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Steel wire ropes for general purposes — Minimum requirements

Câbles en acier pour usages courants — Exigences minimales

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 2408 was prepared by Technical Committee ISO/TC 105, *Steel wire ropes*.

This third edition cancels and replaces the second edition (ISO 2408:1985), which has been technically revised.

Introduction

This International Standard was developed in response to a worldwide demand for a specification giving minimum requirements for ropes for general purposes.

As in previous editions, this edition of ISO 2408 specifies metric sizes and grades of rope for the more common classes of rope. In addition, and for comparison, information is given in this edition on imperial rope sizes and grades in order to assist in the rope selection process and help to ensure that existing levels of safety are maintained on equipment originally designed to use such ropes. In these cases, it is recommended that the equipment designer or rope manufacturer (or other competent person) be consulted prior to ordering a substitute rope.

This International Standard does not restrict itself to those classes covered by the tables: other types, such as ropes with compacted strands and compacted (swaged) ropes, may also conform to it.

Complementing this International Standard is ISO 17893, which covers definitions, designation and classification.

Steel wire ropes for general purposes — Minimum requirements

1 Scope

This International Standard specifies minimum requirements for the manufacture and testing of stranded steel wire ropes for general purposes, including lifting equipment such as cranes and hoists. Ropes for slings are also dealt with, and tables giving minimum breaking forces for the more common sizes, grades and constructions of stranded rope presented. It is applicable to single-layer, rotation-resistant and parallel-closed ropes made from wires of uncoated (bright), zinc-coated and zinc-alloy coated finish in rope diameters of up to 60 mm, supplied as bulk manufacture. It is not applicable to ropes for

— mining purposes,

— aircraft control,

— the petroleum and natural gas industries,

— aerial ropeways and funiculars,

— lifts, or

— fishing purposes.

2 Normative references

The following referenced documents are indispensable for the application 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, *Metallic materials — Tensile testing at ambient temperature*

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

ISO 10425:2003, *Steel wire ropes for the petroleum and natural gas industries — Minimum requirements and terms of acceptance*

ISO 17893[1)], *Steel wire ropes — Vocabulary, designations and classifications*

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1) To be published.

3 Terms and definitions

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

4 Requirements

4.1 Material

4.1.1 Wire

Before ropemaking, 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 A.2 of ISO 10425:2003 meet or exceed the values given in Annex A of this International Standard.

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 2 160

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

All wires of the same nominal diameter in the same wire layer shall be of the same tensile strength grade.

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 for 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.

When uncoiled and under no load the rope shall not be wavy.

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

4.2.2 Wire joints

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

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

If twisting as a joint is performed during rope manufacture, any protruding twisted wire ends shall be removed from the finished rope.

4.2.3 Lubrication

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

The purchaser should specify the rope duty or any particular lubrication requirements.

4.2.4 Preformation and postformation

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

NOTE Some parallel-closed and rotation-resistant ropes could be non-preformed or be only partially preformed.

4.2.5 Construction

The rope construction shall be either one of those covered by the following classes or a construction, including compacted strand ropes and compacted (swaged) ropes, as stated by the manufacturer:

6×7, 6×24FC, 6×37M, 6×19, 6×36, 8×19, 8×36, 6×25TS, 18×7, 34(M) $\times 7$ and 35(W) $\times 7$.

Where only the rope class is specified by the purchaser the construction supplied shall be decided by the manufacturer.

The purchaser should specify the rope construction or class.

4.2.6 Grade

The rope grades for the more common classes of ropes shall be as given in Tables C.1 to C.14.

Intermediate 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 or zinc coated Quality A.

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 zinc alloy Zn95/Al5.

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)[2];

b) left ordinary lay (zS)[3];

c) right lang lay (zZ)[4];

d) left lang lay (sS)[5];

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.

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

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

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

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

Table 2 — Tolerances on rope diameter

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]
$2 \leqslant d < 4$	$^{+8}_{0}$	—
$4 \leqslant d < 6$	$^{+7}_{0}$	$^{+9}_{0}$
$6 \leqslant d < 8$	$^{+6}_{0}$	$^{+8}_{0}$
$\geqslant 8$	$^{+5}_{0}$	$^{+7}_{0}$
[a] For example, 6 × 24FC.		

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

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]
$2 \leqslant d < 4$	7	—
$4 \leqslant d < 6$	6	8
$6 \leqslant d < 8$	5	7
$\geqslant 8$	4	6
[a] For example, 6 × 24FC.		

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 × rope diameter (d).

For other single-layer ropes with round strands (except those with three or four strands), parallel-lay closed ropes and rotation-resistant ropes with round strands or shaped strands, the length of lay of the finished rope shall not exceed 7,25 × rope diameter (d).

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

— $\leqslant$ 400 m: $^{+5}_{0}$ %;

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

— > 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 Tables C.1 to C.14, or

b) as stated by the manufacturer.

For those ropes covered by Tables C.1 to C.14, the minimum breaking force of intermediate rope diameters shall be calculated using the formula given in Annex D with the respective minimum breaking force factors as given in Table D.1.

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; and d) whether or not the manufacturer is operating a quality system in accordance with ISO 9001:2000 certified by an accredited third party certification body.

4.5.2 Ropes produced in series — Manufacturer operating a quality system in accordance with ISO 9001:2000 certified by an accredited third party certification body

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

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 Methods 2 and 3 (see 5.4.2 and 5.4.3),

on a sample from every twentieth production length.

Table 4 — Breaking force testing requirements

Min. breaking force factor	Manufacturer operating a quality system in accordance with ISO 9001:2000, certified by an accredited third party certification body	Manufacturer NOT operating a quality system in accordance with ISO 9001:2000, certified by an accredited third party certification body
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) or 5.4.3 (Method 3) on a sample from every twentieth production length relating to the subgroup of diameters.	Breaking force test in accordance with 5.4.1 (Method 1) on a sample from each production length.
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 Annex B.2 plus periodic test in accordance with 5.4.1 (Method 1), 5.4.2 (Method 2) or 5.4.3 (Method 3) on a sample from every twentieth production length of a given rope diameter and construction.	Breaking force test in accordance with 5.4.1 (Method 1) on a sample from each production length.
NOTE Breaking force type testing demonstrates that a steel wire rope produced in series and certified by the manufacturer as conforming to this International Standard 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

Compliance 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

Compliance 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.

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

5.4 Test on rope for breaking force

5.4.1 Method 1 — Measured breaking force, F_m

The method of test and acceptance criteria shall be in accordance with ISO 3108 except for the following:

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;

d) the test may be terminated without breaking the rope when the minimum breaking force is reached or exceeded;

e) the test may be discounted where the rope fractures within a distance equivalent to six rope diameters from the base of the grip or the termination and the minimum breaking force has not been reached;

f) when the minimum breaking force value is not reached, three additional tests may be carried out, one of which shall achieve or exceed the minimum breaking force value.

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 D, 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.

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.

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.

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 compliance with this standard.

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.

The certificate number shall enable traceability of the rope.

The issuing of a certificate by the manufacturer and whether or not, and which, 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.

6.2 Packaging and marking

6.2.1 Packaging

Ropes shall be supplied on reels.

The purchaser should specify any particular packaging requirements.

6.2.2 Marking

The manufacturer's name and address and certificate number shall be legibly and durably marked on a tag attached to the reel.

Annex A
(normative)

Dimensional and mechanical properties of round wires (before ropemaking)

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 tensile strength grade are the lower (minima) limits for each tensile strength grade.

Table A.1 — Permitted variations in tensile strength

Nominal diameter mm	Permitted variation in tensile strength above nominal N/mm^2
$0,2 \leqslant \delta < 0,5$	390
$0,5 \leqslant \delta < 1,0$	350
$1,0 \leqslant \delta < 1,5$	320
$1,5 \leqslant \delta < 2,0$	290
$2,0 \leqslant \delta < 3,5$	260
$3,5 \leqslant \delta < 7,0$	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.

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	Tolerance		Minimum number of torsions based on test length of $100 \times \delta$								Minimum mass of zinc	
	Bright and galv. or Zn95/Al5 Quality B	Galv. or Zn95/Al5 Quality A	Bright and galvanized or Zn95/Al5 Quality B					Galvanized or Zn95/Al5 Quality A			Galvanized or Zn95/Al5	
mm	mm		Tensile strength grade (N/mm^2)								g/m^2	
			1 370	1 570	1 770	1 960	2 160	1 370	1 570	1 770	1 960	B	A
$0,20 \leqslant \delta < 0,25$	±0,008	—										20	
$0,25 \leqslant \delta < 0,30$	±0,008	—										30	
$0,30 \leqslant \delta < 0,40$	±0,01	±0,025										30	
$0,40 \leqslant \delta < 0,50$	±0,01	±0,025										40	75
$0,50 \leqslant \delta < 0,55$	±0,015	±0,03	34	30	28	25	23					50	90
$0,55 \leqslant \delta < 0,60$	±0,015	±0,03	34	30	28	25	23					50	90
$0,60 \leqslant \delta < 0,65$	±0,015	±0,03	34	30	28	25	23					60	120
$0,65 \leqslant \delta < 0,70$	±0,015	±0,03	34	30	28	25	23					60	120
$0,70 \leqslant \delta < 0,75$	±0,015	±0,03	34	30	28	25	23		21	19	17	60	120
$0,75 \leqslant \delta < 0,80$	±0,015	±0,03	34	30	28	25	23		21	19	17	60	120
$0,80 \leqslant \delta < 0,85$	±0,015	±0,03	34	30	28	25	22		21	19	17	60	140
$0,85 \leqslant \delta < 0,90$	±0,015	±0,03	34	30	28	25	22		21	19	17	60	140
$0,90 \leqslant \delta < 0,95$	±0,015	±0,03	34	30	28	25	22		21	19	17	70	150
$0,95 \leqslant \delta < 1,00$	±0,015	±0,03	34	30	28	25	22		21	19	17	70	150
$1,00 \leqslant \delta < 1,10$	±0,02	±0,04	33	29	26	23	21		20	18	13	80	160
$1,10 \leqslant \delta < 1,20$	±0,02	±0,04	33	29	26	23	21		20	18	13	80	160
$1,20 \leqslant \delta < 1,30$	±0,02	±0,04	33	28	25	22	20		18	15	10	90	170
$1,30 \leqslant \delta < 1,40$	±0,02	±0,04	33	28	25	22	19		18	15	10	90	170
$1,40 \leqslant \delta < 1,50$	±0,02	±0,04	33	28	25	22	19		18	15	10	100	180
$1,50 \leqslant \delta < 1,60$	±0,02	±0,04	33	28	25	22	19		18	15	10	100	180
$1,60 \leqslant \delta < 1,70$	±0,02	±0,04	33	28	25	22	19		18	15	10	100	200
$1,70 \leqslant \delta < 1,80$	±0,02	±0,05	33	28	25	22	19		18	15	10	100	200
$1,80 \leqslant \delta < 1,90$	±0,025	±0,05	32	27	24	21	18		17	14	9	100	200
$1,90 \leqslant \delta < 2,00$	±0,025	±0,05	32	27	24	21	18		17	14	9	110	215
$2,00 \leqslant \delta < 2,10$	±0,025	±0,05	32	27	24	21	18		17	14	9	110	215
$2,10 \leqslant \delta < 2,20$	±0,025	±0,06	32	27	24	21	18		17	14	9	110	215
$2,20 \leqslant \delta < 2,30$	±0,025	±0,06	31	27	24	21	18	20	17	14	9	125	230
$2,30 \leqslant \delta < 2,40$	±0,025	±0,06	30	27	24	21	18	20	17	14	9	125	230
$2,40 \leqslant \delta < 2,50$	±0,025	±0,06	29	26	23	20	18	19	15	12	7	125	230
$2,50 \leqslant \delta < 2,60$	±0,025	±0,06	29	26	23	20	18	19	15	12	7	125	230
$2,60 \leqslant \delta < 2,70$	±0,025	±0,06	29	26	23	20	18	19	15	12	7	125	230
$2,70 \leqslant \delta < 2,80$	±0,025	±0,06	29	26	23	20	18	19	15	12	7	135	240
$2,80 \leqslant \delta < 2,90$	±0,03	±0,07	28	26	23	20	18	19	15	12	7	135	240
$2,90 \leqslant \delta < 3,00$	±0,03	±0,07	28	26	23	20	18	18	15	12	7	135	240
$3,00 \leqslant \delta < 3,10$	±0,03	±0,07	27	25	21	18	16	18	12	8	5	135	240

Table A.2 (*continued*)

Nominal diameter of wire	Tolerance		Minimum number of torsions based on test length of $100 \times \delta$									Minimum mass of zinc	
	Bright and galv. or Zn95/Al5 Quality B	Galv. or Zn95/Al5 Quality A	Bright and galvanized or Zn95/Al5 Quality B					Galvanized or Zn95/Al5 Quality A				Galvanized or Zn95/Al5	
mm	mm		Tensile strength grade (N/mm^2)									g/m^2	
			1 370	1 570	1 770	1 960	2 160	1 370	1 570	1 770	1 960	B	A
$3,10 \leqslant \delta < 3,20$	±0,03	±0,07	27	25	21	18	16	13	12	8	5	135	240
$3,20 \leqslant \delta < 3,30$	±0,03	±0,07	27	25	21	18	16	13	12	8	5	135	250
$3,30 \leqslant \delta < 3,40$	±0,03	±0,07	27	25	21	18	16	13	12	8	5	135	250
$3,40 \leqslant \delta < 3,50$	±0,03	±0,07	27	25	21	18	16	13	12	8	5	135	250
$3,50 \leqslant \delta < 3,60$	±0,03	±0,07	26	24	20	16	14	11	10	6	5	135	250
$3,60 \leqslant \delta < 3,70$	±0,03	±0,07	26	24	20	16	14	11	10	6	5	135	260
$3,70 \leqslant \delta < 3,80$	±0,03	±0,07	25	23	19	15	13	11	8	6	5	135	260
$3,80 \leqslant \delta < 3,90$	±0,03	±0,07	24	22	18	14	12	11	7	6	4	135	260
$3,90 \leqslant \delta < 4,00$	±0,03	±0,07	24	22	18	14	12	10	7	6	4	135	260
$4,00 \leqslant \delta < 4,20$	±0,03	±0,08	23	21	17	13	11	9	6	6	4	150	275
$4,20 \leqslant \delta < 4,40$	±0,03	±0,08	21	19	15	11		8	6	5	4	150	275
$4,40 \leqslant \delta < 4,60$	±0,03	±0,08	20	18	14	10		7	6	5		150	275
$4,60 \leqslant \delta < 4,80$	±0,03	±0,08	18	16	12	8		6	5	4		150	275
$4,80 \leqslant \delta < 5,00$	±0,03	±0,08	17	14	11	7		5	4	3		150	275
$5,00 \leqslant \delta < 5,20$	±0,03	±0,08	17	14	11	7		5	4	3		150	300
$5,20 \leqslant \delta < 5,40$	±0,03	±0,08	14	12	10			5	4	3		160	300
$5,40 \leqslant \delta < 5,60$	±0,04	±0,09	12	10	8			4	3	2		160	300
$5,60 \leqslant \delta < 5,80$	±0,04	±0,09	10	8	6			3	2	2		160	300
$5,80 \leqslant \delta < 6,00$	±0,04	±0,09	8	6	6			3	2	2		160	300
$6,00 \leqslant \delta < 6,25$	±0,04	±0,09	8	6	6			3	2	2		160	300
$6,25 \leqslant \delta < 6,50$	±0,04	±0,09	7	6	5			2	2			160	300
$6,50 \leqslant \delta < 6,75$	±0,04	±0,09	6	5	4			2	2			160	300
$6,75 \leqslant \delta < 7,00$	±0,04	±0,10	6	5	4			2	2			160	300

Annex B
(normative)

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

B.1 Ropes having same min. breaking force factor throughout rope diameter subgroup

The manufacturer shall divide the intended size range into subgroups 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 subgroups representing the intended range and having the same construction, grade and minimum breaking force factor, 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 different nominal diameters.

If all three samples pass the test, all rope sizes within that subgroup 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 subgroup until the requirements are met.

B.2 Ropes having different min. breaking force factors throughout rope diameter subgroup

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, the diameter and construction having that particular minimum breaking force factor shall be deemed to have satisfied the breaking force type testing requirements.

If any 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.

Annex C
(normative)

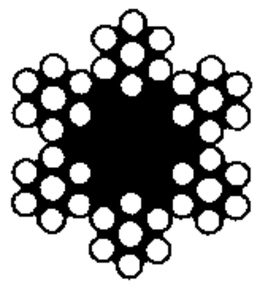
Tables of minimum breaking forces for more common rope classes, sizes and grades

Tables C.1 to C.14 present the minimum breaking forces for the more common classes, sizes and grades of rope.

Higher values of minimum breaking force than those given in these tables may be specified by the manufacturer.

NOTE The values of approximate nominal length mass are given for information.

Table C.1 — Class 6 × 7 with fibre core

Typical cross-section	Typical construction			
	Rope construction	Strand construction	Outer wires	
			Total	Per strand
	6 × 7-FC	1-6	36	6

Nominal rope diameter	Approximate nominal length mass	Minimum breaking force	
		Grade 1770	Grade 1960
mm	kg/100 m	kN	kN
6[a]	12,4	21,2	23,4
6,35	—	—	—
7[a]	16,9	21,8	31,9
7,94	—	—	—
8[a]	22,1	37,6	41,6
9[a]	27,9	47,6	52,7
9,5	—	—	—
10[a]	34,5	58,8	65,1
11[a]	41,7	71,1	78,7
11,1	—	—	—
12[a]	49,7	84,6	93,7
12,7	—	—	—
13[a]	58,3	99,3	110
14[a]	67,6	115	128
14,3	—	—	—
15,9	—	—	—
16[a]	88,3	150	167
18[a]	112	190	211
19[a]	125	212	235
19,1	—	—	—
20[a]	138	235	260
22[a]	167	284	315
22,2	—	—	—
24[a]	199	338	375
25,4	—	—	—
26[a]	233	397	440
28[a]	270	461	510
28,6	—	—	—
31,8	—	—	—
32[a]	353	602	666
34,9	—	—	—
35[a]	423	720	797
36[a]	447	762	843
38	498	849	940
38,1	—	—	—
40[a]	552	940	1 040

[a] Preferred sizes.

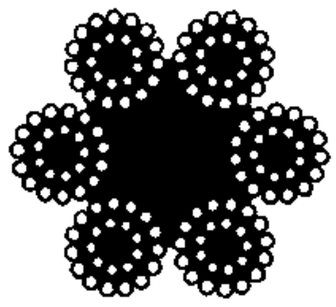
Table C.2 — Class 6 × 7 with steel core

Typical cross-section		Typical construction			
		Rope construction	Strand construction	Outer wires	
				Total	Per strand
		6 × 7-WSC	1-6	36	6
		6 × 7-IWRC	1-6	36	6
Nominal rope diameter	**Approximate nominal length mass**	**Minimum breaking force[a]**			
		Grade 1770		Grade 1960	
mm	kg/100 m	kN		kN	
6[b]	13,8	22,9		25,3	
6,35	—	—		—	
7[b]	18,8	31,1		34,5	
7,94	—	—		—	
8[b]	24,6	40,7		45,0	
9[b]	31,1	51,5		57,0	
9,5	—	—		—	
10[b]	38,4	63,5		70,4	
11[b]	46,5	76,9		85,1	
11,1	—	—		—	
12[b]	55,3	91,5		101	
12,7	—	—		—	
13[b]	64,9	107		119	
14[b]	75,3	125		138	
14,3	—	—		—	
15,9	—	—		—	
16[b]	96,3	163		180	
18[b]	124	206		228	
19[b]	139	229		254	
19,1	—	—		—	
20[b]	154	254		281	
22[b]	186	308		341	
22,2	—	—		—	
24[b]	221	366		405	
25,4	—	—		—	
26[b]	260	430		476	
28[b]	301	498		552	
28,6	—	—		—	
31,8	—	—		—	
32[b]	393	651		721	
34,9	—	—		—	
35[b]	470	778		778	
36[b]	498	824		912	
38[b]	554	918		1 020	
38,1	—	—		—	
40[b]	614	1 020		1 130	

[a] The values shown are for ropes with IWRC.

[b] Preferred sizes.

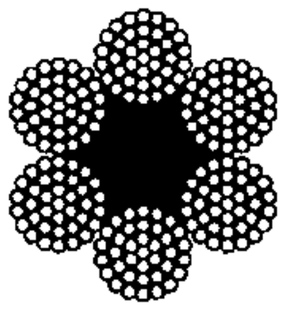
Table C.3 — Class 6 × 24FC with fibre core

Typical cross-section	Typical construction			
	Rope construction	Strand construction	Outer wires	
			Total	Per strand
	6 × 24FC-FC	FC-12/12	72	12
	6 × 24FC-FC	FC-9/15	90	15

Nominal rope diameter	Approximate nominal length mass	Minimum breaking force
		Grade 1570
mm	kg/100 m	kN
8[a]	20,1	28,7
9[a]	25,4	36,4
9,5	28,3	40,5
10[a]	31,4	44,9
11[a]	38,0	54,3
11,1	38,7	55,3
12[a]	45,2	64,7
12,7	50,6	72,4
13[a]	53,1	75,9
14[a]	61,5	88,0
14,3	64,2	91,8
15,9	79,4	114
16[a]	80,4	115
18[a]	102	145
19[a]	113	162
19,1	115	164
20[a]	126	180
22[a]	152	217
22,2	155	221
24[a]	181	259
25,4	203	290
26[a]	212	304
28[a]	246	352
28,6	257	367
31,8	318	454
32[a]	322	460
34,9	382	547
35[a]	385	550
36	407	582
38[a]	453	648
38,1	456	652
40[a]	502	718

[a] Preferred sizes.

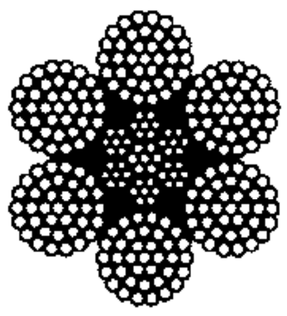
Table C.4 — Class 6 × 37M with fibre core

Typical cross-section	Typical construction			
	Rope construction	Strand construction	Outer wires	
			Total	Per strand
	6 × 37M-FC	1-6/12/18	108	18

Nominal rope diameter	Approximate nominal length mass	Minimum breaking force	
		Grade 1770	Grade 1960
mm	kg/100m	kN	kN
5 [a]	8,65	13,1	14,5
6 [a]	12,5	18,8	20,8
6,35	—	—	—
7 [a]	17,0	25,6	28,3
7,94	—	—	—
8 [a]	22,1	33,4	37,0
9 [a]	28,0	42,3	46,8
9,5	—	—	—
10 [a]	34,6	52,2	57,8
11 [a]	41,9	63,2	70,0
11,1	—	—	—
12 [a]	49,8	75,2	83,3
12,7	—	—	—
13 [a]	58,5	88,2	97,7
14 [a]	67,8	102	113
14,3	—	—	—
15,9	—	—	—
16 [a]	88,6	134	148
18 [a]	112	169	187
19 [a]	125	188	209
19,1	—	—	—
20 [a]	138	209	231
22 [a]	167	253	280
22,2	—	—	—
24 [a]	199	301	333
25,4	—	—	—
26 [a]	239	353	391
28 [a]	271	409	453
28,6	—	—	—
31,8	—	—	—
32 [a]	354	535	592
34,9	—	—	—
35 [a]	424	640	708
36 [a]	448	677	749
38 [a]	500	754	835
38,1	—	—	—
40 [a]	554	835	925
41,3	—	—	—
44	670	1 010	1 120
44,5	—	—	—
45	701	1 060	1 170
47,6	—	—	—
48	797	1 200	1 330
50,8	—	—	—
51	900	1 360	1 500
52	936	1 410	1 560
54,0	—	—	—
56	1 090	1 640	1 810
57,2	—	—	—
60	1 250	1 880	2 080

[a] Preferred sizes.

Table C.5 — Class 6 × 37M with steel core

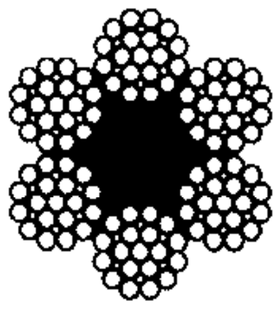
Typical cross-section	Typical construction			
	Rope construction	Strand construction	Outer wires	
			Total	Per strand
	6 × 37M-IWRC	1-6/12/18	108	18

Nominal rope diameter	Approximate nominal length mass	Minimum breaking force[a]	
		Grade 1770	Grade 1960
mm	kg/100 m	kN	kN
8[b]	24,4	39,2	43,4
9[b]	30,9	49,6	54,9
9,5	—	—	—
10[b]	38,1	61,2	67,8
11[b]	46,1	74,1	82,1
11,1	—	—	—
12[b]	54,9	88,2	97,7
12,7	—	—	—
13[b]	64,4	95,4	106
14[b]	74,7	111	126
14,3	—	—	—
15,9	—	—	—
16[b]	97,5	145	160
18[b]	123	183	203
19[b]	138	204	226
19,1	—	—	—
20[b]	152	226	250
22[b]	184	273	303
22,2	—	—	—
24[b]	219	325	360
25,4	—	—	—
26[b]	258	382	423
28[b]	299	443	490
28,6	—	—	—
31,8	—	—	—
32[b]	390	578	640
34,9	—	—	—
35[b]	467	692	766
36[b]	494	732	810
38[b]	550	815	903
38,1	—	—	—
40[b]	610	903	1 000
41,3	—	—	—
44	738	1 090	1 210
44,5	—	—	—
45	772	1 140	1 270
47,6	—	—	—
48	878	1 300	1 440
50,8	—	—	—
51	991	1 470	1 630
52	1 030	1 530	1 690
54,0	—	—	—
56	1 190	1 770	1 960
57,2	—	—	—
60	1 370	2 030	2 250

[a] The values shown are for ropes with IWRC.

[b] Preferred sizes.

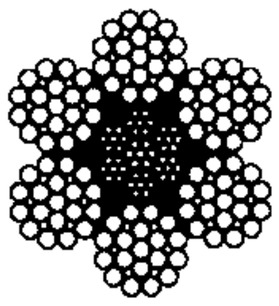
Table C.6 — Class 6 × 19 with fibre core

Typical cross-section	Typical construction			
	Rope construction	Strand construction	Outer wires	
			Total	Per strand
	6 × 19S-FC	1-9-9	54	9
	6 × 21F-FC	1-5-5F-10	60	10
	6 × 26WS-FC	1-5-5+5-10	60	10
	6 × 19W-FC	1-6-6+6	36	12
	6 × 25F-FC	1-6-6F-12	72	12

Nominal rope diameter	Approximate nominal length mass	Minimum breaking force		
		Grade 1770	Grade 1960	Grade 2160
mm	kg/100 m	kN	kN	kN
6[a]	12,9	21,0	23,3	25,7
6,35	—	—	—	—
7[a]	17,6	28,6	31,7	34,9
7,94	—	—	—	—
8[a]	23,0	37,4	41,4	45,6
9[a]	29,1	47,3	52,4	57,7
9,5	—	—	—	—
10[a]	35,9	58,4	64,7	71,3
11[a]	43,3	70,7	78,3	86,2
11,1	—	—	—	—
12[a]	51,7	84,1	93,1	103
12,7	—	—	—	—
13[a]	60,7	98,7	109	120
14[a]	70,4	114	127	140
14,3	—	—	—	—
15,9	—	—	—	—
16[a]	91,9	150	166	182
18[a]	116	189	210	231
19[a]	130	211	233	257
19,1	—	—	—	—
20[a]	144	234	259	285
22[a]	174	283	313	345
22,2	—	—	—	—
24[a]	207	336	373	411
25,4	—	—	—	—
26[a]	243	395	437	482
28[a]	281	458	507	559
28,6	—	—	—	—
31,8	—	—	—	—
32[a]	368	598	662	730
34,9	—	—	—	—
35[a]	440	716	792	873
36[a]	465	757	838	924
38[a]	518	843	934	1 030
38,1	—	—	—	—
40[a]	574	935	1 040	1 140
41,3	—	—	—	—
44[a]	695	1 130	1 250	1 380
44,5	—	—	—	—
45[a]	727	1 180	1 310	1 440
47,6	—	—	—	—
48[a]	827	1 350	1 490	1 640
50,8	—	—	—	—
51[a]	934	1 520	1 680	1 850
52[a]	971	1 580	1 750	1 930
54,0	—	—	—	—
56[a]	1 130	1 830	2 030	2 240
57,2	—	—	—	—
60[a]	1 290	2 100	2 330	2 570

[a] **Preferred sizes.**

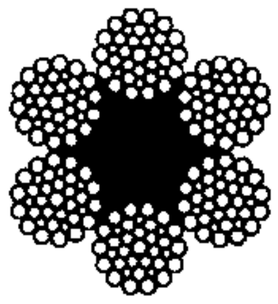
Table C.7 — Class 6 × 19 with steel core

Typical cross-section	Typical construction			
	Rope construction	Strand construction	Outer wires	
			Total	Per strand
	6 × 19S-IWRC	1-9-9	54	9
	6 × 21F-IWRC	1-5-5F-10	60	10
	6 × 26WS-IWRC	1-5-5+5-10	60	10
	6 × 19W-IWRC	1-6-6+6	36	12
	6 × 25F-IWRC	1-6-6F-12	72	12

Nominal rope diameter	Approximate nominal length mass	Minimum breaking force		
		Grade 1770	Grade 1960	Grade 2160
mm	kg/100 m	kN	kN	kN
6[a]	14,4	22,7	25,1	27,7
6,35	—	—	—	—
7[a]	19,6	30,9	34,2	37,7
7,94	—	—	—	—
8[a]	25,6	40,3	44,7	49,2
9[a]	32,4	51,0	56,5	62,3
9,5	—	—	—	—
10[a]	40,0	63,0	69,8	76,9
11[a]	48,4	76,2	84,4	93,0
11,1	—	—	—	—
12[a]	57,6	90,7	100	111
12,7	—	—	—	—
13[a]	67,6	106	118	130
14[a]	78,4	124	137	151
14,3	—	—	—	—
15,9	—	—	—	—
16[a]	102	161	179	197
18[a]	130	204	226	249
19[a]	144	227	252	278
19,1	—	—	—	—
20[a]	160	252	279	308
22[a]	194	305	338	372
22,2	—	—	—	—
24[a]	230	363	402	443
25,4	—	—	—	—
26[a]	270	426	472	520
28[a]	314	494	547	603
28,6	—	—	—	—
31,8	—	—	—	—
32[a]	410	645	715	787
34,9	—	—	—	—
35[a]	490	772	855	942
36[a]	518	817	904	997
38[a]	578	910	1 010	1 110
38,1	—	—	—	—
40[a]	640	1 010	1 120	1 230
41,3	—	—	—	—
44[a]	774	1 220	1 350	1 490
44,5	—	—	—	—
45[a]	810	1 280	1 410	1 560
47,6	—	—	—	—
48[a]	922	1 450	1 610	1 770
50,8	—	—	—	—
51[a]	1 040	1 640	1 810	2 000
52[a]	1 080	1 700	1 890	2 080
54,0	—	—	—	—
56[a]	1 250	1 980	2 190	2 410
57,2	—	—	—	—
60[a]	1 440	2 270	2 510	2 770

[a] **Preferred sizes.**

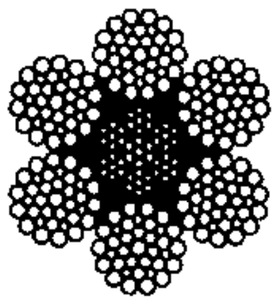
Table C.8 — Class 6 × 36 with fibre core

Typical cross-section	Typical construction			
	Rope construction	Strand construction	Outer wires	
			Total	Per strand
	6 × 31WS-FC	1-6-6+6-12	72	12
	6 × 36WS-FC	1-7-7+7-14	84	14
	6 × 41WS-FC	1-8-8+8-16	96	16
	6 × 41F-FC	1-8-8-8F-16	96	16
	6 × 49WS-FC	1-8-8-8+8-16	96	16
	6 × 46SW-CF	1-9-9+9-18	108	18

Nominal rope diameter	Approximate nominal length mass	Minimum breaking force		
		Grade 1770	Grade 1960	Grade 2160
mm	kg/100 m	kN	kN	kN
6,35	—	—	—	—
7[a]	18,0	28,6	31,7	34,9
7,94	—	—	—	—
8[a]	23,5	37,4	41,4	45,6
9[a]	29,7	47,3	52,4	57,7
9,5	—	—	—	—
10[a]	36,7	58,4	64,7	71,3
11[a]	44,4	70,7	78,3	86,2
11,1	—	—	—	—
12[a]	52,8	84,1	93,1	103
12,7	—	—	—	—
13[a]	62,0	98,7	109	120
14[a]	71,9	114	127	140
14,3	—	—	—	—
15,9	—	—	—	—
16[a]	94,0	150	166	182
18[a]	119	189	210	231
19[a]	132	211	233	257
19,1	—	—	—	—
20[a]	147	234	259	285
22[a]	178	283	313	345
22,2	—	—	—	—
24[a]	211	336	373	411
25,4	—	—	—	—
26[a]	248	395	437	482
28[a]	288	458	507	559
28,6	—	—	—	—
31,8	—	—	—	—
32[a]	376	598	662	730
34,9	—	—	—	—
35[a]	450	716	792	873
36[a]	476	757	838	924
38[a]	530	843	934	1 030
38,1	—	—	—	—
40[a]	587	935	1 040	1 140
41,3	—	—	—	—
44[a]	711	1 130	1 250	1 380
44,5	—	—	—	—
45[a]	743	1 180	1 310	1 440
47,6	—	—	—	—
48[a]	846	1 350	1 490	1 640
50,8	—	—	—	—
51[a]	955	1 520	1 680	1 850
52[a]	992	1 580	1 750	1 930
54,0	—	—	—	—
56[a]	1 150	1 830	2 030	2 240
57,2	—	—	—	—
60[a]	1 320	2 100	2 330	2 570

[a] Preferred sizes.

Table C.9 — Class 6 × 36 with steel core

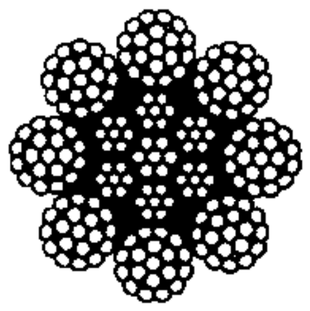
Typical cross-section	Typical construction			
	Rope construction	Strand construction	Outer wires	
			Total	Per strand
	6 × 31WS-IWRC	1-6-6+6-12	72	12
	6 × 36WS-IWRC	1-7-7+7-14	84	14
	6 × 41WS-IWRC	1-8-8+8-16	96	16
	6 × 41F-IWRC	1-8-8-8F-16	96	16
	6 × 49SWS-IWRC	1-8-8-8+8-16	96	16
	6 × 46WS-IWRC	1-9-9+9-18	108	18

Nominal rope diameter	Approximate nominal length mass	Minimum breaking force		
		Grade 1770	Grade 1960	Grade 2160
mm	kg/100 m	kN	kN	kN
6,35	—	—	—	—
7[a]	20,0	30,9	34,2	37,7
7,94	—	—	—	—
8[a]	26,2	40,3	44,7	49,2
9[a]	33,1	51,0	56,5	62,3
9,5	—	—	—	—
10[a]	40,9	63,0	69,8	76,9
11[a]	49,5	76,2	84,4	93,0
11,1	—	—	—	—
12[a]	58,9	90,7	100	111
12,7	—	—	—	—
13[a]	69,1	106	118	130
14[a]	80,2	124	137	151
14,3	—	—	—	—
15,9	—	—	—	—
16[a]	105	161	179	197
18[a]	133	204	226	249
19[a]	148	227	252	278
19,1	—	—	—	—
20[a]	164	252	279	308
22[a]	198	305	338	372
22,2	—	—	—	—
24[a]	236	363	402	443
25,4	—	—	—	—
26[a]	276	426	472	520
28[a]	321	494	547	603
28,6	—	—	—	—
31,8	—	—	—	—
32[a]	419	645	715	787
34,9	—	—	—	—
35[a]	501	772	855	942
36[a]	530	817	904	997
38[a]	591	910	1 010	1 110
38,1	—	—	—	—
40[a]	654	1 010	1 120	1 230
41,3	—	—	—	—
44[a]	792	1 220	1 350	1 490
44,5	—	—	—	—
45[a]	828	1 280	1 410	1 560
47,6	—	—	—	—
48[a]	942	1 450	1 610	1 770
50,8	—	—	—	—
51[a]	1 060	1 640	1 810	2 000
52[a]	1 110	1 700	1 890	2 080
54,0	—	—	—	—
56[a]	1 260	1 980	2 190	2 410
57,2	—	—	—	—
60[a]	1 470	2 270	2 510	2 770

[a] Preferred sizes.

Table C.10 — Class 8 × 19 with steel core

Typical cross-section

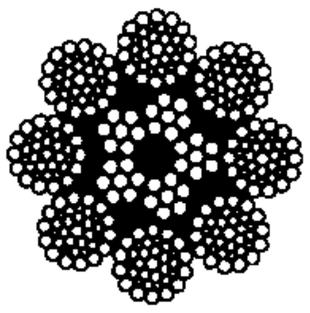


Typical construction			
Rope construction	Strand construction	Outer wires	
		Total	Per strand
8 × 19S-IWRC	1-9-9	72	9
8 × 21F-IWRC	1-5-5F-10	80	10
8 × 26WS-IWRC	1-5-5+5-10	80	10
8 × 19W-IWRC	1-6-6+6	96	12
8 × 25F-IWRC	1-6-6F-12	96	12

Nominal rope diameter	Approximate nominal length mass	Minimum breaking force		
		Grade 1770	Grade 1960	Grade 2160
mm	kg/100 m	kN	kN	kN
6,35	—	—	—	—
7[a]	19,9	30,9	34,2	37,7
7,94	—	—	—	—
8[a]	26,0	40,3	44,7	49,2
9[a]	33,0	51,0	56,5	62,3
9,5	—	—	—	—
10[a]	40,7	63,0	69,8	76,9
11[a]	49,2	76,2	84,4	93,0
11,1	—	—	—	—
12[a]	58,6	90,7	100	111
12,7	—	—	—	—
13[a]	68,8	106	118	130
14[a]	79,8	124	137	151
14,3	—	—	—	—
15,9	—	—	—	—
16[a]	104	161	179	197
18[a]	132	204	226	249
19[a]	147	227	252	278
19,1	—	—	—	—
20[a]	163	252	279	308
22[a]	197	305	338	372
22,2	—	—	—	—
24[a]	234	363	402	443
25,4	—	—	—	—
26[a]	275	426	472	520
28[a]	319	494	547	603
28,6	—	—	—	—
31,8	—	—	—	—
32[a]	417	645	715	787
34,9	—	—	—	—
35[a]	499	772	855	942
36[a]	527	817	904	997
38[a]	588	910	1 010	1 110
38,1	—	—	—	—
40[a]	651	1 010	1 120	1 230
41,3	—	—	—	—
44[a]	788	1 220	1 350	1 490
44,5	—	—	—	—
45[a]	824	1 280	1 410	1 560
47,6	—	—	—	—
48[a]	938	1 450	1 610	1 770
50,8	—	—	—	—
51[a]	1 060	1 640	1 810	2 000
52[a]	1 110	1 700	1 890	2 080
54,0	—	—	—	—
56[a]	1 280	1 980	2 190	2 410
57,2	—	—	—	—
60[a]	1 470	2 270	2 510	2 770

[a] Preferred sizes.

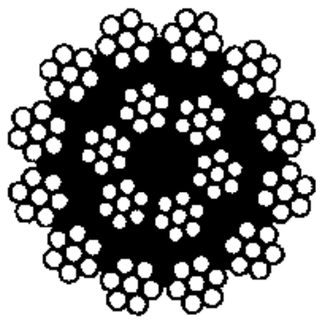
Table C.11 — Class 8 × 36 with steel core

Typical cross-section	Typical construction			
	Rope construction	Strand construction	Outer wires	
			Total	Per strand
	8 × 31WS-IWRC	1-6-6+6-12	96	12
	8 × 36WS-IWRC	1-7-7+7-14	112	14
	8 × 41WS-IWRC	1-8-8+8-16	128	16
	8 × 41F-IWRC	1-8-8-8F-16	128	16
	8 × 49SWS-IWRC	1-8-8-8+8-16	128	16

Nominal rope diameter	Approximate nominal length mass	Minimum breaking force		
		Grade 1770	Grade 1960	Grade 2160
mm	kg/100 m	kN	kN	kN
8[a]	26,7	40,3	44,7	49,2
9[a]	33,8	51,0	56,5	62,3
9,5	—	—	—	—
10[a]	41,7	63,0	69,8	76,9
11[a]	50,5	76,2	84,4	93,0
11,1	—	—	—	—
12[a]	60,0	90,7	100	111
12,7	—	—	—	—
13[a]	70,5	106	118	130
14[a]	81,7	124	137	151
14,3	—	—	—	—
15,9	—	—	—	—
16[a]	107	161	179	197
18[a]	135	204	226	249
19[a]	151	227	252	278
19,1	—	—	—	—
20[a]	167	252	279	308
22[a]	202	305	338	372
22,2	—	—	—	—
24[a]	240	363	402	443
25,4	—	—	—	—
26[a]	282	426	472	520
28[a]	327	494	547	603
28,6	—	—	—	—
31,8	—	—	—	—
32[a]	427	645	715	787
34,9	—	—	—	—
35[a]	511	772	855	942
36[a]	540	817	904	997
38[a]	602	910	1 010	1 110
38,1	—	—	—	—
40[a]	667	1 010	1 120	1 230
41,3	—	—	—	—
44[a]	807	1 220	1 350	1 490
44,5	—	—	—	—
45[a]	844	1 280	1 410	1 560
47,6	—	—	—	—
48[a]	961	1 450	1 610	1 770
50,8	—	—	—	—
51[a]	1 080	1 640	1 810	2 000
52[a]	1 130	1 700	1 890	2 080
54,0	—	—	—	—
56[a]	1 310	1 980	2 190	2 410
57,2	—	—	—	—
60[a]	1 500	2 270	2 510	2 770

[a] Preferred sizes.

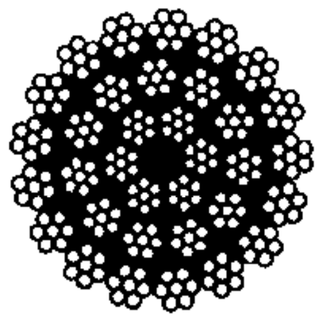
Table C.12 — Class 18 × 7

Typical cross-section	Typical construction			
	Rope construction	Strand construction	Outer wires	
			Total	Per strand
	17 × 7-FC	1-6	66	6
	17 × 7-WSC	1-6	66	6
	18 × 7-FC	1-6	72	6
	18 × 7-WSC	1-6	72	6

Nominal rope diameter	Approximate nominal length mass		Minimum breaking force		
	Rope with FC centre	Rope with WSC centre	Grade 1770	Grade 1960	Grade 2160
mm	kg/100 m	kg/100 m	kN	kN	kN
6[a]	13,8	14,4	20,9	23,1	25,5
6,35	—	—	—	—	—
7[a]	18,7	19,6	28,4	31,5	34,7
7,94	—	—	—	—	—
8[a]	24,4	25,7	37,2	41,1	45,3
9[a]	30,9	32,5	47,0	52,1	57,4
9,5	—	—	—	—	—
10[a]	38,2	40,1	58,1	64,3	70,8
11[a]	46,2	48,5	70,2	77,8	85,7
11,1	—	—	—	—	—
12[a]	55,0	57,7	83,6	92,6	102
12,7	—	—	—	—	—
13[a]	64,6	67,8	98,1	109	120
14[a]	74,9	78,6	114	126	139
14,3	—	—	—	—	—
15,9	—	—	—	—	—
16[a]	97,8	103	149	165	181
18[a]	124	130	188	208	230
19[a]	138	145	210	232	256
19,1	—	—	—	—	—
20[a]	153	160	232	257	283
22[a]	185	194	281	311	343
22,2	—	—	—	—	—
24[a]	220	231	334	370	408
25,4	—	—	—	—	—
26[a]	258	271	392	435	479
28[a]	299	314	455	504	555
28,6	—	—	—	—	—
31,8	—	—	—	—	—
32[a]	391	411	594	658	725
34,9	—	—	—	—	—
35[a]	468	491	711	788	868
36[a]	495	520	752	833	918
38[a]	552	579	838	928	1 020
38,1	—	—	—	—	—

[a] Preferred sizes.

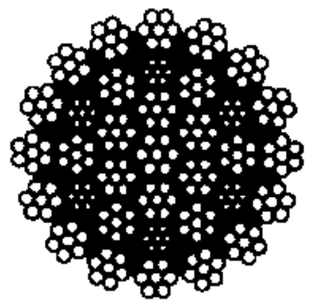
Table C.13 — Class 34(M) × 7

Typical cross-section	Typical construction			
	Rope construction	Strand construction	Outer wires	
			Total	Per strand
	34(M) × 7-FC	1-6	102	6
	34(M) × 7-WSC	1-6	102	6
	36(M) × 7-FC	1-6	108	6
	36(M) × 7-WSC	1-6	108	6

Nominal rope diameter	Approximate nominal length mass		Minimum breaking force	
	Rope with FC centre	Rope with WSC centre	Grade 1770	Grade 2160
mm	kg/100 m	kg/100 m	kN	kN
10[a]	39,0	40,1	56,3	62,3
11[a]	47,2	48,5	68,1	75,4
11,1	—	—	—	—
12[a]	56,2	57,7	81,1	89,8
12,7	—	—	—	—
13[a]	65,9	67,8	95,1	105
14[a]	76,4	78,6	110	122
14,3	—	—	—	—
15,9	—	—	—	—
16[a]	99,8	103	144	160
18[a]	126	130	182	202
19[a]	141	145	203	225
19,1	—	—	—	—
20[a]	156	160	225	249
22[a]	189	194	272	302
22,2	—	—	—	—
24[a]	225	231	324	359
25,4	—	—	—	—
26[a]	264	271	380	421
28[a]	306	314	441	489
28,6	—	—	—	—
31,8	—	—	—	—
32[a]	399	411	576	638
34,9	—	—	—	—
35[a]	478	491	690	764
36[a]	505	520	729	808
38[a]	563	579	813	900
38,1	—	—	—	—
40[a]	624	642	901	997
41,3	—	—	—	—
44[a]	755	776	1 090	1 210

[a] Preferred sizes.

Table C.14 — Class 35(W) × 7

Typical cross-section	Typical construction			
	Rope construction	Strand construction	Outer wires	
			Total	Per strand
	35(w) × 7	1-6	96	6
	40(w) × 7	1-6	108	6

Nominal rope diameter	Approximate nominal length mass	Minimum breaking force		
		Grade 1770	Grade 1960	Grade 2160
mm	kg/100 m	kN	kN	kN
8[a]	29,1	40,8	45,2	48,4
9[a]	36,8	51,6	57,2	61,2
9,5	—	—	—	—
10[a]	45,4	63,7	70,6	75,6
11[a]	54,9	77,1	85,4	91,5
11,1	—	—	—	—
12[a]	65,4	91,8	102	109
12,7	—	—	—	—
13[a]	76,7	108	119	128
14[a]	89,0	125	138	148
14,3	—	—	—	—
15,9	—	—	—	—
16[a]	116	163	181	194
18[a]	147	206	229	245
19[a]	164	230	255	273
19,1	—	—	—	—
20[a]	182	255	282	302
22[a]	220	308	342	366
22,2	—	—	—	—
24[a]	262	367	406	435
25,4	—	—	—	—
26[a]	307	431	477	511
28[a]	356	500	553	593
28,6	—	—	—	—
31,8	—	—	—	—
32[a]	465	652	723	774
34,9	—	—	—	—
35[a]	556	781	864	926
36[a]	588	826	914	980
38[a]	656	920	1 020	1 090
38,1	—	—	—	—
40[a]	726	1 020	1 130	1 210

[a] Preferred sizes.

Annex D
(normative)

Calculation of minimum breaking force for ropes in the Tables of Annex C

The minimum breaking force, F_{min}, expressed in kilonewtons, shall be calculated using the following equation:

$$F_{min} = \frac{d^2 \times R_r \times K}{1000}$$

where

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

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

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

The minimum breaking force factors for those ropes covered by Tables C.1 to C.14 are given in Table D.1.

Table D.1 — Minimum breaking force factors

Class	Minimum breaking force factor
6 × 7 with fibre core (see Table C.1)	0,332
6 × 7 with steel core (see Table C.2)	0,359
6 × 24FC with fibre core (see Table C.3)	0,286
6 × 37M with fibre core (see Table C.4)	0,295
6 × 37M with steel core (see Table C.5)	0,319
6 × 19 with fibre core (see Table C.6)	0,330
6 × 19 with steel core (see Table C.7)	0,356
6 × 36 with fibre core (see Table C.8)	0,330
6 × 36 with steel core (see Table C.9)	0,356
8 × 19 with steel core (see Table C.10)	0,356
8 × 36 with steel core (see Table C.11)	0,356
18 × 7 (see Table C.12)	0,328
34(M) × 7 (see Table C.13)	0,318
35(W) × 7 (see Table C.14)	0,360 (up to rope grade 1960) 0,350 (over rope 1960)

Annex E
(informative)

Tests on wires taken from the rope

E.1 General

If tests on wires are required to be carried out, these are usually in respect of diameter, tensile strength and torsions; and, when applicable, zinc coating.

For the purposes of evaluating the test results, the manufacturer should indicate the nominal dimensions and tensile strength grades of the wires.

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

NOTE These provisions do not apply to compacted strand ropes and compacted (swaged) ropes.

E.2 Sampling

For each layer of strands, including those in the core, one strand of each construction within that layer shall be selected and the wires tested. If there are more than eight strands of the same diameter and construction in one layer, the wires from two strands of that diameter and construction shall be tested.

Unless specified otherwise, the samples of wires taken for tests shall not include filler or centre wires.

E.3 Test methods and acceptance criteria

E.3.1 General

For each requirement, a maximum of 5 % of wires tested, rounded up to the nearest whole number of wires, shall be permitted to lie outside the values specified.

When the same wire fails in more than one test (e.g. torsion and tensile) this is counted as one failure.

E.3.2 Diameter

When tested in accordance with of ISO 2232:1990, 5.1, 5 % of the wires may exceed by up to 50 % the tolerance specified in Annex A.

E.3.3 Tensile strength

When tested in accordance with ISO 6892 or the method given in of ISO 10425:2003, B.2, the measured values shall be in accordance with the values in Annex A with an expanded tolerance of 50 N/mm^2 at the lower end.

For ropes with shaped (e.g. triangular) strands, the expanded tolerance at the lower end shall be equivalent to 5 % of the tensile strength grade of the wire.

E.3.4 Torsion

A length of 100d for the test piece between grips is preferred. If this length cannot be adopted, an alternative length shall be chosen at the wire manufacturer's discretion. In this case the number of torsions which the wire shall withstand shall be proportional to the numbers specified for a test length of 100d.

For ropes with round strands, when tested in accordance with ISO 7800 the method given in of ISO 10425:2003, B.3, as appropriate, the measured values of round wires of 0,5 mm diameter and larger shall be at least 85 % of the values specified in Annex A, rounded down to the next whole number.

For ropes with shaped strands with more than one layer of round wires in the strands, the values resulting from the above for round strands shall be reduced by one torsion each.

For ropes with shaped strands with only one layer of round wires in the strands, the values resulting from the above for round strands shall be reduced by two torsions each.

See E.3.5 for test on wires less than 0,5 mm.

E.3.5 Knot

This test shall apply to wires smaller than 0,5 mm diameter in substitution of the torsion test.

Each single wire with one simple knot shall withstand without breaking a force of at least 45 % of the force corresponding to the tensile strength grade.

E.3.6 Coating of wires

When measured in accordance with ISO 2232:1990, Annex A, the reduction of mass of zinc or Zn 95/Al 5 coating from the pre-spin (before ropemaking) minimum values shall not be more than the values shown in Table E.1.

Table E.1 — Permissible reduction of minimum mass of zinc coating of wires for stranded ropes

Minimum mass before ropemaking g/m^2	Reduction in mass of zinc after ropemaking g/m^2
< 40	2
40 to < 80	4
80 to < 120	6
120 to < 160	8
160 to < 200	10
200 to < 300	15
300 to < 400	20
> 400	25

Annex F
(informative)

Comparison between metric and imperial rope sizes

To assist in rope size selection the following Table compares the differences between metric and imperial nominal rope diameters and their respective diameter tolerances.

Table F.1 — Comparison between metric and imperial rope sizes

Nominal rope diameter		Diameter tolerance	
		Minimum	Maximum
mm	in	mm	mm
6[a]		6,00	6,36
6,35	1/4	6,35	6,73
7[a]		7,00	7,42
7,94	5/16	7,94	8,42
8[a]		8,00	8,40
9[a]		9,00	9,45
9,53	3/8	9,53	10,0
10[a]		10,0	10,5
11[a]		11,0	11,6
11,1	7/16	11,1	11,7
12[a]		12,0	12,6
12,7	1/2	12,7	13,3
13[a]		13,0	13,7
14[a]		14,0	14,7
14,3	9/16	14,3	15,0
15,9	5/8	15,9	16,7
16[a]		16,0	16,8
18[a]		18,0	18,9
19[a]		19,0	20,0
19,1	3/4	19,1	20,0
20[a]		20,0	21,0
22[a]		22,0	23,1
22,2	7/8	22,2	23,3
24[a]		24,0	25,2
25,4	1	25,4	26,7
26[a]		26,0	27,3
28[a]		28,0	29,4
28,6	1-1/8	28,6	30,0
31,8	1-1/4	31,8	33,3
32[a]		32,0	33,6
34,9	1-3/8	34,9	36,7
35[a]		35,0	36,8
36[a]		36,0	37,8
38[a]		38,0	39,9
38,1	1-1/2	38,1	40,0
40[a]		40,0	42,0
41,3	1-5/8	41,3	43,3
44[a]		44,0	46,2
44,5	1-3/4	44,5	46,7
45[a]		45,0	47,3
47,6	1-7/8	47,6	50,0
48[a]		48,0	50,4
50,8	2	50,8	53,3
51[a]		51,0	53,6
52[a]		52,0	54,6
54,0	2-1/8	54,0	56,7
56[a]		56,0	58,8
57,2	2-1/4	57,2	60,0
60[a]		60,0	63,0

[a] Preferred sizes.

Annex G
(informative)

Rope grade equivalents

See Table G.1.

Table G.1 — Comparison of rope grades – for guidance only

Rope grade designation	Equivalent rope grade
IPS	1770
EIPS	1960
EEIPS	2160

Bibliography

[1] ISO 4344, *Steel wire ropes for lifts — Minimum requirements*

[2] ISO 3154:1988, *Stranded ropes for mine hoisting — Technical delivery requirements*

[3] ISO 5614:1988, *Locked coil wire ropes for mine hoisting — Technical delivery requirements*

[4] ISO 9001:2000, *Quality management systems — Requirements*

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