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Ships and marine technology — Floating pneumatic rubber fenders —

Part 1:
High pressure

Navires et technologie maritime — Éperons pneumatiques flottants —

Partie 1: Haute pression

Reference number
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Foreword

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

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 8, *Ships and marine technology*, Subcommittee SC 4, *Outfitting and deck machinery*.

ISO 17357-1 together with ISO 17357-2 cancels and replaces ISO 17357:2002.

ISO 17357 consists of the following parts, under the general title *Ships and marine technology — Floating pneumatic rubber fenders*:

— *Part 1: High pressure*

— *Part 2: Low pressure*

Introduction

This International Standards has been developed to provide guidelines on the quality and performance of all floating pneumatic rubber fenders. Floating pneumatic rubber fenders can play an important role in a ships safe berthing operation and this International Standard is seen as a technical reference to ensure necessary product standards.

Essentially there are two main types of floating pneumatic rubber fender, defined as either high or low pressure fenders. Although manufactured using different techniques, both high and low pressure fenders work by the same principle. The resistance to berthing vessel momentum is provided by a reaction pressure due to compression of the air inside the fender when deformed by the vessels hull. The kinetic energy of the berthing vessel is absorbed during the work done to compress the air inside the fender. Fenders are sized according to the expected duty of the fender in terms of the energy absorption (EA) requirements which will be at the most basic level, a function of the vessel mass and velocity.

Throughout this International Standard, the minimum essential criteria are identified by the use of the keyword “shall”. Recommended criteria are identified by the use of the keyword “should”, and while not mandatory are considered to be of primary importance in providing serviceable, economical, and practical connectors. Deviation from the recommended criteria should occur only after careful consideration, extensive testing, and thorough service evaluation have shown alternative methods to be satisfactory.

The documents in the Bibliography provide information on the usage of the fenders.

Ships and marine technology — Floating pneumatic rubber fenders —

Part 1:
High pressure

1 Scope

This part of ISO 17357 specifies the material, performance, and dimensions of high-pressure floating pneumatic rubber fenders, which are intended to be used for the berthing and mooring of a ship to another ship or berthing structure. It also specifies the test and inspection procedures for high-pressure floating pneumatic rubber fenders.

This part of ISO 17357 does not address any safety hazards associated with its use. It is the user's responsibility to establish appropriate safety and health practices and determine the applicability of regulatory limitations before using this part of ISO 17357.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 34-1:2010, *Rubber, vulcanized or thermoplastic — Determination of tear strength — Part 1: Trouser, angle and crescent test pieces*

ISO 37:2011, *Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties*

ISO 188:2011, *Rubber, vulcanized or thermoplastic — Determination of compression set*

ISO 815-1:2008*Rubber, vulcanized or thermoplastic — Determination of compression set — Part 1: At ambient or elevated temperatures*

ISO 1382:2012, *Rubber — Vocabulary*

ISO 1431-1:2012, *Rubber, vulcanized or thermoplastic — Resistance to ozone cracking — Part 1: Static strain test*

ISO 7619-1:2010, *Rubber, vulcanized or thermoplastic — Determination of indentation hardness — Part 1: Durometer method (Shore hardness)*

ISO 12236:2006, *Geosynthetics — Static puncture test (CBR test)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1382:2012 and the following apply.

3.1
high pressure floating pneumatic rubber fender
fender which is made of synthetic-cord-reinforced rubber sheet with compressed air inside, at initial pressure of 50 kPa or 80 kPa, to enable it to float on the water and work as a shock absorber between two ships, or between ships and berthing structures when they come alongside each other on the water

3.2
outer rubber
rubber layer that covers the outside of the fender to protect the cord layers and the inner liner rubber from abrasion and other external forces

3.3
inner rubber
liner of a rubber membrane that seals the pressurized air inside the fender

3.4
synthetic-tyre-cord layer for reinforcement
layer made of synthetic-tyre-cord fabric, which maintains the internal air pressure of the fender

Note 1 to entry: As the main fibres of the synthetic-tyre-cord fabric are not braided like synthetic canvas fabric or synthetic belt fabric, there are advantages for its fatigue-resistance performance and pressure-holding performance. See Annex A.

3.5
bead ring
steel ring which is placed at one end (or both ends) of the fender and holds the end of cord layers

Note 1 to entry: See Annex B.

3.6
flange opening
steel flange which is mounted on the fender, to which an air valve or safety valve can be adapted

Note 1 to entry: See Annex B.

3.7
guaranteed energy absorption
energy that the fender can absorb without permanent deformation or failure

3.8
reaction force
force produced by a fender reacting to a compressive force

Note 1 to entry: It is equal to the force of the air pressure of the fender multiplied by the contact area of the fender to the ship or berthing structure.

3.9
initial internal pressure
air pressure at which an uncompressed fender operates

3.10
endurable pressure
inner pressure at which a fender bursts

3.11
net-type fender
fender which is covered by a protection net consisting of either chain, wire, or fibre and usually with tyres or rubber sleeves

3.12
sling-type fender
fender which is designed to be used without a protection net

4 Classification

4.1 High-pressure fender types

High-pressure fender types are defined as follows:

a) Type I — Net-type;

b) Type I Single — Net-type and one end with no flange opening and no metal parts. See Annex B;

c) Type II — Sling-type.

4.2 Initial internal pressure

Initial internal pressures are defined as follows:

a) pneumatic 50 (initial internal pressure 50 kPa);

b) pneumatic 80 (initial internal pressure 80 kPa).

5 Ordering or inquiring information

5.1 Information to the manufacturer

The fender purchase order or inquiry should state the following.

a) The International Standard number and applicable year, i.e. ISO 17357-1:2014.

b) Fender size: nominal fender diameter and length: see Table 1 or Table 2.

NOTE If the purchaser requests other sizes, they shall satisfy the requirements of paragraph of 6.3.3.

c) Fender type: see 4.1.

d) Initial internal pressure: see 4.2.

e) Fender colour. If not specified, the colour shall be black.

f) If a safety valve is required for fenders smaller than 2 500 mm in diameter, see 6.1.7.

g) If an identification system is required, see Clause 10.

h) If inspection/evaluation by a major classification society is required, see Clause 12.

5.2 Information from the manufacturer

In order to confirm that the products meet the requirements of this part of ISO 17357, the purchaser can request the manufacturer to provide following information prior to order placement.

a) Prototype fender test certificate

The certificate which confirms successful results of the tests in Clause 8, which are evaluated by a major classification society and are conducted no more than ten years prior to inquiry date.

b) Commercial fender inspection and test certificate

The certificate which confirms successful results of the inspections and the tests in Clause 9, which must be performed on fender which has a diameter equal to or larger than the inquired fender with the same or higher internal pressure, and are evaluated by a major classification society and are conducted no more than ten years prior to inquiry date.

6 Requirements

6.1 General high pressure fender requirements

6.1.1 High pressure floating pneumatic rubber fenders shall consist of a cylindrical air bag with hemispherical heads at both ends, which shall be filled with compressed air. The basic body construction of this fender shall consist of an outer rubber, synthetic-tyre-cord layer (see Annex A) for reinforcement, and an inner rubber. All of these shall be vulcanized firmly.

6.1.2 The outer rubber shall protect the cord layers and inner rubber from abrasion and other external forces. This rubber compound shall have sufficient tensile and tear resistance strength to withstand anticipated weather conditions and severe usage. This rubber shall satisfy the values specified in Table 3.

6.1.3 The inner rubber layer shall seal the air inside. This rubber shall satisfy the requirements specified in Table 3.

6.1.4 The reinforcement synthetic-tyre-cord layers shall be strong enough to hold the internal pressure. In both compressed and non-compressed situations, the fender's endurable pressure shall be as in Table 4 or Table 5.

6.1.5 The flange opening shall be at either end, or both ends, for convenience of air charge and water filling for Type I and Type II. The flange opening shall be at only one end for Type I Single and no metal parts shall be at the other end to make that end safe from permanent deformation when it gets over compression.

6.1.6 The end of the reinforcement-cord layers shall enter the bead ring and be turned up outside the bead ring, which is built-in at the flange opening. Diameter of the bead ring or other steel material around the flange opening shall be less than 0,20 D (D: fender diameter) to make metal parts safe from permanent deformation when it gets over compression near to 80 %. See Annex B. For Type I (Net-type) fenders, the bead ring, and turning up on construction can be excluded.

6.1.7 Fenders of diameter 2 500 mm and larger shall be equipped with a safety valve for releasing excess internal pressure when the fenders are over-compressed accidentally. Fenders which are smaller than 2 500 mm in diameter, can be equipped with a safety valve if required.

6.1.8 The fender shall be equipped with an air valve for inflation and checking air pressure.

6.2 Type requirements

6.2.1 Type I and Type I Single (Net-type) fenders shall be covered by a chain net, wire net, or fibre net. Each end of longitudinal chains, wires, or fibres shall be linked together with one or two ring(s), which shall be connected with a guy-chain or guy-rope. Usually, these nets will be fitted with used tyres or rubber sleeves to provide additional protection to the fender body.

6.2.2 Type II (Sling-type) fenders shall have a lifting device on each end, which shall be connected with a guy-chain or guy-rope.

6.3 Pressure requirements

6.3.1 Pneumatic 50: the internal pressure, endurable pressure, safety-valve setting pressure, and hydraulic test pressure shall be as specified in Table 4.

6.3.2 Pneumatic 80: the internal pressure, endurable pressure, safety-valve setting pressure, and hydraulic test pressure shall be as specified in Table 5.

6.3.3 Sizes not listed in Tables 4 and 5 shall satisfy all the requirements in this sub-clause, using the pressure requirements of the next-larger-diameter size.

EXAMPLE A 2 200 mm diameter fender shall satisfy the pressure requirements of a 2 500 mm diameter fender.

7 Performance

7.1 Specification of performance

The performance of high pressure floating pneumatic rubber fenders shall be specified in terms of guaranteed energy absorption (GEA), reaction force at GEA deflection, and hull pressure at GEA deflection.

7.2 Performance curves

The relationship between the deflection percentage, reaction force, inner pressure (which is equal to the hull pressure), and energy absorption is shown in Figure 1. The reaction force, the inner pressure, and the energy absorption of the fender increase as the deflection percentage increases. From the GEA value, point A is determined on the energy absorption curve and the corresponding deflection percentage is read as the GEA deflection. The reaction force and the hull pressure are then obtained at that deflection percentage value.

7.3 Fender performance

7.3.1 Pneumatic 50: the fenders shall comply with the values specified in Table 1.

7.3.2 Pneumatic 80: The fenders shall comply with the values specified in Table 2.

7.3.3 GEA values shown in Table 1 or Table 2 shall be obtained at (60 ± 5) % deflection.

7.3.4 The tolerance of reaction force at the GEA deflection shall be ±10 %.

7.3.5 Fender performance can be calculated by the formula, which shall be established using the performance test described in 8.1.

8 Performance confirmation of prototype fender test

8.1 General

Each fender, involving different methods of basic construction and/or design, shall require a prototype test.

Fenders of lesser diameter than a prototype confirmed fender, incorporating the same basic design, construction, and fabrication methods but having fewer plies due to the smaller diameter, but satisfying all requirements of this part of ISO 17357, do not require a prototype test.

Manufacturer shall provide the certificate which confirms successful results of the tests which are evaluated by a major classification society and the performance confirmation of prototype fender test shall be done every ten years.

8.2 Performance test, parallel compression test

8.2.1 To determine the performance of the fenders given in Clause 7, a performance test shall be performed. Applying a compressive force perpendicularly to the fender, the fender shall be compressed until its energy absorption reaches the GEA value. The compression speed shall not exceed 80 mm/min. The reaction force and internal pressure shall be recorded at least every 5 % percentage deflection. The percentage deflection, *y*, and the energy absorption, *a*, are calculated as follows.

$$y = \frac{L_c}{D} \times 100 \tag{1}$$

where

y is the percentage deflection;

L_c is the compression length, in millimetres;

D is the original diameter, in millimetres (i.e. the fender diameter at initial pressure).

$$a = \int R(x) dx \tag{2}$$

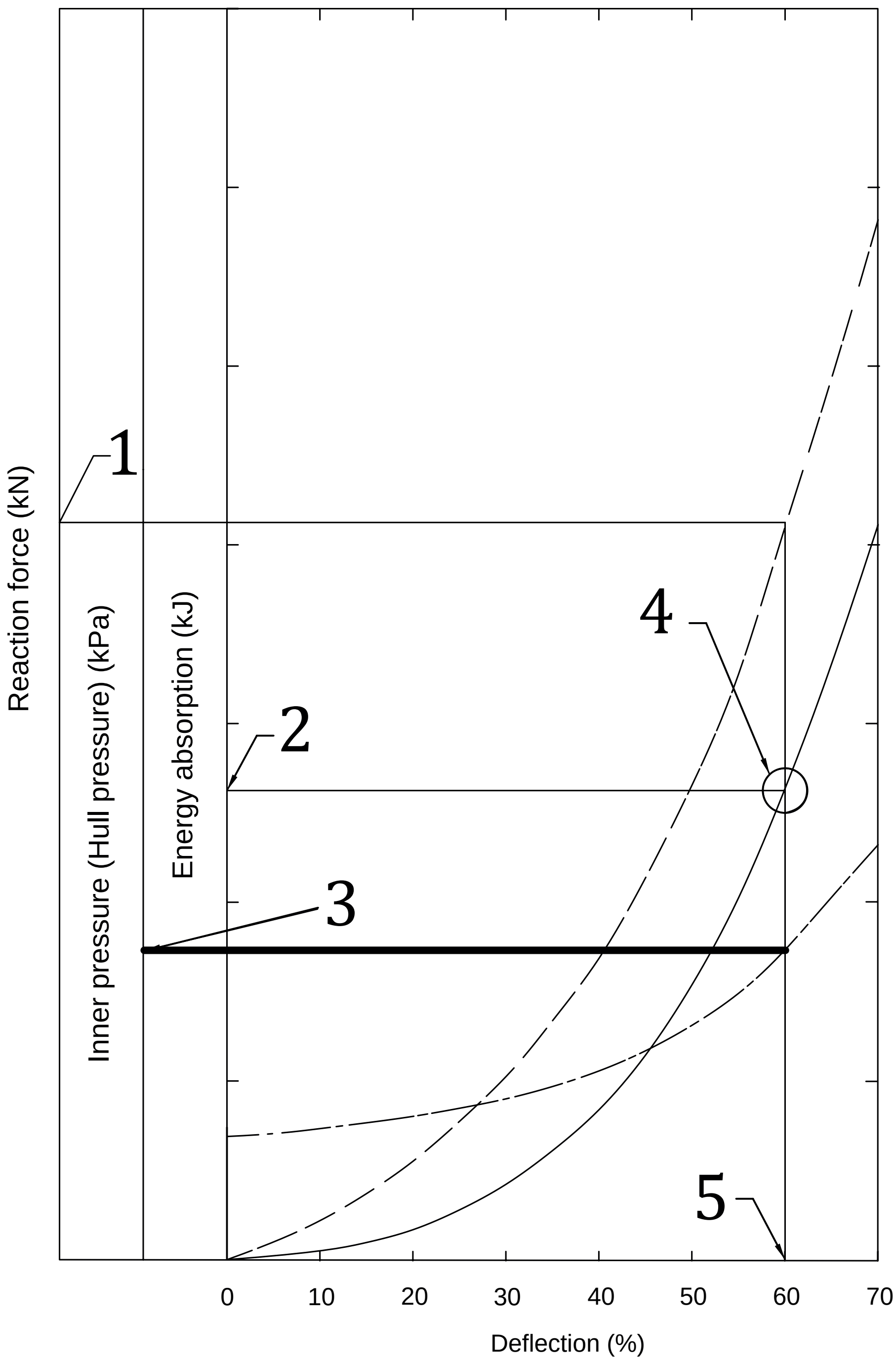
where

$R(x)$ is the reaction at a given deflection;

dx is the incremental deflection.

The test shall be repeated twice with an interval of 5 min between the two tests. The energy absorption and the reaction force shall be obtained from the mean value of the two test records.

A fender meets the required GEA performance if it achieves 100 % of its GEA energy absorption without exceeding 65 % deflection and 110 % of its GEA reaction.



Key

1	reaction force at GEA deflection
2	guaranteed energy absorption (GEA)
3	hull pressure at GEA deflection
4	point A
5	GEA deflection
———————	energy absorption
— — —	reaction force
——— · ———	inner pressure

Figure 1 — Standard performance curve

8.2.2 The test shall be performed using an actual size fender or a miniature size fender larger than one-fifth the size of the actual diameter

EXAMPLE In the case of fenders 4,5 m in diameter, the performance shall be confirmed from the test result of a fender 4,5 m in diameter or a fender larger than 0,9 m in diameter.

8.3 Angular compression test

8.3.1 An angular compression test shall be performed to determine the fender deformation property.

8.3.2 If the fender is too large to be mounted on the testing machine, the test can be performed on a miniature-size fender. The reduction scale shall be such that it will ensure that the tests will be representative.

NOTE It has been shown that 1/30 or larger scale sizes are acceptable if relative performances at parallel and several angular conditions are to be compared at the same fender.

8.4 Durability test

8.4.1 A durability test shall be performed to verify that the products are suitable for use as fenders, and that they have sufficient durability to withstand the berthing energy.

8.4.2 The test shall comprise at least 3 000 repetitive cycles of parallel compression from the original diameter to the maximum deflection. After 3 000 repetitive cycles, there shall be no cracks and other harmful defects on any part of the fender. No reduction of the GEA shall be accepted.

8.4.3 If the fender is too large to be mounted on the testing machine, the test can be performed on a miniature-size fender. The reduction scale shall be the same as that described in 8.3.2.

8.5 Compression-recovery test

8.5.1 Fenders are compressed and released repeatedly over a very short period of time. Therefore, a compression-recovery test shall be performed to confirm that the fenders have sufficient compression recoverability.

8.5.2 After compression of the fender to the guaranteed energy-absorption deflection, the fender shall be kept in this compressed state for 1 min, then the load shall be released instantaneously. The fender diameter shall recover more than 97 % of its original diameter within 5 min after the load to the fender is released.

8.5.3 The test shall be performed using an actual-size fender or a miniature-size fender larger than one-fifth the size of the actual diameter.

EXAMPLE In the case of fenders 4,5 m in diameter, the performance shall be confirmed from the test result of a fender 4,5 m in diameter or a fender larger than 0,9 m in diameter.

8.6 Puncture-resistance test

8.6.1 A puncture-resistance test shall be performed to confirm that the products have sufficient puncture-resistance strength.

8.6.2 The test shall be conducted in accordance with the static puncture test (CBR test) in ISO 12236:2006.

8.6.3 The specimen shall be made using the same materials, construction, and production method, except for the number of ply of the reinforcement cord layer which shall be the number applied for the smallest size fender, i.e. normally two plies.

8.6.4 The force applied to break through the specimen shall be larger than 15 kN.

8.7 Recording condition

Ambient temperature and compression velocity shall be recorded for all of the performance confirmation tests.

9 Test and inspection for commercial fenders

9.1 General

Acceptance testing and inspection for purchased fenders shall be based on the tests and inspections indicated in this clause.

9.2 Material test of rubber

The material test of the outer rubber and the inner rubber shall be conducted in accordance with the specifications given in Table 3 and the results shall satisfy the requirements given in Table 3. Test items 2 to 5 in Table 3 shall be conducted once a year, and once every lot for test item 1.

9.3 Dimensional inspection

The dimensions of all the fenders shall be inspected at the initial internal pressure and the results shall be within the following tolerances:

a) length: +10 %, −5 % ;

b) diameter: +10 %, −5 %.

The diameter shall be obtained from the average of at least two different measurements taken at the middle of the cylindrical section of the fender.

The diameters of bead ring or other steel material around the flange opening shall be inspected, and the results shall be less than 0,20 D (D: fender diameter).

9.4 Air-leakage test

The air-leakage test shall be conducted on all fenders at initial pressure for more than 30 min, and the test results shall confirm that there is no air leakage.

9.5 Hydrostatic-pressure test

The hydrostatic-pressure test shall be performed for 10 min at the hydrostatic pressure shown as “Test pressure at 0 % deflection” in Table 4 or Table 5 and there shall be no leakage of water and no defects during the test.

The frequency of the test shall be one per 20 fenders of each size and pressure. If the customer so requests, one per order of each size and pressure if the quantity is less than 20.

Circumferential and longitudinal lengths shall be measured at 10 kPa pressure and at the test pressure shown in Table 4 or Table 5. The temporary elongation shall be as follows:

a) maximum circumferential temporary elongation:10 %;

b) maximum longitudinal temporary elongation:10 %.

$$e = \frac{\Delta L_t}{L} \times 100 \qquad (3)$$

where

e is the temporary elongation, expressed as a percentage;

ΔL_t is the length increased, in millimetres, at test pressure;

L is the length, in millimetres, at 10 kPa.

The increase in diameter and length shall be obtained by measuring the distance of two points marked circumferentially and longitudinally, at 10 kPa pressure, on the middle of the fender's body.

The distance between the two points shall be larger than one-fifth of the fender's diameter.

10 Marking

Each high pressure fender shall have markings on the fender body to indicate the following information:

— International Standard number for high-pressure floating pneumatic rubber fenders, and applicable year, i.e. ISO 17357-1:2014;

— size (diameter and length);

— initial internal pressure;

— date of manufacture or its abbreviation;

— full or abbreviated name of manufacturer;

— individual serial number;

— type of reinforcement layer.

The markings of the manufacturer, for internal pressure rating and size, shall be of a suitable size and finish to enable clear identification. The letter heights shall be 100 mm minimum for fenders whose diameters are 2 500 mm and larger.

On request, the fenders shall be equipped with an identification system, which is to be buried in the fender's body.

The identification system shall work such that it can identify the fender's serial number. Therefore, in the event that markings disappear, information can still be retrieved from the serial number. The identification system shall be designed to last throughout the fender's life.

11 Documentation

The manufacturer shall provide the purchaser with certification that fenders have been tested and inspected as specified in this part of ISO 17357 and that all the requirements have been met, together with a test and inspection report as well as a material certificate for the synthetic tyre cord which is used for the ordered fenders.

The manufacturer shall provide a maintenance manual, in the format of a logbook, where details could be recorded of all maintenance and repairs carried out on the fender, including safety valves, from new to date. All maintenance and repairs should be carried out in accordance with the manufacturer's guidelines. The manufacturer shall also provide a handling/storage/packing recommendation.

The manufacturer should provide specific technical information relating to serial number, age, initial pressure, safety-valves specification, etc. to the purchaser/operational user upon request; such a request to be accompanied where appropriate and possible by written permission from the original fender purchaser.

12 Inspection and evaluation by a qualified independent inspection service

The purchaser can, at his option, request the inspection and evaluation to be carried out by a major classification society for the ordered fenders. The inspection and evaluation shall cover the following points.

a) Confirmation from the material certificate that tyre cord is used for the ordered fenders. If alternative reinforcement methods to tyre cord are used, test certificates proving that strength and durability are designed and proven to be equal or superior to the tyre cord after exhaustive trials, shall be evaluated and certified by a major classification society as well as a material certificate used for the ordered fenders.

b) Evaluation of material test results of the rubber which is used for the ordered fenders.

c) Evaluation of results of dimensional inspection.

d) Evaluation of results of the air-leakage test.

e) Witness and confirmation of the hydrostatic-pressure test. It is important to confirm the pressure to be matched and the required pressure on the applicable table according to the initial internal pressure 50 kPa or 80 kPa, see Table 4 and Table 5.

f) Witness and confirmation of marking.

Table 1 — Pneumatic 50 fender size and performance requirements

Nominal size diameter × length mm	Initial internal pressure kPa	Guaranteed energy absorption (GEA)	Reaction force at GEA deflection (R)	Hull pressure (Internal pressure) at GEA deflection (P)
		Minimum value at deflection 60 ± 5 % kJ	Tolerance ±10 % kN	Reference value kPa
500 × 1 000	50	6	64	132
600 × 1 000	50	8	74	126
700 × 1 500	50	17	137	135
1 000 × 1 500	50	32	182	122
1 000 × 2 000	50	45	257	132
1 200 × 2 000	50	63	297	126
1 350 × 2 500	50	102	427	130
1 500 × 3 000	50	153	579	132
1 700 × 3 000	50	191	639	128
2 000 × 3 500	50	308	875	128
2 500 × 4 000	50	663	1 381	137
2 500 × 5 500	50	943	2 019	148
3 300 × 4 500	50	1 175	1 884	130
3 300 × 6 500	50	1 814	3 015	146
3 300 × 10 600	50	3 067	5 257	158
4 500 × 9 000	50	4 752	5 747	146
4 500 × 12 000	50	6 473	7 984	154

Table 2 — Pneumatic 80 fender size and performance requirements

Nominal size diameter × length mm	Initial internal pressure kPa	Guaranteed energy absorption (GEA)	Reaction force at GEA deflection (R)	Hull pressure (Internal pressure) at GEA deflection (P)
		Minimum value at deflection 60 ± 5 % kJ	Tolerance ±10 % kN	Reference value kPa
500 × 1 000	80	8	85	174
600 × 1 000	80	11	98	166
700 × 1 500	80	24	180	177
1 000 × 1 500	80	45	239	160
1 000 × 2 000	80	63	338	174
1 200 × 2 000	80	88	390	166
1 350 × 2 500	80	142	561	170
1 500 × 3 000	80	214	761	174
1 700 × 3 000	80	267	840	168
2 000 × 3 500	80	430	1 150	168
2 500 × 4 000	80	925	1 815	180
2 500 × 5 500	80	1 317	2 653	195
3 300 × 4 500	80	1 640	2 476	171
3 300 × 6 500	80	2 532	3 961	191
3 300 × 10 600	80	4 281	6 907	208
4 500 × 9 000	80	6 633	7 551	192
4 500 × 12 000	80	9 037	10 490	202

Table 3 — Outer and inner rubber material requirements

Test item	Test method	Required value	
		Outer rubber	Inner rubber
1. Before aging	–	–	–
1.1 Tensile strength	ISO 37:2011	18 MPa or more	10 MPa or more
1.2 Elongation	ISO 37:2011	400 % or more	400 % or more
1.3 Hardness	ISO 7619-1:2010	60 ± 10 (Durometer hardness Type A)	50 ± 10 (Durometer hardness Type A)
2. After aging	ISO 188:2011	Air oven aging, 70°C ± 1°C, 96 h	Air oven aging, 70°C ± 1°C, 96 h
2.1 Tensile strength	ISO 37:2011	Not less than 80 % of the original property	Not less than 80 % of the original property
2.2 Elongation	ISO 37:2011	Not less than 80 % of the original property	Not less than 80 % of the original property
2.3 Hardness	ISO 7619-1:2010	Not to exceed the original property by more than 8	Not to exceed the original property by more than 8
3. Tear	ISO 34-1:2010	400 N/cm or more	No requirement

NOTE If the colour of the outer cover is not black, the material requirements will differ from those in this table.

[a] Parts of ozone per hundred million of air by volume.

Table 3 *(continued)*

Test item	Test method	Required value	
		Outer rubber	Inner rubber
4. Compression set	ISO 815-1:2008	30 %(70 ± 1 °C, 22hours) or less	No requirement
5. Static ozone aging test	ISO 1431-1:2012	No cracks after elongation by 20 % and exposure to 50 pphm[a] at 40 °C for 96 h	No requirement

NOTE If the colour of the outer cover is not black, the material requirements will differ from those in this table.

[a] Parts of ozone per hundred million of air by volume.

Table 4 — Pneumatic 50 fender pressure requirements

Nominal size diameter × length mm	Internal pressure		Minimum endurable pressure		Safety-valve pressure setting kPa	Testing pressure at 0 % deflection kPa
	at 0 % deflection kPa	at 60 % deflection kPa	at 0 % deflection kPa	at 60 % deflection kPa		
500 × 1 000	50	132	300	462	–	200
600 × 1 000	50	126	300	441	–	200
700 × 1 500	50	135	300	473	–	200
1 000 × 1 500	50	122	300	427	–	200
1 000 × 2 000	50	132	300	462	–	200
1 200 × 2 000	50	126	300	441	–	200
1 350 × 2 500	50	130	300	455	–	200
1 500 × 3 000	50	132	300	462	–	200
1 700 × 3 000	50	128	300	448	–	200
2 000 × 3 500	50	128	300	448	–	200
2 500 × 4 000	50	137	350	480	175	250
2 500 × 5 500	50	148	350	518	175	250
3 300 × 4 500	50	130	350	455	175	250
3 300 × 6 500	50	146	350	511	175	250
3 300 × 10 600	50	158	350	553	175	250
4 500 × 9 000	50	146	350	511	175	250
4 500 × 12 000	50	154	350	539	175	250

Table 5 — Pneumatic 80 fender pressure requirements

Nominal size diameter × length mm	Internal pressure		Minimum endurable pressure		Safety-valve pressure setting kPa	Testing pressure at 0 % deflection kPa
	at 0 % deflection kPa	at 60 % deflection kPa	at 0 % deflection kPa	at 60 % deflection kPa		
500 × 1 000	80	174	480	609	–	250
600 × 1 000	80	166	480	581	–	250
700 × 1 500	80	177	480	620	–	250
1 000 × 1 500	80	160	480	560	–	250
1 000 × 2 000	80	174	480	609	–	250
1 200 × 2 000	80	166	480	581	–	250
1 350 × 2 500	80	170	480	595	–	250

Table 5 *(continued)*

Nominal size diameter × length mm	Internal pressure		Minimum endurable pressure		Safety-valve pressure setting kPa	Testing pressure at 0 % deflection kPa
	at 0 % deflection kPa	at 60 % deflection kPa	at 0 % deflection kPa	at 60 % deflection kPa		
1 500 × 3 000	80	174	480	609	–	250
1 700 × 3 000	80	168	480	588	–	250
2 000 × 3 500	80	168	480	588	–	250
2 500 × 4 000	80	180	560	630	230	300
2 500 × 5 500	80	195	560	683	230	300
3 300 × 4 500	80	171	560	599	230	300
3 300 × 6 500	80	191	560	669	230	300
3 300 × 10 600	80	208	560	728	230	300
4 500 × 9 000	80	192	560	672	230	300
4 500 × 12 000	80	202	560	707	230	300

Annex A
(informative)

Synthetic-tyre-cord layer

A.1 General

The terminology "synthetic-tyre-cord layer" used in this part of ISO 17357 refers to tyre cord made of synthetic fibres.

Synthetic-tyre-cord layers, commonly used in tyres, have been proven to provide strong efficient reinforcement layers in fenders. Each single layer is coated with rubber compound on both sides as well as in between synthetic-tyre-cord threads, hence isolating all cords from each other.

As contact between synthetic-tyre-cord threads does not occur, synthetic tyre cord has the advantage over other reinforcement materials, such as canvas fabric of reducing friction and wear between cord threads during compression, bending, and stretching, and also greatly improves fatigue resistance, endurance life, and pressure-holding performance.

Although canvas fabric such as "belt fabric" or "tyre-cord chafer" is also used as reinforcement in the rubber industry and sometimes mistaken for synthetic tyre cord, it is completely different from synthetic tyre cord and the canvas fabric shall not be used for the high pressure pneumatic floating fender. The difference between synthetic tyre cord and canvas fabric is illustrated in A.1 and A.2. The synthetic-tyre-cord arrangement has an obvious advantage over the canvas-fabric arrangement, as it is able to eliminate friction and wear points between wefts and warps.

A.2 Difference in arrangement of synthetic-tyre-cord and canvas-fabric reinforcement Layers

The arrangement of synthetic-tyre-cord reinforcement layers is shown in Figure A.1.

The arrangement of canvas-fabric reinforcement layers is in shown in Figure A.2.

A.3 Example of difference in the physical property of synthetic tyre cord and canvas Fabric

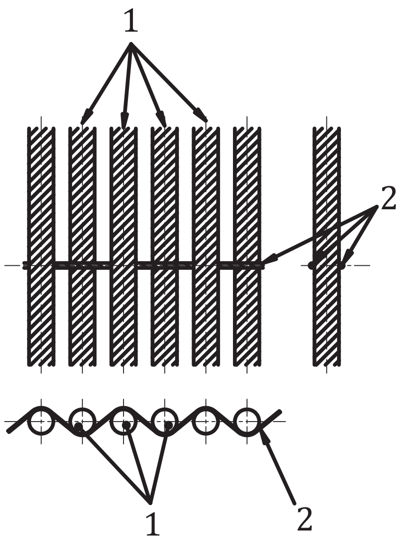
The synthetic-tyre-cord arrangement has strength in one direction only (warp) and the canvas-fabric arrangement has strength in both directions (weft and warp). Tables A.1 and A.2 provide an example of the difference in physical properties between the two.

Table A.1 — Synthetic tyre cord

Item	Unit	Warp	Weft
Density	Ends/inch	24	2
Tensile strength	N/mm^2	20	0,02

Table A.2 — Canvas fabric

Item	Unit	Warp	Weft
Density	Ends/inch	16	16
Tensile strength	N/mm^2	11,6	11,7

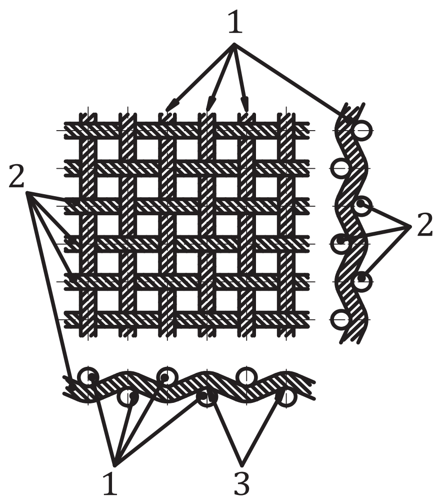


Key

1 warp

2 weft

Figure A.1 — Tyre cord



Key

1 warp

2 weft

3 friction and wear point

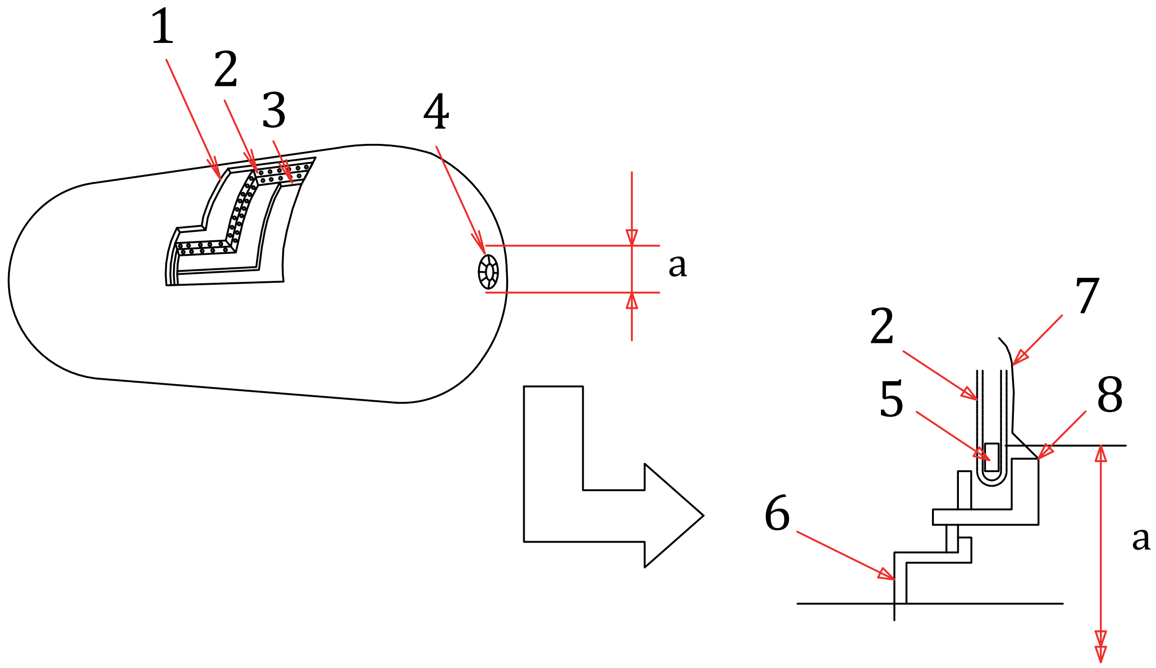
Figure A.2 — Canvas fabric

Annex B
(informative)

Flange opening and bead ring, metal parts

B.1 Diameter limitation

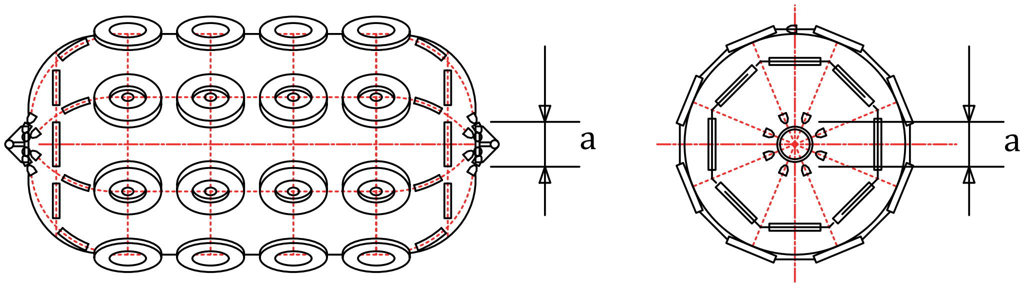
The outside diameter of the bead ring or other steel material of a high pressure fender shall be smaller than 20 % of the fender diameter to make metal parts safe from permanent deformation when it gets over compression near to 80 %. The detail explanations on the fender body and the protection net are illustrated in Figure B.1 and Figure B.2.



Key

1 outer rubber
2 tyre-cord layer
3 inner rubber
4 flange opening, bead ring, and metal parts
5 bead ring
6 flange opening
7 fender body
8 other metal parts
a Less than 0,2 D.

Figure B.1 — Flange opening and bead ring, metal parts on fender body



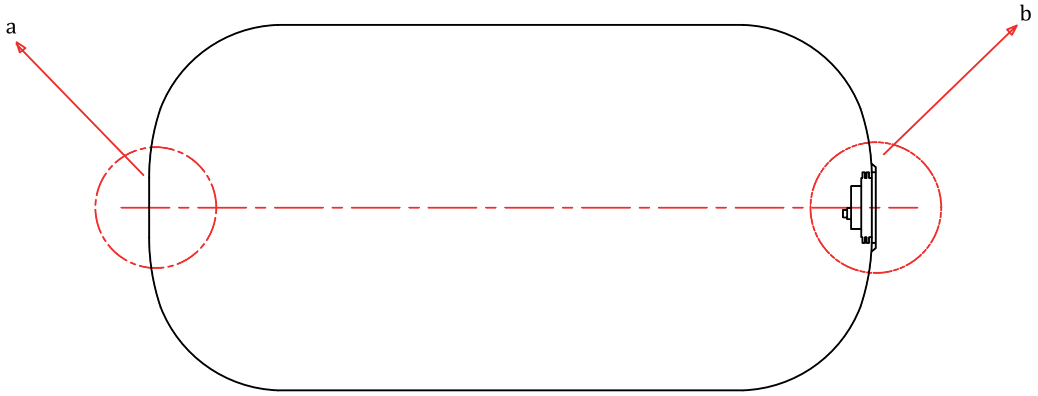
Key

a Less than 0,2 D.

Figure B.2 — Metal parts on protection net

B.2 Type I Single — Net type and one end with no flange opening and no metal parts

The flange opening shall be at only one end for Type I Single and no metal parts shall be at the other end to make that end safe from permanent deformation when it gets over compression. The end which has no flange opening and no metal parts should be installed at the position when the over compression is expected. The feature of Type I Single and the installation arrangement are illustrated in Figure B.3 and Figure B.4.

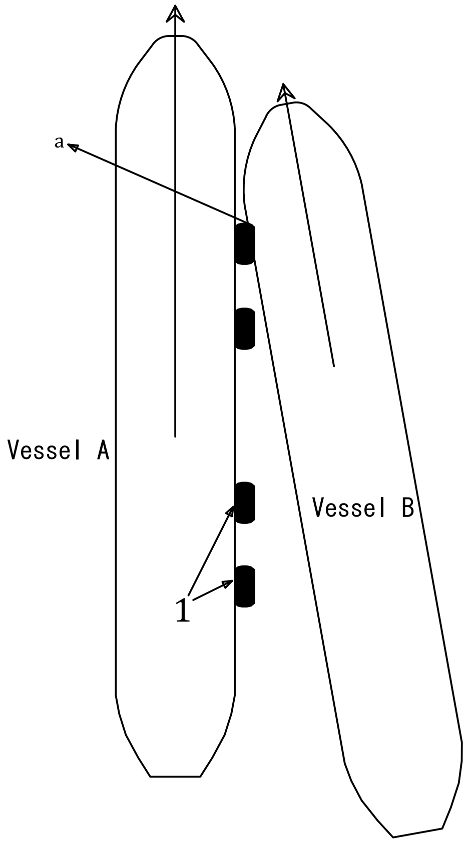


Key

a No flange opening and no metal parts.

b Flange opening and metal parts.

Figure B.3 — Type I Single



Key

1 fenders

a Over compression is expected. The end which has no flange opening and no metal parts should be installed.

Figure B.4 — Type I Single and installation

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