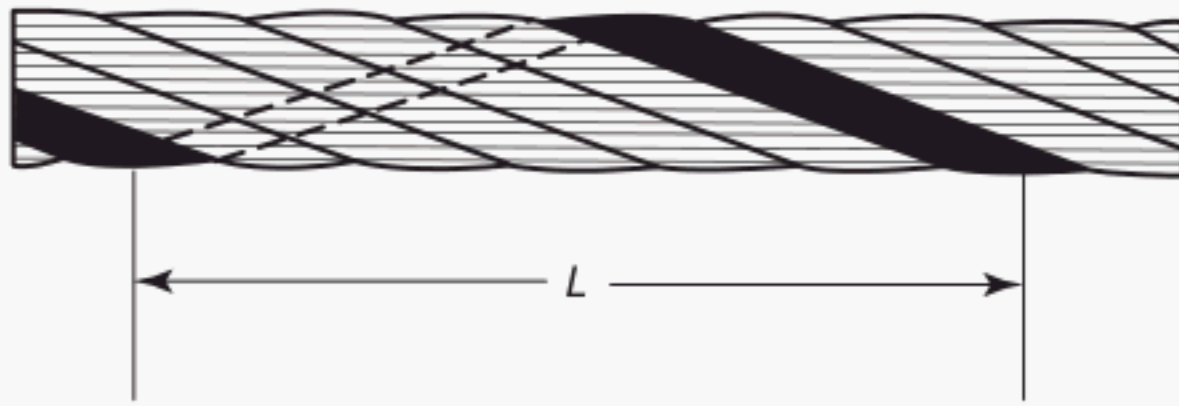


Fig. 1.3.3.2.2-1 Rope Lay Length

1.3.4 Mechanical Properties

1.3.4.1 Wire

1.3.4.1.1 Wire Tensile Strength. 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 the tensile strength grade or wire level as specified in this Standard for outer wire, by wire level as specified by ASTM A 1007 for inner and core wires, or by the tensile strength grade as specified in ISO 2232 for all component wires.

(a) *Wire Level.* A level of requirement for tensile strength in pounds per square inch (e.g., Level 3, see ASTM A 1007).

1.3.4.2.5 Residual Strength. The actual breaking strength of a suspension member at any time during its operational life cycle.

NOTE: The residual strength will be reduced as the suspension member is used and is subjected to wear.

1.3.4.3 Rope Stretch (Extension)

1.3.4.3.1 Constructional Stretch (Extension). The 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.

1.3.4.3.2 Elastic Stretch (Extension). The amount of recoverable extension that follows Hooke's Law within certain limits due to application of a load.

1.3.4.3.3 Permanent Stretch (Extension). Nonelastic extension.

1.3.5 Rope Manufacture

1.3.5.1 Preformation

1.3.5.1.1 Preformed Rope. Rope in which the wires and strands in the rope will not, after removal of any seizing (serving), spring out of the rope formation.

1.3.5.1.2 Nonpreformed Rope. Rope in which the

Table 1.4.1-1 Wire Level or Tensile Strength Grades for Given Rope Grades

Rope Grade [Note (1)]	Wire Level or Tensile Strength Grade	
	Outer	Inner
Iron	Iron/Grade 680	Level 2/Grade 1570; Level 3/Grade 1770; Level 4/Grade 1960
Traction	Traction/Grade 1180	Level 2/Grade 1570; Level 3/ Grade 1770; Level 4/Grade 1960
Extra High Strength	Level 3/Grade 1770	Level 3/Grade 1770; Level 4/Grade 1960; Level 5/Grade 2160
1570 Single	Level 2/Grade 1570	Level 2/Grade 1570
1180/1770 Dual	Traction/Grade 1180	Level 3/Grade 1770; Level 4/Grade 1960
1370/1770 Dual	Level 1/Grade 1370	Level 3/Grade 1770; Level 4/Grade 1960
1770 Single	Level 3/Grade 1770	Level 3/Grade 1770
1960 Single	Grade 1960	Level 4/Grade 1960; Level 5/Grade 2160
2300 Single	Grade 2300	Grade 2300

GENERAL NOTE: "Level" refers to North American tensile strength standards and "Grade" refers to European Tensile test standards.

NOTE:

(1) See section 1.2.

sheaves, unequally tensioned ropes, or severe environmental conditions.

1.3.7.3 Crown Wire Breaks. Fatigue failure of the outer wire following a diameter reduction due to wear.

1.3.7.3.1 Equally Distributed Breaks. Randomly distributed wire breaks throughout the lay of the rope without any pattern.

1.3.7.3.2 Unequally Distributed Breaks. Wire breaks predominating in one or two strands within the lay of the rope.

1.3.7.3.3 Side-by-Side Breaks. Four wire breaks in one strand within the lay of a rope that resembles a staircase.

1.3.7.4 Valley Breaks. Wire breaks that are visible and occur outside of the crown wear area with the crown wire intact.

1.4.1.3 Wire tensile limitations do not apply to compacted strand ropes.

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

1.4.1.5 Wire diameters shall be selected by the manufacturer in accordance with design requirements.

1.4.2 Rope Core

Cores of stranded ropes are normally of either fiber or steel composition. Core lubricants shall be compatible with the lubricant applied during rope stranding, having no deleterious effects on any rope component.

1.4.2.1 Fiber Core. Fiber cores larger than 8 mm (0.315 in.) diameter shall be doubly closed. The cores shall be of uniform hardness, effectively supporting the

Table 1.4.1.1-1 Wire Level or Tensile Strength Grade Requirements

Rope Grade [Note (1)]	Outer Wire Level or Tensile Strength Grade			
	N/mm ²		psi × 10 ³	
	Min.	Max.	Min.	Max.
Iron	680	880	100.0	130.0
Traction	1 180	1 470	170.0	215.0
Extra High Strength	1 670	1 960	245.0	285.0
1570 Tensile	1 570	...	227.8	[Note (2)]
1180/1770 Dual	1 180	...	171.2	[Note (2)]
1370/1770 Dual	1 370	...	198.8	[Note (2)]
1770 Single	1 770	...	256.8	[Note (2)]
1960 Single	1 960	...	284.3	...
2300 Single	2 300	...	333.5	...

NOTES:

(1) See section 1.2.

(2) Maximum tensile strengths vary according to size and shall be in accordance with Section 3.3 of ISO 2232.

Table 1.4.1.1-2 Wire Torsion Requirements

Rope Grade	Outer Wire Minimum Torsion Value (Number of Turns in 100 <i>d</i>)
Iron	Per ASTM A 1007, Wrap Test
Traction	Per ASTM A 1007, 34 turns/100 <i>d</i>
Extra High Strength	Per ASTM A 1007, 29 turns/100 <i>d</i>
1570 Tensile	Per ISO 2232
1180/1770 Dual	Per ISO 2232
1370/1770 Dual	Per ISO 2232
1770 Single	Per ISO 2232
1960 Single	Per ISO 2232
2300 Single	Per ISO 2232

7 mm, unless otherwise specified. Steel cores for ropes 7 mm and smaller may be either a single strand or IWRC. 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.

1.4.3 Rope Lubricant

Steel 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. Rope lubricants shall be of the proper type and consistency for elevator service. Rope lubricant shall have no deleterious effects on any rope component and shall include a rust inhibitor. Lubricants shall comply with ISO 4346.

SECTION 1.5**ROPE WORKMANSHIP AND FINISH****1.5.1 Strand**

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.

1.5.2 Rope

1.5.2.1 The rope shall be uniformly made and the strands shall lie tightly on the core or the underlying strands.

1.5.2.2 The core of a stranded rope shall be designed or selected so that in a new rope under no load, there is clearance between outer strands.

1.5.2.3 Rope ends shall have a minimum of one seizing (serving) applied to secure and maintain the integrity of the rope and prevent its unraveling.

1.5.3 Wire Joints

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

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

1.5.3.3 The minimum distance between joints in any strand shall be 18 times the nominal rope diameter for stranded ropes.

1.5.4 Preformation

Stranded ropes shall be preformed unless otherwise specified.

1.5.5 Prestretching

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: An example of static prestretching practice: rope is subjected to three cycles of tensile loading to 40% of the rope minimum breaking force for 5 min each, returning to 5% of the minimum breaking force between cycles. After the last cycle, the tensile force is completely released.

SECTION 1.6 PROPERTIES AND TOLERANCES OF NEWLY CONSTRUCTED ROPE

1.6.1 Classification

The rope classification shall be specified by the purchaser and shall normally be one of those covered in Mandatory Appendix I, Tables I-1.1-1, I-1.1-2, I-1.1-3, or I-1.1-4, although other classifications and constructions may be supplied by agreement between purchaser and manufacturer or supplier.

NOTE: Where only the rope classification is specified by the purchaser, the construction shall be decided by the manufacturer.

1.6.2 Rope Core

Natural fiber cores are supplied unless otherwise specified with core construction selected by the manufacturer. Other cores shall be the subject of agreement between supplier and purchaser.

1.6.3 Rope Grade

Rope grade shall be one of the following although other grades may be supplied by agreement between

1.6.4 Wire Finish

Unless otherwise specified, steel wire ropes will be furnished with uncoated wires. For steel wire ropes requested with metallic coated wires, the wires shall be galvanized unless otherwise specified by the purchaser.

1.6.4.1 Final-Galvanized Rope. All outer wires shall be supplied as final-galvanized. Inner, filler, and center wires may be supplied as final-galvanized or drawn-galvanized. Minimum weight of coating for galvanized wire shall be as specified in Tables 1.6.4.1-1 and 1.6.4.1-2. An adherence test will be required involving six tightly spaced wraps around a mandrel twice the wire diameter, without peeling or cracking.

1.6.4.1.1 Final Galvanized Rope. Final galvanized rope will be supplied with a minimum nominal breaking force 10% less than that specified in Tables I-1.1-1, I-1.1-2, I-1.1-3, or I-1.1-4.

1.6.4.1.2 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 1.6.4.1-1.

1.6.4.2 Drawn-Galvanized (Zinc Coated) Rope. All the wires shall be drawn-galvanized (zinc coated), including those of any steel core. Minimum weight of coating shall be as specified in Table 1.6.4.1-2.

1.6.4.2.1 Minimum Breaking Forces. Drawn galvanized rope shall be supplied with minimum breaking forces as listed in Table I-1.1-1, I-1.1-2, I-1.1-3, or I-1.1-4 unless otherwise agreed to between supplier and purchaser.

1.6.4.2.2 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 1.6.4.1-2.

1.6.5 Direction and Type of Rope Lay

The direction and type of rope lay shall be as specified

Table 1.6.4.1-1 Weight of Coating for Final-Galvanized or Final-Coated Zn-5Al-MM Rope Wire for Newly Constructed Rope

Diameter of Wire		Minimum Weight of Coating	
mm	in.	kg/m ²	oz/ft ²
0.51 to 1.19 inclusive	0.020 to 0.047 inclusive	0.06	0.20
Over 1.19 to 1.37 inclusive	Over 0.047 to 0.054 inclusive	0.12	0.40
Over 1.37 to 1.60 inclusive	Over 0.054 to 0.063 inclusive	0.15	0.50
Over 1.60 to 2.01 inclusive	Over 0.063 to 0.079 inclusive	0.18	0.60
Over 2.01 to 2.34 inclusive	Over 0.079 to 0.092 inclusive	0.21	0.70
Over 2.34 to 4.88 inclusive	Over 0.092 to 0.192 inclusive	0.24	0.80

Table 1.6.4.1-2 Weight of Coating for Drawn-Galvanized or Drawn-Coated Zn-5Al-MM Rope Wire for Newly Constructed Rope

Diameter of Wire		Minimum Weight of Coating	
mm	in.	kg/m ²	oz/ft ²
0.15 up to 0.25	0.006 up to 0.010	0.010	0.03
		[Note (1)]	[Note (1)]
0.25 to 0.43 inclusive	0.010 to 0.017 inclusive	0.015	0.05
Over 0.43 to 0.71 inclusive	Over 0.017 to 0.028 inclusive	0.03	0.10
Over 0.71 to 1.52 inclusive	Over 0.028 to 0.060 inclusive	0.06	0.20
Over 1.52 to 2.29 inclusive	Over 0.060 to 0.090 inclusive	0.09	0.30
Over 2.29 to 3.56 inclusive	Over 0.090 to 0.140 inclusive	0.12	0.40

NOTE:

(1) The values shown are in accordance with ISO 2020-1:1997.

Table 1.6.6.1.1-1 Tolerances on Rope Diameter (Stranded Rope) for Newly Constructed Rope With Cores of Fiber or Other Nonmetallic Materials

Nominal Rope Diameter, <i>d</i>		Load on Rope	Diameter Tolerance		Out-of-Round Tolerance
mm	in.		Min.	Max.	
10 and less	$\frac{3}{8}$ and less	None	+2%	+6%	5%
		10% MBF	+0%	+4%	3%
Greater than 10	Greater than $\frac{3}{8}$	None	+2%	+5%	5%
		10% MBF	+0%	+3%	3%

GENERAL NOTE: MBF = minimum breaking force.

shall not vary from the nominal diameter by more than the tolerances specified in Tables 1.6.6.1.1-1 and 1.6.6.1.1-2, in accordance with ISO 4344.

1.6.6.1.2 Permissible Differences in Diameter. The difference between any two of the four measurements taken in accordance with 1.7.3.3.1 and expressed as a percentage of the nominal diameter shall not exceed the values given in Table 1.6.6.1.2-1.

1.6.6.2 Lay Length. The lay length of the finished rope shall not exceed $6\frac{3}{4}$ times the nominal rope diameter.

1.6.7 Mechanical Properties

1.6.7.1 Breaking Force. Values for minimum breaking force for the covered classes of rope are specified in Tables I-1.1-1, I-1.1-2, I-1.1-3, or I-1.1-4.

1.6.7.2 Mass. The approximate rope mass shall be as given in Tables I-1.1-1, I-1.1-2, I-1.1-3, or I-1.1-4, or as agreed upon by the manufacturer and purchaser.

1.6.7.3 Length. The actual length of rope supplied, expressed in feet or meters, shall be the specified length under no load subject to the following limits of tolerance:

Table 1.6.6.1.1-2 Tolerances on Rope Diameter (Stranded Rope) for Newly Constructed Rope With Steel or Steel-Based Composite Cores

Nominal Rope Diameter, <i>d</i>		Load on Rope	Diameter Tolerance		Out-of-Round Tolerance
mm	in.		Min.	Max.	
10 and less	$\frac{3}{8}$ and less	None	+0%	+3%	5%
		10% MBF	-1%	+2%	3%
Greater than 10	Greater than $\frac{3}{8}$	None	+0%	+3%	5%
		10% MBF	-1%	+2%	3%

GENERAL NOTES:

(a) The term “steel-based composite cores” refers to rope constructions with steel plus fiber (natural or synthetic) cores.

(b) MBF = minimum breaking force.

Table 1.6.6.1.2-1 Permissible Differences in Rope Diameter for Newly Constructed Rope

Nominal Rope Diameter, <i>d</i>		Percentage Allowable Difference
mm	in.	
8 and less	$\frac{5}{16}$ and less	5%
Greater than 8	Greater than $\frac{5}{16}$	4%

(a) up to and including 400 m (1,300 ft): +5.0% of specified length

(b) over 400 m (1,300 ft) and up to 1 000 m (3,280 ft): +3.5% of specified length

(c) over 1 000 m (3,280 ft): +2.0 % of specified length

NOTE: Ropes required with smaller length tolerance should be the subject of agreement between the supplier and purchaser.

SECTION 1.7 TESTING AND COMPLIANCE FOR NEWLY CONSTRUCTED ROPE

1.7.1 General

Steel wire ropes shall be manufactured in accordance with the applicable requirements of this Standard. The manufacturer shall be able to demonstrate compliance with this Standard by complying with either 1.7.2 or 1.7.3.

1.7.2 Compliance

The manufacture shall operate a quality assurance system that includes a sampling program that meets the following requirements:

1.7.2.1 For each new class or size or grade of a given steel wire rope design, each manufacturer shall be able to present evidence from testing of at least one sample from each of three production lengths, showing that the steel wire rope conforms to the requirements as defined in this Part.

1.7.2.2 Future production lengths of the same class, size, and grade as in 1.7.2.1 shall be deemed to comply when, at a minimum, a sample from every twentieth production length is subjected to and successfully meets the requirements of the breaking force test.

1.7.3 Acceptance Tests

1.7.3.1 Test Piece. When required by 1.7.1, one sample shall be tested from each production length.

1.7.3.2 Test Verification. When requested, the manufacturer shall allow the purchaser or his representative the opportunity to witness acceptance tests or to examine test records, to verify compliance with this Part.

NOTE: Test lengths required by the purchaser should be ordered as additional lengths.

1.7.3.3 Rope

1.7.3.3.1 Diameter. Measurements for diameter shall be taken on a straight portion of the rope at two positions spaced at approximately 1 m (or 3 ft) apart and at each position two diameters at right angles shall be measured. These measurements shall be performed both with and without tension. The respective average of each set of four measurements shall be within the tolerances given in Tables 1.6.6.1.1-1 and 1.6.6.1.1-2. The permissible difference between any two measurements at 90 deg at the same point expressed as a percentage shall be within the out-of-round tolerances given in Tables 1.6.6.1.1-1 and 1.6.6.1.1-2.

1.7.3.3.2 Breaking Force. When measured in accordance with the method specified in ASTM A 931 or ISO 3108, the actual (measured) breaking force obtained shall be equal to or greater than the minimum breaking force specified in the appropriate part of this Part. When the minimum breaking force is not reached, two additional tests are required, both of which have to achieve the minimum breaking force.

1.7.3.4 Rope Wires

1.7.3.4.1 Tests. Tests on wires shall be carried out in respect of diameter, tensile strength, and torsions, and, where applicable, metallic coating in accordance with the methods in ASTM A 1007 or ISO 2232. The manufacturer shall have the option to test wires either before or after fabrication of the rope.

NOTE: After fabrication wire testing does not apply to compacted strand ropes.

1.7.3.4.2 Sampling. All main wires from the equivalent of one complete strand, including steel rope core if applicable, shall be tested. For the purposes of evaluating the test results, the rope manufacturer shall specify the nominal diameters and tensile grades of the wires.

(a) The sample selected shall be of sufficient length to allow for retest.

(b) The wires shall be selected at random.

(c) Filler wires and other non-load bearing wires shall be excluded from this test.

1.7.3.4.3 Levels of Acceptance

(a) *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 standard.

(b) *Wire After Fabrication.* For each requirement in (1), (2) and (3) below, a maximum of 5% of wires tested is permitted to lie outside the values specified, rounded to the nearest whole number of wires. Where the same wire fails in more than one test, this is counted as one failure.

(1) *Diameter.* When tested in accordance with the wire standard referred to in the appropriate part of this standard; the 5% of the wires may exceed, by up to 50%, the specified tolerance for the nominal diameter.

(2) *Tensile Strength.* When tested in accordance with ASTM A 1007, the measured values shall be within the tolerance specified in the wire standard referred to in the appropriate part of this standard with an additional tolerance of 50 N/mm² (7,000 psi) below the minimum value.

(3) *Torsion.* When tested in accordance with ASTM A 1007, the measured values of wires of 0.5 mm (0.020 in.) diameter and greater shall be at least 85% of the values specified in the wire standard referred to in the appropriate part of this standard, rounded down to the next whole number. The measured value of wire diameters less than 0.5 mm (0.020 in.) for 1.7.3.4.3(b)(2) and 1.7.3.4.3(b)(3) shall be at or above the minimum values specified in the appropriate wire standard.

1.7.4 Special Purpose

Manufacturers complying with all requirements of 1.7.2 and 1.7.3 may use calculated breaking force to verify compliance with requirements for

(a) individual production length not included in sample testing; or

(b) individual production lengths of lesser grade ropes of the same size and same design that have not been included in the sample testing.

NOTE: Examples of acceptable quality assurance systems are API Q1, ANSI/ASQC Q9001, and ISO 9001.

SECTION 1.8 ORDERING INFORMATION

1.8.1 Typical Information

Typical information used to order steel wire rope shall include items 1 through 7 in Table 1.8.1-1 and may include but is not limited to additional items noted.

1.8.2 Certification of Conformance and Test

A certificate of conformance and test shall confirm compliance with Part 1. It shall contain all of the information listed in 1.8.2.1. The items in 1.8.2.2 shall be completed as agreed between the supplier and the purchaser.

The additional information listed in 1.8.2.2 and 1.8.2.3 can be supplied under agreement between purchaser and supplier.

1.8.2.1 Confirmation Data

- certificate number
- purchaser name and address
- purchaser order number
- rope supplier name and address
- supplier order number
- number traceable to manufacturer's production length
- nominal length(s) of rope
- rope designation, (nominal diameter, construction and core, lay and grade)
- minimum breaking force in kilonewtons or pounds

1.8.2.2 Tests on Wires and Rope

- quality system registration number of the rope manufacturer, if applicable
- approximate mass in kg/m (lb/ft)
- wire standard used
- number of wires tested
- nominal dimensions of wire
- measured dimensions of wire
- breaking force of wire
- tensile strength of wire

Table 1.8.1-1 Ordering Information

Item	Example 1, SI	Example 2, Imperial
1) Length	100 m	500 ft
2) Size (diameter)	10 mm	$\frac{3}{4}$ in.
3) Rope classification or construction (if known)	6 × 25	8 × 19S
4) Preformed or nonpreformed	Nonpreformed	Preformed
5) Lay direction and type	sZ	Right regular
6) Rope grade	1370/1770 Dual	Traction
7) Wire finish (bright or galvanized and type)	Drawn-galvanized	Uncoated
8) Core type	Synthetic	Natural fiber
9) Applicable standard	ASME A17.6, Part 1	ASME A17.6, Part 1
10) Special requirements		
a) Termination of rope ends	...	...
b) Special length tolerance	...	...
c) Type of certificate	...	...
d) Special packaging and identification	...	...
e) Lubrication, other than as noted in 1.4.3	...	...
f) Prestretching	...	...

- number of torsions completed (and test length)
- mass of zinc (or zinc alloy)
- actual (measured) diameter of rope
- actual (measured) breaking force of rope

1.8.2.3 Additional Information and Certification

- space for additional information
- space for certification with provision for certifying the foregoing, name and position held, signature, and date

SECTION 1.9 PACKAGING AND IDENTIFICATION

1.9.1 Packaging

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

1.9.2 Identification

Each package of rope shall be legibly identified with at least the following information:

- rope supplier and address
- rope length and description
- number traceable to manufacturer's production length

SECTION 1.10 REPLACEMENT CRITERIA

NOTES:

- (1) Replacement criteria for steel wire rope are based on the worst conditions of diameter and wire breaks. Crown wires are subject to both wear that reduces the diameter of the rope and

the breaks that occur in the wear area. Breaks that are visible and occur outside of the crown wear area with the crown wire intact are called valley breaks.

- (2) Where ropes are subjected to reverse bends or where ropes are installed on nonmetallic sheaves or sheaves with nonmetallic liners or inserts, extra attention must be given to the rope due to possible acceleration of valley breaks.

1.10.1 Traction Drive Machines

1.10.1.1 Replacement requirements for steel wire suspension ropes for traction elevators shall be as follows (see Nonmandatory Appendix A):

(a) The steel wire rope(s) shall be replaced if the rope is permanently kinked, bent, or deformed in any way (see 1.10.5).

(b) For rope diameters equal to or greater than 8 mm (0.315 in.), the ropes shall be replaced in accordance with 1.10.1.2(a) through 1.10.1.2(g) and 1.10.3.

(c) For rope diameters less than 8 mm (0.315 in.), the ropes shall be replaced in accordance with 1.10.1.2(a) through (g), 1.10.1.2.1 and 1.10.1.2.2, and 1.10.3. In addition, other replacement criteria based on the application shall be permitted to be applied. The replacement criteria shall be documented in the Maintenance Control Program (see ASME A17.1/CSA B44, requirement 8.6.1.4.1).

1.10.1.2 Criteria for replacement include at least one of the following:

(a) if the broken crown wires are equally distributed among the strands, when the number of broken wires per rope lay in the worst section of rope exceeds the values shown in the "Normal Wear Conditions," first column of Table 1.10.1.2-1

(b) if the distribution of breaks is unequal and broken crown wires predominate in one or two strands, when the number of broken wires per rope lay in the worst section of rope or the minimum diameter exceeds the

**Table 1.10.1.2-1 Wire Breaks:
Crown Wire Breaks Per Lay Length**

6-Strand Rope Applications			
	Normal Wear Conditions	Unfavorable Wear Conditions	Ropes Showing Rouge
Distributed breaks (max.)	24	12	12
Unequal breaks (max.)	8	4	4
4 Side-by-Side Breaks	12	6	6
8- and 9-Strand Rope Applications			
	Normal Wear Conditions	Unfavorable Wear Conditions	Ropes Showing Rouge
Distributed breaks (max.)	32	16	16
Unequal breaks (max.)	10	5	5
4 Side-by-Side Breaks	16	8	8

GENERAL NOTES:

- (a) Where ropes are subjected to reverse bends or where ropes are installed on nonmetallic coated, plastic, fiber-reinforced plastic sheaves or sheaves with nonmetallic liners or inserts, extra attention must be given to any steel wire rope (6, 8, or 9 strand) due to possible acceleration of valley breaks.
- (b) This table does not apply to Winding Drum Machines. See 1.10.2 for replacement criteria.
- (c) No more than one valley break per lay length and no valley breaks allowed if visible rouge.
- (d) For ropes less than 8 mm, also see 1.10.1.2.2 for additional replacement requirements.

values shown in the "Normal Wear Conditions," first column of Table 1.10.1.2-1

(c) if four wires, side by side, are broken across the crown of any strand, when the number of broken wires per rope lay in the worst section of rope exceeds the values shown in the "Normal Wear Conditions," first column of Table 1.10.1.2-1

(d) if an unfavorable condition exists, such as but not limited to corrosion due to external conditions, excessive wear of individual wires in the strands, unequal tension, poor sheave grooves; the criteria for broken crown wires shall be the values indicated in the "Unfavorable Wear Conditions," second column of Table 1.10.1.2-1 for any of the conditions described above

(e) if red dust or rouge exists, the criteria for broken wires shall be the values indicated in the "Rope Showing Rouge," third column of Table 1.10.1.2-1 for any of the conditions described above

(f) if there is more than one valley break per rope lay

(g) if there are any valley breaks at any location where rouge exists

1.10.1.2.1 The elevator manufacturer using information from the rope manufacturer and considering the application, shall establish the design life limit to ensure that the residual strength of wire ropes less than 8 mm (0.315 in.) diameter is not less than 60% of the minimum breaking force at the time of replacement.

1.10.1.2.2 Steel wire ropes of less than 8 mm (0.315 in.) in diameter shall be replaced when there is evidence of rouge.

1.10.2 Winding Drum Machines

Suspension ropes shall be replaced on winding drum machines if

(a) the broken crown wires are equally distributed among the strands, when the number of broken wires per rope lay in the worst section of rope exceeds 12;

(b) the broken crown wires predominate in one or two strands, when the number of broken wires per rope lay in the worst section of rope exceeds 6;

(c) there is more than one valley break per rope lay; or

(d) there are any valley breaks at any location where rouge exists

1.10.3 All Elevator Types

The suspension, compensation, and governor ropes shall be replaced when their actual diameter is reduced below the value shown in Table 1.10.3-1. For nominal diameters not listed in Table 1.10.3-1, the minimum diameter reduction shall be calculated using the criteria outlined in General Notes (a) and (b) of Table 1.10.3-1. Normal wear diameters, unfavorable wear, and rouge conditions as listed in the table shall apply. Compensation and governor ropes shall also conform to 1.10.1.1(a) and 1.10.1.2(a) through 1.10.1.2(g).

Measurement for diameter shall be taken on a straight portion of rope at the worst location. Two measurements at the same position at right angles shall be taken. The ropes shall be replaced if both of these measurements are below the replacement value. However, if only one of the measurements is below the replacement value, then the criteria for wire breaks under "Unfavorable Wear Conditions" shall apply. See Table 1.10.1.2-1.

1.10.4 Replacement of Ropes

Replacement of all ropes, except governor ropes (see ASME A17.1/CSA B44, requirement 8.6.3.4), shall conform to the requirements of 1.10.4.1 through 1.10.4.6.

1.10.4.1 Replacement ropes shall be as specified by the original elevator manufacturer or be at least equivalent in strength, weight, and design.

1.10.4.2 Ropes that have previously been installed and used on another installation shall not be reused.

1.10.4.3 When replacing suspension, compensating, and car or drum counterweight ropes, all ropes in a set shall be replaced, except as permitted by 1.10.5.

Table 1.10.3-1 Minimum Diameter

6-, 8-, and 9-Strand Rope Applications						
Nominal Rope Size	Normal Wear Conditions		Unfavorable Wear Conditions		Ropes Showing Rouge	
	in.	mm	in.	mm	in.	mm
4 mm	0.153	3.875	0.153	3.875	Note (1)	Note (1)
5 mm	0.191	4.844	0.191	4.844	Note (1)	Note (1)
6 mm	0.229	5.813	0.229	5.813	Note (1)	Note (1)
1/4 in.	0.242	6.152	0.242	6.152	Note (1)	Note (1)
6.5 mm	0.248	6.297	0.248	6.297	Note (1)	Note (1)
6.7 mm	0.256	6.491	0.256	6.491	Note (1)	Note (1)
5/16 in.	0.303	7.689	0.303	7.689	Note (1)	Note (1)
8 mm	0.295	7.500	0.295	7.500	0.305	7.750
9 mm	0.332	8.438	0.332	8.438	0.343	8.719
3/8 in.	0.352	8.930	0.352	8.930	0.363	9.227
10 mm	0.369	9.375	0.369	9.375	0.381	9.688
11 mm	0.406	10.31	0.406	10.31	0.420	10.66
7/16 in.	0.410	10.42	0.410	10.42	0.424	10.77
12 mm	0.443	11.25	0.443	11.25	0.458	11.63
1/2 in.	0.469	11.91	0.469	11.91	0.484	12.30
13 mm	0.480	12.19	0.480	12.19	0.496	12.59
14 mm	0.517	13.13	0.517	13.13	0.534	13.56
9/16 in.	0.527	13.39	0.527	13.39	0.545	13.84
15 mm	0.554	14.06	0.554	14.06	0.572	14.53
5/8 in.	0.586	14.88	0.586	14.88	0.605	15.38
16 mm	0.591	15.00	0.591	15.00	0.610	15.50
11/16 in.	0.645	16.37	0.645	16.37	0.666	16.92
18 mm	0.664	16.88	0.664	16.88	0.687	17.44
19 mm	0.701	17.81	0.701	17.81	0.725	18.41
3/4 in.	0.703	17.86	0.703	17.86	0.727	18.45
20 mm	0.738	18.75	0.738	18.75	0.763	19.38
13/16 in.	0.762	19.35	0.762	19.35	0.787	19.99
22 mm	0.812	20.63	0.812	20.63	0.839	21.31
7/8 in.	0.820	20.84	0.820	20.84	0.848	21.53
15/16 in.	0.879	22.32	0.879	22.32	0.908	23.07
1 in.	0.938	23.81	0.938	23.81	0.969	24.61
1 1/8 in.	1.055	26.79	1.055	26.79	1.090	27.68
1 1/4 in.	1.172	29.77	1.172	29.77	1.211	30.76
1 3/8 in.	1.289	32.74	1.289	32.74	1.332	33.83
1 1/2 in.	1.406	35.72	1.406	35.72	1.453	36.91

GENERAL NOTES:

- (a) Maximum allowable diameter reduction below nominal for rope diameters less than 8 mm is 3.125%.
- (b) Maximum allowable diameter reduction below nominal for rope diameters equal to or greater than 8 mm are as follows:
- (1) Normal wear or unfavorable wear conditions is 6.25%.
 - (2) Ropes showing rouge is 3.125%.

NOTE:

- (1) For ropes less than 8 mm, the rope must be replaced if rouge is evident. See 1.10.1.2.2.

1.10.4.4 The ropes in the set shall be new, all from the same manufacturer and of the same material, grade, construction, and diameter.

1.10.4.5 Data tags conforming to ASME A17.1/CSA B44, requirement 2.20.2.2 shall be applied.

1.10.4.6 Suspension, car, and drum counterweight rope fastenings shall conform to ASME A17.1/CSA B44, requirement 2.20.9.

1.10.5 Replacement of a Single Suspension Rope

If one rope of a set is worn or damaged and requires replacement, the entire set of ropes shall be replaced; except, where one rope has been damaged during installation or acceptance testing prior to being subjected to elevator service, it shall be permissible to replace a single damaged rope with a new rope provided that the requirements of 1.10.4.4 and 1.10.5.1 through 1.10.5.1.6 are met.

NOTE: Damage includes but is not limited to kinked ropes.

1.10.5.1 The steel wire rope data for the replacement rope must correspond to the steel wire rope data specified in ASME A17.1/CSA B44, requirement 2.20.2.2.

1.10.5.2 The replacement rope shall be provided with a data tag conforming to ASME A17.1/CSA B44, requirement 2.20.2.2.

1.10.5.3 The suspension ropes, including the damaged rope, shall not have been shortened since their original installation.

1.10.5.4 The diameter of any of the remaining ropes shall not be less than the nominal diameter minus 0.4 mm (0.015 in.).

1.10.5.5 The tension of the new replacement rope shall be checked and adjusted as necessary at semi-monthly intervals over a period of not less than 2 mo after installation. If proper equalization of the rope tension cannot be maintained after 6 mo, the entire set of suspension ropes shall be replaced.

1.10.5.6 The replacement rope shall be provided with the same type of suspension rope fastening used with the other ropes.

MANDATORY APPENDIX I TABLES

SECTION I-1.1 BREAKING FORCE AND DIAMETER TOLERANCE

Tables I-1.1-1, I-1.1-2, I-1.1-3, and I-1.1-4 show the breaking forces and diameter tolerances of the more common classes, sizes, and grades of steel wire rope under Part 1. The following requirements apply:

- (a) Minimum breaking forces listed apply to uncoated or drawn-galvanized ropes.
- (b) Minimum breaking forces for final-galvanized ropes are 10% lower than the values listed.
- (c) Minimum breaking forces for compacted strand ropes are 10% higher than values listed.

Table I-1.1-1 Classification 6 × 19 FC, Round Strand, Fiber Core or Polymer Core

Rope Grade, Minimum Breaking Force (MBF) [Note (2)]																
Approximate Mass			TS		EHS		1180/1770		1370/1770		1770		Diameter, Relaxed			
Diameter		[Note (1)]	Iron	[Note (3)]									in.	mm	in.	mm
in.	mm	lb/ft	kg/m	lbf × 100									in.	mm	in.	mm
...	6	...	0.130	...	...	...	16.3	17.8	18.7	21.0	0.241	6.12	0.250	6.36	0.236	6.00
1/4	6.4	0.10	...	3.6	5.2	...	...	...	...	...	0.255	6.48	0.265	6.73	0.250	6.35
5/16	7.9	0.16	...	5.6	8.1	...	...	...	...	...	0.319	8.10	0.331	8.41	0.313	7.94
...	8	...	0.231	...	...	...	28.9	31.7	33.2	37.4	0.321	8.16	0.334	8.48	0.315	8.00
...	9	...	0.291	...	...	...	36.6	40.1	42.0	47.3	0.361	9.18	0.376	9.54	0.354	9.00
3/8	9.5	0.23	...	8.2	11.6	...	...	...	...	...	0.383	9.72	0.398	10.10	0.375	9.53
...	10	...	0.361	...	...	...	45.2	49.5	51.8	58.4	0.402	10.20	0.417	10.60	0.394	10.00
...	11	...	0.437	...	...	...	54.7	59.9	62.7	70.7	0.442	11.22	0.455	11.55	0.433	11.00
7/16	11.1	0.31	...	11.0	15.7	...	...	...	...	...	0.446	11.33	0.459	11.67	0.438	11.11
...	12	...	0.517	...	...	...	65.1	71.3	74.6	84.1	0.482	12.24	0.496	12.60	0.472	12.00
1/2	12.7	0.40	...	14.5	20.4	...	...	...	...	...	0.510	12.95	0.525	13.34	0.500	12.70
...	13	...	0.610	...	...	...	76.4	83.7	87.6	98.7	0.522	13.26	0.537	13.65	0.512	13.00
...	14	...	0.704	...	...	...	88.6	97.0	102.0	114.0	0.562	14.28	0.579	14.70	0.551	14.00
9/16	14.3	0.51	...	18.5	25.7	...	...	...	...	...	0.574	14.57	0.591	15.00	0.563	14.29
...	15	...	0.808	...	...	...	102.0	111.0	117.0	131.0	0.602	15.30	0.620	15.75	0.591	15.00
5/8	15.9	0.63	...	23.0	31.6	...	...	...	...	...	0.638	16.19	0.656	16.67	0.625	15.88
...	16	...	0.924	...	...	...	116.0	127.0	133.0	150.0	0.643	16.32	0.661	16.80	0.630	16.00
11/16	17.5	0.76	...	27.0	38.2	...	...	...	...	...	0.701	17.81	0.722	18.34	0.688	17.46
...	18	...	1.160	...	...	...	146.0	160.0	168.0	189.0	0.723	18.36	0.744	18.90	0.709	18.00
...	19	...	1.300	...	...	...	163.0	179.0	187.0	211.0	0.763	19.38	0.785	19.95	0.748	19.00
3/4	19.1	0.90	...	32.0	45.2	...	...	...	...	...	0.765	19.43	0.788	20.00	0.750	19.05
...	20	...	1.440	...	...	...	181.0	198.0	207.0	234.0	0.803	20.40	0.827	21.00	0.787	20.00
13/16	20.6	1.06	...	37.0	52.9	...	...	...	...	...	0.829	21.05	0.853	21.67	0.813	20.64
...	22	...	1.750	...	...	...	219.0	240.0	251.0	283.0	0.883	22.44	0.909	23.10	0.866	22.00
7/8	22.2	1.23	...	42.0	61.2	...	...	...	...	...	0.893	22.67	0.919	23.34	0.875	22.23
15/16	23.8	1.41	...	48.0	70.0	...	...	...	...	...	0.956	24.29	0.984	25.00	0.938	23.81
1	25.4	1.60	...	54.0	79.5	...	...	...	...	...	1.020	25.91	1.050	26.67	1.000	25.40
1 1/8	28.6	2.03	...	67.4	...	...	...	...	...	...	1.148	29.15	1.181	30.00	1.125	28.58
1 1/4	31.8	2.50	...	82.0	...	...	...	...	...	...	1.275	32.39	1.313	33.34	1.250	31.75
1 3/8	34.9	3.03	...	98.0	...	...	...	...	...	...	1.403	35.62	1.444	36.67	1.375	34.93
1 1/2	38.1	3.60	...	115.0	...	...	...	...	...	...	1.530	38.86	1.575	40.01	1.500	38.10

Table I-1.1.1-1 Classification 6 × 19 FC, Round Strand, Fiber Core or Polymer Core (Cont'd)

GENERAL NOTES:	
(a)	Precise values of Modulus of Elasticity can be provided by the rope supplier.
(b)	The typical value of Modulus of Elasticity for Classification 6 × 19 fiber core is 10.8 × 10 ⁶ psi.
(c)	To convert GPa to psi, multiply GPa by 145.04 × 10 ³ .
(d)	MBF values are based on ISO 4344 including Annex B and Annex C.
NOTES:	
(1)	Masses may be different for compacted or galvanized ropes.
(2)	Minimum breaking forces for final-galvanized ropes are 10% lower than the values listed. See I-1.1.
(3)	TS is Traction Steel Rope.
(4)	Metric rope numbering is based on the N/mm ² tensile strengths. Dual rope numbering refers to the outer wire and inner wire strengths.
(5)	To convert to lbf multiply kilonewton (kN) by 224.8.

Table I-1.1-2 Classification 8 × 19 FC, Round Strand, Fiber Core or Polymer Core

Rope Grade, Minimum Breaking Force (MBF) [Note (2)]																		
Approximate Mass			TS		1180/1770		1370/1770					Diameter, Relaxed				Diameter, 10% of MBF		
Diameter		[Note (1)]	Iron	[Note (3)]	EHS	[Note (4)]	1770	1570	1770	in.	mm	in.	mm	Max.	in.	mm	Max.	
kN [Note (5)]																		
...	6	...	0.122	...	...	14.5	15.8	16.6	18.7	0.241	6.12	0.250	6.36	0.236	6.00	0.246	6.24
1/4	6.4	0.09	...	3.6	4.5	...	...	...	...	0.255	6.48	0.265	6.73	0.250	6.35	0.260	6.60
5/16	7.9	0.14	...	5.6	6.9	...	...	...	...	0.319	8.10	0.331	8.41	0.313	7.94	0.325	8.26
...	8	...	0.222	...	...	25.7	28.1	29.4	33.2	0.321	8.16	0.334	8.48	0.315	8.00	0.328	8.32
...	9	...	0.275	...	...	32.5	35.6	37.3	42.0	0.361	9.18	0.376	9.54	0.354	9.00	0.369	9.36
3/8	9.5	0.20	...	8.2	9.9	...	...	...	...	0.383	9.72	0.398	10.10	0.375	9.53	0.390	9.91
...	10	...	0.347	...	...	40.1	44.0	46.0	51.9	0.402	10.20	0.417	10.60	0.394	10.00	0.409	10.40
...	11	...	0.420	...	...	48.6	53.2	55.7	62.8	0.442	11.22	0.455	11.55	0.433	11.00	0.446	11.33
7/16	11.1	0.28	...	11.0	13.5	...	...	...	...	0.446	11.33	0.459	11.67	0.438	11.11	0.451	11.45
...	12	...	0.490	...	...	57.8	63.3	66.2	74.7	0.482	12.24	0.496	12.60	0.472	12.00	0.487	12.36
1/2	12.7	0.36	...	14.5	17.5	...	...	...	...	0.510	12.95	0.525	13.34	0.500	12.70	0.515	13.08
...	13	...	0.586	...	...	67.8	74.3	77.7	87.6	0.522	13.26	0.537	13.65	0.512	13.00	0.527	13.39
...	14	...	0.666	...	...	78.7	86.1	90.2	102.0	0.562	14.28	0.579	14.70	0.551	14.00	0.568	14.42
9/16	14.3	0.46	...	18.5	22.1	...	...	...	...	0.574	14.57	0.591	15.00	0.563	14.29	0.579	14.72
...	15	...	0.765	...	...	90.3	98.9	104.0	117.0	0.602	15.30	0.620	15.75	0.591	15.00	0.608	15.45
5/8	15.9	0.57	...	23.0	27.2	...	...	...	...	0.638	16.19	0.656	16.67	0.625	15.88	0.644	16.35
...	16	...	0.888	...	...	103.0	113.0	118.0	133.0	0.643	16.32	0.661	16.80	0.630	16.00	0.649	16.48
11/16	17.5	0.69	...	27.0	32.8	...	...	...	...	0.701	17.81	0.722	18.34	0.688	17.46	0.708	17.99
...	18	...	1.100	...	...	130.0	142.0	149.0	168.0	0.723	18.36	0.744	18.90	0.709	18.00	0.730	18.54
...	19	...	1.250	...	...	145.0	159.0	166.0	187.0	0.763	19.38	0.785	19.95	0.748	19.00	0.770	19.57
3/4	19.1	0.82	...	32.0	38.9	...	...	...	...	0.765	19.43	0.788	20.00	0.750	19.05	0.773	19.62
...	20	...	1.360	...	...	161.0	176.0	184.0	207.0	0.803	20.40	0.827	21.00	0.787	20.00	0.811	20.60
13/16	20.6	0.96	...	37.0	46.0	...	...	...	...	0.829	21.05	0.853	21.67	0.813	20.64	0.837	21.26
...	22	...	1.680	...	...	194.0	213.0	223.0	251.0	0.883	22.44	0.909	23.10	0.866	22.00	0.892	22.66
7/8	22.2	1.11	...	42.0	52.6	...	...	...	...	0.893	22.67	0.919	23.34	0.875	22.23	0.901	22.89
15/16	23.8	1.27	...	48.0	60.0	...	...	...	...	0.956	24.29	0.984	25.00	0.938	23.81	0.966	24.53
1	25.4	1.45	...	54.0	68.4	...	...	...	...	1.020	25.91	1.050	26.67	1.000	25.40	1.030	26.16
1 1/8	28.6	1.84	...	67.4	86.3	...	...	...	...	1.148	29.15	1.181	30.00	1.125	28.58	1.159	29.43
1 1/4	31.8	2.27	...	82.0	106.2	...	...	...	...	1.275	32.39	1.313	33.34	1.250	31.75	1.288	32.70
1 3/8	34.9	2.74	...	98.0	128.2	...	...	...	...	1.403	35.62	1.444	36.67	1.375	34.93	1.416	35.97
1 1/2	38.1	3.26	...	115.4	152.0	...	...	...	...	1.530	38.86	1.575	40.01	1.500	38.10	1.545	39.24

Table I-1.1-2 Classification 8 × 19 FC, Round Strand, Fiber Core or Polymer Core (Cont'd)

GENERAL NOTES:	
(a)	Precise values of Modulus of Elasticity can be provided by the rope supplier.
(b)	The typical value of Modulus of Elasticity for Classification 8 × 19 fiber core is 8.1×10^6 psi.
(c)	To convert GPa to psi, multiply GPa by 145.04×10^3 .
(d)	MBF values are based on ISO 4344 including Annex B and Annex C.
NOTES:	
(1)	Masses may be different for compacted or galvanized ropes.
(2)	Minimum breaking forces for final-galvanized ropes are 10% lower than the values listed. See I-1.1.
(3)	TS is Traction Steel Rope.
(4)	Metric rope numbering is based on the N/mm ² tensile strengths. Dual rope numbering refers to the outer wire and inner wire strengths.
(5)	To convert to lbf multiply kilonewton (kN) by 224.8.

Table I-1.1.3 Classification 8 × 19, Round Strand, Steel Core

Rope Grade, Minimum Breaking Force (MBF) [Note (2)]															
Approximate Mass			TS		1370/1770			1570/1770							
[Note (1)]			[Note (3)]		EHS		[Note (4)]		kN [Note (5)]						
lb/ft			kg/m		lb f × 100										
lb/ft			kg/m		lb f × 100										
lb/ft			kg/m		lb f × 100										
lb/ft			kg/m		lb f × 100										
lb/ft			kg/m		lb f × 100										
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lb/ft			kg/m		lb f × 100										
lb/ft			kg/m		lb f × 100										
lb/ft			kg/m		lb f × 100										
lb/ft			kg/m		lb f × 100										
lb/ft			kg/m		lb f × 1										

Table I-1.1-3 Classification 8 × 19, Round Strand, Steel Core (Cont'd)

GENERAL NOTES:	
(a)	Precise values of Modulus of Elasticity can be provided by the rope supplier.
(b)	The typical value of Modulus of Elasticity for Classification 8 × 19 steel core is 14.5×10^6 psi.
(c)	To convert GPa to psi, multiply GPa by 145.04×10^3 .
(d)	MBF values are based on ISO 4344 including Annex B and Annex C.
NOTES:	
(1)	Masses may be different for compacted or galvanized ropes.
(2)	Minimum breaking forces for final-galvanized ropes are 10% lower than the values listed. See I-1.1.
(3)	TS is Traction Steel Rope.
(4)	Metric rope numbering is based on the N/mm^2 tensile strengths. Dual rope numbering refers to the outer wire and inner wire strengths.
(5)	To convert to lbf multiply kilonewton (kN) by 224.8.

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