
**Rubber seals — Joint rings for water
supply, drainage and sewerage
pipelines — Specification for
materials**

*Joints étanches en caoutchouc — Garnitures de joints de canalisations
d'adduction et d'évacuation d'eau (égouts inclus) — Spécification des
matériaux*

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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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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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 45, *Rubber and rubber products*, Subcommittee SC 4, *Products (other than hoses)*.

This fifth edition cancels and replaces the fourth edition (ISO 4633:2015), which has been technically revised.

The main changes are as follows:

- estimation of lifetime and lifetime classes have been added as optional requirement;
- structural changes in the document.

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.

Rubber seals — Joint rings for water supply, drainage and sewerage pipelines — Specification for materials

WARNING — Persons using this document should be familiar with normal laboratory practice. This document does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices.

1 Scope

This document specifies requirements for materials used in vulcanized rubber seals for the following:

- a) cold drinking-water supplies (up to 50 °C);
- b) drainage, sewerage, and rainwater systems (continuous flow up to 45 °C and intermittent flow up to 95 °C).

The different designations of seals specified are defined according to their type, application, and requirements (see [Table 5](#)).

General requirements for finished joint seals are also given; any additional requirements called for by the particular application are specified in the relevant product standards, taking into account that the performance of pipe joints is a function of the seal material properties, seal geometry, and pipe joint design. This document is intended to be used, where appropriate, with product standards which specify performance requirements for joints.

This document is applicable to joint seals for all pipeline materials, including iron, steel, clay, fibre cement, concrete, reinforced concrete, plastics, and glass-reinforced plastics.

It is applicable to elastomeric components of composite or non-composite seals. In the case of composite seals for materials of hardness ranges from 76 IRHD-M to 95 IRHD-M, the requirements for elongation at break, compression set, and stress relaxation apply only when the material is participating in the sealing function or in the long-term stability of the seal.

Joint seals made with an enclosed void as part of their design are included in the scope of this document.

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

ISO 48-2, *Rubber, vulcanized or thermoplastic — Determination of hardness — Part 2: Hardness between 10 IRHD and 100 IRHD*

ISO 188:2023, *Rubber, vulcanized or thermoplastic — Accelerated ageing and heat resistance tests*

ISO 815-1:2019, *Rubber, vulcanized or thermoplastic — Determination of compression set — Part 1: At ambient or elevated temperatures*

ISO 815-2, *Rubber, vulcanized or thermoplastic — Determination of compression set — Part 2: At low temperatures*

ISO 1431-1, *Rubber, vulcanized or thermoplastic — Resistance to ozone cracking — Part 1: Static and dynamic strain testing*

ISO 1817, *Rubber, vulcanized or thermoplastic — Determination of the effect of liquids*

ISO 3302-1, *Rubber — Tolerances for products — Part 1: Dimensional tolerances*

ISO 3384-1:2019, *Rubber, vulcanized or thermoplastic — Determination of stress relaxation in compression — Part 1: Testing at constant temperature*

ISO 3387, *Rubber — Determination of crystallization effects by hardness measurements*

ISO 9691:1992, *Rubber — Recommendations for the workmanship of pipe joint rings — Description and classification of imperfections*

ISO 11346, *Rubber, vulcanized or thermoplastic — Estimation of life-time and maximum temperature of use*

ISO 23529, *Rubber — General procedures for preparing and conditioning test pieces for physical test methods*

3 Terms and definitions

No terms and definitions are listed in this document.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 Classification

Six classes of material for pipe joint seals are specified in [Table 2](#) and [Table 4](#) and three classes of material in [Table 5](#). A nominal hardness shall be specified within the ranges in [Table 1](#).

Table 1 — Hardness classification

Hardness class ^a	40	50	60	70	80	90
Range of hardness, IRHD-M	36 to 45	46 to 55	56 to 65	66 to 75	76 to 85	86 to 95

^a The hardness class follows directly from the nominal hardness, which is the typical hardness of a specific compound. The hardness class is not a requirement. If a compound has a nominal hardness of 47 IRHD-M, the hardness class is 50. A tolerance of ±5 (see [Table 2](#)) means that the hardness can be between 42 IRHD-M and 52 IRHD-M.

5 Requirements

5.1 General

The materials shall be free of any substances which can have a deleterious effect on the fluid being conveyed, the life of the sealing ring, the pipe, or the fitting. Elastomeric components of composite seals not exposed to the contents of the pipeline are not required to meet the requirements of [5.4](#) to [5.14](#).

5.2 Effect on water quality

For cold-water applications, the materials shall not impair the quality of the water under the conditions of use. The materials shall comply with the national requirements in the country of use.

5.3 Microbiological deterioration

The materials shall be resistant to microbiological deterioration if the application so requires. The test methods and the requirements shall be as specified in national standards.

5.4 Dimensional tolerances

Tolerances shall be specified from the appropriate classes in ISO 3302-1.

5.5 Imperfections and defects

The seals shall be free of defects or irregularities which can affect their function. Classification of imperfections shall be in accordance with ISO 9691, as follows:

- surface imperfections in zones involved in the sealing function, as described in ISO 9691:1992, 4.1.1, shall be considered as defects;
- surface imperfections in zones not involved in the sealing function, as described in ISO 9691:1992, 4.1.2.1 b), shall not be considered as defects.

Major surface imperfections in zones not involved in the sealing function, as described in ISO 9691:1992, 4.1.2.1 a), can be considered as defects. This shall be agreed upon between the interested parties, the acceptance criteria depend upon the seal type or design.

Internal imperfections as described in ISO 9691:1992, 4.2 can be considered as defects. The compressive force referred to in ISO 9691:1992 can be determined in accordance with ISO 7743. The acceptable limiting values of the compressive force shall be agreed upon between the interested parties. These values depend upon the seal type or design.

5.6 Hardness

When determined by the micro-test method specified in ISO 48-2, the hardness shall comply with the requirements given in [Table 2](#).

If the dimensions of a seal are appropriate, the normal test method specified in ISO 48-2 can be used provided that the micro-test method is used for reference purposes.

For the same seal, or along the greatest length of an extruded profile cut to make the seal, the difference between the minimum and maximum hardness shall not be more than 5 IRHD-M. Each value shall be within the specified tolerances.

5.7 Tensile strength and elongation at break

The tensile strength and elongation at break shall be determined by the method specified in ISO 37. Dumb-bell-shaped test pieces of type 1, 2, 3, or 4 shall be used. Type 2 is the preferred type. The test report shall state the dumb-bell type whenever type 2 is not used.

The tensile strength and the elongation at break shall comply with the requirements given in [Table 2](#).

5.8 Compression set in air

5.8.1 General

If the test piece is taken from a seal, then the measurement shall be carried out as far as possible in the direction of compression of the seal in service.

5.8.2 Compression set at 23 °C and 70 °C

When determined by the method A specified in ISO 815-1:2019 at 23 °C and 70 °C using the small, type B, test piece, the compression set shall comply with the requirements given in [Table 2](#).

Where the cross-section is too small to obtain compression buttons from the product as an alternative to moulding buttons, the tension set of the product may be determined using ISO 2285:2019, method A, with a strain of 50 %, and applying the same test conditions (except strain) and requirements as for compression set.

5.8.3 Low-temperature compression set at -10 °C

When determined by the method specified in ISO 815-2 at -10 °C, using the small, type B, test piece and the (30 ± 3) min recovery measurement, the low-temperature compression set shall comply with the requirements given in [Table 2](#).

5.9 Accelerated ageing in air

Test pieces prepared for the determination of hardness (see [5.6](#)) and for the determination of tensile strength and elongation at break (see [5.7](#)) shall be aged in air, by the normal oven method specified in ISO 188:2023 (method A) for 7 days at 70 °C.

The changes in hardness, tensile strength, and elongation at break shall comply with the requirements given in [Table 2](#).

5.10 Stress relaxation in compression

The stress relaxation shall be determined by method A of ISO 3384-1:2019, using the cylindrical test piece after carrying out thermal and mechanical conditioning.

Measurements shall be taken after 3 h, 1 day, 3 days, and 7 days for the 7-day test and after 3 h, 1 day, 3 days, 7 days, 30 days, and 100 days for the 100-day test.

The best-fit straight line shall be determined by regression analysis using a logarithmic time scale and the correlation coefficients derived from these analyses shall not be lower than 0,93 for the 7-day test and 0,83 for the 100-day test. The 7-day and 100-day requirements in [Table 2](#) are those derived from these straight lines. For continuous measurement, using the apparatus described in the first paragraph of ISO 3384-1:2019, 5.2, the 7-day and 100-day requirements in [Table 2](#) are those derived from the measurements at 7 days and 100 days.

The stress relaxation in compression shall comply with the requirements given in [Table 2](#) at the following temperatures and times:

- 7 days at (23 ± 2) °C;
- 100 days at (23 ± 2) °C.

The test temperature shall be maintained within the specified tolerance during the whole period of the test and verified by suitable recording equipment on a continuous basis.

The 100-day test shall be considered as a type approval test.

Where the cross-section is too small to obtain compression buttons from the product, as an alternative to moulding test pieces, the stress relaxation in tension of the product may be determined using ISO 6914:2021, method A with the same requirements as for stress relaxation in compression.

5.11 Volume change in water

When determined by the method specified in ISO 1817 after 7 days of immersion in distilled or deionized water at 70 °C, the change in volume shall comply with the requirements given in [Table 2](#).

5.12 Ozone resistance

When determined by the method specified in ISO 1431-1 under the conditions set out below, the ozone resistance of vulcanized rubber sealing elements, which are attached to the pipe or fittings, shall comply with the requirements given in [Table 2](#).

ozone concentration	(500 ± 50) ppb or (50 ± 5) pphm
temperature	(40 ± 2) °C
pre-tension time	(72 ₋₂ ⁰) h
exposure	(48 ₋₂ ⁰) h
elongation:	
40 IRHD-M, 50 IRHD-M, 60 IRHD-M, 70 IRHD-M	(20 ± 2) %
80 IRHD-M	(15 ± 2) %
90 IRHD-M	(10 ± 1) %
relative humidity	(55 ± 10) %

Rubber sealing elements which are protected by packaging, whether packaged separately or not, up to the time of installation, shall meet the same requirement but using an ozone concentration of (250 ± 50) ppb or (25 ± 5) pphm.

NOTE Parts of ozone per billion of air by volume (ppb) is used in environmental science for atmospheric pollutants, while parts per hundred million (pphm) has been the traditional unit for ozone concentration in the rubber industry. The ozone concentration may also be expressed in mg/m³ or in mPa. The expression mg/m³ indicates the number of ozone molecules in the volume which is available for ozone cracking and depends on both pressure and temperature. ISO 1431-3 contains a formula for conversion.

5.13 Splices of prevulcanized profile ends

5.13.1 Spliced joints

These shall be vulcanized.

5.13.2 Strength of spliced joints

The method in [Annex A](#) shall be used to determine the strength of the spliced joints. There shall be no visible separation in the cross-sectional area of the splice when viewed without magnification.

5.14 Summary of physical property requirements

[Table 2](#) lists the physical requirements. [Table 4](#) lists additional optional requirements.

Table 2 — Physical property requirements

Types WA, WC and WG (see Table 5)				Requirements for hardness classes ^a					
Property	Unit	Test method	Subclause in this document	40	50	60	70	80	90
Permissible tolerance on nominal hardness	IRHD-M	ISO 48-2	5.6	±5	±5	±5	±5	±5	±5
Tensile strength, min.	MPa	ISO 37	5.7	9	9	9	9	9	9
Elongation at break, min.	%	ISO 37	5.7	400	375	300	200	125	100
Compression set, max.									
72 h at 23 °C	%	ISO 815-1	5.8.2	12	12	12	15	15	15
24 h at 70 °C	%	ISO 815-1	5.8.2	20	20	20	20	20	20
72 h at -10 °C	%	ISO 815-2	5.8.3	40	40	50	50	60	60
Ageing, 7 days at 70 °C		ISO 188:2023, method A	5.9						
Hardness change, max./min.	IRHD-M	ISO 48-2		+8/-5	+8/-5	+8/-5	+8/-5	+8/-5	+8/-5
Tensile-strength change, max.	%	ISO 37		-20	-20	-20	-20	-20	-20
Elongation change, max./min.	%	ISO 37		+10/-30	+10/-30	+10/-30	+10/-30	+10/-40	+10/-40
Stress relaxation, max.		ISO 3384-1	5.10						
7 days at 23 °C	%			13	14	15	16	17	18
100 days at 23 °C	%			19	20	22	23	25	26
Volume change in water max./min.									
7 days at 70 °C	%	ISO 1817	5.11	+8/-1	+8/-1	+8/-1	+8/-1	+8/-1	+8/-1
Ozone resistance	—	ISO 1431-1	5.12	No cracking when viewed without magnification					

^a The hardness class follows directly from the nominal hardness, which is the typical hardness of a specific compound. The hardness class is not a requirement. If a compound has a nominal hardness of 47 IRHD-M, the hardness class is 50. A tolerance of ±5 means that the hardness can be between 42 IRHD-M and 52 IRHD-M.

6 Optional requirements

6.1 Low temperature performance at -25 °C, (type L)

When determined by the method specified in ISO 815-2, using the small, type B, test piece at -25 °C the compression set shall comply with the requirements given in [Table 4](#).

When determined by the method specified in ISO 3387, the hardness change at -25 °C shall comply with the requirements given in [Table 4](#).

6.2 Volume change in oil, (type O)

The resistance to oil shall be determined in accordance with ISO 1817. The volume change of test pieces shall be determined after 72 h immersion in standard oils No. 1 (IRM 901) and No. 3 (IRM 903) at a temperature of 70 °C.

The volume change in oil shall comply with the requirements in [Table 4](#).

6.3 Lifetime estimation, (type LT)

6.3.1 General

A lifetime class of the material according to [Table 3](#) can be agreed between the parties concerned, depending on the application. The lifetime estimation tests described in [6.3.2](#) and [6.3.3](#) are performed on a material or on standard test samples prepared out of the final product, not on a finished product in a real system. The result of the lifetime estimation can be used for comparison of different materials for

the same application. For a seal in a real application there are many other factors affecting the lifetime and the performance of the seal. See [Annex D](#).

Table 3 — Lifetime classification

Lifetime class	A	B	C
Years	150	100	50

6.3.2 Method 1 by stress relaxation

The stress relaxation shall be determined by method A or method B of ISO 3384-1:2019 using the cylindrical test piece after carrying out thermal and mechanical conditioning.

Suitable temperatures are chosen according to the guidelines in ISO 11346.

Measurements shall be done at three temperatures to the threshold value of 50 % stress relaxation for method A and 75 % for method B. The times to reach the threshold value in % at each temperature is plotted in an Arrhenius plot according to ISO 11346. The lifetime is determined by extrapolating the line to 20 °C.

NOTE In addition, other temperatures as agreed between the parties concerned, can be used for calculations.

6.3.3 Method 2 by compression set

The compression set shall be determined by method A of ISO 815-1:2019, using the small, type B, test piece.

Suitable temperatures are chosen according to the guidelines in ISO 11346.

Measurements shall be done at three temperatures to the threshold value of 80 % compression set. The times to reach 80 % at each temperature is plotted in an Arrhenius plot according to ISO 11346. The lifetime is determined by extrapolating the line to 20 °C.

NOTE In addition, other temperatures as agreed between the parties concerned, can be used for calculations.

6.4 Summary of optional property requirements

[Table 4](#) lists additional optional property requirements.

Table 4 — Optional property requirements

Types WA, WC and WG (see Table 5)				Optional requirements for hardness classes ^a					
Property	Unit	Test method	Subclause in this document	40	50	60	70	80	90
Compression set, max. 72 h at -25 °C	%	ISO 815-2	6.1	60	60	60	70	70	70
Hardness change, max 168 h at -25 °C	IRHD-M	ISO 3387	6.1	+18	+18	+18	—	—	—
Volume change in oil, max./min. 72 h at 70 °C		ISO 1817	6.2						
Oil No. 1 (IRM 901)	%			±10	±10	±10	±10	±10	±10
Oil No. 3 (IRM 903)	%			+50/-5	+50/-5	+50/-5	+50/-5	+50/-5	+50/-5
Estimation of lifetime ^b : Years at 20 °C		ISO 11346	6.3						

^a The hardness class follows directly from the nominal hardness, which is the typical hardness of a specific compound. The hardness class is not a requirement. If a compound has a nominal hardness of 47 IRHD-M, the hardness class is 50. A tolerance of ±5 (see [Table 2](#)) means that the hardness can be between 42 IRHD-M and 52 IRHD-M.

^b The choice of lifetime class is agreed between the parties concerned, depending on the application. The test is performed on a material, not on a finished product in a real system. See [Annex D](#).

Table 4 (continued)

Types WA, WC and WG (see Table 5)				Optional requirements for hardness classes ^a					
Property	Unit	Test method	Subclause in this document	40	50	60	70	80	90
Life time class A	years			150	150	150	150	150	150
Life time class B	years			100	100	100	100	100	100
Life time class C	years			50	50	50	50	50	50

^a The hardness class follows directly from the nominal hardness, which is the typical hardness of a specific compound. The hardness class is not a requirement. If a compound has a nominal hardness of 47 IRHD-M, the hardness class is 50. A tolerance of ± 5 (see [Table 2](#)) means that the hardness can be between 42 IRHD-M and 52 IRHD-M.

^b The choice of lifetime class is agreed between the parties concerned, depending on the application. The test is performed on a material, not on a finished product in a real system. See [Annex D](#).

7 Test pieces and test temperature

7.1 Preparation of test pieces

Unless otherwise specified, test pieces shall be cut from the finished product by the method specified in ISO 23529. If satisfactory test pieces cannot be prepared in accordance with the instructions given for the appropriate test method, they shall be taken from test slabs or sheets of suitable dimensions, made from the same batch of rubber mix used to make the seals, and moulded under conditions which are comparable with those used in production.

For tests in which different sizes of test piece are permissible, the same size of test piece shall be used for each batch and for any comparative purposes.

7.2 Test temperature

Unless otherwise specified, tests shall be carried out at (23 ± 2) °C.

8 Quality assurance

Quality assurance testing is not an integral part of this document, but guidance can be obtained from [Annex B](#), which recommends appropriate test frequencies, product-control tests and sampling techniques.

Quality assurance should preferably be in accordance with a standard such as ISO 9001.

9 Storage

See [Annex C](#).

10 Designation

Elastomeric seals for pipelines are designated according to their intended application as described in [Table 5](#). The following information shall be used for full designation of the seals:

- description, e.g. O-ring;
- reference to this document, i.e. ISO 4633;
- nominal size, e.g. DN 150;
- type of application, e.g. WA (see [Table 5](#));
- rubber type, e.g. a threshold value of EPDM (see ISO 1629);

— joint name, e.g. manufacturer's tradename.

EXAMPLE O-ring/ISO 4633/DN, 150/WA/EPDM/Tradename.

Table 5 — Designation of elastomeric joint seals by type, application and requirements

	Application	Requirements	Subclause
WA WA+	Cold drinking-water supply (up to 50 °C)	Table 2 Effect on water quality Table 2 and optionally one or more requirements from Table 4	5.2
WC WC+	Cold non-drinking-water supply, drainage, sewerage and rainwater pipes (continuous flow up to 45 °C and intermittent flow up to 95 °C)	Table 2 Table 2 and optionally one or more requirements from Table 4	
WG WG+	Cold non-drinking-water supply, drainage, sewerage and rainwater pipes (continuous flow up to 45 °C and intermittent flow up to 95 °C) with oil resistance	Table 2 and oil resistance Table 2 and optionally one or more requirements from Table 4	6.2

11 Marking and labelling

Each seal or each parcel of seals where individual marking is not practicable, shall be marked clearly and durably with the following information, in such a way that the sealing capability is not impaired:

- nominal size;
- manufacturer's identification mark;
- reference to this document, i.e. ISO 4633, followed by the type of application and the hardness class, e.g. ISO 4633/WA/50;
- third-party certification mark;
- quarter and year of manufacture, e.g. 4Q 2000;
- fact that the seal is low-temperature-resistant (L), if appropriate, e.g. WAL;
- fact that the seal is oil-resistant (O);
- fact that the seal is lifetime tested (LT-class A);
- rubber type, e.g. EPDM (see ISO 1629).

Annex A (normative)

Determination of splice strength

A.1 Principle

A seal spliced from pre-vulcanized rubber is stretched and examined.

A.2 Test piece

Perform the test either on the seal itself or on a test piece 200 mm long with the splice at the mid-point, i.e. such that there is a length of 100 mm on each side of the splice.

A.3 Procedure

Make two reference marks, equidistant from the splice and 50 mm apart, on the seal or test piece, extend the seal or test piece at a rate of $(8,3 \pm 0,8)$ mm/s until the elongation between the reference marks is as specified in [Table A.1](#). Maintain this elongation for 1 min and examine the seal or test piece under tension.

Table A.1 — Required elongation between reference marks for splice strength

Hardness class	Elongation %
40, 50, 60, 70	100
80	75
90	50

Annex B (informative)

Quality assurance

B.1 Type tests

All tests except those having duration in excess of 28 days should be carried out at least annually and whenever the manufacturing technique is changed significantly. Those tests having duration in excess of 28 days should be repeated at five-year intervals. All tests, without exception, should also be carried out initially and whenever the elastomer formulation is changed significantly.

B.2 Product-control test

The tests specified in [5.5](#) and [6.1](#) and the following tests as specified in [Table 2](#) should be carried out using test pieces prepared as in [7.1](#):

- a) tensile strength;
- b) elongation at break;
- c) compression set;
- d) hardness;
- e) splice strength, where appropriate.

B.3 Sampling for product-control tests

Product-control tests should be carried out on batches of finished components, using sampling procedures in accordance with:

- a) ISO 2859-1, with a specified inspection level of, for example, S-2 and an AQL of, for example, 2,5 % for attributes, or
- b) ISO 3951-1, with a specified inspection level of, for example, S-3 and an AQL of, for example, 2,5 % for variables.

These examples do not preclude the use by the manufacturer of more stringent combinations of inspection levels and AQL values from ISO 2859-1 or ISO 3951-1.

Annex C (informative)

Guidance on storage of seals

At all stages between manufacture and use, the seals should be stored in accordance with the recommendations given in ISO 2230.

The following points should be noted:

- a) storage temperature should be below 25 °C and preferably below 15 °C;
- b) seals should be protected from light, in particular strong sunlight and artificial light with a high ultraviolet content;
- c) seals should not be stored in a room with any equipment capable of generating ozone, e.g. mercury-vapour lamps or high-voltage electrical equipment which can give rise to electrical sparks or silent electrical discharges;
- d) seals should be stored in a relaxed condition free from tension, compression, or other deformation and they should not, for example, be suspended from any part of the circumference;
- e) seals should be maintained in a clean condition.

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