GENERAL PROPERTIES OF ELASTOMERS

BUTYL

General Description:
Butyl is produced by copolymerizing isobutylene with small amounts of isoprene (typically 98% polyisobutylene and 2% isoprene). Butyl rubber was first commercialized in the early 1940s. With excellent gas impermeability and air retention along with good flex properties, the first major application of butyl rubber was tire inner tubes.

Butyl rubber has a typical service temperature range between –75° F and +250° F.

Advantages:
Butyl rubber has exceptional resistance to gas and moisture (water and steam) permeation. Butyl rubber also has excellent resistance to oxygenated solvents (ketones and alcohols), alkalis, flexing, and abrasion. Butyl is capable of providing high energy absorption (damping) and thus has excellent electrical isolation performance. Butyl has good resistance to sunlight, ozone, heat aging, animal and vegetable oils, oxidizing chemicals, silicone fluids and greases, ammonia, hydrazine, and phosphate ester type hydraulic fluids (e.g., Skydol, Fyrqeul, Pydraul).

The molecular structure of butyl rubber can be oriented to resist stress. Mechanical properties are retained over a relatively wide stiffness range since reinforcement is not required for good tensile and tear strength.

Limitations:
Butyl rubber is difficult to handle during manufacturing because of its tendency to trap air, blister, and creep. Cold flow characteristics and flame resistance are poor. Butyl is not recommended for use with petroleum oils, fluids, or solvents. Butyl has poor resistance to aromatic hydrocarbons (e.g., Benzol, Toloul), aliphatic hydrocarbons (e.g., kerosene, turpentine), coal, tar, and diester-based lubricants. Cold weather properties for butyl rubber are fair.

Common Applications:
Butyl's excellent impermeability to gas makes it very useful in seals for vacuum applications. Butyl's gas impermeability coupled with its air retention capabilities make butyl popular for use in tire inner liners and inner tubes. Butyl is also used in hydraulics applications where synthetic fluids are used.

EPDM (Ethylene-Propylene-Diene Modified)

General Description:
There are two basic types of EP rubber available in today's market—EP and EPDM. EP is a copolymer of ethylene and propylene, while EPDM is a terpolymer combining ethylene, propylene and a diene monomer. EP uses a peroxide cure system. EPDM uses a sulfur cure system.

EPDM has a typical service temperature range between –65° F and +300° F.

Advantages:
EPDM exhibits exceptionally good resistance to weather aging, ozone, UV exposure, water, heat, phosphate ester base hydraulic fluids (Skydrol, Fyrquel, Pydraul), dilute acids, electrical insulation. EPDM has good to very good resistance to steam, oxygenated solvents (acetone, methyl, ethyl ketone and other ketones), animal and vegetable oils, alkalis, brake fluids, and compression set. EPDM's dynamic and mechanical properties are, in general, between natural rubber and SBR.

Limitations:
EPDM is not recommended for use with petroleum oils, fluids, or solvents because significant swelling would result. EPDM has poor resistance to aromatic hydrocarbons (e.g., Benzol, Toloul) and aliphatic hydrocarbons (e.g., kerosene, turpentine).

Common Applications:
EPDM is one of the most widely used synthetic rubbers in many static and dynamic applications. EPDM is used extensively in outdoor applications where weather and water resistance is required. It can be found in several industries ranging from automotive to HVAC. Gaskets, bumpers, auto parts, auto brake systems, electrical installation, dust covers, weather stripping and conveyor belts are just of the many products that use EPDM.

NATURAL RUBBER

General Description:
Crude natural rubber is found in the juices of many plants (shrubs, vines, and trees), the principal of which is the Hevea Brasiliensis tree, native to Brazil. After the latex is processed, natural rubber becomes an elastomer with excellent mechanical properties.

Natural Rubber has a typical service temperature range between –67° F and +180° F.

Advantages:
Natural rubber has excellent tensile, elongation, tear resistance, resilience, and electrical insulation. Natural rubber's high resilience is only outperformed by some of the more recent man-made polyisoprenes and polybutadienes. Natural rubber exhibits excellent resistance to water and cold flow. Natural rubber has low compression set and can be bonded to a wide range of materials. It also has good flexing qualities at low temperatures that are better than most synthetics, but it is not as good as silicone or some of the special butadiene and SBR compounds. Natural rubber has superb abrasion resistance when it is compounded with carbon black.

Limitations:
Natural rubber deteriorates when exposed to oils, fuels, solvents, petroleum derivatives, and hydraulic fluids. Without special additives, natural rubber has poor resistance to sunlight, oxygen, ozone, and high temperatures.

Common Applications:
Natural rubber can be easily bonded to a wide variety of materials, including fabric and metal. Natural rubber is widely used where many types of acids and bases, except those types that are highly oxidizing, are present. Common applications include tires, tubing, gaskets, belts, hoses, seals, shock mounts, rolls, vibration isolators, electrical components, bumpers, and drive wheels.

NEOPRENE

General Description:
Neoprene was created in 1930 by DuPont as an air and oil resistant substitute for natural rubber. It was the first mass-produced synthetic rubber. Neoprene is a polymer of chloroprene and is considered a general or all-purpose rubber. Neoprene is available in many varieties including non-sulfur modified "W" and the more common sulfur modified "GN" types.

Neoprene has a typical service temperature range between –50° F and +275° F.

Advantages:
Neoprene is known for its versatility. It provides good resistance to moderate exposure to ozone, sunlight, oxidation, weather, oils, gasoline, greases, solvents, petroleum oils, animal and vegetable oils, compression set, silicone oil, refrigerants, ammonia, carbon dioxide, water, and steam. Certain compounds of neoprene are flame resistant and will not support combustion. 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. Resilience and abrasion strength are good. Adhesion to metals and fabrics is very good.

Limitations:
The cost of neoprene is its greatest disadvantage. It is a good multipurpose rubber, but there are other types that offer much better oil, ozone, weather and oxidation resistance at a lower cost when they are used for specific applications. Neoprene has poor resistance to strong oxidizing acids, esters, ketones, chlorinated, aromatic, and nitro hydrocarbons.

Common Applications:
Neoprene is primarily used in applications when the seal is exposed to weathering refrigerants, silicate ester lubricants and high aniline point petroleum oils. Neoprene can be formulated for use in mass transit industries due to its ability to meet ASTM c1166, e162, e662 and SMP800C standards. Common applications include refrigeration seals, Freon/air conditioning, motor mounts, engine coolants, petroleum and chemical tank linings, automotive gaskets and seals, and weather stripping.

NITRILE (Buna-N)

General Description:
Nitrile, or Buna-N, is a copolymer of butadiene and acrylonitrile. It is a general purpose oil-resistant polymer.

Nitrile has a typical service temperature range between –40° F and +275° F.

Advantages:
Nitrile has excellent resistance to oil, gasoline, solvents, mineral and vegetable oils, hydraulic fluid, and fuels. It is recommended for applications that require good oil and grease resistance as well as moderate ozone resistance. With compounding, it is possible to get a fairly good balance between low creep, good resilience, low permanent set and good abrasion resistance. Nitrile is superior to most elastomers with regard to compression set or cold flow, tear and abrasion resistance. Nitrile resists acids and bases with the exception of those having strong oxidizing effects. Nitrile is resistant to a broader range of aromatic hydrocarbons than neoprene. Resistance to heat aging is good.

Limitations:
Nitrile has poor resistance to ketones, chlorinated hydrocarbons, and nitro hydrocarbons. It does not have good ozone, oxygen or sunlight resistance without the addition of special additives. Nitrile's low-temperature resistance is inferior to natural rubber, and although nitrile can be compounded to give improved performance in this area, the gain is normally at the expense of oil and solvent resistance. Conversely, with higher acrylonitrile contents, the solvent resistance is increased but low-temperature flexibility is decreased. Nitrile, like SBR, does not crystallize on stretching. Thus, reinforcing materials, such as carbon blacks, are required to obtain high strength. Tear resistance is inferior to that of natural rubber and electrical insulation is lower.

Common Applications:
Nitrile is recommended when excellent resistance to petroleum oils, gasoline, and/or greases is needed. Nitrile is the most widely used elastomer for sealing products due to its excellent resistance to petroleum products and its wide temperature range. More than 50% of the o-rings sold are nitrile o-rings. Nitrile is also widely used with hydraulic fluid and alcohol applications. Nitrile is commonly used for industrial and automotive applications, in products such as fuel and oil handling hoses, petroleum oil seals, grommets, hydraulic hoses, hydraulic fluid seals, transmission fluid seals, rollers, shock and vibration mounts, and o-rings. Typical applications of the premium grades of NBR include carburetor gaskets, fuel pumps, diaphragms and aircraft hose gaskets. The commercial grades of NBR are usually blends of NBR with other polymers. These less costly blends accommodate less demanding applications where oils and heat are prevalent. Ozone-resistant nitriles are recommended where extended exposure to air and ozone is anticipated.

POLYISOPRENE

General Description:
Polyisoprene is a synthetic elastomer with characteristics equal to, or similar to, those of natural rubber.

Advantages:
Synthetic polyisoprene exhibits excellent resilience and its color uniformity from one batch to another is easy to maintain because of the uniformity of the polymer.

Limitations:
Tensile strength is slightly lower than the tensile strength of natural rubber.

Common Applications:
This elastomer is similar in composition to natural rubber and serves many applications requiring uniform quality and performance especially where color is concerned.

SBR (Styrene Butadiene)

General Description:
SBR, also known as Buna-S, is a synthetic copolymer of styrene and butadiene. SBR was originally developed to replace natural rubber in tires and its use in the manufacture of tires continues to the present day. SBR and natural rubber account for 90% of the total world rubber consumption.

SBR has a typical service temperature range between –50° F and +225° F.

Advantages:
SBR has similar properties to natural rubber, but SBR has superior water resistance, heat resistance, abrasion resistance, low-temperature flexibility, and heat aging properties (i.e., in excess heat SBR hardens and becomes brittle instead of softening like natural rubber does). SBR also has good electrical insulation, alcohol resistance, oxygenated solvent resistance, and mild acid resistance. SBR can be successfully bonded to a wide range of materials.

Limitations:
SBR has poor resistance to oils, fuels, hydraulic fluids, strong acids, greases, fat, and most hydrocarbons. Without special additives, SBR is vulnerable to ozone, oxygen and sunlight.

Common Applications:
SBR is recommended for applications where water, automotive brake fluid, or alcohols with a low molecular weight are present. Common applications include tire, tubes, gaskets, belts, hoses, seals, shock mounts, skirtboard rubber, lining rubber, and conveyor belt covers. SBR is not normally produced in o-ring form.

SILICONE

General Description:
Silicone rubber is a semi-organic synthetic made from sand and alkyl or aryl halides. While silicone rubber looks and feels like organic rubber, it has a completely different type of structure than other elastomers. Silicone rubber consists of a chain of silicon and oxygen atoms rather than carbon and hydrogen atoms as found in other types of rubber. This structure gives silicone rubber a very flexible but weak chain. Silicone's structure also provides a material that has very small change in dynamic characteristics over a wide range of temperature.

Silicone has a typical service temperature range between –150° F and +450° F.

Advantages:
Silicone has a broad temperature range and is generally odorless / non-toxic. Silicone offers excellent resistance to high temperatures, ozone, oxygen, UV light, moisture, and fungus. Silicone also has excellent vibration damping and maintains its dielectric strength. Silicone has low compression set and offers good fatigue resistance, flex resistance, and elongation.

Limitations:
Silicone has poor tensile, tear and abrasion resistance, and is not recommended for use in dynamic applications. Although high strength silicones have been developed, tear and tensile strengths remain relatively low. Silicone has poor resistance to most concentrated solvents, concentrated acids, concentrated alkalines, oils, fuels, hydrocarbons, and steam.

Common Applications:
Silicone is recommended for applications subjected to extremely high or low temperatures. Silicone is often used in industrial applications due to its long service life. Common applications include gaskets, seals, o-rings, and bellows.

GENERAL PROPERTIES OF ELASTOMERS SUMMARY CHART

The chart below provides general information for various common elastomeric compounds and very general features of the most common elastomers. Rubber compounding is a broad field. Basic elastomers are mixed with a variety of chemicals and ingredients to obtain desired physical properties. Many basic polymers are available that can yield compounds with unique physical properties.

Common Name	Designation[2]	Composition[2]	General Properties[1]	General Chemical Resistance[3]	
				Resistant to:	Attacked by:
Butyl	IIR	Isobutylene-isoprene	Very good weathering resistance Excellent dielectric properties Low permeability to air Good flex properties Poor resistance to petroleum-based fluids	Animal and vegetable fats, oils, greases, oxygenated solvents, alkalis, ozone, strong and oxidizing chemicals, silicone fluids and greases, ammonia, phosphate ester type hydraulic fluids	Petroleum oils, fluids, and solvents; coal, tar, and diester-based lubricants and solvents; aliphatic and aromatic hydrocarbons
EPDM	EPDM, EPM	Ethylene-Propylene-Diene Modified	Excellent ozone, chemical, weather, UV, and aging resistance Poor resistance to petroleum-based fluids	Animal and vegetable oils, ozone, strong and oxidizing chemicals, alkalis, brake fluids, phosphate ester type hydraulic fluids	Mineral oils and solvents; petroleum oils, fluids, or solvents; aliphatic and aromatic hydrocarbons
Natural Rubber	NR	Isoprene, natural	Excellent physical properties including abrasion and low temperature resistance Poor resistance to petroleum-based fluids	Most moderate chemicals, wet or dry, organic acids, alcohols, ketones, aldehydes	Ozone, strong acids, fats, oils, fuels, solvents, petroleum derivatives, hydraulic fluids, greases, most hydrocarbons
Neoprene	CR	Chloroprene	Good weathering resistance, resilience, and abrasion strength Flame retarding Moderate resistance to petroleum-based fluids	Moderate chemicals and acids, ozone, oils, fats, gasoline, greases, solvents, petroleum oils, animal and vegetable oils, refrigerants, steam, carbon dioxide	Strong oxidizing acids, esters, ketones, chlorinated, aromatic, and nitro hydrocarbons
Nitrile (Buna-N)	NBR	Nitrile-butadiene	Excellent resistance to petroleum-based fluids Good physical properties such as resistance to tear, abrasion, and heat aging	Many hydrocarbons, fats, oils, gasoline, solvents, mineral and vegetable oils, fuels, greases, hydraulic fluids, chemicals	Ozone (except PVC blends), ketones, esters, aldehydes, chlorinated and nitro hydrocarbons
Polyisoprene	IR	Isoprene, synthetic	Excellent resilience Characteristics equal to, or similar to, those of natural rubber Tensile strength is slightly lower than the tensile strength of natural rubber	Most moderate chemicals, wet or dry, organic acids, alcohols, ketones, aldehydes	Ozone, strong acids, fats, oils, fuels, solvents, petroleum derivatives, hydraulic fluids, greases, most hydrocarbons
SBR	SBR	Styrene Butadiene	Good electrical insulation and resistance to alcohol, oxygenated solvents, and mild acids Similar properties to natural rubber, but has superior low-temp flexibility, heat aging properties, and resistance to water, heat, and abrasion Abrasion resistance to petroleum-based fluids	Most moderate chemicals, wet or dry, organic acids, alcohols, ketones, aldehydes	Ozone, strong acids, fats, oils, fuels, greases, most hydrocarbons
Silicone	Q, Si	Polysiloxane	Excellent high and low temperature properties Excellent vibration damping and maintains its dielectric strength Poor tensile, tear, and abrasion resistance Generally odorless and non-toxic Good fatigue resistance, flex resistance, and elongation	Moderate or oxidizing chemicals, ozone, oxygen, UV light, moisture, fungus, concentrated sodium hydroxide	Many solvents, oils, concentrated acids and alkalines, fuels, dilute sodium hydroxide, hydrocarbons, steam

[1] "Sheet Rubber Handbook – Gasket and Packing Materials" publication #IP-40 of the Rubber Manufacturers Association (RMA).
[2] ASTM C 1418-79
[3] 1979 Yearbook of the Los Angeles Rubber Group, Inc.