

Ningguo Shunda Sealing Co., Ltd.

Shiqiao Industrial Zone

Ningguo, Anhui 242300, China

Phone: +86.159.56197113 Fax: +86.563.4700077

sdarubber@yahoo.com

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This new catalog is the instrument for selecting the right component for every application or the answer to so many of the problems confronted every day by engineers and draftsmen. Seal & Design's o-rings comply with a large number of industry standards and are normally available from stock.

GENERAL PRINCIPLES

FUNCTION

The simple geometry is the main characteristic of an [O-Ring](#) which, in conjunction with proper elastomer selection results in a low cost, easy to use and efficient sealing system. Elastomeric materials, when compressed, react like a high viscosity fluid which transmits applied stress in every direction; consequently, the O-Ring serves as a barrier, blocking the leak paths between the sealing surfaces.

Technical sealing has been defined by DIN Standards as follows:

- A) "Static Seal" - The sealing action created between two mating surfaces with no leakage of liquid or minimal diffusion of gas.
- B) "Dynamic Seal" - The mating surfaces have relative movement with minimal leakage of liquid (useful to protect the sealing efficiency, acting as lubricant).

O-Rings offer several advantages over other sealing systems: simplicity of construction, standardized seal dimensions, wide selection of materials, suitability for both static and dynamic applications, standard dimensioning of glands, low cost due to high volume manufacturing.

Sealing is always achieved through a positive compression or squeezing action, resulting in a deformation of the O-Ring cross-section.

The most important sealing characteristic of an O-Ring is its resistance to compression set or residual deformation.

DESIGN

The design of an O-Ring application is based upon available technical data and the experience of the specification writer to regard to dimensions and available material characteristics within a given environment or application.

O-Ring glands or grooves are normally cylindrical with flat and parallel faces. In high pressure applications, anti-extrusion devices (Back-Up) are used to prevent extrusion of the elastomeric material through the clearance gaps when close tolerance are difficult to maintain.

NORMS AND STANDARDS

The most common international standards for O-Ring dimensions, in addition to ISO 3601/1 are:

USA	SAE AS-568A
Great Britain	BS 1806-BS
Germany	DIN 3771
Sweden	SMS 1586
France	NF T 47 501
Japan	JIS B 2401-77

MATERIALS

CLASSIFICATION OF ELASTOMERS

Elastomers that are intended for, but not limited to, use in automotive applications, are designated by ASTM D2000 on the basis of type (heat resistance) and class (oil resistance).

Resistance's to special fluids or environments (fuels, water, ozone, etc.) are also classified in a similar manner. ASTM D1418 lists different polymers by an abbreviated coding system (NBR, EPDM, ECO, SBR, FKM, etc.)

By utilizing this classification system, guidance is provided to the engineer in the selection of practical, commercially available rubber materials, and to also provide a method for specifying these materials by use of a simple "line call-out" designation.

PHYSICAL CHARACTERISTICS

Physical characteristics of our standard compounds are listed to provide assistance in selecting the proper compound.

A number of proprietary compounds with unique characteristics and hardnesses are available along with additional information from our Technical Sales and Services Department.

CHEMICAL RESISTANCE

Selection of elastomers is normally the final results of a compromise between fluid resistance and last, but not least, the cost of the product.

TEAR AND WEAR RESISTANCE

Tear resistance of elastomer (ASTM D624-B) is very important for those applications where rubber parts are important for those applications where rubber parts are subject to strain and stresses, particularly when surface cuts could cause tears and stresses, particularly when surface cuts are severely damage the effectiveness of the seal.

Wear resistance (ASTM D394) is very important for the correct evaluation of any O-Ring in dynamic sealing application.

Critical factors to be considered are: polymer type, hardness, surface finish, lubrication, relative speed and environment.

ELECTRICAL CHARACTERISTICS

Elastomers have a large use in electric and electronic fields due to their dielectric characteristics and versatility.

Typically, the attention of the project engineer is focused on the electric insulation obtainable with rubber. On request, rubber can also be supplied as an electric conductor or anti static, by means of special additives to the compound.

The most common standards regarding electric characteristics are ASTM D257 and ASTM D991 (volume and surface resistivity), ASTM D149 (dielectric rigidity) and IEC Standards (International Electric Commission).

SPECIAL COMPOUNDS

Seal and Design has the ability to meet the special compounding requirements for a vast number of industries, offering materials previously tested at a variety of temperature and media environments. Seal and Design can also custom formulate compounds with specific characteristics, thus giving an invaluable service to our customers.

USE

Rubber compounds are highly susceptible to extreme temperature limits and harsh chemical application.

ENVIRONMENT

Fluids commonly found in contact with O-Rings, in addition to air, are:

- water
- lubricant oils
- hydraulic oils
- non flammable hydraulic fluids
- fuels
- cooling fluids
- extinguishing fluids
- food/beverages
- medical fluids
- physiological fluids
- pure or mixed gases

FLUID CONTACT CONSEQUENCES

Swell is a very common occurrence when an elastomer comes in contact with various fluids. High temperature and pressures magnify the phenomenon, which is why these factors must be considered at the design stage. A controlled amount of volume increase of the O-Rings can be beneficial in providing a good sealing effect within the system.

Swelling can often be a symptom of decay of the elastomer; that means that original characteristics of the O-Rings, in presence of a great deal of swelling, can cause rapid degradation. High temperature also has a significant influence.

Some elastomeric compounds experience extraction when brought in contact with particular fluids.

A decrease in volume is generated as a consequence of compound extraction and the original precompression is normally lost causing very dangerous result in the decay of original physical properties, Elements within the atmospheric environment can cause harmful effects on rubber compound. Most dangerous are: ozone, UV radiation, humidity (their influence shall be described more in detail in storage condition description).

EXTREME TEMPERATURE CONDITIONS

Low temperatures produce a loss of elasticity and increase the hardness of elastomers. The point at which rubber becomes brittle is normally known as brittle point (ASTM D746, ASTM D2137).

Other common reported low temperature values are TRIO and TR50 (ASTM D1329) which represent temperature. There is a certain relation between TRIO and brittle point.

Continuous operation at high temperatures induces an increase of hardness on almost all types of elastomers and degradation of physical properties, which grows exponentially. High temperatures also cause irreversible surface damages in the form of cracking and subsequent loss of mechanical resistance. Aging phenomenon can be delayed or kept at a minimum level by a proper choice of the elastomer and the use of suitable protecting agents.

The temperature at which surface damage appear is important to foresee the life of rubber products (ref.GME 60 258'Accelerated aging test for elastomers).

PRESSURE - VACUUM

These two physical conditions are antithetical, but have similar effects and limits for O-Ring sealing. An O-Ring used as a static seal can be submitted to continuous pressure of around 3000 psi (at room temperature), provided that gland dimensions and surface finish are suitable and Back-Up rings are utilized. In such application, elastomer selection must be especially resistant to gaseous diffusion and have a recommended hardness of 90 shore A for dynamic applications.

Sharp pressure variations can seriously damage O-Rings, particularly elastomers with limited resistance to gaseous diffusion.

At high pressure, gases and liquids tend to diffuse into the elastomer and surface during a quick decompression causing blisters and tears (Diesel effect) which destroy the O-Rings.

Proper sealing in a vacuum is quite difficult using O-Rings even if glands are very accurate in design and construction. Gaseous diffusion is a key consideration in such cases. For moderate vacuum conditions ($10^4/10^{-5}$ torr), acceptable sealing is obtained with common elastomers (NBR, EPDM). For higher values (up to 10^{-10} torr) metallic seals are available, please consult with a Seal & Design representative.

FOOD COMPATIBILITY

O-Rings in contact with food products require fundamental considerations:

- A) every component of a rubber compound must be tested for potential toxicity and carcinogenicity;
- B) elastomers must not give bad taste or odor to substances with which they come in contact;
- C) even during periods of prolonged contact, the rubber compound must not release any substance impairing food-stuff characteristics.

Listed below are the most recognized organizations and their standards:

USA	FDA (Food and Drug Adm.) USA Title 21 C.F.R. 177 2600;
USA	USDA (United States Dept. Agriculture) 3A Sanitary Standard;
USA	NSF International Standard 41, 61;
D	BGA Recommendations KTW 1.3.13;
UE	82/711/CEE e 90/128/CEE;
Italy	DM 21/3/73, DL 25/1/92, DM 26/4/93.

Organizations and acknowledged standards for drinking water are:

USA	ANSI/NSF 61-92 Drinking water system components
G.B.	BSI 6920 and WBS (Water Bylaws Scheme)

MEDICAL COMPATIBILITY

O-Rings are often used in devices for the production of medicinal substances, and in aggregates for control and analysis. For example:

- medicinal fluids (solutions, fluid mixture, etc.)
- physiological fluids (saliva, blood, urine, gastric juices)

APPLICATIONS

There are several definitions regarding the various types of sealing applications:

- axial static
- radial static
- reciprocating dynamic
- revolving dynamic
- composite dynamic

Dynamic sealing have continuous or intermittent motion.

STATIC OR DYNAMIC APPLICATIONS

To obtain a proper sealing effect, the O-Ring is always deformed (compression), but it is essential to consider some basic elements:

- type of sealing
- seal housing
- fluid to be contained and its concentration
- temperature and pressure of fluid (sudden pressure surge if foreseeable)
- for dynamic sealing, type of motions.

In addition, the compression set of the elastomer must be considered. The deformation to be set on the elastomer elements to assure the proper sealing must be compatible with the compression set of the specific elastomer, especially with thin cross section O-Rings.

DIMENSIONING

O-Ring dimensional selection depends on the type of application, compounds, surface finish, etc. Deformation or squeeze given to an O-Ring is the result of various parameters employed by the specifier. Squeeze must be higher for static applications should be kept to a minimum due to the friction and higher temperatures generated.

Seal lubrication is very important to limit friction and for helping heat exchange thus reducing temperature build-up.

Standard sizes of O-Rings corresponding to several international standards can be found later in our Catalog.

GLANDS, SQUEEZE AND EXTENSION

For proper [O-Ring](#) gland dimensions, it is imperative to consider 2 basic points:

- A) coefficient of thermal expansion of elastomers is more or less 10 times the coefficient of steel;
- B) swelling (volume change) due to fluid contact can be much higher than 10%

The design of sealing system must consider a peculiar property of elastomer as known the "Joule effect". Any elastomer under tensile stress, will shrink whenever temperature increases (Joule effect). When a O-Ring is assembled on a shaft under tension, it tends to contract during an increase in temperature, generating consequently, higher friction and increasing the temperature. The result is a total and rather quick destruction of the O-Ring. Therefore, it is always advisable to assemble O-Ring under compression instead of tension. In such case, an increase of temperature can only decrease the compression, relieving the strain in the assembly.

BACK-UP

Anti-extrusion Back-Up rings function as a containment for the elastomer when subject to high pressure, preventing seal extrusion through the clearance existing in the couplings. When pressure is applied from both directions, Back-Up rings are produced in standard dimensions in 3 styles: solid, single-turn, spiral. Usually they are made of virgin PTFE, Polyurethane or other suitable resins.

SURFACE FINISH

The finish of mating surfaces in contact with O-Rings is critical for heat build-up and premature wear and tear. "Break-out friction can be as high as 3 times the dynamic friction (with lubricant). The former can yield sticking even in the presence of squeeze, lubrication, pressure and temperature existing in the system. Material hardness is recommended to be as near as possible to 70 IRHD, except when different values are required for the application. Table 4 reports recommended surface finishes for glands and mating surfaces.

TABLE 4

GLAND SURFACE FINISH

Surface	Application	Pressure	Roughness Ra um
Housing static diameter	Static	Non pulsating	16
		Pulsating	8
	Dynamic	All types	8
Mating surfaces with O-Ring	Static	Non pulsating	8
		Pulsating	5
	Dynamic	All types	5

RELATIVE SPEEDS

It is difficult to recommend limits of relative speed in dynamic seals due to the wide range of fluids and working conditions. A reference speed limit can be 1.5 ft./sec with particularly well finished surfaces and slightly widened tolerances of gland dimensions utilizing O-Rings with IRHD 80 and system pressure; of 70 psi maximum.

With higher pressure, speed must be drastically reduced.

ASSEMBLY

The function and duration of an O-Ring is dependent upon the assembly procedure and care. It is advisable to comply with the following points:

- A) Dimensioning of glands should conform to values listed in the third section of the hand book.
- B) Avoid sharp edges and rough metallic surfaces. During assembly of O-Rings, it is imperative to use suitable installation tools to make the seal slide, without damage over threads, groves or holes. The stretch of O-Rings during assembly must be kept at a minimum, again using a suitable tool.
- C) O-Rings must be clean, in good shape and slightly lubricated with a compatible lubricant for the elastomer.
- D) Assembly glands and cavities must be cleaned and greased with care.
- E) During assembly, O-Rings already positioned must be protected by suitable means to avoid damage from other components to be assembled (see point B)
- F) Small dimension and high hardness O-Ring should be preferably positioned into composite glands to avoid excessive tensioning and deformations of the elastomer.

When an O-Ring is to be installed by automated assembly, it is advisable to use internally lubricated compounds which are specially formulated to provide lower friction. Special design considerations regarding tolerances, concentricity, etc. should be specified.

GLOSSARY OF O-RING TERMS

AS-568A: Aerospace standard dash numbering system use to assign standard o-ring sizes.

BACK-UP RING: A washer like device (usually made of Teflon or polyurethane) that is installed in a gland, opposite of the pressure side of the o-ring, to prevent extrusion.

BLOOM: A discoloration or change in appearance of the surface of a rubber product caused by the migration of a liquid or a solid to the surface (sulfur bloom or wax bloom). *This does not affect the performance of the seal.

COLD FLOW: Continued deformation under stress, term usually used when describing the characteristics of Teflon.

COMPRESSION SET: The amount by which a material fails to return to its original state after being exposed to stress or load.

CREEP: The progressive relaxation of a material under constant sealing pressure.

CROSS SECTION: An o-ring as viewed if cut at right angles to the parting line, thus showing its internal structure.

CURE: The process by which an elastomeric compound is formed (molded) by the cross linking of several polymers. This is usually done at an accelerated temperature and constant pressure.

CURE DATE: O-ring molding date, represents the quarter and year in which the o-ring was made. (i.e. 3 Q 92).

DUROMETER: A measure of hardness of a rubber compound. Elastomers can carry a reading of 30 (which is softest) to 90 and above (which is hardest) on the Shore A scale. 70 is usually considered a standard hardness.

DYNAMIC SEAL: An o-ring application in which the seal is subject to moving parts.

ELASTOMER: A general term used to describe both the natural and synthetic polymers processing the resilience required to return to approximate original shape after distortion.

ELONGATION: Is the increase in the length of a specimen usually in terms of % of the original length, relative to a given load at breakpoint.

EXTRUSION: Distortion or flow, under pressure, of portion of the seal into the clearance between two mating parts. Back-up rings can usually help this problem.

FLASH: Excess rubber left around a molded part due to cavity overflow and/or parting line of mold surfaces.

I.D.: Inside diameter of an o-ring.

MEMORY: The ability of an elastomeric material to return to its original state after deformation.

MODULUS: Measured stress at 100% elongation.

OFF REGISTER: Misalignment of two halves of one mold causing flash and irregular cross sectional dimensions.

OUTGASSING: Primarily occurs in vacuum applications. The volatile (evaporative) components of some rubber compounds may vaporize in the vacuum and be released into the surrounding environment.

PERMEABILITY: A property of rubber, which allows the passage of gas through the molecular structure of the material.

O.D.: The outside diameter of an o-ring.

RECIPROCATING SEAL: Seals used in moving piston and rod applications.

ROTARY SEAL: Seals used on rotating shafts with the turning shaft protruding through the I.D. of the o-ring.

SEAL: Any device used to prevent the passage of gas or liquid.

SHELF LIFE: The measure of time an o-ring can be stored and still retain its sealing effectiveness. MIL-STD-1523A allows o-ring manufactures a full 40 quarters (10 years; to deliver specified, Nitrile based o-rings.

SIZE, ACTUAL: Actual dimensions of a molded article (including manufacturing tolerances).

SIZE, NOMINAL: Basic dimensions of a molded part from which plus and minus tolerances are developed to account for the range of actual dimensions expected during manufacturing.

SPECIFIC GRAVITY: The weight of a given volume of any substance vs. the weight of an equal volume of H₂O. That number is used to determine the relative density of an elastomer. A specific compound will always have the same specific gravity thus making it a great tool for identification purposes.

STATIC SEAL: Seal designed to work between parts that have no relative motion.

SQUEEZE: Cross sectional compression of an o-ring between two mating parts.

SWELL: Increased seal volume caused by exposure to adverse operating conditions such as oils, fluids, and heat.

TEAR RESISTANCE: Resistance to the growth of a cut test specimen when tension is applied.

TENSILE STRENGTH: Force in pounds per square inch required to cause the rupture of a specimen of rubber material.

VULCANIZATION: A thermo-setting involving the use of heat, pressure and a chemical bonding agent to increase the strength and elasticity of a rubber

