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Fibre ropes for offshore stationkeeping — Polyester

Cordages en fibres pour le maintien en position des structures marines — Polyester

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Contents

Page

Foreword

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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 18692 was prepared by Technical Committee ISO/TC 38, *Textiles*.

Fibre ropes for offshore stationkeeping — Polyester

1 Scope

This International Standard specifies the main characteristics and test methods of new polyester fibre ropes used for offshore stationkeeping.

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 1968, *Fibre ropes and cordage — Vocabulary*

ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

ASTM D 885, *Standard test methods for tire cords, tire cord fabrics, and industrial filament yarns made from manufactured organic-base fibers*

CORDAGE INSTITUTE CI 1503, *Test method for yarn-on-yarn abrasion*

3 Terms and definitions

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

3.1
breaking strength
BS
maximum force applied in straight tension to a rope, which causes it to rupture

3.2
core
central part which is the load-bearing part of the rope

3.3
cover
braided cover or other protective layer, which is placed over the rope core

NOTE The cover has no significant contribution to the rope strength.

3.4
dynamic stiffness
ratio of rope load to strain variations between the lower (trough) and upper (peak) stresses imposed during testing, normalized by the rope minimum breaking strength

See B.3.6.2.

3.5
marine finish
process and substance used on a fibre or yarn to improve the yarn-on-yarn abrasion performance of the product in a marine environment

3.6
marine grade fibre
fibre intended for use in a marine environment, that is provided with marine finish, and that has demonstrated performance in this respect

3.7
material certificate
document prepared by the manufacturer and the fibre producer certifying the type and grade of fibre material, the properties of the fibre, and that the material used in rope production is that which is specified in the rope design specification

3.8
minimum breaking strength
MBS
specified minimum value that the breaking strength of a rope shall achieve when tested following the procedure in this International Standard

NOTE In this International Standard, the specified MBS is that of a terminated rope.

3.9
prototype rope
rope fully complying with the rope design specification made for the purpose of testing either before an order is placed or before regular rope production begins for an order

3.10
qualified rope
rope already certified by the manufacturer as complying with the requirements laid down in this International Standard, including all the relevant prototype testing

3.11
recognized classification society
RCS
classification society being a member of the International Association of Classification Societies (IACS), with recognized and relevant competence and experience in fibre rope mooring, and with established rules/guidelines for related classification/certification activities

3.12
rope construction
manner in which the fibres, yarns and strands are assembled together in making the rope

NOTE In some rope constructions, rope core is made of sub-ropes, i.e. laid or braided ropes, that are assembled together by laying, braiding, or in parallel.

3.13
rope design specification
document which completely describes the design of the rope, including the numbers and arrangements of strands, the strand pitch, the material chemical composition and the manufacturing method

3.14
rope manufacturing specification
document which completely describes the process of making the rope, including instructions for each step of the manufacturing process

3.15
rope production report
document which completely describes the rope product, including rope design, termination design, and assembly length, and which includes the material certificates, material test results and the various checklists

3.16
rope termination
method (e.g. splice, potted socket, wedged socket) by which the rope is attached to the assembly interface

3.17
termination specification
document which completely describes the design of the termination and the process of making that termination, including materials and steps for making or assembling the termination

3.18
torque
moment that produces or tends to produce a twisting or a rotating motion around rope axis, i.e. the tendency of a rope to rotate due to a change in tension

4 Materials

4.1 Rope core material

4.1.1 Fibre tenacity

The fibre used in the core of the rope shall be high tenacity polyester fibre, with an average tenacity not less than 0,78 N/tex and in accordance with Annex A.

4.1.2 Marine grade

The polyester fibres used in the core shall be marine grade fibres.

The yarn-on-yarn abrasion performance shall be verified by tests on wet yarn, in accordance with Annex A, and it shall meet the requirements of A.4.2.1.4.

4.2 Rope cover material

When polyester yarn is used in the protective cover, its minimum tenacity shall be 0,73 N/tex and in accordance with Annex A.

4.3 Other materials

Other materials employed in rope assembly shall be identified in the rope design/manufacturing specification.

For each material, the following shall be specified, as applicable:

a) base material;

b) size (linear density, mass per unit area, …);

c) relevant strength properties (tenacity, hardness, …).

5 Requirements — Rope properties

5.1 Minimum breaking strength

The minimum breaking strength of the rope, when tested according to Clause 7 and Annex B, shall conform to Table 1.

Table 1 — Minimum breaking strength (MBS)

Reference number [a]	Minimum breaking strength kN
106	3 140
118	3 920
132	4 900
150	6 180
160	6 960
170	7 850
180	8 830
190	9 810
200	11 000
212	12 300
224	13 700
236	15 700
250	17 700
265	19 600

[a] The reference number corresponds to the approximate outer diameter of the rope, in millimetres (mm). Actual diameters may vary for a given reference number.

5.2 Minimum core tenacity

The rope minimum core tenacity shall be 0,47 N/tex, measured according to Annex B.

All samples tested shall comply with this minimum value.

5.3 Dynamic stiffness at end of bedding-in

The dynamic stiffness at the end of the bedding-in sequence, obtained at the time of the prototype testing in step 8 of the rope test procedure in B.3.1, shall be between 18 and 28.

NOTE A different range may be specified by the purchaser.

5.4 Torque properties

5.4.1 Torque-neutral rope

A rope is considered torque-neutral if it has a torque factor, Q, of less than 0,005.

$$Q = \frac{T}{d \cdot F}$$

where

Q is the torque factor;

d is the rope diameter, expressed in millimetres (mm);

F is the force applied to the rope, expressed in kilonewtons (kN);

T is the torque generated by the rope, expressed in newton metres (N·m).

The test method to demonstrate torque-neutral behaviour is defined in B.6.1.

Parallel construction ropes having braided sub-ropes or an equal number of left lay and right lay twisted sub-ropes which are all identical in every respect except for twist direction are inherently torque-neutral (see also 6.2). These constructions need not have their torque generation verified.

5.4.2 Torque-matched rope

A rope is considered torque-matched if its torsional characteristic over the design load range is essentially the same as that of the wire rope to which it is to be connected.

When tested as described in B.6.2, the angular rotation in the wire rope element shall not exceed 5° per rope lay.

5.5 Cyclic loading performance

The rope shall have demonstrated performance under cycling loading following the requirements of 7.1.6 and B.5.

5.6 Particle ingress protection

If specified, the rope shall be constructed with a protection of the core against the ingress of particles having a size greater than 20 µm (microns) or as agreed between involved parties. Testing of the protection shall be performed in accordance with B.7. The tests shall be performed on one rope size within the range of Table 1.

6 Requirements — Rope layout and construction

6.1 General

The typical section of a rope shall comprise a rope core, providing intended strength and stiffness, and a cover.

6.2 Type of construction

The rope shall be of one of the following types of construction:

— torque-neutral construction (type TF)*;*

— torque-matched construction (type TM).

The type of rope shall be specified by the purchaser.

NOTE Torque-neutral ropes are intended for use in mooring systems together with chain or torque-neutral spiral strand wire ropes. Torque-matched ropes are intended for use in mooring systems together with six-strand wire ropes or other non torque-neutral wire ropes. Typical constructions are illustrated in Figures E.1 and E.2.

6.3 Rope core

6.3.1 The total number of yarns in the rope shall be at least the number specified in the rope design specification.

6.3.2 Splices are not allowed in the rope core nor in sub-ropes, except for those at the end terminations.

Strands shall be uninterrupted over the length of the rope, with no splice or strand interchange.

NOTE Yarns may be joined if necessary.

6.4 Protective cover

6.4.1 A protective cover shall be provided around the rope core to protect the rope core from mechanical damages (mainly abrasion) during handling and in service.

The protection shall be water-permeable.

6.4.2 A polyester braided protective cover shall have a minimum thickness of 7,0 mm.

Strand interchanges, i.e. the overlapping continuation of an interrupted strand with another identical strand following the same path, are permitted if they are properly staggered.

6.4.3 If an alternative protective cover is used, it shall demonstrate a level of protection equal to that of a polyester braided cover.

6.4.4 A braided cover shall include coloured strands forming a pattern so that rope twist during installation or in service can be identified. There shall be a minimum of one 'S' coloured strand and one 'Z' coloured strand to form a cross on the rope.

An alternative protective cover shall be fitted with an axial stripe of contrasting colour, or other means to identify rope twist during installation or in service.

6.5 Terminations

The terminations shall be made of an eye splice plus abrasion protection materials.

NOTE There may be other terminations provided that they do not jeopardize the rope performance.

The dimensions and arrangement of the eye shall match the diameter and groove shape of the thimble (or other interface piece) to be used for end connections, and shall be the same as for the rope prototype testing.

In the splice area, the integrity and the continuity of rope cover and particle-ingress protection, if fitted, shall be preserved or restored.

The eye and the splice area shall be further covered by an abrasion protection coating such as polyurethane.

Each termination shall be made according to the manufacturing practice as described in the termination specification.

6.6 Length of rope

The standardized bedded-in lengths of the rope sections shall be multiples of one hundred metres (100 m), calculated in accordance with 7.2.2, under 20 % of MBS, unless otherwise agreed on the purchase order or contract.

The calculated length of supplied rope shall be within $\pm$ 1 % of the specified length.

For each supplied rope, the actual length at the reeling tension or during manufacture shall be reported as an indicative value.

The length of short sections intended as inserts shall be mutually agreed between the purchaser and the manufacturer.

Adequate extra length shall be manufactured in order to prepare the samples for testing, which are considered to be part of the delivery.

7 Rope testing

7.1 Prototype testing

7.1.1 General

Prototype tests demonstrate that ropes certified by the manufacturer as complying with the requirements laid down in this International Standard possess the properties specified in this International Standard. The purpose of these tests is to verify the design, material and method of manufacture of each size of finished rope, including protective cover and terminations.

All ropes to be prototype tested shall comply with all the other requirements laid down in this International Standard. The tests specified below shall be carried out on a prototype rope for each size of rope, unless otherwise noted in this Clause 7.

Any change in the design, material, method of manufacture, including protective cover and terminations, which may lead to a modification of the properties as defined in Clause 5 shall require that the prototype tests specified in this International Standard be carried out on the modified rope.

7.1.2 Sampling

The number of rope samples to be tested is given in Table 2.

Table 2 — Number of samples for testing

Test	Number of samples
Breaking strength, core tenacity and stiffness	3
Torque properties	1 [a]
Linear density	1
Cyclic loading endurance	1 [b]
[a] See 7.1.4.	
[b] See 7.1.6.	

7.1.3 Breaking strength, core tenacity and stiffness tests

7.1.3.1 Three samples shall be tested according to the procedure specified in Annex B, and each shall be capable of meeting the requirements of 5.1 (minimum breaking strength), of 5.2 (minimum core tenacity) and of 5.3 (dynamic stiffness at end of bedding-in).

7.1.3.2 The rope core tenacity and dynamic stiffness at end of bedding-in shall be calculated according to the methods defined in B.3.

7.1.3.3 Measurement of the static stiffness and of the dynamic stiffness at other load levels shall be performed within the same tests.

These measurements are, however, not required when results are available for another qualified rope of the same design, material and method of manufacture, with a reference number of not less than 150.

NOTE 1 These measurements are performed for design purposes only. There are no acceptance criteria on these parameters.

NOTE 2 These measurements can be also performed on a separate rope sample (see B.3.5).

7.1.4 Torque properties tests

Where applicable, torque properties tests shall be performed according to the procedure specified in B.6. These tests are, however, not required when results are available for another qualified rope of the same design, material, method of manufacture and termination, with a reference number of not less than 150.

7.1.5 Linear density test

The linear density shall be calculated from the measured weight and elongation according to the method defined in B.4.

7.1.6 Cyclic loading endurance test

7.1.6.1 One sample shall be tested for cyclic loading. However, cyclic loading endurance tests performed with two different sizes of qualified ropes having the same design, material and method of manufacture including protective cover and terminations, are enough to qualify all sizes with an MBS between 50 % of the MBS of the smaller rope and 200 % of the other. The test for cyclic loading is not required if such data is available.

7.1.6.2 The cyclic loading endurance test shall be performed according to the procedure specified in B.5.

A load range shall be selected by the manufacturer, and the rope shall withstand, without breaking, at least the number of cycles for that load range, as given in Figure B.2.

NOTE The value of the breaking force shows the rope residual strength and it is only for information.

7.1.7 Protective cover thickness

The thickness of the protective cover shall be verified.

The thickness of a braided cover shall be measured as twice the thickness of cover strands under the maximum braiding tension.

7.2 Testing of current production

7.2.1 Sampling and testing

When the ropes are already certified by the manufacturer as complying with the requirements laid down in this International Standard, the rope tests, including breaking strength and core tenacity, as well as protective cover thickness verification, shall be performed on one sample taken from the manufacturing process for each type and size of rope.

7.2.2 Length measurement

The bedded-in length of each supplied rope section (other than short sections) shall be calculated from the linear density, ρ_l, by the following formula:

$$L = \frac{(m_T - m_S) \cdot 1000}{\rho_{l,20}}$$

where

L is the length of the rope in metres (m);

m_T is the mass of the total rope length in kilograms (kg);

m_S is the mass of the materials used to form the eyes and the splices in kilograms (kg);

$\rho_{l,20}$ is the linear density of the rope, in ktex, obtained from the prototype test, in accordance with 7.1.5.

The length of short rope sections (i.e. sections of less than 20 m) shall be measured at a load of 2 % of MBS as the length between the centres of termination fittings (i.e. same as L_u on Figure B.1).

8 Report

8.1 Prototype rope

A complete and detailed report of the prototype rope manufacturing shall be supplied, including the fibre manufacturer, the fibre type and finish and all rope characteristics that may influence the mechanical properties, like design, material specifications, method of manufacture, including protective cover and terminations, with sketches or pictures.

A complete and detailed report of type tests, with sketches or pictures of the test set-up, shall also be provided.

8.2 Current production

The manufacturing report of supplied ropes shall be provided. A complete and detailed report of rope tests with sketches and pictures of the test set-up shall also be provided.

9 Certification

The certificate of approval and control, issued by a RCS, shall be presented together with the ropes, in order to ensure that testing and fabrication are in accordance with the approved specifications.

The rope manufacturer shall issue or obtain a rope certificate including at least the following information:

a) reference number;

b) type of construction;

c) linear density;

d) MBS;

e) individual identification number;

f) length at a specified load;

g) length at the reeling handling tension.

NOTE A suggestion for a certificate of conformity can be found in Annex C.

10 Marking, labelling and packaging

10.1 Marking

A tape of at least 3 mm wide printed with a reference identifying the manufacturer shall be incorporated into the rope. The maximum distance between two consecutive markings shall be 0,5 m.

10.2 Labelling

An identification plaque or alternative means shall be installed close to the splice with the following information, as a minimum:

a) purchase identification;

b) individual identification number;

c) reference to this International Standard;

d) type of construction (TF or TM), in accordance with 6.2;

e) rope MBS;

f) rope length at a specified load, according to 7.2.2.

10.3 Packaging

If the assembly is packed on a spool or a reel, these shall be suitable for the applicable transportation means and of appropriate construction in terms of strength.

The packaging shall be marked with the manufacturer's trademark and with the lot identification number.

NOTE The ropes may be delivered in steel reels or in containers. Alternative packaging designs may be provided with the prior approval of the purchaser.

Annex A
(normative)

Fibre qualification and testing

A.1 General

This annex specifies the requirements for fibre qualification and testing.

The requirements related to yarn-on-yarn abrasion performance are only applicable when a marine grade fibre is required.

A.2 Fibre specification

A.2.1 General information

A fibre specification shall include at least the information defined below:

a) identification and general properties of fibre;

b) detailed specification of physical and mechanical properties;

c) yarn-on-yarn abrasion performance.

NOTE General properties of material may be found in the material Safety Data Sheet.

A.2.2 Identification and general properties

The following information shall be provided in the fibre specification:

a) producer of fibres;

b) fibre designation;

c) fibre material (polyester);

d) number of filaments;

e) nominal size (linear density);

f) average tenacity;

g) marine finish designation;

h) finish content;

i) finish solubility in water.

A.2.3 Physical and mechanical properties

The following information shall be provided in the fibre specification, including tolerances on specified properties:

a) linear density;

b) dry break strength;

c) dry elongation to break;

d) dry elongation at a specified load level.

These properties shall be documented by results of tests in accordance with A.4.

A.2.4 Yarn-on-yarn abrasion performance

For a marine grade fibre, wet yarn-on-yarn abrasion performance data shall be also specified and documented by results of tests, in accordance with A.4.2.

A.3 Fibre certificate

For each delivery, the fibre manufacturer shall issue a raw material certificate including at least the following information:

a) fibre designation;

b) merge number/batch identification;

c) size (linear density);

d) dry breaking strength;

e) dry elongation to break;

f) test result of finish application (see A.4.2.3).

For acceptance testing, the above properties shall be obtained from testing on a representative number of samples taken from the delivery, not less than once every 5 000 kg.

For each property, the number of tests, the mean value and the standard deviation or range shall be reported.

A.4 Fibre testing

A.4.1 Fibre linear density and strength

The fibre linear density, strength and elongation shall be tested according to ASTM D 885.

A.4.2 Yarn-on-yarn abrasion performance

A.4.2.1 Qualification testing (efficiency)

A.4.2.1.1 When the fibre is specified to be “marine grade fibre”, qualification testing for efficiency of finish shall be performed on wet yarns in accordance with CI 1503.

A.4.2.1.2 Tests shall be performed at least at three load levels, including one in each of the following ranges:

a) (20 to 30) mN/tex;

b) (35 to 45) mN/tex;

c) (55 to 60) mN/tex.

A minimum of 8 yarns shall be tested for each level.

A.4.2.1.3 The results at each load level shall be derived and reported in accordance with the procedure in CI 1503.

A.4.2.1.4 The mean number of cycles to failure as defined in CI 1503, at each load level shall be above the minimum number of cycles given in Figure A.1 for that level.

NOTE The number of cycles to failure, N, shown in Figure A.1 is given by the equation

$$\lg N = 4{,}5 - \left(\frac{F_{\text{test}}}{30} \right)$$

where F_{test} is the test load, expressed in millinewtons per tex (mN/tex).

A.4.2.2 Qualification testing (persistence)

The persistence of the marine finish in a marine environment shall be demonstrated.

The assessment method shall be duly documented by the fibre producer.

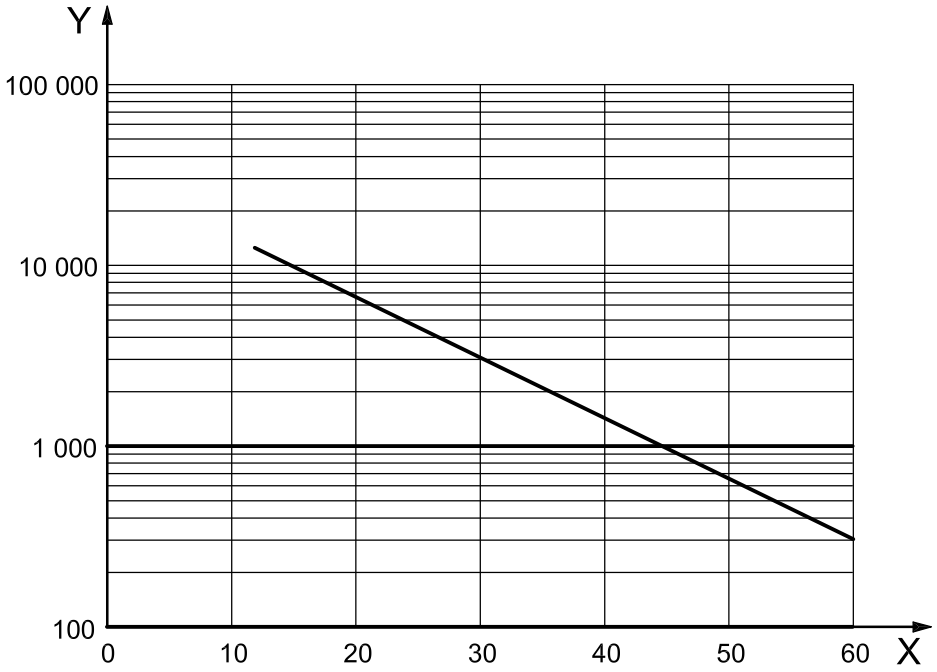
NOTE Yarn-on-yarn abrasion tests after artificial ageing may be used.

A.4.2.3 Testing of current production

The effectiveness of the application of the marine finish during fibre production shall be verified by yarn-on-yarn abrasion tests or another documented testing method.

When a yarn-on-yarn abrasion test is used, the testing shall be performed at least at one load level, on a minimum of four yarns at each test, with an acceptance level not less than the one given in Figure A.1 for that level.

Any other testing method shall be duly documented by the fibre producer.



Key

X test load, F_{test}, in millinewtons per tex (mN/tex)

Y number of cycles to failure, N

Figure A.1 — Minimum requirement for yarn-on-yarn abrasion test

Annex B
(normative)

Rope testing

B.1 General

This annex specifies the requirements for full-size testing of rope samples, and it addresses the following tests:

a) strength and stiffness;

b) linear density;

c) cyclic loading endurance;

d) torque measurement.

This annex also specifies the test on particle ingress resistance in B.7.

B.2 Testing conditions

B.2.1 Rope samples

The rope tests, including strength, cyclic loading endurance and torque measurement shall be performed on samples with terminations that are identical to the supplied ropes. The strength and cyclic loading tests shall be performed with fixed end conditions (without a swivel).

Termination fittings shall be provided, with the same type of material and the same profile and dimensions (radius, groove shape) as the thimbles for the supplied rope.

B.2.2 Ambient conditions

In all tests, the ambient temperature and humidity shall be recorded.

The water used for soaking, wetting and immersing shall be fresh water with no additives.

During the cyclic loading endurance test (see B.5), the rope shall be wetted by a water spray, or immersed, and the temperature shall be controlled in order to avoid over-heating.

The temperature of the out-flowing water should not exceed 30°C.

B.2.3 Testing machine

The testing machine shall be of at least class 2 according to ISO 7500-1 and it shall be of such a type that load (or cross-head displacement) can be controlled at all time, during both extension and retraction.

For the breaking test (step 10 in B.3.1), the use of a test machine with a fixed cross-head speed is acceptable, provided that time to failure is at least 3 min.

B.2.4 Load and elongation measurements

Load shall be measured by a strain gauge system and continuously recorded during each test.

NOTE In the loading sequences specified below, loads are given as a percentage of the specified MBS of the rope.

The measurements of the gauge length elongation of the rope core shall be performed with a system of adequate sensitivity for the intended sequences. Extensometer or video image processing may be used.

The cover and the filter shall be cut for fastening of extensometer ends or for marking of core in case of measurement by video image processing.

B.3 Strength and stiffness test

B.3.1 Test procedure

The following rope test procedure applies to verify the rope MBS, the minimum core specific strength and the stiffness. The test shall be performed according to the steps below:

— step 1: the sample shall be soaked for at least 4 h in fresh water;

— step 2: the sample shall be installed in the test machine;

— step 3: a load of 2 % of MBS shall be applied;

— step 4: the rope shall be marked at each end, at a distance of three times the rope diameter from the last tuck of splices (see Figure B.1);

— step 5: the extensometer shall be installed in a section of the rope undisturbed by the termination, between these marks;

— step 6: a tension of 50 % of the rope MBS shall be applied at a rate of 10 % MBS per minute and held for 30 min;

— step 7: the tension shall be reduced to 10 % of the rope MBS, at a rate of 10 % MBS per minute;

— step 8: a cycling tension between 10 % and 30 % of the rope MBS shall be applied 100 times, without interruption, at a frequency between 0,03 Hz and 0,1 Hz (bedding-in and measurement of dynamic stiffness after bedding-in);

— step 9: when applicable, a cycling tension between specified limits shall be applied for a specified number of cycles (dynamic or static stiffness measurements; see B.3.5), and without interruption; otherwise, this step is omitted;

— step 10: the sample shall be unloaded, the extensometer removed, and the rope pulled to failure, at a loading rate of approximately 20 % MBS per minute.

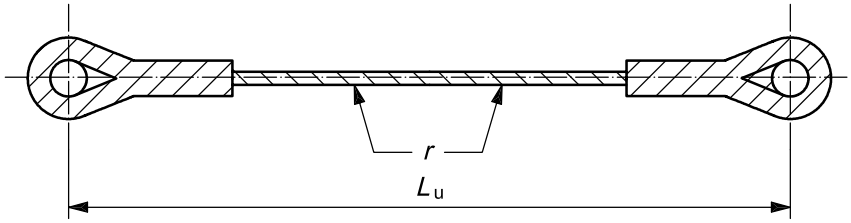


Figure B.1 — Marks “r” on the rope sample

B.3.2 Breaking strength

The tension at break of the rope sample shall be recorded.

All samples tested shall meet the MBS.

If the breaking load of one sample is lower than the MBS, two other samples shall be prepared and tested. The rope is considered to comply with the breaking strength requirement in this International Standard only if the results of both the subsequent two tests meet the MBS.

B.3.3 Load-elongation measurements

The rope test shall include the measurement of the following:

a) load versus total elongation (stroke), four plots as below

   1) steps 5 to 7,

   2) step 8,

   3) step 9 (when performed),

   4) step 10;

b) gauge length (extensometer) elongation (for the prototype rope), three plots as below

   1) load versus elongation encompassing steps 5 to 7,

   2) load versus elongation for the last 3 full cycles at least, in step 8,

   3) load versus elongation for the last 3 full cycles at least, in step 9 (when performed);

c) continuous record for the prototype rope of load and elongation during the 3 cycles of the quasi-static stiffness test.

NOTE Step numbers refer to B.3.1.

B.3.4 Dynamic stiffness at end of bedding-in

The dynamic stiffness at end of bedding-in (step 8 of B.3.1) shall be obtained from the load and gauge length elongation measurements, and shall be calculated according to B.3.6.2.

B.3.5 Quasi-static stiffness and dynamic stiffness

B.3.5.1 The quasi-static stiffness and the dynamic stiffness at other load levels shall be obtained from load and gauge length elongation measurements in step 9 in B.3.1, and calculated according to B.3.6.3 and B.3.6.4.

NOTE Additional measurements of dynamic stiffness may be performed when agreed between the purchaser and the manufacturer (see Annex E).

B.3.5.2 For the measurement of the quasi-static stiffness, the following cycling shall be applied in three full cycles without interruption:

a) slowly load the rope from 10 % of the rope MBS to 30 % of the rope MBS in a period of time between 2 min and 6 min;

b) hold the load at 30 % of the rope MBS for 30 min from the start time of a) above;

c) slowly unload the rope from 30 % of the rope MBS to 10 % of the rope MBS in a period of time between 2 min and 6 min;

d) hold the load at 10 % of the rope MBS for 30 min from the start time of c) above.

This cycling shall be performed during step 9 of B.3.1 above on one sample before the cycling for the dynamic stiffness.

NOTE Other load levels may be considered when agreed between involved parties (see Annex E).

B.3.5.3 For the measurement of the dynamic stiffness, the following cycling shall be applied during step 9 of B.3.1 at a frequency between 0,03 Hz and 0,1 Hz:

— step 9a: on one sample: 100 cycles between 20 % and 30 % of the rope MBS;

— step 9b: on a second sample: 200 cycles between 30 % and 40 % of the rope MBS;

— step 9c: on a third sample: 300 cycles between 40 % and 50 % of the rope MBS.

In the case of an interruption within a set of cycling, this set of cycling shall be repeated.

If the interruption leads to unloading of the rope, the step 8 shall be performed again before re-running the interrupted set of cycling.

B.3.5.4 Alternatively to the above, measurements may be performed as follows.

a) All measurements are performed on the same sample, quasi-static stiffness, then dynamic stiffness, as steps 9a, 9b, and 9c (see B.3.5.3), in ascending order of load. Then, the cycling may be limited to 100 cycles at each level.

b) These measurements are performed on a separate rope sample, in either wet or dry condition according to the steps below:

   1) the sample shall be installed in test machine;

   2) steps 3 to 8 of B.3.1, including measurement of the dynamic stiffness at the end of bedding-in;

   3) step 9 of B.3.1 with cycling as per B.3.5.2 for the measurement of the quasi-static stiffness;

   4) steps 9a, 9b, 9c of B.3.5.3 with cycling for the measurement of the dynamic stiffness.

B.3.6 Calculation of mechanical properties

B.3.6.1 Core tenacity

The rope core tenacity shall be calculated as follows:

$$t = \frac{F_{\mathrm{BS}}}{\rho_{l,\mathrm{c0}}}$$

where

t is the rope core tenacity, expressed in newtons per tex (N/tex);

F_{BS} is the actual breaking strength of the rope, expressed in newtons (N), obtained in step 10 of B.3.1;

$\rho_{l,\mathrm{c0}}$ is the linear density of the rope core, expressed in tex, at 2 % of MBS, as measured during the linear density test (see B.4).

B.3.6.2 Dynamic stiffness at end of bedding-in

The dynamic stiffness at end of bedding-in is calculated from the load-elongation measurement at end of step 8 of B.3.1.

The dynamic stiffness is calculated, as follows:

$$K_{\mathrm{rb}} = \frac{\dfrac{F_{30} - F_{10}}{F_{\mathrm{MBS}}}}{\dfrac{L_{30} - L_{10}}{L_{10}}}$$

where

K_{rb} is the dynamic stiffness after bedding-in;

$F_{30} - F_{10}$ is the recorded variation of load over the 100th cycle;

F_{MBS} is the specified minimum breaking strength of the rope;

$\dfrac{L_{30} - L_{10}}{L_{10}}$ is the elongation (strain variation) between F_{10} and F_{30} over the 100th cycle.

NOTE Alternatively, the stiffness may be obtained from the average slope of the load-elongation plot over the last three full cycles.

B.3.6.3 Dynamic stiffness

When required, the dynamic stiffness is calculated as follows from load-elongation measurements of step 9a, 9b or 9c of B.3.5.3:

$$K_{\mathrm{rd,X->Y}} = \frac{\dfrac{F_{\mathrm{Y}} - F_{\mathrm{X}}}{F_{\mathrm{MBS}}}}{\dfrac{L_{\mathrm{Y}} - L_{\mathrm{X}}}{L_{\mathrm{X}}}}$$

where

$K_{rd,X\rightarrow Y}$ is the dynamic stiffness under cycling between load X and Y;

$F_Y - F_X$ is the recorded variation of load over the last cycle;

$\frac{L_Y - L_X}{L_X}$ is the elongation between F_X and F_Y over the last cycle.

NOTE Alternatively, the stiffness may be obtained from the average slope of the load-elongation plot over the last three full cycles.

B.3.6.4 Quasi-static stiffness

When required, the quasi-static stiffness is calculated as follows from load-elongation measurements:

$$K_{rs,X->Y;1h} = \frac{\frac{F_Y - F_X}{F_{MBS}}}{\frac{L_Y - L_X}{L_X}}$$

where

$K_{rs,X\rightarrow Y;1h}$ is the quasi-static stiffness under cycling between loads X and Y, over a period of 1 h;

$F_Y - F_X$ is the recorded variation of load over the last cycle;

$\frac{L_Y - L_X}{L_X}$ is the recorded elongation between F_X and F_Y over the last cycle.

NOTE 1 Alternatively, the quasi-static stiffness may be obtained by averaging the results over the last three half-cycles.

NOTE 2 The quasi-static stiffness for longer cycling periods may be obtained by extrapolation from the records of load and elongation versus time (see Annex E).

B.4 Linear density

B.4.1 Test procedure

The linear density is calculated from a dry sample of rope with at least 2 m free length (out of splice area, as for marks “r” in B.3.1) taken from the manufacturing process, according to the following procedure, unless otherwise agreed on purchase order or contract:

a) the sample shall be installed in the test machine;

b) a suitable fastening shall be provided in order to ensure no slippage between the cover and the core;

c) the sample shall be submitted to a tension of 2 % of MBS, and a length of about 2 m marked as a reference length, L_{R0};

d) the tension shall be increased to 20 % of the rope MBS, at a rate of 10 % of MBS per minute;

e) a cycling tension between 15 % and 25 % of the rope MBS shall be applied 100 times at a frequency between 0,03 Hz and 0,1 Hz;

f) after cycling, the tension shall be maintained at 20 % of the rope MBS and the reference length, L_{R20}, shall be measured, immediately after this tension is reached;

g) the tension shall be lowered to 2 % of MBS and the reference length, L_{R2}, shall be measured again, immediately after the 2 % tension is reached;

h) after unloading, the sample shall be cut upon the reference length marks. The cut sections shall be flat and perpendicular to the rope longitudinal axis;

i) the mass of the segment shall be measured and recorded;

j) after removing the cover, the mass of the core segment shall be also measured and recorded.

B.4.2 Calculation of linear densities

The linear densities shall be calculated as:

$$\rho_{l,0} = \frac{m_R}{L_{R0}} \quad \rho_{l,20} = \frac{m_R}{L_{R20}} \quad \rho_{l,2} = \frac{m_R}{L_{R2}} \quad \rho_{l,c0} = \frac{m_{RC}}{L_{R0}}$$

where

$\rho_{l,0}$ is the linear density of the rope, expressed in ktex, as manufactured, under 2 % of MBS;

$\rho_{l,20}$ is the linear density of the rope, expressed in ktex, after the rope has been cycled and under 20 % of MBS;

$\rho_{l,2}$ is the linear density of the rope, expressed in ktex, under 2 % of MBS after being mechanically worked to the above procedure;

$\rho_{l,c0}$ is the linear density of the rope core, expressed in ktex, as manufactured, under 2 % of MBS;

m_R is the mass of the reference length, expressed in grams;

m_{RC} is the mass of the reference length of rope core, expressed in grams;

L_{R0} is the length of the reference length, expressed in metres, as manufactured, under 2 % of MBS;

L_{R20} is the length of the reference length, expressed in metres, after the rope has been cycled and under a tension of 20 % of MBS;

L_{R2} is the length of the reference length, expressed in metres, under 2 % of MBS after being mechanically worked to the above procedure.

B.5 Cyclic loading endurance test

B.5.1 Planning

A load range between 40 % and 50 % of MBS shall be selected by the manufacturer.

The corresponding minimum number of cycles shall be obtained from Figure B.2.

The mean load during test shall be such that the maximum load is within 52 % and 55 % of MBS.

NOTE The number of cycles, N, in Figure B.2 is given by the equation:

$$N \cdot R^{5,05} = 166$$

where R is the load range divided by the MBS.

$N = 17\,000$ for $R = 0,4$

$N = 5\,500$ for $R = 0,5$

B.5.2 Test procedure

The cyclic loading test shall be performed as follows:

a) the sample shall be soaked for at least 4 h in fresh water;

b) the sample shall be installed in the test machine;

c) a load of 2 % of the MBS shall be applied;

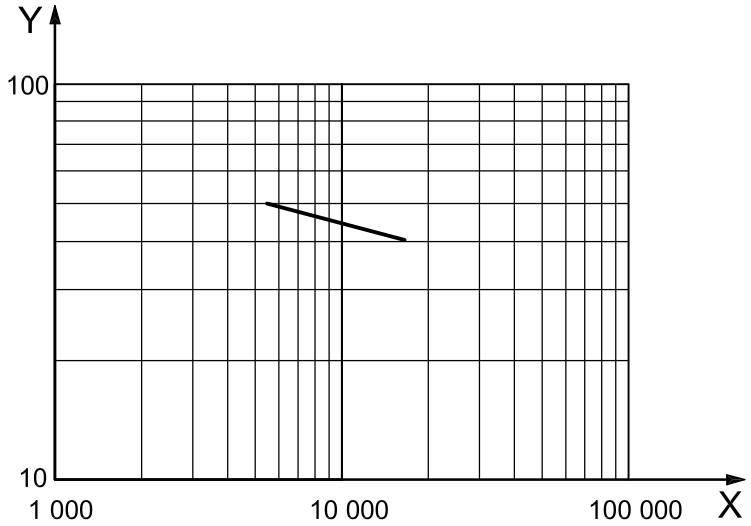
d) a tension of 50 % of the rope MBS shall be applied at a rate of about 10 % of MBS per minute and held for 30 min;

e) the tension shall be reduced to 30 % of the rope MBS at a rate of about 10 % of MBS per minute;

f) cyclic loading between the selected levels shall be applied for at least the specified number of cycles at a frequency between 0,01 Hz and 0,1 Hz;

g) unload the sample, and pull the rope to failure at a loading rate of approximately 20 % of MBS per minute.

NOTE The value of the load at breaking shows the residual strength of the rope and it is only for information.



Key

X endurance (number of cycles), N

Y load range, R (% of MBS)

Figure B.2 — Minimum requirement for cyclic loading test

B.6 Torque measurement

B.6.1 Torque factor

The torque factor shall be verified by the following procedure:

a) a sample of rope, as described in B.2.1, shall be installed in the test machine;

b) a load of 2 % of MBS shall be applied to the sample and the rope diameter, d, measured;

c) a tension of 50 % of the rope MBS shall be applied at a rate of 10 % of MBS per minute and held for 30 min;

d) the tension shall be reduced to 10 % of the rope MBS at a rate of 10 % MBS per minute;

e) a cycling tension between 10 % and 30 % of the rope MBS shall be applied 100 times, without interruption, at a frequency between 0,03 Hz and 0,1 Hz;

f) the tension shall be released and a friction-compensating swivel shall be introduced between one end of the sample and the test machine pin (preferably the fixed end pin);

g) a load of 2 % of MBS shall be applied to the sample;

h) a rigid steel lever shall be firmly attached across the face of the rope end fitting at right angles to the line of applied load;

i) the load shall be reduced to zero and a compression load cell, mounted on a solid base, placed in touching contact with the extremity of the lever;

j) the distance of the load cell contact point from the centre line of the rope shall be measured;

k) the load on the rope, F, shall be increased to 10 % of MBS;

l) the torque in newton metres (N·m), generated by the rope at 10 % of MBS, shall be calculated by reference to the load cell measurement and lever arm length.

The torque factor, Q, shall be calculated using the formula in 5.4.1.

B.6.2 Torsional compatibility

The torsional compatibility shall be verified by the following procedure:

a) equal length samples of the fibre rope and of the wire rope to be matched shall be connected in series and arranged in a test machine with both outer ends fixed;

b) the sample shall be loaded to 2 % of the wire rope component MBS. The length of each rope and the lay length of the wire rope shall be measured;

c) in order to settle the sample, the composite sample shall be cycled 10 times between 2 % and 20 % of wire rope component MBS;

d) the sample shall be held at the 20 % load and the connection between the two ropes shall be provided with means to measure any rotation of the connection, such as a lever;

e) the sample shall be cycled 10 times with a load of $\pm$ 10 % of MBS, and the angular rotation of the connection per cycle shall be noted;

f) the average cyclic degree of rotation per lay of the wire rope shall be calculated and shall not exceed the value specified in 5.4.2.

B.7 Particle ingress resistance

One sample shall be tested as follows:

a) a specimen from a new rope with useful length of at least two times the rope diameter shall be selected;

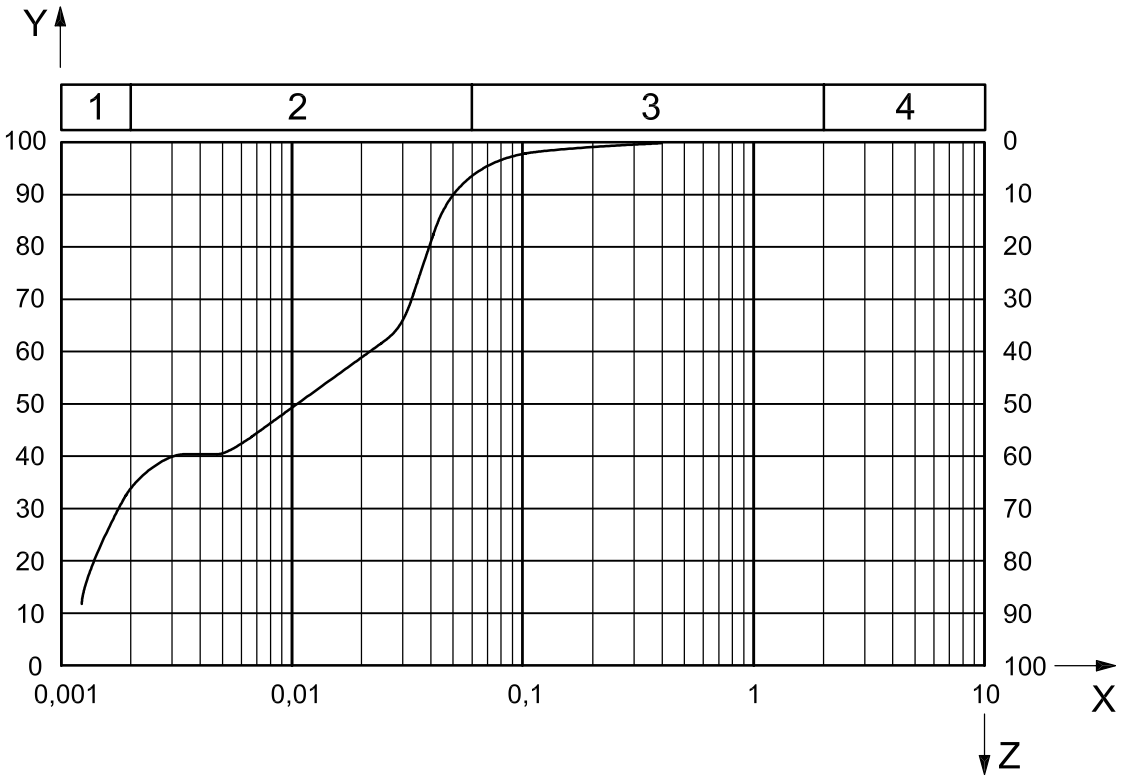
b) the specimen ends shall be sealed with a waterproof compound;

c) the specimen shall be placed into a hyperbaric chamber and it shall be immersed in tap water with a sufficient volume to cover it. It shall be kept for 60 min at atmospheric pressure;

d) an amount of soil shall be added at a proportion of 25 % of water weight. The soil shall meet or exceed the grading shown in Figure B.3;

e) a pressure of 10 MPa shall be applied during a period of 72 h. During this period, the soil shall not be allowed to settle and it shall be kept suspended in water;

f) after this period, the pressure shall be removed and the rope core shall be examined by a scanning electron microscope (SEM) to determine the efficiency of the filter in avoiding soil particle ingress with a size equal to, or greater than, the one stipulated.



Key

1 clay $\leqslant$ 2 µm
2 silt $>$ 2 µm and $\leqslant$ 63 µm
3 sand $>$ 63 µm and $\leqslant$ 2 mm
4 gravel $>$ 2 mm and $\leqslant$ 63 mm
X particle size (mm)
Y passing percentage (%)
Z retained percentage (%)

Figure B.3 — Grading of soil for particle ingress resistance test

Annex C
(informative)

Certificate of conformity — Polyester ropes for offshore stationkeeping

Certificate Number: _____

Purchaser		
Purchaser Order Number	:	
Production Order	:	
ROPE IDENTIFICATION		
Designation	:	
Reference Standard		**ISO 18692**
Material	:	polyester
Reference Number	:	
Type of construction	:	Torque-neutral (type TF) - Torque-matched (type TM) *
Linear density (ktex)	:	
Minimum Breaking Strength (kN)	:	
RCS / Type Approval Certificate number	:	
	:	

* specify

Item	**Rope individual identification number**	**Nominal length (at …% of MBS)** (metres)	**Actual length (at …% of MBS)** (metres)	**Rope length at reeling handling tension** (metres)	**Rope net mass** (kg)**	**Packaging number**
1						
2						
3						
…						

** including termination and fitting

Place: ***Date*:** _____

Quality Control Supervisor

Annex D
(informative)

Guidance for rope handling care

D.1 General considerations

Whenever fibre ropes for offshore stationkeeping are being handled, avoid the following:

a) contact between rope and sharp edges (attention to vessel's drum area and stern roller);

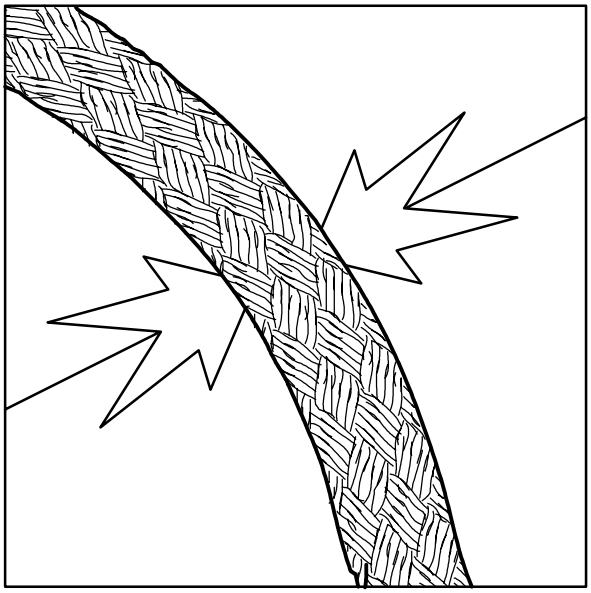


Figure D.1

b) excessive abrasion between rope and rough surfaces (attention to vessel's deck and stern roller);

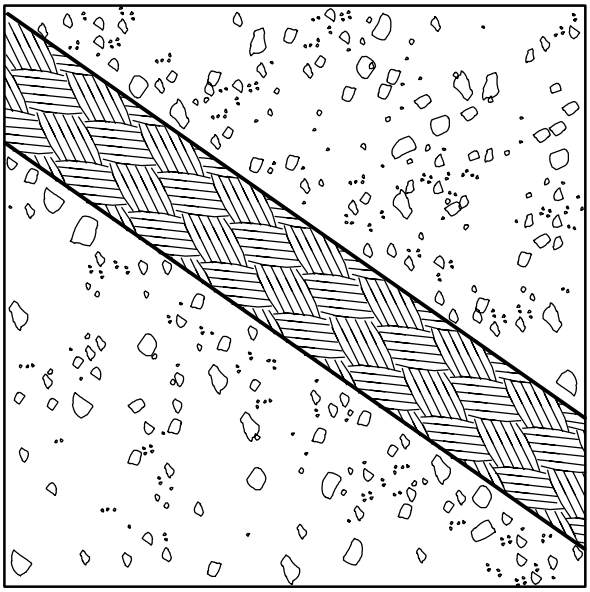


Figure D.2

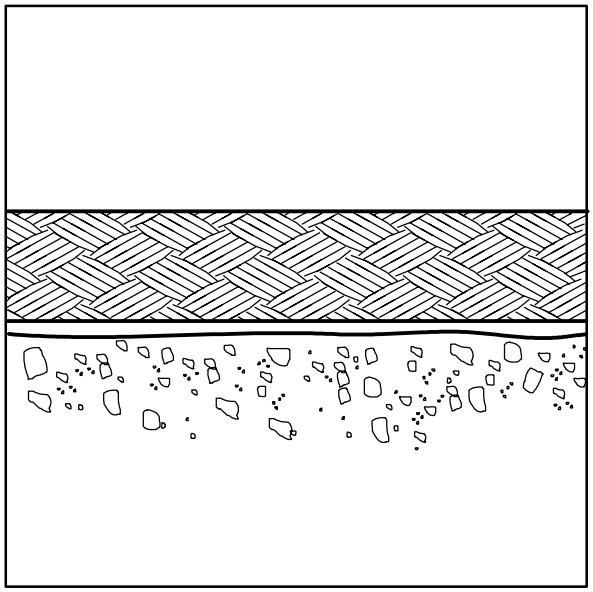


Figure D.3

c) working or handling with sharp tools (knives, blades, steel cables);

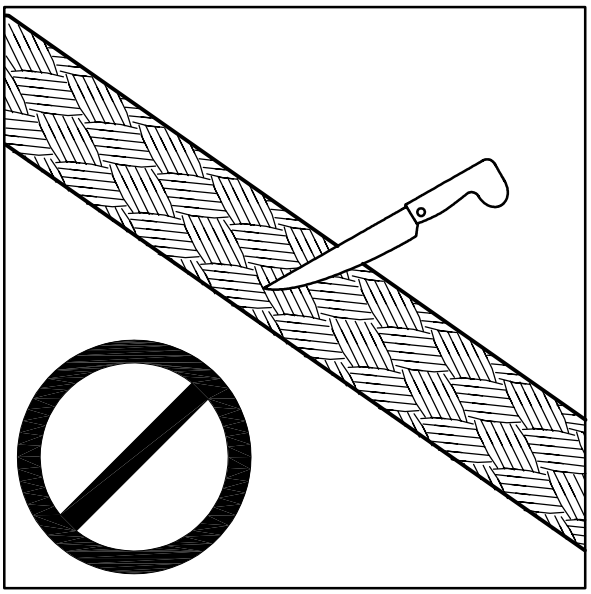


Figure D.4

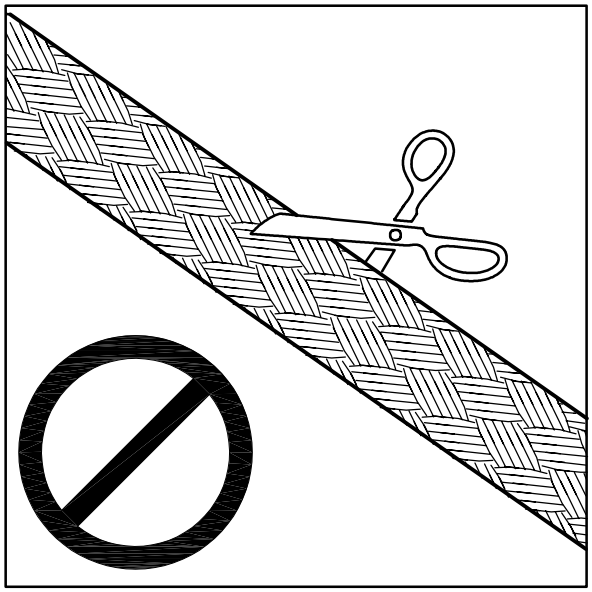


Figure D.5

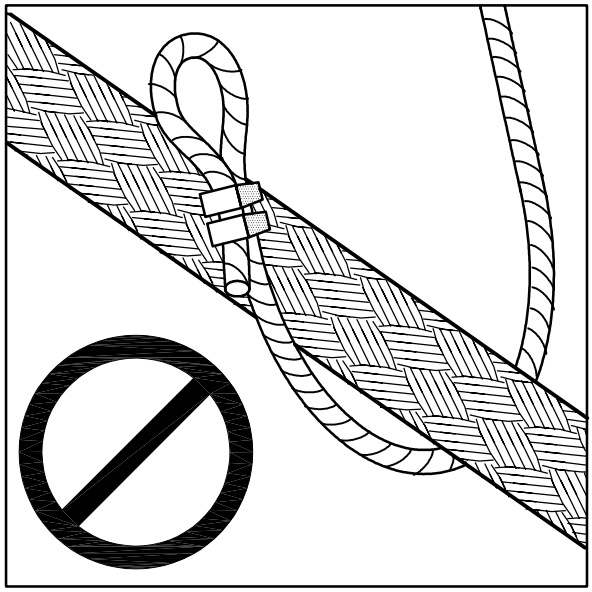


Figure D.6

d) excessive dirt in the rope and work area (oil, mud, scraps);

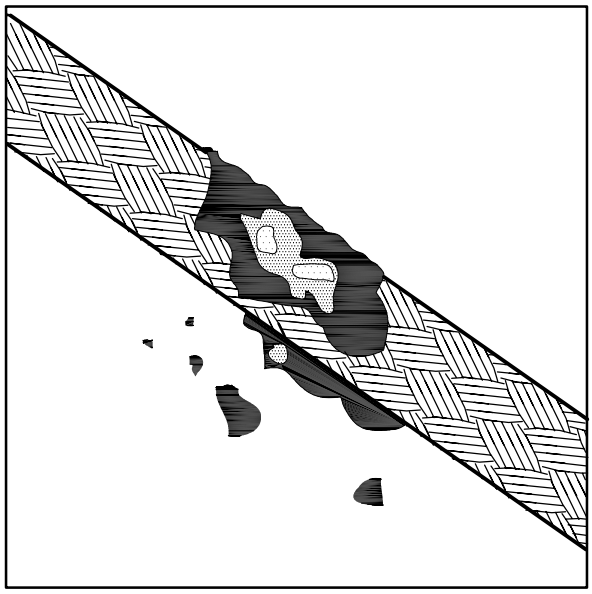


Figure D.7

e) excessive twist or bending in the rope;

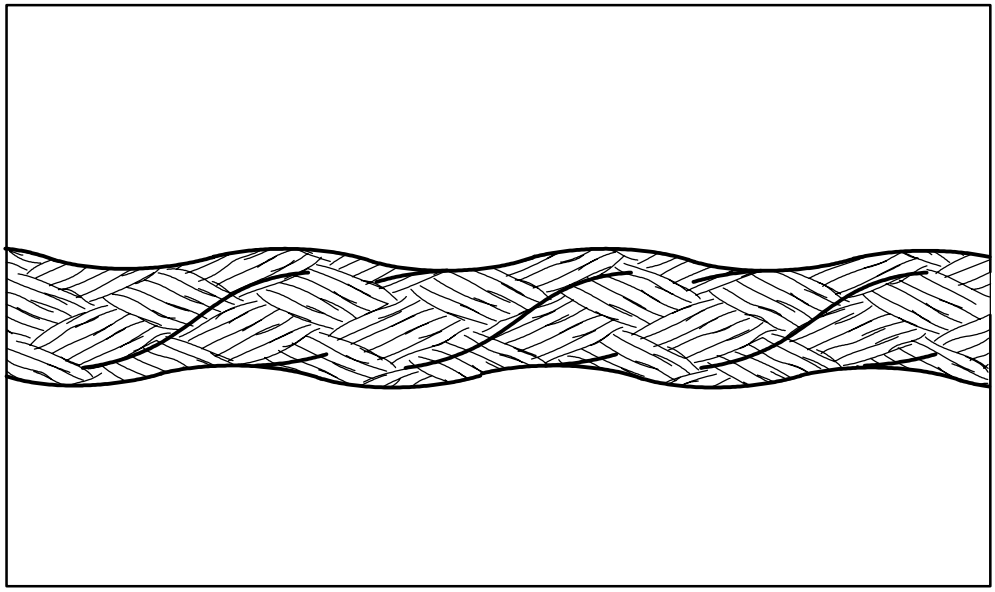


Figure D.8

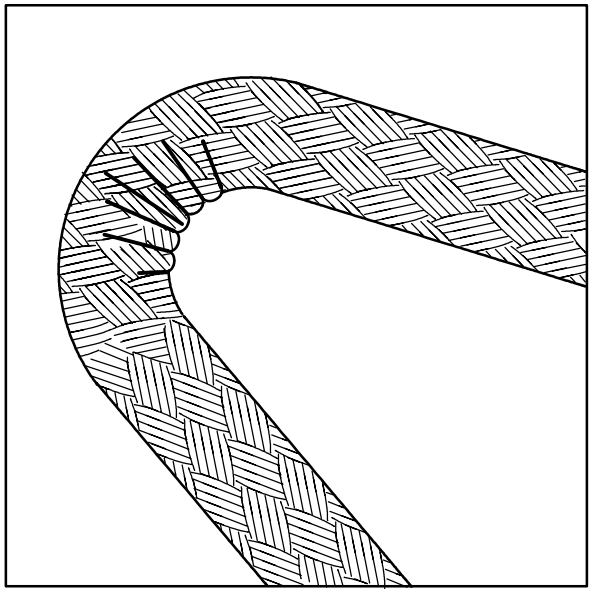


Figure D.9

f) contact with chemicals and prolonged exposure to sunlight.

D.2 Presentation of rope on reels

Fibre ropes for offshore stationkeeping will normally be supplied wound onto steel reels.

Protective packaging material will be wound around the main body of the rope to provide protection during transportation.

Packaging material should be carefully removed without cutting or damaging the rope. Strapping around the packaging may be under high tension and may snap back when cut, so extra care should be taken.

Insert segments will likely be provided in packing crates of considerable dimension. Crates may be handled with a forklift truck of suitable dimension and working load provided the fork positions enable safe lifting. Alternatively, the crates may be lifted by a slinging arrangement provided the slings are connected to the underside of the crate and are positioned to enable equal load distribution and safe lifting. Lifting slings which risk to damage the crate, thereby risking the segments packed inside, are not permitted.

D.3 Reel lifting and handling

When using a crane, reels should be lifted using a specified lifting arrangement.

When lifting reels, the initial load application and final set-down should be conducted as slowly and softly as possible to prevent the imposition of undue acceleration and deceleration forces.

Reels should not be rolled on the floor when loaded with rope. When empty, reels should not be rolled unless it is absolutely essential, and only on flat clear ground and where methods to fully control rolling are applied.

Reels should not be twisted or moved sideways whilst standing on the ground. Forklift trucks should not be used to lift reels in either the full or empty condition.

Where reel cradles are provided, the reel should not be disconnected from the cradle until just prior to installation into the rope spooling mechanism. The use of the cradle will prevent reel rolling, minimize instability and ensure correct reel orientation when in storage.

D.4 Reel storage and maintenance

The ropes should be stored on reels on flat ground in reel cradles, where supplied, or else suitably chocked to prevent any unexpected movement. They should not be stacked on top of each other. The reels should be covered if stored outside to avoid prolonged exposure to sunlight, prevent plant growth on the ropes and to prevent abrasive particles from being deposited into the cover. These measures will ensure that the rope cover is maintained in as good a condition as possible.

Steel spools and other fittings should not be connected to the rope when stored on a reel to avoid chafing the rope cover.

D.5 Installation

D.5.1 Deployment overboard

During deployment overboard, the following precautions are recommended.

a) When a new rope is in contact with the vessel's deck and stern roller, spraying water directly on the rope will help to avoid damage caused by external abrasion and reduce rope internal abrasion between fibres.

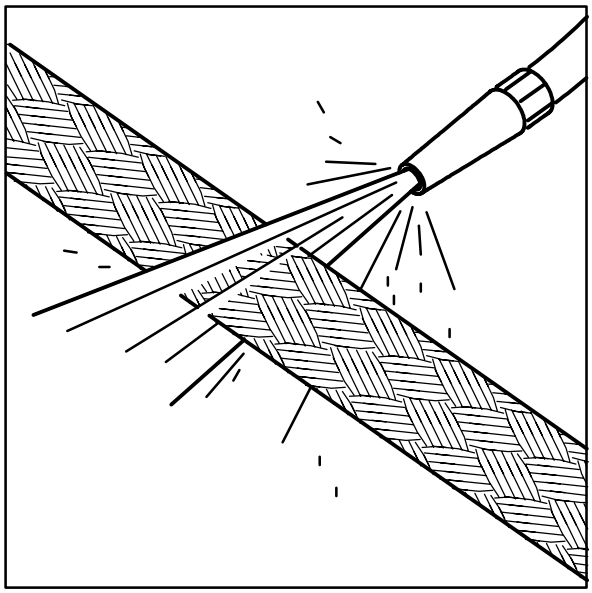


Figure D.10

b) When installing the thimble, avoid excessive opening of the rope eye, which may damage or crack the polyurethane coating.

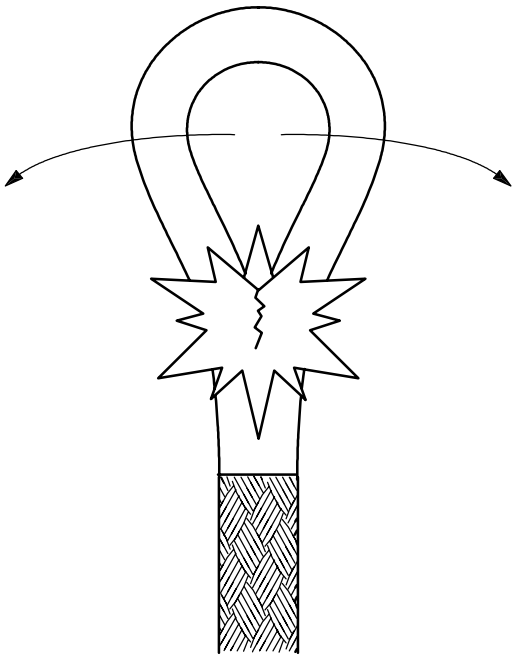


Figure D.11

c) Avoid proximity with works involving fire, corrosive chemical products, or excessive heat. If unavoidable, protect the rope.

Figure D.12

d) Avoid contact of the rope with the seabed.

D.5.2 Line tensions and re-reeling

The maximum line tension during deployment should be calculated and designed not to exceed 10 % of MBS. The deployment of heavy anchors and long lengths of chain may be required. It is recommended that the rope does not support the complete weight of these and they are either pre-deployed or a second line is used. In the latter case, care should be taken to avoid the second line causing damage to the rope both during the deployment and after disconnection. This second work line should ideally be a torque-balanced fibre rope.

The standard reels that ropes are normally transported on will not withstand line tensions over a few tonnes. It is recommended that the ropes be transferred to a winch drum on an anchor-handling vessel or to a purpose-built deployment reel. The lines can then be deployed directly from the winch or from the deployment reel via a dedicated deployment winch. Any temporary connection to the eye during re-reeling should be made using a fibre rope or webbing sling. The load in any connecting rope should be kept to a minimum to avoid cutting into the bearing point of the eye.

To reduce the chances of burying on a drum and possible damage caused to the cover by relative movement of the rope against the layer below, the deployment tension should be designed to be as low as possible. Applying tension during re-reeling onto a winch or storage drum will help avoid burying, along with a good traverse mechanism. As a guide, lines re-reeled at low tension and deployed with a line tension below 5 % of MBS do not experience problems with burying.

D.5.3 Equipment condition

All surfaces with which the rope will come into contact should be smooth and free from sharp edges. Relative movement between the rope and any equipment that it will contact during deployment should be avoided. Special care should be taken to avoid contact between the polyurethane eyes of the rope and metal parts such as winch frameworks.

D.5.4 Rollers and rope bending

Occasional bending and running over rollers is allowable during deployment. The rope should not be repeatedly cycled around rollers for prolonged periods of time. The rope should also not be left for prolonged periods around bends under dynamic loading conditions.

Drums, sheaves and rollers should rotate freely.

The minimum storage D/d ratio is given by the barrel diameter of the transport reels. Insert lengths may utilize a lesser D/d ratio when packed in the original shipment.

D.5.5 Pre-tensioning and hook-up

In order to test the anchors and to remove initial constructional stretch from the tethers, a tensioning programme may be used. It may also be necessary to re-tension the lines from time to time during the early life of the mooring system and after its first storm loading in order to remove further constructional extension from the rope. Line tensions should continue to be monitored and retensioning should be completed when necessary.

When applying high tensions to the rope during deployment or hook-up, the rope and terminations should be clear of any bends or obstructions. The rope should be completely outboard of the deployment vessel and fully submerged in the seawater.

D.6 Identifying damage

D.6.1 Damage to the rope cover

Small external damages, such as dirt and minor abrasion, are very common. The objective of the rope cover and filter is to protect the inner cores. The cover and filter are not considered for calculations of rope performance regarding, for example, breaking strength and stiffness.

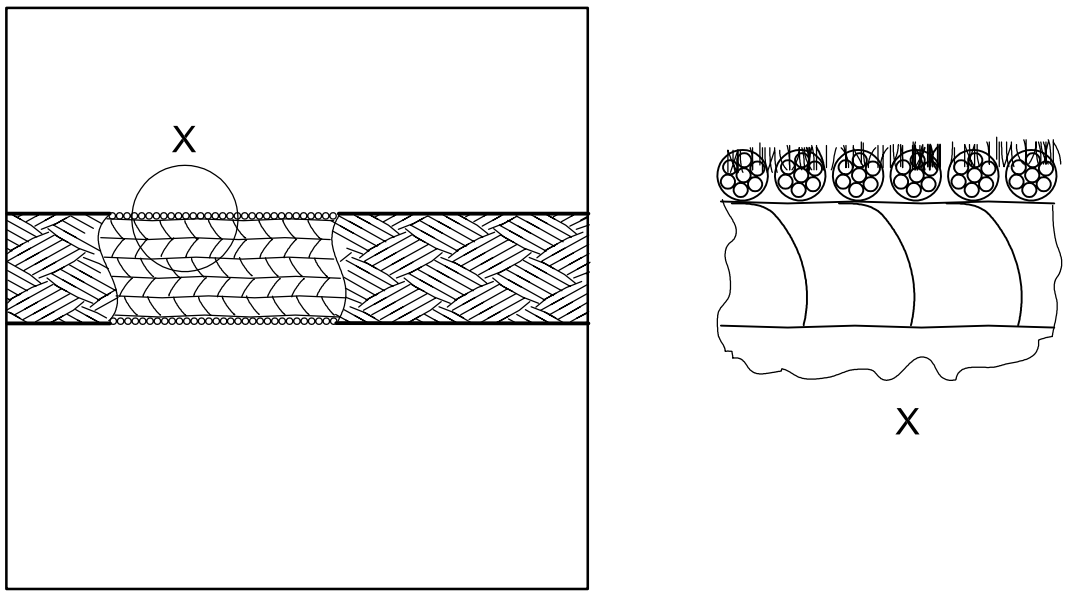


Figure D.13

External damages can be visually identified as the following.

a) Excess dirt which does not represent major damage. The objective of the cover is to protect the rope cores. In this case, wash the area with fresh water.

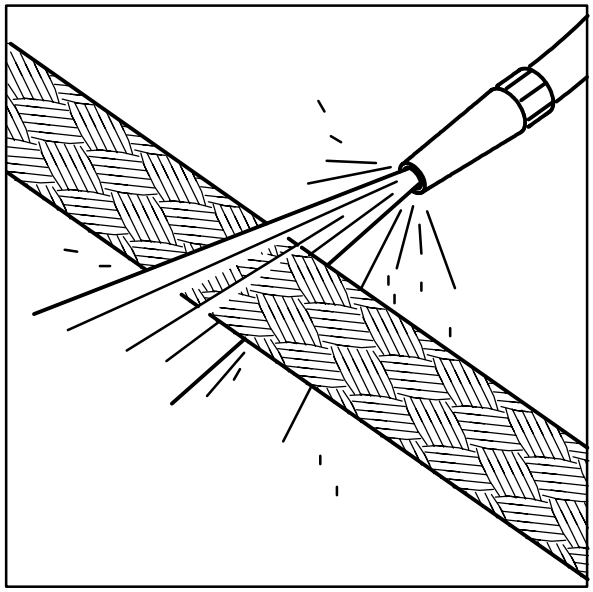


Figure D.14

b) Cuts in the rope cover exposing the cores. In this case, if the exposed area of the core does not show any signs of cuts or dirt, cover the area with small diameter cords in a spiral array and secure them with reinforced adhesive tape; otherwise, the rope should be rejected.

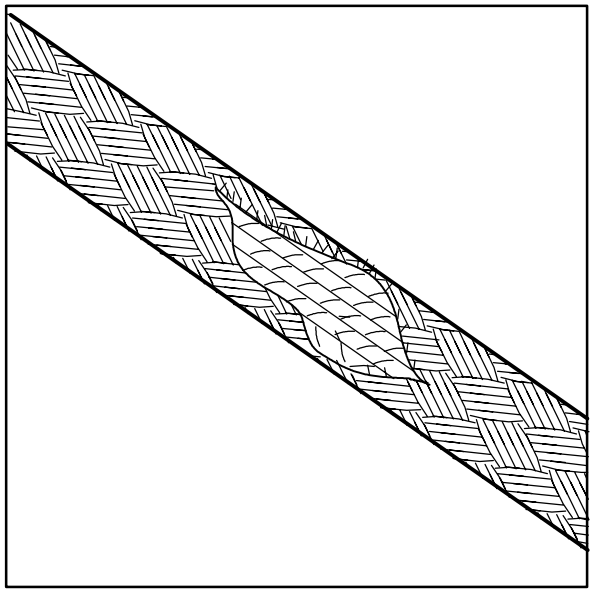


Figure D.15

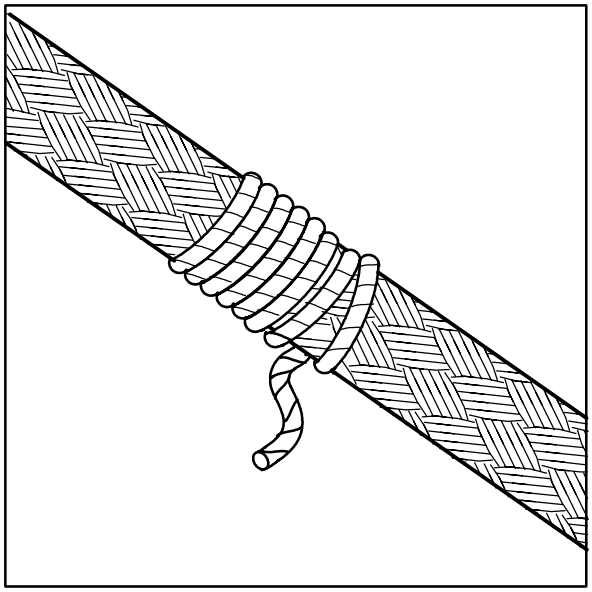


Figure D.16

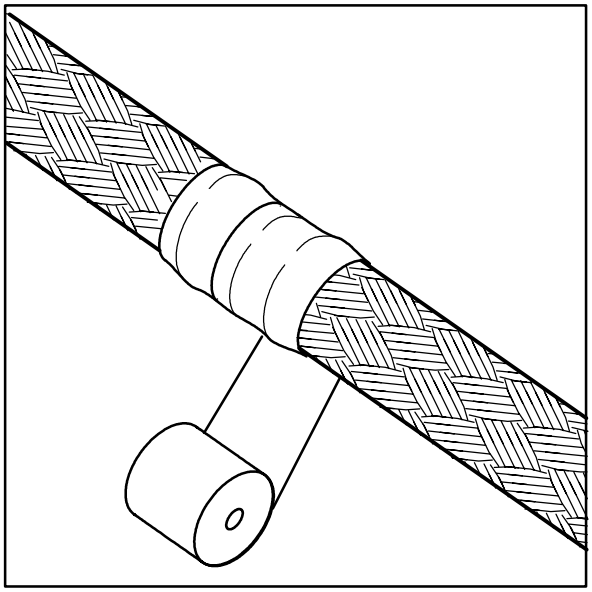


Figure D.17

c) Threadbare cover caused by abrasion, without a cut. In this case, cover the area with reinforced adhesive tape.

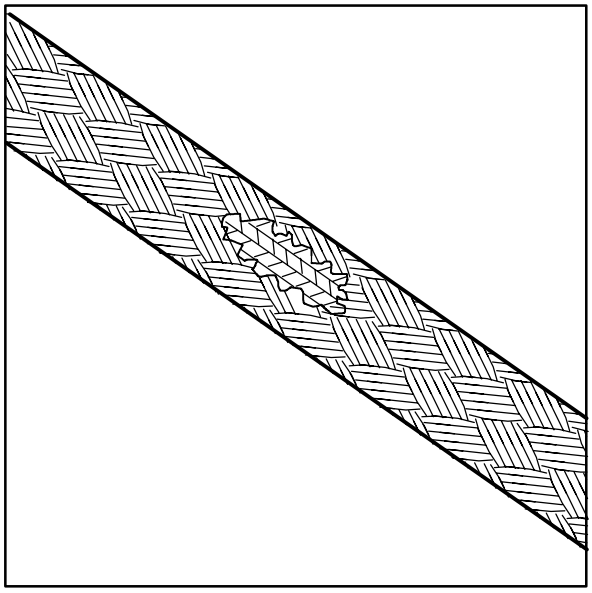


Figure D.18

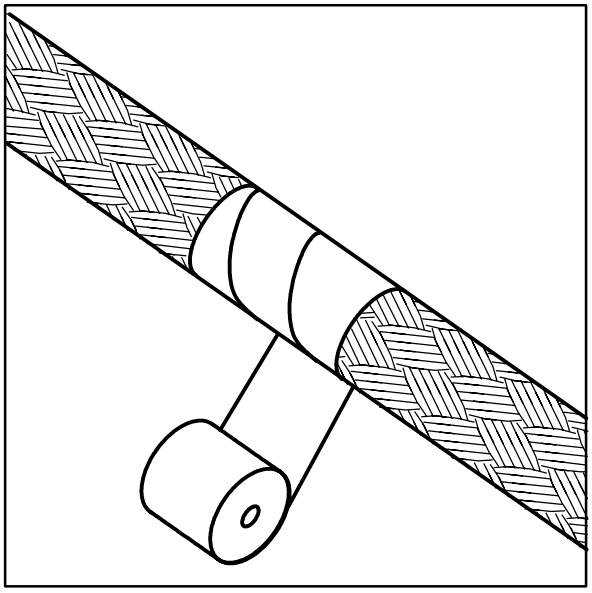


Figure D.19

D.6.2 Damage to the rope core

Ropes with damaged cores should be rejected.

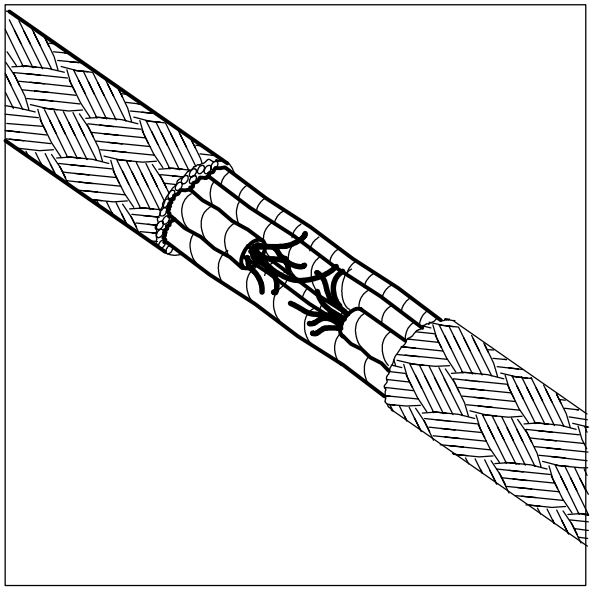


Figure D.20

It should be noted that only major internal damage can be identified visually. Excessive non-linearity in the rope surface may represent internal damage.

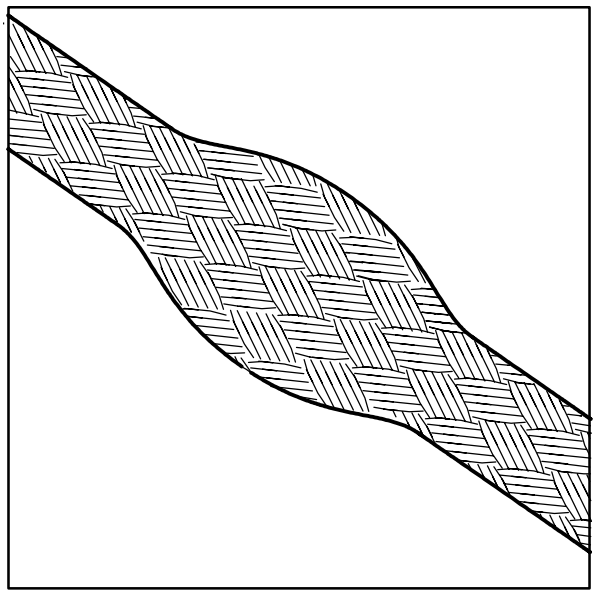


Figure D.21

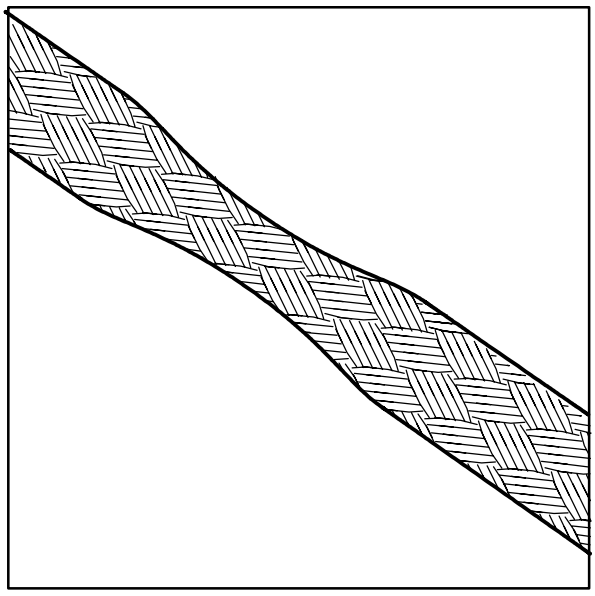


Figure D.22

Annex E
(informative)

Commentary

NOTE Reference is made to the corresponding clauses of this International Standard and its annexes.

E.1 Clause 1 — Scope

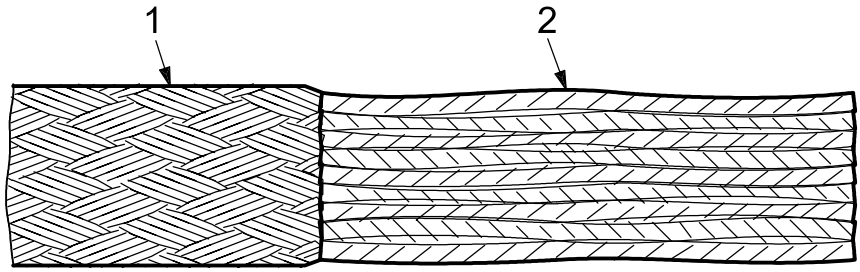
This International Standard covers polyester fibre ropes intended for use as components of anchoring lines forming the stationkeeping system of permanent or mobile offshore floating structures, or for use in a similar application.

The design of stationkeeping systems of offshore floating structures, and the criteria for the application of polyester fibre ropes in such systems, are covered in ISO 19901-7 [2].

In such systems, polyester fibre ropes are typically permanently immersed and freely spanning between end terminations. Contact with the seabed is avoided and may normally happen only in an accidental situation during the handling of lines for installation.

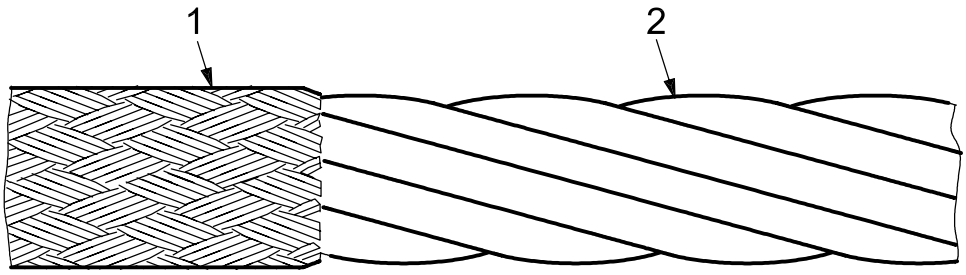
E.2 Subclause 6.2 — Type of construction

Typical constructions of ropes are illustrated in Figures E.1 and E.2.



Key
1 cover
2 sub-ropes

Figure E.1 — Typical torque-neutral parallel construction rope with cover and sub-ropes (type TF)



Key

1 cover

2 rope core

Figure E.2 — Typical torque-matched wire rope construction rope with cover (type TM)

Depending on the rope construction, the rope may be torque-neutral or designed to accommodate a given torque (torque-matched construction).

Torque-matched fibre ropes are intended for use in series with wire ropes. These constructions are specifically designed to reduce torsional fatigue in the wire rope.

E.3 Subclause 6.4 — Protective cover

The endurance of the cover under abrasion could be verified by an abrasion test onto a cylinder, simulating the condition of a rope standing over the stern roller of an installation vessel.

E.4 Subclause 6.6 — Length of rope

The length of rope is defined as the installed length at a typical mean tension, as simulated by the loading and the bedding-in sequence of the typical elongation and linear density test defined in B.4.

Inserts are small sections installed within the mooring lines that are intended for recovery and testing within the program of periodical inspection of the mooring system. The length of insert should be adequate for that purpose.

E.5 Subclauses 7.1.3 and B.3.2 — Breaking strength

The purpose of the test is to verify the breaking strength of the rope against the specified MBS. The testing of three samples provides a margin that is quantifiable.

Adjusting the breaking strength upward or downward from the test results is not considered and it would require more tests (typically 5).

The test sequence includes an initial loading and a bedding-in sequence. Further load-elongation measurements that may be performed in between are not deemed to affect significantly the condition of the rope with respect to the break test.

E.6 Subclause 7.1.3 and Clause B.3 — Dynamic stiffness at end of bedding-in and quasi-static stiffness

The load-elongation properties of fibre ropes under cyclic loading have been investigated in several research and development projects and models have been proposed to quantify the dependence of stiffness on testing parameters (see References [3] to [7] in the Bibliography).

Depending on the construction particulars, a rope of a given strength could exhibit a wide range of stiffness under given conditions: the dynamic stiffness at the end of the standard bedding-in sequence has been found to provide a pertinent indication of the degree of stiffness of a given rope. Then, only a limited amount of testing performed on one rope size only is necessary to verify the rope behaviour and adjust models if needed.

When further data (e.g. stiffness with a different bedding-in sequence or quasi-static stiffness over other load ranges, see E.9) are deemed necessary, additional tests should

— be performed on one rope size (as above), or

— preferably be obtained from measurements on sub-ropes (in the case of parallel construction), if duly calibrated with full-size ropes, by the measurements specified in this International Standard.

E.7 Subclause 7.1.6 and Clause B.5 — Cyclic loading endurance test

The endurance of a rope at moderate load ranges, typical of mooring system response, has been quantified by systematic cyclic loading tests (see Reference [8]), and found far above that of a steel wire rope. Tests also indicated that the prevailing mode of failure of a properly designed and manufactured rope under such conditions is internal abrasion.

Testing to failure by internal abrasion is not practically achievable. The purpose of cyclic loading endurance testing in B.5 is, therefore, to evidence that a particular rope can be expected to have the same endurance as demonstrated by testing projects, and does not present risks of premature failure due to inadequate design or manufacturing.

E.8 Subclauses 7.2.2 and B.4.2 — Length measurement and calculation of linear densities

The objective of the linear density test is to provide data to determine/verify the as-installed length of supplied rope segments. For this purpose, the linear density of the rope after a typical installation sequence is determined.

Other methods of measuring the length of a rope could be used in conjunction with the method specified in this International Standard, but would require a suitable calibration to ensure an accuracy that is consistent with specified length tolerances.

E.9 Subclause B.3.5 — Quasi-static stiffness and dynamic stiffness

The axial stiffness of a rope is defined as the ratio of rope load to strain variations between the lower (trough) and upper (peak) stresses imposed during testing, normalized by the rope minimum breaking strength.

Under the assumption of a linear behaviour, the load-elongation of a line is written as

$$\Delta F = K_1 \cdot \varepsilon$$

where

$$\varepsilon = \frac{\Delta L}{L_1};$$

K_1 is the spring constant of a unit length of line.

Normalization of K_1 gives the following expressions:

$$\frac{\Delta F}{F_{\mathrm{MBS}}} = K_{\mathrm{r}} \cdot \varepsilon$$

where

F_{MBS} is the breaking strength;

K_{r} is a reduced stiffness, which is dimensionless (% / %);

or

$$\frac{\Delta F}{\rho_l} = \frac{E}{\rho} \cdot \varepsilon$$

where

ρ_l is the linear density of the rope core;

$\frac{E}{\rho}$ is the dynamic modulus, expressed in tenacity units (N/tex).

In fibre ropes, normalization by ρ_l has been found appropriate for comparisons over a rather large range of sizes (from yarn to ropes), but normalization by MBS is more practical for the user and it is used in this International Standard.

The quasi-static stiffness, i.e. the stiffness under quasi-static cycling, is defined as a secant stiffness between the end points of successive half-cycles. The results of a 1 h cycling can be extrapolated to more representative durations, e.g. 24 h, as described in the document under Reference [7].

This test is deemed representative for a load range in the order of 20 % of MBS (a load varying between 10 % and 30 % of rope MBS is typically used), but would not provide a valid quasi-static stiffness for substantially higher load ranges (see Reference [9]).

The dynamic stiffness is representative of the near-linear behaviour observed under cycling at frequencies that are typical of vessel slow drift motions and wave actions. A load range smaller than 10 % would be desirable in some cases, but it may lead to difficulties in the measurement of small elongations.

E.10 Clause B.7 — Particle ingress protection

The intent of the particle ingress protection is to prevent risks of damaging the rope core, in the case of accidental contacts with the seabed.

Bibliography

[1] ISO 3, *Preferred numbers — Series of preferred numbers*

[2] ISO 19901-7, *Petroleum and natural gas industries — Specific requirements for offshore structures — Part 7: Stationkeeping systems for floating offshore structures and mobile offshore units*

[3] DEL VECCHIO, C.J.M. *Light weight materials for deep water moorings*, PhD thesis, University of Reading, 1992

[4] BOSMAN, R.L.M. and HOOKER, J. *The Elastic Modulus Characteristics of Polyester Ropes*, OTC10779, 1999

[5] NDE, *Deep water fibre moorings, an engineer's design guide*, OPL, 1999

[6] CASEY, N.F. and BANFIELD, S.J. *Full-Scale Fiber Deepwater Mooring Ropes: Advancing the Knowledge of Spliced Systems*, OTC 14243, 2002

[7] FRANÇOIS, M. and DAVIES, P. *Fibre Rope Deepwater Mooring: A Practical Model for the Analysis of Polyester Mooring Systems*. IBP 247 00, Rio Offshore 2000

[8] BANFIELD, S.J., CASEY, N.F. and NATARAJA, R. *Durability of polyester deepwater mooring rope*. OTC 17510, 2005

[9] FRANÇOIS, M. *Fibre ropes for station keeping: Engineering properties and qualification procedures*, Oceans, 2005

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