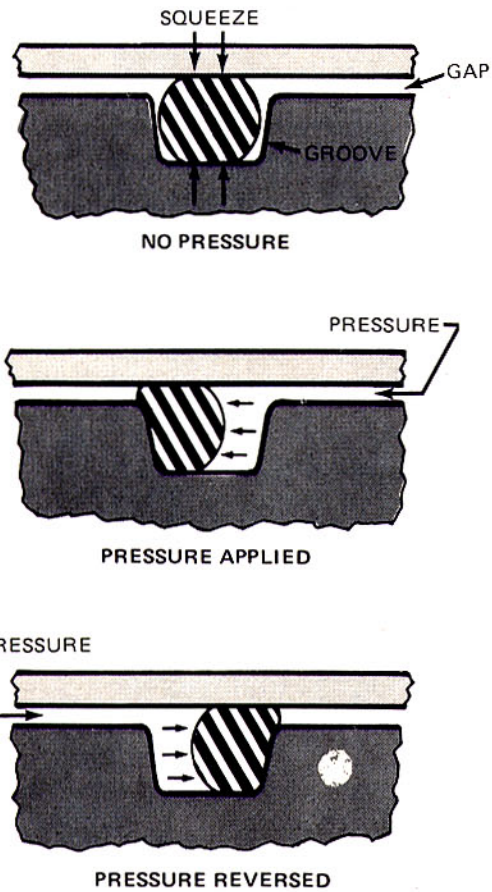
OR-15R

National® O-Ring Design Guide

FEDERAL-MOGUL

National O-Ring Design Guide

What is an O-Ring? An O-Ring is a torus or donut-shaped part of circular cross section made of an elastomeric (rubber) material. O-Rings function as low-cost, compact, reliable and forgiving sealing devices for liquids and gases. Because of the resilience of the elastomer, O-Rings absorb tolerance stack-up on the metal parts they seal.

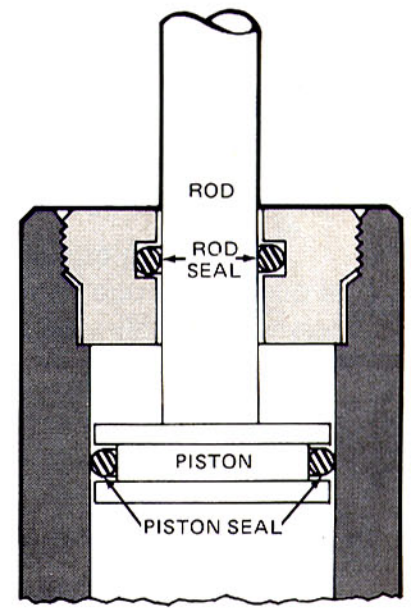


Normal circular cross section of O-Ring is squeezed when properly installed in its gland. Pressure forces O-Ring to low-pressure side of gland.

How do they seal? An O-Ring blocks the gap between two closely spaced surfaces by its memory or tendency to return to original shape when deformed. Normally, the O-Ring is installed in a gland that consists of a rectangular groove and a facing surface. By design, the O-Ring is squeezed into the gland during installation and the resulting force provides sealing at low pressure. As pressure is increased, it is transmitted through the O-Ring to mating surfaces thus augmenting seal effectiveness.

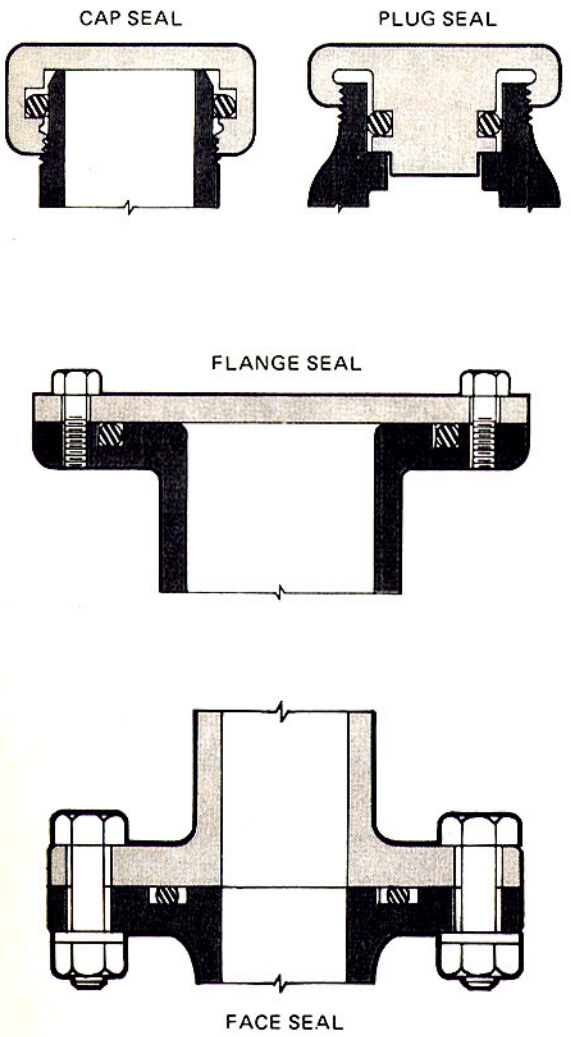
Basic types All O-Ring applications can be classified into two basic types:

dynamic, where there is relative motion between the parts of the gland (a reciprocating rod or piston seal), and



Dynamic seals for reciprocating service are all variations on the piston and rod seal configurations. For rotating applications (usually limited to less than 180 surface ft/min), the groove is usually located in the stationary housing, similar to the rod seal.

static, where the two parts of the gland do not move relative to each other (such as a pipe flange).



Static seals can take many forms. Note that gap in flange and face seals can be essentially zero, permitting sealing of very high pressures.

O-Ring design parameters The proper design for the application of an O-Ring seal falls naturally into two main areas, dimensions and material selection.

Dimensions of both the O-Ring and the gland in which it is installed depend on:

- The size and shape of the parts to be sealed
- The pressure to be contained
- The type of motion, if any

Material selection, that is, the choice of the specific National O-Ring compound, depends on:

- The fluids to be sealed
- The temperature of the application
- The pressure to be contained
- The type of motion, if any
- Material specifications, if any

Design steps The design of an O-Ring application falls logically into seven basic steps:

1. **Select the elastomer**
2. **Select a standard size**
3. **Determine the maximum gap**
4. **Specify gland dimensions**
5. **Check for installation**
6. **Select the specific National compound**
7. **Select the National part number**

Paragraphs dealing with each of these design steps are called out by a color bar to distinguish them from those containing background information. The *second* time you use this guide, you should be able to follow only the color-coded sections.

Elastomer hardness National supplies O-Rings in a wide variety of different compounds. These are all members of 13 general families of elastomers. Research is constantly directed toward improving National compounds to meet increasingly rigorous application demands.

The principal difference between members of the same elastomer family is the hardness as measured by the Shore A durometer;

the higher the durometer number, the harder the compound. (Elastomer hardness measurement is similar to the Rockwell and Brinnell techniques for metals.)

For the great majority of O-Ring applications, a hardness of 70 durometer is optimal. Softer O-Rings with hardness from 40 to 60 are often specified for low pressure or vacuum applications and offer lower breakout friction. Hardnesses of 80 or 90 are specified for their greater abrasion resistance and resistance to extrusion at high pressures. Because the harder O-Rings do not conform as well to surface irregularities, they tend to "weep" or leak slightly at low pressure.

Elastomer families National O-Rings are produced in a variety of different compounds. Each compound is based on one of the elastomer families and is designed to optimize those properties important for O-Ring sealing service. Hardness is the primary difference between O-Ring compounds that are based on the same elastomer.

The following is a brief introduction to the characteristic properties of the various families. For more detailed information, see the Elastomer Compatibility Guide on page 6 and the Fluid Compatibility Table on page 15.

NITRILE (Buna N)

Compounds of these materials are "standard" for most O-Ring service. Nitrile materials perform satisfactorily in a wide variety of fluids including alkaline and salt solutions, petroleum, lubricating, and hydraulic oils, gasoline, alcohol and water.

ETHYLENE-PROPYLENE

Ethylene-propylene compounds have excellent resistance to water, steam, acid, ketones, phosphate esters, automotive brake fluids and ozone. They are not recommended for petroleum oils.

NEOPRENE (Chloroprene)

Good ozone and weather resistance plus excellent resistance to refrigeration fluids are characteristics of the neoprene compounds. They are generally unsatisfactory for use with aromatic hydrocarbons, chlorinated solvents and ketones.

FLUOROCARBON (Viton*, Fluorel*)

The fluorocarbon elastomers have inherent compatibility with a wide range of chemicals and provide high temperature stability. They are suitable for use with petroleum oils, silicone greases and halogenated hydrocarbons, but should not be used with ketones or anhydrous ammonia.

SILICONE

Excellent resistance to extremes of temperature is the outstanding characteristic of silicone compounds. Relatively weak physical strength and abrasion resistance usually limit silicones to static service.

FLUOROSILICONE

These materials combine the good extreme-temperature properties of silicone with resistance to petroleum oils and hydrocarbon fuels.

STYRENE-BUTADIENE (SBR or GRS)

These materials were originally developed during World War II as a substitute for natural rubber. They are used mostly for tires. In O-Rings, they are recommended for use with water, alcohol, silicone oils and automotive brake fluids.

POLYACRYLATE

Outstanding resistance to petroleum fuels and oils is characteristic of these materials. They are also resistant to sunlight and ozone. Polyacrylate is widely used in automotive automatic transmissions and power steering mechanisms.

POLYURETHANE

These materials exhibit outstanding tensile strength and very good abrasion resistance. Resistance to petroleum oils, hydrocarbon fuels, oxygen and ozone is good. Polyurethanes are not recommended for acids, ketones, chlorinated hydrocarbons and water.

BUTYL

Butyls are all-petroleum products with excellent resistance to gas permeation. They are used in vacuum applications and, as ethylene-propylene, are recommended for use with phosphate esters. They are also recommended for ketones and silicone fluids, but not for petroleum oils or fuels.

POLYSULFIDE (Thiokol*)

These materials have outstanding resistance to oils, greases and solvents and remain quite flexible at low temperatures. Heat resistance and mechanical strength are not outstanding. Resistance to ozone, oxygen and weathering are good.

CHLOROSULFONATED POLYETHYLENE (Hypalon*)

These materials have excellent resistance to ozone, oxidents, heat and weathering. Resistance to petroleum base fluids is moderate and mechanical properties are generally lower than other elastomers.

EPICHLOROHYDRIN (Hydrin*, Hercolor*)

These relatively new materials have excellent resistance to hydrocarbon fuels and oils, vegetable oils and ozone. High-temperature resistance is also good for limited term exposure.

*Trademarks:

Hypalon, Viton - E. I. duPont
Fluorel - 3M Co.
Thiokol - Thiokol Chemical Co.
Hercolor - Hercules Chemical Co.
Hydrin - B.F. Goodrich

STEP 1. SELECT THE ELASTOMER

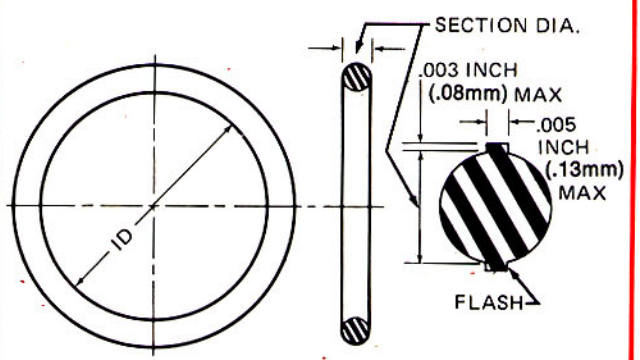
Elastomer selection Picking the proper elastomer for a specific O-Ring application is largely a matter of making the best possible match between elastomer capabilities and application requirements. Sometimes compromises must be made, but usually it is possible to find a material that meets all the specifications.

In using the following Elastomer Compatibility Guide, it is usually best to enter the table through the most critical requirement such as temperature or fluid compatibility. Then, after finding several possible families, the choice can be narrowed by checking the other parameters for each.

The Compatibility Guide is purposely brief in order to show as many parameters as possible for quick comparison. A complete table of fluid compatibilities, showing recommended elastomers for some 500 fluids, can be found on page 15.

STEP 2. SELECT A STANDARD SIZE

O-Ring dimensions An O-Ring is defined dimensionally by its cross-section diameter and inside diameter. National O-Rings are made in five standard cross sections with nominal inside diameters ranging from 1/32 to 26 inches (0.79 to 660 mm). For special applications, National can provide O-Rings to your particular size requirements. The full list



9.1 O-Ring cross section diameter and inside diameter are shown in either decimal inches or in millimeters. Maximum permissible flash dimensions apply regardless of size.

O-RING SEAL ELASTOMER CAPABILITY GUIDE

NOMENCLATURE	NITRILE (BUNAN)	ETHYLENE-PROPYLENE	NEOPRENE (CHLOROPRENE)	FLUORO-CARBON (VITON FLUOREL)	SILICONE
NATIONAL COMPOUND PREFIX	B, C, D	E	N	V	S
ASTM D2000 PREFIX	BG, BK, CH	CA	BC, BE	HK	FC, FE, GE
ASTM D1418 DESIGNATION	NBR	EPDM, EPM	CR	FKM	PVMQ, VMQ
GENERAL					
HARDNESS RANGE, °SHORE A	40-90	50-90	40-80	70-90	40-80
RELATIVE O-RING COST	LOW	LOW	LOW/MOD.	MOD./HIGH	MODERATE
CONTINUOUS HIGH TEMP. LIMIT	257°F,125°C	302°F,150°C	284°F,140°C	437°F,225°C	482°F,250°C
LOW TEMPERATURE CAPABILITY	-67°F,-55°C	-67°F,-55°C	-67°F,-55°C	-40°F,-40°C	-103°F,75°C
DYNAMIC SERVICE/ABRASION RESISTANCE	EXCELLENT	VERY GOOD	VERY GOOD	VERY GOOD	POOR
COMPRESSION SET RESISTANCE	VERY GOOD	VERY GOOD	GOOD	VERY GOOD	EXCELLENT
FLUID COMPATIBILITY					
ACID, INORGANIC	FAIR	GOOD	FAIR/GOOD	EXCELLENT	GOOD
ACID, ORGANIC	GOOD	VERY GOOD	GOOD	GOOD	EXCELLENT
AGING, (OXYGEN, OZONE, WEATHER)	FAIR/POOR	VERY GOOD	GOOD	VERY GOOD	EXCELLENT
AIR	FAIR	VERY GOOD	GOOD	VERY GOOD	EXCELLENT
ALCOHOLS	VERY GOOD	EXCELLENT	VERY GOOD	FAIR	VERY GOOD
ALDEHYDES	FAIR/POOR	VERY GOOD	FAIR/POOR	POOR	GOOD
ALKALIS	FAIR/GOOD	EXCELLENT	GOOD	GOOD	VERY GOOD
AMINES	POOR	VERY GOOD	VERY GOOD	POOR	GOOD
ANIMAL OILS	EXCELLENT	GOOD	GOOD	VERY GOOD	GOOD
ESTERS, ALKYL PHOSPHATE (SKYDROL)	POOR	EXCELLENT	POOR	POOR	GOOD
ESTERS, ARYL PHOSPHATE	FAIR/POOR	EXCELLENT	FAIR/POOR	EXCELLENT	GOOD
ESTERS, SILICATE	GOOD	POOR	FAIR	EXCELLENT	POOR
ETHERS	POOR	FAIR	POOR	POOR	POOR
HYDROCARBON FUELS, ALIPHATIC	EXCELLENT	POOR	FAIR	EXCELLENT	FAIR
HYDROCARBON FUELS, AROMATIC	GOOD	POOR	FAIR/POOR	EXCELLENT	POOR
HYDROCARBONS, HALOGENATED	FAIR/POOR	POOR	POOR	EXCELLENT	POOR
HYDROCARBON OILS, HIGH ANILINE	EXCELLENT	POOR	GOOD	EXCELLENT	VERY GOOD
HYDROCARBON OILS, LOW ANILINE	VERY GOOD	POOR	FAIR/POOR	EXCELLENT	FAIR
IMPERMEABILITY TO GASES	GOOD	GOOD	GOOD	VERY GOOD	POOR
KETONES	POOR	EXCELLENT	POOR	POOR	POOR
SILICONE OILS	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT	GOOD
VEGETABLE OILS	EXCELLENT	GOOD	GOOD	EXCELLENT	EXCELLENT
WATER/STEAM	GOOD	EXCELLENT	FAIR	FAIR	FAIR

NOTE: Chart information is intended for use only in conjunction with text. Marginally compatible fluids or other severe service conditions will reduce recommended high temperature capability and compromise other elastomer properties.

FLUORO-SILICONE	STYRENE-BUTADIENE (GRS)	POLY-ACRYLATE	POLY-URETHANE	BUTYL	POLYSULFIDE (THIOKOL)	CHLORO-SULFONATED POLYETHYLENE (HYPALON)	EPICHLORO-HYDRIN (HYDRIN)
F	G	L	U	J	K	H	Z
FK	AA, BA	DF, DH	BG	AA, BA	AK, BK	CE	DK, DJ
FVMQ,	SBR	ACM	EU	I IR	T	CSM	ECO
60-80	40-80	70-90	60-90	50-70	50-80	50-90	50-90
HIGH	LOW	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE
347°F,175°C	212°F,100°C	347°F,175°C	212°F,100°C	212°F,100°C	212°F,100°C	257°F,125°C	257°F,125°C
-85°F,-65°C	-67°F,-55°C	0°F,-18°C	-67°F,-55°C	-67°F,-55°C	-67°F,-55°C	-67°F,-55°C	-67°F,-55°C
POOR	EXCELLENT	GOOD	EXCELLENT	GOOD	FAIR/POOR	POOR	FAIR
VERY GOOD	GOOD	FAIR	FAIR	FAIR/GOOD	FAIR	FAIR/POOR	FAIR/GOOD
GOOD	FAIR/GOOD	POOR	POOR	GOOD	POOR	EXCELLENT	FAIR
GOOD	GOOD	POOR	POOR	VERY GOOD	GOOD	GOOD	FAIR
EXCELLENT	POOR	EXCELLENT	EXCELLENT	VERY GOOD	EXCELLENT	VERY GOOD	VERY GOOD
VERY GOOD	FAIR	VERY GOOD	GOOD	GOOD	GOOD	EXCELLENT	GOOD
VERY GOOD	VERY GOOD	POOR	POOR	VERY GOOD	FAIR/GOOD	VERY GOOD	GOOD
POOR	FAIR/POOR	POOR	POOR	GOOD	FAIR/GOOD	FAIR/GOOD	POOR
GOOD	FAIR/GOOD	POOR	FAIR/GOOD	EXCELLENT	POOR	EXCELLENT	FAIR
POOR	FAIR	POOR	POOR	GOOD	POOR	POOR	POOR
EXCELLENT	POOR	EXCELLENT	GOOD	GOOD	POOR	GOOD	GOOD
FAIR/POOR	POOR	POOR	POOR	VERY GOOD	POOR	POOR	POOR
VERY GOOD	POOR	POOR	POOR	EXCELLENT	GOOD	FAIR	POOR
VERY GOOD	POOR	FAIR/POOR	POOR	POOR	FAIR/POOR	FAIR	GOOD
FAIR	POOR	FAIR/POOR	FAIR	FAIR/POOR	GOOD	POOR	GOOD
EXCELLENT	POOR	VERY GOOD	GOOD	POOR	EXCELLENT	FAIR	VERY GOOD
VERY GOOD	POOR	POOR	FAIR/POOR	POOR	GOOD	FAIR/POOR	VERY GOOD
VERY GOOD	POOR	FAIR/GOOD	FAIR	POOR	GOOD	FAIR	EXCELLENT
EXCELLENT	POOR	EXCELLENT	EXCELLENT	POOR	VERY GOOD	EXCELLENT	EXCELLENT
VERY GOOD	POOR	EXCELLENT	VERY GOOD	POOR	GOOD	VERY GOOD	EXCELLENT
POOR	FAIR/GOOD	VERY GOOD	FAIR	EXCELLENT	VERY GOOD	VERY GOOD	EXCELLENT
FAIR/POOR	POOR	POOR	POOR	EXCELLENT	GOOD	FAIR	FAIR
EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT
EXCELLENT	POOR	GOOD	FAIR	GOOD	POOR	GOOD	EXCELLENT
FAIR	FAIR	POOR	POOR	EXCELLENT	FAIR	FAIR	GOOD

of standard sizes begins on page 28. The chart below indicates the size ranges by cross section:

Notice that there is considerable overlap in the ID ranges of the five cross sections. The following points should be considered in selection of the proper cross section:

- Use the largest cross section that will fit in the available space
- Larger cross sections are less subject to damage during installation or from abrasion and less subject to roll or twist
- Larger cross sections are less affected by intermittent high temperature
- Stretch and squeeze tolerance conditions are usually more favorable with larger cross sections.

the OD of the bottom of the groove should not exceed 2.10 inches).

Stretch in excess of 5%, combined with prolonged high temperature or a marginally compatible fluid, may cause deterioration. In addition, excessive stretch reduces the area of the cross section, and causes flattening of the normally circular cross section. Thus, excessive stretch can cause leakage.

Squeeze The tendency for an elastomer to return to its original shape when deformed is what makes an O-Ring an effective seal. As we shall see, the depth dimension of the O-Ring gland is smaller than the cross-section diameter of the O-Ring. Thus, when the seal is assembled, the O-Ring is squeezed or preloaded to provide the initial deformation vital to its sealing function.

SIZE RANGE

AS-568 Series No.	Cross Section Dia. (in)	ID (in) Min.	ID (in) Max.	Cross Section Dia. (mm)	ID mm Min.	ID mm Max.
004 to 050	.070	1/16	5 1/4	1.78	1.59	133.4
102 to 178	.103	1/16	9 3/4	2.62	1.59	247.6
201 to 284	.139	3/16	18	3.53	4.76	457.2
309 to 395	.210	7/16	26	5.33	11.11	660.4
425 to 475	.275	4 1/2	26	6.99	114.3	660.4

Stretch An elastomer is a material that will quickly recover its approximate original dimensions upon release after being stretched 100%. Therefore, an O-Ring can be stretched during installation to clear shoulders or other obstructions. However, once seated in the groove, stretch should not exceed 5% of the inside diameter (for example, for a 2-inch ID O-Ring,

The minimum amount of squeeze recommended, regardless of cross section, is 0.006 inch. The maximum squeeze usually recommended is 35% of the cross section diameter. Therefore, after determining gland dimensions in STEP 4, it is wise to check the "worst case" of tolerance build-up to see that squeeze will fall within the 0.006 inch to 35% limits.

STEP 3. DETERMINE MAXIMUM GAP

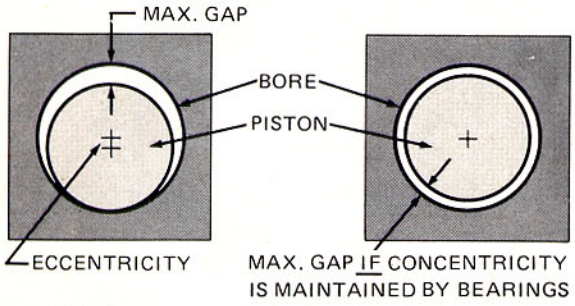
Maximum gap An O-Ring blocks the leak path or "gap" between two closely spaced surfaces. The size of the gap that can be sealed depends on the pressure to be contained and the hardness of the elastomer.

In general, the smaller the gap the higher the cost of machining the mating parts to obtain the required close tolerances. Therefore, to minimize costs, we recommend matching the size of the gap with O-Ring hardness and the highest pressure the system will experience.

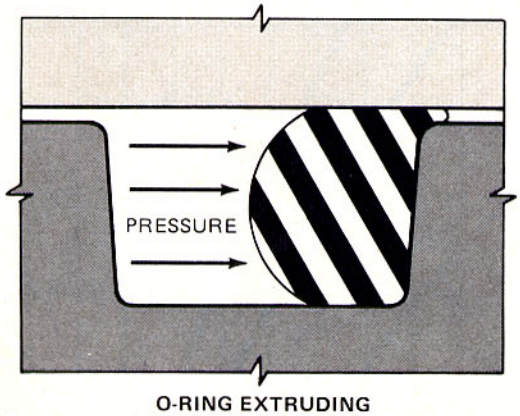
Maximum gap, sometimes called diametral clearance, is the difference between the ID of the bore and the OD of the piston or rod. It is based on the assumption that during operation the piston may be forced to one side of the bore, leaving all clearance on the opposite side. The O-Ring must be capable of sealing this gap. If the concentricity of the bore and piston is rigidly controlled by bearings or other means, the radial clearance may be taken as maximum gap.

To determine maximum gap, refer to the figure on page 10. Find your maximum system pressure on the left side of the chart and follow the pressure line to the colored 70 durometer hardness curve. Read straight down to find the maximum gap and apply this figure to the nominal bore/piston dimensions of your design.

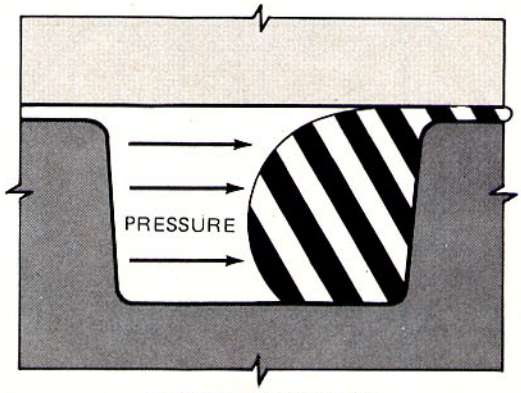
For most applications, the 70 durometer material is most readily available and most economical. If other application requirements suggest a harder or softer material, follow the same procedure for the appropriate hardness. (Note: the 90 durometer curve is applicable where a 70 durometer O-Ring is used with a back-up ring.)



Maximum gap refers to the worst condition the O-Ring may be called upon to seal. Unless the concentricity of the piston or rod with the bore is assured by the design, maximum gap is equal to the difference between piston/rod diameter and bore diameter.

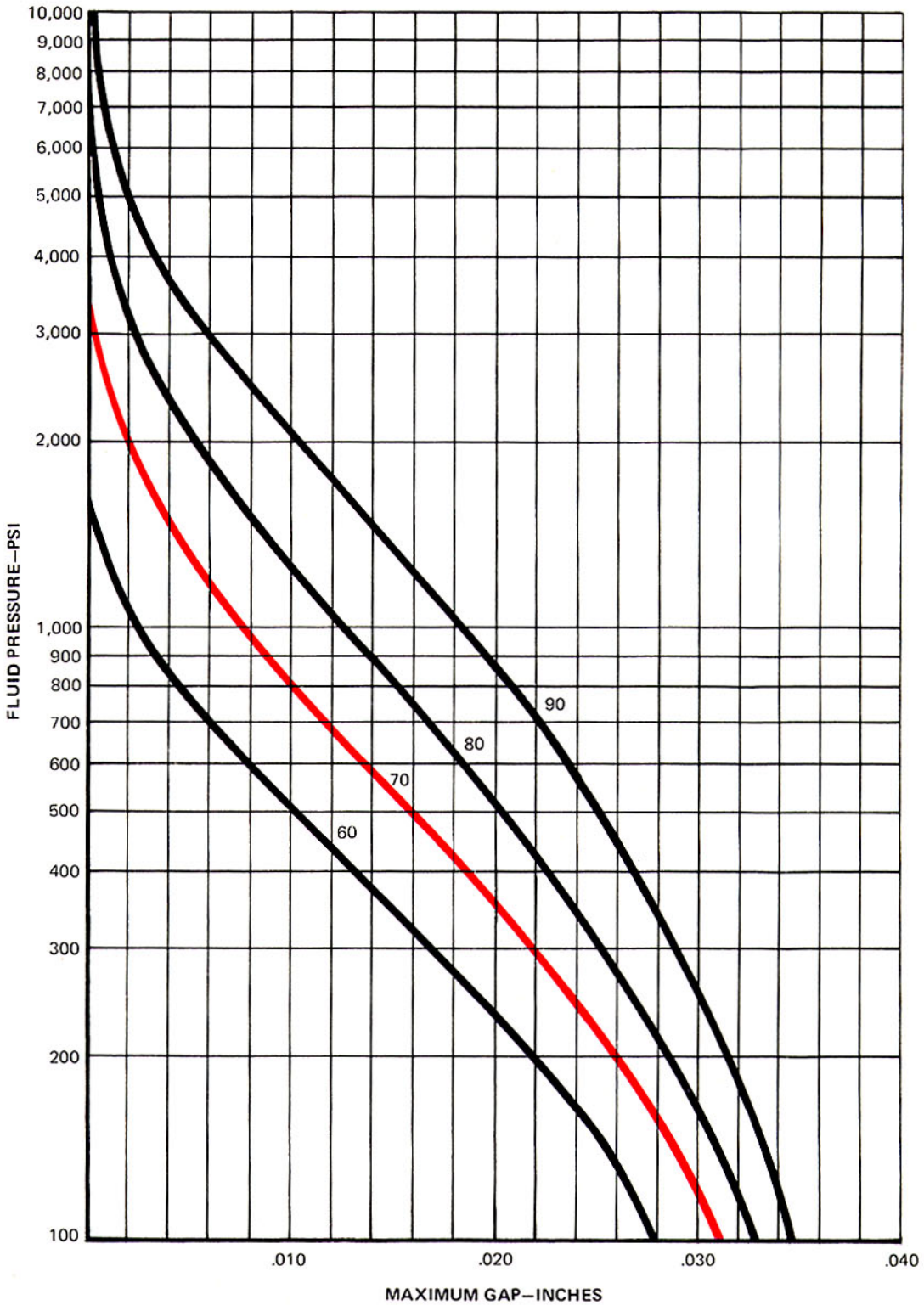


O-RING EXTRUDING



EXTRUSION FAILURE

Extrusion failure of the O-Ring is a consequence of a pressure/gap intersection above the hardness curve on page 10. Such failure usually is evidenced by slow but increasing leakage as tearing of the O-Ring surface progresses.


10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
900
800
700
600
500
400
300
200
100
FLUID PRESSURE—PSI
90
80
70
60
.010
.020
.030
.040
MAXIMUM GAP—INCHES

STEP 4. SPECIFY GLAND DIMENSIONS

Gland dimensions Now that we have established the dimensions of our cylinder and piston, it is an easy matter to determine the dimensions of the groove. The table below shows gland depth, width and radius for the five cross sections for both static and dynamic applications. Remember that to find the ID of a bore groove or the OD of a piston groove, we must add or subtract twice the gland depth to the basic dimensions. (Don't forget to check squeeze as described on page 8.)

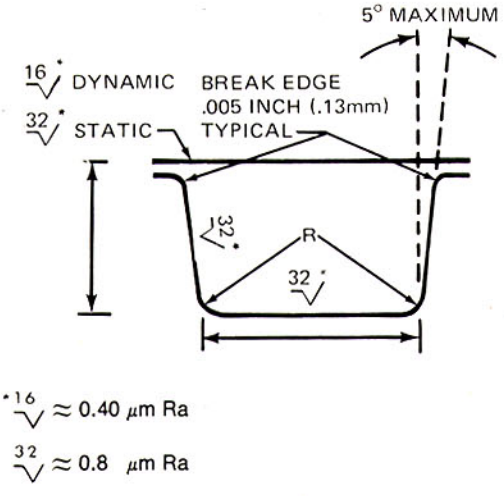
Gland surface finish For static seals, the surface finish of the gland is not extremely critical. For the larger O-Ring cross sections, surface finishes as rough as 128 microinches rms (3.2 μm) may be tolerated if the surface scratches are parallel to the line of sealing. For all cross sections, finishes rougher than 32 microinches (0.8 μm) with sharp surface scratches perpendicular to the line of the seal may cause leakage.

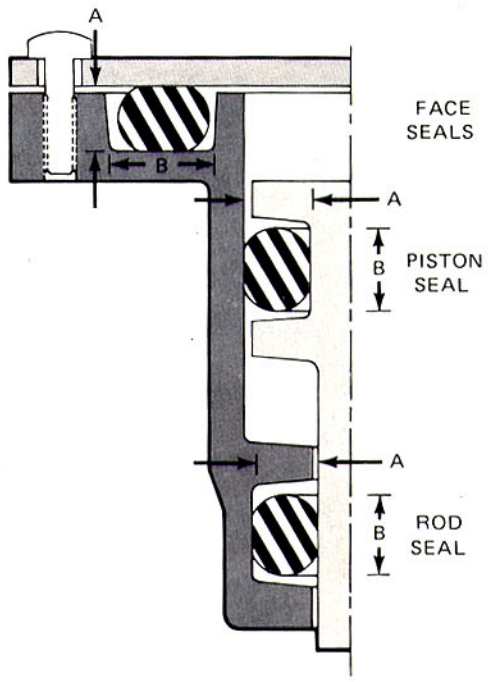
For dynamic seals, a surface finish of 16 microinches (0.4 μm) is recommended, as rate of wear increases rapidly with rougher finishes. For minimum friction, the finish may be improved to about 5 microinches (0.13 μm). Finishes smoother than 5 microinches should be avoided since they may be wiped dry as the rod extends, leaving no lubrication for the return stroke.

GLAND DESIGN GUIDE

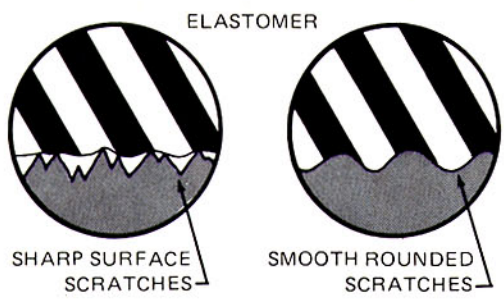
	INCHES					MILLIMETERS				
O-Ring Section Diameter	.070	.103	.139	.210	.275	1.78	2.62	3.53	5.33	6.99
STATIC SEALING										
A Gland Depth	.048 .054	.077 .083	.109 .115	.168 .176	.222 .232	1.22 1.37	1.96 2.11	2.77 2.92	4.27 4.47	5.64 5.89
B Groove Width*	.090 .100	.140 .150	.180 .190	.280 .290	.370 .380	2.29 2.54	3.56 3.81	4.57 4.83	7.11 7.37	9.40 9.65
R Groove Radius (Max.)	.015	.020	.025	.035	.050	.38	.51	.64	.89	1.27
DYNAMIC SEALING										
A Gland Depth	.055 .057	.088 .090	.120 .124	.184 .188	.234 .240	1.40 1.45	2.24 2.29	3.05 3.15	4.67 4.76	5.94 6.10
B Groove Width*	.090 .100	.140 .150	.180 .190	.280 .290	.370 .380	2.29 2.54	3.56 3.81	4.57 4.83	7.11 7.37	9.40 9.65
R Groove Radius (Max.)	.015	.020	.025	.035	.050	.38	.51	.64	.89	1.27

***When using back-up rings, the groove width must be enlarged to accommodate the back-up ring or rings. Use the back-up ring manufacturer's recommendations for the groove width.**





Gland dimensions must be added to or subtracted from appropriate part dimensions. See page 11 for details on gland surface finish.



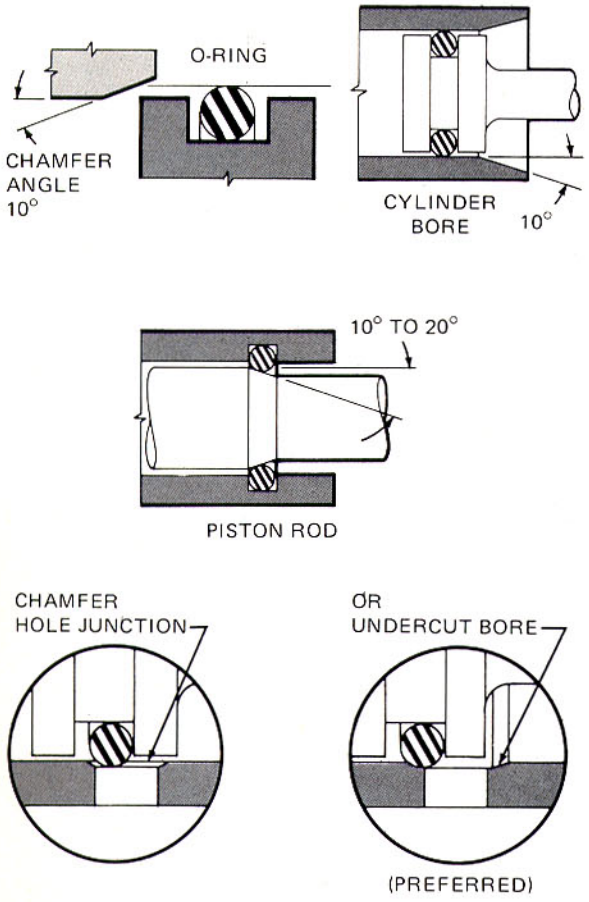
If surface scratches (peaks and valleys) are sharp, elastomer may not be able to conform to the irregularities, permitting leakage. Sharp scratches also cause accelerated abrasion wear. Elastomer easily conforms to surface with smooth, rounded peaks and valleys.

STEP 5. CHECK FOR INSTALLATION

Assembly precautions The effectiveness of a well designed O-Ring seal can be destroyed by improper or careless assembly. Much of the responsibility for proper assembly falls on the designer as he provides a safe route for the O-Ring on its way to the groove. The O-Ring should not pass over sharp shoulders, keyways or threads that could cause cuts or abrasion. Chamfers should be provided on cylinder bores and piston rods so the ring will not be pinched during installation. Tape or sheet metal thimbles can be used during assembly to shield threads or sharp corners over which the O-Ring must pass.

Obviously, cleanliness is important during

assembly. Chips, grit and foreign matter could not only damage the O-Ring but could also contaminate the whole system. Lubrication often makes assembly easier. The system fluid usually makes the best assembly lubricant. Where it is not possible to use system fluid, a lubricant should be selected that is compatible with both the O-Ring compound and the system fluid.



Chamfers on cylinder bore or piston rod permit assembly without pinching O-Ring. When ring must pass over cross-drilled port (not recommended), the hole should be chamfered or undercut.

STEP 6. SELECT THE COMPOUND

Preferred compounds Back in the first design step we selected the elastomer family for our applications. In succeeding steps we selected a standard size and determined the required elastomer hardness. Now it's time to specify the National Seal Compound.

The table on page 14 shows elastomer families with compounds of each by hardness. Nearly all sealing applications can be accommodated with one of these compounds. Not all hardnesses are shown for all elastomers. This does not necessarily mean compounds are unavailable, just that they are non-standard.

Specification compounds National compounds which meet the more popular material specifications are listed beginning on page 19. For convenience, non-material specifications pertaining to O-Rings are also shown. The great number of existing specifications makes a complete list impractical. Please contact us if what you need is not listed.

Special compounds Some seal applications have unusual requirements. National has some appropriately unusual O-Ring compounds. A portion of these are described beginning on page 25. We would like to work with you on unusual or demanding O-Ring applications. Just ask!

STEP 7. SELECT THE NATIONAL PART NUMBER

Part numbers Having selected the proper O-Ring cross section, specified the gland dimensions and selected the compound, the only thing remaining is to put it all together and specify the National Seal O-Ring part number on your blueprint and materials list.

National O-Rings are specified by a three-part number:

XX	-XXX	XXX
Aerospace Standard series	Dash Number	Compound

For example, AS-226 B46 describes an O-Ring with a cross-section diameter of 0.139 inch (3.53 mm), an ID of 1.984 inches (50.39 mm) made of nitrile with a hardness of 70.

PREFERRED COMPOUNDS BY POLYMER AND HARDNESS

POLYMER	HARDNESS, °A SCALE					
	40	50	60	70	80	90
NITRILE (Buna N)	B62	C24	C20	**B46**	C89	C90
ETHYLENE-PROPYLENE			E66	**E50**	E59	E63
NEOPRENE	N27	N30	N6	**N11**	N14	
FLUOROCARBON			V16	**V14**		V23
SILICONE	S71	S64	S66	**S59**	S69	
FLUOROSILICONE			F52	**F80**		
STYRENE-BUTADIENE (SBR)		G22	G43	**G62**		
POLYACRYLATE				**L57**	L51	
POLYURETHANE			U75	**U67**	U65	
BUTYL			J14	**J31**		
POLYSULFIDE			K4			
HYPALON				**H9**	H8	H11
EPICHLOROHYDRIN				**Z4**	Z8	

Shrinkage A majority of compounds produced in the same mold will have similar shrink characteristics, and therefore the parts will have like dimensions. However, some compounds shrink more and when produced in standard molds will result in smaller sizes. These compounds are subject to greater dimensional variation, so require wider tolerances.

When O-Rings from a high-shrink compound are required for a specific size, molds may be made, at additional cost, to compensate for the shrinkage. National's design engineers will assist the designer in any final determination.

FLUID COMPATIBILITY TABLE

KEY:

B, C	Nitrile	J	Butyl	V	Fluorocarbon	G	Styrene-butadiene
E	Ethylene-Propylene	K	Polysulfide	S	Silicone	L	Polyacrylate
N	Neoprene	H	Hypalon*	F	Fluorosilicone	U	Polyurethane

Fluid	National Elastomer (In order of Recommendation)
Acetaldehyde	E
Acetamide	B, E, N
Acetic Acid (Glacial)	E
Acetic Acid (30%)	E
Acetic Anhydride	N, E
Acetone	E
Acetophenone	E
Acetyl Acetone	E
Acetyl Chloride	V, F
Acetylene	E, B
Acetylene Tetrabromide	V, E
Aerozine 50	E
Air (Below 300 °F.)	E, B
Air (Above 300 °V.)	S, V, F
Alkazene	V, F, K
Alum	B, E
Aluminum Acetate	E, B
Aluminum Bromide	B, E, N
Aluminum Chloride	B, E, N
Aluminum Fluoride	B, E, N
Aluminum Nitrate	B, E, N
Aluminum Sulfate	B, E, N
Amines	E
Ammonia (Anhydrous)	E, B
Ammonia (Liquid)	E, B
Ammonium Carbonate	E, N
Ammonium Chloride	B, E, N
Ammonium Hydroxide	E, B
Ammonium Nitrate	B, E
Ammonium Nitrite	B, E
Ammonium Persulfate	E
Ammonium Phosphate	B, E
Ammonium Sulfate	B, E
Ammonium Sulfide	B, E
Amyl Acetate	E
Amyl Alcohol	E
Amyl Borate	B, N, K
Amyl Chloronaphthalene	V, K
Amyl Chloride	V, F
Amyl Naphthalene	V, F

Fluid	National Elastomer (In order of Recommendation)
Anderol L-774	B, V, F
Aniline	E
Aniline Dyes	E
Aniline Hydrochloride	E
Animal Oil (Lard)	B, V, F
Aqua Regia	E, F
Aroclor	V
Arsenic Acid	F, E
Askarel	V, B, F
Asphalt	V, K
Barium Chloride	B, E
Barium Hydroxide	B, E
Barium Sulfide	B, E
Beer (Food)	C
Beet Sugar Liquors (Food)	C
Benzaldehyde	E
Benzene	V, F, K
Benzenesulfonic Acid	V, F, N
Benzine	V, F, K
Benzoic Acid	V, F, K
Benzochloride	V, F, E
Benzophenone	V, F, E
Benzyl Alcohol	V, F, E
Benzyl Benzoate	V, F, E
Benzyl Chloride	V, F
Black Sulfate Liquors	E
Blast Furnace Gas	V, S
Bleach Liquor	E, V
Borax	B, E
Bordeaux Mixture	E, V
Boric Acid	B, E
Boron Fluids (HEF)	V, F
Brake Fluid (Automotive)	E
Bromine	E, V, F
Bromine Water	E, F
Bromobenzene	V, F
Bunker Oil	B, V, F
Butadiene	V, F, E
Butane	B, V, K

Fluid	National Elastomer (In order of Recommendation)
Butter (Food)	C
Butyl Acetate	E
Butyl Acrylate	K
Butyl Alcohol	B, N, V
Butyl Amine	S, E
Butyl Benzoate	E, V
Butyl Carbitol	E
Butylene	V, F, B
Butyl Ether	K
Butyl Butyrate	E, V
Butyl Oleate	V, E
Butyl Stearate	V, F, B
Butyraldehyde	E, K
Butyric Acid	V, E
Calcine Liquors	B, E
Calcium Acetate	E
Calcium Bisulfite	B, N, V
Calcium Chloride	B, E, N
Clacium Hydroxide	B, E, N
Calcium Hypochlorite	E, V
Calcium Nitrate	B, E, N
Calcium Sulfide	B, E, N
Cane Sugar Liquors (Food)	C
Carbitol	E, B
Carbolic Acid	E, F
Carbon Bisulfide	V, F
Carbonic Acid	E, N
Carbon Dioxide	B, E
Carbon Disulfide	V, F
Carbon Monoxide	B, E
Carbon Tetrachloride	V, F
Castor Oil (Food)	C
Cellosolve	E, K
Cellosolve Acetate	E, K
Cellulubes	E, K
China Wood Oil	B, V
Chlorinated Solvents	V, F
Chlorine	E, F
Chlorine Dioxide	E
Chloroacetic Acid	E

Fluid	National Elastomer (In order of Recommendation)
Chloroacetone	E
Chlorobenzene	V, F
Chlorobromomethane	V, F, E
Chlorobutadiene	V, F, E
Chlorododecane	V, F, E
Chloroform	V, F
Chloronaphthalene	V, F
Chlorotoluene	V, F
Chlorox	E, F
Chlorophenol	V
Chrome Plating Solutions	E
Chromic Acid	E
Citric Acid (Food)	C
Cobalt Chloride	B, E
Cocoanut Oil (Food)	C
Cod Liver Oil (Food)	C
Coke Oven Gas	V, F, S
Coolanol	N, V, F
Compass Fluid	B, E
Copper Acetate	E
Copper Chloride	B, E
Copper Cyanide	B, E
Copper Sulfate	B, E
Corn Oil (Food)	C
Cottonseed Oil (Food)	C
Creosote	B, V, F
Cresols	F, V
Crude Oil	V, F
Cutting Oil	B, V, F
Cyclohexane	B, V, F
Decalin	V, F, K
Decane	B, V, F
Deionized Water	E, B
Denatured Alcohol	E, B
Detergents	E, B
Developing Fluids (Photo)	E, N
Diacetone	E
Diacetone Alcohol	E
Dibenzyl Ether	K, E
Dibenzyl Sebacate	V, E
Dibromoethyl Benzene	V, F
Dibutylamine	E, N
Dibutyl Ether	K
Dibutyl Phthalate	E, K
Dibutyl Sebacate	E, K
Dichlorobenzene	V, K
Dichlorobutane	V, B
Dichloro-Isopropyl Ether	K
Dicyclohexylamine	B
Diesel Oil	B, V, F
Diester Syn. Lubricants	B, V, F
Diethylamine	E
Diethyl Ether	K
Diethylene Glycol	E, B
Diethyl Sebacate	V, E
Difluorodibromomethane	E
Diisobutylene	V, B, K
Diisooctyl Sebacate	V, E
Diisopropyl Ketone	E
Dimethyl Formamide	B, S, E
Dimethyl Phthalate	E, V
Dioctyl Phthalate	E, V
Dioctyl Sebacate	V, E
Dioxane	E
Dioxolane	E
Dipentene	V, K, B
Diphenyl	V, F, K
Diphenyl Oxides	V, F
Dowtherm A or E	V, F
Dry Cleaning Fluids	V, F
Epichlorohydrin	E
Ethanolamine	N, E, B
Ethers	K
Ethyl Acetate	E, K
Ethyl Acetoacetate	E, K
Ethyl Acrylate	E, K
Ethyl Alcohol	E, B
Ethyl Benzene	V, F, E
Ethyl Benzoate	V, F, K
Ethyl Cellosolve	E, K
Ethyl Cellulose	B, N, E
Ethyl Chloride	E, B, N
Ethyl Chlorocarbonate	V, F
Ethyl Chloroformate	V, F
Ethylene Chloride	V
Ethylene Chlorohydrin	V, E
Ethylene Diamine	E, B
Ethylene Dibromide	V
Ethylene Dichloride	V
Ethylene Glycol	E, B
Ethylene Oxide	E
Ethylene Trichloride	V
Ethyl Ether	K
Ethyl Formate	V, F, E
Ethyl Hexanol	B, E
Ethyl Mercaptan	V
Ethyl Oxalate	V, K, F
Ethyl Pentachlorobenzene	V, F
Ethyl Silicate	E, B
Ferric Chloride	E, B
Ferric Nitrate	E, B
Ferric Sulfate	E, B
Fluoboric Acid	E, N
Fluorolube	E, B
Fluorochloroethylene	V
Formaldehyde	E, B
Formic Acid	E, N
Freon 11	K, V, B
Freon 12	N, B, K
Freon 13	N, B, K
Freon 13B1	N, B, K
Freon 14	N, B, K
Freon 21	N
Freon 22	N, K, E
Freon 31	N, E
Freon 32	N, E
Freon 112	K, B
Freon 113	N, B, K
Freon 114	N, B, E
Freon 114B2	K, N
Freon 115	B, N, E
Freon 142b	N, B, E
Freon 152a	N, B, E
Freon 218	N, B, E
Freon C316	N, B, K
Freon C318	N, B, E
Freon BF	K, B, N
Freon MF	K, V, B
Freon TF	N, B, E
Fuel Oil	B, V, F
Fumaric Acid	B, V, F
Furfural	E
Furfuryl Alcohol	E
Gallic Acid	V, F, E
Gasoline (Automotive)	B, V, F
Gelatin (Food)	C
Glucose (Food)	C
Glue	B, E
Glycerine	B, E
Glycols	E, B

Fluid	National Elastomer (In order of Recommendation)
Green Sulfate Liquors	E
HEF-2	V
Helium	E
Heptane	B, V, F
Hexaldehyde	E, N
Hexane	B, V, F
Hexene	V, F, K
Hexyl Alcohol	B, V, F
Houghto-Safe 271	B, E, V
620	B, E, V
1010	E, V
1055	E, V
1120	E, V
5040	B, V, F
Hydrolube	B, E, V
Hydraulic Oil (Petroleum)	B, V, F
Hydrazine	E
Hydrobromic Acid	E
Hydrochloric Acid	E
Hydrocyanic Acid	E
Hydrofluoric Acid	E
Hydrofluosilicic Acid	E
Hydrogen	E
Hydrogen Peroxide	F, V, E
Hydrogen Sulfide	E, B
Hydroquinone	V, F
Hypochlorous Acid	E
Iodine	V, E
Isobutyl Alcohol	E, B
Isobutyl Butyrate	E, B
Isododecane	B, V, F
Iso-Octane	B, V, F
Isophorone	E
Isoproptyl Acetate	E, K
Isopropyl Alcohol	E, B
Isopropyl Chloride	V, F
Isopropyl Ether	B, K, N
JP-1 Thru JP-6 Fuel	B, V, F
Kerosene	B, V, F
Lacquers	K, E
Lactic Acid (Food)	C
Lard (Food)	C
Lead Acetate	E
Lead Nitrate	E, B
Lead Sulfamate	N, E, V
Liqroin	B, V, F
Lime Bleach	B, E, V
Lime Sulfur	E, V
Lindol	E, V
Linoleic Acid	S, N
Linseed Oil	B, V, F
Liquid Oxygen	S, V
Liquefied Petroleum Gas (LPG)	B, V, K
Lubricating Oils	B, V, F
Lye	E
Magnesium Chloride	E, B
Magnesium Hydroxide	E, V
Magnesium Sulfate	E, B,
Magnesium Sulfite	E, B
Maleic Acid	V, K
Maleic Anhydride	V
Malic Acid	B, V, F
Mercuric Chloride	E, B
Mercury	E, B
Mesityl Oxide	E, K
Methyl Acetate	E, K
Methyl Acrylate	E, K
Methylacrylic Acid	E, N
Methyl Alcohol	E, N
Methyl Bromide	V, F
Methyl Cellosolve	E
Methyl Chloride	V, F, K
Methyl Cyclopentane	V, F, K
Methylene Chloride	V, F
Methylene Dichloride	V, F
Methyl Ether	E, B
Methyl Ethyl Ketone	E, K
Methyl Formate	N, E
Methyl Isobutyl Ketone	E, K
Methyl Isopropyl Ketone	E, K
Methyl Methacrylate	K
Methyl Oleate	V, E
Methyl Salicylate	E
Milk (Food)	C
Mineral Oil (Food)	C
Monomethylaniline	V
Monobromobenzene	V, K
Monochlorobenzene	V, F
Monoethanolamine	E
Monovinyl Acetylene	E, B
Naphtha	V, B, F
Naphthalene	V, F, K
Napthenic Acid	V, F, B
Natural Gas	B, V, E
Neatsfoot Oil	B, V, F
Nickel Acetate	E, B
Nickel Chloride	E, B
Nickel Sulfate	E, B
Nitric Acid (Dilute)	E
Nitrobenzene	V
Nitroethane	N, E
Nitrogen	E, B
Nitromethane	K, E
Nitropropane	K, E
Non-Toxic Compound (Food)	C
Octadecane	B, V, F
Octane	B, V, K
Octyl Alcohol	E, V
Oleic Acid	B
Oleum Spirits (Food)	C
Oleum	E
Olive Oil (Food)	C
Oronite 8200	N, B, V
Oronite 8515	N, B, V
Ortho-Dichlorobenzene	V, F
OS-45	N, V, F
Oxalic Acid	E, V
Oxygen (Gaseous)	S, E
Ozone	E, N
Paint Solvents	K
Palmitic Acid	B,V,F,K
Para-Dichlorobenzene	V, F
Peanut Oil (Food)	C
Pentane	B, V
Perchloric Acid	F, E
Perchlorethylene	V, K, F
Petrolatum	B, V, F
Petroleum Oils	B, V, F
Phenol	F, V
Phenylbenzene	V, F, K
Phenylethyl Ether	K

Fluid	National Elastomer (In order of Recommendation)
Phenylhydrazine	V, E
Phorone	E
Phosphate Esters, Alkyl	E
Phosphate Esters, Aryl	V, E
Phosphoric Acid (45%)	E
Phosphorous Trichloride	E, V
Pickling Solution	E
Picric Acid	E
Pinene	V, F, B
Pine Oil	B, V, F
Plating Solutions	E
Pneumatic Service	B, E, N
Polyvinyl Acetate	E
Potassium Acetate	E
Potassium Chloride	E, B
Potassium Cyanide	E, B
Potassium Dichromate	E, B
Potassium Hydroxide	E
Potassium Nitrate	E, B
Potassium Sulfate	E, B
Potassium Sulfite	E, B
Prestone	E, B
Propane	B, V
Propyl Acetate	E, K
Propyl Acetone	E, K
Propyl Alcohol	E
Propyl Nitrate	E
Propylene	V, F, K
Propylene Oxide	E
Pyranol	B, V, F
Pydraul 150	E, V
A-200	V, F, K
A C	E, V
F-9	E, V
625	E, V
Pyridine Oil	E
Pyrolube	V, E
Red Oil (MIL-H-5606)	B, V, F
RJ-1	B, V, F
RP-1	B, V, F
Rapeseed Oil	E, V
Sal Ammoniac	E, B
Salicylic Acid	E, V
Salt Water	E, B
Sewage	E, B
Silicate Esters	N, V, F
Silicone Greases	E, B
Silicone Oils	E, B
Siver Cyanide	E, B
Silver Nitrate	E, B
Skydrol	E
Soap Solutions	E, B
Sodium Acetate	E, B
Sodium Bicarbonate	E, B
Sodium Borate	E, B
Sodium Bisulfate	E, B
Sodium Bisulfite	E, B
Sodium Carbonate	E, B
Sodium Chloride	E, B
Sodium Cyanide	E, B
Sodium Dichromate	E, B
Sodium Hydroxide	E, B
Sodium Hypochlorite	E, N
Sodium Metaphosphate	E, B
Sodium Nitrate	E, B
Sodium Perborate	E, B
Sodium Peroxide	E, V
Sodium Phosphate	E, B
Sodium Silicate	E, B
Sodium Sulfate	E, B
Sodium Sulfide	E, B
Sodium Sulfite	E, B
Sodium Thiosulfate	E, B
Soybean Oil (Food)	C
Stannic Chloride	E, B
Stannous Chloride	E, B
Steam	E, B
Stearic Acid	B, E
Stoddard Solvent	B, V, F
Styrene	V, F
Sucrose Solutions (Food)	C
Sulfur	N, E
Sulfur Chlorīde	V, F
Sulfur Dioxide	E, V
Sulfur Hexafluoride	N, E
Sulfur Free Compound	N
Sulfur Trioxide	V, E
Sulfuric Acid	E
Sulfurous Acid	E
Tannic Acid	E, B
Tar	V, B
Tartaric Acid	B, V, F
Tertiary Butyl Alcohol	V, B, E
Tertiary Butyl Catechol	V, E
Tertiary Butyl Mercaptan	V
Tetrabromoethane	V, F
Tetrachloroethane	V, F
Tetrachloroethylene	V, F
Tetraethyl Lead	V, F, B
Tetrahydrofuran	E, K
Tetralin	V, F
Titanium Tetrachloride	V, F
Toluene (Toluol)	V, F
Transformer Oil	B, V, F
Triacetin	E
Tributoxyethyl Phosphate	E, V
Tributyl Mercaptan	V, E
Tributyl Phosphate	E, K
Trichloroethane	V, F
Trichloroacetic Acid	E, B
Trichloroethylene	V, F
Tricresyl Phosphate	E
Triethanolamine	E
Trinitrotoluene	V, N
Trioctyl Phosphate	E
Trisodium Phosphate	E, B
Tung Oil	B, V, F
Turbine Oil	V, B
Turpentine	B, V, F
Unsym. Dimethyl Hydrazine	E
Varnish	V, K, F
Vegetable Oil (Food)	C
Versilube F-50	E, B
Vinegar (Food)	C
Water (Food)	C
Whiskey (Food)	C
Wine (Food)	C
White Pine Oil	V, F, B
Xylene (Xylol)	V, F, B
Xylidenes	B, E
Zinc Acetate	E, B
Zinc Chloride	E, B
Zinc Sulfate	E, B

Brief identification of popular O-Ring related specifications with National part numbers (compound, size, or both), shown where applicable.

SAE J14	Cancelled. Superceded by SAE J 200 and ASTM D2000. See ASTM D2000.
MIL-STD-105	Statistical Sampling.
SAE J 120	Class 1: B46 Class 2: C9 O-Ring size dash numbers correspond with AS 568 series. Dash numbers with "R" prefix denote square section rings.
MIL-STD-129	Marking for shipment and storage.
MIL-STD-130	Identification marking.
MIL-STD-190	Identification marking.
SAE J200	Nomenclature system for specifying properties of rubber. See ASTM D2000.
MIL-STD-413	O-Ring visual inspection guide. National O-Rings comply where specified.
MIL-STD-417	Nomenclature system for specifying properties of rubber supplemental to MIL-R-3065. See MIL-R-3065.
ANA 438	Cancelled. Superceded by MIL-STD-1523.
SAE-J515	Type I: C90 Type II: E63
AS 568	Standard O-Ring sizes. See page 25 for list. (Formerly ARP 568).
FED-STD-601	Rubber sampling and testing procedures.
NAS 617	C83 (Compound per MIL-R-7362) Size dash numbers correspond with AS 568 tube fitting gasket series.
MIL-HDBK-695	Shelf storage of rubber products.
AS 708	Special O-Ring surface condition requirements (top visual quality).
MIL-STD-726	Packaging.
ASTM D735	Cancelled. Superceded by SAE J200 and ASTM D2000. See ASTM D2000.
TT-S-735	Hydrocarbon test fluids.
AS 757	Straight thread boss dimensions.
ZZ-R-765	Classes 2A and 2B, grade 40: S71 Classes 2A and 2B, grade 50: S64 Classes 2A and 2B, grade 60: S66 Classes 2A and 2B, grade 70: S59 Classes 2A and 2B, grade 80: S69 Class 3, grade 50: S77
AIR 786	Rubber/fluid compatibility information.
AS 871	O-Ring dimensional inspection guide.
MIL-G-1149	Type 1, Class 1: N30 Type 1, Class 5: C24 Type 2, Class 1: N11 Type 2, Class 2: G62 Type 2, Class 5: B3
ARP 1231	Gland design considerations.
ARP 1232	Gland design, static, radial squeeze.
ARP 1233	Gland design, dynamic, radial squeeze.
ARP 1234	Gland design, static, axial squeeze.
MIL-STD-1523	Age control requirements applicable to certain nitrile specification compounds.
NAS 1593	V14. O-Ring size dash numbers correspond with AS 568 series.

NAS 1594 V23. O-Ring size dash numbers correspond with AS 568 series.

NAS 1595 V14. O-Ring size dash numbers correspond with AS 568 tube fitting gasket series.

NAS 1596 V23. O-Ring size dash numbers correspond with AS 568 tube fitting gasket series.

NAS 1613 E79. Ethylene propylene O-Rings for Skydrol usage. (NAS 1611 AS 568 series, NAS 1612 tube fitting gasket series).

ASTM D2000 **NOMENCLATURE SYSTEM FOR SPECIFYING PROPERTIES OF RUBBER**

Only the more popular specification descriptions are shown. But National Compounds in compliance with nearly all specification variations are available. Please request further information where required.

ASTM D2000/SAE J200	*National Compound*
NITRILE (Buna N)	
2BG415B14E14E34F17	B62
2BG515B14E14E34F17	C24
2BG615B14E14E34F17	C20
2BG715B14E14E34E51E61	B46
3CH715A25B34E16E36	B46
2BG715B14E14E34F17	B3
6BG815A14B14E14E34	C89
6BG915A14B14E14E34	C90
ETHYLENE-PROPYLENE	
2CA615A25B44C12	E66
2CA720A25B44C12	E50
3BA720A14B13C12F19	E50
3BA820A14B13C12F19	E59
3BA910A14B13C12F17	E63
NEOPRENE*	
2BE415A14B14E14E34F17	N27
2BE515A14B14E14E34F17	N30
2BE615A14B14E14E34F17	N6
2BE715A14B14E14E34F17	N11
2BE815A14B14E14E34F17	N14
FLUOROCARBON (Viton, Fluorel*)	
2HK610A1-10B38E88	V16
2HK715A1-10B38E71E88	V14
3HK915A1-10B38	V23
SILICONE	
2GE407A19B37E16E36F19	S71
5GE507A19B37E16E36F19	S64
5GE607A19B37E16E36F19	S66
7GE707A19B37E16E36F19	S59
7GE807A19B37E16E36F19	S69
FLUOROSILICONE	
2FK608A19E36E71F19	F52
STYRENE-BUTADIENE (SBR)	
3BA520A14B13F17	G22
3BA620A14B13F17	G43
3BA720A14B13F17	G62
POLYACRYLATE	
3DH715A26B16E16E36	L57

ASTM D2000 (continued)

AMS 2817 Individual (unit) packaging.

MIL-R-3065 **NOMENCLATURE SYSTEM FOR SPECIFYING PROPERTIES OF RUBBER**

Only the more popular specification descriptions are shown. But Na-

tional Compounds in compliance with nearly all specification variations are available. Please request further information where required.

MIL-R-3065/MIL-STD-417	*National Compound*
NITRILE (Buna N)	
SB415 A_1 B_1 E_3 E_5 F_1	B62
SB515 A_1 B_1 E_3 E_5 F_1	C24
SB615 A_1 B_1 E_3 E_5 F_1	C20
SB715 A_1 B_1 E_3 E_5	B46
SB715 A_1 B_1 E_3 E_5 F_1	B3
SB815 A_1 B_1 E_3 E_5	B8
SB915 A_1 B_1 E_3 E_5	C32
NEOPRENE*	
SC415 A_1 B_1 E_3 F_1	N27
SC515 A_1 B_1 E_3 F_1	N30
SC615 A_1 B_1 E_3 F_1	N6
SC715 A_1 B_1 E_3 F_1	N11
SC815 A_1 B_1 E_3 F_1	N14
SILICONE	
TA 407 E_1 E_3 F_2 L	S71
TA 507 E_1 E_3 F_2 L	S64
TA 607 E_1 E_3 F_2 GL	S66
TA 707 E_1 E_3 F_2 GL	S59
TA 807 E_1 E_3 F_2 GL	S69
STYRENE-BUTADIENE (SBR)	
RS 520 A_1 B F_1	G22
RS 620 A_1 B F_1	G43
RS 720 A_1 B F_1	G62
POLYACRYLATE	
TB 715 E_3	L57

AMS 3200	B55
AMS 3201	B62
AMS 3202	B54
AMS 3205	C24
AMS 3207	N8
AMS 3208	N10
AMS 3209	N2
AMS 3212	C20
AMS 3213	B8
AMS 3215	B46
AMS 3220	C20
AMS 3222	N30
AMS 3226	B13
AMS 3227	B31
AMS 3228	B14
AMS 3240	N27
AMS 3241	N6
AMS 3242	N14
AMS 3301	S71
AMS 3302	S64

AMS 3303 S66
AMS 3304 S59
AMS 3305 S69
AMS 3326 F52
AMS 3335 S77
AMS 3337 S32
AMS 3345 S77
AMS 3357 S59
MIL-P-4861 Individual (Unit) packaging.
MIL-P-5315 C69
MIL-P-5510 D6
MIL-G-5514 Gland design recommendations.
MIL-P-5516 Class B: C65
AN6227 C65 (compound per MIL-P-5516). O-Ring sizes correspond with AS 568 but dash numbers are different. Interchange:

AN 6227	AS 568	AN 6227	AS 568	AN 6227	AS 568	AN 6227	AS 568
1	006	23	218	45	342	67	440
2	007	24	219	46	343	68	441
3	008	25	220	47	344	69	442
4	009	26	221	48	345	70	443
5	010	27	222	49	346	71	444
6	011	28	325	50	347	72	445
7	012	29	326	51	348	73	446
8	110	30	327	52	349	74	447
9	111	31	328	53	426	75	448
10	112	32	329	54	427	76	449
11	113	33	330	55	428	77	450
12	114	34	331	56	429	78	451
13	115	35	332	57	430	79	452
14	116	36	333	58	431	80	453
15	210	37	334	59	432	81	454
16	211	38	335	60	433	82	455
17	212	39	336	61	434	83	456
18	213	40	337	62	435	84	457
19	214	41	338	63	436	85	458
20	215	42	339	64	437	86	459
21	216	43	340	65	438	87	460
22	217	44	341	66	439	88	425

AN 6230 C65 (compound per MIL-P-5516). O-Ring sizes correspond with AS 568 but dash numbers are different. Interchange:

AN 6230	AS 568	AN 6230	AS 568	AN 6230	AS 568	AN 6230	AS 568
1	223	14	236	27	249	40	262
2	224	15	237	28	250	41	263
3	225	16	238	29	251	42	264
4	226	17	239	30	252	43	265
5	227	18	240	31	253	44	266
6	228	19	241	32	254	45	267
7	229	20	242	33	255	46	268
8	230	21	243	34	256	47	269
9	231	22	244	35	257	48	270
10	232	23	245	36	258	49	271
11	233	24	246	37	259	50	272
12	234	25	247	38	260	51	273
13	235	26	248	39	261	52	274

AN 6290	Cancelled. Superseded by MS 28778.
AMS 7267	S54
AMS 7270	B17
AMS 7271	C71
AMS 7272	C72
AMS 7274	B14
AMS 7277	J31
AMS 7278	V14
AMS 7279	V23
AMS 7280	V14
MIL-R-7362	Type 1: C83
MS 9020	C71 (compound per AMS 7271). Size dash numbers correspond with AS 568 tube fitting gasket series.
MS 9021	C71 (compound per AMS 7271). Size dash numbers correspond with AS 568 series.
MS 9068	S59 (compound per AMS 3304). Size dash numbers correspond with AS 568 series.
MS 9241	C72 (compound per AMS 7272). Size dash numbers correspond with AS 568 series.
MS 9355	C72 (compound per AMS 7272). Size dash numbers correspond with AS 568 series tube fitting gasket series.
MS 9385	S54 (compound per AMS 7267). Size dash numbers correspond with AS 568 series tube fitting gasket series.
MS 9386	S54 (compound per AMS 7267). Size dash numbers correspond with AS 568 series.
MS 9387	V14 (compound per AMS 7278). Size dash numbers correspond functionally with AS 568 tube fitting gasket series. Offered on quotation basis only due to tolerance and parting line projection restrictions.
MS 9388	V14 (compound per AMS 7278). Size dash numbers correspond functionally with AS 568 series. Offered on quotation basis only due to tolerance and parting line projection restrictions.
MIL-Q-9858	Quality requirements. National complies.
MS 9970	V23 (compound per AMS 7279). Size dash numbers correspond functionally with AS 568 series. Offered on quotation basis only due to tolerance and parting line projection restrictions.
MS 17413	Cancelled. Superseded by MS 9388.
MIL-G-17553	Cancelled. Superseded by MIL-P-5516.
MIL-G-21569	Class 1: B46. Quotation basis only due to documentation requirements.
MS 24690	C65 (compound per MIL-P-5516). Size AS 568-015.
MIL-P-25732	C65.
MIL-R-25897	Cancelled. Superseded by MIL-R-83248.
MIL-R-25988	Class 1, Grade 60: F52 Class 1, Grade 70: F80
M25988/1	F80 (compound per MIL-R-25988, Class 1, Grade 70). Size dash numbers correspond with AS 568 series. Offered on quotation basis only due to tolerance restrictions.
M25988/3	F52 (compound per MIL-R-25988, Class 1, Grade 60). Size dash numbers correspond with AS 568 series. Offered on quotation basis only due to tolerance restrictions.

MS 28775 C65 (compound per MIL-P-25732). Size dash numbers correspond with AS 568 series.

MS 28778 D6 (compound per MIL-P-5510). Size dash numbers correspond with AS 568 tube fitting gasket series.

MS 28784 Cancelled. Superseded by MS 28775.

MS 28900 N2 (compound per AMS 3209). Sizes:

Series Number	Inside Diameter Inches(mm)	Tolerance ± Inches(mm)	Section Diameter Inches(mm)	Tolerance ± Inches(mm)
8	.332(8.43)	.005(.13)	.031(.79)	.003(.08)
10	.410(10.41)	.005(.13)	.031(.79)	.003(.08)
12	.526(13.36)	.005(.13)	.031(.79)	.003(.08)
14	.643(16.33)	.005(.13)	.031(.79)	.003(.08)
16	.775(19.69)	.006(.15)	.031(.79)	.003(.08)
18	.898(22.81)	.006(.15)	.031(.79)	.003(.08)
20	.987(25.7)	.006(.15)	.031(.79)	.003(.08)
22	1.112(28.24)	.006(.15)	.031(.79)	.003(.08)
24	1.226(31.14)	.006(.15)	.031(.79)	.003(.08)
28	1.450(36.83)	.010(.15)	.047(.79)	.003(.08)
32	1.670(42.42)	.010(.15)	.047(.79)	.003(.08)
36	1.891(48.03)	.010(.15)	.047(.79)	.003(.08)

MS 29512 C69 (compound per MIL-P-5315). Size dash numbers correspond with AS 568 tube fitting gasket series.

MS 29513 C69 (compound per MIL-P-5315). Size dash numbers correspond with AS 568 series.

MS 29561 C83 (compound per MIL-R-7362). Size dash numbers correspond with AS 568 series.

MS 33666 Size dash numbers correspond with AS 568 series.

MS 33668 Size dash numbers correspon with AS 568 tube fitting gasket series.

MIL-I-45208 Quality requirements. National complies.

MIL-C-45662 Quality requirements. National complies.

MIL-R-83248 Class 1: V14.
Class 2: V23.

M 83248/1 V14 (compound per MIL-R-83248, Class 1). Size dash numbers correspond with AS 568 series.

M 83248/2 V23 (compound per MIL-R-83248, Class 2). Size dash numbers correspond with AS 568 series.

MIL-P-83461 D7

MIL-R-83485 V20

MS 90064 Dash three size: C65 (compound per MIL-P-5516).
Otherwise,
Waveguide Service: S64 (compound per ZZ-R-765, Class 2B, Grade 50).
Dummy Loads: S59 (compound per AMS 3304). Sizes:

Series Number	Inside Diameter Inches(mm)	Tolerance ± Inches(mm)	Section Diameter Inches(mm)	Tolerance ± Inches(mm)
3	This size is as specified by size AS 568-115			
10	This size is as specified by size AS 568-013			
11	.575(14.61)	.010(.25)	.060(1.52)	.003(.08)
12	This size is as specified by size AS 568-213			
13	1.338(33.99)	.006(.15)	.092(2.34)	.003(.08)
14	1.550(39.37)	.010(.25)	.092(2.34)	.003(.08)
15	This size is as specified by size AS 568-227			
16	2.683(68.15)	.015(.38)	.115(2.92)	.005(.13)
17	This size is as specified by size AS 568-346			

AN 123856 through AN 123934

B14 (compound per AMS 7274). O-Ring sizes correspond with AS 568 but dash numbers are different. Interchange:

Series Number	AS 568	Series Number	AS 568	Series Number	AS 568	Series Number	AS 568
123856	-006	123876	-216	123896	-236	123916	-256
123857	-007	123877	-217	123897	-237	123917	-257
123858	-008	123878	-218	123898	-238	123918	-258
123859	-009	123879	-219	123899	-239	123919	-259
123860	-010	123880	-220	123900	-240	123920	-260
123861	-011	123881	-221	123901	-241	123921	-261
123862	-012	123882	-222	123902	-242	123922	-262
123863	-110	123883	-223	123903	-243	123923	-263
123864	-111	123884	-224	123904	-244	123924	-264
123865	-112	123885	-225	123905	-245	123925	-265
123866	-113	123886	-226	123906	-246	123926	-266
123867	-114	123887	-227	123907	-247	123927	-267
123868	-115	123888	-228	123908	-248	123928	-268
123869	-116	123889	-229	123909	-249	123929	-269
123870	-210	123890	-230	123910	-250	123930	-270
123871	-211	123891	-231	123911	-251	123931	-271
123872	-212	123892	-232	123912	-252	123932	-272
123873	-213	123893	-233	123913	-253	123933	-273
123874	-214	123894	-234	123914	-254	123934	-274
123875	-215	123895	-235	123915	-255		

AN 123956 through AN 124034

B17 (compound per AMS 7270). O-Ring sizes correspond with AS 568 but dash numbers are different. Interchange:

Series Number	AS 568	Series Number	AS 568	Series Number	AS 568	Series Number	AS 568
123956	-006	123976	-216	123996	-236	124016	-256
123957	-007	123977	-217	123997	-237	124017	-257
123958	-008	123978	-218	123998	-238	124018	-258
123959	-009	123979	-219	123999	-239	124019	-259
123960	-010	123980	-220	124000	-240	124020	-260
123961	-011	123981	-221	124001	-241	124021	-261
123962	-012	123982	-222	124002	-242	124022	-262
123963	-110	123983	-223	124003	-243	124023	-263
123964	-111	123984	-224	124004	-244	124024	-264
123965	-112	123985	-225	124005	-245	124025	-265
123966	-113	123986	-226	124006	-246	124026	-266
123967	-114	123987	-227	124007	-247	124027	-267
123968	-115	123988	-228	124008	-248	124028	-268
123969	-116	123989	-229	124009	-249	124029	-269
123970	-210	123990	-230	124010	-250	124030	-270
123971	-211	123991	-231	124011	-251	124031	-271
123972	-212	123992	-232	124012	-252	124032	-272
123973	-213	123993	-233	124013	-253	124033	-273
123974	-214	123994	-234	124014	-254	124034	-274
123975	-215	123995	-235	124015	-255		

COLOR

National silicone compounds are usually red, fluorosilicone is blue and most other compounds are black. Several exceptions are listed here. Upon request, O-Rings of any National compound may be furnished with surface color marking to provide positive identification prior to assembly.

Hardness °A, Polymer	National Compound
Brown	
50 SILICONE	S79
70 SILICONE	S60
60 FLUOROCARBON (Viton, Fluorel*)	V16
90 FLUOROCARBON (Viton, Fluorel*)	V9
Grey	
85 HYPALON*	H11

	Pink	
	70 SILICONE	S82
	Red	
	75 FLUOROCARBON (Viton, Fluorel*)	V15
	White	
	70 NITRILE (Buna N)	C43
CYLINDER LINER For sealing wet cylinder liners in diesel engines.	70 SILICONE	S82
DECOMPRESSION Resistant to blistering associated with sealing carbon dioxide and other gases.	70 NITRILE (Buna N)	C47
DRIVE For use as low-torque drive belt or drive wheel.	70 ETHYLENE-PROPYLENE	E50
FOOD Comply with Food and Drug Administration (FDA) requirements. Compound C43 is white color. National can also furnish O-Rings approved by U.S. Department of Agriculture (USDA) and National Sanitation Foundation (NSF).	70 NITRILE (Buna N) 70 NITRILE (Buna N)	C22 C43
FRICTION Compounds containing homogeneously dispursed graphite or molybdenum disulfide for lubricity.	60 NITRILE (Buna N) 70 NITRILE (Buna N) 90 NITRILE (Buna N) 70 NEOPRENE*	C77 C46 C78 N32
GASOLINE and similar fuels and solvents. Compound C9 is recommended for most applications. Compound C84 is extremely swell resistant and may shrink if permitted to dry.	70 NITRILE (Buna N) 70 NITRILE (Buna N)	C9 C84
HOT AIR Capable of sustained service at 527 °F (275 °C).	60 SILICONE 70 SILICONE	S53 S54
LOW TEMPERATURE Flexible at – 150 °F (– 101 °C).	70 SILICONE 50 SILICONE	S32 S77
PERMEATION Resistant to gas permeation.	70 BUTYL 80 EPICHLORO-HYDRIN	J31 Z8
PLASTIC Contact does not degrade surface of polycarbonate plastic.	70 NITRILE (Buna N)	C56
RADIATION Remains serviceable after up to 5×10^8 Roentgens gamma radiation cumulative dosage.	70 ETHYLENE-PROPYLENE	E50
UNDERWRITERS' LABORATORIES Underwriters' Laboratories lists National Compounds B46 and C9 for service following: Anhydrous Ammonia C9 Fuel Oils B46 and C9 Gasoline C9 Kerosene B46 and C9 Natural/LP gas B46 and C9 Naptha B46 and C9	70 NITRILE (Buna N) 70 NITRILE (Buna N)	C9 B46
VACUUM Low permeation and out-gassing.	70 BUTYL 75 FLUOROCARBON (Viton, Fluorel*)	J31 V14

FRACTIONAL (INCH) SIZES

REFERENCE ONLY

AS568 dash number appears to right of O-Ring inside diameter (I.D.) and below sectional diameter.

See table beginning on page 31 for actual dimensions and tolerances.

I.D.	SECTION 1/16	3/32	1/8	3/16
1/32	001*			
3/64	002*			
1/16	003	102		
5/64	004			
3/32	005	103		
1/8	006	104		
5/32	007	105		
3/16	008	106	201	
7/32	009	107		
1/4	010	108	202	
5/16	011	109	203	
3/8	012	110	204	
7/16	013	111	205	309
1/2	014	112	206	310
9/16	015	113	207	311
5/8	016	114	208	312
11/16	017	115	209	313
3/4	018	116	210	314
13/16	019	117	211	315
7/8	020	118	212	316
15/16	021	119	213	317
1	022	120	214	318
1 1/16	023	121	215	319
1 1/8	024	122	216	320
1 3/16	025	123	217	321
1 1/4	026	124	218	322
1 5/16	027	125	219	323
1 3/8	028	126	220	324
1 7/16		127	221	
1 1/2	029	128	222	325
1 9/16		129		
1 5/8	030	130	223	326
1 11/16		131		
1 3/4	031	132	224	327
1 13/16		133		
1 7/8	032	134	225	328
1 15/16		135		
2	033	136	226	329
2 1/16		137		
2 1/8	034	138	227	330

I.D.	SECTION 1/16	3/32	1/8	3/16	1/4
2 3/16		139			
2 1/4	035	140	228	331	
2 5/16		141			
2 3/8	036	142	229	332	
2 7/16		143			
2 1/2	037	144	230	333	
2 9/16		145			
2 5/8	038	146	231	334	
2 11/16		147			
2 3/4	039	148	232	335	
2 13/16		149			
2 7/8	040	150	233	336	
3	041	151	234	337	
3 1/8			235	338	
3 1/4	042	152	236	339	
3 3/8			237	340	
3 1/2	043	153	238	341	
3 5/8			239	342	
3 3/4	044	154	240	343	
3 7/8			241	344	
4	045	155	242	345	
4 1/8			243	346	
4 1/4	046	156	244	347	
4 3/8			245	348	
4 1/2	047	157	246	349	425
4 5/8			247	350	426
4 3/4	048	158	248	351	427
4 7/8			249	352	428
5	049	159	250	353	429
5 1/8			251	354	430
5 1/4	050	160	252	355	431
5 3/8			253	356	432
5 1/2		161	254	357	433
5 5/8			255	358	434
5 3/4		162	256	359	435
5 7/8			257	360	436
6		163	258	361	437
6 1/4		164	259	362	438
6 1/2		165	260	363	439
6 3/4		166	261	364	440

I.D.	SECTION 3/32	1/8	3/16	1/4
7	167	262	365	441
7 1/4	168	263	366	442
7 1/2	169	264	367	443
7 3/4	170	265	368	444
8	171	266	369	445
8 1/4	172	267	370	
8 1/2	173	268	371	446
8 3/4	174	269	372	
9	175	270	373	447
9 1/4	176	271	374	
9 1/2	177	272	375	448
9 3/4	178	273	376	
10		274	377	449
10 1/2		275	378	450
11		276	379	451
11 1/2		277	380	452
12		278	381	453
12 1/2				454
13		279	382	455
13 1/2				456
14		280	383	457
14 1/2				458
15		281	384	459
15 1/2				460
16		282	385	461
16 1/2				462
17		283	386	463
17 1/2				464
18		284	387	465
18 1/2				466
19			388	467
19 1/2				468
20			389	469
21			390	470
22			391	471
23			392	472
24			393	473
25			394	474
26			395	475

Section diameter of AS568-001 is 1/32. Section diameter of AS568-002 is 3/64.

O-RING DIMENSIONS

STANDARD SIZE SERIES NUMBER (AS568)	Nominal I.D.	INCHES Inside Diameter	INCHES Tolerance ±	MILLIMETERS Inside Diameter	MILLIMETERS Tolerance ±
004-050 Cross section diameter = 0.070 ± 0.003 in. (1.78 ± 0.08mm)					
AS-001*	1/32	.029	.004	0.74	.08
AS-002*	3/64	.042	.004	1.07	.08
AS-003*	1/16	.056	.004	1.42	.08
AS-004	5/64	.070	.005	1.78	.13
AS-005	3/32	.101	.005	2.57	.13
AS-006	1/8	.114	.005	2.90	.13
AS-007	5/32	.145	.005	3.68	.13
AS-008	3/16	.176	.005	4.47	.13
AS-009	7/32	.208	.005	5.28	.13
AS-010	1/4	.239	.005	6.07	.13
AS-011	5/16	.301	.005	7.65	.13
AS-012	3/8	.364	.005	9.25	.13
AS-013	7/16	.426	.005	10.82	.13
AS-014	1/2	.489	.005	12.42	.13
AS-015	9/16	.551	.007	14.00	.18
AS-016	5/8	.614	.009	15.60	.23
AS-017	11/16	.676	.009	17.17	.23
AS-018	3/4	.739	.009	18.77	.23
AS-019	13/16	.801	.009	20.35	.23
AS-020	7/8	.864	.009	21.95	.23
AS-021	15/16	.926	.009	23.52	.23
AS-022	1	.989	.010	25.12	.25
AS-023	1 1/16	1.051	.010	26.70	.25
AS-024	1 1/8	1.114	.010	28.30	.25
AS-025	1 3/16	1.176	.011	29.87	.28
AS-026	1 1/4	1.239	.011	31.47	.28
AS-027	1 5/16	1.301	.011	33.05	.28
AS-028	1 3/8	1.364	.013	34.65	.33
AS-029	1 1/2	1.489	.013	37.82	.33
AS-030	1 5/8	1.614	.013	41.00	.33
AS-031	1 3/4	1.739	.015	44.17	.38
AS-032	1 7/8	1.864	.015	47.35	.38
AS-033	2	1.989	.018	50.52	.46
AS-034	2 1/8	2.114	.018	53.70	.46
AS-035	2 1/4	2.239	.018	56.87	.46
AS-036	2 3/8	2.364	.018	60.05	.46
AS-037	2 1/2	2.489	.018	63.22	.46
AS-038	2 5/8	2.614	.020	66.40	.51
AS-039	2 1/4	2.739	.020	69.57	.51
AS-040	2 7/8	2.864	.020	72.75	.51
AS-041	3	2.989	.024	75.92	.61
AS-042	3 1/4	3.239	.024	82.27	.61
AS-043	3 1/2	3.489	.024	88.62	.61
AS-044	3 3/4	3.739	.027	94.97	.69
AS-045	4	3.989	.027	101.32	.69

*Cross section diameters: 001 = 0.040; 002 = 0.050; 003 = 0.060 in.

STANDARD SIZE SERIES NUMBER (AS568)	Nominal I.D.	INCHES Inside Diameter	Tolerance ±	MILLIMETERS Inside Diameter	Tolerance ±
004-050 Cross section diameter = 0.070 ± 0.003 in. (1.78 ± 0.08mm)					
AS-046	4 1/4	4.239	.030	107.67	.76
AS-047	4 1/2	4.489	.030	114.02	.76
AS-048	4 3/4	4.739	.030	120.37	.76
AS-049	5	4.989	.037	126.72	.94
AS-050	5 1/4	5.239	.037	133.07	.94
102-178 Cross section diameter = 0.103 ± 0.003 in. (2.62 ± 0.08mm)					
AS-102	1/16	.049	.005	1.24	.10
AS-103	3/32	.081	.005	2.06	.13
AS-104	1/8	.112	.005	2.84	.13
AS-105	5/32	.143	.005	3.63	.13
AS-106	3/16	.174	.005	4.42	.13
AS-107	7/32	.206	.005	5.23	.13
AS-108	1/4	.237	.005	6.02	.13
AS-109	5/16	.299	.005	7.59	.13
AS-110	3/8	.362	.005	9.19	.13
AS-111	7/16	.424	.005	10.77	.13
AS-112	1/2	.487	.005	12.37	.13
AS-113	9/16	.549	.007	13.94	.18
AS-114	5/8	.612	.009	15.54	.23
AS-115	11/16	.674	.009	17.12	.23
AS-116	3/4	.737	.009	18.72	.23
AS-117	13/16	.799	.010	20.30	.25
AS-118	7/8	.862	.010	21.89	.25
AS-119	15/16	.924	.010	23.47	.25
AS-120	1	.987	.010	25.07	.25
AS-121	1 1/16	1.049	.010	26.64	.25
AS-122	1 1/8	1.112	.010	28.24	.25
AS-123	1 3/16	1.174	.012	29.82	.30
AS-124	1 1/4	1.237	.012	31.42	.30
AS-125	1 5/16	1.299	.012	32.99	.30
AS-126	1 3/8	1.362	.012	34.59	.30
AS-127	1 7/16	1.424	.012	36.17	.30
AS-128	1 1/2	1.487	.012	37.77	.30
AS-129	1 9/16	1.549	.015	39.34	.38
AS-130	1 5/8	1.612	.015	40.94	.38
AS-131	1 11/16	1.674	.015	42.52	.38
AS-132	1 3/4	1.737	.015	44.12	.38
AS-133	1 13/16	1.799	.015	45.69	.38
AS-134	1 7/8	1.862	.015	47.29	.38
AS-135	1 15/16	1.925	.017	48.90	.43
AS-136	2	1.987	.017	50.47	.43
AS-137	2 1/16	2.050	.017	52.07	.43
AS-138	2 1/8	2.112	.017	53.64	.43
AS-139	2 3/16	2.175	.017	55.25	.43
AS-140	2 1/4	2.237	.017	56.82	.43
AS-141	2 5/16	2.300	.020	58.42	.51

STANDARD SIZE SERIES NUMBER (AS568)	Nominal I.D.	INCHES Inside Diameter	Tolerance ±	MILLIMETERS Inside Diameter	Tolerance ±
102-178 Cross section diameter = 0.103 ± 0.003 in. (2.62 ± 0.08mm)					
AS-142	2 3/8	2.362	.020	59.99	.51
AS-143	2 7/16	2.425	.020	61.60	.51
AS-144	2 1/2	2.487	.020	63.17	.51
AS-145	2 9/16	2.550	.020	64.77	.51
AS-146	2 5/8	2.612	.020	66.34	.51
AS-147	2 11/16	2.675	.022	67.95	.56
AS-148	2 3/4	2.737	.022	69.52	.56
AS-149	2 13/16	2.800	.022	71.12	.56
AS-150	2 7/8	2.862	.022	72.69	.56
AS-151	3	2.987	.024	75.87	.61
AS-152	3 1/4	3.237	.024	82.22	.61
AS-153	3 1/2	3.487	.024	88.57	.61
AS-154	3 3/4	3.737	.028	94.92	.71
AS-155	4	3.987	.028	101.27	.71
AS-156	4 1/4	4.237	.030	107.62	.76
AS-157	4 1/2	4.487	.030	113.97	.76
AS-158	4 3/4	4.737	.030	120.32	.76
AS-159	5	4.987	.035	126.67	.89
AS-160	5 1/4	5.237	.035	133.02	.89
AS-161	5 1/2	5.487	.035	139.37	.89
AS-162	5 3/4	5.737	.035	145.72	.89
AS-163	6	5.987	.035	152.07	.89
AS-164	6 1/4	6.237	.040	158.42	1.02
AS-165	6 1/2	6.487	.040	164.77	1.02
AS-166	6 3/4	6.737	.040	171.12	1.02
AS-167	7	6.987	.040	177.47	1.02
AS-168	7 1/4	7.237	.045	183.82	1.14
AS-169	7 1/2	7.487	.045	190.17	1.14
AS-170	7 3/4	7.737	.045	196.52	1.14
AS-171	8	7.987	.045	202.87	1.14
AS-172	8 1/4	8.237	.050	209.22	1.27
AS-173	8 1/2	8.487	.050	215.57	1.27
AS-174	8 3/4	8.737	.050	221.92	1.27
AS-175	9	8.987	.050	228.27	1.27
AS-176	9 1/4	9.237	.055	234.62	1.40
AS-177	9 1/2	9.487	.055	240.97	1.40
AS-178	9 3/4	9.737	.055	247.32	1.40
201-284 Cross section diameter = 0.139 ± 0.004 in. (3.53 ± 0.10mm)					
AS-201	3/16	.171	.005	4.34	.13
AS-202	1/4	.234	.005	5.94	.13
AS-203	5/16	.296	.005	7.52	.13
AS-204	3/8	.359	.005	9.12	.13
AS-205	7/16	.421	.005	10.69	.13
AS-206	1/2	.484	.005	12.29	.13
AS-207	9/16	.546	.007	13.87	.18
AS-208	5/8	.609	.009	15.47	.23

STANDARD SIZE SERIES NUMBER (AS568)	Nominal I.D.	INCHES Inside Diameter	Tolerance ±	MILLIMETERS Inside Diameter	Tolerance ±
201-284 Cross section diameter = 0.139 ± 0.004 in. (3.53 ± 0.10mm)					
AS-209	11/16	.671	.009	17.04	.23
AS-210	3/4	.734	.010	18.64	.25
AS-211	13/16	.796	.010	20.22	.25
AS-212	7/8	.859	.010	21.82	.25
AS-213	15/16	.921	.010	23.39	.25
AS-214	1	.984	.010	24.99	.25
AS-215	1 1/16	1.046	.010	26.57	.25
AS-216	1 1/8	1.109	.012	28.17	.30
AS-217	1 3/16	1.171	.012	29.74	.30
AS-218	1 1/4	1.234	.012	31.34	.30
AS-219	1 5/16	1.296	.012	32.92	.30
AS-220	1 3/8	1.359	.012	34.52	.30
AS-221	1 7/16	1.421	.012	36.09	.30
AS-222	1 1/2	1.484	.015	37.69	.38
AS-223	1 5/8	1.609	.015	40.87	.38
AS-224	1 3/4	1.734	.015	44.04	.38
AS-225	1 7/8	1.859	.018	47.22	.46
AS-226	2	1.984	.018	50.39	.46
AS-227	2 1/8	2.109	.018	53.57	.46
AS-228	2 1/4	2.234	.020	56.74	.51
AS-229	2 3/8	2.359	.020	59.92	.51
AS-230	2 1/2	2.484	.020	63.09	.51
AS-231	2 5/8	2.609	.020	66.27	.51
AS-232	2 3/4	2.734	.024	69.44	.61
AS-233	2 7/8	2.859	.024	72.62	.61
AS-234	3	2.984	.024	75.79	.61
AS-235	3 1/8	3.109	.024	78.97	.61
AS-236	3 1/4	3.234	.024	82.14	.61
AS-237	3 3/8	3.359	.024	85.32	.61
AS-238	3 1/2	3.484	.024	88.49	.61
AS-239	3 5/8	3.609	.028	91.67	.71
AS-240	3 3/4	3.734	.028	94.84	.71
AS-241	3 7/8	3.859	.028	98.02	.71
AS-242	4	3.984	.028	101.19	.71
AS-243	4 1/8	4.109	.028	104.37	.71
AS-244	4 1/4	4.234	.030	107.54	.76
AS-245	4 3/8	4.359	.030	110.72	.76
AS-246	4 1/2	4.484	.030	113.89	.76
AS-247	4 5/8	4.609	.030	117.07	.76
AS-248	4 3/4	4.734	.030	120.24	.76
AS-249	4 7/8	4.859	.035	123.42	.89
AS-250	5	4.984	.035	126.59	.89
AS-251	5 1/8	5.109	.035	129.77	.89
AS-252	5 1/4	5.234	.035	132.94	.89
AS-253	5 3/8	5.359	.035	136.12	.89

STANDARD SIZE SERIES NUMBER (AS568)	Nominal I.D.	INCHES Inside Diameter	INCHES Tolerance ±	MILLIMETERS Inside Diameter	MILLIMETERS Tolerance ±
309-395 Cross section diameter = 0.210 ± 0.005 in. (5.33 ± 0.13mm)					
AS-254	5 1/2	5.484	.035	139.29	.89
AS-255	5 5/8	5.609	.035	142.47	.89
AS-256	5 3/4	5.734	.035	145.64	.89
AS-257	5 7/8	5.859	.035	148.82	.89
AS-258	6	5.984	.035	151.99	.89
AS-259	6 1/4	6.234	.040	158.34	1.02
AS-260	6 1/2	6.484	.040	164.69	1.02
AS-261	6 3/4	6.734	.040	171.04	1.02
AS-262	7	6.984	.040	177.39	1.02
AS-263	7 1/4	7.234	.045	183.74	1.14
AS-264	7 1/2	7.484	.045	190.09	1.14
AS-265	7 3/4	7.734	.045	196.44	1.14
AS-266	8	7.984	.045	202.79	1.14
AS-267	8 1/4	8.234	.050	209.14	1.27
AS-268	8 1/2	8.484	.050	215.49	1.27
AS-269	8 3/4	8.734	.050	221.84	1.27
AS-270	9	8.984	.050	228.19	1.27
AS-271	9 1/4	9.234	.055	234.54	1.40
AS-272	9 1/2	9.484	.055	240.89	1.40
AS-273	9 3/4	9.734	.055	247.24	1.40
AS-274	10	9.984	.055	253.59	1.40
AS-275	10 1/2	10.484	.055	266.29	1.40
AS-276	11	10.984	.065	278.99	1.65
AS-277	11 1/2	11.484	.065	291.69	1.65
AS-278	12	11.984	.065	304.39	1.65
AS-279	13	12.984	.065	329.79	1.65
AS-280	14	13.984	.065	355.19	1.65
AS-281	15	14.984	.065	380.59	1.65
AS-282	16	15.955	.075	405.26	1.91
AS-283	17	16.955	.080	430.66	2.03
AS-284	18	17.955	.085	456.06	2.16
309-395 Cross section diameter = 0.210 ± 0.005 in. (5.33 ± 0.13mm)					
AS-309	7/16	.412	.005	10.46	.13
AS-310	1/2	.475	.005	12.07	.13
AS-311	9/16	.537	.007	13.64	.18
AS-312	5/8	.600	.009	15.24	.23
AS-313	11/16	.662	.009	16.81	.23
AS-314	3/4	.725	.009	18.42	.23
AS-315	13/16	.787	.009	19.99	.23
AS-316	7/8	.850	.009	21.59	.23
AS-317	15/16	.912	.009	23.16	.23
AS-318	1	.975	.010	24.77	.25
AS-319	1 1/16	1.037	.010	26.34	.25
AS-320	1 1/8	1.100	.012	27.94	.25
AS-321	1 3/16	1.162	.012	29.51	.28
AS-322	1 1/4	1.225	.012	31.12	.28

STANDARD SIZE SERIES NUMBER (AS568)	Nominal I.D.	INCHES Inside Diameter	INCHES Tolerance ±	MILLIMETERS Inside Diameter	MILLIMETERS Tolerance ±
309-395 Cross section diameter = 0.210 ± 0.005 in. (5.33 ± 0.13mm)					
AS-323	1 5/16	1.287	.012	32.69	.28
AS-324	1 3/8	1.350	.012	34.29	.28
AS-325	1 1/2	1.475	.015	37.47	.38
AS-326	1 5/8	1.600	.015	40.64	.38
AS-327	1 3/4	1.725	.015	43.82	.38
AS-328	1 7/8	1.850	.015	46.99	.38
AS-329	2	1.975	.018	50.17	.46
AS-330	2 1/8	2.100	.018	53.34	.46
AS-331	2 1/4	2.225	.018	56.52	.46
AS-332	2 3/8	2.350	.018	59.69	.46
AS-333	2 1/2	2.475	.020	62.87	.51
AS-334	2 5/8	2.600	.020	66.04	.51
AS-335	2 3/4	2.725	.020	69.22	.51
AS-336	2 7/8	2.850	.020	72.39	.51
AS-337	3	2.975	.024	75.57	.61
AS-338	3 1/8	3.100	.024	78.74	.61
AS-339	3 1/4	3.225	.024	81.92	.61
AS-340	3 3/8	3.350	.024	85.09	.61
AS-341	3 1/2	3.475	.024	88.27	.61
AS-342	3 5/8	3.600	.028	91.44	.71
AS-343	3 3/4	3.725	.028	94.62	.71
AS-344	3 7/8	3.850	.028	97.79	.71
AS-345	4	3.975	.028	100.97	.71
AS-346	4 1/8	4.100	.028	104.14	.71
AS-347	4 1/4	4.225	.030	107.32	.76
AS-348	4 3/8	4.350	.030	110.49	.76
AS-349	4 1/2	4.475	.030	113.67	.76
AS-350	4 5/8	4.600	.030	116.84	.76
AS-351	4 3/4	4.725	.030	120.02	.76
AS-352	4 7/8	4.850	.030	123.19	.76
AS-353	5	4.975	.037	126.37	.94
AS-354	5 1/8	5.100	.037	129.54	.94
AS-355	5 1/4	5.225	.037	132.72	.94
AS-356	5 3/8	5.350	.037	135.89	.94
AS-357	5 1/2	5.475	.037	139.07	.94
AS-358	5 5/8	5.600	.037	142.24	.94
AS-359	5 3/4	5.725	.037	145.42	.94
AS-360	5 7/8	5.850	.037	148.59	.94
AS-361	6	5.975	.037	151.77	.94
AS-362	6 1/4	6.225	.040	158.12	1.02
AS-363	6 1/2	6.475	.040	164.47	1.02
AS-364	6 3/4	6.725	.040	170.82	1.02
AS-365	7	6.975	.040	177.17	1.02
AS-366	7 1/4	7.225	.045	183.52	1.14
AS-367	7 1/2	7.475	.045	189.87	1.14

STANDARD SIZE SERIES NUMBER (AS568)	Nominal I.D.	INCHES Inside Diameter	INCHES Tolerance ±	MILLIMETERS Inside Diameter	MILLIMETERS Tolerance ±
309-395 Cross section diameter = 0.210 ± 0.005 in. (5.33 ± 0.13mm)					
AS-368	7 3/4	7.725	.045	196.22	1.14
AS-369	8	7.975	.045	202.57	1.14
AS-370	8 1/4	8.225	.050	208.92	1.27
AS-371	8 1/2	8.475	.050	215.27	1.27
AS-372	8 3/4	8.725	.050	221.62	1.27
AS-373	9	8.975	.050	227.97	1.27
AS-374	9 1/4	9.225	.055	234.32	1.40
AS-375	9 1/2	9.475	.055	240.67	1.40
AS-376	9 3/4	9.725	.055	247.02	1.40
AS-377	10	9.975	.055	253.37	1.40
AS-378	10 1/2	10.475	.060	266.07	1.52
AS-379	11	10.975	.060	278.77	1.52
AS-380	11 1/2	11.475	.065	291.47	1.65
AS-381	12	11.975	.065	304.17	1.65
AS-382	13	12.975	.065	329.57	1.65
AS-383	14	13.975	.070	354.97	1.78
AS-384	15	14.975	.070	380.37	1.78
AS-385	16	15.955	.075	405.26	1.91
AS-386	17	16.955	.080	430.66	2.03
AS-387	18	17.955	.085	456.06	2.16
AS-388	19	18.955	.090	481.41	2.29
AS-389	20	19.955	.095	506.81	2.41
AS-390	21	20.955	.095	532.21	2.41
AS-391	22	21.955	.100	557.61	2.54
AS-392	23	22.940	.105	582.68	2.67
AS-393	24	23.940	.110	608.08	2.79
AS-394	25	24.940	.115	633.48	2.92
AS-395	26	25.940	.120	658.88	3.05
425-475 Cross section diameter = 0.275 ± 0.006 in. (6.99 ± 0.15mm)					
AS-425	4 1/2	4.475	.033	113.67	.84
AS-426	4 5/8	4.600	.033	116.84	.84
AS-427	4 3/4	4.725	.033	120.02	.84
AS-428	4 7/8	4.850	.033	123.19	.84
AS-429	5	4.975	.037	126.37	.94
AS-430	5 1/8	5.100	.037	129.54	.94
AS-431	5 1/4	5.225	.037	132.72	.94
AS-432	5 3/8	5.350	.037	135.89	.94
AS-433	5 1/2	5.475	.037	139.07	.94
AS-434	5 5/8	5.600	.037	142.24	.94
AS-435	5 3/4	5.725	.037	145.42	.94
AS-436	5 7/8	5.850	.037	148.59	.94
AS-437	6	5.975	.037	151.77	.94
AS-438	6 1/4	6.225	.040	158.12	.94
AS-439	6 1/2	6.475	.040	164.47	1.02
AS-440	6 3/4	6.725	.040	170.82	1.02
AS-441	7	6.975	.040	177.17	1.02

STANDARD SIZE SERIES NUMBER (AS568)	Nominal I.D.	INCHES Inside Diameter	INCHES Tolerance ±	MILLIMETERS Inside Diameter	MILLIMETERS Tolerance ±
425-475 Cross section diameter = 0.275 ± 0.006 in. (6.99 ± 0.15mm)					
AS-442	7 1/4	7.225	.045	183.52	1.14
AS-443	7 1/2	7.475	.045	189.87	1.14
AS-444	7 3/4	7.725	.045	196.22	1.14
AS-445	8	7.975	.045	202.57	1.14
AS-446	8 1/2	8.475	.055	215.27	1.14
AS-447	9	8.975	.055	227.97	1.40
AS-448	9 1/2	9.475	.055	240.67	1.40
AS-449	10	9.975	.055	253.37	1.40
AS-450	10 1/2	10.475	.060	266.07	1.52
AS-451	11	10.975	.060	278.77	1.52
AS-452	11 1/2	11.475	.060	291.47	1.52
AS-453	12	11.975	.060	304.17	1.52
AS-454	12 1/2	12.475	.060	316.87	1.52
AS-455	13	12.975	.060	329.57	1.52
AS-456	13 1/2	13.475	.070	342.27	1.78
AS-457	14	13.975	.070	354.97	1.78
AS-458	14 1/2	14.475	.070	367.67	1.78
AS-459	15	14.975	.070	380.37	1.78
AS-460	15 1/2	15.475	.070	393.07	1.78
AS-461	16	15.955	.075	405.26	1.91
AS-462	16 1/2	16.455	.075	417.96	1.91
AS-463	17	16.955	.080	430.66	2.03
AS-464	17 1/2	17.455	.085	443.36	2.16
AS-465	18	17.955	.085	456.06	2.16
AS-466	18 1/2	18.455	.085	468.76	2.16
AS-467	19	18.955	.090	481.46	2.29
AS-468	19 1/2	19.455	.090	494.16	2.29
AS-469	20	19.955	.095	506.86	2.41
AS-470	21	20.955	.095	532.26	2.41
AS-471	22	21.955	.100	557.66	2.54
AS-472	23	22.940	.105	582.68	2.67
AS-473	24	23.940	.110	608.08	2.79
AS-474	25	24.940	.115	633.48	2.92
AS-475	26	25.940	.120	658.88	3.05

SIZES FOR STRAIGHT THREAD TUBE FITTINGS

STANDARD SIZE SERIES NUMBER (AS568)	INCHES				Fractional (Inch) Reference	MILLIMETERS			
	Inside Diameter	Tolerance ±	Section	Tolerance ±		Inside Diameter	Tolerance ±	Section	Tolerance ±
AS-901	.185	.005	.056	.003	3/32	4.70	.13	1.42	.08
AS-902	.239	.005	.064	.003	1/8	6.07	.13	1.63	.08
AS-903	.301	.005	.064	.003	3/16	7.65	.13	1.63	.08
AS-904	.351	.005	.072	.003	1/4	8.92	.13	1.83	.08
AS-905	.414	.005	.072	.003	5/16	10.52	.13	1.83	.08
AS-906	.468	.005	.078	.003	3/8	11.89	.13	1.98	.08
AS-907	.530	.007	.082	.003	7/16	13.46	.18	2.08	.08
AS-908	.644	.009	.087	.003	1/2	16.36	.23	2.21	.08
AS-909	.706	.009	.097	.003	9/16	17.93	.23	2.46	.08
AS-910	.755	.009	.097	.003	5/8	19.18	.23	2.46	.08
AS-911	.863	.009	.116	.004	11/16	21.92	.23	2.95	.10
AS-912	.924	.009	.116	.004	3/4	23.47	.23	2.95	.10
AS-913	.986	.010	.116	.004	13/16	25.04	.25	2.95	.10
AS-914	1.047	.010	.116	.004	7/8	26.59	.25	2.95	.10
AS-916	1.171	.010	.116	.004	1	29.74	.25	2.95	.10
AS-918	1.355	.012	.116	.004	1 1/8	34.42	.30	2.95	.10
AS-920	1.475	.014	.118	.004	1 1/4	37.47	.36	3.00	.10
AS-924	1.720	.014	.118	.004	1 1/2	43.69	.36	3.00	.10
AS-928	2.090	.018	.118	.004	1 3/4	53.09	.46	3.00	.10
AS-932	2.337	.018	.118	.004	2	59.36	.46	3.00	.10

Fractional dimensions listed for tube fitting sizes reflect outside diameter of tube, not dimensions of o-ring.

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