The proper selection of materials to be used in fabricating the lip, case and spring of an oil seal is critical for maximum seal performance and life. The following section provides a guide to help you select the most appropriate materials, taking into consideration fluid compatibility, temperature and wear resistance. The information contained in these tables has been derived from deVries International testing, as well as base polymer suppliers and other sources. Compatibility ratings in the following pages are meant as a guide for effective seal design. The suitability of a seal design should always be validated through thorough testing in the assembly in which it will be used.

SELECTING THE PROPER ELASTOMER

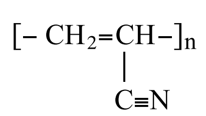
There are four primary considerations in elastomer selection: temperature, chemical compatibility, physical attributes (including abrasion and tear resistance) and cost. The first step in selecting the proper elastomer is determining which polymer family best suits the application. The following is an outline of physical and chemical characteristics pertaining to deVries International's nine most commonly used polymers.

In determining the correct polymer family for your application, the first consideration should be the system's operating temperature. If the upper limit of the temperature range is exceeded, a chemical reaction within the elastomer will cause it to change permanently, resulting in loss of elastic properties needed for effective sealing. Temperatures below the lower limit of the elastomer cause only a non-permanent hardening. As the elastomer warms back within its temperature limits all of its original properties will return.

A seal's compatibility with the fluid to be sealed is determined by the elastomer's stability while immersed in that fluid. Changes in the elastomer's hardness, tensile, elongation, and volume are measured after immersion in the fluid with the smallest changes in these properties identifying the most suitable seal material. A "1" rating reflects maximum stability while a "3" rating shows the greatest physical change and a material not recommended for use in that fluid. (See chart page 25.) The outline of polymer families below will also provide an indication of physical strength as well as relative costs.

NITRILE, N

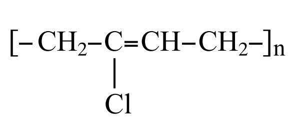
NITRILE



Nitrile or Buna-N is a co-polymer of butadiene and acrylonitrile. Acrylonitrile content determines the elastomer's resistance to petroleum based oils and hydrocarbon fuels. Increasing the acrylonitrile percentage improves the resistance to these fluids, but reduces low temperature flexibility. Other additives can be incorporated into Nitrile to improve low temperature flexibility. With a temperature range –65° to 225°F in oil seal applications, Nitriles exhibit excellent compression set, tear and abrasion resistance. They do not possess good resistance to sunlight, ozone, and outdoor weathering. This material is the most widely used and cost effective oil seal elastomer. Nitrile is considered the cost datum for this section; other elastomers will reflect cost comparisons to Nitrile oil seals.

NEOPRENE, C

NEOPRENE

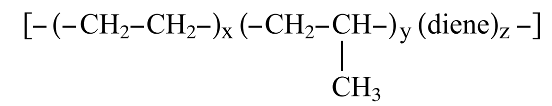


Neoprenes are homopolymers of chlorobutadiene with service temperatures from –65° to 300°F. This material is unique in its limited resistance to petroleum products, ozone and weathering, and relatively low cost. Neoprene typically has a 20% premium over the cost of Nitrile oil seals.

ETHYLENE PROPYLENE, EP, ES

Ethylene propylene is a terpolymer made up of ethylene, propylene and a diene monomer. These materials are used in sealing automotive brake fluids, water, steam and fire resistant hydraulic fluids. They are not recommended for use in petroleum based fluids or di-ester lubricants.

ETHYLENE PROPYLENE

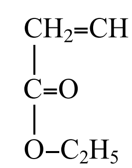


Ethylene Propylene can be processed with two different curing systems: peroxide, EP, with a temperature range of –65° to 300°F and excellent compression set resistance; or sulfur, ES, which handles temperatures from –65° to 212°F and average compression set resistance. Both materials exhibit similar chemical resistance. The ES compounds have a 20% premium over nitrile while the EP materials have a 40% premium.

POLYACRYLATE, PA

Polyacrylate is a co-polymer of ethyl and butyl acrylates. This material has excellent resistance to petroleum products, ozone and sunlight. Its continuous temperature range is between –40° and 300°F when used in oil seals. Polyacrylates have been commonly used in automotive transmissions, transfer cases and power steering units. Higher performance demands of modern car designs have replaced Polyacrylate with higher performance materials such as Fluoroelastomers, HNBR and Vamac. Polyacrylate has 30% premium over Nitrile oil seals.

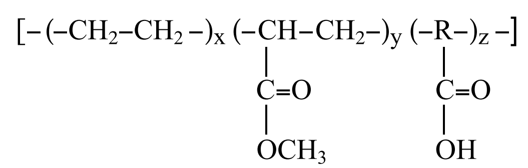
POLYACRYLATE



VAMAC, VM

Vamac polymer, produced by E.I. duPont, is a terpolymer of ethylene, methyl acrylate and carboxylic monomers. Vamac's operational temperature range is between –30° and 350°F. It has excellent resistance to ozone, weathering, water, mineral oils, acid, and good resistance to petroleum oils and transmission fluid. Vamac has a 40% premium over nitrile oil seals.

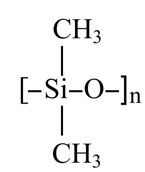
VAMAC



SILICONE, S

Silicone elastomers are produced from silicone, oxygen, hydrogen and carbon and carry a chemical name of Polydimethylsiloxane. Silicone has exceptional dry temperature resistance, being able to handle –80° to 450°F. Silicone possesses excellent resistance to weathering, sunlight and ozone. It is recommended for use in convoluted boots where weathering and flex life are critical. Silicone is normally considered to be a low tensile and tear strength material with marginal resistance to petroleum based products. However, deVries International has developed a high strength, petroleum based grease and oil resistant Silicone which is widely used in heavy duty, air disc brake applications where weathering, abrasion and petroleum resistance are critical. Silicone typically carries an 80% premium over Nitrile oil seals.

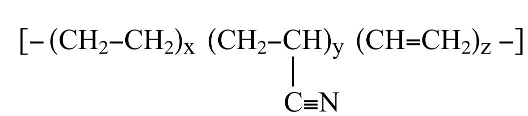
SILICONE



HYDROGENATED NITRILE, HNBR

Hydrogenated Nitrile is a co-polymer of butadiene and acrylonitrile that has been saturated with hydrogen. This is an exceptional material exhibiting tensile strength 50% greater than that of Nitrile and other high strength elastomers. Its temperature range for oil seals is –50° to 300°F. HNBR has excellent tear strength, compression set and chemical resistance to petroleum products, a wide range of solvents, weathering and ozone. It also provides superior steam resistance. HNBR has a 120% premium over Nitrile oil seals.

HYDROGENATED NITRILE



FLUOROELASTOMER, V

Fluoroelastomer, commonly known by its E.I. duPont trade name, Viton, is chemically described as a co-polymer of Vinylidene fluoride and Hexafluoropropylene. This material has comparable strength and wear resistance to Nitrile, but exhibits exceptional temperature and chemical resistance with service limits for oil seals from –40° to 400°F. It has been commonly used as a high performance replacement for Nitrile and Polyacrylate. Fluoroelastomers exhibit the widest range of chemical resistance, including petroleum products, water, ozone, di-esters and acid resistance. It is priced at a 300% premium over Nitrile oil seals.

FLUOROELASTOMER

$$[-(CH_2-CF_2)_x\ (CF_2-\underset{\displaystyle |}{\overset{CF_3}{\overset{|}{C}}}F)_y\ (CF_2-CF_2)_z-]$$

By varying fluorine content, Fluoroelastomers can be designed to handle more aggressive applications. Increasing the fluorine level in the base polymer creates improved fluid resistance but decreases low temperature flexibility. For these applications, where both low temperature and high chemical resistance are required, adding a cure site monomer and peroxide cure system to the high fluorine base polymer produces the best results.

TEFLON, T

Teflon is chemically known as Polytetrafluoroethylene which is a fluorocarbon plastic with a temperature range from –120° to 500°F. It is chemically resistant to virtually all fluids and exhibits excellent dry running properties. As a plastic, this material lacks the elastic resilience of synthetic rubber sealing materials. Teflon is very notch or cut sensitive during seal installation and requires very careful handling. It can become an excellent oil seal component when used in conjunction with other elastomers that will make up for its shortcomings in resilience. A combination of HNBR and reinforced teflon has become an industry standard in automotive air-conditioning compressor shaft seals. Due to the customized nature of teflon shaft seal designs there is not a direct cost correlation to Nitrile oil seals.

TEFLON

$$[-CF_2-CF_2-]_n$$

ELASTOMER, PART NUMBER SYSTEM	CODE
Nitrile (75°) General purpose	2
Nitrile (75°) High-temperature	3
Nitrile (90°)	4
Nitrile (80°) Carboxylated	XN
Nitrile (75°) Food Grade	2FDA
Ethylene-propylene, Peroxide Cure	EP
Ethylene-propylene, Sulfur Cure	ES
Hydrogenated Nitrile	HN
Neoprene	C
Polyacrylate	PA
Silicone	S
Teflon	T
Vamac	VM
Fluoroelastomer	V

The chart above shows the elastomeric material codes used in deVries International's standard oil seal part numbering system.