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Fibre ropes for offshore stationkeeping —

Part 3:
High modulus polyethylene (HMPE)

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

Partie 3: Polyéthylène à haut module

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Foreword

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

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

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

This first edition of ISO 18692-3 cancels and replaces ISO/TS 14909:2012, which has been technically revised. The main changes compared to the previous edition are as follows:

— the document previously published as a Technical Specification has been reorganized as the new ISO 18692-3, taking into account the content of ISO 18692-1:2018.

A list of all parts in the ISO 18692 series can be found on the ISO website.

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

Fibre ropes for offshore stationkeeping —

Part 3:
High modulus polyethylene (HMPE)

1   Scope

This document specifies the main characteristics and test methods of new high modulus polyethylene (HMPE) fibre ropes used for offshore stationkeeping.

2   Normative references

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

ISO 1968, *Fibre ropes and cordage — Vocabulary*

ISO 18692-1:2018, *Fibre ropes for offshore stationkeeping — Part 1: General specification*

3   Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1968 and ISO 18692-1 apply.

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

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

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

4   Materials

The fibre used in the core of the rope shall be high-tenacity HMPE, with an average tenacity of not less than 2,5 N/tex, and qualified and tested in accordance with Annex A.

Rope cover material and other materials employed in rope assembly shall be in accordance with ISO 18692-1.

5   Requirements — Rope properties

5.1   Minimum breaking strength

The minimum breaking strength of the rope, when tested according to ISO 18692-1, shall conform to Table 1.

Table 1 — Minimum breaking strength (MBS)

Reference number[a]	Minimum breaking strength kN
63	2 500
71	3 200
80	4 000
90	5 000
100	6 300
106	7 100
112	8 000
118	9 000
125	10 000
132	11 200
140	12 500
150	14 000
160	16 000
170	18 000
180	20 000
[a] The reference number corresponds to the approximate outer diameter of the rope, in millimetres (mm). Actual diameters can vary for a given reference number.	

5.2 Minimum core tenacity

The minimum tenacity of the rope core shall be 1,3 N/tex, measured according to ISO 18692-1.

All samples tested shall comply with this minimum value.

5.3 Creep properties

The rope creep properties shall be at least as declared by the manufacturer, when tested following the method in Annex B.

5.4 Torque properties

Torque-neutral rope or torque-matched rope shall be defined according to ISO 18692-1.

5.5 Cyclic loading performance

The rope shall have demonstrated performance under cycling loading following the requirements of ISO 18692-1.

5.6 Particle ingress protection

Unless otherwise specified, the rope shall be constructed with a protection of the core against the ingress of particles in accordance with ISO 18692-1.

6 Requirements — Rope layout and construction

Rope layout and construction shall be in accordance with ISO 18692-1.

7 Rope testing

7.1 Type test

7.1.1 General

Type tests shall be performed in accordance with ISO 18692-1 and the specific requirements of this clause.

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[c]	3
Creep	1[a]
Torque properties[a]	1
Linear density	1
Cyclic loading endurance[b]	1
[a] See ISO 18692-1:2018, 7.1.4.	
[b] See ISO 18692-1:2018, 7.1.6.	
[c] See also ISO 18692-1:2018, B.3.5.4.	

7.1.3 Breaking strength tests, core tenacity, and stiffness tests

The number of samples from Table 2 shall be tested, and each sample shall be capable of meeting the requirements of 5.1 and of 5.2.

NOTE   The measurements of the dynamic stiffness at end of bedding-in — and, when required, those of the quasi-static stiffness and the dynamic stiffness at several mean load level — are performed for design purposes only. There are no acceptance criteria on these parameters.

7.1.4 Creep properties test

One sample shall be tested for creep properties in accordance with the test method in Annex B.

This test needs not be performed where data are available from the previous qualification test of another rope (or a sub-rope of it) with the same design, material and method of manufacture of rope core, and a size not less than reference number 71.

7.1.5 Linear density test

The linear density shall be calculated from the measured weight and length according to the method defined in ISO 18692-1:2018, Annex B.

7.1.6 Cyclic loading endurance test

The cyclic loading endurance test shall be performed according to the procedure specified in ISO 18692-1.

The residual strength of the rope shall be not less than 80 % of the MBS.

7.1.7 Protective cover thickness

The thickness of the protective cover shall be verified. See ISO 18692-1:2018, 7.1.7.

7.1.8 Particle ingress protection

See 5.6 and ISO 18692-1:2018, Annex B.

7.2 Testing of current production

Testing of current production shall be in accordance with ISO 18692-1.

8 Report

The report shall be in accordance with ISO 18692-1.

9 Certification

Certification shall be in accordance with ISO 18692-1.

10 Marking, labelling and packaging

The marking, labelling and packaging shall be in accordance with ISO 18692-1.

Annex A
(normative)

Fibre qualification and testing

A.1   General

Fibre qualification and testing shall be in accordance with ISO 18692-1:2018, Annex A, except provisions related to marine finish and yarn-on-yarn abrasion performance, and the following requirements that are related to the creep properties of HMPE fibres.

NOTE   High modulus polyethylene (HMPE) is considered intrinsically marine graded and no "marine finish" is used.

A.2   Creep properties

In addition to data in ISO 18692-1:2018, A.2.3, the following information (extracted from a documented model of fibre creep properties based on test results) shall be made available by the fibre manufacturer to the rope manufacturer, covering:

a)   creep rate (per cent divided by time unit) and allowable extension (%) (or allowable creep time), under a range of specific stresses (N/tex) and temperatures, to cover those expected in operation;

b)   creep rate (per cent divided by time unit) under the tension [and corresponding specific stress (N/tex)] and at the temperature (°C) during rope creep test in accordance with Annex B;

c)   creep rate in the conditions of fibre testing during production.

NOTE 1   The "creep rate" in this subclause refers to the creep rate in the so-called "steady state creep" regime (see Annex C and Reference [2]).

NOTE 2   Data of creep properties are used by the rope manufacturer (or by the purchaser) to evaluate the creep allowable life time of the rope (see Annex C).

A.3   Fibre specification — Physical and mechanical properties

The following information shall be provided in the fibre specification, in addition to those in ISO 18692-1:2018, A.2.3:

a)   elongation (%) in a reference condition, i.e. specified tension (specific stress in N/tex), temperature (°C) and time (h).

These properties shall be documented by results of tests in accordance with A.5.

A.4   Fibre certificate

The following information shall be provided in the material certificate, in addition to those in ISO 18692-1:2018, A.3:

a)   creep test.

For acceptance testing, the above property shall be obtained from testing on a representative number of samples taken from the delivery, not less than once every 10 000 kg.

A.5 Creep — Testing of current production

The creep performance of fibre shall be verified during fibre production by measuring the elongation (per cent per day) in the reference condition given in the fibre specification, i.e. specified tension (specific stress in N/tex), temperature (°C) and time.

NOTE   As an example, the following conditions can be used:

— tension: 0,8 N/tex;

— temperature: 50 °C;

— time: 5 h.

Annex B
(normative)

Creep properties test

B.1 General

This annex specifies the requirements for creep properties test of HMPE ropes for stationkeeping.

NOTE   The objective of this test is to calibrate long-term rope creep rates with data and model of fibre creep (see Annex C).

B.2 Test conditions

B.2.1 Rope samples

The creep tests shall be performed on one sample of the rope to be qualified. For parallel construction ropes, this test can be performed on a sub-rope.

Terminations of samples shall be adequate with respect to intended test sequence.

B.2.2 Ambient conditions

The creep test shall be performed under controlled temperature conditions, and the temperature shall be kept as constant as possible over test duration, within a range of 5 °C.

The ambient temperature and humidity shall be recorded.

B.2.3 Testing machine and measurement

The testing machine and the measurement system shall be in accordance with the provisions of ISO 18692-1:2018, B.2.3 and B.2.4.

B.3 Testing

B.3.1 Planning of test

A testing temperature not exceeding 25 °C shall be selected.

A tension, *T*, not exceeding 55 % of MBS shall be selected.

Alternatively, a testing temperature can be selected in cooperation with yarn supplier and rope user, based on the application to meet the objective of the test mentioned in B.1.

B.3.2 Test procedure

The creep test shall be performed according to the following steps:

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

b)   a load of 2 % of MBS shall be applied;

c)   the extensometer shall be installed in a section of the rope undisturbed by the termination;

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

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

f) a cycling tension between 10 % and 30 % of the rope MBS shall be applied 300 times at a frequency of between 0,03 Hz and 0,1 Hz;

g) the sample shall be loaded at the preselected tension, T, for a minimum period of 7 days (see C.2.4) at the preselected temperature, and the gauge length shall be measured over this duration;

h) the sample shall be unloaded.

B.3.3 Load and elongation measurements

The rope test shall include the measurement of:

a) gauge length elongation (three plots):

1) load versus elongation encompassing load B.3.2 steps c) to e);

2) load versus elongation for the 100th cycle, B.3.2 step f);

3) load and elongation versus time, over the complete duration of B.3.2 step g) (continuous measurement, sampling rate: once per hour, minimum);

b) load versus overall elongation (stroke), two plots as the following:

1) load B.3.2 steps c) to e);

2) the last cycle of load B.3.2 step f)

c) overall elongation (stroke) versus time over the complete duration of B.3.2 step g).

B.3.4 Creep properties

The creep rate (per cent divided by time unit) is to be obtained by fitting of the elongation versus time (in natural scale) over the end of the test [e.g. the second half of B.3.2 step g)].

The specific stress, S_c, during creep test is calculated using Formula (B.1):

$$S_c = \frac{\tau \cdot F_{MBS}}{\rho_{l,c0}} \text{ (N/Tex)} \tag{B.1}$$

where

τ is the tension (in per cent of MBS);

F_{MBS} is the specified minimum breaking strength of the rope, in kilonewtons (kN);

$\rho_{l,c0}$ is the linear density in kilotex, of the rope core as manufactured - or, where the test is performed on a sub-rope, the linear density of the sub-rope- under 2 % of MBS, obtained from the linear density test (see ISO 18692-1:2018, B.4).

The following data shall be recorded:

— type of sample and linear density;

— applied tension, τ, and specific stress, S_c;

— temperature during B.3.2 step g);

— creep rate.

Annex C
(informative)

Additional information and guidance

C.1 General

The clauses in this annex provide additional information and guidance on clauses in the body of this document and its annexes. Reference is also made to ISO 18692-1.

Further additional information and guidance can be found in ISO 18692-1:2018, Annex E.

Further information on HMPE fibres can be found in ISO 9554[4].

C.2 Creep properties (5.3)

C.2.1 Creep of HMPE fibres

Under a constant load, HMPE fibres can show an irreversible deformation (creep) behaviour, which is strongly dependent upon load and temperature. Figures C.1 and C.2 (see Reference [2]) shows a typical creep curve of HMPE, where the elongation of a fibre is plotted as a function of time. Three regimes can be clearly distinguished, characterized by a different behaviour of the creep rate (see Reference [2] for further details):
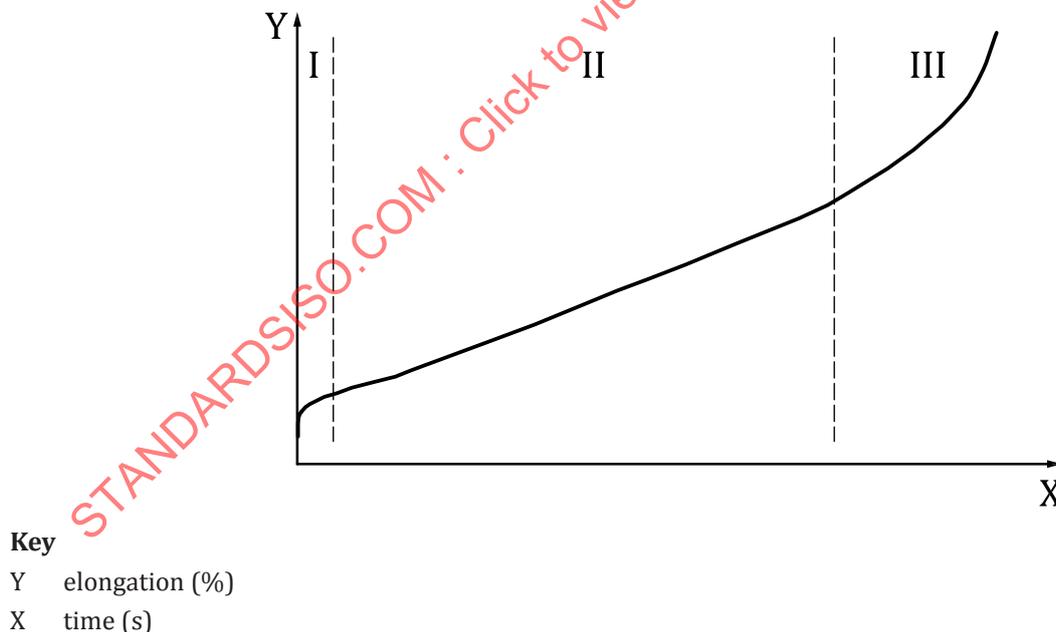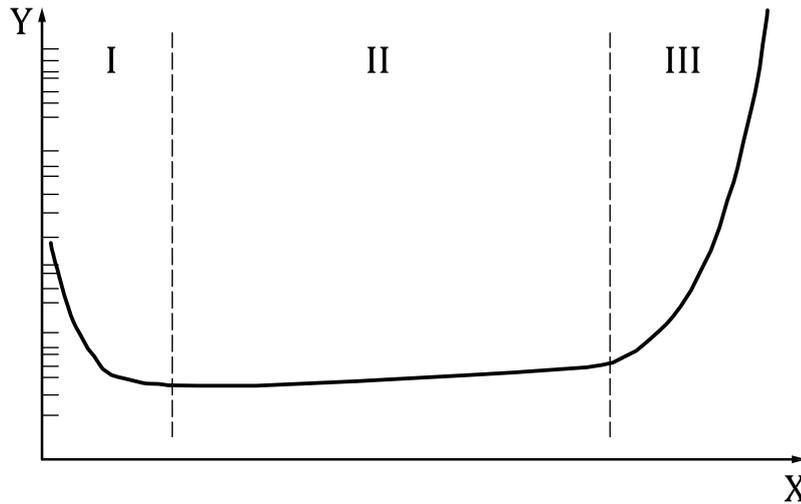

Key
Y   elongation (%)
X   time (s)

Figure C.1 — Typical HMPE creep curve

Key

Y   creep rate (1/s)

X   elongation (%)

Figure C.2 — Typical HMPE creep rate curve

Regime I: "primary creep": in this regime, amorphous realignment takes place. Initially, the creep rate is high, but quickly decreases with time, until a plateau level is reached. The elongation is mostly reversible.

Regime II: "steady-state creep": in this regime, sliding of molecular chains takes place. The elongation is what is defined as plastic creep, which is irreversible.

Regime III: "tertiary creep": in this regime, molecular chains start to break. High strains can start to cause necking in the filaments and can increase the local stress, which further accelerates the strain until breakage.

In this document, "creep" and creep rate refer to the "steady-state creep" of regime II. Creep is strongly dependent on load and temperature.

The transition of creep regime II and III, indicated by acceleration in the creep process, may be used to mark the end of life.

The levelling off of creep rates in creep regime I is marking the end of this regime. Thus, for extrapolations over longer times, creep tests should at least be carried out up to the plateau in the creep rate.

C.2.2   Prediction of rope creep

For HMPE ropes used as components in a stationkeeping system, creep performance (a topic specific to HMPE) should be evaluated (see ISO 19901-7:2013, 14.4) including:

— a prediction of the expected creep per year, thus of the expected life time of rope under the operating conditions, for the most critical area of the rope, i.e. the area which is subjected to the highest ambient temperature and highest tension (generally, the uppermost area of the rope);

— where needed, a prediction of the cumulative creep elongation of the whole line, over the design service life of the rope, for the mooring system in the intact condition.

An evaluation method is outlined in ISO 19901-7:2013, A.14.4. It takes into account that the line is under a variable tension over time. Data of rope creep performance are to be obtained from qualification tests, but getting such information from full-size rope test is neither practicable nor necessary, as creep estimation models can support the creep performance requirements and limit the need for full-size testing.