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Fibre ropes — Determination of certain physical and mechanical properties

Cordages en fibres — Détermination de certaines caractéristiques physiques et mécaniques

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Contents

Page

Foreword

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ISO 2307 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 248, *Textiles and textile products*, in collaboration with Technical Committee ISO/TC 38, *Textiles*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 2307:1990), which has been technically revised.

Fibre ropes — Determination of certain physical and mechanical properties

1 Scope

This International Standard specifies, for ropes of different kinds, a method of determining each of the following characteristics:

— linear density;

— lay length;

— braided pitch;

— elongation;

— breaking force.

The linear density, lay length and braided pitch are measured with the rope under a specified tension called the reference tension, as specified in Annex A.

The elongation corresponds to the measured increase in length of the rope when the tension to which it is subjected is increased from an initial value (reference tension) to a value equal to 50 % of the minimum specified breaking strength of the rope.

The breaking force is the maximum force registered (or reached) during a breaking test on the test piece, carried out on a tensile testing machine with constant rate of traverse of the moving element. The breaking force values given in the tables of rope specifications are only valid when this type of testing machine is used.

When it is not possible to test the whole section of rope, the method described in Annex B may be used, subject to agreement between the parties involved.

This International Standard also provides a method for measuring water repellency, lubrication and finish content and heat setting treatment when requested by the customer.

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 139, *Textiles — Standard atmospheres for conditioning and testing*

ISO 1968, *Fibre ropes and cordage — Terms and definitions*

ISO 9554:—[1)], *Fibre ropes — General specification*

1) To be published. (Revision of ISO 9554:1991)

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1968 apply.

4 Principle

4.1 Calculation of the linear density

The linear density is obtained by measurement of the mass and the length, under a reference tension, of a conditioned test piece (see Clause 9 and Annex C).

4.2 Measurement of the lay length and braided pitch length

This measurement is taken at the time of application of the reference tension.

4.3 Measurement of the elongation of the rope

This measurement is taken by comparing the lengths of a section of the test piece that has been subjected successively to

a) the reference tension;

b) a tension equal to 50 % of the minimum specified breaking force for the rope.

4.4 Measurement of the breaking force

This measurement is carried out by increasing the tension in 4.3 b) to the breaking point.

5 Apparatus

5.1 Tensile testing machine, accommodating the assumed breaking force of the rope, which allows a constant rate of traverse of the moving element in accordance with 9.5 and measurement of breaking force to an accuracy of ± 1 %.

Different types of tensile testing machines may be used:

— pulley-type grip (“cors de chasse” testing machine);

— testing machine with bollards for eye splices;

— wedge-grip testing machine.

In the case of a “cors de chasse” tensile testing machine, the diameter of the pulleys or catches holding down the test pieces shall be equal to at least 10 times that of the rope being tested.

In the case of a testing machine with bollards, the diameter of the bollards passing through the eye-spliced test pieces shall be at least twice the diameter of the rope being tested.

5.2 Balance, allowing measurement of mass to an accuracy of ± 1 %.

6 Sampling

6.1 Sample size

When specified by the purchaser, a lot sample for acceptance testing shall be taken at random in accordance with 6.4.

6.2 Sample unit

If required, test samples shall be taken from each shipping unit in the lot in the number and the length required to perform the specified tests. The test samples shall be included in the delivered mass or length.

As an alternative, the manufacturer's production and inspection records may be used, if agreed upon the purchaser and the manufacturer.

6.3 Composition of the batch to be sampled

Samples shall be taken from a homogeneous batch, i.e. consisting of ropes of the same size and same dimensions and which have been subject to the same series of manufacturing operations and the same control procedure.

6.4 Selection of samples

Take N_S number of samples at random from the batch in accordance with Equation (1):

$$N_S = 0{,}4\sqrt{N} \tag{1}$$

where N is the batch size, expressed as the number of 220-m coils.

When the calculated value of N_S is not a whole number, the number obtained shall be rounded to the nearest whole number.

EXAMPLE 27,5 and 30,35 are rounded to 28 and 30, respectively.

Where $N_S < 1$, take one sample length.

7 Test pieces

7.1 Length

The test piece shall be of adequate length to give an effective length, L_u (see 9.2), between terminations which is at least equal to that given in Table 1, when mounted on the tensile testing machine (see Figure 1).

Table 1 — Effective lengths

Type of rope	Type of mounting device	Minimum effective length, L_u mm
Man-made fibre ropes, reference number $\leqslant$ 10	all types	400
Man-made fibre ropes, reference number $>$ 10 and $<$ 20	"cors de chasse"	400
	bollard type	1 000
	wedge grip	—
Man-made fibre ropes, reference number $\geqslant$ 20	bollard type	2 000[a]
Natural fibre ropes	all types	2 000

[a] If the lay length is greater than 360 mm, L_u shall be increased to 5 lay lengths if possible.

7.2 Number of test pieces

Take one test piece from each sample.

7.3 Taking the test pieces

Take the test piece either from one end of the samples, or from the body of the samples if they are intended to be cut. Take all necessary steps to prevent unlaying. If necessary, remove slightly unlaid ends.

8 Conditioning

Ropes shall be tested in the ambient atmosphere, except in cases of dispute, when the test piece shall be placed in the atmosphere specified in ISO 139 for at least 48 h, immediately prior to testing.

9 Procedure

9.1 General

Perform the procedures specified in 9.2 to 9.7 sequentially.

9.2 Initial measurements

Lay the test piece out straight with a slight hand force (not to exceed 20 % of the reference tension) on a flat surface. Measure the initial length L_0, in metres, to the nearest millimetre.

Mark two "w's" on the test piece, spaced symmetrically with regard to its mid-point, and at a distance apart of l_0 that is greater than 400 mm.

NOTE When $L_u < 400$ mm, L_0 and l_2 are measured on a separate test piece, with a length of 400 mm minimum, following the same procedure; the value l_2 is obtained by applying the appropriate tension by means of weights and a pulley.

Determine the mass, m, expressed in grams, of the test piece to the nearest 0,5 %.

An alternative method for ropes sizes greater than reference number 70 is given in Annex C.

9.3 Mounting the test piece on the testing machine

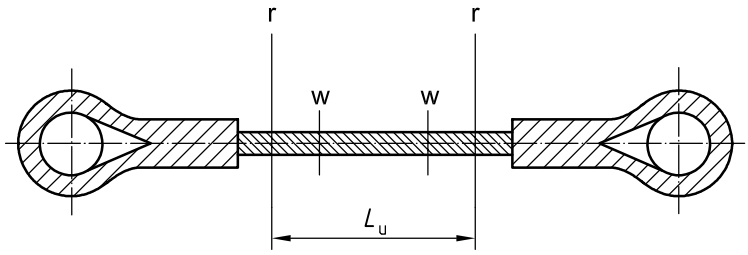
Fix the ends of the test piece onto the machine in order to obtain the effective length of test piece specified in 7.1.

In the case of a test on splices, the eyes shall have a minimum internal length of 6 times the rope diameter when closed; their production is left to the manufacturer's discretion.

In the case of man-made fibre ropes, it is recommended that the ends of the splices be tapered to finish.

Outside the segment l_0, mark two “r's” on the test piece delimiting the section in which a rupture is considered as normal, as shown in Figures 1 to 3.

The distance from each mark “r” to the end of splice (or to the tangent point in the case of a “cors de chasse”) shall be a minimum of two times the diameter and a maximum of three times the diameter of the rope.

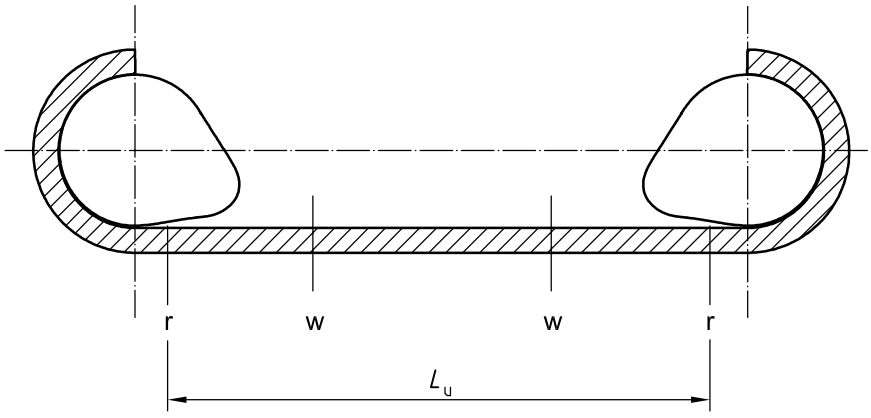


Key

r limiting marks for the standard test

L_u effective length measured with no tension

Figure 1 — Effective length, L_u, for testing machines with bollards for eye splices applied to ropes of reference number 20 and above



Key

r limiting marks for the standard test

L_u effective length measured with no tension

Figure 2 — Effective length, L_u, for pulley-type grips (“cors de chasse”) testing machine applied to ropes of reference number < 20

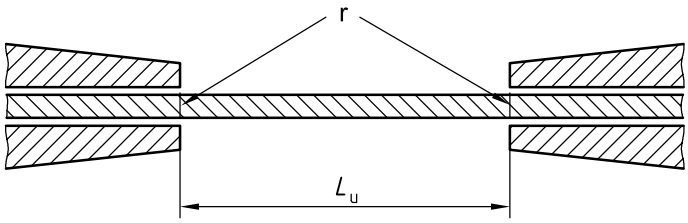


Figure 3 — Effective length, L_u, for wedge-grip testing machine applied to ropes of reference number < 20

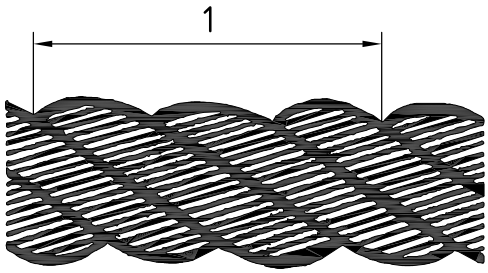
9.4 Measurement of lay and gauge length

Apply the reference tension specified for the type of rope being tested (refer to Annex A) to the test piece and measure the following:

a) the length of the maximum number of lays possible within L_u, expressed in millimetres;

NOTE The length of lay for laid ropes and plait pitch for 8-strand rope are shown in Figures 4, 5 and 6, respectively.

b) the distance between the two "w" marks. Let this distance be l_2, the gauge length, expressed in millimetres, under the reference tension.

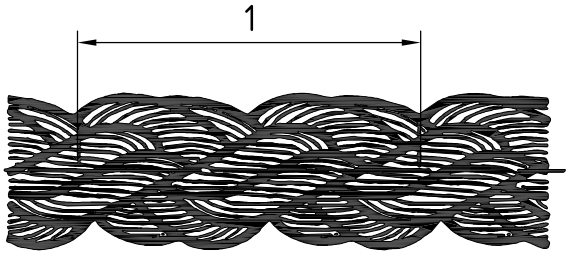


Key

1 one lay of a 3-strand rope

NOTE This applies also to 4- and 6-strand ropes and the figure of one lay of 3-strand rope is provided as an example.

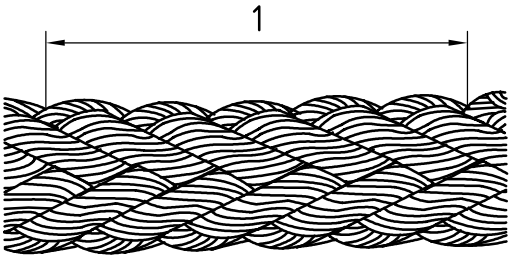
Figure 4 — Length of lay for 3-, 4- and 6-strand ropes



Key

1 one plait pitch

Figure 5 — Length of plait pitch for 8-strand braided rope



Key

1 one plait pitch

Figure 6 — Length of plait pitch for 12-strand braided rope

9.5 Bedding-in of the test piece

Before testing to the breaking point, subject the sample to a cyclic load of three times 50 % of the minimum breaking force of the rope. The test speed of (250 ± 50) mm/min unless otherwise specified in a specific rope standard.

9.6 Measurement of the elongation of the rope

Increase the tension again by moving the moving element of the testing machine. The test shall be carried out at a speed of (250 ± 50) mm/min unless otherwise specified in a specific rope standard.

When the tensile force reaches 50 % of the minimum breaking force, measure the distance between the "w" marks (the stoppage necessary for measurement shall be as brief as possible). Designate this distance as l_3, the gauge length, expressed in millimetres, for a tensile force equal to 50 % of the specified minimum breaking force.

By previous agreement between the purchaser and supplier, a force-elongation curve, recorded during the tensile tests up to 50 % of the minimum breaking force of the rope, may be supplied.

It may be requested that the elongation be determined on a particular test piece. In this case, the procedure given in Annex D shall be followed to obtain the force-elongation co-ordinates.

9.7 Measurement of the breaking force

Continue to increase the tension, at the same speed, until a strand breaks.

Record the breaking force and the place on the test piece where the break occurs.

The specimen shall be deemed to meet the requirements if the break occurs outside "r" marks and at a force not less than 90 % of the minimum breaking force of the cordage. It should not be assumed that the true breaking force of the specimen would be represented by multiplying the result by 10/9.

10 Expression and interpretation of results

10.1 General

For the linear density, lay length or braided pitch and elongation (see 10.2 to 10.4), the numerical result of a test is the arithmetic mean of the individual values obtained on each test piece in the batch. As far as the tensile strength is concerned (see 10.5), the result is expressed by giving the breaking force for each of the test pieces in the batch, without calculating the mean value.

The individual values are obtained as given in 10.2 to 10.5.

10.2 Linear density, ρ_1

The linear density (net mass, in grams per unit length), expressed in kilotex, is given by Equation (2):

$$\rho_1 = \frac{m}{L_1} \tag{2}$$

where

m is the mass, in grams, of the test piece;

L_1 is the length, in metres, of the test piece under the reference tension, as given by Equation (3):

$$L_1 = \frac{l_2 \times L_0}{l_0} \tag{3}$$

where

l_0 is the initial gauge length, expressed in millimetres, measured as specified in 9.2;

l_2 is the gauge length, expressed in millimetres, under the reference tension, measured as specified in 9.4;

L_0 is the initial length, expressed in metres, measured as specified in 9.2.

10.3 Lay or pitch length

The lay, l_p, expressed in millimetres, is given by Equation (4):

$$l_p = \frac{l_n}{n} \tag{4}$$

where l_n is the length of n complete turns of the same strand or, in the case of plaited ropes, the length between n successive plait points (see 9.4).

10.4 Elongation

The value of the elongation, E, expressed as a percentage, is given by Equation (5):

$$E = \frac{(l_3 - l_2) \times 100}{l_2} \tag{5}$$

where

l_2 is the gauge length, expressed in millimetres, under the reference tension;

l_3 is the gauge length, expressed in millimetres, for a tensile force equal to 50 % of the specified minimum breaking force.

10.5 Actual breaking force

Express the breaking force in kilonewtons, indicating whether or not the breakage took place between the “r” marks.

Any test piece which breaks outside the “r” marks is considered to comply with the tensile strength specifications if the force recorded on breakage is not less than 90 % of the minimum specified breaking force;

in such a case, it is not permitted to report as the test result a breaking force with a value other than the value recorded during the test with the indication that the break occurs outside the “r” marks.

11 Test report

The test report shall contain the following information:

a) reference to this International Standard (e.g. ISO 2307:2005);

b) results obtained, expressed in accordance with Clause 10;

c) individual values which were used to calculate the results [except for breaking force values, which will already have been given in b)];

d) particular test conditions (conditioning of the test pieces, type of tensile testing machines used, procedure used for determination of elongation, use of the procedures described in Annexes B and C, where applicable);

e) details of procedure not stipulated in the method and incidents which are likely to have affected the results.

12 Determination of water repellency

12.1 Principle

The increase in mass of the rope is determined after immersion in water for a given period.

12.2 Test pieces

12.2.1 General

Place two marks 450 mm apart on the length of rope, clear of its ends.

12.2.2 Whipping

Place a tight and secure whipping over each mark. The length of these whippings shall not exceed the values specified in Table 2.

12.2.3 Cutting the samples

Detach the samples from the parent length by cutting cleanly across the rope with a sharp knife at right angles to its longitudinal axis at the seizings, so that a suitably seized sample is obtained.

12.2.4 Sealing

To prevent absorption by capillary action, seal the ends off so that the whipping is just covered.

A suitable sealing material is pitch with a small amount of tar added to prevent cracking. Any other suitable sealing material may be used.

12.3 Procedure

12.3.1 First weighing

Weigh carefully each specimen after whipping and sealing, and then place in tap water at a temperature of (20 ± 2) °C, taking care that the specimen is fully submerged, if necessary by weighting down, to a depth of 150 mm.

Do not add water after the specimens have been submerged.

In order to avoid the variations in mass due to atmospheric conditions, carry out the weighing immediately before immersion. Do not carry out the test until at least 24 h after the completion of manufacture of the rope.

12.3.2 Second weighing

After a total immersion of 1 h, take the specimens out of the water and, before weighing, dry them in the following manner. Shake each specimen six times to remove the superfluous water and then roll the sample on blotting paper until no wetting of the paper is observed. Finally, draw the specimens three times through an absorbent cloth, such as towelling. Then weigh the specimens and resubmerge in the water.

12.3.3 Third weighing

After a further 5-h immersion period (making a total of 6 h in all), dry the specimens as described in 12.3.4 and weigh them.

12.3.4 Drying the specimens

Thoroughly dry each specimen by gentle heating if necessary. Take care that the sealing is not affected by the temperature, and that the temperature does not exceed 50 °C. Dry the specimens to a mass slightly less than that obtained at the first weighing, so that after exposure for at least 4 h to normal room atmospheric conditions, the specimens shall return as nearly as possible to their original mass.

12.3.5 Fourth, fifth and sixth weighing

Repeat the procedure described in 12.3.1 to 12.3.4 using the same specimens.

12.4 Results of tests

Record the gain in mass in each of the specimens as a percentage of the original mass (first and fourth weighing), for the 1-h immersion (second and fifth weighing), and for the 6-h immersion (third and sixth weighing).

Table 2 — Length of whipping

Reference number of rope	Maximum length of whipping mm
⩽ 24	15
> 24 but < 48	20
⩾ 48	25

13 Determination of lubrication and finish content

13.1 Reagents

In this test, use reagents of laboratory reagent quality or equivalent.

13.2 Preparation of samples

Unlay the rope into its component yarns. Select at random representative yarns from the unlaid rope. Form these into a hank weighing between 30 g and 50 g.

13.3 Determination of water content

13.3.1 Weigh the hank as prepared in 13.2 to the nearest 10 mg. Designate this mass as m_1.

13.3.2 Distil the water contained in the sample after the addition of a suitable quantity of petroleum ether, and condense it in a graduated receiver.

13.3.3 Continue the distillation until the condensate in the graduated receiver becomes constant. Measure the volume of water to the nearest 0,1 ml. Designate this volume as W.

13.4 Determination of lubrication and finish content

13.4.1 Transfer the hank of yarn into a Soxhlet apparatus, and reflux with petroleum ether (boiling range 60 °C to 80 °C) until the extraction medium flows off in a colourless form, or, if colourless impregnating agents are present, until a specimen taken from the extract evaporates without residue.

13.4.2 Remove the hank from the Soxhlet apparatus, and place in an oven at a temperature of 120 °C until all the solvent has evaporated. Transfer the hank to a desiccator until it has cooled to room temperature.

13.4.3 Re-weigh the sample to the nearest 10 mg. Designate this mass as m_2.

13.5 Calculation of lubrication and finish content

13.5.1 Calculate the percentage of lubrication or finish from Equation (6):

$$L = \frac{(m_1 - W) - m_2}{m_1 - W} \times 100 \qquad (6)$$

13.5.2 Express the result to the nearest 1 %.

14 Heat-setting on polyamide and polyester ropes

To determine whether polyamide and polyester ropes have been thermofixed in accordance with ISO 9554:—[2], 4.4.1, when the production process is unknown, the following test shall be carried out by a competent person.

Cut a sample from the rope with a length of more than 40 times the diameter. Hang the sample vertically. Open by hand the strands of the rope and the yarns of the strands over a length of 40 times the diameter. If the strands and the yarns remain in a helical shape while hanging vertically the rope is deemed to have been thermofixed.

2) To be published. (Revision of ISO 9554:1991)

Annex A
(normative)

Reference tension to be applied to ropes when measuring linear density and lay or pitch length

The reference tension, F_T, expressed in kilonewtons, applied to the specimen shall be calculated from Equation (A.1):

$$F_T = \frac{n_{ref}^2}{8} \times 0{,}01 \qquad \text{(A.1)}$$

where n_{ref} is the reference number, expressed in millimetres.

See Table A.1 for the calculated nominal values of the reference tension to be applied to the ropes and their tolerance, as a function of the reference number of the rope.

Table A.1 — Reference tension to be applied to ropes when measuring linear density and lay or pitch length

Reference number	Reference tension to be applied to the ropes	
	Nominal value kN	Tolerance %
4	0,02 0	± 5
4,5	0,025 3	
6	0,045 0	
8	0,080 0	
9	0,101	
10	0,125	
12	0,180	
14	0,245	
16	0,320	
18	0,405	
20	0,500	
22	0,605	
24	0,720	
26	0,845	
28	0,980	
30	1,13	
32	1,28	
36	1,62	
40	2,00	

Reference number	Reference tension to be applied to the ropes	
	Nominal value kN	Tolerance %
44	2,42	± 5
48	2,88	
52	3,38	
56	3,92	
60	4,50	
64	5,12	
72	6,48	
80	8,00	
88	9,68	
96	11,5	
104	13,5	
112	15,7	
120	18,0	
128	20,5	
136	23,1	
144	25,9	
152	28,9	
160	32,0	
—	—	

Annex B
(informative)

Special procedure for determination of high breaking forces

The method indicated below may be used to calculate the strength only of 3-, 4-, 8- and 12-strand ropes of reference $\geqslant 44$ and made of a single material and of yarns with the same linear density without lubrication, only by agreement between the parties involved, and only on condition that, before determining the breaking force of the yarns, the rope fulfils the specified conditions in all other respects.

In order to obtain the rope yarns necessary for the test, untwist a sufficient length of rope, avoiding any rotation of the individual rope components (yarns, strands) above their own axes. In the case of 3- or 4-strand ropes, 15 yarns shall be tested, of which three shall be selected from the centre of the strands. In the case of 8-strand and 12-strand braided rope, eight yarns in the two directions of twist S and Z shall be tested (i.e. a total of 16 yarns).

The test speed shall be (250 $\pm$ 50) mm/min unless otherwise specified in a specific rope standard.

The yarns selected shall be mounted in turn on the testing machine. During this process, the necessary steps shall be taken to prevent the yarns untwisting before testing.

The mean of the results thus obtained shall be used to determine the breaking force, F_c, of the rope from which the yarns were taken, by applying Equation (B.1)

$$F_c = F_y \times n \times f_r \qquad \text{(B.1)}$$

where

F_y is the mean force of the yarns;

n is the number of yarns in the rope;

f_r is the realization factor (see Table B.1).

Table B.1 — Realization factors

Reference number	Realization factors, f_r [a], for					
	polyester	polyamide	polypropylene	mixed polyolefin (PP/hdPE)	manila (abaca), sisal or hemp	polyethylene (hdPE)
44	0,499	0,613	0,829	0,684	0,598	0,694
48	0,495	0,605	0,820	0,674	0,597	0,688
52	0,492	0,597	0,811	0,663	0,593	0,684
56	0,488	0,591	0,803	0,652	0,590	0,681
60	0,486	0,585	0,795	0,640	0,588	0,677
64	0,484	0,579	0,787	0,640	0,586	0,673
72	0,478	0,569	0,775	0,631	0,580	0,667
80	0,474	0,560	0,764	0,627	0,577	0,661
88	0,470	0,552	0,757	0,621	0,573	0,656
96	0,467	0,544	0,745	0,615	0,569	0,650
104	0,463	0,538	0,739	0,599	—	—
112	0,460	0,532	0,732	0,596	—	—
120	0,457	0,526	0,725	0,596	—	—
128	0,455	0,521	0,718	0,596	—	—
136	0,452	0,517	0,714	0,595	—	—
144	0,451	0,512	0,707	0,594	—	—
160	0,446	0,507	0,702	0,586	—	—

[a] The realization factors apply for 3-, 8- and 12-strand ropes. The realization factors for 4-strand ropes are 10 % lower.

Annex C
(normative)

Alternative method for initial measurements of larger ropes

For ropes sizes greater than reference number 70, draw a length of rope from the reel or coil and lay it out in a straight line on a flat surface. Connect a tensile testing machine to this length between the reel or coil and its end, and anchor the dynamometer to the floor. Connect the end of the rope to a traction device, e.g. a winch. Tension the test length to the value required and maintain the tension for 1 min. Place two marks on the rope 2 m apart then remove the tension and detach the sample from the parent length by cutting cleanly at the two marks.

NOTE This process can be assisted by lapping the rope with adhesive tape at the approximate position of the marks and then placing the marks on top of this tape whilst the rope is under tension. The tape will hold the rope together when it is subsequently cut at these marks and will assist in the presentation of a cleanly cut specimen.

Determine the mass of the test piece and calculate the mass per metre from the result.

Annex D
(normative)

Determination of the load-elongation co-ordinates on a “special” test piece

If it is requested that this be determined, the following procedure shall be followed.

The “special” test piece for the load-elongation test shall be mounted on the testing machine and loaded 10 times to 50 % of the specified minimum breaking strength. The rate of loading and unloading shall be as defined in 9.5 and the time for which each load is maintained or completely removed shall be as short as possible.

After complete removal of the tenth load, a period of 1 h shall be allowed for the test piece to relax, after which the appropriate reference tension specified in Annex A shall be applied.

While the test piece is under this tension, a suitable distance shall be marked on the rope. Increase the tension, recording the load-elongation co-ordinates up to a tension of 50 % of the specified breaking strength.

At no point during this test shall the test piece be disturbed or taken out of the testing machine.

Bibliography

[1] ISO 1140, *Fibre ropes — Polyamide — 3-, 4- and 8-strand ropes*

[2] ISO 1141, *Fibre ropes — Polyester — 3-, 4- and 8-strand ropes*

[3] ISO 1181, *Fibre ropes — Manila and sisal — 3-, 4- and 8-strand ropes*

[4] ISO 1346, *Fibre ropes — Polypropylene split film, monofilament and multifilament (PP2) and polypropylene high tenacity multifilament (PP3) — 3-, 4- and 8-strand ropes*

[5] ISO 1969, *Fibre ropes — Polyethylene — 3- and 4-strand ropes*

[6] EN 1261, *Fibre ropes for general service — Hemp*

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