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Steel wire ropes — Requirements

Câbles en acier — Exigences

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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 105, *Steel wire ropes*.

This fourth edition cancels and replaces the third edition (ISO 2408:2004), which has been technically revised with the following main changes:

— "general purposes" and "minimum" have been deleted from the title;

— "oil and gas industry and fishing" has been deleted in the scope;

— the definitions of "calculated aggregate minimum breaking force of core, F_0" have been increased;

— in Table 1, Rope grade 2160 has been increased to 2 360 MPa;

— the sentence "All wires of the same nominal diameter in the same wire layer shall be of the same tensile strength grade." in 4.1.1 has been deleted;

— in 4.2.2, the sentence "Twisting for wires up to and including 0,4 mm, and brazing for wires over 0,4 mm," has been deleted and has been replaced with "the minimum distance between wire joints within one strand shall be 20 × *d*";

— "type" has been used to replace "duty" in 4.2.3, and the sentence "The purchaser should specify the rope duty or any particular lubrication requirements" has been deleted;

— "Zn-Al coated" has been increased in 4.2.7;

— note d) in 4.5.1 has been deleted;

— the "breaking force testing requirements without ISO quality system" column in Table 4 has been deleted;

— the requirement of measuring instrument for diameter measurement in 5.3 has been increased;

— these sentences in 5.4.1 have been deleted:

"a) the selected test piece shall have its ends secured to ensure that the rope does not unravel;

b) the minimum free test length excluding any rope terminations shall be 600 mm or 30 × nominal rope diameter, whichever is the greater;

c) after 80 % of the minimum breaking force has been applied, the force shall be increased at a rate of not more than 0,5 % of the minimum breaking force per second";

— the "measured aggregate breaking force, $F_{e.m}$" in 5.4.4 has been increased;

— in 6.1.1, g) maximum wire diameter and h) metallic cross-sectional area have been added;

— in 6.1.2 b) mass of coating, "(if applicable)" has been added;

— markings have been detailed in 6.2;

— the sentence "The value of wire exceeding the grades in the table should be agreed by the supplier and purchaser" has been added in Annex A;

— B.2 has been added in Annex B;

— in Annex C (previously Annex D), the metallic cross-section ratio, the weight ratio, and the calculating ratio for compacted strand wire rope columns have been added;

— in Annex D (previously Annex C), 6 × 19 M, 8 × 7, 18 × 19S, 18 × 19W, 36(M) × 7 have been added in rope construction and tables for 4 × 19 class, 4 × 36 class and K4 × 35N class have been added;

— "rope grade equivalents" has been changed to "rope grade approximations" in Annex G, and a note has been added;

— Annex H has been added;

— editorial revisions have been made.

Introduction

This document was developed in response to a worldwide demand for a specification giving requirements for steel wire ropes.

As in previous editions, this document specifies metric sizes and grades of rope for the more common classes of rope; see Annex F. A comparison of rope grades is provided in Annex G.

Steel wire ropes — Requirements

1 Scope

This document specifies requirements for the manufacture, testing, acceptance, packing, marking and issuing of a certificate of quality of wire ropes. It is applicable to round strand ropes and compacted strand ropes made from wires ropes that are uncoated (bright), zinc-coated or Zn-Al coated.

It is not applicable to ropes for

— mining purposes,

— aircraft control,

— aerial ropeways and funiculars, and

— lifts.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2232:1990, *Round drawn wire for general purpose non-alloy steel wire ropes and for large diameter steel wire ropes — Specifications*

ISO 3108, *Steel wire ropes for general purposes — Determination of actual breaking load*

ISO 4345, *Steel wire ropes — Fibre main cores — Specification*

ISO 4346, *Steel wire ropes for general purposes — Lubricants — Basic requirements*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 7800, *Metallic materials — Wire — Simple torsion test*

ISO 17893, *Steel wire ropes — Vocabulary, designation and classification*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17893 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
calculated aggregate minimum breaking force of core
F_0
value of the aggregate minimum breaking force obtained by calculation from the cross-sectional area (based on nominal wire diameter) and tensile strength grade of each wire in the core, as given in the manufacturer's rope design

4 Requirements

4.1 Material

4.1.1 Wire

Before rope making, wires shall conform to the diameter, torsion and, where applicable, coating requirements specified in Annex A.

NOTE 1 Annex A is based on ISO 2232 but with extended wire sizes and wire tensile strength grades.

NOTE 2 For a given wire size and tensile strength grade, the torsional properties of the wires in ISO 10425:2003, A.2 meet or exceed the values given in Annex A.

For those ropes where a rope grade is applicable, the tensile strength grades of the wires shall be subject to the limits given in Table 1.

Table 1 — Tensile strength grades of wires (excluding centre and filler wires) for given rope grades

Rope grade	Range of wire tensile strength grades N/mm^2
1570	1 370 to 1 770
1770	1 570 to 1 960
1960	1 770 to 2 160
2160	1 960 to 2 360

NOTE 3 The minimum breaking force values of those ropes of grades 1570, 1770, 1960 and 2160 as covered by Table D.1 to Table D.14 are calculated on the basis of rope grade and not individual wire tensile strength grades.

The methods of test shall be in accordance with ISO 2232.

4.1.2 Core

Cores of single-layer stranded ropes shall normally be of steel or fibre, although other types such as composites (e.g. steel plus fibre or steel plus polymer) or solid polymer may also be supplied.

The purchaser should specify any particular core type requirements.

Fibre cores for single-layer stranded ropes shall conform to ISO 4345 and rope diameters 8 mm and above shall be doubly closed (i.e. from yarn into strand and from strand into rope).

Natural fibre cores shall be treated with an impregnating compound to inhibit rotting and decay.

Steel cores shall be either an independent wire rope (IWRC) or a wire strand (WSC).

Steel cores of single-layer stranded ropes larger than 12 mm diameter shall be an independent wire rope (IWRC), unless specified otherwise.

4.1.3 Lubricant

Lubricants shall conform to ISO 4346.

4.2 Rope manufacture

4.2.1 General

All the wires in a strand shall have the same direction of lay.

The core, except for compacted (swaged) ropes, shall be designed (steel) or selected (fibre) so that in a new rope under tension on the closing machine, there is clearance between the outer strands.

The completed rope shall be evenly laid and free from loose wires, distorted strands and other irregularities.

The new wire rope shall not have a three-dimensional wave.

Rope ends that have no end fittings shall, when necessary, be secured so as to maintain the integrity of the wire rope and prevent its unlaying.

4.2.2 Wire joints

Wires over 0,4 mm in diameter shall, where necessary, have their ends joined by welding.

Wires up to and including 0,4 mm diameter shall, where necessary, be joined by brazing, welding or by ends being simply inserted in the strand's formation.

The minimum distance between wire joints within one strand shall be 20 × rope diameter (d).

4.2.3 Lubrication

The amount of lubrication and type of lubricant shall be appropriate to the rope type and its use.

4.2.4 Preformation and postformation

Ropes shall be preformed and/or postformed unless specified otherwise by the purchaser.

NOTE Large diameter wire rope, some parallel-closed and rotation-resistant ropes, can be non-preformed or be only partially preformed.

4.2.5 Construction

The rope construction shall be either one of those covered in Annex D, Annex H or as stated by the manufacturer.

If the purchaser only specifies the rope classification, the manufacturer should state the rope construction clearly.

The purchaser should specify the rope construction or classification.

4.2.6 Grade

The rope grades for the more common classes of ropes shall be as given in Table D.1 to Table D.22.

Other rope grades, including those as given in ISO 10425, may be supplied by agreement between the purchaser and the manufacturer, providing all of the other requirements are met.

NOTE Not all ropes will necessarily have a rope grade.

4.2.7 Wire finish

The finish of the wires shall be uncoated (bright), zinc-coated quality B, zinc coated quality A or Zn-Al coated.

For ropes of bright wire finish, substitution of bright wires by zinc-coated wires shall be limited to inner wires, centre wires, filler wires and core wires.

For ropes of zinc coated wire finish, all of the wires shall be zinc coated, including those of any steel core.

Where zinc-coated is specified, this may also include Zn-Al alloy.

4.2.8 Direction and type of lay

The direction and type of rope lay shall be one of the following:

a) right ordinary lay (sZ);

NOTE 1 Formerly referred to as right hand ordinary (designated RHO) and right regular lay (designated RRL).

b) left ordinary lay (zS);

NOTE 2 Formerly referred to as left hand ordinary (designated LHO) and left regular lay (designated LRL).

c) right lang lay (zZ);

NOTE 3 Formerly referred to as right hand langs (designated RHL) or right lang lay (designated RLL).

d) left lang lay (sS);

NOTE 4 Formerly referred to as left hand langs (designated LHL) or left lang lay (designated LLL).

The direction and type of rope lay should be specified by the purchaser.

4.3 Designation and classification

Rope designation and classification shall conform to the system requirements of ISO 17893.

4.4 Dimensions

4.4.1 Diameter

4.4.1.1 General

The nominal diameter shall be the dimension by which the rope is designated.

4.4.1.2 Tolerance

When measured in accordance with 5.3, the measured diameter shall be within the tolerances given in Table 2.

Table 2 — Tolerances on rope diameter

Rope type	Nominal rope diameter d mm	Tolerance as percentage of nominal diameter	
		Ropes with strands that are exclusively of wire or incorporate solid polymer centres	Ropes with strands that incorporate fibre centres[a]
Round steel wire rope	$2 \leq d < 4$	$^{+8}_{0}$	—
	$4 \leq d < 6$	$^{+7}_{0}$	$^{+9}_{0}$
	$6 \leq d < 8$	$^{+6}_{0}$	$^{+8}_{0}$
	$8 \leq d < 60$	$^{+5}_{0}$	$^{+7}_{0}$
	$d \geq 60$	$^{+5}_{0}$	—
Compacted strand rope	$d \geq 10$	$^{+5}_{0}$	—
[a] For example, 6 × 24 FC-FC.			

4.4.1.3 Difference between diameter measurements

The difference between any two of the four measurements taken in accordance with 5.3 and expressed as a percentage of the nominal rope diameter shall not exceed the values given in Table 3.

Table 3 — Permissible differences between any two diameter measurements

Rope type	Nominal rope diameter d mm	Differences as percentage of nominal diameter	
		Ropes with strands that are exclusively of wire or incorporate solid polymer centres	Ropes with strands that incorporate fibre centres[a]
Round steel wire rope	$2 \leq d < 4$	7	—
	$4 \leq d < 6$	6	8
	$6 \leq d < 8$	5	7
	$8 \leq d < 60$	4	6
	$d \geq 60$	4	—
Compacted strand rope	$d \geq 10$	4	—
[a] For example, 6 × 24 FC-FC.			

4.4.2 Lay length

For single-layer ropes of 6 × 7 class, the length of lay of the finished rope shall not exceed 8 × d.

For other single-layer ropes with round strands (except those with three or four strands), parallel closed ropes and rotation-resistant ropes with round strands or shaped strands, the length of lay of the finished rope shall not exceed 7,5 × d.

For single-layer ropes with shaped strands, e.g. triangular strand, the length of lay of the finished rope shall not exceed 10 × d.

4.4.3 Rope length

The length of rope supplied, under no load, shall be equivalent to the specified length subject to the following tolerances:

— ≤400 m: $^{+5}_{0}$ %;

— >400 m and ≤1 000 m: $^{+20}_{0}$ m;

— >1 000 m: $^{+2}_{0}$ %.

4.5 Breaking force

4.5.1 General

The minimum breaking force, F_{min}, for a given rope diameter and construction shall be either

a) as given in Table D.1 to Table D.22 or Table H.1, or

b) as stated by the manufacturer.

For the determination of minimum breaking forces of rope diameters not listed in Table D.1 to Table D.22 or Table H.1, calculations in accordance with Annex C can be used.

When tested in accordance with 5.4.1, the measured breaking force, F_m, shall be greater than or equal to the minimum breaking force, F_{min}.

Breaking force testing requirements shall be in accordance with Table 4.

NOTE The requirements for breaking force testing take into account: a) the rope size; b) whether or not ropes are produced in series, i.e. repeatedly produced; c) whether or not the minimum breaking force factor is consistent throughout a range of diameters.

4.5.2 Ropes produced in series

The manufacturer shall be able to provide the results from type testing in accordance with the sampling and acceptance criteria in Annex B.

Type testing shall be repeated on any rope that has its design changed in any way which results in a modified (e.g. increased) breaking force. If the same design, apart from wire tensile strength grades, is used for ropes of a lower grade or lower breaking force, or both, than the one which has successfully passed the type testing requirements, it shall not be necessary to repeat the tests on those ropes provided the breaking force is calculated with the same spinning loss.

Subsequent production lengths of ropes produced in series shall be deemed to conform to the breaking force requirements when the manufacturer has satisfactorily completed, on a sample from every 20th production length

a) the appropriate type tests (see Annex B), and

b) a periodic breaking force test in accordance with Method 1 (see 5.4.1) or one of the alternative methods, known as Method 2 (see 5.4.2), Method 3 (see 5.4.3) and Method 4 (see 5.4.4).

Table 4 — Breaking force testing requirements

Rope diameter	Min. breaking force factor	Breaking force testing requirements
Up to and including 60 mm	Same factor throughout a subgroup of rope diameters	Breaking force test in accordance with 5.4.1 (Method 1) on a sample from each production length; Or, if produced in series, type testing in accordance with the sampling regime and acceptance criteria of B.1 plus periodic breaking force test in accordance with 5.4.1 (Method 1), 5.4.2 (Method 2), 5.4.3 (Method 3) or 5.4.4 (Method 4)on a sample from every 20th production length relating to the subgroup of diameters.
	Different factor throughout a subgroup of rope diameters	Breaking force test in accordance with 5.4.1 (Method 1) on a sample from each production length; Or, if produced in series, type testing in accordance with the sampling regime and acceptance criteria of B.2 plus periodic test in accordance with 5.4.1 (Method 1), 5.4.2 (Method 2), 5.4.3 (Method 3) or 5.4.4(Method 4) on a sample from every 20th production length of a given rope diameter and construction.
Over 60 mm		Breaking force test in accordance with 5.4.1 (Method 1), 5.4.2 (Method 2), 5.4.3 (Method 3) or 5.4.4 (Method 4)on a sample from each production length, or either of the following: a) if produced in series, type testing in accordance with B.2 plus periodic breaking force test in accordance with 5.4.1 (Method 1), 5.4.2 (Method 2), 5.4.3 (Method 3) or 5.4.4 (Method 4) on a sample from every 20th production length; or b) if produced for supply as a set of ropes of the same design for a specific installation the alternative breaking force testing and sampling as also given in B.2.
NOTE Breaking force type testing demonstrates that a steel wire rope produced in series and certified by the manufacturer as conforming to this document possesses the minimum breaking force stated by the manufacturer. The purpose of these tests is to prove the design, material and method of manufacture.		

5 Verification of requirements and test methods

5.1 Materials

Conformity with the wire, core and lubricant requirements shall be confirmed through a visual verification of the inspection documents supplied with the wire, core and lubricant, respectively.

5.2 Rope manufacture

Conformity with the requirements for wire joints and preformation shall be confirmed through visual verification.

5.3 Test on rope for diameter

Diameter measurements shall be taken on a straight portion of rope, either under no tension or a tension not exceeding 5 % of the minimum breaking force, at two positions spaced at least 1 m apart. At each position, two measurements, at 90° apart, of the circumscribed circle diameter shall be taken. The measuring equipment shall extend over at least two adjacent strands (see Figure 1).

The average of these four measurements shall be the measured in diameter.

For wire rope diameter ≤26 mm, the minimum scale value of the measuring instrument shall be 0,02 mm or less. For wire rope diameter from 26 mm to 100 mm, the minimum scale value of the measuring instrument shall be 0,05 mm or less. For wire rope over 100 mm, the minimum scale value of the measuring instrument shall be 0,1 mm or less.

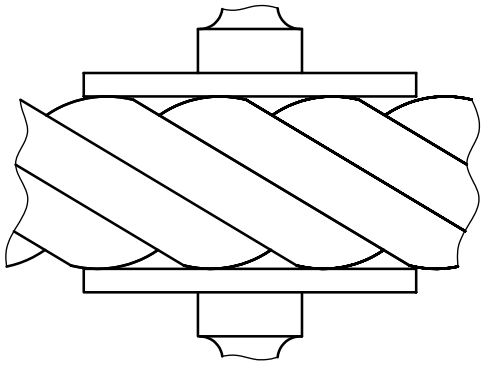


Figure 1 — Method of measuring rope diameter

5.4 Test on rope for breaking force

5.4.1 Method 1: Measured breaking force, F_m

Besides following regulations, the testing method and acceptance shall be in accordance with ISO 3108.

a) If the measured breaking force, F_m, reaches or exceeds the minimum breaking force, F_{min}, the test may be terminated without breaking the rope.

b) If in the first tensile test, the measured breaking force, F_m, does not reach the minimum breaking force, F_{min}, it can be repeated three additional times. Once a test reaches or exceeds the F_{min}, the wire rope has met the minimum breaking force.

c) If the breaking is within the distance 6 times of wire rope diameter from the clamp or the ends, and F_m is less than F_{min}, the testing shall be determined invalid, the invalid test is not counted as one of the four allowed tests.

5.4.2 Method 2: Calculated measured (post-spin) breaking force

Add together the measured breaking forces of all the individual wires after they have been removed from the rope and multiply this value by either

a) the spinning loss factor derived from Annex C, or

b) the partial spinning loss factor obtained from the results of type testing.

The partial spinning loss factor used in the calculation shall be the lowest of the three values obtained from type testing.

In the case of triangular strand ropes, the triangular centre of the strand may be considered as an individual wire.

The wires shall be tested in accordance with the wire tensile test specified in ISO 6892-1.

NOTE The result from this test is known as the "calculated measured (post-spin) breaking force".

When this method (i.e. Method 2) is used for the periodic test (see Table 4) and the calculated measured (post-spin) breaking force value is less than the intended minimum breaking force value, another test using Method 1 shall be carried out.

If the measured (actual) breaking force in this second test fails to meet the intended minimum breaking force value, the minimum breaking force shall be de-rated to a value not exceeding the measured (actual) breaking force value and type testing shall be repeated using Method 1.

In such cases, the rope grade shall either be de-rated in line with the de-rated minimum breaking force value or deleted from the rope designation.

5.4.3 Method 3: Calculated measured (pre-spin) breaking force

Add together the measured breaking forces of all the individual wires before they are laid into the rope and multiply this value by the total spinning loss factor obtained from the results of type testing. The total spinning loss factor used in the calculation shall be the lowest value of the three values obtained from type testing.

The wires shall be tested in accordance with the wire tensile test specified in ISO 6892-1.

NOTE The result from this test is known as the "calculated measured (pre-spin) breaking force".

When this method (i.e. Method 3) is used for the periodic test (see Table 4) and the calculated measured (pre-spin) breaking force value is less than the intended minimum breaking force value, another test using Method 1 shall be carried out.

If the measured breaking force in this second test fails to meet the intended minimum breaking force value, the minimum breaking force shall be de-rated to a value not exceeding the measured breaking force value and type testing shall be repeated using Method 1.

5.4.4 Method 4: Measured aggregate breaking force, $F_{e.m}$

5.4.4.1 The wires from the rope shall be tested in accordance with the wire tensile test specified in ISO 6892-1.

5.4.4.2 Add together the breaking forces of all individual wires if all wires tested.

5.4.4.3 If partial wires are tested, the aggregate breaking force of wires is calculated by Formula (1):

$$F_{e.m} = F_0 + F_1 N_1 + F_2 N_2 + F_3 N_3 + \ldots + F_n N_n \quad (1)$$

where

F_0 is the calculated aggregate minimum breaking force of core;

$F_1, F_2, F_3 \ldots F_n$ is the sum of the measured breaking force of wires in the same construction, same diameter strand and the calculated breaking force of wires not tested;

$N_1, N_2, N_3 \ldots N_n$ are the numbers of the same construction and same diameter strands of wire rope.

The sampling parameters conform to Annex E .

If testing two strands or more for the same construction and same diameter strands, it should be calculated by average value.

In such cases, the rope grade shall either be de-rated in line with the de-rated minimum breaking force value or deleted from the rope designation.

6 Information for use

6.1 Certificate

6.1.1 General

A certificate shall confirm conformity with this document.

Unless specified otherwise by the purchaser, the certificate shall give at least the following information:

a) certificate number;

b) name and address of the manufacturer;

c) quantity and nominal length of rope (optional);

d) rope designation (see ISO 17893);

e) minimum breaking force;

f) date of issue of the certificate and authentication.

g) maximum wire diameter;

h) metallic cross-sectional area;

The certificate number shall enable traceability of the rope.

The issuing of a certificate by the manufacturer and whether or not specific test results are given should be the subject of agreement between the purchaser and the manufacturer.

6.1.2 Test results

When test results are provided, the certificate shall additionally give either a) or b) or both, as follows:

a) breaking force test on rope: state which value, i.e.

   1) measured breaking force, or

   2) calculated measured (post-spin) breaking force, or

   3) calculated measured (pre-spin) breaking force;

b) tests on wires:

   1) number of wires tested;

   2) nominal diameter of wires;

   3) measured breaking force of wire;

   4) tensile strength based on nominal diameter;

   5) number of torsions completed (and test length);

   6) mass of coating (if applicable).

6.2 Packaging and marking

6.2.1 Packaging

Ropes shall be supplied on reels or in coils.

The purchaser should specify any particular packaging requirements.

6.2.2 Marking

6.2.2.1 There should be a marker tape incorporated into the centre of the rope, so as to remain recognizable despite soiling, soaking or discoloration during use.

6.2.2.2 Each coil or reel should have a label, which is firmly fixed in place, with the following information:

— construction;

— diameter;

— length;

— gross weight;

— net weight;

— reel/coil no.;

— manufacturer;

— origin;

— maximum wire diameter;

— metallic cross-sectional area;

or other information agreed by the purchaser and supplier.

Annex A
(normative)

Dimensional and mechanical properties of round wires (before rope making)

A.1 Variations in tensile strength for wire

The variations in tensile strengths shall not exceed the nominal values by an amount greater than those given in Table A.1. The values of nominal tensile strength grade are the lower (minimum) limits for each tensile strength grade.

Table A.1 — Variations in tensile strength

Nominal diameter (mm) δ (mm)	**Variation in tensile strength above nominal** (N/mm^2)
$0{,}20 \leq \delta < 0{,}50$	390
$0{,}50 \leq \delta < 1{,}00$	350
$1{,}00 \leq \delta < 1{,}50$	320
$1{,}50 \leq \delta < 2{,}00$	290
$2{,}00 \leq \delta < 3{,}50$	260
$3{,}50 \leq \delta < 7{,}00$	250

The diameter tolerances, minimum number of torsions and minimum masses of coating for wire tensile strength grades 1370, 1570, 1770, 1960 and 2160 shall be in accordance with the values given in Table A.2.

For intermediate wire tensile strength grades, the values for the next highest grade shall apply. The value of wire exceeding the grades in the table should be agreed by the supplier and purchaser in Annex A.

A.2 Diameter tolerances, minimum number of torsions and minimum masses of zinc for different tensile strength grades

Table A.2 — Diameter tolerances, minimum number of torsions and minimum masses of zinc for tensile strength grades 1370, 1570, 1770, 1960 and 2160

Nominal diameter of wire mm	Tolerance mm		Minimum number of torsions based on test length of 100x									Minimum mass of zinc	
			Bright and galvanized or Zn-Al alloy					Galvanized or Zn-Al alloy				Galvanized or Zn-Al alloy	
			Quality B					Quality A					
			Tensile strength grade N/mm2									g / m2	
	Bright and galv. or Zn-Al alloy Quality B	Galv. or Zn-Al alloy Quality A	1370	1570	1770	1960	2160	1370	1570	1770	1960	B	A
0,20 ≤ δ < 0,25	±0,008	—	—	—	—	—	—	—	—	—	—	20	—
0,25 ≤ δ < 0,30	±0,008	—	—	—	—	—	—	—	—	—	—	30	—
0,30 ≤ δ < 0,40	±0,01	±0,025	—	—	—	—	—	—	—	—	—	30	—
0,40 ≤ δ < 0,50	±0,01	±0,025	—	—	—	—	—	—	—	—	—	40	75
0,50 ≤ δ < 0,55	±0,015	±0,03	34	30	28	25	23	—	—	—	—	50	90
0,55 ≤ δ < 0,60	±0,015	±0,03	34	30	28	25	23	—	—	—	—	50	90
0,60 ≤ δ < 0,70	±0,015	±0,03	34	30	28	25	23	—	—	—	—	60	120
0,70 ≤ δ < 0,75	±0,015	±0,03	34	30	28	25	23	—	21	19	17	60	120
0,75 ≤ δ < 0,80	±0,015	±0,03	34	30	28	25	23	—	21	19	17	60	120
0,80 ≤ δ < 0,90	±0,015	±0,03	34	30	28	25	22	—	21	19	17	60	140
0,90 ≤ δ < 1,00	±0,015	±0,03	34	30	28	25	22	—	21	19	17	70	150
1,00 ≤ δ < 1,10	±0,015	±0,04	34	30	26	23	21	—	20	18	13	80	160
1,10 ≤ δ < 1,20	±0,02	±0,04	33	29	26	23	21	—	20	18	13	80	160
1,20 ≤ δ < 1,40	±0,02	±0,04	33	28	25	22	20	—	18	15	10	90	170
1,40 ≤ δ < 1,60	±0,02	±0,04	33	28	25	22	19	—	18	15	10	100	180
1,60 ≤ δ < 1,70	±0,02	±0,04	33	28	25	22	19	—	18	15	10	100	200
1,70 ≤ δ < 1,80	±0,02	±0,05	33	28	25	22	19	—	18	15	10	100	200
1,80 ≤ δ < 1,90	±0,025	±0,05	32	27	24	21	18	—	17	14	9	110	215
1,90 ≤ δ < 2,10	±0,025	±0,05	32	27	24	21	18	—	17	14	9	110	215
2,10 ≤ δ < 2,20	±0,025	±0,06	32	27	24	21	18	—	17	14	9	110	215
2,20 ≤ δ < 2,30	±0,025	±0,06	31	27	24	21	18	20	17	14	9	125	230
2,30 ≤ δ < 2,40	±0,025	±0,06	30	27	24	21	18	20	17	14	9	125	230
2,40 ≤ δ < 2,50	±0,025	±0,06	29	26	23	20	18	19	15	12	7	125	230
2,50 ≤ δ < 2,60	±0,025	±0,06	29	26	23	20	18	19	15	12	7	125	230
2,60 ≤ δ < 2,70	±0,03	±0,07	29	26	23	20	18	19	15	12	7	125	230
2,70 ≤ δ < 2,80	±0,03	±0,07	29	26	23	20	18	19	15	12	7	125	240
2,80 ≤ δ < 2,90	±0,03	±0,07	28	26	23	20	18	19	15	12	7	135	240
2,90 ≤ δ < 3,00	±0,03	±0,07	28	26	23	20	18	18	15	12	7	135	240
3,00 ≤ δ < 3,10	±0,03	±0,07	27	25	21	18	16	18	12	8	5	135	240

Table A.2 *(continued)*

Nominal diameter of wire mm	Tolerance mm		Minimum number of torsions based on test length of 100x									Minimum mass of zinc	
			Bright and galvanized or Zn-Al alloy					Galvanized or Zn-Al alloy				Galvanized or Zn-Al alloy	
			Quality B					Quality A					
			Tensile strength grade N/mm2									g / m2	
	Bright and galv. or Zn-Al alloy Quality B	Galv. or Zn-Al alloy Quality A	1370	1570	1770	1960	2160	1370	1570	1770	1960	B	A
3,10 ≤ δ < 3,20	±0,03	±0,07	27	25	21	18	16	13	12	8	5	135	240
3,20 ≤ δ < 3,30	±0,03	±0,07	27	25	21	18	16	13	12	8	5	135	250
3,30 ≤ δ < 3,40	±0,03	±0,07	27	25	21	18	16	13	12	8	5	135	250
3,40 ≤ δ < 3,50	±0,03	±0,07	27	25	21	18	16	13	12	8	5	135	250
3,50 ≤ δ < 3,60	±0,03	±0,07	26	24	20	16	14	11	10	6	5	135	250
3,60 ≤ δ < 3,70	±0,03	±0,07	26	24	20	16	14	11	10	6	5	135	260
3,70 ≤ δ < 3,80	±0,03	±0,07	25	23	19	16	13	11	8	6	5	135	260
3,80 ≤ δ < 3,90	±0,03	±0,07	24	22	18	14	12	11	7	6	4	135	260
3,90 ≤ δ < 4,00	±0,03	±0,07	24	22	18	14	12	10	7	6	4	135	260
4,00 ≤ δ < 4,20	±0,03	±0,08	23	20	17	13	11	9	6	6	4	150	275
4,20 ≤ δ < 4,40	±0,03	±0,08	21	19	15	11	10	8	6	5	4	150	275
4,40 ≤ δ < 4,60	±0,03	±0,08	20	18	14	10	10	7	6	5	3	150	275
4,60 ≤ δ < 4,80	±0,03	±0,08	18	16	12	8	9	6	5	4	3	150	275
4,80 ≤ δ < 5,00	±0,03	±0,08	17	14	11	7	9	5	4	3	2	150	275
5,00 ≤ δ < 5,20	±0,03	±0,08	12	14	11	7	8	5	4	3	2	150	300
5,20 ≤ δ < 5,40	±0,03	±0,08	14	12	10	6	—	5	4	3	—	160	300
5,40 ≤ δ < 5,60	±0,04	±0,09	12	10	8	6	—	4	3	2	—	160	300
5,60 ≤ δ < 5,80	±0,04	±0,09	10	8	6	5	—	3	2	2	—	160	300
5,80 ≤ δ <6,00	±0,04	±0,09	8	6	6	5	—	3	2	2	—	160	300
6,00 ≤ δ <6,25	±0,04	±0,09	8	6	6	5	—	3	2	2	—	160	300
6,25 ≤ δ < 6,50	±0,04	±0,09	7	5	5	—	—	2	2	2	—	160	300
6,50 ≤ δ < 6,75	±0,04	±0,09	6	5	4	—	—	2	2	2	—	160	300
6,75 ≤ δ < 7,00	±0,04	±0,10	6	5	4	—	—	2	2	2	—	160	300

Annex B
(normative)

Sampling and acceptance criteria for type testing of ropes produced in series

B.1 Sizes up to and including 60 mm diameter

B.1.1 Ropes having the same minimum breaking force factor throughout a sub-group of rope diameters

The manufacturer shall divide the intended size range into sub-groups based on the following:

— nominal diameter up to and including 6 mm;

— over 6 mm up to and including 12 mm;

— over 12 mm up to and including 24 mm;

— over 24 mm up to and including 48 mm;

— over 48 mm up to and including 60 mm.

For each of the sub-groups representing the intended range and having the same construction, grade and minimum breaking force factor, the manufacturer shall perform breaking force tests in accordance with 5.4.1 on samples from each of three separate production lengths of rope of different nominal diameters.

If all three samples pass the test, all rope sizes within that sub-group of that particular rope construction, grade and minimum breaking force factor shall be deemed to have satisfied the type testing requirements; otherwise, breaking force testing shall continue on a sample from each consecutive production length of rope within that sub-group until the requirements are met.

B.1.2 Ropes having different minimum breaking force factors throughout a sub-group of rope diameters

The manufacturer shall perform a breaking force test in accordance with 5.4.1 on a sample from each of three separate production lengths of rope of the same nominal diameter.

If all three samples pass the test, that diameter and construction having that particular minimum breaking force factor shall be deemed to have satisfied the breaking force type testing requirements.

If one of the samples fails the test, the tests shall be repeated until the measured breaking forces of three consecutive production lengths of that rope diameter and construction meet or exceed the minimum breaking force value.

B.2 Sizes over 60 mm diameter

For each rope of a given diameter, construction and minimum breaking force, the manufacturer shall perform breaking force tests in accordance with 5.4.1 (Method 1), 5.4.2 (Method 2), 5.4.3 (Method 3) and 5.4.4 (Method 4),on samples from each of three separate production lengths.

If all three samples pass the test, that rope diameter and construction having that particular minimum breaking force shall be deemed to have satisfied the breaking force type testing requirements.

If one sample fails the test, the tests shall be repeated until the measured breaking forces of three consecutive production lengths of that rope diameter and construction meet or exceed the minimum breaking force value.

In addition, when the manufacturer intends to produce multiple production lengths of the same rope on the same closing machine with the same machine settings and the same design, the sampling number for breaking force tests would be calculated by formula $\sqrt{N-1}$, and it should be rounded to the integer; the minimum number is 1. The N in the formula means the number of the production lengths (i.e. close to the breaking load).

The ropes shall be deemed to satisfy the requirement if the measured breaking forces, when tested in accordance with 5.4.1 (Method 1), 5.4.2 (Method 2), 5.4.3 (Method 3) or 5.4.4 (Method 4), meet or exceed the minimum value.

If one of the samples fails the test, tests shall be carried out again on samples from each of the remaining production lengths.

Only those ropes that pass the tests shall be deemed to have satisfied the breaking force requirement.

Annex C
(normative)

Calculation of minimum breaking force for ropes in the tables of Annex D and Annex H

C.1 Ropes from 2 mm to 60 mm diameter

The minimum breaking force, F_{min}, expressed in kilonewtons, shall be calculated with Formula (C.1):

$$F_{min} = \frac{d^2 \times R_r \times K}{1\ 000} \quad \text{(C.1)}$$

where

d is the nominal diameter of the rope, in millimetres;

R_r is the rope grade, in newtons per square millimetres;

K is the minimum breaking force factor for a given rope class;

K_1 is the factor for ropes with a fibre core;

K_2 is for rope with an independent wire rope core;

K_3 is for rope with a wire strand core or centre.

Table C.1 summarizes the factors used in the calculation of the minimum breaking force for round stranded ropes covered by Table D.1 to Table D.13.

Table C.2 summarizes the factors used in the calculation of the minimum breaking force for compacted ropes covered by Table D.14 to Table D.22.

Table C.1 — Factors for round stranded wire ropes

Type of rope	Class	Ropes with fibre core			Ropes with steel core or wire strand centre					
		Weight factor	Cross-sectional metallic area factor	Minimum breaking force factor	Weight factor		Cross-sectional metallic area factors		Minimum breaking force factor	
		W1	C1	K1	W2	W3	C2	C3	K2	K3
Single layer round steel wire ropes	6 × 7	0,345	0,369	0,332	0,384	0,396	0,432	0,441	0,359	0,388
	6 × 19	0,359	0,384	0,330	0,400		0,449		0,356	
	6 × 24	0,314	0,329	0,286						
	6 × 36	0,367	0,393	0,330	0,409		0,460		0,356	
	6 × 19M	0,346	0,357	0,307	0,372	0,381	0,398	0,418	0,332	0,362
	6 × 37M	0,346	0,357	0,295	0,381	0,381	0,418	0,418	0,319	0,346
	8 × 7	0,327	0,335	0,291	0,391	0,464	0,439	0,520	0,359	0,404
	8 × 19	0,340	0,349	0,293	0,407		0,457		0,356	
	8 × 36	0,348	0,357	0,293	0,417		0,468		0,356	
Rotation-resistant round steel wire ropes	4 × 19 4 × 36	0,410	0,429	0,360						
	18 × 7 18 × 19	0,382	0,408	0,328		0,401		0,433		0,328
	34(M) × 7	0,390	0,424	0,318		0,401		0,428		0,318
	35(W) × 7					0,454		0,480		0,360[a] 0,350[b]

[a] Up to rope grade 1960.

[b] Rope grade over than 1960 up to 2160.

Table C.2 — Factors for compacted strand wire ropes

Type of rope	Class	Ropes with fibre core			Ropes with steel core or wire strand centre					
		Weight factor	Cross-sectional metallic area factor	MBF factor	Weight factor		Cross-sectional metallic area factor		MBF factor	
		W1	C1	K1	W2	W3	C2	C3	K2	K3
Single layer compacted wire rope	6 × K7	0,410	0,426	0,375						
	6 × K19 6 × K36	0,425	0,453	0,373	0,477		0,516		0,410	
	8 × K19 8 × K36	0,405	0,400	0,330	0,495		0,516		0,410	
Rotation-resistant compacted wire rope	K4 × 35N	0,423	0,429	0,375						
	15 × K7				0,490		0,528		0,410	
	18 × K7 18 × K19	0,427	0,449	0,350		0,470		0,475		0,370
	35(W) × K7					0,510		0,527		0,410

NOTE 1 The weight factors and the cross-sectional factors are only for reference.

NOTE 2 For calculation of weight, cross-sectional metallic area, and minimum breaking force using the factors in this table, refer to ISO 17893.

C.2 Ropes over 60 mm and up to 264 mm diameter

The minimum breaking force, F_{min}, expressed in kilonewtons shall be calculated with Formula (C.2):

$$F_{min} = 8{,}55\ d + 0{,}592\ d^2 - 0\ 000\ 615\ d^3 \quad \text{(C.2)}$$

where

d is the nominal diameter of the rope, in millimetres.

Annex D
(normative)

Tables of minimum breaking forces for more common rope classes, sizes and grades

Table D.1 to Table D.22 give the minimum breaking forces for the more common classes, sizes and grades of rope.

Table D.1 — Class 6 × 7

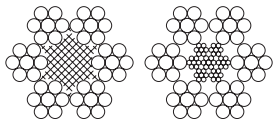
 6 × 7-FC 6 × 7-IWRC Typical cross section			Typical construction					
			Rope construction	Strand construction	No. of outer layer wires			
					Total	Per strand		
			6 × 7	1-6	36	6		
Nominal diameter mm	Approximate weight kg/100 m		Rope grade					
			1570		1770		1960	
			Minimum breaking force, kN					
	FC	IWRC	FC	IWRC	FC	IWRC	FC	IWRC
2	1,38	1,54	2,08	2,25	2,35	2,54	2,60	2,81
3	3,11	3,46	4,69	5,07	5,29	5,72	5,86	6,33
4	5,52	6,14	8,34	9,02	9,40	10,2	10,4	11,3
6	12,4	13,8	18,8	20,3	21,2	22,9	23,4	25,3
7	16,9	18,8	25,5	27,6	28,8	31,1	31,9	34,5
8	22,1	24,6	33,4	36,1	37,6	40,7	41,6	45,0
9	27,9	31,1	42,2	45,7	47,6	51,5	52,7	57,0
10	34,5	38,4	52,1	56,4	58,8	63,5	65,1	70,4
11	41,7	46,5	63,1	68,2	71,1	76,9	78,7	85,1
12	49,7	55,3	75,1	81,2	84,6	91,5	93,7	101
13	58,3	64,9	88,1	95,3	99,3	107	110	119
14	67,6	75,3	102	110	115	125	128	138
16	88,3	98,3	133	144	150	163	167	180
18	112	124	169	183	190	206	211	228
20	138	154	208	225	235	254	260	281
22	167	186	252	273	284	308	315	341
24	199	221	300	325	338	366	375	405
26	233	260	352	381	397	430	440	476
28	270	301	409	442	461	498	510	552
32	353	393	534	577	602	651	666	721
36	447	498	676	730	762	824	843	912
40	552	614	834	902	940	1 020	1 040	1 130
For small diameter ropes (2 mm to 7 mm) with wire strand core (WSC), K3 may be used for the calculation of breaking forces. The values shown are for ropes with IWRC.								

Table D.2 — Class 6 × 19 M

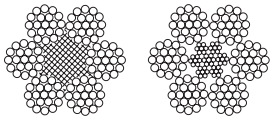
 6 × 19M-FC 6 × 19M-IWRC **Typical cross section**		**Typical construction**					
		Rope construction	**Strand construction**	**No. of outer layer wires**			
				Total	**Per strand**		
		6 × 19M	1-6/12	72	12		
Nominal diameter mm	**Approximate weight** kg/100 m	**Rope grade**					
		1570		1770		1960	
		Minimum breaking force, kN					
	FC	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**
2	1,38	1,49	1,93	2,08	2,17	2,35	2,41	2,60
3	3,11	3,35	4,34	4,69	4,89	5,29	5,42	5,86
4	5,54	5,95	7,71	8,34	8,69	9,40	9,63	10,4
5	8,65	9,30	12,0	13,0	13,6	14,7	15,0	16,3
6	12,5	13,4	17,4	18,8	19,6	21,2	21,7	23,4
7	17,0	18,2	23,6	25,5	26,6	28,8	29,5	31,9
8	22,1	23,8	30,8	33,4	34,8	37,6	38,5	41,6
9	28,0	30,1	39,0	42,2	44,0	47,6	48,7	52,7
10	34,6	37,2	48,2	52,1	54,3	58,8	60,2	65,1
11	41,9	45,0	58,3	63,1	65,8	71,1	72,8	78,7
12	49,8	53,6	69,4	75,1	78,2	84,6	86,6	93,7
13	58,5	62,9	81,5	88,1	91,8	99,3	102	110
14	67,8	72,9	94,5	102	107	115	118	128
16	88,6	95,2	123	133	139	150	154	167
18	112	121	156	169	176	190	195	211
20	138	149	193	208	217	235	241	260
22	167	180	233	252	263	284	291	315
24	199	214	278	300	313	338	347	375
26	234	251	326	352	367	397	407	440
28	271	292	378	409	426	461	472	510
32	354	381	494	534	556	602	616	666
36	448	482	625	676	704	762	780	843
40	554	595	771	834	869	940	963	1 040
44	670	720	933	1 010	1 050	1 140	1 160	1 260
48	797	857	1 110	1 200	1 250	1 350	1 390	1 500
For small diameter ropes (2 mm to 7 mm) with wire strand core (WSC), K3 may be used for the calculation of breaking forces. The values shown are for ropes with IWRC.								

Table D.3 — Class 6 × 24

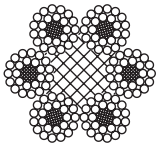
 6 × 24FC-FC **Typical cross section**		**Typical construction**			
		Rope construction	**Strand construction**	**No. of outer layer wires**	
				Total	**Total**
		6 × 24FC 6 × 24FC	FC-12/12 FC-9/15	72 90	12 15
Nominal diameter mm	**Approximate weight** kg/100 m	**Rope grade**			
		1570		1770	
		Minimum breaking force, kN			
	FC	**FC**		**FC**	
8	20,1	28,7		32,4	
9	25,4	36,4		41,0	
10	31,4	44,9		50,6	
11	38,0	54,3		61,3	
12	45,2	64,7		72,9	
13	53,1	75,9		85,6	
14	61,5	88,0		99,2	
15	70,7	101		114	
16	80,4	115		130	
18	102	145		164	
20	126	180		202	
22	152	217		245	
24	181	259		292	
26	212	304		342	
28	246	352		397	
30	283	404		456	
32	322	460		518	
36	407	582		656	
40	502	718		810	
44	608	869		980	

Table D.4 — Class 6 × 37 M

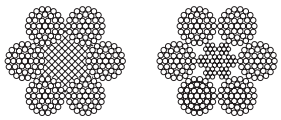
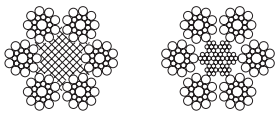
 6 × 37M-FC 6 × 37M-IWRC **Typical cross section**			**Typical construction**					
			Rope construction	**Strand construction**	**No. of outer layer wires**			
					Total	**Per strand**		
			6 × 37M	1-6/12/18	108	18		
Nominal diameter mm	**Approximate weight** kg/100 m		**Rope grade**					
			1570		1770		1960	
			Minimum breaking force, kN					
	FC	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**
5	8,65	9,53	11,6	12,5	13,1	14,1	14,5	15,6
6	12,5	13,7	16,7	18,0	18,8	20,3	20,8	22,5
7	17,0	18,7	22,7	24,5	25,6	27,7	28,3	30,6
8	22,1	24,4	29,6	32,1	33,4	36,1	37,0	40,0
9	28,0	30,9	37,5	40,6	42,3	45,7	46,8	50,6
10	34,6	38,1	46,3	50,1	52,2	56,5	57,8	62,5
11	41,9	46,1	56,0	60,6	63,2	68,3	70,0	75,7
12	49,8	54,9	66,7	72,1	75,2	81,3	83,3	90,0
13	58,5	64,4	78,3	84,6	88,2	95,4	97,7	106
14	67,8	74,7	90,8	98,2	102	111	113	123
16	88,6	97,5	119	128	134	145	148	160
18	112	123	150	162	169	183	187	203
20	138	152	185	200	209	226	231	250
22	167	184	224	242	253	273	280	303
24	199	219	267	288	301	325	333	360
26	234	258	313	339	353	382	391	423
28	271	299	363	393	409	443	453	490
32	354	390	474	513	535	578	592	640
36	448	494	600	649	677	732	749	810
40	554	610	741	801	835	903	925	1 000
44	670	738	897	970	1 010	1 090	1 120	1 210
48	797	878	1 070	1 150	1 200	1 300	1 330	1 440
52	936	1 030	1 250	1 350	1 410	1 530	1 560	1 690
56	1 090	1 190	1 450	1 570	1 640	1 770	1 810	1 960
60	1 250	1 370	1 670	1 800	1 880	2 030	2 080	2 250
For small diameter ropes (5 mm to 7 mm) with wire strand core (WSC), K3 may be used for the calculation of breaking forces. The values shown are for ropes with IWRC.								

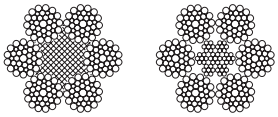
Table D.5 — Class 6 × 19

 6 × 19S-FC 6 × 19S-IWRC **Typical cross section**	Typical construction			
	Rope construction	**Strand construction**	**No. of outer layer wires**	
			Total	**Per strand**
	6 × 19S	1-9-9	54	9
	6 × 21F	1-5-5F-10	60	10
	6 × 26WS	1-5-5+5–10	60	10
	6 × 19W	1-6-6+6	72	12
	6 × 25F	1-6-6F-12	72	12

Nominal diameter mm	**Approximate weight** kg/100 m		**Rope grade**							
			1570		1770		1960		2160	
			Minimum breaking force, kN							
	FC	**IWRC**	**FC**	IWRC	FC	IWRC	FC	IWRC	**FC**	**IWRC**
6	12,9	14,4	18,7	20,1	21,0	22,7	23,3	25,1	25,7	27,7
7	17,6	19,6	25,4	27,4	28,6	30,9	31,7	34,2	34,9	37,7
8	23,0	25,6	33,2	35,8	37,4	40,3	41,4	44,7	45,6	49,2
9	29,1	32,4	42,0	45,3	47,3	51,0	52,4	56,5	57,7	62,3
10	35,9	40,0	51,8	55,9	58,4	63,0	64,7	69,8	71,3	76,9
11	43,4	48,4	62,7	67,6	70,7	76,2	78,3	84,4	86,2	93,0
12	51,7	57,6	74,6	80,5	84,1	90,7	93,1	100	103	111
13	60,7	67,6	87,6	94,5	98,7	106	109	118	120	130
14	70,4	78,4	102	110	114	124	127	137	140	151
16	91,9	102	133	143	150	161	166	179	182	197
18	116	130	168	181	189	204	210	226	231	249
20	144	160	207	224	234	252	259	279	285	308
22	174	194	251	271	283	305	313	338	345	372
24	207	230	298	322	336	363	373	402	411	443
26	243	270	350	378	395	426	437	472	482	520
28	281	314	406	438	458	494	507	547	559	603
32	368	410	531	572	598	645	662	715	730	787
36	465	518	671	724	757	817	838	904	924	997
40	574	640	829	894	935	1 010	1 030	1 120	1 140	1 230
44	695	774	1 000	1 080	1 130	1 220	1 250	1 350	1 380	1 490
48	827	922	1 190	1 290	1 350	1 450	1 490	1 610	1 640	1 770
52	971	1 080	1 400	1 510	1 580	1 700	1 750	1 890	1 930	2 080
56	1 130	1 250	1 620	1 750	1 830	1 980	2 030	2 190	2 240	2 410
60	1 290	1 440	1 870	2 010	2 100	2 270	2 330	2 510	2 570	2 770

For small diameter ropes (6 mm to 8 mm) with wire strand core (WSC), K3 may be used for the calculation of breaking forces. The values shown are for ropes with IWRC.

Table D.6 — Class 6 × 36



6 × 36WS-FC 6 × 36WS-IWRC

Typical cross section

Typical construction			
Rope construction	**Strand construction**	**No. of outer layer wires**	
		Total	**Per strand**
6 × 31WS	1-6-6+6-12	72	12
6 × 29F	1-7-7F-14	84	14
6 × 36WS	1-7-7+7-14	84	14
6 × 37FS	1-6-6F-12-12	72	12
6 × 41WS	1-8-8+8-16	96	16
6 × 41F	1-8-8–8F-16	96	16
6 × 43FS	1-7-7F-14-14	96	14
6 × 49SWS	1-8-8–8+8-16	84	16
6 × 46WS	1-9-9+9-18	108	18
6 × 49FS	1-8-8F-16-16	96	16

Nominal diameter mm	**Approximate weight** kg/100 m		**Rope grade**							
			1570		1770		1960		2160	
			Minimum breaking force, kN							
	FC	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**
7	18,0	20,0	25,4	27,4	28,6	30,9	31,7	34,2	34,9	37,7
8	23,5	26,2	33,2	35,8	37,4	40,3	41,4	44,7	45,6	49,2
9	29,7	33,1	42,0	45,3	47,3	51,0	52,4	56,5	57,7	62,3
10	36,7	40,9	51,8	55,9	58,4	63,0	64,7	69,8	71,3	76,9
11	44,4	49,5	62,7	67,6	70,7	76,2	78,3	84,4	86,2	93,0
12	52,8	58,9	74,6	80,5	84,1	90,7	93,1	100	103	111
13	62,0	69,1	87,6	94,5	98,7	106	109	118	120	130
14	71,9	80,2	102	110	114	124	127	137	140	151
16	94,0	105	133	143	150	161	166	179	182	197
18	119	133	168	181	189	204	210	226	231	249
20	147	164	207	224	234	252	259	279	285	308
22	178	198	251	271	283	305	313	338	345	372
24	211	236	298	322	336	363	373	402	411	443
26	248	276	350	378	395	426	437	472	482	520
28	288	321	406	438	458	494	507	547	559	603
32	376	419	531	572	598	645	662	715	730	787
36	476	530	671	724	757	817	838	904	924	997
40	587	654	829	894	935	1 010	1 030	1 120	1 140	1 230
44	711	792	1 000	1 080	1 130	1 220	1 250	1 350	1 380	1 490
48	846	942	1 190	1 290	1 350	1 450	1 490	1 610	1 640	1 770
52	992	1110	1 400	1 510	1 580	1 700	1 750	1 890	1 930	2 080
56	1 150	1 280	1 620	1 750	1 830	1 980	2 030	2 190	2 240	2 410
60	1 320	1 470	1 870	2 010	2 100	2 270	2 330	2 510	2 570	2 770

Table D.7 — Class 8 × 7

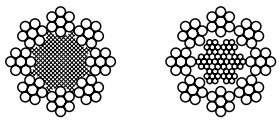
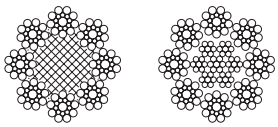
 8 × 7-FC 8 × 7-IWRC Typical cross section			Typical construction					
			Rope construction	Strand construction	No. of outer layer wires			
					Total	Per strand		
			8 × 7	1-6	48	6		
Nominal diameter mm	**Approximate weight** kg/100 m		**Rope grade**					
			1570		1770		1960	
			Minimum breaking force, kN					
	FC	**IWRC**	**FC**	IWRC	FC	IWRC	**FC**	**IWRC**
2	1,31	1,56	1,83	2,25	2,06	2,54	2,28	2,81
3	2,94	3,52	4,11	5,07	4,64	5,72	5,13	6,33
4	5,23	6,26	7,31	9,02	8,24	10,2	9,13	11,3
5	8,18	9,78	11,4	14,1	12,9	15,9	14,3	17,6
6	11,8	14,1	16,4	20,3	18,5	22,9	20,5	25,3
7	16,0	19,2	22,4	27,6	25,2	31,1	27,9	34,5
8	20,9	25,0	29,2	36,1	33,0	40,7	36,5	45,0
9	26,5	31,7	37,0	45,7	41,7	51,5	46,2	57,0
10	32,7	39,1	45,7	56,4	51,5	63,5	57,0	70,4
11	39,6	47,3	55,3	68,2	62,3	76,9	69,0	85,1
12	47,1	56,3	65,8	81,2	74,2	91,5	82,1	101
13	55,3	66,1	77,2	95,3	87,0	107	96,4	119
14	64,1	76,6	89,5	110	101	125	112	138
16	83,7	100	117	144	132	163	146	180
18	106	127	148	183	167	206	185	228
20	131	156	183	225	206	254	228	281
22	158	189	221	273	249	308	276	341
24	188	225	263	325	297	366	329	405
26	221	264	309	381	348	430	386	476
28	256	307	358	442	404	498	447	552
32	335	400	468	577	527	651	584	721
36	424	507	592	730	668	824	739	912
40	523	626	731	902	824	1 020	913	1 130
44	633	757	885	1090	997	1 230	1 100	1 360
48	753	901	1 050	1 300	1 190	1 460	1 310	1 620
For small diameter ropes (2 mm to 8mm) with wire strand core (WSC), K3 may be used for the calculation of breaking forces. The values shown are for ropes with IWRC.								

Table D.8 — Class 8 × 19



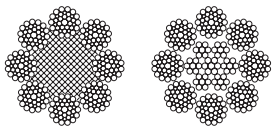
8 × 19S-FC 8 × 19S-IWRC

Typical cross section

Typical construction			
Rope construction	**Strand construction**	**No. of outer layer wires**	
		Total	**Per strand**
8 × 19S	1-9-9	72	9
8 × 21F	1-5-5F-10	80	10
8 × 26WS	1-5-5+5-10	80	10
8 × 19W	1-6-6+6	96	12
8 × 25F	1-6-6F-12	96	12

Nominal diameter mm	**Approximate weight** kg/100m		**Rope grade**							
			1570		1770		1960		2160	
			Minimum breaking force, kN							
	FC	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**
7	16,7	19,9	22,5	27,4	25,4	30,9	28,1	34,2	31,0	37,7
8	21,8	26,0	29,4	35,8	33,2	40,3	36,8	44,7	40,5	49,2
9	27,5	33,0	37,3	45,3	42,0	51,0	46,5	56,5	51,3	62,3
10	34,0	40,7	46,0	55,9	51,9	63,0	57,4	69,8	63,3	76,9
11	41,1	49,2	55,7	67,6	62,8	76,2	69,5	84,4	76,6	93,0
12	49,0	58,6	66,2	80,5	74,7	90,7	82,7	100	91,1	111
13	57,5	68,8	77,7	94,5	87,6	106	97,1	118	107	130
14	66,6	79,8	90,2	110	102	124	113	137	124	151
16	87,0	104	118	143	133	161	147	179	162	197
18	110	132	149	181	168	204	186	226	205	249
20	136	163	184	224	207	252	230	279	253	308
22	165	197	223	271	251	305	278	338	306	372
24	196	234	265	322	299	363	331	402	365	443
26	230	275	311	378	351	426	388	472	428	520
28	267	319	361	438	407	494	450	547	496	603
32	348	417	471	572	531	645	588	715	648	787
36	441	527	596	724	672	817	744	904	820	997
40	544	651	736	894	830	1 010	919	1 120	1 010	1 230
44	658	788	891	1 080	1 000	1 220	1 110	1 350	1 230	1 490
48	783	938	1 060	1 290	1 190	1 450	1 320	1 610	1 460	1 770
52	919	1 100	1 240	1 510	1 400	1 700	1 550	1 890	1 710	2 080
56	1 070	1 280	1 440	1 750	1 630	1 980	1 800	2 190	1 980	2 410
60	1 220	1 470	1 660	2 010	1 870	2 270	2 070	2 510	2 280	2 770

Table D.9 — Class 8 × 36



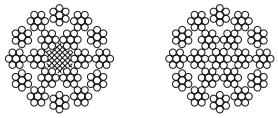
8 × 36WS-FC 8 × 36WS-IWRC

Typical cross section

Typical construction			
Rope construction	**Strand construction**	**No. of outer layer wires**	
		Total	**Per strand**
8 × 31WS	1-6-6+6-12	96	12
8 × 29F	1-7-7F-14	112	14
8 × 36WS	1-7-7+7-14	112	14
8 × 37FS	1-6-6F-12-12	96	12
8 × 41WS	1-8-8+8-16	128	16
8 × 41F	1-8-8–8F-16	128	16
8 × 43FS	1-7-7F-14-14	112	14
8 × 49SWS	1-8-8–8+8-16	128	16
8 × 46WS	1-9-9+9-18	144	18
8 × 49FS	1-8-8F-16-16	128	16

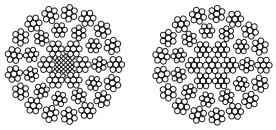
Nominal diameter mm	**Approximate weight** kg/100 m		**Rope grade**							
			1570		1770		1960		2160	
			Minimum breaking force, kN							
	FC	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**
8	22,3	26,7	29,4	35,8	33,2	40,3	36,8	44,7	40,5	49,2
9	28,2	33,8	37,3	45,3	42,0	51,0	46,5	56,5	51,3	62,3
10	34,8	41,7	46,0	55,9	51,9	63,0	57,4	69,8	63,3	76,9
11	42,1	50,5	55,7	67,6	62,8	76,2	69,5	84,4	76,6	93,0
12	50,1	60,0	66,2	80,5	74,7	90,7	82,7	100	91,1	111
13	58,8	70,5	77,7	94,5	87,6	106	97,1	118	107	130
14	68,2	81,7	90,2	110	102	124	113	137	124	151
16	89,1	107	118	143	133	161	147	179	162	197
18	113	135	149	181	168	204	186	226	205	249
20	139	167	184	224	207	252	230	279	253	308
22	168	202	223	271	251	305	278	338	306	372
24	200	240	265	322	299	363	331	402	365	443
26	235	282	311	378	351	426	388	472	428	520
28	273	327	361	438	407	494	450	547	496	603
32	356	427	471	572	531	645	588	715	648	787
36	451	540	596	724	672	817	744	904	820	997
40	557	667	736	894	830	1 010	919	1 120	1 010	1 230
44	674	807	891	1 080	1 000	1 220	1 110	1 350	1 230	1 490
48	802	961	1 060	1 290	1 190	1 450	1 320	1 610	1 460	1 770
52	941	1 130	1 240	1 510	1 400	1 700	1 550	1 890	1 710	2 080
56	1 090	1 310	1 440	1 750	1 630	1 980	1 800	2 190	1 980	2 410
60	1 250	1 500	1 660	2 010	1 870	2 270	2 070	2 510	2 280	2 770

Table D.10 — Class 18 × 7 and 18 × 19

 18 × 7-FC 18 × 7-WSC **Typical cross section**			**Typical construction**			
			Rope construction	**Strand construction**	**No. of outer layer wires**	
					Total	**Per strand**
			17 × 7	1-6	66	6
			18 × 7	1-6	72	6
			18 × 19S	1-9-9	108	9
			18 × 19W	1-6-6+6	144	6

Nominal diameter mm	**Approximate weight** kg/100 m		**Rope grade**			
			1570	1770	1960	2160
			Minimum breaking force, kN			
	FC	**WSC**	**FC/WSC**	**FC/WSC**	**FC/WSC**	**FC/WSC**
6	13,8	14,4	18,5	20,9	23,1	25,5
7	18,7	19,6	25,2	28,4	31,5	34,7
8	24,4	25,7	33,0	37,2	41,1	45,3
9	30,9	32,5	41,7	47,0	52,1	57,4
10	38,2	40,1	51,5	58,1	64,3	70,8
11	46,2	48,5	62,3	70,2	77,8	85,7
12	55,0	57,7	74,2	83,6	92,6	102
13	64,6	67,8	87,0	98,1	109	120
14	74,9	78,6	101	114	126	139
16	97,8	103	132	149	165	181
18	124	130	167	188	208	230
20	153	160	206	232	257	283
22	185	194	249	281	311	343
24	220	231	297	334	370	408
26	258	271	348	392	435	479
28	299	314	404	455	504	555
32	391	411	527	594	658	725
36	495	520	667	752	833	918
40	611	642	824	929	1 030	1 130
44	740	776	997	1 120	1 240	1 370
48	880	924	1 190	1 340	1 480	1 630
52	1 030	1 080	1 390	1 570	1 740	1 920
56	1 200	1 260	1 610	1 820	2 020	2 220
60	1 370	1 440	1 850	2 090	2 310	2 550

Table D.11 — Class 34(M) × 7



34(M) × 7-FC 34(M) × 7-WSC

Typical cross section

Typical construction			
Rope construction	**Strand construction**	**No. of outer layer wires**	
		Total	**Per strand**
34(M) × 7	1-6	102	6
36(M) × 7	1-6	108	6

Nominal diameter mm	**Approximate weight** kg/100 m		**Rope grade**		
			1570	1770	1960
			Minimum breaking force, kN		
	FC	**WSC**	**FC/WSC**	**FC/WSC**	**FC/WSC**
10	39,0	40,1	49,9	56,3	62,3
11	47,2	48,5	60,4	68,1	75,4
12	56,2	57,7	71,9	81,1	89,8
13	65,9	67,8	84,4	95,1	105
14	76,4	78,6	97,9	110	122
16	99,8	103	128	144	160
18	126	130	162	182	202
20	156	160	200	225	249
22	189	194	242	272	302
24	225	231	288	324	359
26	264	271	337	380	421
28	306	314	391	441	489
32	399	411	511	576	638
36	505	520	647	729	808
40	624	642	799	901	997
44	755	776	967	1 090	1 210
48	899	924	1 150	1 300	1 440
52	1 050	1 080	1 350	1520	1 680
56	1 220	1 260	1 570	1 760	1 950
60	1 400	1 440	1 800	2 030	2 240

Table D.12 — Class 35(W) × 7

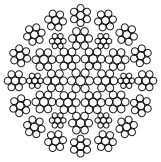
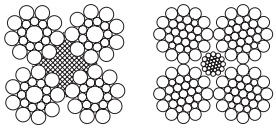
 35(W) × 7 **Typical cross section**		**Typical construction**			
		Rope construction	**Strand construction**	**No. of outer layer wires**	
				Total	**Per strand**
		35(W) × 7	1-6	96	6
		40(W) × 7	1-6	108	6
Nominal diameter	**Approximate weight**	**Rope grade**			
		1570	1770	1960	2160
mm	kg/100 m	**Minimum breaking force,** kN			
8	29,1	36,1	40,8	45,2	48,4
10	45,4	56,5	63,7	70,6	75,6
11	54,9	68,4	77,1	85,4	91,5
12	65,4	81,4	91,8	102	109
13	76,7	95,5	108	119	128
14	89,0	111	125	138	148
16	116	145	163	181	194
18	147	183	206	229	245
20	182	226	255	282	302
22	220	274	308	342	366
24	262	326	367	406	435
26	307	382	431	477	511
28	356	443	500	553	593
32	465	579	652	723	774
36	588	732	826	914	980
40	726	904	1 020	1 130	1 210
44	879	1 090	1 230	1 370	1 460
48	1 050	1 300	1 470	1 630	1 740
52	1 230	1 530	1 720	1 910	2 040
56	1 420	1 770	2 000	2 210	2 370
60	1 630	2 030	2 290	2 540	2 720

Table D.13 — Class 4 × 19 and 4 × 36



4 × 19S-FC 4 × 31WS-WSC

Typical cross section

Typical construction			
Rope construction	**Strand construction**	**No. of outer layer wires**	
		Total	**Per strand**
4 × 19S	1-9-9	36	9
4 × 25F	1-6-6F-12	48	12
4 × 26WS	1-5-5+5-10	40	10
4 × 31WS	1-6-6+6-12	48	12
4 × 36WS	1-7-7+7-14	56	14
4 × 41WS	1-8-8+8-16	64	16

Nominal diameter mm	**Approximate weight** kg/100 m	**Rope grade**		
		1570	1770	1960
		Minimum breaking force, kN		
	FC	**FC or WSC**	**FC or WSC**	**FC or WSC**
8	26,2	36,1	40,8	45,2
9	33,2	45,8	51,6	57,2
10	41,0	56,5	63,7	70,6
11	49,6	68,4	77,1	85,4
12	59,0	81,4	91,8	102
13	69,3	95,5	108	119
14	80,4	111	125	138
16	105	145	163	181
18	133	183	206	229
20	164	226	255	282
22	198	274	308	342
24	236	326	367	406
26	277	382	431	477
28	321	443	500	553
32	420	579	652	723
36	531	732	826	914
40	656	904	1 020	1 130
44	794	1 090	1 230	1 370
48	945	1 300	1 470	1 630

Table D.14 — Class 6 × K7 (compacted wire rope)

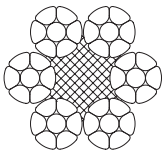
 6 × K7-FC **Typical cross section**		**Typical construction**			
		Rope construction	**Strand construction**	**No. of outer layer wires**	
				Total	**Per strand**
		6 × K7	1-6	36	6
Nominal diameter mm	**Approximate weight** kg/100 m	**Rope grade**			
		1570	1770	1960	
		Minimum breaking force, kN			
	FC	**FC**	**FC**	**FC**	
10	41,0	58,9	66,4	73,5	
11	49,6	71,2	80,3	88,9	
12	59,0	84,8	95,6	106	
13	69,3	99,5	112	124	
14	80,4	115	130	144	
16	105	151	170	188	
18	133	191	215	238	
20	164	236	266	294	
22	198	285	321	356	
24	236	339	382	423	
26	277	398	449	497	
28	321	462	520	576	
32	420	603	680	753	
36	531	763	860	953	
40	656	942	1 060	1 180	

Table D.15 — Class 6 × K19 (compacted wire rope)

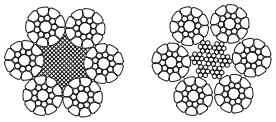
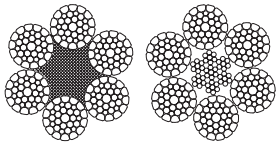
 6 × K19S-FC 6 × K19S-IWRC **Typical cross section**			**Typical construction**			
			Rope construction	**Strand construction**	**No. of outer layer wires**	
					Total	**Per strand**
			6 × K19S	1-9-9	54	9
			6 × K26WS	1-5-5+5-10	60	10
Nominal diameter mm	**Approximate weight** kg/100 m		**Rope grade**			
			1770		1960	
			Minimum breaking force, kN			
	FC	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**
12	61,2	68,7	95,1	105	105	116
13	71,8	80,6	112	123	124	136
14	83,3	93,5	129	142	143	158
16	109	122	169	186	187	206
18	138	155	214	235	237	260
20	170	191	264	290	292	321
22	206	231	320	351	354	389
24	245	275	380	418	421	463
26	287	322	446	491	494	543
28	333	374	518	569	573	630
32	435	488	676	743	749	823
36	551	618	856	941	947	1 040
40	680	763	1 060	1 160	1 170	1 290
44	823	923	1 280	1 400	1 420	1 560
48	979	1 100	1 520	1 670	1 680	1 850
52	1 150	1 290	1 780	1 960	1 980	2 170

Table D.16 — Class 6 × K36 (compacted wire rope)



6 × K36WS-FC 6 × K36WS-IWRC

Typical cross section

Typical construction			
Rope construction	**Strand construction**	**No. of outer layer wires**	
		Total	**Per strand**
6 × K31WS	1-6-6+6-12	72	12
6 × K36WS	1-7-7+7-14	84	14
6 × K41WS	1-8-8+8-16	96	16
6 × K49SWS	1-8-8–8+8-16	84	16
6 × K46WS	1-9-9+9-18	108	18

Nominal diameter mm	**Approximate weight** kg/100 m		**Rope grade**			
			1770		1960	
			Minimum breaking force, kN			
	FC	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**
16	109	122	169	186	187	206
18	138	155	214	235	237	260
20	170	191	264	290	292	321
22	206	231	320	351	354	389
24	245	275	380	418	421	463
26	287	322	446	491	494	543
28	333	374	518	569	573	630
32	435	488	676	743	749	823
36	551	618	856	941	947	1 040
40	680	763	1 060	1 160	1 170	1 290
44	823	923	1 280	1 400	1 410	1 560
48	979	1 100	1 520	1 670	1 680	1 850
52	1 150	1 290	1 780	1 960	1 980	2 170
56	1 330	1 500	2 070	2 280	2 290	2 520
60	1 530	1 720	2 380	2 610	2 630	2 890

Table D.17 — Class 8 × K19 (compacted wire rope)

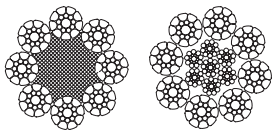
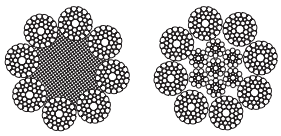
 8 × K19S-FC 8 × K19S-IWRC **Typical cross section**			Typical construction			
			Rope construction	Strand construction	No. of outer layer wires	
					Total	Per strand
			8 × K19S	1-9-9	72	9
			8 × K26WS	1-5-5+5-10	80	10
Nominal diameter mm	Approximate weight kg/100 m		Rope grade			
			1770		1960	
			Minimum breaking force, kN			
	FC	IWRC	FC	IWRC	FC	IWRC
16	104	127	150	186	166	206
18	131	160	189	235	210	260
20	162	198	234	290	259	321
22	196	240	283	351	313	389
24	233	285	336	418	373	463
26	274	335	395	491	437	543
28	318	388	458	569	507	630
32	415	507	598	743	662	823
36	525	642	757	941	838	1 040
40	648	792	935	1 160	1 030	1 290
44	784	958	1 130	1 400	1 250	1 560
48	933	1 140	1 350	1 670	1 490	1 850
52	1 100	1 340	1 580	1 960	1 750	2 170
56	1 270	1 550	1 830	2 280	2 030	2 520
60	1 460	1 780	2 100	2 610	2 330	2 890

Table D.18 — Class 8 × K36 (compacted wire rope)



8 × K41WS-FC 8 × K41WS-IWRC

Typical cross section

Typical construction			
Rope construction	**Strand construction**	**No. of outer layer wires**	
		Total	**Per strand**
8 × K31WS	1-6-6+6-12	96	12
8 × K36WS	1-7-7+7-14	112	14
8 × K41WS	1-8-8+8-16	128	16
8 × K49SWS	1-8-8–8+8-16	128	16
8 × K46WS	1–9-9+9-18	144	18

Nominal diameter mm	**Approximate weight** kg/100 m		**Rope grade**			
			1770		1960	
			Minimum breaking force, kN			
	FC	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**
20	162	198	234	290	259	321
22	196	240	283	351	313	389
24	233	285	336	418	373	463
26	274	335	395	491	437	543
28	318	388	458	569	507	630
32	415	507	598	743	662	823
36	525	642	757	941	838	1 040
40	648	792	935	1 160	1 030	1 290
44	784	958	1 130	1 400	1 250	1 560
48	933	1 140	1 350	1 670	1 490	1 850
52	1 100	1 340	1 580	1 960	1 750	2 170
56	1 270	1 550	1 830	2 280	2 030	2 520
60	1 460	1780	2 100	2 610	2 330	2 890

Table D.19 — Class 15 × K7 (compacted wire rope)

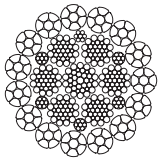
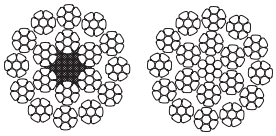
 15 × K7-IWRC **Typical cross section**		**Typical construction**			
		Rope construction	**Strand construction**	**No. of outer layer wires**	
				Total	**Per strand**
		15 × K7	1-6	90	6
		16 × K7	1-6	96	6
Nominal diameter mm	**Approximate weight** kg/100 m	**Rope grade**			
		1770		1960	
		Minimum breaking force, kN			
	IWRC	**IWRC**		**IWRC**	
18	159	235		260	
20	196	290		321	
22	237	351		389	
24	282	418		463	
26	331	491		543	
28	384	569		630	
32	502	743		823	
36	635	941		1 040	
40	784	1 160		1 290	
44	949	1 400		1 560	
48	1 130	1 670		1 850	
52	1 320	1 960		2 170	
56	1 540	2 280		2 520	
60	1 760	2 610		2 890	

Table D.20 — Class 18 × K7 and 18 × K 19 (compacted wire rope)



18 × K7-FC 18 × K7+WSC

Typical cross section

Typical construction			
Rope construction	**Strand construction**	**No. of outer layer wires**	
		Total	**Per strand**
17 × K7	1-6	66	6
18 × K7	1-6	72	6
18 × K19S	1-9-9	108	9

Nominal diameter mm	**Approximate weight** kg/100 m		**Rope grade**			
			1770		1960	
			Minimum breaking force, kN			
	FC	**IWRC**	**FC**	**IWRC**	**FC**	**IWRC**
14	83,7	92,1	121	128	134	142
16	109	120	159	168	176	186
18	138	152	201	212	222	235
20	171	188	248	262	274	290
22	207	227	300	317	332	351
24	246	271	357	377	395	418
26	289	318	419	443	464	490
28	335	368	486	513	538	569
32	437	481	634	671	702	743
36	553	609	803	849	889	940
40	683	752	991	1 050	1 100	1 160
44	827	910	1 200	1 270	1 330	1 400
48	984	1 080	1 430	1 510	1 580	1 670
52	1 150	1 270	1 680	1 770	1 850	1 960
56	1 340	1 470	1 940	2 050	2 150	2 270
60	1 540	1 690	2 230	2 360	2 470	2 610