O-Ring Key Concepts

Abrasion Resistance - Abrasion resistance is a term describing a material surface's resistance to wear, typically from scraping or rubbing. It is typically most important in dynamic seal applications.

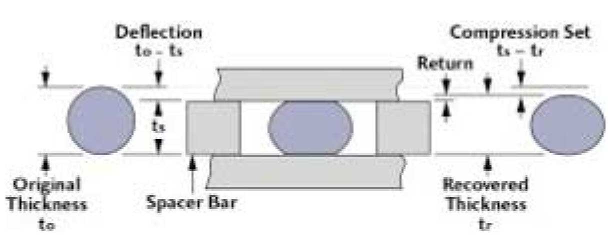
Coefficient of Friction - Coefficient of Friction is important in dynamic seal applications affecting material hardness, lubrication needs and gland surface design. Breakout friction, caused when the dynamic movement is begun, is greater than the running friction of the operation in progress. Typically, an increase in material hardness will increase breakout friction and vice versa.

Coefficient of Thermal Expansion - The Coefficient of Thermal Expansion in linear application is "the ratio of change in length per ºF to the length at 0ºF." In volumetric application with solid materials, it is typically three times the linear coefficient. As a rule of thumb, elastomers have a coefficient of expansion ten times that of steel, a fact that should be considered critically in gland design.

Compound - A compound is a mixture of base polymers and other chemicals which form a finished rubber material engineered for characteristics which provide optimum performance in a particular role. Accelerators, activators, antioxidants, anti ozonants, curing agents, plasticizers, reinforcing agents or other materials may be added o the elastomer to achieve the desired properties. In common parlance, "compound" and "elastomer" are often used interchangeably.

Compression Force - The force required to compress an O-ring enough to maintain an effective seal is critical in some applications.

Compression Set - Compression Set is "the percent of deflection by which an elastomer fails to recover (relaxes) after a fixed time under specified squeeze and temperature or the percent of original thickness." A seal featuring 0% compression set completely resumes its original shape while a seal with 100% compression set just fills the gland and offers no sealing force. Note that the worst possible scenario of a seal exhibiting a high compression set and abnormal shrinkage will typically lead to seal failure.



Corrosion - Corrosion is defined as "the result of chemical action of a fluid and/or the compound on the metal surface of the seal gland." Corrosion is a rare occurrence.

Deterioration - Deterioration describes a condition of permanent chemical change in the seal compound effecting its performance.

Elastomer - The American Society for Testing and Materials (ASTM) defines an "elastomer" is a "high polymer that can be or has been modified to a state exhibiting little plastic flow and quick or nearly complete recovery from an extending force." Elastomers must not break when stretched approximately 100% and, after being stretched and held for 5 minutes, it must retract to within 10% of its original length within 5 minutes after release.

Elongation - Elongation is defined as "an increase in length expressed numerically as a percent of initial length." The elongation measurement at which a part will break determines stretch acceptable during assembly. Elongation is also a measure of a material's ability to recover from peak overload or localized force. Degradation after exposure to a fluid is indicated by a negative change in a material's ability to elongate. Elongation is most critical at smaller gland dimensions.

Fluid Resistance - Fluid typically indicates the gas and/or a liquid that is being sealed. The seal material must resist chemical effects of the fluid on the seal including significant volume shrinkage or swelling, increase or decrease in hardness or tensile strength, or other factors that may lead to excessive deterioration and seal failure.

Gas Permeability - Gas Permeability is the "ability of a gas to pass or diffuse through an elastomer." Permeability increases with temperature and different gases have different rates of permeability. Squeeze increases a seal's resistance to permeability.

Hardness - O-rings made of softer materials flow easily into microfine grooves on the mating surface and perform best in low-pressure applications. O-rings made of harder materials offer greater resistance to flow and a lower coefficient of friction and perform best in high-pressure and most dynamic seal applications. Shore Instrument's Type A Durometer is the instrument typically used to measure the hardness of rubber compounds. The Type D durometer is recommended where the Type A reading is over 90 and, the Wallace Micro Hardness Tester is commonly used for materials that are too thin or provide too small an area for accurate durometer readings.

High Temperature - Elastomers tend to deteriorate when subjected to high temperatures. Volume, compression set, tensile strength, elongation, hardness, and chemical composition may all be irreversibly effected with their associated results effecting the performance of the seal.

Low Temperature - Low temperature effects on seals are typically reversible. Increased hardness, affecting seal flexibility, resilience, set and brittleness is most likely to be encountered and is easily compensated for.

Modulus - Modulus, in pounds per square inch, is defined ad "the stress at a predetermined elongation, usually 100%." Modulus normally increases with increase in hardness and toughness. The higher the modulus, the greater the material's ability to recover from peak overload or localized force and the better its resistance to extrusion.

Polymer - A polymer is the "result of a chemical linking of molecules into a long chain-like structure." For example, plastics and elastomers are both polymers. In this handbook, the term generally refers to a class of elastomers, members of which have similar chemical and physical properties. Nitrile is the polymer of choice in over half of all O-rings.

Resilience - Resilience is "the ability of a compound to return quickly to its original shape after a temporary deflection." This is a property of the compound and can normally be measured only in practical use.

Rubber - For our purposes, "rubber" includes both natural and synthetic materials possessing rubber-like qualities.

Tear Strength - Tear strength is a measure of a material's resistance to tear, noted in pounds per inch. Typically, the tear strength of most compounds is relatively low. If less than 100 lbs. / in., the seal may nick or cut easily during assembly and fail prematurely under further flexing or stress. Poor tear strength also may indicate poor resistance to abrasion, an important consideration in dynamic seal applications.

Tensile Strength - Tensile strength is a measure of the force, in psi (pounds per square inch), required to rupture a specimen of a rubber material. Tensile strength is not a good indicator of resistance to extrusion.

Thermoplastic Polymers - Thermoplastic material will soften when heated, and eventually liquefy, and harden when cooled in a process that is both reversible and repeatable. Thermoset polymers tend to be favored in sealing applications over thermoplastic polymers.

Thermoset Polymers - In an irreversible process, thermoset polymers become permanently "set" in the presence of heat and do not soften when re-heated. They possess superior mechanical, thermal, chemical properties and dimensional stability and tend to be favored in sealing applications over thermoplastic polymers.

Toughness - Toughness is a general describing a material's resistance to the physical forces and includes factors of tensile strength, elongation, compression force, modulus, tear strength and abrasion resistance.

Volume Change -Volume change is the "percent of increase or decrease of the volume of an elastomer after it has been in contact with a fluid." Swell, marked by softening of the elastomer, typically indicates a reduction in resistance to abrasion and tear, and may lead to seal extrusion. Shrinkage, a volume change that is more critical than swell, is normally marked by an increase in hardness and tends to intensify compression set causing the seal to pull away from sealing surfaces and leak. In dynamic applications, shrinkage greater than 3-4% can be serious while 15-20% swell is a typical maximum. In static applications swell 50% swell is acceptable. In many cases, the effectiveness of the seal may be enhanced by swell that balances compression set. For example, a swell of 15% will offset a compression set of 15%.