INTERNATIONAL STANDARD

ISO 3601-5

Second edition
2015-04-01

Corrected version
2016-06-01

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

Reference number
ISO 3601-5:2015(E)

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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*

This corrected version of ISO 3601-5:2015 incorporates the following corrections.

The arrangement and values in the headings and row 1 of Table 2 have been revised.

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.

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).