O-Ring | **Technical Handbook**

NewDealSeals
Manufacturer and Worldwide Supplier
High Performance O-Rings and Seals

NewDealSeals

O-Ring | **Technical Handbook**

Table of Contents

1 Company profile

NewDealSeals was founded in 1994, and, in cooperation with our partner Origom, specializes in manufacturing and supplying the highest quality O-Rings and sealing components in the industry.
With thousands of standard parts in stock, we strive to deliver the products that you need, when you need them and at the best prices available.

The marketing staff of NewDealSeals is trained to speak various languages and with the aid of the most modern computer and communication technologies, we are the customer's reference point for enquiries and technical questions.

NewDealseals and Origom are able to satisfy any kind of requirements from O-Ring and Seal consumers, having at its disposal more then 40 hydraulic presses for the production of O-Rings, tools for more then 6000 different O-Ring sizes (ranges from inside diameter 0.74 to 1500 mm) and dealing with 300 different types of rubber materials.

The production process is kept under constant statistical control (24 hours a day) by means of specific software. The products can be supplied with the relevant Cp and Cpk statistical results of all the production parameters. Through non standard-production process control, it is possible to lower the qualitative – quantitative fault acceptance there hold AQL 0,65 – AQL 0,40 – Zero defect (meant as part per million ppmm). The potential annual production capacity based on a calculation of the average of the sizes is 1,500,000,000 pieces.

We export 65% of our products worldwide, and the industrial fields we serve amongst others are:

- Naval construction - Specializing in Marine Diesel Engines
- Domestic engineering - Specializing in Domestic Heating equipment
- Hydraulic sealing
- Automotive
- Technical trading

2 Quick guide for O-Ring selection

2.1 Select the elastomer

The most important characteristics of the material to be selected are:

- Temperature resistance
- Chemical resistance

The figure below shows the heat and oil resistance of various elastomers. For specific resistance to chemicals see the chemical compatibility guide (section 4.7).

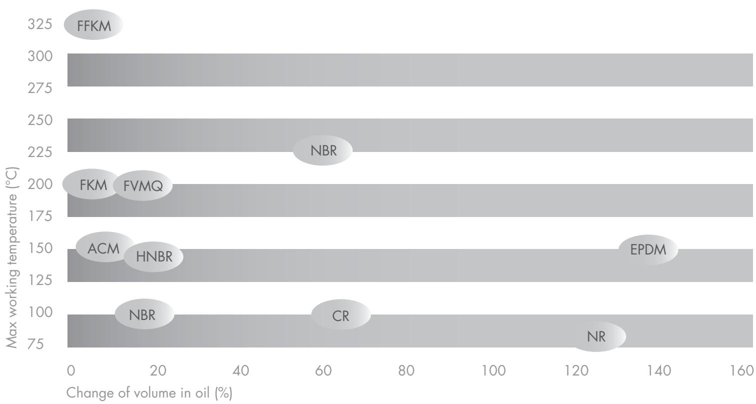


Figure 2-1: Elastomer heat resistance / oil resistance

On the following pages a short list can be found of the most used materials and their main characteristics.

NBR – N70N00L			
Trade name	Temperature range	Chemical resistance	Applications
Nitrile,	-30 / +108°C	hydraulic and lubricating oils	Hydraulic oils, Vegetable oils,
Buna N®,			Animal fats, Acetylene, Alcohols,
Perbunan®		animal and vegetable oils	Water, Air, Fuels.
Chemigum®		aliphatic hydrocarbons:	
		(LPG gases, butane, propane,	
		petroleum oil,petrol, kerosene,	
		diesel fuels) water	
		not compatible with:	
		aromatic hydrocarbons	
		(benzene) chlorinated	
		hydrocarbons (trichloroethylene)	
		polar solvents (ketone, acetone,	
		acetic acid) strong acids	
		brake fluid ozone, weather and	
		atmospheric aging	

Table 2-1: Main characteristics NBR – N70N00L

FKM – V70N00E			
Trade name	Temperature range	Chemical resistance	Applications
Viton®,	-20 / +204°C	hydraulic fluids	high temperature to oils, fats
Fluorel®		mineral and vegetable oils	and fuels
Tecnoflon®		aliphatic hydrocarbons:	chemical industry
		(fuel, butane, propane, natural	vacuum applications
		gas)	
		aromatic hydrocarbons	
		(benzene, toluene)	
		chlorinated hydrocarbons	
		(trichloroethylene, carbon tetra-	
		chloride fuels, also with metha-	
		nol content vacuum	
		ozone, weather and aging	
		resistant	
		not compatible with:	
		glycol based brake fluids,	
		ammonia gas, amines, alkalis	
		superheated steam	

Table 2-2: Main characteristics FKM – V70N00E

HNBR – H70N00C			
Trade name	Temperature range	Chemical resistance	Applications
Therban®, Zetpol®	-25 / +150°C	aliphatic hydrocarbons: (fuel, butane, propane, natural gas) animal and vegetable oils hydraulic fluids water and steam up to 150°C ozone, aging resistant not compatible with: chlorinated hydrocarbons (trichloroethylene, carbon tetrachloride polar solvents (ketone, acetone, acetic acid) strong acids	oil and fuel resistant components automotive industry

Table 2-3: Main characteristics HNBR – H70N00C

EPDM – E70N00L			
Trade name	Temperature range	Chemical resistance	Applications
Nordel®, Keltan®, Buna EP®	-50 / +150°C	hot water and steam (up to 150 °C) glycol based brake fluids organic and inorganic acids cleaning agents, soda and potassium alkalis phosphate-ester based hydraulic fluids polar solvents (alcohol, ketones, esters) ozone, weather and ageing resistant not compatible with: mineral oils	brake fluid components window profiles hot water applications

Table 2-4: Main characteristics EPDM – E70N00L

VMQ – S70R00E			
Trade name	Temperature range	Chemical resistance	Applications
Silicone,	-60 / +230°C	engine and transmission oil	electrical insulation
Elastosil®,		animal and vegetable oils	medical and food industry.
Silastic®		moderate water resistance	for extremely high or low tempera-
		diluted salt solutions	ture range, air, oxygen, dry heat,
		hot air	ozone, hot water to 150°C, and
		excellent ozone, weather and	glycol based brake fluids
		aging resistant	
		not compatible with:	
		superheated steam over 121°C	
		acids and alkalis	
		aromatic mineral oils	
		hydrocarbon based fuels	
		aromatic hydrocarbons	
		(benzene, toluene)	

Table 2-5: Main characteristics VMQ – S70R00E

FFKM – X70N00T			
Trade name	Temperature range	Chemical resistance	Applications
Kalrez®,	-15 / +316°C	hydraulic fluids oils	superior material, chemical
Chemraz®,		most hydrocarbons	resistance equal to PTFE.
Simriz®		majority of chemicals	very expensive material
Parafluor®			
		not compatible with:	
		perfluorinated hydrocarbons,	
		molten alkali metals	

Table 2-6: Main characteristics FFKM – X70N00T

2.2 Select the hardness

The hardness of 70 Shore A is most common and it gives a good sealing performance.
If the pressures is higher >5MPa a hardness of 90 Shore A can be chosen to prevent extrusion of the O-Ring. For pressures of more than 10 MPa (100 bar) we recommend the use of Back-Up rings.
Of course, depending on the application, the material, cross-section and the clearance are important.
For construction details see the more detailed information in the next sections.

Hardness (IRHD)	Pressure (MPa)
70	<5
90	5-10
Back-Up rings necessary	>10

Figure 2-2: Hardness/pressure table

2.3 Select the O-Ring dimensions

Determine the application

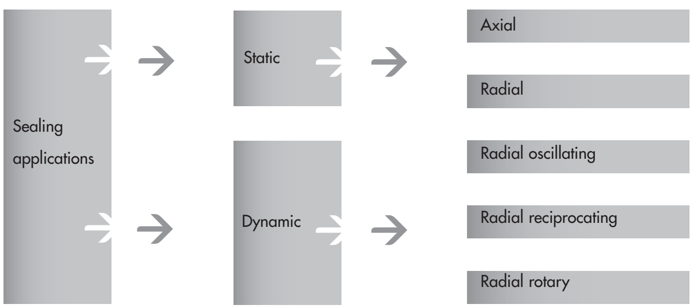


Figure 2-3: Flow chart O-Ring applications

Select the inside diameter (d1)

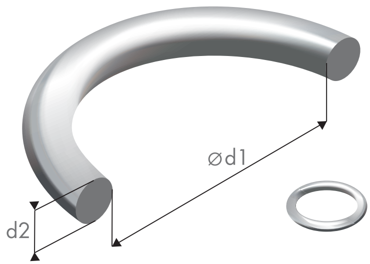


Figure 2-4: O-Ring

Axial installation (static):

- When the pressure is from the inside, the outside diameter of the O-Ring should be 1-2% larger than the outside groove diameter.
- When the pressure is from the outside, the inside diameter of the O-Ring should be 1-3% smaller than the inside groove diameter.

Radial installation (static and dynamic):

- Outer sealing (piston seal)
  The O-Ring inside diameter should be equal or max. 5% smaller than the inside groove diameter.
- Inner sealing (rod seal)
  The O-Ring inside diameter should not differ much, if at all, from the rod diameter, the exception being the O-Ring used as a rotary seal. In this case the O-Ring inside diameter needs to be 3% larger than the rod diameter.

Select the cross-section (d2)

In general an O-Ring with a larger cross-section generally has a better compression set, less swell and accepts larger tolerances. Disadvantages are the larger supporting structure and increased friction. Consequently a smaller cross-section is usually preferred for dynamic applications. The table on the next page can be used as a rough guideline for the cross-sections.

Cross-section (mm)	Inside diameter range (mm)
‡ 1.6	0-13
‡ 2.4	13-25
‡ 3.5	25-40
‡ 5.3	40-115
‡ 7	>115

Table 2-7: Cross-section/inside diameter table

Use standard sizes, preferably according to the AS 568 B section 7.2.

2.4 Select the groove dimensions

The necessary data can be found in the tables.

Static applications:
- Radial and axial installation (Table 6-1)
- Dovetail installation (Table 6-2)
- Crush seal installation (Table 6-3)
- Vacuum applications (Table 6-4)

Dynamic applications:
- Media: hydraulic fluids and lubricating fluids (Table 6-5)
- Media: poor lubrication and gases (Table 6-6)

In the following chapters more information can be found about various O-Ring materials together with their background, characteristics, groove dimensions and quality criteria.

3 Introduction O-Ring

3.1 What is an O-Ring?

An O-Ring is the most commonly used part for static and dynamic seals, with world production amounting to billions per year.
In 1937 Niels A Christensen, a Danish emigrant to the USA was awarded a patent for this ring with the perfect geometrical shape.

The O-Ring is an efficient, cost-effective sealing element for a great diversity of applications.
It is extensively used virtually in all branches of industry.
Elastomer materials in different formulations ensure that almost any medium can be reliably sealed off. The O-Ring is torus, providing an endless round sealing with a circular cross-section.

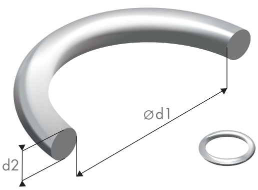


Figure 3-1: O-Ring

O-Ring dimensions:

- Inside diameter d1
  From approx. 0.74 mm to 1500 mm
- Cross-section d2
  From approx. 0.35 mm to 20 mm

3.2 How do O-Rings seal?

An O-Ring seals by blocking any potential leak path of a fluid (liquid or gas) between two closely spaced surfaces. The O-Ring is usually installed in a machined groove in one of the surfaces to be sealed.
As the two surfaces are brought together, they squeeze the cross-section of the O-Ring.
This results in a deformation of the O-Ring cross-section. The greater the squeeze, the larger the deformation.

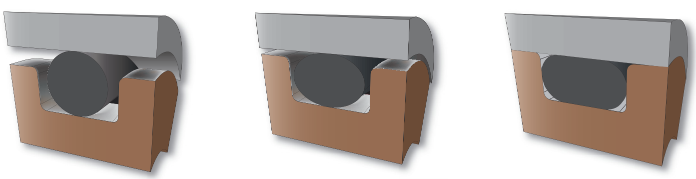


Figure 3-2: O-Ring deformation

It is the unique characteristics of the elastomer material used in O-Rings that makes the O-Ring such a good seal. The elastomer, a highly viscous, incompressible fluid with high surface tension, has a capacity to remember its original shape for a long time.
In low pressure applications (in which the confined fluid exerts little or no pressure on the O-Ring), the tendency of the elastomer to maintain its original shape creates the seal. As the O-Ring is deformed when the mating surfaces are brought together, it exerts a force against the mating surfaces equal to the force necessary to squeeze it, as illustrated in the figure. The areas of contact between the O-Ring and the mating surfaces (contact bands) act as a barrier that blocks the passage of the fluid.

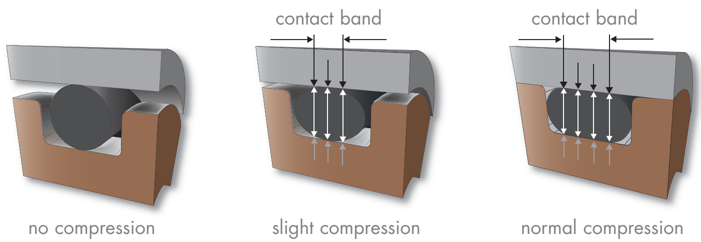


Figure 3-3: O-Ring sealing – low pressure application

In applications in which higher pressure is exerted by the confined fluid, the sealing action of the O-Ring caused by the squeeze of its cross-section is augmented by fluid pressure, transmitted through the elastomer. The O-Ring is forced to the side of the groove, away from the pressure. As it is pressed against the side, the O-Ring cross-section is deformed into a ‘D’ configuration as shown in the Figure. The elastomer exerts equal force in all directions and is forced up to (but not into) the gap between the mating surfaces.

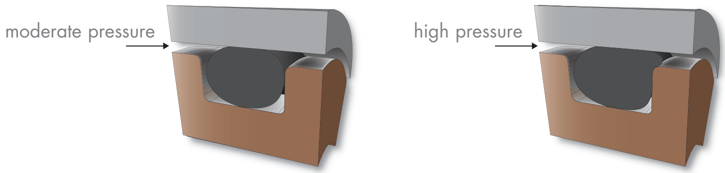


Figure 3-4: O-Ring sealing – moderate and high pressure application

When pressure is released, the O-Ring returns to approximately its original shape on installation, ready for the next application of pressure. The O-Ring is also able to seal in both directions. In a doubly acting system in which pressure application changes form one side of the O-Ring to the other, the O-Ring moves, seating itself in the opposite side of the groove.

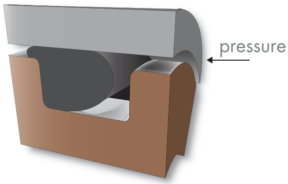


Figure 3-5: O-Ring sealing – reversed pressure application

If pressure exceeds the limits of the O-Ring, or if the gap that the O-Ring must block is too large, the elastomer will enter the narrow gap between the inner and outer surfaces. This may result in extrusion failure, causing the fluid to leak. Extrusion resulting from high pressure and other causes is explained in the section O-Ring failures.

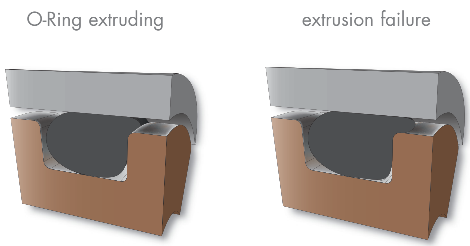


Figure 3-6: O-Ring extrusion

3.3 O-Ring applications

This section provides an overview of the most common types of the O-Ring sealing applications. More specific information is provided in section 5, 'Design recommendations'. All O-Ring sealing applications can be classified as either static or dynamic.

Static seals

In a static application there is no relative motion between parts of the groove which contact the O-Ring. Small amounts of movement, caused by thermal expansion, vibration, bolt stretch or O-Ring response to fluid pressure, do not alter the static definition. Static seals are often categorized according to the direction in which compression is applied to the O-Ring cross-section. There are two basic directions of compression: axial and radial. There are also applications which combine both axial and radial compression (crush seals). However, to achieve the best results the compression should be applied in one direction only to allow the O-Ring expansion.

Static axial seals

In this application the compression is on the top and bottom of the O-Ring, which is similar to a flat gasket. Static axial seals are typically utilized in face seal applications, as illustrated in the figure below.

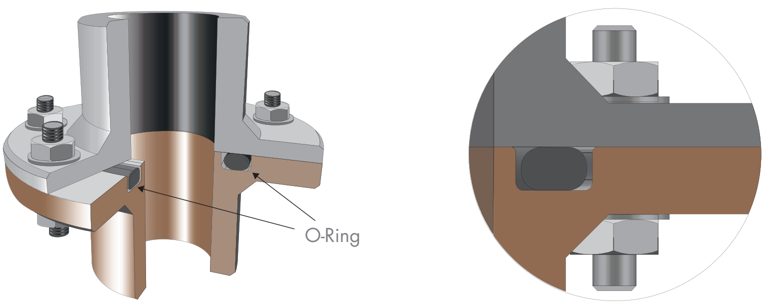


Figure 3-7: Typical static axial seal

Static radial seals

This application means that the compression is between the inside diameter and the outside diameter of the O-Ring. Typical static radial seals are cap seals and plug seals.

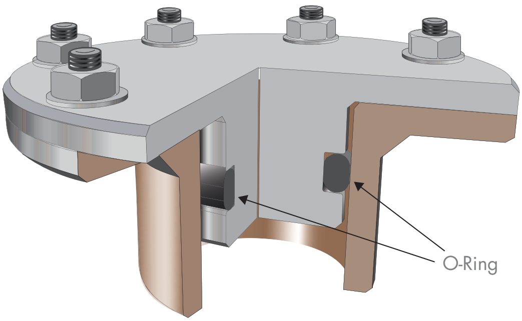


Figure 3-8: Typical static radial seal

Although uncompromised radial or axial compression is the preferred approach, O-Rings are extremely flexible and tend to work in grooves of various shapes and in many directions of compression.
For example, in crush seals the squeeze exerted on the O-Ring is angular (diagonal) through the O-Ring cross-section. In a crush seal application, the O-Ring is confined in a triangular groove whose volume is a little, if at all, greater than the O-Ring.

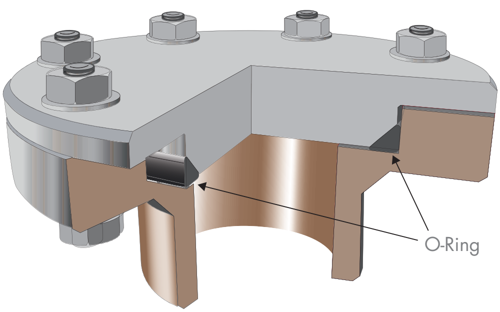


Figure 3-9: Typical crush seal application

The lack of free volume is a disadvantage of the crush seal. The O-Ring is more susceptible to damage during installation and upon high temperature excursions during which the relatively higher coefficient of expansion of the O-Ring may cause the metal components to warp.

Dynamic seals

In dynamic sealing applications there is relative movement between the parts of the groove, i. e. O-Rings are subject to a sliding action against the surface. This motion causes difficulties that cause design problems different from those of static seals. For the great majority of dynamic applications, O-Rings are squeezed radially and are subjected to reciprocating motion, either intermittent or continuous, or, less frequently, to an intermittent rotary or oscillating motion.

Reciprocating seals

In this type of application, there is a relative reciprocating (back and forth) motion along the shaft axis between the inner and outer elements of the groove. O-Rings used in reciprocating applications are called piston or rod seals.

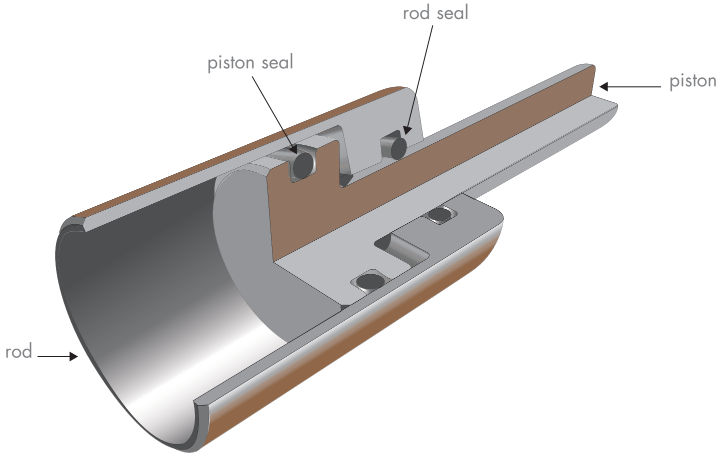


Figure 3-10: Reciprocating seal

Oscillating seals

In this application, the inner and outer components of the groove move in an arc around the axis of the shaft, first in one direction and then in the opposite direction, usually intermittently, with no more than a few turns in each direction. The most common application for oscillating O-Ring seals is in valves.

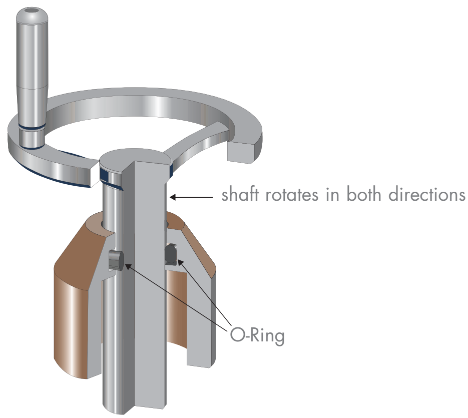


Figure 3-11: Oscillating seal

Other dynamic seals

O-Rings are extremely versatile and may be used in applications in which the data for ordinary reciprocating or oscillating seals do not apply. For example, O-Rings have proven to be practical seals in many rotary applications in which either the inner or outer component of the construction continuously turns around the axis of the shaft. However, special attention has to be paid to the design parameters.

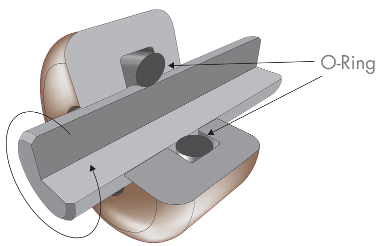


Figure 3-12: Rotary seal

Other types of O-Ring uses

Although O-Rings are most frequently used in hydraulic or liquid containment applications, they are also used in pneumatic and vacuum applications and in non-sealing applications, such as seatbelts and bumpers. Although there are many other applications only a brief explanation of the more common ones is given below.

Pneumatic and vacuum O-Ring sealing

The typical static and dynamic seals illustrated so far are used to seal liquids. Pneumatic and vacuum seals may include standard forms of both static and dynamic sealing applications. However, they are used to seal gases rather than liquids and therefore they require different design considerations.

3.4 Fields of application

On the previous pages we have shown the most common O-Ring applications.
To select the appropriate O-Ring the following parameters have to be considered:

1. Application
- Static (up to 5 MPa (50 Bar); >5 MPa with Back-Up ring)
- Dynamic (up to 5 MPa)

2. Media
- Chemical compatibility against fluids

3. Temperature ranges
- Permanent temperatures
- Peak temperatures
- Exposure duration

4. Process pressures

5. Maximum gap dimensions

6. Relative speed
- Linear max. 0.5 m/s
- Rotating max. 2 m/s

7. Special requirements

With highly stressed seal applications:

- Operating pressures exceeding 5 MPa
- Permanent high temperatures
- Unfavourable gap dimensions

Back-Up rings are recommended as a general principle.

The use of O-Rings for dynamic sealing is limited. The application possibilities are limited by the relative speeds in interaction with the effective pressures. An increase in temperature as a result of frictional heat must also be taken into account.

3.5 Advantages of O-Rings

- They seal over a wide range of pressure, temperature and tolerance.
- Ease of service or re-tightening.
- O-Rings require very little room and are light in weight.
- In many cases an O-Ring can be reused, an advantage over non-elastic flat seals and crush-type gaskets.
- O-Ring failure is usually gradual and easily identified.
- They are cost-effective.

4 Materials

4.1 Introduction

The term 'rubber' originally meant the material obtained from the rubber tree 'Hevea Brasiliensis'. Today a distinction is made between crude rubbers and vulcanized rubbers, or elastomers. Elastomer is the preferred term for vulcanized rubber.
Unlike crude rubber, elastomers are elastic materials i.e. they have the ability to deform considerably under the application of force and then snap back to almost their original shape when the force is removed. The term elastomer is derived from the words elastic polymer. Most of the materials used today are manufactured synthetically.

Modern compounds contain 50 to 60% base polymer. An elastomer compound consists of:

- Reinforcing agents (for example carbon black)
- Vulcanizing agents
- Accelerators
- Plasticizers
- Anti-degrading agents
- Pigments
- Process aids

The compound is made by repeatedly mixing the base polymer with the additives either in a closed Banbury mixer or in an open mixer.

Cross-linking between the polymer chains is formed during the vulcanization process.
Cross-linking of the molecules changes the raw material from a plastic-like to an elastic one.

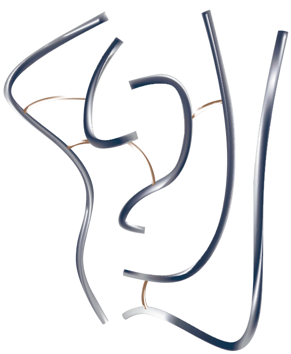


Figure 4-1: Elastomer cross-linked

For more information about the background of the materials please see the section 10, 'Language of rubber'. Most common elastomers will be introduced on the following pages which will facilitate the choice of the right material during the design process of a good sealing solution.

4.2 List of synthetic elastomers

Many elastomer types have been developed to create the best mechanical and chemical properties for specific applications. Elastomers are classified into groups as per ISO 1629 or ASTM D 1418. The following tables provide a summary of the various elastomers and material groups. NewDealSeals can offer a large number of materials within each group.

Designation	Trade Name	Abbreviation ISO 1629	ASTM D 1418
Acrylonite-Butadiene Elastomer (Nitrile Rubber)	Perbunan® Buna-N®	NBR	NBR
Fluorocarbon Elastomer	Viton® Fluorel® Tecnoflon®	FKM	FKM
Ethylene Propylene Diene Elastomer	Dutral® Keltan® Nordel®	EPDM	EPDM
Silicone Elastomer	Elastosil® Rhodorsil® Silastic® Silopren®	VMQ	VMQ
Fluorosilicone Elastomer	Silastic®	FVMQ	FVMQ
Tetrafluorethylene-Propylene Copolymer Elastomer	Aflas®	FEPM	TFE / P
Hydrogenated Acrylonitrile-Butadiene Elastomer	Therban® Zetpol®	HNBR	HNBR
Chloroprene Elastomer	Neoprene® Baypren®	CR	CR
Butyl Elastomer	Esso Butyl®	IIR	IIR
Styrene-Butadiene Elastomer	Buna S® Europrene®	SBR	SBR
Natural Elastomer		NR	WR
Perfluoro Elastomer	Kalrez® Zalak® Chemraz®	FFKM	FFKM

Table 4-1: Elastomers

Chemical name	Abbreviation DIN/ISO 1629	ASTM D 1418
M – Group		
(saturated carbon molecules in main macro-molecule-chain)		
• Polyacrylate Rubber	ACM	ACM
• Ethylene Acrylate Rubber	AEM	
• Chlorosulphonated Polyethylene Rubber	CSM	CSM
• Ethylene Propylene Diene Rubber	EPDM	EPDM
• Ethylene Propylene Rubber	EPM	EPM
• Fluorocarbon Rubber	FKM	FKM
• Perfluoro Rubber	FFKM	FFKM
O – Group		
(with oxygen molecules in the main macro-molecule chain)		
• Epichlorohydrin Rubber	CO	CO
• Epichlorohydrin Copolymer Rubber	ECO	ECO
R – Group		
(unsaturated hydrogene carbon chain)		
• Chloroprene Rubber	CR	CR
• Butyl Rubber	IIR	IIR
• Acrylonitrile Butadiene Rubber	NBR	NBR
• Natural Rubber	NR	NR
• Styrene Butadiene Rubber	SBR	SBR
• Hydrogenated Nitrile Butadiene Rubber	HNBR	HNBR
Q – Group		
(with Silicone in the main chain)		
• Fluorosilicone Rubber	FVMQ	FVMQ
• Methyl Vinyl Silicone Rubber	VMQ	VMQ
U - Group		
(with carbon, oxygen and nitrogen in the main chain)		
• Polyester Urethane	AU	AU
• Polyether Urethane	EU	EU

Table 4-2: The most important types of synthetic rubber, their grouping and abbreviations

4.3 Main properties of elastomers

Elastomers are complex materials that exhibit unique combinations of useful properties.
The first and foremost property is elasticity. All elastomers have the ability to deform substantially by stretching, compression or torsion and then, after removal of the force causing the deformation, snap back to almost their original shape.

Besides elastic recovery, the majority of elastomers possess other useful properties, including:

- Low permeability to air, several gases, water and steam
- Good electrical and thermal insulation
- Good mechanical properties
- The capability of adhering to metals and plastics

By proper selection of compound ingredients, products with improved or specific properties can be designed to meet a wide variety of service conditions.

Main properties:

- Specific weight
- Hardness
- Tensile strength
- Elongation
- Modulus
- Tear strength
- Compressions set
- Resistance to fluids
- Chemical resistance
- Resistance to ozone
- Resistance to low temperatures
- Resistance to accelerating ageing

4.4 Basic elastomers for O-Rings

The following paragraph briefly reviews various elastomers currently available
for use in O-Rings and other seals.

NBR (Acrylonitrile-Butadiene Rubber)

Acrylonitrile-butadiene or nitrile rubbers are copolymers of butadiene and acrylonitrile. The acrylonitrile content of these compounds varies considerably - from 18% to 50% - and influences the physical properties of the finished material. As the acrylonitrile content is increased the following changes in the
vulcanizate properties occur:

- Resistance to petroleum-based fluids and hydrocarbon fuels increases
- Low-temperature flexibility decreases
- Rebound resilience decreases
- Compression set decreases
- Gas permeability decreases
- Heat resistance improves
- Ozone resistance improves
- Abrasion resistance improves
- Tensile strength increases
- Hardness increases
- Density increases

The standard NBR compounds have a medium content of ACN (33%) and are a compromise between the opposing properties of the material. In comparison with other elastomers NBR has good mechanical properties and high wear resistance. NBR is not resistant to weathering and ozone. NBR vulcanizates are the most widely used elastomers for sealing applications because NBR is resistant to a wide range of petroleum-based greases and fluids, vegetable and animal oils, silicone greases and oils, water and aqueous solutions of non oxidizing chemicals. Specially formulated compounds extend the range of applications in which NBR can be used. The operating temperatures range between -30°C and +108°C.

EPM, EPDM (Ethylene-Propylene Rubber)

There are two types of the ethylene-propylene rubbers:

- EPM, a fully saturated copolymer of ethylene and propylene and
- EPDM, a terpolymer of ethylene, propylene and a small percentage of a non-conjugated diene

The EPM rubbers, being completely saturated, require organic peroxides or radiation for vulcanization. The EPDM terpolymers can be vulcanized with peroxides, sulphur or radiation.
The properties of EPM and EPDM rubbers are basically the same. EPDM is the most common sealing material. It has a fair tensile strength over a wide range and excellent resistance to ozone, weathering and chemical attack. Furthermore, EPM and EPDM rubbers exhibit very good electrical insulation properties.
Sulphur-cured compounds have a higher compression set and are less resistant to high temperatures. Peroxide-cured compounds exhibit excellent heat ageing properties and resistance to compression set up to 150°C.
EPDM compounds are resistant to: hot water and steam, non petroleum-based automotive brake fluids, aqueous solutions of inorganic acids, alkalis and salts, alcohols, glycols, ketones (acetone, MEK) and low molecular weight esters.
Their resistance to animal and vegetable oils and fats is moderate.
EPDM is not resistant to mineral oil based fluids and greases, synthetic hydrocarbon lubricants, organic ester based lubricants and hydrocarbon fuels.

FKM (Fluorocarbon Rubber)

Fluoroelastomers were introduced in 1957 (DuPont-Viton®) to meet the need of the aerospace industry for a high-performance seal elastomer. Since then, the use of fluoroelastomers has expanded to many other industries, especially the automotive, fluid power, appliance sectors, and many chemical fields. With over 50 years of proven performance, fluoroelastomer has developed a reputation for outstanding performance in high temperature and extremely corrosive environments.

Fluoroelastomers are highly fluorinated hydrocarbon polymers. In general, all highly fluorinated polymers are very stable and possess exceptional resistance to oxidation, weather, flame, chemical attack and swelling in a wide range of liquids. This stability is mainly due to the high strength of the C-F bond as compared to the C-H bond.

FKM rubbers are available in various grades, which differ mainly in the polymer composition and fluorine content. In combination with the cure system (diamines, bisphenol or peroxides) the properties of the compound can be influenced to meet the requirements of the application.

In general FKM has an outstanding resistance to high temperatures, it's elastomeric properties in hot air are maintained up to 204°C with peak temperatures up to 300°C. FKM elastomers exhibit excellent resistance to swelling in a wide variety of oils, fuels, solvents and chemicals.

They are recommended for:

- Petroleum oils and hydrocarbon fuels
- Organic ester based lubricants
- Silicate ester based lubricants
- Aromatic hydrocarbons (benzene, toluene, xylene)
- Halogenated hydrocarbons (trichloroethylene, carbon tetrachloride)

Despite their excellent resistance to a wide variety of fluids, there are certain chemicals that severely attack FKM compounds.

The use of FKM elastomers is not recommended for:

- Polar solvents, ketones (acetone, MEK) and esters (ethyl acetate)
- Low molecular weight organic acids (formic acid, acetic acid)
- Hot water and steam, unless compounded with lead oxide
- Skydrol fluids
- Glycol based automotive brake fluids
- Anhydrous ammonia and amines
- Hot hydrofluoric or chlorosulphonic acids

The fluid resistance of FKM types improves with increasing fluorine levels. However, as the fluorine content increases the low-temperature flexibility of the polymer decreases, and a compromise must be made between fluid resistance and low temperature flexibility of the final vulcanizate. The low-temperature properties of conventional FKM elastomers are, in general, moderate. For low-temperature applications special FKM types have been developed.

HNBR (Hydrogenated Acrylonitrile-Butadiene Rubber)

Hydrogenated acrylonitrile-butadiene rubbers are produced by selective and controlled hydrogenation of NBR. The highly saturated polymethylene chains demonstrate excellent heat and ozone resistance whereas the nitrile groups provide oil and fuel resistance. Increasing the degree of hydrogenation results in improved heat and ozone resistance.

As would be expected, increasing the nitrile content in HNBR results in reduced swelling in mineral oils, but with hardly any loss in low temperature flexibility compared to the regular NBR. The operating temperature range of HNBR is -25 to +150°C.

HNBR is resistant to:

- Aliphatic hydrocarbons
- Vegetable and animal fats and oils
- HFA, HFB and HFC fluids
- Dilute acids, bases and salt solutions at moderate temperatures
- Water and steam up to 150°C
- Ozone, ageing and weathering

HNBR is not compatible with:

- Chlorinated hydrocarbons
- Polar solvents (ketone and ester)
- Strong acids

HNBR elastomers fill a gap between NBR and FKM in many areas of application. In general they are used to replace NBR whenever the resistance to excessive heat or aggressive environments is critical. In contrast to conventional FKM compounds, HNBR elastomers can withstand basic additives such as amine-based corrosion inhibitors. For this reason, HNBR compounds are used in oil-field operations. They maintain their performance in difficult conditions, whereas NBR and most of the conventional FKM elastomers show a certain amount of degradation.

VMQ (Silicone Rubber)

Silicone rubbers have a backbone that consists of alternating silicon and oxygen atoms (-Si-O-Si-). This is unusual compared to other elastomers which have an organic backbone (-C-C-). Silicone rubber shows excellent heat resistance, cold flexibility, dielectric properties and especially good resistance to oxygen and ozone. Silicone has a high physiological inertness, it is odourless, tasteless and non-toxic. The mechanical properties, however, are poor to moderate. The material should only be used in static applications. Depending on the material the operating temperatures range between -60°C and +200°C (and for a short period of time even up to +230°C).

VMQ is resistant to:

- Engine and transmission oil (for example ASTM oil No.1)
- Animal and vegetable oil and grease
- Brake fluid (non-petroleum base)
- Fire-resistant hydraulic fluid, HFD-R and HFD-S
- High molecular weight chlorinated aromatic hydrocarbons (including flame-resistant insulators and coolant for transformers)
- Moderate water resistance
- Diluted salt solutions
- Ozone, ageing and weather

VMQ is not compatible with:

- Superheated water steam over 121°C (250°F)
- Acids and alkalis
- Low molecular weight chlorinated hydrocarbons (trichloroethylene)
- Aromatic mineral oil
- Hydrocarbon based fuels
- Aromatic hydrocarbons (benzene, toluene)

FVMQ (Fluorosilicone Rubber)

Fluorosilicone rubbers are fluorine-modified silicone rubbers containing trifluoropropyl side groups. These elastomers have the most useful properties of regular silicone plus improved fluid resistance and they also have a more restricted high temperature limit. The operating temperatures range between 60°C and +175°C. FVMQ elastomers are used in circumstances in which low temperature flexibility and low swell in fluids are required.

CR (Chloroprene Rubber)

Chloroprene rubbers are homopolymers of chlorobutadiene.
Neoprene®, the trade name of Dupont for chloroprene rubber, was the first synthetic rubber developed commercially. Generally, the elastomer exhibits generally good ozone, ageing and chemical resistance. The operating temperatures range between -40°C and +100°C (and for a short period of time even up to +120°C).

The properties of chloroprene rubber include:

- Low-flammability (self-extinguishing after removal form the flame)
- Moderate to good resistance to refrigerants
- Poor resistance to hydrocarbon fuels and aromatic and chlorinated hydrocarbons

FFKM (Perfluoro rubber)

Perfluoroelastomer is produced by the copolymerization of tetrafluoroethylene (TFE) and a perfluorinated ether, e.g. perfluoromethylvinylether (PMVE).
The cured polymer does not contain hydrogen atoms in the molecule. The absence of hydrogen increases the heat and chemical resistance as compared to FKM.
Perfluoroelastomers show broad chemical resistance similar to PTFE (DuPont–Teflon®) as well as good heat resistance.
They show low swelling with almost all media. Depending on the material the operating temperatures range between -25°C and +300°C. This high-end material has been on the market since 1968 and is the most expensive elastomer available, comparable to gold.

FFKM parts provide reliable, long-term service with a wide range of aggressive industrial and electronic grade chemicals. It is used in highly aggressive chemical processing, semiconductor wafer processing, pharmaceutical applications, oil and gas recovery, aerospace and petroleum applications.

FEPM (Tetrafluoroethylene-Propylene rubber)

This elastomer is a copolymer of tetrafluoroethylene (TFE) and propylene, also known by its trade name Aflas®. It is an improved ethylene-propylene rubber in which the hydrogen atoms of ethylene are replaced by fluorine. The C-F bond and the saturated polymer chain are responsible for the excellent chemical and heat resistance of the elastomer. The operating temperatures range between -25°C and +300°C.

FE/P is resistant to:

- Amines
- Steam and hot water
- Sour oil and gas
- Hydraulic fluids
- Petroleum oils and greases
- Alcohols
- Acids, alkalis and oxidizing chemicals
- Ozone and weather
- Aromatic and chlorinated hydrocarbons
- Ketones

The compression set resistance is not as good as that of FKM elastomers and the low-temperature flexibility is poor.

AU/EU (Polyurethane rubber)

One must differentiate between polyester urethane (AU) and polyether urethane (EU). AU type urethanes exhibit better resistance to hydraulic fluids. Polyurethane elastomers, as a class, have excellent wear resistance, high tensile strength and high elasticity in comparison with any other elastomers. The operating temperatures range between -25°C and +80°C.

Polyurethane is resistant to:

- Aliphatic hydrocarbons (propane, butane, fuel)
- Mineral oil and grease
- Silicone oil and grease
- Water up to 50°C (EU type)
- Ozone and ageing resistant

Polyurethane is not compatible with:

- Ketones, esters, ethers, alcohols, glycols
- Hot water, steam, alkalis, amines, acids

4.5 Selection of the base compound

System operating temperatures and compatibility with the media to be sealed are the two most important parameters that must be considered when selecting a base polymer. Only when these two factors are identified (together with any lubricants and potential cleaning fluids), can a reliable recommendation be given concerning selection of the proper elastomer base.

Temperature

The application temperatures refer to long-term exposure to non-aggressive media. At higher temperatures, new cross-link sites may be formed between the polymer chains and lead to a loss of seal flexibility.
The stiffness in the polymer chains may be observed as excessive compression set in highly filled (loaded) compounds. This condition prevents an O-Ring cross-section from returning to its original, pre-compressed shape after deformation forces are removed. During compression, a seal changes its original shape to effect a seal. And over time, and at excessive temperature, elastic memory loss in the elastomer seal element can cause leakage. Exceeding the normal maximum temperature limit for a given compound always results in reduced service life.

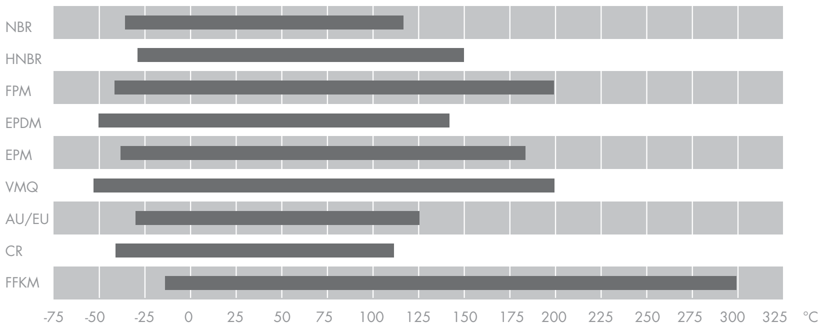


Table 4-3: Temperature ranges of various elastomer materials (medium: air)

Chemical compatibility

Practically all elastomers undergo a physical or chemical change when in contact with a sealed medium. The degree of change depends on the chemical characteristics of the medium and on the system temperature. An aggressive medium becomes more active with increasing temperature. Physical changes are caused by two mechanisms which can work concurrently when:

- The elastomer absorbs a medium
- Plasticizers and other components of the compound are dissolved and extracted or leached out by the media

The result is a volume change, i.e. swelling or shrinkage of the elastomer seal. The degree of the volume change depends on the type of medium, molecular structure of the rubber compound, system temperature, geometrical seal shape (material thickness), and the stressed condition of the rubber part (compression or stretch). When deformed and exposed to a medium, rubber, when confined in a groove, swells significantly less than in a free state (up to 50%) due to a number of factors including reduced surface area in contact with the medium. The limit of permissible volume change varies with the application. For static seals, a volume change of 25% to 30% can be tolerated. Swelling leads to some deterioration of the mechanical properties and, in particular, those properties which improve extrusion resistance. In dynamic applications, swelling leads to increased friction and a higher wear rate. Therefore, a maximum swell of 10% should generally not be exceeded. Shrinkage should also be prevented because the resulting loss of compressive force will increase the risk of leakage.

The extraction of plasticizer from a seal material is sometimes compensated for by partial absorption of the contact medium. However, this situation, can still lead to unexpected shrinkage and resultant leakage if an elastomer dries out and the absorbed fluids evaporate. A chemical reaction between sealed or excluded medium and the elastomer can bring about structural changes in the form of further cross-linking or degrading. The smallest chemical change in an elastomer can lead to significant changes in physical properties, such as embrittlement.

The suitability of an elastomer for a specific application can be established only when the properties under typical working conditions of both, the medium and the elastomer, are known.
If a particular seal material suits a medium, it is referred to as being 'compatible' with that medium. See the next table for a comparison of the properties of commonly used elastomers.

Elastomer	NR	SBR	EPDM	CR	NBR
Hardness (degrees Shore A)	30 - 95	40 - 95	30 - 85	30 - 90	40 - 90
Colour (standard)	Black	Black	Black	Black	Black
Heat resistance					
Constant max. (°C)	75	85	130	95	100
Peak max. (°C)	105	115	150	125	130
Resistance to low temperatures (°C)	-60	-55	-50	-35	-20
Resistance to					
Oxidation	fair	fair	excellent	very good	good
Ozone / weather	poor	poor	excellent	very good	fair
Ageing in oil					
Oil ASTM no.1 at 20°C	poor	poor	fair	excellent	excellent
Oil ASTM no.1 at 100°C	unsatisfactory	unsatisfactory	unsatisfactory	good	good
Oil ASTM no.3 at 20°C	unsatisfactory	unsatisfactory	unsatisfactory	good	excellent
Oil ASTM no.3 at 100°C	unsatisfactory	unsatisfactory	unsatisfactory	fair	good
Resistance to fuel ASTM 'B' at 40°C	unsatisfactory	unsatisfactory	unsatisfactory	poor	fair
Resistance to solvents (20°C)					
Alcohol	good	good	good	good	good
Acetone	fair	fair	good	fair	unsatisfactory
Benzene	unsatisfactory	unsatisfactory	unsatisfactory	unsatisfactory	unsatisfactory
Resistance to chemical products					
Acids	fair	fair	good	good	good
Bases	good	good	good	fair	fair
Physical strength	excellent	good	good	good	good
Compression set	good	good	good	fair	good
Tear strength / abrasion resistance	excellent	good	good	good	good
Resilience	excellent	good	very good	very good	good
Permeability to gas	fair	fair	fair	fair	good
Electrical properties	excellent	excellent	excellent	good	poor
Flame resistance	poor	poor	poor	self-extinguishing	poor
Water resistance	very good	good	excellent	good	good

Table 4-4: Compound properties

Elastomer	ACM	VMQ	HNBR	FKM	FMVQ
Hardness (degrees Shore A)	50 - 85	40 - 80	50 - 95	50 - 95	40 - 80
Colour (standard)	Black	Redbrown	Black	Black	Blue
Heat resistance					
Constant max. (°C)	150	180 / 200	125	205	170
Peak max. (°C)	180	200 / 300	150	300	220
Resistance to low temperatures (°C)	-20	-60	-30	-20	-60
Resistance to					
Oxidation	excellent	excellent	excellent	excellent	excellent
Ozone / weather	excellent	excellent	very good	excellent	excellent
Ageing in oil					
Oil ASTM no.1 at 20°C	excellent	excellent	excellent	excellent	excellent
Oil ASTM no.1 at 100°C	excellent	good	excellent	excellent	excellent
Oil ASTM no.3 at 20°C	excellent	good	fair	excellent	excellent
Oil ASTM no.3 at 100°C	excellent	fair	fair	excellent	excellent
Resistance to fuel ASTM 'B' at 40°C	poor	unsuitable	-	excellent	fair
Resistance to solvents (20°C)					
Alcohol	good	good	excellent	good	good
Acetone	unsatisfactory	fair	good	unsuitable	unsuitable
Benzene	unsatisfactory	unsatisfactory	fair	good	good
Resistance to chemical products					
Acids	poor	fair	good	excellent	good
Bases	poor	fair	good	good	fair
Physical strength	good	fair	good	good	poor
Compression set	good	good	good	good	good
Tear strength / abrasion resistance	good	poor	very good	good	poor
Resilience	poor	good	fair	fair	fair
Permeability to gas	good	poor	good	very good	poor
Electrical properties	fair	excellent	poor	good	excellent
Flame resistance	poor	good	poor	self-extinguishing	self-extinguishing
Water resistance	poor	good	very good	good	good

Table 4-4: Compound properties (Continued)

4.6 Selection of the right properties of a compound

Hardness

Hardness, as applied to elastomers, is defined as the resitance of the surface to penetration by an intender of specific dimensions under specified load. The hardness of the test samples and finished parts made out of elastomer material can be tested by means of the two possible procedures:

- Shore A (according to ISO 868 / ISO 7619 / DIN 53 505 / ASTM D 2240)

- IRHD (International Rubber Hardness Degree according to ISO 48 / ASTM 1414 and 1415)

The hardness scale ranges from 0 (softest) to 100 (hardest).

Shore A Shore D

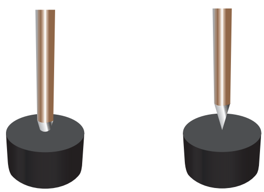


Figure 4-2: Indenter according to Shore A & D

Normal ISO 48 "M" / "CM"

Figure 4-3: Indenter according to IRHD

Material	Instrument	Examples
Soft rubber, sponge rubber, skinned urethane foam, cork	Shore 0 & 00	Pad printers, fruit, tissues, automotive trim
Medium hard rubber, felts, soft polymers, flexible polyurethane	Shore A, Shore "A" Micro (M), IRHD, IRHD Micro (M)	General rubber parts, tyres, rollers, piano felts, sealants, seals, O-Rings
Medium hard rubber, polyurethane, plastics	Shore C	Automotive trim, hard rubber rollers
Hard rubber, rigid polyurethane, thermo plastics, epoxy resin	Shore D	Potting compounds, general plastic parts, vinyl flooring, brake pads, calendar rolls

Table 4-5: Measuring methods for several applications

The size and shape of the indenter used in IRHD readings is much smaller, thus allowing for more accurate measurements on curved surfaces such as an O-Ring cross-section.
Unfortunately, there is no direct correlation between the readings of Shore A and IRHD Scales.
To simplify the comparison, please, see the table below which is based on experience.

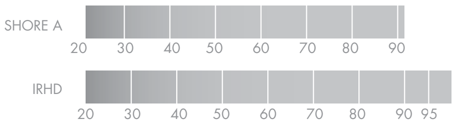


Table 4-6: Shore A and IRHD scale

Softer sealing materials, with lower hardness readings, will flow more easily into the micro fine grooves and imperfections of the mating parts (the gland, bore, rod or seal flanges). This is particularly important in low-pressure seals because they are not activated by fluid pressure. The harder materials offer greater resistance to flow and have a better resistance to extrusion.

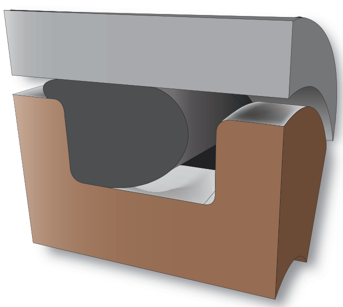


Figure 4-4: Extrusion of an O-Ring

In dynamic applications, the hardness of the O-Ring is doubly important because it also affects both breakout and running friction. Although a harder compound will, in general, have a lower coefficient of friction than a softer material, the actual friction values are actually higher because the compressive load required to squeeze the harder material into the O-Ring gland is much greater.

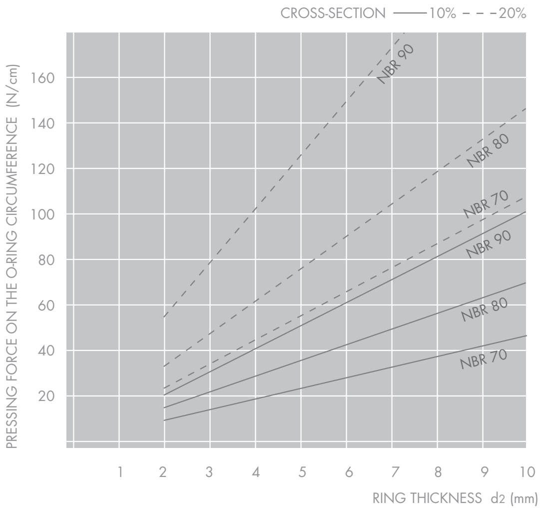


Figure 4-5: Necessary pressing force at 10% and 20% cross-section compression

Compounds which have a Shore A durometer hardness of 70 to 80 are the most suitable compromise for most applications.

Tensile strength

Tensile strength, which is measured in the psi (pounds per square inch) or MPa (Mega Pascals), is the strength required to rupture a specimen of a given elastomer material when it is stressed. Tensile strength is one quality assurance measurement used to ensure compound uniformity. It is also useful as an indicator of deterioration of the compound after it has been in contact with a fluid for long periods. If contact with a fluid results in only a small reduction in tensile strength, seal life may still be relatively long, yet if a large reduction of tensile strength occurs, seal life may be relatively short.

Elongation

Elongation is defined as the increase in length, expressed numerically, as a percentage of initial length. The increase over the original dimension at break is generally reported as ultimate elongation.
This property primarily determines the stretch which can be tolerated during the installation of an O-Ring. Elongation increases in importance as the diameters of a gland become smaller. It is also a measure of the ability of a compound to recover from peak overload, or a force localized in one small area of a seal, when considered in conjunction with tensile strength. An adverse change in the elongation of a compound after exposure to a fluid is a definite sign of degradation of the material. Elongation, like tensile strength, is used throughout the industry as a quality assurance measure for production batches of elastomer materials.

Modulus

Modulus, as used in rubber terminology, refers to stress caused by a predetermined elongation of, usually, 100%. It is expressed in pounds per square inch (psi) or MPa (Mega Pascals). This is actually the elastic modulus of the material. The higher the modulus of a compound, the more likely it is to recover from peak overload, and the better its resistance to extrusion. Modulus usually increases with an increase in hardness. It is probably the best overall indicator of the toughness of a compound, all other factors being equal.

Tear resistance

Tear strength is relatively low for most compounds. However, if it is extremely low (less than 100 lbs/in or 17.5 kN/m), there is increased danger of nicking or cutting the O-Ring during assembly, especially if it must pass over ports, sharp edges or burrs. Once a crack has began to develop compounds with poor tear resistance will fail quickly under further flexing or stress. In dynamic seal applications, inferior tear strength of a compound is also indicative of poor abrasion resistance which may lead to premature wear and early failure of the seal. However, this aspect is usually not characteristic of static applications and need not be considered.

Abrasion resistance

Abrasion resistance is a general term that indicates the wear resistance of a compound. While 'tear resistance' essentially concerns cutting or otherwise rupturing the surface, 'abrasion resistance' concerns scraping or rubbing of the surface. This is of major importance for dynamic seal materials. Only certain elastomers are recommended for dynamic O-Ring service because the moving parts actually come in contact with the seal material. Harder compounds, up to 90 durometer, are usually more resistant to abrasion than softer compounds.

Volume change

Volume change is the increase or decrease in the volume of an elastomer after it has been in contact with a fluid, and is measured in percents (%). Swell or increase in volume is almost always accompanied by a decrease in hardness. As might be expected, excessive swell results in marked softening of the rubber. This condition causes reduced abrasion and tear resistance, and may result in extrusion of the seal under high pressure. For static O-Ring applications a volume swell of up to 30% can usually be tolerated. For dynamic applications, 10 or 15% swell is a reasonable maximum. Shrinkage or decrease in volume is usually accompanied by an increase in hardness. Shrinkage is far more critical than swell. Shrinkage of more than 3 or 4% can cause leakage of moving seals.

Compression set

An important parameter concerning the sealing capability is the compression set (CS) of the O-Ring material. When under compression elastomers show not only their elasticity but also a permanent plastic deformation. The compression set is determined as follows in accordance with ISO 815:

- Standard test piece : Cylindrical disc, diameter 13 mm and height 6 mm
- Deformation : 25%
- Tension release time : 30 minutes

$$CS = \frac{h_0 - h_2}{h_0 - h_1} \cdot 100\%$$

Where h_0 = original height (cross-section d_2)
h_1 = height in the compressed state
h_2 = height after tension release

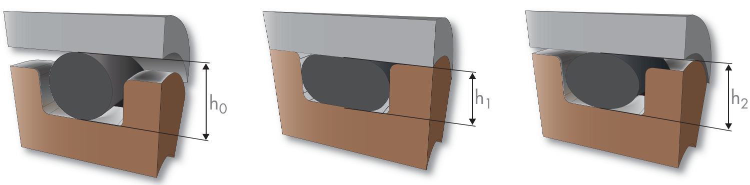


Figure 4-6: Compression set of an O-Ring

Although it is generally desirable to have low compression set properties in a seal material, this is not so critical as it might appear from a practical design standpoint, because of actual service variables. A good balance of all physical properties is usually necessary for optimum seal performance.
For instance, a seal may continue to seal after taking a 100% compression set provided temperature and system pressure remain steady and no motion or force causes a break in the line of seal contact. Also, as mentioned previously, swelling caused by contact with the service fluid may compensate for compression set. Note that in air and in the fluid that causes slight shrinkage, the compound takesa set of approximately 20 to 25%. In the fluid that causes a 20% swell, there is no measurable compression set. The most feared condition is the combination of high compression set and shrinkage which always leads to seal failure unless exceptionally high squeeze is employed.

Thermal effects

All rubber is subject to deterioration at high temperature. Volume change and compression set are both influenced by heat. Hardness is influenced in a rather complex way. The first effect of increased temperature is to soften the compound. This is a physical change which reverses when the temperature drops. However, due to this softening effect, in high pressure applications the O-Ring may begin to flow and extrude through the clearance gap as the temperature rises. If rubber is exposed to high temperatures for a longer time chemical changes will occur slowly. With increasing time at high temperature, chemical changes slowly occur. These cause an increase in hardness, together with volume and compression set changes as mentioned above. Changes in tensile strength and elongation are also noticeable and, since they are of chemical nature, these changes are not reversible.

Any changes induced by low temperature are primarily physical and are reversible. An elastomer will almost completely regain its original properties when warmed. There are several tests that are used to define low temperature characteristics of a compound. The best of the low temperature tests is TR-10 or Temperature Retraction Test. The TR-10 test results are easily reproducible, and the TR-10 is therefore used extensively in many different specifications, not only to assure low-temperature performance but occasionally as a quality assurance measure as well. Most compounds will provide effective sealing at 8°C below their TR-10 temperature values. If low pressures are anticipated at low temperature, hardness should be considered along with the low temperature properties of the compound. As temperature decreases, hardness increases. Low pressures require a soft material that can be easily deformed as it is forced against mating surfaces. In moderate pressure service, low temperature hardness increase is seldom of consequence. However, hardness is only one of several factors which have to be considered when low temperature performance is involved. Flexibility, resilience, compression set and brittleness are probably more basic criteria for sealing at low temperature than measured hardness.

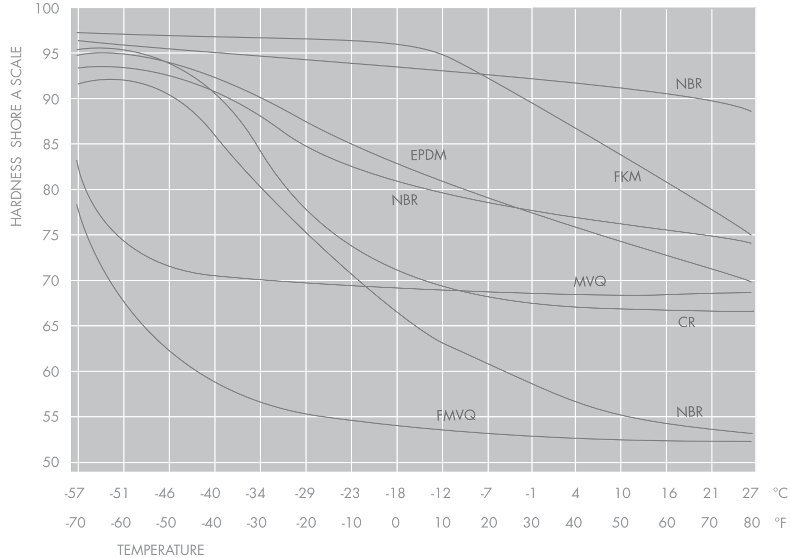


Figure 4-7: Effects of low temperature and rubber hardness

The swelling or shrinkage effect of the fluid that is being sealed must also be taken into account. When the seal swells, it absorbs fluids which may act in much the same way as a low temperature plasticizer, allowing the seal to remain more flexible at low temperature than was possible before the absorption of the fluid. If the seal shrinks, most of the time it is the plasticizer being extracted from the compound. The seal may now lose some of its original flexibility at low temperature.
It may become stiff at a temperature which is 2°C to 5°C higher than that at which it is rated.

Resilience

Resilience is the ability of a compound to return quickly to its original shape after a temporary deflection. Good resilience is vital to a moving seal. Resilience is primarily an inherent property of the elastomer.
It can be improved somewhat by compounding.

Permeability

Permeability is the tendency of gas to pass or diffuse through the elastomer. This should not be confused with leakage which is the fluid getting around the seal. Permeability may be of importance in vacuum service and some pneumatic applications involving extended storage but is seldom of consequence in other applications. It should be understood that permeability increases as temperatures rise, that different gases have different permeability rates, and that the more a seal is compressed, the greater its resistance to permeability.

If an elastomer is subjected to a gas under high pressure, a certain amount of the gas will dissolve and permeate into the elastomer. If the gas pressure is released slowly, the gas trapped inside the elastomer will expand and may escape into the atmosphere without causing any harm. However, if a rapid depressurization occurs, the trapped gas will expand violently. The explosive expansion of the gas can cause blisters on or cracks in or even total destruction of the rubber seal. This phenomenon is known as Explosion after Decompression. The O-Rings with smaller cross-sections usually have better resistance to explosion after decompression than the ones with large cross-sections.

Joule effect

The Joule effect must definitely be taken into account in rubber design. The simplest way of demonstrating this effect is to suspend a weight sufficient to cause elongation of at least 50% on a rubber band.

When the stretched rubber band is warmed up, it does not elongate because of thermal expansion, as may be expected, but it retracts and lifts the weight.

Conversely, when an unloaded strip is heated it expands to the coefficient of expansion for that rubber.

This phenomenon of contraction is called the Joule effect and occurs only when a stretched rubber object is heated. This effect has to be taken into consideration when O-Rings are being used in a dynamic rotary application. The O-Ring with an inner diameter smaller than the shaft is fitted under tension.

The O-Ring heats up due to friction and it contracts. The result is increased friction and temperature. Failure of the O-Ring is characterized by a hard, brittle O-Ring surface. An O-Ring of larger inner diameter must be selected. An inner diameter that is between 1% and 3% larger than the shaft is recommended and the outer diameter of the gland should ensure that the O-Ring is compressed on the shaft surface.

The O-Ring should always be fitted into the bore and never onto the shaft.

Friction

Friction and abrasion are interrelated subjects, as abrasion is a process of wearing away the material surface by friction. If there Is no friction, abrasion will not occur. Friction and abrasion are two important properties when considering elastomeric seals for dynamic applications. High friction can be harmful because it generates heat, which can cause degradation of the material. The friction can be reduced by using a suitable lubricant or by chemical treatment of the elastomer surface. Rubber components with self-contained lubricants may also be used. These compounds are desirable when the continuous presence of a lubricant is uncertain, and when minimal friction is essential.

Electrical properties

Elastomers are good insulators with relatively high electrical resistivity, the non-polar (non oil-resistant) elastomers being better than the polar (oil-resistant) ones. However, the electrical properties of rubber compounds are more dependent on the ingredients than on the basic material. Compounds containing carbon black must be avoided if high resistance is required. In this case, silicone elastomers are the best solution. It is possible to make elastomers antistatic and even conductive by incorporating sufficient quantities of graphite, special types of carbon black, metal powders or polar products into the rubber mix. When special conductive compounds are required, care should be taken to ensure that conductive parts of the compound formula are not dissolved or extracted by the medium being sealed, thus changing the electrical properties.

Thermal expansion

Coefficient of linear expansion is the ratio of the change in length per °C to the length at 0°C. Coefficient of volumetric expansion for solids is approximately three times the linear coefficient. As a rough approximation, elastomers have a coefficient of expansion ten times that of steel (an exception to this is perfluoroelastomer). This important factor must be considered when the operating temperature of a seal differs substantially from normal room temperature. At high temperatures, the thermal expansion of the seal is greater than that of its surrounding material, and this may be further increased by swelling after contact with a fluid. At low temperatures, the thermal contraction of the seal is much higher than that of its surrounding material. Under certain circumstances, leakage can occur even if the seal is still flexible.

4.7 Chemical compatibility guide

This guide is intended to assist the user in determining the suitability of various elastomers for many different chemical environments. The ratings are based on a combination of published literature, laboratory tests, actual field experience, and informed judgments. As laboratory tests do not necessarily predict end-use performance, users of our products should conduct their own evaluations to determine application suitability.

Note: Volume swell is only one indicator of elastomer fluid compatibility and may be based on the solubility parameter alone. Fluid attack on the backbone of the polymer may show up as a change a in physical properties such as tensile strength, elongation at break, and hardness. High temperature and extended exposure times may create more aggressive conditions than cited in this guide.
In some cases, specific elastomer compounds within a material family may provide improved compatibility. Please contact NewDealSeals for assistance in choosing the right elastomer for your application.


2500
2000
1500
1000
000 ml
±5%
900
800
700
600
500
400

Rating system:

1	Little or no effect <10% elastomer may exhibit swelling and/or loss of physical properties under severe conditions.
2	Possible loss of 10–20% elastomer may exhibit swelling in addition to a change in physical properties. It may be suitable for static applications.
3	Noticeable change 20–40% elastomer exhibits a noticeable change in swelling and physical properties. Questionable performance in most applications.
4	Excessive change >40% elastomer not suitable for service.
0	Insufficient information available for rating.

The information given in this chemical compatibility guide is believed to be reliable, but no representation, guarantees or warranties of any kind are made as to its accuracy or suitability for any purpose.

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Acetaldehyde	4	3	2	2	4	4	3	4	2	1	3	4	2
Acetamide	4	1	1	1	2	1	1	1	4	1	4	2	2
Acetanilide	4	1	1	1	3	1	3	3	1	0	1	0	2
Acetic Acid Amide	4	1	1	1	3	1	1	1	4	1	4	2	2
Acetic Acid Ethyl Ester	0	2	2	1	4	0	2	4	0	1	0	4	0
Acetic Aid Methyl Ester	4	2	2	1	4	4	4	4	4	1	4	4	4
Acetic Acid, 25% to 60%	0	0	1	1	3	2	4	2	4	1	4	0	1
Acetic Acid, 5%	4	1	1	1	1	2	2	2	2	0	2	1	1
Acetic Acid, 85%	0	0	0	1	3	0	4	4	4	1	4	0	0
Acetic Acid, Glacial	4	4	2	1	4	4	2	2	4	1	4	3	1
Acetic Aldehyde	4	3	2	2	4	4	3	4	2	1	3	4	2
Acetic Anhydride	4	2	2	1	4	4	4	4	2	1	1	2	3
Acetic Ester	4	4	2	1	4	4	4	4	4	1	4	4	2
Acetoacetic Acid	4	1	1	1	4	1	3	3	1	0	1	0	2
Acetol	4	2	1	1	4	4	4	4	1	1	1	4	4
Acetone	4	4	1	1	4	4	4	4	1	1	1	4	4
Acetone Cyanohydrin	4	1	1	1	4	1	3	3	1	0	1	0	2
Acetonitrile	4	2	1	1	4	1	3	3	1	0	1	1	2
Acetophenetidine	4	4	4	1	1	2	2	2	4	0	4	0	0
Acetophenone	4	4	1	1	4	4	4	4	4	1	4	4	4
Acetotoluidide	4	4	4	1	1	2	2	2	4	0	4	0	0
Acetyl Acetone	4	4	1	1	4	4	4	4	4	0	4	4	4
Acetyl Benzene	4	4	1	1	4	4	4	4	4	1	4	4	4
Acetyl Bromide	4	4	1	1	1	4	4	4	4	0	4	2	4
Acetyl Chloride	4	4	4	1	1	1	4	4	4	1	4	1	3
Acetylene	1	2	1	1	1	1	1	1	2	1	2	1	2
Acetylene Dichloride	4	4	4	1	2	2	2	2	4	0	4	0	0
Acetylene Tetrabromide	0	2	1	1	1	2	4	4	0	0	4	1	4
Acetylene Tetrachloride	4	4	1	1	1	2	4	4	4	1	4	4	4
Acetylsalicylic Acid	4	4	4	1	1	2	2	2	4	0	4	0	0
Acrolein	4	1	1	1	4	1	3	3	1	0	1	0	2
Acryimide	4	1	1	1	3	1	1	1	4	1	4	2	2
Acrylic Acid, Ethyl Ester	4	4	3	1	4	4	4	2	4	1	4	4	4
Acrylonitrile	4	4	4	1	4	4	4	4	3	1	3	2	4
Adipic Acid	0	1	2	1	2	1	1	1	1	1	1	2	0
Aero Lubriplate	1	1	4	1	1	1	1	1	4	0	2	1	2
Aero Shell 17 Grease	1	2	4	1	1	1	1	1	4	0	4	1	2
Aero Shell 1AC Grease	1	2	4	1	1	1	1	1	4	0	4	1	2
Aero Shell 750	2	4	4	1	1	2	2	2	4	0	4	1	4
Aero Shell 7A Grease	1	2	4	1	1	1	2	2	4	0	4	1	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Aerosafe 2300	4	4	1	1	4	3	4	4	4	0	4	3	3
Aerosafe 2300w	4	4	1	1	4	3	4	4	4	0	4	2	3
Aerozene 50, 50% Hydrazine 50% UDMH	0	4	1	2	4	4	3	3	4	0	4	2	4
Air below 200°F	1	1	1	1	1	1	1	1	2	1	2	1	1
Air, 200–300° F	2	2	2	1	1	1	3	3	4	0	4	1	1
Air, 300–400° F	4	4	4	1	1	1	4	4	4	0	4	1	1
Air, 400–500° F	4	4	4	2	3	4	4	4	4	0	4	3	2
Air, Oil-Containing	1	1	4	1	1	1	1	1	4	1	2	0	1
Aliphatic Dicarboxylic Acid	4	4	4	1	1	2	2	2	4	0	4	0	0
Alkanes	1	2	4	1	1	1	1	1	4	0	4	0	2
Alkanesulfonic Acid	1	2	4	1	1	1	1	1	4	0	4	0	2
Alkazene	4	4	4	1	2	2	4	4	4	1	4	2	4
Alkenes	4	4	4	1	1	2	2	2	4	0	4	0	0
Alkyl Acetone	4	1	1	1	4	1	3	3	1	0	1	0	2
Alkyl Alcohol	1	2	4	1	4	1	1	1	4	0	4	0	2
Alkyl Amine	1	2	4	1	4	1	1	1	4	0	4	0	2
Alkyl Aryl Sulfonates	1	2	4	1	1	1	1	1	4	0	4	0	2
Alkyl Aryl Sulfonics	1	2	4	1	1	1	1	1	4	0	4	0	2
Alkyl Benzene	4	4	4	1	2	2	2	2	4	0	4	0	0
Alkyl Chloride	4	4	4	1	2	2	2	2	4	0	4	0	0
Alkyl Naphthalene Sulfonic Acid	1	2	4	1	1	1	1	1	4	0	4	0	2
Alkyl Sulfide	4	4	4	1	1	2	2	2	4	0	4	0	0
Allyl Alcohol	0	2	1	1	4	0	2	2	1	1	1	0	0
Allyl Chloride	0	1	1	1	2	0	2	2	0	0	0	2	0
Allylidene Diacetate	4	1	1	1	3	1	3	3	1	0	1	0	2
Alpha Picoline	4	1	1	1	3	1	3	3	1	0	1	0	2
Alum Potash	4	2	1	1	4	3	2	2	2	0	2	1	3
Aluminum Acetate	4	2	1	1	4	4	2	2	1	1	2	1	4
Aluminum Bromide	1	1	1	1	1	1	1	1	1	0	1	1	1
Aluminum Chlorate	4	1	1	1	3	1	3	3	1	0	1	0	2
Aluminum Chloride	1	1	1	1	1	1	1	1	1	1	1	1	2
Aluminum Fluoride	0	1	1	1	1	1	1	1	2	1	1	1	2
Aluminum Formate	4	1	1	1	4	1	3	3	1	0	1	0	2
Aluminum Hydrate	0	3	2	1	2	0	2	2	0	0	0	1	2
Aluminum Hydroxide	0	3	2	1	1	0	2	2	0	0	0	1	2
Aluminum Linoleate	1	2	4	1	1	1	1	1	4	0	4	0	2
Aluminum Nitrate	0	1	1	1	1	0	1	1	1	1	1	1	2
Aluminum Oxalate	4	1	1	1	3	1	3	3	1	0	1	0	2
Aluminum Phosphate	0	1	1	1	1	0	1	1	0	0	0	1	1
Aluminum Potassium Sulfate	4	1	1	1	1	1	3	3	1	0	1	0	2
Aluminum Salts	1	1	1	1	1	1	1	1	1	0	1	1	1
Aluminum Sodium Sulfate	4	1	1	1	1	1	3	3	1	0	1	0	2
Aluminum Sulfate	4	1	1	1	1	1	1	1	1	1	2	1	1

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Alums	4	1	1	1	1	4	1	1	4	1	1	2	1
Ambrex 33	1	2	4	1	1	3	1	1	4	0	4	1	4
Ambrex 830	1	2	3	1	1	1	1	1	4	0	4	1	2
Amines Mixed (Allyl, Ethyl, etc.)	4	2	2	1	4	4	4	4	2	0	2	2	2
Amino Benzene	4	4	2	1	2	3	4	4	4	1	4	2	4
Aminobenzoic Acid	0	4	2	1	2	0	4	4	0	0	0	1	0
Aminoethanol (2-Aminoethanol)	4	2	2	1	4	4	2	4	2	0	2	0	2
Aminomethane	4	1	1	1	4	1	4	4	2	1	2	0	2
Aminopyridine	0	4	2	1	4	0	4	4	0	0	0	3	0
Ammonia	4	1	1	2	4	4	2	2	1	1	1	2	2
Ammonia and Lithium Metal in Solution	4	4	2	4	4	4	2	4	4	0	4	4	4
Ammonia Gas, Cold	4	1	1	1	4	4	1	1	1	1	1	1	1
Ammonia Gas, Hot	4	2	2	1	4	4	4	4	4	1	4	2	1
Ammonia, Anhydrous Liquid	4	1	1	1	4	4	2	2	4	0	4	3	2
Ammonium Acetate	4	2	1	1	4	1	1	1	1	1	1	0	2
Ammonium Arsenate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Benzoate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Bicarbonate	4	1	1	1	4	1	3	3	1	0	1	0	2
Ammonium Bisulfite	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Bromide	0	1	1	1	1	0	1	1	1	0	1	1	0
Ammonium Carbamate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Carbonate	4	1	1	1	1	0	1	4	1	1	1	1	3
Ammonium Chloride	1	1	1	1	1	4	1	1	1	1	1	1	3
Ammonium Citrate, Dibasic	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Dichromate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Diphosphate	4	1	1	1	1	1	3	3	1	0	1	0	2
Ammonium Fluoride	0	2	1	1	1	0	1	1	4	1	1	1	0
Ammonium Formate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Hydroxide, 3 Molar	4	1	1	2	3	1	1	1	2	0	2	2	1
Ammonium Hydroxide, Concentrated	4	1	1	1	2	1	4	4	3	1	3	1	1
Ammonium Hydroxide, Grade 2	0	1	1	1	2	0	3	3	0	0	0	1	0
Ammonium Iodide	0	1	1	1	1	0	1	1	1	0	1	1	0
Ammonium Lactate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Metaphosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Molybdenate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Nitrate	2	1	1	1	1	3	1	1	4	1	1	1	2
Ammonium Nitrite	0	1	1	1	3	0	1	1	1	0	1	2	2
Ammonium Oxalate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Perchlorate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Persulfate	4	1	1	1	1	1	4	4	1	1	4	1	4
Ammonium Phosphate	0	1	1	1	1	0	1	1	1	1	1	2	1
Ammonium Phosphate, Dibasic	0	1	1	1	1	0	1	1	1	0	1	1	1

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Ammonium Phosphate,													
Monobasic	0	1	1	1	1	0	1	1	1	0	1	2	1
Ammonium Phosphate, Tribasic	0	1	1	1	1	0	1	1	1	0	1	2	1
Ammonium Phosphite	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Picrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Polysulfide	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Salicylate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Salts	3	1	1	1	3	3	1	1	1	0	1	1	1
Ammonium Sulfamate	4	1	1	1	4	1	3	3	1	0	1	0	2
Ammonium Sulfate	4	1	1	1	2	1	1	1	4	1	2	1	1
Ammonium Sulfate Nitrate	4	1	1	1	4	0	1	1	1	0	2	2	0
Ammonium Sulfide	4	1	1	1	2	0	1	1	4	1	2	1	0
Ammonium Sulfite	4	1	1	1	1	1	3	3	1	0	1	0	2
Ammonium Thiocyanate	4	1	1	1	1	1	3	3	1	0	1	0	2
Ammonium Thioglycollate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Thiosulfate	4	1	1	1	1	1	3	3	1	0	1	0	2
Ammonium Tungstate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ammonium Valerate	4	1	1	1	3	1	3	3	1	0	1	0	2
Amyl Acetate	4	4	1	1	4	4	4	4	1	1	4	4	4
Amyl Alcohol	4	2	1	1	2	1	2	2	1	1	2	1	4
Amyl Borate	0	1	4	1	1	0	1	1	4	1	4	1	4
Amyl Butyrate	1	2	4	1	2	1	1	1	4	0	4	0	2
Amyl Chloride	4	4	4	1	1	2	1	1	4	0	4	1	4
Amyl Chloronaphthalene	4	4	4	1	1	2	4	4	4	1	4	2	4
Amyl Cinnamic Aldehyde	4	4	4	1	4	2	2	2	4	0	4	0	0
Amyl Hydride	1	1	4	1	1	3	1	1	4	1	3	0	4
Amyl Laurate	4	4	4	1	2	2	2	2	4	0	4	0	0
Amyl Mercaptan	4	4	4	1	1	2	2	2	4	0	4	0	0
Amyl Naphthalene	2	4	4	1	1	1	4	4	4	0	4	2	4
Amyl Nitrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Amyl Nitrite	4	1	1	1	3	1	3	3	1	0	1	0	2
Amyl Phenol	0	0	0	1	1	0	0	4	4	1	0	0	0
Amyl Propionate	1	2	4	1	2	1	1	1	4	0	4	0	2
Sn-0-3 Grade M	1	2	4	1	1	1	1	1	4	0	4	1	2
An-0-366	1	2	4	1	1	1	1	1	4	0	4	1	4
An-0-6	1	2	4	1	1	1	1	1	4	0	4	1	4
Anderol l-774 (Diester)	2	4	4	1	1	2	2	2	4	0	4	2	4
Anderol l-826 (Diester)	2	4	4	1	1	2	2	2	4	0	4	2	4
Anderol l-829 (Diester)	2	4	4	1	1	2	2	2	4	0	4	2	4
Ang-25 (Diester Base)	2	4	4	1	1	2	2	2	4	0	4	2	2
Ang-25 (Glyceral Ester)	4	2	1	1	1	2	2	2	2	0	2	2	2
Aniline	4	4	2	1	2	3	4	4	4	1	4	2	4
Aniline Dyes	4	2	2	1	2	2	4	4	2	0	2	1	3
Aniline Hydrochloride	4	4	3	1	2	2	4	4	4	1	4	1	4

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Aniline Oil	4	4	2	1	4	3	4	4	4	1	4	2	4
Aniline Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Aniline Sulfite	4	1	1	1	3	1	3	3	1	0	1	0	2
Animal Fats	1	2	2	1	1	1	1	1	4	1	4	1	2
Animal Oil	1	2	2	1	1	1	1	1	4	1	4	2	2
Anisole	0	4	0	1	3	0	4	4	4	1	4	0	0
Anon	0	4	4	1	0	0	4	4	4	1	4	0	0
Ansul Ether 161, 181	4	4	3	1	4	3	3	3	4	0	4	1	4
Ant Oil	4	4	2	2	4	4	4	4	4	1	4	4	4
Anthracene	4	4	4	1	1	2	2	2	4	0	4	0	0
Anthraquinone Sulphonic Acid	0	0	1	1	0	0	2	2	1	1	1	0	0
Antifreeze (Automotive)	4	1	1	1	2	1	1	1	1	1	1	0	1
Antimony Chloride	1	1	1	1	2	1	1	1	1	1	1	1	1
Antimony Pentachloride	1	2	4	1	2	1	1	1	4	0	4	1	4
Antimony Pentafluorides	0	4	0	2	0	0	0	4	4	1	0	0	0
Antimony Tribromide	1	2	4	1	1	1	1	1	4	0	4	1	4
Antimony Trichloride	1	2	1	1	1	1	1	1	1	1	1	1	4
Antimony Trifluoride	1	2	4	2	1	1	1	1	4	0	4	1	4
Antimony Trioxide	1	2	1	1	1	1	1	1	4	0	4	1	4
AN-VV-0-366B Hydraulic	2	2	4	1	1	1	1	1	4	0	4	1	4
Aqua Regia	4	4	3	2	2	3	3	4	4	1	4	3	4
Argon	1	1	1	1	1	2	1	1	1	1	1	1	2
Argon Gas	0	1	1	1	1	0	1	1	0	0	0	1	0
Aroclor 1248	4	4	2	1	1	2	3	3	4	0	4	1	2
Aroclor 1254	4	4	2	1	1	1	4	4	4	0	4	1	3
Aroclor 1260	4	1	2	1	1	1	1	1	1	0	1	1	1
Aromatic Fuel 50%	4	4	4	1	1	2	2	2	4	0	4	2	4
Aromatic Fuels	0	4	4	1	2	2	2	2	0	0	0	2	4
Arsenic Acid	3	1	1	1	1	1	1	1	1	1	1	1	1
Arsenic Trichloride	0	1	4	1	4	0	1	1	0	0	0	4	0
Arsenic Trioxide	0	1	4	1	4	0	1	1	0	0	0	0	0
Arsenic Trisulfide	0	1	4	1	4	0	1	1	0	0	0	0	0
Ascorbic Acid	4	1	1	1	1	1	3	3	1	0	1	0	2
Askarel Transformer Oil	4	4	4	1	1	2	2	2	4	1	4	1	4
Aspartic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Asphalt	2	2	4	1	1	2	2	2	4	1	4	2	4
ASTM Fuel A	1	2	4	1	1	1	1	1	4	1	4	2	4
ASTM Fuel B	4	4	4	1	1	1	1	2	4	1	4	4	4
ASTM Fuel C	4	4	4	1	1	2	2	2	4	1	4	4	4
ASTM Fuel D	4	4	4	1	1	0	2	2	0	0	4	4	4
ASTM Oil No. 1	1	1	4	1	1	1	1	1	4	1	4	1	1
ASTM Oil No. 2	1	2	4	1	1	1	1	1	4	1	4	2	4
ASTM Oil No. 3	1	2	4	1	1	1	1	1	4	1	4	3	2
ASTM Oil No. 4	2	4	4	1	1	2	2	2	4	0	4	2	4

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
ASTM Oil No. 5	0	2	4	1	1	0	1	1	0	0	0	1	0
ATL-857	2	4	4	1	1	2	2	2	4	0	4	1	4
Atlantic Dominion F	1	2	4	1	1	1	1	1	4	0	4	2	4
Atlantic Utro Gear-E	0	2	4	1	1	0	1	1	0	0	0	1	0
Atlantic Utro Gear-EP Lube.	1	2	4	1	1	1	1	1	4	0	4	2	4
Aurex 903R	1	2	4	1	1	4	1	1	2	0	4	1	4
Automatic Transmission Fluid	4	2	4	1	1	1	1	1	4	1	4	1	4
Automotive Brake Fluid	4	2	1	1	4	4	3	3	1	1	1	1	3
Azine	4	4	2	1	4	4	4	4	4	1	4	2	4
Baking Soda	4	1	1	1	1	1	1	1	1	1	1	1	1
Bardol B	4	4	4	1	1	2	4	4	4	0	4	2	4
Barium Carbonate	4	1	1	1	1	1	3	3	1	0	1	0	2
Barium Chlorate	4	1	1	1	1	1	3	3	1	0	1	0	2
Barium Chloride	1	1	1	1	1	1	1	1	1	0	1	1	1
Barium Cyanide	1	1	1	1	1	1	1	1	1	0	1	1	1
Barium Hydroxide	4	1	1	1	1	1	1	1	1	1	1	1	1
Barium Iodide	1	1	1	1	1	1	1	1	1	0	1	1	1
Barium Nitrate	4	1	1	1	1	1	3	3	1	0	1	0	2
Barium Oxide	4	1	1	1	1	1	1	1	1	0	1	1	1
Barium Peroxide	4	1	1	1	3	1	3	3	1	0	1	0	2
Barium Polysulfide	4	1	1	1	3	1	3	3	1	0	1	0	2
Barium Salts	1	1	1	1	1	1	1	1	1	1	1	1	1
Barium Sulfate	0	1	1	1	1	1	1	1	0	0	0	1	1
Barium Sulfide	4	1	1	1	1	1	1	1	1	0	2	1	1
Bayol 35	1	2	4	1	1	1	1	1	4	0	4	1	4
Bayol D	1	2	4	1	1	1	1	1	4	0	4	1	4
Beef Tallow Emulsion, Sulphonated	0	2	4	1	1	2	1	1	4	1	4	0	2
Beer	1	1	1	1	1	1	1	1	1	1	1	1	1
Beet Sugar Liquids	0	1	1	1	1	0	1	1	0	0	0	1	0
Beet Sugar Liquors	4	2	1	1	1	1	1	1	1	0	1	1	1
Benzaldehyde	4	4	1	2	4	4	4	4	2	1	2	2	4
Benzamide	4	4	4	1	1	2	2	2	4	0	4	0	0
Benzanthrone	4	4	4	1	2	2	2	2	4	0	4	0	0
Benzene	4	4	4	1	2	2	4	4	4	1	4	2	4
Benzene Carbonal	4	4	1	2	4	4	4	4	2	1	2	2	4
Benzene Carboxylic Acid	4	2	4	1	1	2	1	4	1	1	1	1	4
Benzene Sulfonic Acid	4	2	4	1	1	2	4	4	4	1	4	1	4
Benzidine	4	4	4	1	1	2	2	2	4	0	4	0	0
Benzidine 3 Sulfonic Acid	4	4	4	1	1	2	2	2	4	0	4	0	0
Benzil	4	4	4	1	1	2	2	2	4	0	4	0	0
Benzilic Acid	4	4	4	1	1	2	2	2	4	0	4	0	0
Benzine	1	2	4	1	1	1	1	1	4	1	4	2	4
Benzocatechol	4	4	4	1	1	2	2	2	4	0	4	0	0

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Benzochloride	4	4	1	1	1	1	4	4	4	0	4	1	0
Benzoic Acid	4	2	4	1	1	2	1	4	1	1	1	1	4
Benzoin	4	4	4	1	1	2	2	2	4	0	4	0	0
Benzonitrile	4	1	1	1	3	1	3	3	1	0	1	0	2
Benzophenone	4	4	2	1	2	1	4	4	0	0	4	1	4
Benzoquinone	4	0	2	1	1	0	0	0	0	0	4	2	0
Benzotrichloride	0	4	1	1	1	0	4	4	0	0	0	3	0
Benzotrifluoride	0	4	1	1	1	0	4	4	0	0	0	1	0
Benzoyl Chloride	4	4	4	1	2	2	4	4	4	0	4	2	0
Benzoyl Sulfonilic Acid	4	4	4	1	1	2	2	2	4	0	4	0	0
Benzyl Acetate	4	1	1	1	4	1	3	3	1	0	1	0	2
Benzyl Alcohol	4	2	2	1	1	2	4	4	4	1	4	2	2
Benzyl Benzoate	4	4	2	1	1	1	4	4	4	1	4	3	4
Benzyl Bromide	4	4	4	1	1	1	4	4	4	0	4	2	4
Benzyl Butyl Phthalate	4	1	1	1	3	1	3	3	1	0	1	0	2
Benzyl Chloride	4	4	4	1	1	1	4	4	4	1	4	2	4
Benzyl Phenol	4	4	4	1	2	2	2	2	4	0	4	0	0
Benzyl Salicylate	4	4	4	1	1	2	2	2	4	0	4	0	0
Beryllium Chloride	3	3	1	1	1	3	1	1	3	0	3	1	3
Beryllium Fluoride	3	3	1	1	1	3	1	1	3	0	3	1	3
Beryllium Oxide	3	3	1	1	1	3	1	1	3	0	3	1	3
Beryllium Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Biphenyl	4	4	4	1	1	2	4	4	4	1	4	2	4
Bismuth Carbonate	4	1	1	1	1	1	3	3	1	0	1	0	2
Bismuth Nitrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Bismuth Oxychloride	4	1	1	1	3	1	3	3	1	0	1	0	2
Bisulfite Lye	0	2	1	2	0	0	2	2	1	1	1	0	0
Bitumen	0	4	0	1	1	0	4	4	0	1	0	0	0
Black Liquor	0	1	2	3	1	0	2	2	0	0	0	2	0
Black Lye	0	2	1	1	1	0	2	2	2	1	2	0	0
Black Point 77	3	3	1	1	1	3	1	1	3	0	3	1	3
Blast Furnace Gas	1	2	4	1	1	2	2	4	4	1	2	1	1
Bleach Liquor	4	2	1	1	1	2	2	3	3	1	3	1	2
Bleach Solutions	0	0	1	1	1	0	0	0	0	0	0	0	0
Bleaching Lye	0	2	1	1	2	0	4	4	4	1	2	0	0
Bone Oil	1	4	2	1	2	1	1	1	4	1	4	1	2
Borax	2	4	1	1	1	2	2	2	2	0	2	1	2
Borax Solutions	2	2	1	1	1	1	1	2	1	1	1	1	1
Bordeaux Mixture	4	2	1	1	1	2	2	2	2	0	2	1	2
Boric Acid	4	1	1	1	1	1	1	1	1	1	1	1	1
Boric Oxide	4	1	1	1	3	1	3	3	1	0	1	0	2
Borneol	4	4	4	1	2	2	2	2	4	0	4	0	0
Bornyl Acetate	4	4	4	1	4	2	2	2	4	0	4	0	0
Bornyl Chloride	4	4	4	1	1	2	2	2	4	0	4	0	0

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Bornyl Formate	4	4	4	1	1	2	2	2	4	0	4	0	0
Boron Fluids	4	4	4	1	1	2	2	2	4	0	4	1	4
Boron Trichloride	0	4	4	1	1	0	2	2	0	0	0	1	0
Boron Trifluoride	0	4	4	1	1	0	2	2	0	0	0	1	0
Brake Fluid DOT3, Glycol Type	4	2	1	4	4	1	3	4	1	1	1	2	1
Brake Fluid, Wagner 21B	4	2	1	4	4	4	3	3	2	1	1	1	3
Bray GG-130	2	4	4	1	1	2	2	2	4	0	4	2	4
Brayco 719-R	4	2	1	4	4	2	3	3	2	0	0	2	2
Brayco 885	2	4	4	1	1	2	2	2	4	0	4	2	4
Brayco 910	3	2	1	1	4	4	2	2	1	0	2	3	4
Bret 710	3	2	1	4	4	4	2	2	1	0	2	2	4
Brine	0	1	1	1	1	1	1	1	0	0	0	1	1
Brom–113	0	4	4	0	0	0	3	3	0	0	4	3	4
Brom–114	0	2	4	1	2	0	2	2	4	0	4	3	4
Bromic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Bromine	4	4	4	1	1	2	4	4	4	1	4	1	4
Bromine Pentafluoride	4	4	4	2	4	4	4	4	4	0	4	4	4
Bromine Trifluoride	4	4	4	2	4	4	4	4	4	0	4	4	4
Bromine Water	4	4	2	1	1	2	4	4	4	1	4	3	4
Bromine, Anhydrous	0	4	4	1	1	2	4	4	0	0	0	1	4
Bromine, Liquid	0	4	0	0	0	0	4	4	4	1	4	0	0
Bromobenzene	4	4	4	1	1	1	4	4	4	1	4	4	4
Bromobenzene Cyanide	4	1	1	1	3	1	3	3	1	0	1	0	2
Bromochloromethane	0	0	2	1	4	2	0	4	0	0	0	3	4
Bromochlorotrifluoroethane	4	4	4	1	1	2	4	4	4	0	4	1	4
Bromoethane	0	4	4	1	1	0	2	2	0	0	0	1	0
Bromoform	4	4	4	1	1	2	2	2	4	0	4	0	0
Bromomethane	3	4	4	1	1	1	2	2	4	0	4	1	0
Bromotrifluoromethane	0	0	1	2	1	2	0	1	0	0	0	0	4
Brucine Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Bunker C Fuel Oil	0	3	4	1	1	0	1	1	0	0	0	2	0
Bunker Oil	1	4	4	1	1	1	1	1	4	1	4	2	2
Butadiene	4	2	4	1	3	1	4	4	4	1	4	2	4
Butane	1	1	4	1	1	1	1	1	4	1	4	2	4
Butane, 2, 2-Dimethyl	1	2	4	1	1	3	1	1	4	0	3	2	4
Butane, 2, 3-Dimethyl	1	2	4	1	1	3	1	1	4	0	3	2	4
Butanediol	4	1	1	1	3	1	1	1	2	1	1	0	2
Butanol	4	2	1	1	1	1	4	4	1	1	1	1	2
Butene 2-ethyl	1	4	4	1	1	3	1	1	4	0	4	1	4
Butter	1	2	1	1	1	1	1	1	4	1	4	1	2
Butyl Acetate	4	4	2	1	4	4	4	4	2	1	4	4	4
Butyl Acetyl Ricinoleate	0	2	1	1	1	2	2	2	4	0	4	1	0
Butyl Acrylate	4	4	4	1	4	4	4	4	4	0	4	4	2
Butyl Alcohol	4	1	2	1	1	1	4	1	1	1	1	1	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Butyl Alcohol, Secondary	4	2	2	1	1	2	2	2	2	0	2	1	2
Butyl Alcohol, Tertiary	4	2	2	1	1	2	2	2	2	0	2	1	2
Butyl Benzoate	4	1	1	1	1	1	3	4	1	0	1	0	2
Butyl Butyrate	4	4	1	1	1	1	4	4	4	0	4	0	0
Butyl Carbitol	4	3	1	1	3	4	4	4	4	1	4	2	4
Butyl Cellosolve	4	3	2	1	4	4	3	3	4	1	4	3	4
Butyl Cellosolve Acetate	4	1	2	1	4	2	3	4	1	0	1	2	2
Butyl Cellosolve Adipate	4	4	2	1	2	2	4	4	4	0	4	2	2
Butyl Chloride	1	2	4	1	1	1	1	1	4	0	4	0	2
Butyl Ether	4	4	3	1	4	3	3	3	4	0	4	0	4
Butyl Glycolate	4	1	1	1	3	1	3	3	1	0	1	0	2
Butyl Lactate	4	1	1	1	3	1	3	3	1	0	1	0	2
Butyl Laurate	4	1	1	1	2	1	3	3	1	0	1	0	2
Butyl Mercaptan	4	4	4	1	4	0	4	4	4	0	4	0	4
Butyl Methacrylate	4	1	1	1	4	1	3	3	1	0	1	0	2
Butyl Oleate	0	4	2	1	1	2	4	4	4	0	4	1	0
Butyl Oxalate	4	1	1	1	3	1	3	3	1	0	1	0	2
Butyl Phenol	4	4	4	1	2	0	4	4	4	1	4	0	4
Butyl Stearate	0	4	4	1	1	2	2	2	4	0	4	1	0
Butylamine	4	4	4	1	4	4	1	3	4	0	4	2	4
Butylbenzoic Acid	4	4	4	1	1	2	2	2	4	0	4	0	0
Butylene	4	2	4	1	1	2	1	2	4	1	4	2	4
Butylene Glycol	0	1	1	1	2	1	1	1	1	1	1	0	1
Butyne Diol	0	2	1	2	2	0	1	1	1	1	1	0	0
Butyraldehyde	4	4	2	2	4	4	4	4	2	1	2	4	4
Butyric Acid	4	2	2	1	3	0	1	4	4	1	4	1	0
Butyric Anhydride	4	1	1	1	3	1	3	3	1	0	1	0	2
Butyrolacetone	4	1	1	1	3	1	3	3	1	0	1	0	2
Butyryl Chloride	4	4	4	1	1	2	2	2	4	0	4	0	0
Cadmium Chloride	4	1	1	1	3	1	3	3	1	0	1	0	2
Cadmium Cyanide	4	1	1	1	1	1	3	1	1	0	1	1	2
Cadmium Nitrate	4	1	1	1	2	1	3	3	1	0	1	0	2
Cadmium Oxide	4	1	1	1	3	1	3	3	1	0	1	0	2
Cadmium Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Cadmium Sulfide	4	1	1	1	3	1	3	3	1	0	1	0	2
Calcine Liquors	4	2	1	1	1	1	1	1	0	0	0	1	0
Calcium Acetate	4	2	1	1	4	4	2	2	1	0	4	1	4
Calcium Arsenate	4	1	1	1	1	1	3	1	1	0	1	1	2
Calcium Benzoate	4	4	4	1	1	2	2	2	4	0	4	0	0
Calcium Bicarbonate	4	1	1	1	2	1	3	3	1	0	1	0	2
Calcium Bisulfide	4	1	1	1	1	1	3	3	1	0	1	0	2
Calcium Bisulfite	3	1	4	1	1	3	1	1	1	1	1	1	3
Calcium Bromide	1	1	1	1	1	1	1	1	1	0	1	1	1
Calcium Carbonate	3	1	1	1	1	1	1	1	1	1	1	1	1

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Calcium Chlorate	4	1	1	1	1	1	3	3	1	0	1	0	2
Calcium Chloride	1	1	1	1	1	1	1	1	4	1	1	1	1
Calcium Chromate	4	1	1	1	3	1	3	3	1	0	1	0	2
Calcium Cyanide	0	1	1	1	1	0	1	1	1	0	1	1	1
Calcium Fluoride	1	1	1	1	1	1	1	1	1	0	1	1	1
Calcium Gluconate	4	1	1	1	3	1	3	3	1	0	1	0	2
Calcium Hydride	1	1	1	1	1	1	1	1	1	0	1	1	1
Calcium Hydrogen Sulfite	0	0	4	1	1	1	0	4	0	0	0	1	1
Calcium Hydrosulfide	4	1	1	1	3	1	3	3	1	0	1	0	2
Calcium Hydroxide	4	1	1	1	1	1	1	1	1	1	1	1	1
Calcium Hypochlorite	4	2	1	1	1	2	2	2	4	1	4	1	2
Calcium Hypophosphite	4	1	1	1	3	1	3	3	1	0	1	0	2
Calcium Lactate	4	1	1	1	3	1	3	3	1	0	1	0	2
Calcium Nitrate	1	1	1	1	1	1	1	1	1	1	1	1	2
Calcium Oxalate	4	1	1	1	3	1	3	3	1	0	1	0	2
Calcium Oxide	1	1	1	1	1	1	1	1	1	0	1	1	1
Calcium Phenolsulfonate	4	1	1	1	3	1	3	3	1	0	1	0	2
Calcium Phosphate	1	2	1	1	1	1	1	1	1	1	1	1	1
Calcium Phosphate Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Calcium Propionate	4	1	1	1	3	1	3	3	1	0	1	0	2
Calcium Salts	1	1	1	1	1	1	1	1	1	0	1	1	2
Calcium Silicate	0	1	1	1	1	0	1	1	1	0	1	1	0
Calcium Stearate	4	4	4	1	1	2	2	2	4	0	4	0	0
Calcium Sulfamate	4	4	4	1	1	2	2	2	4	0	4	0	0
Calcium Sulfate	4	1	1	1	2	1	3	3	1	0	1	0	2
Calcium Sulfide	4	1	1	1	1	1	1	1	2	1	2	1	2
Calcium Sulfite	4	1	1	1	1	1	1	1	2	0	2	1	1
Calcium Thiocyanate	4	1	1	1	3	1	3	3	1	0	1	0	2
Calcium Thiosulfate	4	1	1	1	1	1	2	2	2	0	2	1	1
Calcium Tungstate	4	1	1	1	3	1	3	3	1	0	1	0	2
Caliche Liquors	1	1	1	1	1	1	1	1	1	0	1	1	2
Camphene	4	4	4	1	2	2	2	2	4	0	4	0	0
Camphor	4	2	1	1	2	2	1	1	4	1	4	1	0
Camphorated Oil	0	4	4	1	2	0	2	1	4	1	4	0	0
Camphoric Acid	4	4	4	1	2	2	2	2	4	0	4	0	0
Cane Sugar Liquors	4	1	1	1	1	1	1	1	1	0	1	1	1
Capric Acid	1	2	4	1	2	1	1	1	4	0	4	0	2
Caproic Acid	1	2	4	1	2	1	1	1	4	0	4	0	2
Caproic Aldehyde	4	0	2	1	4	4	0	0	2	0	0	3	2
Caprolactam	1	2	1	1	4	1	1	1	4	0	4	2	2
Capronaldehyde	1	2	4	1	1	1	1	1	4	0	4	0	2
Carbamate	4	2	2	1	1	1	3	3	4	0	4	1	0
Carbitol	4	2	2	1	3	2	2	2	2	0	2	1	2
Carbitol 2	4	3	2	1	2	2	0	2	0	1	2	0	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Carbolic Acid	4	4	2	1	1	1	4	4	4	1	4	1	4
Carbolineum	4	4	4	1	1	1	4	4	4	1	4	0	4
Carbon Bisulfide	3	4	4	1	1	1	4	4	4	0	4	2	4
Carbon Dioxide	1	1	1	1	1	1	1	1	1	0	1	1	1
Carbon Dioxide, Dry	1	1	2	1	1	2	1	1	1	1	1	1	2
Carbon Dioxide, Explosive Decompression Use	1	1	1	1	1	1	1	1	1	0	1	1	1
Carbon Dioxide, Wet	0	2	2	1	1	0	1	1	0	0	0	1	0
Carbon Disulfide	3	4	4	1	2	1	4	4	4	1	4	1	4
Carbon Fluorides	4	4	4	1	1	2	2	2	4	0	4	2	4
Carbon Monoxide	0	2	1	1	1	2	1	1	2	1	2	1	1
Carbon Monoxide, Dry	1	1	1	1	1	1	1	1	1	1	1	0	1
Carbon Monoxide, Wet	1	1	1	1	1	1	1	1	1	1	1	0	1
Carbon Tetrachloride	4	4	4	1	1	2	2	2	4	1	4	4	4
Carbon Tetrafluoride	4	4	4	1	1	2	2	2	4	0	4	2	4
Carbonic Acid	1	2	1	1	1	1	1	4	1	1	2	1	1
Casein	4	1	1	1	1	1	3	3	1	0	1	0	2
Castor Oil	1	1	2	1	1	1	1	1	1	1	1	1	1
Caustic Lime	4	1	1	1	1	1	3	1	1	0	1	1	1
Caustic Potash	4	2	1	1	1	3	2	2	2	1	2	1	3
Caustic Soda	4	2	1	1	4	2	2	2	2	1	2	1	2
Cellosolve	4	4	2	1	4	4	4	4	4	1	4	1	4
Cellosolve Acetate	4	4	2	1	4	4	4	4	4	0	4	3	4
Cellosolve Butyl	4	4	2	4	4	4	4	4	4	0	4	2	4
Celluguard	3	1	1	1	1	1	1	1	1	0	1	1	1
Cellulose Acetate	4	1	1	1	4	1	3	3	1	0	1	0	2
Cellulose Acetate Butyrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Cellulose Ether	4	1	1	1	3	1	3	3	1	0	1	0	2
Cellulose Nitrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Cellulose Tripropionate	4	1	1	1	3	1	3	3	1	0	1	0	2
Cellulube A60	0	4	2	1	3	3	4	4	0	0	0	2	2
Cellulube, Phosphate Esters	0	0	1	1	1	3	0	4	0	0	0	2	1
Cellutherm 2505A	2	4	4	1	1	2	2	2	4	0	4	1	4
Cement, Portland	0	0	1	1	1	0	0	1	0	0	0	1	0
Cerium Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Cerous Chloride	4	1	1	1	3	1	3	3	1	0	1	0	2
Cerous Fluoride	4	1	1	1	3	1	3	3	1	0	1	0	2
Cerous Nitrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Cetane (Hexadecane)	1	2	4	1	1	3	1	1	4	0	4	1	4
Cetyl Alcohol	1	2	4	1	1	1	1	1	4	0	4	0	2
China Wood Oil	1	2	4	1	1	2	1	1	4	1	4	2	4
Chloracetic Acid	4	1	2	1	4	4	4	4	4	1	4	0	0
Chloral	4	1	1	1	4	1	3	3	1	0	1	0	2
Chloral Hydrate, Aqueous	0	4	2	1	2	0	4	4	4	1	4	0	0

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Chloramine	0	1	1	1	4	0	1	1	1	1	1	0	0
Chloranthraquinone	4	4	4	1	1	2	2	2	4	0	4	0	0
Chlordane	0	3	4	1	1	2	2	2	4	0	4	1	4
Chlorethanol	0	4	2	2	4	0	4	4	4	1	4	0	0
Chlorextol	2	2	4	1	1	2	2	2	4	0	4	1	4
Chloric acid	4	4	2	1	2	1	4	4	4	1	4	0	2
Chloride of Lime, Aqueous	0	4	1	1	1	0	4	4	4	1	4	0	0
Chlorinated Naphthalene	0	0	4	1	2	2	0	4	0	0	0	4	4
Chlorinated Salt Brine	0	4	4	1	1	0	4	4	0	0	0	1	0
Chlorinated Solvents	4	4	4	1	1	1	4	4	4	1	4	4	4
Chlorinated Solvents, Dry	4	4	4	1	1	1	4	4	4	0	4	2	4
Chlorinated Solvents, Wet	4	4	4	1	1	1	4	4	4	0	4	2	4
Chlorine	4	4	4	1	1	2	2	2	4	0	4	3	0
Chlorine Dioxide	4	4	3	2	1	2	4	4	4	1	4	3	3
Chlorine Dioxide, 8% Cl as NaClO2 in Solution	4	4	4	1	1	2	4	4	4	0	4	2	0
Chlorine Trifluoride	4	4	4	2	4	4	4	4	4	1	4	4	4
Chlorine Water	0	4	2	1	1	0	3	3	4	1	4	1	4
Chlorine, Dry Gas	4	2	4	1	1	1	3	4	4	1	4	3	4
Chlorine, Liquid	0	4	2	2	2	0	4	4	4	1	4	0	0
Chlorine, Plasma	0	0	0	3	0	0	0	0	0	0	0	0	0
Chlorine, Wet	4	4	2	2	2	2	4	4	4	1	4	2	4
Chlorine, Wet Gas	0	4	2	2	2	0	4	4	4	1	4	0	0
Chloro 1-Nitro Ethane	4	4	4	1	4	4	4	4	4	0	4	3	4
Chloro Oxyfluorides	0	0	0	2	0	0	0	0	0	0	0	0	0
Chloro Xylenols	4	4	4	1	1	2	2	2	4	0	4	0	0
Chloroacetaldehyde	4	1	1	2	4	1	3	3	1	0	1	0	2
Chloroacetic Acid	4	4	2	1	4	4	4	4	4	0	4	2	0
Chloroacetone	4	4	1	1	4	4	4	4	4	0	4	4	4
Chloroamino Benzoic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Chloroaniline	4	1	2	1	3	1	3	4	1	0	1	2	2
Chlorobenzaldehyde	4	1	1	1	4	1	3	3	1	0	1	0	2
Chlorobenzene	4	4	4	1	1	2	4	4	4	1	4	2	4
Chlorobenzene Chloride	4	4	4	1	1	2	2	2	4	0	4	0	0
Chlorobenzene Trifluoride	4	4	4	1	1	2	2	2	4	0	4	0	0
Chlorobenzochloride	4	4	4	1	1	2	2	2	4	0	4	0	0
Chlorobenzotrifluoride	4	4	4	1	1	2	2	4	4	0	4	0	4
Chlorobromomethane	4	4	2	1	1	2	4	4	4	1	4	3	4
Chlorobromopropane	4	4	4	1	1	2	2	2	4	0	4	0	0
Cchlorobutadiene	4	4	4	1	1	2	4	4	4	0	4	3	4
Chlorobutane	1	2	4	1	1	1	1	1	4	0	4	0	2
Chlorododecane	4	4	4	1	1	1	4	4	4	0	4	2	4
Chloroethane	1	2	4	1	1	1	1	1	4	0	4	0	2
Chloroethane Sulfonic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Chloroethylbenzene	4	4	4	1	1	2	2	2	4	0	4	4	0
Chloroform	4	4	4	1	2	3	4	4	4	1	4	4	4
Chlorohydrin	4	1	1	1	1	1	3	1	1	0	1	1	2
Chloronaphthalene	4	4	4	1	1	2	4	4	4	0	4	4	4
Chloronitrobenzene	4	1	1	1	3	1	3	3	1	0	1	0	2
Chloronitroethane	0	0	4	1	4	4	0	4	0	0	0	0	4
Chlorophenol	0	0	4	1	1	2	0	4	0	0	0	0	4
Chlorophenol, Ortho	4	1	1	1	2	1	3	3	1	0	1	0	2
Chlorophenol, Para	4	1	1	1	2	1	3	3	1	0	1	0	2
Chloropicrin	4	4	4	1	1	2	2	2	4	0	4	0	0
Chloroprene	4	4	4	1	1	2	2	4	4	0	4	3	4
Chlorosulfonic Acid	4	4	4	1	4	4	4	4	4	1	4	4	4
Chlorotoluene	4	4	4	1	1	2	4	4	4	0	4	2	4
Chlorotoluene Sulfonic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Chlorotoluidine	4	4	4	1	4	2	2	2	4	0	4	0	0
Chlorotrifluoroethylene	0	0	0	2	0	0	0	0	0	0	0	0	0
Chlorox	4	2	2	1	1	1	2	2	4	0	4	1	0
Chlorsulphonic Acid	4	4	4	0	0	4	4	4	4	1	4	0	4
Cholesterol	4	4	4	1	1	2	2	2	4	0	4	0	0
Chrome Alum	4	1	1	1	1	0	1	1	1	0	1	3	1
Chrome Plating Solution	4	4	2	1	1	2	4	4	4	1	4	1	2
Chromic Acid	4	4	2	1	1	2	4	4	4	1	4	1	3
Chromic Oxide	0	4	2	1	1	0	4	4	0	0	0	1	0
Chromium Potassium Sulfate	0	2	2	1	1	0	2	2	0	0	0	2	0
Cinnamic Acid	4	4	4	1	1	2	2	2	4	0	4	0	0
Cinnamic Alcohol	4	4	4	1	1	2	2	2	4	0	4	0	0
Cinnamic Aldehyde	4	4	4	1	3	2	2	2	4	0	4	0	0
Circo Light Process Oil	1	2	4	1	1	1	1	1	4	0	4	1	4
Citric Acid	0	1	1	1	1	1	1	1	1	1	1	1	1
City Service 65, 120, 250	1	2	4	1	1	1	1	1	4	0	4	1	4
City Service Kool Motor Oil 140	1	2	4	1	1	1	1	1	4	0	4	1	4
City Service Pacemaker No. 2	1	2	4	1	1	1	1	1	4	0	4	1	4
Clophen	4	4	4	0	2	0	0	0	1	0	4	0	4
Clophen-A types	0	4	0	1	1	1	4	4	4	1	4	0	1
Clorox	0	0	2	1	1	2	0	2	0	0	0	0	2
Coal Tar	0	2	4	1	1	1	1	1	0	0	0	1	4
Cobalt Chloride	1	1	1	1	1	1	1	1	1	0	1	1	2
Cobalt Chloride, 2N	4	1	1	1	1	1	1	1	1	0	1	1	1
Cobaltous Acetate	4	1	1	1	4	1	3	3	1	0	1	0	2
Cobaltous Bromide	4	1	1	1	1	1	1	1	1	0	1	1	1
Cobaltous Chloride	0	0	1	1	1	1	0	1	0	0	0	1	2
Cobaltous Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Coconut Fat	1	2	4	1	1	1	1	1	4	1	4	0	1
Coconut Fatty Alcohol	0	1	2	1	1	0	1	1	2	1	2	0	0

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Coconut Oil	1	3	3	1	1	1	1	1	4	1	4	1	1
Cod Liver Oil	1	2	1	1	1	1	1	1	2	1	2	1	2
Codeine	4	4	4	1	1	2	2	2	4	0	4	0	0
Coffee	4	1	1	1	1	1	1	1	1	0	1	1	1
Coke Oven Gas	4	4	4	1	1	2	4	4	4	1	4	1	2
Coliche Liquors	0	1	2	0	0	0	2	2	1	0	2	2	0
Convelex 10	0	4	3	1	1	0	4	4	4	0	4	2	4
Coolanol	4	2	4	1	1	1	1	1	4	0	4	1	4
Copper Acetate	4	2	1	1	4	4	2	2	1	0	4	4	4
Copper Ammonium Acetate	4	1	1	1	3	1	3	3	1	0	1	0	2
Copper Carbonate	4	1	1	1	1	1	3	3	1	0	1	0	2
Copper Chloride	1	2	1	1	1	1	1	1	1	1	1	1	1
Copper Cyanide	1	1	1	1	1	1	1	1	1	0	1	2	1
Copper Fluoride	0	2	1	1	1	0	1	1	1	1	1	0	0
Copper Gluconate	4	1	1	1	3	1	3	3	1	0	1	0	2
Copper Nitrate	0	2	2	1	1	0	1	2	1	1	1	2	0
Copper oxide	1	1	1	1	1	1	1	1	1	0	1	1	1
Copper Salts	1	1	1	1	1	1	1	1	1	0	1	1	1
Copper Sulfate	4	1	1	1	1	1	1	1	1	1	1	1	1
Copper Sulfate 10%	4	1	1	1	1	1	1	1	2	0	2	1	1
Copper Sulfate 50%	4	1	1	1	1	1	1	1	1	0	2	1	1
Corn Oil	1	3	3	1	1	1	1	1	4	1	4	1	1
Cottonseed Oil	1	3	3	1	1	1	1	1	2	1	2	1	1
Creosote, Coal Tar	1	2	4	1	1	1	1	1	4	1	4	1	4
Creosote, Wood	1	2	4	1	1	1	1	1	4	0	4	2	4
Creosylic acid	4	4	4	1	1	0	1	4	4	0	4	1	0
Cresol	4	4	4	1	1	2	4	4	4	1	4	1	4
Cresylic Acid	4	4	4	1	1	2	4	4	4	0	4	1	4
Crotonaldehyde	4	4	1	1	4	2	2	2	2	1	2	0	0
Crotonic Acid	4	4	2	1	2	4	2	4	4	0	4	0	4
Crude Oil, Asphalt Base	1	2	4	1	1	2	2	2	4	1	4	1	4
Cumaldehyde	4	4	4	1	1	2	2	2	4	0	4	0	0
Cumene	4	4	4	1	1	2	4	4	4	0	4	3	4
Cupric Sulfate	0	1	1	1	1	0	1	1	0	0	0	1	0
Cutting Oil	1	2	4	1	1	1	1	1	4	0	4	1	4
Cyanogen Chloride	0	4	3	1	2	0	3	4	0	0	0	3	0
Cyclohexane	2	4	4	1	1	2	1	1	4	1	4	2	4
Cyclohexanol	0	4	4	1	1	1	1	1	4	1	4	1	4
Cyclohexanone	4	4	2	1	4	4	4	4	4	1	4	3	4
Cyclohexene	4	4	4	1	3	2	2	2	4	0	4	0	0
Cyclohexylamine	1	4	4	1	4	1	4	4	4	1	4	0	2
Cyclohexylamine Laurate	1	2	4	1	1	1	1	1	4	0	4	0	2
Cyclopentadiene	4	4	4	1	3	2	2	2	4	0	4	0	0
Cyclopentane	2	3	4	1	1	1	1	1	4	0	4	2	4

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Cyclopolyolefins	2	3	4	1	3	1	1	1	4	0	4	2	4
Cymene	4	4	4	1	1	2	0	4	4	0	4	0	4
DDT													
(Dichlorodiphenyltrichloroethane)	4	4	4	1	1	1	2	4	4	0	4	0	4
Decahydronaphthalene	0	0	4	1	1	1	0	4	0	0	0	0	4
Decalin	0	4	4	1	1	1	4	4	4	0	4	2	4
Decane	1	3	4	1	1	1	1	1	4	0	4	1	2
Deionized Water	4	1	2	1	1	1	2	2	1	0	1	2	2
Delco Brake Fluid	0	2	1	1	4	4	3	3	0	0	1	1	3
Delta H	2	4	4	2	2	0	4	4	4	1	4	0	0
Delvac													
1100, 1110, 1120, 1130	0	2	4	1	1	0	1	1	0	0	0	1	1
Denatured Alcohol	4	1	1	1	1	1	1	1	1	1	1	1	1
Desmodur	4	4	4	0	0	0	4	0	2	4	4	0	4
Desmophen 2000	0	0	0	0	0	0	1	1	0	1	1	0	0
Detergent Solutions	4	2	1	1	1	1	1	1	1	1	1	1	1
Detergents	0	2	1	2	2	0	1	1	4	1	2	0	0
Developing Fluids	0	1	2	1	1	1	1	1	1	0	2	1	1
Dexron	1	2	4	1	1	2	1	1	4	0	4	2	4
Dextrin	1	1	1	1	1	1	1	1	1	1	1	0	1
Dextro Lactic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Dextron	0	2	4	1	1	2	1	1	0	0	0	1	4
Dextrose	4	1	1	1	1	1	3	3	1	0	1	0	2
Diacetone	4	4	1	1	4	4	4	4	4	1	4	2	4
Diacetone Alcohol	4	2	1	1	4	4	4	4	1	1	1	4	4
Dialkyl Sulfates	4	1	1	1	3	1	3	3	1	0	1	0	2
Diamylamine	1	2	4	1	4	1	1	1	4	0	4	0	2
Diazinon	0	3	4	1	2	2	3	3	4	0	4	4	4
Dibenzyl	4	4	4	1	2	2	2	2	4	0	4	0	0
Dibenzyl Ether	0	4	2	1	4	0	4	4	4	1	4	3	0
Dibenzyl sebacate	4	4	2	1	2	3	4	4	4	0	4	1	3
Dibromodifluoromethane	0	0	2	1	0	0	0	4	0	0	0	0	4
Dibromoethane	4	4	4	1	1	2	2	2	4	0	4	0	0
Dibromoethylbenzene	4	4	4	1	2	2	4	4	4	0	4	4	4
Dibromotetrafluoroethane	0	0	4	2	2	0	0	2	0	0	0	4	4
Dibutyl Cellosolve Adipate	4	1	1	1	3	1	3	3	1	0	1	0	2
Dibutyl Ether	3	4	3	1	3	3	4	4	4	1	4	4	4
Dibutyl Methylenedithio													
Glycolate	4	4	4	1	1	2	2	2	4	0	4	0	0
Dibutyl Phthalate	4	4	2	1	3	3	4	4	4	1	4	2	2
Dibutyl Sebacate	4	4	2	1	4	2	4	4	4	1	4	2	2
Dibutyl Thioglycolate	4	4	4	1	1	2	2	2	4	0	4	0	0
Dibutyl Thiourea	4	4	4	1	1	2	2	2	4	0	4	0	0
Dibutylamine	4	3	4	1	4	4	4	4	4	0	4	2	3

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Dicapryl Phthalate	0	0	2	1	2	2	0	4	0	0	0	0	3
Dichclorobutane	0	4	4	1	1	0	2	2	0	0	0	1	0
Dichloracetic Acid	0	4	1	2	4	0	4	4	4	1	4	0	0
Dichlorethane	4	4	4	2	2	0	4	4	4	1	4	0	4
Dichlorethylene	0	4	0	2	2	0	4	4	4	1	4	0	0
Dichloroacetic Acid	4	4	4	1	1	2	2	2	4	0	4	0	0
Dichloroaniline	4	1	1	1	4	1	3	3	1	0	1	0	2
Dichlorobenzene	4	4	4	1	1	2	4	4	4	1	4	3	4
Dichlorobutane	4	4	4	1	1	2	2	2	4	1	4	1	4
Dichlorobutene	4	4	4	1	2	2	4	4	4	1	4	0	0
Dichlorodiethyl Sulfide	0	0	1	1	0	0	0	0	0	0	0	0	1
Dichlorodiphenyldichloroethane	4	4	4	1	1	2	2	2	4	0	4	0	0
Dichloroethane	4	4	4	1	1	2	2	2	4	0	4	0	0
Dichloroethylene	4	4	4	1	2	2	2	2	4	0	4	0	0
Dichlorohydrin	4	1	1	1	3	1	3	3	1	0	1	0	2
Dichloroisopropyl Ether	3	4	3	1	3	3	4	4	4	0	4	3	4
Dichloromethane	4	4	4	1	3	2	4	4	4	1	4	0	4
Dichlorophenol	4	4	4	1	2	2	2	2	4	0	4	0	0
Dichlorophenoxyacetic Acid	4	4	4	1	1	2	2	2	4	0	4	0	0
Dichloropropane	4	4	4	1	1	2	2	2	4	0	4	0	0
Dichloropropene	4	4	4	1	2	2	2	2	4	0	4	0	0
Dicyclohexylamine	4	4	4	1	4	4	1	3	4	0	4	3	2
Dicyclohexylammonium Nitrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Dieldrin	4	4	4	1	4	2	2	2	4	0	4	0	0
Diesel Fuel	2	2	4	1	1	1	1	1	4	1	4	0	2
Diesel Oil	1	3	4	1	1	1	1	1	4	1	4	1	4
Di-Ester Synthetic Lubricants	2	4	4	1	1	2	2	2	4	0	4	1	4
Diethanolamine	4	1	1	1	3	1	3	3	1	0	1	0	2
Diethyl Carbonate	4	1	1	1	1	1	3	3	1	0	1	0	2
Diethyl Ether	3	3	4	1	4	3	4	4	4	1	4	4	4
Diethyl Phthalate	4	4	4	1	1	2	2	2	4	0	4	0	0
Diethyl Sebacate	4	4	2	1	2	2	3	4	4	1	4	2	2
Diethyl Sulfate	0	4	1	1	3	0	4	4	0	0	0	2	2
Diethylamine	4	4	2	1	4	4	2	2	4	1	4	4	2
Diethylaniline	4	1	1	1	3	1	3	3	1	0	1	0	2
Diethylbenzene	0	4	4	1	1	3	4	4	0	0	0	3	4
Diethylene Glycol	2	1	1	1	1	1	1	1	1	1	1	1	2
Diethylene Glycol Butyl Ether	0	0	1	1	3	4	0	4	0	0	0	2	4
Diethylhexyl Phthalate	0	0	2	1	2	2	0	4	0	0	0	2	3
Diethylhexyl Sebacate	0	0	2	1	1	3	0	4	0	0	0	1	3
Difluorodibromomethane	4	4	2	1	0	0	4	4	4	0	4	2	4
Difluoroethane	4	4	4	1	4	2	2	2	4	0	4	0	0
Difluoromonochloroethane	4	4	4	1	1	2	2	2	4	0	4	0	0
Diglycol Chloroformate	4	1	1	1	3	1	3	3	1	0	1	0	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Diglycolic Acid	4	2	1	1	1	1	2	2	1	1	1	0	2
Dihexyl Phthalate	0	4	0	2	4	0	4	4	4	1	4	0	0
Dihydroxydiphenylsulfone	4	1	1	1	3	1	3	3	1	0	1	0	2
Diisobutyl Ketone	0	4	1	1	4	0	4	4	2	1	4	1	0
Diisobutylcarbinol	1	2	4	1	1	1	1	1	4	0	4	0	2
Diisobutylene	4	4	4	1	1	3	2	2	4	0	4	2	4
Diisooctyl Sebacate	4	4	3	1	2	3	3	3	4	0	4	2	3
Diisopropyl Ether	0	0	0	1	1	0	0	0	0	0	0	0	0
Diisopropyl Ketone	4	4	1	1	4	4	4	4	4	0	4	2	4
Diisopropylbenzene	4	4	4	1	1	2	2	4	4	0	4	0	0
Diisopropylidene Acetone	4	4	3	1	4	4	2	4	4	0	4	0	4
Dimethyl Acetamide	4	1	1	1	4	1	3	3	1	0	1	0	2
Dimethyl Aniline	4	4	4	1	4	2	2	2	4	0	4	0	0
Dimethyl Disulfide	1	2	4	1	1	1	1	1	4	0	4	0	2
Dimethyl Ether	0	4	4	1	4	1	4	4	2	1	4	4	1
Dimethyl Formaldehyde	4	1	1	1	4	1	3	3	1	0	1	0	2
Dimethyl Formamide	4	4	2	1	4	4	3	3	2	1	4	3	2
Dimethyl Hydrazine	4	1	1	1	4	1	3	3	1	0	1	0	2
Dimethyl Phenyl Carbinol	4	4	4	1	1	2	2	2	4	0	4	0	0
Dimethyl Phenyl Methanol	4	4	4	1	1	2	2	2	4	0	4	0	0
Dimethyl Phthalate	4	4	2	1	2	2	4	4	4	1	4	2	0
Dimethyl Sulfoxide	4	1	1	1	4	1	3	3	1	0	1	2	2
Dimethyl Terephthalate	4	4	4	1	2	2	2	2	4	0	4	0	0
Dimethylamine	4	4	1	2	4	4	4	4	4	1	4	2	2
Dimethylaniline	0	0	2	1	4	4	0	3	0	0	0	0	4
Dimethylether	0	3	4	1	4	0	4	4	0	0	0	4	0
Dinitrochlorobenzene	4	4	4	1	1	2	2	2	4	0	4	0	0
Dinitrogen Tetroxide	0	0	0	2	0	0	0	0	0	0	0	0	0
Dinitrotoluene	4	4	4	1	4	4	4	4	4	0	4	4	4
Dinonyl Phtalate	0	4	0	2	4	0	4	4	4	1	4	0	0
Dioctyl Phthalate	4	4	2	1	1	2	4	4	4	1	4	2	3
Dioctyl Sebacate	4	4	2	1	1	3	4	4	4	1	4	2	3
Dioctylamine	1	2	4	1	1	1	1	1	4	0	4	0	2
Dioxane	4	4	2	1	4	4	4	4	2	1	2	4	4
Dioxolane	4	4	2	1	4	4	4	4	4	0	4	4	4
Dipentene	4	4	4	1	1	3	2	2	4	1	4	3	4
Diphenyl	4	4	4	1	1	2	4	4	4	1	4	2	4
Diphenyl Oxides	4	4	4	1	1	2	4	4	4	1	4	2	3
Diphenylamine	4	4	4	1	4	2	2	2	4	0	4	0	0
Diphenylpropane	4	4	4	1	2	2	2	2	4	0	4	0	0
Disilane	0	0	0	1	0	0	0	0	0	0	0	0	0
Dodecylbenzene	4	4	4	1	1	2	2	2	4	0	4	0	0
Dow Chemical 50-4	0	2	1	2	4	4	3	3	0	0	1	4	0
Dow Chemical ET378	3	4	3	2	3	0	4	4	4	0	4	3	4

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Dow Chemical ET588	0	2	1	2	4	4	3	3	0	0	1	4	0
Dow Corning 11	1	1	1	1	1	1	2	1	1	0	1	1	3
Dow Corning 1208, 4050, 6620, F-60, XF-60	0	1	1	1	1	0	1	1	0	0	0	1	1
Dow Corning 1265 Fluorosilicone Fluid	1	1	1	1	1	3	2	2	1	0	1	1	1
Dow Corning 200	1	1	1	1	1	2	2	1	1	0	1	1	3
Dow Corning 220	0	1	1	1	1	0	1	1	0	0	0	1	0
Dow Corning 3	1	1	1	1	1	1	2	1	1	0	1	1	3
Dow Corning 33	1	1	1	1	1	2	2	1	1	0	1	1	3
Dow Corning 4	1	1	1	1	1	1	2	1	1	0	1	1	3
Dow Corning 44	1	1	1	1	1	2	2	1	1	0	1	1	3
Dow Corning 5	1	1	1	1	1	2	2	1	1	0	1	1	3
Dow Corning 510	1	1	1	1	1	2	2	2	1	0	1	1	3
Dow Corning 55	1	1	1	1	1	2	2	1	1	0	1	1	3
Dow Corning 550	1	1	1	1	1	2	1	1	1	1	1	1	3
Dow Corning 704	1	1	1	1	1	2	2	2	1	0	1	0	3
Dow Corning 705	1	1	1	1	1	2	2	2	1	0	1	1	3
Dow Corning 710	1	1	1	1	1	2	2	2	1	0	1	1	3
Dow Corning F-60 Fluid	1	1	1	1	1	1	1	1	1	0	1	1	4
Dow Corning F-61 Fluid	1	1	1	1	1	1	1	1	1	0	1	1	4
Dow Guard	3	1	1	1	1	1	1	1	1	0	1	1	1
Dowtherm 209	0	2	1	1	1	3	3	3	0	0	0	1	3
Dowtherm A	4	4	4	1	1	2	4	4	4	1	4	2	4
Dowtherm E	4	4	4	1	1	2	4	4	4	0	4	1	4
Drinking Water	4	2	1	1	1	1	1	1	1	0	1	1	1
Dry Cleaning Fluids	4	4	4	2	1	2	3	3	4	0	4	3	4
Dte 20 Series	2	1	4	1	1	2	2	2	2	0	0	2	4
DTE Light Oil	0	2	4	1	1	1	1	1	3	0	4	1	3
Elco 28-EP Lubricant	1	3	4	1	1	1	1	1	4	0	4	1	2
Engine Oils	1	2	4	1	1	1	1	1	4	1	4	0	2
Epichlorohydrin	4	4	2	1	4	4	4	4	4	1	4	4	4
Epoxy Resins	0	1	1	1	4	0	3	3	0	0	0	2	0
Esam-6 Fluid	0	2	1	1	4	4	4	4	0	0	1	4	0
Essential Oils	0	4	4	1	2	0	4	4	4	1	4	0	0
Esso Fuel 208	1	2	4	1	1	1	1	1	4	0	4	1	4
Esso Golden Gasoline	4	4	4	1	1	1	2	2	4	0	4	3	4
Esso Motor Oil	1	3	4	1	1	1	1	1	4	0	4	1	4
Esso Transmission Fluid, Type A	1	2	4	1	1	1	1	1	4	0	4	1	4
Esso WS2812	2	4	4	1	1	1	1	1	4	0	4	1	4
Esso XP90-EP Lubricant	1	2	4	1	1	1	1	1	4	0	4	1	4
Esstic 42, 43	1	2	4	1	1	1	1	1	4	0	4	1	4
Ethanal	4	3	2	2	4	4	3	4	2	1	3	4	2
Ethane	1	2	4	1	1	2	1	1	4	1	4	0	4

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Ethanethiol	0	0	3	1	2	0	0	4	0	0	0	0	3
Ethanol	4	1	1	1	3	1	3	3	1	1	1	1	2
Ethanol with Acetic Acid, Fermentation Mixture	0	4	1	1	0	0	4	4	1	1	1	0	0
Ethanolamine	4	2	2	1	4	4	2	4	2	0	2	0	2
Ethers	3	4	4	1	4	3	4	4	4	0	4	4	4
Ethoxyethyl Acetate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ethyl Acetate	4	4	2	1	4	4	4	4	4	1	4	4	2
Ethyl Acetoacetate	4	4	2	1	4	4	4	4	3	0	3	4	2
Ethyl Acrylate	4	4	2	1	4	4	4	4	4	1	4	3	2
Ethyl Alcohol	4	1	1	1	2	1	3	1	1	1	1	1	2
Ethyl Benzene	4	4	4	1	1	1	4	4	4	1	4	3	4
Ethyl Benzoate	4	4	4	1	1	1	4	4	4	1	4	3	4
Ethyl Bromide	0	4	4	1	1	1	2	2	4	0	0	1	0
Ethyl Cellosolve	4	4	2	1	4	4	4	4	4	0	4	0	4
Ethyl Cellulose	4	2	2	1	4	4	2	2	2	1	2	0	3
Ethyl Chloride	3	2	2	1	1	1	1	1	2	1	2	2	4
Ethyl Chlorocarbonate	4	4	4	1	1	2	4	4	4	1	4	2	4
Ethyl Chloroformate	4	4	2	1	4	4	4	4	4	0	4	0	4
Ethyl Cyanide	0	0	4	1	4	0	0	1	0	0	0	1	0
Ethyl Cyclopentane	0	3	4	1	1	1	1	1	0	0	0	2	4
Ethyl Dibromide	0	4	3	1	1	0	4	4	0	0	0	2	0
Ethyl Dichloride	0	4	3	1	1	0	4	4	0	0	0	1	0
Ethyl Ether	4	4	3	1	4	4	4	4	2	1	4	4	4
Ethyl Formate	0	2	2	2	1	1	4	4	4	1	4	1	0
Ethyl Hexanol	4	1	1	1	1	1	1	1	1	1	1	0	2
Ethyl Lactate	4	1	1	1	3	1	3	3	1	0	1	0	2
Ethyl Mercaptan	0	3	0	1	2	0	4	4	4	1	4	0	3
Ethyl Nitrite	4	1	1	1	3	1	3	3	1	0	1	0	2
Ethyl Oxalate	4	4	1	1	1	2	4	4	4	1	4	0	4
Ethyl Pentachlorobenzene	4	4	4	1	1	2	4	4	4	1	4	0	4
Ethyl Pyridine	4	4	4	1	1	2	2	2	4	0	4	0	0
Ethyl Silicate	0	1	1	1	1	1	1	1	2	1	2	0	4
Ethyl Stearate	4	4	4	1	1	2	2	2	4	0	4	0	0
Ethyl Sulfate	0	4	1	1	4	0	4	4	0	0	0	1	0
Ethyl T-Butyl Ether	0	3	3	1	1	0	3	3	0	0	0	2	0
Ethyl Valerate	4	4	4	1	1	2	2	2	4	0	4	0	0
Ethylacrylic Acid	4	2	2	0	0	4	4	4	4	0	4	0	4
Ethylamine	4	1	1	1	4	1	3	3	1	0	1	0	2
Ethylene	4	4	2	1	1	1	2	1	4	1	4	0	4
Ethylene Chloride	4	2	4	1	2	2	2	4	2	1	2	0	4
Ethylene Chlorohydrin	4	2	2	1	1	2	4	4	2	0	2	1	3
Ethylene Cyanohydrin	4	4	4	1	1	2	2	2	4	0	4	0	0
Ethylene Diamine	4	4	1	2	4	4	4	4	2	1	2	2	4

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Ethylene Dibromide	4	4	3	1	2	3	4	4	4	0	4	0	4
Ethylene Dichloride	4	4	3	1	1	3	4	4	4	1	4	1	4
Ethylene Glycol	4	1	1	1	1	1	1	1	4	1	1	1	1
Ethylene Glycol Butyl Ether	0	0	2	1	4	4	0	3	0	0	0	3	0
Ethylene Glycol Butyl Ether Acetate	0	0	2	1	4	2	0	4	0	0	0	2	2
Ethylene Glycol Ethyl Ether Acetate	0	0	2	1	4	4	0	4	0	0	0	3	4
Ethylene Hydrochloride	4	4	3	1	1	3	4	4	4	0	4	0	4
Ethylene Oxide	4	4	3	1	4	4	4	4	4	1	4	4	4
Ethylene Oxide, 12% and Freon 12, 80%	4	4	2	4	4	4	3	3	4	0	4	0	4
Ethylene Trichloride	4	4	3	1	1	3	4	4	4	1	4	4	4
Ethylenediamine	0	0	1	2	4	4	0	1	0	0	0	2	1
Ethylmorpholine	4	4	4	1	1	2	2	2	4	0	4	0	0
Ethylmorpholinestannous Octotate	0	0	2	1	4	0	0	4	0	0	0	0	0
Ethylsulfuric Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Exhaust Gases, Containing Carbon Dioxide	1	1	1	1	1	1	1	1	1	1	1	0	1
Exhaust Gases, Containing Carbon Monoxide	1	1	1	1	1	1	1	1	1	1	1	0	1
Exhaust Gases, Containing Hydrogen Chloride	0	1	1	1	1	0	2	2	1	1	1	0	0
Exhaust Gases, Containing Hydrogen Fluoride	0	1	1	1	1	0	1	1	1	1	1	0	0
Exhaust Gases, Containing Nitrous Gases	4	1	1	1	1	2	0	0	4	1	0	0	4
Exhaust Gases, Containing Sulphur Dioxide	0	1	1	1	1	0	2	2	2	1	2	0	0
Exhaust Gases, Containing Sulphuric Acid	0	2	1	1	1	0	4	4	2	1	2	0	0
Fam Test Fuels DIN 51 604-A	0	4	4	1	1	1	2	2	4	1	4	0	4
Fam Test Fuels DIN 51 604-C	4	4	4	1	0	2	4	4	4	1	4	0	4
Fatty Acids	0	2	3	1	1	0	2	2	4	1	4	1	3
Fatty Alcohol	1	1	2	1	1	0	1	1	2	1	2	0	1
FC 11 (Trichlorofluoromethane)	4	4	4	2	2	2	2	2	4	1	4	4	4
FC 112 (1,2-Difluorotetrachloroethane)	0	2	4	1	1	2	2	2	4	1	4	4	4
FC 113 (1,1,2-Trichloro–1,2,2-Trifluoroethane)	1	1	4	2	2	4	1	1	4	1	2	4	4
FC 113 and High & Low Aniline Oil	0	2	4	3	2	0	1	1	0	0	0	4	0

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
FC 114 (1,2-Dichlorotetrafluoroethane)	0	1	1	2	1	2	1	1	1	1	1	4	4
FC 114B2 (Dibromotetrafluoroethane)	0	1	4	2	2	0	2	2	4	1	4	4	4
FC 115 (Chloropentafluoroethane)	0	1	1	2	2	0	1	1	1	0	1	4	0
FC 116 (Hexafluoroethane)	0	1	1	2	2	0	1	1	1	0	1	0	0
FC 12 (Dichlorodifluoromethane)	0	1	2	2	2	4	2	1	2	1	1	4	4
FC 12 and ASTM Oil #2, 50/50 Mixture	0	3	4	1	1	2	2	2	4	0	4	4	4
FC 12 and Suniso 4G, 50/50 Mixture	0	3	4	1	1	2	2	2	4	0	4	0	4
FC 123 (Dichlorotrifluoroethane)	0	0	0	1	0	0	0	0	0	0	0	0	0
FC 124 (2-Chloro-1,1,1, 2-Tetrafluoroethane)	0	0	0	2	0	0	0	0	0	0	0	0	0
FC 125 (Pentafluoroethane)	0	0	0	2	0	0	0	0	0	0	0	0	0
FC 13 (Chlorotrifluoromethane)	0	1	1	2	1	4	2	1	1	1	1	0	4
FC 134A (1,1,1, 2-Tetrafluoroethane)	0	1	1	1	4	0	2	2	0	1	0	0	0
FC 13B1 (Bromotrifluoromethane)	0	1	1	2	2	2	1	1	1	0	1	0	4
FC 14 (Tetrafluoromethane)	0	1	1	1	1	0	1	1	1	0	1	0	4
FC 142B (Difluorochloroethane)	0	1	4	2	2	0	2	2	0	0	0	4	0
FC 143A (1,1,1-Trifluoroethane)	0	0	4	1	1	2	0	4	0	0	0	2	4
FC 152A (Difluoroethane)	0	0	1	1	4	0	0	1	0	0	0	0	0
FC 21 (Dichlorofluoromethane)	0	3	4	1	4	0	4	4	4	1	4	0	4
FC 218	0	0	1	2	1	0	0	1	0	0	0	0	0
FC 22 (Chlorodifluoromethane) 2	4	2	4	4	3	4	1	1	1	1	0	4	
FC 22 and ASTM Oil #2, 50/50 Mixture	2	2	4	1	2	2	4	4	4	0	4	0	4
FC 31	0	1	1	2	4	0	4	4	2	1	2	0	0
FC 32	0	1	1	1	4	0	1	1	1	1	1	4	0
FC 43	0	1	1	1	1	1	1	1	0	0	4	1	1
FC 502, F22 and F316	0	1	1	2	2	0	2	2	1	0	1	0	0
FC 70	0	0	0	2	1	0	0	0	0	0	0	0	0
FC 75	0	1	1	4	2	2	1	1	0	0	4	3	1
FC 77, Fluorocarbon	0	1	1	1	2	2	1	1	0	0	4	0	1
FC BF	0	2	4	2	1	0	2	2	4	0	4	0	4
FC C316	0	0	1	2	1	0	0	1	0	0	0	0	0
FC C318 (Octafluoro-Tetraethylene)	0	1	1	2	2	0	1	1	1	1	1	4	0

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
FC K-142B	0	1	1	4	4	4	1	1	2	0	1	0	0
FC K-152a	0	1	1	4	4	4	1	1	1	0	1	0	0
FC MF	0	4	4	2	2	2	2	2	4	0	4	4	4
FC PCA	0	1	4	3	2	2	1	1	4	0	2	4	4
FC TA	0	0	2	2	3	3	0	1	0	0	0	0	3
FC TC	0	0	2	2	1	1	0	1	0	0	0	0	4
FC TF (1,1,2-Trichloro-1,2,2-Trifluoroethane)	0	1	2	3	2	2	1	1	4	1	2	4	4
FC TMC	0	0	3	2	1	1	0	2	0	0	0	0	3
FC T-P35	0	0	1	2	1	1	0	1	0	0	0	0	1
FC T-WD602	0	0	2	2	1	1	0	2	0	0	0	0	4
Fermentation Gas	0	1	0	1	1	1	1	1	4	1	4	0	1
Ferric Acetate	4	1	1	1	4	4	3	3	1	0	1	0	2
Ferric Ammonium Sulfate	4	1	1	1	3	3	3	3	1	0	1	0	2
Ferric Chloride	1	2	1	1	1	1	1	1	1	0	1	1	2
Ferric Ferrocyanide	4	1	1	1	3	3	3	3	1	0	1	0	2
Ferric Hydroxide	4	1	1	1	1	1	3	3	1	0	1	0	2
Ferric Nitrate	1	1	1	1	1	1	1	1	1	0	1	1	3
Ferric Persulfate	0	1	1	1	1	1	1	1	0	0	0	1	0
Ferric Sulfate	0	1	1	1	1	1	1	1	0	0	0	1	2
Ferrous Ammonium Citrate	4	1	1	1	3	3	3	3	1	0	1	0	2
Ferrous Ammonium Sulfate	4	1	1	1	2	2	3	3	1	0	1	0	2
Ferrous Carbonate	4	1	1	1	3	3	3	3	1	0	1	0	2
Ferrous Iodide	4	1	1	1	3	3	3	3	1	0	1	0	2
Ferrous Sulfate	4	1	1	1	1	1	3	3	1	0	1	0	2
Ferrous Tartrate	4	1	1	1	3	3	3	3	1	0	1	0	2
Fish Oil	1	1	4	1	1	1	1	1	2	1	2	0	1
Fluorinated Cyclic Ethers	0	0	1	1	0	0	0	0	0	0	0	0	0
Fluorine Gas	0	0	4	2	2	2	4	4	4	1	0	0	4
Fluorine Liquid	0	0	4	2	2	2	4	4	0	0	0	0	0
Fluorobenzene	4	4	4	1	1	1	4	4	4	1	4	0	4
Fluoroboric Acid	0	0	1	1	0	0	0	1	0	0	0	0	0
Fluorocarbon Oils	0	0	1	2	0	0	0	0	0	1	0	0	1
Fluorolube	0	1	1	2	2	2	1	1	0	0	4	2	1
Fluorosilicic Acid	0	1	2	1	1	1	1	1	1	1	1	1	4
Fomblin	0	0	0	1	1	1	0	0	0	0	0	0	0
Formaldehyde	4	2	2	1	4	4	2	2	1	1	1	4	2
Formamide	4	4	1	1	3	3	3	3	1	1	1	2	2
Formic Acid	0	4	1	2	4	4	4	2	2	1	2	3	2
Fruit Juice	0	2	1	1	1	1	2	2	4	1	1	0	1
Fuel Oil	1	2	4	1	1	1	1	1	4	1	4	1	4
Fuel Oil No. 6	1	4	4	1	1	1	2	2	4	0	4	1	1
Fuel Oil, 1 and 2	1	2	4	1	1	1	1	1	4	0	4	0	4
Fuel Oil, Acidic	1	2	4	1	1	1	1	1	4	0	4	1	1

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Fumaric Acid	4	2	2	1	1	1	1	1	3	0	2	1	2
Furaldehyde	0	4	2	2	4	0	4	4	0	0	0	4	0
Furan	4	4	4	1	4	0	4	4	4	1	4	4	4
Furane	0	0	0	2	4	0	0	0	0	1	0	0	0
Furfural	4	4	2	2	4	4	4	4	4	1	4	4	4
Furfuryl Alcohol	4	4	2	1	2	4	4	4	4	1	4	2	4
Furnace Gas, Dry	0	2	1	1	1	1	4	4	1	1	1	0	1
Furyl Carbinol	4	4	2	1	4	4	4	4	4	0	4	2	4
Fyrquel 150, 220, 300, 550	4	4	1	1	1	2	4	4	4	0	4	1	1
Fyrquel 90, 100, 150, 220, 500	0	4	1	1	1	3	4	4	0	0	0	1	1
Fyrquel A60	0	4	2	1	1	3	4	4	0	0	0	2	1
Galden	0	0	0	4	1	0	0	0	0	0	0	2	0
Gallic Acid	4	2	2	1	1	1	2	2	1	1	2	1	0
Gas liquor	4	4	4	1	1	4	1	1	4	1	4	0	4
Gas oil	1	2	4	1	1	1	1	1	4	1	4	0	2
Gasohol	4	4	4	1	0	2	4	4	4	1	4	0	4
Gasoline	4	4	4	1	1	1	1	1	4	1	4	2	4
Gelatin	2	1	1	1	1	1	1	1	1	1	1	0	1
Girling Brake Fluid	0	2	1	4	3	4	3	3	0	0	1	0	0
Glauber's Salt	2	2	2	1	1	1	1	4	1	1	1	1	0
Gluconic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Glucose	0	2	1	1	1	1	1	1	1	1	1	1	1
Glutamic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Glycerin	4	1	1	1	1	1	1	1	1	1	1	1	1
Glycerol Chlorhydrin	0	4	2	2	0	0	4	4	2	1	2	0	0
Glycerol Dichlorohydrin	4	1	1	1	3	1	3	3	1	0	1	0	2
Glycerol Monochlorohydrin	4	1	1	1	3	1	3	3	1	0	1	0	2
Glycerol Triacetate	4	1	1	1	3	1	3	3	1	0	1	0	2
Glycerophosphoric Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Glyceryl Phosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Glycidol	4	1	1	1	3	1	3	3	1	0	1	0	2
Glycine, Aqueous, 10%	0	1	1	1	1	0	2	2	2	1	2	0	0
Glycol Monoether	0	0	0	1	0	0	0	0	0	0	0	0	0
Glycolic Acid	4	2	1	1	1	1	1	1	1	1	1	0	1
Glycols	4	1	1	1	1	1	1	1	1	1	1	1	1
Glycoxylic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Grease, Petroleum Base	1	3	4	1	1	1	1	1	4	1	4	0	4
Green Sulfate Liquor	4	2	1	1	1	2	2	2	2	0	2	1	1
Gulf Crown Grease	1	2	4	1	1	1	1	1	4	0	4	1	4
Gulf Endurance Oils	1	2	4	1	1	1	1	1	4	0	4	1	4
Gulf FR Fluids (Emulsion)	1	2	4	1	1	1	1	1	4	0	4	1	4
Gulf FR G-Fluids	4	1	1	1	1	1	1	1	1	0	1	0	1
Gulf FR P-Fluids	4	4	2	1	2	2	4	4	4	0	4	0	1
Gulf Harmony Oils	1	2	4	1	1	1	1	1	4	0	4	1	4

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Gulf High Temperature Grease	1	2	4	1	1	1	1	1	4	0	4	1	4
Gulf Legion Oils	1	2	4	1	1	1	1	1	4	0	4	1	4
Gulf Paramount Oils	1	2	4	1	1	1	1	1	4	0	4	1	4
Gulf Security Oils	1	2	4	1	1	1	1	1	4	0	4	1	4
Halothane	4	4	4	2	1	2	4	4	4	0	4	1	4
Halowax Oil	0	4	4	2	1	1	4	4	4	0	4	1	4
Hannifin Lube A	1	1	4	1	1	1	1	1	4	0	2	1	2
Heating Oil, Mineral-Oil Based	1	2	4	1	1	1	1	1	4	1	4	0	2
Heavy Water	4	2	1	1	2	1	1	1	1	0	1	1	1
HEF-2 (Trialkyl Pentaborane)	4	4	4	1	1	2	2	2	4	0	4	1	4
Helium	1	1	1	1	1	1	1	1	1	1	1	1	1
Henkel P3 Solution	0	2	1	1	0	0	1	1	2	1	1	0	0
Heptachlor	4	4	4	1	2	2	2	2	4	0	4	0	0
Heptachlorobutene	4	4	4	1	1	2	2	2	4	0	4	0	0
Heptaldehyde	1	2	4	1	4	1	1	1	4	0	4	0	2
Heptane	1	2	4	1	1	3	1	1	4	1	4	3	4
Heptanoic Acid	1	2	4	1	1	1	1	1	4	0	4	0	2
Hexachloroacetone	4	1	1	1	4	1	3	4	1	0	1	4	2
Hexachlorobutadiene	4	4	4	1	1	2	4	4	4	1	4	0	0
Hexachlorobutene	4	4	4	1	1	2	2	2	4	0	4	0	0
Hexachlorocyclohexane	0	0	0	1	1	0	0	0	4	1	4	0	0
Hexachloroethane	4	4	4	1	2	2	2	2	4	0	4	0	0
Hexadecane	0	0	4	1	1	3	0	1	0	0	0	1	4
Hexafluoroethane	0	1	1	2	2	0	1	1	0	0	0	3	0
Hexaldehyde	0	4	1	1	4	4	4	4	4	1	4	0	2
Hexamethylene	1	2	4	1	1	1	1	1	4	0	4	0	2
Hexamethylene Diammonium													
Adipate	4	4	4	1	1	2	2	2	4	0	4	0	0
Hexamethylenediamine	4	1	1	2	4	1	3	3	1	0	1	0	2
Hexamethylenetetramine	4	1	1	2	4	1	3	3	1	0	1	0	2
Hexane	1	2	4	1	1	1	1	1	4	1	4	2	4
Hexane Triol	0	2	1	1	1	1	1	1	0	1	0	0	1
Hexene-1	1	2	4	1	1	1	2	2	4	1	4	3	4
Hexone	4	1	1	1	4	1	3	3	1	0	1	0	2
Hexyl Acetate	1	2	4	1	4	1	1	1	4	0	4	0	2
Hexyl Alcohol	4	2	3	1	1	2	1	1	1	1	1	0	2
Hexylene Glycol	4	1	1	1	1	1	3	3	1	0	1	0	2
Hexylresorcinol	4	4	4	1	2	2	2	2	4	0	4	0	0
High Viscosity Lubricant H2	4	2	1	1	1	2	1	1	0	0	1	1	1
High Viscosity Lubricant U4	4	2	1	1	1	2	1	1	0	0	1	1	1
Hi-Lo MS No. 1	4	4	1	4	4	3	4	4	4	0	4	3	3
Houghto-Safe 1010													
Phosphate Ester	4	4	1	1	1	2	4	4	4	0	4	0	3
Houghto-Safe 1055													

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Phosphate Ester	4	4	1	1	1	2	4	4	4	0	4	0	3
Houghto-Safe 1120													
Phosphate Ester	4	4	2	1	1	2	4	4	4	0	4	0	3
Houghto-Safe 271													
(Water & Glycol Base)	4	2	1	1	2	2	1	1	0	0	1	1	2
Houghto-Safe 416 & 500 Series	0	0	1	0	0	0	1	1	0	0	0	0	0
Houghto-Safe 5040													
(Water & Oil Emulsion)	4	2	4	1	1	2	1	1	4	0	4	0	3
Houghto-Safe 620													
(Water & Glycol Base)	4	2	1	1	2	2	1	1	0	0	1	1	2
Hydraulic Fluids,													
Hydraulic Oils DIN 51524	1	2	4	1	1	1	1	1	4	1	4	0	2
Hydraulic Fluids,													
Oil-in-Water Emulsions HFA	0	2	4	1	0	0	1	1	4	1	4	0	0
Hydraulic Fluids,													
Phosphoric Acid Ester HFD	4	4	0	1	0	4	4	4	4	1	4	0	4
Hydraulic Fluids,													
Polyglycol-Water Emulsions HFC	0	2	1	1	1	1	1	1	1	1	1	0	1
Hydraulic Fluids, Water-in-Oil													
Emulsions HFB	0	2	4	1	0	0	0	0	4	1	4	0	0
Hydraulic Oil,													
Petroleum Base Aircraft	0	2	4	1	1	1	1	1	4	1	0	1	2
Hydraulic Oil,													
Petroleum Base Industrial	1	2	4	1	1	1	1	1	4	1	4	0	2
Hydraulic Oils, Synthetic Base	4	4	4	1	3	2	2	2	4	0	4	0	0
Hydrazine	0	2	1	2	4	4	2	2	1	1	2	1	3
Hydrazine Dihydrochloride	4	1	1	1	4	1	3	3	1	0	1	0	2
Hydrazine Hydrate	4	2	1	1	4	2	2	2	4	1	2	0	2
Hydrazine, Anhydrous	4	2	2	1	4	4	4	4	4	0	1	2	0
Hydriodic Acid	4	4	4	1	1	2	2	2	4	0	4	0	0
Hydrobromic Acid	4	2	1	1	1	3	2	4	1	1	4	1	4
Hydrobromic Acid, 40%	4	2	1	1	1	3	4	4	1	0	4	0	4
Hydrobromic Acid, Gas	4	0	1	0	1	4	0	4	2	1	3	0	4
Hydrocarbons, Saturated	1	2	4	1	1	1	1	1	4	0	4	0	4
Hydrochloric Acid	4	2	1	1	1	0	2	1	1	1	1	1	0
Hydrochloric Acid,													
3 Molar to 158°F	3	2	1	1	1	3	2	2	3	0	3	0	4
Hydrochloric Acid, Cold 37%	0	4	3	1	1	0	2	4	0	0	0	1	0
Hydrochloric Acid, Concentrated	0	4	2	1	1	3	4	2	2	1	2	0	4
Hydrochloric Acid Concentr. to 158°F	4	4	4	1	1	4	4	4	4	0	4	0	4
Hydrochloric Acid, Hot 37%	4	4	3	1	1	2	4	4	4	0	4	1	3
Hydrocyanic Acid	4	2	1	1	1	2	2	2	1	1	2	1	3
Hydro-Drive MIH-10,													
Petroleum Base	1	2	4	1	1	1	1	1	4	0	4	0	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Hydro-Drive MIH-50, Petroleum Base	1	2	4	1	1	1	1	1	4	0	4	0	2
Hydrofluoric Acid	4	4	4	1	1	4	4	4	0	1	0	2	4
Hydrofluoric Acid, Anhydrous	0	0	3	1	4	4	0	4	0	0	0	0	4
Hydrofluoric Acid, Concentrated Cold	0	0	2	2	0	0	0	0	0	1	2	0	0
Hydrofluoric Acid, Concentrated Hot	0	0	4	1	4	4	0	4	0	0	0	0	4
Hydrofluorosilicic Acid	0	2	1	1	1	4	2	2	1	0	2	1	4
Hydrogen Bromide	0	3	1	1	1	0	3	3	0	0	0	2	0
Hydrogen Chloride, Anhydrous	0	0	1	1	1	0	0	4	0	0	0	1	0
Hydrogen Chloride, gas	0	4	1	1	1	0	4	4	2	1	2	1	0
Hydrogen Cyanide	0	2	1	1	2	0	4	1	0	0	0	1	0
Hydrogen Fluoride	0	4	3	1	4	0	4	4	0	0	0	1	0
Hydrogen Fluoride, Anhydrous	4	0	2	2	4	4	4	4	4	0	4	2	4
Hydrogen Gas	2	1	1	1	1	3	1	1	2	1	2	1	3
Hydrogen Gas, Hot	2	1	1	1	1	3	1	1	2	0	2	0	3
Hydrogen Peroxide	4	4	1	1	1	2	4	2	4	1	4	1	2
Hydrogen Peroxide, 90%	4	4	3	1	2	2	4	4	4	0	4	1	2
Hydrogen Sulfide, Dry Cold	4	1	1	1	4	3	1	1	2	1	2	1	3
Hydrogen Sulfide, Dry Hot	4	2	1	1	4	3	4	1	4	0	4	1	3
Hydrogen Sulfide, Wet Cold	4	1	1	1	4	3	2	1	2	1	1	1	3
Hydrogen Sulfide, Wet Hot	4	2	1	1	4	3	4	1	4	0	4	1	3
Hydrolube, Water & Ethylene Glycol	4	2	1	1	1	2	1	1	0	0	1	1	2
Hydroquinol	0	4	4	2	1	0	4	4	0	0	0	3	0
Hydroquinone	2	4	4	2	2	2	1	3	2	1	2	3	2
Hydrosulphite, Aqueous	0	2	1	2	0	0	2	2	1	1	1	0	0
Hydroxyacetic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Hydroxycitronellal	4	4	0	1	1	2	0	0	4	0	4	0	0
Hydroxylamine Sulfate	0	2	1	2	0	1	1	1	1	1	1	0	1
Hydyne	4	2	1	2	4	4	2	2	2	0	2	0	4
Hyjet	0	4	1	1	4	4	4	4	0	0	0	2	4
Hyjet IV and IVA	4	4	1	4	4	4	4	4	4	0	4	0	4
Hyjet S4	0	4	1	1	4	0	4	4	0	0	0	2	0
Hyjet W	0	4	1	1	4	0	4	4	0	0	0	2	0
Hypochlorous Acid	4	4	2	1	1	0	4	4	2	0	4	0	0
Indole	4	4	0	1	1	2	0	0	4	0	4	0	0
Industron FF44	1	2	4	1	1	1	1	1	4	0	4	1	4
Industron FF48	1	2	4	1	1	1	1	1	4	0	4	1	4
Industron FF53	1	2	4	1	1	1	1	1	4	0	4	1	4
Industron FF80	1	2	4	1	1	1	1	1	4	0	4	1	4
Ink	1	1	1	1	2	1	2	1	1	1	1	0	1
Insulin	4	1	1	1	3	1	3	3	1	0	1	0	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Iodic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Iodine	0	4	2	1	1	1	1	2	4	1	2	1	3
Iodine Pentafluoride	4	4	4	2	4	4	4	4	4	0	4	4	4
Iodine, Tincture	0	2	1	1	1	2	1	1	1	1	1	0	2
Iodoform	4	4	1	1	3	2	0	0	4	1	4	0	0
Iron(III) Chloride	0	1	1	1	1	0	1	1	1	1	1	0	0
Isoamyl Acetate	4	1	1	1	4	1	3	3	1	0	1	0	2
Isoamyl Butyrate	4	1	1	1	4	1	3	3	1	0	1	0	2
Isoamyl Valerate	4	1	1	1	1	1	3	3	1	0	1	0	2
Isoboreol	4	4	0	1	1	2	0	0	4	0	4	0	0
Isobutane	1	2	4	1	1	1	1	1	4	0	4	0	2
Isobutanol	4	1	1	1	1	2	2	2	1	1	1	0	1
Isobutyl Acetate	4	1	1	1	4	1	3	3	1	0	1	0	2
Isobutyl Alcohol	4	1	1	1	1	2	2	2	1	1	2	1	1
Isobutyl Chloride	0	4	4	1	2	0	4	4	0	0	0	4	0
Isobutyl Ether	0	3	4	1	4	0	2	2	0	0	0	4	0
Isobutyl Methyl Ketone	4	1	1	1	4	1	3	3	1	0	1	0	2
Isobutyl N-Butyrate	4	4	1	1	1	1	4	4	4	0	4	1	0
Isobutyl Phosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Isobutylene	4	4	0	1	1	2	0	0	4	0	4	0	0
Isobutyraldehyde	0	3	2	2	4	0	2	3	0	0	0	4	0
Isobutyric acid	0	4	2	1	3	0	1	2	0	0	0	3	2
Isocrotyl chloride	4	4	0	1	1	2	0	0	4	0	4	0	0
Isodecanol	1	2	4	1	2	1	1	1	4	0	4	0	2
Isododecane	4	2	4	1	1	1	1	1	4	0	4	1	4
Isoeugenol	1	2	4	1	2	1	1	1	4	0	4	0	2
Isooctane	1	2	4	1	1	1	1	1	4	1	4	2	4
Isopentane	1	2	4	1	1	1	1	1	4	0	4	0	2
Isophorone	4	4	1	1	4	4	4	4	4	1	4	2	4
Isopropanol	4	2	1	1	1	2	2	2	1	1	1	1	1
Isopropyl Acetate	4	4	2	1	4	4	4	4	4	1	4	4	4
Isopropyl Chloride	4	4	4	1	1	2	4	4	4	1	4	4	4
Isopropyl Ether	3	4	4	1	4	3	2	2	4	1	4	4	4
Isopropylacetone	4	1	1	1	3	1	3	3	1	0	1	0	2
Isopropylamine	4	1	1	1	3	1	3	3	1	0	1	0	2
Jet Fuel A	4	4	4	1	1	2	2	2	4	0	4	0	0
JP-10	4	4	4	1	1	1	3	3	4	0	4	0	4
JP-3	2	4	4	1	1	1	1	1	4	1	4	2	4
JP-4	2	4	4	1	1	2	1	1	4	1	4	2	4
JP-5	2	4	4	1	1	2	1	1	4	1	4	2	4
JP-6	2	4	4	1	1	2	1	1	4	1	4	2	4
JP-8	1	3	4	1	1	2	1	4	4	0	4	2	4
JP-9	4	4	4	1	1	2	3	3	4	0	4	0	4
JP-9 -11	4	4	4	1	1	2	4	4	4	0	4	0	4

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
JPX	0	2	4	1	4	0	0	1	0	0	0	2	0
Kel-F Liquids	0	2	1	3	3	2	2	1	0	0	1	3	1
Kerosene	1	4	4	1	1	1	1	1	4	1	4	2	4
Keystone #87HX-Grease	1	4	4	1	1	1	1	1	4	0	4	1	4
Lacquer Solvents	4	4	4	1	4	4	4	4	4	1	4	4	4
Lacquers	4	4	4	1	4	4	4	4	4	1	4	4	4
Lactams	0	4	2	1	2	4	4	4	4	1	4	3	0
Lactic Acid, Cold	4	1	1	1	1	1	1	1	1	0	1	0	1
Lactic Acid, Hot	4	4	4	1	1	2	2	4	4	0	4	0	2
Lactones	4	4	2	4	4	4	4	4	4	0	4	0	2
Lard	1	2	2	1	1	1	1	1	4	1	4	1	2
Lauric Acid	1	2	4	1	1	1	1	1	4	0	4	0	2
Lauryl Alcohol	0	1	2	1	1	0	0	1	2	1	2	0	0
Lavender Oil	2	4	4	1	1	2	2	2	0	1	0	1	4
LB 135	0	1	1	1	1	0	0	1	0	0	0	1	0
Lead Acetate	4	2	1	1	4	4	4	2	4	1	1	4	4
Lead Arsenate	4	1	1	1	3	1	1	3	1	0	1	0	2
Lead Bromide	4	1	1	1	3	1	1	3	1	0	1	0	2
Lead Carbonate	4	1	1	1	3	1	1	3	1	0	1	0	2
Lead Chloride	4	1	1	1	1	1	1	3	1	0	1	0	2
Lead Chromate	4	1	1	1	3	1	1	3	1	0	1	0	2
Lead Dioxide	4	1	1	1	2	1	1	3	1	0	1	0	2
Lead Linoleate	4	1	1	1	3	1	1	3	1	0	1	0	2
Lead Nitrate	0	1	1	1	1	1	1	1	1	1	1	2	2
Lead Oxide	4	1	1	1	2	1	1	1	1	0	1	1	2
Lead Sulfamate	4	1	1	1	1	1	1	2	2	0	2	0	2
Lehigh X1169	1	2	4	1	1	1	1	1	4	0	4	1	4
Lehigh X1170	1	2	4	1	1	1	1	1	4	0	4	1	4
Lemon Juice, Undiluted	0	2	0	1	0	0	0	1	1	1	1	0	1
Light Grease	0	4	4	1	1	0	0	1	0	0	0	1	0
Ligroin	1	2	4	1	1	1	1	1	4	0	4	2	4
Lime Bleach	0	1	1	1	1	1	1	1	0	0	0	1	2
Lime Sulfur	4	4	1	1	1	1	1	4	4	0	4	0	1
Lindol Hydraulic Fluid, Phosphate Ester Type	4	4	1	1	2	3	3	4	4	1	4	1	3
Linoleic Acid	0	2	4	1	2	0	0	2	4	1	4	1	2
Linseed Oil	1	1	3	1	1	1	1	1	2	1	2	1	1
Liquefied Petroleum Gas	3	2	4	1	1	3	3	1	4	1	4	2	3
Liquid Oxygen	4	4	4	2	4	4	4	4	4	0	4	4	4
Liquimoly	1	2	4	1	1	1	1	1	4	0	4	1	4
Liquor	1	1	1	1	1	1	1	1	1	1	1	1	1
Lithium Bromide	4	2	1	1	2	1	1	1	1	1	1	0	1
Lithium Carbonate	4	1	1	1	3	1	1	3	1	0	1	0	2
Lithium Chloride	4	2	1	1	1	1	1	1	1	1	1	0	1

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Lithium Citrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Lithium Hydroxide	4	1	1	1	3	1	3	2	1	0	1	1	2
Lithium Hypochlorite	4	1	1	1	3	1	3	3	1	0	1	0	2
Lithium Nitrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Lithium Nitrite	4	1	1	1	3	1	3	3	1	0	1	0	2
Lithium Perchlorate	4	1	1	1	3	1	3	3	1	0	1	0	2
Lithium Salicylate	4	1	1	1	3	1	3	3	1	0	1	0	2
Lithopone	4	1	1	1	3	1	3	3	1	0	1	0	2
Lubricating Oils, Crude & Refined	0	3	4	1	1	0	2	2	0	0	0	1	0
Lubricating Oils, Diester	2	3	4	1	2	2	2	2	4	0	4	2	4
Lubricating Oils, Petroleum	1	2	4	1	1	1	1	1	4	1	4	1	4
Lubricating Oils, SAE 10, 20, 30, 40, 50	1	2	4	1	1	1	1	1	4	0	4	1	4
Lubricating Oils, Synthetic Base	4	4	0	1	1	2	0	0	4	0	4	0	0
Lye	4	2	1	1	2	2	2	2	1	1	2	1	2
Machine Oil, Mineral	1	2	4	1	1	1	1	1	4	1	4	0	2
Magnesium Chloride	4	1	1	1	1	1	1	1	1	1	1	1	1
Magnesium Hydroxide	4	2	1	1	1	0	2	2	2	0	2	1	0
Magnesium Salts	1	1	1	1	1	1	1	1	1	0	1	1	1
Magnesium Sulfate	4	2	1	1	1	1	1	1	2	1	1	0	1
Magnesium Sulfite	4	1	1	1	2	1	1	1	2	0	2	0	1
Maize Oil	0	2	4	1	1	0	1	1	4	1	4	0	0
Malathion	0	0	4	1	2	2	2	2	4	0	4	0	4
Maleic Acid	4	4	4	1	1	0	4	4	4	1	4	1	4
Maleic Anhydride	4	4	4	1	4	0	4	4	4	0	4	1	0
Maleic Hydrazide	4	1	1	1	3	1	3	3	1	0	1	0	2
Malic Acid	4	2	4	1	1	1	1	1	3	0	2	1	2
Mandelic Acid	4	1	1	1	4	1	3	3	1	0	1	0	2
Manganese Acetate	4	1	1	1	4	1	3	3	1	0	1	0	2
Manganese Carbonate	4	1	1	1	2	1	3	3	1	0	1	0	2
Manganese Chloride	4	1	1	1	3	1	3	3	1	0	1	0	2
Manganese Dioxide	4	1	1	1	3	1	3	3	1	0	1	0	2
Manganese Gluconate	4	1	1	1	3	1	3	3	1	0	1	0	2
Manganese Hypophosphite	4	1	1	1	3	1	3	3	1	0	1	0	2
Manganese Linoleate	4	1	1	1	3	1	3	3	1	0	1	0	2
Manganese Phosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Manganese Sulfate	4	1	1	1	1	1	3	3	1	0	1	0	2
Manganous Chloride	4	1	1	1	3	1	3	3	1	0	1	0	2
Manganous Phosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Manganous Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Mannitol	4	1	1	1	3	1	3	3	1	0	1	0	2
Margarine	1	2	4	1	1	1	1	1	4	1	4	0	1
Marsh Gas	1	1	2	1	1	1	1	1	2	1	2	0	1

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
MCS 312	4	4	4	1	1	1	4	4	4	0	4	0	1
MCS 352	4	4	1	4	4	3	4	4	4	0	4	0	3
MCS 463	4	4	1	4	4	3	4	4	4	0	4	0	3
MEA (Ethanolamine)	0	0	2	1	4	4	0	4	0	0	0	0	2
Menthol	0	4	4	1	2	0	4	4	4	1	4	0	0
Mercaptan	1	2	4	1	3	1	1	1	4	0	4	0	2
Mercaptobenzothiazole	4	4	1	1	1	2	3	3	4	0	4	1	0
Mercuric Acetate	4	1	1	1	4	1	3	3	1	0	1	0	2
Mercuric Chloride	0	1	1	1	1	1	1	1	1	1	1	1	1
Mercuric Cyanide	4	1	1	1	2	1	3	3	1	0	1	0	2
Mercuric Iodide	4	1	1	1	3	1	3	3	1	0	1	0	2
Mercuric Nitrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Mercuric Sulfate	4	1	1	1	2	1	3	3	1	0	1	0	2
Mercuric Sulfite	4	1	1	1	3	1	3	3	1	0	1	0	2
Mercurous Nitrate, Hydrated	4	1	1	1	2	1	3	3	1	0	1	0	2
Mercury	1	1	1	1	1	1	1	1	1	1	1	1	1
Mercury Chloride	4	1	1	1	3	1	3	3	1	0	1	0	2
Mercury Fulminate	4	1	1	1	3	1	3	3	1	0	1	0	2
Mercury Salts	4	2	1	1	1	1	1	1	1	1	1	0	1
Mercury Vapor	0	1	1	1	1	0	1	1	1	0	1	1	0
Mesityl Oxide	4	4	2	1	4	4	4	4	4	1	4	4	4
Metaldehyde	4	1	1	1	4	1	3	3	1	0	1	0	2
Methacrylic Acid	4	1	2	1	3	4	3	3	1	0	1	2	4
Methallyl Chloride	4	4	0	1	1	2	0	0	4	0	4	0	0
Methane	1	2	4	1	1	2	1	1	2	1	2	2	4
Methanol	4	1	1	1	4	1	2	1	1	1	1	1	1
Methoxy Butanol	0	2	2	1	1	0	1	1	4	1	4	0	0
Methoxyethanol	4	1	1	1	3	1	3	3	1	0	1	0	2
Methyl 2-Pyrrolidone	0	0	2	1	2	2	0	0	0	0	0	0	2
Methyl Abietate	4	4	0	1	2	2	0	0	4	0	4	0	0
Methyl Acetate	4	2	2	1	4	4	4	4	4	1	4	4	4
Methyl Acetoacetate	4	4	2	1	4	4	4	4	0	0	0	4	2
Methyl Acetophenone	4	4	0	1	4	2	0	0	4	0	4	0	0
Methyl Acrylate	4	4	2	1	4	4	4	4	4	1	4	4	4
Methyl Acrylic Acid	4	2	2	1	3	4	4	4	4	1	4	0	4
Methyl Amylketone	4	1	1	1	4	1	3	3	1	0	1	0	2
Methyl Anthranilate	4	4	0	1	2	2	0	0	4	0	4	0	0
Methyl Benzoate	4	4	4	1	1	1	4	4	4	0	4	2	4
Methyl Bromide	3	4	4	1	1	1	2	2	4	1	4	2	4
Methyl Butanethiol	0	0	4	1	1	0	0	4	0	0	0	1	4
Methyl Butanol	4	2	1	1	1	1	2	2	1	1	2	1	4
Methyl Butyl Ketone	4	4	1	1	4	4	4	4	4	1	4	4	4
Methyl Butyrate Cellosolve	4	1	1	1	3	1	3	3	1	0	1	0	2
Methyl Butyrate Chloride	4	1	1	1	3	1	3	3	1	0	1	0	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Methyl Carbonate	4	4	4	1	1	2	4	4	4	0	4	2	4
Methyl Cellosolve	4	3	2	1	4	4	3	3	4	1	4	1	4
Methyl Cellulose	4	2	2	1	4	4	2	2	2	0	2	1	2
Methyl Chloride	4	4	3	1	2	2	4	4	4	1	4	4	4
Methyl Chloroacetate	4	1	1	1	4	1	3	3	1	0	1	0	2
Methyl Chloroform	0	4	4	1	2	2	4	4	0	0	0	4	4
Methyl Chloroformate	4	4	4	1	2	2	4	4	4	0	4	1	4
Methyl Cyanide	4	2	1	1	2	1	3	3	1	0	1	1	2
Methyl Cyclohexanone	1	2	4	1	4	1	1	1	4	0	4	0	2
Methyl Dichloride	4	4	0	1	1	2	0	0	4	0	4	0	0
Methyl Ether	4	3	2	1	4	1	1	1	4	1	4	4	1
Methyl Ethyl Ketone	4	4	1	1	4	4	4	4	4	1	4	4	4
Methyl Ethyl Ketone Peroxide	4	4	4	1	4	4	4	4	4	0	4	0	2
Methyl Ethyl Oleate	4	4	0	1	1	2	0	0	4	0	4	0	0
Methyl Formate	0	2	2	1	4	0	4	4	4	0	4	4	0
Methyl Hexyl Ketone	4	1	1	1	4	1	3	3	1	0	1	0	2
Methyl Iodide	1	2	4	1	1	1	1	1	4	0	4	0	2
Methyl Isobutyl Ketone	4	4	3	1	4	4	4	4	4	1	4	4	4
Methyl Isocyanate	4	1	1	1	4	1	3	3	1	0	1	0	2
Methyl Isopropyl Ketone	4	4	2	1	4	4	4	4	4	0	4	0	4
Methyl Isovalerate	4	4	0	1	1	2	0	0	4	0	4	0	0
Methyl Lactate	4	1	1	1	3	1	3	3	1	0	1	0	2
Methyl Mercaptan	0	0	1	1	3	0	0	0	0	1	0	0	0
Methyl Methacrylate	4	4	4	1	4	4	4	4	4	1	4	4	4
Methyl Oleate	0	4	2	1	2	2	4	4	4	1	4	1	0
Methyl Pentadiene	4	4	0	1	1	2	0	0	4	0	4	0	0
Methyl Phenylacetate	4	4	0	1	4	2	0	0	4	0	4	0	0
Methyl Propyl Salicylate	0	4	2	0	2	0	0	4	4	1	0	2	0
Methyl Salicylate	0	4	2	1	2	0	4	4	3	0	3	0	0
Methyl T-Butyl Ether	0	3	3	1	4	0	3	3	0	0	0	2	0
Methyl Valerate	4	4	0	1	1	2	0	0	4	0	4	0	0
Methylamine	4	1	1	1	4	1	4	4	2	1	2	0	2
Methylamyl Acetate	4	1	1	1	3	1	3	3	1	0	1	0	2
Methylcyclopentane	4	4	4	1	1	2	4	4	4	0	4	2	4
Methylene Bromide	4	4	4	1	3	1	0	2	4	0	4	0	0
Methylene Chloride	4	4	4	1	3	2	4	4	4	1	4	2	4
Methylene Di-P-Phenylene Isocyanate	4	1	1	1	3	1	3	3	1	0	1	0	2
Methylene Iodide	4	4	0	1	1	2	0	0	4	0	4	0	0
Methylglycerol	4	1	1	1	3	1	3	3	1	0	1	0	2
Methylisobutyl Carbinol	1	2	4	1	1	1	1	1	4	0	4	0	2
Methylpyrrolidine	4	4	0	1	1	2	0	0	4	0	4	0	0
Methylpyrrolidone	4	4	0	1	1	2	0	0	4	0	4	0	0
Methylsulfuric Acid	4	1	1	1	3	1	3	3	1	0	1	0	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
MIL-A-6091	4	1	1	1	1	1	2	2	1	0	1	0	1
MIL-C-4339	1	4	4	1	1	1	1	1	4	0	4	0	3
MIL-C-7024	2	2	4	1	1	1	1	1	4	0	4	0	4
MIL-C-8188	3	4	4	1	2	2	2	2	4	0	4	0	4
MIL-E-9500	4	1	1	1	1	1	1	1	1	0	1	0	1
MIL-F-16884	1	3	4	1	1	1	1	1	4	0	4	0	4
MIL-F-17111	1	2	4	1	1	2	1	1	4	0	4	0	4
MIL-F-25558	1	2	4	1	1	1	1	1	4	0	4	1	4
MIL-F-25656	2	4	4	1	1	2	1	1	4	0	4	0	4
MIL-F-5566	4	2	1	1	1	1	2	2	1	0	2	0	1
MIL-F-81912	4	4	4	1	1	2	3	3	4	0	4	0	4
MIL-F-82522	2	4	4	1	1	1	2	2	4	0	4	1	4
MIL-G-10924	2	2	4	1	1	1	1	1	4	0	4	0	4
MIL-G-15793	1	2	4	1	1	2	1	1	4	0	4	0	4
MIL-G-21568	1	1	1	1	1	1	1	1	1	0	1	0	4
MIL-G-25013	1	2	1	1	1	1	1	1	2	0	1	0	4
MIL-G-25537	2	2	4	1	1	1	1	1	4	0	4	0	4
MIL-G-25760	2	2	4	1	1	2	2	2	4	0	4	0	4
MIL-G-3278	1	4	4	1	1	2	2	2	4	0	4	0	4
MIL-G-3545	1	2	4	1	1	1	1	1	4	0	4	0	4
MIL-G-4343	1	2	3	1	1	1	2	2	1	0	1	0	3
MIL-G-5572	2	4	4	1	1	1	1	1	4	0	4	0	4
MIL-G-7118	3	2	4	1	1	1	2	2	4	0	4	0	4
MIL-G-7187	1	4	4	1	1	1	1	1	4	0	4	0	4
MIL-G-7421	4	2	4	1	1	2	2	2	4	0	4	0	4
MIL-G-7711	2	4	4	1	1	1	1	1	4	0	4	0	2
MIL-H-13910	2	1	1	1	1	2	1	1	1	0	1	0	4
MIL-H-19457	4	4	2	1	1	4	4	4	4	0	4	0	3
MIL-H-22251	0	2	1	0	0	0	2	2	0	0	2	0	4
MIL-H-27601	1	2	4	1	1	2	1	1	4	0	4	0	4
MIL-H-46170 –15°F to +400°F	2	2	4	1	1	1	1	1	4	0	4	0	4
MIL-H-46170 –20°F to +275°F	2	2	4	1	1	1	1	1	4	0	4	0	4
MIL-H-46170 –55°F to +275°F	2	2	4	1	1	1	1	1	4	0	4	0	4
MIL-H-46170 –65°F to +275°F	2	2	4	1	1	1	1	1	4	0	4	0	4
MIL-H-5606 –65°F to +235°F	2	2	4	1	1	1	1	1	4	0	4	1	4
MIL-H-5606 –65°F to +275°F	2	2	4	1	1	1	1	1	4	0	4	1	4
MIL-H-6083	1	1	4	1	1	1	1	1	2	0	4	0	4
MIL-H-7083	4	2	1	1	2	1	1	1	2	0	2	0	1
MIL-H-8446	3	1	4	1	1	1	2	2	4	0	4	1	4
MIL-J-5161	1	4	4	1	1	1	2	2	4	0	4	0	4
Milk	4	1	1	1	1	1	1	1	1	1	1	1	1
Milk of Lime	0	2	0	1	1	0	4	4	4	1	2	0	0
MIL-L-15016	1	2	4	1	1	2	1	1	4	0	4	0	4
MIL-L-15017	1	2	4	1	1	2	1	1	4	0	4	0	4

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
MIL-L-17331	0	0	4	1	1	0	1	1	4	0	4	4	4
MIL-L-2104	1	2	4	1	1	1	1	1	4	0	4	4	4
MIL-L-21260	1	2	4	1	1	1	1	1	4	0	4	4	4
MIL-L-23699	3	3	4	1	1	2	2	2	4	0	4	4	4
MIL-L-25681	2	2	1	1	1	2	2	2	2	0	2	2	4
MIL-L-3150	2	2	4	1	1	1	1	1	4	0	4	4	4
MIL-L-6081	1	2	4	1	1	1	1	1	4	0	4	4	4
MIL-L-6082	1	2	4	1	1	1	1	1	4	0	4	4	3
MIL-L-6085	2	4	4	1	1	2	2	2	4	0	4	4	4
MIL-L-6387	2	4	4	1	1	2	2	2	4	0	4	4	4
MIL-L-7808	2	4	4	1	1	2	2	2	4	1	4	4	4
MIL-L-7808A	2	4	4	1	1	2	2	2	4	0	4	4	4
MIL-L-7870	1	2	4	1	1	1	1	1	4	0	4	4	4
MIL-L-9000	1	2	4	1	1	2	1	1	4	0	4	4	4
MIL-L-9236	2	4	4	1	1	2	2	2	4	0	4	4	4
MIL-O-3503	2	2	4	1	1	1	1	1	4	0	4	4	4
MIL-P-27402	0	2	1	0	0	0	2	2	0	0	2	2	4
MIL-R-25576	1	2	4	1	1	1	1	1	4	0	4	4	4
MIL-S-3136 Type I Fuel	1	2	4	1	1	1	1	1	4	0	4	4	4
MIL-S-3136 Type II Fuel	3	4	4	1	1	2	2	2	4	0	4	4	4
MIL-S-3136 Type III Fuel	3	4	4	1	1	2	2	2	4	0	4	4	4
MIL-S-3136 Type IV Oil, High Swell	1	4	4	1	1	1	1	1	4	0	4	4	2
MIL-S-3136 Type IV Oil, Low Swell	1	1	4	1	1	1	1	1	4	0	4	4	3
MIL-S-3136 Type V Oil, Medium Swell	1	2	1	1	1	1	1	2	4	0	4	4	1
MIL-S-81087	1	1	1	1	1	2	1	1	1	0	1	1	3
MIL-T-5624	2	4	4	1	1	2	1	1	4	0	4	4	4
MIL-T-83133	1	3	4	1	1	2	1	1	4	0	4	4	4
Mineral Oils	1	4	3	1	1	1	1	1	4	1	4	4	2
Mineral Water	0	2	1	1	1	1	1	1	1	1	1	1	1
Mixed Acid Etchants	0	0	4	1	3	4	0	4	0	0	0	0	4
Mixed Acids	4	1	1	1	3	1	3	3	1	0	1	1	2
MLO-7277	3	4	4	1	1	3	3	3	4	0	4	4	4
MLO-7557	3	4	4	1	1	3	3	3	4	0	4	4	4
MLO-8200	0	1	4	1	1	1	2	2	4	0	4	4	4
MLO-8515	3	1	4	1	1	1	2	2	4	0	4	4	4
Mobil 24DTE	0	2	4	1	1	0	1	1	0	0	0	0	0
Mobil HF	0	2	4	1	1	0	1	1	0	0	0	0	0
Mobil SHC 500 Series	1	2	4	1	1	2	3	3	0	0	0	0	2
Mobil SHC 600 Series	1	2	4	1	1	2	3	3	0	0	4	4	3
Mobil Therm 600	0	2	4	1	1	0	1	1	0	0	0	0	0
Mobil Velocite C	0	2	4	1	1	0	1	1	0	0	0	0	0

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Mobilgas WA200 ATF	0	2	4	1	1	0	1	1	0	0	0	1	0
Mobilgear 600 Series	1	1	3	1	1	1	3	3	4	0	4	0	1
Mobilgear SHC ISO Series	1	2	3	1	1	1	3	3	4	0	4	0	1
Mobilgrease HP	1	2	4	1	1	1	2	2	4	0	4	0	2
Mobilgrease HTS	1	2	4	1	1	1	2	2	4	0	4	0	2
Mobilgrease SM	1	2	4	1	1	1	2	2	4	0	4	0	2
Mobilith AW Series	1	2	4	1	1	1	2	2	4	0	4	0	2
Mobilith SHC Series	1	3	4	1	1	1	2	2	4	0	4	0	2
Mobilmistlube Series	1	1	3	1	1	1	3	3	4	0	4	0	1
Mobiloil SAE 20	0	2	4	1	1	0	1	1	0	0	0	1	0
Mobilux	0	2	4	1	1	0	1	1	0	0	0	1	0
Molasses	0	2	2	1	1	0	1	1	4	1	4	0	0
Molybdenum Disulfide Grease	0	4	4	1	2	0	1	1	0	0	0	1	0
Molybdenum Oxide	4	1	1	1	3	1	3	3	1	0	1	0	2
Molybdenum Trioxide	4	1	1	1	3	1	3	3	1	0	1	0	2
Molybdic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Monobromobenzene	4	4	4	1	2	4	4	4	4	1	4	4	4
Monobromotoluene	4	4	0	1	1	2	0	0	4	0	4	0	0
Monochloracetic Acid	0	2	1	2	0	0	2	2	4	1	4	0	0
Monochloracetic Acid, Ethyl Ester	4	4	2	1	2	4	4	4	4	1	4	0	4
Monochloracetic Acid, Methyl Ester	4	4	1	1	2	4	4	4	4	1	4	0	4
Monochloroacetic Acid	4	1	1	1	4	1	3	3	1	0	1	0	2
Monochlorobenzene	4	4	4	1	2	2	4	4	4	0	4	4	4
Monochlorobutene	4	4	0	1	1	2	0	0	4	0	4	0	0
Monoethanolamine	4	4	2	1	4	4	4	4	2	0	2	0	2
Monoethyl Amine	4	1	1	1	3	1	3	3	1	0	1	0	2
Monoisopropylamine	4	1	1	1	3	1	3	3	1	0	1	0	2
Monomethyl Aniline	4	1	1	1	2	1	4	4	1	0	1	2	2
Monomethyl Ether	0	0	0	1	1	0	0	0	0	0	0	0	0
Monomethyl Hydrazine	0	2	1	2	4	0	2	2	0	0	2	2	4
Monomethylamine	4	1	1	1	3	1	3	3	1	0	1	0	2
Monomethylaniline	4	4	4	1	3	0	4	4	4	0	4	2	0
Mononitrotoluene	4	1	1	1	3	1	3	3	1	0	1	0	2
Mononitrotoluene, 40% & Dinitrotoluene, 60%	4	4	1	2	3	3	4	4	4	0	4	3	4
Monovinyl Acetate	4	4	2	0	0	1	0	4	4	1	4	0	4
Monovinyl Acetylene	0	2	1	1	1	0	1	1	2	0	2	3	2
Mopar Brake Fluid	0	2	1	1	4	4	3	3	0	0	1	1	3
Morpholine	4	4	2	1	1	2	4	4	4	1	4	0	0
Motor Oils	1	2	4	1	1	1	1	1	4	0	4	0	2
Myristic Acid	4	4	0	1	1	2	0	0	4	0	4	0	0
Myristyl Alcohol	1	1	1	1	1	0	1	1	1	1	1	0	0

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Naftolen ZD	0	4	4	1	1	0	0	2	4	1	4	0	0
Naphtha	2	4	4	1	1	2	2	2	4	1	4	2	4
Naphthalene	0	4	4	1	1	1	1	4	4	1	4	3	4
Naphthalene Chloride	4	4	0	1	1	2	2	0	4	0	4	0	0
Naphthalene Sulfonic Acid	4	4	0	1	1	2	2	0	4	0	4	0	0
Naphthalenic	0	4	4	1	1	1	1	2	4	1	4	1	4
Naphthalenic Acid	4	4	0	1	1	2	2	0	4	0	4	0	0
Naphthalonic Acid	4	4	0	1	1	2	2	0	4	0	4	0	0
Naphthenic Acid	0	4	4	1	1	1	1	2	4	0	4	1	4
Naphthoic Acid	0	0	0	1	1	1	1	2	0	1	0	0	0
Naptha	2	4	4	1	1	2	2	2	4	0	4	0	4
Natural Gas	2	1	4	1	1	3	3	1	4	1	3	1	2
Neatsfoot Oil	1	4	2	1	1	1	1	1	4	1	4	1	2
Neon	1	1	1	1	1	1	1	1	1	0	1	1	1
Neville Acid	4	4	2	1	1	2	2	4	4	0	4	1	4
Neville-Winter Acid	0	0	2	1	1	2	2	4	0	0	0	1	4
Nickel Acetate	4	2	1	1	4	4	4	2	1	1	1	4	4
Nickel Ammonium Sulfate	4	1	1	1	2	1	1	1	1	0	1	1	2
Nickel Chloride	3	2	1	1	1	1	1	1	1	1	1	1	1
Nickel Cyanide	4	1	1	1	3	1	1	3	1	0	1	0	2
Nickel Nitrate	4	1	1	1	1	1	1	3	1	0	1	0	2
Nickel Salts	3	2	1	1	1	1	1	1	1	0	1	1	1
Nickel Sulfate	4	1	1	1	1	1	1	1	1	1	1	1	1
Nicotinamide	4	4	0	1	1	2	2	0	4	0	4	0	0
Nicotinamide Hydrochloride	4	1	1	1	3	1	1	3	1	0	1	0	2
Nicotine	4	4	0	1	2	2	2	0	4	0	4	0	0
Nicotine Sulfate	4	1	1	1	3	1	1	3	1	0	1	0	2
Niter Cake	4	1	1	1	1	1	1	1	1	0	1	1	1
Nitric Acid, 0–50%	4	2	3	1	1	2	2	4	4	1	2	2	2
Nitric Acid, 3M to 158°F	4	4	2	2	2	4	4	4	0	0	3	0	4
Nitric Acid, 50__ 1_0_	0	0	4	1	2	4	4	4	0	0	0	3	4
Nitric Acid, Concentrated	0	4	4	1	4	0	0	4	4	1	4	2	0
Nitric Acid, Concentrated to 158°F	4	4	4	4	4	4	4	4	4	0	4	0	4
Nitric Acid, Red Fuming	0	4	4	1	3	4	4	4	0	0	0	3	4
Nitric Acid, White Fuming	0	4	4	2	4	0	0	4	4	1	4	0	0
Nitroaniline	4	1	1	1	3	1	1	3	1	0	1	0	2
Nitroaniline, Meta	4	1	1	1	3	1	1	3	1	0	1	0	2
Nitrobenzene	4	4	4	1	3	4	4	4	4	1	4	1	4
Nitrobenzoic Acid	4	1	1	1	3	1	1	3	1	0	1	0	2
Nitrocellulose	4	1	1	1	3	1	1	3	1	0	1	0	2
Nitrochlorobenzene	4	1	1	1	3	1	1	3	1	0	1	0	2
Nitrochloroform	4	1	1	1	3	1	1	3	1	0	1	0	2
Nitrodiethylaniline	4	1	1	1	3	1	1	3	1	0	1	0	2
Nitroethane	4	2	2	1	4	4	4	4	2	1	2	1	4

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Nitrofluorobenzene	4	1	1	1	3	1	3	3	1	0	1	0	2
Nitrogen	1	1	1	1	1	1	1	1	1	1	1	1	1
Nitrogen Dioxide	0	0	0	1	4	0	0	0	0	0	0	0	0
Nitrogen Oxides	4	1	1	1	4	1	3	3	1	0	1	0	2
Nitrogen Tetroxide	4	4	4	2	4	4	4	4	4	1	4	3	4
Nitrogen Trifluoride	0	0	0	1	0	0	0	0	0	0	0	0	0
Nitroglycerine	4	1	1	1	1	1	4	4	2	1	2	0	2
Nitroglycol	0	2	1	1	1	0	4	4	0	1	0	0	0
Nitrogylcerol	4	1	1	1	3	1	3	3	1	0	1	0	2
Nitroisopropylbenzene	4	1	1	1	3	1	3	3	1	0	1	0	2
Nitromethane	4	3	2	1	4	4	4	4	2	1	2	3	4
Nitrophenol	4	1	1	1	4	1	3	3	1	0	1	0	2
Nitropropane	4	4	2	1	4	4	4	4	2	1	2	2	4
Nitrothiophene	4	1	1	1	3	1	3	3	1	0	1	0	2
Nitrotoluene	4	1	1	1	3	1	3	3	1	0	1	0	2
Nitrotoluene, Ortho	4	4	4	1	3	4	4	4	4	1	4	0	4
Nitrous Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Nitrous Gases	4	4	1	1	1	4	4	4	4	1	4	0	4
Nitrous Oxide	1	1	1	1	1	1	1	1	1	1	1	3	1
Nivac 20, 30	0	1	1	1	1	0	1	1	0	0	0	1	0
Nonane	1	2	4	1	1	1	1	1	4	0	4	0	2
Noryl GE Phenolic	0	0	1	0	0	0	1	1	0	0	0	0	0
Nyvac FR200 Mobil	0	2	1	1	1	0	1	1	4	0	4	0	0
Octachlorotoluene	4	4	4	1	1	2	4	4	4	0	4	0	4
Octadecane	2	2	4	1	1	1	1	1	4	0	4	1	4
Octafluorocyclobutane	0	0	1	2	2	0	0	0	0	0	0	0	0
Octanal	1	2	4	1	4	1	1	1	4	0	4	0	2
Octane	4	4	4	1	1	2	1	2	4	1	4	0	4
Octyl Acetate	4	1	1	1	4	1	3	3	1	0	1	0	2
Octyl Alcohol	4	2	1	1	1	2	2	2	2	1	2	1	2
Octyl Chloride	1	2	4	1	2	1	1	1	4	0	4	0	2
Octyl Cresol	4	4	4	2	2	4	0	0	4	1	4	0	4
Octyl Phthalate	4	4	0	1	3	2	0	0	4	0	4	0	0
Oil of Turpentine	0	4	4	1	1	0	2	2	4	1	4	0	0
Olefins	4	4	0	1	1	2	0	0	4	0	4	0	0
Oleic Acid	1	2	4	1	2	2	1	3	4	1	4	1	4
Oleum	4	4	4	1	2	2	4	4	4	1	4	1	4
Oleum Spirits	0	3	4	1	1	2	2	2	4	0	4	0	4
Oleyl Alcohol	1	1	1	1	1	1	1	1	1	1	1	0	1
Olive Oil	1	2	2	1	1	1	1	1	2	1	2	1	3
Oronite 8200	0	1	4	1	1	1	2	2	4	0	4	1	4
Oronite 8515	0	1	4	1	1	1	2	2	4	0	4	1	4
Orthochloroethyl Benzene	4	4	4	1	2	2	4	4	4	0	4	4	4
OS 70	0	1	4	1	1	2	2	2	4	0	4	1	4

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
OS45 Type 111,													
Silicate Ester Based	0	1	4	1	1	2	2	2	4	0	4	1	4
OS45 Type 1V	0	1	4	1	1	2	2	2	4	0	4	1	4
Oxalic Acid	0	2	1	1	1	1	2	2	3	1	2	1	2
Oxygen, Cold	2	1	1	1	1	1	2	2	2	1	2	4	1
Oxygen, Hot	4	4	4	1	2	1	4	4	4	1	4	4	2
Oxygen, Liquid	0	4	4	2	4	0	4	4	0	0	0	4	0
Ozonated Deionized Water	4	1	2	1	3	1	3	3	1	0	1	0	2
Ozone	2	2	1	1	1	1	3	4	4	1	4	1	1
Paint Thinner, Duco	4	4	4	1	3	2	4	4	4	0	4	3	4
Palm Kernel Fatty Acid	0	1	4	1	1	0	1	1	4	1	4	0	0
Palmitic Acid	0	2	2	1	1	1	1	1	4	1	4	1	4
Paraffin Emulsions	1	1	4	1	1	1	1	1	4	1	4	0	1
Paraffin Oil	1	1	4	1	1	1	1	1	4	1	4	0	1
Paraffins	1	1	4	1	1	1	1	1	4	1	4	0	2
Paraldehyde	4	1	1	1	4	1	3	3	1	0	1	0	2
Par-Al-Ketone	4	4	4	2	4	4	4	4	4	0	4	4	4
Parathion	4	4	0	1	1	2	0	0	4	0	4	0	0
Parker O-Lube	1	1	4	1	1	1	1	1	4	0	2	1	2
Peanut Oil	1	3	3	1	1	1	1	1	4	1	4	1	1
Pectin	1	1	1	1	1	1	1	1	1	1	1	0	1
Penicillin	4	4	0	1	1	2	0	0	4	0	4	0	0
Pentachlorodiphenyl	0	4	4	0	0	0	4	4	4	1	4	0	0
Pentachloroethane	4	4	0	1	2	2	0	0	4	0	4	0	0
Pentachlorophenol	4	1	1	1	2	1	3	3	1	0	1	0	2
Pentaerythritol	4	1	1	1	1	1	3	1	1	0	1	1	2
Pentaerythritol Tetranitrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Pentafluoroethane	0	0	0	2	0	0	0	0	0	0	0	0	0
Pentane	1	1	4	1	1	3	1	1	4	1	3	0	4
Pentane, 2-4-Dimethyl	1	2	4	1	1	3	1	1	4	0	4	0	4
Pentane, 2-Methyl	1	2	4	1	1	3	1	1	4	0	4	0	4
Pentane, 3-Methyl	1	2	4	1	1	3	1	1	4	0	4	0	4
Pentyl Pentanoate	1	2	4	1	1	1	1	1	4	0	4	0	2
Peracetic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Peracetic Acid, < 1%	4	4	1	1	1	4	4	4	4	1	4	0	4
Peracetic Acid, < 10%	4	4	2	1	0	4	4	4	4	1	4	0	4
Perchloric Acid	4	4	2	1	1	1	4	4	4	1	4	1	4
Perchloroethylene	4	4	4	1	1	2	4	2	4	1	4	4	4
Perfluoropropane	0	0	0	2	0	0	0	0	0	0	0	0	0
Perfluorotriethylamine	0	0	0	2	0	0	0	0	0	0	0	0	0
Petro Oil, Crude Above 250	0	4	4	1	2	0	4	4	0	0	0	2	0
Petro Oil, Crude Below 250	0	2	4	1	1	0	1	1	0	0	0	1	0
Petrol	2	2	4	1	1	1	2	2	4	1	4	0	4
Petrol/Benzene Mixture,													

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
50/50%	4	4	4	1	1	2	4	4	4	4	4	0	4
Petrol/Benzene Mixture,													
60/40%	4	4	4	1	1	2	4	4	4	4	4	0	4
Petrol/Benzene Mixture,													
70/30%	2	4	4	1	1	1	4	2	4	4	4	0	4
Petrol/Benzene Mixture,													
80/20%	2	4	4	1	1	1	4	2	4	4	4	0	4
Petrol/Benzene/Ethanol,													
50/30/20%	4	4	4	1	0	2	4	4	4	4	4	0	4
Petrolatum	1	2	4	1	1	1	1	1	4	4	4	0	4
Petrolatum Ether	1	2	4	1	2	1	1	1	4	4	4	0	2
Petroleum < 121°C/250°F	1	2	4	1	2	2	1	1	4	4	4	1	2
Petroleum > 121°C/250°F	1	2	4	1	3	4	1	4	4	4	4	2	4
Petroleum Ether	1	2	4	1	1	1	2	1	4	4	4	0	2
Petroleum Oil, Above 250°F	4	4	4	1	2	4	4	4	4	4	4	0	4
Petroleum Oil, Below 250°F	2	2	4	1	1	2	1	1	4	4	4	0	2
Petroleum Oil, Crude	1	2	4	1	2	1	1	1	4	4	4	1	4
Phenetole	0	0	4	1	4	4	0	4	0	0	0	4	4
Phenol	4	4	4	1	1	2	4	4	4	4	4	1	4
Phenol, 70%	4	4	4	1	1	2	4	4	4	4	4	0	4
Phenol, 85%	4	4	4	1	2	2	4	4	4	4	4	0	4
Phenolic Sulfonate	4	1	1	1	3	1	3	3	1	1	1	0	2
Phenolsulfonic Acid	4	1	1	1	1	1	3	3	1	1	1	0	2
Phenyl Amine	4	4	2	1	2	3	4	4	4	4	4	2	4
Phenyl Ethyl Ether	4	4	4	2	4	4	4	4	4	4	4	4	4
Phenyl Hydrazine	0	4	4	1	2	0	2	2	4	4	4	1	0
Phenylacetamide	4	4	0	1	1	2	0	0	4	4	4	0	0
Phenylacetate	4	1	1	1	4	1	3	3	1	1	1	0	2
Phenylacetic Acid	4	1	1	1	3	1	3	3	1	1	1	0	2
Phenylbenzene	4	4	4	1	1	2	4	4	4	4	4	3	4
Phenylenediamine	0	0	0	1	4	0	0	0	0	0	0	0	0
Phenylethyl Alcohol	4	4	0	1	1	2	0	0	4	4	4	0	0
Phenylethyl Ether	4	4	4	1	4	4	4	4	4	4	4	4	4
Phenylethyl Malonic Ester	4	4	0	1	1	2	0	0	4	4	4	0	0
Phenylglycerine	4	1	1	1	3	1	3	3	1	1	1	0	2
Phenylhydrazine	4	4	4	1	3	0	4	4	1	1	2	1	4
Phenylhydrazine Chlorhydrate	0	4	1	2	2	0	2	2	4	4	4	0	0
Phenylhydrazine Hydrochloride	4	1	1	1	3	1	3	3	1	1	1	0	2
Phenylmercuric Acetate	4	1	1	1	4	1	3	3	1	1	1	0	2
Phorone	4	4	1	1	4	4	4	4	4	4	4	4	4
Phosgene	0	0	0	1	4	0	0	0	0	0	0	0	0
Phosphine	0	2	1	1	2	0	4	4	1	1	0	0	0
Phosphoric Acid	3	3	1	1	1	3	4	4	2	2	1	1	4
Phosphoric Acid, 20%	0	0	1	1	1	2	0	4	0	0	0	1	3

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Phosphoric Acid, 3M to 158°F	3	2	1	1	1	2	1	1	0	0	2	1	2
Phosphoric Acid, 80%	0	0	1	1	1	3	0	4	0	0	0	1	4
Phosphoric Acid,													
Concentrated Room Temp	2	2	1	1	1	3	2	2	0	0	1	0	3
Phosphoric Acid,													
Concentrated to 158°F	3	3	1	1	1	3	4	4	0	0	2	0	4
Phosphorous Oxychloride	0	0	0	1	0	0	4	4	0	1	0	0	0
Phosphorous Trichloride	4	4	1	1	1	1	4	4	1	1	4	1	0
Phosphorous Trichloride Acid	0	4	1	1	1	0	4	4	0	0	0	1	0
Photographic Developer	0	2	1	1	1	0	2	2	1	1	1	0	0
Photographic Emulsions	0	1	1	1	1	0	1	1	1	1	1	0	0
Photographic Fixing Baths	0	2	1	1	1	0	2	2	1	1	1	0	0
Phthalic Acid	4	2	1	1	2	1	1	1	4	1	1	0	2
Phthalic Anhydride	4	1	2	1	4	1	3	3	1	0	1	3	2
Pickling Solution	4	4	3	1	1	4	4	4	4	1	4	2	4
Picric Acid	0	1	2	1	1	2	2	2	2	1	2	0	4
Picric Acid, Aqueous	0	2	1	1	1	1	1	1	1	1	1	0	1
Picric Acid, Molten	0	2	2	1	1	2	2	2	2	0	2	0	4
Pine Needle Oil	1	4	4	1	1	1	2	2	4	1	4	0	2
Pine Oil	1	4	4	1	1	1	1	1	4	1	4	1	4
Pine Tar	1	2	4	1	1	1	1	1	4	0	4	0	2
Pinene	4	3	4	1	1	1	2	2	4	1	4	1	4
Piperazine	4	4	0	1	1	2	0	0	4	0	4	0	0
Piperidine	4	4	4	1	4	4	4	4	4	1	4	0	4
Plating Solution, Chrome	4	4	2	1	1	2	4	4	4	0	4	1	4
Plating Solution, Cobalt	0	1	1	1	1	0	1	1	0	0	0	1	0
Plating Solution, Copper	0	1	1	1	1	0	1	1	0	0	0	1	0
Plating Solution, Gold	0	1	1	1	1	0	1	1	0	0	0	1	0
Plating Solution, Indium	0	1	1	1	1	0	1	1	0	0	0	1	0
Plating Solution, Iron	0	1	1	1	1	0	1	1	0	0	0	1	0
Plating Solution, Lead	0	1	1	1	1	0	1	1	0	0	0	1	0
Plating Solution, Nickel	0	1	1	1	1	0	1	1	0	0	0	1	0
Plating Solution, Others	0	4	1	1	1	0	1	1	4	0	4	1	4
Plating Solution, Silver	0	1	1	1	1	0	1	1	0	0	0	1	0
Plating Solution, Tin	0	1	1	1	1	0	1	1	0	0	0	1	0
Plating Solution, Zinc	0	1	1	1	1	0	1	1	0	0	0	1	0
Pneumatic Service	4	1	1	1	1	4	1	1	4	0	4	1	4
Polyethylene Glycol	0	2	1	1	1	0	2	2	0	0	0	1	0
Polyglycerol	4	1	1	1	3	1	3	3	1	0	1	0	2
Polyglycol	4	1	1	1	3	1	3	3	1	0	1	0	2
Polyvinyl Acetate Emulsion	0	2	1	1	3	0	1	1	2	0	4	1	0
Potash, Aqueous	0	2	1	1	1	1	1	1	1	1	1	0	1
Potassium Acetate	4	2	1	1	4	4	2	2	1	1	1	0	4
Potassium Acid Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Potassium Alum	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Aluminum Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Antimonate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Bicarbonate	4	1	1	1	1	1	3	3	1	0	1	0	2
Potassium Bichromate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Bifluoride	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Bisulfate	4	2	1	1	1	1	1	1	1	1	1	0	2
Potassium Bisulfite	4	1	1	1	1	1	3	3	1	0	1	0	2
Potassium Bitartrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Borate, Aqueous	0	2	1	1	1	0	1	1	1	1	1	0	0
Potassium Bromate, 10%	0	2	1	1	1	0	1	1	1	1	1	0	0
Potassium Bromide	4	2	1	1	2	1	1	1	1	1	1	0	2
Potassium Carbonate	4	2	1	1	2	1	1	1	1	1	1	0	1
Potassium Chlorate	4	2	1	1	2	1	4	4	2	1	2	0	2
Potassium Chloride	1	1	1	1	1	1	1	1	1	1	1	1	1
Potassium Chromate	4	2	1	1	2	1	2	2	1	1	1	0	2
Potassium Citrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Copper Cyanide	0	0	1	1	1	1	0	1	0	0	0	1	1
Potassium Cupro Cyanide	1	1	1	1	1	1	1	1	1	0	1	1	1
Potassium Cyanate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Cyanide	1	1	1	1	1	1	1	1	1	1	1	1	1
Potassium Dichromate	1	1	1	1	1	1	1	1	4	1	2	1	1
Potassium Diphosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Ferricyanide	4	1	1	1	2	1	3	3	1	0	1	0	2
Potassium Fluoride	4	1	1	1	1	1	3	3	1	0	1	0	2
Potassium Glucocyanate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Hydroxide	4	2	1	1	4	3	2	2	2	0	2	1	3
Potassium Hypochlorite	4	1	1	1	4	1	3	3	1	0	1	0	2
Potassium Iodate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Iodide	4	2	1	1	1	1	1	1	2	1	1	0	2
Potassium Metabisulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Metachromate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Monochromate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Nitrate	1	1	1	1	1	1	1	1	1	1	1	1	1
Potassium Nitrite	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Oxalate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Perchlorate	4	2	1	1	1	1	4	4	4	1	4	0	2
Potassium Perfluoro Acetate	0	0	0	1	0	0	0	0	0	0	0	0	0
Potassium Permanganate	4	2	1	1	2	1	4	4	4	1	2	0	2
Potassium Persulfate	4	4	1	1	1	1	4	4	4	1	2	0	2
Potassium Phosphate, Acidic	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Phosphate, Alkaline	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Phosphate, Dibasic or Tribasic	4	1	1	1	3	1	3	3	1	0	1	0	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Potassium Pyrosulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Salts	1	1	1	1	1	1	1	1	1	0	1	1	1
Potassium Sodium Tartrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Stannate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Stearate	4	1	1	1	2	1	3	3	1	0	1	0	2
Potassium Sulfate	4	1	1	1	1	1	1	1	1	1	1	1	1
Potassium Sulfide	4	1	1	1	1	1	3	3	1	0	1	0	2
Potassium Sulfite	4	1	1	1	1	1	1	1	2	0	2	0	1
Potassium Tartrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Thiocyanate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Thiosulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium Triphosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Potassium, Molten	0	0	0	4	0	0	0	0	0	0	0	0	0
Prestone Antifreeze	4	1	1	1	2	1	1	1	1	0	1	2	1
PRL-High Temp, Hydraulic Oil	1	2	4	1	1	1	2	2	4	0	4	1	2
Producer Gas	2	2	4	1	1	2	1	1	4	2	4	1	2
Propane	1	2	4	1	1	2	1	1	4	1	4	1	4
Propanoic Acid Nitrile	4	4	4	1	3	4	4	4	3	1	3	2	4
Propanol	4	1	1	1	1	1	1	1	1	1	1	1	1
Propanone (2-Propanone)	4	4	1	1	4	4	4	4	1	1	1	4	4
Propargyl Alcohol	0	1	1	1	1	0	1	1	2	1	0	0	0
Propionaldehyde	4	1	1	1	4	1	3	3	1	0	1	0	2
Propionic Acid	4	2	1	1	4	1	1	1	1	1	1	0	2
Propionitrile	0	2	4	1	4	0	1	1	0	0	0	1	0
Propyl Acetate	4	4	2	1	4	4	4	4	4	4	4	4	4
Propyl Acetone	4	4	1	1	4	4	4	4	4	0	4	4	4
Propyl Nitrate	4	4	2	1	1	4	4	4	4	0	4	0	4
Propyl Propionate	4	1	2	1	4	4	3	4	1	0	1	0	4
Propylamine	4	1	1	2	4	1	3	3	1	0	1	0	2
Propylbenzene	4	4	0	1	1	2	0	0	4	0	4	0	0
Propylene	4	4	4	1	1	2	4	4	4	1	4	1	4
Propylene Chloride	4	4	0	1	1	2	0	0	4	0	4	0	0
Propylene Chlorohydrin	4	4	0	1	1	2	0	0	4	0	4	0	0
Propylene Dichloride	4	4	0	1	2	2	0	0	4	0	4	0	0
Propylene Glycol	4	1	1	1	1	1	1	1	1	1	1	1	2
Propylene Imine	4	4	0	1	1	2	0	0	4	0	4	0	0
Propylene Oxide	4	4	2	1	4	4	4	4	4	1	4	4	4
PRS-3000	0	0	2	1	2	2	0	0	0	0	0	0	2
Pydraul 10E	4	4	1	2	1	4	4	4	4	1	4	1	1
Pydraul 115E	4	4	1	2	1	3	4	4	4	0	4	1	4
Pydraul 230C, 312C, 540C & A200	4	4	4	2	1	4	4	4	4	1	4	1	4
Pydraul 29ELT, 30E, 50E, 65E & 90E	4	4	1	2	1	1	4	4	4	1	4	1	1

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Pyranol Transformer Oil	1	2	4	1	1	1	1	1	4	0	4	1	4
Pyridine	4	4	2	1	4	4	4	4	4	1	4	2	4
Pyridine Oil	4	4	2	4	4	4	4	4	4	0	4	0	4
Pyridine Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Pyridine Sulfonic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Pyrogallol	4	4	4	1	1	2	2	2	4	0	4	0	0
Pyrogard 42, 43, 53 & 55	4	4	1	1	2	4	4	4	4	1	4	2	4
Pyrogard C&D	0	2	4	1	1	2	1	1	4	0	4	1	3
Pyroligneous Acid	4	2	2	1	4	4	4	4	4	0	4	4	0
Pyrolube	4	4	2	1	1	2	4	4	4	0	4	1	2
Pyrosulfuric Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Pyrosulfuryl Chloride	4	4	4	1	1	2	2	2	4	0	4	0	0
Pyrrole	4	4	4	1	4	4	4	4	4	1	4	0	2
Pyruvic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Quinidine	4	4	4	1	1	2	2	2	4	0	4	0	0
Quinine	4	4	4	1	1	2	2	2	4	0	4	0	0
Quinine Bisulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Quinine Hydrochloride	4	1	1	1	3	1	3	3	1	0	1	0	2
Quinine Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Quinine Tartrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Quinizarin	4	4	4	1	1	2	2	2	4	0	4	0	0
Quinoline	4	4	4	1	1	2	2	2	4	0	4	0	0
Quinone	4	4	4	1	2	2	2	2	4	0	4	0	0
Radiation, Gamma,													
1.0 E+07 Rads	3	3	2	2	4	4	3	3	4	1	3	1	2
Raffinate	4	4	4	1	1	2	2	2	4	0	4	0	0
Rapeseed Oil	2	2	1	1	1	1	2	2	4	1	4	1	4
Red Line 100 Oil	1	2	4	1	1	1	1	1	4	0	4	1	4
Red Oil (MIL-H-5606)	1	3	3	1	1	1	1	1	4	1	4	1	4
Resorcinol	4	1	4	1	1	1	3	4	1	0	1	1	2
Riboflavin	4	4	4	1	1	2	2	2	4	0	4	0	0
Ricinoleic Aacid	4	4	4	1	1	2	2	2	4	0	4	0	0
Rosin	4	4	4	1	1	2	2	2	4	0	4	0	0
Saccharin Solution	4	1	1	1	3	1	3	3	1	0	1	0	2
Sagrotan	0	2	1	1	1	1	2	2	1	1	1	0	1
Sal Ammoniac	1	1	1	1	1	1	1	1	1	0	1	1	2
Salicylic Acid	0	1	1	1	1	1	2	2	1	1	1	1	0
Salt Water	0	1	1	1	1	1	1	1	1	1	1	1	1
Santosafe 300	4	4	3	1	1	1	4	4	4	0	4	1	1
Sea Salt	0	2	1	1	1	0	1	1	0	0	0	1	0
Sea Water	4	2	1	1	1	1	1	1	1	1	1	1	1
Sebacic Acid	4	1	1	1	2	1	3	3	1	0	1	0	2
Selenic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Selenious Acid	4	1	1	1	3	1	3	3	1	0	1	0	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Sewage	4	2	1	1	1	1	1	1	1	0	1	1	1
SF 1147 GE Silicone Fluid	0	0	3	1	1	0	2	2	0	0	0	0	4
SF 1154 GE Silicone Fluid	1	1	1	1	1	1	2	2	1	0	1	0	4
SF 96 GE Silicone Fluid	1	1	1	1	1	1	2	2	1	0	1	0	4
Shell 3XF Mine Fluid	4	2	4	1	1	1	1	1	4	0	4	1	0
Shell Alvania Grease	1	2	4	1	1	1	1	1	4	0	4	1	2
Shell Carnea 19 & 29	1	4	4	1	1	1	1	1	4	0	4	1	0
Shell Diala	1	2	4	1	1	1	1	1	4	0	4	1	4
Shell Irus 905	1	2	4	1	1	1	1	1	4	0	4	1	4
Shell Lo Hydrax 27 and 29	1	2	4	1	1	1	1	1	4	0	4	0	4
Shell Macome 72	1	2	4	1	1	1	1	1	4	0	4	0	4
Shell Tellus 27, Petroleum Base	0	2	4	1	1	1	1	1	0	0	0	1	4
Shell Tellus 32, Petroleum Base	1	2	4	1	1	1	1	1	4	0	4	0	4
Shell Tellus 33	0	2	4	1	1	0	1	1	0	0	0	1	0
Shell Tellus 68	1	2	4	1	1	1	1	1	4	0	4	0	4
Shell UMF, 5% Aromatic	1	2	4	1	1	1	1	1	4	0	4	1	4
Shellac	4	1	1	1	2	1	3	3	1	0	1	0	2
Silicate Esters	0	1	4	1	1	1	2	2	4	0	4	1	4
Silicic Acid, Aqueous	0	2	1	1	1	0	1	1	1	1	1	0	0
Silicon Tetrachloride	0	0	0	2	0	0	0	0	0	0	0	0	0
Silicon Tetrafluoride	0	0	0	2	0	0	0	0	0	0	0	0	0
Silicone Greases	1	1	1	1	1	1	1	1	1	1	1	1	3
Silicone Oils	1	1	1	1	1	1	1	1	2	1	1	1	4
Silver Bromide	4	1	1	1	3	1	3	3	1	0	1	0	2
Silver Chloride	4	1	1	1	3	1	3	3	1	0	1	0	2
Silver Cyanide	4	1	1	1	2	1	3	3	1	0	1	0	2
Silver Nitrate	1	1	1	1	1	1	2	2	1	1	1	1	1
Silver Salts, Aqueous	0	2	1	1	1	1	2	2	2	1	2	0	1
Silver Sulfate	4	1	1	1	2	1	3	3	1	0	1	0	2
Sinclair Opaline CX-EP Lube	1	2	4	1	1	2	1	1	4	0	4	1	4
Skelly, Solvent B, C, E	0	4	4	1	1	1	1	1	4	0	4	0	0
Skydrol 500	4	4	1	1	4	3	4	4	4	1	4	1	3
Skydrol 500 B4	4	4	1	1	4	3	4	4	4	0	4	0	3
Skydrol 7000	0	4	1	1	3	3	4	4	0	0	0	1	3
Skydrol LD-4	4	4	1	4	4	3	4	4	4	0	4	0	3
Soap Solutions	4	2	1	1	1	1	1	1	1	1	1	1	1
Socony Mobile Type A	1	2	4	1	1	2	1	1	4	0	4	1	4
Socony Vacuum													
AMV AC781 Grease	1	2	4	1	1	2	1	1	4	0	4	1	4
Socony Vacuum PD959B	1	2	4	1	1	1	1	1	4	0	4	1	4
Soda Ash	0	1	1	1	1	1	1	1	1	0	1	1	1
Soda, Aqueous	0	2	1	1	1	1	1	1	1	1	1	0	1
Sodium Acetate	3	2	1	1	4	4	2	2	1	0	4	2	4
Sodium Acid Bisulfate	4	1	1	1	3	1	3	3	1	0	1	0	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Sodium Acid Fluoride	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Acid Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Aluminate	4	1	1	1	2	1	3	3	1	0	1	0	2
Sodium Aluminate Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Anthraquinone Disulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Antimonate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Arsenate	4	1	1	1	2	1	3	3	1	0	1	0	2
Sodium Arsenite	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Benzoate	4	2	1	1	2	1	1	1	1	1	1	0	2
Sodium Bicarbonate	4	1	1	1	1	1	1	1	1	1	1	1	1
Sodium Bichromate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Bifluoride	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Bisulfate	4	1	1	1	1	1	1	1	1	0	2	1	1
Sodium Bisulfide	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Bisulfite	4	1	1	1	1	1	1	1	1	1	1	1	1
Sodium Bitartrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Borate	0	1	1	1	1	1	1	1	1	0	1	1	1
Sodium Bromate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Bromide	4	1	1	1	2	1	3	3	1	0	1	0	2
Sodium Carbonate	4	1	1	1	1	1	1	1	1	1	1	1	1
Sodium Chlorate	4	4	1	1	2	1	4	4	4	1	4	0	2
Sodium Chloride	1	1	1	1	1	1	1	1	1	1	1	1	1
Sodium Chlorite	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Chloroacetate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Chromate	4	1	1	1	2	1	3	3	1	0	1	0	2
Sodium Citrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Cyanamide	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Cyanate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Cyanide	0	1	1	1	1	1	1	1	1	0	1	1	1
Sodium Diacetate	4	1	1	1	4	1	3	3	1	0	1	0	2
Sodium Diphenyl Sulfonate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Diphosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Disilicate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Ethylate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Ferricyanide	4	1	1	1	1	1	3	3	1	0	1	0	2
Sodium Ferrocyanide	4	1	1	1	1	1	3	3	1	0	1	0	2
Sodium Fluoride	4	1	1	1	1	1	3	3	1	0	1	0	2
Sodium Fluorosilicate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Glutamate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Hydrogen Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Hydrosulfide	4	1	1	1	2	1	3	3	1	0	1	0	2
Sodium Hydrosulfite	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Hydroxide	4	2	1	1	2	2	2	2	1	0	2	1	2
Sodium Hydroxide Pellets	0	2	1	1	4	0	2	2	0	0	0	1	0

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Sodium Hypochlorite	4	2	1	1	1	2	2	2	4	1	4	1	2
Sodium Hypophosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Hypophosphite	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Hyposulfite	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Iodide	4	1	1	1	2	1	3	3	1	0	1	0	2
Sodium Lactate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Metaphosphate	0	2	1	1	1	1	1	1	1	0	1	1	0
Sodium Metasilicate	4	1	1	1	2	1	3	3	1	0	1	0	2
Sodium Methylate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Monophosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Nitrate	0	2	1	1	1	0	2	2	1	1	1	1	4
Sodium Nitrite	0	2	1	1	1	0	2	2	1	1	1	0	0
Sodium Oleate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Orthosilicate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Oxalate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Perborate	0	2	1	1	1	1	2	2	2	0	2	1	2
Sodium Percarbonate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Perchlorate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Peroxide	4	2	1	1	2	1	2	2	2	0	2	1	4
Sodium Persulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Phenolate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Phenoxide	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Phosphate, Dibasic	1	2	1	1	1	0	1	1	1	1	1	1	4
Sodium Phosphate, Tribasic	1	2	1	1	1	0	1	1	1	0	1	1	1
Sodium Phosphate, Monobasic	1	2	1	1	1	0	1	1	1	0	1	1	4
Sodium Plumbite	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Pyrophosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Resinate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Salicylate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Salts	1	2	1	1	1	1	1	1	1	0	1	1	1
Sodium Silicate	0	1	1	1	1	0	1	1	1	1	1	1	0
Sodium Stannate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Sulfate	4	2	1	1	1	1	1	1	1	1	1	0	1
Sodium Sulfate Decahydrate	0	0	2	1	1	1	0	4	0	0	0	1	0
Sodium Sulfate, Anhydrous	0	0	1	1	1	1	0	1	0	0	0	0	1
Sodium Sulfide	4	2	1	1	1	1	2	2	4	1	2	0	1
Sodium Sulfite	4	1	1	1	1	1	1	1	2	0	2	1	1
Sodium Sulfocyanide	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Tartrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Tetraborate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Tetraphosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Tetrasulfide	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Thioarsenate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Thiocyanate	4	1	1	1	1	1	3	3	1	0	1	0	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Sodium Thiosulfate	4	1	1	1	1	1	4	2	1	1	1	0	1
Sodium Trichloroacetate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Triphosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Sodium Tripolyphosphate	0	0	1	1	2	0	0	4	0	0	0	1	0
Sodium, Molten	0	0	0	4	0	0	0	0	0	0	0	0	0
Solvasol 1, 2 & 3	2	2	4	1	2	1	1	1	4	0	4	4	4
Solvasol 73	2	2	4	1	1	1	2	2	4	0	4	4	4
Solvasol 74	2	2	4	1	1	1	2	2	4	0	4	4	4
Sorbitol	4	1	1	1	2	1	3	3	1	0	1	0	2
Sour Crude Oil	4	4	4	1	4	4	3	3	4	0	4	0	4
Sour Natural Gas	4	4	4	1	4	4	3	3	4	0	4	0	4
Soybean Oil	1	3	3	1	1	1	1	1	4	1	4	1	1
Spermaceti	0	2	4	1	1	0	1	1	4	1	0	0	0
Spindle Oil	1	2	4	1	1	1	1	1	4	1	4	0	1
Spry	1	2	2	1	1	1	1	1	4	0	4	1	1
SR-10 Fuel	2	4	4	1	1	1	1	1	4	0	4	1	4
SR-6 Fuel	2	4	4	1	1	1	2	2	4	0	4	1	4
Standard Clean 2	0	0	0	1	0	4	0	0	0	0	0	0	4
Standard Oil Mobilube													
GX90-EP Lube	1	2	4	1	1	1	1	1	4	0	4	1	4
Stannic Ammonium Chloride	4	1	1	1	3	1	3	3	1	0	1	0	2
Stannic Chloride	0	4	1	1	1	1	1	1	1	0	1	1	2
Stannic Chloride, 50%	0	4	1	1	1	1	1	1	1	0	1	0	2
Stannic Tetrachloride	4	1	1	1	3	1	3	3	1	0	1	0	2
Stannous Bisulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Stannous Bromide	4	1	1	1	3	1	3	3	1	0	1	0	2
Stannous Chloride	0	1	1	1	1	1	1	1	1	0	1	1	2
Stannous Fluoride	4	1	1	1	1	1	3	3	1	0	1	0	2
Stannous Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Starch Syrup	0	1	1	1	1	0	1	1	1	1	1	0	0
Starch, Aqueous	0	1	1	1	1	1	1	1	1	1	1	0	1
Stauffer 7700	2	4	4	1	1	2	2	2	4	0	4	3	4
Steam	0	4	1	2	2	4	4	4	4	1	4	0	4
Steam < 149°C/300°F	0	4	1	1	2	4	4	4	0	0	0	2	3
Steam > 149°C/300°F	0	4	4	2	4	4	4	4	0	0	0	3	4
Steam Below 400°G	4	4	3	2	4	4	4	4	4	1	4	1	3
Steam, 400°-500°f	4	4	3	4	4	4	4	4	4	0	4	0	4
Stearic Acid	1	2	2	1	1	1	2	2	4	1	1	1	2
Stoddard Solvent	1	4	4	1	1	1	1	1	4	1	4	2	4
Strontium Acetate	4	1	1	1	4	1	3	3	1	0	1	0	2
Strontium Carbonate	4	1	1	1	3	1	3	3	1	0	1	0	2
Strontium Chloride	4	1	1	1	3	1	3	3	1	0	1	0	2
Strontium Hydroxide	4	1	1	1	3	1	3	3	1	0	1	0	2
Strontium Nitrate	4	1	1	1	3	1	3	3	1	0	1	0	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Styrene	4	4	4	1	2	3	4	4	4	1	4	4	4
Succinic Acid	4	2	1	1	2	1	1	1	1	1	1	0	2
Sucrose Solutions	4	2	1	1	1	1	1	1	1	1	1	0	1
Sugar Syrup	0	0	1	1	1	0	1	1	1	1	0	0	0
Sulfamic Acid	4	1	1	1	2	1	3	3	1	0	1	0	2
Sulfanilic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Sulfanilic Chloride	4	4	4	1	1	2	2	2	4	0	4	0	0
Sulfanilimide	4	4	4	1	1	2	2	2	4	0	4	0	0
Sulfite Liquors	4	1	2	1	2	2	3	2	1	0	1	0	4
Sulfolane	0	2	1	1	2	0	2	2	0	0	0	1	0
Sulfonated Oils	4	4	4	1	1	2	2	2	4	0	4	0	0
Sulfonic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Sulfonyl Choride	4	1	1	2	3	1	3	3	1	0	1	0	2
Sulfur	4	1	1	1	1	1	4	4	4	1	4	0	0
Sulfur (Molten 250°F)	4	3	3	1	1	1	4	4	4	0	4	1	3
Sulfur Chloride	4	4	4	1	1	1	4	4	4	1	4	1	3
Sulfur Dioxide	0	0	1	1	3	2	0	4	0	0	0	2	2
Sulfur Dioxide Gas, Dry	4	4	1	1	2	2	4	4	2	1	2	2	2
Sulfur Dioxide Gas, Wet	4	2	1	1	2	2	4	4	4	1	4	2	2
Sulfur Dioxide, Liquefied	4	4	1	1	2	2	4	4	4	1	4	2	2
Sulfur Hexafluoride	4	1	1	2	2	2	2	2	4	1	1	3	2
Sulfur Liquors	4	2	2	1	1	2	2	2	2	0	2	0	4
Sulfur Monochloride	1	2	4	1	1	1	1	1	4	0	4	0	2
Sulfur Tetrafluoride	0	0	0	2	3	0	0	0	0	0	0	0	0
Sulfur Trioxide	4	4	2	1	1	2	4	4	2	1	3	2	2
Sulfuric Acid	2	4	1	1	1	1	2	2	2	1	2	1	1
Sulfuric Acid, 20% Oleum	4	1	1	1	1	1	3	2	1	0	1	0	1
Sulfuric Acid, Concentrated Room Temp	0	4	4	1	1	4	4	4	4	1	2	4	4
Sulfuric Acid, Concentrated to 158°F	4	4	4	1	2	4	0	4	0	0	4	0	4
Sulfuric Chlorohydrin	4	1	1	1	3	1	3	3	1	0	1	0	2
Sulfurous Acid	4	2	2	1	3	0	2	2	2	1	2	1	4
Sulfuryl Chloride	4	4	2	1	1	1	4	4	2	1	2	0	2
Sulphur Dioxide, Aqueous	0	4	1	1	1	0	4	4	4	1	2	0	0
Sunoco 3661	1	2	4	1	1	1	1	1	4	0	4	1	4
Sunoco All Purpose Grease	1	2	4	1	1	1	1	1	4	0	4	0	4
Sunoco SAE 10	1	2	4	1	1	1	1	1	4	0	4	1	4
Sunsafe (Fire Resistant Fluid)	4	2	4	1	1	1	1	1	4	0	4	1	0
Supershell Gasoline	2	2	4	1	2	2	1	1	4	0	4	3	4
Swanfinch EP Lubricant	1	4	4	1	1	1	1	1	4	0	4	2	4
Swanfinch Hypoid 90	1	2	4	1	1	1	1	1	4	0	4	1	4
Tallow	1	2	4	1	1	1	1	1	4	1	4	0	2
T-Amyl Methyl Ether	0	0	0	1	4	0	0	0	0	0	0	0	0

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Tannic Acid	2	2	1	1	1	1	1	1	1	1	2	1	2
Tanning Extract	2	2	1	1	1	1	1	1	1	1	1	0	1
Tar Oil	0	4	4	1	0	0	4	4	4	1	4	0	0
Tar, Bituminous	4	3	4	1	1	1	4	2	4	1	4	1	2
Tartaric Acid	0	2	2	1	2	1	1	1	1	1	1	1	1
T-Butyl Alcohol	4	2	2	1	1	2	2	2	2	1	2	1	2
T-Butyl Catechol	4	2	2	1	1	1	4	4	4	0	2	0	0
T-Butyl Mercaptan	4	4	4	1	1	0	4	4	4	1	4	1	4
T-Butylcatechol	0	2	2	1	1	1	4	4	0	0	0	1	0
Terephthalic Acid	4	1	1	1	1	1	3	3	1	0	1	0	2
Terpineol	0	4	3	1	1	1	2	2	4	0	4	1	0
Terpinyl Acetate	4	4	4	1	4	2	2	2	4	0	4	0	0
Tetrabromoethane	4	4	4	1	1	2	4	4	4	0	4	3	4
Tetrabromomethane	4	4	4	1	1	2	2	4	4	0	4	3	4
Tetrabutyl Titanate	0	2	1	1	1	4	2	2	2	1	2	1	4
Tetrachloroethane	4	4	4	1	1	2	4	4	4	1	4	4	4
Tetrachloroethylene	4	4	1	1	1	2	4	4	4	1	4	4	4
Tetraethyl Lead	0	4	4	1	1	2	2	2	4	1	4	3	0
Tetraethyl Lead Blend	0	4	4	1	1	2	2	2	4	0	4	3	0
Tetraethylorthosilicate	0	0	1	1	1	1	0	1	0	0	0	0	4
Tetrafluoromethane	0	0	1	1	1	0	0	1	0	0	0	0	4
Tetrahydrofuran	4	4	3	1	4	4	4	4	4	1	4	4	4
Tetrahydronaphthalene	4	4	4	1	1	1	4	4	4	1	4	4	4
Tetramethyl Ammonium Hydroxide	4	1	1	1	3	1	3	3	1	0	1	0	2
Tetramethyldihydropyridine	4	4	4	1	1	2	2	2	4	0	4	0	0
Tetraphosphoglucosate	4	1	1	1	3	1	3	3	1	0	1	0	2
Texaco 3450 Gear Oil	1	4	4	1	1	1	1	1	4	0	4	1	4
Texaco Capella A & AA	1	2	4	1	1	1	1	1	4	0	4	1	4
Texaco Meropa 220, No Lead	1	2	4	1	1	1	1	1	4	0	4	1	4
Texaco Regal B	1	4	4	1	1	1	1	1	4	0	4	1	4
Texaco Uni-Temp Grease	1	2	4	1	1	1	1	1	4	0	4	1	2
Texamatic A 1581 Fluid	1	2	4	1	1	2	1	1	4	0	4	0	4
Texamatic A 3401 Fluid	1	2	4	1	1	2	1	1	4	0	4	1	4
Texamatic A 3525 Fluid	1	2	4	1	1	2	1	1	4	0	4	1	4
Texamatic A 3528 Fluid	1	2	4	1	1	2	1	1	4	0	4	1	4
Texamatic A Transmission Oil	1	2	4	1	1	2	1	1	4	0	4	1	4
Texas 1500 Oil	1	2	4	1	1	1	1	1	4	0	4	1	2
Therminol 44	4	4	4	1	1	0	4	4	0	0	0	0	4
Therminol 55	2	4	4	1	1	0	2	2	0	0	0	0	4
Therminol VP-1, 60, 65	4	4	4	1	1	0	4	4	0	0	0	0	2
Thioamyl Alcohol	1	2	4	1	1	1	1	1	4	0	4	0	2
Thiodiacetic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Thioethanol	4	1	1	1	3	1	3	3	1	0	1	0	2

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Thioglycolic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Thiokol TP-90B	0	2	1	1	2	2	4	4	0	0	4	1	0
Thiokol TP-95	0	2	1	1	2	2	4	4	0	0	4	1	0
Thionyl Chloride	4	4	3	1	2	2	4	4	2	1	2	0	0
Thiophene	4	4	4	1	4	2	4	4	4	1	4	0	0
Thiophosphoryl Chloride	4	1	1	1	3	1	3	3	1	0	1	0	2
Thiourea	4	1	1	1	3	1	3	3	1	0	1	0	2
Thorium Nitrate	4	1	1	1	3	1	3	3	1	0	1	0	2
Tidewater Multigear, 140 EP Lube	1	2	4	1	1	1	1	1	4	0	4	1	4
Tidewater Oil, Beedol	1	2	4	1	1	1	1	1	4	0	4	1	2
Tin Ammonium Chloride	4	1	1	1	3	1	3	3	1	0	1	0	2
Tin Chloride	1	2	1	1	1	1	1	1	1	1	1	0	2
Tin Tetrachloride	1	2	4	1	1	1	1	1	4	0	4	0	2
Titanic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Titanium Dioxide	4	1	1	1	2	1	3	3	1	0	1	0	2
Titanium Sulfate	4	1	1	1	3	1	3	3	1	0	1	0	2
Titanium Tetrachloride	2	2	4	2	1	2	2	2	1	1	1	2	4
Toluene	4	4	4	1	2	2	4	4	4	1	4	4	4
Toluene Diisocyanate	4	4	2	1	4	4	4	4	4	0	4	4	4
Toluene Sulfonic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Toluene Sulfonyl Chloride	4	4	4	1	1	2	2	2	4	0	4	0	0
Toluenesulfonic Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Toluidine	4	4	4	1	3	2	2	2	4	0	4	0	0
Toluol	4	1	1	1	3	1	3	3	1	0	1	0	2
Toluquinone	4	4	4	1	1	2	2	2	4	0	4	0	0
Tolylaldehyde, PARA	4	1	1	1	3	1	3	3	1	0	1	0	2
Tosyl Arginine Methyl Ester	0	4	3	1	4	0	4	4	0	0	0	4	0
Town Gas, Benzene Free	1	2	4	1	1	1	1	1	4	1	4	0	1
Transformer Oil	1	4	4	1	1	1	1	1	4	1	4	1	2
Transmission Fluid, Type A	1	2	4	1	1	1	1	1	4	1	4	1	2
Triacetin	4	2	1	1	4	4	2	2	2	1	4	4	0
Triallyl Phosphate	0	0	1	1	1	2	0	4	0	0	0	1	3
Triaryl Phosphate	4	4	1	1	1	2	4	4	4	0	4	1	3
Tribromomethylbenzene	4	4	4	1	1	2	2	2	4	0	4	0	0
Tributoxyethyl Phosphate	4	4	1	1	2	2	4	4	4	1	4	1	0
Tributyl Citrate	4	1	1	1	4	1	3	3	1	0	1	0	2
Tributyl Mercaptan	4	4	4	1	2	3	4	4	4	0	4	0	4
Tributyl Phosphate	4	4	1	1	4	4	4	4	4	1	4	2	4
Trichloroacetic Acid	4	4	2	1	4	4	2	2	2	1	2	3	0
Trichloroacetyl Chloride	4	4	4	1	1	2	2	2	4	0	4	0	0
Trichlorobenzene	4	4	4	1	2	2	2	2	4	0	4	0	0
Trichloroethane	4	4	4	1	1	2	4	4	4	0	4	4	4
Trichloroethanolamine	4	1	1	1	3	1	3	3	1	0	1	0	2
Trichloroethyl Phosphate	0	4	0	2	4	0	4	4	0	1	0	0	0

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Trichloroethylene	4	4	4	1	1	2	3	3	4	1	4	4	4
Trichlorofluoromethane	0	0	4	2	2	2	0	2	0	0	0	4	4
Trichloromethane	4	4	4	1	1	2	4	4	4	0	4	0	4
Trichloronitromethane	4	1	1	1	3	1	3	3	1	0	1	0	2
Trichloropropane	4	4	4	1	1	2	4	4	4	0	4	0	4
Trichlorosilane	4	4	4	1	1	2	4	4	4	0	4	0	4
Trichlorotrifluoroethane	0	1	4	2	2	4	1	2	0	0	0	4	4
Tricresyl Phosphate	4	4	1	1	1	2	4	4	4	1	4	1	3
Triethanolamine	4	2	2	2	4	4	3	3	4	1	2	1	4
Triethyl Aluminium	0	0	3	1	2	0	0	4	0	1	0	0	0
Triethyl Borane	0	0	3	1	1	0	0	4	0	1	0	0	0
Triethyl Phosphate	4	4	4	1	1	2	2	2	4	0	4	0	0
Triethylene Glycol	4	1	1	1	2	1	3	3	1	0	1	0	2
Triethylenetetramine	4	1	1	1	4	1	3	3	1	0	1	0	2
Trifluoroacetic Acid	4	1	1	2	3	1	3	3	1	0	1	0	2
Trifluoroethane	4	4	4	1	1	2	4	4	4	0	4	2	4
Trifluoromethane	4	4	4	1	1	2	4	4	4	0	4	0	4
Trifluorovinylchloride	4	4	4	1	1	2	2	2	4	0	4	0	0
Triglycol	0	1	1	1	1	0	1	1	1	1	1	0	0
Triisopropylbenzylchloride	4	4	4	1	1	2	2	2	4	0	4	0	0
Trimethyl Borate	4	4	4	1	1	2	2	2	4	0	4	0	0
Trimethylamine	4	1	1	2	4	1	3	3	1	0	1	0	2
Trimethylbenzene	4	4	4	1	1	2	2	2	4	0	4	0	0
Trimethylolpropane	0	2	2	1	1	0	4	4	2	1	0	0	0
Trimethylpentane	1	2	4	1	1	1	1	1	4	0	4	0	2
Trinitrotoluene	4	2	4	1	2	2	4	4	4	1	4	2	0
Trioctyl Phosphate	4	4	2	1	2	2	4	4	4	1	4	1	3
Triphenyl Phosphite	4	1	1	1	3	1	3	3	1	0	1	0	2
Tripoly Phosphate	4	3	1	1	2	1	4	4	4	0	4	1	3
Tripotassium Phosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Trisodium Phosphate	4	2	1	1	1	1	1	1	1	1	1	0	1
Tung Oil	0	2	4	1	1	2	1	1	4	0	4	1	4
Tungsten Hexafluoride	0	0	0	1	0	0	0	0	0	0	0	0	0
Turbine Oil	1	4	4	1	1	1	1	1	4	1	4	1	4
Turbo Oil #35	1	2	4	1	1	1	1	1	4	0	4	1	4
Turpentine	2	4	4	1	2	2	1	1	4	1	4	1	4
Ucon Hydrolube J-4	4	2	1	1	1	2	1	2	0	0	1	1	1
Ucon Lubricant 50-HB-100	0	1	1	1	1	1	1	1	1	0	1	0	1
Ucon Lubricant 50-HB-260	0	1	1	1	1	1	1	1	1	0	1	0	1
Ucon Lubricant 50-HB-5100	0	1	1	1	1	1	1	1	1	0	1	0	1
Ucon Lubricant 50-HB-55	0	1	1	1	1	1	1	1	1	0	1	0	1
Ucon Lubricant 50-HB-660	0	1	1	1	1	1	1	1	1	0	1	0	1
Ucon Lubricant LB-1145	0	1	1	1	1	1	1	1	1	0	1	0	1
Ucon Lubricant LB-135	0	1	1	1	1	1	1	1	1	0	1	0	1

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
Ucon Lubricant LB-285	0	1	1	1	1	1	1	1	1	0	1	0	1
Ucon Lubricant LB-300x	0	1	1	1	1	1	1	1	1	0	1	0	1
Ucon Lubricant LB-625	0	1	1	1	1	1	1	1	1	0	1	0	1
Ucon Lubricant LB-65	0	1	1	1	1	1	1	1	2	0	2	1	1
Ucon Oil 50-HB-280X	0	2	1	1	3	0	2	2	0	0	0	1	0
Ucon Oil Heat Transfer 500	0	1	1	1	1	1	1	1	1	0	1	0	1
Ucon Oil LB-385	0	1	1	1	4	1	1	1	1	0	1	1	1
Ucon Oil LB-400X	0	1	1	1	4	1	1	1	1	0	1	1	1
Ultra Pure Deionized Water	4	1	2	1	2	1	3	3	1	0	1	2	2
Undecylenic Acid	4	4	4	1	1	2	2	2	4	0	4	0	0
Undecylic Acid	4	4	4	1	1	2	2	2	4	0	4	0	0
Univis 40 Hydraulic Fluid	1	2	4	1	1	1	1	1	4	0	4	1	4
Univolt No. 35 Mineral Oil	1	2	4	1	1	1	1	1	4	0	4	1	4
Unsymmetrical Dimethyl Hydrazine	0	2	1	2	4	4	2	2	1	0	2	3	4
Uranium Hexachloride	0	0	0	1	1	0	0	0	0	0	0	0	0
Urea	0	2	1	1	1	0	1	1	1	1	1	0	0
Uric Acid	4	1	1	1	3	1	3	3	1	0	1	0	2
Valeraldehyde	4	1	1	1	4	1	3	3	1	0	1	0	2
Valeric Acid	4	1	1	1	1	1	3	3	1	0	1	0	2
Vanadium Oxide	1	2	4	1	1	1	1	1	4	0	4	0	2
Vanadium Pentoxide	1	2	4	1	1	1	1	1	4	0	4	0	2
Varnish	4	4	4	1	1	2	2	2	4	1	4	2	4
Vaseline	1	1	4	1	1	1	1	1	4	1	4	0	2
Vaseline Oil	1	1	4	1	1	1	1	1	4	1	4	0	2
Vegetable Oils	1	3	3	1	1	1	1	1	4	0	4	1	1
Versilube F44, F55	0	1	1	1	1	1	1	1	0	0	0	1	3
Versilube F-50	1	1	1	1	1	1	1	1	1	0	1	1	3
Vinegar	4	2	1	1	1	3	2	2	2	1	2	0	3
Vinyl Acetate	0	2	2	1	4	0	2	4	0	1	0	4	0
Vinyl Benzene	4	4	4	1	1	2	2	2	4	0	4	0	0
Vinyl Benzoate	4	4	4	1	1	2	2	2	4	0	4	0	0
Vinyl Chloride	4	4	4	1	2	2	2	4	4	1	4	0	0
Vinyl Cyanide	4	4	4	1	3	4	4	4	3	1	3	2	4
Vinyl Fluoride	4	4	4	1	2	2	2	2	4	0	4	0	0
Vinylidene Chloride	4	4	4	1	1	2	2	2	4	0	4	0	0
Vinylpyridine	4	4	4	1	1	2	2	2	4	0	4	0	0
Vitriol, White	4	1	1	1	3	1	3	3	1	0	1	0	2
Water	4	2	1	1	1	1	1	1	1	1	1	1	2
Wax Alcohol	0	2	4	1	1	0	2	1	4	1	0	0	0
Wemco C	1	2	4	1	1	1	1	1	4	0	4	1	4
Whiskey	4	1	1	1	1	1	1	1	1	1	1	1	1
White Liquor	0	1	1	1	1	0	1	1	0	0	0	1	0
White Lye	0	2	1	2	4	0	2	2	4	1	1	0	0

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide (Continued)

	ACM	CR	EPDM	FFKM	FKM	FMVQ	HNBR	NBR	NR	PTFE	SBR	TFE	VMQ
White Oil	1	2	4	1	1	1	1	1	4	1	4	1	1
White Pine Oil	0	4	4	1	1	1	2	2	4	0	4	1	4
White Pine Tar	0	4	4	1	1	1	2	2	4	1	4	0	4
White Spirit	1	2	4	1	1	0	2	1	4	1	4	0	0
Wine	4	1	1	1	1	1	1	1	1	1	1	1	1
Wolmar Salts	2	2	1	1	1	1	1	1	1	0	1	1	1
Wood Alcohol	4	1	1	1	4	1	1	1	1	0	1	0	1
Wood Oil	1	2	4	1	1	2	1	1	4	0	4	1	4
Wool Fat	1	1	1	1	1	1	1	1	2	1	1	0	1
Xenon	1	1	1	1	1	1	1	1	1	0	1	1	1
Xylamon, Wood Preservative	4	4	4	1	2	0	4	4	4	1	4	0	0
Xylene	4	4	4	1	2	1	4	4	4	1	4	4	4
Xylidenes-													
Mixed-Aromatic Amines	4	4	1	1	4	4	3	3	4	0	4	2	4
Xylidine	0	0	4	1	4	4	0	3	0	0	0	2	4
Xylol	4	4	4	1	1	1	4	4	4	0	4	4	4
Yeast, Aqueous	0	1	1	1	1	1	1	1	1	1	1	0	1
Zeolites	1	1	1	1	1	1	1	1	1	1	1	1	1
Zinc Acetate	1	2	1	1	4	4	2	2	1	1	4	3	4
Zinc Ammonium Chloride	4	1	1	1	3	1	3	3	1	0	1	0	2
Zinc Chloride	4	1	1	1	1	1	1	1	1	0	1	1	1
Zinc Chromate	4	1	1	1	3	1	3	3	1	0	1	0	2
Zinc Cyanide	4	1	1	1	3	1	3	3	1	0	1	0	2
Zinc Diethyldithiocarbamate	4	1	1	1	3	1	3	3	1	0	1	0	2
Zinc Dihydrogen Phosphate	4	1	1	1	3	1	3	3	1	0	1	0	2
Zinc Hydrosulfite	4	1	1	1	3	1	3	3	1	0	1	0	2
Zinc Nitrate	4	0	1	1	1	1	1	1	1	0	1	0	0
Zinc Oxide	4	0	1	1	1	1	1	1	1	0	1	0	0
Zinc Phenolsulfonate	4	1	1	1	3	1	3	3	1	0	1	0	2
Zinc Phosphate	4	1	1	1	1	1	1	1	1	0	1	0	1
Zinc Salts	4	1	1	1	1	1	1	1	1	0	1	1	1
Zinc Stearate	4	1	1	1	3	1	3	3	1	0	1	0	2
Zinc Sulfate	4	1	1	1	1	1	1	1	2	0	2	1	1
Zinc Sulfide	4	1	1	1	3	1	3	3	1	0	1	0	2
Zirconium Nitrate	4	1	1	1	1	1	1	1	2	0	2	0	1

1 Little or no effect - 2 Possible loss of physical properties - 3 Noticeable change - 4 Not suitable - 0 Insufficient info

Table 4-7: Chemical compatibility guide

4.8 Standard materials

The following pages show the physical properties of NewDealSeals/Origom most common standard compounds.

Material	Colour	Code
NBR 70	black	N70N00L
NBR 90	black	N90N00L
HNBR 70	black	H70N00C
EPDM 70	black	E70N00L
FKM 70	black	V70N00E
FKM 90	black	V90N00E
FKM 70	green	V70V00E
VMQ 70	redbrown	S70R00E

Many applications require approved compounds for a guaranteed performance. Origom has developed several compounds which meet the requirements made by the following authorities:

- DVGW - KTW
- FDA
- DGS
- NSF
- UL
- WRAS

See the table on the next pages for a list of currently available approved compounds. Of course, many other compounds for all kinds of applications are also available and, in addition, a compound suitable for your unique requirements can easily be developed. Our staff will be pleased to provide the best assistance possible in selecting the most appropriate compound.


NEW
DEAL
SEALS

DESCRIPTION	CODE	INSTITUTE	APPROVAL NR.	APPLICATION	
NBR 70 SH	N70N00L	DVGW	DIN EN 549 (04/1995) Classe B1/H3	DIN-DVGW NG 5112AT0061	• GAS
FKM 70 SH	V70N00E	DVGW	DIN EN 549 (04/1995) Classe E1/H3	DIN-DVGW NG 5112AT0060	
SILICONE 70 SH	S70R00E	DVGW	DIN EN 549 (04/1995) Classe E1/H3	DIN-DVGW NG 5112AM0219	
NBR 70 SH	N70N05C	DVGW	DIN EN 549 (04/1995) Classe B1/H3	DIN-DVGW NG 5112AR0534	
FKM 70 SH	V70V05T	DVGW	DIN EN 549 (04/1995) Classe E1/H3	DIN-DVGW NG 5112BP0289	
NBR 70 SH	N70N06G	TZW	DIRETTIVA KTW (BGes.Bl. Jg.86.6.Mitt.ff) im Bereich Dichtungen D1 und D2		• POTABLE WATER
NBR 85 SH	N85N00G	TZW	DIRETTIVA KTW (BGes.Bl. Jg.86.6.Mitt.ff) im Bereich Dichtungen D1 und D2		

Table 4-8: Approved compounds

DESCRIPTION	CODE	INSTITUTE	APPROVAL NR.	APPLICATION	
NBR 70 SH	N70N06G	CERISIE	F.D.A. - TITLE 21 - Parts 170 to 199 - Item 177.2600 (e) ed (f)	544	• FOOD
NBR 70 SH	N70N05C	CERISIE	F.D.A. - TITLE 21 - Parts 170 to 199 - Item 177.2600 (e) ed (f)	289/B	
EPDM 70 SH PEROXIDE CURED	E70N00C	CERISIE	F.D.A. - TITLE 21 - Parts 170 to 199 - Item 177.2600 (e) ed (f)	289/A	
EPDM 80 SH PEROXIDE CURED	E80N00C	CERISIE	F.D.A. - TITLE 21 - Parts 170 to 199 - Item 177.2600 (e) ed (f)	402/A	
NBR 70 SH	N70N06G	ISTITUT PASTEUR DE LILLE	CIRCOLARE DGS/VS4 n°2000/232-27 Aprile 2000 ANNEXE C	//	• POTABLE WATER
SILICONE 40 SH	S40B00E	ISTITUT PASTEUR DE LILLE	CIRCOLARE DGS/VS4 n°2000/232-27 Aprile 2000 ANNEXE C	//	
NBR 85 SH	N85N00G	ISTITUT PASTEUR DE LILLE	CIRCOLARE DGS/VS4 n°2000/232- 27 Aprile 2000 ANNEXE C	//	
EPDM 70 SH PEROXIDE CURED	E70N01C	ISTITUT PASTEUR DE LILLE	CIRCOLARE DGS/VS4 n°2000/232-27 Aprile 2000 CIRCOLARE DGS/VS4 n°99/217-12 Aprile 1999	04 MAT LI 020	
EPDM 60 SH PEROXIDE CURED	E60N01C	ISTITUT PASTEUR DE LILLE	CIRCOLARE DGS/VS4 n°2000/232-27 Aprile 2000 CIRCOLARE DGS/VS4 n°99/217-12 Aprile 1999	08 CLP LI 002	

Table 4-8: Approved compounds (Continued)

DESCRIPTION	CODE	INSTITUTE	APPROVAL NR.	APPLICATION	
NBR 70 SH	N70N06G	NSF	NSF/ANSI STANDARD 61/6 – 61/9	1A500-01/ 1A501-01	• POTABLE WATER
NBR 85 SH	N85N00G	NSF	NSF/ANSI STANDARD 61/6 – 61/9	1A500-01/ 1A501-01	
EPDM 70 SH PEROXIDE CURED	E70N01C	NSF	NSF/ANSI STANDARD 61/	1A500-01/ 1A501-01	
EPDM 70 SH	E70N01S	UL	UL 157 COMPONENT – GASKETS AND SEALS	MH29605	• LAUNDRY & DISH WASHING DETERGENTS
EPDM 70 SH PEROXIDE CURED	E70N01C	MPA	DIRETTIVA KTW (BGes.Bl. Jg.86.6.Mitt.ff) im Bereich Dichtungen D1 und D2 DIN EN 681-1 (05/2003) Type WB		• POTABLE WATER
NBR 70 SH	N70N06G	WRC / WRAS	WATER REGULATION ADVISORY SCHEME – BS 6920 FOR COLD AND HOT WATER		• POTABLE WATER

Table 4-8: Approved compounds (Continued)

ORIGOM S.p.A. GUARNIZIONI INDUSTRIALI Mod ORI 042 - Rev 02 del 20-02-06	SCHEDA TECNICA MESCOLA *TECHNICAL DATA SHEET*	MESCOLA *COMPOUND*	N70N00L		
		DESCRIZIONE *DESCRIPTION*	NBR 70 NERA		
		REVISIONE *INDEX* N°	3	Data *Date*	20/12/2006

VULCANIZZAZIONE PROVINI / *CURING CONDITIONS*							RICOTTURA / *POST CURING*
Placche / *Test sheets*	H = 2 mm	20	Min	a	160	°C	3 Ore / *Hours* a 130 °C
Placche / *Test sheets*	H = 6 mm	40	Min	a	160	°C	
Tassello / *Button 1*	H = 12,5 mm D = 29 mm	50	Min	a	160	°C	
Tassello / *Button 2*	H = 6 mm D = 36 mm		Min	a		°C	

Caratteristiche ***Technical properties***	**Metodo di prova** ***Test method***	**Valori garantiti** ***Guaranteed Values***	**Unità di misura** ***Unit of measure***
Durezza / *Hardness*	ASTM D 2240	70+/-5	Shore A
Densità / *Specific gravity*	ASTM D 1817	1,24+/-0,02	g/cm3
Carico di rottura / *Tensile strenght*	ASTM D 412 C	≥ 14	N/mm2 (Mpa)
Allungamento a rottura / *Elongation*	ASTM D 412 C	≥ 300	%
Lacerazione / *Tear resistance*	ASTM D 624 B	≥ 40	N/mm
Lacerazione / *Tear resistance*	DIN 53515	≥ 14	N/mm
Compression set deform. 25% 168 Ore a 100 °C	DIN 53517 A	≤ 40	%
Compression set deform. 25% 22 Ore a 100 °C	ASTM D 395 B	≤ 10	%
Compression set deform. 25% 70 Ore a 100 °C	ASTM D 395 B	≤ 15	%
Compression set deform. 25% 72 Ore a 0 °C	DIN 53517 A	≤ 40	%
Modulo / *Model* al 100%	DIN 53504	≥ 4,5	N/mm2 (Mpa)
Res. Freddo / *Cold test* - Brittleness *	ASTM D 2137 A	≤ -25	°C
Res. Freddo / *Cold test* - TR 10	ASTM D 1329	≤ -20	°C
Res. Freddo / *Cold test* - TR 50	ASTM D 1329	≤ -15	°C

Prova ozono / *Ozone resistence test* *test method:*	concentrazione *concentration*	pphm dopo / *after*	ore a / *hours*	°C	Allungamento *Elongation*	%

Accettabilità: nessuna screpolatura visibile ad occhio nudo / *acceptability: no visible crack to naked eyes*

Ambiente *Environment*	Metodo *Test method*	Tempo *Time*	Temp. [°C]	Δ Sh.A Durezza *Hardness* Richiesto *Required*	Δ % Carico rottura *Tensile strenght* Richiesto *Required*	Δ % Allungamento *Elongation* Richiesto *Required*	Δ % Volume *Volume* Richiesto *Required*	Δ % Peso *Weight* Richiesto *Required*
ARIA	ASTM D 573	70	100	+8/-10	≥-20	≥-25	0/-5	
ARIA	ASTM D 573	168	100	+/-10	≥-40	≥-40		
ASTM 1	ASTM D 471	70	100	-5/+6	≥-25	≥-45	-8/+5	
ASTM 2	ASTM D 471	168	80	+/-10				+15/-10
ASTM 3	ASTM D 471	70	100	-10/+0	≥-45	≥-45	0/+15	
H2O DISTILL.	ASTM D 471	70	100	+/-10			+/-15	
N PENTANO+	ASTM D 471	72	23					+10/-5
+ AIR DRY	ASTM D 573	168	40					+5/-8

Table 4-9: Physical and mechanical properties NBR 70 BLACK

ORIGOM S.p.A. GUARNIZIONI INDUSTRIALI Mod ORI 042 - Rev 02 del 20-02-06	SCHEDA TECNICA MESCOLA *TECHNICAL DATA SHEET*	MESCOLA *COMPOUND*	N70N00L
		DESCRIZIONE *DESCRIPTION*	NBR 70 NERA
		REVISIONE *INDEX* N°	3 Data *Date* 20/12/2006

VULCANIZZAZIONE PROVINI / *CURING CONDITIONS*							RICOTTURA / *POST CURING*
Placche / *Test sheets*	H = 2 mm	20	Min	a	160	°C	3 Ore / *Hours* a 130 °C
Placche / *Test sheets*	H = 6 mm	40	Min	a	160	°C	
Tassello / *Button 1*	H = 12,5 mm D = 29 mm	50	Min	a	160	°C	
Tassello / *Button 2*	H = 6 mm D = 36 mm		Min	a		°C	

Note / *Notes*
Resistenza calore – Aria 70 ore a 125°C con provino raffreddato e piegato attorno a mandrino Ø 2 mm nessuna rottura – Risultato **OK**
Heat Resistance – Air 70 hours at 125°C with test sample cooled and turned around Ø 2 mm expander no cracking – Result **OK**
Resistenza alla basse temperature – Aria 2 ore a –30°C provino riportato a temperatura ambiente e piegato attorno a mandrino Ø 2 mm nessuna rottura – Risultato **OK**
Low Temperature Resistance – Air 2 hours at –30°C test sample brought back to ambient temperature and turned around Ø 2 mm expander no cracking – Result **OK**
According to :ASTM D 2000 SAE J 200 M2 BG 714 B14 EA14 EO14 EO34 (Z1)*
According to: WN 2020
According to: DIN EN 549 B1 H3(0°C at 80°C)

Prove effettuabili presso Laboratorio interno nostro Fornitore. Laboratorio non accreditato da ente terzo.
Tests may be carried out at our own Supplier's inside Laboratory. This Laboratory has not been credited by a third institute.

Data / *Date* 20/12/2006 Compilato da / *Compiled* by : Mauro Freti

Table 4-9: Physical and mechanical properties NBR 70 BLACK (Continued)

ORIGOM S.p.A. GUARNIZIONI INDUSTRIALI Mod ORI 042 - Rev 02 del 20-02-06	SCHEDA TECNICA MESCOLA *TECHNICAL DATA SHEET*	MESCOLA *COMPOUND*	N90N00L
		DESCRIZIONE *DESCRIPTION*	NBR 90 SH. NERO
		REVISIONE *INDEX* N°	2 — Data / *Date* 22/12/2006

VULCANIZZAZIONE PROVINI / *CURING CONDITIONS*							RICOTTURA / *POST CURING*
Placche / *Test sheets*	H = 2 mm	20	Min	a	160	°C	
Placche / *Test sheets*	H = 6 mm		Min	a		°C	Ore / *Hours* a °C
Tassello / *Button 1*	H = 12,5 mm D = 29 mm	50	Min	a	160	°C	
Tassello / *Button 2*	H = 6 mm D = 36 mm		Min	a		°C	

Caratteristiche ***Technical properties***	**Metodo di prova** ***Test method***	**Valori garantiti** ***Guaranteed Values***	**Unità di misura** ***Unit of measure***
Durezza / *Hardness*	ASTM D 2240	90+/-5	Shore A
Densità / *Specific gravity*	ASTM D 1817	1,29+/-0,02	g/cm3
Carico di rottura / *Tensile strenght*	ASTM D 412 C	≥ 15	N/mm2 (Mpa)
Allungamento a rottura / *Elongation*	ASTM D 412 C	≥ 100	%
Lacerazione / *Tear resistance*	ASTM D 624 B	≥ 40	N/mm
Lacerazione / *Tear resistance*	DIN 53515	≥ 17	N/mm
Compression set deform. 25% 70 Ore a 125 °C	ASTM D 395 B	≤ 30	%
Compression set deform. 25% 70 Ore a 100 °C	ASTM D 395 B	≤ 17	%
Modulo / *Model* al 100%	DIN 53504	≥ 4,5	N/mm2 (Mpa)
Res. Freddo / *Cold test* - Brittleness	ASTM D 2137 A	≤ -24	°C
Res. Freddo / *Cold test* - TR 10	ASTM D 1329	≤ -20	°C

Prova ozono / *Ozone resistence test* — concentrazione / *concentration* — pphm dopo / *after* — ore a / *hours* — °C — Allungamento / *Elongation* — %
test method:

Accettabilità: nessuna screpolatura visibile ad occhio nudo / *acceptability: no visible crack to naked eyes*

Ambiente *Environment*	Metodo *Test method*	Tempo *Time*	Temp. [°C]	Δ Sh.A Durezza *Hardness* Richiesto *Required*	Δ % Carico rottura *Tensile strenght* Richiesto *Required*	Δ % Allungamento *Elongation* Richiesto *Required*	Δ % Volume *Volume* Richiesto *Required*	Δ % Peso *Weight* Richiesto *Required*
ARIA	ASTM D 573	70	100	≤+8	≥-20	≥-30	0/-5	
ASTM 1	ASTM D 471	70	100	-5/+6	≥-25	≥-45	-8/+5	
ASTM 3	ASTM D 471	70	100	0/-10	≥-45	≥-45	0/+15	

Note / *Notes*

Resistenza calore – Aria 70 ore a 125°C con provino raffreddato e piegato attorno a mandrino Ø 2 mm nessuna rottura – Risultato **OK**

Heat Resistance – Air 70 hours at 125°C with test sample cooled and turned around Ø 2 mm expander no cracking – Result **OK**

Resistenza alla basse temperature – Aria 2 ore a –30°C provino riportato a temperatura ambiente e piegato attorno a mandrino Ø 2 mm nessuna rottura – Risultato **OK**

Low Temperature Resistance – Air 2 hours at –30°C test sample brought back to ambient temperature and turned around Ø 2 mm expander no cracking – Result **OK**

According to WN 2020

Prove effettuabili presso Laboratorio interno nostro Fornitore. Laboratorio non accreditato da ente terzo.
Tests may be carried out at our own Supplier's inside Laboratory. This Laboratory has not been credited by a third institute.

Data / *Date* 22/12/2006 — Compilato da / *Compiled* by : Mauro Freti

Table 4-10: Physical and mechanical properties NBR 90 BLACK

ORIGOM S.p.A. GUARNIZIONI INDUSTRIALI Mod ORI 042 - Rev 02 del 20-02-06	SCHEDA TECNICA MESCOLA *TECHNICAL DATA SHEET*	MESCOLA *COMPOUND*	E70N00L
		DESCRIZIONE *DESCRIPTION*	EPDM 70SH.NERO
		REVISIONE *INDEX* N°	2 — Data / *Date* 14/11/2006

VULCANIZZAZIONE PROVINI / *CURING CONDITIONS*							RICOTTURA / *POST CURING*
Placche / *Test sheets*	H = 2 mm	20	Min	a	160	°C	Ore / *Hours* a °C
Placche / *Test sheets*	H = 6 mm		Min	a		°C	
Tassello / *Button 1*	H = 12,5 mm D = 29 mm	50	Min	a	160	°C	
Tassello / *Button 2*	H = 6 mm D = 36 mm		Min	a		°C	

Caratteristiche ***Technical properties***	**Metodo di prova** ***Test method***	**Valori garantiti** ***Guaranteed Values***	**Unità di misura** ***Unit of measure***
Durezza / *Hardness*	ASTM D 2240	70+/-5	Shore A
Densità / *Specific gravity*	ASTM D 1817	1,14+/-0,02	g/cm3
Carico di rottura / *Tensile strenght*	ASTM D 412 C	≥ 13	N/mm2 (Mpa)
Allungamento a rottura / *Elongation*	ASTM D 412 C	≥ 300	%
Lacerazione / *Tear resistance*	ASTM D 624 B	≥ 30	N/mm
Lacerazione / *Tear resistance*	DIN 53515	≥	N/mm
Compression set deform. 25% 70 Ore a 70 °C	ASTM D 395 B	≤ 20	%
Compression set deform. 25% 70 Ore a 100 °C	ASTM D 395 B	≤ 35	%
Compression set deform. 25% 70 Ore a 125 °C	ASTM D 395 B	≤ 35	%
Modulo / *Model* al 100%	ASTM D 412 C	≥	N/mm2 (Mpa)
Res. Freddo / *Cold test* - Brittleness	ASTM D 2137 A	≤	°C
Res. Freddo / *Cold test* - TR 10	ASTM D 1329	≤	°C
Res. Freddo / *Cold test* - TR 50	ASTM D 1329	≤	°C
Ceneri / *Ash*	ASTM D 297		%
Resa elastica / *Rebound*	ISO 4662	≥ 35	%

Prova ozono / *Ozone resistence test* *test method:* — concentrazione / *concentration* 50 pphm dopo / *after* 72 ore a / *hours* 25 °C — Allungamento / *Elongation* 20 %

Accettabilità: nessuna screpolatura visibile ad occhio nudo / *acceptability: no visible crack to naked eyes*

Ambiente *Environment*	Metodo *Test method*	Tempo *Time*	Temp. [°C]	Δ Sh.A Durezza *Hardness* Richiesto *Required*	Δ % Carico rottura *Tensile strenght* Richiesto *Required*	Δ % Allungamento *Elongation* Richiesto *Required*	Δ % Volume *Volume* Richiesto *Required*	Δ % Peso *Weight* Richiesto *Required*
ARIA	ASTM D 573	70	100	0/+5	+/-20	+/-25	+/-5	
ARIA	ASTM D 573	70	125	≤ +10	+/-20	≥ -50	+/-5	
H2O DISTIL.	ASTM D 471	70	100	0/+5	+/-20	+/-25	+/-5	

Note / *Notes*

Prove effettuabili presso Laboratorio interno nostro Fornitore. Laboratorio non accreditato da ente terzo.
Tests may be carried out at our own Supplier's inside Laboratory. This Laboratory has not been credited by a third institute.

Data / *Date* 14/11/2006 Compilato da / *Compiled* by : Freti Mauro

Table 4-11: Physical and mechanical properties EPDM 70 BLACK

ORIGOM S.p.A. GUARNIZIONI INDUSTRIALI Mod ORI 042 - Rev 02 del 20-02-06	SCHEDA TECNICA MESCOLA *TECHNICAL DATA SHEET*	MESCOLA *COMPOUND*	V70N00E		
		DESCRIZIONE *DESCRIPTION*	FKM 70 SH. NERO		
		REVISIONE *INDEX* N°	3	Data *Date*	16/11/2006

VULCANIZZAZIONE PROVINI / *CURING CONDITIONS*						RICOTTURA / *POST CURING*
Placche / *Test sheets*	H = 2 mm	10	Min a	180	°C	
Placche / *Test sheets*	H = 6 mm	40	Min a	165	°C	24 Ore / *Hours* a 240 °C
Tassello / *Button 1*	H = 12,5 mm D = 29 mm	40	Min a	165	°C	
Tassello / *Button 2*	H = 6 mm D = 36 mm		Min a		°C	

Caratteristiche ***Technical properties***	**Metodo di prova** ***Test method***	**Valori garantiti** ***Guaranteed Values***	**Unità di misura** ***Unit of measure***
Durezza / *Hardness*	ASTM D 2240	70+/-5	Shore A
Densità / *Specific gravity*	ASTM D 1817	1,87+/-0,02	g/cm3
Carico di rottura / *Tensile strenght*	ASTM D 412 C	≥ 11	N/mm2 (Mpa)
Allungamento a rottura / *Elongation*	ASTM D 412 C	≥ 150	%
Lacerazione / *Tear resistance*	ASTM D 624 B	≥	N/mm
Lacerazione / *Tear resistance*	DIN 53515	≥	N/mm
Compression set deform. 25% 22 Ore a 200 °C	ASTM D 395 B	≤ 15	%
Compression set deform. 25% 70 Ore a 200 °C	ASTM D 395 B	≤ 20	%
Compression set deform. 25% Ore a °C	DIN 53517 A	≤	%
Modulo / *Model* al 100%	ASTM D 412 C	≥	N/mm2 (Mpa)
Res. Freddo / *Cold test* - Brittleness	ASTM D 2137 A	≤	°C
Res. Freddo / *Cold test* - TR 10	ASTM D 1329	≤	°C
Res. Freddo / *Cold test* - TR 50	ASTM D 1329	≤	°C
Ceneri / *Ash*	ASTM D 297		%
Resa elastica / *Rebound*	ASTM D 1054	≥	%

Prova ozono / *Ozone resistence test* *test method:*	concentrazione *concentration*	pphm dopo / *after*	ore a / *hours*	°C	Allungamento *Elongation*	%

Accettabilità: nessuna screpolatura visibile ad occhio nudo / *acceptability: no visible crack to naked eyes*

Ambiente *Environment*	Metodo *Test method*	Tempo *Time*	Temp. [°C]	Δ Sh.A Durezza *Hardness* Richiesto *Required*	Δ % Carico rottura *Tensile strenght* Richiesto *Required*	Δ % Allungamento *Elongation* Richiesto *Required*	Δ % Volume *Volume* Richiesto *Required*	Δ % Peso *Weight* Richiesto *Required*
ARIA	ASTM D 573	70	250	≤ +10	≥-25	≥-25		
ASTM 1	ASTM D 471	70	150	+/-5	≥-10	≥-20	+/-5	
ASTM 3	ASTM D 471	70	150	+/-5	≥-15	≥-25	≤ +10	

Note / *Notes*

Prove effettuabili presso Laboratorio interno nostro Fornitore. Laboratorio non accreditato da ente terzo.
Tests may be carried out at our own Supplier's inside Laboratory. This Laboratory has not been credited by a third institute.

Data / *Date* 16/11/2006   Compilato da / *Compiled* by : Freti Mauro

Table 4-12: Physical and mechanical properties FKM 70 BLACK

ORIGOM S.p.A. GUARNIZIONI INDUSTRIALI Mod ORI 042 - Rev 02 del 20-02-06	SCHEDA TECNICA MESCOLA *TECHNICAL DATA SHEET*	MESCOLA *COMPOUND*	V90N00E		
		DESCRIZIONE *DESCRIPTION*	FKM 90 SH. NERO		
		REVISIONE *INDEX* N°	2	Data *Date*	23/11/2006

VULCANIZZAZIONE PROVINI / *CURING CONDITIONS*							RICOTTURA / *POST CURING*
Placche / *Test sheets*	H = 2 mm	10	Min	a	180	°C	
Placche / *Test sheets*	H = 6 mm	40	Min	a	165	°C	24 Ore / *Hours* a 240 °C
Tassello / *Button 1*	H = 12,5 mm D = 29 mm	40	Min	a	165	°C	
Tassello / *Button 2*	H = 6 mm D = 36 mm		Min	a		°C	

Caratteristiche ***Technical properties***	**Metodo di prova** ***Test method***	**Valori garantiti** ***Guaranteed Values***	**Unità di misura** ***Unit of measure***
Durezza / *Hardness*	ASTM D 2240	90+/-5	Shore A
Densità / *Specific gravity*	ASTM D 1817	2,06+/-0,02	g/cm3
Carico di rottura / *Tensile strenght*	ASTM D 412 C	≥ 10	N/mm2 (Mpa)
Allungamento a rottura / *Elongation*	ASTM D 412 C	≥ 100	%
Lacerazione / *Tear resistance*	ASTM D 624 B	≥	N/mm
Lacerazione / *Tear resistance*	DIN 53515	≥	N/mm
Compression set deform. 25% 22 Ore a 200 °C	DIN 53517 A	≤ 15	%
Compression set deform. 25% 70 Ore a 200 °C	DIN 53517 A	≤ 30	%
Compression set deform. 25% 70 Ore a 150 °C	DIN 53517 A	≤ 20	%
Modulo / *Model* al 100%	ASTM D 412 C	≥	N/mm2 (Mpa)
Res. Freddo / *Cold test* - Brittleness	ASTM D 2137 A	≤	°C
Res. Freddo / *Cold test* - TR 10	ASTM D 1329	≤ -10	°C
Res. Freddo / *Cold test* - TR 50	ASTM D 1329	≤	°C
Ceneri / *Ash*	ASTM D 297		%
Resa elastica / *Rebound*	ASTM D 1054	≥	%

Prova ozono / *Ozone resistence test* *test method:*	concentrazione *concentration*	pphm dopo / *after*	ore a / *hours*	°C	Allungamento *Elongation*	%

Accettabilità: nessuna screpolatura visibile ad occhio nudo / *acceptability: no visible crack to naked eyes*

Ambiente *Environment*	Metodo *Test method*	Tempo *Time*	Temp. [°C]	Δ Sh.A Durezza *Hardness* Richiesto *Required*	Δ % Carico rottura *Tensile strenght* Richiesto *Required*	Δ % Allungamento *Elongation* Richiesto *Required*	Δ % Volume *Volume* Richiesto *Required*	Δ % Peso *Weight* Richiesto *Required*
ARIA	DIN 53508	70	250	≤+10	≥-25	≥-25		
ASTM 1	DIN 53521	70	150	+/-5	≥-10	≥-20	+/-5	
ASTM 3	DIN 53521	70	150	+/-5	≥-15	≥-20	≤+10	
ARIA	DIN 53508	672	200	≤+10				
SAE 30/40	DIN 53521	672	150				0/+10	
DIESEL	DIN 53521	672	100				0/+10	
H2O+ANTIC.	DIN 53521	672	100				0/+15	
H2O	DIN 53521	672	130				-5/+10	

According to 4-107.270.909 (Rif fpm 90SH.)

Prove effettuabili presso Laboratorio interno nostro Fornitore. Laboratorio non accreditato da ente terzo.
Tests may be carried out at our own Supplier's inside Laboratory. This Laboratory has not been credited by a third institute.

Data / *Date* 23/11/2006 Compilato da / *Compiled* by : Freti Mauro

Table 4-13: Physical and mechanical properties FKM 90 BLACK

ORIGOM S.p.A. GUARNIZIONI INDUSTRIALI Mod ORI 042 - Rev 02 del 20-02-06	SCHEDA TECNICA MESCOLA *TECHNICAL DATA SHEET*	MESCOLA *COMPOUND*	V70V00E		
		DESCRIZIONE *DESCRIPTION*	FKM 70 SH. VERDE		
		REVISIONE *INDEX* N°	2	Data *Date*	16/11/2006

VULCANIZZAZIONE PROVINI / *CURING CONDITIONS*							RICOTTURA / *POST CURING*
Placche / *Test sheets*	H = 2 mm	10	Min	a	180	°C	24 Ore / *Hours* a 240 °C
Placche / *Test sheets*	H = 6 mm	40	Min	a	165	°C	
Tassello / *Button 1*	H = 12,5 mm D = 29 mm	40	Min	a	165	°C	
Tassello / *Button 2*	H = 6 mm D = 36 mm		Min	a		°C	

Caratteristiche ***Technical properties***	**Metodo di prova** ***Test method***	**Valori garantiti** ***Guaranteed Values***	**Unità di misura** ***Unit of measure***
Durezza / *Hardness*	ASTM D 2240	70+/-5	Shore A
Densità / *Specific gravity*	ASTM D 1817	2,20+/-0,02	g/cm3
Carico di rottura / *Tensile strenght*	ASTM D 412 C	≥ 12	N/mm2 (Mpa)
Allungamento a rottura / *Elongation*	ASTM D 412 C	≥ 125	%
Lacerazione / *Tear resistance*	ASTM D 624 B	≥ 30	N/mm
Lacerazione / *Tear resistance*	DIN 53515	≥	N/mm
Compression set deform. 25% 24 Ore a 175 °C	ASTM D 395 B	≤ 20	%
Compression set deform. 25% Ore a °C	ASTM D 395 B	≤	%
Compression set deform. 25% Ore a °C	DIN 53517 A	≤	%
Modulo / *Model* al 100%	ASTM D 412 C	≥	N/mm2 (Mpa)
Res. Freddo / *Cold test* - Brittleness	ASTM D 2137 A	≤	°C
Res. Freddo / *Cold test* - TR 10	ASTM D 1329	≤ -12	°C
Res. Freddo / *Cold test* - TR 50	ASTM D 1329	≤	°C
Ceneri / *Ash*	ASTM D 297		%
Resa elastica / *Rebound*	ASTM D 1054	≥	%

Prova ozono / *Ozone resistence test* test method: concentrazione / *concentration* pphm dopo / *after* ore a / *hours* °C Allungamento / *Elongation* %

Accettabilità: nessuna screpolatura visibile ad occhio nudo / *acceptability: no visible crack to naked eyes*

Ambiente *Environment*	Metodo *Test method*	Tempo *Time*	Temp. [°C]	Δ Sh.A Durezza *Hardness*	Δ % Carico rottura *Tensile strenght*	Δ % Allungamento *Elongation*	Δ % Volume *Volume*	Δ % Peso *Weight*
				Richiesto *Required*	Richiesto *Required*	Richiesto *Required*	Richiesto *Required*	Richiesto *Required*
ARIA	ASTM D 573	70	250	≤ +5	≥-25	≥-25		
ASTM 1	ASTM D 471	70	150	+/-5	≥-20	≥-25	+/-5	
ASTM 3	ASTM D 471	70	150	+/-5	≥-20	≥-30	≤ +5	
FUEL C	ASTM D 471	70	23	≥-5			≤ +10	

Note / *Notes*

Prove effettuabili presso Laboratorio interno nostro Fornitore. Laboratorio non accreditato da ente terzo.
Tests may be carried out at our own Supplier's inside Laboratory. This Laboratory has not been credited by a third institute.

Data / *Date* 16/11/2006 Compilato da / *Compiled* by : Freti Mauro

Table 4-14: Physical and mechanical properties FKM 70 GREEN

ORIGOM S.p.A GUARNIZIONI INDUSTRIALI Mod. ORI 042	SCHEDA TECNICA MESCOLA *TECHNICAL DATA SHEET*	MESCOLA / *COMPOUND*: S70R00E DESCRIZIONE / *DESCRIPTION*: Silicone 70 sh. rosso REV. 2 19/10/01

VULCANIZZAZIONE PROVINI/*CURING CONDITIONS*							RICOTTURA/*POST CURING*
Placche/*Test sheets*	H = 2 mm	10	Min	a	180	°C	4 ore / *hours* a 200 °C
Placche/*Test sheets*	H = 6 mm	40	Min	a	165	°C	
Tassello/*Button* 1	H = 12.5 mm D = 29 mm	40	Min	a	165	°C	
Tassello/*Button* 2	H = 6 mm D = 36 mm		Min	a		°C	

Caratteristiche / *Technical properties*	**Metodo di prova / *Test method***	**Valori garantiti / *Guaranteed values***	**Unità di misura / *Unit of measure***
Durezza / *Hardness*	ASTM D 2240	70+/-5	Shore A
Densità / *Specific gravity*	ASTM D 1817	1.41+/-0.02	g/cm3
Carico di rottura / *Tensile strenght*	ASTM D 412 C	>=50	Kg/cm2
Allungamento a rottura / *Elongation*	ASTM D 412 C	>=170	%
Lacerazione / *Tear resistence*	ASTM D 624 C		Kg/cm
Lacerazione / *Tear resistence*	DIN 53515		N/mm
Compression set deform. 25% 24 ore / *hours* a 175 °C	ASTM D 395 B	<=30	%
Compression set deform. 25% ore a °C	ASTM D 395 B		%
Compression set deform. 25% ore a °C	ASTM D 395 B		%
Modulo / *Model* al 100%	ASTM 412 C		N/mm2
Res. Freddo / *Cold test - Brittleness*	ASTM D 2137 A		°C
Res.Freddo / *Cold test - TR 10*	ASTM D 1329		°C
Res.Freddo / *Cold test - TR 50*	ASTM D 1329		°C
Ceneri / *Ashes*	ASTM D 297		%
Resa elastica / *Rebound*	ASTM D 1054		%

Prova ozono – concentrazione / *ozone resistence test – concentration* pphm dopo / *after* ore a / *hours to* Allungamento / *elongation*

Accettabilità: nessuna screpolatura visibile ad occhio nudo / *acceptability: no visible crack to naked eye*

Ambiente *Environment*	Metodo *Test method*	Tempo *Time*	Temp °C	Δ P.ti Sh.A Durezza / *Hardness*	Δ % Carico rottura *Tensile strenght*	Δ % Allungamento *Elongation*	Δ % Volume *Volume*	Δ % Peso *Weight*
				Garantito *Guaranteed*	Garantito *Guaranteed*	Garantito *Guaranteed*	Garantito *Guaranteed*	Garantito *Guaranteed*
ARIA	ASTM D 573	70	200	+/-10	>=-25	>=-45		
ASTM 1	ASTM D 471	70	150	>=-10	>=-20	>=-30	<=+10	
ASTM 3	ASTM D 471	70	150	>=-30	>=-50	>=-40	<=+50	

Data/*date* 19/10/01 Compilato da / *compiled by*: GRAZIANI ROBERTO

Table 4-15: Physical and mechanical properties VMQ 70 RED BROWN

ORIGOM S.p.A. GUARNIZIONI INDUSTRIALI	SCHEDA TECNICA MESCOLA *TECHNICAL DATA SHEET*	MESCOLA *COMPOUND*	H70N00C		
		DESCRIZIONE *DESCRIPTION*	HNBR 70 SH.NERO		
Mod ORI 042 - Rev 02 del 20-02-06		REVISIONE *INDEX* N°	4	Data *Date*	06/11/2006

VULCANIZZAZIONE PROVINI / *CURING CONDITIONS*							RICOTTURA / *POST CURING*
Placche / *Test sheets*	H = 2 mm	12	Min	a	177	°C	4 Ore / *Hours* a 160 °C
Placche / *Test sheets*	H = 6 mm	12	Min	a	177	°C	
Tassello / *Button 1*	H = 12,5 mm D = 29 mm	12	Min	a	177	°C	
Tassello / *Button 2*	H = 6 mm D = 36 mm	12	Min	a	177	°C	

Caratteristiche ***Technical properties***	**Metodo di prova** ***Test method***	**Valori garantiti** ***Guaranteed Values***	**Unità di misura** ***Unit of measure***
Durezza / *Hardness*	ASTM D 2240	70+/-5	Shore A
Densità / *Specific gravity*	ASTM D 1817	1,22+/-0,02	g/cm3
Carico di rottura / *Tensile strenght*	ASTM D 412 C	21+5	N/mm2 (Mpa)
Allungamento a rottura / *Elongation*	ASTM D 412 C	285+50	%
Lacerazione / *Tear resistance*	ASTM D 624 B	≥ 40	N/mm
Abrasione / *Abrasion Test*	DIN 53516	≤ 150	N/mm
Compression set deform. 25% 22 Ore a 175 °C	ASTM D 395 B	≤ 25	%
Compression set deform. 25% 70 Ore a 175 °C	ASTM D 395 B	≤ 45	%
Compression set deform. 25% 168 Ore a 100 °C	ASTM D 395 B	≤ 23	%
Compression set deform. 25% 24 Ore a 200 °C	ASTM D 395 B	≤ 40	%
Compression set deform. 25% 70 Ore a 23 °C	ASTM D 395 B	≤ 12	%
Compression set deform. 25% 22 Ore a 150 °C	ISO 815 B	≤ 25	%
Compression set deform. 25% 70 Ore a 150 °C	ISO 815 B	≤ 35	%
Tensionsion set deform. 25% 22 Ore a 100 °C	ASTM D 412 C	≤ 23	%
Modulo / *Model* al 100%	ASTM D 412 C	≥ 4	N/mm2 (Mpa)
Res. Freddo / *Cold test* - Brittleness	ASTM D 2137 A	≤ -40	°C
Res. Freddo / *Cold test* - TR 10	ASTM D 1329	≤ -20	°C
Res. Freddo / *Cold test* - TR 30	ASTM D 1329	≤ -10	°C
Res. Freddo / *Cold test* *	6h at -50°C	-50 no cracks	°C
Res. Freddo / *Cold test* **	24h at -35°C	-35 no cracks	°C
Resa elastica / *Rebound*	ASTM D 1054	≥ 40	%

Prova ozono / *Ozone resistence test* — *test method:* concentrazione / *concentration* 50 pphm dopo / *after* 96 ore a / *hours* 30 °C — Allungamento / *Elongation* 40 %

Accettabilità: nessuna screpolatura visibile ad occhio nudo / *acceptability: no visible crack to naked eyes*

Ambiente *Environment*	Metodo *Test method*	Tempo *Time*	Temp. [°C]	Δ Sh.A Durezza *Hardness* Richiesto *Required*	Δ % Carico rottura *Tensile strenght* Richiesto *Required*	Δ % Allungamento *Elongation* Richiesto *Required*	Δ % Volume *Volume* Richiesto *Required*	Δ % Peso *Weight* Richiesto *Required*
ARIA	ASTM D 573	72	125	≤+5		≥-30		
ARIA	ASTM D 573	94	70	0/+3	≥ 6	200/550		
FAM B	ASTM D 471	46	50	-30/-35			+102/+97	+68/+65
AIR DRY	ASTM D 573	22	70	+4/+0,5	16/+10,5	215/+140	-4/-4,5	-4,5/-5,5

Table 4-16: Physical and mechanical properties HNBR 70 BLACK

ORIGOM S.p.A. GUARNIZIONI INDUSTRIALI Mod ORI 042 - Rev 02 del 20-02-06	SCHEDA TECNICA MESCOLA *TECHNICAL DATA SHEET*	MESCOLA *COMPOUND*	H70N00C
		DESCRIZIONE *DESCRIPTION*	HNBR 70 SH.NERO
		REVISIONE *INDEX* N°	4 Data *Date* 06/11/2006

VULCANIZZAZIONE PROVINI / *CURING CONDITIONS*							RICOTTURA / *POST CURING*
Placche / *Test sheets*	H = 2 mm	12	Min	a	177	°C	4 Ore / *Hours* a 160 °C
Placche / *Test sheets*	H = 6 mm	12	Min	a	177	°C	
Tassello / *Button 1*	H = 12,5 mm D = 29 mm	12	Min	a	177	°C	
Tassello / *Button 2*	H = 6 mm D = 36 mm	12	Min	a	177	°C	

Note / ***Notes***
* **Prova di piegamento a freddo dopo condizionam. del provino 6H a -50°C/Fold up test after cooling 6H at -50°C**
** **Prova di piegamento a freddo dopo condizionam. del provino 24H a -35°C/Fold up test after cooling 24H at -35°C**
According to VW 2.8.1 C70 standard (11/2003)
According to Pierburg N 8.21381.00

Prove effettuabili presso Laboratorio interno nostro Fornitore. Laboratorio non accreditato da ente terzo.
Tests may be carried out at our own Supplier's inside Laboratory. This Laboratory has not been credited by a third institute.

Data / *Date* 07/11/2006   Compilato da / *Compiled* by : Freti Mauro

Table 4-16: Physical and mechanical properties HNBR 70 BLACK (Continued)

5 Design recommendations

5.1 Select the O-Ring size

Before selecting specific groove dimensions, it is necessary to know what size O-Ring is needed.
To complete this design step the following has to be established:

- Application
- Approximate size of the application (bore or piston diameter)
- Location of the groove (bore or piston/rod)

5.1.1 Select the inside diameter

O-Rings can be used in a wide variety of ways. Firstly, determine whether the application is static or dynamic. Secondly, establish whether the direction of the compression is axial, radial or different. The design information mentioned below should be taken into account for the inside diameter of the O-Ring.

Application: Static axial (flange seal)

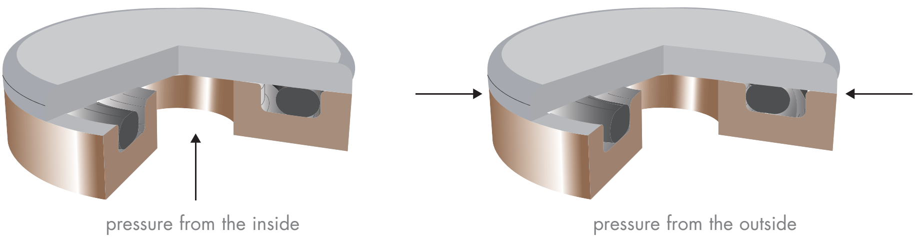


Figure 5-1: Axial installation, static

The pressure direction must be considered when specifying the dimensions of the O-Ring. If there is external pressure, the inside diameter of the ring should correspond to the inside diameter of the groove or be slightly smaller (1-3%). If there is internal pressure, the outside diameter of the ring should correspond to the outside diameter of the groove or be slightly larger (1-2%). This prevents that, due to the swelling pressure, movement of the O-Ring in the groove occurs, thus leading to a greater deformation and wear.

Application: Static axial (flange seal – trapezoidal or dovetail groove)

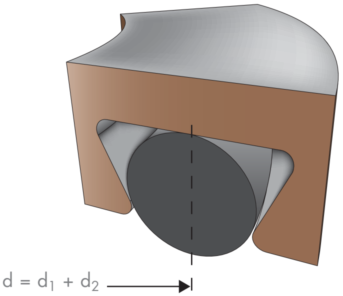


Figure 5-2: Static axial (flange seal – trapezoidal or dovetail groove)

The inside diameter can be selected as the diameter d – cross-section.

Application: Static (crush seal – triangular groove)

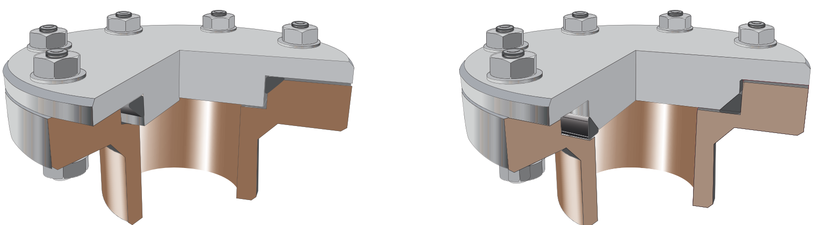
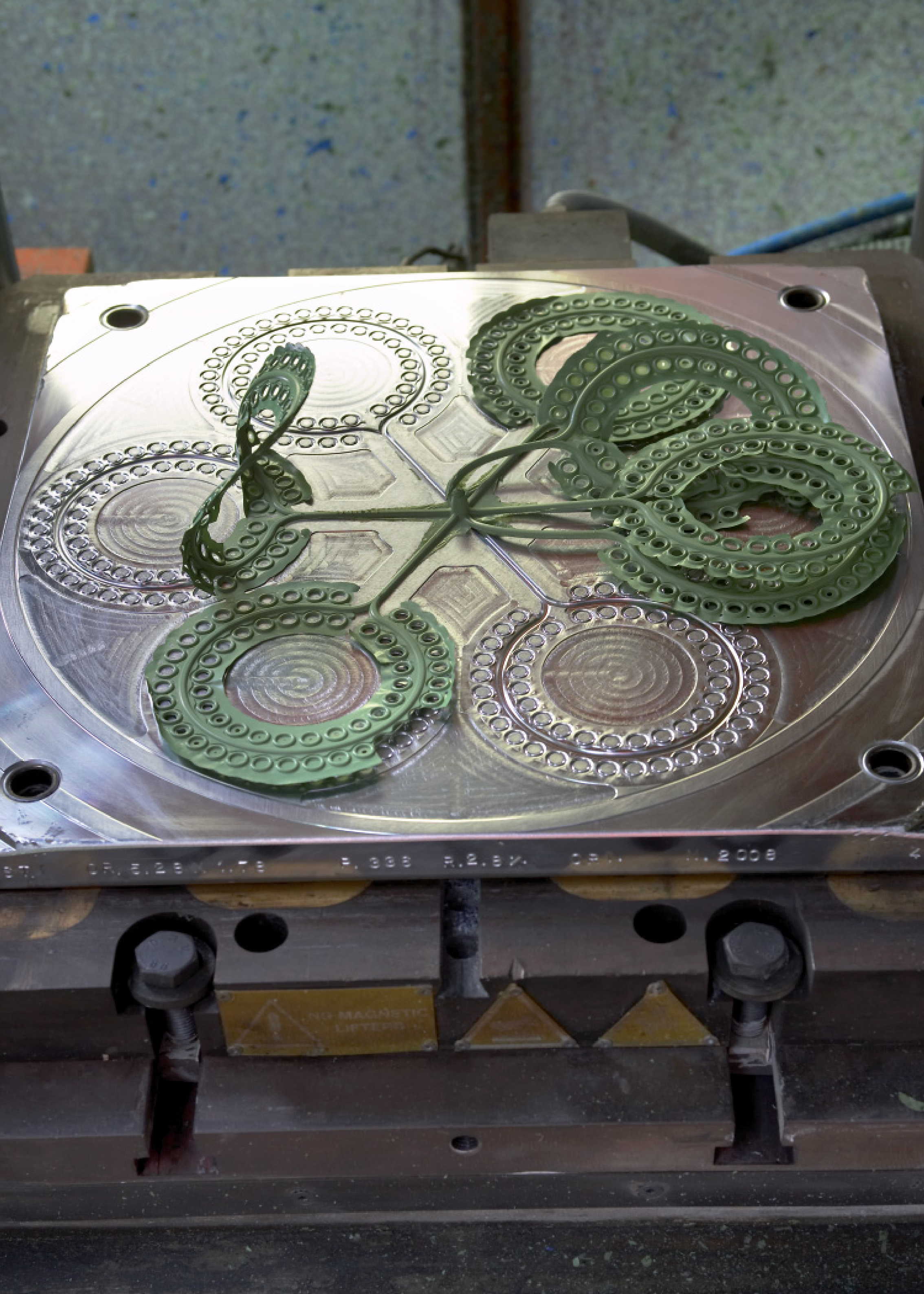


Figure 5-3: Static (crush seal - triangular groove)

For construction type A and to facilitate assembly choose an inside diameter which is1-5% smaller than the cover. In case of construction type B choose such a diameter so that the compression of the outside diameter of the O-Ring amounts to no more than 2%.


NO MAGNETIC LIFTERS

Application: Dynamic and static radial

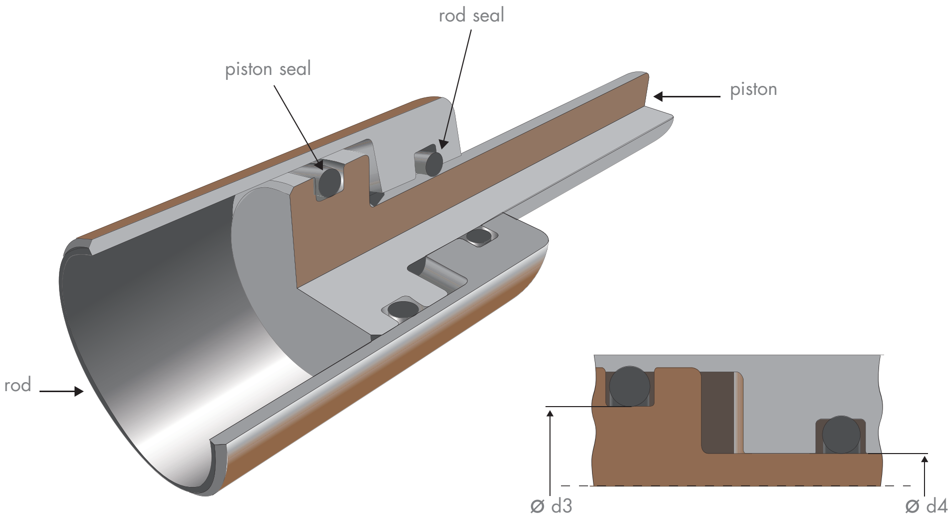


Figure 5-4: Piston & rod

- Inner sealing (rod)
  The O-Ring size should be selected so that the inside diameter d1 has the smallest possible

  deviation from the diameter to be sealed d4.
- Outer sealing (piston)
  The O-Ring size should be selected so that the inside diameter d1 is equal to or smaller than groove diameter d3.

However, if the O-Ring is used as a rotary seal the following points have to be taken into consideration:

The rotary seal principle is based on the fact that an elongated elastomer ring contracts when heated (Joule effect). According to the normal design criteria the O-Ring inside diameter d1 is slightly smaller than the shaft diameter, and the heat generated by friction causes the ring to contract even more. This results in a higher pressure on the rotating shaft which prevents the forming of a lubricating film under the seal and causes even higher friction resulting in increased wear and a premature failure of the seal. This can be prevented by choosing the seal ring whose inside diameter is approximately 2 to 5% larger than the diameter of the shaft to be sealed. The installation in the groove means that the seal ring is compressed radially and is pressed against the shaft by the groove diameter. The seal ring is thus slightly corrugated in the groove, a fact which facilitates lubrication.

In case of dynamic sealing, a distinction must be made between hydraulics and pneumatics in O-Ring applications. Due to the friction resistance, the deformation is minimised compared to static seals. This is especially the case when lubrication is poor, as it happens when lubricated air is not available. In these kinds of applications the initial compression of the O-Ring has to be reduced by a few percent. Lubricated air gives more or less the same results as in a hydraulic application.

Standard dimensions

We recommend the use of the already available standard sizes. See our list of most common standard sizes with the preference for the standard AS 568 B.

5.1.2 Select the cross-section

Several standard cross-section diameters are usually available when designing an O-Ring seal. A number of factors have to be considered when deciding which one to use, and some of these factors are somewhat contradictory. In a dynamic, reciprocating application, the choice is narrowed because the table does not include the smallest O-Ring sizes. For any given piston or rod diameter, O-Rings with smaller cross-section diameters are inherently less stable than those with larger cross-sections which tend to twist in the groove when reciprocating motion occurs. This leads to early O-Ring spiral failure followed by leakage. Nevertheless, for many dynamic applications, there is a lot of choice as to cross-sections, and the larger cross-sections will prove to be the more stable ones. The reduced breakaway and running friction obtainable with a smaller cross-section O-Ring counterweighs this factor. These and other factors, which have to be considered, are tabulated in Table 5-1.

EFFECTS OF CROSS-SECTION	
LARGER SECTION	SMALLER SECTION
DYNAMIC RECIPROCATING SEALS	
More stable	Less stable
More friction	Less friction
ALL SEALS	
• Requires larger supporting structure	• Requires less space - reduces weight
• Better compression set [1]	• Poorer compression set [1]
• Less volume swell in fluid	• More volume swell in fluid
• Less resistant to explosive	• More resistant to explosive
decompression	decompression
• Allows use of larger tolerances	• Requires closer tolerances to
while still controlling squeeze adequately	control squeeze. More likely to
• Less sensitive to dirt, lint, scratches etc	leak due to dirt, lint, scratches etc
• Poorer physical properties [2]	• Better physical properties [2]

Cost and availability are other factors to consider, and these would need to be
determined for the particular size being considered.

(1) Particularly true for nitrile and fluorocarbon elastomers. Doubtful for enhylene propylenes and silicones.

(2) Applies to tensile and elongation of nitriles, elongation of fluorocarbons.

Table 5-1: Effects of cross-section

5.2 Select the hardness / radial clearance

Pressure has a bearing on O-Ring seal design as it can affect the choice of compound shore hardness. At very low pressures, proper sealing may be more easily achieved with lower durometer hardness (50-60 Shore A). At higher pressures, the combination of pressure and material shore hardness determine the maximum clearance that may safely be tolerated (see Figure 5-5). Cyclic fluctuation of pressure can cause local extrusion of the O-Ring resulting in 'nibbling' (see section 9, 'O-Ring failure analysis'), particularly if peak system pressures are high enough to cause expansion of the cylinder wall. One remedy could be to stiffen the cylinder to limit the expansion so that the bore to piston clearance does not exceed a safe value.

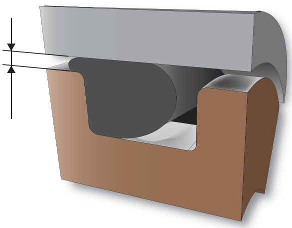


Figure 5-5: Extrusion of an O-Ring

O-Ring cross-section d2 (mm)	up to 2	2 - 3	3 - 5	5 - 7	above 7
O-Rings with hardness of 70 Shore A					
Pressure (MPa)	Radial clearance S (mm)				
≤ 3.50	0.08	0.09	0.10	0.13	0.15
≤ 7.00	0.05	0.07	0.08	0.09	0.10
≤ 10.50	0.03	0.04	0.05	0.07	0.08
O-Rings with hardness of 90 Shore A					
Pressure (MPa)	Radial clearance S (mm)				
≤ 3.50	0.13	0.15	0.20	0.23	0.25
≤ 7.00	0.10	0.13	0.15	0.18	0.20
≤ 10.50	0.07	0.09	0.10	0.13	0.15
≤ 14.00	0.05	0.07	0.08	0.09	0.10
≤ 17.50	0.04	0.05	0.07	0.08	0.09
≤ 21.00	0.03	0.04	0.05	0.07	0.08
≤ 35.00	0.02	0.03	0.03	0.04	0.04

Table 5-2: Maximum radial clearances

Reduce the clearance shown by 60% when using silicone or fluorsilicone elastomers.

Extrusion of O-Rings can also be prevented by the use of anti-extrusion (Back-Up) devices. These are thin rings made out of much harder material fitted into the groove between the seal and the clearance gaps, which essentially provide zero clearance. They are available in hard elastomer compounds, PTFE and special plastics. Please contact NewDealSeals if you need further information.


7
6
5

5.3 Determine the groove dimensions

5.3.1 Introduction

The design of the O-Ring seal has already been produced for the majority of standard applications. The necessary data for groove dimensions can easily be selected.
The following paragraphs deal with the more important design factors that generally apply to all O-Ring seals.

5.3.2 Temperature

Operating temperature (from -60°C to +325°C depending on material and media resistance), or to be more exact, the range of system temperatures, may require some minor modification of the groove design. Groove dimensions given in the static and dynamic seal design sections are calculated for the temperature ranges listed for standard compounds. If the operation is only to be at a high temperature, groove volume may need to be increased to compensate for thermal expansion of the O-Ring. Conversely, for operation only at low temperature, a better seal may result from reducing the groove depth, thereby obtaining the proper squeeze on the contracted O-Ring.
Such special designs for high and low temperature environments are seldom required. The minimum squeeze values for the various O-Ring cross-section diameters given in the design tables (see section 6, 'Groove design') of the static and dynamic seal design sections are usually satisfactory.

5.3.3 Initial compression

The tendency of an O-Ring to attempt to return to its original uncompressed shape when the cross-section is deflected is the main reason why O-Rings make such excellent seals. Obviously then, squeeze is a major consideration in O-Ring seal design. In dynamic applications, the maximum recommended squeeze is approximately 16%, due to friction and wear considerations, though smaller cross-sections may be squeezed as much as 25%. When used as a static seal, the maximum recommended squeeze for most elastomers is 30%, although this amount may cause assembly problems in a radial squeeze seal design. In a face seal situation, however, a 30% squeeze is often beneficial because recovery is more complete in this range, and the seal may function at a somewhat lower temperature. There is a danger in squeezing much more than 30% since the extra stress induced may contribute to early seal deterioration. Somewhat higher squeeze may be used if the seal will not be exposed to high temperatures or to fluids that tend to attack the elastomer and cause additional swell.

In any given application it is always prudent to adopt the largest possible O-Ring cross-section in relation to the inside diameter d1 when selecting the cross-section d2. It is particularly advisable to select the next larger cross-section in connection with unfavourable tolerance conditions.

When radially installed O-Rings can be (depending on the given application) extended by max. 5% and compressed by max. 3%.

The sealing effect of the O-Ring is the result of its initial compression. Depending on the application, the following values should be achieved:

- Dynamic sealing 6 - 20%
- Static sealing 15 - 30%

The recommended initial O-Ring compression in relation to the cross-section and the application is:

- Hydraulics minimum 6%
- Pneumatics minimum 2%

In special applications in the field of pneumatics O-Rings are installed entirely free of any initial compression.

Please find on the next page the figures which show the permissible range of initial squeeze as a function of the cross-section.

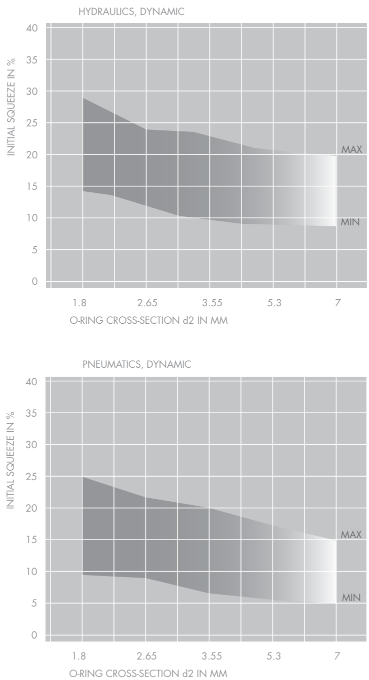


Figure 5-6: Permissible range of initial squeeze as a function of cross-section, radial dynamic

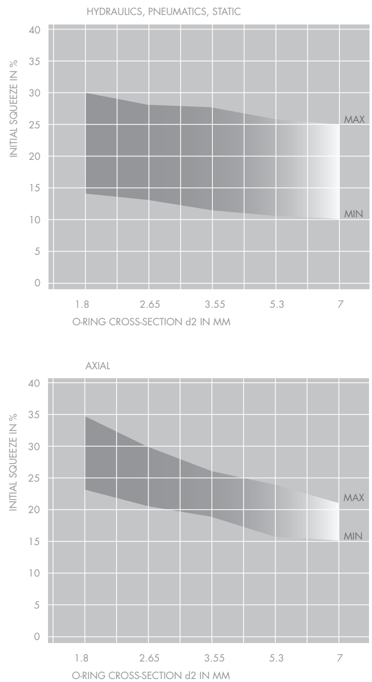


Figure 5-7: Permissible range of initial squeeze as a function of cross-section, radial static and axial

5.3.4 O-Ring compression force

The force required to compress each linear centimetre of an O-Ring seal depends mainly on the shore hardness of the O-Ring, its cross-section, and the amount of compression desired. Even if all these factors are the same, the compressive force per cm for two rings will still vary if the rings are made from different compounds or if their inside diameters are different. The anticipated load for a given installation is not fixed, but is a range of values.

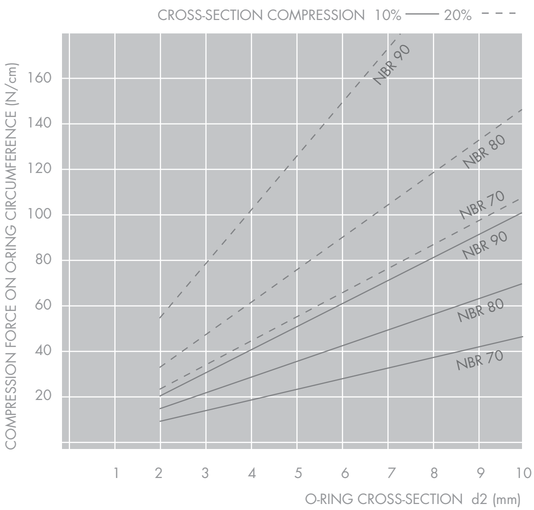


Figure 5-8: Compression forces on the O-Ring circumference depending on the material

5.3.5 Groove fill

The percentage of groove volume that an O-Ring cross-section displaces in its confining groove is called 'groove fill'. Most O-Ring seal applications call for a groove fill of between 60% to 85% of the available volume with the optimum fill being 75%. The reason for the 60% to 85% range is because of potential tolerance stacking, O-Ring volume swell and possible thermal expansion of the seal. It is essential to allow for at least 10% free volume in any elastomer sealing groove.

5.4 Seal housing design

5.4.1 Lead-in chamfer

Lead-in chamfers should be incorporated in the design of the construction. This will prevent damage to the seal during installation.

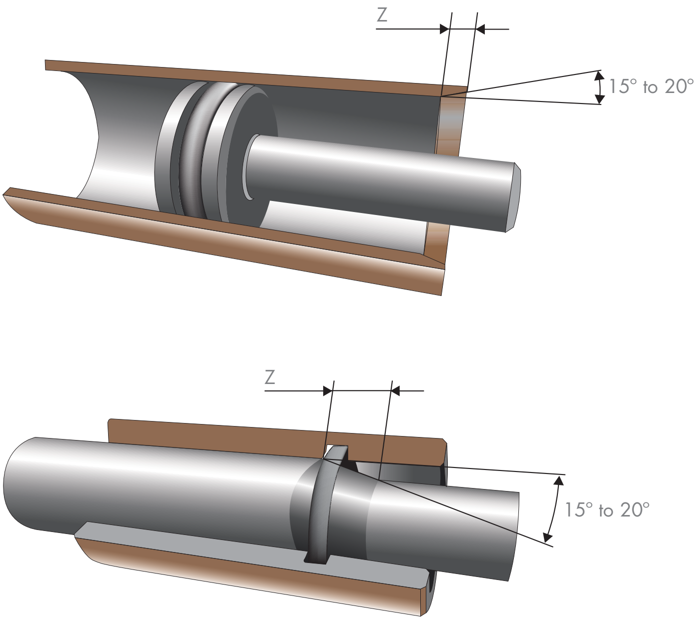


Figure 5-9: Lead-in chamfer

The next table gives the minimum lengths of the installation angle for piston and rod seals dependant on the cross-section d2.

Lead-in chamfers length Z min. (mm)		O-Ring cross-section d2 (mm)
15°	20°	
2.5	1.5	up to 1.78 / 1.80
3.0	2.0	up to 2.62 / 2.65
3.5	2.5	up to 3.53 / 3.55
4.5	3.5	up to 5.33 / 5.30
5.0	4.0	up to 7.00
6.0	4.5	above 7.00

Table 5-3: Lead-in chamfer lengths (The surface roughness of a lead-in chamber is: R_z < 6,3 μm and R_a < 0,8 μm)

5.4.2 Surfaces

The contact surface must conform with minimum quality standards to achieve an optimal sealing effect (see Table 5-4). The permissible surface roughness values must not be exceeded with dynamic seal applications or with pulsating pressures.

application	radial dynamic		radial, axial static	
surface	sliding surface	groove surface	contact /groove surfaces	
			constant press.	pulsating press.
R_{max} (μm) Roughness	1.0 - 4.0	≤ 16	≤ 16	≤ 10
R_a (μm) Roughness	0.1 - 0.4	≤ 1.6	≤ 1.6	≤ 0.8
R_z (μm) Roughness	0.63 - 2.5	≤ 10	≤ 10	≤ 6.3

Table 5-4: Permissible surface roughness values

5.4.3 Vacuum applications

Fluorelastomers (FKM) are now the preferred material for vacuum applications. Among the rubber polymers used for seals, it has one of the lowest permeability rates for gases. FKM compounds also have low outgassing or weight loss characteristics and good physical properties for a seal.

The rate of the flow of gases from the pressure side to the vacuum side of an elastomeric seal depends to a great extent on how the seal is designed. Increased O-Ring squeeze reduces permeability by increasing the length of the path the gas has to travel (width of ring) and by decreasing the area available for the entry of the gas (groove depth). Increasing the squeeze also tends to force the rubber into any small irregularities in the mating metal surface, and thus prevents leakage around the seal. The vacuum grease aids the seal by filling these microscopic pits and grooves, thus reducing leakage around the ring, and at the same time it may be changing the surface tension favourably and result in a reduced rate of surface absorbtion.

Surface roughness of the groove surfaces is more critical in sealing pressurized gases or vacuum, as a gas will find its way through extremely minute passages. Therefore, surfaces against which an O-Ring must seal should have a surface roughness value lower than usual.

See the table below:

pressure	bottom / top	sides
vacuum	0.8 µm R_a	1.6 µm R_a
1100-1300 Pa	0.4 µm R_a	1.6 µm R_a
1300-1500 Pa	0.1 µm R_a	1.6 µm R_a

Table 5-5: Surface finish of vacuum groove

5.5 Installation

5.5.1 Assembly

Assembly must be done with great care so that the O-Ring is properly placed in the groove and is not damaged as the groove assembly is closed. Some of the more important design features to ensure this are:

- The inside diameter stretch, as installed in the groove, should not be more than 5%. Excessive stretch will shorten the life of most O-Ring materials.

- The inside diameter expansion needed to reach the groove during assembly ordinarily does not exceed 25-50% and should not exceed 50% of the ultimate elongation of the chosen compound. However, for small diameter O-Rings, it may be necessary to exceed this rule of thumb. If so, sufficient time should be allowed for the O-Ring to return to its normal diameter before closing the groove assembly.

- The O-Ring should not be twisted. Twisting during installation will most readily occur with O-Rings having a large ratio of inside diameter to cross-section diameter.

- O-Rings should never be forced over unprotected sharp corners, threads, keyways, slots, splines, ports, or other sharp edges. If impossible to avoid by proper design, then thimbles, supports, or other shielding arrangements must be used during assembly to prevent damage to the seal.

- Closure of the groove assembly must not pinch the O-Ring at the groove corners.

5.5.2 Lubrication

Lubrication of O-Ring seals is extremely important for installation and operation of dynamic seals as well as proper seating of static seals. The general rule for use of lubrication is: The greatest benefit in using a lubricant is obtained during the initial installation of the O-Ring.

5.5.3 Cleanliness

Cleanliness is vitally important to assure proper sealing action and long O-Ring life. Every precaution must be taken to ensure that all component parts are clean at time of assembly. Foreign particles (dust, dirt, metal chips, grit, etc.) in the groove may cause leakage and can damage the O-Ring, reducing its life.

6 O-Ring groove design

6.1 Static applications

6.1.1 Groove dimensions for radial and axial installation

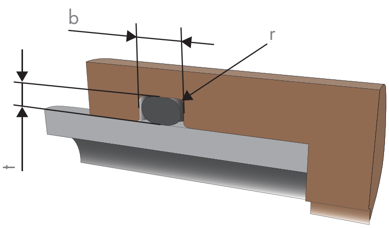


Figure 6-1: Inside sealing radial

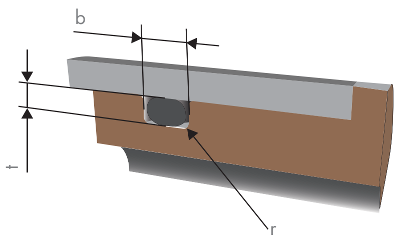


Figure 6-2: Outside sealing radial

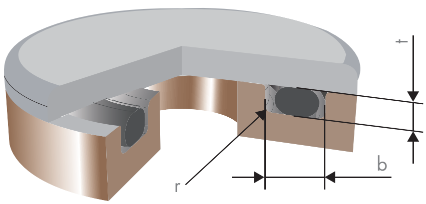


Figure 6-3: Axial sealing

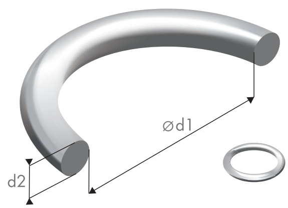


Figure 6-4: O-Ring

CROSS-SECTION	RADIAL INSTALLATION		AXIAL INSTALLATION		RADIUS
	GROOVE DEPTH	GROOVE WIDTH	GROOVE DEPTH	GROOVE WIDTH	
d2	t +0.05	b +0.2	t +0.05	b +0.2	r ±0.2
0.50	0.35	0.80	0.35	0.80	0.20
0.74	0.50	1.00	0.50	1.00	0.20
1.00	0.70	1.40	0.70	1.40	0.20
1.02	0.70	1.40	0.70	1.40	0.20
1.20	0.85	1.70	0.85	1.70	0.20
1.25	0.90	1.70	0.90	1.80	0.20
1.27	0.90	1.70	0.90	1.80	0.20
1.30	0.95	1.80	0.95	1.80	0.20
1.42	1.05	1.90	1.05	2.00	0.30
1.50	1.10	2.00	1.10	2.10	0.30
1.52	1.10	2.00	1.10	2.10	0.30
1.60	1.20	2.10	1.20	2.20	0.30
1.63	1.20	2.10	1.20	2.20	0.30
1.78	1.30	2.40	1.30	2.60	0.30
1.80	1.30	2.40	1.30	2.60	0.30
1.83	1.35	2.50	1.35	2.60	0.30
1.90	1.40	2.60	1.40	2.70	0.30
1.98	1.50	2.70	1.50	2.80	0.30
2.00	1.50	2.70	1.50	2.80	0.30
2.08	1.55	2.80	1.55	2.90	0.30
2.10	1.55	2.80	1.55	2.90	0.30
2.20	1.60	3.00	1.60	3.00	0.30
2.26	1.70	3.00	1.70	3.10	0.30
2.30	1.75	3.10	1.75	3.10	0.30
2.34	1.75	3.10	1.75	3.10	0.30
2.40	1.80	3.20	1.80	3.30	0.30
2.46	1.85	3.30	1.85	3.40	0.30
2.50	1.90	3.30	1.85	3.40	0.30
2.62	2.00	3.60	2.00	3.80	0.30
2.65	2.00	3.60	2.00	3.80	0.30
2.70	2.05	3.60	2.05	3.80	0.30
2.80	2.10	3.70	2.10	3.90	0.60
2.92	2.20	3.90	2.20	4.00	0.60
2.95	2.20	3.90	2.20	4.00	0.60
3.00	2.30	4.00	2.30	4.00	0.60
3.10	2.40	4.10	2.40	4.10	0.60
3.50	2.65	4.60	2.65	4.70	0.60
3.53	2.70	4.80	2.70	5.00	0.60
3.55	2.70	4.80	2.70	5.00	0.60
3.60	2.80	4.80	2.80	5.10	0.60

Table 6-1: Groove dimensions in mm for radial and axial installation

CROSS-SECTION	RADIAL INSTALLATION		AXIAL INSTALLATION		RADIUS
	GROOVE DEPTH	GROOVE WIDTH	GROOVE DEPTH	GROOVE WIDTH	
d2	t +0.05	b +0.2	t +0.05	b +0.2	r ±0.2
4.00	3.10	5.20	3.10	5.30	0.60
4.50	3.50	5.80	3.50	5.90	0.60
5.00	4.00	6.60	4.00	6.70	0.60
5.30	4.30	7.10	4.30	7.30	0.60
5.33	4.30	7.10	4.30	7.30	0.60
5.50	4.50	7.10	4.50	7.30	0.60
5.70	4.60	7.20	4.60	7.40	0.60
6.00	4.90	7.40	4.90	7.60	0.60
6.50	5.40	8.00	5.40	8.20	1.00
6.99	5.80	9.50	5.80	9.70	1.00
7.00	5.80	9.50	5.80	9.70	1.00
7.50	6.30	9.70	6.30	9.90	1.00
8.00	6.70	9.80	6.70	10.00	1.00
8.40	7.10	10.00	7.10	10.30	1.00
9.00	7.70	10.60	7.70	10.90	1.50
9.50	8.20	11.00	8.20	11.40	1.50
10.00	8.60	11.60	8.60	12.00	2.00
12.00	10.60	13.50	10.60	14.00	2.00

Table 6-1: Groove dimensions in mm for radial and axial installation (Continued)

6.1.2 Groove dimensions for dovetail installation

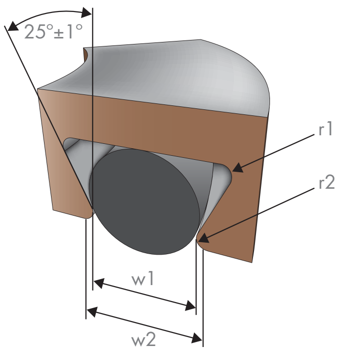


Figure 6-5: Flange seal

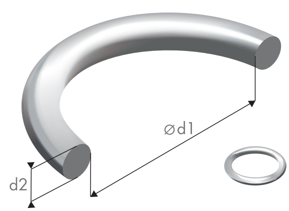


Figure 6-6: O-Ring

CROSS-SECTION	GROOVE DIMENSIONS				
	GROOVE WIDTH		GROOVE DEPTH	RADIUS (MAX)	
d2	w1 +/-0.05	w2 +/-0.05	t +/-0.05	r1	r2
3.53	2.90	3.10	2.90	0.60	0.25
4.00	3.40	3.50	3.30	0.70	0.25
4.50	3.80	4.00	3.70	0.70	0.30
5.00	4.30	4.40	4.10	0.80	0.30
5.30 / 5.33	4.60	4.70	4.40	0.90	0.30
5.50	4.60	4.80	4.50	0.90	0.30
5.70	4.70	5.00	4.70	0.90	0.30
6.00	5.00	5.50	5.00	1.00	0.40
6.50	5.40	5.90	5.40	1.10	0.40
6.99 / 7.00	5.95	6.30	5.90	1.20	0.40
7.50	6.20	6.70	6.20	1.20	0.40
8.00	6.70	7.30	6.70	1.30	0.50
8.40	7.30	7.90	7.30	1.50	0.50
9.00	7.50	8.10	7.50	1.50	0.50
10.00	8.30	9.00	8.30	1.70	0.60

Table 6-2: Groove dimensions in mm for dovetail installation

6.1.3 Groove dimensions for crush seal installation

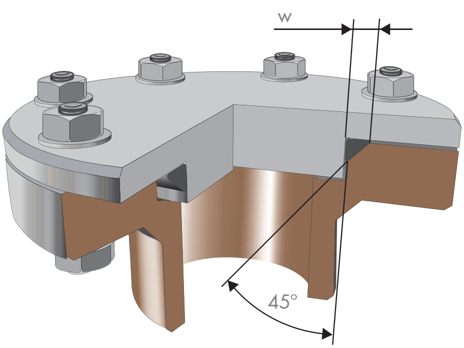


Figure 6-7: Crush seal installation

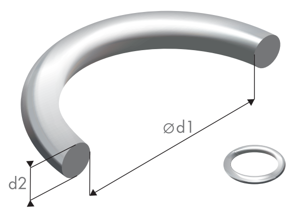


Figure 6-8: O-Ring

CROSS-SECTION	GROOVE DIMENSIONS	
d2	WIDTH (w)	TOLERANCES
1.00	1.40	+/-0.04
1.50	2.10	+/-0.06
1.60	2.30	+/-0.06
1.78	2.45	+/-0.07
1.80	2.45	+/-0.07
2.00	2.75	+/-0.08
2.40	3.40	+/-0.10
2.50	3.50	+/-0.10
2.62	3.60	+/-0.10
2.65	3.60	+/-0.10
3.00	4.20	+/-0.12
3.50	4.90	+/-0.14
3.53	5.00	+/-0.14
3.55	5.00	+/-0.14
4.00	5.70	+/-0.16
4.50	6.30	+/-0.18
5.00	7.10	+/-0.20
5.30	7.60	+/-0.21
5.33	7.60	+/-0.21
5.50	7.80	+/-0.22
5.70	8.10	+/-0.23
6.00	8.50	+/-0.24
6.50	9.30	+/-0.26
6.99	9.90	+/-0.28
7.00	9.90	+/-0.28
7.50	10.60	+/-0.30
8.00	11.40	+/-0.32
8.40	11.90	+/-0.36
9.00	12.80	+/-0.40
10.00	14.10	+/-0.40
12.00	16.90	+/-0.48
15.00	21.40	+/-0.60

Table 6-3: Groove dimensions in mm for crush seal installation

6.1.4 Groove dimensions for vacuum applications

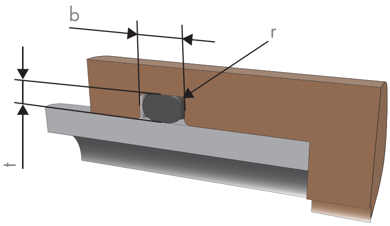


Figure 6-9: Inside sealing radial

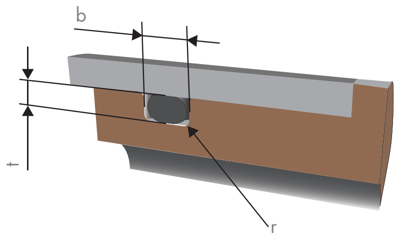


Figure 6-10: Outside sealing radial

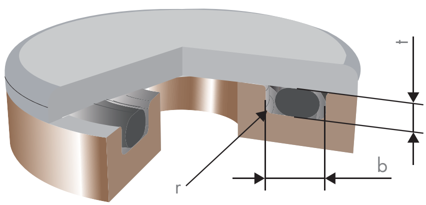


Figure 6-11: Axial sealing

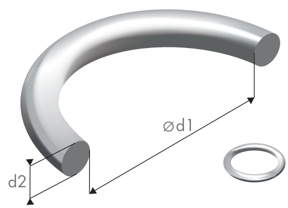


Figure 6-12: O-Ring

CROSS-SECTION	GROOVE DIMENSIONS	
	GROOVE DEPTH	GROOVE WIDTH
d2	t +0.05-0.00	b +0.15-0.00
1.78	1.27	2.11
2.62	1.88	3.00
3.53	2.57	3.99
5.33	3.86	5.99
7.00	5.11	7.75

Table 6-4: Groove dimensions in mm for vacuum applications

6.2 Dynamic applications

Groove dimensions for dynamic applications

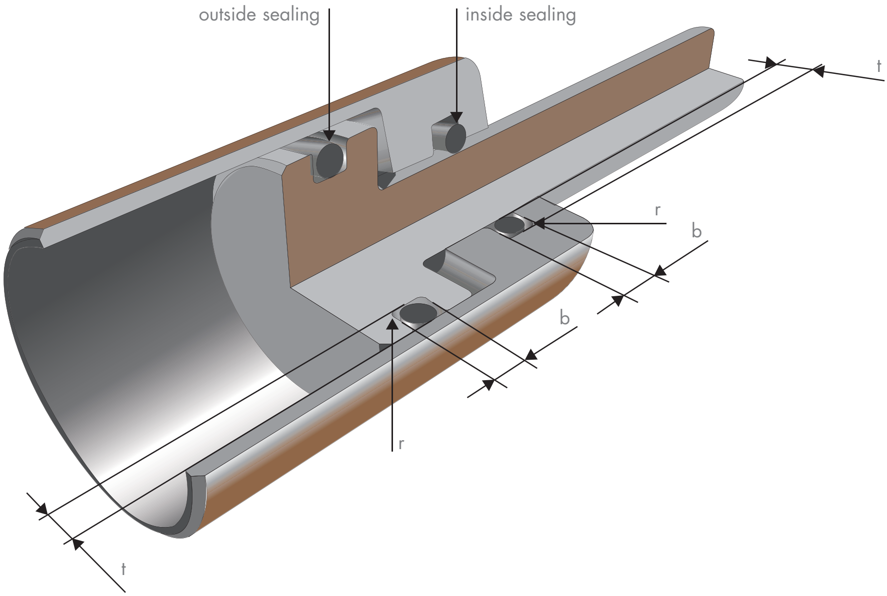


Figure 6-13: Inside sealing and outside sealing

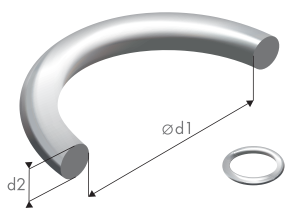


Figure 6-14: O-Ring

CROSS-SECTION	GROOVE DIMENSIONS		
	RADIAL INSTALLATION		RADIUS
	GROOVE DEPTH	GROOVE WIDTH	
d2	t +0.05	b +0.2	r ±0.2
1.50	1.25	2.00	0.30
1.52	1.25	2.00	0.30
1.60	1.30	2.10	0.30
1.63	1.30	2.10	0.30
1.78	1.45	2.40	0.30
1.80	1.45	2.40	0.30
1.83	1.50	2.50	0.30
1.90	1.55	2.60	0.30
1.98	1.65	2.70	0.30
2.00	1.65	2.70	0.30
2.08	1.75	2.80	0.30
2.10	1.75	2.80	0.30
2.20	1.85	3.00	0.30
2.26	1.90	3.00	0.30
2.30	1.95	3.10	0.30
2.34	1.95	3.10	0.30
2.40	2.05	3.20	0.30
2.46	2.10	3.30	0.30
2.50	2.15	3.30	0.30
2.62	2.25	3.60	0.30
2.65	2.25	3.60	0.30
2.70	2.30	3.60	0.30
2.80	2.40	3.70	0.60
2.92	2.50	3.90	0.60
2.95	2.50	3.90	0.60
3.00	2.60	4.00	0.60
3.10	2.70	4.10	0.60

Table 6-5: Groove dimensions in mm for radial and axial installation (oscillating movements)
Media: hydraulic fluids and lubricating fluids (Continued)

CROSS-SECTION	GROOVE DIMENSIONS		
	RADIAL INSTALLATION		RADIUS
	GROOVE DEPTH	GROOVE WIDTH	
d2	t +0.05	b +0.2	r ±0.2
3.50	3.05	4.60	0.60
3.53	3.10	4.80	0.60
3.55	3.10	4.80	0.60
3.60	3.15	4.80	0.60
4.00	3.50	5.20	0.60
4.50	4.00	5.80	0.60
5.00	4.40	6.60	0.60
5.30	4.70	7.10	0.60
5.33	4.70	7.10	0.60
5.50	4.80	7.10	0.60
5.70	5.00	7.20	0.60
6.00	5.30	7.40	0.60
6.50	5.70	8.00	1.00
6.99	6.10	9.50	1.00
7.00	6.10	9.50	1.00
7.50	6.60	9.70	1.00
8.00	7.10	9.80	1.00
8.40	7.50	10.00	1.00
9.00	8.10	10.60	1.50
9.50	8.60	11.00	1.50
10.00	9.10	11.60	2.00
12.00	11.00	13.50	2.00

Table 6-5: Groove dimensions in mm for radial and axial installation (oscillating movements)
Media: hydraulic fluids and lubricating fluids

The sealing of a rotating shaft should only be attempted with an O-Ring if there is no room for the installation of an effective seal and if the operating conditions are not severe. An oil seal is in any case more dependable. For more information please contact our technical department.

CROSS-SECTION	GROOVE DIMENSIONS		
	RADIAL INSTALLATION		RADIUS
	GROOVE DEPTH	GROOVE WIDTH	
d2	t +0.05	b +0.2	r ±0.2
1.50	1.25	2.00	0.30
1.52	1.25	2.00	0.30
1.60	1.35	2.10	0.30
1.63	1.35	2.10	0.30
1.78	1.50	2.40	0.30
1.80	1.50	2.40	0.30
1.83	1.55	2.50	0.30
1.90	1.60	2.60	0.30
1.98	1.70	2.70	0.30
2.00	1.70	2.70	0.30
2.08	1.80	2.80	0.30
2.10	1.80	2.80	0.30
2.20	1.90	3.00	0.30
2.26	1.95	3.00	0.30
2.30	2.00	3.10	0.30
2.34	2.00	3.10	0.30
2.40	2.10	3.20	0.30
2.46	2.20	3.30	0.30
2.50	2.25	3.30	0.30
2.62	2.30	3.60	0.30
2.65	2.30	3.60	0.30
2.70	2.35	3.60	0.30
2.80	2.45	3.70	0.60
2.92	2.55	3.90	0.60
2.95	2.55	3.90	0.60
3.00	2.65	4.00	0.60
3.10	2.75	4.10	0.60

Table 6-6: Groove dimensions in mm for radial and axial installation (oscillating movements)
Media: poor lubrication and gases (Continued)

CROSS-SECTION	GROOVE DIMENSIONS		
	RADIAL INSTALLATION		RADIUS
	GROOVE DEPTH	GROOVE WIDTH	
d2	t +0.05	b +0.2	r ±0.2
3.50	3.15	4.60	0.60
3.53	3.15	4.80	0.60
3.55	3.15	4.80	0.60
3.60	3.20	4.80	0.60
4.00	3.55	5.20	0.60
4.50	4.10	5.80	0.60
5.00	4.50	6.60	0.60
5.30	4.80	7.10	0.60
5.33	4.80	7.10	0.60
5.50	4.90	7.10	0.60
5.70	5.10	7.20	0.60
6.00	5.45	7.40	0.60
6.50	5.85	8.00	1.00
6.99	6.35	9.50	1.00
7.00	6.35	9.50	1.00
7.50	6.85	9.70	1.00
8.00	7.30	9.80	1.00
8.40	7.70	10.00	1.00
9.00	8.30	10.60	1.50
9.50	8.80	11.00	1.50
10.00	9.20	11.60	2.00
12.00	11.00	13.50	2.00

Table 6-6: Groove dimensions in mm for radial and axial installation (oscillating movements)
Media: poor lubrication and gases

7 Standard O-Ring Dimensions

7.1 International standards

Table 7-1 shows the cross-sections as used in the various O-Ring standards.
The most common standards are the AS 568 B and the ISO 3601-1. The O-Ring dimensions as described in section 7.2 are constantly being kept in stock in the materials NBR70 and FKM70. Our on-line stock also includes metric and other sizes in many different materials.

American St. AS 568 B British Standard BS 1806	German Standard metric DIN 3771	Japanese Standard JIS B 2401	Swedish Standard SMS 1586	International Standard ISO 3601-1	French Standard NFT47-501	American Standard AS 568 A Series 990
1,78	1,00	1,90	1,60	1,80	1,90	1,02
2,62	1,50	2,40	2,40	2,65	2,70	1,42
3,53	2,00	3,10	3,00	3,55	3,60	1,63
5,33	2,50	3,50	5,70	5,30	5,30	1,83
6,99	3,00	5,70	8,40	7,00	7,00	1,98
	3,50	8,40				2,08
	4,00					2,20
	4,50					2,46
	5,00					2,95
	5,50					3,00
	6,00					
	7,00					
	8,00					
	10,00					
	12,00					

Table 7-1: Cross-section in mm according to various O-Ring standards

The standard inside diameters are given in the following sections.
The tolerances for the AS 568 B standard are indicated in the same table.

The International Organization for Standardization issued ISO 3601-1 in 1978 and revised it in 1988 and 2002. Another major revision is being developed to bring ISO sizes in line with the sizes in Aerospace Standard AS 568 B. Currently, ISO sizes do not use a dash numbering system like the Aerospace Standard. ISO cross-sectional diameters differ from the Aerospace Standard by less than 0.001 inch.
Therefore, many AS 568 B sizes are interchangeable with an ISO size. Be sure to consult ISO 3601-1 for specific dimensions, as inside diameters may differ. The tolerances of AS 568 B, introduced in 2001, are a combination of the former Class I and Class II tolerances of AS 568. In 2001, AS 568 B was issued to modernize the scope and notes of the standard without affecting the dimensions, tolerances, or dash numbers.


50
DEGA
DEGA

7.2 AS 568 B

	Nominal size (inches)			Actual size (inches)				Actual size (mm)			
Dash No.	Inside diameter d1	Outside diameter	Cross-section d2	Inside diameter d1	Tol. ±	CS	Tol. ±	Inside diameter	Tol. ±	Cross-section d2	Tol. ±
001	1/32	3/32	1/32	.029	.004	.040	.003	0,74	0,10	1,02	0.08
002	3/64	9/64	3/64	.042	.004	.050	.003	1,07	0,10	1,27	0.08
003	1/16	3/16	1/16	.056	.004	.060	.003	1,42	0,10	1,52	0.08
004	5/64	13/64	1/16	.070	.005	.070	.003	1,78	0,13	1,78	0.08
005	3/32	7/32	1/16	.101	.005	.070	.003	2,57	0,13	1,78	0.08
006	1/8	1/4	1/16	.114	.005	.070	.003	2,90	0,13	1,78	0.08
007	5/32	9/32	1/16	.145	.005	.070	.003	3,68	0,13	1,78	0.08
008	3/16	5/16	1/16	.176	.005	.070	.003	4,47	0,13	1,78	0.08
009	7/32	11/32	1/16	.208	.005	.070	.003	5,28	0,13	1,78	0.08
010	1/4	3/8	1/16	.239	.005	.070	.003	6,07	0,13	1,78	0.08
011	5/16	7/16	1/16	.301	.005	.070	.003	7,65	0,13	1,78	0.08
012	3/8	1/2	1/16	.364	.005	.070	.003	9,25	0,13	1,78	0.08
013	7/16	9/16	1/16	.426	.005	.070	.003	10,82	0,13	1,78	0.08
014	1/2	5/8	1/16	.489	.005	.070	.003	12,42	0,13	1,78	0.08
015	9/16	11/16	1/16	.551	.007	.070	.003	14,00	0,18	1,78	0.08
016	5/8	3/4	1/16	.614	.009	.070	.003	15,60	0,23	1,78	0.08
017	11/16	13/16	1/16	.676	.009	.070	.003	17,17	0,23	1,78	0.08
018	3/4	7/8	1/16	.739	.009	.070	.003	18,77	0,23	1,78	0.08
019	13/16	15/16	1/16	.801	.009	.070	.003	20,35	0,23	1,78	0.08
020	7/8	1	1/16	.864	.009	.070	.003	21,95	0,23	1,78	0.08
021	15/16	1- 1/16	1/16	.926	.009	.070	.003	23,52	0,23	1,78	0.08
022	1	1/8	1/16	.989	.010	.070	.003	25,12	0,25	1,78	0.08
023	1- 1/16	1- 3/16	1/16	1.051	.010	.070	.003	26,70	0,25	1,78	0.08
024	1- 1/8	1- 1/4	1/16	1.114	.010	.070	.003	28,30	0,25	1,78	0.08
025	1- 3/16	1- 5/16	1/16	1.176	.011	.070	.003	29,87	0,28	1,78	0.08
026	1- 1/4	1- 3/8	1/16	1.239	.011	.070	.003	31,47	0,28	1,78	0.08
027	1- 5/16	1- 7/16	1/16	1.301	.011	.070	.003	33,05	0,28	1,78	0.08
028	1- 3/8	1- 1/2	1/16	1.364	.013	.070	.003	34,65	0,33	1,78	0.08
029	1- 1/2	1- 5/8	1/16	1.489	.013	.070	.003	37,82	0,33	1,78	0.08
030	1- 5/8	1- 3/4	1/16	1.614	.013	.070	.003	41,00	0,33	1,78	0.08
031	1- 3/4	1- 7/8	1/16	1.739	.015	.070	.003	44,17	0,38	1,78	0.08
032	1- 7/8	2	1/16	1.864	.015	.070	.003	47,35	0,38	1,78	0.08
033	2	2- 1/8	1/16	1.989	.018	.070	.003	50,52	0,46	1,78	0.08
034	2- 1/8	2- 1/4	1/16	2.114	.018	.070	.003	53,70	0,46	1,78	0.08
035	2- 1/4	2- 3/8	1/16	2.239	.018	.070	.003	56,87	0,46	1,78	0.08

Table 7-2: AS 568 B

	Nominal size (inches)			Actual size (inches)				Actual size (mm)			
Dash No.	Inside diameter d1	Outside diameter	Cross-section d2	Inside diameter d1	Tol. ±	CS	Tol. ±	Inside diameter	Tol. ±	Cross-section d2	Tol. ±
036	2- 3/8	2- 1/2	1/16	2.364	.018	.070	.003	60,05	0,46	1,78	0.08
037	2- 1/2	2- 5/8	1/16	2.489	.018	.070	.003	63,22	0,46	1,78	0.08
038	2- 5/8	2- 3/4	1/16	2.614	.020	.070	.003	66,40	0,51	1,78	0.08
039	2- 3/4	2- 7/8	1/16	2.739	.020	.070	.003	69,57	0,51	1,78	0.08
040	2- 7/8	3	1/16	2.864	.020	.070	.003	72,75	0,51	1,78	0.08
041	3	3- 1/8	1/16	2.989	.024	.070	.003	75,92	0,61	1,78	0.08
042	3- 1/4	3- 3/8	1/16	3.239	.024	.070	.003	82,27	0,61	1,78	0.08
043	3- 1/2	3- 5/8	1/16	3.489	.024	.070	.003	88,62	0,61	1,78	0.08
044	3- 3/4	3- 7/8	1/16	3.739	.027	.070	.003	94,97	0,69	1,78	0.08
045	4	4- 1/8	1/16	3.989	.027	.070	.003	101,32	0,69	1,78	0.08
046	4- 1/4	4- 3/8	1/16	4.239	.030	.070	.003	107,67	0,76	1,78	0.08
047	4- 1/2	4- 5/8	1/16	4.489	.030	.070	.003	114,02	0,76	1,78	0.08
048	4- 3/4	4- 7/8	1/16	4.739	.030	.070	.003	120,37	0,76	1,78	0.08
049	5	5- 1/8	1/16	4.989	.037	.070	.003	126,72	0,94	1,78	0.08
050	5- 1/4	5- 3/8	1/16	5.239	.037	.070	.003	133,07	0,94	1,78	0.08
102	1/16	1/4	3/32	.049	.005	.103	.003	1,24	0,13	2,62	0.08
103	3/32	9/32	3/32	.081	.005	.103	.003	2,06	0,13	2,62	0.08
104	1/8	5/16	3/32	.112	.005	.103	.003	2,84	0,13	2,62	0.08
105	5/32	11/32	3/32	.143	.005	.103	.003	3,63	0,13	2,62	0.08
106	3/16	3/8	3/32	.174	.005	.103	.003	4,42	0,13	2,62	0.08
107	7/32	13/32	3/32	.206	.005	.103	.003	5,23	0,13	2,62	0.08
108	1/4	7/16	3/32	.237	.005	.103	.003	6,02	0,13	2,62	0.08
109	5/16	1/2	3/32	.299	.005	.103	.003	7,59	0,13	2,62	0.08
110	3/8	9/16	3/32	.362	.005	.103	.003	9,19	0,13	2,62	0.08
111	7/16	5/8	3/32	.424	.005	.103	.003	10,77	0,13	2,62	0.08
112	1/2	11/16	3/32	.487	.005	.103	.003	12,37	0,13	2,62	0.08
113	9/16	3/4	3/32	.549	.007	.103	.003	13,94	0,18	2,62	0.08
114	5/8	13/16	3/32	.612	.009	.103	.003	15,54	0,23	2,62	0.08
115	11/16	7/8	3/32	.674	.009	.103	.003	17,12	0,23	2,62	0.08
116	3/4	15/16	3/32	.737	.009	.103	.003	18,72	0,23	2,62	0.08
117	13/16	1	3/32	.799	.010	.103	.003	20,30	0,25	2,62	0.08
118	7/8	1- 1/16	3/32	.862	.010	.103	.003	21,89	0,25	2,62	0.08
119	15/16	1- 1/8	3/32	.924	.010	.103	.003	23,47	0,25	2,62	0.08
120	1	1- 3/16	3/32	.987	.010	.103	.003	25,07	0,25	2,62	0.08
121	1- 1/16	1- 1/4	3/32	1.049	.010	.103	.003	26,64	0,25	2,62	0.08
122	1- 1/8	1- 5/16	3/32	1.112	.010	.103	.003	28,24	0,25	2,62	0.08
123	1- 3/16	1- 3/8	3/32	1.174	.012	.103	.003	29,82	0,30	2,62	0.08

Table 7-2: AS 568 B (Continued)

	Nominal size (inches)			Actual size (inches)				Actual size (mm)			
Dash No.	Inside diameter d1	Outside diameter	Cross-section d2	Inside diameter d1	Tol. ±	CS	Tol. ±	Inside diameter	Tol. ±	Cross-section d2	Tol. ±
024	1- 1/8	1- 1/4	1/16	1.114	.010	.070	.003	28,30	0,25	1,78	0.08
025	1- 3/16	1- 5/16	1/16	1.176	.011	.070	.003	29,87	0,28	1,78	0.08
026	1- 1/4	1- 3/8	1/16	1.239	.011	.070	.003	31,47	0,28	1,78	0.08
027	1- 5/16	1- 7/16	1/16	1.301	.011	.070	.003	33,05	0,28	1,78	0.08
028	1- 3/8	1- 1/2	1/16	1.364	.013	.070	.003	34,65	0,33	1,78	0.08
029	1- 1/2	1- 5/8	1/16	1.489	.013	.070	.003	37,82	0,33	1,78	0.08
030	1- 5/8	1- 3/4	1/16	1.614	.013	.070	.003	41,00	0,33	1,78	0.08
031	1- 3/4	1- 7/8	1/16	1.739	.015	.070	.003	44,17	0,38	1,78	0.08
032	1- 7/8	2	1/16	1.864	.015	.070	.003	47,35	0,38	1,78	0.08
033	2	2- 1/8	1/16	1.989	.018	.070	.003	50,52	0,46	1,78	0.08
034	2- 1/8	2- 1/4	1/16	2.114	.018	.070	.003	53,70	0,46	1,78	0.08
035	2- 1/4	2- 3/8	1/16	2.239	.018	.070	.003	56,87	0,46	1,78	0.08
036	2- 3/8	2- 1/2	1/16	2.364	.018	.070	.003	60,05	0,46	1,78	0.08
037	2- 1/2	2- 5/8	1/16	2.489	.018	.070	.003	63,22	0,46	1,78	0.08
038	2- 5/8	2- 3/4	1/16	2.614	.020	.070	.003	66,40	0,51	1,78	0.08
039	2- 3/4	2- 7/8	1/16	2.739	.020	.070	.003	69,57	0,51	1,78	0.08
040	2- 7/8	3	1/16	2.864	.020	.070	.003	72,75	0,51	1,78	0.08
041	3	3- 1/8	1/16	2.989	.024	.070	.003	75,92	0,61	1,78	0.08
042	3- 1/4	3- 3/8	1/16	3.239	.024	.070	.003	82,27	0,61	1,78	0.08
043	3- 1/2	3- 5/8	1/16	3.489	.024	.070	.003	88,62	0,61	1,78	0.08
044	3- 3/4	3- 7/8	1/16	3.739	.027	.070	.003	94,97	0,69	1,78	0.08
045	4	4- 1/8	1/16	3.989	.027	.070	.003	101,32	0,69	1,78	0.08
046	4- 1/4	4- 3/8	1/16	4.239	.030	.070	.003	107,67	0,76	1,78	0.08
047	4- 1/2	4- 5/8	1/16	4.489	.030	.070	.003	114,02	0,76	1,78	0.08
048	4- 3/4	4- 7/8	1/16	4.739	.030	.070	.003	120,37	0,76	1,78	0.08
049	5	5- 1/8	1/16	4.989	.037	.070	.003	126,72	0,94	1,78	0.08
050	5- 1/4	5- 3/8	1/16	5.239	.037	.070	.003	133,07	0,94	1,78	0.08
102	1/16	1/4	3/32	.049	.005	.103	.003	1,24	0,13	2,62	0.08
103	3/32	9/32	3/32	.081	.005	.103	.003	2,06	0,13	2,62	0.08
104	1/8	5/16	3/32	.112	.005	.103	.003	2,84	0,13	2,62	0.08
105	5/32	11/32	3/32	.143	.005	.103	.003	3,63	0,13	2,62	0.08
106	3/16	3/8	3/32	.174	.005	.103	.003	4,42	0,13	2,62	0.08
107	7/32	13/32	3/32	.206	.005	.103	.003	5,23	0,13	2,62	0.08
108	1/4	7/16	3/32	.237	.005	.103	.003	6,02	0,13	2,62	0.08
109	5/16	1/2	3/32	.299	.005	.103	.003	7,59	0,13	2,62	0.08
110	3/8	9/16	3/32	.362	.005	.103	.003	9,19	0,13	2,62	0.08
111	7/16	5/8	3/32	.424	.005	.103	.003	10,77	0,13	2,62	0.08

Table 7-2: AS 568 B (Continued)

	Nominal size (inches)			Actual size (inches)				Actual size (mm)			
Dash No.	Inside diameter d1	Outside diameter	Cross-section d2	Inside diameter d1	Tol. ±	CS	Tol. ±	Inside diameter	Tol. ±	Cross-section d2	Tol. ±
112	1/2	11/16	3/32	.487	.005	.103	.003	12,37	0,13	2,62	0.08
113	9/16	3/4	3/32	.549	.007	.103	.003	13,94	0,18	2,62	0.08
114	5/8	13/16	3/32	.612	.009	.103	.003	15,54	0,23	2,62	0.08
115	11/16	7/8	3/32	.674	.009	.103	.003	17,12	0,23	2,62	0.08
116	3/4	15/16	3/32	.737	.009	.103	.003	18,72	0,23	2,62	0.08
117	13/16	1	3/32	.799	.010	.103	.003	20,30	0,25	2,62	0.08
118	7/8	1- 1/16	3/32	.862	.010	.103	.003	21,89	0,25	2,62	0.08
119	15/16	1- 1/8	3/32	.924	.010	.103	.003	23,47	0,25	2,62	0.08
120	1	1- 3/16	3/32	.987	.010	.103	.003	25,07	0,25	2,62	0.08
121	1- 1/16	1- 1/4	3/32	1.049	.010	.103	.003	26,64	0,25	2,62	0.08
122	1- 1/8	1- 5/16	3/32	1.112	.010	.103	.003	28,24	0,25	2,62	0.08
123	1- 3/16	1- 3/8	3/32	1.174	.012	.103	.003	29,82	0,30	2,62	0.08
124	1- 1/4	1- 7/16	3/32	1.237	.012	.103	.003	31,42	0,30	2,62	0.08
125	1- 5/16	1- 1/2	3/32	1.299	.012	.103	.003	32,99	0,30	2,62	0.08
126	1- 3/8	1- 9/16	3/32	1.362	.012	.103	.003	34,59	0,30	2,62	0.08
127	1- 7/16	1- 5/8	3/32	1.424	.012	.103	.003	36,17	0,30	2,62	0.08
128	1- 1/2	1- 11/16	3/32	1.487	.012	.103	.003	37,77	0,30	2,62	0.08
129	1- 9/16	1- 3/4	3/32	1.549	.015	.103	.003	39,34	0,38	2,62	0.08
130	1- 5/8	1- 13/16	3/32	1.612	.015	.103	.003	40,94	0,38	2,62	0.08
131	1- 11/16	1- 7/8	3/32	1.674	.015	.103	.003	42,52	0,38	2,62	0.08
132	1- 3/4	1- 15/16	3/32	1.737	.015	.103	.003	44,12	0,38	2,62	0.08
133	1- 13/16	2	3/32	1.799	.015	.103	.003	45,69	0,38	2,62	0.08
134	1- 7/8	2- 1/16	3/32	1.862	.015	.103	.003	47,29	0,38	2,62	0.08
135	1- 15/16	2- 1/8	3/32	1.925	.017	.103	.003	48,90	0,43	2,62	0.08
136	2	2- 3/16	3/32	1.987	.017	.103	.003	50,47	0,43	2,62	0.08
137	2- 1/16	2- 1/4	3/32	2.050	.017	.103	.003	52,07	0,43	2,62	0.08
138	2- 1/8	2- 5/16	3/32	2.112	.017	.103	.003	53,64	0,43	2,62	0.08
139	2- 3/16	2- 3/8	3/32	2.175	.017	.103	.003	55,25	0,43	2,62	0.08
140	2- 1/4	2- 7/16	3/32	2.237	.017	.103	.003	56,82	0,43	2,62	0.08
141	2- 5/16	2- 1/2	3/32	2.300	.020	.103	.003	58,42	0,51	2,62	0.08
142	2- 3/8	2- 9/16	3/32	2.362	.020	.103	.003	59,99	0,51	2,62	0.08
143	2- 7/16	2- 5/8	3/32	2.425	.020	.103	.003	61,60	0,51	2,62	0.08
144	2- 1/2	2- 11/16	3/32	2.487	.020	.103	.003	63,17	0,51	2,62	0.08
145	2- 9/16	2- 3/4	3/32	2.550	.020	.103	.003	64,77	0,51	2,62	0.08
146	2- 5/8	2- 13/16	3/32	2.612	.020	.103	.003	66,34	0,51	2,62	0.08
147	2- 11/16	2- 7/8	3/32	2.675	.022	.103	.003	67,95	0,56	2,62	0.08
148	2- 3/4	2- 15/16	3/32	2.737	.022	.103	.003	69,52	0,56	2,62	0.08

Table 7-2: AS 568 B (Continued)

	Nominal size (inches)			Actual size (inches)				Actual size (mm)			
Dash No.	Inside diameter d1	Outside diameter	Cross-section d2	Inside diameter d1	Tol. ±	CS	Tol. ±	Inside diameter	Tol. ±	Cross-section d2	Tol. ±
149	2- 13/16	3	3/32	2.800	.022	.103	.003	71,12	0,56	2,62	0.08
150	2- 7/8	3- 1/16	3/32	2.862	.022	.103	.003	72,69	0,56	2,62	0.08
151	3	3- 3/16	3/32	2.987	.024	.103	.003	75,87	0,61	2,62	0.08
152	3- 1/4	3- 7/16	3/32	3.237	.024	.103	.003	82,22	0,61	2,62	0.08
153	3- 1/2	3- 11/16	3/32	3.487	.024	.103	.003	88,57	0,61	2,62	0.08
154	3- 3/4	3- 15/16	3/32	3.737	.028	.103	.003	94,92	0,71	2,62	0.08
155	4	4- 3/16	3/32	3.987	.028	.103	.003	101,27	0,71	2,62	0.08
156	4- 1/4	4- 7/16	3/32	4.237	.030	.103	.003	107,62	0,76	2,62	0.08
157	4- 1/2	4- 11/16	3/32	4.487	.030	.103	.003	113,97	0,76	2,62	0.08
158	4- 3/4	4- 15/16	3/32	4.737	.030	.103	.003	120,32	0,76	2,62	0.08
159	5	5- 3/16	3/32	4.987	.035	.103	.003	126,67	0,89	2,62	0.08
160	5- 1/4	5- 7/16	3/32	5.237	.035	.103	.003	133,02	0,89	2,62	0.08
161	5- 1/2	5- 11/16	3/32	5.487	.035	.103	.003	139,37	0,89	2,62	0.08
162	5- 3/4	5- 15/16	3/32	5.737	.035	.103	.003	145,72	0,89	2,62	0.08
163	6	6- 3/16	3/32	5.987	.035	.103	.003	152,07	0,89	2,62	0.08
164	6- 1/4	6- 7/16	3/32	6.237	.040	.103	.003	158,42	1,02	2,62	0.08
165	6- 1/2	6- 11/16	3/32	6.487	.040	.103	.003	164,77	1,02	2,62	0.08
166	6- 3/4	6- 15/16	3/32	6.737	.040	.103	.003	171,12	1,02	2,62	0.08
167	7	7- 3/16	3/32	6.987	.040	.103	.003	177,47	1,02	2,62	0.08
168	7- 1/4	7- 7/16	3/32	7.237	.045	.103	.003	183,82	1,14	2,62	0.08
169	7- 1/2	7- 11/16	3/32	7.487	.045	.103	.003	190,17	1,14	2,62	0.08
170	7- 3/4	7- 15/16	3/32	7.737	.045	.103	.003	196,52	1,14	2,62	0.08
171	8	8- 3/16	3/32	7.987	.045	.103	.003	202,87	1,14	2,62	0.08
172	8- 1/4	8- 7/16	3/32	8.237	.050	.103	.003	209,22	1,27	2,62	0.08
173	8- 1/2	8- 11/16	3/32	8.487	.050	.103	.003	215,57	1,27	2,62	0.08
174	8- 3/4	8- 15/16	3/32	8.737	.050	.103	.003	221,92	1,27	2,62	0.08
175	9	9- 3/16	3/32	8.987	.050	.103	.003	228,27	1,27	2,62	0.08
176	9- 1/4	9- 7/16	3/32	9.237	.055	.103	.003	234,62	1,40	2,62	0.08
177	9- 1/2	9- 11/16	3/32	9.487	.055	.103	.003	240,97	1,40	2,62	0.08
178	9- 3/4	9- 15/16	3/32	9.737	.055	.103	.003	247,32	1,40	2,62	0.08
201	3/16	7/16	1/8	.171	.055	.139	.004	4,34	0,13	3,53	0.10
202	1/4	1/2	1/8	.234	.005	.139	.004	5,94	0,13	3,53	0.10
203	5/16	9/16	1/8	.296	.005	.139	.004	7,52	0,13	3,53	0.10
204	3/8	5/8	1/8	.359	.005	.139	.004	9,12	0,13	3,53	0.10
205	7/16	11/16	1/8	.421	.005	.139	.004	10,69	0,13	3,53	0.10
206	1/2	3/4	1/8	.484	.005	.139	.004	12,29	0,13	3,53	0.10
207	9/16	13/16	1/8	.546	.007	.139	.004	13,87	0,18	3,53	0.10

Table 7-2: AS 568 B (Continued)

	Nominal size (inches)			Actual size (inches)				Actual size (mm)			
Dash No.	Inside diameter d1	Outside diameter	Cross-section d2	Inside diameter d1	Tol. ±	CS	Tol. ±	Inside diameter	Tol. ±	Cross-section d2	Tol. ±
208	5/8	7/8	1/8	.609	.009	.139	.004	15,47	0,23	3,53	0.10
209	11/16	15/16	1/8	.671	.010	.139	.004	17,04	0,23	3,53	0.10
210	3/4	1	1/8	.734	.010	.139	.004	18,64	0,25	3,53	0.10
211	13/16	1- 1/16	1/8	.796	.010	.139	.004	20,22	0,25	3,53	0.10
212	7/8	1- 1/8	1/8	.859	.010	.139	.004	21,82	0,25	3,53	0.10
213	15/16	1- 3/16	1/8	.921	.010	.139	.004	23,39	0,25	3,53	0.10
214	1	1- 1/4	1/8	.984	.010	.139	.004	24,99	0,25	3,53	0.10
215	1- 1/16	1- 5/16	1/8	1.046	.010	.139	.004	26,57	0,25	3,53	0.10
216	1- 1/8	1- 3/8	1/8	1.109	.012	.139	.004	28,17	0,30	3,53	0.10
217	1- 3/16	1- 7/16	1/8	1.171	.012	.139	.004	29,74	0,30	3,53	0.10
218	1- 1/4	1- 1/2	1/8	1.234	.012	.139	.004	31,34	0,30	3,53	0.10
219	1- 5/16	1- 9/16	1/8	1.296	.012	.139	.004	32,92	0,30	3,53	0.10
220	1- 3/8	1- 5/8	1/8	1.359	.012	.139	.004	34,52	0,30	3,53	0.10
221	1- 7/16	1- 11/16	1/8	1.421	.012	.139	.004	36,09	0,30	3,53	0.10
222	1- 1/2	1- 3/4	1/8	1.484	.015	.139	.004	37,69	0,38	3,53	0.10
223	1- 5/8	1- 7/8	1/8	1.609	.015	.139	.004	40,87	0,38	3,53	0.10
224	1- 3/4	2	1/8	1.734	.015	.139	.004	44,04	0,38	3,53	0.10
225	1- 7/8	2- 1/8	1/8	1.859	.015	.139	.004	47,22	0,46	3,53	0.10
226	2	2- 1/4	1/8	1.984	.018	.139	.004	50,39	0,46	3,53	0.10
227	2- 1/16	2- 3/8	1/8	2.109	.018	.139	.004	53,57	0,46	3,53	0.10
228	2- 1/4	2- 1/2	1/8	2.234	.020	.139	.004	56,74	0,51	3,53	0.10
229	2- 3/8	2- 5/8	1/8	2.359	.020	.139	.004	59,92	0,51	3,53	0.10
230	2- 1/2	2- 3/4	1/8	2.484	.020	.139	.004	63,09	0,51	3,53	0.10
231	2- 5/8	2- 7/8	1/8	2.609	.020	.139	.004	66,27	0,51	3,53	0.10
232	2- 3/4	3	1/8	2.734	.024	.139	.004	69,44	0,61	3,53	0.10
233	2- 7/8	3- 1/8	1/8	2.859	.024	.139	.004	72,62	0,61	3,53	0.10
234	3	3- 1/4	1/8	2.984	.024	.139	.004	75,79	0,61	3,53	0.10
235	3- 1/8	3- 3/8	1/8	3.109	.024	.139	.004	78,97	0,61	3,53	0.10
236	3- 1/4	3- 1/2	1/8	3.234	.024	.139	.004	82,14	0,61	3,53	0.10
237	3- 3/8	3- 5/8	1/8	3.359	.024	.139	.004	85,32	0,61	3,53	0.10
238	3- 1/2	3- 3/4	1/8	3.484	.024	.139	.004	88,49	0,61	3,53	0.10
239	3- 5/8	3- 7/8	1/8	3.609	.024	.139	.004	91,67	0,71	3,53	0.10
240	3- 3/4	4	1/8	3.734	.028	.139	.004	94,84	0,71	3,53	0.10
241	3- 7/8	4- 1/8	1/8	3.859	.028	.139	.004	98,02	0,71	3,53	0.10
242	4	4- 1/4	1/8	3.984	.028	.139	.004	101,19	0,71	3,53	0.10
243	4- 1/8	4- 3/8	1/8	4.109	.028	.139	.004	104,37	0,71	3,53	0.10
244	4- 1/4	4- 1/2	1/8	4.234	.030	.139	.004	107,54	0,76	3,53	0.10

Table 7-2: AS 568 B (Continued)

	Nominal size (inches)			Actual size (inches)				Actual size (mm)			
Dash No.	Inside diameter d1	Outside diameter	Cross-section d2	Inside diameter d1	Tol. ±	CS	Tol. ±	Inside diameter	Tol. ±	Cross-section d2	Tol. ±
245	4- 3/8	4- 5/8	1/8	4.359	.030	.139	.004	110,72	0,76	3,53	0.10
246	4- 1/2	4- 3/4	1/8	4.484	.030	.139	.004	113,89	0,76	3,53	0.10
247	4- 5/8	4- 7/8	1/8	4.609	.030	.139	.004	117,07	0,76	3,53	0.10
248	4- 3/4	5	1/8	4.734	.030	.139	.004	120,24	0,76	3,53	0.10
249	4- 7/8	5- 1/8	1/8	4.859	.035	.139	.004	123,42	0,89	3,53	0.10
250	5	5- 1/4	1/8	4.984	.035	.139	.004	126,59	0,89	3,53	0.10
251	5- 1/8	5- 3/8	1/8	5.109	.035	.139	.004	129,77	0,89	3,53	0.10
252	5- 1/4	5- 1/2	1/8	5.234	.035	.139	.004	132,94	0,89	3,53	0.10
253	5- 3/8	5- 5/8	1/8	5.359	.035	.139	.004	136,12	0,89	3,53	0.10
254	5- 1/2	5- 3/4	1/8	5.484	.035	.139	.004	139,29	0,89	3,53	0.10
255	5- 5/8	5- 7/8	1/8	5.609	.035	.139	.004	142,47	0,89	3,53	0.10
256	5- 3/4	6	1/8	5.734	.035	.139	.004	145,64	0,89	3,53	0.10
257	5- 7/8	6- 1/8	1/8	5.859	.035	.139	.004	148,82	0,89	3,53	0.10
258	6	6- 1/4	1/8	5.984	.035	.139	.004	151,99	0,89	3,53	0.10
259	6- 1/4	6- 1/2	1/8	6.234	.040	.139	.004	158,34	1,02	3,53	0.10
260	6- 1/2	6- 3/4	1/8	6.484	.040	.139	.004	164,69	1,02	3,53	0.10
261	6- 3/4	7	1/8	6.734	.040	.139	.004	171,04	1,02	3,53	0.10
262	7	7- 1/4	1/8	6.984	.040	.139	.004	177,39	1,02	3,53	0.10
263	7- 1/4	7- 1/2	1/8	7.234	.045	.139	.004	183,74	1,14	3,53	0.10
264	7- 1/2	7- 3/4	1/8	7.484	.045	.139	.004	190.09	1,14	3,53	0.10
265	7- 3/4	8	1/8	7.734	.045	.139	.004	196,44	1,14	3,53	0.10
266	8	8- 1/4	1/8	7.984	.045	.139	.004	202,79	1,14	3,53	0.10
267	8- 1/4	8- 1/2	1/8	8.234	.050	.139	.004	209,14	1,27	3,53	0.10
268	8- 1/2	8- 3/4	1/8	8.484	.050	.139	.004	215,49	1,27	3,53	0.10
269	8- 3/4	9	1/8	8.734	.050	.139	.004	221,84	1,27	3,53	0.10
270	9	9- 1/4	1/8	8.984	.050	.139	.004	228,19	1,27	3,53	0.10
271	9- 1/4	9- 1/2	1/8	9.234	.055	.139	.004	234,54	1,40	3,53	0.10
272	9- 1/2	9- 3/4	1/8	9.484	.055	.139	.004	240,89	1,40	3,53	0.10
273	9- 3/4	10	1/8	9.734	.055	.139	.004	247,24	1,40	3,53	0.10
274	10	10- 1/4	1/8	9.984	.055	.139	.004	253,59	1,40	3,53	0.10
275	10- 1/2	10- 3/4	1/8	10.484	.055	.139	.004	266,29	1,40	3,53	0.10
276	11	11- 1/4	1/8	10.984	.065	.139	.004	278,99	1,65	3,53	0.10
277	11- 1/2	11- 3/4	1/8	11.484	.065	.139	.004	291,69	1,65	3,53	0.10
278	12	12- 1/4	1/8	11.984	.065	.139	.004	304,39	1,65	3,53	0.10
279	13	13- 1/4	1/8	12.984	.065	.139	.004	329,79	1,65	3,53	0.10
280	14	14- 1/4	1/8	13.984	.065	.139	.004	355,19	1,65	3,53	0.10
281	15	15- 1/4	1/8	14.984	.065	.139	.004	380,59	1,65	3,53	0.10

Table 7-2: AS 568 B (Continued)

	Nominal size (inches)			Actual size (inches)				Actual size (mm)			
Dash No.	Inside diameter d1	Outside diameter	Cross-section d2	Inside diameter d1	Tol. ±	CS	Tol. ±	Inside diameter	Tol. ±	Cross-section d2	Tol. ±
282	16	16- 1/4	1/8	15.955	.075	.139	.004	405,26	1,91	3,53	0.10
283	17	17- 1/4	1/8	16.955	.080	.139	.004	430,66	2,03	3,53	0.10
284	18	18- 1/4	1/8	17.955	.085	.139	.004	456,06	2,16	3,53	0.10
309	7/16	13/16	3/16	.412	.005	.210	.005	10,46	0,13	5,33	0.13
310	1/2	7/8	3/16	.475	.005	.210	.005	12,07	0,13	5,33	0.13
311	9/16	15/16	3/16	.537	.007	.210	.005	13,64	0,18	5,33	0.13
312	5/8	1	3/16	.600	.009	.210	.005	15,24	0,23	5,33	0.13
313	11/16	1- 1/16	3/16	.662	.009	.210	.005	16,81	0,23	5,33	0.13
314	3/4	1- 1/8	3/16	.725	.010	.210	.005	18,42	0,25	5,33	0.13
315	13/16	1- 3/16	3/16	.787	.010	.210	.005	19,99	0,25	5,33	0.13
316	7/8	1- 1/4	3/16	.850	.010	.210	.005	21,59	0,25	5,33	0.13
317	15/16	1- 5/16	3/16	.912	.010	.210	.005	23,16	0,25	5,33	0.13
318	1	1- 3/8	3/16	.975	.010	.210	.005	24,77	0,25	5,33	0.13
319	1- 1/16	1- 7/16	3/16	1.037	.010	.210	.005	26,34	0,25	5,33	0.13
320	1- 1/8	1- 1/2	3/16	1.100	.012	.210	.005	27,94	0,30	5,33	0.13
321	1- 3/16	1- 9/16	3/16	1.162	.012	.210	.005	29,51	0,30	5,33	0.13
322	1- 1/4	1- 5/8	3/16	1.225	.012	.210	.005	31,12	0,30	5,33	0.13
323	1- 5/16	1- 11/16	3/16	1.287	.012	.210	.005	32,69	0,30	5,33	0.13
324	1- 3/8	1- 3/4	3/16	1.350	.012	.210	.005	34,29	0,30	5,33	0.13
325	1- 1/2	1- 7/8	3/16	1.475	.015	.210	.005	37,47	0,38	5,33	0.13
326	1- 5/8	2	3/16	1.600	.015	.210	.005	40,64	0,38	5,33	0.13
327	1- 3/4	2- 1/8	3/16	1.725	.015	.210	.005	43,82	0,38	5,33	0.13
328	1- 7/8	2- 1/4	3/16	1.850	.015	.210	.005	46,99	0,38	5,33	0.13
329	2	2- 3/8	3/16	1.975	.018	.210	.005	50,17	0,46	5,33	0.13
330	2- 1/8	2- 1/2	3/16	2.100	.018	.210	.005	53,34	0,46	5,33	0.13
331	2- 1/4	2- 5/8	3/16	2.225	.018	.210	.005	56,52	0,46	5,33	0.13
332	2- 3/8	2- 3/4	3/16	2.350	.018	.210	.005	59,69	0,46	5,33	0.13
333	2- 1/2	2- 7/8	3/16	2.475	.020	.210	.005	62,87	0,51	5,33	0.13
334	2- 5/8	3	3/16	2.600	.020	.210	.005	66.04	0.51	5,33	0.13
335	2- 3/4	3- 1/8	3/16	2.725	.020	.210	.005	69,22	0,51	5,33	0.13
336	2- 7/8	3- 1/4	3/16	2.850	.020	.210	.005	72,39	0,51	5,33	0.13
337	3	3- 3/8	3/16	2.975	.024	.210	.005	75,37	0,61	5,33	0.13
338	3- 1/8	3- 1/2	3/16	3.100	.024	.210	.005	78,74	0,61	5,33	0.13
339	3- 1/4	3- 5/8	3/16	3.225	.024	.210	.005	81,92	0,61	5,33	0.13
340	3- 3/8	3- 3/4	3/16	3.350	.024	.210	.005	85,09	0,61	5,33	0.13
341	3- 1/2	3- 7/8	3/16	3.475	.024	.210	.005	88,27	0,61	5,33	0.13
342	3- 5/8	4	3/16	3.600	.028	.210	.005	91,44	0,71	5,33	0.13

Table 7-2: AS 568 B (Continued)

	Nominal size (inches)			Actual size (inches)				Actual size (mm)			
Dash No.	Inside diameter d1	Outside diameter	Cross-section d2	Inside diameter d1	Tol. ±	CS	Tol. ±	Inside diameter	Tol. ±	Cross-section d2	Tol. ±
343	3- 3/4	4- 1/8	3/16	3.725	.028	.210	.005	94,62	0,71	5,33	0.13
344	3- 7/8	4- 1/4	3/16	3.850	.028	.210	.005	97,79	0,71	5,33	0.13
345	4	4- 3/8	3/16	3.975	.028	.210	.005	100,97	0,71	5,33	0.13
346	4- 1/8	4- 1/2	3/16	4.100	.028	.210	.005	104,14	0,71	5,33	0.13
347	4- 1/4	4- 5/8	3/16	4.225	.030	.210	.005	107,32	0,76	5,33	0.13
348	4- 3/8	4- 3/4	3/16	4.350	.030	.210	.005	110,49	0,76	5,33	0.13
349	4- 1/2	4- 7/8	3/16	4.475	.030	.210	.005	113,67	0,76	5,33	0.13
350	4- 5/8	5	3/16	4.600	.030	.210	.005	116,84	0,76	5,33	0.13
351	4- 3/4	5- 1/8	3/16	4.725	.030	.210	.005	120,02	0,76	5,33	0.13
352	4- 7/8	5- 1/4	3/16	4.850	.030	.210	.005	123,19	0,76	5,33	0.13
353	5	5- 3/8	3/16	4.975	.037	.210	.005	126,37	0,94	5,33	0.13
354	5- 1/8	5- 1/2	3/16	5.100	.037	.210	.005	129,54	0,94	5,33	0.13
355	5- 1/4	5- 3/8	3/16	5.225	.037	.210	.005	132,72	0,94	5,33	0.13
356	5- 3/8	5- 3/4	3/16	5.350	.037	.210	.005	135,89	0,94	5,33	0.13
357	5- 1/2	5- 7/8	3/16	5.475	.037	.210	.005	139,07	0,94	5,33	0.13
358	5- 5/8	6	3/16	5.600	.037	.210	.005	142,24	0,94	5,33	0.13
359	5- 3/4	6- 1/8	3/16	5.725	.037	.210	.005	145,42	0,94	5,33	0.13
360	5- 7/8	6- 1/4	3/16	5.850	.037	.210	.005	148,59	0,94	5,33	0.13
361	6	6- 3/8	3/16	5.975	.037	.210	.005	151,77	0,94	5,33	0.13
362	6- 1/4	6- 5/8	3/16	6.225	.040	.210	.005	158,12	1,02	5,33	0.13
363	6- 1/2	6- 7/8	3/16	6.475	.040	.210	.005	164,47	1,02	5,33	0.13
364	6- 3/4	7- 1/8	3/16	6.725	.040	.210	.005	170,82	1,02	5,33	0.13
365	7	7- 3/8	3/16	6.975	.040	.210	.005	177,17	1,02	5,33	0.13
366	7- 1/4	7- 5/8	3/16	7.225	.045	.210	.005	183,52	1,14	5,33	0.13
367	7- 1/2	7- 7/8	3/16	7.475	.045	.210	.005	189,87	1,14	5,33	0.13
368	7- 3/4	8- 1/8	3/16	7.725	.045	.210	.005	196,22	1,14	5,33	0.13
369	8	8- 3/8	3/16	7.925	.045	.210	.005	202,57	1,14	5,33	0.13
370	8- 1/4	8- 5/8	3/16	8.225	.050	.210	.005	208,92	1,27	5,33	0.13
371	8- 1/2	8- 7/8	3/16	8.475	.050	.210	.005	215,27	1,27	5,33	0.13
372	8- 3/4	9- 1/8	3/16	8.725	.050	.210	.005	221,62	1,27	5,33	0.13
373	9	9- 3/8	3/16	8.975	.050	.210	.005	227,97	1,27	5,33	0.13
374	9- 1/4	9- 5/8	3/16	9.225	.055	.210	.005	234,32	1,40	5,33	0.13
375	9- 1/2	9- 7/8	3/16	9.475	.055	.210	.005	240,67	1,40	5,33	0.13
376	9- 3/4	10- 1/8	3/16	9.725	.055	.210	.005	247,02	1,40	5,33	0.13
377	10	10- 3/8	3/16	9.975	.055	.210	.005	253,37	1,40	5,33	0.13
378	10- 1/2	10- 7/8	3/16	10.475	.060	.210	.005	266,07	1,52	5,33	0.13
379	11	11- 3/8	3/16	10.975	.060	.210	.005	278,77	1,52	5,33	0.13

Table 7-2: AS 568 B (Continued)

	Nominal size (inches)			Actual size (inches)				Actual size (mm)			
Dash No.	Inside diameter d1	Outside diameter	Cross-section d2	Inside diameter d1	Tol. ±	CS	Tol. ±	Inside diameter	Tol. ±	Cross-section d2	Tol. ±
380	11- 1/2	11- 7/8	3/16	11.475	.065	.210	.005	291,47	1,65	5,33	0.13
381	12	12- 3/8	3/16	11.975	.065	.210	.005	304,17	1,65	5,33	0.13
382	13	13- 3/8	3/16	12.975	.065	.210	.005	329,57	1,65	5,33	0.13
383	14	14- 3/8	3/16	13.975	.070	.210	.005	354,97	1,78	5,33	0.13
384	15	15- 3/8	3/16	14.975	.070	.210	.005	380,37	1,78	5,33	0.13
385	16	16- 3/8	3/16	15.955	.075	.210	.005	405,26	1,91	5,33	0.13
386	17	17- 3/8	3/16	16.955	.080	.210	.005	430,66	2,03	5,33	0.13
387	18	18- 3/8	3/16	17.955	.085	.210	.005	456,06	2,16	5,33	0.13
388	19	19- 3/8	3/16	18.955	.090	.210	.005	481,41	2,29	5,33	0.13
389	20	20- 3/8	3/16	19.955	.095	.210	.005	506,81	2,41	5,33	0.13
390	21	21- 3/8	3/16	20.955	.095	.210	.005	532,21	2,41	5,33	0.13
391	22	22- 3/8	3/16	21.955	.100	.210	.005	557,61	2,54	5,33	0.13
392	23	23- 3/8	3/16	22.940	.105	.210	.005	582,68	2,67	5,33	0.13
393	24	24- 3/8	3/16	23.940	.110	.210	.005	608,08	2,79	5,33	0.13
394	25	25- 3/8	3/16	24.940	.115	.210	.005	633,48	2,92	5,33	0.13
395	26	26- 3/8	3/16	25.940	.120	.210	.005	658,88	3,05	5,33	0.13
425	4- 1/2	5	1/4	4.475	.033	.275	.006	113,67	0,84	6,99	0.15
426	4- 5/8	5- 1/8	1/4	4.600	.033	.275	.006	116,84	0,84	6,99	0.15
427	4- 3/4	5- 1/4	1/4	4.725	.033	.275	.006	120,02	0,84	6,99	0.15
428	4- 7/8	5- 3/8	1/4	4.850	.033	.275	.006	123,19	0,84	6,99	0.15
429	5	5- 1/2	1/4	4.975	.037	.275	.006	126,37	0,94	6,99	0.15
430	5- 1/8	5- 5/8	1/4	5.100	.037	.275	.006	129,54	0,94	6,99	0.15
431	5- 1/4	5- 3/4	1/4	5.225	.037	.275	.006	132,72	0,94	6,99	0.15
432	5- 3/8	5- 7/8	1/4	5.350	.037	.275	.006	135,89	0,94	6,99	0.15
433	5- 1/2	6	1/4	5.475	.037	.275	.006	139,07	0,94	6,99	0.15
434	5- 5/8	6- 1/8	1/4	5.600	.037	.275	.006	142,24	0,94	6,99	0.15
435	5- 3/4	6- 1/4	1/4	5.725	.037	.275	.006	145,42	0,94	6,99	0.15
436	5- 7/8	6- 3/8	1/4	5.850	.037	.275	.006	148,59	0,94	6,99	0.15
437	6	6- 1/2	1/4	5.975	.037	.275	.006	151,77	0,94	6,99	0.15
438	6- 1/4	6- 3/4	1/4	6.225	.040	.275	.006	158,12	1,02	6,99	0.15
439	6- 1/2	7	1/4	6.475	.040	.275	.006	164,47	1,02	6,99	0.15
440	6- 3/4	7- 1/4	1/4	6.725	.040	.275	.006	170,82	1,02	6,99	0.15
441	7	7- 1/2	1/4	6.975	.040	.275	.006	177,17	1,02	6,99	0.15
442	7- 1/4	7- 3/4	1/4	7.225	.045	.275	.006	183,52	1,14	6,99	0.15
443	7- 1/2	8	1/4	7.475	.045	.275	.006	189,87	1,14	6,99	0.15
444	7- 3/4	8- 1/4	1/4	7.725	.045	.275	.006	196,22	1,14	6,99	0.15
445	8	8- 1/2	1/4	7.975	.045	.275	.006	202,57	1,14	6,99	0.15

Table 7-2: AS 568 B (Continued)

	Nominal size (inches)			Actual size (inches)				Actual size (mm)			
Dash No.	Inside diameter d1	Outside diameter	Cross-section d2	Inside diameter d1	Tol. ±	CS	Tol. ±	Inside diameter	Tol. ±	Cross-section d2	Tol. ±
446	8- 1/2	9	1/4	8.475	.055	.275	.006	215,27	1,40	6,99	0.15
447	9	9- 1/2	1/4	8.975	.055	.275	.006	227,97	1,40	6,99	0.15
448	9- 1/2	10	1/4	9.475	.055	.275	.006	240,67	1,40	6,99	0.15
449	10	10- 1/2	1/4	9.975	.055	.275	.006	253,37	1,40	6,99	0.15
450	10- 1/2	11	1/4	10.475	.060	.275	.006	266,07	1,52	6,99	0.15
451	11	11- 1/2	1/4	10.975	.060	.275	.006	278,77	1,52	6,99	0.15
452	11- 1/2	12	1/4	11.475	.060	.275	.006	291,47	1,52	6,99	0.15
453	12	12- 1/2	1/4	11.975	.060	.275	.006	304,17	1,52	6,99	0.15
454	12- 1/2	13	1/4	12.475	.060	.275	.006	316,87	1,52	6,99	0.15
455	13	13- 1/2	1/4	12.975	.060	.275	.006	329,57	1,52	6,99	0.15
456	13- 1/2	14	1/4	13.475	.070	.275	.006	342,27	1,78	6,99	0.15
457	14	14- 1/2	1/4	13.975	.070	.275	.006	354,97	1,78	6,99	0.15
458	14- 1/2	15	1/4	14.475	.070	.275	.006	367,67	1,78	6,99	0.15
459	15	15- 1/2	1/4	14.975	.070	.275	.006	380,37	1,78	6,99	0.15
460	15- 1/2	16	1/4	15.475	.070	.275	.006	393,07	1,78	6,99	0.15
461	16	16- 1/2	1/4	15.955	.075	.275	.006	405,26	1,91	6,99	0.15
462	16- 1/2	17	1/4	16.455	.075	.275	.006	417,96	1,91	6,99	0.15
463	17	17- 1/2	1/4	16.955	.080	.275	.006	430,66	2,03	6,99	0.15
464	17- 1/2	18	1/4	17.455	.085	.275	.006	443,36	2,16	6,99	0.15
465	18	18- 1/2	1/4	17.955	.085	.275	.006	456,06	2,16	6,99	0.15
466	18- 1/2	19	1/4	18.455	.085	.275	.006	468,76	2,16	6,99	0.15
467	19	19- 1/2	1/4	18.955	.090	.275	.006	481,46	2,29	6,99	0.15
468	19- 1/2	20	1/4	19.455	.090	.275	.006	494,16	2,29	6,99	0.15
469	20	20- 1/2	1/4	19.955	.095	.275	.006	506,86	2,41	6,99	0.15
470	21	21- 1/2	1/4	20.955	.095	.275	.006	532,26	2,41	6,99	0.15
471	22	22- 1/2	1/4	21.955	.100	.275	.006	557,66	2,54	6,99	0.15
472	23	23- 1/2	1/4	22.940	.105	.275	.006	582,68	2,67	6,99	0.15
473	24	24- 1/2	1/4	23.940	.110	.275	.006	608,08	2,79	6,99	0.15
474	25	25- 1/2	1/4	24.940	.115	.275	.006	633,48	2,92	6,99	0.15
475	26	26- 1/2	1/4	25.940	.120	.275	.006	658,88	3,05	6,99	0.15

Table 7-2: AS 568 B (Continued)

	Nominal size (inches)			Actual size (inches)				Actual size (mm)			
Dash No.	Inside diameter d1	Outside diameter	Cross-section d2	Inside diameter d1	Tol. ±	CS	Tol. ±	Inside diameter	Tol. ±	Cross-section d2	Tol. ±
901				.185	.005	.056	.003	4,70	0,13	1,42	0.08
902				.239	.005	.064	.003	6,07	0,13	1,63	0.08
903				.301	.005	.064	.003	7,65	0,13	1,63	0.08
904				.351	.005	.072	.003	8,92	0,13	1,83	0.08
905				.414	.005	.072	.003	10,52	0,13	1,83	0.08
906				.468	.005	.078	.003	11,89	0,13	1,98	0.08
907				.530	.007	.082	.003	13,46	0,18	2,08	0.08
908				.644	.009	.087	.003	16,36	0,23	2,21	0.08
909				.706	.009	.097	.003	17,93	0,23	2,46	0.08
910				.755	.009	.097	.003	19,18	0,23	2,46	0.08
911				.863	.009	.116	.004	21,92	0,23	2,95	0.10
912				.924	.009	.116	.004	23,47	0,23	2,95	0.10
913				.986	.010	.116	.004	25,04	0,26	2,95	0.10
914				1.047	.010	.116	.004	26,59	0,26	2,95	0.10
916				1.171	.010	.116	.004	29,74	0,26	2,95	0.10
918				1.355	.012	.116	.004	34,42	0,30	2,95	0.10
920				1.475	.014	.118	.004	37,47	0,36	3,00	0.10
924				1.720	.014	.118	.004	43,69	0,36	3,00	0.10
928				2.090	.018	.118	.004	53,09	0,46	3,00	0.10
932				2.337	.018	.118	.004	59,36	0,46	3,00	0.10

Table 7-2: AS 568 B (Continued)

7.3 ISO 3601-1 / DIN 3771

d1 (mm)	d2 (mm) 1.8 +/-0.08	2.65 +/-0.09	3.55 +/-0.1	5.3 +/-0.13	7 +/-0.15
1.8	X				
2	X				
2.24	X				
2.5	X				
2.8	X				
3.15	X				
3.55	X				
3.75	X				
4	X				
4.5	X				
4.75	X				
4.87	X				
5	X				
5.15	X				
5.3	X				
5.6	X				
6	X				
6.3	X				
6.7	X				
6.9	X				
7.1	X				
7.5	X				
8	X				
8.5	X				
8.75	X				
9	X				
9.5	X				
9.75	X				
10	X				
10.6	X				
11.2	X				
11.6	X				
11.8	X				
12.1	X				
12.5	X				
12.8	X				
13.2	X				
14	X	X			
14.5	X	X			
15	X	X			
15.5	X	X			
16	X	X			
17	X	X			
18	X	X	X		
19	X	X	X		
20	X	X	X		
20.6	X	X	X		
23.6	X	X	X		
24.3	X	X	X		
25	X	X	X		
25.8	X	X	X		
26.5	X	X	X		
27.3	X	X	X		
28	X	X	X		
29	X	X	X		
30	X	X	X		
31.5		X	X		
32.5		X	X		
33.5		X	X		
34.5		X	X		
35.5		X	X		
36.5		X	X		
37.5		X	X		
38.7		X	X		
40		X	X	X	
41.2		X	X	X	
42.5		X	X	X	
43.7		X	X	X	

Table 7-3: ISO 3601-1 / DIN 3771

d1 (mm)	d2 (mm)				
	1.8 +/-0.08	2.65 +/-0.09	3.55 +/-0.1	5.3 +/-0.13	7 +/-0.15
45		X	X	X	
46.2		X	X	X	
47.5		X	X	X	
48.7		X	X	X	
50		X	X	X	
51.5		X	X	X	
53		X	X	X	
54.5		X	X	X	
56		X	X	X	
58		X	X	X	
60		X	X	X	
61.5		X	X	X	
63		X	X	X	
65		X	X	X	
67		X	X	X	
69		X	X	X	
71		X	X	X	
73		X	X	X	
75		X	X	X	
77.5		X	X	X	
80		X	X	X	
82.5		X	X	X	
85		X	X	X	
87.5		X	X	X	
90		X	X	X	
92.5		X	X	X	
95		X	X	X	
97.5		X	X	X	
100		X	X	X	
103		X	X	X	
106		X	X	X	
109			X	X	X
112			X	X	X
115			X	X	X

d1 (mm)	d2 (mm)				
	1.8 +/-0.08	2.65 +/-0.09	3.55 +/-0.1	5.3 +/-0.13	7 +/-0.15
118			X	X	X
122			X	X	X
125			X	X	X
128			X	X	X
132			X	X	X
136			X	X	X
140			X	X	X
142.5			X	X	X
145			X	X	X
147.5			X	X	X
150			X	X	X
152.5			X	X	X
155			X	X	X
157.5			X	X	X
160			X	X	X
162.5			X	X	X
165			X	X	X
167.5			X	X	X
170			X	X	X
172.5			X	X	X
175			X	X	X
177.5			X	X	X
180			X	X	X
182.5			X	X	X
185			X	X	X
187.5			X	X	X
190			X	X	X
195			X	X	X
200			X	X	X
203				X	X
206				X	X
212				X	X
218				X	X
224				X	X

Table 7-3: ISO 3601-1 / DIN 3771 (Continued)

d1 (mm)	d2 (mm)				
	1.8 +/-0.08	2.65 +/-0.09	3.55 +/-0.1	5.3 +/-0.13	7 +/-0.15
227				X	X
230				X	X
236				X	X
239				X	X
243				X	X
250				X	X
254				X	X
258				X	X
261				X	X
265				X	X
268				X	X
272				X	X
276				X	X
280				X	X
283				X	X
286				X	X
290				X	X
295				X	X
300				X	X
303				X	X
307				X	X
311				X	X
315				X	X
320				X	X
325				X	X
330				X	X
335				X	X
340				X	X
345				X	X
350				X	X
355				X	X
360				X	X
365				X	X
370				X	X

d1 (mm)	d2 (mm)				
	1.8 +/-0.08	2.65 +/-0.09	3.55 +/-0.1	5.3 +/-0.13	7 +/-0.15
375					X
379					X
383					X
387					X
391					X
395					X
400					X
406					X
412					X
418					X
425					X
429					X
433					X
437					X
443					X
450					X
456					X
462					X
466					X
470					X
475					X
479					X
483					X
487					X
493					X
500					X
508					X
515					X
523					X
530					X
538					X
545					X
553					X
560					X

Table 7-3: ISO 3601-1 / DIN 3771 (Continued)

d1 (mm)	d2 (mm)				
	1.8 +/-0.08	2.65 +/-0.09	3.55 +/-0.1	5.3 +/-0.13	7 +/-0.15
570					X
580					X
590					X
600					X
608					X
615					X
623					X
630					X
640					X
650					X
660					X
670					X

Table 7-3: ISO 3601-1 / DIN 3771 (Continued)

7.4 SMS 1586

d1 x d2 (mm)	d1 x d2 (mm)	d1 x d2 (mm)
3,1 x 1,6	24,2 x 3,0	104,1 x 5,7
4,1 x 1,6	26,2 x 3,0	109,1 x 5,7
5,1 x 1,6	29,2 x 3,0	114,3 x 5,7
6,1 x 1,6	32,2 x 3,0	119,3 x 5,7
7,1 x 1,6	34,2 x 3,0	124,3 x 5,7
8,1 x 1,6	36,2 x 3,0	129,3 x 5,7
9,1 x 1,6	39,2 x 3,0	134,3 x 5,7
10,1 x 1,6	42,2 x 3,0	139,3 x 5,7
11,1 x 1,6	44,2 x 3,0	144,3 x 5,7
12,1 x 1,6	49,5 x 3,0	149,3 x 5,7
13,1 x 1,6	54,5 x 3,0	154,3 x 5,7
14,1 x 1,6	59,5 x 3,0	159,3 x 5,7
15,1 x 1,6	64,5 x 3,0	164,3 x 5,7
16,1 x 1,6	69,5 x 3,0	169,3 x 5,7
17,1 x 1,6	74,5 x 3,0	174,3 x 5,7
18,1 x 1,6	79,5 x 3,0	179,3 x 5,7
19,1 x 1,6	84,5 x 3,0	184,3 x 5,7
22,1 x 1,6	89,5 x 3,0	189,3 x 5,7
25,1 x 1,6	94,5 x 3,0	194,3 x 5,7
27,1 x 1,6	99,5 x 3,0	199,3 x 5,7
29,1 x 1,6	104,5 x 3,0	209,3 x 5,7
32,1 x 1,6	109,5 x 3,0	219,3 x 5,7
35,1 x 1,6	114,5 x 3,0	229,3 x 5,7
37,1 x 1,6	119,5 x 3,0	239,3 x 5,7
3,3 x 2,4	124,5 x 3,0	249,3 x 5,7
4,3 x 2,4	129,5 x 3,0	259,3 x 5,7
5,3 x 2,4	134,5 x 3,0	269,3 x 5,7
6,3 x 2,4	139,5 x 3,0	279,3 x 5,7
7,3 x 2,4	144,5 x 3,0	289,3 x 5,7
8,3 x 2,4	44,2 x 5,7	299,3 x 5,7
9,3 x 2,4	49,2 x 5,7	319,3 x 5,7
10,3 x 2,4	54,2 x 5,7	339,3 x 5,7
11,3 x 2,4	59,2 x 5,7	359,3 x 5,7
12,3 x 2,4	64,2 x 5,7	379,3 x 5,7
13,3 x 2,4	69,2 x 5,7	399,3 x 5,7
14,3 x 2,4	74,2 x 5,7	419,3 x 5,7
15,3 x 2,4	79,2 x 5,7	439,3 x 5,7
16,3 x 2,4	84,1 x 5,7	459,3 x 5,7
17,3 x 2,4	89,1 x 5,7	479,3 x 5,7
19,2 x 3,0	94,1 x 5,7	499,3 x 5,7
22,2 x 3,0	99,1 x 5,7	144,1 x 8,4

Table 7-4: SMS 1586

d1 x d2 (mm)	d1 x d2 (mm)	d1 x d2 (mm)
149,1 x 8,4	179,1 x 8,4	219,1 x 8,4
154,1 x 8,4	184,1 x 8,4	229,1 x 8,4
159,1 x 8,4	189,1 x 8,4	239,1 x 8,4
164,1 x 8,4	194,1 x 8,4	249,1 x 8,4
169,1 x 8,4	199,1 x 8,4	
174,1 x 8,4	209,1 x 8,4	

Table 7-4: SMS 1586 (Continued)

7.5 Metric sizes

d2 (mm)	d1 Range (mm)
1	
1.5	
2	
2.5	
3	
3.5	
4	
4.5	
5	
5.5	
6	
6.5	1-1500
7	
7.5	
8	
8.5	
9	
9.5	
10	
12	
14	
16	
18	
20	

Table 7-5: Metric sizes

Tools of the most common sizes are available. Due to different shrinkage factors of various materials it can be possible that the existing tools are not suited to meet the dimensional requirements. Special dimensions are available on request. Please contact our office for further details.

8 O-Ring quality acceptance criteria

O-Rings may be subject to tests concerning:

- The physical-mechanical properties
- The dimensional-quality properties

The physical-mechanical characteristics are practically the same as described in section 4.3, 'Main properties of elastomers'.
As far as the dimensional-quality characteristics are concerned, reference is made to the sizes of the O-Ring and the condition of the surface.
Our standard procedure covers:

- Testing of the hardness
- Measurement of the sizes
- Control of the surface

These criteria are described in the ISO standard 3601-1.

8.1 Inside diameters (d1), cross-section (d2) and tolerances (ISO 3601-1)

The O-Ring is defined by the internal diameter d1 and the cross-section d2 as shown in the figure below:

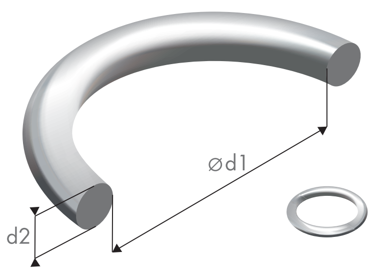


Figure 8-1: O-Ring

In our O-Ring production the tolerances given in the ISO 3601-1 standard for the control of the O-Rings are used.


digi test
Giugno 20
PARKER
0.0 IRHD
POWER

The tables of these tolerances can be found below.

CROSS-SECTION d2 (mm)	TOLERANCES ± (mm)
d2 ≤ 1.80	0.08
1.80 < d2 ≤ 2.65	0.09
2.65 < d2 ≤ 3.55	0.1
3.55 < d2 ≤ 5.30	0.13
5.30 < d2 ≤ 7.00	0.15
7.00 < d2 ≤ 8.00	0.18
8.00 < d2 ≤ 10.00	0.21
10.00 < d2 ≤ 12.00	0.25
d2 > 12.00	ON REQUEST

Table 8-1: Tolerances for O-Ring cross-sections based on ISO 3601-1

INSIDE DIAMETER d1 (mm)	TOLERANCES ± (mm)
d1 ≤ 2.80	0.13
2.80 < d1 ≤ 4.00	0.14
4.00 < d1 ≤ 5.30	0.15
5.30 < d1 ≤ 7.10	0.16
7.10 < d1 ≤ 8.50	0.17
8.50 < d1 ≤ 9.75	0.18
9.75 < d1 ≤ 10.60	0.19
10.60 < d1 ≤ 11.80	0.2
11.80 < d1 ≤ 13.20	0.21
13.20 < d1 ≤ 15.00	0.22
15.00 < d1 ≤ 16.00	0.23
16.00 < d1 ≤ 17.00	0.24
17.00 < d1 ≤ 19.00	0.25
19.00 < d1 ≤ 20.60	0.26
20.60 < d1 ≤ 21.20	0.27
21.20 < d1 ≤ 22.40	0.28
22.40 < d1 ≤ 23.60	0.29
23.60 < d1 ≤ 25.00	0.3
25.00 < d1 ≤ 26.50	0.31
26.50 < d1 ≤ 28.00	0.32
28.00 < d1 ≤ 29.00	0.33
29.00 < d1 ≤ 30.00	0.34
30.00 < d1 ≤ 31.50	0.35

Table 8-2: Tolerances for O-Ring inside diameters based on ISO 3601-1

INSIDE DIAMETER d1 (mm)	TOLERANCES ± (mm)
31.50 < d1 ≤ 33.50	0.36
33.50 < d1 ≤ 34.50	0.37
34.50 < d1 ≤ 36.50	0.38
36.50 < d1 ≤ 37.50	0.36
37.50 < d1 ≤ 38.70	0.39
38.70 < d1 ≤ 40.00	0.41
40.00 < d1 ≤ 41.20	0.42
41.20 < d1 ≤ 42.50	0.43
42.50 < d1 ≤ 45.00	0.44
45.00 < d1 ≤ 46.20	0.45
46.20 < d1 ≤ 47.50	0.46
47.50 < d1 ≤ 48.70	0.47
48.70 < d1 ≤ 50.00	0.48
50.00 < d1 ≤ 51.50	0.49
51.50 < d1 ≤ 53.00	0.5
53.00 < d1 ≤ 54.50	0.51
54.50 < d1 ≤ 56.00	0.52
56.00 < d1 ≤ 58.00	0.54
58.00 < d1 ≤ 60.00	0.55
60.00 < d1 ≤ 61.50	0.56
61.50 < d1 ≤ 63.00	0.57
63.00 < d1 ≤ 65.00	0.58
65.00 < d1 ≤ 67.00	0.6
67.00 < d1 ≤ 69.00	0.61
69.00 < d1 ≤ 71.00	0.63
71.00 < d1 ≤ 73.00	0.64
73.00 < d1 ≤ 75.00	0.65
75.00 < d1 ≤ 77.50	0.67
77.50 < d1 ≤ 80.00	0.69
80.00 < d1 ≤ 82.50	0.71
82.50 < d1 ≤ 85.00	0.72
85.00 < d1 ≤ 87.50	0.74
87.50 < d1 ≤ 90.00	0.76
90.00 < d1 ≤ 92.50	0.77
92.50 < d1 ≤ 95.00	0.79
95.00 < d1 ≤ 97.50	0.81
97.50 < d1 ≤ 100.00	0.82
100.00 < d1 ≤ 103.00	0.85
103.00 < d1 ≤ 106.00	0.87
106.00 < d1 ≤ 109.00	0.89
109.00 < d1 ≤ 112.00	0.91
112.00 < d1 ≤ 115.00	0.93
115.00 < d1 ≤ 118.00	0.95

Table 8-2: Tolerances for O-Ring inside diameters based on ISO 3601-1 (Continued)

INSIDE DIAMETER d1 (mm)	TOLERANCES ± (mm)
118.00 < d1 ≤ 122.00	0.97
122.00 < d1 ≤ 125.00	0.99
125.00 < d1 ≤ 128.00	1.01
128.00 < d1 ≤ 132.00	1.04
132.00 < d1 ≤ 136.00	1.07
136.00 < d1 ≤ 140.00	1.09
140.00 < d1 ≤ 142.50	1.11
142.50 < d1 ≤ 145.00	1.13
145.00 < d1 ≤ 147.50	1.14
147.50 < d1 ≤ 150.00	1.16
150.00 < d1 ≤ 152.50	1.18
152.50 < d1 ≤ 155.00	1.19
155.00 < d1 ≤ 157.50	1.21
157.50 < d1 ≤ 160.00	1.23
160.00 < d1 ≤ 162.50	1.24
162.50 < d1 ≤ 165.00	1.26
165.00 < d1 ≤ 167.50	1.28
167.50 < d1 ≤ 170.00	1.29
170.00 < d1 ≤ 172.50	1.31
172.50 < d1 ≤ 175.00	1.33
175.00 < d1 ≤ 177.50	1.34
177.50 < d1 ≤ 180.00	1.36
180.00 < d1 ≤ 182.50	1.38
182.50 < d1 ≤ 185.00	1.39
185.00 < d1 ≤ 187.50	1.41
187.50 < d1 ≤ 190.00	1.43
190.00 < d1 ≤ 195.00	1.46
195.00 < d1 ≤ 200.00	1.49
200.00 < d1 ≤ 203.00	1.51
203.00 < d1 ≤ 206.00	1.53
206.00 < d1 ≤ 212.00	1.57
212.00 < d1 ≤ 218.00	1.61
218.00 < d1 ≤ 224.00	1.65
224.00 < d1 ≤ 227.00	1.67
227.00 < d1 ≤ 230.00	1.69
230.00 < d1 ≤ 236.00	1.73
236.00 < d1 ≤ 239.00	1.75
239.00 < d1 ≤ 243.00	1.77
243.00 < d1 ≤ 250.00	1.82
250.00 < d1 ≤ 254.00	1.84
254.00 < d1 ≤ 258.00	1.87
258.00 < d1 ≤ 261.00	1.89
261.00 < d1 ≤ 265.00	1.91

Table 8-2: Tolerances for O-Ring inside diameters based on ISO 3601-1 (Continued)

INSIDE DIAMETER d1 (mm)	TOLERANCES ± (mm)
265.00 < d1 ≤ 268.00	1.92
268.00 < d1 ≤ 272.00	1.96
272.00 < d1 ≤ 276.00	1.98
276.00 < d1 ≤ 280.00	2.01
280.00 < d1 ≤ 283.00	2.03
283.00 < d1 ≤ 286.00	2.05
286.00 < d1 ≤ 290.00	2.08
290.00 < d1 ≤ 295.00	2.11
295.00 < d1 ≤ 300.00	2.14
300.00 < d1 ≤ 303.00	2.16
303.00 < d1 ≤ 307.00	2.19
307.00 < d1 ≤ 311.00	2.21
311.00 < d1 ≤ 315.00	2.24
315.00 < d1 ≤ 320.00	2.27
320.00 < d1 ≤ 325.00	2.3
325.00 < d1 ≤ 330.00	2.33
330.00 < d1 ≤ 335.00	2.36
335.00 < d1 ≤ 340.00	2.4
340.00 < d1 ≤ 345.00	2.43
345.00 < d1 ≤ 350.00	2.46
350.00 < d1 ≤ 355.00	2.49
355.00 < d1 ≤ 360.00	2.52
360.00 < d1 ≤ 365.00	2.56
365.00 < d1 ≤ 370.00	2.59
370.00 < d1 ≤ 375.00	2.62
375.00 < d1 ≤ 379.00	2.64
379.00 < d1 ≤ 383.00	2.67
383.00 < d1 ≤ 387.00	2.7
387.00 < d1 ≤ 391.00	2.72
391.00 < d1 ≤ 395.00	2.75
395.00 < d1 ≤ 400.00	2.78
400.00 < d1 ≤ 406.00	2.82
406.00 < d1 ≤ 412.00	2.85
412.00 < d1 ≤ 418.00	2.89
418.00 < d1 ≤ 425.00	2.93
425.00 < d1 ≤ 429.00	2.96
429.00 < d1 ≤ 433.00	2.99
433.00 < d1 ≤ 437.00	3.01
437.00 < d1 ≤ 443.00	3.05
443.00 < d1 ≤ 450.00	3.09
450.00 < d1 ≤ 456.00	3.13
456.00 < d1 ≤ 462.00	3.17
462.00 < d1 ≤ 466.00	3.19

Table 8-2: Tolerances for O-Ring inside diameters based on ISO 3601-1 (Continued)

INSIDE DIAMETER d1 (mm)	TOLERANCES ± (mm)
466.00 < d1 ≤ 470.00	3.22
470.00 < d1 ≤ 475.00	3.25
475.00 < d1 ≤ 479.00	3.28
479.00 < d1 ≤ 483.00	3.3
483.00 < d1 ≤ 487.00	3.33
487.00 < d1 ≤ 493.00	3.36
493.00 < d1 ≤ 500.00	3.41
500.00 < d1 ≤ 508.00	3.46
508.00 < d1 ≤ 515.00	3.5
515.00 < d1 ≤ 523.00	3.55
523.00 < d1 ≤ 530.00	3.6
530.00 < d1 ≤ 538.00	3.65
538.00 < d1 ≤ 545.00	3.69
545.00 < d1 ≤ 553.00	3.74
553.00 < d1 ≤ 560.00	3.78
560.00 < d1 ≤ 570.00	3.85
570.00 < d1 ≤ 580.00	3.91
580.00 < d1 ≤ 590.00	3.97
590.00 < d1 ≤ 600.00	4.03
600.00 < d1 ≤ 608.00	4.08
608.00 < d1 ≤ 615.00	4.12
615.00 < d1 ≤ 623.00	4.17
623.00 < d1 ≤ 630.00	4.22
630.00 < d1 ≤ 640.00	4.28
640.00 < d1 ≤ 650.00	4.34
650.00 < d1 ≤ 660.00	4.4
660.00 < d1 ≤ 670.00	4.47
d1 > 670.00	approximately ± 0,7%

Table 8-2: Tolerances for O-Ring inside diameters based on ISO 3601-1 (Continued)

8.2 Control of the surface (ISO 3601-3)

The standard acceptance criteria for surface defects are described in the ISO standard 3601-3 grade N, which is also being used as the standard in our production facilities.

The types of faults are:
Off-set, flash, backrind, excessive trimming, flow marks and non-fills and indentations.
The permitted dimensions of these defects are shown in the table below.

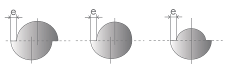
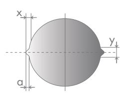
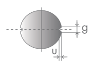
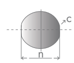
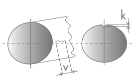
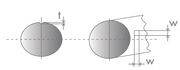
Type of defects based on ISO 3601-3	Schematic illustration	Dim	Max. accaptable limits based on ISO 3601-3 Grade N Cross-section d2 (mm)				
			> 0.8 ≤ 2.25	> 2.25 ≤ 3.15	> 3.15 ≤ 4.50	> 4.50 ≤ 6.30	> 6.30 ≤ 8.40
Offset		e	0.08	0.10	0.13	0.15	0.15
Flash		x	0.1	0.12	0.14	0.16	0.18
		y	0.1	0.12	0.14	0.16	0.18
		a	When flash can be differentiated, it shall not exceed 0.07 mm.				
Backrind		g	0.18	0.27	0.36	0.53	0.7
		u	0.08	0.08	0.1	0.1	0.13
Area of excessive trimming		n	Trimming is allowed provided the dimension n is not reduced below the minimum diameter d2 for the O-Ring.				
Flow marks (Radial orientation not permitted)		v	1.5	1.5	6.5	6.5	6.5
		k	0.08	0.08	0.08	0.08	0.08
Non-fills and indentations		w	0.6	0.8	1	1.3	1.7
		t	0.08	0.08	0.1	0.1	0.13

Table 8-3: Permitted dimensions for surface defects

Having established which defects are permitted and to what degree, it is important to establish firstly the sample quantity to be tested and secondly within which maximum quantities the supply can be considered acceptable. The reference standard for this is the ISO 2859 part 1.
The standard control is carried out on the basis of a simple sampling plan with AQL 1.0 level II.

The sample size code letter is chosen from the table below.

LOT OF BATCH SIZE	SPECIAL INSPECTION LEVELS				GENERAL INSPECTION LEVELS		
	S-1	S-2	S-3	S-4	I	II	III
2 TO 8	A	A	A	A	A	A	B
9 TO 15	A	A	A	A	A	B	C
16 TO 25	A	A	B	B	B	C	D
26 TO 50	B	B	B	C	C	D	E
51 TO 90	B	B	C	C	C	E	F
91 TO 150	B	B	C	D	D	F	G
151 TO 280	C	C	D	E	E	G	H
281 TO 500	C	C	D	E	F	H	J
501 TO 1200	C	C	E	F	G	J	K
1201 TO 3200	D	D	E	G	H	K	L
3201 TO 10 000	D	D	F	G	J	L	M
10 001 TO 35 000	D	D	F	H	K	M	N
35 001 TO 150 000	E	E	G	J	L	N	P
150 001 TO 500 000	E	E	G	J	M	P	Q
500 001 AND OVER	E	E	H	K	N	Q	R

Table 8-4: Sample size code letters

In combination with the selected acceptable quality level the quantity for acceptance or rejection is shown in the following table.

SAMPLE SIZE CODE LETTER	SAMPLE SIZE	ACCEPTABLE QUALITY LEVELS (NORMAL INSPECTION)																									
		0,010	0,015	0,025	0,040	0,065	0,10	0,15	0,25	0,40	0,65	1,0	1,5	2,5	4,0	6,5	10	15	25	40	65	100	150	250	400	650	1000
		Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re	Ac-Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31
B	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45
C	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↑	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑
D	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑	↑
E	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45	↑	↑	↑
F	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑
G	32	↓	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑
H	50	↓	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑
J	80	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑
K	125	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
L	200	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
M	315	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
N	500	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
P	800	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
Q	1250	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
R	2000	↑	↑	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑

↓ USE FIRST SAMPLING PLAN BELOW ARROW. IF SAMPLE SIZE EQUALS, OR EXCEEDS, LOT OF BATCH SIZE, CARRY OUT 100% INSPECTION

↑ USE FIRST SAMPLING PLAN ABOVE ARROW

Ac ACCEPTANCE NUMBER

Re REJECTION NUMBER

Table 8-5: Sample sizes

Our production plants are certified in accordance with the international standards ISO 9001, QS 9000 and TS 16949. For specific quality criteria according to customer requirements please contact our office.

9 O-Ring failure analysis

The failure of an O-Ring in service can usually be attributed to a combination of causes. It is important to maximize sealing life and reliability by reducing the probability of seal failure by good design practices, proper compound selection testing and training of personnel. There are several factors that can lead to O-Ring failure. A summary of the most common failures is listed below.

Compression set

Figure 9-1: Failure due to compression set

This failure is most common to both static and dynamic sealing applications.
This type of failure produces flat surfaces on the sides of the O-Ring that were compressed.

Sources of compression set failure:

- The elastomer used has poor compression set resistance
- The elastomer used has limited resistance to heat
- The O-Ring swells in the groove due to fluid incompatibility
- The O-Ring has too much squeeze in the groove

Suggested solutions:

- Use a higher quality, low compression set material
- Check the compatibility of the O-Ring material with the fluid
- Select a material resistant to the heat produced during operation
- Double check the groove dimensions for proper squeeze

Extrusion and nibbling

Figure 9-2: Failure due to extrusion and nibbling

Extrusion and nibbling are primarily found in dynamic applications. They may also be found in static applications subject to high pressure pulsing.
A ridge, nibbles and small missing pieces of the material along either the inner diameter or outer diameter resulting from the down-stream side of the O-Ring will be found.

Sources of extrusion and nibbling:

- Excessive system pressures
- Too much clearance between mating parts
- Material too soft
- O-Ring body too large for the groove
- Improperly machined groove

Suggested solutions:

- Decrease or regulate system pressure
- Select a harder material
- Refit mating parts
- Determine correct O-Ring cross-section
- Add Back-Up rings

Spiral damage

Figure 9-3: Failure due to spiral damage

This failure can be found on long stroke hydraulic piston seals. The surface of the O-Ring appears to have been twisted and shows deep spiral cuts, usually at a 45° angle.

Sources of spiral damage:

- Side loads causing excessive clearance
- Eccentric components
- Inadequate lubrication
- Material too soft
- Moving speed too slow
- Uneven surface finishes

Suggested solutions:

- Decrease the clearances between components
- Check for roundness of fitting parts
- Machine surfaces to suitable finishes
- Provide lubrication
- Select a harder material
- Use Back-Up rings

Abrasion

Figure 9-4: Failure due to abrasion

This failure is most common in dynamic applications, like reciprocating and rotary shafts. This type of failure produces a flattened surface on the side of the O-Ring body subjected to the movement.

Sources of abrasion:

- The metal surfaces are too rough and are abrasive to the O-Ring
- The metal surfaces are too smooth, causing inadequate lubrication
- No lubrication in the design
- Operating temperatures are too high
- The system fluid is contaminated with abrasive particles

Suggested solutions:

- Change surface finishes recommended
- Provide adequate lubrication
- Use a material suitable for higher temperatures
- Eliminate any source of contamination
- Select a more abrasion resistant O-Ring material

Heat hardening and oxidation

Figure 9-5: Failure due to heat hardening and oxidation

This failure can be visible in both static and dynamic O-Rings. A flattened area will appear on the dynamic surface. Sometimes cracked, hardened and pitted areas can be seen throughout the entire surface.

Sources of heat hardening and oxidation:

- Temperatures are higher than recommended for the material
- Elastomers becoming dry and parts of the material evaporating
- Oxidation

Suggested solutions:

- Lower the operating temperatures of the system
- Select O-Ring material suited for higher temperatures

Weathering or ozone cracking

Figure 9-6: Failure due to weathering or ozone cracking

This failure is caused by exposure of either static or dynamic sealing O-Ring to weather, pollutions and UV light. This failure shows many small cracks perpendicular to the direction of stress.

Source of weathering or ozone cracking:
- Ozone attack of the polymer chains, causing cracks on the outside surface

Suggested solution:
- Select ozone resistant materials

Explosive decompression

Figure 9-7: Failure due to explosive decompression

Explosive decompression causes random ruptures, blisters, crater-like pores and small slits, which have originated within the O-Ring body.

Sources of explosive decompression:
- Gases permeating the O-Ring material under high pressure conditions
- Rapid decompression of those gases
- Micro-explosions occurring as decompression occurs

Suggested solutions:
- Increase time for decompression
- Slow system cycles down
- Use a harder material (to 90° Shore A)
- Select a smaller O-Ring cross-section
- Select a decompression resistant material

Figure 9-8: Failure due to installation

When this failure occurs short nicks or scratches or peeling on the surface of the O-Ring can be noticed.

Sources of installation failure:

- The use of sharp edged tools
- Sharp corners on the O-Ring groove
- Sharp threads that the O-Ring passes over
- No lead-in chamfer
- O-Ring not properly lubricated
- O-Ring twisted or trapped during installation

Suggested solutions:

- Break all sharp edges on metal components
- Provide a 20° lead-in chamfer
- Lubricate the O-Ring during installation
- Cover all threads with masking tape

Space Shuttle Challenger Disaster

The Space Shuttle Challenger Disaster took place when Challenger, a Space Shuttle operated by NASA, broke apart 73 seconds into its flight leading to the deaths of its seven crew members. The spacecraft disintegrated over the Atlantic Ocean, off the coast of central Florida, United States on January 28, 1986. Disintegration of the shuttle stack began 73 seconds into its flight after an O-Ring seal in its right solid rocket booster (SRB) failed at lift-off.

Figure 9-9: Space Shuttle Challenger Disaster

10 Language of rubber

10.1 Introduction

Rubber is no longer the exotic and mysterious material it used to be when the Spanish explorers first brought back bouncy balls from the jungles of the New World. Everyone in the modern world has played with rubber bands, driven on rubber tires, sprayed water from a rubber hose, sat in a car with rubber seals around the doors and windows and even has their underwear held up by elastic waistbands made from rubber thread. We may be unaware of the rubber seals and hoses that are essential to the working of our cars and planes, the specialized rubber tubes that milk our cows and the thousands of other applications of rubber that support the ease and convenience of modern life, but they surround us all the time. Many people are aware that there is more than one kind of rubber, and some even understand that different kinds of rubber have very different properties, just as different kinds of metals do. However, the great bulk of the substantial body of concepts and practices that apply to rubber, which we generally refer to as Rubber Technology, is not common knowledge. In this introduction we will present the basics of Rubber Technology in a reasonably simplified and not overly technical way, so as to provide a basis of understanding to those not initiated in the field.

10.2 A little bit of chemistry

Everything material is made up of the tiny building blocks of matter we call atoms and a combination of more atoms forms a molecule. A very basic molecule that is universally known is the water molecule, which is made up of one oxygen atom in combination with two hydrogen atoms. Chemists describe molecules in a form of shorthand, in which water is known as H2O. Other well-known molecule is atmospheric oxygen, which is O2. Millions of kinds of molecules are known, ranging from the simple ones like oxygen to extremely complicated molecules with many dozens of atoms of assorted types in them. Sometimes a given kind of atom can link up to others of its own kind in many ways. Carbon atoms have this capacity and there are more kinds of molecules containing carbon atoms than all the other kinds of molecules. Carbon atoms in combination with hydrogen atoms make up a very extensive series of molecules called hydrocarbons, the first four of which are shown below.

CH_4	$C2H_6$	C_3H_8	C_4H_{10}
methane	ethane	propane	butane

Figure 10-1: Hydrocarbons

The kind of formula that only has the atoms and their numbers, like C_2H_6, does not say anything about how the atoms really connect with each other. For that, a chemist will use a structural formula, which for ethane looks like this:

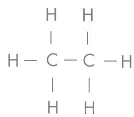


Figure 10-2: Ethane

The short solid lines between the atoms show where chemical bonds exist, so we can see that there are six single bonds between the carbon atoms and the hydrogen atoms and one single bond between the two carbon atoms. However, also other kinds of chemical bonds exist, such as double bonds and even triple bonds. In a slightly different molecule, ethylene, there is a double bond between the carbons, so the molecule's structure becomes:

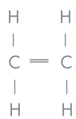


Figure 10-3: Ethylene

Ethylene is also a gas like ethane, but double bonds are more reactive than single bonds, so the ethylene will take part in various chemical reactions for which ethane is more or less inert.

10.3 Polymerization

The reaction that is important for this chapter is a chain reaction in which ethylene molecules start hooking up to each other and continue to do so, eventually forming a very long molecule.
What happens is that by some means (heat, a catalyst of some sort) one ethylene molecule breaks down slightly only to change into a highly reactive forms known as free radicals. The first free radical molecule attacks another ethylene molecule and hooks onto one side of it, and then it is no longer a free radical; but at the same time the other side of the second molecule turns into a new free radical, which goes on to attack another nearby ethylene molecule. This process goes on and on, until something stops it or until there are no more reactive ethylene molecules left. The simplified diagram on the next page outlines the process.

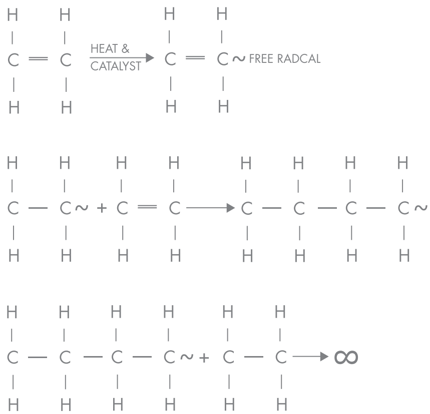


Figure 10-4: Polymerization

This kind of reaction is called polymerization, leading to the creation of very long molecules containing thousands of atoms in a repeating pattern. Think of the individual ethylene molecules as single pieces of chain links, and the polymerization is what converts all the individual links into an actual long chain. The end result of this reaction is making a polymer, in this case polyethylene, which is made from the original small molecules (called monomers). The chemist would represent the polymer as the figure shown below.

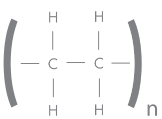


Figure 10-5: Polyethylene

The chain is a repeating pattern of links which are shown inside the parentheses, and the ‘n’ outside the parentheses indicates that there are many links in the chain. As the chain of atoms grows in length, the properties of the resulting molecule start to differ in some ways from those of the monomer from which it was formed. Depending on how the polymerization reaction is run, ‘n’ can be a low number, 25 for example, and the material then has the consistency of grease. As the number of units in the chain goes up, the properties of the polymer change. With ‘n’ of 75 it would be a polyethylene wax and when ‘n’ is a very high number, 5000 or more, the material is then a high-density polyethylene plastic. Many kinds of molecules can take part in polymerization reactions. All plastics are polymeric materials, and polyethylene, polypropylene, polystyrene and polyvinyl chloride (PVC) are common industrial plastics. These materials are firm to the touch and will only bend to a limited degree before they break or permanently deform.

10.4 From polymerization to synthetic rubber

What makes rubber different from plastics and all other kinds of materials is the fact that it will undergo major deformation and recover essentially unchanged. Technically this is called having high elasticity and the alternate name for rubber is elastomer, which is a shortened term for elastic polymer.
Elastomers are polymers that can be made into a form that stretches to at least double its length and yet when released returns to almost its original length in a very short period of time.
The explanation of why some polymers are plastics and some are elastomers involves more advanced insight in Polymer Science, which is beyond this introduction.
What is important is that numerous kinds of polymers are elastomers and together they form a family of materials, in much the same way as the many kinds of metals also form a family of materials.

So polymers are basically very long molecules made up from some kind of repeating unit (or units, since it is possible to have more than one reactive monomer used in the polymerization reaction, like making up a chain from a number of steel links and brass links). The chemical characteristics of the monomer will naturally affect the final characteristics of the polymer; for instance a chemical that is like the monomer and mixes with it readily tends to act like a solvent for the polymer made from that monomer. Petroleum oils are usually made up of hydrocarbon molecules and elastomers that are made from hydrocarbon monomers will swell substantially in such oils.

Natural Rubber, which is obtained primarily from the latex of a tree originally discovered in Brazil, is polyisoprene, the structure of which is shown below.

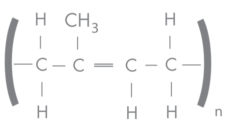


Figure 10-6: Molecular diagram of Natural Rubber

This is a simple hydrocarbon polymer and consequently, Natural Rubber is severely affected by most oils. Other common types of hydrocarbon elastomers are Butadiene Rubber, Styrene-Butadiene Rubber, and Ethylene-Propylene-Diene Rubber and they are also subject to considerable swelling and softening by oils.

If the polymer is modified from a hydrocarbon structure to something a little different, its properties will change accordingly. Neoprene® was one of the early synthetic elastomers and it is much more resistant to oils (in 1931, DuPont started to manufacture neoprene). The reason is that even though its structure is extremely similar to polyisoprene, it has one very important difference, which can be seen in the molecular diagram.

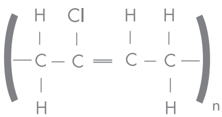


Figure 10-7: Molecular diagram of Neoprene

What was a small group of one carbon and three hydrogen atoms (CH3, a methyl group) on the isoprene unit has been replaced by a single chlorine atom. The presence of the chlorine atom, which is very different from carbon and hydrogen atoms, makes the molecule polar; that is, there is an uneven distribution of positive and negative charges across the atoms.
Since the polymer is no longer a simple hydrocarbon and has become polar, nonpolar hydrocarbon oils are no longer compatible with it and Neoprene has a substantial degree of oil resistance.
Other polymers that were constructed to be oil resistant include Nitrile Rubber, Hypalon®, Polyacrylates, and Urethane types.

The chemistry of the chain units has other effects as well. In the polyisoprene molecule there is still a double bond between the two central carbons and double bonds are chemically reactive. This is useful for the purpose of vulcanization, but has a downside. The double bonds are susceptible to attacks by oxygen and ozone and over time the rubber will undergo substantial deterioration as a result. Ethylene-Propylene-Diene Rubber does not have any double bonds after vulcanization, and therefore ages much better than Natural Rubber and is almost impervious to attack from ozone.
Many properties of the polymer depend on the monomer's characteristics; for instance, how the polymer chain is affected by temperature. One kind of elastomer will be useable for long periods at 120°C, but will stiffen and lose its rubbery character at -10°C; another type of elastomer will be fully flexible at -40°C, but break down in a few days at 120°C.

Other structural characteristics of the polymer, unrelated to monomer chemistry, also have important effects. How long the polymer chains are and whether they are all simple straight chains or have some side chains coming off the main length of the long molecule, is also important. The longer the chains, the more easily they are intertwined and tangled, which makes the polymer more viscous, more difficult to mix and make flow. Side chains, often referred to as branching, also contribute to viscosity.

Viscosity characteristics are much more important to the behaviour of rubber while it is being processed than they are to its final properties as a finished article. Processing can include many steps, which fall roughly into four groups: Mixing, Forming, Curing and Finishing. While the end user or engineer will concentrate on the final properties of the rubber article, the rubber technologist will be just as concerned about how well the material will process. It is all too possible to develop an elastomeric material that is just barely useable in the laboratory to make test specimens, but will cause total disaster in any attempt to use it in the factory to really make a final product.

10.5 Introduction to compounding

Many polymeric articles are largely made up of the polymer itself, with only a small fraction of other ingredients. For instance, plastic parts often consist for 90-95% of the polymer, with just some colouring and protective chemicals added. However, that is seldom the case for rubber articles. It is possible to make a rubber compound mostly of polymer, such as baby bottle nipples, which used to be over 90% Natural Rubber, with just one or two chemicals added to help processing and others to vulcanize the polymer. However, most of the time the polymer is mixed with numerous other ingredients which all play different roles in giving the final material desirable properties. There are usually six to twenty ingredients in typical rubber compounds and the polymer generally makes up for 50 to 60% of the total weight of the mixture. Any particular mixture of elastomeric polymer and other ingredients is referred to as a compound and the actual proportions of all the ingredients are called a recipe or a formula or a formulation. For some polymers there are an enormous number of possible ingredients, each of which can be used across a range of final concentrations, so that the number of actual formulations that a rubber technologist could draw up is infinite. For other specialty polymers considerably fewer ingredients are useable, but the total of possible recipes is still huge.

A rubber compound is the term applied to a mixture of polymers and other ingredients, to produce a usable rubber material. There are three facets of compound development that the formulating chemist faces:

- Final physical and chemical properties
- Processing properties
- Cost

Depending on how demanding the application is for the rubber article, point one may be quite difficult or not difficult at all. If the product is a cheap automotive floor mat, there is no challenge, but if it is a specialized oil well pipe seal, which will be used miles down into the earth at boiling hot temperatures and high pressure for months on end and in the presence of some very corrosive chemicals, then it is quite a different story.

The second point may also have to encounter a number of difficulties. Moulding a simple shape that does not require tight dimensional tolerances, such as a hockey puck, can be done with a compound that does not flow well and is very sensitive to temperature. Making a large number of tiny parts of a complicated shape all at once in a single mould using an injection process, so that the rubber has to flow long distances in small, hot passages before coming to rest in its final shape, can be quite challenging. Very slight differences in the compound's viscosity or sensitivity to temperature will immediately affect the process, almost invariably in a very undesirable fashion.

Last in the list is cost, yet in some parts of the industry cost is the overriding consideration. The compounder is then restricted, sometimes very seriously, in the choice of ingredients for the formula; this often drives him/her to attempt maximum use of inexpensive ingredients (like ground limestone) and minimal use of more costly ingredients (such as protective additives or even the polymer itself). Even for quality products there is frequently some pricing pressure in a competitive market, so while cost may not be primary concern, it is still a major focal point for the compounder.

10.6 Vulcanization

Chewing gum is made from an elastic polymer and so is rubber band, but obviously they do not act in the same way. The chewing gum does not have a particular shape of its own, but can be deformed and even pulled apart without using too much force; it is sticky and dissolves in many solvents. The rubber band does have a stable shape, although it can be made to deform: from that shape; however, it takes a good deal more force to stretch the rubber band than it does to pull apart an equal amount of chewing gum. Moreover, the rubber band will recover its own shape as soon as the force stretching is removed. The band is not sticky and although it swells up considerably in gasoline, it does not dissolve.
Why this sharp contrast in properties? Because the chewing gum is not vulcanized and the rubber band is. At room temperature an elastic polymer that has not been vulcanized is a mass of long, tangled polymer chains that are still free to slide past each other. Technically, the polymer is not a solid, it is a very viscous liquid and liquids do not have shape and can be made to flow.

But if somehow that mass of tangled polymer chains undergoes many individual chemical reactions, each of which permanently ties two points on neighbouring chains to each other, everything changes. These ties between adjacent chains are called cross-links and as soon as there is even one cross-link for every several hundred units along the polymer chain, the chains can no longer slide freely past each other. They become like a bundle of pieces of string that has had just a few knots tied between the different bits of string. The bundle cannot be pulled apart into two or more smaller bundles anymore, at least not without breaking some strands or the knots that join them.

This process known as vulcanization is the creation of chemical cross-links between the elastomer chains. The cross-links transform the mass of polymer chains from a high viscosity liquid to a real solid, with a definite shape and greatly increased resistance to being deformed. This is a chemical reaction between the polymer and some kind of vulcanizing agent (also called a curative or curing agent in the industry), which requires exposure to a high temperature for a period of time. The resulting cross-links also prevent the polymer from dissolving into solution when exposed to some chemically similar solvent.
(But the solvent molecules still "like" the polymer chains, so they slide between them and are absorbed like water into a sponge, which is why rubbers like Viton® materials will swell up when put into a solvent of acetone.

Since there are significant differences in the chemistry of different kinds of elastomers, they do not all undergo exactly the same kind of vulcanization reactions, but their polymer chains can be cross-linked in one way or the other. The best known kind of vulcanizations uses sulphur molecules (S8), which, when heated, react with Natural Rubber to make little bridges of sulphur atoms between the parts of two chains where the double bonds used to be. In modern times chemists have synthesized numerous molecules that contain some sulphur atoms and also react either to work with plain sulphur molecules to make the vulcanization reaction proceed faster, or in some cases can produce cross-links in elastomers even if no sulphur molecules are present. Several other elastomer types are also cross-linked using sulphur and sulphur derivatives.

There are other kinds of vulcanizing chemicals, some of which can be used in several kinds of elastomers, for instance peroxides; while other chemicals are extremely specific to a single kind of elastomer, such as the combination of platinum catalyst and silane molecules that cross-link only certain types of silicone rubber. When more than one kind or combination of curatives can be used to make cross-links for a given elastomer, the final properties of the rubber usually change with the variations in the vulcanizing system. These changes can often be quite significant.


37
MIR
37

Moreover, the variations in cure system will almost always change the processing of the rubber.
On the one hand, if the vulcanization reaction is made to proceed faster, the time needed to complete the reaction is shortened, which makes the process more efficient from the viewpoint of the manufacturer; on the other hand, if the reaction starts too soon or proceeds too quickly, the compound will not flow well enough to properly form the desired shape of the final product and the product will be defective.
Thus the relationship between the cure system and the processing characteristics and the material's final properties can become complex, especially when there is some intricacy as far as geometry is concerned or when aspects of the process start to play a role.

If the combination of temperature and time to which the compound is exposed does not really allow the transfer of enough heat energy into the rubber to quite complete the cross-linking reaction, the elastomer can still look and feel fairly normal. However, then it is actually in a condition known as marginal cure or undercure and some of its properties will be deficient. Failure to achieve the proper state of cure leads to poor functioning and/or shortened life of rubber products, therefor calculating the right vulcanizing conditions and monitoring them to ensure good cure are important functions in Rubber Technology.

10.7 Properties of rubber

A materials' scientist or engineer always characterizes materials by a collection of properties, often properties that have to do with the ability of the material to fulfil some purpose. For example a metallurgist will want to know the hardness of steel (on something known as a Rockwell scale), its tensile strength and perhaps something about its fatigue life. These can all be useful in predicting how well the particular alloy will work in some application, or how the engineer should design the metal part using that alloy so that it will function as desired.

Elastomers are more complex materials than metals and can be tested in many different ways to evaluate many properties, some of which may relate to actual function but many of which do not. Like metals, rubber compounds can be tested for hardness and tensile strength. The most used hardness scale is the Shore A durometer scale. Its dial reads from 0 to 100, but it is most meaningful from about 20 to perhaps 95 durometer. A rubber band is usually on the soft end, at about 30 points of the scale, while a hard boot heel will read approximately 75 durometer. The durometer rating does not provide informa-tion only on how hard the rubber surface is, but also correlates roughly with how stiff the rubber is, that is, how much force is needed to deform it. Naturally, one of the key properties of any rubber compound is its ability to stretch or elongate. In the standard tensile test the point at which the specimen breaks is measured and compared to the starting length of one section of the specimen. The increase in length at the breaking point is converted to a percentage change and reported as the ultimate elongation (UE) or elongation at break (EB) or often just as the elongation. Some compounds will stretch over 800% some hard compounds stretch only 125-200%, but many typical rubber compounds have elongations between 250-500%.

Elastomers are much more sensitive to the environment in general than metals, so scientists and engineers are very interested in judging the comparative resistance of compounds to various environmental factors. These include heat, cold, oxygen, ozone, oils, solvents, weathering and simple ageing. In addition, a rubber part subjected to some constant load or deformation (like a mount that supports a piece of equipment or an O-Ring that is compressed) will gradually react to the situation which is called stress relaxation. This means the rubber will slowly assume a changed shape related to the load it has been subjected to and in many functions that means the rubber part will not perform as well as it did when new.

Therefore an assortment of tests exists dealing with environmental resistance and stress relaxation characteristics of rubber compounds. They often involve first performing routine tests such as tensile strength and hardness on standard test specimens. Then another set of test specimens from the same lot is exposed to whatever environmental conditions are of interest, such as soaking in oil, at a selected combination of time and temperature. The temperature is normally raised in order to accelerate the environmental attack on the rubber and allow for the use of reasonably short test time, such as 22, 70, or 168 hours. Normally the rubber undergoes some degree of change due to the test conditions.

After the environmental exposure of the test specimens, they are then subjected to the same routine test as the unexposed specimens. The change in properties from original material to the conditioned material is then calculated. For instance, after an oil soak test the hardness decreases by several points, the tensile strength also decreases by a certain percentage, and there is also an increase in the volume of the rubber section due to absorption of the fluid. After heat ageing in air, many compounds will increase in hardness, decrease in elongation, and lose a percentage of their original weight.

There are also many tests that do not compare original and conditioned specimens, such as tear strength tests, flex tests and low temperature brittleness tests, just to name a few.
Among the more commonly measured test properties for elastomers, described in official publications of the American Society for Testing and Materials (ASTM), are included:

- Durometer hardness
- Elongation
- Tear Strength
- Fluid Resistance
- Ozone Resistance
- Compression Set Resistance (relates to stress relaxation)
- Tensile Strength
- 100% and/or 300% Modulus
- Abrasion Resistance
- Low Temperature Tolerance
- Flex Life

It is important to understand that generally speaking all these tests results are meaningful only as a basis for comparing different rubber compounds. That is, observing that after a heat ageing test at 125°C for 70 hours a compound goes from an original elongation of 500% down to 250% does not enable anyone to calculate how many years a radiator hose made of the compound will function under the hood of some car or truck.
However, if a second compound intended for the same type of hose goes from 450% elongation to 350% elongation in the same test, it is very logical to conclude that the heat tolerance of the second compound is better than that of the first and that therefore hoses made from it will last longer, all other things being equal.
This is not to say that laboratory tests are never useful in making judgments about how suitable a compound is for some application. When a test has definite relevance to the expected conditions of use and functionality of the rubber product, it can certainly provide significant insight into the likely success or failure of the compound for that function. Various specialized tests, often developed through lengthy programmes and correlation studies with field experience, are known to be good indicators of real time functionality for some rubber products. However, most of the time simple, easy, and inexpen-sive laboratory tests do not permit any sort of life prediction, other than to say that failure to meet the test requirements strongly implies the compound will not function in the particular application. (If the compound fails a flex test at some low temperature, it will probably not be useful at that tempera-ture or lower.)

Another significant point is that properties of rubber compounds are subject to an appreciable degree of normal scatter. If the exactly same formula were mixed and tested in ten different laboratories, the elongations observed might average 400%, yet the range of individual laboratory results could easily range from 340 to 460%. This would not demonstrate that anyone had done anything wrong, or that any one batch was truly better than any other. If a detailed comparison has to be made between compounds, then at least some basic statistics have to be gathered from more than one set of samples.

Storage of rubber seals

In order for rubber seals to maintain their characteristics, the environment in which they are stored is of vital importance. Seals that are treated properly remain unaltered for long periods of time, although it is advisable not to exceed the following limits:

- NBR (Nitrile, Buna-N®) 4 years
- FKM (Viton®) 10 years
- VMQ, FMVQ (Silicone) 10 years
- EPDM, EPM 6 years
- CR (Neoprene®) 4 years

Ideal storage conditions

Heat
Storage temperature from +10°C to +23°C.
The products must not be stored close to sources of heat.

Humidity
Humidity and steam must be avoided. The optimum relative humidity of the air ranges from 65% to 75%.

Oxygen
The seals should be stored in hermetically sealed bags and, if possible, in their original unopened bags.

Ozone
Equipment that lets off ozone such as electronic motors, electronic equipment, installations that produce sparks, halogen lighting, etc. should not be placed in the storage area.

Contact
During storage care should be taken that the O-Rings do not come into contact with solvents, fuels, lubricants (oils and greases), chemical substances, acids, etc. Furthermore, prolonged contact with brass, copper and not stainless steel is also harmful.

Cleaning
If necessary, the O-Rings should be cleaned with water and soap without using organic solvents such as petrol, benzene, turpentine, etc., and blunt objects or sandpaper should not be used.

Further precautions
Do not stretch, bend or hang the O-Rings. Do not subject them to permanent weights.

12 Glossary

A

Abrasion The wearing away of a surface in service by mechanical action such as rubbing, scraping or erosion.

Abrasion Resistance The ability of a rubber compound to resist mechanical wear.

Absorption The physical mechanism by which one substance attracts and takes up another substance (liquid, gas, or vapor) into its interior.

Accelerator A substance which hastens the vulcanization of an elastomer causing it to take place in a shorter time or at a lower temperature.

Acid Resistant Withstands the action of acids.

Adsorption The physical mechanism by which one substance attracts another substance (either solid, liquid, gas, or vapor) to its surface and through molecular forces causes the incident substance to adhere thereon.

Ageing To undergo changes in physical properties with age or lapse of time.

Antioxidant An organic substance which inhibits or retards oxidation.

Atmospheric Cracking Cracks produced in surface of rubber articles by exposure to atmospheric conditions.

Axial Directed along, or parallel to, an axis. In case of a seal ring, the axial direction is perpendicular to the plane of the seal, and would be described as the "up and down" direction if the seal ring were to be placed flat upon a desktop.

B

Back-Up Ring (anti-extrusion device) a ring of relatively hard and tough material placed in the gland between the O-Ring and groove side walls, to prevent extrusion of the O-Ring.

Back–Up Washer A washer made from certain material that will add strength or support when installed next to the seal. This prevents the seal from being pinched and evenly distributes the load.

Bleeding Migration to the surface of plasticizers, waxes, or similar materials to form a film or beads.

Bore A hole in a component which permits the passage of a shaft.

Break A separation or discontinuity in any part of an article.
Break-Out Force to inaugurate sliding. Expressed in the same terms as friction. An excessive break-out value is taken as an indication of the development of adhesion.
Brittleness: Tendency to crack when deformed.
Buna-N Same as nitrile rubber.
Butyl A copolymer of isobutylene with small amounts of isoprene.

C

Cavity The features of a mould which are directly responsible for forming the final shape of a moulded part. Mould cavities are formed from two or more mating components of a mold.
Coefficient of Thermal Expansion: Average expansion per degree over a stated temperature range expressed as a fraction of initial dimension. May be linear or volumetric.
Cold Flexibility Flexibility following exposure to a predetermined low temperature for a predetermined time.
Cold Resistant Able to withstand the effects of cold or low temperatures without loss of serviceability.
Compound A term applied to a mixture of polymers and other ingredients, to produce a usable rubber material.
Compression Modulus The ratio of the compressive stress to the resulting compressive strain (the latter expressed as a fraction of the original height or thickness in the direction of the force). Compression modulus may be either static or dynamic.
Compression Set The amount by which a rubber specimen fails to return to original shape after release of compressive load.
Copolymer A polymer consisting of two different monomers chemically combined.
Corrosion (Packing) Corrosion of rigid member (usually metal) where it contacts packing. The actual corroding agent is fluid medium trapped in the interface.
Cracking A sharp break or fissure in the surface. Generally due to excessive strain.
Cross-linking Agents A chemical or chemicals that bond together the polymer chains of a rubber together during the molding process.
Cross-Section A seal as viewed if cut at right angles to the mold parting line showing internal structure.

Cross-Sectional Reduction (of a Seal) The reduction in thickness of a seal's cross-section as a result of material displacement caused by a stretch applied to the seal. (See also Necking)

Cross-Sectional Compression, Percent (of a Seal)
The deformation placed on a rubber part to affect a seal.
It is expressed as a percentage of the seal's original (undeformed) cross-section. (See also Squeeze)

Crush Bead A deformable feature, normally taking the form of a continuous, small, hemispherical radius, on an insert which is used to help control which surfaces of the part will be covered by rubber during the moulding process. During the moulding process as the mould closes on the insert, the crush bead is deformed, creating a tight seal which confines rubber to the desired area of the part.

Crush Ring See Crush Bead

Cure See Vulcanization.

Cylinder Chamber in which piston, plunger, ram, rod, or shaft is driven by or against the system fluid.

D

Diffusion The mixing of two or more substances (solids, liquids, gases, or combinations thereof) due to the intermingling motion of their individual molecules. Gases
diffuse more readily than liquids; similarly, liquids diffuse more readily than solids.

Durometer (a) An instrument for measuring the hardness of rubber. Measures the resistance to the penetration of an indenter point into the surface of rubber.
(b) Numerical scale of rubber hardness.

Dynamic An application in which the seal is subject to movement, or moving parts contact the seal.

Dynamic Seal A seal required to prevent leakage past parts which are in relative motion.

E

Elasticity The property of an article which tends to return it to its original shape after deformation.

Elastomer Any synthetic or natural material with resilience or memory sufficient to return to its original shape after major or minor distortion.

Elongation Generally means "ultimate elongation" or percent increase in original length of a specimen when it breaks.
Extrusion Distortion or flow, under pressure, of portion of seal into clearance between mating metal parts.

F

Face Seal A seal between two flat surfaces.
Filler Chemically inert, finely divided material added to the elastomer to aid it in processing and improve its physical properties, i.e., abrasion resistance and strength — giving it varying degrees of hardness.
Fixed Dimension Any dimension assigned to a feature of a moulded part which is formed from a part of the mold which is machined into a single mold cavity component. Fixed dimensions, since there are fewer variables affecting the formation of the part's feature, typically have smaller associated tolerances than closure dimensions.
Flash Excess rubber left around rubber part after moulding due to space between mating mould surfaces; removed by trimming.
Flex Resistance The relative ability of a rubber article to withstand dynamic bending stresses.
Fluid A liquid or a gas.
Friction Resistance to motion due to the contact of surfaces.
Friction (Breakout) Friction developed during initial or starting motion.
Friction (Running) Constant friction developed during operation of a dynamic O-Ring.

G

Groove Cavity into which O-Ring is installed. Includes the groove and mating surface of second part which together confine the O-Ring.
Groove Depth The groove depth is the distance from the sealing surface to the seal groove surface. The groove depth determines how much the seal is compressed and therefore how much cross-sectional compression (squeeze) is applied to the seal.

H

Hardness Resistance to a distorting force. Measured by the relative resistance of the material to an indenter point of any one of a number of standard hardness testing instruments.

Hardness Shore A The rubber durometer hardness as measured on a Shore “A” gauge. Higher numbers indicate harder material. 35 Shore “A” durometer reading is considered soft. 90 is considered hard.

Homogeneous (a) General - a material of uniform composition throughout. (b) In seals - a rubber seal without fabric or metal reinforcement.

I

I.D. (Inner Diameter) The innermost (smallest diameter) surface of a circular object, such as a bore or a round seal. The term I.D. is frequently used to indicate both the circumferential surface itself as well as the measured diameter of that surface.

I.R.H.D. (International Rubber Hardness Degrees)
A system of characterizing an elastomer by its resistance to penetration of a known geometry indenter by a known force. The microtechnique is reproducible on irregular as well as flat surfaces and on cross-sections as small as 1mm in thickness (.04"). Measurements taken using the IRHD scale are similar, but not identical, to those obtained using the Shore A scale.

Injection Moulding A moulding method in which a rubber or plastic material is heated and forced under pressure into the mould cavity.

Insert A term referring to a metal or plastic component, placed ("inserted") into a mould cavity prior to the start of the moulding cycle, to which rubber or plastic is chemically and/or physically bonded during the moulding process.

J

Joule Effect A phenomenon characteristic of rubber where rubber which is in tension, when heated, contracts rather than expands. This effect only occurs when rubber is subject to strain while being heated - unstrained rubber will expand as it is heated (like most materials). This effect has serious consequences for the design of a high speed, rotary shaft seal using a Quad-Ring® (or O-Ring).

In order to function correctly, in a free state the seal inside diameter must be larger than the outside diameter of the shaft. The seal groove is then designed in such a way that when the Quad-Ring® is placed in the groove, it is compressed onto the shaft. This prevents the frictional heat and the resulting contraction of the seal due to the Joule Effect frominitiating a cycle (frictional heat causes contraction, causing more friction, generating more heat, leading to more contraction, etc.) causing rapid seal failure.

L

Leakage Rate The rate at which a fluid (either gas or liquid) passes a barrier. Total Leakage Rate includes the amounts that diffuse or permeate through the material of the barrier as well as the amount that escapes around it.
Life Test A laboratory procedure used to determine the amount and duration of resistance of an article to a specific set of destructive forces or conditions.
Linear Expansion Expansion in any one linear dimension or the average of all linear dimensions.
Low Temperature Flexibility The ability of a rubber product to be flexed, bent or bowed at low temperatures without cracking.

M

Memory Tendency of a material to return to original shape after deformation.
Microhardness A measurement of rubber hardness for specimens below .25 inches (6.35mm) in thickness. Microhardness, like Shore A durometer, is also a measurement of indentation.
Modulus Tensile stress at a specified elongation. (Usually 100% elongation for elastomers).
Modulus of Elasticity One of the several measurements of stiffness or resistance to deformation, but often incorrectly used to indicate specifically static tension modulus.

N

Nitrile (Buna-N) The most commonly used elastomer for O-Rings because of its resistance to petroleum fluids, good physical properties and useful temperature range.

O

Oil Resistant Ability of a vulcanized rubber to resist the swelling and deteriorating effects of various type oils.
Oil Swell The change in volume of a rubber article due to absorption of oil or other fluid.
O-Ring A torus; a circle of material with round cross-section which effects a seal through squeeze and pressure.
O-Ring Seal The combination of a gland and an O-Ring providing a fluid-tight closure. (Some designs may permit momentary or minimum leakage.)
Moving (Dynamic) — O-Ring seal in which there is relative motion between some gland parts and the O-Ring — oscillating, reciprocating, or rotary motion.
Non-moving (Static) — O-Ring seal in which there is no relative motion between any part of the gland and the O-Ring (distortion from fluid pressure or swell from fluid immersion is excluded).
Ozone Resistance Ability to withstand the deteriorating effect of ozone (which usually causes cracking).
Oxidation The reaction of oxygen on a rubber product, usually detected by a change in the appearance or feel of the surface or by a change in physical properties.

P

Permeability The rate at which a liquid or gas under pressure passes through a solid material by diffusion and solution.
In rubber terminology, it is the rate of gas flow expressed in atmospheric cubic centimeters per second through an elastomeric material one centimeter square and one centimeter thick (atm cc/cmÇ/cm sec).
Piston Seal A bore seal in which the seal is mounted in a groove machined into a piston. The term piston seal usually implies an application involving linear reciprocating motion.
Polymer A material formed by the joining together of many (poly) individual units (mer) of one or more monomers; synonymous with elastomer.
Porosity Quality or state of being porous.
Post Cure The second step in the vulcanization process for the more exotic elastomers. Provides stabilization of parts and drives off decomposition products resulting from the vulcanization process.

R

Radial Directed along a radius. With a seal ring, the radial direction is in the plane of the seal, and would be parallel to the desktop were the seal ring to be placed flat upon a desktop. The radial direction is perpendicular to the seal axis.

Reciprocating Seal A seal used in a linear motion application which experiences a repeated reversal of direction of travel.

Reinforcing Agent An ingredient added to a rubber formulation which enhances the material's mechanical properties. Carbon black is a common reinforcing agent used in rubber.

Resilient Capable of returning to original size and shape after deformation.

Rod See Shaft

Rod Seal A sealing system, usually in a radial orientation, in which the primary sealing surface is between the I.D. of a seal ring and the O.D. of a shaft.

Rotary seal A seal such as an O-Ring or a Quad-Ring® seal, exposed on either the I.D. or O.D. sealing surface to a rotating component (e.g. shaft seals). Minnesota Rubber defines a rotating seal as a "rotary" seal if the rotational surface speed is greater than 20 feet/min.

Rubber Same as elastomer.

Rubber, Natural Raw or crude rubber obtained from plant sources.

Rubber, Synthetic Manufactured or man-made elastomers.

S

Seal Any device used to prevent the passage of a fluid (gas or liquid).

Sealing Surface Any location where a seal and a mating surface come in contact with the intention of forming a barrier to prevent the passage of some type of medium, such as a fluid or a gas. This term is often used interchangeably with the more specific term Primary Sealing Surface.

Service Operating conditions to be met.

Shaft Reciprocating or rotating member usually within cylinder; not in contact with walls.

Shelf-Aging The change in a material's properties which occurs in storage after some time.

Shore A Hardness See Hardness and Durometer.

Shrinkage Decreased volume of seal, usually caused by extraction of soluble constituents by fluids followed by airdrying.

Silicone Rubber Elastomer that retains good properties through extra wide temperature range.

Size, Actual Actual dimensions of the O-Ring or other seal, including tolerance limits.

Size, Nominal Approximate size of part in fractional dimensions. May also indicate the actual size of the groove into which a nominal size seal fits.

Size Number Number assigned to indicate inside and cross section diameters of an O-Ring. Sizes established in SAE standard AS 568A have been adopted by the military and industry.

Specific Gravity The ratio of the weight of a given substance to the weight of an equal volume of water at a specified temperature.

Squeeze Cross-section diametral compression of O-Ring between surface of the groove bottom and surface of other mating metal part in the gland assembly.

Static Seal Part designed to seal between parts having no relative motion. See Gasket.

Strain Deflection due to a force.

Stress Force per unit of original cross-section area.

Stress Relaxation Decreasing stress with constant strain over a given time interval (viscoelastic response).

Sun Checking Surface cracks, checks or crazing caused by exposure to direct or indirect sunlight.

Surface Finish A term usually used in reference to the roughness parameter of a surface's texture, generally expressed in units of microinches (Ìin) or micrometers (Ìm).

Swell Increased volume of a specimen caused by immersion into a fluid (usually a liquid).

T

Tear Resistance Resistance to growth of a cut or nick when tension is applied to the cut specimen commonly expressed as pounds per inch thickness.

Tensile Strength The extension force per cross-sectional area required to fracture a material specimen.

Temperature Range Maximum and minimum temperature limits within which a seal compound will function in a given application.

Tensile Strength Force in pounds per square inch required to cause the rupture of a specimen of a rubber material.
Terpolymer A polymer consisting of three different, chemically combined monomers.
Thermal Effects Deterioration at higher temperatures.
Thermal Expansion Expansion caused by increase in temperature. May be linear or volumetric.

U

Ultimate Elongation See Elongation.

V

Viscosity The property of fluids and plastic solids by which Enables them to resist an instantaneous change of shape, i.e., resistance to flow.
Volume Change A change in the volume of a seal as a result of immersion into a fluid expressed as a percentage of the original volume.
Volume Swell Increase in physical size caused by the swelling action of a liquid.
Vulcanization A thermo-setting reaction involving the use of heat and pressure, resulting in greatly increased strength and elasticity of rubber-like materials.
Vulcanizing Agent A material which produces vulcanization of an elastomer.

W

Weathering The detrimental effect upon an elastomer or plastic after outdoor exposure.
Width Seal cross-section or thickness.

Notes

Contact

NewDealSeals
Manufacturer and Worldwide Supplier
High Performance O-Rings and Seals

Energiestraat 2 | 1749 DN Warmenhuizen | the Netherlands
P.O.Box 30 | 1749 ZG Warmenhuizen | the Netherlands

T +31 226 362 233 | F +31 226 362 239
E office@newdealseals.com | www.newdealseals.com

ORIGOM® SPA
GUARNIZIONI INDUSTRIALI

Publication | NewDealSeals, 2008 The Netherlands
Research & redaction | NewDealSeals (Ed de Graaf)
Design | www.idkliniek.nl
Printing | Print Factory, Broek op Langedijk