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Sealux – Oring

General Overview

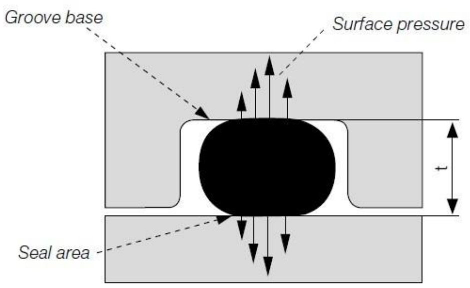
For several years, we have developed strong expertise in the design and development of O-rings. This rubber component is an efficient and cost-effective sealing element for many applications.

Our O-rings are manufactured in accordance with standards such as AS568, BS 1806, and BS ISO 3601-1, as well as in custom designs. Thanks to our extensive stock and wide range of tooling, we are able to supply a large number of O-rings within very short lead times.

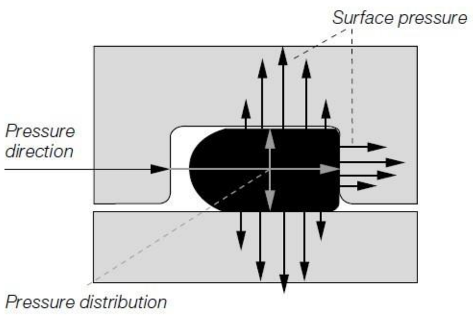
For more specific requirements, we are also able to provide custom-made O-rings or molded parts.

Operating Principle of the O-Ring

The O-ring is installed in a groove with a depth smaller than the cross-section of the O-ring in order to create an initial compression. The deformation of the elastomer generates a force, due to its elasticity, against the groove walls, thereby ensuring fluid sealing at low pressure. O-rings are used in two types of applications: static applications and dynamic applications, which are more demanding.



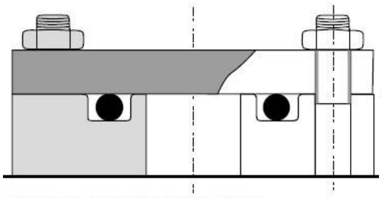
Compressed O-Ring in installation space without pressure



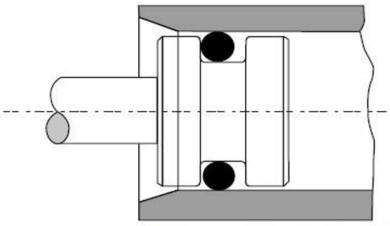
Compressed O-Ring in installation space under pressure

In general, for static applications, an initial compression rate of 15 to 30% is recommended, whereas for dynamic applications (hydraulic, pneumatic) it typically ranges from 6 to 20%. As the groove depth is determined by this compression rate, the groove width must be adapted to accommodate the elliptical shape of the O-ring after compression and to allow the fluid to enter the groove so that uniform pressure can be applied to the O-ring. The main effect to be avoided is overfilling of the groove. It is therefore commonly accepted that a groove fill of less than 85% is optimal, leaving sufficient space to accommodate thermal expansion or swelling caused by contact with the medium.

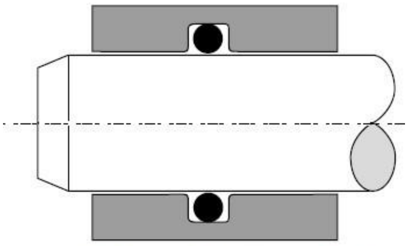
The table below summarizes some groove dimensions for static and dynamic applications.



Flange seals / axial sealing



Piston seals / radial sealing



Rod seals / radial sealing

Below is the table showing standard compression values according to O-ring cross-sections:

Static Application (flange groove)			**Dynamic Application (Hydraulic)**		
O-ring cross-section	**Groove depth**	**Groove width (without BAE)**	**O-ring cross-section**	**Grooce depth**	**Groove width (without BAE)**
1.5	1.15	2.1	1.5	1.3	2.1
1.78	1.4	2.4	1.78	1.55	2.4
2	1.65	2.8	2	1.75	2.8
2.4	1.75	3.2	2.4	2.05	3.2
2.5	2.05	3.3	2.5	2.2	3.3
2.62	2.2	3.6	2.62	2.35	3.6
3	2.3	4.1	3	2.6	4.1
3.5	2.9	4.8	3.5	3.15	4.8
3.53	2.9	4.8	3.5	3.15	4.8
4	3.4	4.8	4	3.5	4.8
4.5	3.8	6	4.5	4	5.9
5	4.2	6.7	5	4.5	6.5
5.33	4.4	7.1	5.33	4.7	7.1
5.7	4.45	7.6	5.7	5.05	7.6
6	5.1	7.9	6	5.4	7.9
6.99	6	9.4	6.99	6.3	9.5
8	6.8	10.6	8	7.15	10.8

8.4	6.65	11	8.4	7.6	11.2
9	7.6	12.1	9	8.1	12.4
10	8.5	13.3	10	9	13.9

Groove top radius : 0.3mm (tore < 3mm), 0.6mm (3mm ≤ tore < 5.5mm), 1mm (5.5mm ≤ tore)
Groove top radius : 0.2mm

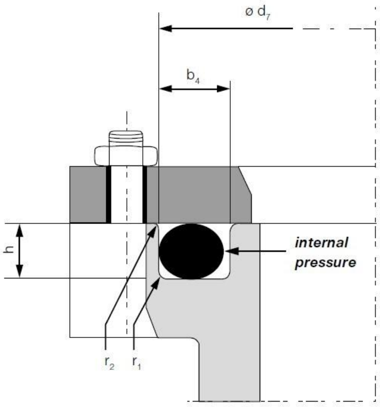
Selection of O-Ring Diameter

Static application

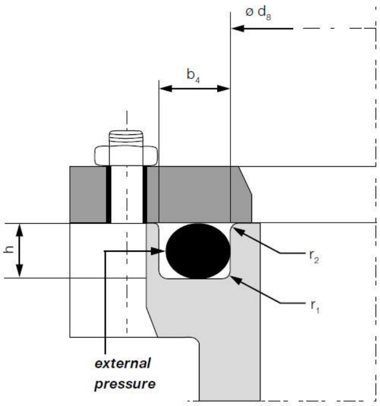
For installations with internal pressure, an O-ring with an outside diameter equal to or slightly larger (0 to 3%) than the groove diameter should be selected, so that the O-ring is slightly compressed on its diameter.

For installations with external pressure, an O-ring with an inside diameter equal to or slightly smaller (0 to 3%) than the groove diameter should be selected, so that the O-ring is slightly stretched. For a given inside diameter, increasing the cross-section results in longer seal service life, improved resistance to twisting, and reduced sensitivity to tolerances during tightening. The table below shows indicative limits of inside diameter as a function of standard O-ring cross-sections.

O-ring cross-section (mm)	1.87	2.62	3.53	5.33	6.99
Inside diameter (mm)	<20	<40	<200	<400	>400



Flange seal – internal pressure



Flange seal – external pressure

Dynamic application

For use of the O-ring as a piston seal, an O-ring with an inside diameter slightly smaller (1–6%) than the inside diameter of the groove on the rod should be selected, so that the O-ring is installed under slight tension.

For use of the O-ring as a rod seal, an O-ring with an outside diameter slightly larger (1–3%) than the outside diameter of the groove should be selected, so that the O-ring is installed under slight compression.

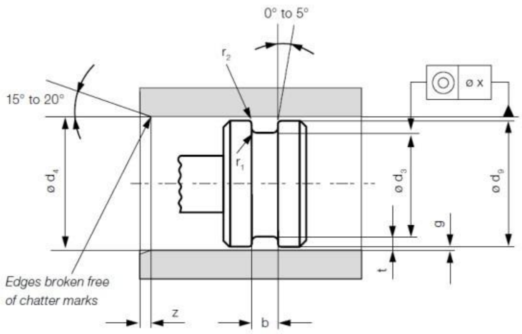
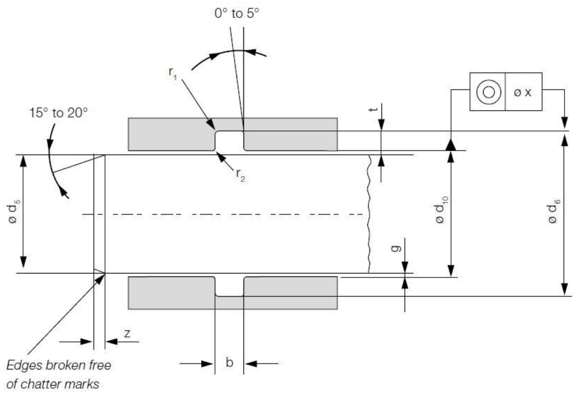


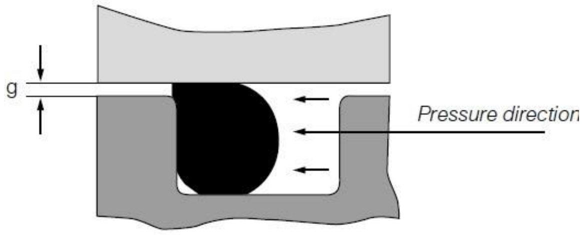
Illustration of the installation space in a radial piston seal



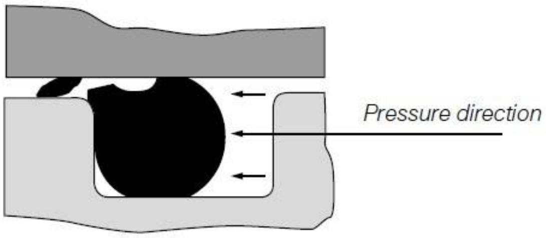
High-pressure application

When the pressure is too high, the seal may be damaged by it (extrusion phenomenon) and no longer perform its sealing function. To prevent this issue, two solutions can be considered. First, the hardness of the O-ring, which is generally 70 Shore A, can be increased to 90 Shore A (recommended when the pressure exceeds 63 bar). Second, one or two anti-extrusion back-up rings (BAE) with a higher hardness than the O-ring can be installed. These rings, generally made of PTFE or PEEK, have very precise dimensions and act as a barrier between the O-ring and the mechanical gap/clearance. They are strongly recommended when the pressure exceeds 100 bar (up to 400 bar).

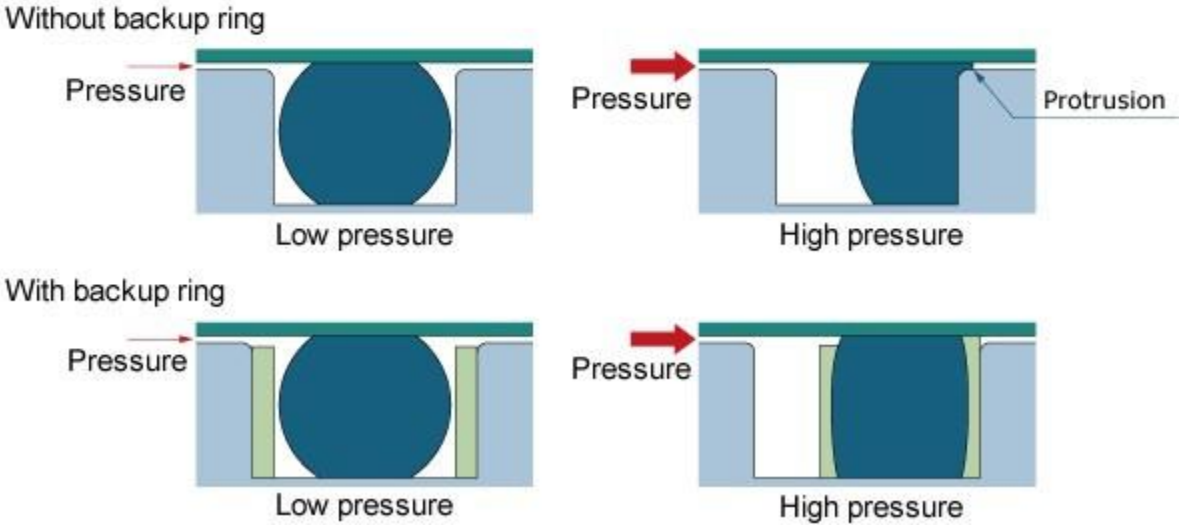
O-ring cross-section (mm)	Back-up ring thickness (mm)
1.87	1.5
2.62	1.5
3.53	1.5
5.33	1.8
6.99	2.6



O-Ring behaviour under pressure



Extruded O-Ring



O-ring cross-section (mm)	< 2	2 -> 3	3 -> 5	5 -> 7	➢ 7
O-ring hardness 70 shore A					
Pressure (bar)	**Mechanical clearance (mm)**				
≤ 35	**0.08**	**0.09**	**0.1**	**0.13**	**0.15**
≤ 70	**0.05**	**0.07**	**0.08**	**0.09**	**0.1**
≤ 100	**0.03**	**0.04**	**0.05**	**0.07**	**0.08**
O-ring hardness 90 shore A					

Pressure (bar)	Mechanical clearance (mm)				
≤ 35	0.13	0.15	0.2	0.23	0.25
≤ 70	0.1	0.13	0.15	0.18	0.2
≤ 100	0.07	0.09	0.1	0.13	0.15
≤ 140	0.05	0.07	0.08	0.09	0.1
≤ 175	0.04	0.06	0.07	0.08	0.09
≤ 210	0.03	0.04	0.05	0.07	0.08
≤ 350	0.020	0.03	0.03	0.04	0.04

Elastomers

Below is a non-exhaustive list of the different elastomers available. Each material has its own specific characteristics (temperature resistance, chemical resistance, mechanical properties).

Temperature :

Three types of temperature limits must be considered when selecting the material:

Minimum temperature :

The temperature at which the elastomer loses its elasticity and mechanical properties (tensile strength, etc.), known as the glass transition temperature. This process is reversible if the temperature increases again.

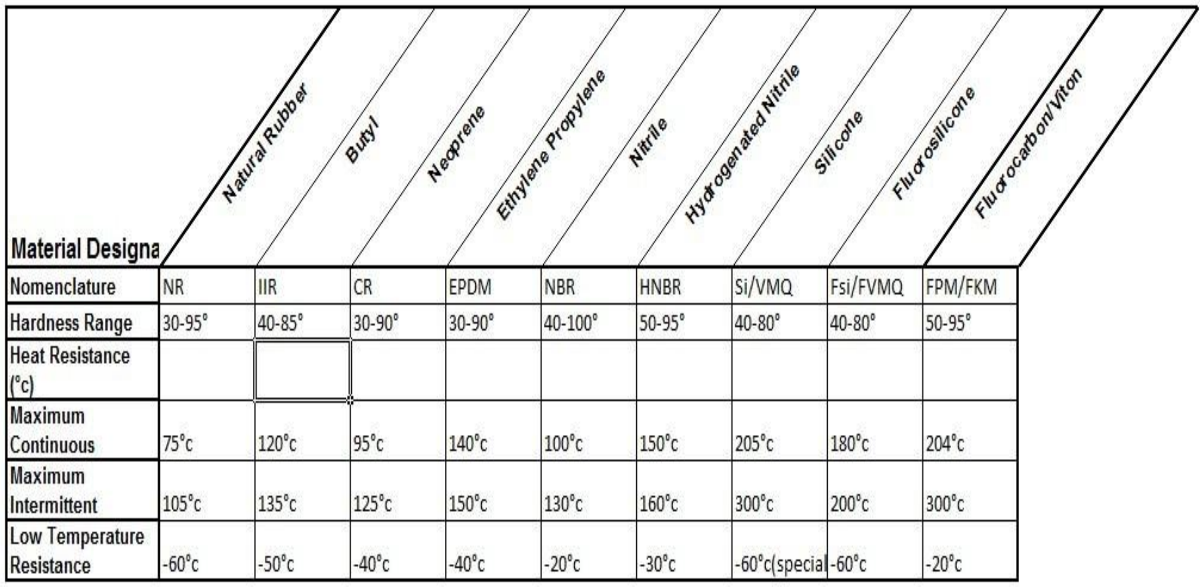
Maximum temperature :

The temperature at which the elastomer breaks down or cracks if it is exposed for too long. This process is irreversible.

Peak temperature :

The maximum temperature to which an elastomer can be exposed for a short period without being damaged and while retaining its physical properties.

Important note: Exposure temperature limits depend on the type of medium (air, water, oil, etc.).



Material Designa	*Natural Rubber*	*Butyl*	*Neoprene*	*Ethylene Propylene*	*Nitrile*	*Hydrogenated Nitrile*	*Silicone*	*Fluorosilicone*	*Fluorocarbon/Viton*
Nomenclature	NR	IIR	CR	EPDM	NBR	HNBR	Si/VMQ	Fsi/FVMQ	FPM/FKM
Hardness Range	30-95°	40-85°	30-90°	30-90°	40-100°	50-95°	40-80°	40-80°	50-95°
Heat Resistance (°c)									
Maximum Continuous	75°c	120°c	95°c	140°c	100°c	150°c	205°c	180°c	204°c
Maximum Intermittent	105°c	135°c	125°c	150°c	130°c	160°c	300°c	200°c	300°c
Low Temperature Resistance	-60°c	-50°c	-40°c	-40°c	-20°c	-30°c	-60°c(special	-60°c	-20°c

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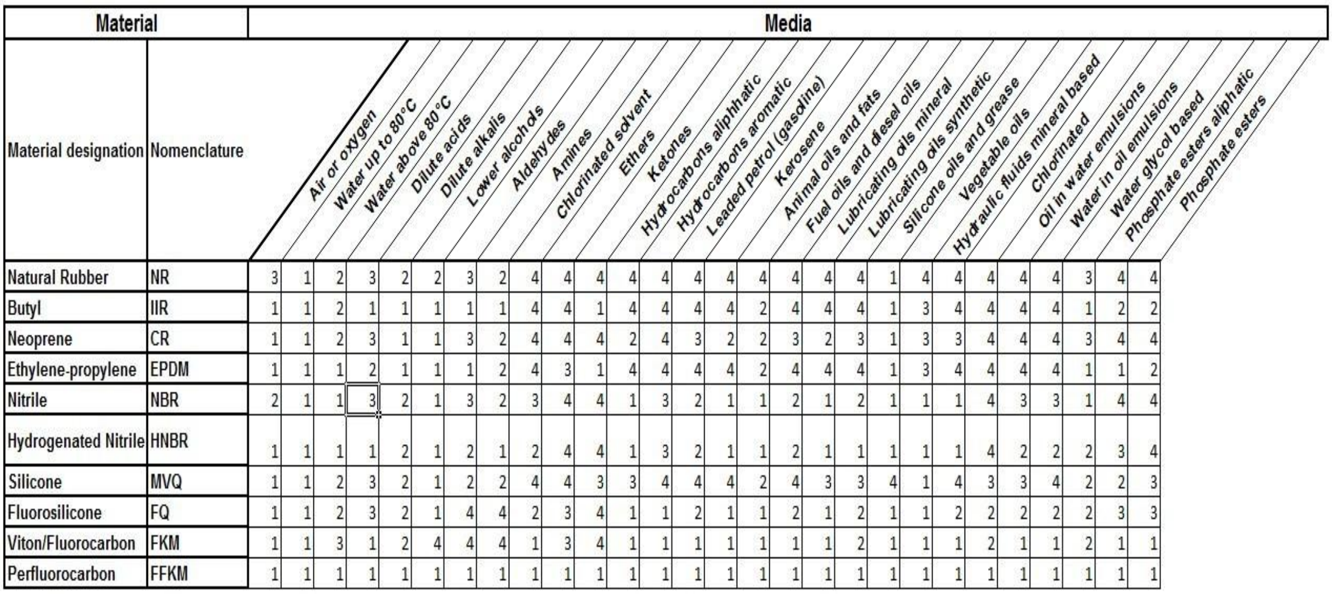
In addition to temperature, the chemical compatibility of the elastomer must be considered when selecting materials. Chemical incompatibility can lead to two types of changes in the seal. First, physical changes, causing the seal to swell or shrink and thus no longer be able to perform its sealing function—either because it is mechanically damaged by its housing (for example, cracking due to over-compression) as a result of swelling, or because it no longer provides sufficient pressure against the sealing surfaces due to shrinkage. Second, chemical changes in the elastomer's structure itself (for example, the breaking of covalent bonds between polymer chains) can cause the elastomer to become rigid or brittle, lead to the appearance of cracks, and result in a loss of elasticity.

To ensure optimal sealing performance, the correct material must be selected based on elastomer chemical compatibility charts (see below).



Material		Media																											
Material designation	Nomenclature	Air or oxygen	Water up to 80°C	Water above 80°C	Dilute acids	Dilute alkalis	Lower alcohols	Aldehydes	Amines	Chlorinated solvent	Ethers	Ketones	Hydrocarbons aliphhatic	Hydrocarbons aromatic	Leaded petrol (gasoline)	Kerosene	Animal oils and fats	Fuel oils and diesel oils	Lubricating oils mineral	Lubricating oils synthetic	Silicone oils and grease	Vegetable oils	Hydraulic fluids mineral based	Chlorinated	Oil in water emulsions	Water in oil emulsions	Water glycol based	Phosphate esters aliphatic	Phosphate esters
Natural Rubber	NR	3	1	2	3	2	2	3	2	4	4	4	4	4	4	4	4	4	4	4	1	4	4	4	4	4	3	4	4
Butyl	IIR	1	1	2	1	1	1	1	1	4	4	1	4	4	4	4	2	4	4	4	1	3	4	4	4	4	1	2	2
Neoprene	CR	1	1	2	3	1	1	3	2	4	4	4	2	4	3	2	2	3	2	3	1	3	3	4	4	4	3	4	4
Ethylene-propylene	EPDM	1	1	1	2	1	1	1	2	4	3	1	4	4	4	4	2	4	4	4	1	3	4	4	4	4	1	1	2
Nitrile	NBR	2	1	1	3	2	1	3	2	3	4	4	1	3	2	1	1	2	1	2	1	1	1	4	3	3	1	4	4
Hydrogenated Nitrile	HNBR	1	1	1	1	2	1	2	1	2	4	4	1	3	2	1	1	2	1	1	1	1	1	4	2	2	2	3	4
Silicone	MVQ	1	1	2	3	2	1	2	2	4	4	3	3	4	4	4	2	4	3	3	4	1	4	3	3	4	2	2	3
Fluorosilicone	FQ	1	1	2	3	2	1	4	4	2	3	4	1	1	2	1	1	2	1	2	1	1	2	2	2	2	2	3	3
Viton/Fluorocarbon	FKM	1	1	3	1	2	4	4	4	1	3	4	1	1	1	1	1	1	1	2	1	1	1	2	1	1	2	1	1
Perfluorocarbon	FFKM	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Other phenomena likely to damage the O-ring

Rapid gas decompression :

The extrusion phenomenon illustrated above is not the only pressure-related mechanism that can damage a seal. When pressure decreases rapidly, a significant pressure differential is created between the gas contained inside the seal (due to gas diffusion into the seal / permeability) and the pressure outside the seal (ambient pressure). This pressure differential causes the gas trapped inside the seal to expand rapidly out of the O-ring. If the physical strength of the seal is not sufficient to withstand this rapid expansion, cracks and/or blisters may appear in the O-ring. The severity of this phenomenon is influenced by the type of elastomer (permeability), the magnitude of decompression, the type of gas, temperature, and the O-ring cross-section.

Failure due to over-compression

In the event of excessive tightening, swelling, or excessive thermal expansion, cracking may occur in the seal. This crack appears in a plane parallel to the clamping force and renders the seal ineffective.

Shaving (shearing) effect (Dynamic application):

This phenomenon occurs when the O-ring is subjected to continuous pressure in a sharp-edged groove (see groove top radius). If the O-ring rotates within the groove, the outer layer of the O-ring may be cut in the mechanical clearance, resulting in a shaving (shearing) effect.

Diesel effect (dynamic):

This phenomenon occurs when air is trapped in a double-acting piston and mixes with the oil. During high-frequency cycles and rapid pressure increases, this air/oil mixture can self-ignite (rapid pressure increase → rapid temperature rise). If this phenomenon occurs near the seal, the O-ring may be damaged by melting of the elastomer.

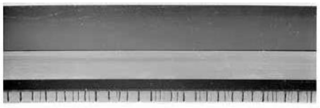
Lack of lubrication (dynamic) :

This phenomenon occurs when the rod stroke is too short relative to the seal contact surface (a minimum stroke with a ratio of 2.5 times the friction surface is recommended). In this case, part of the seal (on the non-pressurized side) operates dry, and abrasion in this area can damage the seal. In addition, abrasion residues are pushed to the bottom of the groove and may cause the seal to stick and/or create a non-uniform contact surface, thereby compromising sealing performance. For cylinders with short strokes, it is important to select a seal with a small contact surface.

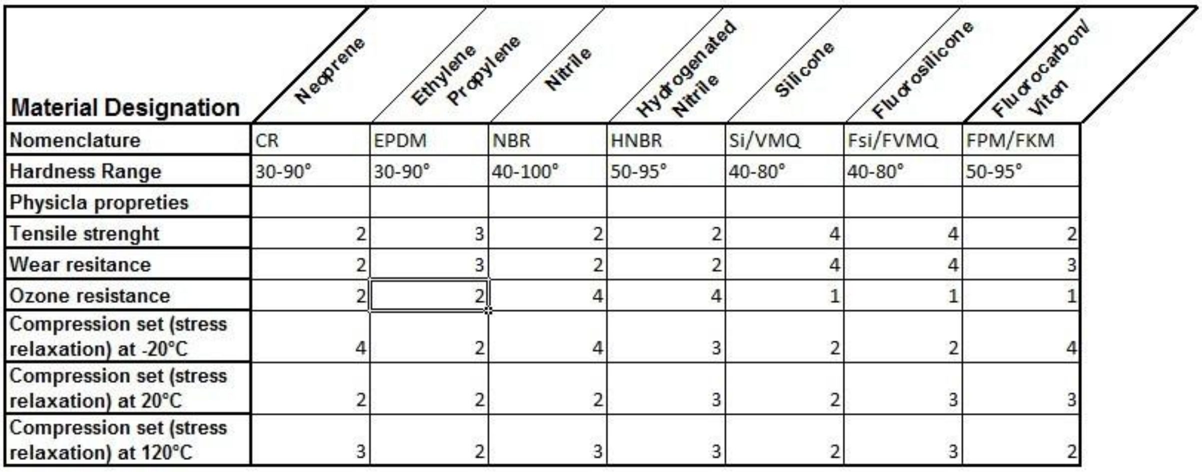
Pumping effect (dynamic)

This phenomenon occurs when, in a double-acting cylinder, pressure is trapped in the cavity located between the two piston seals. This trapped pressure creates a constant load on both seals, increasing wear and the risk of extrusion. To prevent this effect, it is recommended to use at least one single-acting seal (≠ O-ring) to allow pressure to be relieved.

Mechanical wear :

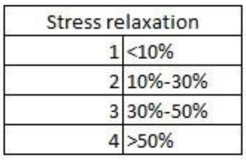


Wear and abrasion can be caused by dynamic movement or by an external environment in contact with the seal that is abrasive. Wear resulting from movement is characterized by markings in the direction of motion (axial for piston and rod seals, circumferential for rotary movements). Abrasion can also generate heat on the O-ring and cause cracking on the contact surface. One solution to this problem is a PTFE coating.



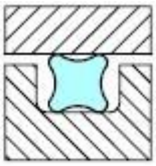
Material Designation	Neoprene	Ethylene Propylene	Nitrile	Hydrogenated Nitrile	Silicone	Fluorosilicone	Fluorocarbon/ Viton
Nomenclature	CR	EPDM	NBR	HNBR	Si/VMQ	Fsi/FVMQ	FPM/FKM
Hardness Range	30-90°	30-90°	40-100°	50-95°	40-80°	40-80°	50-95°
Physicla propreties							
Tensile strenght	2	3	2	2	4	4	2
Wear resitance	2	3	2	2	4	4	3
Ozone resistance	2	2	4	4	1	1	1
Compression set (stress relaxation) at -20°C	4	2	4	3	2	2	4
Compression set (stress relaxation) at 20°C	2	2	2	3	2	3	3
Compression set (stress relaxation) at 120°C	3	2	3	3	2	3	2

Propriétés mecaniques	
1	Excellent
2	Bon
3	Moyen
4	Faible

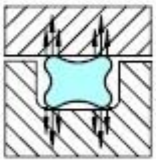


Stress relaxation	
1	<10%
2	10%-30%
3	30%-50%
4	>50%

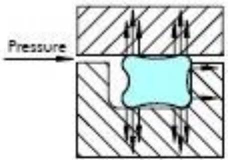
Quad ring



In dynamic applications, the O-ring is sometimes replaced by a Quad-Ring. The Quad-Ring features an "X"-shaped profile, with its four rounded lobes acting as sealing lips. The main advantages of the Quad-Ring are:



- **It can be installed in narrow grooves where space is limited.**
- **It provides improved lubrication by retaining a lubricant reservoir between the two sealing lips.**
- **It also helps prevent the twisting problem that can occur during the installation of certain O-rings.**



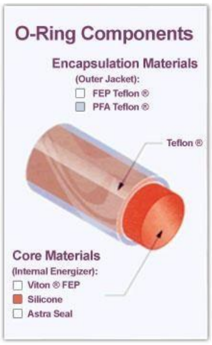
These four lobes provide superior sealing performance and make it possible to locate the seal's "parting line" not on the sealing surface (as in the case of an O-ring) but in the groove between the lobes.

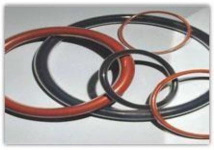
Like the O-ring, the Quad-Ring can also be used as a rotary seal when space is limited. In this case, in order to maintain acceptable friction forces and thus maximize seal service life, good lubrication, a hardness greater than 70 Shore A, and low compression (±5%) are essential (seal outer diameter > groove outer diameter). The maximum acceptable rotational speed for this type of seal is 4 m/s (depending on pressure, up to 150 bar with back-up rings).

FEP O-rings

These O-rings consist of an elastomer core and a Teflon (PTFE) jacket (≠ PTFE coating). They are used when the chemical medium is too aggressive for elastomers (⇒ Teflon jacket) and when the seal must retain a certain elasticity to seal the fluid (⇒ elastomer core).

Comparaison of encapsulated O-rings versus other alternatives:





Alternatives	Advantages of the encapsulated O-ring compared to the alternative
PTFE massif	Similar chemical resistance, no creep, and can be used with cold fluids
Enveloppe PTFE	Complete PTFE encapsulation of the elastomer prevents chemical attack on the elastomer
Perfluoroelastomer (FFKM)	Comparable sealing performance with lower chemical and temperature resistance than FFKM, offering a more economical solution

Materials:

Elastomer core :

Viton® (FKM) : The most commonly used, as it offers the best compression set performance and good chemical resistance.

Silicone (VMQ) : Less expensive than FKM and capable of ensuring sealing performance at low temperatures.

Teflon jacket:

FEP (Fluoroethylene Propylene): Standard material.

PFA (perfluoroalkoxy) : Better abrasion resistance than FEP, used with silicone cores for high-temperature applications (up to 260°C).

Jacket thickness:

O-ring cross-section	1.78	2.62	3.53	5.33	6.99
Jacket thickness (mm)	0.12	0.15	0.2	0.3	0.35

Certification

Most materials are available in food-grade quality (FDA approval).

Some materials such as PTFE, FEP, and PFA are also approved to USP Class VI for pharmaceutical processes.