ASME A17.6-2022

(Revision of ASME A17.6-2017)

Standard for Elevator Suspension, Compensation, and Governor Systems

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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The American Society of Mechanical Engineers
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FOREWORD

This is the second edition of a Standard for elevator suspension and compensation systems as well as ropes for governor applications. This Standard has been developed by the American Society of Mechanical Engineers (ASME) to provide guidance to the elevator industry for the appropriate use of means for suspension, compensation, and governors. The second edition includes standards for three technologies for elevators, namely: steel wire ropes, aramid fiber ropes, and noncircular elastomeric-coated steel suspension members. Uniform standards for these important items are necessary to ensure consistent levels of safety and to provide guidance for the manufacturers of these items as well as the designers, manufacturers, installers, maintainers, and inspectors of elevator equipment.

As other technologies emerge and are deemed to be suitable for similar applications, this Standard will be expanded to include criteria for their usage.

In developing this Standard, experts were assembled from the steel wire rope, aramid fiber rope, and noncircular elastomeric-coated steel suspension members engineering and manufacturing fields. Relevant existing standards were studied during the development of this Standard and are referenced where appropriate. The scope of this Standard covers North American and international requirements in a comprehensive manner and does not conflict with existing American or international standards. This Standard is intended to be used in conjunction with the ASME A17.1/CSA B44, Safety Code for Elevators and Escalators, and related Codes and standards.

Steel Wire Rope for Elevators. Steel wire rope has been used for many years in the elevator industry, for suspension, compensation, and governor applications.

Due to the large range of applications in this diverse market, many variations of steel wire ropes are in current use. Examples include rope of regular and lang lay, left and right lay, preformed and nonpreformed. Such ropes may be of a variety of wire materials, from iron to high tensile steel and may be of corrosion resistant construction. Various core materials including natural and synthetic fiber and steel may also be used. Nominal Imperial dimensions as well as SI dimensional ropes are used.

In recognition of the importance of this vital elevator component and the unique practices of the North American industry, this Standard was developed. This Standard covers the current applications and provides strength and material criteria as well as testing, compliance, inspection, replacement, and ordering information. Imperial and SI dimensions are addressed in the Standard. The purpose of this Standard is to enhance public safety and to provide guidance to manufacturers and users of steel wire rope.

Aramid Fiber Ropes and Elastomeric-Coated Steel Belts. With the appearance in the market place of new suspension and compensation means technologies, such as aramid fiber ropes and noncircular elastomeric-coated steel suspension members for elevators, the need for standards that will ensure the safe application of these items became evident. This Standard addresses these important technologies.

In developing the standards, extensive test results were studied and the properties and durability of the new suspension and compensation means were examined. The work included visits to major laboratories at which all aspects of the noncircular elastomeric-coated steel suspension members were tested.

The work included a visit to the factory of a major manufacturer of aramid fiber and technical presentations by experts in this technology. The test work of a major laboratory and field results from the application of aramid fiber rope on elevators were also studied.

Test facilities where the noncircular elastomeric-coated steel suspension members were extensively tested on elevators were also visited. In addition, technical presentations on the noncircular elastomeric-coated steel suspension members regarding their construction and testing took place.

Tests on both aramid fiber ropes and noncircular elastomeric-coated steel suspension members included life, durability, resistance to damage, traction, replacement criteria, effects of the environment, and many other criteria. This work was extremely helpful in developing the standards and building confidence in the validity of the requirements.

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PREFACE

GENERAL

This is one of many standards developed by the American Society of Mechanical Engineers (ASME) under the general auspices of the American National Standards Institute (ANSI). Safety codes and standards are intended to enhance public health and safety. Revisions result from committee consideration of factors such as technological advances, new data, and changing environmental and industry needs. Revisions do not imply that previous editions were inadequate.

This Standard is referenced by and intended to be used in conjunction with ASME A17.1/CSA B44, Safety Code for Elevators and Escalators, and related Codes and standards. Written inquiries regarding this Standard should be addressed to the Secretary of the ASME A17 Standards Committee.

NOTE: Referenced Codes, Standards, and Test Methods that appear with no date indicated shall be the edition in effect at the time of publication of this Standard.

FORM AND ARRANGEMENT

This Standard consists of three Parts, each covering a specific technology related to elevator suspension and compensation means and governor ropes. The Foreword, Preface, and Notes that are included in this document are not part of this American National Standard. They are advisory in nature and are intended for clarification only.

SCOPE

This Standard covers the means and members of suspension, compensation, and governor systems for elevators within the scope of ASME A17.1/CSA B44.

NOTE: It must be determined by the individual working committees as to the level of appropriateness of applying the New Technologies in their particular applications.

This Standard includes the material properties, design, testing, inspection, and replacement criteria for these means. It includes the requirements for steel wire rope, aramid fiber rope, and noncircular elastomeric-coated steel suspension members, and provides direction for future constructions as new technology develops.

INTRODUCTION

This Standard is intended to be used with ASME A17.1/CSA B44, Safety Code for Elevators and Escalators, A17.2, Guide for the Inspection of Elevators, Escalators, and Moving Walks, and A17.3, Safety Code for Existing Elevators and Escalators, and other Codes and Standards referenced by these Standards as well as other related Standards.

The ASME A17.1/CSA B44 Code specifically references the suspension and compensation means and governor systems covered by this Standard. This Standard was developed to provide safe, consistent criteria for steel wire rope, aramid fiber rope, noncircular elastomeric-coated steel suspension members and other means of suspension and compensation used in the Elevator Industry.

Part 1 covers steel wire rope.

Part 2 covers aramid fiber rope.

Part 3 covers noncircular elastomeric-coated steel suspension members.

The Standard is under the auspices of the ASME A17.1 Standards Committee and is subject to the operating procedures of this Committee.

ASME ELEVATOR PUBLICATIONS

The American Society of Mechanical Engineers (ASME) has developed and published safety codes and standards for elevators, escalators, and related equipment since the first edition of A17.1, Safety Code for Elevators and Escalators, which was published in 1921.

This Code is one of the numerous codes and standards that have been or are being developed by The American Society of Mechanical Engineers.

The following publications are of special interest to users of this Code. For prices and availability:

Tel: 800-843-2763
Fax: 973-882-1717
E-Mail: customercare@asme.org
ASME Website: www.asme.org/shop

ASME A18.1, Safety Standard for Platform Lifts and Stairway Chairlifts. This safety Standard covers the design, construction, installation, operation, inspection, testing, maintenance, and repair of inclined stairway chairlifts and inclined and vertical platform lifts intended for transportation of a mobility impaired person only.

ASME A17.6-2022
SUMMARY OF CHANGES

Following approval by the ASME A17 Committee and ASME, and after public review, ASME A17.6-2022 was approved by the American National Standards Institute on October 10, 2022.

ASME A17.6-2022 includes the following changes identified by a margin note, **(22)**.

Page	*Location*	*Change*
1	Section 1.1	Last sentence of first paragraph deleted
1	Section 1.2	References moved to Mandatory Appendix III
4	1.3.1.4.3	Revised
4	1.3.2.2.1	Revised
9	1.6.4	(1) 1.6.4.1 deleted in its entirety (2) Former 1.6.4.2, 1.6.4.2.1, and 1.6.4.2.2 redesignated as 1.6.4.1, 1.6.4.1.1, and 1.6.4.1.2, respectively (3) Former Table 1.6.4.1-1 deleted
10	Table 1.6.4.1-1	Former Table 1.6.4.1-2 redesignated
13	Section 1.10	Text below heading revised
13	1.10.1.2	Note added
17	Part 2	Deleted
18	Section 3.2	References moved to Mandatory Appendix III
20	3.7.2	Subparagraph (c) revised
21	3.7.4	Last paragraph added
22	Part 4	Added
25	Mandatory Appendix I	Revised in its entirety
43	Mandatory Appendix II	Added
50	Mandatory Appendix III	Added
52	Figure A-1	Revised

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Part 1
Stranded Carbon Steel Wire Ropes for Elevators

SECTION 1.1
SCOPE

(22)

Part 1 covers the general requirements for the more common types of stranded steel wire ropes for hoisting, compensation, and governor applications on passenger or freight elevators. Included in the scope of this Part are steel wire ropes in various grades and constructions from 4 mm to 38 mm ($^{5}/_{32}$ in. to $1^{1}/_{2}$ in.) manufactured from uncoated wire or metallic coated wire.

Part 1 covers regular lay and lang lay, preformed and nonpreformed elevator rope in nominal Imperial dimensions as well as SI dimensions. Various constructions of steel wire rope are covered, i.e., Seale, Warrington, and Filler. Part 1 covers the broad range of wire materials in current use including Iron, Traction, Extra High Strength Traction, 1570 Single, 1180/1770 Dual, 1370/1770 Dual, 1770 Single, 1960 Single, and 2300 Single. Various rope core materials in current use are covered by this Part including natural and synthetic fiber cores and steel cores. This Part covers ropes made from uncoated wires or metallic coated wires (e.g., galvanized). This Part includes criteria for testing and compliance of rope, replacement of rope, and ordering information for steel wire rope.

NOTE: Part 1 is written in the combined format, presenting requirements for rope products in both Imperial units, utilized historically in the SI and U.S. Customary units as recognized by current international standards. The values stated in SI (metric) units or Imperial units are to be regarded separately. The values are not exact equivalents; therefore, each system must be used independently of the other.

SECTION 1.2
REFERENCES

(22)

See Mandatory Appendix III.

SECTION 1.3
TERMINOLOGY

1.3.1 Descriptions of Terms Specific to Rope Elements

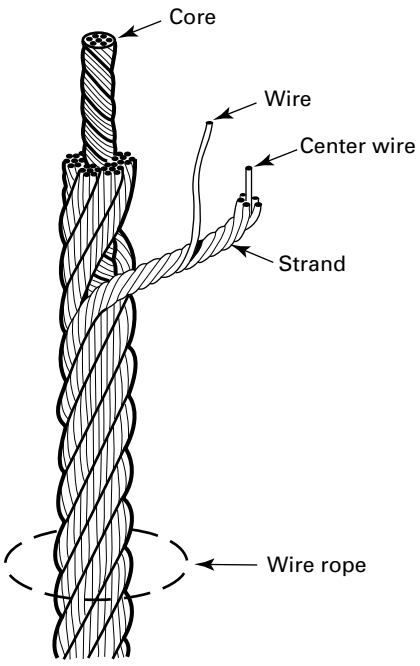
1.3.1.1 Stranded Steel Wire Rope. An assembly of strands laid helically in one layer around a core. See Figure 1.3.1.1-1.

1.3.1.2 Wire. A single continuous length of steel with a circular uniform cross-section cold drawn from a rod.

1.3.1.2.1 Finish and Quality of Coating. The condition of the surface finish of the wire, e.g., uncoated or metallic coated (zinc or zinc alloy) shall comply with the following:

(a) Uncoated Wire. Carbon steel wire that does not have a metallic coating; formerly referred to as bright wire.

Figure 1.3.1.1-1
Elements of Stranded Steel Wire Rope



(b) Metallic Coated Wire. Carbon steel wire that has a metallic coating.

(1) Final-Galvanized Wire. Coated carbon steel wire with a zinc coating applied after the final wire drawing operation.

(2) Drawn-Galvanized Wire. Coated carbon steel wire with a zinc coating applied prior to the final wire drawing operation.

(3) Final-Coated Zn-5Al-MM Wire. Coated carbon steel wire with a zinc-aluminum alloy (mischmetal) coating applied after the final wire drawing operation.

(4) Drawn-Zn-5Al-MM Wire. Coated carbon steel wire with a zinc-aluminum alloy (mischmetal) coating applied prior to the final wire drawing operation.

1.3.1.2.2 Function

(a) Load-Bearing Wires (Main Wires). Those wires in a rope that are considered as contributing toward the breaking force of the rope.

(b) Non-Load-Bearing Wires. Those wires in a rope that are considered as not contributing towards the breaking force of the rope.

(c) Filler Wires. Comparatively small wires used in certain constructions to create the necessary number of interstices for supporting the next layer of covering wires.

(d) Seizing (Serving) Wires or Strands. Those single wires or strands used for making a close-wound helical serving to retain the elements of a rope in their assembled position.

1.3.1.2.3 Position

(a) Center Wire. Wire positioned at the center of a strand of a stranded rope.

(b) Inner Wire. All wires except center, filler, core, and outer wires of a stranded rope.

(c) Outer Wire. All wires in the outer layer of the strand of a stranded rope.

(1) Crown Wire. The visible portion of the helically laid outer wire that contacts the wear surfaces.

(2) Valley Wire. The visible portion of the helically laid outer wire that does not contact the wear surfaces.

(d) Core Wire. All wires comprising the core of a stranded rope, where applicable.

1.3.1.2.4 Layer of Wires. 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 wire. Filler wires do not constitute a separate layer.

1.3.1.3 Strands

1.3.1.3.1 Strand. 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 wire.

1.3.1.3.2 Shape of Cross-Section

(a) Round Strand. Strand having a perpendicular cross-section that is approximately the shape of a circle. See Figure 1.3.1.3.2-1.

(b) Compacted Round Strand. A round strand that has been subjected to a compacting process such as drawing, rolling, or swaging. See Figure 1.3.1.3.2-2.

1.3.1.3.3 Strand Lay Direction. 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. See Figure 1.3.1.3.3-1.

1.3.1.3.4 Strand Type and Constructions: Parallel Lay. 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 wire layers are equal, and the wire of any two superimposed layers are parallel to each other resulting in linear contact.

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

There are three types of parallel lay constructions commonly used for elevator rope, which are as follows:

(a) Seale (S). Construction having same number of wires in each layer, e.g., 9-9-1. See Figure 1.3.1.3.4-1.

(b) Warrington (W). Construction having an 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 plus sign (+) in between and parentheses around the layer, e.g., (6 + 6). See Figure 1.3.1.3.4-2.

(c) Filler (F). 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." See Figure 1.3.1.3.4-3.

1.3.1.4 Rope Cores. Central elements, usually of fiber or steel around which the strands are helically laid. Rope cores shall have a rope manufacturer-specific identification marker incorporated during core manufacture or during closing of finished rope. The marker shall be of filament, fiber, or ribbon material. See Figure 1.3.1.4-1.

1.3.1.4.1 Fiber Core (FC). An element made from either natural or synthetic fibers.

Figure 1.3.1.3.2-1
Round Strand

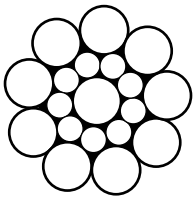
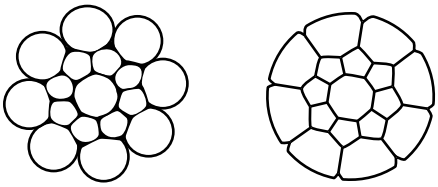


Figure 1.3.1.3.2-2
Compacted Round Strand:
Before and After Compacting



(a) Before (b) After

Figure 1.3.1.3.3-1
Lay Direction of Strands
for Stranded Ropes

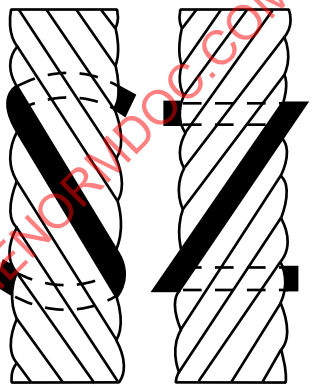


Figure 1.3.1.3.4-1
Seale Construction
(e.g., 19S, 9-9-1)

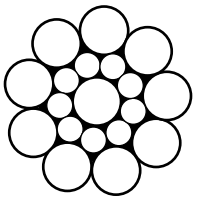


Figure 1.3.1.3.4-2
Warrington Construction
[e.g., 19W, (6+6)-6-1]

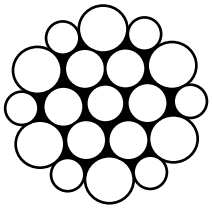


Figure 1.3.1.3.4-3
Filler Construction
(e.g., 25F, 12-6F-6-1)

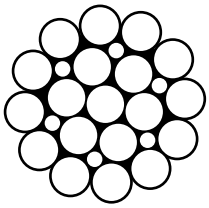
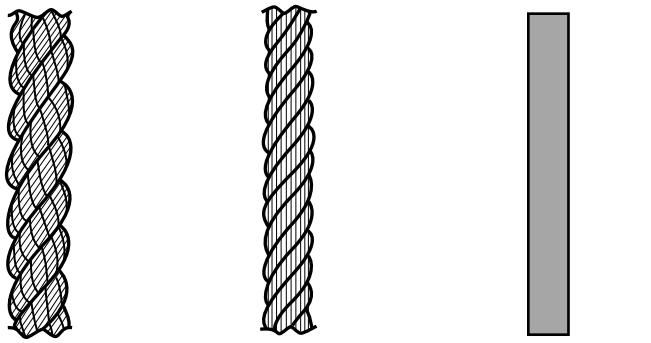


Figure 1.3.1.4-1
Examples of Cores



(a) Fiber Core

(b) Independent Wire Rope Core (IWRC)

(c) Polymer Core

1.3.1.4.2 Independent Wire Rope Core (IWRC). A core constructed as a round stranded steel wire rope. The core and/or its outer strands may also be covered or filled with either fiber or solid polymer.

(22) **1.3.1.4.3 Polymer Core.** A single element of solid polymer material that is either cylindrical or shaped (grooved).

1.3.1.5 Lubrication

1.3.1.5.1 Rope Lubricant. A material applied during the manufacture of a strand, core, or rope in elevator systems, reducing internal friction and/or providing protection against corrosion.

1.3.1.5.2 Impregnating Compound. A material used in the manufacture of natural fiber cores for the purpose of preserving fiber integrity in service and providing protection against rotting and decay of the fiber material.

1.3.2 Descriptions of Elements Specific to Rope Assemblies

1.3.2.1 Rope Types

1.3.2.1.1 Stranded Rope. An assembly of several strands laid helically around a core.

(a) Single Layer. Rope consisting of one layer of strands laid helically around a core.

(b) Compacted Strand. Rope in which the strands, prior to closing of the rope, are subjected to a compacting process such as drawing, rolling, or swaging.

(c) Multilayered. Ropes consisting of multiple layers of strands laid helically around a core.

1.3.2.2 Rope Classification and Construction

(22) **1.3.2.2.1 Rope Classification.** A grouping of ropes of similar characteristics (e.g., for stranded ropes, the number of strands and their shape, the nominal number of wires in one strand, the actual number of outer wires in one strand, and the actual number of wire layers in one strand). For classification details refer to Mandatory Appendix I, Tables I-1-1 through I-1-9.

1.3.2.2.2 Rope Construction. The 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 designation details refer to Mandatory Appendix I, Tables I-1-1 through I-1-9.

NOTE: Rope construction is designated by listing the number of outer strands followed by the number of wires in each strand and the designation for the type of construction, e.g., 6 × 25F. The "×" symbol is read as "by."

1.3.2.3 Rope Grade. A level of requirement of breaking force that is designated either by a number (e.g., 1570, 1770) or historical grade designations (e.g., Traction, Extra High Strength). See 1.6.3.

NOTE: Rope grade does not imply that the actual tensile strength of the wires in the rope are necessarily of this grade as multiple wire grades can be used in the same rope.

1.3.2.4 Rope Lay

1.3.2.4.1 Lay Direction of Rope. The direction right (Z) or left (S) corresponding to the direction of lay of the outer strands in a stranded rope in relation to the longitudinal axis of the rope.

1.3.2.4.2 Lay Types. See Figure 1.3.2.4.2-1.

(a) Regular (Ordinary). 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.

(b) Lang Lay. Stranded rope in which the direction of lay of the wires in the outer strands is the same direction as that of the outer strands in the rope.

1.3.3 Dimensional Characteristics

1.3.3.1 Diameter of Rope

1.3.3.1.1 Diameter of Round Rope. The diameter, *d*, of a circle that circumscribes the rope cross-section. Diameter is expressed in millimeters (mm) or inches (in.). See Figure 1.3.3.1.1-1.

1.3.3.2 Lay Length

1.3.3.2.1 Strand Lay Length. 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. See Figure 1.3.3.2.1-1.

1.3.3.2.2 Rope Lay Length. That distance measured parallel to the longitudinal rope axis in which the outer strands of a stranded rope make one complete turn (or helix) about the axis of the rope. See Figure 1.3.3.2.2-1.

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 A1007 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., see ASTM A1007, Level 3).

(b) Tensile Strength Grade. A level of requirement for tensile strength. It is designated by a value according to the lower limit of tensile strength and is used when specifying wire.

1.3.4.1.2 Torsions. A measure of wire ductility normally expressed as the number of 360-deg revolutions that a wire can withstand before breakage occurs using the prescribed test method in ASTM A1007 or ISO 2232. Torsion requirements are based on the wire diameter and wire level or tensile strength grade, as found in the appropriate wire standard.

1.3.4.2 Rope

1.3.4.2.1 Minimum Breaking Force (MBF). A specified value that the actual (measured) breaking force must meet or exceed in a prescribed tensile test.

1.3.4.2.2 Actual (Measured) Breaking Force. The breaking force obtained using the prescribed tensile test method in ASTM A931 or ISO 3108.

1.3.4.2.3 Calculated Breaking Force. The value of breaking force obtained from the sum of the measured breaking forces of the load-bearing wires in the rope, before rope making, multiplied by the measured spinning efficiency.

1.3.4.2.4 Measured Spinning Efficiency. The ratio between the measured breaking force of the rope and the sum of the measured breaking forces of the wires, before rope making.

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

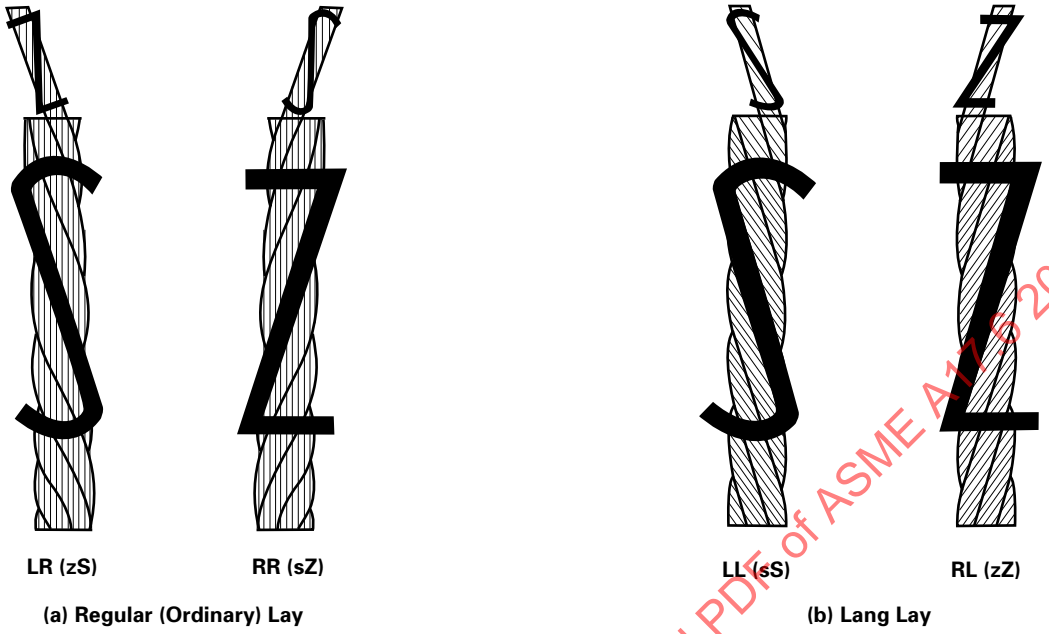
1.3.5.1.1 Preformed Rope. Rope in which the wires and strands in the rope will not, after removal of any seizing (serving), spring out of the rope formation.

1.3.5.1.2 Nonpreformed Rope. Rope in which the wires and strands in the rope will, after removal of any seizing (serving), spring out of the rope formation.

1.3.5.2 Prestretching. The name given to a process that results in the removal of a limited amount of constructional stretch.

1.3.5.3 Production Length. The 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.

Figure 1.3.2.4.2-1
Regular (Ordinary) Lay and Lang Lay



(a) Regular (Ordinary) Lay

(b) Lang Lay

GENERAL NOTE: The lowercase first letter denotes strand direction; the uppercase second letter denotes rope direction.

Figure 1.3.3.1.1-1
Diameter of Round Rope

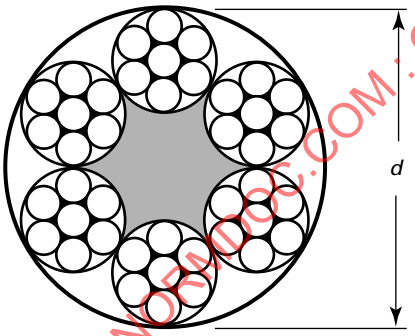


Figure 1.3.3.2.1-1
Strand Lay Length

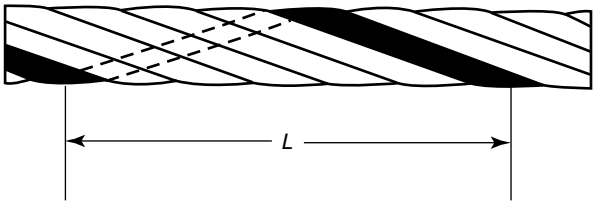


Figure 1.3.3.2.2-1
Rope Lay Length

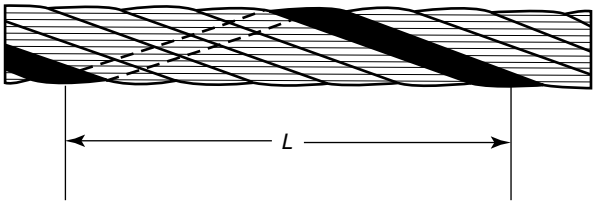


Table 1.4.1-1
Wire Level or Tensile Strength Grades for Given Rope Grades

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.

1.3.6 Values

1.3.6.1 Nominal Value. The conventional value by which a physical characteristic is designated.

1.3.6.2 Actual (Measured) Value. Value derived from direct measurement in a prescribed manner.

1.3.6.3 Minimum Value. Specified value that an actual value must meet or exceed.

1.3.6.4 Maximum Value. Specified value that an actual value must not exceed.

1.3.7 Rope Degradation

1.3.7.1 Normal Wear. Ropes showing wear equally on all strands around the circumference of the rope.

1.3.7.2 Unfavorable Wear. Ropes showing uneven wear and/or rouging due to poor installation, worn 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.

SECTION 1.4
MATERIAL

1.4.1 Rope Wire

The wires used in rope making shall comply with the appropriate parts of this Standard, ASTM A1007 for rope wire, ISO 2232, or equivalent. For those wires covered by the tables, the manufacturer, subject to the limits in Table 1.4.1-1, shall decide the tensile grade so that the minimum breaking force of the rope is achieved.

1.4.1.1 Outer wires shall be made to the tensile ranges specified in Table 1.4.1.1-1 and torsion requirements specified in Table 1.4.1.1-2.

1.4.1.2 Wire tensile limitations in Table 1.4.1-1 do not apply to center, filler, and core wires.

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 strands.

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 ISO 2232, Section 3.3.

1.4.2.1.1 Natural Fiber Core. All natural fiber cores shall be hard-twisted, sisal or manila vegetable fiber made in accordance with ISO 4345. Core lubricant content shall be 10% to 15% by weight of the dry fiber material that shall be measured by the method in ISO 4345, Appendix C.

1.4.2.1.2 Synthetic Fiber Core. Synthetic fiber cores shall be made of fiber made from polyolefins (i.e., polypropylene or polyethylene), polyester, or other suitable synthetic fiber agreed to by purchaser and supplier. Lubricant content shall be the subject of agreement between purchaser and supplier.

1.4.2.2 Steel Core. Steel main cores, use subject to agreement between supplier and purchaser, shall be an independent wire rope core (IWRC) for ropes larger than 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.

Table 1.4.1.1-2
Wire Torsion Requirements

Rope Grade	Outer Wire Minimum Torsion Value (Number of Turns in 100*d*)
Iron	Per ASTM A1007, Wrap Test
Traction	Per ASTM A1007, 34 turns/100*d*
Extra High Strength	Per ASTM A1007, 29 turns/100*d*
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

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 through I-1-9, 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 purchaser and manufacturer or supplier.

(a) Rope grades for SI units (see Mandatory Appendix I, Tables I-1-1 through I-1-9)

(1) 1570 Single: normal hoisting applications

(2) 1180/1770 Dual: normal hoisting applications

(3) 1370/1770 Dual: normal hoisting applications

(4) 1770 Single: high-speed/high-loading applications

(5) 1960 Single: special hoisting applications

(6) 2300 Single: special hoisting applications

(b) Rope grades for Imperial units (see Tables I-1.1 through I-1-9)

(1) Iron: applications other than hoist rope

(2) Traction: normal hoisting applications

(3) Extra High Strength: high-speed/high-loading applications

1.6.4 Wire Finish (22)

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 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 1.6.4.1-1.

1.6.4.1.1 Minimum Breaking Forces. Drawn-galvanized rope shall be supplied with minimum breaking forces as listed in Mandatory Appendix I, Tables I-1-1 through I-1-9 unless otherwise agreed to between supplier and purchaser.

1.6.4.1.2 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 1.6.4.1-1.

1.6.5 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:

(a) right regular (ordinary) lay (sZ)

(b) left regular (ordinary) lay (zS)

(c) right lang lay (zZ)

(d) left lang lay (sS)

Right regular (ordinary) lay will be supplied for 6- and 8-strand constructions unless otherwise specified by the purchaser.

1.6.6 Dimensions

1.6.6.1 Rope Diameter. The nominal diameter shall be as specified by the purchaser and shall be the dimension by which the rope is designated. See Figure 1.3.3.1.1-1.

1.6.6.1.1 Tolerance on Rope Diameter. When measured in accordance with 1.7.3.3.1, the actual diameter 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 6.75 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 Mandatory Appendix I, Tables I-1-1 through I-1-9.

(22) **Table 1.6.4.1-1**
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 [Note (1)]	0.03 [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, *d*			Diameter Tolerance		
mm	in.	Load on Rope	Min.	Max.	Out-of-Round Tolerance
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.

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, *d*			Diameter Tolerance		
mm	in.	Load on Rope	Min.	Max.	Out-of-Round Tolerance
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, *d*		Percentage Allowable Difference
mm	in.	
8 and less	$^{5}/_{16}$ and less	5%
Greater than 8	Greater than $^{5}/_{16}$	4%

1.6.7.2 Mass. The approximate rope mass shall be as given in Mandatory Appendix I, Tables I-1-1 through I-1-9, 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:

(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 manufacturer shall operate a quality assurance system that includes a sampling program that meets the following requirements:

1.7.2.1 For each new class, 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 A931 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 A1007 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 A1007, 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/mm^2 (7,000 psi) below the minimum value.

(3) Torsion. When tested in accordance with ASTM A1007, 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 (2) and (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 (a). The items in (b) shall be completed as agreed between the supplier and the purchaser.

The additional information listed in (b) and (c) can be supplied under agreement between purchaser and supplier.

(a) Confirmation Data

(1) certificate number
(2) purchaser name and address
(3) purchaser order number
(4) rope supplier name and address
(5) supplier order number
(6) number traceable to manufacturer's production length
(7) nominal length(s) of rope
(8) rope designation (nominal diameter, construction and core, lay and grade)
(9) minimum breaking force in kilonewtons or pounds

(b) Tests on Wires and Rope

(1) quality system registration number of the rope manufacturer, if applicable
(2) approximate mass in kg/m (lb/ft)
(3) wire standard used
(4) number of wires tested
(5) nominal dimensions of wire
(6) measured dimensions of wire
(7) breaking force of wire
(8) tensile strength of wire
(9) number of torsions completed (and test length)
(10) mass of zinc (or zinc alloy)
(11) actual (measured) diameter of rope
(l2) actual (measured) breaking force of rope

(c) Additional Information and Certification

(1) space for additional information
(2) 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.

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	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	...	...

1.9.2 Identification

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

(a) rope supplier and address

(b) rope length and description

(c) number traceable to manufacturer's production length

SECTION 1.10
REPLACEMENT CRITERIA

(22)

Replacement criteria for steel wire rope are based on the worst conditions of diameter reduction, wire breaks, damage, and unfavorable conditions. 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.

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 1.10.1.2(g), 1.10.1.2.1, and 1.10.3. In addition, other replacement criteria based on the application shall be permitted to be applied and 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: (22)

(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 first column of Table 1.10.1.2-1, "Normal Wear Conditions."

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

(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 first column of Table 1.10.1.2-1, "Normal Wear Conditions."

(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, or poor sheave grooves. The criteria for broken crown wires shall be the values indicated in the second column of Table 1.10.1.2-1, "Unfavorable Wear Conditions."

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

Break Type	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
Break Type	**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 (0.315 in.), also see 1.10.1.2.1 for additional replacement requirements.

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

(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.

NOTE [1.10.1.2(f) and (g)]: 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 due to possible acceleration of valley breaks.

1.10.1.2.1 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 any of the following applies:

(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.

(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 Table 1.10.3-1, General Notes (a) and (b). 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.

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 of 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 semimonthly intervals over a period of not less than 2 months after installation. If proper equalization of the rope tension cannot be maintained after 6 months, 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.

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

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 1.10.1.2.1.

Part 2
Aramid Fiber Ropes for Elevators

(22)

DELETED

Part 3
Noncircular Elastomeric-Coated Steel Suspension Members for Elevators

SECTION 3.1
SCOPE

Part 3 covers the general requirements for noncircular elastomeric-coated steel suspension members for suspension and compensation applications on elevators within the Scope of ASME A17.1/CSA B44.

NOTE: This Part is written in SI units recognized by the ASME A17.1/CSA B44 Code.

SECTION 3.2
REFERENCES

(22)

See Mandatory Appendix III.

SECTION 3.3
TERMINOLOGY

3.3.1 Descriptions of Terms Specific to Part 3

3.3.1.1 Steel Cord. An assembly of steel strands each comprising several steel wires. The strands are helically laid around a central core strand. See 1.3.1.4.2. For definition of wire, see 1.3.1.2. For definition of strand, see 1.3.1.3.1.

3.3.1.2 Noncircular Elastomeric-Coated Steel Suspension Member. A noncircular suspension member, such as an elastomeric-coated steel belt comprising several steel cords arranged in parallel and molded within a coating.

3.3.1.3 Cord Cores. The central elements, usually of steel (unless specified otherwise) around which the strands are helically laid.

3.3.1.4 Noncircular Elastomeric-Coated Steel Suspension Member Grade. A level of requirement of the breaking force of the noncircular elastomeric-coated steel suspension member, which is designated by the minimum breaking force in kilonewtons (kN).

3.3.2 Dimensional Characteristics

3.3.2.1 Steel Cords

3.3.2.1.1 Cord Diameter. The diameter of a circle that circumscribes the cross-section of a cord. This diameter is used for evaluating diameter ratios.

3.3.2.1.2 Cord Lay Length. That distance measured parallel to the longitudinal member axis, in which the outer strands of the cord make one complete turn about the axis of the cord.

3.3.2.1.3 Number of strands in a cord.

3.3.2.1.4 Number of steel wires in a strand.

3.3.2.2 Molded Noncircular Elastomeric-Coated Steel Suspension Member

3.3.2.2.1 Number of steel cords in a noncircular elastomeric-coated steel suspension member.

3.3.2.2.2 Cord Pitch. The spacing between adjacent cord centerlines in the noncircular elastomeric-coated steel suspension member.

3.3.2.2.3 Noncircular Elastomeric-Coated Steel Suspension Member Width. The dimension of the cross-section of the molded noncircular suspension member, measured in the direction of sheave axis.

3.3.2.2.4 Noncircular Elastomeric-Coated Steel Suspension Member Thickness. The dimension of the cross-section of the molded noncircular suspension member measured perpendicular to the direction of the sheave axis.

3.3.3 Mechanical Properties

3.3.3.1 Steel Cord, Minimum Breaking Force (MBF). Specified value that the actual (measured) steel cord breaking force must meet or exceed in a prescribed tensile test.

3.3.3.2 Rated Breaking Force. A value of breaking force, less than or equal to minimum breaking force, published by the manufacturer to which ASME A17.1/CSA B44 rope factors of safety are applied.

3.3.3.3 Noncircular Elastomeric-Coated Steel Suspension Member, Minimum Breaking Force. Specified value that the actual (measured) noncircular elastomeric-coated steel suspension member breaking force must meet or exceed in a prescribed tensile test.

3.3.3.4 Noncircular Elastomeric-Coated Steel Suspension Member Stretch (Extension)

3.3.3.4.1 Constructional Stretch. Amount of extension that is attributed to the initial bedding down of the wires within strands and the strands within the cords due to member loading.

3.3.3.4.2 Elastic Stretch. Amount of recoverable extension that follows Hooke's Law, within certain limits due to application of load.

3.3.3.4.3 Permanent Stretch. Nonelastic extension.

3.3.3.5 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.

SECTION 3.4
MATERIAL

3.4.1 Construction

3.4.1.1 Steel wire used in cord construction may be carbon or alloy steel manufactured to meet the tensile strength properties and durability requirements specified by the noncircular elastomeric-coated steel suspension member manufacturer or user. Specified wire tensile strength values shall be within the range stated as follows. Mechanical properties shall be measured to ASTM D2969-89.

Specified Tensile Strength, N/mm^2	
Min.	Max.
1 570	3 500

3.4.1.2 Steel wires or cords may be plated with corrosion reducing materials as required by the noncircular elastomeric-coated steel suspension member manufacturer or user.

3.4.1.3 Elastomeric coating material may be polyurethane or other suitable material that meets the durability, flexibility, and traction requirements specified by the noncircular elastomeric-coated steel suspension member manufacturer or user. Mechanical properties to be measured to ASTM D1456, D2240, D5963, D395, or equivalents of these.

SECTION 3.5
PROPERTIES AND TOLERANCES

3.5.1 Classification

Noncircular elastomeric-coated steel suspension member shall be classified by the width and thickness, number of cords, cord diameter, and coating material.

3.5.2 Cord Core

Cords shall be constructed with a steel core unless specified otherwise. Other cores shall be determined by agreement between supplier and purchaser.

3.5.3 Noncircular Elastomeric-Coated Steel Suspension Member Grade

See 3.3.1.4.

3.5.4 Cord Lay

The cord lay shall be specified between purchaser and manufacturer.

3.5.5 Noncircular Elastomeric-Coated Steel Suspension Member Mass

The suspension member mass shall be specified in kg/m (lb/ft) by the manufacturer.

3.5.6 Noncircular Elastomeric-Coated Steel Suspension Member Length

The actual length of noncircular elastomeric-coated steel suspension member supplied expressed in meters shall be specified by the manufacturers subject to tolerances agreed upon by manufacturer and purchaser.

3.5.7 Dimensional Tolerances

Tolerances on cord diameter shall be agreed upon by manufacturer and purchaser. The dimensional tolerances of the noncircular elastomeric-coated steel suspension members shall be as indicated in Table 3.5.7-1.

Table 3.5.7-1
Tolerances on Nominal Noncircular Elastomeric-Coated Steel Suspension Members Sizes

Load on Suspension Member, kN	Tolerance				
	Width		Thickness		
	Min.	Max.	Min.	Max.	Flatness
0 to 10% MBF	−5%	+5%	−5%	+5%	3%

SECTION 3.6
TESTING AND COMPLIANCE

3.6.1 General

Noncircular elastomeric-coated steel suspension members shall be manufactured in accordance with the applicable requirements of this Standard. The manufacturer shall be able to demonstrate compliance with this Part by complying with either 3.6.2 or 3.6.3.

3.6.2 Compliance

The manufacturer shall operate a quality assurance system that includes a sampling program that meets the requirements of 3.6.2.1 and 3.6.2.2.

3.6.2.1 For each new class, size, or grade of a given noncircular elastomeric-coated steel suspension member 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 noncircular elastomeric-coated steel suspension member conforms to the minimum requirements as defined in this Part.

3.6.2.2 Future production lengths of the same class, size, and grade as in 3.6.2.1 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.

3.6.3 Acceptance Tests

3.6.3.1 Test Piece. One sample shall be tested from each production length.

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

SECTION 3.7
REPLACEMENT CRITERIA

3.7.1 Replacement of Members

Replacement of all noncircular elastomeric-coated steel suspension members shall conform to the requirements of 3.7.1.1 through 3.7.1.6.

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

3.7.1.2 Members that have previously been installed and used on another installation shall not be reused.

3.7.1.3 When replacing suspension or compensating members, all members in a set shall be replaced, except as permitted by 3.7.3.

3.7.1.4 The members in the set shall be new, all from the same manufacturer and of the same material, grade, construction, and dimensions.

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

3.7.1.6 Suspension or compensating member fastenings shall conform to ASME A17.1/CSA B44, requirement 2.20.9.

3.7.2 Replacement Due to Wear (22)

The noncircular elastomeric-coated steel suspension member shall be replaced when any of the following occurs:

(a) The steel cords, strands or wires break through the elastomeric coating.

(b) The elastomeric coating has been worn so that any steel cord is exposed to wear.

(c) There is evidence of red rouging on any part of the noncircular elastomeric-coated steel suspension member. (In noncircular elastomeric-coated steel suspension members manufactured with transverse slots, rouging will first be evident in the slots, however not all red discoloration is rouging).

If any one member is replaced due to wear, the complete set of similarly used members on that elevator shall be replaced.

3.7.3 Replacement Due to Damage

The noncircular elastomeric-coated steel suspension member shall be replaced when load-carrying cords are damaged by an exterior source. Damage to the member coating itself is not a criterion for replacement as long as load-carrying cords have not been damaged or exposed to wear. If one member of a set is damaged during installation or acceptance testing prior to being subjected to elevator service, it is permissible to replace the damaged member only. In all other cases, the entire set must be replaced.

3.7.3.1 The member data for the replacement member must correspond to the member data specified in ASME A17.1/CSA B44, requirement 2.20.2.2.

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

3.7.3.3 The suspension members, including the damaged member, shall not have been shortened since their original installation.

3.7.3.4 The dimensions of any of the remaining members shall comply with Table 3.5.7-1.

3.7.3.5 The tension of the new replacement member shall be checked and adjusted as necessary at semimonthly intervals over a period of not less than 2 months after installation. If proper equalization of the member tension cannot be maintained after 6 months, the entire set of suspension members shall be replaced.

3.7.3.6 The replacement member shall be provided with the same type of suspension member fastening used with the other members.

3.7.3.7 The noncircular elastomeric-coated steel suspension member shall be replaced if the member is permanently kinked, bent, or deformed in any way.

3.7.4 Replacement Due to Residual Strength Criterion (22)

The noncircular elastomeric-coated steel suspension member shall be replaced when the residual strength criterion of the load-carrying cords is reached.

The elevator manufacturer using information from the noncircular elastomeric-coated steel suspension member manufacturer and considering the application, shall establish the residual strength criterion to ensure that the residual strength of the noncircular elastomeric-coated steel suspension member is not less than 60% of the rated breaking force at the time of replacement.

See also ASME A17.1/CSA B44, Requirement 2.20.8.3.

Part 4
(22) Suspension, Safety, and Guide Ropes for Wind Turbine Tower Elevators and Suspension and Governor Ropes for ASME A17.1/CSA B44 Part 5, Special Application Elevators

SECTION 4.1
SCOPE

Part 4 covers the general requirements for the types of stranded steel wire ropes for hoisting, guiding, and safety applications for wind turbine tower elevators and those designated in ASME A17.1/CSA B44, Part 5. Included in the scope of this Part are steel wire ropes in various grades and constructions from 8 mm to 13 mm (0.312 in. to 0.513 in.) manufactured from metallic coated wire.

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 steel wire 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.

All applicable references are found under Mandatory Appendix III.

NOTE: This Part is written in the combined format, presenting requirements for rope products in both Imperial units, used historically in the U.S. U. S. Customary and SI units as recognized by CSA B44 and ASME A17.1 standards. The values stated in SI (metric) units or Imperial units are to be regarded separately. The values are not exact equivalents; therefore, each system must be used independently of the other.

SECTION 4.2
TERMINOLOGY

See Section 1.3.

SECTION 4.3
MATERIAL

See Section 1.4.

SECTION 4.4
ROPE WORKMANSHIP AND FINISH

See Section 1.5.

SECTION 4.5
PROPERTIES AND TOLERANCES OF NEWLY CONSTRUCTED WIRE ROPE

The rope classification shall be specified by the purchaser and shall conform to Section 1.6 and be one of those covered in Mandatory Appendix II, Tables II-1-1 through II-1-7.

Lay length shall not exceed 7.25 times the nominal rope diameter.

SECTION 4.6
TESTING AND COMPLIANCE FOR NEWLY CONSTRUCTED ROPE

Wire ropes shall conform to Section 1.7 and in addition, one sample from each production lot shall be tested in accordance with ASTM A931, ISO 3108, or EN 12385-4.

SECTION 4.7
REPLACEMENT CRITERIA

Rope replacement criteria only applies to ropes shown in Mandatory Appendix II and shall conform to requirements of this Section. Other manufacturers' recommended criteria shall be included in the Maintenance Control Program (see ASME A17.1/CSA B44, requirement 8.6.1), with sufficient detail to ensure that inspection criterion is provided.

4.7.1 Replacement Due to Damage

Replacement requirements for suspension, safety, and guide steel wire ropes shall conform to 4.7.1 through 4.7.4.

4.7.2 Replacement Due to Deformation

Steel wire rope(s) shall be replaced if the rope is permanently kinked, bent, or deformed in any way.

4.7.3 Replacement Due to Wire Breaks

Steel wire rope(s) shall be replaced if any of the following conditions are found:

Table 4.7.3-1
Wire Breaks: Crown Wire Breaks per Lay Length

Maximum Number of Breaks in 4-, 5-, 6-, and 7-Strand Rope Applications		
Normal Wear Conditions: Equally Distributed Breaks	Unfavorable Wear Conditions	
	Breaks in One Strand	Ropes Showing Rouge
8	4	4

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 due to possible acceleration of valley breaks.
(b) No more than one valley break per lay length and no valley breaks allowed if visible rouge.
(c) Wire breaks based on ISO 4309 RC1 ropes (ordinary lay).

(a) 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 first column of Table 4.7.3-1, "Normal Wear Conditions."

(b) 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 values shown in the first column of Table 4.7.3-1, "Normal Wear Conditions."

(c) 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 first column of Table 4.7.3-1, "Normal Wear Conditions."

(d) an unfavorable condition exists, such as but not limited to corrosion due to external conditions, excessive wear of individual wires in the strands, or poor sheave groove. The criteria for broken crown wires shall be the values indicated in the second column of Table 4.7.3-1, "Unfavorable Wear Conditions" for any of the conditions described above.

(e) red dust or rouge exists, the criteria for broken wires shall be the values indicated in the third column of Table 4.7.3-1, "Rope Showing Rouge" for any of the conditions described above.

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

(g) there is more than one valley break per rope lay.

4.7.4 Replacement Due to Diameter Reduction

The suspension, safety, and guide ropes shall be replaced when their actual diameter is reduced below the value shown in Table 4.7.4-1. For nominal diameters not listed in Table 4.7.4-1, the minimum diameter reduction shall be calculated using the criteria outlined in Table 4.7.4-1, General Notes.

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 maximum number of wire breaks shall be reduced to four per lay length.

4.7.5 Replacement Due to Diameter Reduction

Replacement of Suspension, Safety, and Guide ropes shall conform to 4.7.5.1 through 4.7.5.7.

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

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

4.7.5.3 Replacement ropes shall be new and of the same material, grade, construction, and diameter.

Table 4.7.4-1
Minimum Diameter

Part 4 Rope Applications					
Nominal Rope Size (Imperial)	Nominal Rope Size (SI)	Fiber and Polymer Core Ropes, Normal Wear Conditions		Steel Core Ropes, Unfavorable Wear, or Ropes Showing Rouge	
in.	mm	in.	mm	in.	mm
5/16	...	0.293	7.44	0.303	7.69
...	8	0.295	7.50	0.305	7.75
...	8.4	0.310	7.88	0.320	8.14
...	9	0.332	8.44	0.343	8.72
3/8	...	0.352	8.93	0.363	9.23
...	10	0.369	9.38	0.381	9.69
...	10.2	0.376	9.56	0.389	9.88
...	11	0.406	10.31	0.420	10.66
7/16	...	0.410	10.42	0.424	10.77
...	11.5	0.424	10.78	0.439	11.14
...	12	0.443	11.25	0.458	11.63
1/2	...	0.469	11.91	0.484	12.30
...	13	0.480	12.19	0.496	12.59

GENERAL NOTES:
(a) Maximum allowable diameter reduction below nominal for rope diameters is 6.25%.
(b) Ropes with unfavorable wear conditions or showing rouge is 3.125%.
(c) Ropes with classification 18 × 7 shall be considered under the steel core conditions, which is 3.125%.

4.7.5.4 Data tags shall be provided and conform to ASME A17.8/CSA B44.8 requirement 2.20.2.13 for wind turbine tower elevators or ASME A17.1/CSA B44 requirement 2.20.2.2 for Special Application Elevators.

4.7.5.5 Suspension rope fastenings shall conform to ASME A17.8/CSA B44.8 requirement 2.20 for wind turbine tower elevators or ASME A17.1/CSA B44 requirement 2.20 for Special Application Elevators.

4.7.5.6 For wind turbine tower elevators, when either the suspension rope or safety rope is replaced, both ropes shall be replaced.

4.7.5.7 For wind turbine tower elevators, a readily visible hour meter shall be provided on all elevator cars and the suspension ropes shall be replaced after 250 h of operation. See also 4.7.5.6.

MANDATORY APPENDIX I
ROPE CLASSIFICATIONS USED IN PART 1

(22)

SECTION I-1
BREAKING FORCE AND DIAMETER TOLERANCE

Tables I-1-1 through I-1-9 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
Classification 6 × 19 FC, Round Strand, Fiber Core or Polymer Core

Diameter		Approximate Mass [Note (2)]		Rope Grade, Minimum Breaking Force (MBF) [Note (1)]							Diameter, Relaxed				Diameter, 10% of MBF			
				Iron	TS [Note (3)]	EHS	1180/ 1770 [Note (4)]	1370/ 1770	1570	1770	Min.		Max.		Min.		Max.	
in.	mm	lb/ft	kg/m	lbf × 1,000			kN [Note (5)]				in.	mm	in.	mm	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	0.246	6.24
1/4	6.4	0.10	...	2.2	3.6	5.2	...	...	...	...	0.255	6.48	0.265	6.73	0.250	6.35	0.260	6.60
5/16	7.9	0.16	...	3.2	5.6	8.1	...	...	...	...	0.319	8.10	0.331	8.41	0.313	7.94	0.325	8.26
...	8	...	0.231	...	...	...	28.9	31.7	33.2	37.4	0.321	8.16	0.334	8.48	0.315	8.00	0.328	8.32
...	9	...	0.291	...	...	...	36.6	40.1	42.0	47.3	0.361	9.18	0.376	9.54	0.354	9.00	0.369	9.36
3/8	9.5	0.23	...	5.0	8.2	11.6	...	...	...	...	0.383	9.72	0.398	10.10	0.375	9.53	0.390	9.91
...	10	...	0.361	...	...	...	45.2	49.5	51.8	58.4	0.402	10.20	0.417	10.60	0.394	10.00	0.409	10.40
...	11	...	0.437	...	...	...	54.7	59.9	62.7	70.7	0.442	11.22	0.455	11.55	0.433	11.00	0.446	11.33
7/16	11.1	0.31	...	6.4	11.0	15.7	...	...	...	...	0.446	11.33	0.459	11.67	0.438	11.11	0.451	11.45
...	12	...	0.517	...	...	...	65.1	71.3	74.6	84.1	0.482	12.24	0.496	12.60	0.472	12.00	0.487	12.36
1/2	12.7	0.40	...	8.4	14.5	20.4	...	...	...	...	0.510	12.95	0.525	13.34	0.500	12.70	0.515	13.08
...	13	...	0.610	...	...	...	76.4	83.7	87.6	98.7	0.522	13.26	0.537	13.65	0.512	13.00	0.527	13.39
...	14	...	0.704	...	...	...	88.6	97.0	102.0	114.0	0.562	14.28	0.579	14.70	0.551	14.00	0.568	14.42
9/16	14.3	0.51	...	10.6	18.5	25.7	...	...	...	...	0.574	14.57	0.591	15.00	0.563	14.29	0.579	14.72
...	15	...	0.808	...	...	...	102.0	111.0	117.0	131.0	0.602	15.30	0.620	15.75	0.591	15.00	0.608	15.45
5/8	15.9	0.63	...	12.8	23.0	31.6	...	...	...	...	0.638	16.19	0.656	16.67	0.625	15.88	0.644	16.35
...	16	...	0.924	...	...	...	116.0	127.0	133.0	150.0	0.643	16.32	0.661	16.80	0.630	16.00	0.649	16.48
11/16	17.5	0.76	...	15.5	27.0	38.2	...	...	...	...	0.701	17.81	0.722	18.34	0.688	17.46	0.708	17.99
...	18	...	1.160	...	...	...	146.0	160.0	168.0	189.0	0.723	18.36	0.744	18.90	0.709	18.00	0.730	18.54
...	19	...	1.300	...	...	...	163.0	179.0	187.0	211.0	0.763	19.38	0.785	19.95	0.748	19.00	0.770	19.57
3/4	19.1	0.90	...	18.2	32.0	45.2	...	...	...	...	0.765	19.43	0.788	20.00	0.750	19.05	0.773	19.62
...	20	...	1.440	...	...	...	181.0	198.0	207.0	234.0	0.803	20.40	0.827	21.00	0.787	20.00	0.811	20.60
13/16	20.6	1.06	...	21.5	37.0	52.9	...	...	...	...	0.829	21.05	0.853	21.67	0.813	20.64	0.837	21.26
...	22	...	1.750	...	...	...	219.0	240.0	251.0	283.0	0.883	22.44	0.909	23.10	0.866	22.00	0.892	22.66
7/8	22.2	1.23	...	24.8	42.0	61.2	...	...	...	...	0.893	22.67	0.919	23.34	0.875	22.23	0.901	22.89
15/16	23.8	1.41	...	28.5	48.0	70.0	...	...	...	...	0.956	24.29	0.984	25.00	0.938	23.81	0.966	24.53
1	25.4	1.60	...	32.0	54.0	79.5	...	...	...	...	1.020	25.91	1.050	26.67	1.000	25.40	1.030	26.16
1 1/8	28.6	2.03	...	40.5	67.4	...	...	...	...	...	1.148	29.15	1.181	30.00	1.125	28.58	1.159	29.43
1 1/4	31.8	2.50	...	49.8	82.0	...	...	...	...	...	1.275	32.39	1.313	33.34	1.250	31.75	1.288	32.70
1 3/8	34.9	3.03	...	60.0	98.0	...	...	...	...	...	1.403	35.62	1.444	36.67	1.375	34.93	1.416	35.97
1 1/2	38.1	3.60	...	71.2	115.0	...	...	...	...	...	1.530	38.86	1.575	40.01	1.500	38.10	1.545	39.24

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.

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

GENERAL NOTES: (Cont'd)
(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) Minimum breaking forces for final-galvanized ropes are 10% lower than the values listed. See Section I-1.
(2) Masses may be different for compacted or galvanized ropes.
(3) TS = 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 kilonewtons (kN) by 224.8.

(22)

Table I-1-2
Classification 8 × *n*, Round Strand, Fiber Core or Polymer Core

Diameter		Approximate Mass [Note (2)]		Rope Grade, Minimum Breaking Force (MBF) [Note (1)]							Diameter, Relaxed				Diameter, 10% of MBF			
				Iron	TS [Note (3)]	EHS	1180/1770 [Note (4)]	1370/1770	1570	1770	Min.		Max.		Min.		Max.	
in.	mm	lb/ft	kg/m	lbf × 1,000			kN [Note (5)]				in.	mm	in.	mm	in.	mm	in.	mm
...	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	...	1.8	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	...	2.9	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	...	4.2	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	...	5.6	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	...	7.2	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	...	9.2	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	...	11.2	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	...	13.4	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	...	16.0	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	...	18.6	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	...	21.4	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	...	24.6	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	...	28.0	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	...	35.2	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	...	43.3	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	...	52.2	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	...	61.9	115.4	152.0	...	...	...	...	1.530	38.86	1.575	40.01	1.500	38.10	1.545	39.24

GENERAL NOTES:

(a) The use of *n* in the title of this table designates the number of wires in the outer strands (see 1.3.1.3).

(b) Precise values of modulus of elasticity can be provided by the rope supplier.

Table I-1-2
Classification 8 × *n*, Round Strand, Fiber Core or Polymer Core (Cont'd)

GENERAL NOTES: (Cont'd)
(c) The typical value of modulus of elasticity for classification 8 × 19 fiber core is 8.1×10^6 psi.
(d) To convert GPa to psi, multiply GPa by 145.04×10^3.
(e) MBF values are based on ISO 4344 including Annex B and Annex C.

NOTES:
(1) Minimum breaking forces for final-galvanized ropes are 10% lower than the values listed. See Section I-1.
(2) Masses may be different for compacted or galvanized ropes.
(3) TS = 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 kilonewtons (kN) by 224.8.

Table I-1-3
Classification 8 × *n*, Round Strand, Steel Core, IWRC

Diameter		Approximate Mass [Note (2)]		Rope Grade, Minimum Breaking Force (MBF) [Note (1)]							Diameter, Relaxed				Diameter, 10% of MBF			
				TS [Note (3)]	EHS	1370/1770 [Note (4)]	1570/1770	1570	1770	1960	Min.		Max.		Min.		Max.	
in.	mm	lb/ft	kg/m	lbf × 1,000		kN [Note (5)]					in.	mm	in.	mm	in.	mm	in.	mm
...	6	...	0.147	...	...	20.1	21.4	20.1	22.7	...	0.236	6.00	0.243	6.18	0.234	5.94	0.241	6.12
1/4	6.4	0.111	...	5.1	5.7	...	...	...	...	...	0.250	6.35	0.258	6.54	0.248	6.29	0.255	6.48
...	6.5	...	0.172	...	...	...	...	...	...	29.5	0.256	6.50	0.264	6.70	0.253	6.44	0.261	6.63
5/16	7.9	0.172	...	7.9	8.9	...	...	...	...	...	0.313	7.94	0.322	8.18	0.309	7.86	0.319	8.10
...	8	...	0.260	...	...	35.8	38.0	35.8	40.3	...	0.315	8.00	0.324	8.24	0.312	7.92	0.321	8.16
...	9	...	0.330	...	...	45.3	48.2	45.3	51.0	...	0.354	9.00	0.365	9.27	0.351	8.91	0.361	9.18
3/8	9.5	0.247	...	11.4	12.9	...	...	...	...	...	0.375	9.53	0.386	9.81	0.371	9.43	0.383	9.72
...	10	...	0.407	...	...	55.9	59.5	55.9	63.0	...	0.394	10.00	0.406	10.30	0.390	9.90	0.402	10.20
...	11	...	0.492	...	...	67.6	71.9	67.6	76.2	...	0.433	11.00	0.446	11.33	0.429	10.89	0.442	11.22
7/16	11.1	0.337	...	15.5	17.5	...	...	...	...	...	0.438	11.11	0.451	11.45	0.433	11.00	0.446	11.33
...	12	...	0.586	...	...	80.5	85.6	80.5	90.7	...	0.472	12.00	0.487	12.36	0.468	11.88	0.482	12.24
1/2	12.7	0.441	...	20.3	22.8	...	...	...	...	...	0.500	12.70	0.515	13.08	0.495	12.57	0.510	12.95
...	13	...	0.688	...	...	94.5	100.0	94.5	106.0	...	0.512	13.00	0.527	13.39	0.507	12.87	0.522	13.26
...	14	...	0.798	...	...	110.0	117.0	110.0	124.0	...	0.551	14.00	0.568	14.42	0.546	13.86	0.562	14.28
9/16	14.3	0.560	...	25.6	28.9	...	...	...	...	...	0.563	14.29	0.579	14.72	0.557	14.14	0.574	14.57
...	15	...	0.916	...	...	126.0	134.0	126.0	142.0	...	0.591	15.00	0.608	15.45	0.585	14.85	0.602	15.30
5/8	15.9	0.692	...	31.7	35.7	...	...	...	...	...	0.625	15.88	0.644	16.35	0.619	15.72	0.638	16.19
...	16	...	1.040	...	...	143.0	152.0	143.0	161.0	...	0.630	16.00	0.649	16.48	0.624	15.84	0.643	16.32
11/16	17.5	0.838	...	38.3	43.2	...	...	...	...	...	0.688	17.46	0.708	17.99	0.681	17.29	0.701	17.81
...	18	...	1.320	...	...	181.0	193.0	181.0	204.0	...	0.709	18.00	0.730	18.54	0.702	17.82	0.000	18.36
...	19	...	1.470	...	...	202.0	215.0	202.0	227.0	...	0.748	19.00	0.770	19.57	0.741	18.81	0.763	19.38
3/4	19.1	0.998	...	45.6	51.4	...	...	...	...	...	0.750	19.05	0.773	19.62	0.743	18.86	0.765	19.43
...	20	...	1.630	...	...	224.0	238.0	224.0	252.0	...	0.787	20.00	0.811	20.60	0.780	19.80	0.803	20.40
13/16	20.6	1.160	...	53.5	60.3	...	...	...	...	...	0.813	20.64	0.837	21.26	0.804	20.43	0.829	21.05
...	22	...	1.970	...	...	...	...	...	...	...	0.866	22.00	0.892	22.66	0.857	21.78	0.883	22.44
7/8	22.2	1.350	...	62.1	70.0	...	...	...	...	...	0.875	22.23	0.901	22.89	0.866	22.00	0.893	22.67
15/16	23.8	1.550	...	71.2	80.3	...	...	...	...	...	0.938	23.81	0.966	24.53	0.928	23.57	0.956	24.29
1	25.4	1.760	...	81.1	91.4	...	...	...	...	...	1.000	25.40	1.030	26.16	0.990	25.15	1.020	25.91
1 1/8	28.6	2.240	...	103.0	116.0	...	...	...	...	...	1.125	28.58	1.159	29.43	1.114	28.29	1.148	29.15
1 1/4	31.8	2.770	...	127.0	143.0	...	...	...	...	...	1.250	31.75	1.288	32.70	1.238	31.43	1.275	32.39
1 3/8	34.9	3.330	...	153.0	173.0	...	...	...	...	...	1.375	34.93	1.416	35.97	1.361	34.58	1.403	35.62
1 1/2	38.1	3.970	...	182.0	206.0	...	...	...	...	...	1.500	38.10	1.545	39.24	1.485	37.72	1.530	38.86

Table I-1-3
Classification 8 × *n*, Round Strand, Steel Core, IWRC (Cont'd)

GENERAL NOTES:
(a) The use of *n* in the title of this table designates the number of wires in the outer strands (see 1.3.1.3).
(b) Precise values of modulus of elasticity can be provided by the rope supplier.
(c) The typical value of modulus of elasticity for classification 8 × 19 steel core is 14.5×10^6 psi.
(d) To convert GPa to psi, multiply GPa by 145.04×10^3.
(e) MBF values are based on ISO 4344 including Annex B and Annex C.

NOTES:
(1) Minimum breaking forces for final-galvanized ropes are 10% lower than the values listed. See Section I-1.
(2) Masses may be different for compacted or galvanized ropes.
(3) TS = 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 kilonewtons (kN) by 224.8.

Table I-1-4
Classification 8 × *n*, Round Strand, Steel Core, PWRC

Diameter		Approximate Mass [Note (2)]		Rope Grade, Minimum Breaking Force (MBF) [Note (1)]							Diameter, Relaxed				Diameter, 10% of MBF			
				TS [Note (3)]	EHS	1370/1770 [Note (4)]	1570/1770	1570	1770	1960	Min.		Max.		Min.		Max.	
in.	mm	lb/ft	kg/m	lbf × 1,000		kN [Note (5)]					in.	mm	in.	mm	in.	mm	in.	mm
...	6	...	0.165	...	...	22.9	24.3	22.9	25.8	28.6	0.236	6.00	0.243	6.18	0.234	5.94	0.241	6.12
1/4	6.4	0.126	...	5.9	6.6	...	...	...	...	...	0.250	6.35	0.258	6.54	0.248	6.29	0.255	6.48
...	6.5	...	0.193	...	...	...	...	...	...	...	0.256	6.50	0.264	6.70	0.253	6.44	0.261	6.63
5/16	7.9	0.192	8.9	10.1	...	...	...	...	...	...	0.313	7.94	0.322	8.18	0.309	7.86	0.319	8.10
...	8	...	0.292	...	...	40.7	43.3	40.7	45.9	50.8	0.315	8.00	0.324	8.24	0.312	7.92	0.321	8.16
...	9	...	0.370	...	...	51.5	54.8	51.5	58.1	64.3	0.354	9.00	0.365	9.27	0.351	8.91	0.361	8.18
3/8	9.5	0.277	...	12.9	14.5	...	...	...	...	...	0.375	9.53	0.386	9.81	0.371	9.43	0.383	9.72
...	10	...	0.457	...	...	63.6	67.6	63.6	71.7	79.4	0.394	10.00	0.406	10.30	0.390	9.90	0.402	10.20
...	11	...	0.553	...	...	76.9	81.8	76.9	86.7	96.0	0.433	11.00	0.446	11.33	0.429	10.89	0.442	11.22
7/16	11.1	0.378	...	17.6	19.8	...	...	...	...	...	0.438	11.11	0.451	11.45	0.433	11.00	0.446	11.33
...	12	...	0.658	...	...	91.6	97.4	91.6	103.2	114.3	0.472	12.00	0.487	12.36	0.468	11.88	0.482	12.24
1/2	12.7	0.495	...	23.0	26.0	...	...	...	...	...	0.500	12.70	0.515	13.08	0.495	12.57	0.510	12.95
...	13	...	0.772	...	...	107.5	114.3	107.5	121.2	134.2	0.512	13.00	0.527	13.39	0.507	12.87	0.522	13.26
...	14	...	0.896	...	...	124.6	132.6	124.6	140.5	155.6	0.551	14.00	0.568	14.42	0.546	13.86	0.562	14.28
9/16	14.3	0.628	...	29.2	32.9	...	...	...	...	...	0.563	14.29	0.579	14.72	0.557	14.14	0.574	14.57
...	15	...	1.028	...	...	143.0	152.0	143.0	161.0	179.0	0.591	15.00	0.608	15.45	0.585	14.85	0.602	15.30
5/8	15.9	0.776	...	36.1	40.7	...	...	...	...	...	0.625	15.88	0.644	16.35	0.619	15.72	0.638	16.19
...	16	...	1.170	...	...	163.0	173.0	163.0	184.0	203.0	0.630	16.00	0.649	16.48	0.624	15.84	0.643	36.32
11/16	17.5	0.940	...	43.8	49.3	...	...	...	...	...	0.688	17.46	0.708	17.99	0.681	17.29	0.701	17.81
...	18	...	1.481	...	...	206.0	219.0	206.0	232.0	257.0	0.709	18.00	0.730	18.54	0.702	17.82	0.723	18.36
...	19	...	1.650	...	...	230.0	244.0	230.0	259.0	287.0	0.748	19.00	0.770	19.57	0.741	18.81	0.763	19.38
3/4	19.1	1.120	...	52.1	58.8	...	...	...	...	...	0.750	19.05	0.773	19.62	0.743	18.86	0.765	19.43
...	20	...	1.828	...	...	254.0	271.0	254.0	287.0	318.0	0.787	20.00	0.811	20.60	0.780	19.80	0.803	20.40
13/16	20.6	1.303	...	60.6	68.4	...	...	...	...	...	0.813	20.64	0.837	21.26	0.804	20.43	0.829	21.05
...	22	...	2.212	...	...	308.0	327.0	308.0	347.0	384.0	0.866	22.00	0.892	22.66	0.857	21.78	0.883	22.44
7/8	22.2	1.513	...	70.4	79.4	...	...	...	...	...	0.875	22.23	0.901	22.89	0.866	22.00	0.893	22.67
15/16	23.8	1.739	...	80.9	91.3	...	...	...	...	...	0.938	23.81	0.966	24.53	0.928	23.57	0.956	24.29
1	25.4	1.981	...	92.2	103.9	...	...	...	...	...	1.000	25.40	1.030	26.16	0.990	25.15	1.020	25.91
1 1/8	28.6	2.512	...	116.9	131.8	...	...	...	...	...	1.125	28.58	1.159	29.43	1.114	28.29	1.148	29.15
1 1/4	31.8	3.105	...	144.5	162.9	...	...	...	...	...	1.250	31.75	1.288	32.70	1.238	31.43	1.275	32.39
1 3/8	34.9	3.740	...	174.0	196.2	...	...	...	...	...	1.375	34.93	1.416	35.97	1.361	34.58	1.403	35.62
1 1/2	38.1	4.458	...	207.4	233.9	...	...	...	...	...	1.500	38.10	1.545	39.24	1.485	37.72	1.530	38.86

Table I-1-4
Classification 8 × *n*, Round Strand, Steel Core, PWRC (Cont'd)

GENERAL NOTES:
(a) The use of *n* in the title of this table designates the number of wires in the outer strands (see 1.3.1.3).
(b) Precise values of modulus of elasticity can be provided by the rope supplier.
(c) The typical value of modulus of elasticity for classification 8 × 19 steel core is 14.5×10^6 psi.
(d) To convert GPa to psi, multiply GPa by 145.04×10^3.
(e) MBF values are based on ISO 4344, including Annex B and Annex C.

NOTES:
(1) Minimum breaking forces for final-galvanized ropes are 10% lower than the values listed. See Section I-1.
(2) Masses may be different for compacted or galvanized ropes.
(3) TS = 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 kilonewtons (kN) by 224.8.

Table I-1-5
Classification 8 × *n*, Round Strand, Composite Steel Core (CSC)

Diameter		Approximate Mass [Note (2)]		Rope Grade, Minimum Breaking Force (MBF) [Note (1)]							Diameter, Relaxed				Diameter, 10% of MBF			
				TS [Note (3)]	EHS	1370/1770 [Note (4)]	1570/1770	1570	1770	1960	Min.		Max.		Min.		Max.	
in.	mm	lb/ft	kg/m	lbf × 1,000		kN [Note (5)]					in.	mm	in.	mm	in.	mm	in.	mm
...	6	...	0.139	...	...	19.5	20.7	19.5	22.0	24.3	0.236	6.00	0.243	6.18	0.234	5.94	0.241	6.12
1/4	6.4	0.106	...	5.0	5.6	...	...	...	...	...	0.250	6.35	0.258	6.54	0.248	6.29	0.255	6.48
...	6.5	...	0.163	...	...	...	...	...	...	29.5	0.256	6.50	0.264	6.70	0.253	6.44	0.261	6.63
5/16	7.9	0.161	...	7.6	8.6	...	...	...	...	...	0.313	7.94	0.322	8.18	0.309	7.86	0.319	8.10
...	8	...	0.246	...	...	34.7	36.9	34.7	39.1	43.3	0.315	8.00	0.324	8.24	0.312	7.92	0.321	8.16
...	9	...	0.312	...	...	43.9	46.7	43.9	49.5	54.8	0.354	9.00	0.365	9.27	0.351	8.91	0.361	8.18
3/8	9.5	0.233	...	11.0	12.4	...	...	...	...	...	0.375	9.53	0.386	9.81	0.371	9.43	0.383	9.72
...	10	...	0.385	...	...	54.2	57.6	54.2	61.1	67.6	0.394	10.00	0.406	10.30	0.390	9.90	0.402	10.20
...	11	...	0.466	...	...	65.5	69.7	65.5	73.9	81.8	0.433	11.00	0.446	11.33	0.429	10.89	0.442	11.22
7/16	11.1	0.319	...	15.0	16.9	...	...	...	...	...	0.438	11.11	0.451	11.45	0.433	11.00	0.446	11.33
...	12	...	0.554	...	...	78.0	83.0	78.0	87.9	97.4	0.472	12.00	0.487	12.36	0.468	11.88	0.482	12.24
1/2	12.7	0.417	...	19.6	22.1	...	...	...	...	...	0.500	12.70	0.515	13.08	0.495	12.57	0.510	12.95
...	13	...	0.651	...	...	91.5	97.4	91.5	103.2	114.3	0.512	13.00	0.527	13.39	0.507	12.87	0.522	13.26
...	14	...	0.755	...	...	106.2	112.9	106.2	119.7	132.5	0.551	14.00	0.568	14.42	0.546	13.86	0.562	14.28
9/16	14.3	0.529	...	24.9	28.1	...	...	...	...	...	0.563	14.29	0.579	14.72	0.557	14.14	0.574	14.57
...	15	...	0.866	...	...	122.0	130.0	122.0	137.0	152.0	0.591	15.00	0.608	15.45	0.585	14.85	0.602	15.30
5/8	15.9	0.654	...	30.8	34.7	...	...	...	...	...	0.625	15.88	0.644	16.35	0.619	15.72	0.638	16.19
...	16	...	0.986	...	...	139.0	147.0	139.0	156.0	173.0	0.630	16.00	0.649	16.48	0.624	15.84	0.643	36.32
11/16	17.5	0.792	...	37.3	42.0	...	...	...	...	...	0.688	17.46	0.708	17.99	0.681	17.29	0.701	17.81
...	18	...	1.247	...	...	175.0	187.0	175.0	198.0	219.0	0.709	18.00	0.730	18.54	0.702	17.82	0.723	18.36
...	19	...	1.390	...	...	196.0	208.0	196.0	220.0	244.0	0.748	19.00	0.770	19.57	0.741	18.81	0.763	19.38
3/4	19.1	0.944	...	44.4	50.1	...	...	...	...	...	0.750	19.05	0.773	19.62	0.743	18.86	0.765	19.43
...	20	...	1.540	...	...	217.0	230.0	217.0	244.0	270.0	0.787	20.00	0.811	20.60	0.780	19.80	0.803	20.40
13/16	20.6	1.098	...	51.7	58.2	...	...	...	...	...	0.813	20.64	0.837	21.26	0.804	20.43	0.829	21.05
...	22	...	1.863	...	...	262.0	279.0	262.0	296.0	327.0	0.866	22.00	0.892	22.66	0.857	21.78	0.883	22.44
7/8	22.2	1.275	...	60.0	67.6	...	...	...	...	...	0.875	22.23	0.901	22.89	0.866	22.00	0.893	22.67
15/16	23.8	1.465	...	68.9	77.7	...	...	...	...	...	0.938	23.81	0.966	24.53	0.928	23.57	0.956	24.29
1	25.4	1.669	...	78.5	88.5	...	...	...	...	...	1.000	25.40	1.030	26.16	0.990	25.15	1.020	25.91
1 1/8	28.6	2.116	...	99.6	112.2	...	...	...	...	...	1.125	28.58	1.159	29.43	1.114	28.29	1.148	29.15
1 1/4	31.8	2.616	...	123.1	138.8	...	...	...	...	...	1.250	31.75	1.288	32.70	1.238	31.43	1.275	32.39
1 3/8	34.9	3.151	...	148.3	167.1	...	...	...	...	...	1.375	34.93	1.416	35.97	1.361	34.58	1.403	35.62
1 1/2	38.1	3.755	...	176.7	199.2	...	...	...	...	...	1.500	38.10	1.545	39.24	1.485	37.72	1.530	38.86

Table I-1-5
Classification 8 × *n*, Round Strand, Composite Steel Core (CSC) (Cont'd)

GENERAL NOTES:
(a) The use of *n* in the title of this table designates the number of wires in the outer strands (see 1.3.1.3).
(b) Precise values of modulus of elasticity can be provided by the rope supplier.
(c) The typical value of modulus of elasticity for classification 8 × 19 steel core is 14.5×10^6 psi.
(d) To convert GPa to psi, multiply GPa by 145.04×10^3.
(e) MBF values are based on ISO 4344, including Annex B and Annex C.

NOTES:
(1) Minimum breaking forces for final-galvanized ropes are 10% lower than the values listed. See Section I-1.
(2) Masses may be different for compacted or galvanized ropes.
(3) TS = 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 kilonewtons (kN) by 224.8.

Table I-1-6
Classification 9 × *n*, Round Strand, Steel Core (IWRC)

Diameter		Approximate Mass [Note (2)]		Rope Grade, Minimum Breaking Force (MBF) [Note (1)]							Diameter, Relaxed				Diameter, 10% of MBF			
				TS [Note (3)]	EHS	1370/1770 [Note (4)]	1570/1770	1570	1770	1960	Min.		Max.		Min.		Max.	
in.	mm	lb/ft	kg/m	lbf × 1,000		kN [Note (5)]					in.	mm	in.	mm	in.	mm	in.	mm
...	6	...	0.155	...	...	22.2	23.6	22.2	25.0	27.7	0.236	6.00	0.243	6.18	0.234	5.94	0.241	6.12
1/4	6.4	0.118	...	5.7	6.4	...	...	...	...	...	0.250	6.35	0.258	6.54	0.248	6.29	0.255	6.48
...	6.5	...	0.182	...	...	...	...	...	...	29.5	0.256	6.50	0.264	6.70	0.253	6.44	0.261	6.63
5/16	7.9	0.180	...	8.6	9.7	...	...	...	...	...	0.313	7.94	0.322	8.18	0.309	7.86	0.319	8.10
...	8	...	0.275	...	...	39.4	41.9	39.4	44.4	49.2	0.315	8.00	0.324	8.24	0.312	7.92	0.321	8.16
...	9	...	0.348	...	...	49.9	53.0	49.9	56.2	54.8	0.354	9.00	0.365	9.27	0.351	8.91	0.361	8.18
3/8	9.5	0.261	...	12.5	14.1	...	...	...	...	...	0.375	9.53	0.386	9.81	0.371	9.43	0.383	9.72
...	10	...	0.430	...	...	61.5	65.5	61.5	69.4	76.8	0.394	10.00	0.406	10.30	0.390	9.90	0.402	10.20
...	11	...	0.520	...	...	74.5	79.2	74.5	84.0	93.0	0.433	11.00	0.446	11.33	0.429	10.89	0.442	11.22
7/16	11.1	0.356	...	17.0	19.2	...	...	...	...	...	0.438	11.11	0.451	11.45	0.433	11.00	0.446	11.33
...	12	...	0.619	...	...	88.6	94.3	88.6	99.9	110.6	0.472	12.00	0.487	12.36	0.468	11.88	0.482	12.24
1/2	12.7	0.466	...	22.3	25.1	...	...	...	...	...	0.500	12.70	0.515	13.08	0.495	12.57	0.510	12.95
...	13	...	0.727	...	...	104.0	110.6	104.0	117.3	129.8	0.512	13.00	0.527	13.39	0.507	12.87	0.522	13.26
...	14	...	0.843	...	...	120.6	128.3	120.6	136.0	150.6	0.551	14.00	0.568	14.42	0.546	13.86	0.562	14.28
9/16	14.3	0.591	...	28.3	31.9	...	...	...	...	...	0.563	14.29	0.579	14.72	0.557	14.14	0.574	14.57
...	15	...	0.968	...	...	138.0	147.0	138.0	156.0	173.0	0.591	15.00	0.608	15.45	0.585	14.85	0.602	15.30
5/8	15.9	0.730	...	35.0	39.4	...	...	...	...	...	0.625	15.88	0.644	16.35	0.619	15.72	0.638	16.19
...	16	...	1.101	...	...	158.0	168.0	158.0	178.0	197.0	0.630	16.00	0.649	16.48	0.624	15.84	0.643	36.32
11/16	17.5	0.885	...	42.4	47.8	...	...	...	...	...	0.688	17.46	0.708	17.99	0.681	17.29	0.701	17.81
...	18	...	1.393	...	...	199.0	212.0	199.0	225.0	249.0	0.709	18.00	0.730	18.54	0.702	17.82	0.723	18.36
...	19	...	1.552	...	...	222.0	236.0	222.0	250.0	277.0	0.748	19.00	0.770	19.57	0.741	18.81	0.763	19.38
3/4	19.1	1.054	...	50.5	56.9	...	...	...	...	...	0.750	19.05	0.773	19.62	0.743	18.86	0.765	19.43
...	20	...	1.720	...	...	246.0	262.0	246.0	278.0	307.0	0.787	20.00	0.811	20.60	0.780	19.80	0.803	20.40
13/16	20.6	1.226	...	58.7	66.2	...	...	...	...	...	0.813	20.64	0.837	21.26	0.804	20.43	0.829	21.05
...	22	...	2.081	...	...	298.0	317.0	298.0	336.0	372.0	0.866	22.00	0.892	22.66	0.857	21.78	0.883	22.44
7/8	22.2	1.424	...	68.2	76.8	...	...	...	...	...	0.875	22.23	0.901	22.89	0.866	22.00	0.893	22.67
15/16	23.8	1.637	...	78.3	88.3	...	...	...	...	...	0.938	23.81	0.966	24.53	0.928	23.57	0.956	24.29
1	25.4	1.864	...	89.2	100.5	...	...	...	...	...	1.000	25.40	1.030	26.16	0.990	25.15	1.020	25.91
1 1/8	28.6	2.363	...	113.1	127.5	...	...	...	...	...	1.125	28.58	1.159	29.43	1.114	28.29	1.148	29.15
1 1/4	31.8	2.922	...	139.9	157.7	...	...	...	...	...	1.250	31.75	1.288	32.70	1.238	31.43	1.275	32.39
1 3/8	34.9	3.519	...	168.5	189.9	...	...	...	...	...	1.375	34.93	1.416	35.97	1.361	34.58	1.403	35.62
1 1/2	38.1	4.194	...	200.8	226.3	...	...	...	...	...	1.500	38.10	1.545	39.24	1.485	37.72	1.530	38.86

Table I-1-6
Classification 9 × *n*, Round Strand, Steel Core (IWRC) (Cont'd)

GENERAL NOTES:
(a) The use of *n* in the title of this table designates the number of wires in the outer strands (see 1.3.1.3).
(b) Precise values of modulus of elasticity can be provided by the rope supplier.
(c) The typical value of modulus of elasticity for classification 8 × 19 steel core is 14.5×10^6 psi.
(d) To convert GPa to psi, multiply GPa by 145.04×10^3.
(e) MBF values are based on ISO 4344, including Annex B and Annex C.

NOTES:
(1) Minimum breaking forces for final-galvanized ropes are 10% lower than the values listed. See Section I-1.
(2) Masses may be different for compacted or galvanized ropes.
(3) TS = 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 kilonewtons (kN) by 224.8.

Table I-1-7
Classification 9 × *n*, Round Strand, Steel Core (PWRC)

Diameter		Approximate Mass [Note (2)]		Rope Grade, Minimum Breaking Force (MBF) [Note (1)]							Diameter, Relaxed				Diameter, 10% of MBF			
				TS [Note (3)]	EHS	1370/1770 [Note (4)]	1570/1770	1570	1770	1960	Min.		Max.		Min.		Max.	
in.	mm	lb/ft	kg/m	lbf × 1,000		kN [Note (5)]					in.	mm	in.	mm	in.	mm	in.	mm
...	6	...	0.159	...	...	23.9	25.4	23.9	27.0	29.8	0.236	6.00	0.243	6.18	0.234	5.94	0.241	6.12
1/4	6.4	0.122	...	6.1	6.9	...	...	...	...	...	0.250	6.35	0.258	6.54	0.248	6.29	0.255	6.48
...	6.5	...	0.187	...	...	...	...	...	...	29.5	0.256	6.50	0.264	6.70	0.253	6.44	0.261	6.63
5/16	7.9	0.186	...	9.3	10.5	...	...	...	...	...	0.313	7.94	0.322	8.18	0.309	7.86	0.319	8.10
...	8	...	0.284	...	...	42.5	45.2	42.5	47.9	53.1	0.315	8.00	0.324	8.24	0.312	7.92	0.321	8.16
...	9	...	0.359	...	...	53.8	57.2	53.8	60.6	67.2	0.354	9.00	0.365	9.27	0.351	8.91	0.361	8.18
3/8	9.5	0.269	...	13.5	15.2	...	...	...	...	...	0.375	9.53	0.386	9.81	0.371	9.43	0.383	9.72
...	10	...	0.433	...	...	66.4	70.6	66.4	74.9	82.9	0.394	10.00	0.406	10.30	0.390	9.90	0.402	10.20
...	11	...	0.536	...	...	80.4	85.5	80.4	90.6	100.3	0.433	11.00	0.446	11.33	0.429	10.89	0.442	11.22
7/16	11.1	0.367	...	18.4	20.7	...	...	...	...	...	0.438	11.11	0.451	11.45	0.433	11.00	0.446	11.33
...	12	...	0.638	...	...	95.6	101.7	95.6	107.8	119.4	0.472	12.00	0.487	12.36	0.468	11.88	0.482	12.24
1/2	12.7	0.480	...	24.1	27.1	...	...	...	...	...	0.500	12.70	0.515	13.08	0.495	12.57	0.510	12.95
...	13	...	0.749	...	...	112.2	119.4	112.2	126.5	140.1	0.512	13.00	0.527	13.39	0.507	12.87	0.522	13.26
...	14	...	0.868	...	...	130.2	138.5	130.2	146.7	162.5	0.551	14.00	0.568	14.42	0.546	13.86	0.562	14.28
9/16	14.3	0.609	...	30.5	34.4	...	...	...	...	...	0.563	14.29	0.579	14.72	0.557	14.14	0.574	14.57
...	15	...	0.997	...	...	149.0	159.0	149.0	168.0	187.0	0.591	15.00	0.608	15.45	0.585	14.85	0.602	15.30
5/8	15.9	0.753	...	37.7	42.5	...	...	...	...	...	0.625	15.88	0.644	16.35	0.619	15.72	0.638	16.19
...	16	...	1.134	...	...	170.0	181.0	170.0	192.0	212.0	0.630	16.00	0.649	16.48	0.624	15.84	0.643	36.32
11/16	17.5	0.912	...	45.7	51.5	...	...	...	...	...	0.688	17.46	0.708	17.99	0.681	17.29	0.701	17.81
...	18	...	1.435	...	...	215.0	219.0	215.0	243.0	269.0	0.709	18.00	0.730	18.54	0.702	17.82	0.723	18.36
...	19	...	1.599	...	...	240.0	255.0	240.0	270.0	299.0	0.748	19.00	0.770	19.57	0.741	18.81	0.763	19.38
3/4	19.1	1.086	...	54.4	64.4	...	...	...	...	...	0.750	19.05	0.773	19.62	0.743	18.86	0.765	19.43
...	20	...	1.772	...	...	266.0	283.0	266.0	299.0	332.0	0.787	20.00	0.811	20.60	0.780	19.80	0.803	20.40
13/16	20.6	1.263	...	63.3	71.4	...	...	...	...	...	0.813	20.64	0.837	21.26	0.804	20.43	0.829	21.05
...	22	...	2.144	...	...	321.0	342.0	321.0	362.0	401.0	0.866	22.00	0.892	22.66	0.857	21.78	0.883	22.44
7/8	22.2	1.467	...	73.6	82.9	...	...	...	...	...	0.875	22.23	0.901	22.89	0.866	22.00	0.893	22.67
15/16	23.8	1.686	...	84.5	95.3	...	...	...	...	...	0.938	23.81	0.966	24.53	0.928	23.57	0.956	24.29
1	25.4	1.921	...	96.3	108.6	...	...	...	...	...	1.000	25.40	1.030	26.16	0.990	25.15	1.020	25.91
1 1/8	28.6	2.435	...	122.1	137.6	...	...	...	...	...	1.125	28.58	1.159	29.43	1.114	28.29	1.148	29.15
1 1/4	31.8	3.010	...	150.9	170.1	...	...	...	...	...	1.250	31.75	1.288	32.70	1.238	31.43	1.275	32.39
1 3/8	34.9	3.626	...	181.8	204.9	...	...	...	...	...	1.375	34.93	1.416	35.97	1.361	34.58	1.403	35.62
1 1/2	38.1	4.321	...	216.6	244.2	...	...	...	...	...	1.500	38.10	1.545	39.24	1.485	37.72	1.530	38.86

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