SECTION FOUR

O-RING SEALING ELASTOMERS

- Elastomer Basics
- Elastomer Types
  - Dichtomatik Standard Elastomers
  - Details, Data and Properties
- O-Ring Lubrication Options
- Elastomer Testing and Approvals
- ASTM D2000

O-RING SEALING ELASTOMERS

Since o-rings are homogeneous (consist of rubber only), the ability of the o-ring to seal is directly dependent on the elastomer and its ability to maintain its sealing force over time. Therefore, elastomer selection is at least as important as properly specifying the o-ring size and the gland size and details.

ELASTOMER BASICS

Before selecting an elastomer, it is important to have a basic understanding of what an elastomer is and what makes it unique as a class of materials. To understand elastomers, one has to first have a basic understanding of polymers.

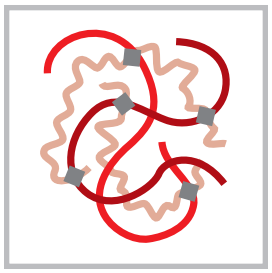
Polymers are long chains of repeating chemical units, or monomers. The chemical skeletal structures may be linear, cyclic or branched. Materials that consist largely of polymer chains can be divided into three basic families.

Plastics

Plastics are rigid long-chain polymers which are not usually connected or cross-linked. Plastics can either be thermoplastics, meaning they can be heated and cooled without changing properties, or thermosets, where an increase in temperature changes the chemical structure and properties. As a class of materials, plastics have low elongation and high elongation set.

Elastomers

Elastomers are flexible long-chain polymers which are capable of cross-linking. Cross-linking chemically bonds polymer chains which can prevent reversion to a non-cross-linked polymer at elevated temperatures. The cross-link is the key to the elastic, or "rubbery," properties of these materials. The elasticity provides resiliency in sealing applications.



Thermoplastic Elastomers

Thermoplastic elastomers, or TPEs, attempt to combine the properties of elastomers with the processing ease of thermoplastics. They are the result of a physical combination of soft, elastic polymer segments and hard, crystalline segments which are capable of cross-linking. Thermoplastic elastomers are generally classified by their structure rather than by their chemical makeup.

ELASTOMER TYPES

Elastomers are split into types or families based on the basic polymer from which they are made. The following table contains the nomenclature used for the different elastomer types per ASTM D 1418 and ISO 1629.

Within each elastomer type, the individual elastomers vary in the fillers, softeners (plasticizers), processing aids, curing agents, accelerators and other additives that they contain. The properties of the base polymer, the types and quantities of the additives and how the elastomer is processed are what determine the chemical and physical properties that may make a particular elastomer right or wrong for an application.

Chemical Description	Abbreviation ASTM D 1418	ISO/DIN 1629
Acrylonitrile-butadiene rubber	NBR	NBR
Hydrogenated acrylonitrile-butadiene rubber	HNBR	(HNBR)
Fluorocarbon rubber	FKM	FPM
Perfluoroelastomer	FFKM	(FFPM)
Ethylene propylene diene rubber	EPDM	EPDM
Silicone rubber	VMQ	VMQ
Fluorosilicone rubber	FVMQ	FVMQ
Chloroprene (or Neoprene) rubber	CR	CR
Polyester urethane	AU	AU
Polyether urethane	EU	EU
Natural rubber	NR	NR
Polyacrylate rubber	ACM	ACM
Ethylene Acrylic (Vamac®)	AEM	AEM
Styrene-butadiene rubber	SBR	SBR
Ethylene oxide epichlorohydrine rubber	ECO	ECO
Chlorosulfonated polyethylene	CSM	CSM
Butadiene rubber	BR	BR
Isoprene rubber	IR	IR
Butyl rubber	IIR	IIR

( ) = not listed in the standard.

DICHTOMATIK ELASTOMERS

Dichtomatik offers eight different standard o-ring materials. The table below indicates the name, the elastomer type and hardness and an ASTM D2000 call-out for each of these standard materials. Dichtomatik is committed to maintaining inventory of each AS568 size in each of the eight materials.

In addition to these standard materials, Dichtomatik maintains an extensive offering of non-standard materials and will also develop materials to meet these requirements of your application. Please contact Dichtomatik for assistance in identifying the best elastomer for your application.

DICHTOMATIK ELASTOMERS		
Name	Description	ASTM D2000 Call-out
N70R	NBR 70	M2BG714 EA14 EF11 EO14 EO34
N90R	NBR 90	M2BG914 B14 EA14 EF11 EF21 EO34
V575	FKM 75	M6HK810 A1-10 B38 EF31 Z1= 75 ± 5 duro
V603	FKM 75 Brown	M6HK810 A1-10 B38 C12 EF31 EO88 Z1= 75 ± 5 duro
S570	Silicone 70	M7GE705 B37 EA14 EO16 F19 G11
E868	EPDM 70 (peroxide cured)	M3CA720 A25 B35 C32 EA14 F19
U876	Polyurethane 70	n/a
U877	Polyurethane 90	n/a

O-RING SEALING ELASTOMERS

ELASTOMER TYPE DETAILS

Details are provided here for some of the more common o-ring sealing elastomers. General descriptions are provided in the text. Additional details on several of the elastomers are provided in the tables. Further information regarding compatibility with specific chemical species can be obtained in the chemical compatibility tables in the next section.

NBR

NBR is a very commonly used material for o-rings because of its good mechanical properties, its resistance to lubricants and greases and its relatively low cost. The physical and chemical resistance properties of NBR materials are determined by the acrylonitrile (ACN) content of the base polymer which can vary between 18% and 50%. Low ACN content ensures good flexibility at low temperatures, but offers limited resistance to oils and fuels. As the ACN content increases, the low temperature flexibility reduces and the resistance to oils and fuels improves.

Physical and chemical resistance properties of NBR materials are also affected by the cure system of the polymer. Peroxide-cured materials have improved physical properties, chemical resistance and thermal properties as compared to sulfur-donor-cured materials.

Standard grades of NBR are typically resistant to mineral oil-based lubricants and greases, many grades of hydraulic fluids, aliphatic hydrocarbons, silicone oils and greases and water to about 80°C.

NBR is generally not resistant to aromatic and chlorinated hydrocarbons, fuels with a high aromatic content, polar solvents, glycol-based brake fluids and non-flammable hydraulic fluids (HFD). NBR also has low resistance to ozone, weathering and aging, but in many applications this has no negative effect.

HNBR

HNBR is obtained by partially or fully hydrogenating NBR. This leads to considerable improvement of the resistance to heat, ozone and aging, and gives it very good mechanical properties. The media resistance compares to that of NBR.

EPDM

EPDM materials generally have a high resistance to hot water, steam, aging and chemicals, and are suitable for a wide range of application temperatures. They are divided into sulfur-cured and peroxide-cured types. Peroxide-cured compounds are suitable for higher temperatures and have much lower compression sets.

EPDM has good resistance to hot water and steam, detergents, caustic potash solutions, sodium hydroxide solutions, silicone oils and greases, many polar solvents and many diluted acids and chemicals. Special formulations are excellent for use with glycol-based brake fluids.

EPDM materials are totally unsuitable for use with all mineral oil products—lubricants, oils, fuels.

Silicone

Silicone rubbers are noted for their ability to be used over a wide temperature range and for excellent resistance to ozone, weathering and aging. Compared with most other sealing elastomers, the physical properties of silicones are poor. Generally, silicone materials are physiologically harmless so they are commonly used by the food and drug industries.

Standard silicones are resistant to water (to 100°C), aliphatic engine and transmission oils and animal and plant oils and fats.

Silicones are generally not resistant to fuels, aromatic mineral oils, steam (short term to 120°C possible), silicone oils and greases, acids or alkalis.

Fluorosilicone

Although fluorosilicone elastomers have the same mechanical properties as silicones, they are far more resistant to oils and fuels. The temperature range of applications is somewhat more restricted than that of silicones.

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ELASTOMER TYPE DETAILS *–continued*

FKM

FKM materials are noted for their very high resistance to heat and a wide variety of chemicals. Other key benefits include excellent resistance to aging and ozone, very low gas permeability and the fact that the materials are self-extinguishing.

Standard FKM materials have excellent resistance to mineral oils and greases, aliphatic, aromatic and chlorinated hydrocarbons, fuels, non-flammable hydraulic fluids (HFD) and many organic solvents and chemicals.

In addition to the standard FKM materials, a number of specialty materials with different monomer compositions and fluorine content (65% to 71%) are available that offer improved chemical or temperature resistance and/or better low temperature performance.

FKM materials are generally not resistant to hot water, steam, polar solvents, glycol-based brake fluids and low molecular weight organic acids.

Polyurethane

Polyurethanes differ from classic elastomers in that they have much better mechanical properties. In particular they have a high resistance to abrasion, wear and extrusion, a high tensile strength and excellent tear resistance. Polyurethanes are generally resistant to aging and ozone, mineral oils and greases, silicone oils and greases, non-flammable hydraulic fluids HFA & HFB, water up to 50°C and aliphatic hydrocarbons.

ADDITIONAL ELASTOMERS

FFKM

FFKM materials combine the outstanding heat and chemical resistance of PTFE with the elastic behavior of FKM elastomers. FFKM materials are very expensive and are typically used only when absolutely needed.

Chloroprene

Chloroprene materials have excellent resistance to ozone, aging and weathering and good mechanical properties. They have average resistance to mineral oils and are suitable for use with many refrigerants.

SBR

SBR materials are frequently used in glycol-based brake fluids, water, alcohols, glycols and silicone oils and greases.

TFE/P

Tetrafluoroethylene/propylene rubber (or Aflas®) is a fluorocarbon elastomer that is noted for its exceptional thermal and chemical resistance. TFE/P is well suited for use with hot water, steam, acids, alkaline solutions, ammonia, amines, alloyed engine and transmission oils, brake fluids (based on glycol, mineral oil and silicone oil), crude oil and sour gas.

ACM

ACM or polyacrylate is used mainly by the automotive industry, as it is resistant to most engine oils and transmission fluids, even at high temperatures.

O-RING SEALING ELASTOMERS

PROPERTIES OF ELASTOMERS

Basic Property	NBR	HNBR	EPDM Sulfur	EPDM Peroxide	VMQ	FVMQ	FKM	AU/EU	CR	FFKM
Compression Set Resistance	◆	◆	□	◆	■	■	◆	□	■	□
Tear Strength	■	◆	□	■	▼	□	◆	■	■	■
Abrasion Resistance	■	■	■	■	▼	□	■/□	◆	■	□
Aging Resistance	▼	■	■	■	◆	◆	◆	◆	■	◆
Ozone Resistance	▼	■	■	■	◆	◆	◆	◆	■	◆
Resistance to Oil & Grease	■	■	●	●	□	■	◆	■	□	◆
Fuel Resistance	▼*	□	●	●	▼	■	■*	□	□	◆
Resistance to Hot Water	175°F *	212°F	265°F	300°F	212°F	212°F	175°F *	120°F	175°F	‡
	80°C	100°C	130°C	150°C	100°C	100°C	80°C	50°C	80°C	
Resistance to Steam	●	●	265°F	350°F	250°F †	250°F †	●	●	●	‡
			130°C	175°C	120°C	120°C				
High Temp–Standard	212°F	300°F	265°F	300°F	390°F	350°F	390°F	212°F	212°F	500°F
	100°C	150°C	130°C	150°C	200°C	175°C	200°C	100°C	100°C	260°C
High Temp–Special	250°F	n/a	n/a	n/a	480°F	n/a	n/a	n/a	n/a	625°F
	120°C				250°C					330°C
Low Temp–Standard	–22°F	–22°F	–50°F	–60°F	–65°F	–65°F	5°F	–40°F	–40°F	5°F
	–30°C	–30°C	–45°C	–50°C	–55°C	–55°C	–15°C	–40°C	–40°C	–15°C
Low Temp–Special	–60°F	–40°C	n/a	n/a	n/a	n/a	–30°F	n/a	–60°F	–30°F
	–50°C	–40°C					–35°C		–50°C	–35°C

◆ Very Good ■ Good □ Average ▼ Poor ● Not Recommended

*Better results with special compound †Short term only ‡Depends on compound

ELASTOMER TYPE DATA

	NBR	HNBR	EPDM
Brief Description:	copolymers of acrylonitrile and butadiene	copolymers of acrylonitrile and butadiene with selective hydrogenation of butadiene groups	terpolymers of ethylene, propylene and diene monomers
ASTM D1418 Designation:	NBR	HNBR	EPDM
ISO/DIN 1629 Designation:	NBR	n/a	EPDM
Trade Names:	Chemigum–Goodyear Hycar–Goodrich Krynac–Polysar, Ltd Nysyn–Copolymer Rubber Paracril–Uniroyal Perbunan–Bayer Nipol–Nippon Zeon Europrene–Enimont	Zetpol–Nippon Zeon Therban–Bayer Tornac–Polysar, Ltd.	Nordel–DupontDow Elastomers Vistalon–Exxon Dutral–EniChem Keltan–DSM Buna EP–Bayer Epcar–Goodrich Royalene–Uniroyal
Standard Color(s):	Black	Black, Green	Black
ASTM D2000 Code(s):	BF, BG, BK, CH	DH	AA, BA, CA, DA
Hardness Range:	40 to 95	50 to 90	40 to 90
Common Variations	acrylonitrile content (18% to 50%) sulfur-donor cured vs. peroxide cured drinking water application approved (NSF, WRc, KTW) FDA compliant XNBR (improved wear resistance)	acrylonitrile content (18% to 50%) sulfur-donor cured vs. peroxide cured residual double bond content (<1% to 10%) special compound for refrigerants	sulfur-donor cured vs. peroxide cured drinking water application (NSF, WRc, KTW) brake application formulation

	SILICONE	FLUOROSILICONE	FKM
Brief Description:	polydimethylsiloxane with vinyl and/or phenyl groups	polydimethylsiloxane with vinyl, phenyl and CF3 groups	co-, ter- and tetra-polymers of fluoronated hydrocarbon monomers
ASTM D1418 Designation:	VMQ	FVMQ	FKM
ISO/DIN 1629 Designation:	VMQ	FMQ	FPM
Trade Names:	Bayosoline–Bayer Silastic–Dow Corning Silplus–GE	Silastic LS–Dow Corning FSE–GE	Viton–DupontDow Elastomers Fluorel–Dyneon Technoflon–Ausimont Dai-el–Daikin
Standard Color(s):	Red (Rust)	Blue	Black
ASTM D2000 Code(s):	FC, FE, GE	FK	HK
Hardness Range:	25 to 80	50 to 80	50 to 95
Common Variations	low temperature high temperature high tensile strength and tear strength FDA compliant	high modulus	Copolymer or terpolymer Degree of fluorination (A, B, F, GB, GF, GFLT, GBLT, GLT, ETP)

O-RING SEALING ELASTOMERS

O-RING LUBRICATION

Most o-rings require some sort of lubrication for storage (to keep the parts from sticking together), for installation or for automatic feeding. Many lubrication options are available depending on the requirements of your application.

Shorter-term lubrication of the o-ring can be accomplished by coating the exterior of the part with:

- Silicone oil
- Graphite
- Molybdenum disulfide (MoS_2)
- Talcum Powder

Longer-term external lubrication can be realized with:

- PTFE coating
- Applying other dry lubricants to the surface

Some applications benefit from the use of an internally lubricated elastomer. Internal lubrication is typically accomplished in one of two ways.

1. A lubricant (typically an oil or wax) that is somewhat incompatible with the elastomer is added to the elastomer during compounding. The incompatibility causes the lubricant to "bloom" to the surface of the molded part over time, thus providing longer-term lubrication.
2. A non-blooming lubricant, such as molybdenum disulfide or PTFE, is added during compounding to provide even longer-term lubrication.

Please contact Dichtomatik North America for assistance in identifying the best lubrication choice for your application.

APPROVALS

Dichtomatik offers many materials that meet the requirements of or are approved by organizations that establish industrial standards or requirements. Some examples of these are:

- NSF-61, WRc, KTW approved materials for drinking water applications
- FDA-compliant materials for o-rings in contact with food or drugs
- UL157-listed materials for specific fluid contact applications such as oil or gasoline
- USDA 3A sanitary standard approved materials

ELASTOMER TESTING

The best sources for information on testing methods are ASTM, ISO and DIN (the organizations that write the standards). For reference purposes, the table below shows which standards are used for common standard elastomer tests.

ASTM D 1414 is also available. It provides instructions on how many standard elastomer tests are to be modified to be used specifically for testing molded o-rings rather than standard test specimens.

On a material data sheet it is important to know whether the data reported was obtained by testing slabs and buttons or by testing actual o-rings, as the results may differ.

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ELASTOMER TESTING *–continued*

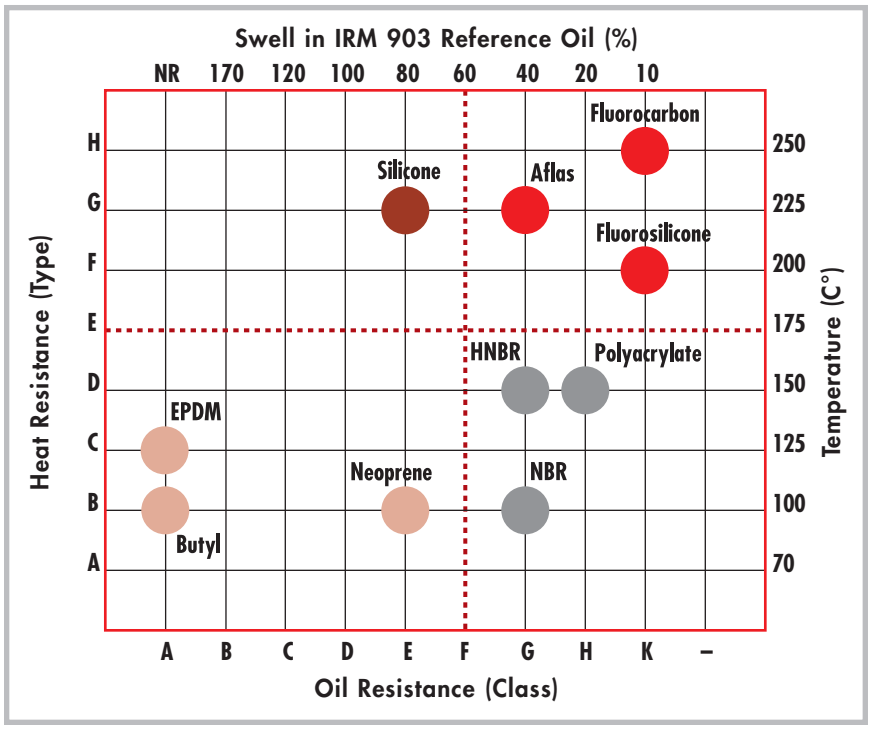
Elastomer Property or Test	ELASTOMER TESTS ASTM	ISO	DIN
Hardness (Shore A)	D 2240	7619	53505
Hardness (IRHD)	D 1415	48	53519
Tensile Strength	D 412	37	53504
Ultimate Elongation	D 412	37	53504
Modulus	D 412	37	53504
Brittleness Point	D 2137	812	53546
Temperature Retraction	D 1329	2921	n/a
Tear Strength	D 624	34, 816	53507, 53515
Compression Set	D 395	815	53517
Air Aging	D 573, D 865	188	53508
Immersion Testing	D 471	1817	53521
Ozone/Weather Resistance	D 1171	1431	53509

ASTM D2000 PRIMER

ASTM D2000 is published by The American Society for Testing & Materials as ***Standard Classification System for Rubber Products in Automotive Applications***. ASTM D2000 is an exact functional equivalent of ***SAE Recommended Practice J200***.

The purpose of the standard is to offer guidance on the types of materials available, to indicate what level of performance can be expected from the materials, and to offer a means of providing a "line call-out" designation for materials.

The materials are identified initially by type, which is an indication of heat resistance, and by class, which is based on oil resistance. The temperature resistance and the oil resistance are indicated with letter designations as shown to the right.



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ASTM D2000 PRIMER *–continued*

Within each type/class combination, the hardness, tensile strength and class can be specified. Each class also has additional available test requirements that must be met by the material. These requirements are often referred to as suffix requirements.

The actual specification is required to fully interpret an ASTM D2000 line callout, but an example line callout is shown and explained below.

ASTM D2000 M6HK810 A1-10 B38 EF31Z1

Units (M = SI Units)
Grade Number (1 = No Suffix Requirement)
Type (Heat Resistance)
Class (Oil Resistance)
Hardness (e.g. 8 = 80 Shore A)
Tensile Strength (e.g. 10 = 10 MPa)
Suffix Letter: A Heat Resistance
B Compression Set
EA Aqueous Fluid Resistance
EF Fuel Fluid Resistance
EO Oil/Lubricant Fluid Resistance
F Low Temperature Resistance
G Tear Resistance
R Resilience
Suffix Number 1st Digit = Test Method
2nd Digit = Test Temperature
Special "Z" Callout (Needs to be Specified)

It is important to note that the "Z" callouts are meaningless unless the requirement is specified. In the case of the above line callout, the callout provided on the print would have to be as shown below so that the Z callout is specified.

ASTM D2000 M6HK810 A1-10 B38 EF31Z1

Z1: Hardness = 75±5 Duro A