9
8×21F	1–5–5F–10	80	10
8×26WS	1–5–(5+5)–10	80	10
8×19W	1–6–(6+6)	96	12
8×25F	1–6–6F–12	96	12

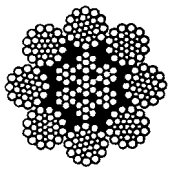

8×25 Filler Wire IWRC

Diameter		Approx. Mass		Minimum Breaking Force[A]						Diameter Range	
				IPS	1770	EIP	1960	EEIP	2160	Min.	Max.
in.	mm	lb/ft	kg/m	Tons	kN	Tons	kN	Tons	kN	in.	in.
	6	0.11	0.161		22.7		25.1		27.7	0.236	0.250
¼		0.12	0.180	2.94		3.40				0.250	0.265
	7	0.15	0.219		30.9		34.2		37.7	0.276	0.292
5⁄16		0.19	0.281	4.58		5.27				0.313	0.331
	8	0.19	0.285		40.3		44.7		49.2	0.315	0.331
	9	0.24	0.361		51.0		56.5		62.3	0.354	0.372
⅜		0.27	0.405	6.56		7.55		8.30		0.375	0.394
	10	0.30	0.446		63.0		69.8		76.9	0.394	0.413
	11	0.36	0.540		76.2		84.4		93.0	0.433	0.455
7⁄16		0.37	0.551	8.89		10.2		11.2		0.438	0.459
	12	0.43	0.642		90.7		100		111	0.472	0.496
½		0.48	0.719	11.5		13.3		14.6		0.500	0.525
	13	0.51	0.754		106		118		130	0.512	0.537
	14	0.59	0.874		124		137		151	0.551	0.579
9⁄16		0.61	0.910	14.5		16.8		18.5		0.563	0.591
⅝		0.76	1.124	17.7		20.6		22.7		0.625	0.656
	16	0.77	1.142		161		179		197	0.630	0.661
	18	0.97	1.445		204		226		249	0.709	0.744
	19	1.08	1.610		227		252		278	0.748	0.785
¾		1.09	1.619	25.6		29.4		32.4		0.750	0.788
	20	1.20	1.784		252		279		308	0.787	0.827
	22	1.45	2.159		305		338		372	0.866	0.909
⅞		1.48	2.203	34.6		39.8		43.8		0.875	0.919
	24	1.73	2.569		363		402		443	0.945	0.992
1		1.93	2.877	44.9		51.7		56.9		1.000	1.050
	26	2.03	3.015		426		472		520	1.024	1.075
	28	2.35	3.497		494		547		603	1.102	1.157
1⅛		2.45	3.642	56.5		65.0		71.5		1.125	1.181
1¼		3.02	4.496	69.4		79.9		87.9		1.250	1.313
	32	3.07	4.567		645		715		787	1.260	1.323
1⅜		3.66	5.440	83.5		96.0		106		1.375	1.444
	36	3.88	5.780		817		904		997	1.417	1.488
1½		4.35	6.474	98.9		114		125		1.500	1.575
	40	4.80	7.136		1008		1116		1230	1.575	1.654
1⅝		5.11	7.598	115		132		146		1.625	1.706
	44	5.80	8.635		1220		1351		1489	1.732	1.819
1¾		5.92	8.812	133		153		169		1.750	1.838
1⅞		6.80	10.116	152		174		192		1.875	1.969
	48	6.91	10.276		1452		1608		1772	1.890	1.984
2		7.73	11.510	172		198		217		2.000	2.100
	52	8.10	12.060		1704		1887		2079	2.047	2.150
2⅛		8.73	12.993	192		221		243		2.125	2.231
	56	9.40	13.987		1976		2188		2411	2.205	2.315
2¼		9.79	14.567	215		247		272		2.250	2.363
	60	10.79	16.056		2268		2512		2768	2.362	2.480
2⅜		10.91	16.230	239		274		301		2.375	2.494

[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 19 Classification 8×36 Steel Core

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	8	Wires	29 to 57
	Outer Strands	8	Outer Wires	12 to 18
	Layer of Strands	1	Layer of Wires	3 to 4
	Wires in Rope (excluding steel core)	232 to 456		

Typical Examples		Number of Outer Wires	
Rope	Strand	Total	Per Strand
8×31WS	1–6–(6+6)–12	96	12
8×36WS	1–7–(7+7)–14	112	14
8×41WS	1–8–(8+8)–16	128	16
8×41SF	1–8–8–8F–16	128	16
8×49SWS	1–8–8–(8+8)–16	128	16
8×46WS	1–9–(9+9)–18	144	18

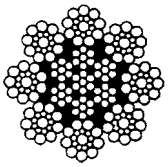
8×31
Warrington Seale
IWRC

Diameter		Approx. Mass		Minimum Breaking Force[A]						Diameter Range	
				IPS	1770	EIP	1960	EEIP	2160	Min.	Max.
in.	mm	lb/ft	kg/m	Tons	kN	Tons	kN	Tons	kN	in.	in.
	6	0.11	0.161		22.7		25.1		27.7	0.236	0.250
¼		0.12	0.180	2.94		3.40				0.250	0.265
	7	0.15	0.219		30.9		34.2		37.7	0.276	0.292
5/16		0.19	0.281	4.58		5.27				0.313	0.331
	8	0.19	0.285		40.3		44.7		49.2	0.315	0.331
	9	0.24	0.361		51.0		56.5		62.3	0.354	0.372
3/8		0.27	0.405	6.56		7.55		8.30		0.375	0.394
	10	0.30	0.446		63.0		69.8		76.9	0.394	0.413
	11	0.36	0.540		76.2		84.4		93.0	0.433	0.455
7/16		0.37	0.551	8.89		10.2		11.2		0.438	0.459
	12	0.43	0.642		90.7		100		111	0.472	0.496
½		0.48	0.719	11.5		13.3		14.6		0.500	0.525
	13	0.51	0.754		106		118		130	0.512	0.537
	14	0.59	0.874		124		137		151	0.551	0.579
9/16		0.61	0.910	14.5		16.8		18.5		0.563	0.591
5/8		0.76	1.124	17.7		20.6		22.7		0.625	0.656
	16	0.77	1.142		161		179		197	0.630	0.661
	18	0.97	1.445		204		226		249	0.709	0.744
	19	1.08	1.610		227		252		278	0.748	0.785
¾		1.09	1.619	25.6		29.4		32.4		0.750	0.788
	20	1.20	1.784		252		279		308	0.787	0.827
	22	1.45	2.159		305		338		372	0.866	0.909
7/8		1.48	2.203	34.6		39.8		43.8		0.875	0.919
	24	1.73	2.569		363		402		443	0.945	0.992
1		1.93	2.877	44.9		51.7		56.9		1.000	1.050
	26	2.03	3.015		426		472		520	1.024	1.075
	28	2.35	3.497		494		547		603	1.102	1.157
1⅛		2.45	3.642	56.5		65.0		71.5		1.125	1.181
1¼		3.02	4.496	69.4		79.9		87.9		1.250	1.313
	32	3.07	4.567		645		715		787	1.260	1.323
1⅜		3.66	5.440	83.5		96.0		106		1.375	1.444
	36	3.88	5.780		817		904		997	1.417	1.488
1½		4.35	6.474	98.9		114		125		1.500	1.575
	40	4.80	7.136		1008		1116		1230	1.575	1.654
1⅝		5.11	7.598	115		132		146		1.625	1.706
	44	5.80	8.635		1220		1351		1489	1.732	1.819
1¾		5.92	8.812	133		153		169		1.750	1.838
1⅞		6.80	10.116	152		174		192		1.875	1.969
	48	6.91	10.276		1452		1608		1772	1.890	1.984
2		7.73	11.510	172		198		217		2.000	2.100
	52	8.10	12.060		1704		1887		2079	2.047	2.150
2⅛		8.73	12.993	192		221		243		2.125	2.231
	56	9.40	13.987		1976		2188		2411	2.205	2.315
2¼		9.79	14.567	215		247		272		2.250	2.363
	60	10.79	16.056		2268		2512		2768	2.362	2.480
2⅜		10.91	16.230	239		274		301		2.375	2.494

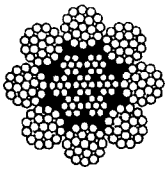
[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 20 Classification 8×19 Rotation Resistant—Category 3

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
 8×19 Seale IWRC	Strands	8	Wires	15 to 26
	Outer Strands	8	Outer Wires	7 to 12
	Layer of Strands	1	Layer of Wires	2 to 3
	Wires in Rope (excluding steel core)	120 to 232		

Typical Examples		Number of Outer Wires	
Rope	Strand	Total	Per Strand
8×19S	1–9–9	72	9
8×21F	1–5–5F-10	80	10
8×26WS	1–5–(5+5)–10	80	10
8×19W	1–6–(6+6)	96	12
8×25F	1–6–6F–12	96	12

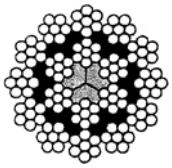

8×25
Filler Wire
IWRC

Diameter		Approx. Mass		Minimum Breaking Force[A]			Diameter Range	
in.	mm	lb/ft	kg/m	IPS Tons	EIP Tons	EEIP Tons	Min. in.	Max. in.
½	12.7	0.47	0.700	10.1	11.6	12.8	0.500	0.525
9/16	14.3	0.60	0.886	12.8	14.7	16.2	0.563	0.591
5/8	15.9	0.74	1.094	15.7	18.1	19.9	0.625	0.656
3/4	19.1	1.06	1.575	22.5	25.9	28.5	0.750	0.788
7/8	22.2	1.44	2.144	30.5	35.0	38.5	0.875	0.919
1	25.4	1.88	2.800	39.6	45.5	50.1	1.000	1.050
1 1/8	28.6	2.38	3.544	49.8	57.3	63.0	1.125	1.181
1 1/4	31.8	2.94	4.375	61.3	70.5	77.6	1.250	1.313
1 3/8	34.9	3.56	5.294	73.8	84.9	93.4	1.375	1.444
1 1/2	38.1	4.23	6.300	87.3	100	110	1.500	1.575

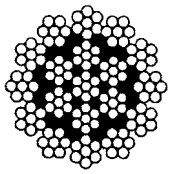
[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 21 Classification 19×7 Rotation Resistant–Category 2

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
 18×7 FC	Strands	17 to 18	Wires	5 to 7
	Outer Strands	10 to 13	Outer Wires	4 to 6
	Layer of Strands	2	Layer of Wires	1
	Wires in Rope (excluding steel core)	85 to 126		

Typical Examples		Number of Outer Wires	
Rope	Strand	Total	Per Strand
17×7	1–6	66	6
18×7	1–6	72	6
19×7	1–6	72	6

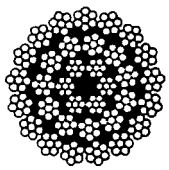

19×7

Diameter		Approx. Mass				Minimum Breaking Force[A]				Diameter Range	
		Fiber		WSC		IPS	1770	EIP	1960	Min.	Max.
in.	mm	lb/ft	kg/m	lb/ft	kg/m	Tons	kN	Tons	kN	in.	in.
	6	0.10	0.144	0.10	0.151		20.9		23.1	0.236	0.248
¼		0.11	0.161	0.11	0.169	2.51		2.77		0.250	0.263
	7	0.13	0.196	0.14	0.205		28.4		31.5	0.276	0.289
5/16		0.17	0.251	0.18	0.264	3.90		4.30		0.313	0.328
	8	0.17	0.255	0.18	0.268		37.2		41.1	0.315	0.331
	9	0.22	0.323	0.23	0.339		47.0		52.1	0.354	0.372
3/8		0.24	0.362	0.26	0.380	5.59		6.15		0.375	0.394
	10	0.27	0.399	0.28	0.419		58.1		64.3	0.394	0.413
	11	0.32	0.483	0.34	0.507		70.2		77.8	0.433	0.455
7/16		0.33	0.493	0.35	0.517	7.58		8.33		0.438	0.459
	12	0.39	0.575	0.41	0.603		83.6		92.6	0.472	0.496
½		0.43	0.644	0.45	0.676	9.85		10.8		0.500	0.525
	13	0.45	0.674	0.48	0.708		98.1		109	0.512	0.537
	14	0.53	0.782	0.55	0.821		114		126	0.551	0.579
9/16		0.55	0.814	0.57	0.855	12.4		13.6		0.563	0.591
5/8		0.68	1.006	0.71	1.056	15.3		16.8		0.625	0.656
	16	0.69	1.021	0.72	1.073		149		165	0.630	0.661
	18	0.87	1.293	0.91	1.358		188		208	0.709	0.744
	19	0.97	1.440	1.02	1.513		210		232	0.748	0.785
¾		0.97	1.448	1.02	1.521	21.8		24.0		0.750	0.788
	20	1.07	1.596	1.13	1.676		232		257	0.787	0.827
	22	1.30	1.931	1.36	2.028		281		311	0.866	0.909
7/8		1.32	1.971	1.39	2.070	29.5		32.5		0.875	0.919
	24	1.54	2.298	1.62	2.413		334		370	0.945	0.992
1		1.73	2.574	1.82	2.703	38.3		42.2		1.000	1.050
	26	1.81	2.697	1.90	2.832		392		435	1.024	1.075
	28	2.10	3.128	2.21	3.285		455		504	1.102	1.157
1⅛		2.19	3.258	2.30	3.421	48.2		53.1		1.125	1.181
1¼		2.70	4.022	2.84	4.224	59.2		65.1		1.250	1.313
	32	2.75	4.086	2.88	4.291		594		658	1.260	1.323
1⅜		3.27	4.867	3.43	5.111	71.3		78.4		1.375	1.444
	36	3.47	5.171	3.65	5.430		752		833	1.417	1.488
1½		3.89	5.792	4.09	6.082	84.4		92.8		1.500	1.575

[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 22 Classification 34×7 Rotation Resistant—Category 2

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	34 to 36	Wires	5 to 9
	Outer Strands	12 to 18	Outer Wires	4 to 8
	Layer of Strands	3	Layer of Wires	1
	Wires in Rope (excluding steel core)	170 to 324		

Typical Examples		Number of Outer Wires	
Rope	Strand	Total	Per Strand
34×7	1–6	102	6
17:11/6–C			
36×7	1–6	108	6
18:12/6–C			

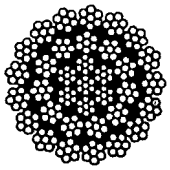
34×7

Diameter		Approx. Mass				Minimum Breaking Force[A]				Diameter Range	
		Fiber		WSC		1770		1960		Min.	Max.
in.	mm	lb/ft	kg/m	lb/ft	kg/m	Tons	kN	Tons	kN	in.	in.
	6	0.09	0.140	0.10	0.144		20.3		22.4	0.236	0.250
¼		0.11	0.157	0.11	0.162	2.55		2.83		0.250	0.265
	7	0.13	0.191	0.13	0.196		27.6		30.5	0.276	0.292
5⁄16		0.17	0.246	0.17	0.253	3.99		4.41		0.313	0.331
	8	0.17	0.250	0.17	0.257		36.0		39.9	0.315	0.331
	9	0.21	0.316	0.22	0.325		45.6		50.5	0.354	0.372
⅜		0.24	0.354	0.24	0.364	5.74		6.36		0.375	0.394
	10	0.26	0.390	0.27	0.401		56.3		62.3	0.394	0.413
	11	0.32	0.472	0.33	0.485		68.1		75.4	0.433	0.455
7⁄16		0.32	0.482	0.33	0.495	7.81		8.65		0.438	0.459
	12	0.38	0.562	0.39	0.577		81.1		89.8	0.472	0.496
½		0.42	0.629	0.43	0.647	10.2		11.3		0.500	0.525
	13	0.44	0.659	0.46	0.678		95.1		105.3	0.512	0.537
	14	0.51	0.764	0.53	0.786		110		122	0.551	0.579
9⁄16		0.53	0.796	0.55	0.819	12.9		14.3		0.563	0.591
⅝		0.66	0.983	0.68	1.011	15.9		17.7		0.625	0.656
	16	0.67	0.998	0.69	1.027		144		160	0.630	0.661
	18	0.85	1.264	0.87	1.299		182		202	0.709	0.744
	19	0.95	1.408	0.97	1.448		203		225	0.748	0.785
¾		0.95	1.415	0.98	1.455	23.0		25.4		0.750	0.788
	20	1.05	1.560	1.08	1.604		225		249	0.787	0.827
	22	1.27	1.888	1.30	1.941		272		302	0.866	0.909
⅞		1.29	1.926	1.33	1.981	31.3		34.6		0.875	0.919
	24	1.51	2.246	1.55	2.310		324		359	0.945	0.992
1		1.69	2.516	1.74	2.587	40.8		45.2		1.000	1.050
	26	1.77	2.636	1.82	2.711		380		421	1.024	1.075
	28	2.05	3.058	2.11	3.144		441		489	1.102	1.157
1⅛		2.14	3.184	2.20	3.274	51.7		57.2		1.125	1.181
1¼		2.64	3.931	2.72	4.042	63.8		70.6		1.250	1.313
	32	2.68	3.994	2.76	4.106		576		638	1.260	1.323
1⅜		3.20	4.757	3.29	4.891	77.2		85.5		1.375	1.444
	36	3.40	5.054	3.49	5.197		729		808	1.417	1.488
1½		3.80	5.661	3.91	5.821	91.8		102		1.500	1.575
	40	4.19	6.240	4.31	6.416		901		997	1.575	1.654
1⅝		4.46	6.644	4.59	6.832	108		119		1.625	1.706

[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 23 Classification 35×7 Rotation Resistant—Category 1

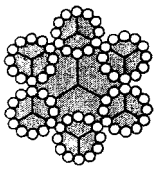
Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	35	Wires	5 to 9
	Outer Strands	16	Outer Wires	4 to 8
	Layer of Strands	3	Layer of Wires	1
	Wires in Rope (excluding steel core)	238		
35×7	Typical Examples		Number of Outer Wires	
	Rope	Strand	Total	Per Strand
	35×7	1–6	96	6

Diameter		Approx. Mass		Minimum Breaking Force[A]						Diameter Range	
		WSC		1770		1960		2160		Min.	Max.
in.	mm	lb/ft	kg/m	Tons	kN	Tons	kN	Tons	kN	in.	in.
	9	0.25	0.369		55.4		60.2		66.6	0.354	0.372
3/8		0.28	0.413	6.98		7.46		8.22		0.375	0.394
	10	0.31	0.455		69.2		75.4		83.5	0.394	0.413
	11	0.37	0.551		83.1		90.6		100	0.433	0.455
7/16		0.38	0.562	9.53		10.1		11.2		0.438	0.459
	12	0.44	0.655		99.9		106		119	0.472	0.496
1/2		0.49	0.734	12.6		13.6		14.6		0.500	0.525
	13	0.52	0.769		117		127		142	0.512	0.537
	14	0.60	0.892		136		147		165	0.551	0.579
9/16		0.62	0.929	15.9		17.3		18.5		0.563	0.591
5/8		0.77	1.147	19.7		21.7		22.8		0.625	0.656
	16	0.78	1.165		178		193		217	0.630	0.661
	18	0.99	1.474		223		241		271	0.709	0.744
	19	1.10	1.643		251		275		308	0.748	0.785
3/4		1.11	1.651	28.4		30.9		32.9		0.750	0.788
	20	1.22	1.820		278		299		336	0.787	0.827
	22	1.48	2.202		337		368		413	0.866	0.909
7/8		1.51	2.247	38.7		41.6		44.7		0.875	0.919
	24	1.76	2.621		401		439		493	0.945	0.992
1		1.97	2.935	50.3		54.4		58.4		1.000	1.050
	26	2.07	3.076		469		514		576	1.024	1.075
	28	2.40	3.567		549		596		646	1.102	1.157
1 1/8		2.50	3.715	64.3		68.9		73.9		1.125	1.181
1 1/4		3.08	4.587	78.8		86		91.3		1.250	1.313
	32	3.13	4.659		711		765		829	1.260	1.323
1 3/8		3.73	5.550	95.4		106		110		1.375	1.444
	36	3.96	5.897		906		977		1060	1.417	1.488
1 1/2		4.44	6.605	114		120		131		1.500	1.575
	40	4.89	7.280		1112		1200		1300	1.575	1.654
1 5/8		5.21	7.752	134		140		154		1.625	1.706

[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

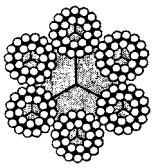
TABLE 24 Classification 6×12 Fiber Core

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	6	Wires	12
	Outer Strands	6	Outer Wires	12
	Layer of Strands	1	Layer of Wires	1
	Wires in Rope (excluding steel core)	72		
	Typical Examples		Number of Outer Wires	
6×12 Running Rope FC	Rope	Strand	Total	per Strand
	6×12	FC-12	72	12

Diameter			Approx. Mass	Minimum Breaking Force	Diameter Range	
in.	mm	lb/ft	kg/m	IPS Tons	Min. in.	Max. in.
5/16	7.9	0.10	0.152	2	0.313	0.328
3/8	9.5	0.15	0.219	3.36	0.375	0.394
7/16	11.1	0.20	0.298	4.55	0.438	0.459
1/2	12.7	0.26	0.389	5.91	0.500	0.525
9/16	14.3	0.33	0.492	7.45	0.563	0.591
5/8	15.9	0.41	0.607	9.16	0.625	0.656
3/4	19.1	0.59	0.875	13.1	0.750	0.788
13/16	20.6	0.69	1.026	15.3	0.813	0.853
7/8	22.2	0.80	1.190	17.7	0.875	0.919
1	25.4	1.04	1.555	23.0	1.000	1.050

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

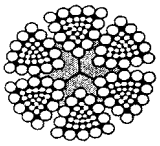
TABLE 25 Classification 6×24 Fiber Core

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	6	Wires	24
	Outer Strands	6	Outer Wires	12–16
	Layer of Strands	1	Layer of Wires	2
	Wires in Rope (excluding steel core)	144		
	Typical Examples		Number of Outer Wires	
	Rope	Strand	Total	per Strand
6×24 (2 operation) Hawser Rope FC	6×24	FC/9/15	90	15
	6×24W	FC/8-(8+8)	96	16
	6×24S	FC/12-12	72	12

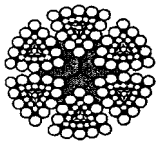
Diameter			Approx. Mass	Minimum Breaking Force	Diameter Range	
in.	mm	lb/ft	kg/m	IPS Tons	Min. in.	Max. in.
3/8	9.5	0.19	0.289	4.77	0.375	0.394
1/2	12.7	0.34	0.513	8.40	0.500	0.525
9/16	14.3	0.44	0.649	10.6	0.563	0.591
5/8	15.9	0.54	0.801	13.0	0.625	0.656
3/4	19.1	0.78	1.154	18.6	0.750	0.788
7/8	22.2	1.06	1.571	25.2	0.875	0.919
1	25.4	1.38	2.052	32.8	1.000	1.050
1 1/8	28.6	1.74	2.597	41.2	1.125	1.181
1 1/4	31.8	2.15	3.206	50.7	1.250	1.313
1 3/8	34.9	2.61	3.879	61.0	1.375	1.444
1 1/2	38.1	3.10	4.616	72.3	1.500	1.575
1 5/8	41.3	3.64	5.418	84.5	1.625	1.706
1 3/4	44.5	4.22	6.283	97.5	1.750	1.838
1 7/8	47.6	4.85	7.213	111	1.875	1.969
2	50.8	5.51	8.206	126	2.000	2.100

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 26 Classification 6×25 Triangular Strand Fiber Core

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
 6×30 Style G Flattened Strand (Plaited Center) FC	Strands	6	Wires	144
	Outer Strands	6	Outer Wires	72
	Layer of Strands	1	Layer of Wires	2
	Wires in Rope			

Typical Examples		Number of Outer Wires	
Rope	Strand	Total	Per Strand
6×25B	1/12/12	72	12
6×30G	(3×2)/12/12	72	12
6×27H	3/12/12	72	12
6×31V	1–6/12/12	72	12



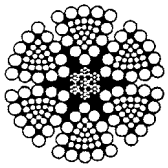
6×31 Style V (Brangle Center) FC

Diameter		Approx. Mass		Minimum Breaking Force[A]			Diameter Range	
in.	mm	lb/ft	kg/m	IPS Tons	EIP Tons	EEIP Tons	Min. in.	Max. in.
½	12.7	0.45	0.669	11.8	13.0	14.3	0.500	0.525
9⁄16	14.3	0.57	0.847	14.9	16.4	18.0	0.563	0.591
⅝	15.9	0.70	1.046	18.3	20.1	22.1	0.625	0.656
¾	19.1	1.01	1.506	26.2	28.8	31.7	0.750	0.788
⅞	22.2	1.38	2.050	35.4	38.9	42.8	0.875	0.919
1	25.4	1.80	2.677	46.0	50.6	55.7	1.000	1.050
1⅛	28.6	2.28	3.389	57.9	63.7	70.1	1.125	1.181
1¼	31.8	2.81	4.183	71.0	78.1	85.9	1.250	1.313
1⅜	34.9	3.40	5.062	85.5	94.1	103	1.375	1.444
1½	38.1	4.05	6.024	101	111	122	1.500	1.575
1⅝	41.3	4.75	7.070	118	130	143	1.625	1.706
1¾	44.5	5.51	8.200	138	152	167	1.750	1.838
1⅞	47.6	6.33	9.413	155	171	188	1.875	1.969
2	50.8	7.20	10.710	176	194	213	2.000	2.100
2⅛	54.0	8.12	12.090	196	215	237	2.125	2.231
2¼	57.2	9.11	13.554	220	240	264	2.250	2.363
2⅜	60.3	10.15	15.102	241	265	292	2.375	2.494

[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 27 Classification 6×25 Triangular Strand Steel Core

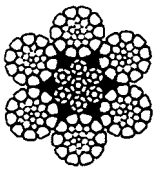
Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	6	Wires	144
	Outer Strands	6	Outer Wires	72
	Layer of Strands	1	Layer of Wires	2
	Wires in Rope			
	Typical Examples		Number of Outer Wires	
	Rope	Strand	Total	Per Strand
	6×25B	1/12/12	72	12
	6×30G	(3×2)/12/12	72	12
	6×27H	3/12/12	72	12
	6×31V	1–6/12/12	72	12
6×30 Style G Flattened Strand (Plated Center) IWRC				

Diameter		Approx. Mass		Minimum Breaking Force[A]			Diameter Range	
in.	mm	lb/ft	kg/m	IPS Tons	EIP Tons	EEIP Tons	Min. in.	Max. in.
½	12.7	0.47	0.703	12.6	14.0	15.4	0.500	0.525
9/16	14.3	0.60	0.890	16.0	17.6	19.4	0.563	0.591
⅝	15.9	0.74	1.099	19.6	21.7	23.9	0.625	0.656
¾	19.1	1.06	1.582	28.1	31.0	34.1	0.750	0.788
⅞	22.2	1.45	2.154	38.0	41.9	46.1	0.875	0.919
1	25.4	1.89	2.813	49.4	54.4	59.8	1.000	1.050
1⅛	28.6	2.39	3.560	62.2	68.5	75.4	1.125	1.181
1¼	31.8	2.95	4.395	76.3	84.0	92.4	1.250	1.313
1⅜	34.9	3.57	5.318	91.9	101	111	1.375	1.444
1½	38.1	4.25	6.329	108	119	131	1.500	1.575
1⅝	41.3	4.99	7.428	127	140	154	1.625	1.706
1¾	44.5	5.79	8.615	146	161	177	1.750	1.838
1⅞	47.6	6.65	9.889	167	184	202	1.875	1.969
2	50.8	7.56	11.252	189	207	228	2.000	2.100
2⅛	54.0	8.54	12.702	211	232	255	2.125	2.231
2¼	57.2	9.57	14.240	237	260	286	2.250	2.363
2⅜	60.3	10.66	15.867	261	287	316	2.375	2.494

[A] Minimum breaking force for final-galvanized ropes 10 % lower than values listed.

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

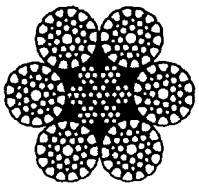
TABLE 28 Classification 6×19 Compacted Strand (CS)

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	6	Wires	15 to 26
	Outer Strands	6	Outer Wires	7 to 12
	Layer of Strands	1	Layer of Wires	2 to 3
	Wires in Rope	90 to 156		
	Typical Examples		Number of Outer Wires	
	Rope	Strand	Total	Per Strand
	6×19S	1–9–9	54	9
	6×21F	1–5–5F–10	60	10
6×26 Warrington Seale Compacted Strand IWRC	6×26WS	1–5–(5+5)–10	60	10
	6×19W	1–6–(6+6)	72	12
	6×25F	1–6–6F–12	72	12

Diameter		Approx. Mass		Minimum Breaking Force				Diameter Range	
				EIP	1960	EEIP	2160	Min.	Max.
in.	mm	lb/ft	kg/m	Tons	kN	Tons	kN	in.	in.
3/8		0.282	0.419	8.30		9.13		0.375	0.394
	10	0.310	0.462		85.3		91.5	0.394	0.413
	11	0.376	0.559		98.1		113	0.433	0.455
7/16		0.383	0.571	11.2		12.3		0.438	0.459
	12	0.447	0.665		114		127	0.472	0.496
1/2		0.501	0.745	14.6		16.1		0.500	0.525
	13	0.525	0.781		147		157	0.512	0.537
	14	0.609	0.906		169		183	0.551	0.579
9/16		0.634	0.943	18.5		20.4		0.563	0.591
5/8		0.782	1.164	22.7		25.0		0.625	0.656
	16	0.795	1.183		217		228	0.630	0.661
	18	1.006	1.497		275		298	0.709	0.744
	19	1.121	1.668		302		323	0.748	0.785
3/4		1.127	1.677	32.4		35.6		0.750	0.788
	20	1.242	1.848		333		355	0.787	0.827
	22	1.503	2.236		398		423	0.866	0.909
7/8		1.534	2.282	43.8		48.2		0.875	0.919
	24	1.788	2.661		487		518	0.945	0.992
1		2.003	2.981	56.9		62.6		1.000	1.050
	26	2.099	3.123		576		610	1.024	1.075
	28	2.434	3.622		655		700	1.102	1.157
1 1/8		2.535	3.772	71.5		78.7		1.125	1.181
1 1/4		3.130	4.657	87.9		96.7		1.250	1.313
	32	3.179	4.731		844		914	1.260	1.323
1 3/8		3.787	5.635	106		117		1.375	1.444
	36	4.024	5.988		1060		1120	1.417	1.488
1 1/2		4.507	6.706	125		138		1.500	1.575
	40	4.967	7.392		1290		1320	1.575	1.654
1 5/8		5.289	7.871	146		161		1.625	1.706
	44	6.011	8.944		1500		1590	1.732	1.819
1 3/4		6.134	9.128	169		186		1.750	1.838
1 7/8		7.042	10.479	192		211		1.875	1.969
	48	7.153	10.644		1880		1890	1.890	1.984
2		8.012	11.923	217		239		2.000	2.100
	52	8.395	12.492		2130		2220	2.047	2.150
2 1/8		9.045	13.460	243		267		2.125	2.231
	56	9.736	14.488		2470		2574	2.205	2.315
2 1/4		10.140	15.090	272		299		2.250	2.363

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

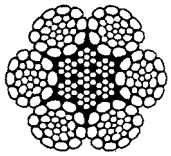
TABLE 29 Classification 6×36 Compacted Strand (CS)

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	6	Wires	27 to 49
	Outer Strands	6	Outer Wires	12 to 18
	Layer of Strands	1	Layer of Wires	27 to 49
	Wires in Rope	156 to 276		
6×36 Compacted Strand	Typical Examples		Number of Outer Wires	
	Rope	Strand	Total	Per Strand
	6×31WS	1–6–(6+6)–12	72	12
	6×36WS	1–7–(7+7)–14	84	14
	6×41WS	1–8–(8+8)–16	96	16
	6×41SF	1–8–8–8F–16	96	16
	6×49SWS	1–8–8–(8+8)–16	96	16
	6×46WS	1–9–(9+9)–18	108	18

Diameter		Approx. Mass		Minimum Breaking Force				Diameter Range	
in.	mm	lb/ft	kg/m	EIP Tons	1960 kN	EEIP Tons	2160 kN	Min. in.	Max. in.
3/8		0.282	0.419	8.30		9.13		0.375	0.394
	10	0.310	0.462		85.3		91.5	0.394	0.413
	11	0.376	0.559		98.1		113	0.433	0.455
7/16		0.383	0.571	11.2		12.3		0.438	0.459
	12	0.447	0.665		114		127	0.472	0.496
1/2		0.501	0.745	14.6		16.1		0.500	0.525
	13	0.525	0.781		147		157	0.512	0.537
	14	0.609	0.906		169		183	0.551	0.579
9/16		0.634	0.943	18.5		20.4		0.563	0.591
5/8		0.782	1.164	22.7		25.0		0.625	0.656
	16	0.795	1.183		217		228	0.630	0.661
	18	1.006	1.497		275		298	0.709	0.744
	19	1.121	1.668		302		323	0.748	0.785
3/4		1.127	1.677	32.4		35.6		0.750	0.788
	20	1.242	1.848		333		355	0.787	0.827
	22	1.503	2.236		398		423	0.866	0.909
7/8		1.534	2.282	43.8		48.2		0.875	0.919
	24	1.788	2.661		487		518	0.945	0.992
1		2.003	2.981	56.9		62.6		1.000	1.050
	26	2.099	3.123		576		610	1.024	1.075
	28	2.434	3.622		655		700	1.102	1.157
1 1/8		2.535	3.772	71.5		78.7		1.125	1.181
1 1/4		3.130	4.657	87.9		96.7		1.250	1.313
	32	3.179	4.731		844		914	1.260	1.323
1 3/8		3.787	5.635	106		117		1.375	1.444
	36	4.024	5.988		1060		1120	1.417	1.488
1 1/2		4.507	6.706	125		138		1.500	1.575
	40	4.967	7.392		1290		1320	1.575	1.654
1 5/8		5.289	7.871	146		161		1.625	1.706
	44	6.011	8.944		1500		1590	1.732	1.819
1 3/4		6.134	9.128	169		186		1.750	1.838
1 7/8		7.042	10.479	192		211		1.875	1.969
	48	7.153	10.644		1880		1890	1.890	1.984
2		8.012	11.923	217		239		2.000	2.100
	52	8.395	12.492		2130		2220	2.047	2.150
2 1/8		9.045	13.460	243		267		2.125	2.231
	56	9.736	14.488		2470		2574	2.205	2.315
2 1/4		10.140	15.090	272		299		2.250	2.363

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

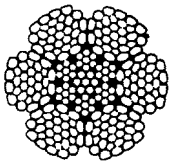
TABLE 30 Classification 6×19 Swaged Rope (SW)

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	6	Wires	15–26
	Outer Strands	6	Outer Wires	7–12
	Layer of Strands	1	Layer of Wires	2–3
	Wires in Rope (excluding steel core)	90–156		
	Typical Examples		Number of Outer Wires	
	Rope	Strand	Total	per Strand
	6×19S	1–9–9	54	9
	6×21F	1–5–5F–10	60	10
6×26 Warrington Compacted (Swaged) IWRC	6×26WS	1–5–(5+5)–10	60	10
	6×19W	1–6–(6+6)	72	12
	6×25F	1–6–6F–12	72	12

Diameter			Approx. Mass	Minimum Breaking Force	Diameter Range	
in.	mm	lb/ft	kg/m	EIP Tons	Min. in.	Max. in.
½	12.7	0.55	0.826	15.5	0.500	0.525
9/16	14.3	0.70	1.045	19.6	0.563	0.591
5/8	15.9	0.87	1.290	24.2	0.625	0.656
¾	19.1	1.25	1.858	34.9	0.750	0.788
7/8	22.2	1.70	2.529	47.4	0.875	0.919
1	25.4	2.22	3.303	62.0	1.000	1.050
1⅛	28.6	2.81	4.181	73.5	1.125	1.181
1¼	31.8	3.47	5.161	90.0	1.250	1.313
1⅜	34.9	4.20	6.245	106	1.375	1.444
1½	38.1	4.99	7.432	130	1.500	1.575

Note—To convert to kilonewtons (kN), multiply tons by 8.896.
Note—Also called compacted rope.

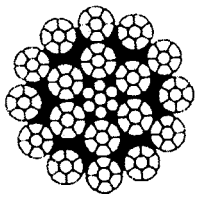
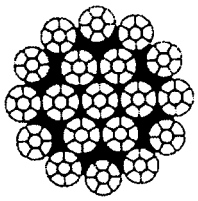
TABLE 31 Classification 6×36 Swaged Rope (SW)

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	6	Wires	27–49
	Outer Strands	6	Outer Wires	12–18
	Layer of Strands	1	Layer of Wires	3–4
	Wires in Rope (excluding steel core)	156–276		
	Typical Examples		Number of Outer Wires	
	Rope	Strand	Total	per Strand
6×31 Warrington Seale Compacted (Swaged) IWRC	6×31WS	1–6–(6+6)–12	72	12
	6×36WS	1–7–(7+7)–14	84	14
	6×41WS	1–8–(8+8)–16	96	16
	6×41SF	1–8–8–8F–16	96	16
	6×49SWS	1–8–8–(8+8)–16	96	16
	6×46WS	1–9–(9+9)–18	108	18

Diameter			Approx. Mass	Minimum Breaking Force	Diameter Range	
in.	mm	lb/ft	kg/m	EIP Tons	Min. in.	Max. in.
½	12.7	0.55	0.826	15.5	0.500	0.525
9/16	14.3	0.70	1.045	19.6	0.563	0.591
5/8	15.9	0.87	1.290	24.2	0.625	0.656
¾	19.1	1.25	1.858	34.9	0.750	0.788
7/8	22.2	1.70	2.529	47.4	0.875	0.919
1	25.4	2.22	3.303	62.0	1.000	1.050
1⅛	28.6	2.81	4.181	73.5	1.125	1.181
1¼	31.8	3.47	5.161	90.0	1.250	1.313
1⅜	34.9	4.20	6.245	106	1.375	1.444
1½	38.1	4.99	7.432	130	1.500	1.575

Note—To convert to kilonewtons (kN), multiply tons by 8.896.
Note—Also called compacted rope.

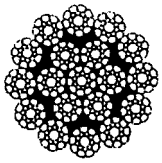
TABLE 32 Classification 19×7 Compacted Strand (CS) Rotation Resistant—Category 2

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
 18×7 Compacted Strand	Strands	17 to 18	Wires	5 to 7
	Outer Strands	10 to 13	Outer Wires	4 to 6
	Layer of Strands	2	Layer of Wires	1
	Wires in Rope (excluding steel core)	85 to 126		
 19×7 Compacted Strand	Typical Examples		Number of Outer Wires	
	Rope	Strand	Total	Per Strand
	17×7	1–6	66	6
	18×7	1–6	72	6
	19×7	1–6	72	6

Diameter		Approx. Mass		Minimum Breaking Force				Diameter Range	
				EIP	1960	EEIP	2160	Min.	Max.
in.	mm	lb/ft	kg/m	Tons	kN	Tons	kN	in.	in.
	6	0.12	0.181		30.7		34.0	0.236	0.248
¼		0.14	0.203	3.74		4.11		0.250	0.263
	7	0.17	0.247		39.8		44.1	0.276	0.289
5⁄16		0.21	0.318	5.80		6.38		0.313	0.328
	8	0.22	0.323		54.2		60.0	0.315	0.331
	9	0.27	0.408		67.6		74.8	0.354	0.372
3⁄8		0.31	0.457	7.55		8.30		0.375	0.394
	10	0.34	0.504		84.3		93.3	0.394	0.413
	11	0.41	0.610		105		116	0.433	0.455
7⁄16		0.42	0.622	10.2		11.2		0.438	0.459
	12	0.49	0.726		121		133	0.472	0.496
½		0.55	0.813	13.3		14.6		0.500	0.525
	13	0.57	0.852		147		162	0.512	0.537
	14	0.66	0.988		167		185	0.551	0.579
9⁄16		0.69	1.029	16.8		18.5		0.563	0.591
5⁄8		0.85	1.270	20.6		22.7		0.625	0.656
	16	0.87	1.290		219		243	0.630	0.661
	18	1.10	1.633		278		308	0.709	0.744
	19	1.22	1.819		304		337	0.748	0.785
¾		1.23	1.829	29.4		32.4		0.750	0.788
	20	1.35	2.016		336		372	0.787	0.827
	22	1.64	2.439		412		457	0.866	0.909
7⁄8		1.67	2.490	39.8		43.8		0.875	0.919
	24	1.95	2.903		476		541	0.945	0.992
1		2.19	3.252	51.7		56.9		1.000	1.050

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

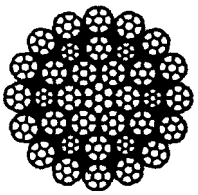
TABLE 33 Classification 19×19 Compacted Strand (CS) Rotation Resistant—Category 2

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	17 to 18	Wires	15 to 26
	Outer Strands	10 to 13	Outer Wires	7 to 12
	Layer of Strands	2	Layer of Wires	2 to 3
	Wires in Rope (excluding steel core)	255 to 468		
19×19 Seale Compacted Strand	Typical Examples		Number of Outer Wires	
	Rope	Strand	Total	Per Strand
	17×19S	1–9–9	99	9
	18×19S	1–9–9	108	9
	18×26WS	1–5–(5+5)–10	120	10
	19×19S	1–9–9	108	9
	19×26WS	1–5–(5+5)–10	120	10

Diameter		Approx. Mass		Minimum Breaking Force				Diameter Range	
in.	mm	lb/ft	kg/m	EIP Tons	1960 kN	EEIP Tons	2160 kN	Min. in.	Max. in.
3/8		0.31	0.462	7.55		8.3		0.375	0.394
	10	0.34	0.509		84.3		93.3	0.394	0.413
	11	0.41	0.616		105		116	0.433	0.455
7/16		0.42	0.629	10.2		11.2		0.438	0.459
	12	0.49	0.733		121		133	0.472	0.496
1/2		0.55	0.821	13.3		14.6		0.500	0.525
	13	0.58	0.860		147		162	0.512	0.537
	14	0.67	0.998		160		180	0.551	0.579
9/16		0.70	1.039	16.8		18.5		0.563	0.591
5/8		0.86	1.283	20.6		22.7		0.625	0.656
	16	0.88	1.303		215		241	0.630	0.661
	18	1.11	1.649		266		299	0.709	0.744
	19	1.23	1.837		300		337	0.748	0.785
3/4		1.24	1.847	29.4		32.4		0.750	0.788
	20	1.37	2.036		335		376	0.787	0.827
	22	1.66	2.464		405		454	0.866	0.909
7/8		1.69	2.514	39.8		43.8		0.875	0.919
	24	1.97	2.932		482		540	0.945	0.992
1		2.21	3.284	51.7		56.9		1.000	1.050
	26	2.31	3.441		572		637	1.024	1.075
	28	2.68	3.991		662		743	1.102	1.157
1 1/8		2.79	4.156	65.0		71.5		1.125	1.181
1 1/4		3.45	5.131	79.9		87.9		1.250	1.313
	32	3.50	5.212		859		964	1.260	1.323
1 3/8		4.17	6.209	96.0		106		1.375	1.444
	36	4.43	6.597		1085		1218	1.417	1.488
1 1/2		4.97	7.389	114		125		1.500	1.575
	40	5.47	8.144		1340		1503	1.575	1.654
1 5/8		5.83	8.671	132		145		1.625	1.706

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

TABLE 34 Classification 35×7 Compacted Strand (CS) Rotation Resistant—Category 1

Cross Section Examples	Construction of Rope		Construction of Strand	
	Item	Quantity	Item	Quantity
	Strands	35	Wires	5 to 9
	Outer Strands	16	Outer Wires	4 to 8
	Layer of Strands	3	Layer of Wires	1
	Wires in Rope	238		
	Typical Examples		Number of Outer Wires	
	Rope	Strand	Total	Per Strand
35×7 Compacted Strand	35×7	1–6	96	6

Diameter		Approx. Mass		Minimum Breaking Force				Diameter Range	
				1960		2160		Min.	Max.
in.	mm	lb/ft	kg/m	Tons	kN	Tons	kN	in.	in.
	10	0.33	0.497		87.6		98.3	0.394	0.413
	11	0.40	0.601		105		118	0.433	0.455
7/16		0.41	0.614	12.1		13.4		0.438	0.459
	12	0.48	0.716		124		140	0.472	0.496
1/2		0.54	0.802	15.4		17.4		0.500	0.525
	13	0.56	0.840		144		162	0.512	0.537
	14	0.65	0.974		168		188	0.551	0.579
9/16		0.68	1.015	19.7		22.0		0.563	0.591
5/8		0.84	1.253	25.2		28.2		0.625	0.656
	16	0.85	1.272		224		251	0.630	0.661
	18	1.08	1.610		274		308	0.709	0.744
	19	1.21	1.794		307		344	0.748	0.785
3/4		1.21	1.804	34.5		38.7		0.750	0.788
	20	1.34	1.988		341		382	0.787	0.827
	22	1.62	2.405		415		466	0.866	0.909
7/8		1.65	2.455	47.2		53.0		0.875	0.919
	24	1.92	2.863		491		555	0.945	0.992
1		2.15	3.206	62.4		70.0		1.000	1.050
	26	2.26	3.360		588		660	1.024	1.075
	28	2.62	3.896		676		758	1.102	1.157
1 1/8		2.73	4.058	77.5		86.9		1.125	1.181
1 1/4		3.37	5.010	98.1		110		1.250	1.313
	32	3.42	5.089		873		980	1.260	1.323
1 3/8		4.07	6.062	117		124		1.375	1.444
	36	4.33	6.441		1110		1232	1.417	1.488
1 1/2		4.85	7.215	138		147		1.500	1.575
	40	5.34	7.952		1390		1521	1.575	1.654
1 5/8		5.69	8.467	167		182		1.625	1.706

Note—To convert to kilonewtons (kN), multiply tons by 8.896.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A 1023/A 1023M – 02) that may impact the use of this standard. (Approved Sept. 1, 2007.)

(*1*) Changed reference to 8.2.3.1 to 8.6.1 in Sections 6.6.1.1 and 6.6.1.2.

(*2*) Added wire sizes 0.0045 in. to 0.010 in. in Table 4.