O-rings

Materials

Most O-rings are made of elastomers or rubber materials. The term „elastomer" refers to the elasticity of rubber materials which change their shape already when exposed to a minor force and recover their original shape instantly when the force is removed. The basis of these elastomers is caoutchouc. Caoutchouc can be obtained as natural caoutchouc from plantations or as is common for O-rings today almost exclusively from synthetic caoutchouc in the chemical industry.

To meet the different requirements on modern sealing materials several different basic caoutchoucs and within these many different compounds are available. Each compound follows a specific, defined and controlled recipe and consists, in addition of the basic caoutchouc, of fillers, softeners, vulcanising agents, processing aids and other additives.

The actual O-ring is shaped from the caoutchouc mixture in a second technological step. During this step, the plastic caoutchouc is converted to resilient rubber material in a mold under pressure and temperature.

Abbreviations

Chemical designation of the basic polymer	Abbreviations acc. to DIN ISO 1629	ASTM D 1418
Acrylonitrile-butadiene rubber	NBR	NBR
Hydrogenated acrylonitrile-butadiene rubber	HNBR	HNBR
Fluoro rubber	FKM	FKM
Perfluorinated rubber	FFKM	FFKM
Ethylene propylene diene rubber	EPDM	EPDM
Silicone rubber / vinyl methyl polysiloxane	VMQ	VMQ
Fluoro silicone rubber/ fluoromethyl polysiloxane	FVMQ	FVMQ
Tetrafluoroethylene propylene rubber	FEPM	FEPM
Polyacrylate rubber	ACM	ACM
Chloroprene rubber	CR	CR
Styrene butadiene rubber	SBR	SBR
Chloro sulfonyl polyethylene	CSM	CSM
Epichlorohydrine rubber	ECO	ECO
Butadiene rubber	BR	BR
Isobutene-isoprene rubber	IIR	IIR
Isoprene rubber	IR	IR
Polyester urethane	AU	AU
Polyether urethane	EU	EU
Natural rubber	NR	NR

Standard materials on stock

Properties	Hardness [Shore A]	Color	Low temp [°C]	High temp. [°C]	short term [°C]
NBR	70	black	-30	+100	+120
	80	black	-25	+100	+120
	90	black	-25	+100	+120
FKM	80	brown	-15	+200	
EPDM standard	70	black	-45	+130	
EPDM peroxide	70	black	-50	+150	
VMQ (silicone)	70	red	-55	+200	

General descriptions of the materials

Acrylonitrile-butadiene rubber – NBR

Among standard seals such as O-rings and radial shaft seals, NBR is the most widely used material. The reasons for this are good mechanical properties, high abrasion resistance, low gas permeability and the high resistance to mineral oil based oils and greases.

NBR is a copolymer of butadiene and acrylonitrile. Depending on the application, the content of acrylonitrile can vary between 18% and 50%. Low ACN content improves cold flexibility at the expense of the resistance to oil and fuel. High ACN content improves the resistance to oil and fuel while reducing the cold flexibility and increasing compression set.

To obtain balanced properties, our standard NBR materials have an average ACN content around 30%.

NBR has good resistance to:

- mineral oil-based oils and greases
- aliphatic hydrocarbons
- vegetable and animal oils and fats
- hydraulic oils H, H-L, H-LP
- hydraulic fluids HFA, HFB, HFC
- silicone oils and silicone greases
- water (max. 80°C)

NBR is not resistant to:

- fuels with high aromatic content
- aromatic hydrocarbons
- chlorinated hydrocarbons
- non-polar solvents
- hydraulic fluid HFD
- glycol-based brake fluids
- ozone, weathering, ageing

Application temperature range:

- Standard types -30°C to +100°C (short term 120°C)
- Special grades possible down to -50°C

Hydrogenated acrylonitrile-butadiene rubber – HNBR

HNBR is obtained by selective hydrogenation of the double bond of the butadiene molecules of the NBR rubber. With higher degrees of hydrogenation HNBR exhibits distinctly better resistance to high temperatures, ozone and ageing as well as improved mechanical properties.

The media resistance of HNBR is the same as that of NBR.

Application temperature range:

- -30°C to +150°C
  down to -50°C is realistic with special grades

Fluoro rubber – FKM

FKM materials have conquered many applications in which high thermal and / or chemical resistance is required. FKM also has excellent resistance to ozone, weathering and ageing. Very low gas permeability, FKM is recommended for vacuum applications.

FKM has good resistance to:

- mineral oil-based oils and greases
- aliphatic hydrocarbons
- aromatic hydrocarbons
- chlorinated hydrocarbons
- hydraulic fluids HFD
- vegetable and animal oils and fats
- silicone oils and silicone greases
- fuels
- non-polar solvents
- ozone, weathering, ageing

FKM is not resistant to:

- glycol-based brake fluids
- polar solvents (e.g., acetone)
- superheated steam
- hot water
- amines, alkalis
- low-molecular organic acids (e.g., acetic acid)

Application temperature range:

- -25 to +250°C
  down to -50°C is realistic with special grades

Perfluorinated rubber – FFKM

FFKM materials are elastomers with the highest chemical and heat resistance. Some FFKM types can be exposed to temperatures a little above 300°C. The resistance to chemicals is nearly universal and compares to that of PTFE. The advantage of FFKM is the combination of the chemical and thermal stability of PTFE with the elastic properties of an elastomer material.

These special-purpose elastomers are used wherever safety requirements and high maintenance input justify the high price of these materials and where standard elastomers cannot be used.

FFKM has good resistance to:

- virtually all chemicals
- ozone, weathering, ageing

FFKM is not resistant to:

- fluorinated compounds

Application temperature range:

- -15°C to +260°C
  special grades can be used down to -40°C or up to +340°C

Ethylene propylene diene rubber – EPDM

EPDM can be used in a wide temperature range, has good resistance to ozone, weathering and ageing and is resistant to hot water and steam. Peroxide cured EPDM materials have better resistance to temperature and chemicals and obtain better compression set values than sulfur cured EPDM.

EPDM has good resistance to:

- hot water and hot steam
- many polar solvents (e.g., alcohols, ketones, esters)
- many organic and inorganic acids and bases
- washing brines
- silicone oils and silicone greases
- glycol-based brake fluids (special grades required)
- ozone, weathering, ageing

EPDM is not resistant to:

- all kinds of mineral oil products (oils, greases, fuels)

Application temperature range:

- -45°C to +130°C (sulfur cured)
- -55°C to +150°C (peroxide cured)

Silicone rubber – VMQ

Silicone materials have excellent aging resistance, oxygen, ozone, ultraviolet radiation and weathering and a very wide application temperature range with excellent cold flexibility. Silicone is physiologically harmless and therefore very good in food and medical product applications. Silicone has good electrical insulation properties and is highly permeable to gas. Due to the weak mechanical properties, silicone O-rings are preferably used in static.

Silicone has good resistance to:

- animal and vegetable oils and fats
- water (max.100°C)
- aliphatic engine and gear oils
- ozone, weathering, ageing

Silicone is not resistant to:

- silicone oils and greases
- aromatic mineral oils
- fuels
- steam over 120°C
- acids and alkalis

Application temperature range:

- -60°C to +200°C
- +230°C can be obtained by special grades

Fluoro silicone rubber – FVMQ

Fluorosilicones have substantially better resistance to mineral oils and fuels than normal silicones. The mechanical/technological properties are similar to those of silicones, with some restrictions on temperature resistance.

Application temperature range:

- -60°C to +200°C

Tetrafluoroethylene-propylene rubber – FEPM (Aflas® Asahi Glass Co. Ltd.)

FEPM materials are special elastomers from the group of fluoroelastomers.
They have good chemical resistance and cover a wide range of temperature applications. Their main applications include oil field and chemical industry applications.

FEPM has good resistance to:

- crude oil
- sour gas
- hot water, steam
- polar solvents, alcohols, amines
- many concentrated acids and bases
- engine and gear oil containing additives

Application temperature range:

- -10°C to +200°C (short term +230°C)

Acrylate rubber – ACM

ACM has good resistance to mineral oils with additives at higher temperatures. This makes ACM a preferred material in the automotive industry.

ACM has good resistance to:

- mineral oil-based engine, gear and ATF oils
- ozone, weathering, ageing

ACM is not resistant to:

- glycol-based brake fluids
- aromatic and chlorinated hydrocarbons
- hot water, steam
- acids and bases

Application temperature range:

- 30°C to +160°C

Chloroprene rubber – CR

CR has good mechanical properties and good resistance to ozone, weathering and ageing. This makes the material preferred for outdoor applications or for bellows.

CR has good resistance to:

- many refrigerants (ammonia, carbon dioxide, freons)
- ozone, weathering, ageing

Application temperature range:

- -40°C to +100°C

Polyurethanes (polyester urethane – AU / polyether urethane – EU)

Most of the polyurethanes used for the production of seals are in the group of thermoplastic elastomers. Within the limits of application temperatures, the elastic behavior of polyurethane is typical for elastomers. Polyurethanes have excellent mechanical properties such as extrusion resistance, high resistance to abrasion and wear, tensile strength and tear resistance. This makes polyurethanes suitable for applications with high dynamic loads.

Polyurethane has good resistance to:

- mineral oils and greases
- water, water-oil mixtures (max.50°C)
- aliphatic engine and gear oils
- silicone oils and greases
- ozone, oxygen, ageing

Polyurethane is not resistant to:

- hot water, steam
- aromatic and chlorinated hydrocarbons
- acids, alkalis, amines
- glycol-based brake fluids
- alcohols, glycols, ketones, esters, ether

Application temperature range:

- -40°C to +100°C

Material resistance

The choice of the right material depends essentially on the temperature and media resistance.

The application temperature ranges of the different materials specified above apply to air or in media with no aggressive effect on the elastomer within that temperature range. If a material is exposed to higher temperatures than permitted, that material will normally become hard and increasingly permanently deformed. Generally, temperatures higher than permitted (even short term) reduce the life of the material.

Media compatibility is assessed on how the properties of the elastomer change under the physical and chemical effect of the medium. Such changes of properties can be, e.g.:

- volume change
- swelling due to absorption of the medium in the material
- shrinkage due to the extraction of soluble components in the compound (mostly softeners) of the material
- change of hardness (softening or hardening)
- change of tensile strength and ultimate elongation

The permitted limits within which properties can change are not fixed and depend on the concrete application (static, dynamic, standard or critical).

Material tests

The quality compounds of material and of finished products include exactly specified regular tests of materials.
All relevant properties of the materials are monitored on the basis of standard tests. When interpreting and comparing test results, note that the results obtained from standard test specimens and finished parts can deviate strongly from each other. Comparable, repeatable results can only be obtained from the same test specimens and the same parameters.

Important tests for documentation in our materials data sheets are the following:

Hardness

The hardness of standard test specimens and finished products is tested as follows:

Shore A according to DIN ISO 7619-1
(former DIN 53505) or ASTM D 2240
or
IRHD according to DIN ISO 48 micro hardness IRHD
(International Rubber Hardness Degrees)

In the hardness test, the resistance of the rubber specimen against penetration of an intender under a defined compressive force is measured. Shore A and micro IRHD are different from each other in the shape of the intender and the magnitude of the test force applied. Accordingly, the micro IRHD test is suitable specially for specimens with a small cross section.

In both cases, the hardness scale extends form 0 /10 to 100, with 100 as the highest hardness. The tolerance of the nominal hardness of a material is ±5 Shore A / IRHD.
Hardness comparisons in data sheets (test specimens with parallel surfaces) with values of O-ring tests (curved surface) can deviate substantially from each other.

Tensile strength and ultimate elongation

Both parameters are determined in the tensile test according to DIN 53504 / ASTM D 412. The tensile strength is the force needed to tear a standard specimen related to the cross section of the unelongated specimen. The ultimate elongation is the elongation obtained by a standard specimen at the moment of tearing (expressed in % of the marked measuring distance).

Tear resistance

The tear resistance can be measured on a strip test specimen or an angle specimen. In both cases, the force at which a defined notched standard test specimen resists to the propagation of tear is measured (related to the thickness of the specimen).

Resistance to low temperatures

The mechanical properties of elastomers change with temperature. If the temperature drops, ultimate elongation and elasticity are reduced whereas hardness, tensile strength and compression set increase. Sooner or later, each elastomer arrives at a point at which the material becomes so brittle and hard that it breaks like glass under impact stress.

To be able to assess the behavior of a material at low temperatures, several tests can be performed. For example, the TR10 (temperature retraction) value or the brittleness point are defined. The low temperature limit of the material can be estimated from the interpretation of the results.

Compression set

Compression set is the permanent set of a test specimen, which has been deformed in defined conditions, after its complete relaxation. Depending on the temperature and duration of the deforming the test specimen will not return completely to its original thickness.

The test is made according to DIN ISO 815 or ASTM D 395 B; the result is expressed in %. Ideally, the test specimen fully recovers its original height, which would be equivalent to 0% compression set. If a test specimen does not recover at all after compression, this means its compression set is 100%.

Compression set results can only be compared with each other if test method, compression, geometry of the test specimen, the test temperature and the test time are the same. The compression set is often referred to for assessing the long-term behavior of seals in installed, i.e., compressed state under the effect of temperature.

Change of properties after ageing

To assess the behavior of sealing materials under the action of heat and / or media, ageing tests are performed. Elastomer samples are placed in a heating oven and aged artificially in air or in a contact medium at a defined temperature for a defined period of time. Hardness, tensile strength, ultimate elongation and volume are measured and compared before and after ageing. The less these values change, the better is the material suited for the medium for which it is tested.

Material approval

Many of our materials have special approvals or releases for certain safety related applications, e.g., gas, drinking water or food, petrochemical or oil and gas applications. Compliance with the applicable norms and regulations is tested and certified by an independent testing body or testing laboratory and such tests are repeated regularly.

If one material is certified for different applications, the applications of this material can be bundled, which saves cost. In this way, one seal can supply the needs of several international markets.

Material approval / certification:

Approval / certification Test specification	Institute	Application	Scope
EN 549 (former DIN 3535 part 1+ part 2)	DVGW Deutscher Verein des Gas und Wasserfaches e.V.	Gas	Europe
EN 682 (former DIN 3535 part 3)		Gas	Europe
KTW		Drinking water	Germany
DVGW W270		Drinking water	Germany
DVGW W534		Drinking water	Germany
EN 681-1		Drinking water	Europa
WRAS (former WRC) BS 6920	WRAS Water Regulations Advisory Scheme	Drinking water	UK
NSF 61	NSF National Sanitary Foundation	Drinking water	USA
ACS Attestation Conformité Sanitaire	Institut Pasteur	Drinking water	France
KIWA	KIWA	Drinking water	Netherlands
BelgAqua	BelgAqua	Drinking water	Belgium
acc. to FDA	FDA Food and Drug Administration	Food	USA
BfR (former BGVV)	BfR Bundesinstitut für Risikobewertung	Food	Germany
UL94	UL Underwriter Laboratories	Fire protection	USA
BAM	BAM Bundesanstalt für Materialforschung und -prüfung	Gaseous oxygen	Germany
AED / Sour gas environments			

Antifriction treatments / surface coatings

Reduced friction is an ever more topical subject. Whether for minimizing installation forces, ease of singling and further handling in automatic installation or for extension of service life in dynamic applications, reduced friction generally has many advantages.

We will be glad to advise you and recommend a method suitable for your application.

Method	Application	Durability of the coating / treatment
Talcum treatment	Prevention of sticking together	Short to medium-term
Siliconizing	+ Reduction of the force of installation	
Molykoting		
Graphitizing		
Halogenating	+ automatic installation, Dynamic applications	Medium to long-term
PTFE solid coating		Long-term
Bonded solid coatings		