BS ISO 3601-5:2015

BSI Standards Publication

Fluid power systems — O-rings

Part 5: Specification of elastomeric materials for industrial applications

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National foreword

This British Standard is the UK implementation of ISO 3601-5:2015.

The UK participation in its preparation was entrusted to Technical Committee MCE/11, Fluid seals and their housings.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Fluid power systems — O-rings —

Part 5: Specification of elastomeric materials for industrial applications

Transmissions hydrauliques et pneumatiques — Joints toriques —

Partie 5: Matériaux élastomères convenant pour applications industrielles

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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 131, *Fluid power systems*, Subcommittee SC 7, *Sealing devices*.

This second edition cancels and replaces the first edition (ISO 3601-5:2002), which has been technically revised.

ISO 3601 consists of the following parts, under the general title *Fluid power systems — O-rings*:

— *Part 1: Inside diameters, cross-sections, tolerances and designation codes*

— *Part 2: Housing dimensions for general applications*

— *Part 3: Quality acceptance criteria*

— *Part 4: Anti-extrusion rings (back-up rings)*

— *Part 5: Suitability of elastomeric materials for industrial applications*

Introduction

In fluid power systems, power is transmitted and controlled through a fluid (liquid or gas) under pressure within an enclosed circuit. One component of such a system can be a toroidal sealing, an O-ring. This part of ISO 3601 evaluates the suitability of a number of elastomeric materials (rubber) which can be used for O-rings in industrial applications.

INTERNATIONAL STANDARD **ISO 3601-5:2015(E)**

Fluid power systems — O-rings —

Part 5: Specification of elastomeric materials for industrial applications

1 Scope

This part of ISO 3601 contains the material specification of a selection of standard elastomeric materials (rubber) for O-rings used in general industrial applications. It also indicates the ability of the materials to satisfy many of the requirements associated with fluid power components.

Only materials which are in universal usage are specified; other compounds are available and can be used.

The required physical properties and test methods (including test specimen) should be agreed upon between equipment manufacturer/user and O-ring manufacturer/supplier.

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

ISO 48, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

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

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

ISO 1382, *Rubber — Vocabulary*

ISO 1629, *Rubber and latices — Nomenclature*

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

ISO 2921, *Rubber, vulcanized — Determination of low-temperature retraction (TR test)*

ISO 3601-1, *Fluid power systems — O-rings — Part 1: Inside diameters, cross-sections, tolerances and designation codes*

ISO 5598, *Fluid power systems and components — Vocabulary*

ASTM D1414, *Standard Test Methods for Rubber O-Rings*

3 Terms, definitions, and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3601-1, ISO 1382, and ISO 5598 apply.

3.2 Symbols

d_1 inside diameter of O-ring

d_2 cross section diameter of O-ring

4 Materials

4.1 Commonly used elastomeric materials

Table 1 gives a selection of elastomeric materials commonly used for O-rings in general industrial applications.

Table 1 — Commonly used elastomeric materials for O-rings

Basic elastomer	Code[a]	Curing system	Nominal hardness (IRHD)[b] °, CM
Acrylonitrile-butadiene	NBR	S	70, 90
Acrylonitrile-butadiene	NBR	P	75, 90
Hydrogenated NBR	HNBR		75, 90
Fluorocarbon	FKM		70, 75, 80, 90
Silicone	VMQ		70
Ethylene-propylene-diene	EPDM	S	70, 80
Ethylene-propylene-diene	EPDM	P	70, 80
Polyacrylate	ACM		70

NOTE Other hardness and materials are possible depending on the application.

[a] Codes in accordance with ISO 1629.

[b] See ISO 48.

4.2 Curing systems

An important process in moulding operations to make O-rings is vulcanization. Vulcanization is a chemical process for converting rubber or related polymers into more durable and, in case of elastomers, more elastic materials through the addition of sulfur or other equivalent “curatives.” These additives modify the polymer by forming crosslinks between individual polymer chains.

The curing system used depends on the polymer type and the desired properties. Two of the most widely and often used systems are sulfur (S) and peroxide (P) curing systems.

NOTE Not all curing systems are suitable for all elastomers.

4.3 O-ring requirements

The O-ring requirements of the basic elastomers according to Table 1 are specified in Table 2. This table can be used for the inspection of production parts, incoming goods, or in case of complaints.

Table 2 — O-ring requirements

		NBR S		NBR P		HNBR		FKM		VMQ		EPDM S		EPDM P		ACM		Test method
Hardness (IRHD)	°, CM[c]	70	90	75	90	75	90	70	75	80	90	70	70	80	70	80	70	ISO 48 CM
Tolerance in hardness for	—	—																
$d_2 \geq 1{,}60$ mm	°, CM[c]	+5/-5																
$d_2 < 1{,}60$ mm	°, CM[c]	+5/-8																
Compression set, max.[a]	%	35	35	30	30	40	50	25	25	25	30	35	30	35	30	30	40	ISO 815-1, Method A
24 (+0/-2) h[b] at temperature	°C	100	100	100	100	150	150	200	200	200	200	175	100	100	150	150	150	
Compression set, max.	%	50	50	40	40	45	50	30	30	30	30	40	40	40	35	35	50	ISO 815-1, Method A
for $d_2 \geq 2{,}62$ mm 72 (+0/-2) h[b] at temperature	°C	100	100	100	100	125	125	175	175	175	175	175	100	100	125	125	150	
Compression set, max.[a]	%	50	50	45	50	45	50	30	30	30	30	50	45	45	35	35	50	ISO 815-1, Method A
for $d_2 < 2{,}62$ mm 72 (+0/-2) h[b] at temperature	°C	100	100	100	100	125	125	175	175	175	175	175	100	100	125	125	150	

NOTE 1 The frequency of the lot testing should be agreed between the supplier and purchaser at the time of order.

NOTE 2 For all values $d_2 < 1$ mm, no reliable measurement procedures have been developed.

[a] For values $d_2 < 2$ mm, the limits can be increased by +5 %.

[b] Purchaser and supplier should agree upon the duration of the compression set test.

[c] For indication of the hardness, see ISO 48.

4.4 Detailed requirements of O-ring materials

Operating conditions shall be taken into consideration when O-ring materials are selected.

Therefore users should determine the compatibility of the O-ring material with the operational parameters (e.g. fluid, temperature, pressure, etc.) of the application.

The detailed requirements of O-ring materials according to Table 1 are specified in Tables 3 to 10. These tables should be used to qualify standard O-ring materials.

Table 3 — O-ring material NBR (sulfur cured)

Properties	Unit	Test specimen	NBR sulfur cured		Test method
			70	90	
Hardness (IRHD)	°, M	2 mm sheet	70 ± 5	90 ± 5	ISO 48 M
Hardness (IRHD)	°, CM	O-ring[a]	70 ± 5	90 ± 5	ISO 48 CM
Tensile strength, min.	MPa	2 mm sheet	12	10	ISO 37
Tensile strength, min.	MPa	O-ring[a]	10	8	ASTM D1414
Elongation at break, min.	%	2 mm sheet	250	125	ISO 37
Elongation at break, min.	%	O-ring[a]	200	100	ASTM D1414
Compression set, max. 24 (+0/-2) h at 100 °C	%	O-ring[a]	35	35	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 100 °C	%	Button type B ⌀ 13 mm × 6 mm	40	40	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 100 °C	%	O-ring[a]	50	50	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 100 °C	%	Button type B ⌀ 13 mm × 6 mm	60	70	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 100 °C	%	O-ring[a]	65	75	ISO 815-1, Method A
Heat ageing, 72 (+0/-2) h / 100 °C	—	—	—	—	ISO 188
Hardness change, max.	°, M	2 mm sheet	+8	+8	ISO 48 M
Hardness change, max.	°, CM	O-ring[a]	+8	+8	ISO 48 CM
Heat ageing,168 (+0/-2) h / 100 °C	—	—	—	—	ISO 188
Hardness change, max.	°, M	2 mm sheet	+10	+10	ISO 48 M
Hardness change, max.	°, CM	O-ring[a]	+10	+10	ISO 48 CM
Change of tensile strength	%	2 mm sheet	±25	±25	ISO 37
Change of tensile strength	%	O-ring[a]	±25	±30	ASTM D1414
Change of elongation at break	%	2 mm sheet	±40	±40	ISO 37
Change of elongation at break	%	O-ring[a]	±50	±50	ASTM D1414
Cold flexibility TR10, (colder than)	°C	2 mm sheet	−20	−18	ISO 2921
Cold flexibility TR10, (colder than)	°C	O-ring[a]	−20	−18	ISO 2921
Immersion test in ISO Oil No. 1 72 (+0/-2) h / 100 °C	—	—	—	—	ISO 1817
Volume change	%	2 mm sheet	+5/-15	+5/-15	ISO 1817
Volume change	%	O-ring[a]	+5/-15	+5/-15	ISO 1817
Hardness change	°, M	2 mm sheet	+10/-6	+8/-5	ISO 48 M
Hardness change	°, CM	O-ring[a]	+10/-6	+8/-5	ISO 48 CM
Immersion test in ISO Oil No.3 72 (+0/-2) h / 100 °C	—	—	—	—	ISO 1817
Volume change	%	2 mm sheet	+15/0	+15/0	ISO 1817
Volume change	%	O-ring[a]	+15/0	+15/0	ISO 1817
Hardness change	°, M	2 mm sheet	+5/-10	+5/-10	ISO 48 M
Hardness change	°, CM	O-ring[a]	+5/-10	+5/-10	ISO 48 CM

NOTE Variations of physical properties (particularly hardness, see ISO 48) can occur between test sheets and O-rings made from the same compound. For qualification, either test specimen (sheet or O-ring) is acceptable.

[a] O-ring size ISO 3601-1-214 (d_1 = 24,99 mm; d_2 = 3,53 mm).

Table 4 — O-ring material NBR (peroxide cured)

Properties	Unit	Test specimen	NBR peroxide cured		Test method
			75	90	
Hardness (IRHD)	°, M	2 mm sheet	75 ± 5	90 ± 5	ISO 48 M
Hardness (IRHD)	°, CM	O-ring[a]	75 ± 5	90 ± 5	ISO 48 CM
Tensile strength, min.	MPa	2 mm sheet	12	10	ISO 37
Tensile strength, min.	MPa	O-ring[a]	10	8	ASTM D1414
Elongation at break, min.	%	2 mm sheet	150	90	ISO 37
Elongation at break, min.	%	O-ring[a]	150	90	ASTM D1414
Compression set, max. 24 (+0/-2) h at 100 °C	%	O-ring[a]	30	30	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 100 °C	%	Button type B ⌀ 13 mm × 6 mm	40	40	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 100 °C	%	O-ring[a]	40	40	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 100 °C	%	Button type B ⌀ 13 mm × 6 mm	50	60	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 100 °C	%	O-ring[a]	55	65	ISO 815-1, Method A
Heat ageing, 72 (+0/-2) h / 100 °C	—	—	—	—	ISO 188
Hardness change, max.	°, M	2 mm sheet	+8	+8	ISO 48 M
Hardness change, max.	°, CM	O-ring[a]	+8	+8	ISO 48 CM
Heat ageing,168 (+0/-2) h / 100 °C	—	—	—	—	ISO 188
Hardness change, max.	°, M	2 mm sheet	+10	+10	ISO 48 M
Hardness change, max.	°, CM	O-ring[a]	+10	+10	ISO 48 CM
Change of tensile strength	%	2 mm sheet	±25	±25	ISO 37
Change of tensile strength	%	O-ring[a]	±25	±25	ASTM D1414
Change of elongation at break	%	2 mm sheet	±50	±40	ISO 37
Change of elongation at break	%	O-ring[a]	±50	±50	ASTM D1414
Cold flexibility TR10, (colder than)	°C	2 mm sheet	−20	−18	ISO 2921
Cold flexibility TR10, (colder than)	°C	O-ring[a]	−20	−18	ISO 2921
Immersion test in ISO Oil No. 1 72 (+0/-2) h / 100 °C	—	—	—	—	ISO 1817
Volume change	%	2 mm sheet	+5/-15	+5/-15	ISO 1817
Volume change	%	O-ring[a]	+5/-15	+5/-15	ISO 1817
Hardness change	°, M	2 mm sheet	+10/-6	+8/-5	ISO 48 M
Hardness change	°, CM	O-ring[a]	+10/-6	+8/-5	ISO 48 CM
Immersion test in ISO Oil No.3 72 (+0/-2) h / 100 °C	—	—	—	—	ISO 1817
Volume change	%	2 mm sheet	+15/0	+15/0	ISO 1817
Volume change	%	O-ring[a]	+15/0	+15/0	ISO 1817
Hardness change	°, M	2 mm sheet	+5/-10	+5/-10	ISO 48 M
Hardness change	°, CM	O-ring[a]	+5/-10	+5/-10	ISO 48 CM

NOTE Variations of physical properties (particularly hardness, see ISO 48) can occur between test sheets and O-rings made from the same compound. For qualification either test specimen (sheet or O-ring) is acceptable.

[a] O-ring size ISO 3601-1-214 (d_1 = 24,99 mm; d_2 = 3,53 mm).

Table 5 — O-ring material HNBR

Properties	Unit	Test specimen	HNBR		Test method
			75	90	
Hardness (IRHD)	°, M	2 mm sheet	75 ± 5	90 ± 5	ISO 48 M
Hardness (IRHD)	°, CM	O-ring[a]	75 ± 5	90 ± 5	ISO 48 CM
Tensile strength, min.	MPa	2 mm sheet	16	16	ISO 37
Tensile strength, min.	MPa	O-ring[a]	14	13	ASTM D1414
Elongation at break, min.	%	2 mm sheet	200	125	ISO 37
Elongation at break, min.	%	O-ring[a]	200	100	ASTM D1414
Compression set, max. 24 (+0/-2) h at 150 °C	%	O-ring[a]	40	50	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 125 °C	%	Button type B ⌀ 13 mm × 6 mm	40	45	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 125 °C	%	O-ring[a]	40	50	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 125 °C	%	Button type B ⌀ 13 mm × 6 mm	60	70	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 125 °C	%	O-ring[a]	70	75	ISO 815-1, Method A
Heat ageing, 72 (+0/-2) h / 150 °C	—	—	—	—	ISO 188
Hardness change, max.	°, M	2 mm sheet	+8	+8	ISO 48 M
Hardness change, max.	°, CM	O-ring[a]	+8	+8	ISO 48 CM
Heat ageing,168 (+0/-2) h / 150 °C	—	—	—	—	ISO 188
Hardness change, max.	°, M	2 mm sheet	+10	+10	ISO 48 M
Hardness change, max.	°, CM	O-ring[a]	+10	+10	ISO 48 CM
Change of tensile strength	%	2 mm sheet	±25	±30	ISO 37
Change of tensile strength	%	O-ring[a]	±25	±30	ASTM D1414
Change of elongation at break	%	2 mm sheet	±30	±40	ISO 37
Change of elongation at break	%	O-ring[a]	±40	±50	ASTM D1414
Cold flexibility TR10, (colder than)	°C	2 mm sheet	–18	–15	ISO 2921
Cold flexibility TR10, (colder than)	°C	O-ring[a]	–18	–15	ISO 2921
Immersion test in ISO Oil No. 1 72 (+0/-2) h / 125 °C	—	—	—	—	ISO 1817
Volume change	%	2 mm sheet	+5/-10	+5/-8	ISO 1817
Volume change	%	O-ring[a]	+5/-8	+5/-8	ISO 1817
Hardness change	°, M	2 mm sheet	+8/-5	+8/-5	ISO 48 M
Hardness change	°, CM	O-ring[a]	+8/-5	+8/-5	ISO 48 CM
Immersion test in ISO Oil No.3 72 (+0/-2) h / 125 °C	—	—	—	—	ISO 1817
Volume change	%	2 mm sheet	+25/0	+20/0	ISO 1817
Volume change	%	O-ring[a]	+25/0	+20/0	ISO 1817
Hardness change	°, M	2 mm sheet	+5/-15	+5/-15	ISO 48 M
Hardness change	°, CM	O-ring[a]	+5/-15	+5/-15	ISO 48 CM

NOTE Variations of physical properties (particularly hardness, see ISO 48) can occur between test sheets and O-rings made from the same compound. For qualification either test specimen (sheet or O-ring) is acceptable.

[a] O-ring size ISO 3601-1-214 (d_1 = 24,99 mm; d_2 = 3,53 mm).

Table 6 — O-ring material FKM

Properties	Unit	Test specimen	FKM				Test method
			70	75	80	90	
Hardness (IRHD)	°, M	2 mm sheet	70 ± 5	75 ± 5	80 ± 5	90 ± 5	ISO 48 M
Hardness (IRHD)	°, CM	O-ring[a]	70 ± 5	75 ± 5	80 ± 5	90 ± 5	ISO 48 CM
Tensile strength, min.	MPa	2 mm sheet	10	10	10	10	ISO 37
Tensile strength, min.	MPa	O-ring[a]	8	8	8	8	ASTM D1414
Elongation at break, min.	%	2 mm sheet	150	150	125	100	ISO 37
Elongation at break, min.	%	O-ring[a]	150	150	125	100	ASTM D1414
Compression set, max. 24 (+0/-2) h at 200 °C	%	O-ring[a]	25	25	25	30	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 175 °C	%	Button type B ⌀ 13 mm × 6 mm	25	25	25	30	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 175 °C	%	O-ring[a]	30	30	30	30	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 175 °C	%	Button type B ⌀ 13 mm × 6 mm	40	40	40	45	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 175 °C	%	O-ring[a]	45	45	45	50	ISO 815-1, Method A
Heat ageing, 72 (+0/-2) h / 200 °C	—	—	—	—	—	—	ISO 188
Hardness change	°, M	2 mm sheet	±5	±5	±5	+3/-5	ISO 48 M
Hardness change	°, CM	O-ring[a]	±5	±5	±5	+3/-5	ISO 48 CM
Heat ageing,168 (+0/-2) h / 200 °C	—	—	—	—	—	—	ISO 188
Hardness change	°, M	2 mm sheet	±6	±6	±6	±6	ISO 48 M
Hardness change	°, CM	O-ring[a]	±6	±6	±6	±6	ISO 48 CM
Change of tensile strength	%	2 mm sheet	±15	±15	±15	±20	ISO 37
Change of tensile strength	%	O-ring[a]	±20	±20	±20	±20	ASTM D1414
Change of elongation at break	%	2 mm sheet	±25	±25	±25	±30	ISO 37
Change of elongation at break	%	O-ring[a]	±30	±30	±30	±30	ASTM D1414
Cold flexibility TR10, (colder than)	°C	2 mm sheet	–12	–12	–12	–12	ISO 2921
Cold flexibility TR10, (colder than)	°C	O-ring[a]	–12	–12	–12	–12	ISO 2921
Immersion test in Isooctane toluene 50:50 72 (+0/-2) h / 23 °C	—	—	—	—	—	—	ISO 1817
Volume change	%	2 mm sheet	+10/0	+10/0	+10/0	+10/0	ISO 1817
Volume change	%	O-ring[a]	+10/0	+10/0	+10/0	+10/0	ISO 1817
Hardness change	°, M	2 mm sheet	±5	±5	±5	±5	ISO 48 M
Hardness change	°, CM	O-ring[a]	±5	±5	±5	±5	ISO 48 CM
Immersion test in ISO Oil No.3 72 (+0/-2) h / 150 °C	—	—	—	—	—	—	ISO 1817
Volume change	%	2 mm sheet	+5/0	+5/0	+5/0	+5/0	ISO 1817
Volume change	%	O-ring[a]	+5/0	+5/0	+5/0	+5/0	ISO 1817
Hardness change	°, M	2 mm sheet	±5	±5	±5	±5	ISO 48 M
Hardness change	°, CM	O-ring[a]	±5	±5	±5	±5	ISO 48 CM

NOTE Variations of physical properties (particularly hardness, see ISO 48) can occur between test sheets and O-rings made from the same compound. For qualification either test specimen (sheet or O-ring) is acceptable.

[a] O-ring size ISO 3601-1-214 (d_1 = 24,99 mm; d_2 = 3,53 mm).

Table 7 — O-ring material VMQ

Properties	Unit	Test specimen	VMQ	Test method
			70	
Hardness (IRHD)	°, M	2 mm sheet	70 ± 5	ISO 48 M
Hardness (IRHD)	°, CM	O-ring[a]	70 ± 5	ISO 48 CM
Tensile strength, min.	MPa	2 mm sheet	6	ISO 37
Tensile strength, min.	MPa	O-ring[a]	5	ASTM D1414
Elongation at break, min.	%	2 mm sheet	150	ISO 37
Elongation at break, min.	%	O-ring[a]	125	ASTM D1414
Compression set, max. 24 (+0/-2) h at 175 °C	%	O-ring[a]	35	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 175 °C	%	Button type B ⌀ 13 mm × 6 mm	35	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 175 °C	%	O-ring[a]	40	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 175 °C	%	Button type B ⌀ 13 mm × 6 mm	55	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 175 °C	%	O-ring[a]	70	ISO 815-1, Method A
Heat ageing, 72 (+0/-2) h / 200 °C	—	—	—	ISO 188
Hardness change	°, M	2 mm sheet	±5	ISO 48 M
Hardness change	°, CM	O-ring[a]	±5	ISO 48 CM
Heat ageing,168 (+0/-2) h / 200 °C	—	—	—	ISO 188
Hardness change	°, M	2 mm sheet	±6	ISO 48 M
Hardness change	°, CM	O-ring[a]	±6	ISO 48 CM
Change of tensile strength	%	2 mm sheet	±25	ISO 37
Change of tensile strength	%	O-ring[a]	±30	ASTM D1414
Change of elongation at break	%	2 mm sheet	±35	ISO 37
Change of elongation at break	%	O-ring[a]	±35	ASTM D1414
Cold flexibility TR10, (colder than)	°C	2 mm sheet	−40	ISO 2921
Cold flexibility TR10, (colder than)	°C	O-ring[a]	−40	ISO 2921
Immersion test in ISO Oil No. 1 72 (+0/-2) h / 100 °C	—	—	—	ISO 1817
Volume change	%	2 mm sheet	+10/-5	ISO 1817
Volume change	%	O-ring[a]	+10/-5	ISO 1817
Hardness change	°, M	2 mm sheet	±8	ISO 48 M
Hardness change	°, CM	O-ring[a]	±8	ISO 48 CM
Immersion test in ISO Oil No.3 72 (+0/-2) h / 100 °C	—	—	—	ISO 1817
Volume change	%	2 mm sheet	+60/0	ISO 1817
Volume change	%	O-ring[a]	+60/0	ISO 1817
Hardness change	°, M	2 mm sheet	0/-35	ISO 48 M
Hardness change	°, CM	O-ring[a]	0/-35	ISO 48 CM

NOTE Variations of physical properties (particularly hardness, see ISO 48) can occur between test sheets and O-rings made from the same compound. For qualification either test specimen (sheet or O-ring) is acceptable.

[a] O-ring size ISO 3601-1-214 (d_1 = 24,99 mm; d_2 = 3,53 mm).

Table 8 — O-ring material EPDM (sulfur cured)

Properties	Unit	Test specimen	EPDM sulfur cured		Test method
			70	80	
Hardness (IRHD)	°, M	2 mm sheet	70 ± 5	80 ± 5	ISO 48 M
Hardness (IRHD)	°, CM	O-ring[a]	70 ± 5	80 ± 5	ISO 48 CM
Tensile strength, min.	MPa	2 mm sheet	10	10	ISO 37
Tensile strength, min.	MPa	O-ring[a]	8	8	ASTM D1414
Elongation at break, min.	%	2 mm sheet	250	175	ISO 37
Elongation at break, min.	%	O-ring[a]	200	125	ASTM D1414
Compression set, max. 24 (+0/-2) h at 100 °C	%	O-ring[a]	30	35	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 100 °C	%	Button type B ⌀ 13 mm × 6 mm	30	35	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 100 °C	%	O-ring[a]	40	40	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 100 °C	%	Button type B ⌀ 13 mm × 6 mm	60	60	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 100 °C	%	O-ring[a]	65	65	ISO 815-1, Method A
Heat ageing, 72 (+0/-2) h / 125 °C	—	—	—	—	ISO 188
Hardness change, max.	°, M	2 mm sheet	+8	+8	ISO 48 M
Hardness change, max.	°, CM	O-ring[a]	+8	+8	ISO 48 CM
Heat ageing,168 (+0/-2) h / 125 °C	—	—	—	—	ISO 188
Hardness change, max.	°, M	2 mm sheet	+12	+10	ISO 48 M
Hardness change, max.	°, CM	O-ring[a]	+12	+10	ISO 48 CM
Change of tensile strength	%	2 mm sheet	±40	±40	ISO 37
Change of tensile strength	%	O-ring[a]	±40	±40	ASTM D1414
Change of elongation at break	%	2 mm sheet	±50	±50	ISO 37
Change of elongation at break	%	O-ring[a]	±50	±50	ASTM D1414
Cold flexibility TR10, (colder than)	°C	2 mm sheet	−40	−40	ISO 2921
Cold flexibility TR10, (colder than)	°C	O-ring[a]	−40	−40	ISO 2921

NOTE Variations of physical properties (particularly hardness, see ISO 48) can occur between test sheets and O-rings made from the same compound. For qualification either test specimen (sheet or O-ring) is acceptable.

[a] O-ring size ISO 3601-1-214 (d_1 = 24,99 mm; d_2 = 3,53 mm).

Table 9 — O-ring material EPDM (peroxide cured)

Properties	Unit	Test specimen	EPDM peroxide cured		Test method
			70	80	
Hardness (IRHD)	°, M	2 mm sheet	70 ± 5	80 ± 5	ISO 48 M
Hardness (IRHD)	°, CM	O-ring[a]	70 ± 5	80 ± 5	ISO 48 CM
Tensile strength, min.	MPa	2 mm sheet	10	10	ISO 37
Tensile strength, min.	MPa	O-ring[a]	8	8	ASTM D1414
Elongation at break, min.	%	2 mm sheet	150	120	ISO 37
Elongation at break, min.	%	O-ring[a]	120	120	ASTM D1414
Compression set, max. 24 (+0/-2) h at 150 °C	%	O-ring[a]	30	30	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 125 °C	%	Button type B ⌀ 13 mm × 6 mm	25	25	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 125 °C	%	O-ring[a]	35	35	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 125 °C	%	Button type B ⌀ 13 mm × 6 mm	40	40	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 125 °C	%	O-ring[a]	50	50	ISO 815-1, Method A
Heat ageing, 72 (+0/-2) h / 150 °C	—	—	—	—	ISO 188
Hardness change, max.	°, M	2 mm sheet	+8	+8	ISO 48 M
Hardness change, max.	°, CM	O-ring[a]	+8	+8	ISO 48 CM
Heat ageing,168 (+0/-2) h / 150 °C	—	—	—	—	ISO 188
Hardness change, max.	°, M	2 mm sheet	+12	+10	ISO 48 M
Hardness change, max.	°, CM	O-ring[a]	+12	+10	ISO 48 CM
Change of tensile strength	%	2 mm sheet	±40	±40	ISO 37
Change of tensile strength	%	O-ring[a]	±40	±40	ASTM D1414
Change of elongation at break	%	2 mm sheet	±50	±50	ISO 37
Change of elongation at break	%	O-ring[a]	±50	±50	ASTM D1414
Cold flexibility TR10, (colder than)	°C	2 mm sheet	−40	−40	ISO 2921
Cold flexibility TR10, (colder than)	°C	O-ring[a]	−40	−40	ISO 2921

NOTE Variations of physical properties (particularly hardness, see ISO 48) can occur between test sheets and O-rings made from the same compound. For qualification either test specimen (sheet or O-ring) is acceptable.

[a] O-ring size ISO 3601-1-214 (d_1 = 24,99 mm; d_2 = 3,53 mm).

Table 10 — O-ring material ACM

Properties	Unit	Test specimen	ACM	Test method
			70	
Hardness (IRHD)	°, M	2 mm sheet	70 ± 5	ISO 48 M
Hardness (IRHD)	°, CM	O-ring[a]	70 ± 5	ISO 48 CM
Tensile strength, min.	MPa	2 mm sheet	8	ISO 37
Tensile strength, min.	MPa	O-ring[a]	7	ASTM D1414
Elongation at break, min.	%	2 mm sheet	150	ISO 37
Elongation at break, min.	%	O-ring[a]	100	ASTM D1414
Compression set, max. 24 (+0/-2) h at 150 °C	%	O-ring[a]	40	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 150 °C	%	Button type B ⌀ 13 mm × 6 mm	40	ISO 815-1, Method A
Compression set, max. 72 (+0/-2) h at 150 °C	%	O-ring[a]	50	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 150 °C	%	Button type B ⌀ 13 mm × 6 mm	50	ISO 815-1, Method A
Compression set, max. 336 (+0/-2) h at 150 °C	%	O-ring[a]	65	ISO 815-1, Method A
Heat ageing, 72 (+0/-2) h / 150 °C	—	—	—	ISO 188
Hardness change, max.	°, M	2 mm sheet	+8	ISO 48 M
Hardness change, max.	°, CM	O-ring[a]	+8	ISO 48 CM
Heat ageing,168 (+0/-2) h / 150 °C	—	—	—	ISO 188
Hardness change, max.	°, M	2 mm sheet	+10	ISO 48 M
Hardness change, max.	°, CM	O-ring[a]	+10	ISO 48 CM
Change of tensile strength	%	2 mm sheet	±25	ISO 37
Change of tensile strength	%	O-ring[a]	±25	ASTM D1414
Change of elongation at break	%	2 mm sheet	±30	ISO 37
Change of elongation at break	%	O-ring[a]	±30	ASTM D1414
Cold flexibility TR10, (colder than)	°C	2 mm sheet	−10	ISO 2921
Cold flexibility TR10, (colder than)	°C	O-ring[a]	−10	ISO 2921
Immersion test in ISO Oil No. 1 72 (+0/-2) h / 150 °C	—	—	—	ISO 1817
Volume change	%	2 mm sheet	0/-10	ISO 1817
Volume change	%	O-ring[a]	0/-10	ISO 1817
Hardness change	°, M	2 mm sheet	+10/0	ISO 48 M
Hardness change	°, CM	O-ring[a]	+10/0	ISO 48 CM
Immersion test in ISO Oil No.3 72 (+0/-2) h / 150 °C	—	—	—	ISO 1817
Volume change	%	2 mm sheet	+25/0	ISO 1817
Volume change	%	O-ring[a]	+25/0	ISO 1817
Hardness change	°, M	2 mm sheet	0/-15	ISO 48 M
Hardness change	°, CM	O-ring[a]	0/-15	ISO 48 CM

NOTE Variations of physical properties (particularly hardness, see ISO 48) can occur between test sheets and O-rings made from the same compound. For qualification either test specimen (sheet or O-ring) is acceptable.

[a] O-ring size ISO 3601-1-214 (d_1 = 24,99 mm; d_2 = 3,53 mm).

5 Designation system

The vulcanized O-ring rubber material according to Table 1 shall be designated by "Material" followed by a reference to this part of ISO 3601, followed by the code for the material, followed by the hardness and the symbol of the curing system, if specified, separated by a hyphen.

EXAMPLE 1 Material ISO 3601-5 EPDM 70-S.

EXAMPLE 2 Material ISO 3601-5 FKM 75.

6 Identification statement

Manufacturers are recommended to use the following statement in test reports, catalogues, and sales literature when electing to comply with this part of ISO 3601:

"Elastomeric materials for O-ring in accordance with ISO 3601-5, *Fluid power systems — O-rings — Part 5: Specification of elastomeric materials for general industrial applications.*"

Annex A
(informative)

O-ring stress/strain and compression set testing

Rubber mixing is a physical mastication process. As a result, there are areas in any batch of rubber that exhibit material ingredient inhomogeneities. These areas can contain filler aggregates or polymer rich areas that can affect the physical properties of the material. This is very significant for O-rings and for this reason the actual O-rings should be tested to accurately ascertain the properties of the parts. Rubber slabs do not accurately represent the properties of the O-rings, especially the stress/strain properties.

Many of the tests performed on O-rings are independent of the size of the O-ring being tested. However, there are some tests, specifically stress/strain properties, that are a function of the O-ring's size.

This annex specifies the O-ring sizes (Table A.1) considered suitable for testing when verifying the consistent processing and the initial physical and ageing properties of O-rings.

Table A.1 — Suitable Test Sizes

O-ring Cross-section (mm)	ISO 3601-1 Size Designation
1,78	ISO 3601-1–011 through –050
2,62	ISO 3601-1–110 through –163
3,53	ISO 3601-1–204 through –258
5,33	ISO 3601-1–309 through –360
6,99	ISO 3601-1–425 through –450

For all other sizes, either special fixtures are required or the tests should be conducted on ISO 3601-1-214 O-rings of identical material batch and state of cure as the end item.

According to ASTM D 1414, 8.3.1, the tensile testing for all size O-rings should be carried out at a strain rate of 500 ± 50 mm min on a machine capable of accommodating the elongation of the test specimen.

NOTE Very large cross-section O-rings can exhibit mechanical properties that would be out of the range of the load cells for some tensile testing equipment, therefore, the load cell range should be verified before testing begins.

Because a batch of rubber can exhibit material ingredient inhomogeneities, the larger the inside diameter of the O-ring being tested, the higher the statistical probability that these inhomogeneities can cause a non-uniform stress concentration which can result in a premature break during testing. Therefore, for larger inside diameter O-rings, more samples should be tested to account for batch to batch variations and allow for a more accurate assessment of the material and finished article.

Compression set values obtained from plied discs or plugs cannot be compared directly to those obtained from O-rings due to geometrical differences and likelihood of differences in material ingredient homogeneities. Because the properties of the O-ring are what affect the performance of a component and not those of plied discs, finished O-rings should be used as the test specimens for compression set testing. Compression set values can also differ between O-ring cross sections, generally with larger cross sections having better compression set values than smaller cross sections. Since compression set properties are very important in determining how well a seal performs, the actual cross section of the seal to be used in an application should be tested.

ICS 23.100.60; 83.140.50

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