O-RINGS

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Introduction

The sealing effect of an O-ring is based on the fact that elastomers (rubber) type materials are easily deformed whilst only being slightly compressed.

The applications for O-rings are amongst others

- hydraulic and pneumatic cylinders
- sanitary and heating installations
- chemical and petrochemical plants

These applications can be distinguished in static and dynamic applications:

Static applications under pressure

As a static seal, O-rings can be found in flange connections, cover seals, under bolts, as valve seats, etc. With the correct groove size it is possible to seal extremely high pressures, in excess of 1000 bar.

Static applications in vacuum

The use of O-ring seals in a high vacuum requires special demands on the finish of the grooves and the O-ring material selection (elastomer gas tightness). Generally the grooves must be designed so the O-ring's volume completely fills the groove. Machining of the grooves should be more precise and with tighter tolerances. We can assist you with the design if required.

Axial dynamic applications

This common use occurs in hydraulic and pneumatic cylinders. The operating conditions may vary widely making it difficult to indicate fixed limits for pressure, rubbing speed ,etc. The graph below illustrates the relationship between speed, pressure and hardness of the O-rings to be used. This graph may be used as a guideline.

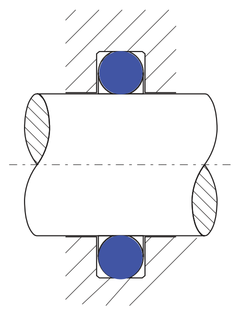
Rotating and oscillating

O-rings are well suited for sealing non-continuous reciprocally rotating parts, such as valve rods, hose connectors and the like. The use of O-rings in continuously rotating environments is very limited. If the m/sec. space available does not allow another solution, an O-ring seal may be necessary but provided the speed does not exceed 5 m/sec. The medium must also provide lubricating properties while all groove sizes must meet the requirements. In those cases only very low pressures can be sealed.

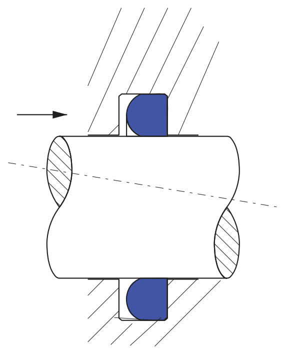
* Under pulsating pressures the O-ring seal must be considered a dynamic seal

The sealing effect in details

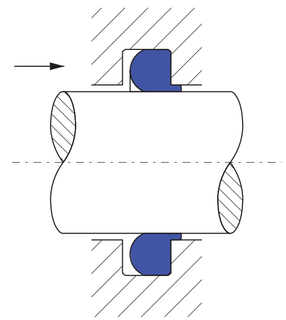
An O-ring is fitted under apre-stress whereby a seal is created at low pressure



At increased pressure the O-ring is deformed further and stretches in the direc-tion of the gap to be sealed, resulting in a seal.



The gap must be kept to a minimum to prevent extru-sion and damage to the O-ring. In some cases the use of backup rings is recommended.



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Materials and types of O-rings

O-rings are made from virtually all elastomers, i.e. synthetic rubbers, from PTFE and, for some applications, from a combination of different materials, such as our TV, TS, PV and PS O-rings. Best known and most widely used are O-rings made of NBR (nitrile rubber). Its excellent oil resistant qualities are combined with superior mechanical properties. The special requirements of the chemical and food industries were and are at the origin of the development of a large variety of materials and types The table below offers a summary of the general properties of widely used O-ring materials. The table on the next page illustrates the types of O-rings with their main properties and chemical resistance limitations.

properties	NR	SBR	IIR	EPDM	NBR	ECO	CR	CSM	AU	SI	FKM	PUR	PTFE	HTCR	Kalrez®
tear strength	1	2	3	3	3	3	2	3	2	4	3	1		2	2
elongation at break	1	1	1	2	1	2	1	3	1	3	2		3	2	3
elasticity	2	2	4	2	2	1	2	3	2	2	4	2		1	2
resistance to wear	1	1	2	2	1	2	1	2	1	3	3	1	3	1	1
tear resistance	1	2	2	2	2	2	1	3	2	4	2	1	2	1	1
electric disruptive strength	1	1	1	1	3	4	3	4	3	1	3	2	1	2	1
max. hot air temperature °	+90	+100	+140	+150	+130	+145	+120	+130	+120	+200	+220	+80	+260	+232	+260
min. cold air temperature °C	-50	- 40	-40	-20	-40	-40	- 30	- 20	-20	- 80	- 25	-35	-190	0	-20
ageing resistance	3	2	1	1	3	1	1	1	1	1	1	1	1	1	1
ozone resistance	4	3	2	1	2	1	1	1	1	1	1	1	1	1	1
oil and fat resistance	4	4	4	3	1	1	2	2	1	1	1	2	1	1	1
acid resistance	2	2	2	1	3	4	2	2	4	4	1	4	1	3	4
alkali resistance	2	2	1	1	2	4	1	1	4	4	1	4	2	2	2
steam up to 170 °C	4	4	2	1	4		4	4	4	3	4	4	1	1	1
steam up to 250 °C														1	1
petrol	4	3	4	4	1	1	3	2	1	4	1	2	1	4	1
unleaded petrol	4	3	4	4	2	1	3	4	4	4	4	4	1	4	2
benzene	4	4	4	4	4	4	4	4	2	4	1	4	1	3	2
mineral oil	4	1	1	3	1		3	4	4	1	1	4	1	2	1
hot water	2	2	1	2	2	3	2	2	4	4	2	4	1	1	1

1 = Excellent, 2 = Good, 3 = Moderate, 4 = Poor
The above values are guidelines only and non-binding.
Factors such as pressure and temperature may affect chemical resistance. Please contact us in case of doubt.

HTCR O-rings:

Our HTCR (High Temperature Chemical Resistant) O-rings are made of a elastomer whose major property is its resistance to steam. In addition the HTCR O-rings tolerate high temperatures and may be used with hydraulic liquids and caustic materials.

Perfluoroelastomer O-rings (Kalrez):

Perfluoroelastomer O-rings may be manufactured from different compounds to optimise certain properties.
Kalrez O-rings have very special properties. The chemical resistance of perfluoroelastomer is virtually the same as that of PTFE Kalrez O-rings are also resistant to high temperatures while the O-ring behaves as a high quality elastomer.

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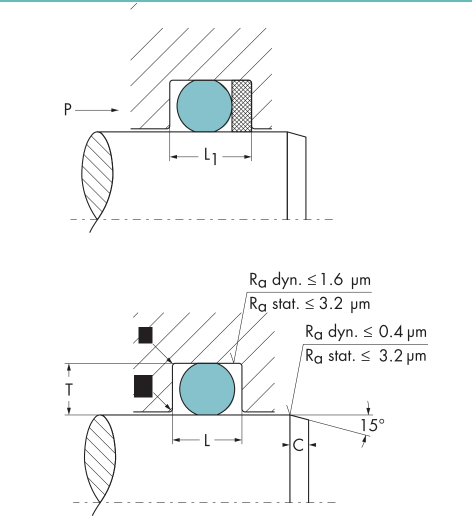
Main properties and chemical resistance limitations

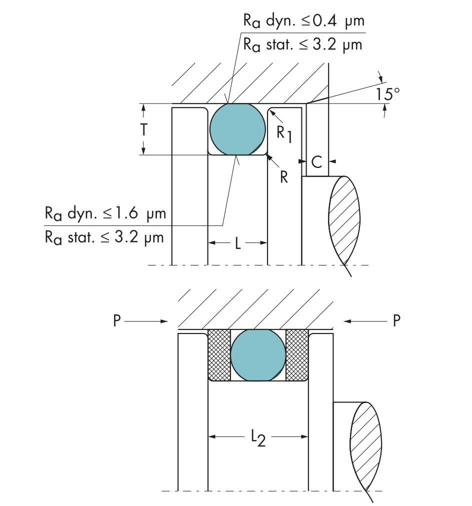
Elastomer Based	Color	Hardness +/- 5°	Properties
NBR (nitrile)	Black	70-80-90° Shore (A)	Generally for hydraulic and pneumatic use in hydraulic oils, HFC and HFA fluids. Resistant to mineral oil and mineral oil products, animal and vegetable oils, gasoline, domestic fuel oil, butane, propane, methane and ethene. In air up to 90 °C, in water up to 70 °C. Not resistant to: Aromatic hydrocarbons (toluene, benzene), trichloroethene, perchloroethene, ketones, esters, ether, glycol-based braking fluids and easily flammable pressure fluids (HFD).
FKM (Viton®)	Black	70-80° Shore (A)	For high temperatures, hot oil and aromatic solvents. Superior chemical resistance. Resistant to liquids based on phosphate esters, chlorinated hydrocarbons, oxygen and ozone, coolants (freon). Not resistant to: Steam and hot water, polar solvents (such as ketones), esters, ethanol, amine, liquid ammonia and glycol-based braking fluids.
EPDM	Black	70-80-90° Shore (A)	For use in steam (max. temperature 170 °C), hot air up to 150 °C, easily flammable hydraulic fluids based on phosphate esters, braking fluids not based on mineral oil. Not resistant to: Gasoline, mineral oils, aromatic and chlorinated hydrocarbons.
Silicones	Red/brown	70° Shore (A)	For high temperatures. Can be used in hot air up to 210 °C. Oxygen, water, food stuffs. Good properties at low temperatures (-60 °C). Not resistant to: Motor fuels, aromates, chlorinated solvents, esters, ketones, concentrated acids, lyes and steam.
Chloroprene (Neoprene®)	Black	70° Shore (A)	Resistant to seawater, resistant to aging and ozone, many types of coolants (freons), mineral oils, lyes and acids. Not resistant to: Aromates, ketones, esters, ether and chlorinated hydrocarbons.
PTFE (Teflon®)	White		Resistant to all chemicals except liquid alkaline metals and fluorides at higher pressures and temperatures. Temperature range -200 °C to +260 °C
FEP/Viton® FEP/Silicones	Transparent		Resistant to virtually all chemicals with the exception of liquid alkaline metals and fluorides at higher pressures and temperatures. Temperature range -40 °C to +215 °C (260 °C for short periods).
PFA/Viton® PFA/Silicones	Transparent		Resistant to virtually all chemicals with the exception of liquid alkaline metals and fluorides at higher pressures and temperatures. Temperature range -40 °C to +215 °C (260 °C for short periods).
HTCR	Black	Standard 74° Shore (A)	HTCR O-rings are used under high temperature conditions in media such as steam, caustics, hydraulic fluids, oils and gasses. HTCR O-rings may be used in most cases where FKM (Viton®) is not resistant. Not resistant to: Gasoline mixtures, polar solvents, aromates (toluene, xylene), chloroform, diethylether, freon T.F., M.E.K.
Kalrez®		80° Shore (A)	Kalrez® O-rings are used in chemical media at high temperatures. The O-rings are resistant to hot water and steam and to amines. Temperature range: -20 °C to +260 °C. Not resistant to: Inorganic acids and hot air over +200 °C.

Design data for grooves

Proper functioning of an O-ring seal depends amongst other things on correct groove design and finish. As a rule of thumb, the O-ring's cord diameter must be selected as large as possible to prevent the risk of O-ring extrusion. Groove sizes, tolerance and groove finish are dependent on the application, whether it be static, axial, rotating or oscillating. The following tables offer recommendations on O-ring groove sizes



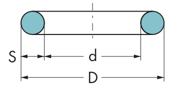
Inner sealing



Outer sealing

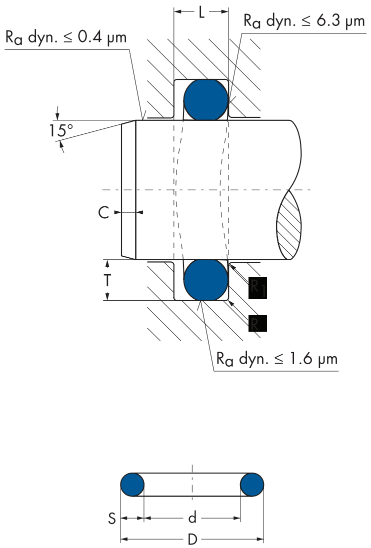
Cord Diam. S [mm]	Groove Depth T [mm] Dynamic Hydraulics	Groove Depth T [mm] Dynamic Pneumatics	Tol.	Groove Depth T [mm] Static Hydraulic Pneumatic	Tol.	Groove Width [mm] L +0.2	Groove Width [mm] L_1 +0.2	Groove Width [mm] L_2 +0.2	R	R1	C
1	0.88	0.88	-0.02	0.85	-0.02	1.1	-	-	0.1	0.1	1.2
1.2	1.07	1.07		1.05		1.3					
1.25	1.1	1.1		1.07		1.4					
1.5	1.35	1.35		1.3	-0.05	1.6	2.8	4			
1.6	1.45	1.45		1.4		1.9	3.1	4.3			
1.78	1.6	1.6		1.55		2.1	3.3	4.5			
2	1.8	1.8		1.75		2.3	3.5	4.7	0.2		1.5
2.4	2.15	2.15		2.1		2.8	4.4	6			
2.5	2.25	2.25		2.2	-0.1	2.9	4.5	6.1			
2.62	2.35	2.35		2.3		3	4.6	6.2			
3	2.7	2.75		2.6		3.4	5	6.6			2
3.15	2.85	2.9	-0.03	2.75		3.6	5.6	7.6		0.2	
3.53	3.2	3.25		3.05		4	6	8			
4	3.65	3.7		3.5		4.5	6.5	8.5	0.3		2.5
4.5	4.1	4.2		3.95		5	7.5	10			
5	4.55	4.65		4.4		5.5	8	10.5	0.4		
5.33	4.9	5		4.7		5.9	8.4	10.9			
5.5	5.05	5.15		4.85		6.1	8.6	11.1			3.5
5.7	5.2	5.35		5		6.3	8.8	11.3			
6	5.5	5.65		5.25		6.7	9.2	11.7	0.5		
6.3	5.75	5.9		5.55		7	10	13			
6.5	5.95	6.1	-0.05	5.7		7.2	10.2	13.2			
6.99	6.4	6.6		6.15		7.7	10.7	13.7			
8	7.3	7.6		7		8.6	11.6	14.6	0.6		4.5
8.4	7.7	7.9		7.4		9	12.5	16			
9	8.25	8.5		7.9		9.6	13.1	16.6			
10	9.2	9.5		8.8		10.7	14.2	17.7			

Selection of the O-ring, outer or inner sealing for cylinder or rod seal
Outer: Outer O-ring D equal or up to 6% smaller than cylinder diameter.
Inner: Inner O-ring diameter d equal or 2% larger than rod diameter.



Selection criteria

The selection of the correct O-ring for a particular application depends on the familiar criteria of: pressure, medium and temperature. Medium and temperature largely determine the choice of O-ring material.
This selection can be made with the aid of the tables.



Cord Diam.Ø S [mm]	Groove Depth [mm]		Groove Width [mm]		R [mm]	R_1 [mm]	C [mm]
	T	Tol.	L	Tol.			
1	0.9	-0.02	1.1	+0.1	0.1	0.1	1.2
1.2	1.1		1.35				
1.25	1.15		1.4				
1.5	1.4		1.65				
1.6	1.5		1.75				
1.78	1.7		2				
2	1.85		2.2		0.2		1.5
2.4	2.25		2.65				
2.5	2.35		2.75				
2.62	2.5		2.9				
3	2.85		3.3				2
3.15	3	-0.03	3.45			0.2	
3.53	3.3		3.85				
4	3.5		4.4		0.3		2.5
4.5	4.3		5				
5	4.75		5.5		0.4		
5.33	5.05		5.8				
5.5	5.25		6.1				3.5
5.7	5.4		6.3				
6	5.7		6.6		0.5		
6.3	6		6.9				
6.5	6.2	-0.05	7.2				
6.99	6.65		7.7				
8	7.5		8.8		0.6		4.5
8.4	8		9.3				
9	8.55		9.9				
10	9.5		11				

d = 1.05 x shaft diameter

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Hardness

The table below summarizes O-ring hardness in relation to the pressure and the structural gap to be sealed. If the existing design has a greater gap than desired, this problem may be solved by the use of backup rings.

Hardness °shore (A)	Pressure [bar]	Cord Diameter [mm]				
		1.78	2.62	3.53	5.33	6.99
60	20	0.18	0.23	0.28	0.3	0.35
	40	0.13	0.18	0.23	0.25	0.3
	63	0.1	0.13	0.15	0.18	0.2
	100	0.05	0.08	0.1	0.13	0.15
70	40	0.2	0.25	0.3	0.35	0.4
	63	0.15	0.18	0.23	0.25	0.3
	100	0.1	0.13	0.15	0.18	0.2
	160	0.05	0.08	0.1	0.12	0.1
	180	0.025	0.04	0.05	0.06	0.08
80	40	0.25	0.3	0.4	0.45	0.5
	63	0.2	0.25	0.3	0.35	0.4
	100	0.13	0.18	0.2	0.25	0.3
	160	0.1	0.13	0.15	0.18	0.2
	180	0.08	0.1	0.13	0.15	0.18
	250	0.05	0.08	0.1	0.12	0.15
90	40	0.35	0.4	0.45	0.5	0.5
	63	0.3	0.35	0.4	0.45	0.5
	100	0.25	0.3	0.35	0.38	0.45
	160	0.2	0.23	0.25	0.3	0.35
	180	0.15	0.18	0.2	0.25	0.3
	250	0.13	0.15	0.17	0.2	0.25
	355	0.08	0.1	0.13	0.15	0.2

Waranty exclusion
In view of the variety of different installation and operation conditions and application as well as process engineering options, the information given in this datasheet can only provide approximate guidance and cannot be used as basis for warranty claims.

Backup rings

If the structural gap is (too) large, the use of one or two back-up rings may prevent O-ring extrusion through the gap. Backup rings are generally made of PTFE or of a carbon- or glass-filled PTFE, thus ensuring that the temperature range and chemical resistance do not cause problems. Backup rings are always custom-made to fit the structure in question and are available in two styles (Figure 1)

1. divided straight ring
2. key ring mode

To prevent manufacturing errors in backup ring styles we need you to indicate the exact size of the structural parts as illustrated in the drawing opposite.

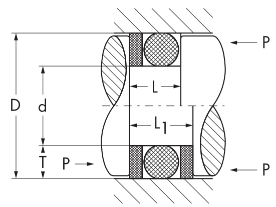
Outer sea

1. Cylinder diameter D
2. Groove diameter d or groove depth T
3. Groove width L of L
4. O-ring cross-section S
5. Static or dynamic seal

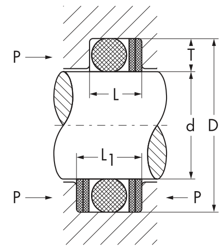
Inner seal

1. Rod diameter d
2. Groove diameter D or groove depth T
3. Groove width L of L
4. O-ring cross-section S
5. Static or dynamic seal

For available O-ring sizes and tolerances we refer to our O-ring size tables



Outer seal



Inner seal

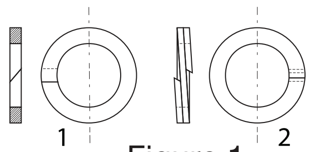


Figure 1