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Oil-Resistant Rubbers

Machine Design
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These rubbers include grades suitable for service at temperatures to 250°C and having maximum resistance to oils and greases. Some are considered specialty materials and are quite expensive.

Neoprene (CR; BC, BE): Except for polybutadiene and polyisoprene, neoprene is perhaps the most rubberlike of all, particularly with regard to dynamic response. Neoprenes are a large family of rubbers that have a property profile approaching that of natural rubber, and with better resistance to oils, ozone, oxidation, and flame. They age better and do not soften on heat exposure, although high-temperature tensile strength may be lower than that of NR.

These materials, like NR, can be used to make soft, high-strength compounds. A significant difference is that, in addition to neoprene being more costly than NR by the pound, its density is about 25% greater than that of natural rubber. Neoprenes do not have the low-temperature flexibility of natural rubber, which detracts from their use in low-temperature shock or impact applications.

General-purpose neoprenes are used in hose, belting, wire and cable, footwear, coated fabrics, tires, mountings, bearing pads, pump impellers, adhesives, seals for windows and curtain-wall panels, and flashing and roofing. Neoprene latex is used for adhesives, dip-coated goods, and cellular cushioning jackets.

Chlorinated polyethylene (CM; DE): This family of elastomers is produced by the random chlorination of high-density polyethylene. Because of the high degree of chemical saturation of the polymer chain, the most desirable properties are obtained by crosslinking with the use of peroxides or by radiation. Sulfur donor cure systems are available that produce vulcanizates with only minor performance losses compared to that of peroxide cures. However, the free radical crosslinking by means of peroxides is most commonly used and permits easy and safe processing, with outstanding shelf stability and optimum cured properties.

Chlorinated polyethylene elastomers, sold by the Dow Chemical Co. under the trade name Tyrin, are used in automotive hose applications, premium hydraulic hose, chemical hose, tubing, belting, sheet packing, foams, wire and cable, and in a variety of molded products. Properties include excellent ozone and weather resistance, heat resistance to 300°F (to 350°F in many types of oil), dynamic flexing resistance and good abrasion resistance.

Chlorosulfonated polyethylene (CSM; DE): This material, more commonly known as Hypalon (Du Pont), can be compounded to have an excellent combination of properties including virtually total resistance to ozone and excellent resistance to abrasion, weather, heat, flame, oxidizing chemicals, and crack growth. In addition, CSM has low moisture absorption, good dielectric properties, and can be made in a wide range of colors because it does not require carbon black for reinforcement. Resistance to oil is similar to that of neoprene. Low-temperature flexibility is fair at -40°F.

Hypalon is a special-purpose rubber, not particularly recommended for dynamic applications. It is used generally where its outstanding environmental resistance is needed. Typical applications include coated fabrics, maintenance coatings, tank liners, protective boots for spark plugs and electrical connectors, cable jacketing, and sheeting for pond liners and roofing.

Nitrile (NBR; BF, BG, BK, CH): The nitriles are copolymers of butadiene and acrylonitrile, used primarily for applications requiring resistance to petroleum oils and gasoline. Resistance to aromatic hydrocarbons is better than that of neoprene but not as good as that of polysulfide. NBR has excellent resistance to mineral and vegetable 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 except those having strong oxidizing effects. Resistance to heat aging is good, often a key advantage over NR.

With higher acrylonitrile content, the solvent resistance of an NBR compound is increased but low-temperature flexibility is decreased. Low-temperature resistance is inferior to that of natural rubber, and although NBR can be compounded to give improved performance in this area, the gain is usually at the expense of oil and solvent resistance. As with SBR, this material does not crystallize on stretching, and reinforcing materials are required to obtain high strength. With compounding, nitrile rubbers can provide a good balance of 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 increased resistance to petroleum oils, gasoline, or aromatic hydrocarbons is required. Uses of NBR include carburetor and fuel-pump diaphragms and aircraft hoses and gaskets. In many of these applications, the nitriles compete with polysulfides and neoprenes.

Epichlorohydrin (CO, ECO; CH): Epichlorohydrin rubber is available as a homopolymer (CO) and a copolymer (ECO) of epichlorohydrin. Reinforced, these rubbers have moderate tensile strength and elongation properties, plus an unusual combination of other characteristics. One of these is low heat buildup, which makes them suitable for applications involving cyclic shock or vibration.

The homopolymer has outstanding resistance to ozone, good resistance to swelling by oils, intermediate heat resistance, extremely low permeability to gases, and excellent weathering properties. This rubber also has low resilience characteristics and low-temperature flexibility only to 5°F -- characteristics that may be unsuitable for some applications.

The copolymer is more resilient and has low-temperature flexibility to -40°F, but it is more permeable to gases. Oil resistance of both compounds is about the same. Typical applications include bladders, diaphragms, vibration-control equipment, mounts, vibration dampers, seals, gaskets, fuel hose, rollers, and belting.

Ethylene/acrylic: This family of rubbers is sold by Du Pont, under the trade name of Vamac. Introduced in 1975 in masterbatch form, the family was expanded in 1983 by the addition of a gum polymer. Vamac materials provide, at a moderate price, heat and fluid resistance surpassed by only the more expensive, specialty polymers such as fluorocarbons and fluorosilicones. The material has very good resistance to hot oils, hydrocarbon-based or glycol-based proprietary lubricants, transmission and power-steering fluids. It is not recommended for use with esters, ketones, highly aromatic fluids or high-pressure steam. A special feature of Vamac is its nearly constant damping characteristic over broad ranges of temperature, frequency, and amplitude.

The polymer is recommended for applications requiring a durable, set-resistant rubber with good low-temperature properties and resistance to the combined deteriorating influences of heat, oil, and weather. It is used in various automotive components such as mounts, gaskets, seals, boots, and ignition-wire jackets. Electrical applications include oil-well platform cable jackets, plenum cable, transit-wire jackets, and marine cable.

Perfluoroelastomer (FFKM): Chemical resistance of perfluoroelastomer parts is similar to that of PTFE, and mechanical properties are similar to those of the fluorocarbon rubbers. This high-performance, high-priced rubber, produced by Du Pont as Kalrez, and by Greene, Tweed & Co. as Chemraz, is essentially unaffected by all fluids, including aliphatic and aromatic hydrocarbons, esters, ethers, ketones, oils, lubricants, and most acids. However, some fully halogenated fluids and strong oxidizing acids may cause swelling. The parts are suitable for continuous service to 290°C and intermittent service to 316°C. Resistance to ozone, weather, and flame is exceptional. Radiation resistance is good and high-vacuum performance excellent.

Perfluoroelastomer parts are used primarily in demanding fluid-sealing applications in the chemical-processing, oil-production, aerospace, and aircraft industries.

Acrylate (ACM, ANM; DF, DH): These are specialty rubbers based on polymers of methyl, ethyl, or other alkyl acrylates. They are highly resistant to oxygen and ozone, and their heat resistance is superior to that of all other commercial rubbers except the silicones and the fluorine-containing rubbers. Water resistance is poor, however, so the acrylates are not recommended for use with steam or water-soluble materials such as methanol or ethylene glycol. However, flex life is excellent as is permeability resistance. Resistance to oil swell and deterioration is also excellent at high temperatures.

Low-temperature flexibility is not good, and these rubbers decompose in alkaline solutions and are swelled by acids. Low-temperature flexibility and water resistance can be improved, but only with a marked decrease in heat and oil resistance. These materials are used extensively for bearing seals in transmissions, and for O-rings and gaskets.

Polysulfide (PTR; AK, BK): These polymers have outstanding resistance to oils, greases, and solvents, but they have an unpleasant odor, resilience is poor, and heat resistance is only fair. Abrasion resistance is half that of natural rubber, and tensile strength ranges from 1,200 to 1,400 psi. However, these values are retained after extended immersion in oil.

Basic properties of polysulfide polymers are determined by the type of chain structure and the number of sulfur atoms in the polysulfide groups. Increased sulfur concentration improves solvent and oil resistance, and also reduces permeability to gases. These materials are used in gasoline hose, printing rolls, caulking, adhesives, and binders.

Silicone (VMPQ, PVMQ; MQ, PMQ, FC, FE, GE): Silicone rubber comprises a versatile family of semiorganic synthetics that look and feel like organic rubber, yet have a completely different type of structure from other rubbers. The backbone of the rubber 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, which provides a remarkably small change in dynamic characteristics over a wide temperature range.

Silicone rubbers have no molecular orientation or crystallization or stretching and must be strengthened by reinforcing materials. The cost of silicone rubbers is not as dependent on petroleum cost as are costs of the synthetic organic rubbers. Although silicones are at the high end of the cost range for rubbers, they can be made to withstand temperatures as high as 600°F without deterioration. At the other end of the scale, silicones retain useful flexibility at -150°F.

While the strength of silicone rubbers is lower than that of other rubbers, these materials have outstanding fatigue and flex resistance. They do not require high tensile strength to serve in dynamic applications. Fall-off in tensile properties with extended exposure to high temperature is much less than for other rubbers. Resistance to chemical deterioration, oils, oxygen, and ozone is also retained under these conditions. Chemical inertness makes these materials well suited for surgical and food-processing equipment. One and two-part silicone sealants are used as structural adhesives and weatherseals in commercial buildings.

Fluorosilicone (FVMQ; FK): This type of silicone provides most of the useful qualities of the regular silicones plus improved resistance to many hydrocarbon fluids such as fuels. Exceptions are ketones and phosphate esters; however, FVMQ rubbers can be blended with conventional dimethyl silicones, which have good resistance to these fluids at temperatures to 300°F. The FVMQ rubbers are most useful where the best in low-temperature flexibility is required in addition to fluid resistance, although resistance to fluids (especially those containing aromatics) is poorer than that of the FKM-type fluorocarbon rubbers.

Fluorosilicone rubbers have moderate dielectric properties, low compression set, and excellent resistance to ozone and weathering. They are expensive and definitely special purpose. Typical applications include seals, tank linings, diaphragms, O-rings, and protective boots in electrical equipment.

Fluorocarbon (FKM; HK): Generally produced as a copolymer of vinylidene fluoride and hexafluoropropylene, the fluorocarbons are high-performance, high-cost rubbers known generally as Viton (Du Pont) and Fluorel (3M). These rubbers have outstanding resistance to heat and to many chemicals, oils, and solvents compared to any other commercial rubber. In air, fluorocarbon rubber parts retain at least half of their original properties after 16-hr exposure at 600°F. These same compounds offer low-temperature stability to -40°F.

In the reinforced state, these rubbers offer moderate tensile strength but relatively low elongation properties. They resist oxidation and ozone, and they do not support combustion. Several versions are available, and conventional compounding produces formulations within a hardness range of 65 to 95 Shore A. Fluorocarbon rubbers are severely attacked by highly polar fluids such as ketones, hydrazine, anhydrous ammonia, and Skydrol (phosphate ester) hydraulic fluids. Postcuring is required to develop optimum properties. Typical applications are seals, gaskets, diaphragms, pump impellers, tubing, and vacuum and radiation equipment.

Urethane (AU, EU; BG): These rubbers, combinations of polyesters or polyethers and diisocyanates, are unusual in that physical properties do not depend on compounding materials. Urethanes crosslink and undergo chain extension to produce a wide variety of compounds. They are available as castable or liquid materials and as solids or millable gums.

Urethane polymers have outstanding abrasion resistance, excellent tensile strength and load-bearing capacity, and elongation potential, accompanied by high hardness. Other properties include low-temperature resistance, high tear strength, either high or low coefficient of friction, good radiation resistance, and good elasticity and resilience, even in very hard stocks.

Typical applications include seals, bumpers, metal-forming dies, valve seats, liners, coupling elements, rollers, wheels, and conveyor belts, especially where abrasive conditions are present.

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