NATURAL RUBBER

This is nature's main "ready-made" contribution to the elastomer field. Its chief source is the Hevea Brasiliensis, a commercially grown tree found principally in the Far East. The bulk of natural rubber used for today's engineering applications is plantation rubber, smoked sheet and pale crepe being the best and most important. Natural rubber, polyisoprene, still offers the optimum balance of properties necessary for high performance in many demanding mechanical applications. Quality compounds can be made for a wide range of stiffness requirements.

It has high resilience, outperformed only by some of the more recent man-made polyisoprenes and polybutadienes. It exhibits very good tensile and tear properties over a wide stiffness range and has excellent resistance to cold flow. It is possible to make compounds that exhibit low permanent set at temperatures up to 200 F. Abrasion resistance is good, though inferior to BR (polybutadiene) and SBR (styrene-butadiene). Natural rubber has better low-temperature flexibility than most synthetics, but is not as good as silicone rubber or some of the special butadiene and SBR compounds. Natural rubber compounds can be made with a wide range of electrical properties.

Natural rubber does not age as well as many of the synthetics nor is it as chemically inert as some. It is inferior to many of the synthetics for heat aging, resistance to sunlight, oxygen, ozone, solvents or oils.

It can be bonded satisfactorily to a wide range of materials and is used in a variety of application, including tires, gaskets, seals, rolls, hose, tubing, vibration isolators, shock mounts, electrical components, bumpers, drive wheels, etc. It is the material used for most high performance applications unless some specific environmental condition is met.

SBR

SBR is a synthetic copolymer of styrene and butadiene. Although it is one of the earlier synthetics, it still represents the largest variety being made today. The copolymer includes a number of types, each developed for specific applications. It can be obtained in the form of latex or as a dry product, similar to natural rubber.

The general balance of properties that can be obtained is a little below that obtainable with natural rubber, but the cost of the base material is lower and fluctuates less. Certain types give slightly better wear resistance in tire treads; others provide better low-temperature flexibility. It has about the same resistance to solvents and chemicals as natural rubber but has superior water resistance.

On heat aging, it hardens and becomes brittle instead of softening as does natural rubber. Pure gum (unreinforced) high-strength compounds cannot be made since molecular alignment to oppose stress is difficult; crystallization does not occur. Resistance to sunlight and ozone is about the same as natural rubber. It can be bonded to a wide variety of materials and used in many products interchangeably with natural rubber.

Broadly then, SBR allows controlled cost preparation of materials providing good wear resistance, low-temperature flexibility and good resistance to sunlight and ozone, with wide bonding latitude.

HIGH QUALITY NEOPRENE

Neoprene is a polymer of chloroprene and has several properties superior to natural rubber, such as better resistance to gasoline, sunlight, ozone and oxidation. It is not only flame resistant, but will not support combustion. It has good resistance to the corrosive action of chemicals, and its water resistance is as good as natural rubber. It has good resistance to heat, and does not soften as does natural rubber under severe exposure. Resilience is almost equal to natural rubber, being surpassed today only by the butadienes.

Compression set and creep characteristics vary in different forms, from types that are inferior to natural rubber to other types which are better — particularly under high-temperature long-time service. The tear resistance is equal to natural rubber at room temperature; at elevated temperatures tear resistance is poor but can be improved to some extent by compounding with reinforcing materials.

Neoprene is commonly blended with other polymers for various applications. The term "commercial" neoprene is used to describe a blended neoprene. Physical properties of a "commercial" neoprene will vary widely.

EPDM

Ethylene-Propylene-Diene Modified (EPDM) is a copolymer of ethylene and propylene which has outstanding resistance to aging, weathering, ozone, oxygen and many chemicals. High and low temperature stability as well as steam and water resistance are excellent. Dynamic and mechanical properties are, in general, between natural rubber and SBR.

EPDM finds uses in many static and dynamic applications where the above properties are important. It can be extruded or molded. It should not be used where continual contact with petroleum based products is required.

NBR

NBR or nitrile elastomers are copolymers of butadiene and acrylonitrile, used primarily for application requiring excellent resistance to petroleum oils and gasoline. Resistance to aromatic hyrocarbons is better than Neoprene but not as good as polysulfide. NBR has excellent resistance to mineral and vegestable oils, but relatively poor resistance to the swelling action of oxygenated solvents such as acetone, methyl ethyl ketone and other ketones. It has good resistance to acids and bases with the exception of those having strong oxidizing effects. Resistance to heat aging is good, often a key advantage over natural rubber.

With higher acrylonitrile contents, the solvent resistance is increased but low-temperature flexibility is decreased. Low-temperature resistance is inferior to natural rubber, and although NBR can be compounded to give improved performance in this area, the gain is normally at the expense of oil and solvent resistance. As with SBR, this material does not crystalize on stretching and reinforcing materials are required to obtain high strength. With compounding it is possible to get a fairly good balance between low creep, good resilience, low permanent set and good abrasion resistance.

Tear resistance is inferior to that of natural rubber and electrical insulation is lower. NBR is used instead of natural rubber where added resistance to petroleum oils, gasoline or aromatic hydrocarbons is required. The properties of this elastomer make it useful for carburetor and fuelpump diaphragms, aircraft hoses and gaskets, where it competes with polysulfide and the neoprene elastomers.

SILICONE RUBBER*

Silicone rubber is one of the versatile family of semi-organic synthetics known as silicones that look and feel like organic rubber, yet have a completely different type of structure than other elastomers. The backbone of the elastomer is not a chain of carbon atoms but an arrangement of silicone and oxygen atoms. This structure gives a very flexible chain with weak interchain forces. This accounts for the remarkable small change in dynamic characteristics over a wide range of temperature. Silicone elastomers show no molecular orientation or crystalization on stretching and must be strengthened by reinforcing materials.

Silica-reinforced elastomers available today have tensile strengths approaching 2000 psi compared with peak values of only 600 psi for earlier grades. In addition, elongations of more than 600% have been achieved as compared to a maximum of 300% for the earlier materials.

Silicone elastomers can be made that will withstand temperatures as high as 600 F without serious deterioration, and at the other end of the temperature scale will retain flexibility −150 F. The elastomers remain flexible and are serviceable over this entire temperature range. No plasticizers are needed that might cause some sacrifice in properties in some temperature range.

While silicone elastomers have lower strength than other élastomers, they are amazingly fatigue and flex resistant, probably as a result of their chemical inertness. They do not require high tensile and tear strength to make suitable for dynamic applications. Fall off in tensile properties at higher temperatures is less than for other elastomers and these values are retained on extended exposure. Resistance to chemical deterioration, oils, oxygen and ozone is also retained under these conditions. Chemical inertness makes these materials of special interest for surgical equipment and food processing.

By changing molecular arrangement, silicone elastomers can be produced with special characteristics such as: low compression set, low-temperature resistance, high-temperature resistance, or high dielectric strength. These types provide a tremendous range of property balance, and still others are under development or in final stages of field testing.

FLUOROCARBON POLYMER

Fluorocarbons are the end product of the copolymerization of highly fluorinated olefins.

Fluorocarbons find unique usage in hot oil environments where outstanding compression set is also required. Typical properties at 400°F for a 70 Shore A hardness compound would be 15% to 30 % compression set and less than 5% volume swell in ASTM #3 oil or automatic transmission fluid.

Fluorocarbons are resistant to the effects of ozone, oxygen and sunlight.

Practical compounds are available in 60-90 Shore A durometer hardness.

Typical examples of trade names are "Viton" and "Flourel."

*Extracted from Product Engineering January 8, 1962. Copyright 1962 by McGraw-Hill Publishing Company, Inc.

CHEMICAL RESISTANCE

THE GENERAL CHEMICAL RESISTANCE OF VARIOUS RUBBERS & PLASTICS

Key: (S) Satisfactory, (U) Unsatisfactory, (—) Unknown

CHEMICAL	Natural Rubber	S.B.R.	Neoprene	Buna N	Viton	Hypalon	E.P.T.	Butyl	Polyethylene	Teflon
Acetic Acid—Dilute	U	U	U	U	U	U	S	S	S	S
—30%	U	U	U	U	U	U	S	U	S	S
—Glacial	U	U	U	U	U	U	S	U	S	S
Acetone	U	S	U	U	U	U	S	S	S	S
Acrolein	U	U	—	—	—	—	—	—	—	S
Allyl Alcohol	S	S	S	S	S	S	S	S	S	S
Allyl Chloride	U	—	U	U	—	U	—	—	S	S
Alum	S	S	S	S	S	S	S	S	S	S
Ammonia Anhydrous	S	S	S	U	U	U	S	S	S	S
Ammonium Hydroxide	U	U	U	U	U	S	S	S	S	S
Ammonium Nitrate	S	S	S	S	S	S	S	S	S	S
Aniline	U	U	U	U	U	U	S	S	S	S
Asphalt	U	U	S	S	—	U	U	U	S	S
Benzene	U	U	U	U	S	U	U	U	S	S
Butyl Acetate	U	U	U	U	U	U	U	U	S	S
Butyl Alcohol	S	S	S	S	S	S	S	S	S	S
Butyl Carbitol	U	U	S	S	S	S	S	S	S	S
Butyl Cellosolve	U	U	S	S	S	S	S	S	S	S
Calcium Chloride	S	S	S	S	S	S	S	S	S	S
Carbital	U	U	S	S	—	—	S	S	—	S
Carbon Tetrachloride	U	U	U	U	S	U	U	U	S	S
Cellosolve	U	U	S	S	—	S	S	S	S	S
Cellosolve Acetate	U	U	U	U	U	U	—	S	S	S
Corn Syrup	U	U	U	S	S	U	U	S	S	S
Isophorone	U	U	U	U	U	—	—	—	—	S
Jet Fuel (JP-1 to JP-5)	U	U	S	S	S	U	U	U	S	S
Kerosene	U	U	S	S	S	U	U	U	S	S
Mesital Oxide	U	U	U	U	—	—	—	U	—	S
Methyl Alcohol	S	S	S	S	S	S	S	S	S	S
Methyl Amyl Acetate	U	U	U	U	U	U	U	—	S	S
Methyl Cellosolve	U	U	S	—	—	S	—	S	—	S
Methyl Ethyl Ketone	U	U	U	U	U	U	S	U	S	S
Methyl Isobutyl Carbinol	S	S	S	S	S	S	S	S	S	S
Methyl IsoButyl Ketone	U	U	U	U	U	U	S	U	S	S
Methyl Methacrylate	U	U	U	U	U	S	U	U	S	S
Methylene Chloride	U	U	U	U	S	U	U	—	S	S
Milk	U	S	S	S	U	S	—	S	S	S
Molasses	S	U	U	S	U	U	U	U	S	S
Monochlorobenzene	U	U	U	U	S	U	U	U	S	S
Naptha	U	U	U	S	S	U	U	U	S	S
Nitric Acid—10%	U	U	S	U	U	S	S	S	S	S
—70%	U	U	U	U	U	S	U	U	S	S
—Fuming	U	U	U	U	U	U	U	U	U	S
Oil, Crude	U	U	S	S	S	S	U	U	S	S
Oil, Lubricating	U	U	S	S	S	S	U	U	S	S
Oil, Vegetable	U	U	S	S	S	S	U	U	S	S
Oleic Acid	U	U	S	S	—	U	S	S	S	S
Palmitic Acid	U	U	U	S	U	U	—	—	S	S
Phenol	U	U	—	U	S	S	—	U	S	S
Cyclohexanone	U	U	U	U	—	U	—	U	S	S
Di-Acetone Alcohol	U	U	S	U	U	S	S	S	S	S
Di-Iso Butyl Ketone	U	U	U	U	U	U	S	U	S	S
Di-Isopropyl Ether	U	U	U	S	U	U	U	—	—	S
Di-Octyl Phthalate	U	U	U	U	—	U	S	S	S	S
Epichlorohydrin	U	—	U	U	—	U	—	—	S	S
Ethyl Acetate	U	U	U	U	U	U	U	S	S	S
Ethyl Alcohol	S	S	S	S	S	S	S	S	S	S
Ethyl Amyl Ketone	U	U	U	U	U	—	S	U	S	S
Ethyl Chloride	S	S	S	S	S	S	U	S	S	S
2—Ethyl Hexanol	U	—	U	U	—	U	—	—	S	S
Ethylene Glycol	S	S	S	S	S	S	S	S	S	S
Formaldehyde	U	S	U	U	S	S	S	S	S	S
Freon 12	S	U	S	S	S	S	S	S	S	S
Freon 13	U	U	S	S	U	U	U	S	S	S
Freon 21	U	U	U	S	U	U	U	U	S	S
Freon 22	U	U	S	S	U	U	U	S	S	S
Gasoline	U	U	S	S	S	U	U	U	S	S
Glycerine	S	S	S	S	S	S	S	S	S	S
Grease	U	U	S	S	S	S	U	U	S	S
Hexane	U	U	S	S	S	S	U	U	S	S
Hexylene Glycol	S	S	S	S	S	S	—	S	S	S
Hydrochloric Acid—10%	S	U	U	U	S	S	S	S	S	S
38%	U	U	U	U	S	S	S	S	S	S
Phosphoric Acid—50%	S	S	S	S	S	S	S	S	S	S
—80%	S	S	S	S	S	S	S	S	S	S
Propane Gas, Liquid	U	U	S	U	U	S	U	U	S	S
Propyl Acetate	U	U	U	U	U	U	U	U	S	S
Propyl Alcohol	S	S	S	S	S	S	S	S	S	S
Propylene Glycol	—	—	—	—	—	—	S	S	S	S
Sodium Hydroxide	U	U	U	U	U	U	S	S	S	S
Sodium Silicate	S	S	S	S	S	S	S	S	S	S
Stearic Acid	U	U	S	S	—	S	—	—	S	S
Styrene	U	U	U	U	S	U	U	U	—	S
Sulfur	U	U	S	U	S	S	U	U	U	S
Sulfur, Molten	U	U	U	U	U	U	U	U	U	S
Sulfuric Acid—10%	S	S	S	S	S	S	S	S	S	S
—70%	U	U	U	U	S	S	S	S	S	S
—Fuming	U	U	U	U	S	U	U	U	S	S
Tall Oil (Liquid Rosin)	U	U	S	S	S	U	U	U	S	S
Tallow	U	U	S	S	S	S	U	U	S	S
Tar	U	U	S	S	—	S	U	U	U	S
Toluene	U	U	U	U	S	U	U	U	S	S
Trichloroethane	—	—	—	—	—	—	—	—	—	S
Trichloroethylene	U	U	U	U	S	U	U	U	S	S
Urea	S	S	S	S	S	S	—	—	S	S
Wax	U	U	S	S	S	S	U	U	S	S
Xylol	U	U	U	U	S	U	U	U	S	S

ASTM D-2000

CLASSIFICATION SYSTEM FOR ELASTOMERIC MATERIALS

EXAMPLE: 2BA610 A14 C12 L14

While not a part of the specification itself, the following chart presents the assigned material prefix letters and the polymer such prefix would normally call out. This is the conversion equivalent applicable under:

D-2000 and J-200	D-735 and J-14
AA—Natural, SBR, Butyl, Isoprene	R
AK—Polysulphide	SA
BA—Ethylene-Propylene, Heat Resistant SBR and Butyl	—
BC—Chloroprene-Neoprene	SC
BE—Chloroprene-Neoprene (lower oil swell and comp. set)	—
BF—Nitrile—E14-E34 Requirements	—
BG—Nitrile—E51-E61 Requirements	SB
BK—Organic Dihalide (Thiokol)	SA
CA—Ethylene-Propylene	—
CE—Chlorosulfanated Polyethylene (Hypalon)	—
CH—Nitrile	—
DF—Polyacrilic (Butyl-Acrylate Type)	—
DH—Polyacrilic	TB
FC—Silicone	TA
FE—Silicone	—
FK—Fluorinated Silicone	—
GE—Silicone	—
HK—Fluorinated Elastomers (Viton)	—

1ST DESIGNATE (2)

Grade number — used to designate supplemental requirements beyond the basic call out. Your supplier can develop this.

2ND DESIGNATE (B)

Indicative of heat resistant requirements at which polymer shall be tested. (See Table 1.)

TABLE 1
BASIC REQUIREMENTS FOR ESTABLISHING TYPE BY TEMPERATURE

Type	Test Temperature °C	Test Temperature °F	Type	Test Temperature °C	Test Temperature °F
A	70	158	F	200	392
B	100	212	G	225	437
C	125	257	H	250	482
D	150	302	J	275	527
E	175	347			

3RD DESIGNATE (A)

Indicative of degree of oil resistance as measured by volume swell under test procedures. (See Table 2.)

TABLE 2 — BASIC REQUIREMENTS FOR ESTABLISHING CLASS BY VOLUME SWELL

Class	Volume Swell, Max. %	Class	Volume Swell, Max. %
A	No requirement	F	60
B	140	G	40
C	120	H	30
D	100	J	20
E	80	K	10

4TH DESIGNATE (6)

Indicative of hardness required, as 60 ± 5 Shore "A"

5TH AND 6TH DESIGNATE (1 & 0)

Indicative of tensile strength required, as 1,000 PSI written in hundreds of PSI

7TH DESIGNATE

The suffix letters (A, C, L) indicate supplemental requirements for particular applications that set up more rigid test procedures — beyond the basic call out. (See Table 3.)

TABLE 3 — MEANING OF SUFFIX LETTERS

Suffix Letter	Test Required	Suffix Letter	Test Required
A	Heat Resistance	J	Abrasion Resistance
B	Compression Set	K	Adhesion
C	Ozone or Weather Resistance	L	Water Resistance
		M	Flammability Resist.
D	Compression Deflection Resistance	N	Impact Resistance
		P	Staining Resistance
E	Fluid Resistance	R	Resilience
F	Low Temperature Resistance	Z	Any special requirement to be specified in detail
G	Tear Resistance		
H	Flex Resistance		

8TH DESIGNATE

The suffix numbers (14, 12, 14) indicate the ASTM test method applicable by the first digit. (See Table 4.)

9TH DESIGNATE

The suffix numbers, (in this case 14-12-14) the second digit denotes the temperature at which the test shall be conducted. (See Table 5.)

TABLE 5

FOR SUFFIX LETTERS A-B-C-E-G-K-L	FOR SUFFIX LETTER: F
1 = 73 Deg. F.	4 = Zero Deg. F.
2 = 100 Deg. F.	5 = Minus 13 Deg. F.
3 = 158 Deg. F.	6 = Minus 31 Deg. F.
4 = 212 Deg. F.	7 = Minus 40 Deg. F.
5 = 257 Deg. F.	8 = Minus 58 Deg. F.
6 = 302 Deg. F.	9 = Minus 67 Deg. F.
	10 = Minus 85 Deg. F.
	11 = Minus 103 Deg. F.