C. OTTO GEHRCKENS
SEAL TECHNOLOGY

O-Ring Basics

Everything about O-ring seals

For our customers' advantage

The world's largest O-ring warehouse

COG is your independent manufacturer and leading supplier of precision O-rings and elastomer seals. As an owner-managed family business now in its fifth generation, we draw on more than 150 years' expertise. Because only with in-depth knowledge of the subject can we respond to our customers' complex requirements – and satisfy you with our solutions.

Our dialogue with you forms our central focus. Your wishes and challenges provide our impetus. At the same time, our experience in the development and manufacture of materials forms the basis for being able to offer you proven products in dependable high quality – And at the same time to notch up innovations that set new standards for your sector.

More than 270 employees are committed to this objective, monitoring the market and tackling relevant topics, in order to be able to rapidly react to new challenges with solutions-based approaches. In addition, delivery capability and flexibility are of highest importance. We serve our customers from the world's largest O-ring warehouse. The manufacture of the smallest series also forms part of our service, in order to realise the perfect product for your requirements.

There's always lots involved. We will assist in your success. And delight you with our unparalleled expertise.

Jan Metzger
Managing Director

Ingo Metzger
Managing Director

Please visit our website ***www.cog.de/en*** *for more information or contact our sealing experts directly.*

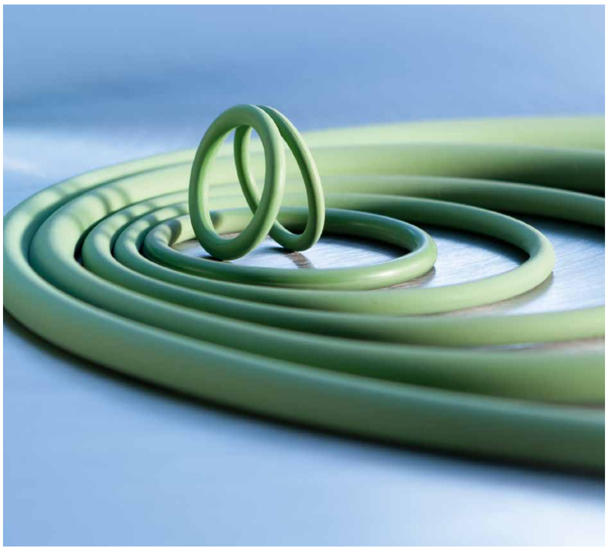
COG at a glance

- Founded in 1867 in Pinneberg, near Hamburg
- Owner managed family business employing over 270 staff
- Supplier and independent manufacturer of O-rings and precision seals
- World's largest O-ring warehouse (over 45,000 items kept in stock for immediate delivery)
- State of the art logistics centre for maximum delivery capability
- Tools available for over 23,000 different O-ring dimensions
- Close cooperation with leading manufacturers of raw materials
- Approvals/certifications for a wide variety of materials, including among others DVGW, NORSOK Standard M-710, ISO 23936-2, BAM, FDA, USP, 3-A Sanitary Standard, BfR, NSF/ANSI and many more
- Our own mixing and compound development facilities
- Our own toolshop
- COG's technology centre for material development
- Quality management to DIN EN ISO 9001
- Environmental management to DIN EN ISO 14001
- Climate-neutral business operations according to PRIMAKLIMA

Sustainability plays an important role at COG:
For many years we have been working successfully on minimizing the environmental impact and were one of the first companies in the industry to receive the "climate-neutral business operation" certification in 2020.

Content

General



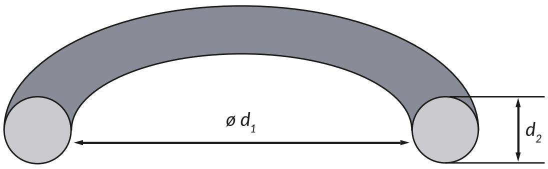
An O-ring seal is a means of preventing unwanted leakage or loss of fluid or gas (i. e. media generally).

The O-ring is the most popular form of seal as it is simple to install and needs little installation space. Given correct grooving and material choice, the seal can be used for a very long time within the rubber's temperature limits both as a fixed and as a moving part.

Description

An O-ring is a closed circle usually made of flexible rubber (elastomer). The dimensions are defined by the inside diameter d_1 and the cross-section d_2.

O-ring-sizing



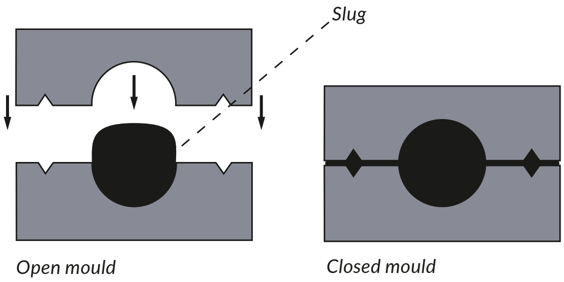
O-rings are gaplessly and seamlessly made of various types of caoutchouc in heated injection or press moulds by vulcanisation (cross-linking).

Manufacturing processes

Generally there are two different manufacturing processes for the production of elastomer O-rings possible:

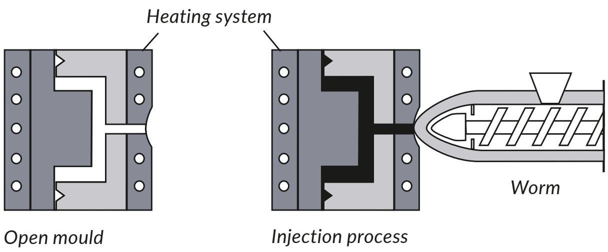
- **Compression moulding process**
  (Compression moulding = CM process)
- **Injection moulding process**
  (Injection moulding = IM process)

Compression process



In CM the slug is manually inserted in the tool (mould) before the two mould halves consisting of an upper and a lower part are closed. As this process is very time-consuming, it is primarily suitable for manufacturing smaller quantities and larger dimensions.

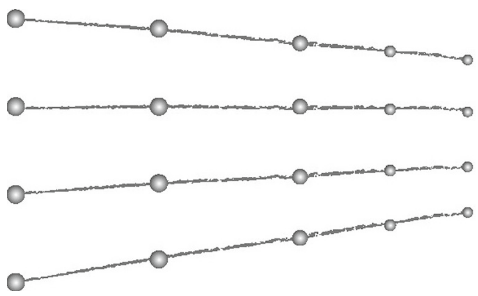
Injection process



In IM the slug is automatically injected into the tool, which contains several O-ring cavities. This process is particularly suitable for large quantities and small dimensions.

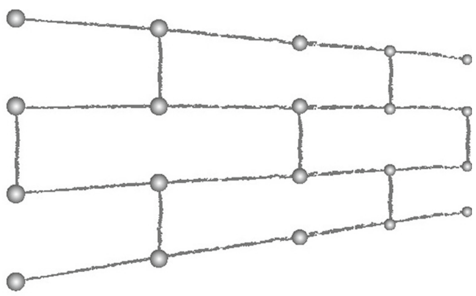
Elastomers / rubber

Elastomers are polymers whose macromolecules have been linked with one another to form a network with cross-connections. As a result they show the typical rubbery and elastic properties. The raw, non-networked product is called rubber (caoutchouc), and is either obtained from plants that yield the substance or produced synthetically.



Picture of rubber (caoutchouc) macromolecules

Vulcanisation results in the networking of the macromolecules – that is to say, the formation of chemical cross-links between the polymer chains. This has the effect that following the termination of an enforced change of form, elastomers will return to their original shape.



Picture of rubber macromolecules (cross-linked)

The components of a formula are generally given in phr (parts per hundred rubber). This is the number of parts of filler material in relation to 100 parts of rubber (polymer).

Materials

Technical rubber materials are structured on the basis of a formula. In terms of chemical resistance, the polymer is the weakest link of the different constituent components as compared with the media to be sealed off.

The choice of the right sealing material is often hence restricted to basic polymer(s). In practice, other influences, such as the type of cross-linking, the quantity of softener(s) used and the type of filler employed may be of significance due to the recipe used. Polymer tolerability alone is hence no guarantee of a reliable seal but is a major precondition.

Constituent components of a sample formula for NBR rubber

Ingredient	Quantity in phr	Contigent in %
Rubber (polymer)	100.0	39.0
Filler materails (soot)	90.0	35.1
Softener (mineral oil)	50.0	19.4
Processing aids	3.0	1.2
Ageing prevention media	4.0	1.5
Cross-linking media (sulphur)	2.0	0.8
Activator (organic product)	1.7	0.7
Dispersant (stearic acid)	2.0	0.8
Cross-linking activator (zinc oxide)	4.0	1.5
total	**256.7**	**100.0**

Rubber nomenclature

The synthesis rubbers are classified per **ISO 1629** or **ASTM D 1418**. Rubbers in solid form are classified in the following groups according to the chemical composition of their polymer chain.

Overview of the major rubber types

Group	Chemical name	DIN ISO 1629	ASTM D 1418	COG no.
M	Polyacrylate rubber	ACM	ACM	AC ...
M	Chlorpolyethylene rubber	CM	CM	--
M	Ethylene acrylate rubber	AEM	AEM	--
M	Chlorsulphurated-polyethylene rubber	CSM	CSM	--
M	Ethylene-propylene rubber	EPM	EPM	EP ...
M	Ethylene-propylene-(dien) rubber	EPDM	EPDM	AP ...
M	Fluoride rubber	FKM	FKM	BF ... HF ... LT ... Vi ...
		FEPM	FEPM	AF... Vi ...
M	Perfluor rubber	FFKM	FFKM	COG Resist® Perlast®
O	Epichlorhydrine rubber	CO	CO	--
O	Epichlorhydrine-copolymer rubber	ECO	ECO	--
R	Butadine rubber	BR	BR	--
R	Chloroprene rubber	CR	CR	NE ...
R	Isobutene-isopropene rubber	IIR	IIR	BT ...
R	Isopropene rubber	IR	IR	--
R	Acrylnitrile-butadine rubber	NBR	NBR	P ...
R	Hydrated acrylnitrile-butadiene rubber	HNBR	HNBR	HNBR ...
R	Natural-rubber	NR	NR	K ...
R	Styrol-butadine rubber	SBR	SBR	--
Q	Fluor-vinyl-methyl-silicone rubber	FVMQ	FVMQ	Si ... FL
Q	Phenyl-vinyl-methyl-silicone rubber	PVMQ	PVMQ	Si ...
Q	Vinyl-methyl rubber	VMQ	VMQ	Si ...
U	Polyesterurethane rubber	AU	AU	COG VarioPur® PU ...
U	Polyetherurethane rubber	EU	EU	EU ...

The most common rubbers with trade names

The table below provides an overview of some selected rubbers from which elastomer sealing materials are made with their abbreviations and a selection of trade names.

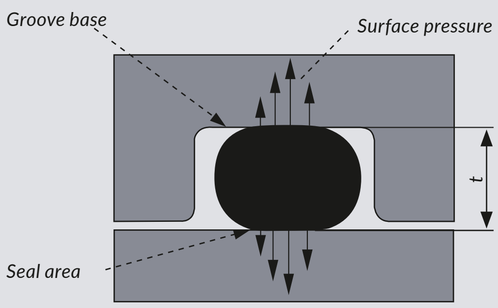
A list of the resistances of different types of rubber can be found on page 38.

Basic rubber	Abbrevation	Trade name (selection)
Acrylnitrile-butadiene rubber	NBR	Perbunan®, Europrene N®, Krynac®
Styrol-butadiene rubber	SBR	Europrene®, Buna-S®
Hydrated acrylnitrile-butadiene rubber	HNBR	Therban®, Zetpol®
Chloroprene rubber	CR	Neoprene®
Acrylate rubber	ACM	Nipol AR®, HyTemp®
Ethylene acrylate rubber	AEM	Vamac®
Fluoro rubber	FKM	Viton™, Dai-El®, Tecnoflon®
	FEPM	Viton™ Extreme™, Aflas®
Perfluoro rubber	FFKM	COG Resist®, Perlast®, Kalrez®, Chemraz®
Silicone rubber	VMQ	Elastosil®, Silopren®
Fluor-silicone rubber	FVMQ	Silastic®
Polyethane rubber	AU/EU	COG VarioPur®, Urepan®, Adiprene®
Ethylene-propylene-(dien) rubber	EPM, EPDM	Buna EP®, Dutral®, Nordel™
Epichlorhydrine rubber	ECO	Hydrin®
Polyisoprene rubber	IR	Natsyn®

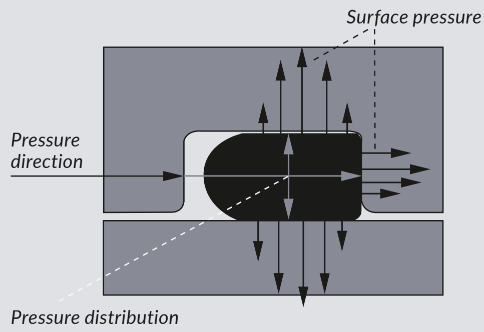
Overview of some types of rubber (incomplete list)

How they work

Compressed O-ring in installation space without pressure



Compressed O-ring in installation space under pressure



The **seal effect** of the O-ring is created by the elastic deformation of its cross-section (d_2) in an appropriately designed installation space or slot. This means that the circular cross-section is deformed to become elliptical, which closes the gaps between the contact surfaces and at the ground of the groove. This generates a surface compression which is essential if the insulating effect is to be achieved.

The scale of the deformation of the O-ring diameter is essentially dependent on the groove depth t. This deformation is generally stated in the form of a compression percentage, and is shown on diagrams.

The compression factor is stated as the percentage by which the cross-section d_2 is reduced when compressed in its installed state. While the compression percentage remains the same, the deformation forces increase as the cross-section (d_2) increases. To balance this out, as d_2 increases the compression percentage is correspondingly reduced.

If the medium to be sealed is under pressure then additional pressure is exerted on the O-ring, which is beneficial to the seal and increases its effectiveness (surface pressure increases).

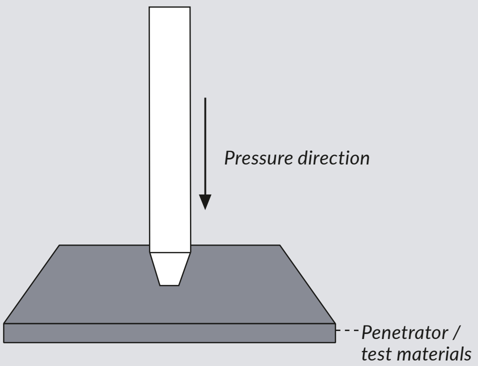
The pressure pushes the O-ring against the groove flank opposite the source of the pressure. The seal gap should be as small as possible to prevent the ring from being pressed into it. In radial seals there should be a tolerance pairing of H8/f7, in axial seals H11/h11.

If not, or if higher pressures are anticipated, then the material(s) chosen should ensure maximum possible O-ring hardness. Otherwise the extrusion may occur and the O-ring might be destroyed.

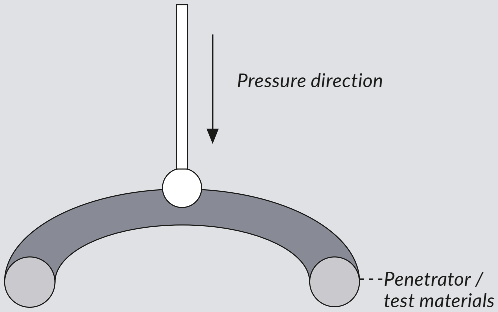
The cross-section d_2 must always exceed the depth of the installation space.

Hardness

Hardness measurement in Shore A



Hardness measurement in °IRHD



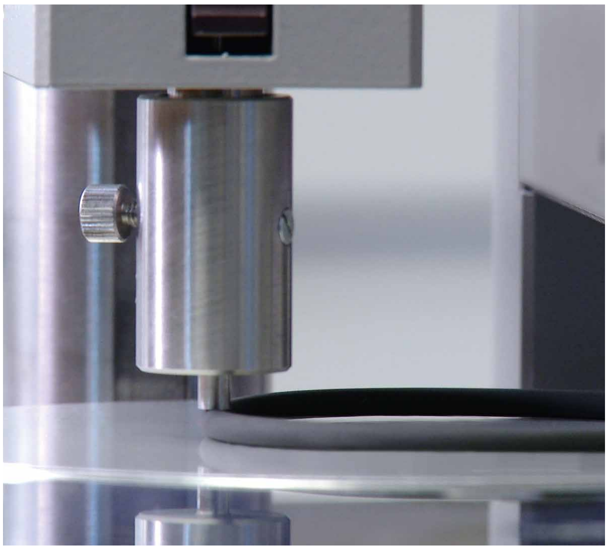
Hardness is the resistance of a body to penetration by a harder body of a specific shape at a specific pressure over a specific time.

It is measured in Shore or °IRHD (International Rubber Hardness Degree). Comparable values are determined using standard samples and given in Shore A units. For measurements on finished products °IRHD is usual. Hardness values of finished products deviate from those of standard samples as their thickness, curved surface or values measured at the edges are not comparable and the metrology procedures differ.

With a cross-section of ≤ 1.6 mm, measurements of the hardness of the O-ring are no longer meaningful.

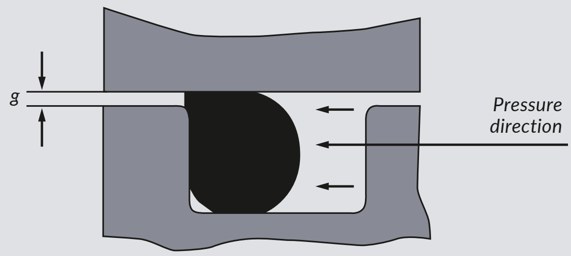
The picture above left shows the penetrating body (a pyramid stump) for hardness measurement in **Shore A (DIN ISO 48-4)**. This test method is only suitable for measuring hardness on flat test materials. The picture above right shows the penetrating body (a sphere) for hardness measurement in **°IRHD (DIN ISO 48-2 CM method)**.

Hardness must be adjusted to e. g. pressure load. The softer the elastomer the easier it is deformed under pressure and pressed into the gap to be sealed. On the other side softer elastomers seal at low pressures and between uneven surfaces due to its greater flexibility.

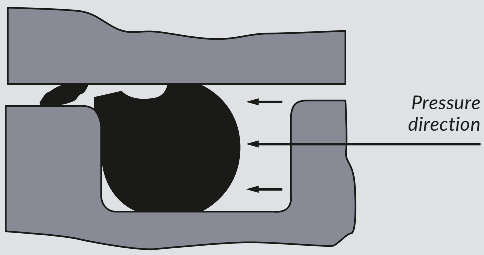


Pressure loading

O-ring behaviour under pressure



Extruded O-ring



The extrusion angle is largely determined by the gap size g between the parts of the machinery. The clearance depends on process, manufacturing method, tolerances influencing clearance, the breathing of the parts under pressure and so on. The gap should be as small as possible.

Excessive gaps can cause elastomer destruction by extrusion (gap extrusion). O-rings of 90 Shore A hardness permit slightly larger gaps than standard-O-rings of 70 Shore A. The table of guide values below of gap sizes for standard elastomers are maximum values if the components are centred.

Cross-section d_2	up to 2	2.01 – 3	3.01 – 5	5.01 – 7	over 7.01
O-ring hardness 70 Shore A					
Pressure (bar)	Gap g				
≤ 35	0.08	0.09	0.10	0.13	0.15
≤ 70	0.05	0.07	0.08	0.09	0.10
≤ 100	0.03	0.04	0.05	0.07	0.08
O-ring hardness 90 Shore A					
Pressure (bar)	Gap g				
≤ 35	0.13	0.15	0.20	0.23	0.25
≤ 70	0.10	0.13	0.15	0.18	0.20
≤ 100	0.07	0.09	0.10	0.13	0.15
≤ 140	0.05	0.07	0.08	0.09	0.10
≤ 175	0.04	0.05	0.07	0.08	0.09
≤ 210	0.03	0.04	0.05	0.07	0.08
≤ 350	0.02	0.03	0.03	0.04	0.04

All details are based upon experience values and to be considered solely as guidelines. All measurements in mm.

At high pressure, we recommend the use of a back-up ring (see page 34).

Thermal characteristics

The operating temperature depends on the media to be sealed. 100 °C air temperature resistance in an O-ring is hence not the same as 100 °C oil resistance.


Extreme thermal stress on an O-ring

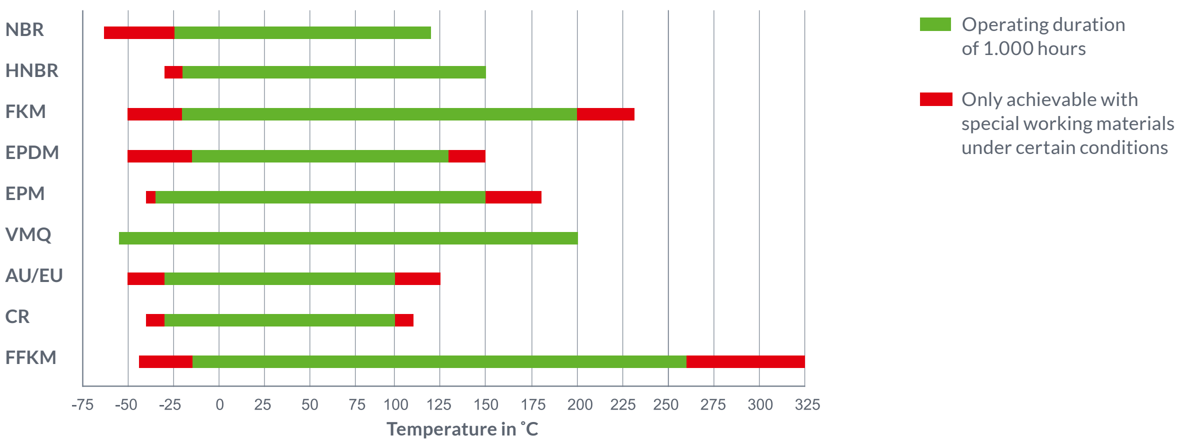
Elastomers display optimal characteristics over a wide temperature range and have a long service life. Depending on the type of rubber used, there are two temperature ranges in which this is not the case.

Below a specific temperature – known as the glass transition temperature – elastomers lose their elasticity and mechanical stress resistance. This process is reversible, i. e. after rewarming the original characteristics return. **The upper temperature limit** is determined by the influencing media. Permanently exceeding this upper limit leads to destruction of the elastomer and is irreversible.

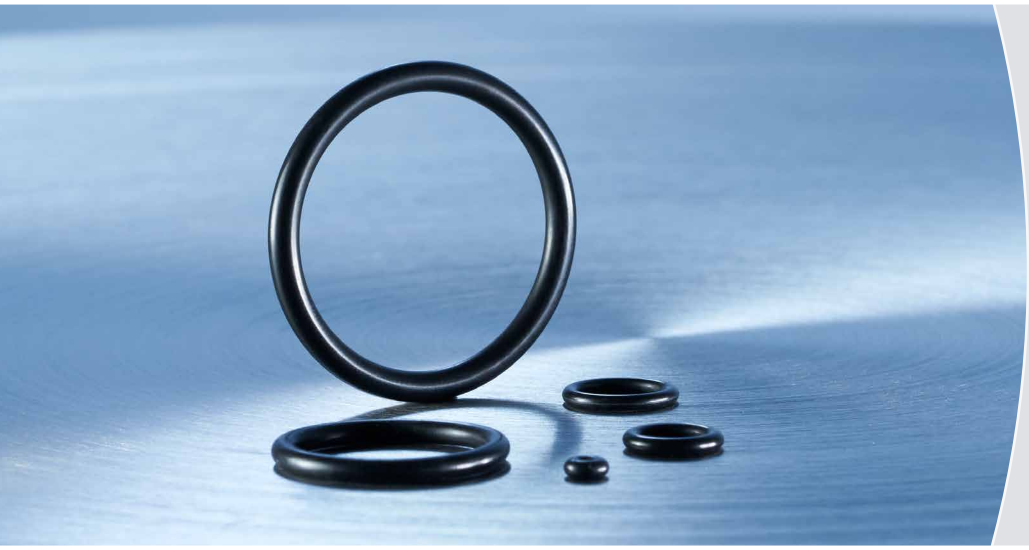
Elastomer operating temperatures

The permissible temperature range depends on the material(s) used. It is important to differentiate between permanent temperature (constant or operating temperature) and temporary temperature (peak temperature).

Temperature ranges of various elastomer materials
(medium: air)



Elastomer media resistance



A list of the resistances of different types of rubber can be found on page 38 et seq.

Physical processes

An elastomer's resistance to the various surrounding media it comes into contact with is of central importance, as this contact can lead to severe changes in the elastomer material.

These processes primarily lead to volume change (swelling or shrinking) of an elastomer in a medium. An elastomer can soak up a medium and swell causing its technical properties to change (e. g. lowered tear resistance or hardness). This doesn't mean the seal ceases to function. However, excessive swelling may lead to the installation space (groove) being overfilled and the O-ring being mechanically destroyed. Details of swelling values can be found in relevant literature, resistance list or determined with practical experimentation, which is a better option. Please contact us for information.

Elastomer shrinkage is due to mixture ingredients (e. g. softener) being separated out of the medium (e. g. mineral oil). This may lead to the seal pressure becoming too low or non-existent and result in leakage. This must be avoided at all costs.

Chemical aggression

Chemical attacks split the polymer chain, leading to destruction of the elastomer. This makes the material hard and brittle and it loses its elastic properties.

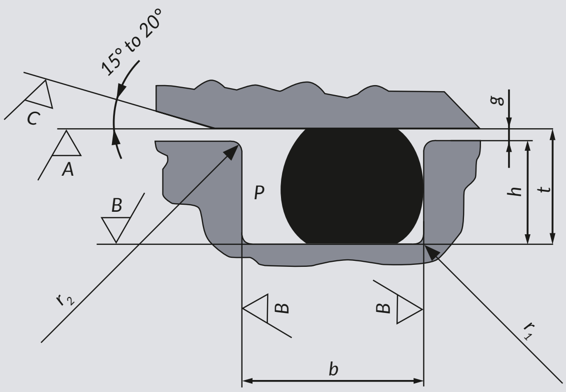
Details of chemical resistance can be found either in the materials specifications, the relevant literature or resistance lists (e. g. COG resistance list). Chemical aggression must also be avoided at all costs.

Chemical aggression and physical shrinkage of an O-ring must always be avoided.

Illustration of chemical aggression on an O-ring

Groove geometry for O-ring installation spaces

Illustration of a typical rectangular groove



Key:

t = groove depth
b = groove width
h = height of the installation space
g = size of gap to be sealed
P = media pressure
A = opposing surface
B = groove flank surfaces and groove base
C = surface of the insertion angle
r_1 = radius in the base of the groove
r_2 = radius on the upper edge of the groove

O-rings must be laid in purpose-made grooves if they are to seal properly. These installation spaces are usually made with a rotary chisel in a shaft or drill hole, or with a milling machine in a workpiece. Groove geometry is usually rectangular.

The illustration above shows a typical rectangular groove with dimensions as recommended in the relevant standards.

Determining groove depth (t)

The relationship of the O-ring cross-section (d_2) to the groove depth (t) determines the initial compression. The choice of groove depth depends on its intended use. In static use initial compression should be between 15 and 30 %. In dynamic use a greater groove depth and hence lower compression should be chosen, usually between 6 and 20 %.

Determining groove width (b)

Groove width (b) is determined by the O-ring cross-section (d_2) and the elliptical shape after compression plus a free space in which the medium can enter to guarantee even pressure on the seal.

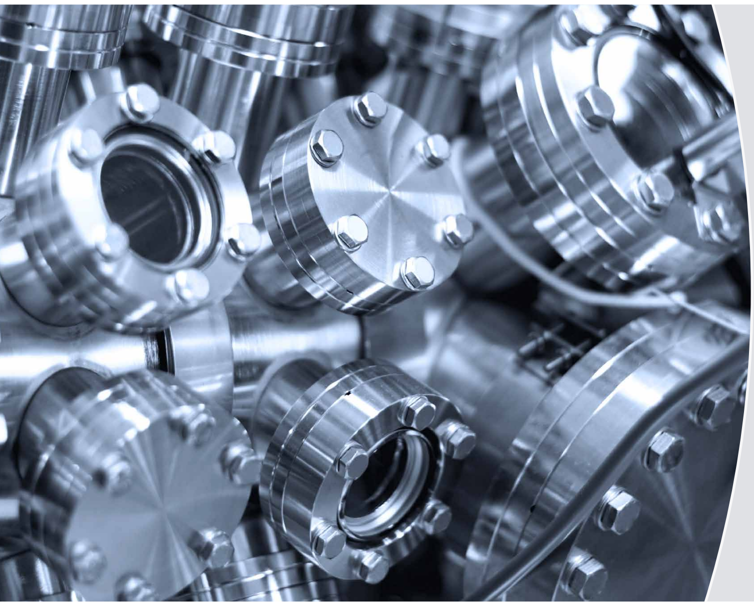
The main objective when selecting a size for the groove width is to avoid groove overfill. It is therefore usually assumed when designing the groove that the O-ring should fill it by up to 85 % so that there is space for expansion (swelling, thermal extension), if needed.

The groove depth has a decisive effect on O-ring pressure.

The groove width needs to be adapted to a possible volume increase of the O-ring.

Definition of installation types

There are various O-ring installation options. Basically one differentiates according to the direction of deformation of the O-ring cross-section, according to radial and axial deformation.



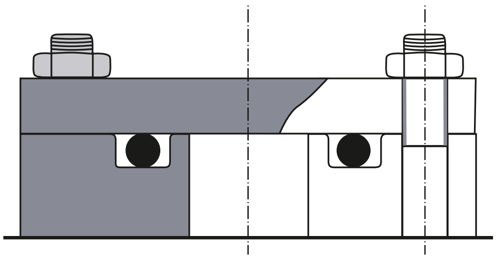
A differentiation is also made between **radial deformation** "external seal" (internal groove, piston seal) and "internal seal" (external groove, rod seal).

Most O-rings are statically stressed seals. If the seal is between machinery parts that move towards to each other then the seal is dynamic. O-rings only present a technically optimal solution for dynamic seals in exceptional cases.

O-ring installation types

Flange seal:

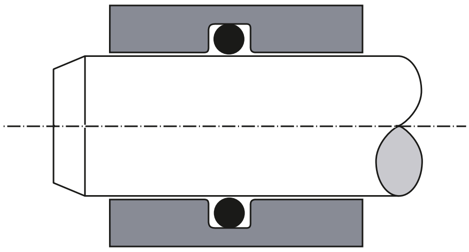
The groove is in the flange and is screwed down by a cover plate.



Flange seals / axial sealing

Rod seal:

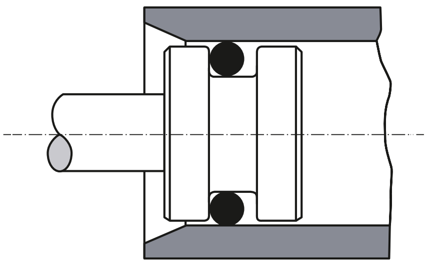
The groove is on the exterior which is called a rod seal.



Rod seals / radial sealing

Piston seal:

The groove is on the interior, which is called a piston seal.



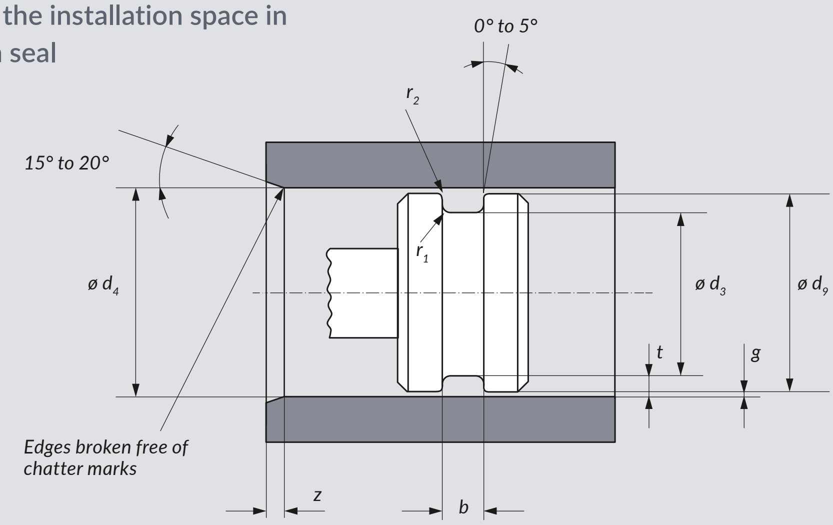
Piston seals / radial sealing

Furthermore, special conditions sometimes mean that special installation types can also be necessary, such as **trapezoidal** or **triangular grooves**.

For more information on trapezoidal and triangular grooves, see page 25.

Radial, static or dynamic installation external seal (piston seal)

Illustration of the installation space in a radial piston seal



The diagram above shows a radial, static or dynamic installation of an O-ring in a piston seal. This seal type is preferable in radial installation.

The table on the right provides more details about the names and installation spaces as well as the O-ring.

Designation	Tolerance	Explanation
b	+ 0.25	Width of the O-ring installation space (groove width)
d_3	h11	Inside diameter of the installation space (groove base diameter)
d_4	H8	Drill hole diameter
d_9	f7	Piston diameter (shaft diameter)
g		Gap size
r_1	± 0.1 ... 0.2	Radius in the base of the groove
r_2	± 0.1	Radius on the upper edge of the groove
t		Radial depth of the installation space (groove depth)
z		Length of installation angle (> d_2 / 2), *please see table page 27*

Further information about piston seals can be found on page 16 and 17.

O-ring installation sizes in a radial piston seal

The following table shows a selection of installation dimensions dependant on cross-section d_2.

d_2	b	t		r_1	r_2	z_{min}
		static	dynamic			
1.00	1.58	0.70	0.75	0.30	0.1	0.62
1.50	2.19	1.05	1.15	0.30	0.1	0.92
1.78	2.53	1.30	1.40	0.30	0.1	1.10
2.00	2.78	1.50	1.60	0.30	0.1	1.15
2.50	3.37	1.90	2.00	0.30	0.1	1.43
2.62	3.51	2.00	2.10	0.30	0.1	1.50
3.00	3.98	2.30	2.40	0.60	0.2	1.53
3.53	4.67	2.70	2.80	0.60	0.2	1.80
4.00	5.23	3.10	3.30	0.60	0.2	2.03
4.50	5.90	3.50	3.80	0.60	0.2	2.28
5.00	6.48	3.90	4.30	0.60	0.2	2.53
5.33	6.86	4.20	4.60	0.60	0.2	2.70
5.50	7.05	4.40	4.80	1.00	0.2	2.83
6.00	7.59	4.80	5.20	1.00	0.2	3.09
6.50	8.17	5.30	5.60	1.00	0.2	3.35
6.99	8.68	5.80	6.00	1.00	0.2	3.60
7.50	9.29	6.30	6.50	1.00	0.2	3.86
8.00	9.88	6.80	7.00	1.00	0.2	4.12
9.00	11.14	7.70	7.90	1.00	0.2	4.64
10.00	12.38	8.60	8.80	1.00	0.2	5.15

Please note: The values given in the table are only indications and are intended as approximate guidelines. Users are strongly advised to check these values for every specific situation (e. g. by repeated testing). In particular, the contact with the media to be sealed, the temperature at the time of use and the installation conditions may lead to deviations from the values given above. All measurements in mm.

Strictly speaking the table values only apply to NBR O-rings with a hardness of 70 Shore A. However, experience shows that they can be used for other materials and hardnesses although the groove depth may need adjusting.

The values are calculated based on a possible swelling of up to 15 %. If there is less swelling then the groove width can be reduced accordingly.

Determining the inside diameter d_1

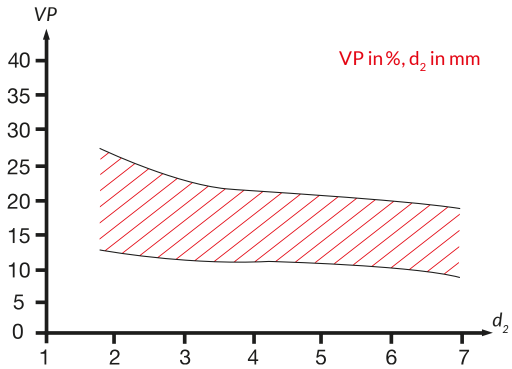
In static or dynamic radial external O-ring seals the inside diameter d_1 must be approximately 1–6 % smaller than the groove base diameter d_3.

This means that the O-ring should be installed slightly stretched.

Compression in radial seals (piston seal)

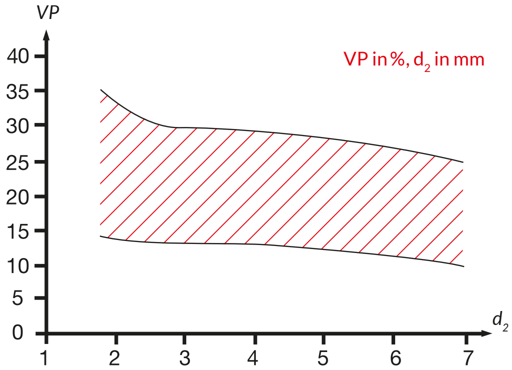
The diagrams below show the permissible ranges of O-ring compression depending on cross-section d_2.

Dynamic seal compression



Compression diagram for a hydraulic dynamic application

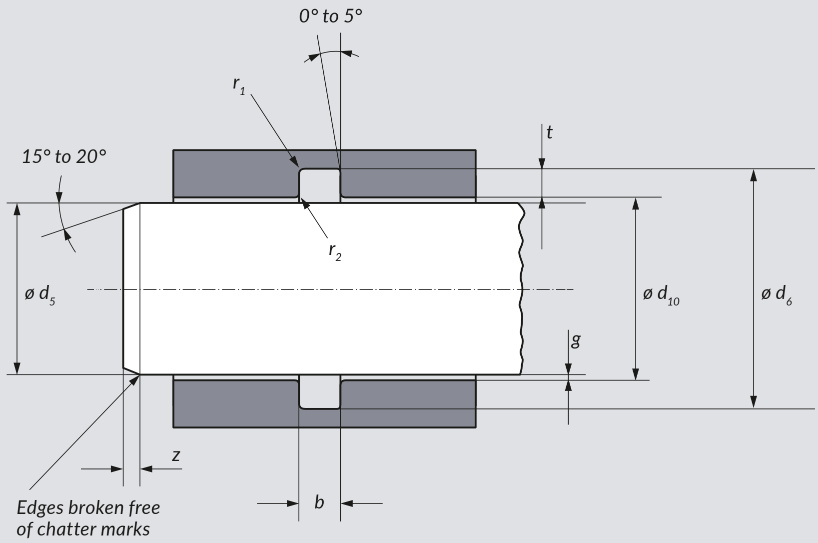
Static seal compression



Compression diagram for a hydraulic static application

Radial, static or dynamic installation, internal seal (rod seal)

This figure shows the schematic cross-sectional view of the installation space for the application case of the radial static resp. dynamic installation of the O-ring in a rod seal.



The following table provides more details about the names and installation spaces as well as the O-ring.

Designation	Tolerance	Explanation
d_{10}	H8	Drill hole diameter
d_5	f7	Rod diameter
d_6	H11	External diameter of the installation space (groove base diameter)
b	+ 0.25	Width of the O-ring installation space (groove width)
g		Gap size
t		Radial depth of the installation space (groove depth)
r_1	± 0.1 ... 0.2	Radius in the base of the groove
r_2	± 0.1	Radius on the upper edge of the groove
z		Length of installation angle (> d_2 / 2), *please see table at page 27*

Installation note: *The O-ring should be installed slightly stretched.*

O-ring installation sizes in a static or dynamic radial rod seal

The following table shows a selection of installation dimensions dependant on cross-section d_2.

d_2	b	t		r_1	r_2	z_{min}
		static	dynamic			
1.00	1.58	0.70	0.75	0.30	0.1	0.62
1.50	2.19	1.05	1.15	0.30	0.1	0.92
1.78	2.53	1.30	1.40	0.30	0.1	1.10
2.00	2.78	1.50	1.60	0.30	0.1	1.15
2.50	3.37	1.90	2.00	0.30	0.1	1.43
2.62	3.51	2.00	2.10	0.30	0.1	1.50
3.00	3.98	2.30	2.40	0.60	0.2	1.53
3.53	4.67	2.70	2.80	0.60	0.2	1.80
4.00	5.23	3.10	3.30	0.60	0.2	2.03
4.50	5.90	3.50	3.80	0.60	0.2	2.28
5.00	6.48	3.90	4.30	0.60	0.2	2.53
5.33	6.86	4.20	4.60	0.60	0.2	2.70
5.50	7.05	4.40	4.80	1.00	0.2	2.83
6.00	7.59	4.80	5.20	1.00	0.2	3.09
6.50	8.17	5.30	5.60	1.00	0.2	3.35
6.99	8.68	5.80	6.00	1.00	0.2	3.60
7.50	9.29	6.30	6.50	1.00	0.2	3.86
8.00	9.88	6.80	7.00	1.00	0.2	4.12
9.00	11.14	7.70	7.90	1.00	0.2	4.64
10.00	12.38	8.60	8.80	1.00	0.2	5.15

Please note: The values given in the table are only indications and are intended as approximate guidelines. Users are strongly advised to check these values for every specific situation (e. g. by repeated testing). In particular, the contact with the media to be sealed, the temperature at the time of use and the installation conditions may lead to deviations from the values given above. All measurements in mm.

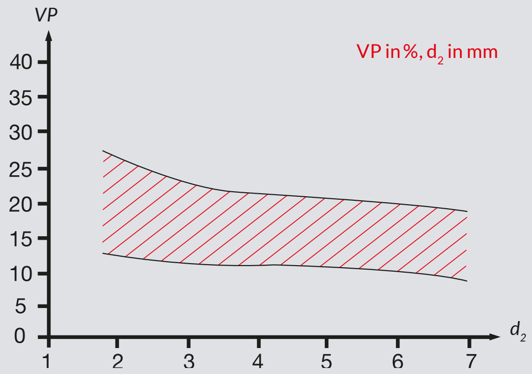
Strictly speaking the table values only apply to NBR O-rings with a hardness of 70 Shore A. However, experience shows that they can be used for other materials and hardnesses although the groove depth may need adjusting.

The values are calculated based on a possible swelling of up to 15 %. If there is less swelling then the groove width can be reduced accordingly.

Compression in radial seals (rod seal)

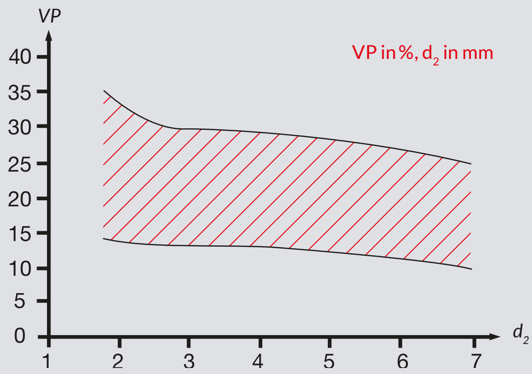
The diagrams below show the permissible ranges of the O-ring compression depending on cross-section d_2.

Dynamic seal compression



Compression diagram for a hydraulic dynamic application

Static seal compression



Compression diagram for a hydraulic static application

Determining the inside diameter d_1

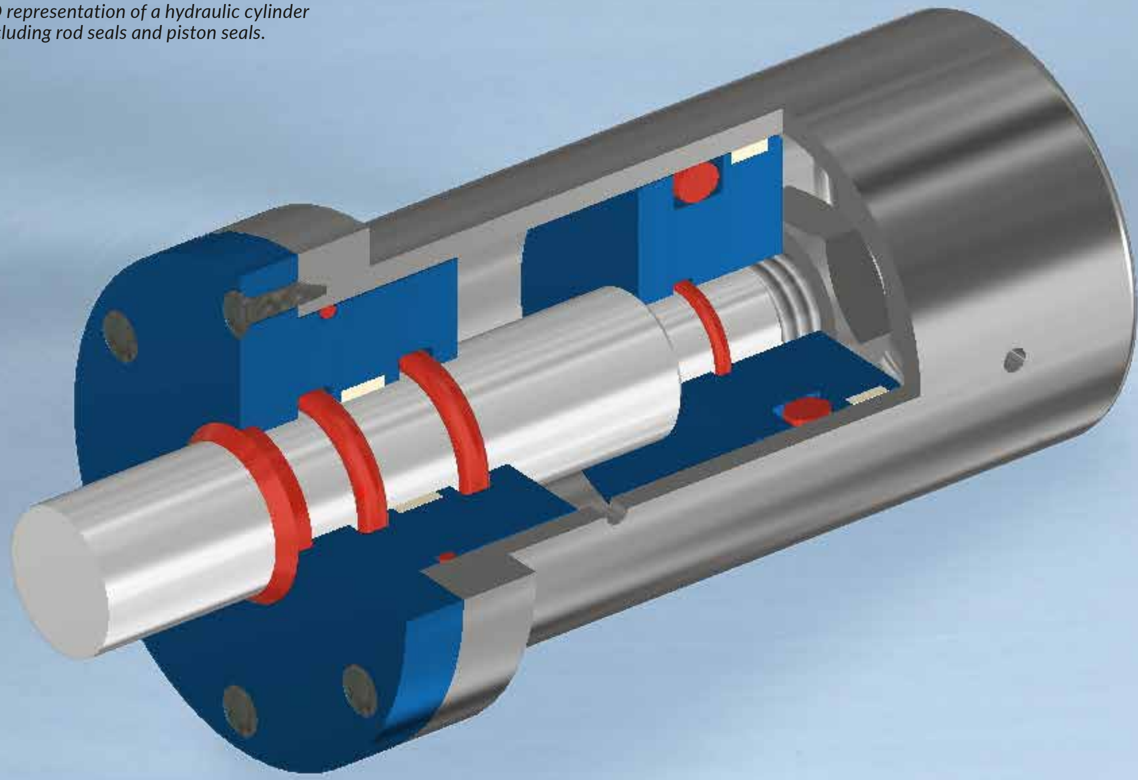
In the event of a **dynamic radial internal seal,** an O-ring must be chosen whose external diameter (d_1 + $2d_2$) is approximately 1–3 % greater than the external diameter of the installation space d_6.

The reason for this recommendation is the so-called Gough-Joule effect. Elastomer materials have a tendency to contract when under tension.

If an O-ring is fitted stretched, the tension increases as a result of this effect, which in turn increases friction. The result is that material wear also increases.

To counter this effect, O-rings in dynamic rod seals should always be fitted slightly compressed with a maximum elongation of approx. 6 %.

3D representation of a hydraulic cylinder including rod seals and piston seals.



Axial, static installation (flange seal)

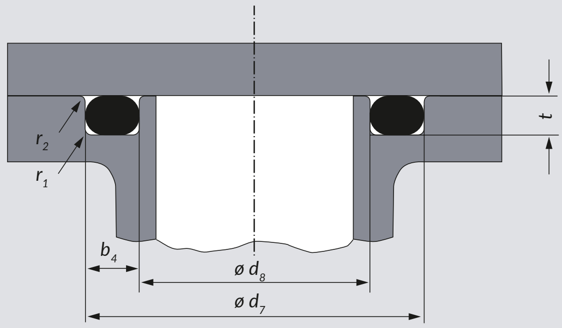


Illustration of the installation space of an axial seal

This adjoining figure shows the schematic cross-sectional view of the installation space for the application case of the axial flange seal.

The following table provides more details about the names and installation spaces as well as the O-ring.

Designation	Tolerance	Explanation
d_7	H11	External axial diameter
d_8	h11	Internal axial diameters
b_4	+ 0.20	With of the O-ring installation space (groove width)
t	+ 0.1	Radial depth of the installation space (groove depth)
r_1	± 0.1... 0.2	Radius in the base of the groove
r_2	± 0.1	Radius on the upper edge of the groove

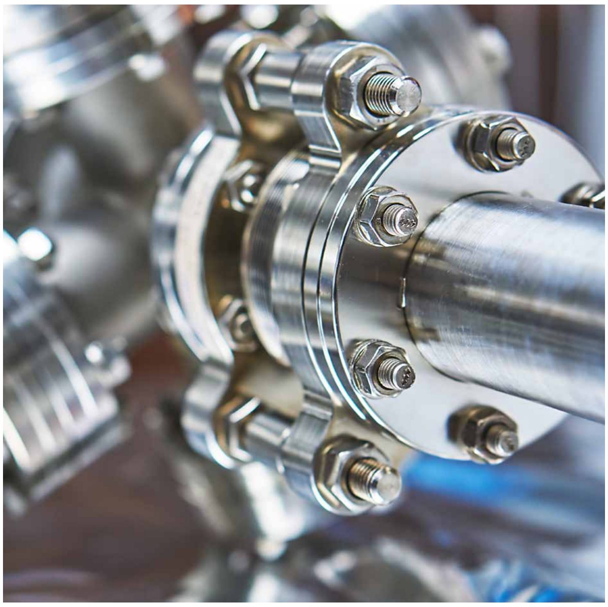


Illustration of a flange seal application

In axial static installations the pressure direction should be considered when selecting the O-ring.

O-ring installation dimensions in an axial flange seal

The following table shows a selection of installation dimensions dependant on cross-section d_2.

d_2	b_4	t	r_1	r_2
1.00	1.90	0.70	0.30	0.1
1.50	2.80	1.10	0.30	0.1
1.78	3.20	1.30	0.30	0.1
2.00	3.40	1.50	0.30	0.1
2.50	3.90	1.90	0.30	0.1
2.62	4.00	2.00	0.30	0.1
3.00	4.60	2.30	0.60	0.2
3.53	5.30	2.70	0.60	0.2
4.00	6.00	3.10	0.60	0.2
4.50	6.50	3.50	0.60	0.2
5.00	7.40	3.90	0.60	0.2
5.33	7.60	4.20	0.60	0.2
5.50	7.60	4.40	1.00	0.2
6.00	8.00	4.80	1.00	0.2
6.50	8.40	5.30	1.00	0.2
6.99	8.70	5.70	1.00	0.2
7.50	9.50	6.20	1.00	0.2
8.00	9.80	6.70	1.00	0.2
9.00	11.10	7.60	1.00	0.2
10.00	12.20	8.60	1.00	0.2

Please note: The values given in the table are only indications and are intended as approximate guidelines. Users are strongly advised to check these values for every specific situation (e. g. by repeated testing). In particular, the contact with the media to be sealed, the temperature at the time of use and the installation conditions may lead to deviations from the values given above. All measurements in mm.

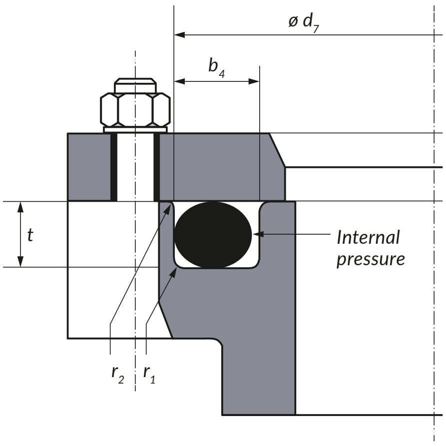
Strictly speaking the table values only apply to NBR O-rings with a hardness of 70 Shore A. However, experience shows that they can be used for other materials and hardnesses although the groove depth may need adjusting.

The values are calculated based on a possible swelling of up to 15 %. If there is less swelling then the groove width can be reduced accordingly.

Determining inside diameter given internal pressure

In installations with internal pressure the external diameter of the O-ring (d_1 + $2d_2$) should be on a par with the external groove diameter d_7. This means that the O-rings are installed slightly compressed and should hence have a similar external diameter to that of the installation space d_7.

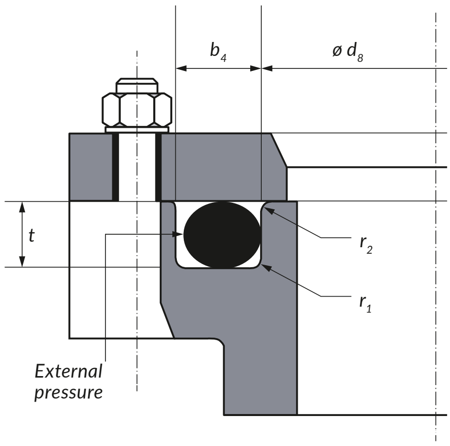
Flange seal – internal pressure



Determining inside diameter given external pressure

In installations with external pressure the inside diameter d_1 of the O-ring should be on a par with the internal groove diameter d_8. This means that the O-rings are installed slightly stretched and should hence have a similar internal diameter to that of the installation space d_8.

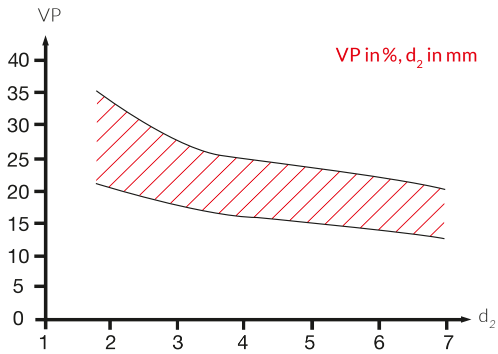
Flange seal – external pressure



Observe pressure direction!

Compression in axial, static seals (flange seal)

The diagram opposite shows the compression permissible range of O-ring compression dependant on the cross-section d_2.

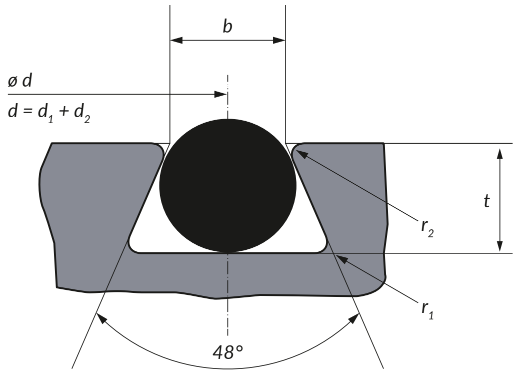


Compression diagram for a hydraulic axial application

Trapezoidal groove

A trapezoidal groove is used if the O-ring must be held during installation or when starting and stopping tools and machinery, or if, as a result of the flow, vacuums occur which press the seal out of the groove. We recommend this method only when cross-section $d_2 \geq 2.5$ mm. To make installation into the trapezoidal groove easier, O-rings are usually fitted slightly elongated. The circumference of the inner diameter should be 3 % to 6 % smaller than the circumferential inside edge of the groove. We also recommend using a dismantling groove.

Groove width (b) in trapezoidal grooves is measured at the edges before deburring. The radius r_2 must be such that the O-ring is not damaged during installation in the groove and there is no gap extrusion at high pressure.



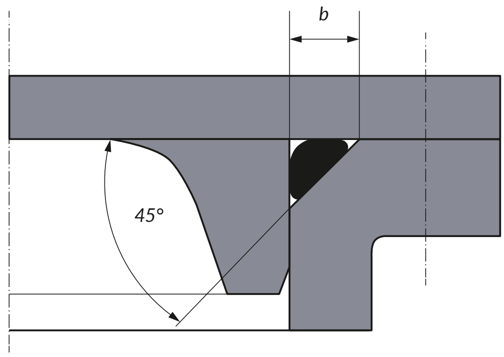
Trapezoidal groove installation dimensions

d_2	b ± 0.05	t ± 0.05	r_2	r_1
2.50	2.30	2.00	0.25	0.40
2.62	2.40	2.10	0.25	0.40
3.00	2.70	2.40	0.25	0.40
3.55	3.20	2.80	0.25	0.80
4.00	3.70	3.10	0.25	0.80
5.00	4.40	4.00	0.25	0.80
5.33	4.80	4.20	0.40	0.80
6.00	5.50	4.80	0.40	0.80
7.00	6.50	5.60	0.40	1.60
8.00	7.50	6.50	0.40	1.60
9.00	8.50	7.20	0.40	1.60
10.00	9.50	8.60	0.40	1.60

Triangular groove

This groove shape is used in flange and cover seals. In this type of installation space the O-ring has contact on three sides. However, a defined O-ring contact pressure is not guaranteed. The manufacturing can also present difficulties as the tolerances specified are difficult to meet and the seal function can not always be ensured. The groove offers little space for any swelling of the O-ring.

If this groove shape is unavoidable then the dimensions and tolerances in the following table should be adhered to. The O-ring cross-section d_2 should exceed 3 mm if at all possible.



Triangular groove installation dimensions

d_2	b
1.78	2.40 + 0.10
2.00	2.70 + 0.10
2.50	3.40 + 0.15
2.62	3.50 + 0.15
3.00	4.00 + 0.20
3.53	4.70 + 0.20
4.00	5.40 + 0.20
5.00	6.70 + 0.25
5.33	7.10 + 0.25
6.00	8.00 + 0.30
6.99	9.40 + 0.30
8.00	10.80 + 0.30
8.40	11.30 + 0.30
10.00	13.60 + 0.35

Note: These are orientation values, which must be verified in advance for the specific application (e.g. through trials). Above all, the contact with media to be sealed, application temperature and installation conditions can lead to deviations. All measurements in mm.

O-ring installation types

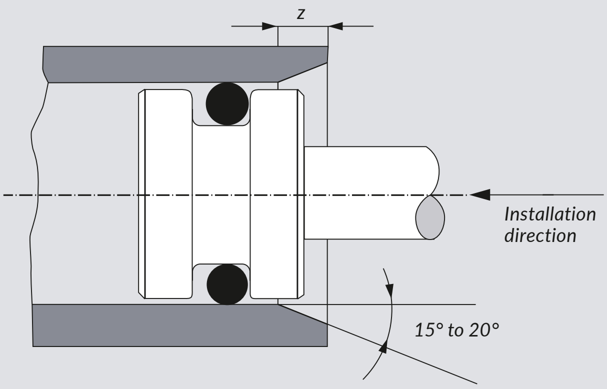
The primary installation tips at a glance:

- Never pull O-rings over sharp edges
- There must not be any dirt or residue in the groove or on the O-ring
- Avoid any potential confusion with other O-rings (see colour coding if present)
- Never use adhesive on an O-ring (possible hardening)
- Do not go over drill holes
- Whenever possible use installation grease/oil. But the material must be resistance against the grease (e. g. do not use mineral oil/Vaseline with EPDM!)
- Detergents/cleansers must be checked for O-ring compatibility
- Do not use any hard or sharp-edged tools.
- O-rings must never sit in threads or thread runs.
- Short-term expansion of the O-ring's inside diameter by as much as 20 % is permissible for installation purposes. (Exceptions are those with small cord sizes less than 1.5 mm and elastomers whose hardness is greater than 80 °IRHD.)

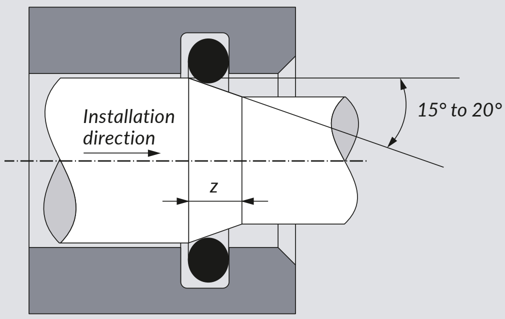
Installation angles

To avoid O-ring damage during installation installation angles for drill holes and shafts must be considered during the design stage.

Installation angle for piston seals



Installation angle for rod seals



The table below shows the minimum lengths of the installation angle for piston and rod seals dependant on cross-section d_2.

Minimum installation angle lengths

d_2	z at 15°	z at 20°
to 1.80	2.5	2.0
1.81 – 2.62	3.0	2.5
2.63 – 3.53	3.5	3.0
3.54 – 5.33	4.0	3.5
5.34 – 7.00	5.0	4.0
over 7.01	6.0	4.5

All measurements in mm.

O-rings are very sensitive to sharp edges. All edges over which the O-ring is to be pulled or against which it will press must therefore be rounded or deburred. This is a major condition for safe installation.

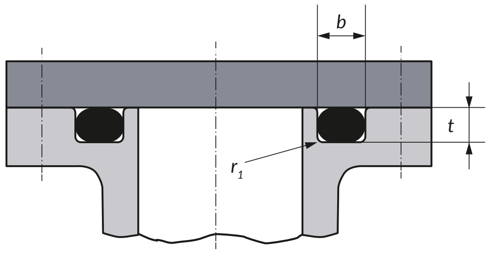
Installation space for PTFE O-rings

O-rings made from thermoplastic PTFE material are not form-compressed but manufactured under tension and differ in this fact from elastomer O-rings. They can hence be made in any size.

PTFE O-rings have little elasticity. The O-rings used should hence have dimensions identical to the nominal dimensions to be sealed. Installation ought preferably to be in axially easily accessible grooves.

Illustration of an installation space for PTFE O-rings

The following diagram shows the installation space for static axial installation.



Installation dimensions for PTFE O-rings

d_2	b + 0.1	t + 0.05	r_1
1.00	1.20	0.85	0.2
1.50	1.70	1.30	0.2
1.80	2.00	1.60	0.4
2.00	2.20	1.80	0.5
2.50	2.80	2.25	0.5
2.65	2.90	2.35	0.6
3.00	3.30	2.70	0.8
3.55	3.90	3.15	1.0
4.00	4.40	3.60	1.0
5.00	5.50	4.50	1.0
5.30	5.90	4.80	1.2
6.00	6.60	5.60	1.2
7.00	7.70	6.30	1.5
8.00	8.80	7.20	1.5

The table above shows a selection of dimensions for groove width (b) and depth (t) dependant on cross-section d_2.

Designations of the installation space and of the O-ring

Designation	Explanation
b	Width of the O-ring installation space (groove width)
d_2	Cross-section
r_2	Radius at the base of the installation space
t	Radial depth of the installation space (groove depth)

Installation space for FEP- and PFA-coated O-rings

FEP-coated O-rings

FEP-coated O-rings offer the best of both worlds. Very high resistance to the widest range of media and at the same time good elasticity. This is because of these O-rings' two-component system. FEP-coated O-rings have an elastic core made from FKM or silicone (VMQ). The respective elastic core is seamlessly coated all around with a thin covering of FEP. While the O-ring's core provides the necessary elasticity, the FEP coating is resistant to chemical media.

PFA-coated O-rings

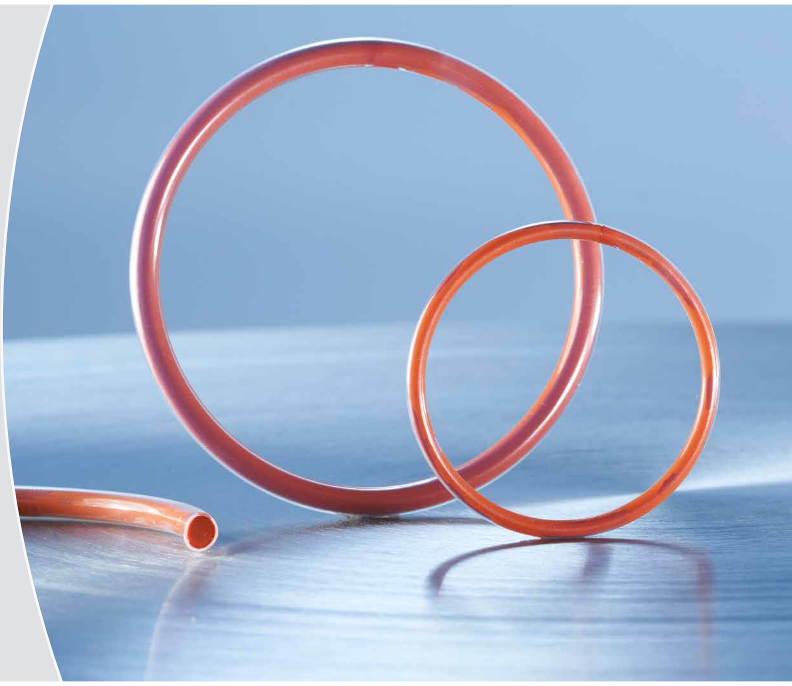
For the very highest temperatures: As well as FEP coatings, COG also offers PFA coating. PFA possesses virtually the same chemical resistance and the same properties as PTFE. However, PFA-coated O-rings can be used at higher temperatures than FEP-coated O-rings, while their low temperature flexibility is the same.

Installation spaces for FEP- and PFA-coated O-rings

The following table shows a selection of dimensions for groove width (b) and depth (t) on cross-section d_2.

cross-section d_2	groove depth t	groove width b
1.78	1.30	2.30
2.62	2.00	3.40
3.53	2.75	4.50
5.33	4.30	6.90
7.00	5.85	9.10

All measurements in mm.

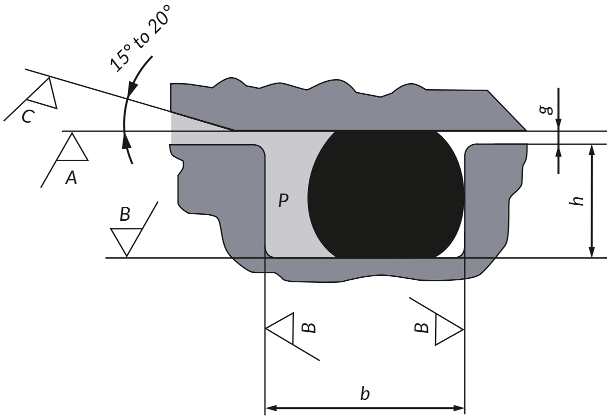


Installation notes: *When it comes to fitting FEP- and PFA-coated O-rings, virtually the same recommendations apply as for standard elastomer O-rings. However, when fitting them, bear in mind that because of their coatings, the O-rings should be subjected to only minimum stretching and compression.*

Surface roughness

Surface specifications depend above all on the product's intended purpose and so no generally valid limiting values for roughness can be given. The table below gives values for surface roughness that cover most possible sealing uses. *They are only to be considered as recommendations.*

Installation space design illustration



Surface roughness values

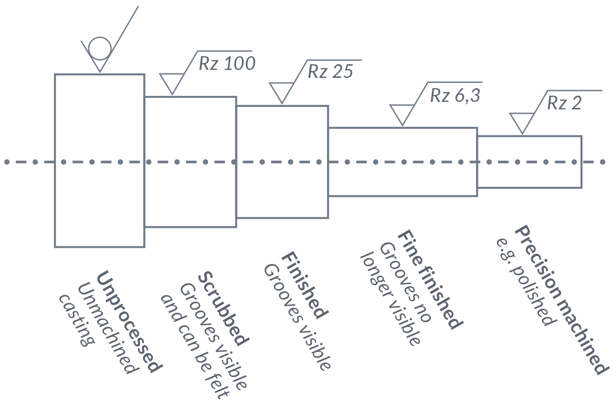
Surface	Pressure	Rz (µm)	Ra (µm)
Groove base (B)	static/ dynamic	6.3	1.6
Groove flanks (B)	static/ dynamic	6.3	1.6
Seal area (A)	static	6.3	1.6
Seal area (A)	dynamic	1.6	0.4
Installation angle (C)	--	6.3	1.6

Explanations

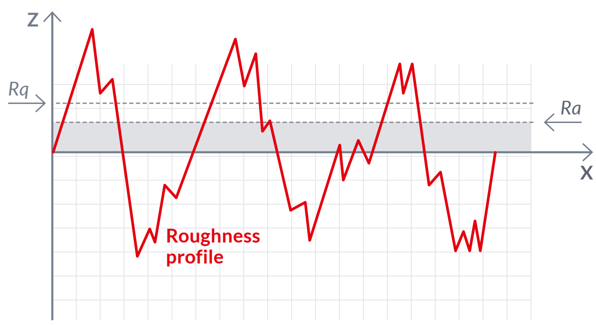
In the field of sealing technology, surface roughness is generally specified using the parameters **Ra** and **Rz**. The central roughness value Ra is the arithmetic average of all profile deviations from the centre or reference line. The average roughness depth Rz is the arithmetic average of the individual roughnesses (profile heights) of five adjacent individual measurement lengths. In roughness profiles, **Rq** defines the quadratic average.

Overview of different degrees of surface roughness

The graphic below shows the various levels of roughness degrees, from coarse to fine.



Example of a roughness measurement



Surface treatment

O-rings can be subjected to special surface treatment e. g. to adjust adhesion, reduce friction or simplify installation. The following benefits may be accrued depending on the individual case and the coating procedure used:

- Better separation
- Assembly simplification
- Anti-adhesion effect
- Friction reduction / reduction of wear and tear
- Silicone and paint cross-linking malfunction prevention
- Improvement in lubrication characteristics
- Stick-slip reduction
- Reduction of breakaway force
- Simplification of automated installation

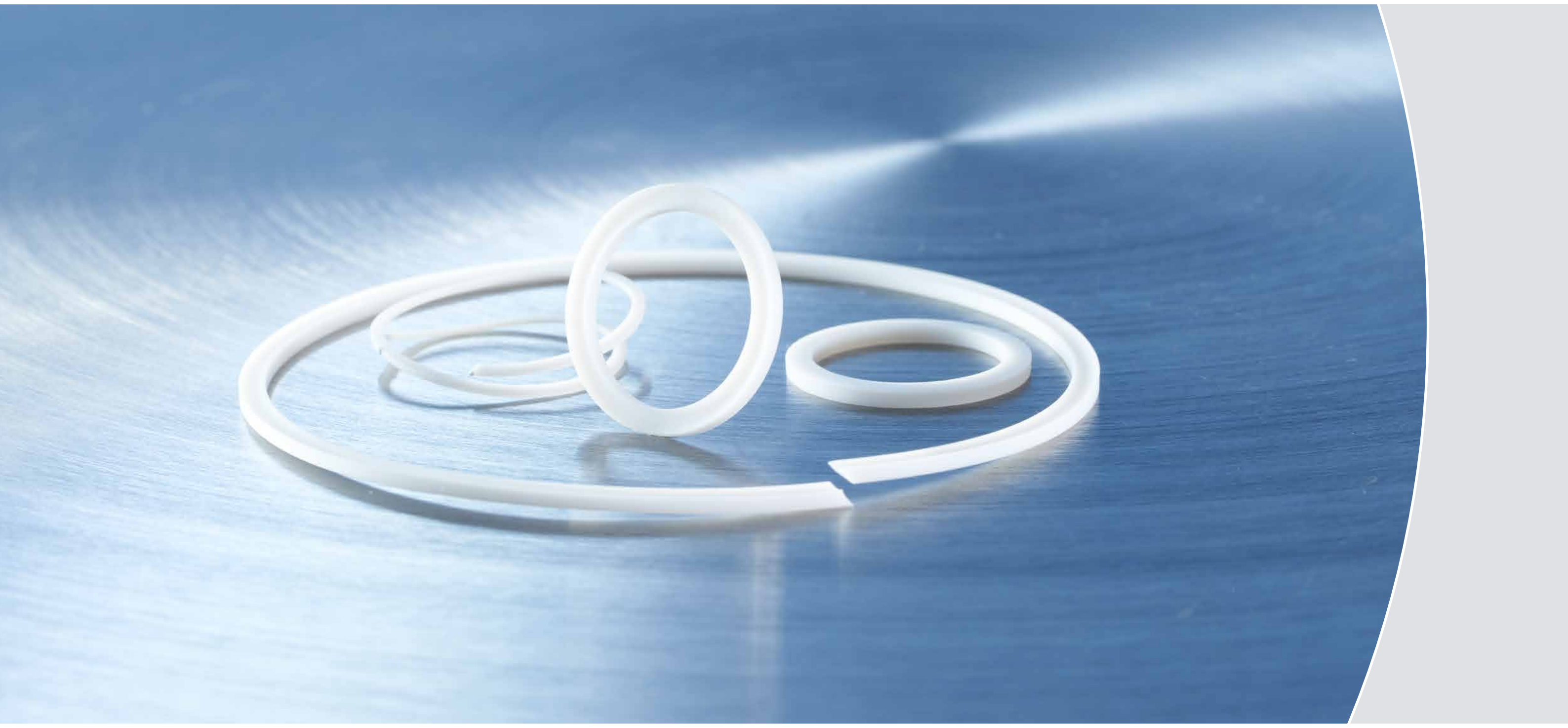
”LABS-free” O-rings

"LABS-free" O-rings are free of substances which cause paint cross-linking malfunctions. Such O-rings are particularly suitable for use in compressed air systems used in painting engineering and above all in the automotive industry. Elastomers may contain substances which cause paint cross-linking to malfunction. The causatory substances can be released into the air or by contact with elastomers and then land on the surface(s) to be painted and cause irregularities. The O-rings intended for this use are hence subjected to a special treatment to ensure they are free of such substances.

Coating options and their typical uses

Name	Type of treatment	Purpose of treatment
PTFE-MS	Water-dilutable single-component anti-friction coating for elastomers	Separation and easy running of elastomers for initial installation and automatic processing
PTFE-FDA	Water-dilutable, FDA-compliant single-component anti-friction coating for elastomers. Complies with VDA 232-101 (‘Global Automotive Declarable Substances List’)	Friction reduction
PTFE transparent	Water-dilutable two-component anti-friction coating for elastomers containing PTFE	Friction reduction, suitable for dynamic applications
PTFE black	Water-dilutable two-component anti-friction coating for elastomers containing PTFE. Complies with VDA 232-101	Friction reduction, suitable for dynamic applications
PTFE grey	Water-dilutable two-component anti-friction coating for elastomers containing PTFE	Friction reduction
PTFE colour	Water-dilutable two-component anti-friction coating for elastomers in various colours. Complies with VDA 232-101	Friction reduction and colour differentiation
Polysiloxane	Water-dilutable single-component anti-friction coating for elastomers containing graphite	Elastomer friction reduction, very smooth surface, suitable for light dynamic applications
Talc powdering	Talcum powder	Separation/Ease of installation
Molycoting	MoS2 powder	Separation/Ease of installation
Teflon	PTFE powder	Separation/Ease of installation
Graphitising	Graphite powder	Separation/Ease of installation
Parylene coating	Polymerisation in a vacuum by condensation from the gas phase	Reduce elastomer friction
Washing	Washing in deionised water	Cleaning of elastomer parts
Washing	Washing in deionised water	Cleaning of elastomer parts
Plasma cleaning	Cleaning in oxygen plasma	Cleaning to meet extremely high cleanliness requirements, including among other applications in medical technology, semiconductor manufacturing and high vacuum applications

Back-up rings



Why back-up rings are used

O-rings count among a machine's most sensitive components, and must be protected from pressure damage. Where constructions do not permit the sealing gap to be designed so that it is sufficiently small in relation to the system pressure, back-up rings can be used in conjunction with elastomer O-rings. When high pressure occurs or wider gaps have to be sealed, back-up rings prevent O-rings from being destroyed as a result of the O-ring being forced into the sealing gap. Such material damage leads to leaks (see page 10).

The back-up rings are predominantly made from PTFE, as this material has the best properties for the most applications: an enormous temperature range spanning -200 °C to 260 °C, the appropriate hardness and a virtually universal resistance to the majority of media. PTFE's flow properties protect the softer rubber rings from mechanical damage.

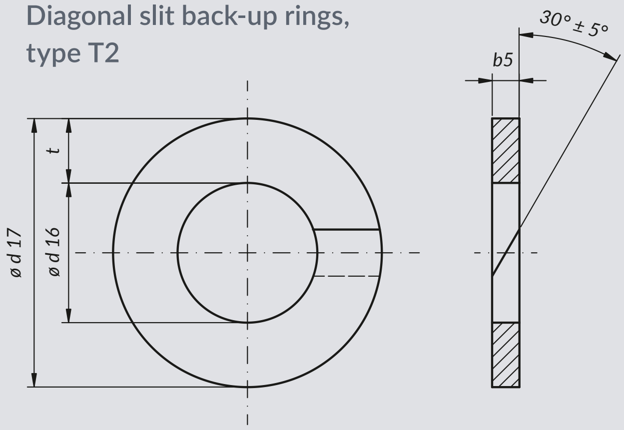
To do so, the back-up rings are fitted behind the O-ring on the non-pressure side, or, if pressure direction changes, at both sides. When it is under pressure, the back-up ring deforms and therefore bridges the gap that must be sealed.

Depending on the application, the following variants of ISO 3601-4-compliant back-up rings are used:

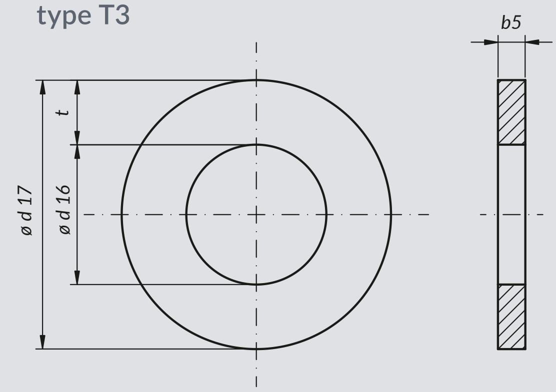
- Spiral back-up rings, type T1
- Diagonal slit back-up rings, type T2
- Unslit back-up rings, type T3
- Diagonal slit concave back-up rings, type T4
- Unslit concave back-up rings, type T5

Custom special types are also possible.

Diagonal slit back-up rings,
type T2



Unslit back-up rings,
type T3



Diagonal slit back-up rings, type T2

Thanks to its slit, this most commonly used type of back-up ring is relatively easy to fit in piston seals or rod seals. They are often used in machine construction.

Type T2 diagonal slit back-up rings are used at system pressures of 15 MPa (150 bar) to 20 MPa (200 bar).

Unslit back-up rings, type T3

Their geometry is relatively basic. A disadvantage of this design is that split installation spaces are generally required, as installation would otherwise be extremely difficult.

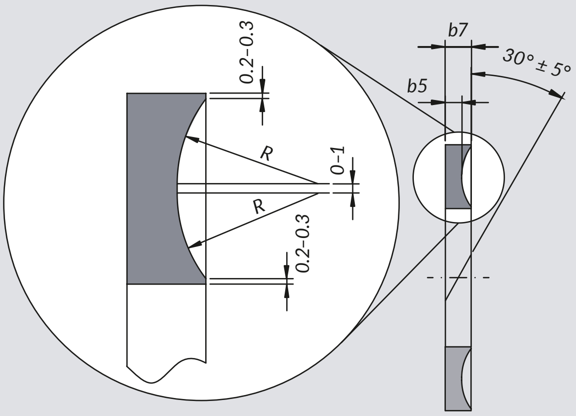
Type T3 unslit back-up rings are used at system pressures of > 25 MPa (250 bar) and/or temperatures > 135 °C.

Back-up ring dimensions based on O-ring cord thicknesses d_2 (types T2 and T3)

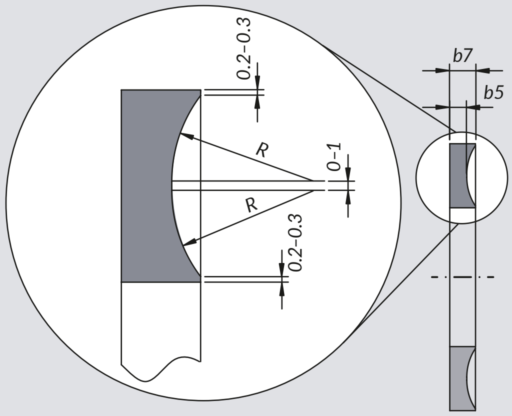
d_2	1.78	2.62	3.53	5.33	6.99
b5 ±0.1	1.4	1.4	1.8	1.8	2.6

All measurements in mm.

Diagonal slit concave back-up rings,
type T4



Unslit concave back-up rings,
type T5



Diagonal slit concave back-up rings, type T4

The concave form of these O-rings has been specially developed to provide O-rings with optimum protection, especially where pulsating pressure is present. Thanks to the slit, they are relatively easy to fit into a piston or rod seal.

Concave full-type back-up rings are used at system pressures of 15 MPa (150 bar) to 20 MPa (200 bar) and also where there is pulsating pressure.

Back-up ring dimensions based on O-ring cord thicknesses d_2

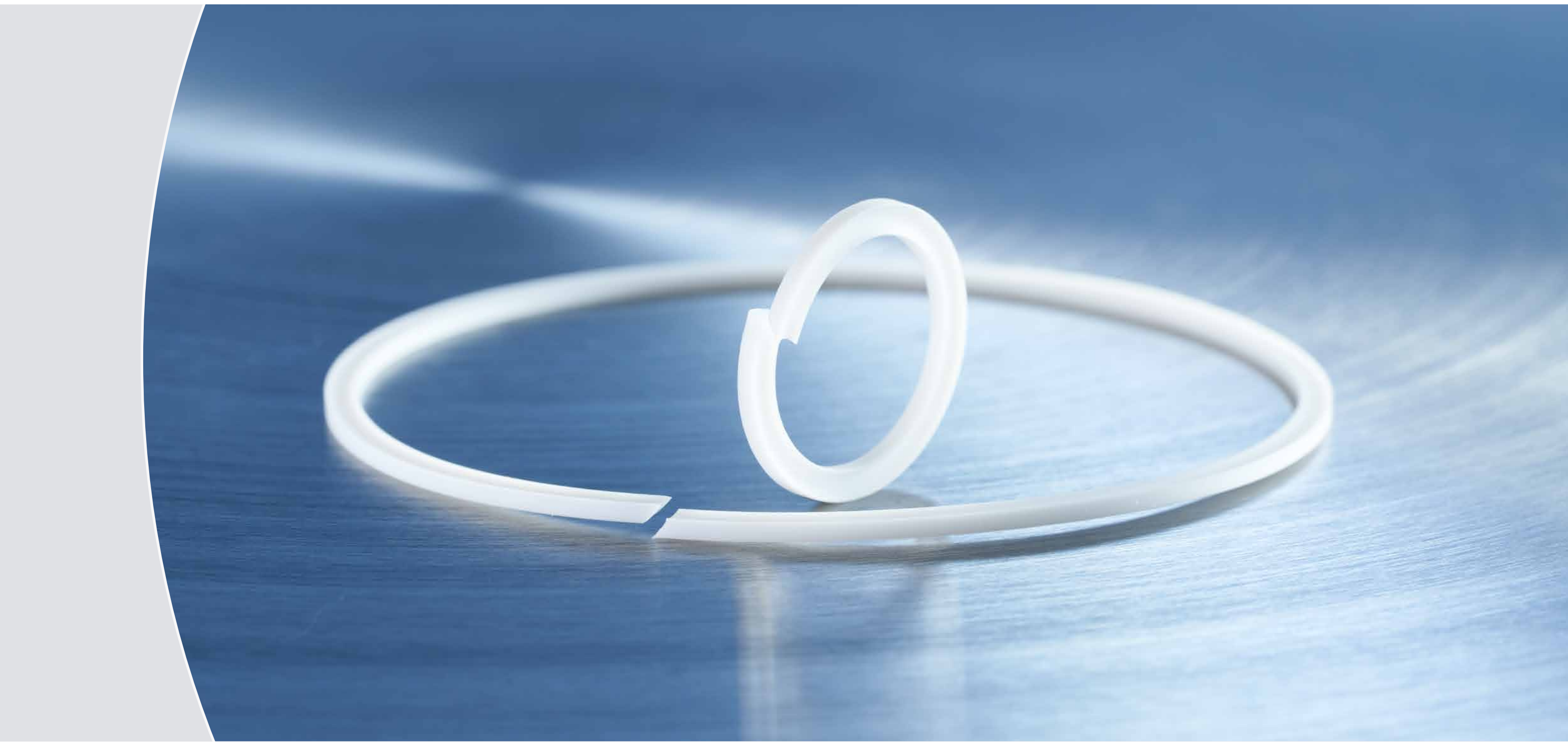
d_2	b5 ±0.1	b7 ±0.1	R
1.78	1.4	1.7	1.2
2.62	1.4	1.8	1.6
3.53	1.8	2.0	2.0
5.33	1.8	2.8	3.0
6.99	2.6	4.1	4.0

All measurements in mm.

Unslit concave back-up rings, type T5

The function of this variant of back-up ring is essentially the same as that of type T4. Thanks to the concave form of their contact finish, these O-rings maintain their contours to approximately the same degree, and can therefore to some extent provide a dependable seal at extreme pressures.

From a constructional point of view, the type T1 spiral back-up rings and special variants can be regarded as critical. We recommend a technical application consultation.



Positioning the back-up ring

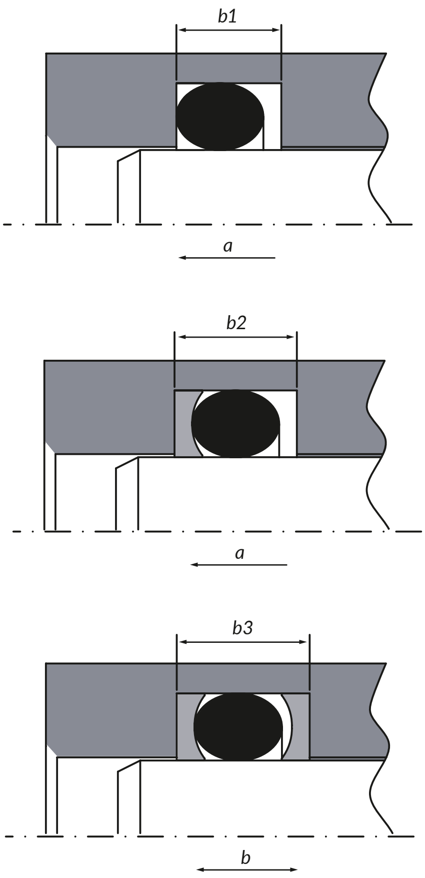
Depending on the pressure supply, the back-up ring must be installed on the non-pressure side. If pressure changes, they must be fitted at both sides. In order to prevent confusion about the installation side, it is also possible to use two back-up rings.

The required groove widths b2 and b3 are calculated from the previously determined constructional groove width without back-up ring, plus back-up ring width b5 or double back-up ring width 2 x b5 where 2 back-up rings are used.

Notes

b1 = Groove width without back-up ring
b2 = Groove width with one back-up ring
b3 = Groove width with two back-up rings
a = Pressure comes from one direction (moves in direction of the arrow)
b = Pressure can affect the O-ring from both directions

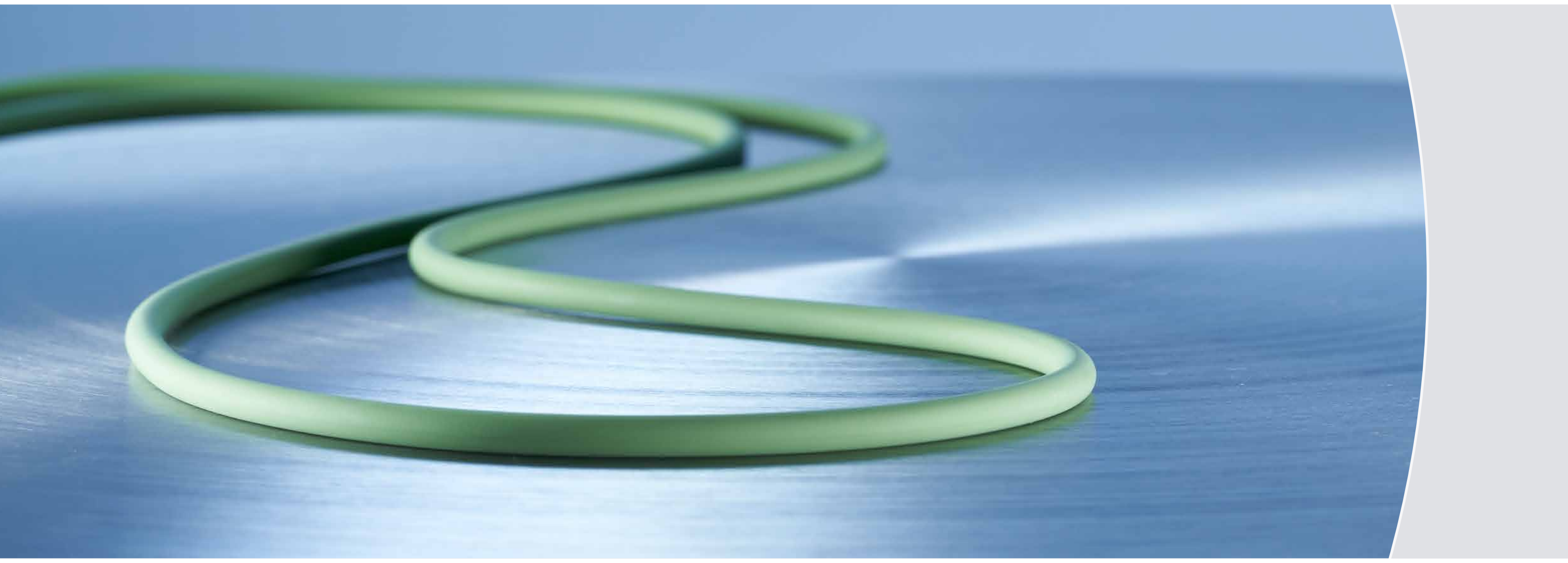
Positioning the back-up ring in a rod application



Endless vulcanisation

O-rings can be manufactured by various processes, and can have a length of up to 3,000 mm (and also larger if required), with different cord sizes and material qualities.

Endless vulcanisation enables uniform complete vulcanisation of O-rings across their entire diameter.



The dimensional tolerance of the O-ring cords and surfaces meets the ISO 3601 standard. The O-rings manufactured in this way correspond to O-rings with smaller dimensions manufactured using conventional techniques.

Compared to other processes, uniform vulcanisation ensures there are no weak points on the joints. This enables longer-lasting and considerably higher quality seals in various areas of application, such as for example in the high vacuum range or when used with gaseous media.

The endless vulcanisation process is ideal where more rigorous demands apply, as lower tolerances and the resulting high degree of precision are possible when using this production method.

Other procedures:

Glue

Glued O-rings are extruded cords whose ends have been joined together using adhesive. The adhesive must be chosen according to the elastomer material used, as well as to operating conditions such as pressure, temperature and the medium being used.

Vulcanised joints

O-rings with vulcanised joints are produced by holding the cord ends together in a special device in which the ends are then hot vulcanised with a suitable adhesive mixture.

The disadvantages of these two processes are the inferior physical properties in the seam/glued area and the greater tolerances compared to O-rings produced using endless vulcanisation.

O-ring storage

Seals stored for long periods may change their physical characteristics. Such changes may include hardening, softening, cracking and other forms of surface degeneration. This is due to one or more influences such as deformation, oxygen, light, ozone, heat, damp, oil or solvent.

Basic instructions on storage, cleaning and preservation of elastomer seals are laid down in the DIN 7716 and ISO 2230 standards.

ISO 2230 contains advice on storing rubber items. The table below gives the maximum storage periods split into three groups.

Elastomer storage periods

Rubber base	Maximum storage period	Extension
BR, NR, IR, SBR, AU, EU	5 years	2 years
NBR, XNBR, HNBR, CO, ECO, CR, IIR, BIIR, CIIR	7 years	3 years
ACM, CM, CSM, EPM, EPDM, FEPM, FKM, FFKM, VMQ, PVMQ, FVMQ	10 years	5 years

Important influencing factors:

Certain conditions must be met when storing rubber products.

Heat
Storage temperature for elastomers should preferably be in the +5 °C to +25 °C range. Avoid direct contact with heat sources such as radiators or sunlight.

Moisture
Relative humidity should be below 70 % in the storage space. Extremely damp or dry conditions should be avoided.

Light
Elastomer seals should be protected from light when stored. Direct sunlight and strong artificial light with a UV content in particular are to be avoided. We recommend covering windows in storage spaces with red or orange materials.

Oxygen and ozone
If possible elastomers should be packaged or put in airtight containers to protect them from circulating air.

Deformation
Elastomers should be stored in an untensioned condition if possible. Large O-rings can be stored coiled to save space. If the inside diameter d_1 > 300 mm, the O-ring may be looped over once (i. e. in a figure of 8). It should never be bent.

Chemical resistance list

This list uses a rating system to show the chemical resistance of various elastomer materials to different operating media. The following data is based on tests and information provided by our suppliers and customers.

Because of the different application conditions and composition of the media, this data must only be regarded as a guide. The data is nonbinding and must be checked on a case-by-case basis. All information relates to room temperature unless otherwise stated.

The specific data are to be understood as follows:

- **A** = Elastomer exhibits no or minimal swelling
- **B** = Elastomer exhibits low to moderate swelling
- **C** = Elastomer exhibits moderate to strong swelling
- **D** = Not recommended
- **–** = Unknown / Not checked

A

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
1-chlorine-1-nitro ethane	D	D	D	–	D	D	D	D	D	–	D	A	C
Acetaldehyde	B	A	D	–	C	D	D	B	D	–	D	A	C
Acetamide (acetic acid amide)	D	A	A	A	B	D	D	B	A	A	B	A	A
Acetic acid, 30%	B	A	B	–	A	D	D	A	B	–	B	A	A
Acetic acid, glacial acetic acid	B	A	C	B	D	D	D	B	D	–	C	A	B
Acetic anhydride	B	B	C	D	B	D	D	C	D	B	D	A	C
Acetone	C	A	D	D	C	D	D	C	D	D	D	A	B
Acetophenone	D	A	D	D	D	D	D	D	D	–	D	A	C
Acetyl chloride (acetic acid chloride)	D	D	D	D	D	D	D	C	A	–	A	A	A
Acetylene (ethyne)	B	A	A	–	B	D	D	B	–	–	A	A	A
Acrylonitrile	D	D	D	D	D	D	D	D	D	–	C	A	C
Adipic acid (E 355)	A	A	A	A	A	–	–	–	A	–	A	A	A
Aluminium acetate (aqueous solution)	A	A	B	–	B	D	D	D	D	–	D	A	C
Aluminium chloride (aqueous solution)	A	A	A	A	A	C	A	B	A	–	A	A	A
Aluminium fluoride (aqueous solution)	B	A	A	A	A	C	–	B	A	–	A	A	A
Aluminium nitrate (aqueous solution)	A	A	A	A	A	C	–	B	–	–	A	A	A
Aluminium phosphate (aqueous solution)	A	A	A	A	A	–	–	A	–	–	A	A	A
Aluminium sulphate (aqueous solution)	A	A	A	A	A	D	D	A	A	–	A	A	A
Ammonia (gaseous, cold)	A	A	A	A	A	C	D	A	D	A	D	A	B
Ammonia (gaseous, hot)	D	B	D	D	B	D	D	A	D	–	D	A	B
Ammonia, anhydrous	D	A	B	B	A	D	D	C	D	–	D	A	B
Ammonium carbonate (aqueous solution)	A	–	D	D	A	D	D	–	–	A	A	A	A
Ammonium chloride (aqueous solution)	A	A	A	A	A	A	–	–	–	–	A	A	A
Ammonium hydroxide (concentrated)	D	A	D	–	A	D	D	A	B	–	B	A	A
Ammonium nitrate (aqueous solution)	C	A	A	A	A	D	B	–	–	A	A	A	A
Ammonium nitrite (aqueous solution)	A	A	A	A	A	–	–	B	–	–	A	A	A
Ammonium persulphate (aqueous solution)	A	A	D	D	A	D	D	–	–	–	A	A	A
Ammonium phosphate (aqueous solution)	A	A	A	–	A	–	–	A	–	–	A	A	A
Ammonium sulphate (aqueous solution)	A	A	A	A	A	A	D	–	–	–	B	A	A
Amyl acetate (acetic acid amyl ester)	D	C	D	D	D	D	D	D	D	–	D	A	B

A

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Amyl alcohol (pentanol)	B	A	B	B	B	D	D	D	A	–	B	A	A
Amyl borate	D	D	A	A	A	–	–	–	–	–	A	A	A
Amyl chlornaphtalene	D	D	D	D	D	D	D	D	B	–	A	A	A
Amyl naphtalene	D	D	D	D	D	D	B	D	A	–	A	A	A
Aniline (aminobenzene)	D	A	D	–	D	D	D	D	C	A	C	A	A
Aniline dye	B	A	D	D	B	D	D	C	B	–	B	A	A
Aniline hydrochloride	B	B	B	–	D	D	D	D	B	–	B	A	A
Animal fat	D	B	A	A	B	A	A	B	A	–	A	A	A
Aqua regia	D	C	D	D	D	D	D	D	C	–	B	A	A
Arsenic acid	B	A	A	A	A	C	C	A	A	–	A	A	A
Arsenic trichloride (aqueous solution)	D	C	A	A	A	–	–	–	–	–	D	A	C
Asphalt	D	D	B	–	B	B	B	D	B	–	A	A	A

B

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Banana oil (amyl acetate)	D	C	D	D	D	D	D	D	D	–	D	A	B
Barium chloride (aqueous solution)	A	A	A	A	A	A	A	A	A	–	A	A	A
Barium hydroxide (aqueous solution)	A	A	A	A	A	D	D	A	A	–	A	A	A
Barium sulphate (aqueous solution)	A	A	A	A	A	A	D	A	A	–	A	A	A
Barium sulphide (aqueous solution)	A	A	A	A	A	A	D	A	A	–	A	A	A
Beer	A	A	A	A	A	B	D	A	A	–	A	A	A
Beet sugar liquid	A	A	A	A	B	D	D	A	A	–	A	–	–
Benzaldehyde (artificial bitter almond oil)	D	A	D	D	D	D	D	B	C	B	D	B	C
Benzene	D	D	D	D	D	C	D	D	C	C	A	A	A
Benzine (nitro benzine, ligroin)	D	D	A	–	B	B	A	D	A	–	A	A	A
Benzoic acid (E 210)	D	C	C	–	D	D	C	C	B	–	A	A	A
Benzol sulphonic acid	D	C	D	–	B	D	D	D	B	–	A	B	A
Benzoyl chloride	D	D	D	–	D	–	D	–	B	–	B	A	A
Benzyl alcohol	D	A	D	–	B	D	D	B	B	A	A	A	A
Benzyl benzoate	D	B	D	–	D	–	D	–	A	–	A	A	A
Benzyl chloride	D	D	D	–	D	D	D	D	B	A	A	A	A
Biphenyl (diphenyl, phenylbenzene)	D	D	D	D	D	D	D	D	B	–	A	A	A
Blast furnace gas (furnace gas)	D	D	D	D	D	D	D	A	B	–	A	A	A
Bleach solution	D	A	D	B	D	D	D	B	B	A	A	A	A
Borax solution (disodium tetraborat)	B	A	B	A	A	A	B	B	B	–	A	A	A
Bordeaux mixture	B	A	B	–	B	D	D	B	B	–	A	A	–
Boric acid	A	A	A	A	A	A	D	A	A	–	A	A	A
Bromine trifluoride	D	D	D	D	D	D	D	D	D	–	D	B	C
Bromine water	D	B	D	C	D	D	D	D	B	–	A	A	A
Bromine, anhydrous	D	D	D	–	D	D	D	D	B	–	A	A	A
Bromobenzene	D	D	D	D	D	D	D	D	A	–	A	A	A
Bromochloromethane	D	B	D	D	D	D	D	D	B	–	A	A	A
Bunker oil	D	D	A	A	D	B	A	B	A	–	A	A	A
Butadiene	D	C	D	–	D	D	D	D	B	–	A	A	A
Butane	D	D	A	A	A	A	A	D	A	–	A	A	A
Butter (animal fat)	D	A	A	A	B	A	A	B	A	–	A	A	A
Butyl acetate (acetic acid butylester)	D	C	D	–	D	D	D	D	D	D	D	A	C

B

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Butyl acetylricinoleate	D	A	C	B	B	D	–	–	B	–	A	A	A
Butyl acrylate	D	D	D	D	D	–	D	–	D	–	D	A	C
Butyl alcohol (butanol)	A	B	A	A	A	D	D	B	B	A	A	A	A
Butyl benzoate	C	B	D	–	D	–	D	–	A	–	A	A	A
Butyl ethyl diglycol (CARBITOL)	D	A	D	D	C	–	D	D	D	–	C	A	A
Butyl glycol ether (CELLOSOLVE)	D	A	C	C	C	D	D	–	D	–	D	A	B
Butyl stearate (stearic acid butyl ester)	D	C	B	B	D	–	–	–	B	A	A	A	A
Butylamine	D	B	C	C	D	D	D	D	D	–	D	A	C
Butylene (butene)	D	D	B	D	C	D	D	D	B	–	A	A	A
Butyloleate	D	B	D	D	D	–	–	–	B	–	A	A	A
Butyraldrehyde (butanal)	D	B	D	–	C	D	D	D	D	–	D	B	C

C

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Calcium acetate (aqueous solution)	A	A	B	B	B	D	D	D	D	A	D	A	C
Calcium chloride (aqueous solution)	A	A	A	A	A	A	A	A	A	A	A	A	A
Calcium hydrogen sulphate (aqueous solution)	D	D	D	A	A	A	D	A	A	–	A	A	A
Calcium hydroxide (aqueous solution)	A	A	A	A	A	A	D	A	A	A	A	A	A
Calcium hypochlorite (aqueous solution)	C	A	B	B	C	D	D	B	B	A	A	A	A
Calcium nitrate (aqueous solution)	A	A	A	A	A	A	A	B	A	A	A	A	A
Calcium sulphide (aqueous solution)	B	A	A	A	A	A	D	B	A	A	A	A	A
Cane sugar liquid	A	A	A	–	A	D	D	A	A	–	A	A	A
Carbamate	D	B	C	–	B	D	D	–	A	–	A	A	A
Carbitol (ethyl diglycol)	B	B	B	–	B	D	D	B	B	–	B	A	B
Carbolic acid (phenol)	D	B	D	D	C	C	D	D	A	–	A	A	A
Carbon dioxide	B	B	A	A	B	A	–	B	A	–	A	A	A
Carbon disulphide	D	D	C	D	D	–	C	D	A	A	A	A	A
Carbon monoxide	B	A	A	A	B	A	A	A	B	–	A	A	A
Carbon tetrachloride	D	D	C	B	D	D	D	D	C	D	A	B	B
Carbonic acid	A	A	B	A	A	A	A	A	A	–	A	A	A
Castor oil	A	B	A	A	A	A	A	A	A	A	A	A	A
Cellosolve (ethylene glycol ether)	D	B	D	–	D	D	D	D	D	–	C	A	C
Cellosolve acetate (glycol acetate)	D	B	D	D	D	D	D	D	D	–	D	A	C
Chalk sulphur solution	D	A	D	A	A	–	D	A	A	–	A	A	A
Chalk whitener	A	A	A	A	B	–	D	B	A	–	A	A	A
China wood oil (China tung oil)	D	C	A	A	B	C	–	D	B	–	A	A	–
Chlorine dioxide	D	C	D	D	D	D	D	–	B	–	A	A	A
Chlorine trifluoride	D	D	D	D	D	D	D	D	C	–	D	B	C
Chlorine, dry	D	D	D	C	C	D	D	D	A	–	A	A	A
Chlorine, wet	D	C	D	C	C	D	D	D	B	–	B	A	A
Chloroacetic acid	D	A	D	D	D	D	D	–	D	–	D	A	B
Chloroacetone	D	A	D	D	C	D	D	D	D	–	D	A	B
Chlorobenzene	D	D	D	D	D	D	D	D	B	–	A	A	A
Chlorododecane	D	D	D	D	D	D	D	D	A	–	A	A	A
Chloroform (trichloromethane)	D	D	D	D	D	D	D	D	D	D	A	A	A
Chloroprene (chlorobutadiene)	D	D	D	D	D	D	D	D	B	–	A	A	A
Chlorosulphic acid	D	D	D	–	D	D	D	D	D	A	D	A	B

C

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Chlorotoluene	D	D	D	D	D	D	D	D	B	–	A	A	A
Chlorox (sodium hypochlorite)	D	B	B	B	A	D	D	B	B	–	A	A	A
Chrome plating solution	D	B	D	D	D	D	D	B	B	–	A	A	–
Chromic acid	D	C	D	D	C	D	D	C	C	A	A	A	A
Citric acid	A	A	A	A	A	A	–	A	A	A	A	A	A
Coal tar (creosote)	D	D	A	–	B	C	A	D	A	–	A	–	–
Cobalt dichloride (aqueous solution)	A	A	A	A	A	D	D	B	A	–	A	A	A
Coconut oil	D	C	A	A	B	B	A	A	A	–	A	A	A
Cod liver oil	D	A	A	A	B	A	A	B	A	–	A	A	–
Coke oven gas	D	D	D	D	D	D	D	B	B	–	A	A	A
Copper acetate (aqueous solution)	A	A	B	B	B	D	D	D	D	–	D	A	C
Copper chloride (aqueous solution)	A	A	A	A	B	A	A	A	A	–	A	A	A
Copper cyanide (aqueous solution)	A	A	A	A	A	A	A	A	A	–	A	A	A
Copper sulphate (aqueous solution)	B	A	A	A	A	A	A	A	A	–	A	A	A
Cotton seed oil	D	B	A	A	B	A	A	A	A	A	A	A	–
Creosote coal tar	D	D	A	A	B	C	A	D	A	–	A	A	A
Cresol (methyl phenol)	D	D	D	–	C	D	D	D	B	A	A	A	A
Cresylic acid	D	D	D	A	C	D	D	D	B	A	A	A	A
Cumene (isopropylbenzene)	D	D	D	D	D	D	D	D	B	–	A	A	A
Cyclohexane (hexamethylene)	D	D	A	A	C	A	A	D	B	B	A	A	A
Cyclohexanol (hexahydrophenol, anol)	D	C	C	A	A	–	–	D	A	–	A	A	A
Cyclohexanone (pimelic ketone, anone)	D	B	D	D	D	D	D	D	D	B	D	A	C

D

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Decaline (decahydronaphthalene)	D	D	D	–	D	–	–	D	A	–	A	A	A
Decane	D	D	A	A	D	B	A	B	A	–	A	A	A
Developer fluid (photography)	A	B	A	A	A	–	–	A	A	–	A	A	–
Diacetone	D	A	D	–	D	D	D	D	D	–	D	A	B
Diacetone alcohol	D	A	D	D	B	D	D	B	D	–	D	A	B
Dibenzyl ether	D	B	D	D	C	B	–	–	–	–	D	A	C
Dibenzyl sebacate	D	B	D	D	D	B	D	C	C	–	B	A	A
Dibromethylbenzene	D	D	D	D	D	D	D	D	B	–	B	A	A
Dibutyl ether	D	C	D	D	C	B	C	D	C	–	C	A	B
Dibutyl sebacate (DBS)	D	B	D	D	D	D	D	B	B	–	B	A	A
Dibutylamine	D	C	D	–	D	D	D	C	D	–	D	A	C
Dibutylphthalate (DBP)	D	B	D	D	D	C	D	B	C	–	C	A	A
Dichloro isopropyl ether	D	C	D	D	D	B	C	D	C	–	C	A	B
Dicyclohexylamine	D	D	C	C	D	D	D	–	D	–	D	A	B
Diesel fuel	D	D	A	A	C	C	A	D	A	C	A	A	A
Diethyl benzene	D	D	D	–	D	D	–	D	C	–	A	A	A
Diethyl sebacate	D	B	B	C	D	D	D	B	B	–	B	A	A
Diethylamine	B	B	B	–	B	C	D	B	D	–	D	A	B
Diethylene glycol	A	A	A	–	A	D	B	B	A	–	A	A	A
Diisobutylene (isooctene)	D	D	B	A	D	D	D	D	C	–	A	A	A
Diisopropyl ketone	D	A	D	–	D	D	D	D	D	–	D	A	C
Diisopropylbenzene	D	D	D	–	D	–	–	–	B	–	A	A	A

D

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Diisopropyliden acetone (phoron)	D	C	D	–	D	D	D	D	D	–	D	A	C
Dimethyl ether (methyl ether)	D	D	A	A	C	–	D	A	A	–	D	A	C
Dimethyl formamide (DMF)	D	B	B	–	C	D	D	B	D	A	D	A	B
Dimethyl phthalate (DMP)	D	B	D	D	D	–	D	–	B	–	B	A	A
Dimethylaniline (xylidine, aminoxylole)	C	B	C	–	C	D	D	D	D	–	D	A	B
Dinitrotoluene (DNT)	D	D	D	D	D	D	D	D	D	–	D	A	C
Dioctyl sebacate (DOS)	D	B	D	D	D	B	D	C	C	A	B	A	A
Dioctylphthalate (DOP)	D	B	C	–	D	D	D	C	B	B	B	A	A
Dioxane	D	B	D	D	D	D	D	D	C	D	D	A	C
Dioxolane (glycol methyl ether)	D	B	D	D	D	D	D	D	D	D	D	A	C
Dipentene (paint thinner)	D	D	B	B	D	D	D	D	C	–	A	A	–
Diphenyl (biphenyl, phenylbenzene)	D	D	D	D	D	D	D	D	B	B	A	A	A
Diphenyl oxide	D	D	D	D	D	D	D	C	B	B	A	A	A
Dowtherm oil	D	D	D	D	D	C	D	C	B	–	A	A	–

E

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Epichlorohydrin	D	B	D	D	D	D	D	D	D	–	D	B	C
Ethane	D	D	A	–	B	C	A	D	B	–	A	A	A
Ethanolamine (aminoethanol) (MEA)	B	B	B	–	B	C	D	B	D	A	D	A	C
Ethyl (ethanethiol)	D	C	D	–	C	–	–	C	–	–	B	A	A
Ethyl acetate (acetic acid ethyl ester)	D	B	D	–	C	D	D	B	D	D	D	A	C
Ethyl acetoacetate	C	B	D	–	C	D	D	B	D	–	D	A	C
Ethyl acrylate	D	B	D	–	D	D	D	B	D	–	D	A	C
Ethyl alcohol	A	A	A	A	A	D	D	A	A	–	A	A	A
Ethyl alcohol (ethanol)	A	A	A	A	A	D	D	A	A	A	B	A	A
Ethyl benzene	D	D	D	–	D	D	D	D	A	B	A	A	A
Ethyl benzoate	A	A	D	–	D	D	D	D	A	C	A	A	A
Ethyl cellosolve (glycol diethyl ether)	D	D	D	–	D	D	D	D	D	–	D	A	B
Ethyl cellulose	B	B	B	–	B	B	D	C	D	–	D	A	C
Ethyl chloride (chlorethane)	D	C	A	–	D	B	D	D	A	–	A	A	A
Ethyl chlorocarbonate	D	B	D	–	D	D	D	D	B	–	A	A	A
Ethyl chloroformate	D	B	D	–	D	D	D	D	D	–	D	A	–
Ethyl ether (diethyl ether)	D	C	C	–	C	C	D	D	C	–	D	A	C
Ethyl formate (ethyl methanoate)	D	B	D	–	B	–	–	–	A	–	A	B	A
Ethyl oxalate	A	A	D	–	C	A	D	D	B	–	A	A	A
Ethyl pentachlorobenzene	D	D	D	–	D	D	D	D	B	–	A	A	A
Ethyl silicate	B	A	A	–	A	–	–	–	A	–	A	A	A
Ethylendiamene	A	A	A	A	A	D	D	A	D	–	D	B	C
Ethylene (ethene)	C	B	A	–	C	–	–	–	A	–	A	A	A
Ethylene chlorhydrine	B	B	D	–	B	D	D	C	B	A	A	A	A
Ethylene chloride	D	C	D	–	D	D	D	D	C	–	B	A	A
Ethylene glycol (glycol)	A	A	A	A	A	D	C	A	A	–	A	B	A
Ethylene oxide (oxirane, epoxide)	D	C	D	–	D	D	D	D	D	–	D	A	D
Ethylene trichloride	D	C	D	D	D	D	D	D	C	–	A	A	A
Ethyline dichloride (1,2 dichlorethane)	D	C	D	–	D	D	D	D	C	B	A	A	A

F

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Fatty acids	D	C	B	B	B	–	–	C	–	–	A	A	A
Fish oil (train oil)	D	D	A	–	D	–	–	A	A	–	A	A	–
Fluorine (liquid)	D	D	D	–	D	D	D	D	–	–	C	B	–
Fluorobenzene	D	D	D	–	D	D	D	D	B	–	A	A	A
Fluoroboric acid	A	A	A	–	A	–	–	–	–	–	–	A	–
Fluorolube	B	A	A	A	B	–	–	A	B	–	B	B	–
Formaldehyde (RT) (methanal)	B	A	C	B	B	D	D	B	D	A	D	A	C
Formic acid (methanoic acid)	B	A	B	–	A	C	–	B	C	B	C	B	C
Fuel oil	D	D	A	A	B	B	A	D	A	–	A	A	–
Fumaric acid	C	B	A	A	B	–	D	B	A	–	A	A	–
Furan	D	C	D	D	D	–	D	–	–	–	D	A	C
Furfural (furfurol)	D	B	D	D	C	C	D	D	–	B	D	B	C
Fyrquel (cellulube)	D	A	D	D	D	D	D	A	C	–	A	–	–

G

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Gallic acid	A	B	B	B	B	D	D	–	A	–	A	A	A
Gelatine	A	A	A	–	A	D	D	A	A	–	A	A	A
Generator gas	D	D	A	–	B	A	B	B	B	–	A	A	A
Glauber salt (aqueous solution)	B	B	D	D	B	–	D	–	A	–	A	A	A
Glucose (dextrose, grape sugar)	A	A	A	A	A	D	–	A	A	–	A	A	A
Glue (DIN 16920)	B	A	A	–	A	A	–	A	A	–	A	–	A
Glycerine (glycerole, E422)	A	A	A	–	A	A	C	A	A	A	A	A	A
Glycol (1,2-diol)	A	A	A	A	A	D	D	A	A	–	A	A	A
Green sulphate broth	B	A	B	B	B	A	B	A	B	–	A	B	–

H

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Halowax oil	D	D	D	D	D	–	–	D	A	–	A	B	–
Hexafluorosilicic acid	B	B	A	A	B	–	–	D	D	–	A	A	A
Hexane	D	D	A	A	B	B	A	D	A	–	A	A	A
Hexanol	B	C	A	–	B	D	D	B	B	–	A	A	A
Hydraulic oils (mineral oil-based)	D	D	A	A	B	A	A	C	A	–	A	A	A
Hydrazine (diamide, diazane)	A	A	B	D	B	D	–	C	D	–	D	B	C
Hydrobromic acid	A	A	D	D	D	D	D	D	C	–	A	A	A
Hydrobromic acid (40%)	A	A	D	–	B	D	D	D	C	–	A	A	A
Hydrochloric acid (cold) 37%	B	A	C	–	B	D	D	C	B	A	A	A	A
Hydrochloric acid (hot) 37%	D	C	D	–	D	D	D	D	C	B	B	A	–
Hydrocyanic acid	B	A	B	B	B	–	D	C	B	–	A	A	A
Hydrofluoric acid, anhydrous	D	C	D	–	D	D	D	D	D	–	D	A	C
Hydrofluoric acid, concentrated (cold)	D	C	D	–	D	C	D	D	D	A	D	A	–
Hydrofluoric acid, concentrated (hot)	D	D	D	–	D	D	D	D	D	–	D	A	C
Hydrogen gas	B	A	A	A	A	A	B	C	C	–	A	A	A
Hydrogen peroxide (90%)	D	B	D	B	D	–	D	B	B	A	B	A	A
Hydrogen sulphide (wet) cold	D	A	D	A	B	–	D	C	C	–	D	A	C
Hydrogen sulphide (wet) hot	D	A	D	D	C	–	D	C	C	–	D	A	C
Hydroquinone	B	B	C	D	D	–	D	–	B	–	B	B	A
Hypochlorous acid	B	B	D	D	D	–	D	–	–	–	A	A	–

I

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Iodine pentafluoride	D	D	D	D	D	D	D	D	D	–	D	B	C
Iodoform (triodomethane, antiseptic)	D	D	–	–	D	–	–	–	–	–	C	A	B
i-propylacetate	D	B	D	–	D	D	D	D	D	–	D	A	–
Iron (III) chloride (aqueous solution)	A	A	A	A	A	A	A	B	A	–	A	A	A
Iron (III) nitrate (aqueous solution)	A	A	A	A	A	A	A	C	A	–	A	A	A
Iron (III) sulphate (aqueous solution)	A	A	A	A	A	A	A	B	A	–	A	A	A
Isobutyl alcohol (isobutanol)	A	A	B	B	A	D	D	A	B	–	A	A	A
Isooctane	D	D	A	A	B	B	A	D	A	B	A	A	A
Isophorone	D	C	D	D	D	C	D	D	D	B	D	A	C
Isopropyl alcohol (isopropanol)	A	A	B	B	B	C	D	A	B	–	A	A	A
Isopropyl chloride	D	D	D	D	D	D	D	D	B	–	A	A	A
Isopropyl ether	D	D	B	B	C	B	C	D	C	D	D	A	C
Isopropylacetate	D	B	D	D	D	D	D	D	D	–	D	A	B

K

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Kerosene (lamp kerosene; DIN 51636)	D	D	A	A	B	A	A	D	A	A	A	A	A

L

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Kerosene (lamp kerosene; DIN 51636)	D	D	A	A	B	A	A	D	A	A	A	A	A
Kerosene (lamp kerosene; DIN 51636)	D	D	A	A	B	A	A	D	A	A	A	A	A
Kerosene (lamp kerosene; DIN 51636)	D	D	A	A	B	A	A	D	A	A	A	A	A
Kerosene (lamp kerosene; DIN 51636)	D	D	A	A	B	A	A	D	A	A	A	A	A
Kerosene (lamp kerosene; DIN 51636)	D	D	A	A	B	A	A	D	A	A	A	A	A
Kerosene (lamp kerosene; DIN 51636)	D	D	A	A	B	A	A	D	A	A	A	A	A
Kerosene (lamp kerosene; DIN 51636)	D	D	A	A	B	A	A	D	A	A	A	A	A
Kerosene (lamp kerosene; DIN 51636)	D	D	A	A	B	A	A	D	A	A	A	A	A
Kerosene (lamp kerosene; DIN 51636)	D	D	A	A	B	A	A	D	A	A	A	A	A
Kerosene (lamp kerosene; DIN 51636)	D	D	A	A	B	A	A	D	A	A	A	A	A
Kerosene (lamp kerosene; DIN 51636)	D	D	A	A	B	A	A	D	A	A	A	A	A
Kerosene (lamp kerosene; DIN 51636)	D	D	A	A	B	A	A	D	A	A	A	A	A
Kerosene (lamp kerosene; DIN 51636)	D	D	A	A	B	A	A	D	A	A	A	A	A

M

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Magnesium chloride (aqueous solution)	A	A	A	A	A	A	A	A	A	A	A	A	A
Magnesium hydroxide (aqueous solution)	B	A	B	B	A	D	D	–	–	–	A	A	A
Magnesium sulphate (aqueous solution)	B	A	A	–	A	–	D	A	A	–	A	A	A
Maize oil	D	C	A	A	C	A	A	A	A	–	A	A	A
Maleic acid (butenedioic acid)	C	B	D	D	C	–	D	–	–	–	A	A	A
Maleic anhydride (MSA)	C	B	D	D	C	–	D	–	–	–	D	A	B
Malic acid	C	B	A	A	C	–	D	B	A	–	A	A	A
Mercury	A	A	A	A	A	A	–	–	–	–	A	A	A
Mercury (III) chloride (aqueous solution)	A	A	A	A	A	–	–	–	–	–	A	A	A
Mesityl oxide	D	B	D	D	D	D	D	D	D	D	D	A	C
Methane	D	D	A	A	B	C	A	D	B	–	A	A	A

Methyl acetate (acetic acid methyl ester)	C	A	D	D	B	D	D	D	D	–	D	A	B
Methyl acrylate	D	B	D	–	B	D	D	D	D	–	D	A	C
Methyl alcohol (methanol)	A	A	A	A	A	D	D	A	A	A	D	A	A
Methyl bromide (bromomethane)	D	D	B	B	D	–	–	–	A	–	A	A	A
Methyl butyl ketone (propyl acetone)	D	A	D	D	D	D	D	C	D	–	D	A	B
Methyl cellosolve (methylene glycol ether)	D	B	C	C	C	D	D	D	D	A	D	A	B
Methyl chloride (monochloromethane)	D	C	D	D	D	D	D	D	B	–	B	A	A
Methyl ether (dimethyl ether)	D	D	A	A	C	–	D	A	A	–	D	A	B
Methyl ethyl ketone (MEK)	D	A	D	–	C	D	D	D	D	D	D	A	B
Methyl formate (methyl methanoate)	D	B	D	D	B	–	–	–	–	–	D	A	B
Methyl isobutyl ketone (MIBK)	D	B	D	D	D	D	D	D	D	D	D	A	B
Methyl methacrylate (MMA)	D	C	D	D	D	–	D	D	D	–	D	A	B
Methyl oleate	D	B	D	D	D	–	–	–	B	–	B	A	A
Methyl pentane	D	D	D	D	D	D	D	D	B	–	A	A	A
Methyl salicylate (salicyclin acid methyl ester)	C	B	D	–	D	–	–	–	–	C	B	A	A
Methylene chloride (dichloromethane)	D	C	D	–	D	D	D	D	B	B	B	A	B
Milk	A	A	A	A	A	D	D	A	A	A	A	A	A
Mineral oil	D	C	A	A	B	A	A	B	A	A	A	A	A
Monochlorobenzene	D	D	D	D	D	D	D	D	B	–	A	A	A
Monoethanolamine	B	A	D	–	D	D	D	B	D	–	D	A	B
Monomethyl aniline (MMA)	D	B	D	D	D	D	D	–	–	–	B	A	A
Monomethyl ether	D	D	A	–	C	–	D	A	A	–	D	A	A
Mustard gas	A	A	–	–	A	–	–	A	–	–	A	A	–
Monomethyl aniline (MMA)	D	B	D	D	D	D	D	–	–	–	B	A	A
Monomethyl ether	D	D	A	–	C	–	D	A	A	–	D	A	A
Mustard gas	A	A	–	–	A	–	–	A	–	–	A	A	–

N

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Naphtalene	D	D	D	D	D	B	–	D	A	A	A	A	A
Naphtha	D	D	B	B	C	B	B	D	B	–	A	A	A
Naphthenic acid	D	D	B	–	D	–	–	D	A	B	A	A	A
Natural gas	B	D	A	A	A	B	B	A	D	–	A	A	A
Neville Winthers acid	D	B	D	D	D	–	D	D	B	–	A	A	A
n-hexaldehyde	D	A	D	–	A	B	–	B	D	–	D	A	C
n-hexene-1	D	D	B	B	B	B	A	D	A	–	A	A	A
Nickel acetate (aqueous solution)	A	A	B	B	B	D	D	D	D	–	D	A	B
Nickel chloride (aqueous solution)	A	A	A	A	A	C	C	A	A	–	A	A	A
Nickel sulphate (aqueous solution)	B	A	A	A	A	C	D	A	A	–	A	A	A
Nitirc acid, red fumes	D	D	D	D	D	D	D	D	D	B	C	B	A
Nitric acid (concentrated)	D	D	D	D	D	D	D	D	C	B	B	A	A
Nitric acid (diluted)	D	B	D	–	B	C	D	B	B	B	A	A	A
Nitrobenzene	D	A	D	D	D	D	D	D	D	A	B	A	A
Nitrobenzene (petroleum ether)	D	D	A	A	B	B	A	D	A	–	A	A	–
Nitroethane	B	B	D	–	C	D	D	D	D	B	D	A	C
Nitrogen	A	A	A	–	A	A	A	A	A	A	A	A	A
Nitrogen tetroxicide	D	C	D	D	D	D	D	D	D	–	D	A	C
Nitromethane	B	B	D	D	B	D	D	D	D	–	D	A	C
n-octane	D	D	B	–	B	D	D	D	B	–	A	A	A
n-propylacetate (acetic acid propyl ester)	D	B	D	–	D	D	D	D	D	–	D	A	C

O

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
o-chlornaphtalene	D	D	D	–	D	D	D	D	B	–	A	A	A
Octa chlorotoluene	D	D	D	–	D	D	D	D	B	–	A	A	A
Octa decane	D	D	A	D	B	A	B	D	A	–	A	A	A
Octyl alcohol (octanol)	B	C	B	B	A	D	D	B	B	–	A	A	A
o-dichlorobenzene	D	D	D	–	D	D	D	D	B	–	A	A	A
Oleic acid	D	D	C	A	C	B	D	D	–	A	B	A	A
Olive oil	D	B	A	A	B	A	A	C	A	–	A	A	A
Oxalic acid (ethane diacide, clover acid)	B	A	B	B	B	–	–	B	A	–	A	A	A
Oxygen, (93–204°C)	D	C	D	D	D	D	D	B	D	–	B	A	–
Oxygen, cold	B	A	B	D	A	A	B	A	A	–	A	A	A
Ozone	D	A	D	D	C	A	B	A	B	A	A	A	A

P

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Paint	D	D	B	B	D	C	D	D	B	–	A	A	A
Paint (cellulose paint)	D	D	D	D	D	D	D	D	D	–	D	A	B
Paint thinner	D	D	D	D	D	D	D	D	D	D	D	A	B
Palmitic acid (n-hexadecanoic acid)	B	B	A	A	B	A	–	D	A	–	A	A	A
Paraffin oil (white oil)	D	D	A	A	B	A	A	D	A	–	A	A	A
p-cymene	D	D	D	–	D	D	D	D	B	–	A	A	A
Peanut oil	D	C	A	–	C	B	A	A	A	–	A	A	–
Perchloric acid	D	B	D	–	B	D	D	D	A	–	A	A	A
Petroleum gas, liquid (LPG)	D	D	A	A	B	A	C	C	C	–	A	A	A
Petroleum, < 121°C	D	D	A	–	B	B	B	B	B	–	A	A	A
Petroleum, > 121°C	D	D	D	–	B	D	D	D	D	–	B	A	–
Phenol (carbolic acid)	D	B	D	D	D	D	D	D	A	A	A	A	A
Phenylbenzene	D	D	D	D	D	D	D	D	B	–	A	A	A
Phenylethyl ether	D	D	D	D	D	D	D	D	D	–	D	A	B
Phenylhydrazine	A	B	D	–	D	D	D	–	–	–	B	A	B
Phoron (diisopropyliden acetone)	D	C	D	D	D	D	D	D	D	–	D	A	C
Phosphorus trichloride	D	A	D	D	D	–	–	–	A	–	A	A	A
Phosporic acid (20%)	B	A	B	–	B	A	–	B	B	–	A	A	A
Phosporic acid (45%)	C	A	D	–	B	A	–	C	B	A	A	A	A
Pickling solution	D	C	D	–	D	D	D	D	D	–	B	–	A
Picric acid (2,4,6-trinitrophenol)	B	B	B	–	A	B	–	D	B	–	A	A	A
Pinene	D	D	B	–	C	B	D	D	B	–	A	A	A
Piperidine (hexahydropyridine)	D	D	D	–	D	D	D	D	D	–	D	A	C
Plant oil	D	C	A	A	C	–	A	B	A	–	A	A	A
Plating solution for chrome	D	A	–	D	D	–	–	D	–	–	A	A	A
Plating solution for other metals	D	A	A	A	D	–	–	D	–	–	A	A	A
Polyvinyl acetate emulsion	B	A	–	–	B	–	–	–	–	–	–	–	–
Potassium acetate (aqueous solution)	A	A	B	–	B	D	D	D	D	A	D	A	C
Potassium chloride (aqueous solution)	A	A	A	A	A	A	A	A	A	A	A	A	A
Potassium chromate (aqueous solution)	B	A	A	A	A	B	A	A	A	–	A	A	A
Potassium copper cyanide (aqueous solution)	A	A	A	A	A	A	A	A	A	–	A	A	A
Potassium cyanide (aqueous solution)	A	A	A	A	A	A	A	A	A	–	A	A	A
Potassium hydroxide (aqueous solution)	B	A	B	B	B	D	D	C	C	A	D	A	A

P

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Potassium nitrate (aqueous solution)	A	A	A	A	A	A	A	A	A	A	A	A	A
Potassium sulphate (aqueous solution)	B	A	A	A	A	A	D	A	A	–	A	A	A
Propane	D	D	A	A	B	C	A	D	B	–	A	A	A
Propyl acetone (methyl butyl ketone)	D	A	D	D	D	D	D	C	D	–	D	A	B
Propyl alcohol (propanol)	A	A	A	A	A	D	D	A	A	A	A	A	A
Propyl nitrate	D	B	D	A	D	–	D	D	D	–	D	A	B
Propyline (propene)	D	D	D	D	D	D	D	D	B	–	A	A	A
Propyline oxide	D	B	D	D	D	D	D	D	D	–	D	A	D
Pyridine	D	B	D	D	D	–	D	D	D	–	D	A	C
Pyroligneous acid	D	B	D	D	B	D	D	–	D	–	D	–	C
Pyrroline	C	C	D	–	D	–	D	B	C	–	D	A	B

R

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Rapeseed oil	D	A	B	B	B	B	B	D	A	–	A	A	A

S

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Sal ammoniac (ammonium chloride)	A	A	A	A	A	A	A	B	A	–	A	A	A
Salicyclic acid (2-hydroxybenzoic acid)	A	A	B	B	A	–	–	–	A	–	A	A	A
Salt water	A	A	A	A	B	B	D	A	A	–	A	A	A
Silicate ester	D	D	B	B	A	A	–	D	A	–	A	A	A
Silicone grease	A	A	A	A	A	A	A	C	A	–	A	A	A
Silicone oil	A	A	A	A	A	A	A	C	A	–	A	A	A
Silver nitrate	A	A	B	B	A	A	A	A	A	–	A	A	A
Soap solution	B	A	A	A	B	C	D	A	A	–	A	A	A
Soda, crystal water anhydrous	A	A	A	A	A	–	–	A	A	–	A	A	A
Sodium acetate (aqueous solution)	A	A	B	B	B	D	D	D	D	–	D	A	A
Sodium bicarbonate (aqueous solution)	A	A	A	A	A	–	–	A	A	–	A	A	–
Sodium bisulphate (aqueous solution)	A	A	A	A	A	–	D	A	A	A	A	–	–
Sodium borate (aqueous solution)	A	A	A	A	A	–	–	A	A	A	A	A	A
Sodium chloride (aqueous solution)	A	A	A	A	A	A	–	A	A	A	A	A	A
Sodium cyanide (aqueous solution)	A	A	A	A	A	–	–	A	A	–	A	A	A
Sodium hydroxide (aqueous solution)	A	A	B	B	A	D	C	B	B	A	B	A	A
Sodium hypochlorite (aqueous solution)	D	B	B	B	A	D	D	B	B	A	A	A	A
Sodium metaphosphate (aqueous solution)	A	A	A	A	B	–	–	–	A	–	A	A	A
Sodium nitrate (aqueous solution)	B	A	B	–	B	–	–	D	–	A	A	A	A
Sodium perborate (aqueous solution)	B	A	B	B	B	–	–	B	A	–	A	A	A
Sodium peroxide (aqueous solution)	B	A	B	B	B	D	D	D	A	–	B	A	A
Sodium phosphate (aqueous solution)	A	A	A	A	B	A	A	D	–	A	A	A	A
Sodium silicate (aqueous solution)	A	A	A	A	A	–	–	–	–	A	A	A	A
Sodium sulphate (aqueous solution)	B	A	A	D	A	A	D	A	A	A	A	A	A
Sodium thiosulphate (aqueous solution)	B	A	B	–	A	A	D	A	A	–	A	A	A
Soya oil (soya bean oil)	D	C	A	A	B	B	A	A	A	–	A	A	A
Stearic acid (octadecanoic acid)	B	B	B	B	B	A	–	B	–	A	A	A	A
Styrene, monomer (phenylethylene)	D	D	D	D	D	C	D	D	C	B	B	A	A
Sucrose solution (cane sugar)	A	A	A	B	B	D	D	A	A	–	A	A	–

S

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Sulphite lye	B	B	B	–	B	–	D	D	B	–	A	A	A
Sulphur	D	A	D	D	A	–	D	C	A	–	A	A	A
Sulphur chloride (aqueous solution)	D	D	C	D	C	–	D	C	A	–	A	A	A
Sulphur dioxide (dry)	B	A	D	D	D	–	D	B	B	B	B	A	A
Sulphur dioxide (liquid under pressure)	D	A	D	D	D	–	D	B	B	–	B	A	–
Sulphur dioxide (wet)	D	A	D	D	B	–	D	B	B	–	B	A	A
Sulphur hexafluoride	D	A	B	B	A	–	D	B	B	–	A	B	B
Sulphur trioxide	B	B	D	D	D	–	D	B	B	–	A	A	A
Sulphuric acid (20% oleum)	D	D	D	B	D	D	D	D	D	A	A	A	A
Sulphuric acid (concentrated)	D	C	D	–	D	D	D	D	D	A	A	A	A
Sulphuric acid (diluted)	C	B	C	–	B	C	B	D	C	A	A	A	A
Sulphurous acid	B	B	B	B	B	C	D	D	–	–	C	A	B

T

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
Tannic acid (tannin)	A	A	A	A	A	A	D	B	–	–	A	A	A
Tar, bituminous	D	C	B	B	C	–	D	B	A	–	A	A	A
Tartaric acid	C	B	A	A	B	A	–	A	A	–	A	A	A
Terpineol	D	C	B	B	D	B	–	–	A	–	A	A	A
Tetra bromoethane	D	D	D	D	D	–	D	D	B	–	A	A	A
Tetrabromomethane (carbon tetrabromide)	D	D	D	–	D	–	–	D	B	–	A	A	A
Tetrachloroethylene (PER)	D	D	D	D	D	D	D	D	B	D	A	A	A
Tetraethyl lead	D	D	B	B	B	–	–	–	B	–	A	A	A
Tetrahydrofuran (THF)	D	C	D	D	D	C	D	D	D	D	D	A	C
Tetralin (tetrahydronaphthalene)	D	D	D	D	D	–	–	D	A	–	B	A	–
Thionyl chloride (sulphurous acid dichloride)	D	C	D	–	D	D	D	–	–	–	B	A	A
Tin chloride (aqueous solution)	A	A	A	A	A	–	–	B	A	–	A	A	A
Tin tetrachloride (aqueous solution)	A	A	A	A	B	–	–	B	A	–	A	A	A
Titanium tetrachloride	D	D	B	B	D	D	D	D	B	–	A	A	A
Toluene (methyl benzene)	D	D	D	D	D	D	D	D	B	D	B	A	A
Toluene diisocyanate (TDI)	D	B	D	D	D	–	D	D	D	–	D	A	C
Transformer oil	D	D	A	A	B	A	B	B	A	–	A	A	A
Triacetin (glycerin triacetate)	B	A	B	B	B	D	D	–	D	–	D	A	B
Tributoxyethyl phosphate	B	A	D	D	D	D	D	–	B	–	A	A	A
Tributyl mercaptan	D	D	D	–	D	–	D	D	C	–	A	A	A
Tributyl phosphate (TBP)	B	B	D	D	D	D	D	D	D	A	D	A	C
Trichloroacetic acid (TCA)	C	B	B	B	D	D	D	–	D	–	D	A	B
Trichloroethane	D	D	D	D	D	D	D	D	B	–	A	A	A
Trichloroethylene (trichloroethen, tri) (TCE)	D	D	D	C	D	D	D	D	B	D	A	A	A
Tricresyl phosphate (TCP)	D	D	D	D	C	D	D	C	B	A	A	A	A
Triethanolamine (TEA)	B	A	B	C	A	D	D	–	D	A	D	B	C
Triethylaluminium (aluminium triethyl)	D	C	D	–	D	D	D	–	–	–	B	A	A
Triethylborane	D	C	D	–	D	D	D	–	–	–	A	A	A
Trinitrotoluene (TNT)	D	D	D	D	B	–	D	–	B	–	B	A	A
Trioctyl phosphate	D	A	D	–	D	D	D	C	B	–	B	A	A
Tung oil (China wood oil)	D	C	A	A	B	C	–	D	B	–	A	A	–
Turbine oil	D	D	B	A	D	A	A	D	B	–	A	A	–

Medium	NR	EPDM	NBR	HNBR	CR	AU	ACM	VMQ	FVMQ	TFE/P	FKM	FFKM	ETP
T													
Turpentine	D	D	A	A	D	D	B	D	B	C	A	A	A
U													
Unsymmetrical dimethylhydrazine	A	A	B	B	B	–	–	D	D	–	D	B	C
V													
Vinegar	B	A	B	B	B	D	D	A	C	–	A	A	A
Vinyl chloride (chloroethylene, chloroethene)	D	D	D	–	D	D	D	–	–	B	A	A	A
W													
Waste water (in accordance with DIN 4045)	B	B	A	A	B	D	D	B	A	–	A	A	A
Water	A	A	A	A	A	C	D	A	A	A	A	A	A
Water vapour (< 149°C)	D	A	D	D	C	D	D	C	D	A	D	A	A
Water vapour (> 149°C)	D	C	D	D	D	D	D	D	D	A	D	A	–
Whisky and wine	A	A	A	A	A	B	D	A	A	–	A	A	A
X													
Xylene (xylene, dimethyl benzene)	D	D	D	D	D	D	D	D	A	C	A	A	A
Xylidine (amino xylene, dimethylaniline)	C	B	C	C	C	D	D	D	D	–	D	A	C
Z													
Zeolite	A	A	A	A	A	–	–	–	A	–	A	A	A
Zinc acetate (aqueous solution)	A	A	B	B	B	D	D	D	D	–	D	A	B
Zinc chloride (aqueous solution)	A	A	A	A	A	A	D	A	A	A	A	A	A
Zinc sulphate (aqueous solution)	B	A	A	A	A	–	D	A	A	A	A	A	A

Certifications / Approvals

Special requirements to elastomer sealing materials.

Test certificate/ Regulation	Application/Country	Criteria/Standards	COG materials of the following ASTM groups
ACS approval French Standard NF XP P41-250. Part 1-3	Plastic in contact with drinking water *Country of origin: France*	Testing of formulation based on "Synoptic Documents" – storage test (microbe test)	**EPDM**
AED test	Non-metallic materials in oil and gas production	ISO 23936-2	**FKM**
BAM test report *(Recommendation made by Germany´s Bundesanstalt für Materialforschung und -prüfung)*	Seals for use in fittings and equipment for gaseous oxygen *Country of origin: Germany*	Regulation B 7 "oxygen" of the professional association for the chemical industry	**FKM**
BfR Recommendation (Federal Institute for Risk Assessment)	Plastics in contact with foods *Country of origin: Germany*	XV recommendation for silicone materials XXI recommendation for nature and synthetic rubbers	**VMQ**
Biological assessment of medical products	Applications in the medical and pharmaceutical sector	DIN EN ISO 10993	**EPDM, FKM**
DVGW release for gas (German Association for Gas and Water)	Sealing material made of elastomers for gas appliances and gas plants *Country of origin: Germany*	DIN EN 549	**FKM, HNBR, NBR**
DVGW release for gas (German Association for Gas and Water)	Sealing material made of elastomers for gas supply lines and gas pipelines *Country of origin: Germany*	DIN EN 682	**FKM, NBR**
DVGW release for water (German Association for Gas and Water)	Materials and components for drinking water: Seal materials for drinking water plants *Country of origin: Germany*	DVGW W 534	**EPDM**
DVGW W270 recommendation (German Association for Gas and Water)	Materials in drinking water applications *Country of origin: Germany*	Microbiologic testing; proliferation of microorganisms on materials	**EPDM, NBR**
FDA regulation (Food and Drug Administration)	Materials for use in food and pharmaceutical industries *Country of origin: USA*	FDA 21. CFR Part 177.2600 (ingredients, compatibility tests)	**EPDM, EPM, FEPM, FKM, FFKM, HNBR, NBR, VMQ**

Test certificate/ Regulation	Application/Country	Criteria/Standards	COG materials of the following ASTM groups
KTW-BWGL, Annex D* (successor to the Elastomer Guideline) **During the transition period, a test report in accordance with the Elastomer Guideline can be used*	Seals in drinking water installation *Country of origin: Germany*	Assessment of the hygienic suitability of elastomers in contact with drinking water	**EPDM, NBR**
NACE acid gas test	Elastomers in contact with natural gases containing H_2S *Country of origin: USA*	Nace TM 0187	**FKM**
Standard for material requirements for use in water	Material requirements for pipeline seals	DIN EN 681-1	**EPDM**
NORSOK test	Non-metallic materials in oil and gas production	NORSOK Standard M-710. Annex A and Annex B	**FKM, FFKM, HNBR**
NSF release (National Sanitation Foundation)	Food and sanitary facilities *Country of origin: USA*	NSF standards and criteria	**EPDM, NBR**
USP certification (United States Pharmacopeia, USA)	Use in medical and pharmaceutical industries *Country of origin: USA*	Varying testing requirements: USP Class I to VI Chapter 87 'Test for cytotoxicity', Chapter 88 'Biological reactivity test in vivo'	**EPDM, FKM, FFKM, VMQ**
WRAS release (Water Regulations Advisory Scheme)	Plastics in contact with drinking water *Country of origin: Great Britain*	British Standard BS 6920	**EPDM, NBR**
3-A Sanitary Standard (3-A Sanitary Standard Inc.)	Materials for use in hygienic dairy and food industry plants *Country of origin: USA*	3-A Sanitary Standards and criteria, Class I to IV	**EPDM, FKM, FFKM, NBR, VMQ**

The table above only provides a sample of all our certifications and approvals. Extensive up-to-date information can be found at www.cog.de/en.

The ISO 3601 standard

The ISO 3601 standard currently consists of 5 parts:

- **ISO 3601-1**
  "Inside diameters, cross-sections, tolerances and designation codes"
- **ISO 3601-2**
  "Housing dimensions for general applications"
- **ISO 3601-3**
  "Form and surface deviations"
- **ISO 3601-4**
  "Back-up rings"
- **ISO 3601-5**
  "Specification of elastomeric metarials for industrial applications"

Permissible deviations for the inside diameter of O-rings in accordance with ISO 3601, Class B

The exact tolerance levels based on ISO 3601. Class B for O-rings with reference to general industrial applications can be calculated using the following formula:

Formula: $\Delta d_1 = \pm [(d_1^{0.95} \times 0.009) + 0.11]$

Permissible deviations for O-ring cross-sections according to ISO 3601, Class B

The following table gives an overview of dimensions and permissible tolerances.

For general industrial applications (Size code 001 – 475)

cross-section d_2 (mm)	1.02	1.27	1.52	1.78	2.62	3.53	5.33	6.99
permissible deviations ±	0.08	0.08	0.08	0.08	0.09	0.10	0.13	0.15

All measurements in mm.

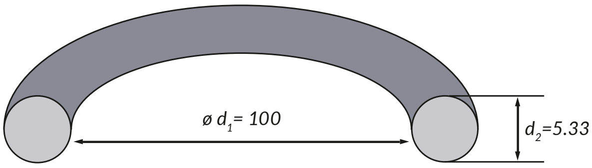
For general industrial applications (Not standardized O-rings)

cross-section d_2 (mm)	$0.80 < d_2 \leq 2.25$	$2.25 < d_2 \leq 3.15$	$3.15 < d_2 \leq 4.50$	$4.50 < d_2 \leq 6.30$	$6.30 < d_2 \leq 8.40$
permissible deviations ±	0.08	0.09	0.10	0.13	0.15

All measurements in mm.

Example

Calculation of **tolerances**
on the O-ring 100 mm x 5.33 mm



Deviation for the inside diameter Δd_1 using the following formula:
$\Delta d_1 = \pm [(d_1^{0.95} \times 0.009) + 0.11] = \pm [(100^{0.95} \times 0.009) + 0.11] = \pm 0.825$ mm

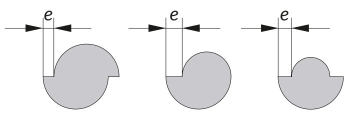
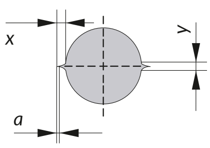
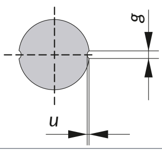
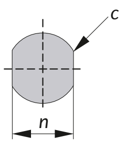
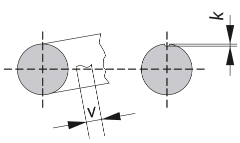
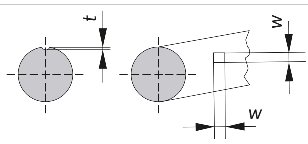
*With an inner diameter of 100 mm, the tolerance according to the formula is = **± 0,825 mm***

Deviation for the cross-section Δd_2
Please compare table of permissible deviations on page 52.

*Δd_2 = 5,33 mm ± **0,13 mm***

Result: O-ring 100 mm ± 0.825 mm x 5.33 mm ± 0.13 mm

Form and surface deviations for O-rings in accordance with ISO 3601, Characteristic N

Type of deviation	Schematic representation (in cross-section)	Dimensions	>0.8 ≤2.25	>2.25 ≤3.15	>3.15 ≤4.50	>4.50 ≤6.30	>6.30 ≤8.40
Offset and form deviation		e	0.08	0.10	0.13	0.15	0.15
Combined, burr		x	0.10	0.12	0.14	0.16	0.18
		y	0.10	0.12	0.14	0.16	0.18
		a	no more than 0.07 mm				
Indentation		g	0.18	0.27	0.36	0.53	0.70
		u	0.08	0.08	0.10	0.10	0.13
Deburring area		n	Deburring ist allowed if the minimum diameter n is not greater than d_2.				
Row lines, radial expansion, not permissible		v	1.50	1.50	6.50	6.50	6.50
		k	0.08	0.08	0.08	0.08	0.08
Recesses, indentation points		w	0.60	0.80	1.00	1.30	1.70
		t	0.08	0.08	0.10	0.10	0.13

All measurements in mm.

Index of key words

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