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Stainless-steel wire ropes

Câbles en acier inoxydables

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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).

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For an explanation of 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 www.iso.org/iso/foreword.html.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Stainless-steel wire ropes

1 Scope

This document specifies requirements for manufacture, classification, test methods, packaging, marking and issuing of a certificate for stainless-steel wire ropes.

It is applicable to stainless-steel wire ropes (hereafter referred to as ropes) for instruments, mechanical transmission, cable, sling, shock absorber vibration, yacht, architecture and structure.

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 2020-2, *Aerospace — Preformed flexible steel wire rope for aircraft controls — Part 2: Technical specification*

ISO 3108, *Steel wire ropes — Test method — Determination of measured breaking force*

ISO 7802, *Metallic materials — Wire — Wrapping test*

ISO 15510, *Stainless steels — Chemical composition*

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 terminology databases for use in standardization at the following addresses:

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

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

3.1
stainless steel
steel with at least 10,5 % (mass fraction) Cr and maximum 1,2 % (mass fraction) C

[SOURCE: ISO 15510:2014, 3.1, modified — Note 1 to entry removed.]

3.2
surface status

3.2.1
cleanliness
freedom from visible residue such as lubricating grease, powder and oil

3.2.2
lubricated
coated with grease, rust-proof oil or fatigue oil

3.3
lot
series of ropes manufactured under basically the same time period and consistent conditions, and which have the same construction and diameter

4 Ordering information

The contract in accordance with this document shall at least include the following main contents:

a) number of this document (ISO 3444);

b) product name, if relevant;

c) construction (designation);

d) nominal rope diameter;

e) minimum breaking force;

f) type of core, if relevant;

g) lay type and direction;

h) delivery surface status (cleanliness, lubricated, or other requirements);

i) quantity (length, mass);

j) steel name;

k) other specific requirements including detection methods, physical and chemical properties.

5 Requirements

5.1 Materials

5.1.1 Stainless steel

Stainless steel shall conform to ISO 15510. Steel names can be agreed by the purchaser and the manufacturer.

5.1.2 Wire

5.1.2.1 Tolerance on diameter

The tolerance on the nominal wire diameter shall be in accordance with the values given in Table 1.

Table 1 — Tolerance on wire diameter

Nominal wire diameter, δ mm	Tolerance on diameter mm
$\delta < 0{,}10$	±0,005
$0{,}10 \leq \delta < 0{,}20$	±0,008
$0{,}20 \leq \delta < 0{,}40$	±0,010
$0{,}40 \leq \delta < 1{,}00$	±0,015
$1{,}00 \leq \delta < 1{,}60$	±0,025
$1{,}60 \leq \delta < 3{,}70$	±0,030
$3{,}70 \leq \delta < 6{,}00$	±0,040
$\delta \geq 6{,}00$	±0,045

5.1.2.2 Tensile-strength grade

The tensile-strength grades of wires shall make the ropes meet the minimum breaking force given in this document or the requirements of the purchaser.

5.1.2.3 Wrapping test

Before rope making, wires shall not be broken when performing the wrapping test in accordance with 6.2.2.

5.1.2.4 Wire finish

The finish of the wires shall not have cracks, ring and other defects that may affect the use.

5.1.3 Core

Cores of ropes shall normally be of steel (WSC or IWRC) or fibre (NFC or SFC). In addition, solid polymer (SPC) may also be supplied.

The purchaser should specify any other particular core type requirements. In the centre strand, the centre wire of rope can be properly bolded to ensure adequate support.

5.2 Rope manufacture

5.2.1 General

The completed ropes shall be evenly laid, tight, smooth, and free from loose wires, distorted strands and other irregularities. The surface status of ropes can be agreed by the purchaser and manufacturer.

5.2.2 Wire joints

5.2.2.1 For single-layer ropes, the minimum distance between wire joints within one strand should be 50 × rope diameter (d). Wires over 0,4 mm in diameter shall have their ends joined by welding. Wires having up to and including a 0,4 mm diameter shall be joined by welding or by ends being inserted in the strand's formation. Partial crossing of the wires at the inserted ends is allowed, but the wire ends shall be sealed inside the strands and not be exposed.

5.2.2.2 For spiral strand ropes, the distance between two wire joints shall not be less than 50 m. For the finished spiral strand ropes, the joint in any length shall not exceed one and the welding position of each wire shall be obviously marked on the ropes. Flash butt welding or upset butt welding shall be

used for wire joints. Weld joints should not break during assembly and spooling and need to be ground, to prevent from consequence on diameter.

5.2.3 Lubrication

5.2.3.1 Ropes can be coated with a small amount of neutral grease. For ropes with fibre cores and solid polymer cores, the amount of lubrication and type of rope lubricant shall be agreed by the purchaser and manufacturer.

5.2.3.2 After the purchaser's approval, the remaining grease on the surface of ropes for medical equipment, decoration and fitness equipment can be cleaned.

5.2.3.3 For ropes for automobile, control, aeronautical use and other safety-related purposes, the remaining grease on the surface should be retained.

5.2.4 Rope construction

See Annex A for the construction examples of the ropes. Other rope constructions can be stated by the manufacturer.

5.3 Designation and classification

5.3.1 Designation

Ropes shall be ordered in accordance with this document and be designated as follows.

Figure 1 gives the designation of single-layer rope.

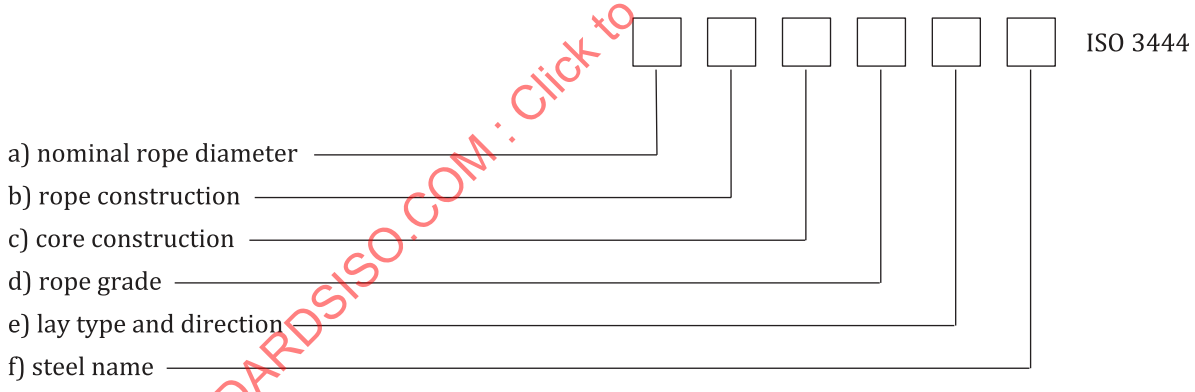


Figure 1 — Designation of single-layer rope

NOTE 1 Rope grades that classified to Grade A and Grade B for single-layer ropes are given in Table 3.

EXAMPLE 1 A rope with a nominal rope diameter of 2 mm, rope construction of 6×7-WSC, rope grade of Grade A, right ordinary lay (sZ) and steel name of X3CrNiMo17–12–3 is designated:

2 6×7-WSC A sZ X3CrNiMo17–12–3 ISO 3444.

Figure 2 gives the designation of spiral strand rope.

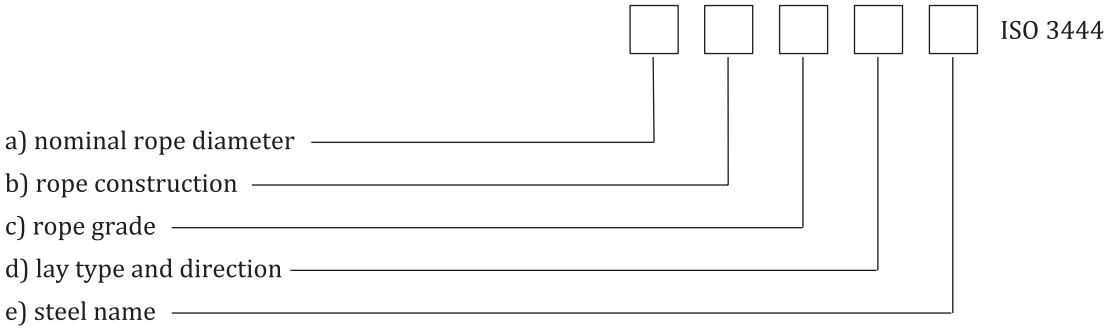


Figure 2 — Designation of spiral strand rope

NOTE 2 Rope grades for spiral strand ropes are classified to 1150 and 1500.

EXAMPLE 2 A rope with a nominal rope diameter of 6 mm, rope construction of 1 × 7, rope grade of 1500, left lay (S) and steel name of X5CrNi18–10 is designated:

6 1×7 1500 S X5CrNi18–10 ISO 3444.

5.3.2 Classification

The rope classes for single-layer ropes and spiral strand ropes shall be in accordance with ISO 17893.

5.4 Dimensions

5.4.1 Diameter

The rope diameter shall be within the tolerances given in Table 2. The other tolerance requirements shall be agreed by the purchaser and the manufacturer.

Table 2 — Tolerance on rope diameter

Nominal rope diameter, d mm	**Tolerance as percentage of nominal diameter**
$d < 2$	+10 0
$2 \leq d < 4$	+8 0
$4 \leq d < 6$	+7 0
$6 \leq d < 8$	+6 0
$d \geq 8$	+5 0

5.4.2 Out-of-roundness

The out-of-roundness of rope shall not be more than half the tolerance on nominal rope diameter.

5.4.3 Rope length

Rope length shall be specified in the ordering information. Otherwise it shall be determined by the manufacturer.

5.4.4 Lay length

5.4.4.1 Lay length of single-layer rope shall be no more than 8 × rope diameter.

5.4.4.2 Lay length of spiral strand rope shall be no more than 14 × rope diameter, unless otherwise agreed with the purchaser.

5.5 Mechanical properties

5.5.1 Breaking force

5.5.1.1 For single-layer ropes, according to different steel names, there are two classes Grade A and Grade B as in Table 3. The minimum breaking forces for single-layer ropes shall be either as given in Table B.3 and Table B.4 in Annex B or as stated by the manufacturer.

Table 3 — Classes according to different steel names

Class	Steel names
Grade A	X9CrNi18–9 X5CrNi18–10 X10CrNi18–8
Grade B	X5CrNiMo17–12–2 X2CrNiMo17–12–2 X4CrNi18–12 X15CrNiSi25–21

5.5.1.2 For spiral strand ropes, the minimum breaking forces for rope grades 1150 and 1500 shall be as given in Table B.5 in Annex B. Other rope grades shall be agreed between the purchaser and the manufacturer.

5.5.1.3 For the determination of minimum breaking forces of rope diameters not listed in Table B.3 to Table B.5, calculations in accordance with Formula (B.1) can be used or agreed by the purchaser and manufacturer.

5.5.2 Elongation

5.5.2.1 Special requirements, such as the permanent elongation and elastic elongation of single-layer ropes, can be specified in accordance with the ordering information between the purchaser and manufacturer.

5.5.2.2 The permanent elongation of spiral strand ropes shall not be more than 1,50 %.

5.5.3 Bend fatigue property

If the purchaser has requirements for bend fatigue property of the ropes, the test conditions and specific requirements of bend fatigue property shall be agreed by the purchaser and the manufacturer.

5.6 Other requirements

Other technical requirements shall be agreed between the purchaser and manufacturer.

6 Inspection

6.1 General

The inspection shall be carried out by the manufacturer.

6.2 Test methods

6.2.1 Chemical composition test

6.2.1.1 In case it is requested when ordering, the rope manufacturer should choose a suitable chemical analysis method to conduct the test after purchasing stainless steel. In cases of dispute, the analysis shall be carried out by a laboratory approved by the two parties. In these cases, the reference method of analysis shall be agreed upon, and where possible the method of analysis should be taken from ISO/TR 9769.

6.2.1.2 The main chemical composition of alloying elements for ropes, such as Cr and Ni, shall be analysed. The alloying elements to be tested shall be agreed and specified in the ordering information. The detection elements to be tested of the common steel names are shown in Table 4.

Table 4 — Steel name and necessary detection elements

Steel name	Necessary detection elements
X9CrNi18–9 X5CrNi18–10 X10CrNi18–8 X4CrNi18–12	Cr, Ni
X5CrNiMo17–12–2 X2CrNiMo17–12–2	Cr, Ni, Mo
X15CrNiSi25–21	Cr, Ni, Si

6.2.2 Wrapping test of wire

When coiled for 8 turns around a mandrel of equal diameter to the wire, the wire shall not break, and the test shall be carried out in accordance with ISO 7802.

6.2.3 Test on rope for diameter

6.2.3.1 For a rope diameter ≤2 mm, the minimum scale value of the measuring instrument shall be ≤0,01 mm. For a rope diameter over 2 mm, the minimum scale value of the measuring instrument shall be ≤0,02 mm.

6.2.3.2 For a rope diameter ≤5 mm, the measuring equipment shall extend over at least two adjacent strands. Diameter measurements shall be taken on a straight portion of rope under no tension, 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 average of these four measurements shall be the measured in actual diameter.

6.2.3.3 For a rope diameter over 5 mm, diameter measurements shall be taken on a straight portion of rope under no tension, at two positions spaced at least 10 m apart. At each position, two measurements, at 90° apart, of the circumscribed circle diameter shall be taken. The average of these four measurements shall be the measured in actual diameter.

6.2.3.4 Out-of-roundness shall be measured in accordance with 6.2.3.1, 6.2.3.2, 6.2.3.3. The difference between the maximum and the minimum diameter at any cross-section shall conform to 5.4.2.

6.2.3.5 When in dispute, diameter measurements should be taken under a tension not exceeding 5 % of the minimum breaking force.

6.2.4 Inspection of internal stresses

Release two opposite strands about 2 × rope lay length from rope end, then reset these strands in rope, the strands shall not be loosened.

6.2.5 Straightness inspection

For a nominal rope diameter < 6 mm, the straightness shall be measured. Under no tension, put the rope with the length of 6 m on a horizontal surface between two parallel lines at a distance of 75 mm apart. The rope shall not collide with any parallel straight line except 500 mm at the end. The rope to be tested shall not be cut from the coil.

6.2.6 Tensile test

6.2.6.1 Test on rope for breaking force: the testing method shall be in accordance with ISO 3108.

6.2.6.2 Test on rope for elongation: the test shall be measured by clamp the rope piece on a suitable tensile testing machine under an initial load 2 % of the minimum breaking force. Mark the distance above 250 mm as the gauge length L_1. Then load to 60 % of the minimum breaking force at the tensile speed not exceeding 50 mm/min, and measure the gauge length L_2. Then unload to the initial load and measure the gauge length L_3. The elongation is calculated by Formulae (1), (2) and (3):

$$\delta_e = \frac{L_2 - L_3}{L_1} \tag{1}$$

$$\delta_p = \frac{L_3 - L_1}{L_1} \tag{2}$$

$$\delta = \delta_e + \delta_p \tag{3}$$

where

δ_e is the elastic elongation; in percentage;

δ_p is the permanent elongation; in percentage;

δ is the elongation; in percentage;

L_1 is the gauge length where mark the distance above 250 mm under an initial load 2 % of the minimum breaking force; in mm;

L_2 is the gauge length when loading to 60 % of the minimum breaking force; in mm;

L_3 is the gauge length when unloading to the initial load; in mm.

6.2.7 Bend fatigue test

The bend fatigue test shall be conducted according to ISO 2020-2 or agreed by the purchaser and the manufacturer.

6.2.8 Inspection of surface quality

Surface quality shall be inspected by visual and tactile means.

6.3 Sampling and acceptance criteria

According to size of lot, samples for testing shall be taken in accordance with Table 5. Other methods of sampling should be agreed between the purchaser and manufacturer.

Table 5 — Sampling and acceptance criteria

Size of lot	Number of samples	Number failures for acceptance	Number failures for rejection
1	1	0	1
2 to 8	2	0	1
9 to 15	3	0	1
16 to 25	5	1	2
26 to 50	8	1	2
51 to 150	13	1	2
151 to 280	20	2	3

7 Delivery conditions

7.1 General

The delivery surface status of ropes shall be cleanliness or lubricated. Other surface status of ropes should be agreed between the purchaser and manufacturer. Ropes shall be delivered according to length or mass.

7.2 Certificate

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;

e) minimum breaking force;

f) date of issue of the certificate and authentication;

g) steel name;

h) surface status (cleanliness, lubricated, or other requirements);

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 the agreement between the purchaser and the manufacturer.

7.3 Packaging and marking

7.3.1 Packaging

Ropes shall be supplied on reels or in coils. Packaging shall conform to the technical agreement and the order contract. The purchaser should specify any particular packaging requirements.

7.3.2 Marking

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

— construction;

— diameter;

— length;

— gross mass;

— net mass;

— reel no.;

— manufacturer;

— origin;

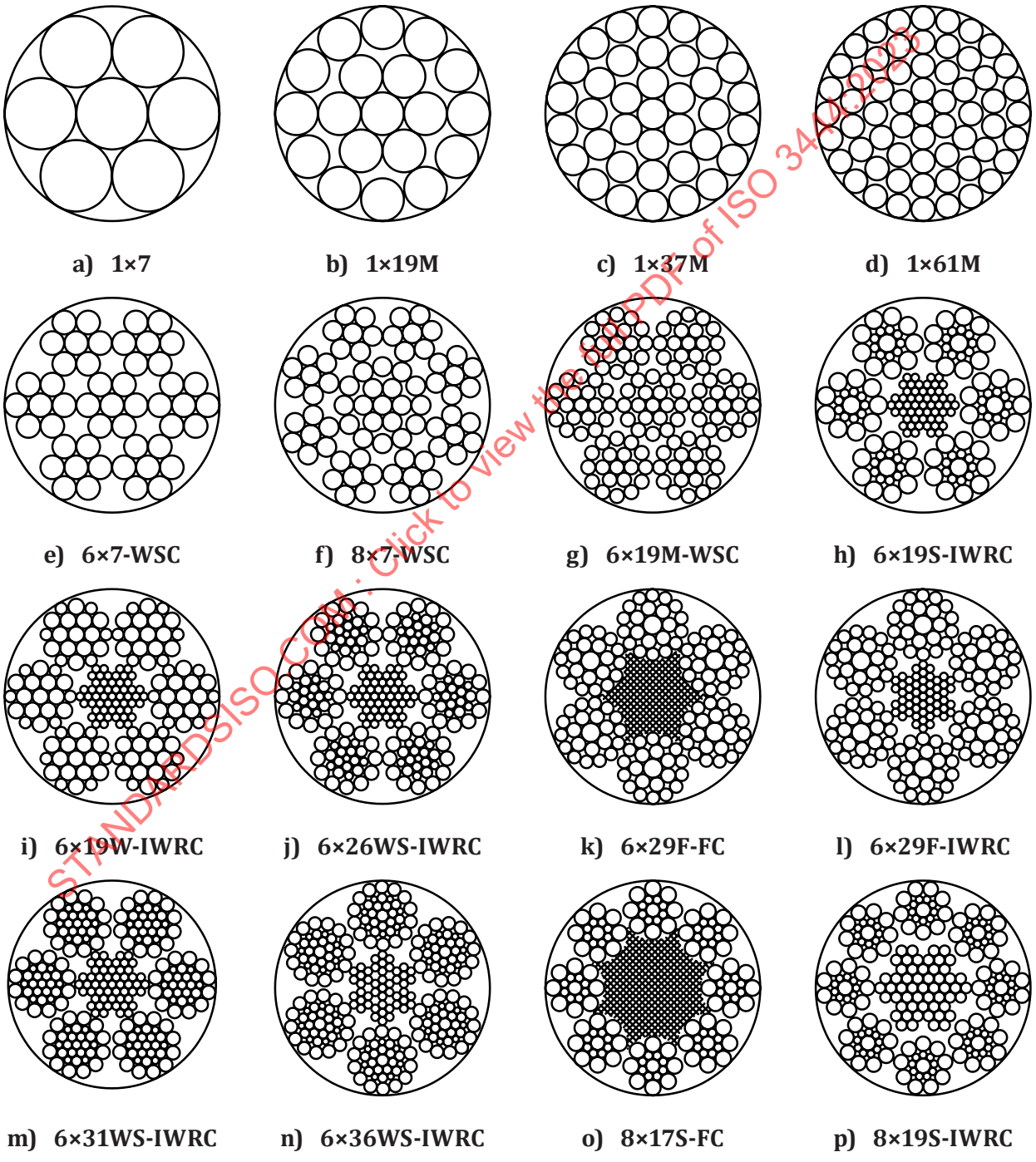
— surface status (cleanliness, lubricated, or other requirements);

or other information agreed by the purchaser and manufacturer. The reel number shall enable traceability of the rope.

Annex A
(informative)

Construction examples of stainless-steel wire ropes

Figure A.1 gives the construction examples of the ropes.

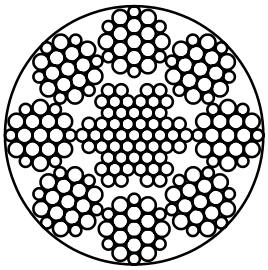


a) 1×7 b) 1×19M c) 1×37M d) 1×61M

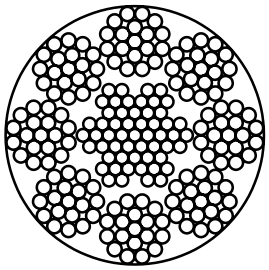
e) 6×7-WSC f) 8×7-WSC g) 6×19M-WSC h) 6×19S-IWRC

i) 6×19W-IWRC j) 6×26WS-IWRC k) 6×29F-FC l) 6×29F-IWRC

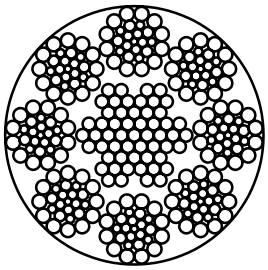
m) 6×31WS-IWRC n) 6×36WS-IWRC o) 8×17S-FC p) 8×19S-IWRC



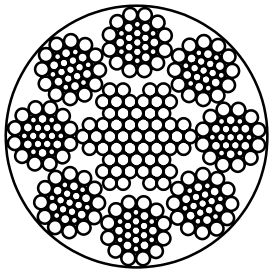
q) 8×19W-IWRC



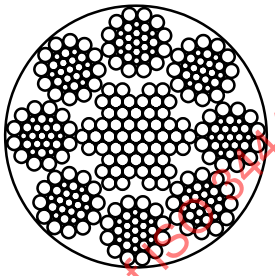
r) 8×25F -IWRC



s) 8×26WS-IWRC



t) 8×31WS-IWRC



u) 8×36WS-IWRC

Figure A.1 — Construction examples of the ropes

Annex B
(normative)

Minimum breaking forces for the ropes

B.1 Calculation of minimum breaking force

B.1.1 Calculation formula

The minimum breaking force of the rope shall be calculated with Formula (B.1).

$$F_{\min} = \frac{d^2 \times R \times K}{1\,000} \tag{B.1}$$

where

$F_{\min}$ is the minimum breaking force of the rope; in kilonewtons;

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

R is the rope grade; in newtons per square millimetres;

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

B.1.2 Minimum breaking force factor for single-layer rope

Table B.1 summarizes the factors used in the calculation of the minimum breaking force for single-layer ropes covered by Table B.3 and Table B.4.

Table B.1 — Factors for single-layer ropes

Construction	Ropes with fibre core	Ropes with an independent wire rope core or wire strand centre	
	Minimum breaking force factor K_1	Minimum breaking force factor K_2	Minimum breaking force factor K_3
6×7			0,388
8×7			0,356
6×19M		0,332	0,362
6×19	0,330	0,356	
6×36	0,330	0,356	
8×19	0,293	0,356	
8×36	0,293	0,356	

K_1 is the factor for ropes with a fibre core.

K_2 is the factor for rope with an independent wire rope core.

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

B.1.3 Minimum breaking force factor for spiral strand rope

Table B.2 summarizes the factors used in the calculation of the minimum breaking force for spiral strand ropes covered by Table B.5.

Table B.2 — Factors for spiral strand ropes

Construction	Minimum breaking force factor K
1×7	0,462
1×19M	0,454
1×37M	0,445
1×61M	0,435

B.2 Minimum breaking force for single-layer rope

Table B.3 and Table B.4 give the minimum breaking forces for single-layer ropes.

Table B.3 — Minimum breaking forces for 6×7, 8×7, 6×19M ropes

Construction	Nominal rope diameter [mm]	Minimum breaking force kN					
		Grade A			Grade B		
		1770	1670	1570	1570	1470	1370
6×7-WSC	0,50	0,172	-	-	0,152	-	-
	0,60	0,247	-	-	0,219	-	-
	0,70	0,337	-	-	0,298	-	-
	0,80	0,440	-	-	0,390	-	-
	0,90	0,556	-	-	0,493	-	-
	1,0	0,687	-	-	0,609	-	-
	1,2	0,989	-	-	0,877	-	-
	1,5	1,55	-	-	1,37	-	-
	1,6	1,76	-	-	1,56	-	-
	1,8	2,23	-	-	1,97	-	-
	2,0	2,75	-	-	2,44	-	-
	2,4	3,96	-	-	3,51	-	-
	3,0	6,18	-	-	5,48	-	-
	3,2	7,03	-	-	6,24	-	-
	3,5	8,41	-	-	7,46	-	-
	4,0	11,0	-	-	9,75	-	-
	4,5	13,9	-	-	12,3	-	-
	5,0	17,2	-	-	15,2	-	-
	6,0	24,7	-	-	21,9	-	-
	8,0	44,0	-	-	39,0	-	-

Table B.3 *(continued)*

Construction	Nominal rope diameter [mm]	Minimum breaking force kN					
		Grade A			Grade B		
		1770	1670	1570	1570	1470	1370
8×7-WSC	1,0	0,630	-	-	0,559	-	-
	1,5	1,42	-	-	1,26	-	-
	2,0	2,52	-	-	2,24	-	-
6×19M-WSC	1,2	0,923	-	-	0,818	-	-
	1,6	1,64	-	-	1,45	-	-
	2,0	2,56	-	-	2,27	-	-
	2,4	3,69	-	-	3,27	-	-
	3,2	6,56	-	-	5,82	-	-
	4,0	10,3	-	-	9,09	-	-
	4,8	14,8	-	-	13,1	-	-
	5,6	20,1	-	-	17,8	-	-
	6,4	26,2	-	-	23,3	-	-
	7,2	33,2	-	-	29,5	-	-
	8,0	41,0	-	-	36,4	-	-
	9,5	57,8	-	-	51,3	-	-
6×19M-IWRC	10,0	58,8	-	-	52,1	-	-
	12,0	84,6	-	-	75,1	-	-
	14,0	115	-	-	102	-	-
	16,0	-	142	-	-	125	-
	18,0	-	180	-	-	158	-
	20,0	-	222	-	-	195	-
	22,0	-	-	252	-	-	220
	24,0	-	-	300	-	-	262
	26,0	-	-	352	-	-	307
	28,0	-	-	409	-	-	357
	30,0	-	-	469	-	-	409