SELEC OF POLYMER

Contents

1 General

Flexible materials differ from other materials not simply because they are "elastic". The characteristic features are,
in many respects, different. There are hardly any constants, and most properties are greatly dependent on the
temperature and other external influences, many even on size and shape.and hardness for various aplication

Elastomers are all cross-linked high polymers with rubberlike properties (min. 100% elongation at 20 °C).

2 Designation

Table 1 Overview

Abbreviation to[1] ISO 1629	ASTM D 1418	Chemical name	Trade name
NR	NR	Natural caoutchouc	Natsyn
SBR	SBR	Styrene-butadiene caoutchouc	Buna S
IIR	IIR	Butyl caoutchouc	Esso Butyl
EPDM	EPDM	Ethylene-propylene-diene caoutchouc	Buna AP
NBR	NBR	Acrylonitrile-butadiene caoutchouc	Perbunan N
HNBR	HNBR	Hydrogenized acrylnitril-butadiene caoutchouc	Therban, Tornac
CR	CR	Chloroprene caoutchouc	Bayprene, Neoprene
CSM	CSM	Chlorine-sulfonized polyethylene	Hypalon
ACM	ACM	Acrylate caoutchouc	Cyanacryl
FPM	FKM	Fluorine caoutchouc	Viton, Fluorel
MFQ	FVMQ	Fluorine-silicone caoutchouc	Silastic
MVQ	VMQ	Silicone caoutchouc	Silopren
AU	AU	Polyester-urethane caoutchouc	Vulkollan
[2] -	TFE/P	Tetrafluorethylene-propylene-copolymer caoutchouc	Aflas, Tefzel
[2] -	FFPM	Perfluorine caoutchouc	Kalrez, Zalak

[1] At Voith, elastomers are designated to ISO 1629. Exceptions are marked with ( ).[2]

Note:
The material abbreviation is formed from the abbreviation to ISO 1629 and Shore A hardness to DIN 53505, e.g.:

NBR 70

Abbreviation to ISO 1629 Shore A hardness to DIN 53505

4 Physical properties

The table values apply only to test specimens according to the indicated standards and cannot be unrestrictedly transferred to molded parts. These values are also influenced by installation and surrounding fluid.

Table 2

Abbre-viation to ISO 1629	Density to DIN53479	Service temperature	Shore A hardness to DIN53479	Tensile strength to DIN 53504	Elongation at tear to DIN 53504	Compression Set (CS) to ISO 815	Test specimen Type B(13x6.3) at temperature
	g/cm³	°C		N/mm²	%	%	°C
NR1.3		-50 to +80	20 to 90	15 to 30	100 to 800	15 to 50	70
SBR1.2		-50 to +100	30 to 90	7 to 30	100 to 800	15 to 50	100
IIR1.2		-40 to +130	40 to 80	7 to 17	400 to 800	> 60	100
EPDM1.1		-50 to +130	40 to 80	7 to 18	150 to 500	20 to 60	150
NBR1.3		-30 to +100	40 to 90	7 to 25	100 to 700	15 to 60	100
HNBR1.1 to 1.2		-25 to +150	70 to 90	min. 18	min. 250	max. 40	150
CR1.4		-40 to +100	20 to 90	7 to 25	100 to 800	25 to 80	100
CSM1.2		-20 to +120	50 to 80	15 to 25	200 to 500	50 to 80	100
ACM1.4		-30 to +150	50 to 90	5 to 13	100 to 350	25 to 60	150
FPM1.9		-20 to +200	70 to 90	7 to 17	100 to 300	20 to 80	200
MFQ1.6		-55 to +175	30 to 80	4 to 9	100 to 400	20 to 25	200
MVQ1.3		-60 to +200	30 to 80	4 to 9	100 to 400	20 to 25	200
AU1.3		-30 to +80	50 to 90	25 to 50	300 to 700	17 to 70	70
2)TFE/P1.62		-40 to +200	70 to 90	min. 17	150 to 350	max. 56	200
2)FFPM2.02		0 to +288	80 to 90	min. 13	120 to 130	max. 53	288

Explanation of terms

Shore A hardness to DIN 53505
Hardness is understood to mean the resistance of a body to the penetration of a harder body of a certain shape under a defined compressive force.

Tensile strength to DIN 53504
The tensile strength is the force that has to be applied to rupture a standard specimen elongated under certain conditions, related to the cross-sectional area of the unelongated specimen.

Elongation at tear to DIN 53504
The elongation at tear is the existing elongation at the moment of tearing of a standard specimen.

Compression set to ISO 815
Compression set is understood to mean the remaining change in shape of a standard specimen deformed under certain conditions after it has been fully relieved.

2) See Page 2

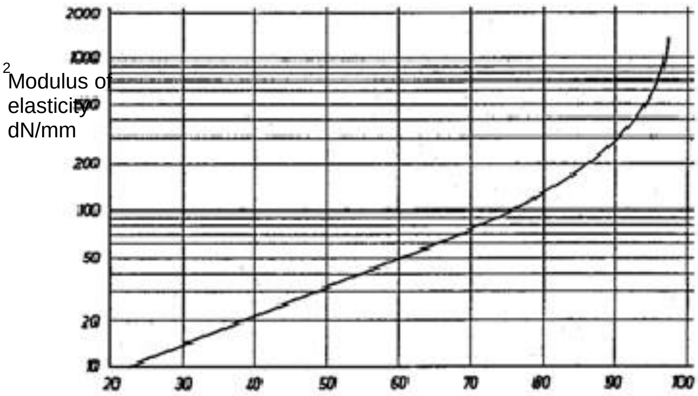
4.1 Hardness

Hardness is the most used characteristic for rubberlike materials.
The hardness of the elastomers is indicated in Shore A to DIN 53505.
Generally, ±5 hardness degrees (Shore) is taken as the tolerance for hardness measurements.

4.2 Relationship between hardness and modulus of elasticity

Hooke's law is applicable to elastomers only in a limited deformation range, which may differ from material to material.
Between the hardness in Shore A and the modulus of elasticity there is an approximate relationship at a strain in compression of 10 %.
The hardness is not, however, generally related to the modulus of elasticity for major deformations, even if a material with a greater hardness generally at the same time has a higher modulus of elasticity.

Fig. 1



The tension value determined in the tensile test (DIN 53504) is frequently referred to as the "modulus of elasticity".
This designation is not correct, as there is no proportionality between tension and elongation at high expansions.

5 Temperature behavior

The mechanical properties of elastomers are greatly influenced by the ambient temperature.
At very low temperatures, the elasticity decreases and hardness increases until, finally, a "frozen-in" state is reached, in which the material is steel-like elastic or glasslike brittle, depending on the structure. If the material is brought up to normal temperature, its elastic properties fully return.
At high temperatures the behavior of the material is mainly determined by permanent changes.

5.1 Joule effect

If rubber is heated in expanded state, contrary to expectations it contracts.
This phenomenon is termed 'Joule Effect'.
This must be observed when using O-rings.

6 Electrical properties

The electrical properties of the elastomers extend over a wide range and can be particularly influenced by the selection of the fillers.
Materials with both semi-conductor properties and with a high insulation capacity can be manufactured.

7 Chemical properties

For the selection of a suitable material, consideration of the chemical resistance and the swelling behavior are decisive. The temperature must be known and with what fluids the material comes into contact.
The chemical attack of gases and fluids cause similar changes in the materials to those caused by heat aging. Here, too, swelling or hardening may occur, and particularly faster and more intensively at higher temperature than at lower temperature.
While agreement can be reached extensively with the physical properties, it is more difficult to obtain binding information with the chemical resistance due to differing formulations. Table 4 contains values according to the manufacturer's data which can be reached by all products. This does not rule out the possibility that better results can be achieved with certain manufacturers.
In special applications and under special operating conditions it is advantageous to consult the manufacturer so that, where required, trials can be performed under conditions that are as close to real conditions as possible.

Table 3 Chemical resistance

Fluid		Temp. °C	NR	SBR	IIR	EPDM	NBR	HNBR	CR	CSM
ATE brake fluid		100	1	1	1	1	3	3	2	4
AT foil		100	4	4	4	4	1	1	2	3
Benzene N		40	3	3	3	3	1	1	2	3
Steam		130	3	3	1	1	3	2	3	2
Steam		170	4	4	4	4	4	4	4	4
Diesel fuel		60	3	3	3	3	1	1	2	3
Grease	mineral	80	3	3	3	3	1	1	2	4
Grease	ester	80	4	4	4	4	2	2	4	4
Oil	mineral	80	3	3	3	3	1	1	2	3
Oil	ester	80	4	4	4	4	2	2	4	4
Air	pure	80	1	1	1	1	1	1	1	1
Air	oil-contain.	80	3	3	3	3	1	1	2	4
Seawater		20	1	1	1	1	1	1	1	1
Water		100	2	1	1	1	1	1	2	1

continued

Fluid		Temp. °C	ACM	FPM	MFQ	MVQ	AU			TFE/P	FFPM
ATE brake fluid		100	3	3	1	1	4			2	1
ATF oil		100	3	1	1	2	2			2	1
Benzene N		40	1	1	3	1				2	1
Steam		130	4	1	3	3	3			1	1
Steam		170	4	4	4	4	4			2	1
Diesel fuel		60	1	1	1	2	1			2	1
Grease	mineral	80	1	1	1	1	1			1	1
Grease	ester	80	1	4	4	4	4			1	1
Oil	mineral	80	1	2	2	2	1			1	1
Oil	ester	80	1	4	4	4	4			1	1
Air	pure	80	1	1	1	1	1			1	1
Air	oil-contain.	80	1	1	1	1	1			1	1
Seawater		20	4	1	1	1	2			1	1
Water		100	4	1	4	2	3			1	1

Legend: 1 = little or no attack
2 = weak to moderate attack
3 = strong attack to complete destruction
4 = not suitable

With ATF oils give preference to FPM.

7.1 Ozone, aging and weather resistance

Table 4

Material	NR	SBR	IIR	EPDM	NBR	HNBR	CR
Ozone	2-3	2-3	1-2	1	2-3	1	1-2
Aging and	2-3	2-3	1-2	1	2-3	1	1-2
Weather resistance	2-3	2-3	1-2	1	2-3	1	1-2

continued

Material	CSM	ACM FPM		MFQ MVQ AU TFE/P				FFPM
Ozone	1	11		1111				1
Aging and	1	11		1111				1
Weather resistance	1	11		12-311				1

Legend:

1 = little or no attack
2 = weak to moderate attack
3 = strong attack to complete destruction

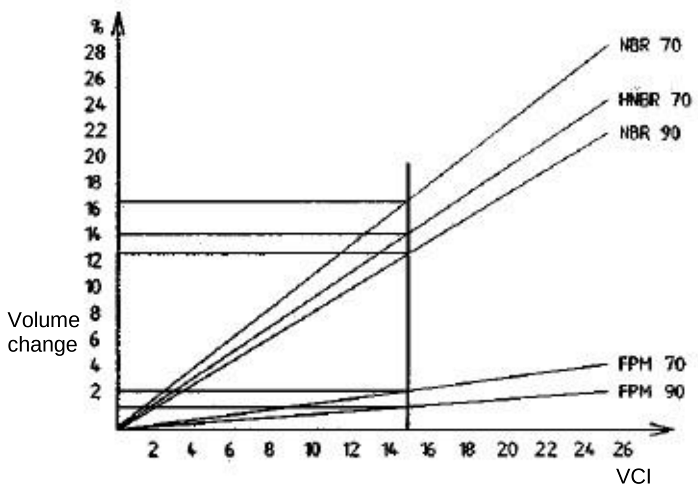
8 Volume Change Index (VCI)

The changes in volume, hardness, tensile strength and elongation at tear of a standard reference elastomer to ISO 6072 due to the effect of a fluid under specific test conditions form a Volume Change Index (VCI) for this fluid.
If the VCI of an oil is known, then it is possible to predict the maximum volume change of all elastomers in the oil concerned.
The VCI is indicated by the rubber manufacturers.

Table 5 VCI of various mineral oils

Mineral oil	VCI	Mineral oil	VCI
BP Energol HLP100	3.7-4.7	Mobil Vac HLP16	14-15
Esso Nuto H54 (HLP36)	5.9-6.9	Shell Tellus 15	14.7-15.7
DEA Rando Oil HDC (HLP36)	7.7-8.7	BP Energol HP20	19-20
Shell Tellus 923 (HLP16)	9.2-10.2	Shell Tellus 11	32.9-33.9

Fig. 2 Volume change of various rubber grades in mineral oils



Example:
For mineral oil with EVI 15 the following volume change values result:
Approx. 1 % for FPM 90
Approx. 2 % for FPM 70
Approx. 13 % for NBR 90
Approx. 14 % for HNBR 70
Approx. 17 % for NBR 70

The values are intended as a guideline.
As a rule, a maximum volume change of +25 % applies to static seals with O-rings.
In the case of dynamic inserts, the volume change of +7 % should not be exceeded.
Any shrinkage of the material should be avoided.

9 Detection by the flame test

Further information on the nature and structure of an unknown rubber specimen can be obtained testing its flammability.

Table 6

Flammability			
Within the flame	Outside the flame	Color of the residue	Elastomer
Hardly flammable	Extinguishes immediately	Black	FPM; FFPM; TFE/P
Flammable	Extinguishes after a short time Continues to burn	Black	CR, CSM
Flammable	Black smoke Continues to burn	Black	NR, SBR, NBR, EPDM, IIR; ACM, HNBR
Flammable	White smoke Continues to burn and drips or extinguishes	Volume increase White coating	MFQ, MVQ
Flammable, Dripping of burning or melted parts		Black	AU

10 Storage, cleaning and maintenance requirements

(Excerpt from DIN 7716)

General

Under unfavorable storage conditions or if improperly used, most rubber products change their physical properties. They may become unusable due to excessive hardening, softening, permanent set or by spalling, cracks or other surface defects. The changes may be caused by the effect of oxygen, ozone, heat, light, humidity, solvents or by storage under tension.

Storeroom

The storeroom should be cool, dry, dust-free and moderately ventilated.

Temperature

Rubber products should not be stored below -10 °C and above +25 °C.

Heating

The distance between the heating element and the stored material must be at least 1 m. The temperature of the stored articles should not exceed +25 °C.

Humidity

Storage in humid storerooms should be avoided. Take care that there is no condensation. The most favorable relative air humidity is below 65 %.

Lighting

The rubber products should be protected against light, especially against direct sunlight and against strong, artificial light with a high percentage of ultraviolet rays.

Oxygen and ozone

The rubber products should be protected against air changes, particularly draughts, by wrapping, storage in air-tight containers or by other means.

Deformations

Take care that rubber products are stored tension-free, i.e. without tension, pressure or other deformations, as tensions favor both permanent set and cracking. O-rings must not be stored hanging on a hook.

Copper and manganese have a damaging effect on rubber products, which is why the products must not be stored in contact with these metals.

Cleaning and maintenance

Rubber products can be cleaned with soap and warm water. The cleaned articles should be dried at room temperature.

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