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Technical Note

Materials engineering with elastomers - How to select an elastomer?

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Abstract

Practical problems such as the replacement of one O-ring or valve seal on an old machine can be solved faster if a proper pre-selection of candidate elastomers is made. So, the aim of this article is to provide to the readers an easy to use tool for the pre-selection of main current elastomers and advice on fully testing prior formal selection.

Keywords: elastomers; pre-selection; comparative properties; trade names.

1. Introduction

The term "rubber" originally meant the reticulated material obtained from the rubber tree (*Hevea brasiliensis*), but today it identifies any thermoset or thermoplastic elastomeric material. The terms "rubber" and "elastomer" are very often used interchangeably [1].

The term elastomer, that derives from the words elastic polymer, may be defined as a natural or synthetic material that have the ability to deform considerably under the application of force and then snap back to almost their original shape when the force is removed.

Most of elastomers used today are manufactured synthetically and they serve engineering's needs in fields dealing with sealing, corrosion protection, abrasions and friction resistance, shock absorption, vibration and noise control, waterproofing and all types of load-bearing products [1,2].

The ASTM D1418 standards defines an elastomer in both dry and latex form according the chemical composition of the polymer chain, whereas the ASTM D2000 standards is a classification system for specifying elastomers for automotive use which has been adopted by other industries and that designates elastomers by their resistance to heat aging and swelling in oil [1,3].

Until 1932 the natural rubber, with different vulcanization degrees, was used as the sole elastomer. Later on the synthetic elastomers came enlarge the properties range of these materials, mainly in what concerns to organic solvents, oils and ozone resistance [4]. Although nowadays over 20 different polymers are used in the production of synthetic elastomers, Table 1 presents only the most frequent and with reasonable accessibility. The objective of the referred Table is to allow the selection of elastomers that fulfil operation requirements and, if the replacement is needed, facilitate the selection.

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Table 1. Comparative properties of the main types of current use elastomers [4,5]

General Properties	Natural rubber	Styrene-butadiene	Butyl	Ethylene propylene	Nitrile butadiene	Hydrogenated nitrile butadiene	Chlorsulfonated polyethylene	Silicone	Polyurethane	Fluorelastomer	Epichlorohydrin
ASTM D1418	NR	SBR	IIR	EPDM, EPR	NBR	HNBR	CMS	VMQ, PVMQ	AU, EU	FKM	ECO
ASTM 2000	AA	AA, BA	BA	BA, CA, DA	BF, BG, BK	BF	CE	GE/FE	BG	HK	DK
Hardness range (Shore A)	20-90	40-90	40-75	30-90	20-95	70-90	40-95	10-85	10A - 80D	50-95	40-95
Specific gravity (base material)	0.93	0.94	0.92	0.86	1.0	0.98	1.12-1.28	1.1-1.6	1.06	1.85	1.36/1.27
Tensile strength (MPa)	>20	<6.9	>10	<7	<7	<8.4	>17	<10	<8	>12	---
Tear resistance	Good	Fair	Good	Good	Fair	Good	Fair	Poor	Excellent	Fair	Fair
Abrasive resistance	Excellent	Good	Good	Good	Good	Good	Excellent	Poor	Excellent	Good	Good
Compression set	Good	Excellent	Fair	Good	Good	Good	Fair	Fair	Good	Very good	Fair
Temperature range (ºC)	-55 - +90	-50 - +100	-40 - +120	-50 - +150	-40 - +100	-25 - +150	-20 - +120	-50 - +200	-25 - +100	-20 - +200	-40 - +120
Cold	Excellent	Good	Bad	Excellent	Very good	Good	Good	Excellent	Poor at 21ºC	Good	Poor/Fair
Hot	Excellent	Good	Very good	Excellent	Very good	Very good	Good	Excellent	Good at R.T.	Excellent	Poor/Fair
Dielectric strength	Excellent	Good	Excellent	Excellent	Poor	Fair	Very good	Good	Excellent	Good	Good
Electrical insulation	Good to Excellent	Good	Good to Excellent	Good	Poor	Fair	Good	Excellent	Fair	Fair	Fair
Flame resistance	Fair	Fair	Very low	Fair to Poor	Fair	Low	Low	Fair	Fair	Very Low	Very Low
Aliphatic hydrocarbons	Poor	Poor	Poor	Poor	Excellent	Good	Good	Poor	Excellent	Excellent	Good
Aromatic hydrocarbons	Poor	Poor	Poor	Poor	Good	Good	Fair	Poor	Fair to Good	Excellent	Good
Oxygenated (cetones, etc.)	Good	Poor	Good	Good	Poor	Poor	Poor	Fair	Poor	Poor	Poor
Lacquer solvents	Poor	Poor	Poor	Good	Fair	Poor	Poor	Poor	Poor	Poor	Fair
Swelling in lubricating oil	Poor	Poor	Poor	Poor	Very Good	Very Good	Good to Excellent	Fair	Excellent	Excellent	Very Good
Oil & Gasoline	Poor	Poor	Poor	Poor	Excellent	Very Good	Good	Fair	Excellent	Excellent	Excellent
Animal & Vegetable oils	Poor to Good	Poor to Good	Excellent	Good	Excellent	Very Good	Good	Good	Excellent	Excellent	Excellent
Water absorption	Very Good	Very Good	Very Good	Excellent	Good	Very Good	Very Good	Good	Good at 21ºC Poor at 100ºC	Very Good	Good
Oxidation	Good	Good	Excellent	Excellent	Good	Good	Excellent	Excellent	Excellent	Excellent	Good
Ozone	Fair	Fair	Good	Excellent	Fair	Very Good	Excellent	Excellent	Excellent	Excellent	Very Good
UV radiation	Poor	Fair	Very Good	Very Good	Fair	Very Good	Excellent	Excellent	Good	Very Good	Good
Flame	Poor	Poor	Poor	Poor	Poor	Fair	Good	Fair	Fair	Good	Fair/Poor
Heat	Good	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good	Excellent	Very Good
Cold	Excellent	Good	Good	Excellent	Good	Excellent	Good	Excellent	Excellent	Good	Fair/Good

Since the elastomers properties are dependent not only from the basis polymer but also from the processability parameters and the additives such as plasticizers, pigments and anti-degrading agents [2,4] in Table 1 are presented the typical average values for the current elastomers. Because of it, after a pre-selection made based on the data presented in Table 1, the parts' suitability to the operation conditions should be checked in detail and, for critical applications, laboratory tests should be performed to simulate the use and aging conditions to evaluate the potential risks in use and the durability.

In order to make easier the search of commercial elastomers of different types, in Table 2 we present the trade names of the most relevant ones.

Table 2. Trade names of the main elastomer types [2,6,7]

Elastomer type	Trade names
cis-polyisoprene (Natural Rubber (NR))	NATSYN®, HORIRUB®NR
Styrene-butadiene (SBR)	BUNA-S®, KER®, EUROPRENE®, CARIFLEX®, PLIOFLEX®, PLIOLITE®, CAROM®, SOLPRENE®
Butyl (IIR)	BUCAR ®, EXXON BUTYL®, POLYSAR BUTYL®, ESSO BUTYL®
Ethylene-propylene (EPDM)	NORDEL®, KELTAN®, VISTALON ®, DUTRAL®, BUNA EP®, EPSYN®, EPCAR®, ROYALENE®, POLYSAR-EDM®
Nitrile butadiene (NBR)	PERBUNAN®, BUNA-N®, HYCAR®, EUROPRENE-N®, NIPOL®, BREON®, BUTAKON®, CHEMIGUM®, BUTACRIL®, PARACIL®, KRYNAC®
Hydrogenated nitrile butadiene (HNBR)	THERBAN®, ZETPOL®, TORNAC®
Chloroprene (CR)	NEOPRENE®, BAYPRENE®, DENKA CHLOROPRENE ®, SKYPRENE®, BUTCLOR®
Chlorsulfonated polyethylene (CSM)	HYPALON®, NORALON®
Silicone (PVMQ)	SILOPREN®, SILASTIC®, RHODORSIL®, SILPLUS®
Polyurethane (AU/EU)	VULKOLLAN®, UREPAN®, ADIPRENE®, VIBRATHANE®, PELLETHANE®, ELASTOTHANE®, DESMOPAN®, ESTANE®.
Fluorelastomer (FKM)	VITON®, FLUOREL®, TECNOFLON®, DAI-EL®
Epichloroihydrin (ECO)	HYDRIN®, HERCLOR®, GECHRON®

Some elastomers properties such as ultraviolet radiation resistance, hardness and fire resistance are hardly dependent of the chemical formulation, and can be improved changing the additives content during the production process. However, the resultant advantages should be severely weighted because it can compromise the mechanical performance of the elastomer [4].

The discussed types of elastomers are suitable for the common applications, so none of them present suitable properties for special applications; so in this case should be used specialty polymers, usually more expensive and with longer delivery time [4].

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References

[1] D.V. Rosato, Plastics encyclopedia and dictionary, 1st ed. Hanser Ed., New York, 1993; pp. 21.

[2] NewDealSeals (Manufacturer and Worldwide Supplier High Performance O-Rings and Seals), O-Ring Technical Handbook, 1st ed. NewDealSeals Ed., Netherlands; 2008, pp. 26-29.

[3] ASTM D1418 – 10a, Standard Practice for Rubber and Rubber Latices Nomenclature.
http://www.astm.org/Standards/D1418.html

[4] J.C.M. Bordado, Selecção de elastómeros. Boletim SPM, Sociedade Portuguesa de Materiais, Outubro - Dezembro, 1987; pp. 4-5.

[5] Properties of Elastomers. (http://www.aag-gummi.dk/pictures_org/Gummikvaliter-egenskaber.pdf)

[6] Precision Polymer Engineering Ltd (PPE), A technical guide to Elastomer Compounds and Chemical Compatibility, 2006; pp. 14-17.
(www.darcoid.com/.../Elastomer%20guide%20chemical%20compatibility.pdf)

[7] Common rubber types.
(www.horiaki.net/html/rubber_characteristics.html).