Seal® ENGINEERING

# Sealing solutions for demanding industrial applications

## Technical handbook

Seals overview, guidelines for seal design and arrangement and material compatibility lists.


**Seal Engineering AS** develops and produces sealing solutions for demanding industrial applications. With direct access to leading experts, specialised know-how, innovative engineering skills and sincere customer care, Seal Engineering has the experience, organisation, facilities and network to serve multiple industries with engineered sealing solutions.

## The company

Seal Engineering AS is a Norwegian limited liability company that was established under the name of Seal-Jet Norge AS in 1997. The company name was changed in 2012 to strengthen and highlight the service aspect of our activity, so that we stand out both as a production company and a service provider in our industry.

## Product range and markets

We make a great number of sealing products in our factory. Once one of our solutions has been qualified, we standardise production for an efficient purchase-ordering relationship between us and the customer. We serve multiple industries like oil & gas industry, hydropower industry, process industry and marine industry.

- Standard and customized sealing products for hydraulic and pneumatic applications in a wide range of materials
- O-rings
- Molded parts, rubber-to-metal bonding
- Spring energized seals
- Large diameter seals

# Contents


| | |
|---|---|
| 4 | MATERIALS OVERVIEW |
| 10 | SUGGESTED MATERIALS |
| 16 | SEALS OVERVIEW |
| 43 | HOUSING |
| 66 | O-RINGS |
| 84 | MATERIAL SPECIFICATIONS |

# Materials overview

In order to optimize sealing effect, the key features are seal profile and seal material. This chapter will give an overview of the standard materials which we use for the production of seals, gaskets and other machined parts.

Seal Engineering AS considers the materials presented in this chapter as standard for turning of seals, gaskets and other parts. All the listed materials are kept in stock in a variety of dimensions, up to 1500 mm outside diameter, available for same day delivery. We can also deliver seals in diameter up to 4000 mm (thermoplastic elastomers – polyurethanes), 1500 mm (elastomers) and 2000 mm (thermoplastics).
For detailed specifications regarding chemical compatibility, mechanical, electrical and thermal properties, please see chapter "Material Specifications".

In addition to the materials presented here we are able to offer a large variety of different materials to suit special applications. Contact Seal Engineering AS for datasheets or technical advice.

## Thermoplastic elastomers

**Thermoplastic elastomers belong to the elastomer-family of materials. The elastomer-family consists of materials that can be highly expanded by exerting relatively little power. Because of their structure, elastomers have a high retractibility, which means the remaining deformation is very small.**

Unlike elastomers (rubber), thermoplastic elastomers are physically, but not chemically cross-linked, therefore they can be melted at higher temperatures and can be processed with traditional thermoplastic processing techniques. Thermoplastic elastomers are soluble and generally they swell less in comparison to their chemically cross-linked equivalents. The thermoplastic elastomers Seal Engineering AS offers are various types of polyurethanes, abbreviation PU.

Polyurethanes have superior mechanical properties compared to elastomers and with the variety of different polyurethanes presented here, PU will be the preferred material for many sealing systems.

### Material: HPU™

GENERAL DESCRIPTION: HPU is a hydrolysis-resistant thermoplastic polyurethane elastomer. HPU's high resistance to hydrolysis (hydrolysis is degradation in water) is rarely found in polyurethanes. It is stable in water up to +90°C and has an outstanding resistance in mineral oil. Because of its resistance to hydrolysis, HPU is particularly recommended for the use in purewater and seawater, for HFA and HFB fluids and biologically degradable hydraulic fluids (vegetable oils and synthetic esters) and food articles. HPU is KTW approved and complies with FDA standards. HPU also has excellent resistance against explosive decompression (ED).

**TEMPERATURE RANGE:** -20 °C to 110 °C

### Material: LPU™

GENERAL DESCRIPTION: LPU is a thermoplastic polyurethane elastomer which is modified for low temperature applications, with a minimum service temperature of - 50°C. LPU has an high abrasive resistance, low compression set, high physical properties and tear strength. Products made from this material can be used in mineral oil and in bio-degradable hydraulic oils like vegetable oils and synthetic esters.

**TEMPERATURE RANGE:** -50 °C to 110 °C

### Material: SPU™

GENERAL DESCRIPTION: SPU is a polyurethane that has been optimized in regard of the tribological characteristics (friction and wear), achieved by an addition of a synergetic combination of solid lubricants. This special material is therefore best suited for the most severe applications for water hydraulics or badly lubricated systems as well as in oil-free pneumatics. Chemical properties similar to HPU.

**TEMPERATURE RANGE:** -20 °C to 110 °C

### Material: XHPU™

GENERAL DESCRIPTION: XHPU is a hard grade polyurethane (shore 60D) with chemical properties similar to HPU. This material is specially developed to replace PTFE-based materials in sliding seals/composite seals (our profiles K08, S09 and others) in systems with adequate temperature and media (up to 110°C and media as for HPU). Used in composite seals, XHPU exhibits greater resistance to extrusion, less leakage, longer life-time and easier installation properties than the traditional PTFE-based seals. A comparison between XHPU and PTFE-based seals is shown in the "Suggested Materials" section.

**TEMPERATURE RANGE:** -20 °C to 110 °C

### Material: XSPU™

GENERAL DESCRIPTION: XSPU is a hard grade polyurethane (shore 57D) that has been optimised in regard of the tribological characteristics (friction and wear), achieved by an addition of a synergetic combination of solid lubricants. The chemical properties are similar to HPU. This material replaces PTFE-based materials for the same seals as XHPU, but is better suited in systems where low friction is crucial (water hydraulics, badly lubricated etc.).

**TEMPERATURE RANGE:** -20 °C to 121 °C

# Elastomers

**Elastomers – rubbers – are materials that can be highly expanded by exerting relatively little power. Because of their structure, elastomers have a high retractibility, which means the remaining deformation is very small.**

The rubber materials are polymers, which are formed by cross-linked macromolecules with various vulcanization additives. Due to their chemical bonds, they begin to decompose at high temperatures and they do not melt. In addition the cross-link ensures that rubber materials do not dissolve. However, they do suffer more or less intensive swell or shrinkage depending on the medium. Elastomers have in general inferior mechanical properties compared to polyurethanes. However the different elastomers display other qualities such as chemical and temperature resistance combined with elasticity, and are widely used for different types of seals.

## Material: RU1™

GENERAL DESCRIPTION: RU1 is a Nitrile Butadiene Rubber (NBR). RU1 has a good resistance to mineral oils and greases and HFA, HFB and HFC pressure fluids. However, the material is not resistant to glycol-based brake fluids, HFD fluids, aromatic fluids (such as benzene), esters, ketones and amines or concentrated acids and bases. RU1 is also on stock in a low-temperature grade, with a minimum working temperature of – 50ºC.

**TEMPERATURE RANGE:** -30 ºC to 100 ºC

## Material: RU2™

GENERAL DESCRIPTION: RU2 is an elastomer based on fluororubber with similar properties to Viton® type B. This material is also referred to as FKM (ISO). RU2 has high resistance against heat, weathering, ozone and many chemical ingredients. RU2 is compatible with mineral oils and greases containing sulphur, HFD pressure fluids (nearly all phosphate esters and chlorinated hydrocarbons), crude oil and sour gas. RU2 shows excellent resistance against explosive decompression (ED). RU2 is not resistant against anhydrous ammonia, amines, ketones, esters, hot water and low molecular weight organic acids. RU2 is also on stock in a FDA compliant grade and with different hardness (75º-95º shore A).

**TEMPERATURE RANGE:** -20 ºC to 200 ºC

## Material: RU3™

GENERAL DESCRIPTION: RU3 is a perox-cured elastomer based on ethylene-propylene rubber, often referred to as EPDM. RU3 has an outstanding stability against hot water, steam, washing agents, polar organic solvents and glycol based brake fluids. RU3 is not resistant against mineral oil and other unpolar media. The stability to weathering, ozone and ageing is good. RU3 is also on stock in a FDA compliant grade and a hard grade (93 º shore A).

**TEMPERATURE RANGE:** -50 ºC to 150 ºC

## Material: RU4™

GENERAL DESCRIPTION: RU4 is a hydrogenated or saturated acrylonitrile-butadiene rubber, often referred to as H-NBR. RU4 is suitable for applications with aliphatic hydrocarbons like propane or butane and mineral oils and greases (for short times up to 170°C) and also for sulfonated crude oil. Furthermore, it can be used in many diluted acids and bases and salt solutions even at elevated temperatures and in glycol-water mixtures. RU4 is not compatible with fuels with a high content of aromatic hydrocarbons (premium blend petrol), gasolines (petrol / alcohol blends) ketones, esters, ethers and chlorinated hydrocarbons like trichloroethylene and tetrachloroethy-lene. RU4 complies with FDA-recommendations. RU4 is also on stock in hard grade (93ºshore A), ED-grade, low-temperature grade (-40ºC) and ED/low-temperature grade (-30ºC).

**TEMPERATURE RANGE:** -25 ºC to 150 ºC



## Material: RU5™

GENERAL DESCRIPTION: RU5 is a silicone rubber, or VMQ. Owing to the poor mechanical properties, which are noticeably lower in comparison to other rubbers, RU5 is mostly used for static applications. RU5 is highly resistant against weathering, ozone and ageing, and also has a wide temperature range (-60 to +200 ºC). The compatibility with mineral oils depends on the content of aromatic hydrocarbons in the oil. RU5 complies with FDA-recommendations.

**TEMPERATURE RANGE:** -60 ºC to 200 ºC

## Material: RU6™

GENERAL DESCRIPTION: RU6 is a tetraflourethylene-propylene material, often referred to as Aflas®, FEPM or TFE/P. This material is well suited against HFA, HFB, HFC and HFD liquids. In addition this material has excellent resistance against steam and hot water. Good resistance against various chemicals.

**TEMPERATURE RANGE:** -10 ºC to 200 ºC

# High-performance sealing materials

Seal Engineering AS is dedicated to find the best overall sealing solutions and materials with special attention to functionality, reliability and low overall life-cycle cost. Our engineered high-perfomance sealing solutions require state-of-the-art sealing materials. Visit our website for more information.

- RU16™ - FKM fluoroelastomer, peroxide-cured (Solvay Tecnoflon VPL85540)
- RU21™ - DuPont™ Kalrez® FFKM
- RU23™ - Based on Chemours´ Viton® Extreme ETP-600S
- RU25™ - Based on Tecnoflon PFR 95HT
- RU35™ - Based on a peroxide-cured FKM terpolymer
- RU39™ - Based on a peroxide-cured, hydrogenated acrylonitrile-butadiene rubber (HNBR)
- RU41™ - Based on Tecnoflon PFR LT
- PL1™ - DuPont™ Vespel® CR 6100
- PL18™ - Greene Tweed Arlon® 3000XT Enhanced PEEK

# Thermoplastics

**Thermoplastics are polymer materials, which compared to elastomers, are essentially harder and more rigid. Depending on the chemical structure, the properties vary from hard and stiff, to ductile and flexible. Due to the morphological structure, extensive stretching is non-reversible and moulded parts remain in the deformed state. We make a distinction between PTFE-based thermoplastics and other thermoplastics.**

PTFE (polytetrafluorethylene) and modified PTFE materials with or without fillers, have extremely good resistance to chemicals and will only be degraded by molten alkali metals and elementary fluorine at high temperatures. However, for some of the PTFE-based materials the fillers may be attacked and destroyed by certain other chemicals. In addition these materials have a general working area between -200ºC and +260ºC, making them widely used for extreme conditions in respect to chemicals and temperature.

# PTFE-based thermoplastics

## Material: FL1™ Virgin PTFE

GENERAL DESCRIPTION: Excellent chemical and thermal resistance. FDA-approved. Limited mechanical properties. If improved mechanical properties are required FL5™ or a filled PTFE should be considered.

## Material: FL2™ PTFE filled with with glass fibres/molybdenum disulphide

GENERAL DESCRIPTION: Because of its special composition, FL2 has good physical properties and distinctly better creep behaviour than PTFE-virgin. Also higher wear resistance than most PTFE with fillers.

## Material: FL3™ PTFE filled with bronze

GENERAL DESCRIPTION: FL3 material has good mechanical properties, and can be used at higher loads compared to FL2 and FL5.

## Material: FL4™ Modified PTFE filled with carbon

GENERAL DESCRIPTION: Excellent compression and wear resistance, good thermal conductivity and low permeability. Suitable for a wide range of applications.

## Material: FL5™ Modified PTFE

GENERAL DESCRIPTION: FL5 has the same chemical properties as PTFE-virgin, and is also defined as a homopolymer according to ISO 12086. FL5 has highly improved mechanical properties in comparison to PTFE-virgin, see also the "Suggested Materials" section. Seal Engineering AS considers FL5 to be our standard "PTFE-virgin". FL5 is compliant with FDA-regulations.

## Material: FL14™ PTFE filled with Ekonol®

GENERAL DESCRIPTION: FL14 has excellent wear resistance. The filler is very gentle to mating metal surfaces, making it a good choice for rotary applications. FL14 is FDA approved and widely used in the food industry.

# Other PTFE-based materials

In addition to the PTFE-based materials described above we can manufacture seals, gaskets and other details in a variety of other PTFE materials with fillers specifically suited for a given application. We have either in stock or with short delivery time approximately 20 different PTFE-based materials to offer.
Contact Seal Engineering AS for special applications or materials.



# General thermoplastic materials

## Material: POM1

GENERAL DESCRIPTION: POM1 is a semi-crystalline polyacetal-copolymer which is used for backup-rings, guide-rings, bushings, scrapers and for precision-machined parts with tight tolerances. POM1 is one of the most important engineering thermoplastics with good physical properties, low water absorption and good chemical resistance. POM1 can be used in mineral oils, in water-based fire-resistant hydraulic fluids (HFA, HFB and HFC fluids). Concentrated acids and bases will attack and destroy it. POM1 (white) may be used in applications for food and drug, and is compliant with BGVV and EC-regulations.

**TEMPERATURE RANGE:** -45 °C to 100 °C.

## Material: PEEK1

GENERAL DESCRIPTION: PEEK1 is a polyetheretherketone with high tensile strength, stiffness, high temperature resistance and good sliding and friction behaviour. In addition PEEK1 has good resistance against numerous chemicals, and is therefore often used in demanding applications with regards to pressure, temperature and chemicals, or when there is a combination of these parameters. PEEK1 is compliant with FDA-regulations.

**TEMPERATURE RANGE:** -100 °C to 260 °C.

## Material: PA1

GENERAL DESCRIPTION: PA1 is a cast polyamide with good sliding properties and is used for back-up rings, guide rings and bearing components instead of POM1 for a diameters above 260 mm. PA1 can be used in mineral oils and water-based fire-resistant hydraulic fluids. When designing parts with PA1 for an application in water or water-based fluids, the swelling of the material must be taken into account, as PA1 absorbs water up to eight weight percent.

**TEMPERATURE RANGE:** -40 °C to 110 °C.

## Material: PE1

GENERAL DESCRIPTION: PE1 is extremely resistant to abrasion and is often used for pneumatic systems, or as sealing against abrasive media. This material has excellent chemical resistance, low friction, very low water absorption and good extrusion resistance. PE1 is compliant to FDA-regulations.

**TEMPERATURE RANGE:** -200 °C to 80 °C.

# Other thermoplastic materials

In addition to the materials mentioned above, Seal Engineering AS can manufacture seals and other machined details in almost any other thermoplastic, each with unique properties to suit a given application. Most of these materials are also available with different fillers, widening the range of applications even more.

| Abbreviation | Chemical name | Abbreviation | Chemical name |
|---|---|---|---|
| **PA** | Polyamide | **PC** | Polycarbonate |
| **POM** | Polyacetal (Polyoxymethylene) | **PSU** | Polysulphone |
| **PET** | Polyethylene terpthalate | **PES** | Polyether Sulphone |
| **PEEK** | Polyetheretherketone | **PPS** | Polyphenylene Sulphide |
| **PE** | Polyethylene | **PPSU** | Polyphenylsulphone |
| **PP** | Polypropylene | **PEI** | Polyetherimide |
| **PVC** | Polyvinyl Chloride | **PAI** | Polyamideimide |
| **PMMA** | Polymethyl methacrylate | **PBI** | Polybenzimidazole |
| **ABS** | Acrylnitrile Butadiene Styrene | **PI** | Polyimide |

# Suggested materials

Choosing materials is a task that often requires a lot of investigation and compromises between different desirable properties. For a given application there may be a number of different materials that are well suited, but our job is to find the best suited material.

Solely looking at the procurement price is often very misleading, as this does not consider actual life-cycle cost for a given product. Downtime, equipment failure and repair cost due to a faulty seal is many times higher than the cost of the seal, even in cases when some of the more expensive materials are chosen.

Seal Engineering AS is dedicated to find the best overall sealing solutions and materials with special attention to functionality, reliability and low overall life-cycle cost.
Seals are faced with an ever increasing demand for higher pressure, temperature, functionality and longevity.

This means that some of the "traditional" materials no longer are as well suited as they used to be. Advances in material science are resulting in new and improved materials, suited to meet these increased demands.
Progress made in the field of material science forces both suppliers and customers to evaluate their previous material selection for a given application.

The following section will show some of the advances in material technology, and give some guidelines for selecting the right material for a given application.

## Improved material for sliding seals

**Elastomer energized seals – often referred to as sliding seals, step seals or composite seals – have traditionally consisted of a PTFE-based sealing element in addition to the elastomer energizer – usually an O-ring.**

PTFE-based sealing systems meet the demands of low friction and stick-slip free operation very well. Often they cannot stand up against increasing technological requirements, especially with regards to wear-resistance, leakage behaviour and ease of installation and assembly.

## Hard grade polyurethanes

As an alternative to the PTFE-based seals we offer special hard grade polyurethanes XHPU (60 shore D) and XSPU (57 shore D). These materials meet all the necessary requirements:

- Low friction and no stick-slip behaviour
- Outstanding leakage performance
- Superior extrusion and wear characteristics
- Excellent installation properties

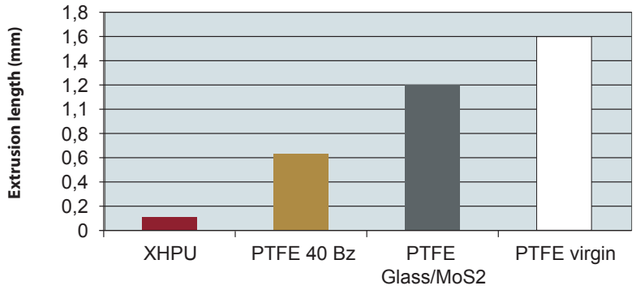
Due to these criteria, seals based on these special polyurethanes are an ideal replacement for conventional PTFE-based composite seals, provided that the temperature range or pressure fluid are within the recommended operating parameters. XHPU and XSPU can be used up to 110ºC, and for media such as mineral based hydraulic oil fluids, HFA and HFB fluids, biologically degradable oils and water.

Extensive test-rig investigations and finite element analysis have shown that seals based on these special polyurethanes are an ideal replacement of PTFE-based composite seals for most common fluid power systems.

# Comparative tests

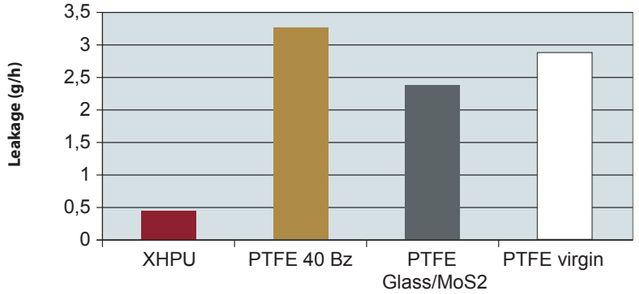
XHPU shows superior extrusion and wear characteristics. XHPU seals are capable of higher pressure ranges and/or larger extrusion gaps than comparable PTFE-based sealing systems and have, due to their superior wear characteristics, a longer lifetime.

*Graph 1, Extrusion length of composite seal materials*



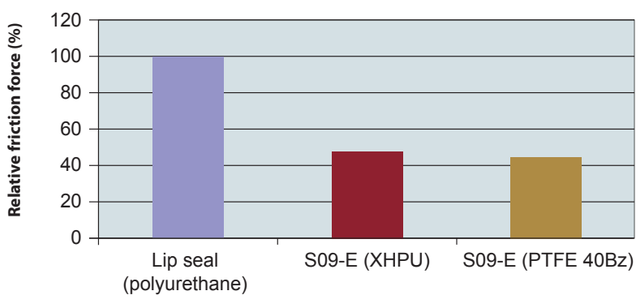

The requirement of low rod sealing leakage with PTFE-based seals is normally only obtained by fitting seals in multipart solutions (tandem arrangement) or in combination with a secondary lip seal. The superior low leakage values of XHPU and XSPU materials make these seal profiles, even without multipart solutions, ideal for many hydraulic applications.

*Graph 2, Leakage of composite seal materials*




Based on the excellent tribological properties of the XHPU and XSPU materials, the friction force are on the level of high-grade PTFE seals and less than 50% of standard polyurethane lip seals. Extensive tests showed also that the stick-slip performance is absolutely comparable to standard PTFE sealing systems.

*Graph 3, Friction force of standard seals*

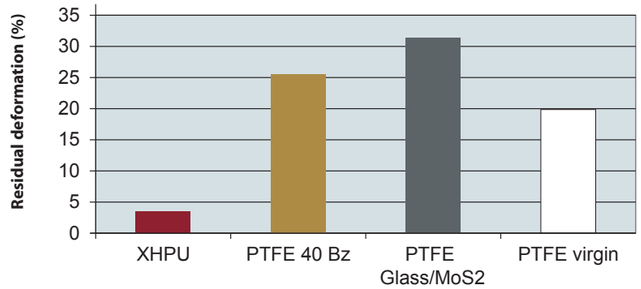



# Easier installation

A major factor in the consideration of PTFE-sealing systems (fig. 1) are the problems associated with installation.
These factors are due to the mechanical properties of PTFE-based materials. The thermoplastic elastomer material XHPU overcomes these problems.
Compared to PTFE-based seals, XHPU seals show the same material hardness; but considerably lower residual deformation and mounting forces. An additional benefit is the resistance to scratches and notches during assembly, which can be a major problem with PTFE-based materials.

Due to the excellent deformation behaviour of the XHPU materials, the complex and costly installation tools such as expanding and calibration sleeves and loading mandrels are no longer needed. You can simply snap-in or stretch the seals into the housing without any tools (fig. 2).

*Graph 4, Residual deformation of seal materials*



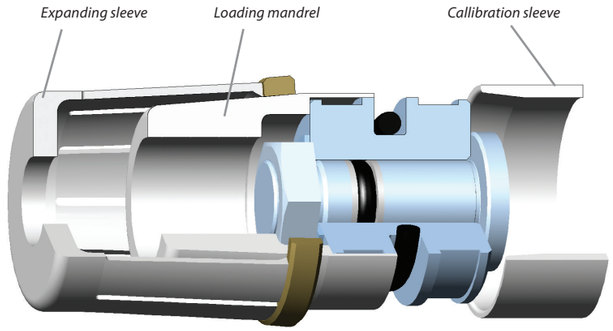




*Fig. 1, Installation of PTFE-based seals requires special tools*

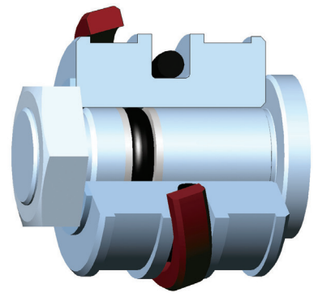


*Fig. 2, Installation of XHPU seals is made with simple or no tools*

# Comparison of XHPU and PTFE materials with FE-analysis

The step design of the dynamic sealing surface is also used for seals of XHPU, however small modifications of the XHPU design amplify the improvements which are created by the excellent properties of the material. The pictures from the FE-analysis show the difference. Owing to the higher flexibility of the material compared with PTFE compounds, the XHPU seals show a very regular stress/strain allocation under a load of up to several hundred bar.

The dynamic sealing edge is more evenly and not as highly loaded as at the PTFE design which leads to a minimum of wear and a long operation life at simultaneously excellent sealing performance. Also the extrusion endangered heel area of the seal shows a strong stress reduction which leads to an excellent extrusion resistance and an optimised back pumping ability.

*Table 1, Comparison of PTFE and XHPU*

| PTFE-based | Properties | XHPU |
|---|---|---|
| 3 | Pressure | 5 |
| 3 | Wear | 5 |
| 2 | Leakage | 5 |
| 5 | Friction/stick-slip | 4 |
| 1 | Installation | 5 |

1=Bad, 5=Excellent

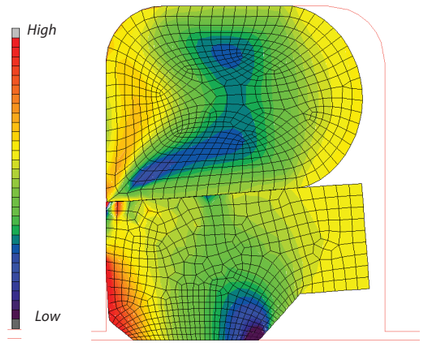



*Fig. 3, S09-E in PTFE*

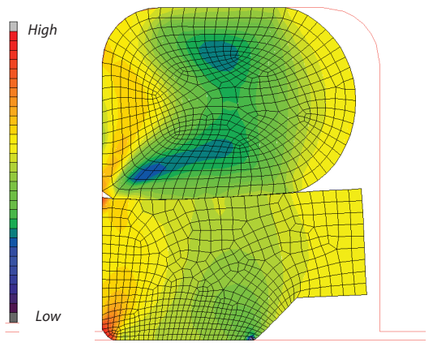



*Fig. 4, S09-E in XHPU*

## Conclusion

The test results shown above are a clear evidence that sliding seals made of XHPU and XSPU outperform seals made of PTFE-based materials for a wide range of applications. Only special fluids and/or elevated temperatures are reasons to use PTFE-based seals.

The improved wear resistance achieved by the use of seals made from XHPU and XSPU will not only lead to an extended lifetime compared to PTFE-based systems, but also have a lower demand for surface finish. Furthermore, the better extrusion resistance allows higher pressure range or larger component tolerances (extrusion gaps) than comparable PTFE-based seals. These benefits along with less leakage, good friction properties and easier installation give XHPU and XSPU tremendous advantages compared to the traditional PTFE-based seals.



# Modified PTFE

For applications with aggressive media and/or high temperature, PTFE or PTFE with fillers are often the preferred seal materials due to their excellent chemical and thermal resistance. Unfortunately PTFE-virgin has poor mechanical properties, and different fillers are needed to obtain enhanced mechanical properties. However, these filled materials are still restricted with regards to mechanical properties given the PTFE-virgin basis, and may also experience less resistance to some media (the fillers are attacked). In addition, some applications require the homopolymer structure of PTFE- virgin (food and drug applications, semiconductor etc.) with poor mechanical properties as an undesirable effect.

For many applications the solution can be a modified PTFE which has the same chemical and thermal resistance as PTFE-virgin, but exhibits several enhanced properties. In addition, according to ISO 12086, this material can still be classified as a homopolymer.

The modified PTFE results in several enhanced properties compared to PTFE-virgin. The most advantageous properties are:

- Substantially lower deformation under load. About the same cold flow as PTFE with 25% glass fibre. This is an important feature where fillers may cause contamination or reduced chemical resistance.
- Improved stress recovery, particularly at elevated temperatures. This is an important feature for seals and gaskets where improved stress recovery can translate to longer sealability or less retorquing of parts.
- Reduced tensile strain/flow. This makes for easier installation for parts that require stretching.
- Reduced permeation. This is an important feature when the material is used to protect against aggressive media, for instance as gaskets.
- Smoother surface of machined parts. This results in greater contact area of the seal, important for sealing against gas.

# Seals overview

The range of seals presented in this chapter is based on decades of experience in dynamic and static sealing solutions. The use of modern finite element analysis programs (FEA) for non-linear material behaviour in combination with best-practise manufacturing know-how results in optimized seal profiles delivering excellent sealing characteristics and reliable performance.

**This chapter is an introduction to our standard range of sealing profiles. The highlighted profiles are described in more detail in the next chapter. The profiles presented here are available in many different materials and even material groups.**

We have divided the material groups into five main categories in the following manner:

- **RU-group:** RU1, RU2, RU3, RU4, RU5 and RU6.
- **PU-group:** HPU, LPU and SPU.
- **XPU-group:** XHPU and XSPU.
- **FL- group:** FL2, FL3, FL5, FL13 and other PTFE-based materials.
- *– includes almost every polymer available for turning, but also other materials such as various types of metal.

The material categories apply to the seal part of a seal set. Material for energizer, backup ring, support ring, collar and spring is depending on the application.

The indicated temperature ranges apply to the material group. The specific temperature range depends on the application (pressure, media, extrusion gap) and which material is selected within the material group. For specific temperature range of different materials see Materials Overview and Material Specifications.

The specified pressure limits apply for normal operation parameters for each seal type and is to be used as guiding only. The pressure limit for a specific seal will depend on several parameters such as radial gap, temperature, speed, seal profile proportions and of course material selection.

The specified maximum speed is depending on several factors, such as lubrication, surface, temperature and seal geometry. The speed limits apply for adequate lubrication and running surface finishes as recommended. For PU the maximum speed 0.5, 0.7 and 1.4 m/s apply to SPU, for other PU materials the values are 0.4, 0.5 and 1 m/s respectively.

## Note:

For design purposes please bear in mind that the operation parameters for each seal represent general conditions. Not all maximum values can be utilized at the same time. However, depending on the application, higher pressure and speed can be attained in most cases.

## Wipers

**The function of a wiper is to prevent particles from entering the components in a hydraulic or pneumatic circuit, cylinders or valves. This helps prevent contamination of the media which will damage the seals and metal surfaces.**

The lip of the wiper is designed to have a pre-load with the piston rod, and this has an influence on the break-out friction.

Double acting wipers have the additional function of wiping off residual fluid film passing the rod seal, to avoid any external leakage.

Wipers are usually made from rubbers, polyurethanes or thermoplastics. Some have metal casing for press fit mounting. Special designs and different materials are available for applications where compensation for large radial movements, a stiffer inner lip, temperature or media resistance is required.

In addition to seal profile and material, indicated dimensions are required to process an order. Multi-element wipers are generally supplied as a complete set, e.g. the O-ring in A27 does not have to be ordered separately.

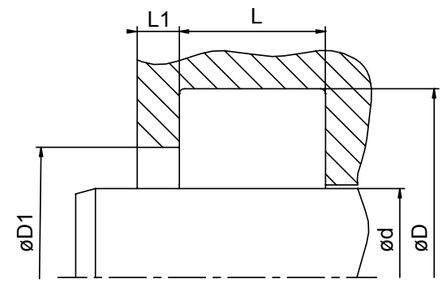
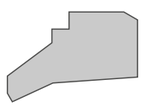
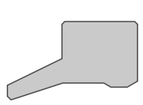


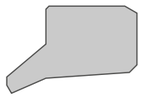
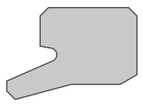
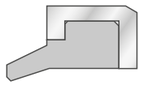
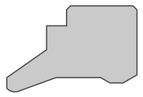
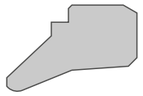
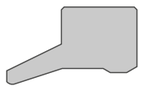
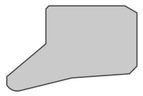
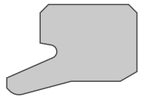

*Fig. 1, Housing for wiper.*

*Table 1, Order details*

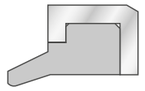
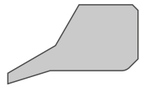
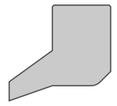
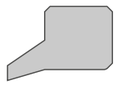
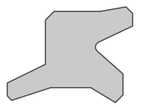
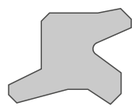
| | |
|---|---|
| ød | inside diameter (rod) |
| øD | outside diameter |
| $øD_1$ | outside diameter (if applicable) |
| L | groove length |
| H | total wiper height (if applicable) |

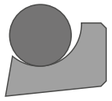
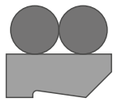
## Profiles overview

| Profile | *DESCRIPTION* | *MATERIAL CODE* |
|---|---|---|
| **A01-A**  | **Hydraulic, single acting**<br>Wiper with press fit on outside diameter, providing a technically accurate closure at the cylinder. Wiping edge assures a reliable protection against penetration of dust and dirt whilst allowing backflow of residual oil film. Back support area prevents tilting of wiper. For housings according to ISO 6195-Type A. | PU<br>RU |
| **A01-B**  | **Hydraulic, single acting**<br>As profile A01-A, but without back support area. For housings according to ISO 6195-Type A. | PU<br>RU |
| **A02-A**  | **Hydraulic, single acting**<br>Wiper with press fit on outside diameter. Wiping edge assures a reliable protection against penetration of dust and dirt whilst allowing backflow of residual oil film. Back support area prevents tilting of wiper. | PU<br>RU |

| PROFILE | DESCRIPTION | MATERIAL CODE |
|---|---|---|
| **A02-B**  | **Hydraulic, single acting**<br>Wiper with press fit on outside diameter. Wiping edge assures a reliable protection against penetration of dust and dirt whilst allowing backflow of residual oil film. | PU<br>RU |
| **A02-I**  | **Hydraulic, single acting**<br>As profile A02-A, but without back support area. Special housing design according to ISO 6195-Type C. | PU<br>RU |
| **A03-A**  | **Hydraulic, single acting**<br>Wiper with mounting cage for press fit installation into axially open housings. Wiping edge assures a reliable protection against penetration of dust and dirt, the use of plastic mounting cages avoids corrosion in the press fit. For housings according to ISO 6195-Type B. | PU<br>RU |
| **A04-A**  | **Pneumatic, single acting**<br>Wiper with press fit on outside diameter, providing a technically accurate closure at the cylinder. Special design of wiping lip allows retention of initial lubricating film. Back support area prevents tilting of wiper. For housings according to ISO 6195-Type A. | PU<br>RU |
| **A04-B**  | **Pneumatic, single acting**<br>As profile A04-A, but without back support area. For housings according to ISO 6195-Type A. | PU<br>RU |
| **A05-A**  | **Pneumatic, single acting**<br>Wiper with press fit on outside diameter. Special design of wiping lip allows retention of initial lubricating film. Back support area prevents tilting of wiper. | PU<br>RU |
| **A05-B**  | **Pneumatic, single acting**<br>As profile A05-A, but without back support area. Special design of wiping lip allows retention of initial lubricating film. | PU<br>RU |
| **A05-I**  | **Pneumatic, single acting**<br>Wiper with press fit on outside diameter. Special housing design according ISO 6195-Type C. | PU<br>RU |



| PROFILE | DESCRIPTION | MATERIAL CODE |
|---|---|---|
| **A06-A**  | **Pneumatic, single acting**<br>Wiper with mounting cage for press fit installation into axially open housings. Special design of wiping lip allows retention of initial lubricating film, the use of plastic mounting cages avoids corrosion at the press-fit. For housings according to ISO 6195-TypeB. | PU<br>RU |
| **A07-A**  | **Hydraulic, single acting**<br>Wiper to fit in angled housings (30°).Design mainly used for equipment based on inches, but also available in metric dimensions. | PU<br>RU |
| **A08-A**  | **Hydraulic/pneumatic, single acting**<br>Wiper usually fixed in housing with clamp flange. Mainly used for replacement in old hydraulic and pneumatic cylinders or for secondary applications. | PU<br>RU |
| **A08-B**  | **Hydraulic/pneumatic, single acting**<br>Wiper usually fixed in housing with clamp flange. Mainly used for replacement in old hydraulic and pneumatic cylinders or for secondary applications. | PU<br>RU |
| **A09-A**  | **Hydraulic, single acting**<br>Wiper with dimensioning according to common types used in USA. For housings according to AN 6231, ANSI/B 93.35 | PU<br>RU |
| **A10-A**  | **Hydraulic, single acting**<br>Wiper with dimensioning according to common types used in USA. Fixed relation between cross-section and height of wiper. For housings according to AN 6231, ANSI/B 93.35. | PU<br>RU |
| **A11-A**  | **Hydraulic/pneumatic, double acting**<br>Wiper including additional sealing lip. Often used in combination with composite seals/sliding seals, type S09, to reduce residual oil film. Also used as complete solution for pneumatic applications in small diameter range. Max. allowed pressure load: 16 bar (230 psi). | PU<br>RU |
| **A11-I**  | **Hydraulic/pneumatic, double acting**<br>as profile A11-A, special housing design according to ISO 6195-Type C. | PU<br>RU |

| PROFILE | DESCRIPTION | MATERIAL CODE |
|---|---|---|
| **A12-A**  | **Hydraulic, single acting**<br>Wiper with technically accurate closure at the cylinder providing reliable protection, even for heavy contamination. | PU<br>RU |
| **A12-B**  | **Hydraulic, double acting**<br>Wiper with technically accurate closure at the cylinder providing reliable protection, even for heavy contamination. Also including additional sealing lip. Used in combination with composite seals/sliding seals, type S09, to reduce residual oil film. | PU<br>RU |
| **A13-A**  | **Hydraulic/pneumatic, single acting**<br>Scraper ring, mainly used in combination with wiper A02 or A01. Firmly clinging dirt and extremely heavy soiling (mud, tar, ice) is wiped off, following elastomeric wiper is protected from damage. Material properties should provide good dry running properties, high stiffness and breaking strength. | * |
| **A25-F**  | **Hydraulic/pneumatic, single acting**<br>Wiper with O-ring as preloading element. O-ring maintains equal contact pressure. Good dry running properties, no "stick-slip". Excellent chemical and thermal resistance (depends on O-ring) with PTFE-materials. Improved wiping, longevity and easier installation with XPU. | XPU<br>FL |
| **A26-F**  | **Hydraulic/pneumatic, double acting**<br>Wiper with two O-rings as preloading elements. Wiping edge assures a reliable protection against penetration of dust and dirt. Additional sealing lip for reduction of residual oil film if used in combination with seals type S09. Excellent chemical and thermal resistance (depends on O-ring) with PTFE-material. Improved wiping, longevity and easier installation with XPU. | XPU<br>FL |
| **A27-F**  | **Hydraulic/pneumatic, double acting**<br>Wiper with O-ring as preloading element. Wiping edge assures a reliable protection against penetration of dust and dirt. Additional sealing lip for reduction of residual oil film if used in combination with seals type S09. Excellent chemical and thermal resistance (depends on O-ring) with PTFE-material. Improved wiping, longevity and easier installation with XPU. | XPU<br>FL |

Common material for A03/A06 housing/cage is POM or PEEK. Other material choices can be made depending on the application, e.g. A25 in PEEK for ice wiper.

The maximum speed is dependent on several factors such as lubrication, surface, temperature and seal profile. The maximum speeds apply for adequate lubrication and running surfaces as recommended.

*Table 2, Maximum speed*

| Material | Max. speed |
|---|---|
| RU | 4 m/s |
| PU | 4 m/s (5 m/s for SPU) |
| XPU | 5 m/s |
| FL | 10 m/s |



# Rod Seals

**The major function of the rod seal is to prevent the media from leaking trough the rod gland when the cylinder is pressurized. In order to work properly a small lubrication film should pass under the seal, and return (back-pumping) to the cylinder when the rod is retracting. Depending on the application one or two (sometimes more) rod seals are used for maximum sealability. The primary rod seal must withstand the system pressure.**

The technical demands are many and also diverse, good sealing effect, media resistance, resistance against pressure/extrusion, wear/operational reliability, resistance against high or low temperature, low friction/stick-slip, good back-pumping ability, simple installation and compact form.

Our rod seals meet these high expectations in combination with good economic- and service life value.

In addition to seal profile and material, indicated dimensions are required to process an order. Multi-element rod seals are generally supplied as a complete set, e.g. the O-ring in S09 does not have to be ordered separately.

*Table 3, Order details*

| | |
|---|---|
| ød | rod diameter |
| øD | groove diameter |
| L | groove length |

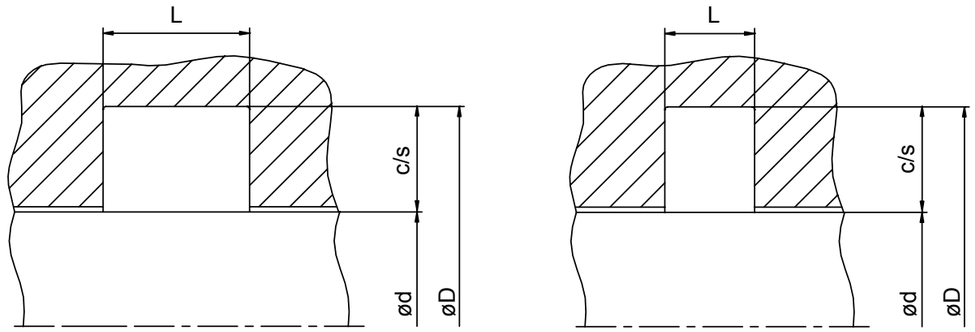
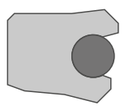
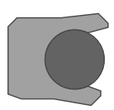
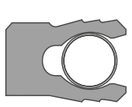


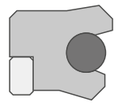
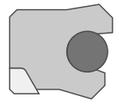
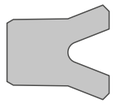
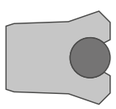
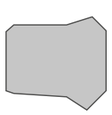
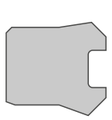

*Fig. 2, Housings for rod seals*

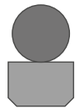
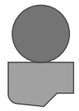
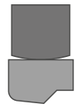
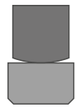
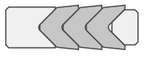
# Profiles overview

| PROFILE | DESCRIPTION | TEMPERATURE | MAX. SPEED | MAX. PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **S01-P**<br>**S01-R**<br>  | **Hydraulic, single acting**<br>Asymmetric rod seal for standard applications. Press fit on outside diameter maintains stable fit in the housing. Design provides ultimate sealing effect over a wide temperature range and good back-pumping ability. Also used as secondary seal in combination with seal type S09. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.7 m/s<br>0.5 m/s | 400 bar (5.800 psi)<br>160 bar (2.300 psi) | PU<br>RU |
| **S02-P**<br>**S02-R**<br>  | **Hydraulic, single acting**<br>Asymmetric rod seal for standard applications as S01, but due to design with active backup ring suitable for larger extrusion gaps or higher pressure range. S02-P/S02-R for standard housing design | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.7 m/s<br>0.5 m/s | 700 bar (10.000 psi)<br>400 bar (5.800 psi) | PU<br>RU |
| **S02-PD**<br>**S02-RD**<br>  | **Hydraulic, single acting**<br>Asymmetric rod seal for standard applications as S01, but due to design with active backup ring suitable for larger extrusion gaps or higher pressure range. S02-PD/S02-RD for short housings | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.7 m/s<br>0.5 m/s | 700 bar (10.000 psi)<br>400 bar (5.800 psi) | PU<br>RU |
| **S02-S**<br>  | **Hydraulic, single acting**<br>Asymmetric rod seal. Design with active backup ring suitable for larger extrusion gaps or higher pressure range. Good resistance to pressure shock. Always used as a primary seal in sealing systems. | -50 °C ... +110 °C | 0.7 m/s | 600 bar (8700 psi) | PU |
| **S03-P**<br>  | **Hydraulic, single acting**<br>O-ring activated asymmetric rod seal. Press fit on outside diameter maintains stable fit in the housing. Design provides ultimate sealing effect. Especially suitable for short stroke applications (e.g. spindle seals, coupling actuators) | -50 °C ... +110 °C | 0,7 m/s | 400 bar (5800 psi) | PU |
| **S03-F**<br>  | **Hydraulic, single acting**<br>O-ring activated asymmetric rod seal. Low friction, good dry running properties and adaptation possibilities for diverse temperatures and media by selection of suitable seal and O-ring material. Almost no dead spots as required for applications in food & pharmaceutical industry. | -60 °C ... +200 °C | 1 m/s | As designed | * |
| **S03-S**<br>  | **Hydraulic, single acting**<br>Helicoil spring activated asymmetric rod seal. Low friction and good dry running properties, excellent chemical and thermal resistance. Mainly used in chemical, pharmaceutical and food industry. | -200 °C ...+260 °C | 1 m/s | As designed | * |

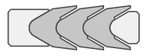
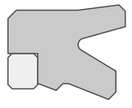
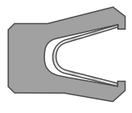
Highlighted profile(s): Recommended by Seal Engineering AS. See chapter 4 for details.

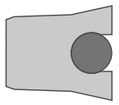
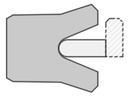
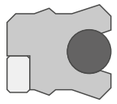
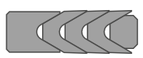
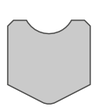


| PROFILE | DESCRIPTION | TEMPERATURE | MAX. SPEED | MAX. PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **S04-P**<br>  | **Hydraulic, single acting**<br>Asymmetric rod seal for standard applications as S03-P, but due to design with active backup ring suitable for larger extrusion gaps or higher pressure range. S04-P for standard housing design | -50 °C ... +110 °C | 0,7 m/s | 700 bar (10.000 psi) | PU |
| **S04-PD**<br>  | **Hydraulic, single acting**<br>Asymmetric rod seal for standard applications as S03-P, but due to design with active backup ring suitable for larger extrusion gaps or higher pressure range. S04-PD for short housings. | -50 °C ... +110 °C | 0,7 m/s | 700 bar (10.000 psi) | PU |
| **S05-P**<br>**S05-R**<br>  | **Pneumatic, single acting**<br>Asymmetric rod seal, extremely wear resistant, for use in lubricated or dry pneumatic applications. Special design of sealing lip allows retention of initial lubricating film. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 1.4 m/s<br>1 m/s | 25 bar (360 psi)<br>25 bar (360 psi) | PU<br>RU |
| **S06-P**<br>**S06-R**<br>  | **Hydraulic, single acting**<br>Symmetric rod seal for simple standard applications, not recommended for new designs (profile S01 should be preferred). | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0,7 m/s<br>0,5 m/s | 400 bar (5800 psi)<br>160 bar (2300 psi) | PU<br>RU |
| **S07-P**<br>  | **Hydraulic, single acting**<br>O-ring activated symmetric rod seal for simple standard applications, not recommended for new designs (profile S03-P preferred). | -50 °C ... +110 °C | 0,7 m/s | 400 bar (5800 psi) | PU |
| **S08-P**<br>**S08-R**<br>  | **Hydraulic, single acting**<br>Asymmetric compact rod seal with stable fit in the housing. Compact design mainly used to seal high viscosity fluids or for extremely small housings, not suitable for high speed applications. S08-P compact design, no groove | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0,4 m/s<br>0,3 m/s | 400 bar (5800 psi)<br>160 bar (2300 psi) | PU<br>RU |
| **S08-PE**<br>  | **Hydraulic, single acting**<br>Asymmetric compact rod seal with stable fit in the housing. Compact design mainly used to seal high viscosity fluids or for extremely small housings, not suitable for high speed applications. S08-PE with small groove. | -50 °C ... +110 °C | 0,4 m/s | 400 bar (5800 psi) | PU |

| PROFILE | DESCRIPTION | TEMPERATURE | MAX. SPEED | MAX. PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **S09-E**  | **Hydraulic, single acting** O-ring activated asymmetric rod seal. Low friction. In tandem design together with double acting wipers for extreme low or high speed or positioning functions. As primary seal in combination with secondary S01-P seal with good resistance to pressure shocks used in mobile hydraulics, machine tools, injection moulding machines, heavy hydraulics. | -50 °C ... +200 °C<br>-20 °C ... +110 °C | 10 m/s<br>5 m/s | 600 bar (8700 psi)<br>600 bar (8700 psi) | FL<br>XPU |
| **S09-D**  | **Hydraulic, double acting** O-ring activated symmetric rod seal, low friction. For extreme low or high speed, suitable for positioning functions. | -50 °C ... +200 °C<br>-20 °C ... +110 °C | 10 m/s<br>5 m/s | 600 bar (8700 psi)<br>600 bar (8700 psi) | FL<br>XPU |
| **S09-P**  | **Hydraulic, single acting** O-ring activated asymmetric PU rod seal with excellent dynamic sealing capacity. Used as secondary seal in tandem design (together with primary S09-E) to minimize residual oil film. For mobile hydraulics, injection moulding machines, heavy hydraulics. | -50 °C ... +110 °C | 1.4 m/s | 400 bar (5800 psi) | PU |
| **S09-ES**  | **Hydraulic, single acting** Profile ring-activated asymmetric rod seal, similar to S09-E, but special heavy duty design for heavy industry hydraulics or for special housing dimensions. | -50 °C ... +200 °C<br>-20 °C ... +110 °C | 10 m/s<br>5 m/s | 600 bar (8700 psi)<br>600 bar (8700 psi) | FL<br>XPU |
| **S09-DS**  | **Hydraulic, double acting** Profile ring-activated symmetric rod seal, similar to S09-D, but special heavy duty design for heavy industry hydraulics or for special housing dimensions. | -50 °C ... +200 °C<br>-20 °C ... +110 °C | 10 m/s<br>5 m/s | 600 bar (8700 psi)<br>600 bar (8700 psi) | FL<br>XPU |
| **S1012-M**  | **Hydraulic, single acting** Chevron sealing set, parting surface design. For heavy industry hydraulics. Due to different geometry type M cannot be interchanged with type T. Important with axial play in the groove to avoid extensive friction. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0,7 m/s<br>0,5 m/s | 600 bar (8700 psi)<br>400 bar (5800 psi) | PU<br>RU |
| **S1012-T**  | **Hydraulic, single acting** Chevron sealing set, machined surface design. For heavy industry hydraulics. Due to different geometry type T cannot be interchanged with type M. Important with axial play in the groove to avoid extensive friction. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0,7 m/s<br>0,5 m/s | 600 bar (8700 psi)<br>400 bar (5800 psi) | PU<br>RU |

Highlighted profile(s): Recommended by Seal Jet Engineering AS. See chapter 4 for details.

| PROFILE | DESCRIPTION | TEMPERATURE | MAX. SPEED | MAX. PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **S1315-T**  | **Hydraulic, single acting** Chevron sealing set, design with flexible sealing lips, good sealing ability in higher pressure range. For heavy industry hydraulics, water-hydraulic systems. Important with axial play in the groove to avoid extensive friction. | -50 °C ... +110 °C | 0,7 m/s | 600 bar (8700 psi) | PU |
| **S16-A**  | **Hydraulic/pneumatic, single acting** Simple hat seal, usually fixed in housing with clamp flange. Mainly used for replacement in old hydraulic and pneumatic cylinders or for secondary applications. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0,7 m/s<br>0,5 m/s | 100 bar (1450 psi)<br>60 bar (870 psi) | PU<br>RU |
| **S16-B**  | **Hydraulic/pneumatic, single acting** Simple hat seal, usually fixed in housing with clamp flange. Mainly used for replacement in old hydraulic and pneumatic cylinders or for secondary applications. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0,7 m/s<br>0,5 m/s | 100 bar (1450 psi)<br>60 bar (870 psi) | PU<br>RU |
| **S17-P**<br>**S17-R**  | **Hydraulic, single acting** Asymmetric rod seal with additional sealing- respectively stabilizing lip. Press fit on outside diameter maintains stable fit in the housing. Design mainly used for telescopic cylinders, mobile hydraulic or for special housing dimensions. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0,7 m/s<br>0,5 m/s | 400 bar (5800 psi)<br>160 bar (2300 psi) | PU<br>RU |
| **S18-P**<br>**S18-R**  | **Hydraulic, single acting** Asymmetric rod seal as S17-P, but due to design with active backup ring suitable for larger extrusion gaps or higher pressure range. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0,7 m/s<br>0,5 m/s | 600 bar (8700 psi)<br>350 bar (5000 psi) | PU<br>RU |
| **S19-F**  | **PTFE-rodseal, single acting** Finger spring activated asymmetric PTFE rod seal, low friction and good dry running properties, excellent chemical and thermal resistance, mainly used in chemical, pharmaceutical and food industry. Hi-clean version available. | -200 °C ... +260 °C | As designed | As designed | * |
| **S20-R**  | **Hydraulic, double acting** Space saving, compact rod seal, fits standard O-ring housings. Advantage compared to O-ring: integrated active backup rings for high pressure, design with press fit on outside diameter maintains non-twisting in dynamic applications. | -50 °C ... +200 °C | 0,5 m/s | 700 bar (10000 psi) | RU |

| PROFILE | DESCRIPTION | TEMPERATURE | MAX. SPEED | MAX. PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **S21-P**  | **Hydraulic, single acting** O-ring activated symmetric rod seal with sharp-edged sealing lips, good sealing effect for high viscosity fluids, not recommended for new designs (profile S03-P preferred). | -50 °C ... +110 | 0,7 m/s | 400 bar (5800 psi) | PU |
| **S22-P** **S22-R**  | **Hydraulic, single acting** Symmetric rod seal with support ring for simple applications to serve repair purpose, not recommended for new designs (profile S01-P preferred). Retainer ring in angled design possible. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0,7 m/s<br>0,5 m/s | 400 bar (5800 psi)<br>160 bar (2300 psi) | PU<br>RU |
| **S24-P**  | **Hydraulic, single acting** O-ring activated rod seal with additional stabilizing lips and integrated active back ring for larger extrusion gaps, mainly used in mining industry. | -50 °C ... +110 °C | 0,7 m/s | 700 bar (10000 psi) | PU |
| **S2527-F**  | **PTFE chevron set, single acting** Optimized for low pressure, unequal angled chevron design results in good contact pressure even in low pressure range. External spring pretension necessary. Mainly used in chemical, pharmaceutical and food industry. | -200 °C ... +260 °C | 1,5 m/s | 100 bar (1450 psi) | FL |
| **S2931-F**  | **PTFE chevron set, single acting** Optimized for high pressure, equal angled chevron design suitable for high pressure range. External spring pretension necessary. Mainly used in chemical, pharmaceutical and food industry. | -200 °C ... +260 °C | 1,5 m/s | 315 bar (4500 psi) | FL |
| **S32-P**  | **Hydraulic, single acting** Chevron set, design with extremely flexible sealing lips for difficult operating conditions (bad guiding, large tolerance range). Available as complete seal as well as intermediate chevrons only (in case of metal male and female adaptors). | -50 °C ... +110 °C<br>-200 °C ...+200 °C | 0,7 m/s<br>0,5 m/s | 500 bar (7200 psi)<br>250 bar (3600 psi) | PU<br>RU |
| **S35-P**  | **Hydraulic, double acting** Compact rod seal with almost no dead spots as required for applications in food and pharmaceutical industry, also commonly used as O-ring replacement, because design with press fit on outside diameter maintains non-twisting in dynamic applications. | -50 °C ... +110 °C | 0,4 m/s | 400 bar (5800 psi) | PU |



# Piston Seals

**The main function of a piston seal is to maintain sealing between the piston and cylinder bore, ensuring that energy in the media builds up pressure inside the cylinder and transforms this to mechanical force through the cylinder rod.**

Normally, a relatively thick lubrication film can be permitted between the piston seal and the cylinder bore surface as long as there is no significant loss of effect, or need to separate two different media. This way friction during the stroke action is minimized, which leads to reduction in wear and increases the service life of the seal. The transportation of fluid during dynamic function is small and insignificant in most operating conditions, but leakage at standstill position should be minimal.

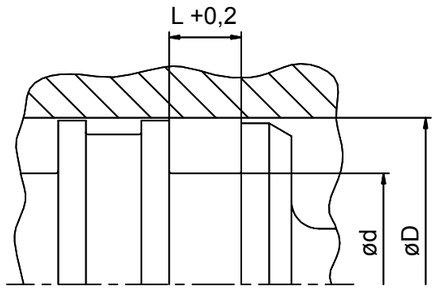



*Fig. 3, Housing for piston seal*

The piston seal in single-acting cylinders should leave a minimum of lubrication film during the non pressure return movement of the piston. Otherwise the transportation of fluid will build up on the atmosphere side and could result in failure or accident. Designers must take care when considering leakage control versus good sealing properties.

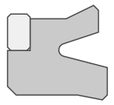
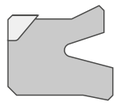
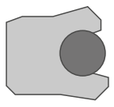
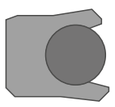
The Seal Engineering AS line of seals are available in a large variety of types, unlimited number of sizes and numerous materials and energizers to satisfy your sealing requirements. The seals will be turned with great precision in one of our CNC machines by well-skilled craftsmen to your specific design, whether it is custom-designed or follow popular standards.

In addition to seal profile and material, indicated dimensions are required to process an order. Multi-element piston seals are generally supplied as a complete set, e.g. the O-ring in K08 does not have to be ordered separately.

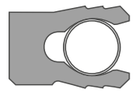
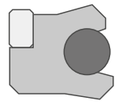
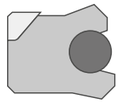
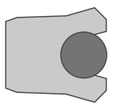
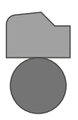
*Table 4, Order details*

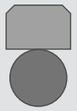
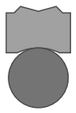
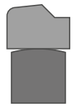
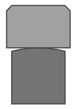
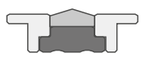
| | |
|---|---|
| øD | cylinder bore |
| Ød | groove diameter |
| L | groove length |

# Profiles overview

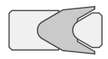
| PROFILE | DESCRIPTION | TEMPERATURE | MAX. SPEED | MAX. PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **K01-P**<br>**K01-R**<br>  | **Hydraulic, single acting**<br>Asymmetric piston seal for standard applications. Design provides stable fit in the housing, ultimate sealing effect over a wide temperature range. Avoids extensive drag pressure. Back-to-back arrangement for double acting pistons or to separate different fluids. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.7 m/s<br>0.5 m/s | 400 bar (5800 psi)<br>160 bar (2300 psi) | PU<br>RU |
| **K01-PE**<br>**K01-RE**<br>  | **Hydraulic, single acting**<br>Asymmetric piston seal for standard applications. Design provides stable fit in the housing, ultimate sealing effect over a wide temperature range. Suitable for single acting cylinders due to improved static sealing. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.7 m/s<br>0.5 m/s | 400 bar (5800 psi)<br>160 bar (2300 psi) | PU<br>RU |
| **K02-P**<br>**K02-R**<br>  | **Hydraulic, single acting**<br>Asymmetric piston seal for standard applications as K01, but due to design with active backup ring suitable for higher pressure range or larger extrusion gaps. K02-P/K02-R for standard housing design. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.7 m/s<br>0.5 m/s | 700 bar (10.000 psi)<br>400 bar (5800 psi) | PU<br>RU |
| **K02-PD**<br>**K02-RD**<br>  | **Hydraulic, single acting**<br>Asymmetric piston seal for standard applications as K01, but due to design with active backup ring suitable for higher pressure or larger extrusion gaps. K02-PD/K02-RD for short housings. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.7 m/s<br>0.5 m/s | 700 bar (10.000 psi)<br>400 bar (5800 psi) | PU<br>RU |
| **K03-P**<br>  | **Hydraulic, single acting**<br>O-ring activated asymmetric piston seal. Interference fit on inside diameter maintains stable fit in the housing. Design provides ultimate sealing effect. Especially suitable for short stroke applications (e.g. spindle seals, coupling actuators) | -50 °C ... +110 °C | 0.7 m/s | 400 bar (5800 psi) | PU |
| **K03-F**<br>  | **Hydraulic piston seal, single acting**<br>O-ring activated, asymmetric piston seal, low friction and no stick-slip effect. Good adaptation possibilities for various temperatures and media by selection of suitable seal and O-ring material, almost no dead spots as required for applications in food and pharmaceutical industry. | -60 °C ... +200 °C | As designed | As designed | * |

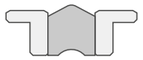
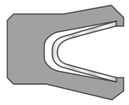
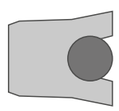
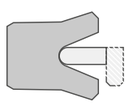
Highlighted profile(s): Recommended by Seal Engineering AS. See chapter 4 for details.

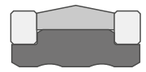
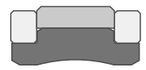
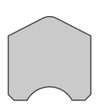
| PROFILE | DESCRIPTION | TEMPERATURE | MAX. SPEED | MAX. PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **K03-S**<br>  | **Hydraulic piston seal, single acting**<br>Helicoil-spring activated, asymmetric piston seal, low friction and no stick-slip effect, excellent chemical and thermal resistance, mainly used in chemical, pharmaceutical and food industry or for valves. | -200 °C ...+260 °C | As designed | As designed | * |
| **K04-P**<br>  | **Hydraulic, single acting**<br>Asymmetric piston seal for standard applications as K03-P, but due to design with active backup ring suitable for larger extrusion gaps or higher pressure. K04-P for standard housing design. | -50 °C ... +110 °C | 0.7 m/s | 700 bar (10.000 psi) | PU |
| **K04-PD**<br>  | **Hydraulic, single acting**<br>Asymmetric piston seal for standard applications as K03-P, but due to design with active backup ring suitable for larger extrusion gaps. K04-PD for short housings. | -50 °C ... +110 °C | 0.7 m/s | 700 bar (10.000 psi) | PU |
| **K05-P**<br>**K05-R**<br>  | **Pneumatic, single acting**<br>Asymmetric piston seal, extremely wear resistant, for use in lubricated or dry pneumatic applications. Special design of sealing lip allows retention of initial lubricating film. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 1.4 m/s<br>1 m/s | 25 bar (360 psi)<br>25 bar (360 psi) | PU<br>RU |
| **K06-P**<br>**K06-R**<br>  | **Hydraulic, single acting**<br>Symmetric piston seal for simple standard applications, not recommended for new designs (profile K01 preferred). | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.7 m/s<br>0.5 m/s | 400 bar (5800 psi)<br>160 bar (2300 psi) | PU<br>RU |
| **K07-P**<br>  | **Hydraulic, single acting**<br>O-ring activated symmetric piston seal for simple standard applications, not recommended for new designs (profile K03-P preferred). | -50 °C ... +110 °C | 0.7 m/s | 400 bar (5800 psi) | PU |
| **K08-E**<br>  | **Hydraulic, single acting**<br>O-ring activated asymmetric piston seal, low friction. For extreme low or high speed. Suitable for positioning functions. | -50 °C ... +200 °C<br>-20 °C ... +110 °C | 10 m/s<br>5 m/s | 600 bar (5800 psi)<br>600 bar (5800 psi) | FL<br>XPU |

| PROFILE | DESCRIPTION | TEMPERATURE | MAX. SPEED | MAX. PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **K08-D**  | **Hydraulic, double acting** O-ring activated symmetric piston seal, low friction. For extreme low or high speed, suitable for positioning functions. For mobile hydraulics, machine tools, injection moulding machines, heavy hydraulics. | -50 °C ... +200 °C<br>-20 °C ... +110 °C | 10 m/s<br>5 m/s | 600 bar (8700 psi)<br>600 bar (8700 psi) | FL<br>XPU |
| **K08-P**  | **Hydraulic, double acting** O-ring activated symmetric PU piston seal with excellent static and dynamic sealing capacity, extremely wear resistant. | -50 °C ... +110 °C | 1.4 m/s | 350 bar (5000 psi) | PU |
| **K08-ES**  | **Hydraulic, single acting** Profile-ring activated asymmetric piston seal, similar to K08-E, but special heavy duty design. For heavy industry hydraulics or for special housing dimensions. | -50 °C ... +200 °C<br>-20 °C ... +110 °C | 10 m/s<br>5 m/s | 600 bar (8700 psi)<br>600 bar (8700 psi) | FL<br>XPU |
| **K08-DS**  | **Hydraulic, double acting** Profile-ring activated symmetric piston seal, similar to K08-D, but special heavy duty design. For heavy industry hydraulics or for special housing dimensions. | -50 °C ... +200 °C<br>-20 °C ... +110 °C | 10 m/s<br>5 m/s | 600 bar (8700 psi)<br>600 bar (8700 psi) | FL<br>XPU |
| **K09-N**  | **Hydraulic, double acting** Profile-ring activated compact piston seal with integrated guiding elements. Excellent static sealing capacity. Commonly used in standard cylinders. | -30 °C ... +110 °C | 0.7 m/s | 600 bar (8700 psi) | PU |
| **K09-D**  | **Hydraulic, double acting** Profile-ring activated compact piston seal with integrated guiding elements. Excellent static and dynamic sealing capacity. | -30 °C ... +110 °C | 0.7 m/s | 600 bar (8700 psi) | PU |
| **K09-H**  | **Hydraulic, double acting** Profile-ring activated compact piston seal with integrated guiding elements. Design for high pressure range, excellent static sealing capacity. Mainly used in mining/tunnelling industry. | -30 °C ... +110 °C | 0.3 m/s | As designed | PU |

Highlighted profile(s): Recommended by Seal Engineering AS. See chapter 4 for details.

| PROFILE | DESCRIPTION | TEMPERATURE | MAX. SPEED | MAX. PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **K09-F**  | **Hydraulic, double acting** Profile-ring activated compact piston seal with integrated guiding elements. Low friction, good chemical and thermal resistance with PTFE. Improved sealing, longevity and easier installation with XPU. | -30 °C ... +200 °C<br>-20 °C ... +110 °C | 10 m/s<br>5 m/s | 600 bar (8700 psi)<br>600 bar (7200 psi) | FL<br>XPU |
| **K1012-T**  | **Hydraulic, single acting** Chevron sealing set, machined surface design. For back-to-back arrangement with one intermediate chevron, in single acting applications more intermediate chevrons possible. For heavy industry hydraulics. Due to different geometry type M cannot be interchanged with type T. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.7 m/s<br>0.5 m/s | 600 bar (8700 psi)<br>400 bar (5800 psi) | PU<br>RU |
| **K1012-M**  | **Hydraulic, single acting** Chevron sealing set, parted surface design. For back-to-back arrangement with one intermediate chevron , in single acting applications more intermediate chevrons possible. For heavy industry hydraulics. Due to different geometry type T cannot be interchanged with type M. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.7 m/s<br>0.5 m/s | 600 bar (8700 psi)<br>400 bar (5800 psi) | PU<br>RU |
| **K1315-T**  | **Hydraulic, single acting** Chevron sealing set, design with flexible sealing lips, good sealing ability. For heavy industry hydraulics, water hydraulic systems. | -50 °C ... +110 °C | 0.7 m/s | 600 bar (8700 psi) | PU |
| **K16-A**  | **Hydraulic/pneumatic, single acting** Simple cup seal, usually fixed on the piston by means of a clamping plate. Mainly used for replacement in old hydraulic and pneumatic cylinders or for low-grade secondary applications. Also used for food filling/portioning equipment. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.7 m/s<br>0.5 m/s | 100 bar (1450 psi)<br>60 bar (870 psi) | PU<br>RU |

| PROFILE | DESCRIPTION | TEMPERATURE | MAX. SPEED | MAX. PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **K16-B**  | **Hydraulic/pneumatic, single acting** Simple cup seal, usually fixed on the piston by means of a clamping plate. Mainly used for replacement in old hydraulic and pneumatic cylinders or for low-grade secondary applications. Also used for food filling/portioning equipment. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.7 m/s<br>0.5 m/s | 100 bar (1450 psi)<br>60 bar (870 psi) | PU<br>RU |
| **K17-P**<br>**K17-R**  | **Hydraulic, double acting** Space saving, compact piston seal with integrated guiding elements. Excellent static sealing capacity, suitable for small housings. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.7 m/s<br>0.5 m/s | 400 bar (5800 psi)<br>250 bar (3600 psi) | PU<br>RU |
| **K19-F**  | **PTFE-piston seal, single acting** Finger-spring activated asymmetric PTFE piston seal, low friction and good dry running properties, excellent chemical and thermal resistance, mainly used in chemical, pharmaceutical and food industry. Hi-clean version available. | -200 °C ... +260 °C | As designed | As designed | * |
| **K20-R**  | **Hydraulic, double acting** Space saving, compact piston seal, suitable for standard O-ring housings. Advantage compared to O-ring: integrated active backup rings for high pressure. Design with stretch fit on inside diameter prevents twisting in dynamic applications. | -50 °C ... +200 °C | 0.5 m/s | 700 bar (10000 psi) | RU |
| **K21-P**  | **Hydraulic, single acting** O-ring activated symmetric rod seal with sharp-edged sealing lips, good sealing effect for high viscosity fluids, not recommended for new designs (profile K03-P preferred). | -50 °C ... +110 °C | 0.7 m/s | 400 bar (5800 psi) | PU |
| **K22-P**<br>**K22-R**  | **Hydraulic, single acting** Symmetric piston seal with support ring for simple applications to serve repair purpose, not recommended for new designs (profile K01-P preferred). Retainer ring in angled design possible. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.7 m/s<br>0.5 m/s | 400 bar (5800 psi)<br>160 bar (2300 psi) | PU<br>RU |

| PROFILE | DESCRIPTION | TEMPERATURE | MAX. SPEED | MAX. PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **K23-N**  | **Hydraulic, double acting** Profile-ring activated compact piston seal with integrated backup rings, excellent static sealing capacity. External guiding elements required. | -30 °C ... +110 °C | 0,7 m/s | 600 bar (8700 psi) | PU |
| **K23-D**  | **Hydraulic, double acting** Profile-ring activated compact piston seal with integrated backup rings. Excellent static and dynamic sealing capacity. External guiding elements required. | -30 °C ... +110 °C | 0,7 m/s | 600 bar (8700 psi) | PU |
| **K23-H**  | **Hydraulic, double acting** Profile-ring activated compact piston seal with integrated backup rings. Design for high pressure range, excellent static sealing capacity. Mainly used in mining/tunnelling industry. External guiding elements required. | -30 °C ... +110 °C | 0,3 m/s | As designed | PU |
| **K23-F**  | **Hydraulic, double acting** Profile-ring activated compact seal with integrated backup rings. Low friction, good chemical and thermal resistance with PTFE. Improved sealing, longevity and easier installation with XPU. External guiding elements required. | -30 °C ... +200 °C<br>-20 °C ... +110 °C | 1.5 m/s<br>1.0 m/s | 600 bar (8700 psi)<br>600 bar (8700 psi) | FL<br>XPU |
| **K24-P**  | **Hydraulic, single acting** Chevron ring with flexible lip design. Replacement part for standard commercial housings (male and female adapter mainly made of metal). | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0,7 m/s<br>0,5 m/s | 500 bar (7200 psi)<br>250 bar (3600 psi) | PU<br>RU |
| **K32-P**  | **Hydraulic, single acting** Chevron sealing set, design with extremely flexible sealing lips for difficult operating conditions like bad guiding, large tolerance range. Available as total chevron sealing set as well as intermediate chevrons only (in case of metal male and female adapters). | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0,7 m/s<br>0,5 m/s | 500 bar (7200 psi)<br>250 bar (3600 psi) | PU<br>RU |
| **K35-P**  | **Hydraulic, double acting** Compact piston seal with almost no dead spots as required for applications in food and pharmaceutical industry. Also commonly used as O-ring replacement. Design with press fit on outside diameter maintains non-twisting in dynamic applications. | -50 °C ... +110 °C | 0,5 m/s | 400 bar (5800 psi) | PU |

# Guide Rings

**The function of guide rings is to prevent metallic contact between surfaces of moving parts. In order to obtain correct positioning the guide rings must have capability to withstand radial loads acting on piston and rod.**

Guide rings made out of fabric reinforced resin and various thermoplastics have replaced the use of metallic guides. This has resulted in a considerably longer service life for hydraulic cylinders.

Are you familiar with the functional parameters such as service temperature, load, speed and type of hydraulic medium? We will help you when choosing the most appropriate guide ring material!

The profiles presented below are also suitable as construction elements, and can be supplied in almost any material. Contact Seal Engineering AS for technical advice.

In addition to material, indicated dimensions are required to process an order.

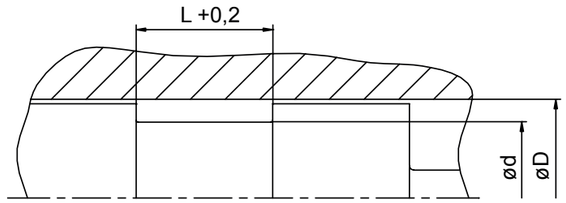



*Fig. 4, Piston guide ring*

*Table 5, Piston guide ring, F01*

| | |
|---|---|
| ØD | cylinder bore |
| Ød | groove diameter |
| L | groove length |

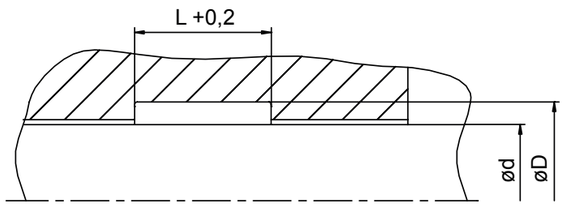



*Fig. 5, Rod guide ring*

*Table 6, Rod guide ring, F01*

| | |
|---|---|
| Ød | rod diameter |
| ØD | groove diameter |
| L | groove length |



# Profiles overview

Please observe that the presented guide rings are well suited as generic construction elements, as well as traditional bushing/bearing elements!

| *PROFILE* | *DESCRIPTION* |
|---|---|
| **F01**  | **Guide ring F01**<br>Most common guide ring for rod or piston application. Used in many standard cylinders, majority of applications require split version for installation into closed housings, non split design available (bushings). |
| **F02**  | **Guide ring F02**<br>For rod or piston application, split and non split design available. Not only used as guide ring, also as plain washer or spacer. |
| **F03**  | **Guide ring F03**<br>For piston application. Angled design combines guide ring and backup ring function. Split and non split design available. |
| **F04**  | **Guide ring F04**<br>As profile F03 but for rod application. |

| *PROFILE* | *DESCRIPTION* |
|---|---|
| **F05**  | **Guide ring F05**<br>With integrated collar on inside diameter, for piston application. Split and non split design available. |
| **F06**  | **Guide ring F06**<br>With integrated collar on outside diameter, for rod application. Split and non split design available. |
| **F07**  | **Guide ring F07**<br>With groove on inside diameter, for piston application. Split and non split design available. |
| **F08**  | **Guide ring F08**<br>With groove on outside diameter, for rod application. Split and non split design available. |

*Table 7, Guide ring specifications*

| *MATERIAL* | *TEMPERATURE* | *MAX. SPEED* | *MAX COMPRESSIVE STRENGTH (dynamic, perpendicular) ** |
|---|---|---|---|
| **FL2** | -200 °C ... +260 °C | 15 m/s | 6 N/mm2 |
| **FL3** | -200 °C ... +260 °C | 15 m/s | 7.5 N/mm2 |
| **FL13** | -200 °C ... +260 °C | 15 m/s | 10 N/mm2 |
| **POM1** | -50 °C ... +100 °C | 4 m/s | 25 N/mm2 |
| **PA1** | -40 °C ... +100 °C | 4 m/s | 20 N/mm2 |
| **ST200** | -40 °C ... +130 °C | 1 m/s | 90 N/mm2 |

*Valid for 0.1 m/s and 60 ºC. Increased speed and/or temperature will reduce maximum value.
Several other materials are available. If the listed materials does not suit your application contact Seal Engineering AS.

# Backup rings

**O-rings are often used as static sealing elements in hydraulic systems. However, they tend to extrude into the radial gap between the steel parts already at low pressures and are thereby destroyed. A possible solution is to combine O-rings with backup rings.**

At high pressures other types of seals may also be in danger of being extruded through the radial gap. The use of backup rings is a widely used solution for this problem.

The right material must be selected to suit the need of the application with respect to pressure, gap, temperature and media.

## Profiles overview

| PROFILE | DESCRIPTION |
|---|---|
| **ST08**  | **Backup ring** Common inactive backup ring, mainly used with O-rings to avoid gap extrusion. Split and non split design available. |
| **ST09**  | **Backup ring** Common active backup ring especially for O-rings to avoid gap extrusion. Split and non split design available |
| **ST10**  | **Backup ring** Standard active backup ring for piston seal type PD. Normally already included in PD-type seal profiles, designed for automatic pressure activation. Split and non split design available. |

| PROFILE | DESCRIPTION |
|---|---|
| **ST11**  | **Backup ring** Standard active backup ring for rod seal type PD. Normally already included in PD-type seal profiles, designed for automatic pressure activation. Split and non split design available. |
| **ST12**  | **Backup ring** Triangular backup ring for rod applications. Fits in special shaped housings. Also used as integrated active backup ring in special high pressure or low friction seal profiles. Split and non split design available. |
| **ST13**  | **Backup ring** Triangular backup ring for piston applications. Fits in special shaped housings. Also used as integrated active backup ring in special high pressure or low friction seal profiles. Split and non split design available. |

*Table 8, Temperature range for backup rings*

| Material | Temperature |
|---|---|
| FL2 | -200 °C ... +260 °C |
| FL3 | -200 °C ... +260 °C |
| FL5 | -200 °C ... +260 °C |
| FL13 | -200 °C ... +260 °C |
| POM1 | -50 °C ... +100 °C |
| PA1 | -40 °C ... +100 °C |
| PEEK1 | -60 ºC … +260 ºC |
| PU | -50 °C ... +110 °C |
| XPU | -20 ºC … +110 ºC |

Several other materials are available. If the listed materials does not suit your application contact Seal Engineering AS.



# Rotary seals

**Rotary seals are used in a variety of applications, mainly for sealing of media against rotating shafts. Rotary seals are used in various applications, and the type of seal used is dependant on many factors such as type of movement (rotating, oscillating, spiral moving), velocity, pressure, temperature, media and direction of pressure(s).**

In addition to seal profile and material, indicated dimensions are required to process an order. Multi-element rotary seals are generally supplied as a complete set, e.g. the O-ring in R09 does not have to be ordered separately.

*Table 9, Order details*

| | |
|---|---|
| ød | inside diameter |
| øD | ouside diameter |
| L | groove length |

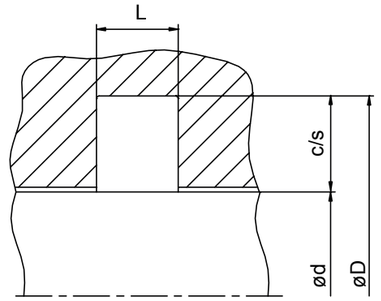
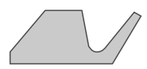
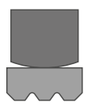
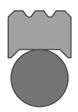


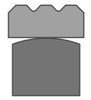
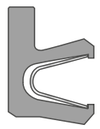
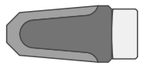

*Fig 6, Housing for rotary seal*

## Profiles overview

| PROFILE | DESCRIPTION | TEMPERATURE | MAX SPEED | MAX. PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **R01-P / R01-R**  | **Single acting rotary shaft seal** Spring-loaded lip seal with retainer ring for press-fit installation into axially open housings. Wide range of applications in every sector of industry, mainly as protecting element for bearings. | -40 °C ... +80 °C<br>-50 °C ... +200 °C | 6 m/s<br>30 m/s | 0.5 bar (7 psi)<br>0.5 bar (7 psi) | PU<br>RU |
| **R01-AF**  | **Single acting rotary shaft seal** Spring- loaded lip seal with solid outer section for axially open housings with clamping plate fixation. Mainly used for rolling mills, large gear mechanisms in heavy duty machinery, for shipbuilding industry and civil engineering. | -40 °C ... +80 °C<br>-50 °C ... +200 °C | 6 m/s<br>30 m/s | 0.5 bar (7 psi)<br>0.5 bar (7 psi) | PU<br>RU |
| **R01-AS**  | **Single acting rotary shaft seal** Split version of a spring-loaded lip seal with solid outer section for axially open housings with clamping plate fixation. Mainly used for repair purpose on rolling mills, large gear mechanisms in heavy duty machinery, for shipbuilding industry and civil engineering. | -40 °C ... +80 °C<br>-50 °C ... +200 °C | 6 m/s<br>30 m/s | 0.5 bar (7 psi)<br>0.5 bar (7 psi) | PU<br>RU |

| PROFILE | DESCRIPTION | TEMPERATURE | MAX SPEED | MAX PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **R01-F**  | **Single acting rotary shaft seal** Spring-loaded lip seal for press fit installation into axially open housing. Integrated O-ring necessary for static sealing in the housing. Excellent chemical and thermal resistance, suitable for high speed/pressure applications. | -100 °C +260 °C | 10 m/s | 15 bar (210 psi) | FL |
| **R02-P / R02-R**  | **Single acting rotary shaft seal** As profile R01-P/R01-R, but with additional dust-lip to avoid ingress of dust and dirt. | -40 °C ... +80 °C<br>-50 °C ... +200 °C | 6 m/s<br>30 m/s | 0.5 bar (7 psi)<br>0.5 bar (7 psi) | PU<br>RU |
| **R03-P / R03-R**  | **Double acting rotary seal** Rotary seal with integrated backup rings for pivoting motion in hydraulic systems. Press fit on outside diameter maintains stable fit in the housing, backup rings permit larger extrusion gap / higher pressure. Mainly used for rotary pivots on excavators, grabs | -40 °C ... +100 °C<br>-30 °C ... +200 °C | 0.3 m/s<br>0.2 m/s | 400 bar (5800 psi)<br>250 bar (3600 psi) | PU<br>RU |
| **R04-A**  | **Double acting rotary seal** Space saving rotary seal for pivoting motion in hydraulic systems. Press fit on outside diameter maintains stable fit in the housing, dynamic sealing lips on inside diameter. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.3 m/s<br>0.2 m/s | 160 bar (2300 psi)<br>100 bar (1450 psi) | PU<br>RU |
| **R05-A**  | **Double acting rotary seal** Space saving rotary seal for pivoting motion in hydraulic systems. Interference fit on inside diameter maintains stable fit in the housing, dynamic sealing lips on outside diameter. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 0.3 m/s<br>0.2 m/s | 160 bar (2300 psi)<br>100 bar (1450 psi) | PU<br>RU |
| **R06-P / R06-R**  | **Axially acting rotary seal** Elastic, excellent wear resistant V-Ring with interference fit on the shaft, rotates with the shaft, sealing axially against shaft collars, thrust blocks or the outer race of roller bearings, protecting the bearing against dust, dirt, oil splash, water splash and similar media. Acting as a seal- and slinger ring. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 25 m/s<br>25 m/s | N/A | PU<br>RU |

| PROFILE | DESCRIPTION | TEMPERATURE | MAX SPEED | MAX PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **R07-P / R07-R**  | **Axially acting rotary seal** Elastic, excellent wear resistant V-Ring with interference fit on the shaft, rotates with the shaft, sealing axially against shaft collars, thrust blocks or the outer race of roller bearings, protecting the bearing against dust, dirt, oil splash, water splash and similar media. Acting as a seal- and slinger ring. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | 25 m/s<br>25 m/s | N/A | PU<br>RU |
| **R08-A**  | **Single acting rotary seal** Spring-less rotary lip seal with arbitrary preload on inside and outside diameter in order to design the seal to different specific needs. | As designed | As designed | As designed | As designed |
| **R09-F**  | **Double acting rotary seal** O-ring activated, low friction rotary seal. Mainly used in applications with alternating pressure from one side of the seal to the other, such as hose reels, swivel joints, rotating track rings and machine tool hydraulics. Good chemical and thermal resistance achievable by selection of suitable O-ring material with PTFE-materials. Improved sealing, longevity and easier installation with XPU. | -50 °C ... +200 °C<br>-20 °C ... +110 °C | 0.4 m/s<br>0,2 m/s | 350 bar (5000 psi)<br>350 bar (5000 psi) | FL<br>XPU |
| **R09-FS**  | **Double acting rotary seal** As profile R09-F, but with a profile ring energizer instead of the O-ring. For heavy duty applications and non standard housings. | -30 °C ... +200 °C<br>-30 °C ... +100 °C | 0.4 m/s<br>0,2 m/s | 350 bar (5000 psi)<br>350 bar (5000 psi) | FL<br>XPU |
| **R10-F**  | **Double acting rotary seal** O-ring activated, low friction, rotary seal. Mainly used in applications with alternating pressure from one side of the seal to the other, such as hose reels, swivel joints, rotating track rings and machine tool hydraulics. Good chemical and thermal resistance achievable by selection of suitable O-ring material with PTFE-materials. Improved sealing, longevity and easier installation with XPU. | -50 °C ... +200 °C<br>-20 °C ... +110 °C | 0.4 m/s<br>0,2 m/s | 350 bar (5000 psi)<br>350 bar (5000 psi) | FL<br>XPU |

| PROFILE | DESCRIPTION | TEMPERATURE | MAX SPEED | MAX PRESSURE | MATERIAL CODE |
|---|---|---|---|---|---|
| **R10-FS**  | **Double acting rotary seal**<br>As profile R10-F, but with a profile ring energizer instead of the O-ring. For heavy duty applications and non standard housings. | -30 °C ... +200 °C<br>-20 °C ... +110 °C | 0.4 m/s<br>0,2 m/s | 350 bar (5000 psi)<br>350 bar (5000 psi) | FL<br>XPU |
| **R11-F**  | **Single acting PTFE rotary seal**<br>Space saving rotary seal, deformed sealing lip acts self adjusting on increasing temperature. For axially open housings with clamping plate fixation, elastic secondary seal or integrated O-ring necessary for static sealing in the housing. Excellent chemical and thermal resistance, suitable for high speed applications. | -200 °C ... +260 °C | 20 m/s | 5 bar (72psi) | FL |
| **R12-F**  | **Single acting PTFE flange seal**<br>Finger-spring activated flange seal, excellent chemical and thermal resistance, mainly used on flanges, fittings or pivoting joints in chemical industry. | -200 °C ... +260 °C | As designed | As designed | * |
| **R19-F**  | **Single acting PTFE rotary seal**<br>Finger-spring activated PTFE seal with integrated clamping flange on the back of seal for clamping fixation, acting as anti-twist device. Excellent chemical and thermal resistance. Suitable for relatively high pressure and high speed. | -200 °C ... +260 °C | As designed | As designed | * |
| **R30-A**  | **Valve-stem seal with PTFE jacket**<br>For low friction. Rubber energizer automatically increases preload as leakage results in swell. Mainly used as valve seal in oil industry/ offshore applications. Rubber energizer and backup ring material to suit application. | -25 °C ... +200 °C | 0.5 m/s | 1000 bar (14500 psi) | FL/RU |



# Static seals

**In addition to the well known O-ring - profile R13 - the following are our standard machined profiles for static sealing. They are widely used in all kinds of applications and can be modified to suit your specific needs. See section "O-ring and O-ring replacements" for more details regarding O-rings and other static sealing solutions.**

| | |
|---|---|
| ød | inside diameter |
| øD | ouside diameter |
| L | groove length |

*Table 10, Order details*
*For seals with circular or square cross sections, inner diameter and cross section are sufficient dimensions for ordering*

## Profiles overview

| PROFILE | DESCRIPTION | TEMPERATURE | MAX PRESSURE | MATERIAL CODE |
|---|---|---|---|---|
| **R13**  | **O-ring**<br>Well known, simple O-ring with proven reliability in multiple applications in every sector of industry. Excellent adaptation possibilities for diverse temperatures and media by selection of suitable seal material. Mainly used as static seal or as preloading element for composite-seals. For dynamic applications we recommend profiles like S20/K20 or S35/K35. | -200 °C... +260 °C | As designed | * |
| **R14**  | **Square ring**<br>Simple square ring, mainly used for static applications or as gaskets. Excellent adaptation possibilities for diverse temperatures and media by selection of suitable seal material. | -200 °C... +260 °C | As designed | * |
| **R15-P**  | **Double seal**<br>Improved sealing compared to O-ring. During assembly no twisting will occur and there is no risk of bad backup ring position. O-ring and backup ring are more sensitive to pressure pulsing resulting in ingress of dirt in between the sealing elements. High resistance to extrusion by material choice. | -50 °C... +110 °C<br>-50 °C... +200 °C | As designed<br>As designed | PU<br>RU |

| PROFILE | DESCRIPTION | TEMPERATURE | MAX PRESSURE | MATERIAL CODE |
|---|---|---|---|---|
| **R16-R**  | **X-ring**<br>Permits larger tolerances both radial and axial. Avoid twist during assembly and under linear movement. Lower contact pressure and reservoir for lubrication result in lower friction. | 50 °C... +110 °C<br>-50 °C... +200 °C | As designed<br>As designed | PU<br>RU |
| **R20-P**  | **Single acting flange seal**<br>Flange seal for static applications, suitable for high pressure range. Direction of pressurization (from inside or outside) must be indicated when ordering the seal. | -50 °C ... +110 °C | As designed<br>As designed | PU<br>RU |
| **R35-A**  | **Single acting flange seal**<br>Flange seal for static applications, suitable for high pressure range. Direction of pressurization (from inside or outside) must be indicated when ordering the seal. | -50 °C ... +110 °C<br>-50 °C ... +200 °C | As designed<br>As designed | PU<br>RU |



# Seal and housing recommendations

Seal Engineering AS innovative and modern production technology together with our unique experience enables us to produce seals to fit almost every housing and application. However, for new designs we recommend that certain guidelines regarding the housing dimensions are followed. These guidelines are presented in this chapter for the most common and suitable seal profiles.

In addition to the housing recommendations profiles S01-P, S09-E, K01-P/PE and K08-D are described in more detail. Given the correct material choices these profiles will meet the demands for most applications for rod and piston-sealing

## Wipers – housing recommendations

### A01-A

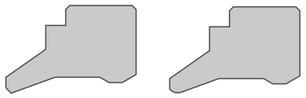
**A01-A is a recommended wiper with press fit on outside diameter, providing technically accurate closure at the cylinder.**

- Wiping edge assures a reliable protection against penetration of dust and dirt
- Backflow of residual lubrication film
- Back support area prevents tilting of wiper
- For housings according to ISO 6195-TypeA

### A27-F

**A27-F is a recommended wiper with O-ring as preloading element.**

- Wiping edge assures a reliable protection against penetration of dust and dirt
- Excellent chemical and thermal resistance (depends on O-ring) with PTFE-material
- Improved wiping, longevity and easier installation with XPU

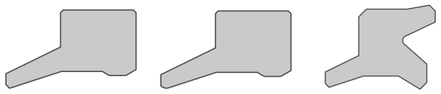


*A01-A* *A04-A*

*Table 1, Wipers A01 and A04. Dimensions recommended for standard housing.*

| ød | øD | øD$_1$ | L | L$_1$ | H* | R$_1$ (max) | R$_2$ (max) |
|---|---|---|---|---|---|---|---|
| 6 – 100 | ød+8 | ød+6 | 4 | 1 | 7 | 0.4 | 0.3 |
| 100 – 150 | ød+12 | ød+9 | 5.5 | 1.5 | 10 | 0.4 | 0.4 |
| > 150 | ød+15 | ød+11 | 6.5 | 2 | 13 | 0.4 | 0.6 |

** H=Total wiper height*

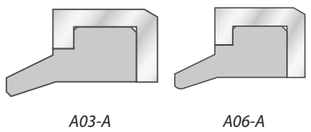


*A02-A* *A05-A* *A11-A*

*Table 2, Wipers A02, A05 and A11. Dimensions recommended for standard housing.*

| ød | øD | øD$_1$ | L | L$_1$ | H* | R$_1$ (max) | R$_2$ (max) |
|---|---|---|---|---|---|---|---|
| 6 – 50 | ød+8 | ød+4 | 5 | min. 2 | 8 | 0.4 | 0.3 |
| 50 – 100 | ød+10 | ød+5 | 6 | min. 2 | 9.7 | 0.4 | 0.4 |
| > 100 | ød+15 | ød+7.5 | 8.5 | min. 2 | 13 | 0.4 | 0.6 |

** H=Total wiper height*



*A03-A* *A06-A*

*Table 3, Wipers A03 and A06.*
*Dimensions recommended for standard housing.*

| ød | øD | L | H* | C | R$_1$ (max) |
|---|---|---|---|---|---|
| 6 – 10 | ød+8 | 5 | 8 | 0.8 | 0.4 |
| 10 – 100 | ød+10 | 7 | 10 | 1.0 | 0.4 |
| 100 – 200 | ød+15 | 9 | 12 | 1.2 | 0.4 |
| > 200 | ød+20 | 12 | 16 | 1.5 | 0.4 |

** H=Total wiper height*

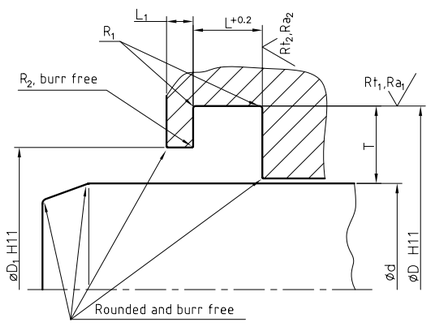



*Fig. 1, Housing for wiper A01, A02, A04, A05, A11.*

*Lead-in chamfer on the rod is designed to suit the rod seal used. For surface finish see end of section.*

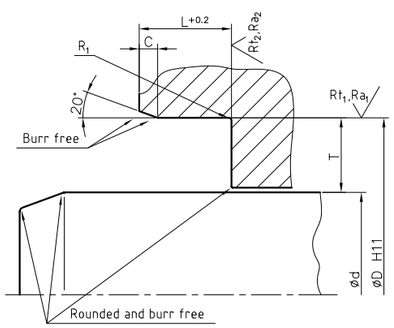



*Fig. 2, Housing for wiper A03, A06.*

*Lead-in chamfer on the rod is designed to suit the rod seal used. For surface finish see end of section.*



*A12-A*

*Table 4, Wiper A12-A. Dimensions recommended for standard housing.*

| ød | øD | øD$_1$ | L | L$_1$ | H* | R$_1$ (max) | R$_2$ (max) |
|---|---|---|---|---|---|---|---|
| 11 – 100 | ød+8 | ød+4 | 3.1 | 1.5 | 10.5 | 0.4 | 0.3 |
| 100 – 150 | ød+10 | ød+5 | 6.0 | 2.0 | 13.0 | 0.4 | 0.4 |
| 150 – 600 | ød+15 | ød+7.5 | 8.5 | 3.0 | 19.0 | 0.4 | 0.4 |

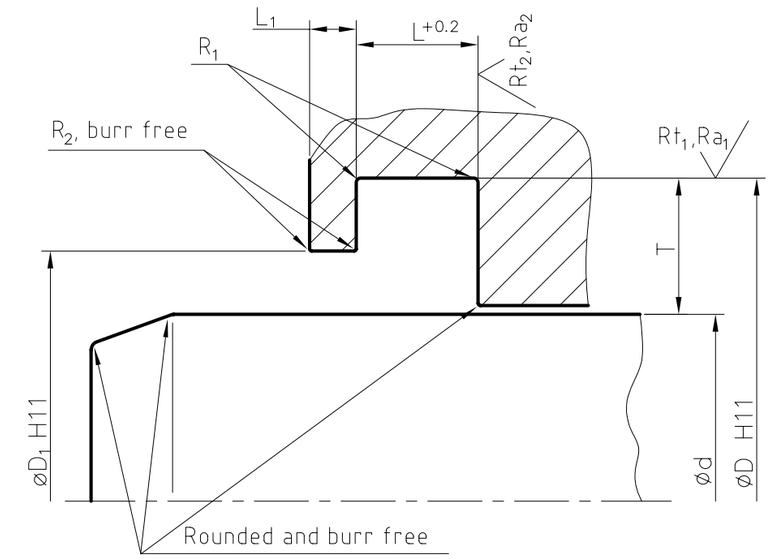
***Total height**

*A12-B*

*Table 5, Wiper A12-B. Dimensions recommended for standard housing.*

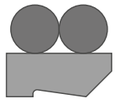
| ød | øD | øD$_1$ | L | L$_1$ | H* | R$_1$ (max) | R$_2$ (max) |
|---|---|---|---|---|---|---|---|
| 5 – 50 | ød+8 | ød+4 | 5 | 1.5 | 10.1 | 0.4 | 0.3 |
| 50 –100 | ød+10 | ød+5 | 6.0 | 2.0 | 12.6 | 0.4 | 0.4 |
| 100 – 600 | ød+15 | ød+7.5 | 8.6 | 3.0 | 18.4 | 0.4 | 0.4 |

***Total height**




*Lead-in chamfer on the rod is designed to suit the rod seal used. For surface finish see end of section.*

*Fig. 3, Housing for wiper A12.*



*A26-F*

*Table 6, Wiper A26-F. Dimensions recommended for standard housing.*

| ød | øD | øD$_1$ | L | R$_1$ (max) | R$_2$ (max) | O-ring (2x) |
|---|---|---|---|---|---|---|
| 20 – 50 | ød+7.6 | ød+1.0 | 4.2 | 0.4 | 0.2 | BS 0xx/1.78 |
| 40 – 80 | ød+8.8 | ød+1.5 | 6.3 | 1.2 | 0.2 | BS 1xx/2.62 |
| 70 – 165 | ød+12.2 | ød+2.0 | 8.1 | 2.0 | 0.2 | BS 2xx/3.53 |
| 140 – 525 | ød+16.5 | ød+2.0 | 11.5 | 2.0 | 0.2 | BS 3xx/5.33 |
| 400 – 650 | ød+24.0 | ød+2.5 | 15.5 | 2.0 | 0.2 | BS 4xx/6.99 |
| > 650 | ød+27.3 | ød+2.5 | 18.0 | 2.0 | 0.2 | 8.4 |

*A27-F*

*Table 7, Wiper A27-F. Dimensions recommended for standard housing.*

| ød | øD | øD$_1$ | L | R$_1$ (max) | R$_2$ (max) | O-ring |
|---|---|---|---|---|---|---|
| 6 – 70 | ød+4.8 | ød+1.5 | 3.7 | 0.4 | 0.2 | BS 0xx/1.78 |
| 12 – 155 | ød+6.8 | ød+1.5 | 5.0 | 0.7 | 0.2 | BS 1xx/2.62 |
| 45 – 325 | ød+8.8 | ød+1.5 | 6.0 | 1.0 | 0.2 | BS 2xx/3.53 |
| 145 – 540 | ød+12.2 | ød+2.0 | 8.4 | 1.5 | 0.2 | BS 3xx/5.33 |
| 265 – 650 | ød+16.0 | ød+2.0 | 11.0 | 1.5 | 0.2 | BS 4xx/6.99 |
| > 400 | ød+20.0 | ød+2.5 | 14.0 | 2.0 | 0.2 | 8.4 |

*Lead-in chamfer on the rod is designed to suit the rod seal used. For surface finish see end of section.*

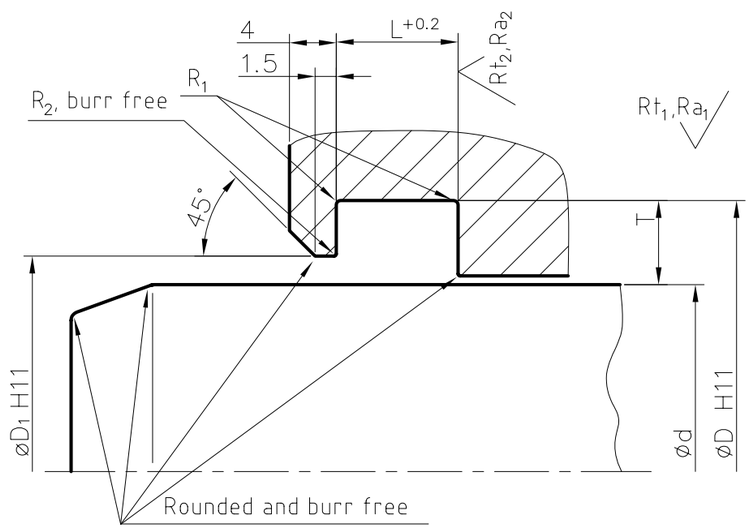



*Fig. 4 , Housing for wiper A26, A27.*



# Rod seals – housing recommendations

S01-P is our standard u-cup rod seal. This profile can be produced in different polyurethanes, with HPU being the most versatile and widely used.

*S01-P profile*

## S01-P

**S01-P has the following advantages:**

- Excellent static and dynamic sealing
- Good back-pumping ability
- High wear resistance/operational reliability
- Good chemical resistance
- Can be used as an individual seal or as secondary seal within sealing systems
- Small cross sections possible

**Technical data:**

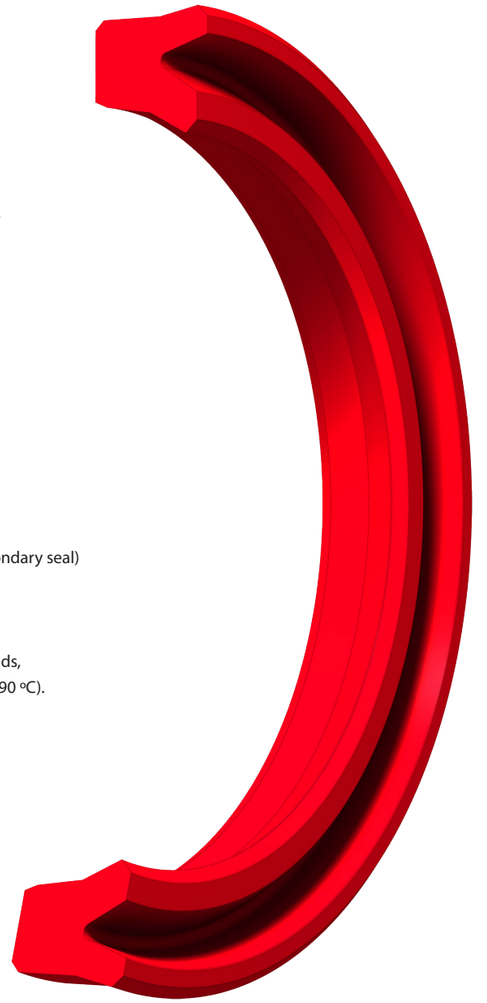
**Material:**
HPU

**Pressure:**
Up to 400 bar

**Speed:**
Up to 0.5 m/s (1.5 m/s possible if used as secondary seal)

**Temperature:**
- 20 °C to 110 °C

**Media:**
Mineral based hydraulic oils, HFA and HFB fluids, biologically degradable oils and water (up to 90 °C).



*S01-P in HPU*

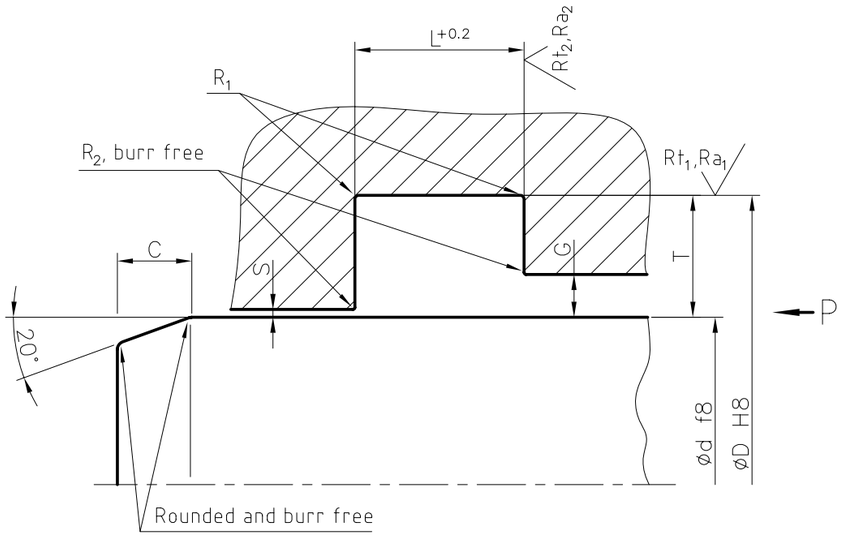



*Fig. 5, Housing for rod seal S01*

*Lead-in chamfer, C, avoids damage to seal during installation. Surface roughness Rt < 4 µm. For surface finish see end of section.*

*Table 8, Dimensions recommended for standard housings for S01-P.*
*G: governed by design of guide ring groove or depending on the application*

| Rod ød | øD | L | $R_1$ (max) | $R_2$ (max) | C | Max radial extrusion gap "S"* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 100 bar | 200 bar | 300 bar | 400 bar |
| 5 – 45 | ød + 8 | 6.3 | 0.4 | 0.2 | 2.0 | 0.20 | 0.15 | 0.13 | 0.10 |
| 20 – 50 | ød + 10 | 7.5 | 0.4 | 0.2 | 2.5 | 0.25 | 0.20 | 0.18 | 0.15 |
| 30 – 90 | ød + 13 | 9.5 | 0.4 | 0.2 | 3.3 | 0.35 | 0.30 | 0.25 | 0.20 |
| 40 – 200 | ød + 15 | 11 | 0.8 | 0.2 | 3.8 | 0.40 | 0.35 | 0.30 | 0.25 |
| 120 – 300 | ød + 20 | 14.5 | 0.8 | 0.2 | 5.0 | 0.50 | 0.45 | 0.40 | 0.35 |
| 180 – 500 | ød + 25 | 18 | 0.8 | 0.2 | 6.3 | 0.60 | 0.55 | 0.50 | 0.45 |
| 400 – 700 | ød + 30 | 24 | 0.8 | 0.2 | 7.5 | 0.65 | 0.60 | 0.55 | 0.50 |
| > 700 | ød + 40 | 32 | 0.8 | 0.2 | 10.0 | 0.80 | 0.70 | 0.65 | 0.60 |

**specified extrusion gap is valid for a temperature of 50 °C. Increased temperature will reduce permissible gap.*

S01-P can also be produced to fit almost any non standard housing.

For applications demanding higher pressure or larger gaps, S02-P (with active backup ring) is preferred. For demands regarding higher temperatures or increased chemical resistance profiles S01 and S02 may also be produced in different kinds of rubbers, called S01-R and S02-R.

Contact Seal Engineering AS for technical advice.



## S09-E in XHPU

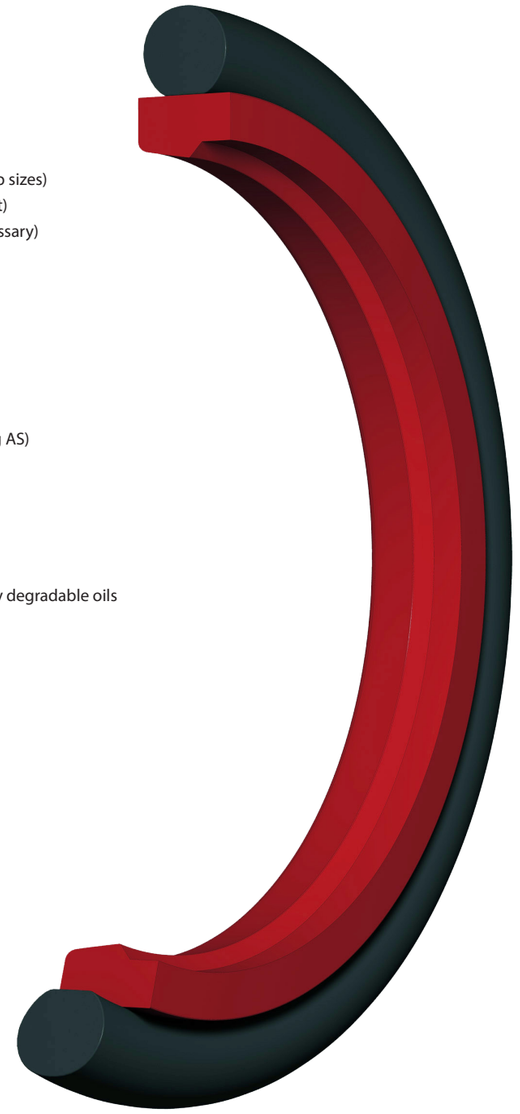
Profile S09-E is a single acting rod seal, consisting of a sealing element and an elastomeric O-ring energizer. We supply profile S09-E in XHPU/XSPU (hard grade polyurethanes) and PTFE-based materials. S09-E in XHPU should be the preferred choice for standard hydraulic; up to 110 °C, whereas PTFE-based materials are the right choice for elevated temperatures, excellent chemical resistance or very low friction. Together these materials are able to meet the demands of almost any application.

*S09-E profile*

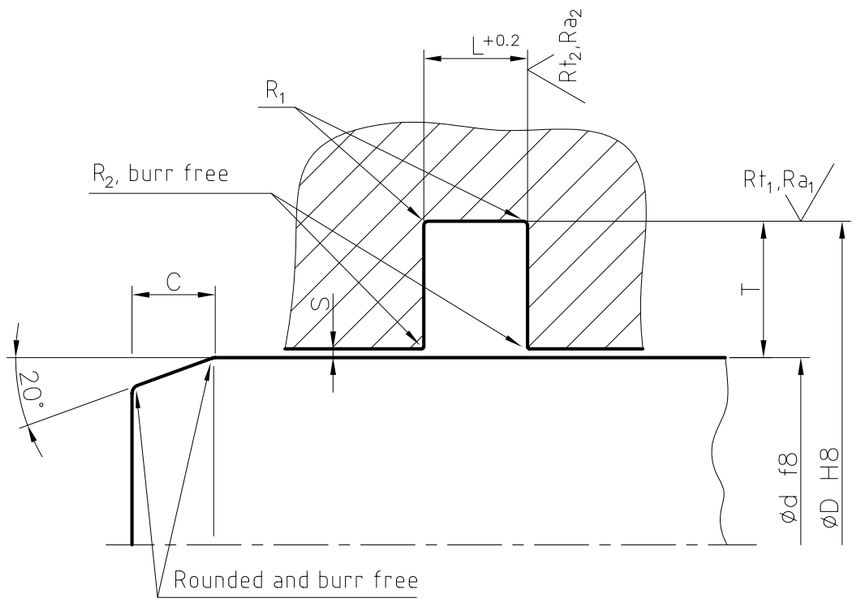
**S09-E in XHPU has the following advantages:**

- Excellent static and dynamic sealing effect
- High wear resistance/operational reliability
- Excellent extrusion resistance (for high pressure/large gap sizes)
- Very good back-pumping ability (optimized sealing effect)
- Easy installation (no mounting and calibration tools necessary)
- Compact design
- Low friction, good stick-slip properties

**Technical data:**
**Material:**
XHPU
**Pressure:**
Up to 600 bar (for higher pressures contact Seal Engineering AS)
**Speed:**
Up to 5 m/s
**Temperature:**
- 20 °C to 110 °C
**Media:**
Mineral based hydraulic oils, HFA and HFB fluids, biologically degradable oils and water (up to 90 °C).



*S09-E in XHPU/NBR*




*Lead-in chamfer, C, avoids damage to seal during installation. Surface roughness Rt < 4 µm. For surface finish see end of section.*

*Fig. 6, Housing for rod seal S09.*

*Table 9, Dimensions recommended for standard housing for S09-E.*

| Rod ød | øD | L | $R_1$ (max) | $R_2$ (max) | C | O-ring | Max radial extrusion gap "S"* | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 100 bar | 200 bar | 400 bar | 600 bar |
| 5 – 7.9 | ød + 4.9 | 2.2 | 0.4 | 0.2 | 2.5 | BS 0xx/1.78 | 0.3 | 0.3 | 0.2 | 0.1 |
| 8 – 18.9 | ød + 7.3 | 3.2 | 0.6 | 0.2 | 3.5 | BS 1xx/2.62 | 0.4 | 0.3 | 0.2 | 0.1 |
| 19 – 37.9 | ød + 10.7 | 4.2 | 1.0 | 0.2 | 4.5 | BS 2xx/3.53 | 0.5 | 0.4 | 0.3 | 0.2 |
| 38 – 199.9 | ød + 15.1 | 6.3 | 1.3 | 0.2 | 5.0 | BS 3xx/5.33 | 0.5 | 0.4 | 0.3 | 0.2 |
| 200 – 255.9 | ød + 20.5 | 8.1 | 1.8 | 0.2 | 6.0 | BS 4xx/6.99 | 0.7 | 0.5 | 0.4 | 0.2 |
| 256 – 649.9 | ød + 24 | 8.1 | 1.8 | 0.2 | 8.0 | BS 4xx/6.99 | 0.7 | 0.5 | 0.4 | 0.2 |
| 650 – 999.9 | ød + 27.3 | 9.5 | 2.5 | 0.2 | 10.0 | 8.40 | 0.8 | 0.7 | 0.5 | 0.3 |
| > 1000 | ød + 38 | 13.8 | 3.0 | 0.2 | 12.0 | 12.0 | 1.1 | 0.8 | 0.7 | 0.4 |

**specified extrusion gap valid up to 80 ºC, between 80 ºC and 100 ºC the gap size must be reduced by 25%.*

We can also supply S09-E or S09-ES to suit almost any non-standard housing.
Contact Seal Engineering AS for technical advice.

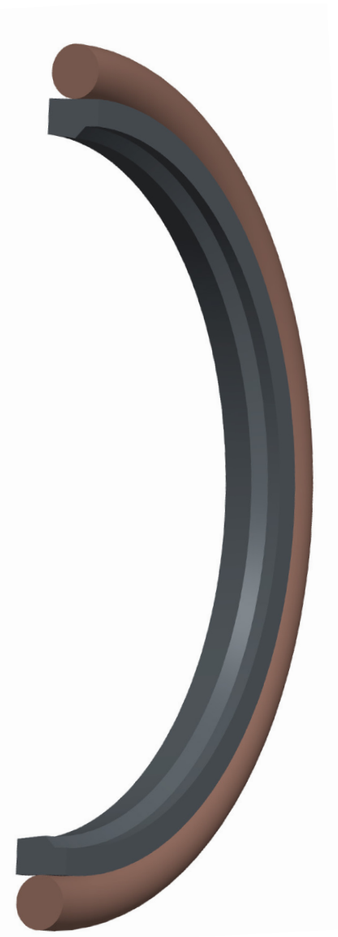


## S09-E in PTFE-based materials

**S09-E in PTFE-based materials has the following advantages:**

- Excellent chemical resistance (depending on O-ring material)
- Excellent temperature resistance (depending on O-ring material)
- Very low friction, excellent stick-slip behaviour
- Suitable for high speed applications
- Excellent extrusion resistance (given suitable filler)
- Compact design

**Technical data:**
**Material:**
PTFE-based
**Pressure:**
Up to 600 bar (for higher pressures contact Seal Engineering AS)
**Speed:**
Up to 10 m/s
**Temperature:**
- 50 ºC to 200 ºC (for higher temperatures contact Seal Engineering AS)
**Media:**
Resistant to all chemicals except elementary fluorine and molten alkali metals



*S09-E in FL2/RU2*

*Table 10, Dimensions recommended for standard housing for S09-E.*

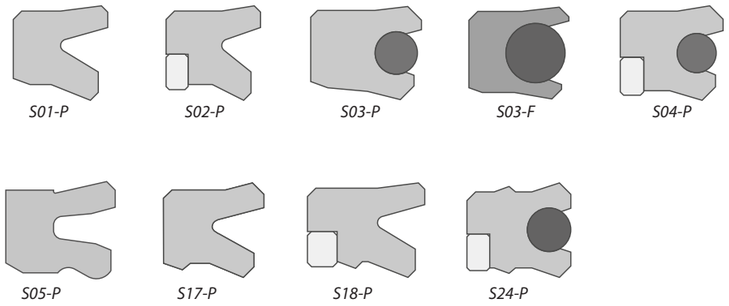
| Rod ød | øD | L | $R_1$ (max) | $R_2$ (max) | C | O-ring | Max radial extrusion gap "S"* | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 100 bar | 200 bar | 400 bar | 600 bar |
| 5 – 7.9 | ød + 4.9 | 2.2 | 0.4 | 0.2 | 2.5 | BS 0xx/1.78 | 0.3 | 0.3 | 0.2 | 0.1 |
| 8 – 18.9 | ød + 7.3 | 3.2 | 0.6 | 0.2 | 3.5 | BS 1xx/2.62 | 0.4 | 0.3 | 0.2 | 0.1 |
| 19 – 37.9 | ød + 10.7 | 4.2 | 1.0 | 0.2 | 4.5 | BS 2xx/3.53 | 0.5 | 0.4 | 0.3 | 0.2 |
| 38 – 199.9 | ød + 15.1 | 6.3 | 1.3 | 0.2 | 5.0 | BS 3xx/5.33 | 0.5 | 0.4 | 0.3 | 0.2 |
| 200 – 255.9 | ød + 20.5 | 8.1 | 1.8 | 0.2 | 6.0 | BS 4xx/6.99 | 0.7 | 0.5 | 0.4 | 0.2 |
| 256 – 649.9 | ød + 24 | 8.1 | 1.8 | 0.2 | 8.0 | BS 4xx/6.99 | 0.7 | 0.5 | 0.4 | 0.2 |
| 650 – 999.9 | ød + 27.2 | 9.5 | 2.5 | 0.2 | 10.0 | 8.40 | 0.8 | 0.7 | 0.5 | 0.3 |
| > 1000 | ød + 38 | 13.8 | 3.0 | 0.2 | 12.0 | 12.0 | 1.1 | 0.8 | 0.7 | 0.4 |

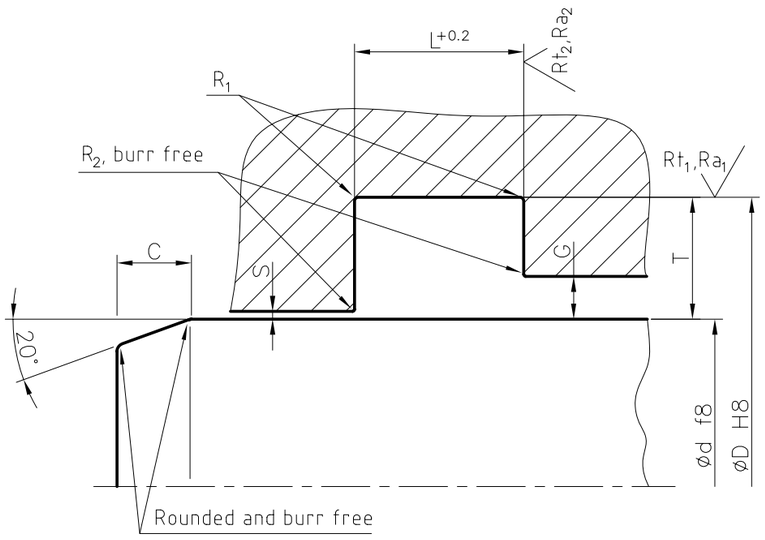
** specified extrusion gap is only valid for certain types of fillers and temperature.*

We can also supply S09-E or S09-ES to suit almost any non-standard housing.
Contact Seal Engineering AS for technical advice.

# Other profiles

U-cup rod seals S01, S02, S03, S04, S05, S17, S18 and S24. Dimensions recommended for standard housing, partly based on ISO 5597.




*Lead-in chamfer, C, avoids damage to seal during installation. Surface roughness Rt < 4 µm.*
*For surface finish see end of section.*

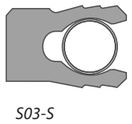
*Fig. 7, Housing for rod seals S01, S02, S03, S04, S05, S17, S18, S24*

*Table 11, Dimensions recommended for standard housings for U-cup rod seals.*
*G: governed by design of guide ring groove or depending on the application*

| Rod ød | øD | L | $R_1$ (max) | $R_2$ (max) | C |
|---|---|---|---|---|---|
| 5 – 45 | ød + 8 | 6.3 | 0.4 | 0.2 | 2.0 |
| 20 – 50 | ød + 10 | 7.5 | 0.4 | 0.2 | 2.5 |
| 30 – 90 | ød + 13 | 9.5 | 0.4 | 0.2 | 3.3 |
| 40 – 200 | ød + 15 | 11 | 0.8 | 0.2 | 3.8 |
| 120 – 300 | ød + 20 | 14.5 | 0.8 | 0.2 | 5.0 |
| 180 – 500 | ød + 25 | 18 | 0.8 | 0.2 | 6.3 |
| 400 – 700 | ød + 30 | 24 | 0.8 | 0.2 | 7.5 |
| > 700 | ød + 40 | 32 | 0.8 | 0.2 | 10.0 |

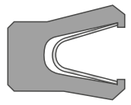


*Table 12, Spring-energized rod seal S03-S. Dimensions recommended for standard housing. Use of split groove is recommended, for closed or semi-closed groove please contact Seal Engineering AS.*




| Rod ød | øD | L | $R_1$ (max) | $R_2$ (max) | C |
|---|---|---|---|---|---|
| 10 – 70 | ød + 6 | 4.7 | 0.4 | 0.2 | 5.0 |
| 15 – 100 | ød + 8 | 5.5 | 0.4 | 0.2 | 5.0 |
| 20 – 200 | ød + 10 | 8.0 | 0.4 | 0.2 | 5.0 |
| 30 – 300 | ød + 12 | 8.5 | 0.4 | 0.2 | 7.5 |
| 40 – 500 | ød + 15 | 11.5 | 0.8 | 0.2 | 7.5 |
| 50 – 1000 | ød + 20 | 15.5 | 0.8 | 0.2 | 10.0 |
| 70 – 1400 | ød + 25 | 18.5 | 0.8 | 0.2 | 10.0 |
| 100 – 1400 | ød + 30 | 23.0 | 0.8 | 0.2 | 12.0 |
| 100 – 2000 | ød + 40 | 30.5 | 0.8 | | 12.0 |

*Table 13, Spring-energized rod seal S19-F. Dimensions recommended for standard housing. Use of split groove is recommended, for closed or semi-closed groove please contact Seal Engineering AS.*




| Rod ød | øD | L | $R_1$ (max) | $R_2$ (max) | C | (O-ring equivalent) |
|---|---|---|---|---|---|---|
| 10 – 110 | ød + 4.5 | 3.6 | 0.4 | 0.2 | 5.0 | BS 1xx/2.62 |
| 20 – 220 | ød + 6.2 | 4.8 | 0.4 | 0.2 | 5.0 | BS 2xx/3.53 |
| 40 – 410 | ød + 9.4 | 7.1 | 0.4 | 0.2 | 7.5 | BS 3xx/5.33 |
| 120 – 1115 | ød + 12.2 | 9.5 | 0.4 | 0.2 | 12.0 | BS 4xx/6.99 |
| > 1000 | ød + 19 | 15 | 0.8 | 0.2 | 12.0 | |

*Lead-in chamfer, C, avoids damage to seal during installation. Surface roughness Rt < 4 µm.*
*For surface finish see end of section.*

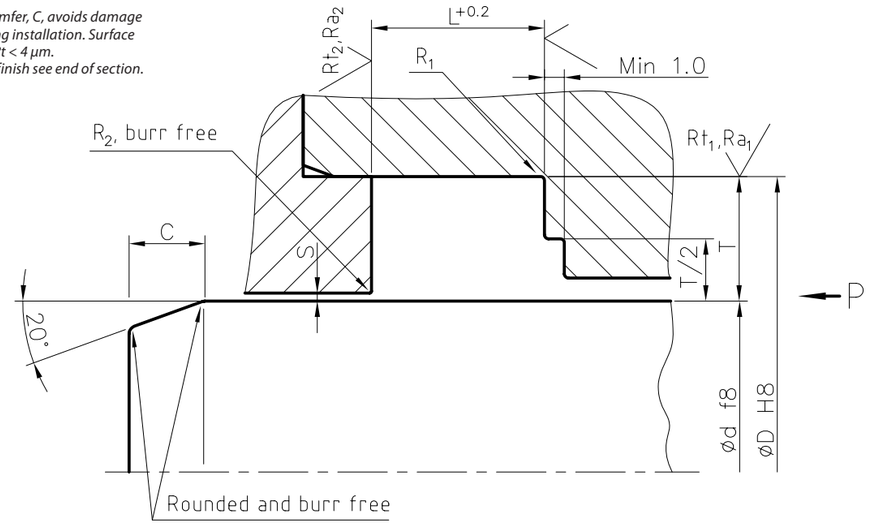
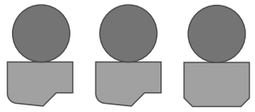


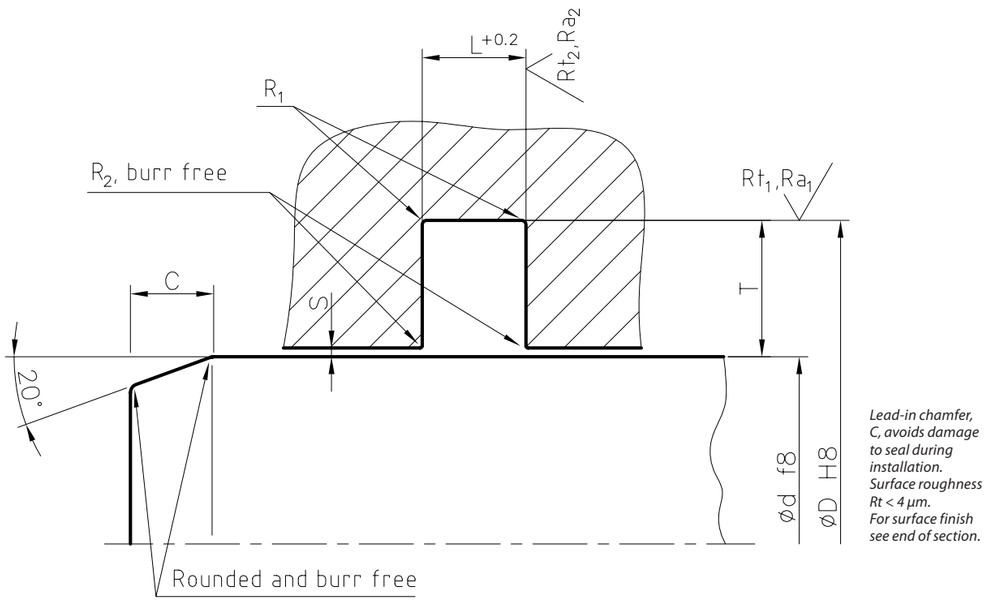

*Fig. 8, Housing for rod seals S03-S, S19-S*

*Table 14, Dimensions recommended for standard housing for rod seals S09-E, S09-P, S09-D.*

| Rod ød | øD | L | $R_1$ (max) | $R_2$ (max) | C | O-ring |
|---|---|---|---|---|---|---|
| 5 – 7.9 | ød + 4.9 | 2.2 | 0.4 | 0.2 | 2.5 | BS 0xx/1.78 |
| 8 – 18.9 | ød + 7.3 | 3.2 | 0.6 | 0.2 | 3.5 | BS 1xx/2.62 |
| 19 – 37.9 | ød + 10.7 | 4.2 | 1.0 | 0.2 | 4.5 | BS 2xx/3.53 |
| 38 – 199.9 | ød + 15.1 | 6.3 | 1.3 | 0.2 | 5.0 | BS 3xx/5.33 |
| 200 – 255.9 | ød + 20.5 | 8.1 | 1.8 | 0.2 | 6.0 | BS 4xx/6.99 |
| 256 – 649.9 | ød + 24 | 8.1 | 1.8 | 0.2 | 8.0 | BS 4xx/6.99 |
| 650 – 999.9 | ød + 27.3 | 9.5 | 2.5 | 0.2 | 10.0 | 8.40 |
| > 1000 | ød + 38 | 13.8 | 3.0 | 0.2 | 12.0 | 12.0 |



*S09-E* *S09-P* *S09-D*




*Lead-in chamfer, C, avoids damage to seal during installation. Surface roughness Rt < 4 µm. For surface finish see end of section.*

*Fig. 9, Housing for rod seals S09*

## Rod seal housing details

*Table 15*

| Surface roughness* | $R_t$ (µm) | $R_a$ (µm) |
|---|---|---|
| Sliding surface for PU/RUBBER seals<br>Sliding surface for PTFE seals | ≤ 2.5<br>≤ 2.0 | ≤ 0.1 - 0.5<br>≤ 0.05 - 0.3 |
| Bottom of groove ($Rt_1$/$Ra_1$)<br>Groove face ($Rt_2$/$Ra_2$) | ≤ 6.3<br>≤ 15 | ≤ 0.8<br>≤ 3.2 |
| Bearing area, $R_{mr}$ | 50% – 95% (cutting depth 0.5 $R_z$, based on $c_{ref}$ = 0%) | |

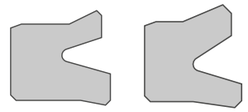
**Surface roughness recommendations are typical values only. Contact Seal Engineering AS for application specific recommendations.*



# Piston seals – housing recommendations

## K01-P and K01-PE

K01 is our standard single acting u-cup seal piston seal. For single acting cylinders K01-PE is the preferred profile, whereas K01-P is preferred in back-to-back arrangements. These profiles can be produced in different polyurethanes, with HPU being the most versatile and widely used.



*K01-P* *K01-PE*

**K01 has the following advantages:**

- Excellent static and dynamic sealing
- Excellent holding/positioning capability for single acting cylinders (K01-PE)
- Back-to-back arrangements for double acting cylinders or for separation of fluids (K01-P)
- High wear resistance/operational reliability
- Good chemical resistance
- Small cross sections possible

**Technical data:**

**Material:**
HPU

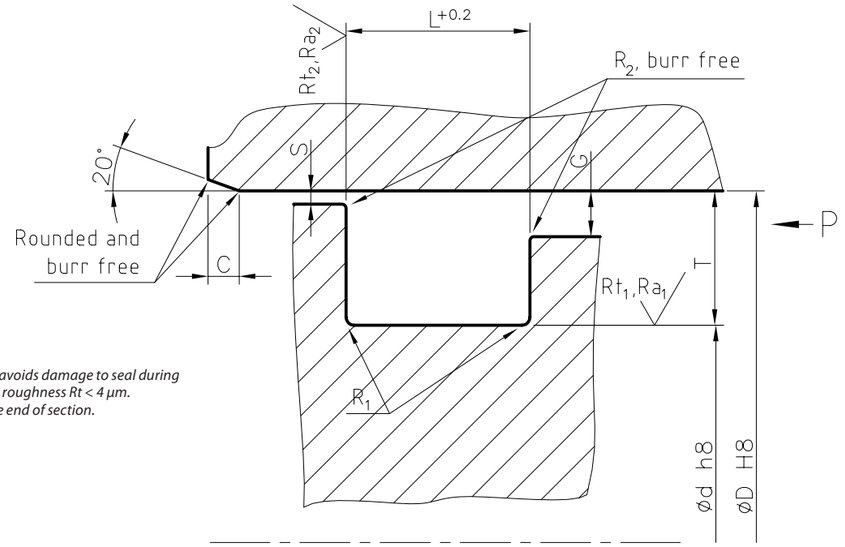
**Pressure:**
Up to 400 bar

**Speed:**
Up to 0.5 m/s

**Temperature:**
- 20 °C to 110 °C

**Media:**
Mineral based hydraulic oils, HFA and HFB fluids, biologically degradable oils and water (up to 90 °C).

*K01-P in HPU*




*Lead-in chamfer, C, avoids damage to seal during installation. Surface roughness Rt < 4 µm. For surface finish see end of section.*

*Fig. 10, Housing for piston seals K01*

*Table 16, Dimensions recommended for standard housings for K01-P.*
*G: governed by design of guide ring groove or depending on the application*

| Bore øD | ød | L | $R_1$ (max) | $R_2$ (max) | C | Max radial extrusion gap "S"* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 100 bar | 200 bar | 300 bar | 400 bar |
| 12 – 40 | øD - 8 | 6 | 0.4 | 0.2 | 2.0 | 0.20 | 0.15 | 0.13 | 0.10 |
| 25 – 60 | øD - 10 | 7 | 0.4 | 0.2 | 2.5 | 0.25 | 0.20 | 0.18 | 0.15 |
| 50 – 140 | øD – 15 | 9.5 | 0.8 | 0.2 | 3.8 | 0.40 | 0.35 | 0.30 | 0.25 |
| 100 – 300 | øD - 20 | 12.5 | 0.8 | 0.2 | 5.0 | 0.50 | 0.45 | 0.40 | 0.30 |
| 125 – 500 | øD – 25 | 16 | 0.8 | 0.2 | 6.3 | 0.55 | 0.50 | 0.45 | 0.40 |
| 500 – 750 | øD - 30 | 20 | 0.8 | 0.2 | 7.5 | 0.60 | 0.55 | 0.50 | 0.45 |
| > 750 | øD - 40 | 26 | 0.8 | 0.2 | 10.0 | 0.70 | 0.60 | 0.55 | 0.50 |

**specified extrusion gap is valid for a temperature of 50 °C. Increased temperature will reduce permissible gap.*

K01 can also be produced to fit almost any non standard housing.

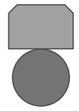
For applications demanding higher pressure or larger gaps, K02-P (with active backup ring) is preferred. For demands regarding higher temperatures or increased chemical resistance profiles K01 and K02 may also be produced in different kinds of rubbers, called K01-R and K02-R.

Contact Seal Engineering AS for technical advice.



## K08-D

Profile K08-D is a double acting piston seal, consisting of a sealing element and elastomeric O-ring energizer. We supply profile K08-D in XHPU/XSPU (hard grade polyurethanes) and PTFE-based materials. K08-D in XHPU should be the preferred choice for standard hydraulic; up to 110 °C, whereas PTFE-based materials are the right choice for elevated temperatures, excellent chemical resistance or very low friction. Together these materials are able to meet the demands of almost any application.

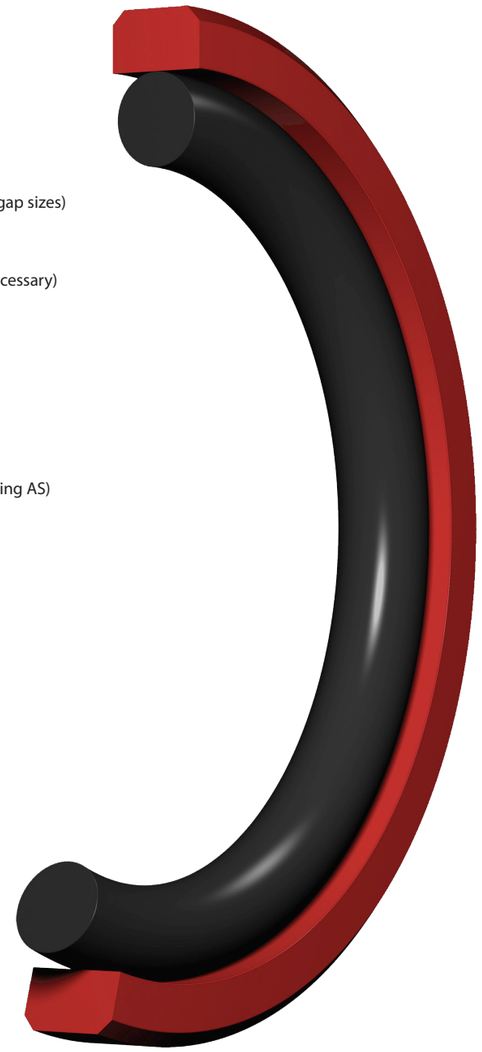


*K08-D*

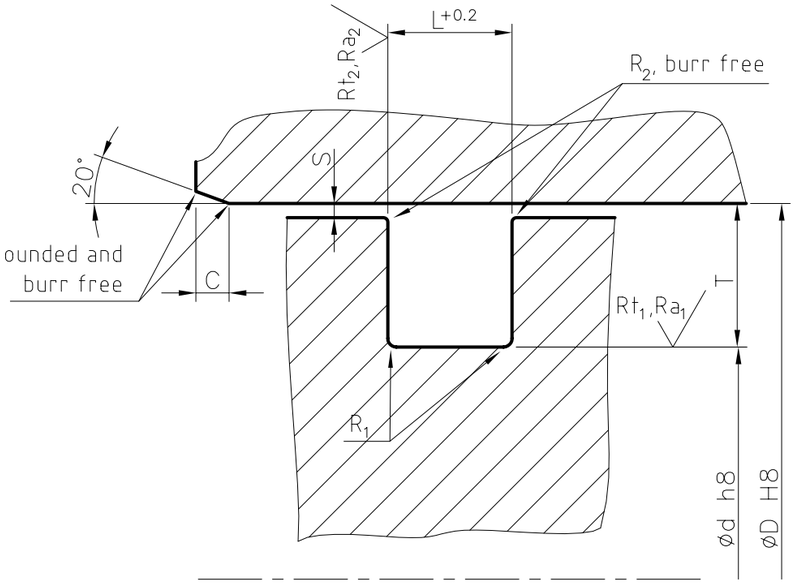
**K08-D in XHPU has the following advantages:**

- Good static and dynamic sealing effect
- High wear resistance/operational reliability
- Excellent extrusion resistance (for high pressure/large gap sizes)
- Fast pressurisation/no "blow-by" effect
- Low friction, good stick-slip properties
- Easy installation (no mounting and calibration tools necessary)
- Compact design

**Technical data:**
**Material:**
XHPU
**Pressure:**
Up to 600 bar (for higher pressures contact Seal Engineering AS)
**Speed:**
Up to 5 m/s
**Temperature:**
- 30 °C to 110 °C
**Media:**
Mineral based hydraulic oils, HFA and HFB fluids, biologically degradable oils and water (up to 90 °C).



*K08-D in XHPU/RU1*




*Lead-in chamfer, C, avoids damage to seal during installation. Surface roughness Rt < 4 µm. For surface finish see end of section.*

*Fig. 11, Housing for piston seals K08.*

*Table 17, Dimensions recommended for standard housing for K08-D.*

| Standard bore øD | Extended bore øD | ød | L | $R_1$ (max) | $R_2$ (max) | C | O-ring | Max radial extrusion gap "S"* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 100 bar | 200 bar | 400 bar | 600 bar |
| 8 – 14.9 | 8 – 40 | øD - 4.9 | 2.2 | 0.4 | 0.2 | 2.5 | BS 0xx/1.78 | 0.3 | 0.3 | 0.2 | 0.1 |
| 15 – 39.9 | 15 – 80 | øD - 7.5 | 3.2 | 0.6 | 0.2 | 3.5 | BS 1xx/2.62 | 0.4 | 0.3 | 0.2 | 0.1 |
| 40 – 79.9 | 15 – 133 | øD - 11 | 4.2 | 1.0 | 0.2 | 4.5 | BS 2xx/3.53 | 0.5 | 0.4 | 0.3 | 0.2 |
| 80 – 132.9 | 40 – 330 | øD - 15.5 | 6.3 | 1.3 | 0.2 | 5.0 | BS 3xx/5.33 | 0.5 | 0.4 | 0.3 | 0.2 |
| 133 – 329.9 | 80 – 670 | øD - 21 | 8.1 | 1.8 | 0.2 | 6.0 | BS 4xx/6.99 | 0.7 | 0.5 | 0.4 | 0.2 |
| 330 – 669.9 | 133 – 1000 | øD - 24.5 | 8.1 | 1.8 | 0.2 | 8.0 | BS 4xx/6.99 | 0.7 | 0.5 | 0.4 | 0.2 |
| 670 – 999.9 | 330 – 1000 | øD - 28 | 9.5 | 2.5 | 0.2 | 10.0 | 8.4 | 0.8 | 0.7 | 0.5 | 0.3 |
| > 1000 | | øD - 38 | 13.8 | 3.0 | 0.2 | 12.0 | 12.0 | 1.1 | 0.8 | 0.7 | 0.4 |

**specified extrusion gap valid up to 80 ºC, between 80 ºC and 100 ºC the gap size must be reduced by 25%*

We can also supply K08D or K08-DS to suit almost any non-standard housing. Contact Seal Engineering AS for technical advice.



**K08-D in PTFE-based materials has the following advantages:**

- Excellent chemical resistance (depending on O-ring material)
- Excellent temperature resistance (depending on O-ring material)
- Very low friction, excellent stick-slip behaviour
- Suitable for high speed applications
- Fast pressurisation/no "blow-by" effect
- Excellent extrusion resistance (given suitable filler)
- Compact design

**Technical data:**
**Material:**
PTFE-based
**Pressure:**
Up to 600 bar (for higher pressures contact Seal Engineering AS)
**Speed:**
Up to 10 m/s
**Temperature:**
- 50 ºC to 200 ºC (for higher temperatures contact Seal Engineering AS)
**Media:**
Resistant to all chemicals except elementary fluorine and molten alkali metals

*K08-D in FL13/RU2*

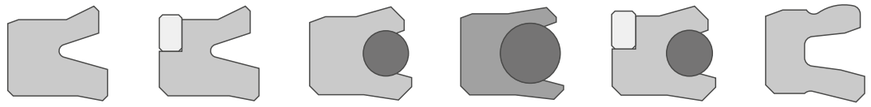
*Table 18, Dimensions recommended for standard housing for K08-D. $R_2 = 0.2$*

| Standard bore øD | Extended bore øD | ød | L | $R_1$ (max) | $R_2$ (max) | C | O-ring | Max radial extrusion gap "S"* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 100 bar | 200 bar | 400 bar | 600 bar |
| 8 – 14.9 | 8 – 40 | øD - 4.9 | 2.2 | 0.4 | 0.2 | 2.5 | BS 0xx/1.78 | 0.3 | 0.3 | 0.2 | 0.1 |
| 15 – 39.9 | 15 – 80 | øD - 7.5 | 3.2 | 0.6 | 0.2 | 3.5 | BS 1xx/2.62 | 0.4 | 0.3 | 0.2 | 0.1 |
| 40 – 79.9 | 15 – 133 | øD - 11 | 4.2 | 1.0 | 0.2 | 4.5 | BS 2xx/3.53 | 0.5 | 0.4 | 0.3 | 0.2 |
| 80 – 132.9 | 40 – 330 | øD - 15.5 | 6.3 | 1.3 | 0.2 | 5.0 | BS 3xx/5.33 | 0.5 | 0.4 | 0.3 | 0.2 |
| 133 – 329.9 | 80 – 670 | øD - 21 | 8.1 | 1.8 | 0.2 | 6.0 | BS 4xx/6.99 | 0.7 | 0.5 | 0.4 | 0.2 |
| 330 – 669.9 | 133 – 1000 | øD - 24.5 | 8.1 | 1.8 | 0.2 | 8.0 | BS 4xx/6.99 | 0.7 | 0.5 | 0.4 | 0.2 |
| 670 – 999.9 | 330 – 1000 | øD - 28 | 9.5 | 2.5 | 0.2 | 10.0 | 8.4 | 0.8 | 0.7 | 0.5 | 0.3 |
| > 1000 | | øD - 38 | 13.8 | 3.0 | 0.2 | 12.0 | 12.0 | 1.1 | 0.8 | 0.7 | 0.4 |

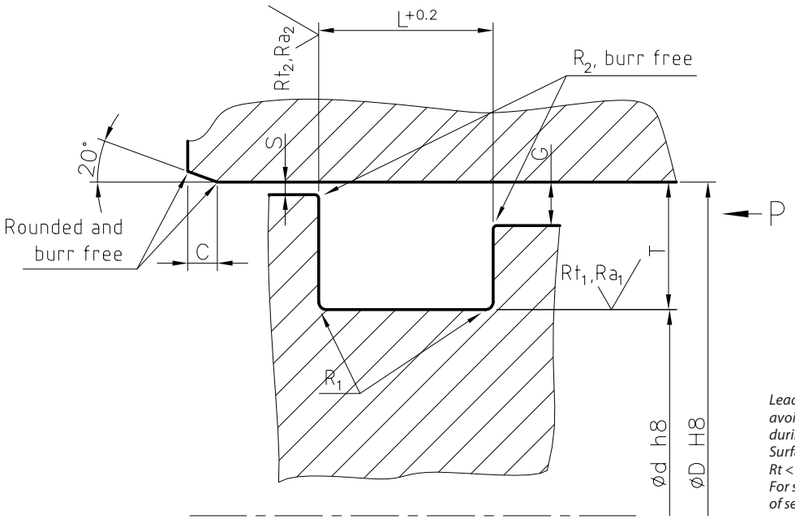
** specified extrusion gap is only valid for certain types of fillers and temperature*

We can also supply K08-D or K08-DS to suit almost any non-standard housing.
Contact Seal Engineering AS for tecnical advice.

# Other profiles



*K01-P* *K02-P* *K03-P* *K03-F* *K04-P* *K05-P*

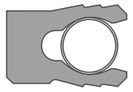



*Lead-in chamfer, C, avoids damage to seal during installation. Surface roughness Rt < 4 µm. For surface finish see end of section.*

*Fig. 12, Housing for piston seals K01, K02, K03, K04, K05.*

*Table 19, Dimensions recommended for standard housings for U-cup piston seals K01, K02, K03, K04 and K05. G: governed by design of guide ring groove or depending on the application.*

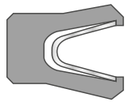
| Bore øD | ød | L | $R_1$ (max) | $R_2$ (max) | C |
|---|---|---|---|---|---|
| 12 – 40 | øD - 8 | 6 | 0.4 | 0.2 | 2.0 |
| 25 – 60 | øD - 10 | 7 | 0.4 | 0.2 | 2.5 |
| 50 – 140 | øD – 15 | 9.5 | 0.8 | 0.2 | 3.8 |
| 100 – 300 | øD - 20 | 12.5 | 0.8 | 0.2 | 5.0 |
| 125 – 500 | øD – 25 | 16 | 0.8 | 0.2 | 6.3 |
| 500 – 750 | øD - 30 | 20 | 0.8 | 0.2 | 7.5 |
| > 750 | øD - 40 | 26 | 0.8 | 0.2 | 10.0 |



*K03-S*

*Table 20, Spring-energized piston seal K03-S. Dimensions recommended for standard housing. Use of split groove is recommended, for closed or semi-closed groove please contact Seal Engineering AS.*

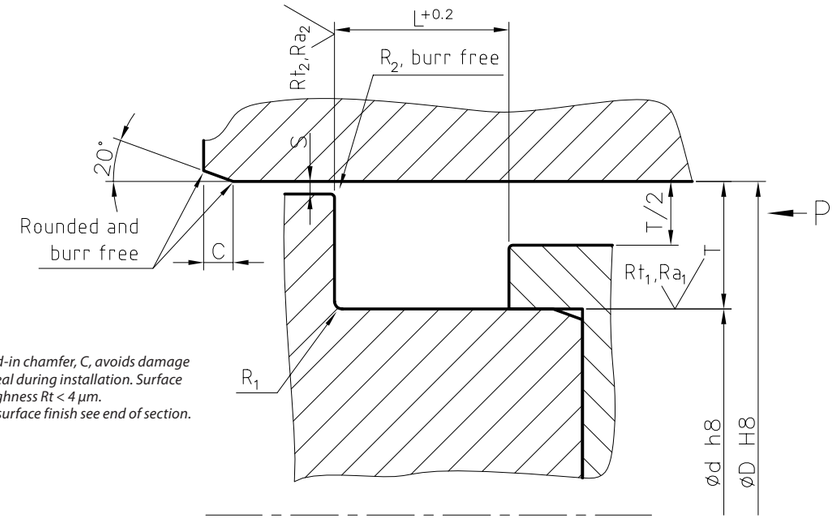
| Bore øD | ød | L | $R_1$ (max) | $R_2$ (max) | C |
|---|---|---|---|---|---|
| 20 – 70 | øD - 6 | 4.7 | 0.4 | 0.2 | 5.0 |
| 30 – 100 | øD - 8 | 5.5 | 0.4 | 0.2 | 5.0 |
| 40 – 200 | øD - 10 | 8.0 | 0.4 | 0.2 | 5.0 |
| 50 – 300 | øD - 12 | 8.5 | 0.4 | 0.2 | 7.5 |
| 70 – 500 | øD - 15 | 11.5 | 0.8 | 0.2 | 7.5 |
| 90 – 1000 | øD - 20 | 15.5 | 0.8 | 0.2 | 10.0 |
| 120 – 1400 | øD - 25 | 18.5 | 0.8 | 0.2 | 10.0 |
| 160 – 1400 | øD - 30 | 23.0 | 0.8 | 0.2 | 12.0 |
| 180 – 2000 | øD - 40 | 30.5 | 0.8 | 0.2 | 12.0 |



*K19-F*

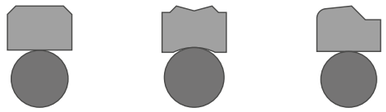
*Table 21, Spring-energized u-cup piston seals K19-F. Dimensions recommended for standard housing. Use of split groove is recommended, for closed or semi-closed groove please contact Seal Engineering AS.*

| Bore øD | ød | L | $R_1$ | C |
|---|---|---|---|---|
| 12 – 40 | øD - 8 | 6 | 0.4 | |
| 25 – 60 | øD - 10 | 7 | 0.4 | |
| 50 – 140 | øD – 15 | 9.5 | 0.4 | |
| 100 – 300 | øD - 20 | 12.5 | | |
| 125 – 500 | øD – 25 | 16 | | |
| 500 – 750 | øD - 30 | 20 | | |
| > 750 | øD - 40 | 26 | | |




*Lead-in chamfer, C, avoids damage to seal during installation. Surface roughness Rt < 4 µm. For surface finish see end of section.*

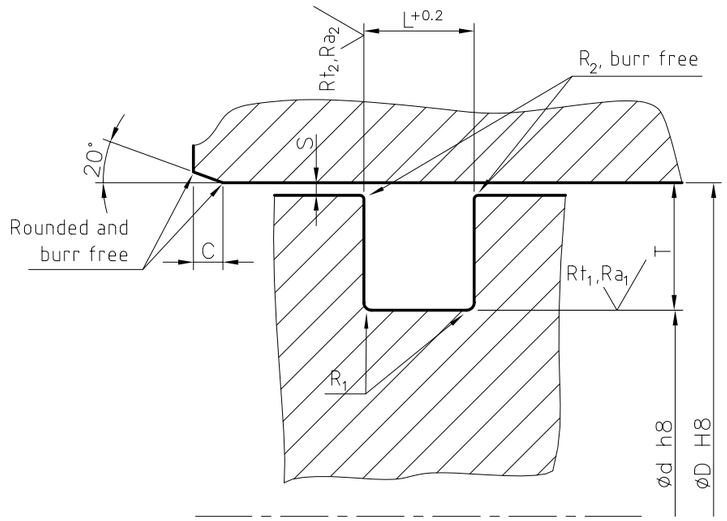
*Fig. 13, Housing for piston seals K03-S, K19-F.*



*K08-D* *K08-P* *K08-E*

*Table 22, Piston seals K08-D, K08-P and K08-E. Dimensions recommended for standard housing.*

| Standard bore øD | Extended bore øD | ød | L | $R_1$ (max) | $R_2$ (max) | C | O-ring |
|---|---|---|---|---|---|---|---|
| 8 – 14.9 | 8 – 40 | øD - 4.9 | 2.2 | 0.4 | 0.2 | 2.5 | BS 0xx/1.78 |
| 15 – 39.9 | 15 – 80 | øD - 7.5 | 3.2 | 0.6 | 0.2 | 3.5 | BS 1xx/2.62 |
| 40 – 79.9 | 15 – 133 | øD - 11 | 4.2 | 1.0 | 0.2 | 4.5 | BS 2xx/3.53 |
| 80 – 132.9 | 40 – 330 | øD - 15.5 | 6.3 | 1.3 | 0.2 | 5.0 | BS 3xx/5.33 |
| 133 – 329.9 | 80 – 670 | øD - 21 | 8.1 | 1.8 | 0.2 | 6.0 | BS 4xx/6.99 |
| 330 – 669.9 | 133 – 1000 | øD - 24.5 | 8.1 | 1.8 | 0.2 | 8.0 | BS 4xx/6.99 |
| 670 – 999.9 | 330 – 1000 | øD - 28 | 9.5 | 2.5 | 0.2 | 10.0 | 8.4 |
| > 1000 | | øD - 38 | 13.8 | 3.0 | 0.2 | 12.0 | 12.0 |




*Lead-in chamfer, C, avoids damage to seal during installation.*
*Surface roughness Rt < 4 µm.*
*For surface finish see end of section.*

*Fig. 14, Housing for piston seals K08*

## Piston seal housing details

*Table 23*

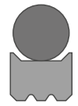
| Surface roughness* | $R_t$ (µm) | $R_a$ (µm) |
|---|---|---|
| Sliding surface for PU/RUBBER seals<br>Sliding surface for PTFE seals | ≤ 2.5<br>≤ 2.0 | ≤ 0.1 - 0.5<br>≤ 0.05 - 0.3 |
| Bottom of groove ($Rt_1$/$Ra_1$)<br>Groove face ($Rt_2$/$Ra_2$) | ≤ 6.3<br>≤ 15 | ≤ 0.8<br>≤ 3.2 |
| Bearing area, $R_{mr}$ | 50% – 95% (cutting depth 0.5 $R_z$, based on $c_{ref}$ = 0%) | |

**Surface roughness recommendations are typical values only. Contact Seal Engineering for application specific recommendations.*



# Rotary seals – housing recommendations

R09-F



*R09-F*

*Table 24, Dimensions recommended for standard housing for R09-F.*

| Rod ød | øD | L | $R_1$ (max) | $R_2$ (max) | C | O-ring |
|---|---|---|---|---|---|---|
| 8 – 70 | ød + 4.9 | 2.2 | 0.4 | 0.2 | 2.5 | BS 0xx/1.78 |
| 12 – 140 | ød + 7.5 | 3.2 | 0.6 | 0.2 | 3.5 | BS 1xx/2.62 |
| 20 – 320 | ød + 11 | 4.2 | 1.0 | 0.2 | 4.5 | BS 2xx/3.53 |
| 60 – 450 | ød + 15.5 | 6.3 | 1.3 | 0.2 | 5.0 | BS 3xx/5.33 |
| 130 – 650 | ød + 21 | 8.1 | 1.8 | 0.2 | 6.0 | BS 4xx/6.99 |
| > 600 | ød + 28 | 9.5 | 2.5 | 0.2 | 10.0 | 8.40 |

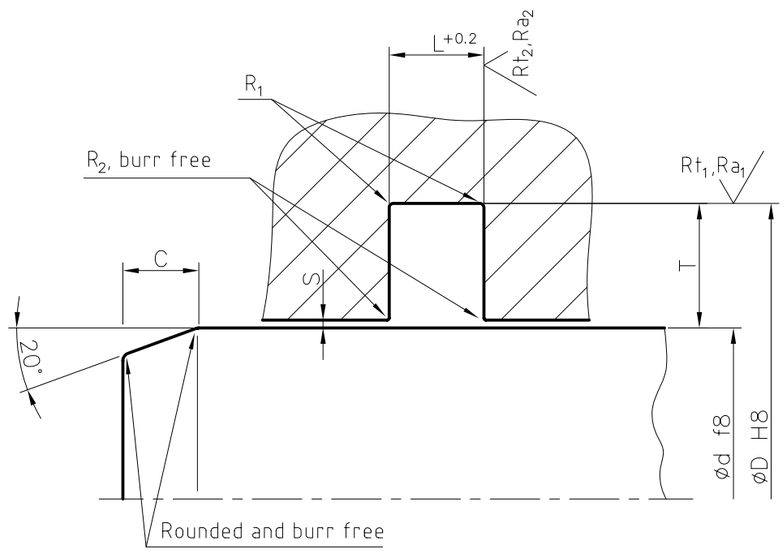


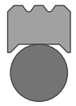

*Fig. 15, Housing for rotary seal R09*

*Lead-in chamfer, C, avoids damage to seal during installation. Surface roughness Rt < 4 µm.*
*For surface finish see end of section.*

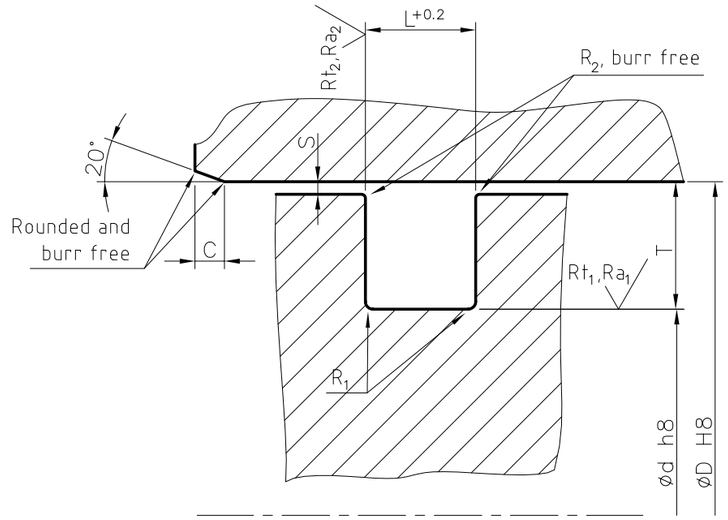
## R10-F

*Table 25, Dimensions recommended for standard housing for R10-F.*

| Bore øD | ød | L | $R_1$ (max) | $R_2$ (max) | C | O-ring |
|---|---|---|---|---|---|---|
| 10 – 85 | øD - 4.9 | 2.2 | 0.4 | 0.2 | 2.5 | BS 0xx/1.78 |
| 20 – 160 | øD - 7.5 | 3.2 | 0.6 | 0.2 | 3.5 | BS 1xx/2.62 |
| 50 – 300 | øD - 11 | 4.2 | 1.0 | 0.2 | 4.5 | BS 2xx/3.53 |
| 70 – 500 | øD - 15.5 | 6.3 | 1.3 | 0.2 | 5.0 | BS 3xx/5.33 |
| 125 – 690 | øD - 21 | 8.1 | 1.8 | 0.2 | 6.0 | BS 4xx/6.99 |
| > 600 | øD - 28 | 9.5 | 2.5 | 0.2 | 10.0 | 8.40 |



*R10-F*




*Lead-in chamfer, C, avoids damage to seal during installation. Surface roughness Rt < 4 µm. For surface finish see end of section.*

*Fig. 16, Housing for rotary seal R10*

## Rotary seal housing details

*Table 26*

| Surface roughness* | $R_t$ (µm) | $R_a$ (µm) |
|---|---|---|
| Sliding surface for PU/RUBBER seals<br>Sliding surface for PTFE seals | ≤ 2.5<br>≤ 2.0 | ≤ 0.1 - 0.5<br>≤ 0.05 - 0.3 |
| Bottom of groove ($Rt_1/Ra_1$)<br>Groove face ($Rt_2/Ra_2$) | ≤ 6.3<br>≤ 15 | ≤ 0.8<br>≤ 3.2 |
| Bearing area, $R_{mr}$ | 50% – 95% (cutting depth 0.5 $R_z$, based on $c_{ref}$ = 0%) | |

**Surface roughness recommendations are typical values only. Contact Seal Engineering AS for application specific recommendations.*



## Guide rings – housing recommendations

*Table 27, Common groove widths for F01*

| L |
|---|
| 4.2 |
| 5.6 |
| 9.7 |
| 15 |
| 20 |
| 25 |
| 30 |
| 50 |

*Table 28, Guide ring F01 dimension recommendations*

| Diameter | Cross section T |
|---|---|
| 10-50 | 1.5–2.0 |
| 40-280 | 2.5-3.0 |
| > 160 | 4.0 |

In addition to the listed values we are able to produce guide rings within a much wider dimension range, to suit existing groove dimensions or specific needs of your application.

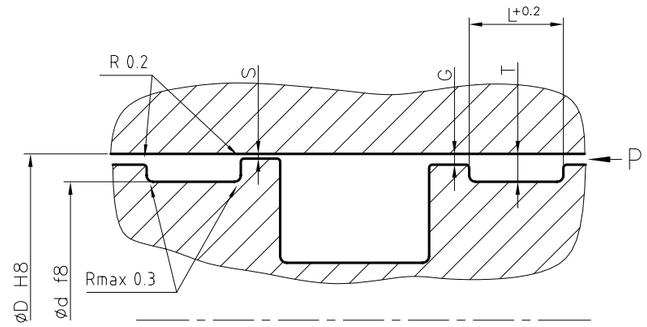



*Fig. 17, Housing for guide ring F01 (piston).*

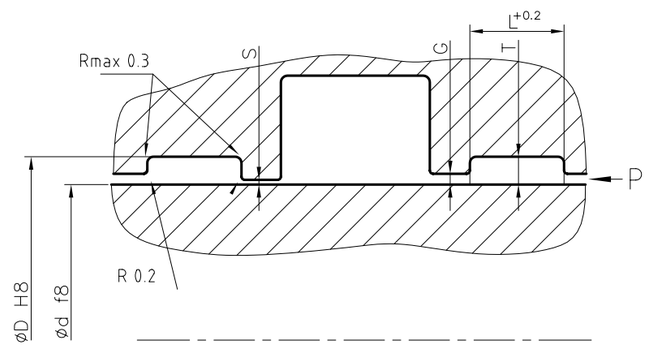



*Fig. 18, Housing for guide ring F01 (rod).*

The minimum value for G and S is governed by the fact that the maximum radial play of the guide ring must be smaller than the maximum radial play of the metal parts. To ensure proper functioning and sufficient axial support of the guide ring, the maximum value of G is T/2.

The bore in front (pressure-side) of single-acting seals is often governed by the design of the guide ring groove.

The maximum allowable radial gap S on the non-pressure side of the seal is dependent on factors such as seal type, pressure, material, temperature, speed, medium etc., and may differ from the values of G. For design purposes both G and S must be within their respective limits.

Contact Seal Engineering AS for technical advice.

# O-rings

In this chapter we present the most common seal used for static sealing, the O-ring. However, the term "static seal" is not entirely correct, since the O-ring is also used for dynamic sealing in some applications. In addition to cover many of the aspects regarding O-rings we will also present profiles that are suitable to replace O-rings in both static and in dynamic applications.
These O-ring replacements represent an improvement in overall sealing effect, and should definitely be considered for both design and maintenance purposes.

Seal Engineering AS stocks thousands of different O-ring dimensions in many different materials. In addition we are able to produce O-rings and O-ring replacement profiles in any diameter up to 1500 mm outside diameter for same day delivery. This applies to both elastomer (rubber), thermoplastic elastomer (polyurethane) and thermoplastic materials. Larger O-rings and other profiles are available in outside diameter up to 4000 mm.

We also offer state of the art warm vulcanized O-rings, available for same day delivery in almost infinite diameter.
Although this chapter only covers the most common profiles used for static sealing we are able to design and produce special sealing profiles to accommodate almost any application.

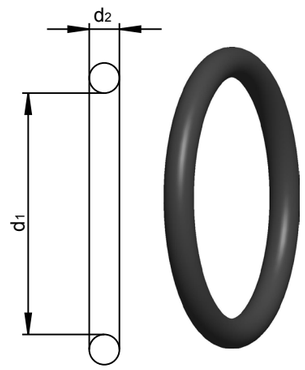



*Fig.1, O-ring*

**The O-ring's simple and effective design has made it the world's most widely used seal. O-rings are very cost effective to produce in large quantities, and are easy to install. Given correct grooves and O-ring material, the O-ring may be used to seal against almost any liquid or gas.**

The size of an O-ring is always determined by inside diameter ($d_1$) x cross section ($d_2$).
O-rings can be delivered with inside diameters from 0.5 mm and upwards, and in cross sections ranging from 0.5 mm – 50 mm.

O-rings can be used in many applications, but preferably as a static seal. However, O-rings are also used as dynamic piston seals, rod seals, seals for rotating shafts, wipers, drive belts and as energizers in sliding seals (composite seals).

## O-ring materials

The extended range requires special compounds and/or intermittent short term operation. In addition, most of these materials are also available in special compounds to suit given criteria such as different hardness, food-grade, resistant to explosive decompression (ED), high-temperature, low temperature, low friction etc. For special applications contact Seal Engineering AS.

**O-rings are available in a variety of different materials. The materials described below are the most frequently used. The indicated temperature range is depending on the quality, and is given as a standard range and as an extended range.**

### NBR (Nitrile-Butadien-Rubber, Perbunan®)

NBR is the most common material used for O-rings, and has good resistance against mineral based oils, fuels and grease. NBR also exhibits low gas permeation and very low compression set. NBR is typically used for oil-based hydraulics, given that the temperature is within working parameters. **Temperature range -35 °C to 110 °C. Extended range -50 °C to 125 °C.**

### FEPM (Tetrafluorthylene-propylene, TFE/P, Aflas®)

FEPM is resistant to a wide range of chemicals and HFA, HFB, HFC and HFD liquids. FEPM is often used when there are mixtures of different media such as sour gas and oil, amine corrosion inhibitors, hot water, steam, and media with high PH. For many applications FEPM outperforms both FKM and FFKM with regards to overall sealability. **Temperature range -0 °C to 225 °C. Extended range -10 °C to 250 °C.**

### FKM (Fluorelastomer, FPM, Viton®)

FKM has excellent resistance against high temperatures, aliphatic and aromatic hydrocarbons, chlorine solutions and petroleum based liquids. In addition, FKM is resistant to a wide range of different chemicals. Please note that standard FKM is not resistant against hot water (maximum 80 °C). **Temperature range -15 °C to 200 °C. Extended range -35 ° to 275 °C.**

### FFKM (Perfluorelastomer, Kalrez®, Chemraz®, Perlast®, Simriz®)

FFKM has outstanding chemical and temperature resistance, combined with the elasticity of an elastomer. FFKM is resistant to most kinds of acids, solvents, drilling fluids and high temperature steam. FFKM also has low degassing when used in vacuum applications. **Temperature range -20 °C to 260 °C. Extended range -30 °C to 330 °C.**

### EPDM (Ethylene-Propylene-Diene-Rubber)

EPDM has excellent resistance against ozon, water and steam. In addition, EPDM is resistant to a range of different chemicals, including glycol based brake fluids. Because of its nonpolarity, EPDM is not resistant to mineral oils and greases, as this causes extensive swelling. **Temperature range -40 °C to 150 °C. Extended range -50 °C to 175 °C.**

### VMQ (Silicone-Rubber)

VMQ has good resistance to temperature, ozone and weathering. Due to poor mechanical properties VMQ is best suited for static applications. **Temperature range -60 °C to 200 °C. Extended range -90 °C to 260 °C.**

### HNBR (Hydrogenated Nitrile-Butadiene-Rubber)

HNBR is an enhanced NBR with good resistance to temperature, abrasion, ozone, weathering, and has low compression set. HNBR is also resistant to various oil additives, hydrogen sulphide and amines found in crude oil. **Temperature range -20 °C to 150 °C. Extended range – 35 °C to 175 °C.**

### FVMQ (Fluorsilicone-rubber)

FVMQ is a modified silicone often used against oils and fuels given large variations in temperature. FVMQ has the same good resistance to ozone and weathering as VMQ, and similar poor mechanical properties. **Temperature range -60 ° C to 200 °C. Extended range -100 °C to 210 °C.**

### CR (Chloroprene-Rubber, Neoprene®)

CR has very good resistance to ozone, weathering and saltwater, and is also resistant against cooling liquids such as Freon. **Temperature range -35 °C to 100 °C. Extended range -50 °C to 115 °C.**

### PTFE (Polytetrafluorethylene, Teflon®)

PTFE has excellent resistance against chemicals and temperature. PTFE is resistant to all known chemicals, acids and solvents except molten alkali metals and elementary fluorine at high temperatures. PTFE can have various fillers to suit a given application. **Temperature range -200 °C to 260 °C.**

### FEP (Teflon FEP®)

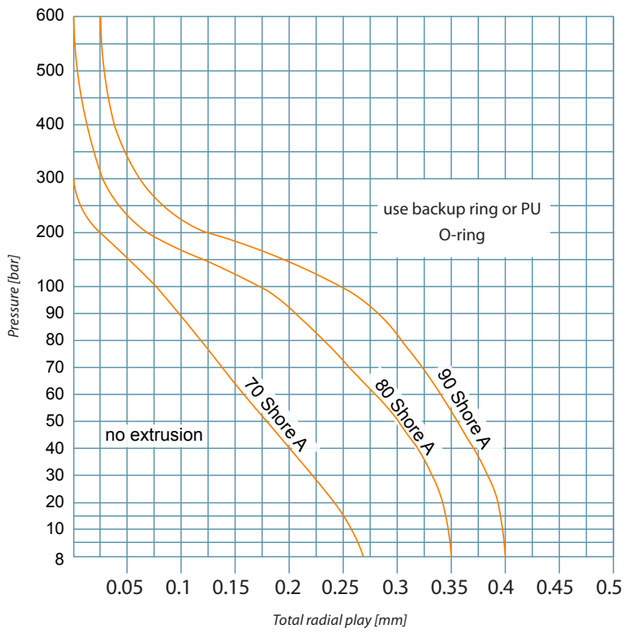
FEP O-rings has a core of either VMQ or FKM, encapsulated by Teflon FEP®. This gives chemical resistance close to that of PTFE, but better elasticity than PTFE O-rings. FEP O-rings are only to be used as static seals. **Temperature range -100 °C to 200 °C.**

### PU (Polyurethane)

PU is extremely resistant to abrasion compared to most elastomers, and is often used for applications with high demands for longevity and/or high pressure. PU is also a natural choice for dynamic sealing. PU is available in many different compounds to suit a given application, see section *Materials Overview, thermoplastic elastomers.* **Temperature range -50 °C to 110 °C. Extended range up to 130 °C.**

## Pressure resistance

*Fig. 2, Pressure resistance*




The diagram shows maximum pressure before extrusion for a given hardness and radial play. For pressure or radial play outside the limits, use of backup rings or harder materials (e.g. polyurethane) is recommended. Other profiles are also an alternative.

The diagram is valid for a temperature up to 70° C, and does not consider the barrelling of cylinders under pressure.

Please note that for O-rings in material VMQ and FVMQ the radial play is half of what is shown in the diagram.

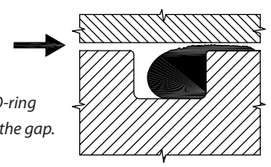


*Fig. 3, Example of O-ring extruding through the gap.*

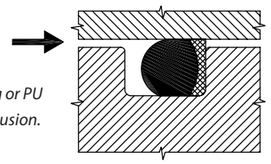


*Fig. 4, The use of backup ring or PU O-ring may prevent gap extrusion.*

## Preload

Preloading of the O-ring's cross section is decisive for the O-ring to work properly. The preloading assures the following:

- Sealing effect even at low pressures.
- Minimize the effect of the production tolerances, both for steel parts and O-rings.
- Compensate for compression set in the O-ring material.
- Compensate for wear and tear both for steel parts and O-rings.

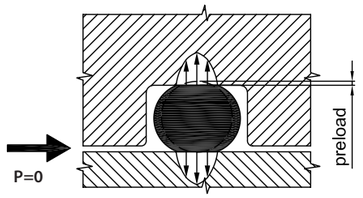



*Fig. 5, O-ring without system pressure*

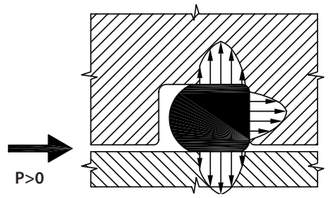



*Fig. 6, O-ring with system pressure*

Depending on the application, the following values for preload apply in respect to the cross section for radial installation in hydraulic systems.

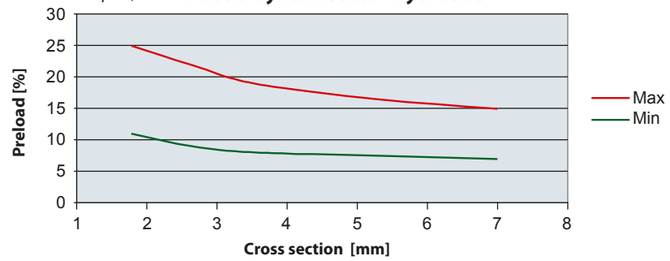
**Dynamic applications:** 7 to 25%
**Static applications**: 11 to 30%

For axial installation, recommended preload is between 15 to 35%.

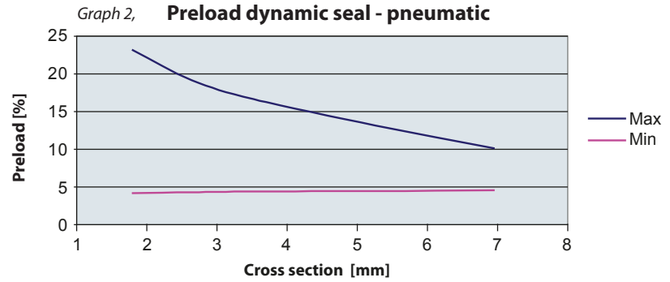
As a general rule the O-ring should fill approximately 75% of the area in the groove.

When designing O-ring grooves, the diagrams shown can be used to determine the preload.

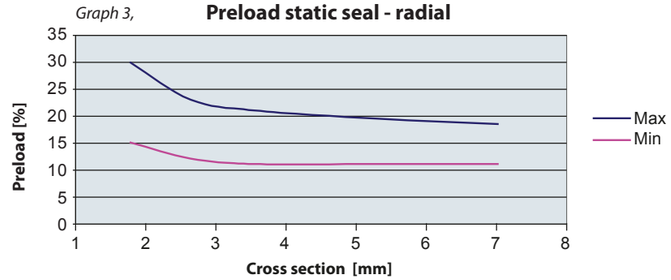
*Graph 1,* **Preload dynamic seal - hydraulic**



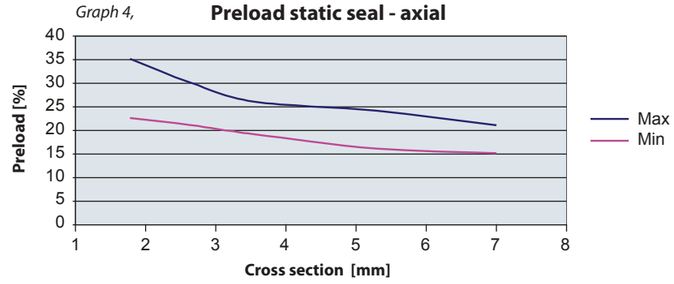

*Graph 2,* **Preload dynamic seal - pneumatic**




*Graph 3,* **Preload static seal - radial**




*Graph 4,* **Preload static seal - axial**



# Elongation – compression

**For maximum sealability the O-ring should either be elongated or compressed when installed, depending on the application. The following guidelines should be considered:**

For installation in an internal groove (fig. 7 and 8) the O-ring should be stretched between 1-3 % of the diameter. Maximum elongation is 6%.
For installation in an external grove (fig. 9 and 10) the O-ring should be compressed between 1-2%. Maximum compression is 3%.
The reason for elongating or compressing the O-ring is to minimize movement during pressure cycles, and to bridge production tolerances on both steel parts and the O-ring, thereby optimizing the service life of the O-ring.

Exceeding these guidelines will result in either to much decrease or increase of the O-ring's cross section, which in turn may have a negative effect on the service life of the O-ring. In addition excessive compression will make the O-ring difficult or impossible to install.
The decrease of cross section is approximately half of the elongation, meaning that 1 % elongation yields 0.5% reduction of cross section.

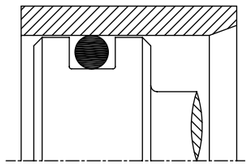


*Fig. 7, Internal groove*

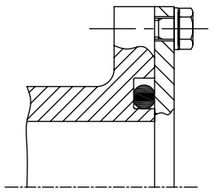


*Fig. 8, Internal groove*

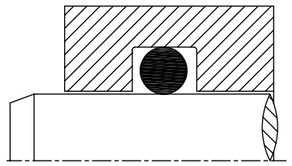


*Fig. 9, External groove*

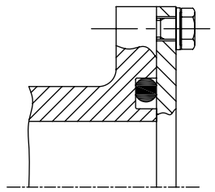


*Fig. 10, External groove*

In order to determine to force needed for static installation of O-rings, we need to know the compression forces. The compression forces depend on the initial preload of the cross section and the hardness of the O-ring (Shore). The graph shows the specific compression force per cm of the seal circumference as a function of the cross section.

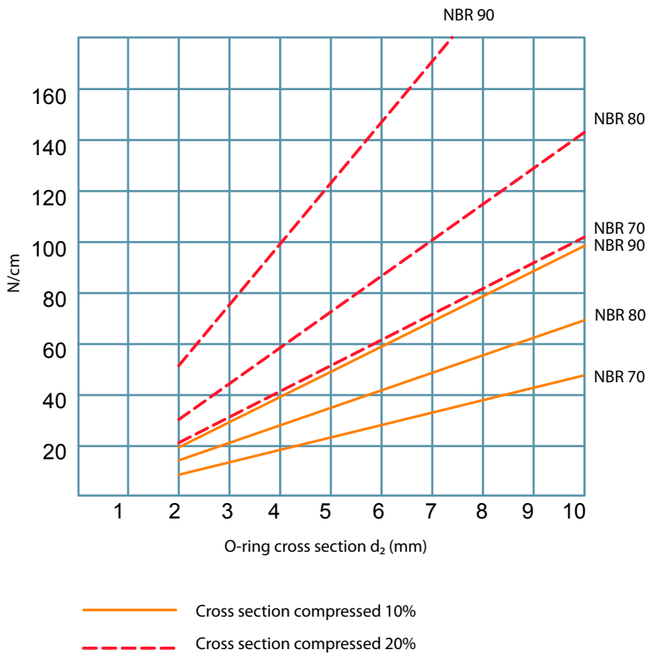



*Fig. 11, Compression forces*

# Installation recommendations

**A rectangular groove is preferred for all new designs. Designs with bevelled groove flanks up to 5° are permissible. The radius $r_2$ shown in the drawing should be maximum 0.4 mm.**

Our backup ring profile ST09 is preferred for use in combinations with O-rings. For ordering purposes measurement $h_1$ is given. To determine free space in the groove $h_2$ should be used. Cross section of the backup ring should be equal to the cross section of the groove.

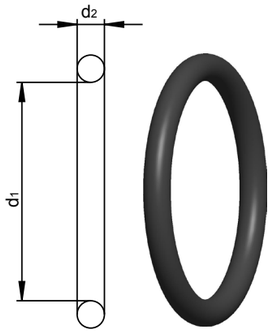



*Fig. 12, O-ring*

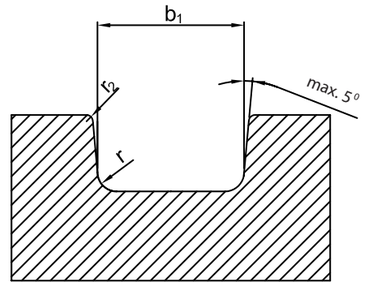



*Fig. 13, O-ring groove with bevelled flanks*

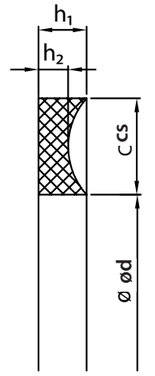
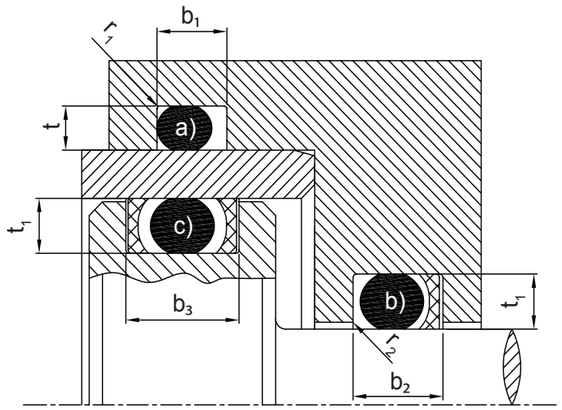



*Fig. 14, Backup-ring ST09*

**Examples:**



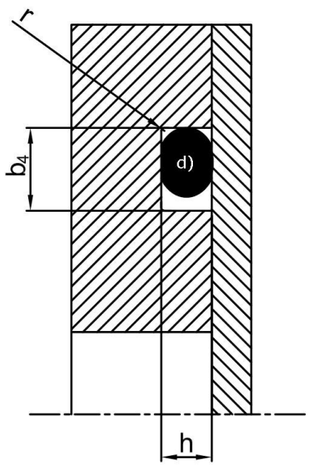




*Fig. 15, O-rings, examples of different functions:*
*a) Static, radial sealing with no backup*
*b) Dynamic, radial sealing with one backup-ring*
*c) Dynamic, radial sealing with two backup-rings*
*d) Axial sealing*

*Table 1*

| Installation recommendations for rectangular groove | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Cross section** | **Radial installation** | | | | | | **Axial installation** | | **Radius** |
| | **Groove depth** | | **Groove width** | | | | **Groove depth** | **Groove width** | |
| | **Static** | **Dynamic** | **No backup** | **1 backup** | **2 backups** | **Backup ring** | | | |
| **$d_2$** | **$t + 0.05$** | **$t_1 + 0.05$** | **$b_1 + 0.2$** | **$b_2 + 0.2$** | **$b_3 + 0.3$** | **height $h_1/h_2$** | **$h + 0.05$** | **$b_4 + 0.2$** | **r (max)*** |
| 1.5 | 1.10 | 1.25 | 2.00 | 3.00 | 4.00 | 1.10/1.00 | 1.10 | 2.10 | 0.30 |
| 1.6 | 1.20 | 1.30 | 2.10 | 3.10 | 4.10 | 1.10/1.00 | 1.20 | 2.20 | 0.30 |
| 1.78 | 1.30 | 1.45 | 2.40 | 3.80 | 5.20 | 1.50/1.40 | 1.30 | 2.50 | 0.30 |
| 1.90 | 1.40 | 1.55 | 2.60 | 4.00 | 5.40 | 1.50/1.40 | 1.40 | 2.70 | 0.30 |
| 2.00 | 1.50 | 1.65 | 2.70 | 4.10 | 5.50 | 1.60/1.40 | 1.50 | 2.80 | 0.30 |
| 2.40 | 1.80 | 2.05 | 3.20 | 4.60 | 6.00 | 1.60/1.40 | 1.80 | 3.30 | 0.30 |
| 2.50 | 1.85 | 2.15 | 3.30 | 4.70 | 6.10 | 1.60/1.40 | 1.85 | 3.40 | 0.30 |
| 2.62 | 2.00 | 2.25 | 3.60 | 5.00 | 6.40 | 1.60/1.40 | 2.00 | 3.70 | 0.60 |
| 3.00 | 2.30 | 2.60 | 4.00 | 5.40 | 6.80 | 1.70/1.40 | 2.30 | 4.10 | 0.60 |
| 3.10 | 2.40 | 2.70 | 4.10 | 5.50 | 6.90 | 1.70/1.40 | 2.40 | 4.20 | 0.60 |
| 3.53 | 2.70 | 3.10 | 4.80 | 6.20 | 7.60 | 1.70/1.40 | 2.70 | 4.90 | 0.60 |
| 4.00 | 3.10 | 3.50 | 5.20 | 6.90 | 8.60 | 2.10/1.70 | 3.10 | 5.30 | 0.60 |
| 4.50 | 3.50 | 4.00 | 5.80 | 7.50 | 9.20 | 2.10/1.70 | 3.50 | 5.90 | 0.60 |
| 5.00 | 4.00 | 4.40 | 6.60 | 8.30 | 10.00 | 2.20/1.70 | 4.00 | 6.70 | 0.60 |
| 5.33 | 4.30 | 4.70 | 7.10 | 8.80 | 10.50 | 2.20/1.70 | 4.30 | 7.30 | 0.60 |
| 5.50 | 4.50 | 4.80 | 7.10 | 8.80 | 10.50 | 2.20/1.70 | 4.50 | 7.30 | 0.60 |
| 5.70 | 4.60 | 5.00 | 7.20 | 8.90 | 10.60 | 2.30/1.70 | 4.60 | 7.40 | 0.60 |
| 6.00 | 4.90 | 5.30 | 7.40 | 9.10 | 10.80 | 2.30/1.70 | 4.90 | 7.60 | 0.60 |
| 6.50 | 5.40 | 5.70 | 8.00 | 9.70 | 11.40 | 2.30/1.70 | 5.40 | 8.20 | 1.00 |
| 6.99 | 5.80 | 6.10 | 8.60 | 11.10 | 13.60 | 3.20/2.50 | 5.80 | 9.70 | 1.00 |
| 7.50 | 6.30 | 6.60 | 9.10 | 11.60 | 14.10 | 3.20/2.50 | 6.30 | 9.90 | 1.00 |
| 8.00 | 6.70 | 7.10 | 9.80 | 12.30 | 14.80 | 3.20/2.50 | 6.70 | 10.00 | 1.00 |
| 8.40 | 7.10 | 7.50 | 10.00 | 12.50 | 15.00 | 3.40/2.50 | 7.10 | 10.30 | 1.00 |
| 9.00 | 7.70 | 8.10 | 10.60 | 13.10 | 15.60 | 3.40/2.50 | 7.70 | 10.90 | 1.50 |
| 10.00 | 8.60 | 9.10 | 11.60 | 14.10 | 16.60 | 3.60/2.50 | 8.60 | 12.00 | 2.00 |
| 12.00 | 10.60 | 11.00 | 13.50 | 16.00 | 18.50 | 3.80/2.50 | 10.60 | 14.00 | 2.00 |

*Groove recommendations only valid for normal swell of the O-ring. Higher than normal swell due to thermal and/or chemical influence might require different groove size.*
** If a back-up ring is used the recommended radius should always be r (max) 0.40.*

*Table 2*

| Installation recommendations for trapezoidal groove | | | | | |
|---|---|---|---|---|---|
| **Cross section** | **Groove depth** | **Grove width** | **Groove width** | **Radius (max)** | |
| **$d_2$** | **$h_1 \pm 0.05$** | **$b_1 \pm 0.05w$** | **$b_2 \pm 0.05$** | **$r_1$** | **$r_2$** |
| 3.53 | 2.90 | 2.90 | 3.20 | 0.80 | 0.25 |
| 4.00 | 3.20 | 3.40 | 3.70 | 0.80 | 0.25 |
| 5.00 | 4.20 | 4.30 | 4.60 | 0.80 | 0.25 |
| 5.33 | 4.60 | 4.60 | 4.90 | 0.80 | 0.25 |
| 5.70 | 4.80 | 4.75 | 5.25 | 0.80 | 0.40 |
| 6.00 | 5.10 | 5.05 | 5.55 | 0.80 | 0.40 |
| 6.99 | 6.00 | 6.00 | 6.50 | 1.60 | 0.40 |
| 8.00 | 6.90 | 6.85 | 7.45 | 1.60 | 0.50 |
| 8.40 | 7.30 | 7.25 | 7.85 | 1.60 | 0.50 |

The trapezoidal groove is not recommended for standard applications, but may prove useful in special cases. For instance in overhead installations a trapezoidal groove will prevent the O-ring from falling out of the groove.
The trapezoidal groove is only recommended for O-ring cross section from 3.53 mm.

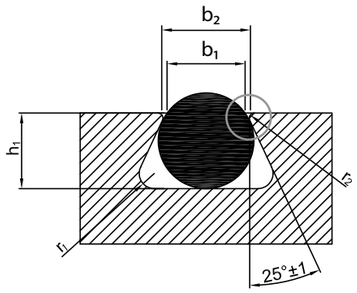



*Fig. 16, Trapezoidal groove*

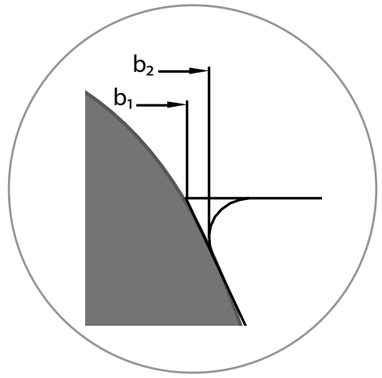



*Fig. 17, Detail of trapezoidal groove*

Triangular grooves can be used for threaded flanges and caps.
For proper functioning of the O-ring the groove must be machined according to the measurements given in the table. The use of rectangular grooves is preferred.

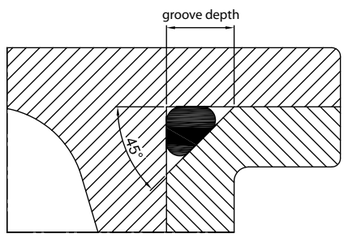



*Fig. 18, Triangular groove*

*Table 3*

| Installation triangular groove | | |
|---|---|---|
| **Cross section** | **Groove depth** | **Groove depth** |
| **$d_2$** | **$t_1$** | **tolerance [+]** |
| 1.60 | 2.10 | 0.10 |
| 1.78 | 2.40 | 0.10 |
| 2.40 | 3.30 | 0.10 |
| 2.62 | 3.50 | 0.10 |
| 3.00 | 4.10 | 0.20 |
| 3.53 | 4.90 | 0.20 |
| 5.00 | 6.90 | 0.20 |
| 5.33 | 7.35 | 0.20 |
| 5.70 | 7.85 | 0.20 |
| 6.99 | 9.60 | 0.30 |
| 8.00 | 11.00 | 0.30 |
| 8.40 | 11.55 | 0.30 |

For axial movement there are two ways of installing O-rings in pneumatic systems; radial compressed or floating fit.
For compressed O-rings the compressions should be minimum 4% and up to 23%, depending on the cross section (see also section "PRELOAD"). To avoid excessive friction and wear the compression should be kept small. Smaller compression also makes it possible with smaller groove widths.

Floating fit is suitable when O-rings are used as piston seals. The cross section of the O-ring is not compressed and this reduces friction and wear. One disadvantage is that the sealing effect is not reached until the O-ring closes the gap between piston and cylinder wall. Some air/gas may escape during the pressure build-up.
With floating fit the outside diameter of the O-ring should be 2 to 4 % larger than the cylinder diameter, and the O-ring must not rest on the bottom of the groove.

*Table 4*

| Installation pneumatic dynamic applications – Floating fit | | |
|---|---|---|
| **Cross section** | **Groove depth** | **Groove width** |
| **$d_2$** | **$t + 0.05$** | **$b_1 + 0.2$** |
| 1.78 | 2.10 | 2.20 |
| 2.40 | 2.70 | 2.80 |
| 2.62 | 3.00 | 3.10 |
| 3.00 | 3.40 | 3.50 |
| 3.53 | 4.00 | 4.10 |
| 5.33 | 6.00 | 6.10 |
| 5.70 | 6.40 | 6.50 |
| 6.99 | 7.90 | 8.00 |

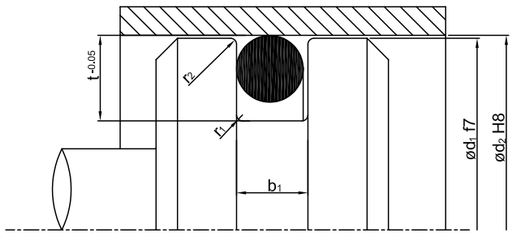



*Fig. 19, Pneumatic floating fit*

When using O-rings for sealing a vacuum some different design criteria must be followed.

- The O-ring should fill the groove nearly 100%, as a larger contact area will reduce the diffusion rate trough the O-ring.
- Preload of approximately 30% is recommended, even for larger cross sections.
- The surfaces to be sealed and the groove must have good surface finish.
- The O-ring material should have low gas permeation rate and low compression set.

*Table 5*

| Installation recommendations for vacuum | | | |
|---|---|---|---|
| **Cross section** | **Groove depth** | **Groove width** | **Radius (max)** |
| **$d_2$** | **$t \pm 0.05$** | **$b_1 \pm 0.05$** | **$r_1$** |
| 1.78 | 1.25 | 2.10 | 0.2 |
| 2.62 | 1.85 | 3.10 | 0.3 |
| 3.53 | 2.50 | 4.15 | 0.3 |
| 5.33 | 3.70 | 6.30 | 0.4 |
| 6.99 | 4.90 | 8.20 | 0.4 |

*$r_2$ max is 0.2*



# Surfaces and installation

**Elastomeric O-rings will to a great extent adapt to irregular surfaces, but surface finish is absolutely crucial for the sealability and longevity of the O-ring. Even for static applications pressure pulses and temperature changes will cause movements of the O-ring relative to the steel parts. We recommend that the guidelines shown are used for machining of grooves and mating surfaces.**

*Table 6*

| Surface finish | | | | |
|---|---|---|---|---|
| **Type of load** | **Surface** | $R_{max}$ [µm] | $R_z$ [µm] | $R_a$ [µm] |
| **Radial - dynamic** | **Mating surface (bore, rod, shaft)** | 1.0 - 4.0 | 0.63 - 2.5 | 0.1 - 0.4 |
| | **Groove surface** | 16.0 | ≤ 10.0 | ≤ 1.6 |
| **Radial - static** | **Mating surface** | ≤ 16.0 | ≤ 10.0 | ≤ 1.6 |
| **Axial - static** | **Groove surface** | | | |
| **Pulsating pressures** | **Mating surface Groove surface** | ≤ 10.0 | ≤ 6.3 | ≤ 0.8 |

*Table 7*

| Surface profile | $R_a$ | $R_z$ | $R_{mr}$ |
|---|---|---|---|
| CLOSED | 0.1 | 1.0 | 70% |
| OPEN | 0.2 | 1.0 | 15% |

The material contact surface, $R_{mr}$, is crucial for dynamic applications as this has a huge impact on the wear of the O-ring material, and subsequently the expected life-time of the O-ring. The values $R_a$, $R_z$, $R_{max}$, can be within limits, but if the surface profile is open the O-ring will fail sooner due to wear/abrasion than with a closed profile.

*Table 8*

| Lead-in chamfers | | |
|---|---|---|
| **Lead-in chamfers** | | **Cross section** |
| **Z min** | | **$d_2$** |
| 15° | 20° | |
| 2.5 | 1.5 | up to 1.78 |
| 3.0 | 2.0 | up to 2.62 |
| 3.5 | 2.5 | up to 3.53 |
| 4.5 | 3.5 | up to 5.33 |
| 5.0 | 4.0 | up to 6.99 |
| 6.0 | 4.5 | above 6.99 |

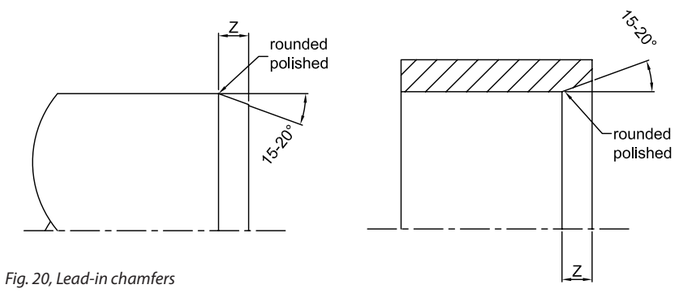



*Fig. 20, Lead-in chamfers*

O-rings are easily damaged during assembly if the steel parts are not properly machined. Since O-rings are squeezed during installation, lead-in chamfers and rounded edges are vital to avoid damage to the O-rings.

# Installation guidelines, O-rings

- Lead-in chamfer and rounded edges on all parts that passes the O-ring.
- All parts should be cleaned and free from particles and dirt.
- Threads should be covered by tape, shims or mounting tools.
- O-rings and opposite parts should be lubricated by O-ring lube or the medium to be sealed against.
- Never use tools with sharp edges.
- Do not roll the O-ring into the groove.
- Do not over-stretch the O-ring during assembly. Up to 50% elongation is usually permissible during assembly. Pay extra attention for small diameters. Vulcanized O-rings are especially sensitive to elongation, and must not be stretched in the joint.

# PU O-rings

**Due to PU´s exceptional high resistance to abrasion and extrusion, this material is increasingly used for O-rings and other seals.**

O-rings made of PU should be considered under the following conditions:

- High pressure
- Large gaps
- Limited space (no room for backup-ring)
- Dynamic applications
- O-ring has to pass bores
- Couplings and connectors, or other applications with frequent opening and closing
- Sealing against gas

Seal Engeneering AS offers a wide range of different PU materials, each with unique properties to suit most applications up to 110 °C. Below is a short description of the different materials (see also chapter "Materials overview").

- HPU – resistant against hydrolysis, HFA and HFB-fluids, biological degradable liquids and mineral based oils. FDA approved
- XHPU – harder grade of HPU for higher pressures or larger gaps
- SPU – same resistance as HPU, with enhanced friction properties for use in gas, pneumatic or other applications where low friction is desired
- XSPU – harder grade of SPU for higher pressures or larger gaps
- LPU – low temperature grade for applications down to -50 °C

PU O-rings can be used in the same grooves as for elastomer O-rings. Seal Engeneering AS manufactures O-rings up to 1500 mm outside diameter, and cross section from 1.6 mm, with short lead times (same day delivery if necessary). In addition we can supply O-rings up to 4000 mm outside diameter.

# PTFE O-rings

O-rings can also be delivered in PTFE-based materials. PTFE-based O-rings are only to be used as static seals, and should be considered given the following conditions:

- High demands for chemical resistance
- High or low temperature (260 °C to – 200 °C)
- Resistance against ageing
- Food or drug applications

Seal Engeneering AS manufactures O-rings in PTFE-based materials up to 1500 mm outside diameter, cross section from 1.6 mm. In addition we can supply PTFE O-rings up to 2000 mm outside diameter.

PTFE is a thermoplastic material with low elasticity, and has limited possibility to be stretched or compressed during installation.

Groove dimensions are different from those for elastomers, and installation in axial easily accessible and radial spilt grooves is recommended.

*Table 9*

| Installation recommendations for ptfe o-rings | | | |
|---|---|---|---|
| **Cross section** | **Groove depth** | **Groove width** | **Radius (max)** |
| **$d_2$** | **t ± 0.05** | **$b_1$ + 0.1** | **r** |
| 1.60 | 1.4 | 1.80 | 0.3 |
| 1.78 | 1.6 | 2.00 | 0.4 |
| 2.00 | 1.8 | 2.20 | 0.5 |
| 2.40 | 2.15 | 2.60 | 0.5 |
| 2.62 | 2.35 | 2.90 | 0.6 |
| 3.00 | 2.70 | 3.30 | 0.8 |
| 3.53 | 3.15 | 3.90 | 1.0 |
| 4.00 | 3.60 | 4.40 | 1.0 |
| 5.00 | 4.50 | 5.50 | 1.0 |
| 5.33 | 4.80 | 5.90 | 1.2 |
| 5.70 | 5.10 | 6.30 | 1.2 |
| 6.00 | 5.60 | 6.60 | 1.2 |
| 6.99 | 6.30 | 7.70 | 1.5 |
| 8.00 | 7.20 | 8.80 | 1.5 |
| 8.40 | 7.55 | 9.20 | 2.0 |

*$r_2$ maximum 0.2*



# O-ring production

**Seal Engineering AS has several thousand O-ring dimensions in different materials in stock, but we are also able to manufacture O-rings either by turning or by warm vulcanization of O-ring cord. As a result of this we are able offer same day delivery of any size up to 1500 mm outside diameter for turned O-rings, and infinite diameter for warm vulcanized O-rings.**

The major advantage of turned O-rings is the absence of the somewhat weaker joint found in vulcanized or glued O-rings. In addition Seal Engineering AS offers greater flexibility regarding cross section for turned O-rings as all cross sections from 1.6 mm and upwards are available. Turned O-rings have all the same application areas as moulded O-rings.
We offer turned O-rings in materials such as NBR, HNBR, FKM (Viton®), EPDM, FEPM (Aflas®), VMQ (Silicone), different PU materials and PTFE-based materials.

Warm vulcanization is a superior joining process compared to gluing. However, these types of O-rings are mainly recommended for static seals. We offer warm vulcanized O-rings in materials such as NBR, EPDM, FKM, Viton®GF, VMQ (Silicone) and PU . Other materials are available on request. Tolerance on inside diameter for warm vulcanized O-rings is ± 0.5%.

# O-ring dimensions

O-rings are available in almost any dimension, however some dimensions are more widely used than others and act as a standard both with regards to diameter and cross section.

From a designers viewpoint we recommend the use either of standard "BS 1806" or "SMS 1586". The following pages list the dimensions for those two standards.

*Table 10*

| O-rings – SMS 1586 standard dimensions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **$d_2$ 1,60** | | **$d_2$ 2,40** | | **$d_2$ 3,00** | | **$d_2$ 5,70** | | **$d_2$ 8,40** | |
| **$d_1$** | **$d_2$** | **$d_1$** | **$d_2$** | **$d_1$** | **$d_2$** | **$d_1$** | **$d_2$** | **$d_1$** | **$d_2$** |
| 3,10 | 1,60 | 3,30 | 2,40 | 19,20 | 3,00 | 44,20 | 5,70 | 144,10 | 8,40 |
| 4,10 | 1,60 | 4,30 | 2,40 | 22,20 | 3,00 | 49,20 | 5,70 | 149,10 | 8,40 |
| 5,10 | 1,60 | 5,30 | 2,40 | 24,20 | 3,00 | 54,20 | 5,70 | 154,10 | 8,40 |
| 6,10 | 1,60 | 6,30 | 2,40 | 26,20 | 3,00 | 59,20 | 5,70 | 159,10 | 8,40 |
| 7,10 | 1,60 | 7,30 | 2,40 | 29,20 | 3,00 | 64,20 | 5,70 | 164,10 | 8,40 |
| 8,10 | 1,60 | 8,30 | 2,40 | 32,20 | 3,00 | 69,20 | 5,70 | 169,10 | 8,40 |
| 9,10 | 1,60 | 9,30 | 2,40 | 34,20 | 3,00 | 74,20 | 5,70 | 174,10 | 8,40 |
| 10,10 | 1,60 | 10,30 | 2,40 | 36,20 | 3,00 | 79,20 | 5,70 | 179,10 | 8,40 |
| 11,10 | 1,60 | 11,30 | 2,40 | 39,20 | 3,00 | 84,10 | 5,70 | 184,10 | 8,40 |
| 12,10 | 1,60 | 12,30 | 2,40 | 42,20 | 3,00 | 89,10 | 5,70 | 189,10 | 8,40 |
| 13,10 | 1,60 | 13,30 | 2,40 | 44,20 | 3,00 | 94,10 | 5,70 | 194,10 | 8,40 |
| 14,10 | 1,60 | 14,30 | 2,40 | 49,50 | 3,00 | 99,10 | 5,70 | 199,10 | 8,40 |
| 15,10 | 1,60 | 15,30 | 2,40 | 54,50 | 3,00 | 104,10 | 5,70 | 209,10 | 8,40 |
| 16,10 | 1,60 | 16,30 | 2,40 | 59,50 | 3,00 | 109,10 | 5,70 | 219,10 | 8,40 |
| 17,10 | 1,60 | 17,30 | 2,40 | 64,50 | 3,00 | 114,30 | 5,70 | 229,10 | 8,40 |
| 18,10 | 1,60 | | | 69,50 | 3,00 | 119,30 | 5,70 | 239,10 | 8,40 |
| 19,10 | 1,60 | | | 74,50 | 3,00 | 124,30 | 5,70 | 249,10 | 8,40 |
| 20,10 | 1,60 | | | 79,50 | 3,00 | 129,30 | 5,70 | | |
| 21,10 | 1,60 | | | 84,50 | 3,00 | 134,30 | 5,70 | | |
| 22,10 | 1,60 | | | 89,50 | 3,00 | 139,30 | 5,70 | | |

| O-rings – SMS 1586 standard dimensions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $d_2$ 1,60 | | $d_2$ 2,40 | | $d_2$ 3,00 | | $d_2$ 5,70 | | $d_2$ 8,40 | |
| $d_1$ | $d_2$ | $d_1$ | $d_2$ | $d_1$ | $d_2$ | $d_1$ | $d_2$ | $d_1$ | $d_2$ |
| 23,10 | 1,60 | | | 94,50 | 3,00 | 144,30 | 5,70 | | |
| 24,10 | 1,60 | | | 99,50 | 3,00 | 149,30 | 5,70 | | |
| 25,10 | 1,60 | | | 104,50 | 3,00 | 154,30 | 5,70 | | |
| 26,10 | 1,60 | | | 108,50 | 3,00 | 159,30 | 5,70 | | |
| 27,10 | 1,60 | | | 114,50 | 3,00 | 164,30 | 5,70 | | |
| 28,10 | 1,60 | | | 119,50 | 3,00 | 169,30 | 5,70 | | |
| 29,10 | 1,60 | | | 124,50 | 3,00 | 174,30 | 5,70 | | |
| 30,10 | 1,60 | | | 129,50 | 3,00 | 179,30 | 5,70 | | |
| 31,10 | 1,60 | | | 134,50 | 3,00 | 184,30 | 5,70 | | |
| 32,10 | 1,60 | | | 139,50 | 3,00 | 189,30 | 5,70 | | |
| 33,10 | 1,60 | | | 144,50 | 3,00 | 194,30 | 5,70 | | |
| 34,10 | 1,60 | | | | | 199,30 | 5,70 | | |
| 35,10 | 1,60 | | | | | 209,30 | 5,70 | | |
| 36,10 | 1,60 | | | | | 219,30 | 5,70 | | |
| 37,10 | 1,60 | | | | | 229,30 | 5,70 | | |
| | | | | | | 239,50 | 5,70 | | |
| | | | | | | 249,30 | 5,70 | | |
| | | | | | | 259,30 | 5,70 | | |
| | | | | | | 269,30 | 5,70 | | |
| | | | | | | 279,30 | 5,70 | | |
| | | | | | | 289,30 | 5,70 | | |
| | | | | | | 299,30 | 5,70 | | |
| | | | | | | 319,30 | 5,70 | | |
| | | | | | | 339,30 | 5,70 | | |
| | | | | | | 359,30 | 5,70 | | |
| | | | | | | 379,30 | 5,70 | | |
| | | | | | | 399,30 | 5,70 | | |
| | | | | | | 419,30 | 5,70 | | |
| | | | | | | 439,30 | 5,70 | | |
| | | | | | | 459,30 | 5,70 | | |
| | | | | | | 479,30 | 5,70 | | |
| | | | | | | 499,30 | 5,70 | | |



*Table 11*

| BS standard dimensions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $d_2$ | 1,78 | $d_2$ | 2,62 | $d_2$ | 3,53 | $d_2$ | 5,33 | $d_2$ | 6,99 |
| BS no. | d1 | BS no. | d1 | BS no. | d1 | BS no. | d1 | BS no. | d1 |
| BS 001* | 0,74 | BS 102 | 1,24 | BS 201 | 4,34 | BS 309 | 10,46 | BS 425 | 113,67 |
| BS 002* | 1,07 | BS 103 | 2,06 | BS 202 | 5,94 | BS 310 | 12,07 | BS 426 | 116,84 |
| BS 003* | 1,42 | BS 104 | 2,84 | BS 203 | 7,52 | BS 311 | 13,64 | BS 427 | 120,02 |
| BS 004 | 1,78 | BS 105 | 3,63 | BS 204 | 9,12 | BS 312 | 15,24 | BS 428 | 123,19 |
| BS 005 | 2,57 | BS 106 | 4,42 | BS 205 | 10,69 | BS 313 | 16,81 | BS 429 | 126,37 |
| BS 006 | 2,90 | BS 107 | 5,23 | BS 206 | 12,29 | BS 314 | 18,42 | BS 430 | 129,54 |
| BS 007 | 3,68 | BS 108 | 6,02 | BS 207 | 13,87 | BS 315 | 19,99 | BS 431 | 132,72 |
| BS 008 | 4,47 | BS 109 | 7,59 | BS 208 | 15,47 | BS 316 | 21,59 | BS 432 | 135,89 |
| BS 009 | 5,28 | BS 110 | 9,19 | BS 209 | 17,04 | BS 317 | 23,16 | BS 433 | 139,07 |
| BS 010 | 6,07 | BS 111 | 10,77 | BS 210 | 18,64 | BS 318 | 24,77 | BS 434 | 142,24 |
| BS 011 | 7,65 | BS 112 | 12,37 | BS 211 | 20,22 | BS 319 | 26,34 | BS 435 | 145,42 |
| BS 012 | 9,25 | BS 113 | 13,94 | BS 212 | 21,82 | BS 320 | 27,94 | BS 436 | 148,59 |
| BS 013 | 10,82 | BS 114 | 15,54 | BS 213 | 23,39 | BS 321 | 29,51 | BS 437 | 151,77 |
| BS 014 | 12,42 | BS 115 | 17,12 | BS 214 | 24,99 | BS 322 | 31,12 | BS 438 | 158,12 |
| BS 015 | 14,00 | BS 116 | 18,72 | BS 215 | 26,57 | BS 323 | 32,69 | BS 439 | 164,47 |
| BS 016 | 15,60 | BS 117 | 20,29 | BS 216 | 28,17 | BS 324 | 34,29 | BS 440 | 170,82 |
| BS 017 | 17,17 | BS 118 | 21,89 | BS 217 | 29,74 | BS 325 | 37,47 | BS 441 | 177,17 |
| BS 018 | 18,77 | BS 119 | 23,47 | BS 218 | 31,34 | BS 326 | 40,64 | BS 442 | 183,52 |
| BS 019 | 20,35 | BS 120 | 25,07 | BS 219 | 32,92 | BS 327 | 43,82 | BS 443 | 189,87 |
| BS 020 | 21,95 | BS 121 | 26,64 | BS 220 | 34,52 | BS 328 | 46,99 | BS 444 | 196,22 |
| BS 021 | 23,52 | BS 122 | 28,24 | BS 221 | 36,09 | BS 329 | 50,17 | BS 445 | 202,57 |
| BS 022 | 25,12 | BS 123 | 29,82 | BS 222 | 37,69 | BS 330 | 53,34 | BS 446 | 215,27 |
| BS 023 | 26,70 | BS 124 | 31,42 | BS 223 | 40,87 | BS 331 | 56,52 | BS 447 | 227,97 |
| BS 024 | 28,30 | BS 125 | 32,99 | BS 224 | 44,04 | BS 332 | 59,69 | BS 448 | 240,67 |
| BS 025 | 29,87 | BS 126 | 34,59 | BS 225 | 47,22 | BS 333 | 62,87 | BS 449 | 253,37 |
| BS 026 | 31,47 | BS 127 | 36,17 | BS 226 | 50,39 | BS 334 | 66,04 | BS 450 | 266,07 |
| BS 027 | 33,05 | BS 128 | 37,77 | BS 227 | 53,57 | BS 335 | 69,22 | BS 451 | 278,77 |
| BS 028 | 34,65 | BS 129 | 39,34 | BS 228 | 56,74 | BS 336 | 72,39 | BS 452 | 291,47 |
| BS 029 | 37,82 | BS 130 | 40,94 | BS 229 | 59,92 | BS 337 | 75,57 | BS 453 | 304,17 |
| BS 030 | 41,00 | BS 131 | 42,52 | BS 230 | 63,09 | BS 338 | 78,74 | BS 454 | 316,87 |
| BS 031 | 44,17 | BS 132 | 44,12 | BS 231 | 66,27 | BS 339 | 81,92 | BS 455 | 329,57 |
| BS 032 | 47,35 | BS 133 | 45,69 | BS 232 | 69,44 | BS 340 | 85,09 | BS 456 | 342,27 |
| BS 033 | 50,52 | BS 134 | 47,29 | BS 233 | 72,62 | BS 341 | 88,27 | BS 457 | 354,97 |
| BS 034 | 53,70 | BS 135 | 48,90 | BS 234 | 75,79 | BS 342 | 91,44 | BS 458 | 367,67 |
| BS 035 | 56,87 | BS 136 | 50,47 | BS 235 | 78,97 | BS 343 | 94,62 | BS 459 | 380,37 |
| BS 036 | 60,05 | BS 137 | 52,07 | BS 236 | 82,14 | BS 344 | 97,79 | BS 460 | 393,07 |
| BS 037 | 63,22 | BS 138 | 53,64 | BS 237 | 85,32 | BS 345 | 100,97 | BS 461 | 405,26 |
| BS 038 | 66,40 | BS 139 | 55,25 | BS 238 | 88,49 | BS 346 | 104,14 | BS 462 | 417,96 |
| BS 039 | 69,57 | BS 140 | 56,82 | BS 239 | 91,67 | BS 347 | 107,32 | BS 463 | 430,66 |
| BS 040 | 72,75 | BS 141 | 58,42 | BS 240 | 94,84 | BS 348 | 110,49 | BS 464 | 443,36 |
| BS 041 | 75,92 | BS 142 | 59,99 | BS 241 | 98,02 | BS 349 | 113,67 | BS 465 | 456,03 |
| BS 042 | 82,27 | BS 143 | 61,60 | BS 242 | 101,19 | BS 350 | 116,84 | BS 466 | 468,76 |
| BS 043 | 88,62 | BS 144 | 63,17 | BS 243 | 104,37 | BS 351 | 120,02 | BS 467 | 481,46 |
| BS 044 | 94,97 | BS 145 | 64,77 | BS 244 | 107,54 | BS 352 | 123,19 | BS 468 | 494,16 |

* cross section 1.02, 1.27, 1.52 respectively

| BS standard dimensions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $d_2$ | 1,78 | $d_2$ | 2,62 | $d_2$ | 3,53 | $d_2$ | 5,33 | $d_2$ | 6,99 |
| **BS no.** | **d1** | **BS no.** | **d1** | **BS no.** | **d1** | **BS no.** | **d1** | **BS no.** | **d1** |
| BS 045 | 101,32 | BS 146 | 66,34 | BS 245 | 110,72 | BS 353 | 126,37 | BS 469 | 506,86 |
| BS 046 | 107,67 | BS 147 | 67,95 | BS 246 | 113,89 | BS 354 | 129,54 | BS 470 | 532,26 |
| BS 047 | 114,02 | BS 148 | 69,52 | BS 247 | 117,07 | BS 355 | 132,72 | BS 471 | 557,66 |
| BS 048 | 120,37 | BS 149 | 71,12 | BS 248 | 120,24 | BS 356 | 135,89 | BS 472 | 582,68 |
| BS 049 | 126,72 | BS 150 | 72,69 | BS 249 | 123,42 | BS 357 | 139,07 | BS 473 | 608,08 |
| BS 050 | 133,07 | BS 151 | 75,87 | BS 250 | 126,59 | BS 358 | 142,24 | BS 474 | 633,48 |
| | | BS 152 | 82,22 | BS 251 | 129,77 | BS 359 | 145,42 | BS 475 | 658,88 |
| | | BS 153 | 88,57 | BS 252 | 132,94 | BS 360 | 148,59 | | |
| | | BS 154 | 94,92 | BS 253 | 136,12 | BS 361 | 151,77 | | |
| | | BS 155 | 101,27 | BS 254 | 139,29 | BS 362 | 158,12 | | |
| | | BS 156 | 107,62 | BS 255 | 142,47 | BS 363 | 164,47 | | |
| | | BS 157 | 113,97 | BS 256 | 145,64 | BS 364 | 170,82 | | |
| | | BS 158 | 120,32 | BS 257 | 148,82 | BS 365 | 177,17 | | |
| | | BS 159 | 126,67 | BS 258 | 151,99 | BS 366 | 183,52 | | |
| | | BS 160 | 133,02 | BS 259 | 158,34 | BS 367 | 189,87 | | |
| | | BS 161 | 139,37 | BS 260 | 164,69 | BS 368 | 196,22 | | |
| | | BS 162 | 145,72 | BS 261 | 171,04 | BS 369 | 202,57 | | |
| | | BS 163 | 152,07 | BS 262 | 177,39 | BS 370 | 208,92 | | |
| | | BS 164 | 158,42 | BS 263 | 183,74 | BS 371 | 215,27 | | |
| | | BS 165 | 164,77 | BS 264 | 190,09 | BS 372 | 221,62 | | |
| | | BS 166 | 171,12 | BS 265 | 196,44 | BS 373 | 227,97 | | |
| | | BS 167 | 177,47 | BS 266 | 202,79 | BS 374 | 234,32 | | |
| | | BS 168 | 183,82 | BS 267 | 209,14 | BS 375 | 240,67 | | |
| | | BS 169 | 190,17 | BS 268 | 215,49 | BS 376 | 247,02 | | |
| | | BS 170 | 196,52 | BS 269 | 221,84 | BS 377 | 253,37 | | |
| | | BS 171 | 202,87 | BS 270 | 228,19 | BS 378 | 266,07 | | |
| | | BS 172 | 209,22 | BS 271 | 234,54 | BS 379 | 278,77 | | |
| | | BS 173 | 215,57 | BS 272 | 240,89 | BS 380 | 291,47 | | |
| | | BS 174 | 221,92 | BS 273 | 247,24 | BS 381 | 304,17 | | |
| | | BS 175 | 228,27 | BS 274 | 253,59 | BS 382 | 329,57 | | |
| | | BS 176 | 234,62 | BS 275 | 266,29 | BS 383 | 354,97 | | |
| | | BS 177 | 240,97 | BS 276 | 278,99 | BS 384 | 380,37 | | |
| | | BS 178 | 247,32 | BS 277 | 291,69 | BS 385 | 405,26 | | |
| | | | | BS 278 | 304,39 | BS 386 | 430,66 | | |
| | | | | BS 279 | 329,79 | BS 387 | 456,06 | | |
| | | | | BS 280 | 355,19 | BS 388 | 481,41 | | |
| | | | | BS 281 | 380,59 | BS 389 | 506,81 | | |
| | | | | BS 282 | 405,26 | BS 390 | 532,21 | | |
| | | | | BS 283 | 430,66 | BS 391 | 557,61 | | |
| | | | | BS 284 | 456,06 | BS 392 | 582,68 | | |
| | | | | | | BS 393 | 608,08 | | |
| | | | | | | BS 394 | 633,48 | | |
| | | | | | | BS 395 | 658,88 | | |



# O-ring replacements

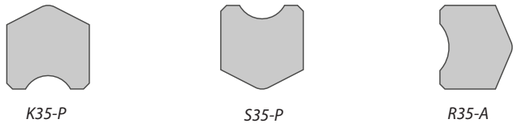
**Although the O-ring is the worlds most widely used seal, the design has certain limitations regarding sealability, pressure resistance and dynamic sealing.**

**Seal Engineering AS offers O-ring replacements suitable for improved sealing, higher pressures and also for dynamic sealing, while maintaining the key features for the O-ring's success: simple design, easy assembly and relatively small grooves.**

## K35-P for dynamic applications

Profile K35-P is a single piece double acting compact seal developed for a wide range of static and dynamic applications. The seal profile is optimized for PU materials, which in combination with the compact seal geometry lead to high pressure resistance and long service life.

The K35-P is an optimized alternative to conventional O-rings, especially for dynamic applications. The K35-P is for outside sealing, but we also offer profile S35-P for inside sealing and R35-P for axial sealing. The description of K35-P also applies for S35-P and R35-P.



*K35-P* *S35-P* *R35-A*

Since the K35-P profile is designed with a radial preload of the cross section, no activating pressure is needed for low pressure ranges to obtain a compact sealing, as is often the case for standard lipseals. At higher pressure the deformation of the cross section generates a contact pressure distribution in the area of the sealing gap which leads to excellent dynamic sealing, also for increased speeds. Meanwhile the risk of gap extrusion is minimised by the seal geometry and choice of material.
The seal geometry has almost no dead spots, and this makes it suitable for food and drug industry (cleaning and sterilization purposes).

K35-P is available for outside diameters up to 1500 mm for same day delivery, and can be supplied in outside diameter up to 4000 mm.

For applications with working temperature above 110 °C, or media not suitable for polyurethane, K35-P can also be supplied in elastomer materials. See "Materials overview" to find the suitable material.

*Table 12*

**Operating conditions:**

| Material | Temperature | Max surface speed | Max pressure* |
|---|---|---|---|
| HPU | -20 to 110 °C | 0.4 m/s | 400 bar |
| SPU | -20 to 110 °C | 0.5 m/s | 400 bar |
| LPU | -50 to 110 °C | 0.4 m/s | 400 bar |

Please note that it is not recommended to use all maximum values simultaneously. Surface speed limits apply only in the presence of adequate lubrication.

** Pressure rating is dependent on the size of the extrusion gap.*

The cross section of the K35-P is adaptable for almost all existing groove dimensions. These seals are normally very easy to install, as they can be snapped into closed grooves.
For design purposes we recommend a ratio of cross section/height (L) of 1:1.35.

Compared to O-rings the K35-P profile has the following advantages:

- High resistance to pressure and extrusion.
- Excellent dynamic sealing.
- Outstanding sealing behaviour over long periods.
- Long service life.
- Low compression set.
- No twisting in the groove.
- No relative movement during pressure cycles.
- No additional backup ring needed.
- Good compensation for production tolerances.

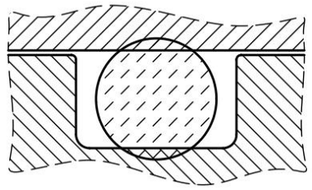


*Fig 22, O-ring groove with O-ring*

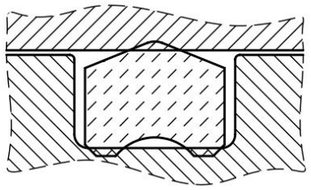


*Fig 23, Similar groove with K35-P*

**S20-R and K20-R for dynamic applications**

*S20-R*

*K20-R*

Space saving compact seals, suitable for standard O-Ring housings. Integrated active back-up rings for high pressure. Design with press respectively stretch fit prevents twisting in dynamic applications. Available in a wide range of material combination.

## R14

Profile R14 is a square ring, and can be delivered with or without chamfer. For static sealing no chamfer is necessary, but for other applications we deliver with suitable chamfer.
The R14 profile usually has a square cross section, but can also be manufactured to other dimensions. This profile can be used in the same housings as O-rings, and with the same demands for surface roughness.

R14 is an excellent alternative to O-rings for axial static sealing, especially for high pressures or large extrusion gaps. The square form remains practically constant even at high pressures.

The R14 profile is resistant to pressures above 500 bar, depending on the gap and material choice. For high pressure applications contact Seal Engineering AS for detailed information.

As an O-ring replacement R14 is normally manufactured in either one of our outstanding PU or elastomer (rubber) compounds. However, we can supply the R14 profile in almost any material, suitable to cover most demands regarding pressure, media, and sealability. Dimensions up to 1500 mm outside diameter are available for same day delivery.

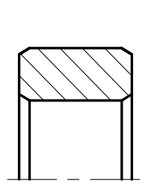


*Fig. 24, Profile R14 with chamfer.*

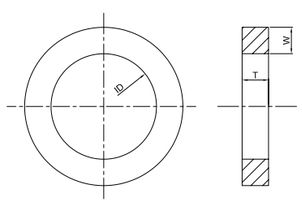
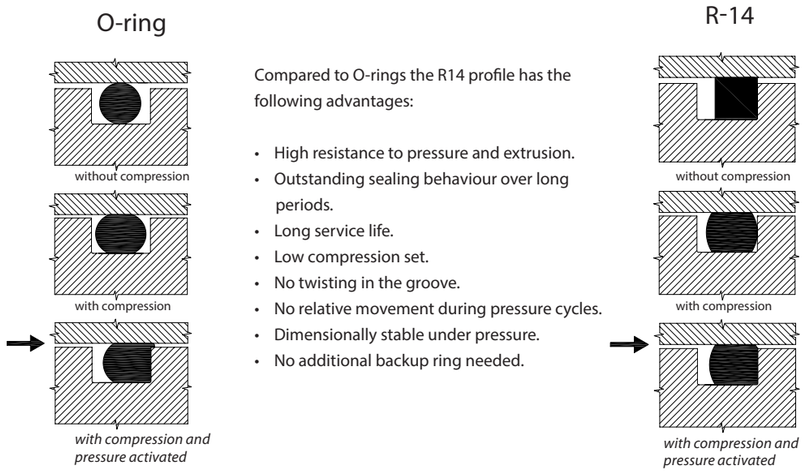



*Fig. 25, Profile R14 without chamfer*




Compared to O-rings the R14 profile has the following advantages:

- High resistance to pressure and extrusion.
- Outstanding sealing behaviour over long periods.
- Long service life.
- Low compression set.
- No twisting in the groove.
- No relative movement during pressure cycles.
- Dimensionally stable under pressure.
- No additional backup ring needed.

*Fig. 26, Comparison between O-ring and R14.*

## R15-P

The R15 profile is designed for radial static sealing, and can replace O-rings or O-rings with backup rings. The O-ring or O-ring with backup ring solution has weaknesses since the O-ring may become twisted during assembly and/or the backup ring may not be ideally positioned. In high pressure applications with limited space, the use of backup ring may also be restricted.

The design of the R15 profile eliminates these problems, and the seal is also capable of pressures of 500 bar with a radial gap of 0.2 mm. In addition this profile can be used in the same grooves as O-rings, with the same surface finish requirements.

The geometry with the dual sealing lip bridges production tolerances and it also makes for easy assembly.

The R15 seal is available in PU and elastomers up to 1500 mm outside diameter for same day delivery.

Compared to O-rings the R15 profile has the following advantages:

- High resistance to pressure and extrusion.
- Outstanding sealing behaviour over long periods.
- Long service life.
- Low compression set.
- No twisting in the groove.
- No relative movement during pressure cycles.
- Dimensionally stable under pressure.
- No additional backup ring needed.
- Good compensation for production tolerances.

*R15-P*

# Material specifications

In this chapter we present three tables with more detailed information regarding our standard materials for turning of seals.
Table 1 lists general thermal, mechanical, electric and chemical properties.

Table 2 has more detailed information of material compatibility for various specific chemicals.

Table 3 lists material compatibility for many commonly used pressure fluids.

When using these tables to find a suitable material for your application pay extra attention to temperature and concentration of the chemical whenever this is listed. These factors may greatly influence on the mechanical and chemical properties of the material.

For technical advice, information for materials not listed or data sheets on specific materials contact Seal Engineering AS.

*Table 1*

| PROPERTIES* | Test method | Unit | HPU | SPU | LPU | XHPU | XSPU |
|---|---|---|---|---|---|---|---|
| **Colour** | - | - | red | antra-cithe | blue | dark red | dark grey |
| **Density** | DIN 53479 | g/cm³ | 1.2 | 1.24 | 1.17 | 1.22 | 1.26 |
| **THERMAL PROPERTIES** | | | | | | | |
| **Glass transition temperature (1)** | - | °C | - | - | - | - | - |
| Max. Service temperature | - | °C | 110 | 110 | 110 | 110 | 110 |
| Min. service temperature | - | °C | -20 | -20 | -50 | -20 | -20 |
| **MECHANICAL PROPERTIES** | | | | | | | |
| **Tensile test (2)** | | | | | | | |
| -Tensile strength (3) | DIN 53504 | MPa | 50 | 50 | 50 | 53 | 45 |
| -Elongation at break (3) | DIN 53504 | % | 330 | 380 | 450 | 350 | 350 |
| -100% modulus (3) | DIN 53504 | MPa | 13 | 17 | 12 | 20 | 24 |
| **Compression set (4)** | | | | | | | |
| -after 24h at 70°C/20% deformation | - | % | 27 | 25 | - | 26 | 24 |
| -after 24h at 100°C/20% deformation | - | % | 33 | 30 | - | 30 | 30 |
| -after 70h at 70°C/20% deformation | DIN 53517 | % | 20 | - | 20 | - | - |
| **Tear strength** | DIN 53515 | N/mm | 100 | 120 | 80 | 140 | 160 |
| **Rebound resilience** | | | 29 | - | 50 | - | - |
| **Abrasion** | DIN 53516 | mm³ | 17 | 17 | 15 | 20 | 20 |
| **Durometer hardness Shore A (5)** | DIN 53505 | - | 95 | 95 | 95 | - | - |
| **Durometer hardness Shore D (5)** | DIN 53505 | - | - | - | - | 60 | 57 |
| **ELECTRICAL PROPERTIES** | | | | | | | |
| **-Electric strength (6)** | IEC 60243 | kV/mm | - | - | - | - | - |
| **-Volume resistivity** | IEC 60093 | Ω cm | >10¹⁰ | >10¹⁰ | >10¹⁰ | >10¹⁰ | >10¹⁰ |
| **-Relative permittivity ER at 50Hz/ 1MHz** | IEC 60250 | - | -/- | -/- | -/- | -/- | -/- |
| **-Dielectric dissipation factor tan d at 50Hz/1MHz** | IEC 60250 | - | -/- | -/- | -/- | -/- | -/- |
| **CHEMICAL & ENVIRONMENTAL RESISTANCE (7)** | | | | | | | |
| **Acids** | | | | | | | |
| -inorganic diluted | | | + | 0 | - | + | + |
| -inorganic consentrated | | | - | - | - | - | - |
| -organic diluted | | | + | + | 0 | + | + |
| -organic consentrated | | | 0 | 0 | - | 0 | 0 |
| **Alkalies -general** | | | 0 | 0 | - | 0 | 0 |
| **Alcohol -general (excl. Methanol)** | | | + | + | - | + | + |
| **Biocides** | | | | | | | |
| -diluted | | | + | + | 0 | + | + |
| -consentrated | | | - | - | - | - | - |
| **Brines -general** | | | + | + | 0 | + | + |
| **Carbon dioxide** | | | + | + | 0 | + | + |
| **Corrosion inhibitors** | | | | | | | |
| -amine based | | | 0 | 0 | - | 0 | 0 |
| -potassium based | | | + | + | 0 | + | + |
| **Crude oil** | | | | | | | |
| -sweet | | | + | + | + | + | + |
| -sour; up to 5% H2S | | | + | + | 0 | + | + |
| -sour; above 5% H2S | | | + | 0 | - | + | 0 |

| PROPERTIES* | Test method | Unit | HPU | SPU | LPU | XHPU | XSPU |
|---|---|---|---|---|---|---|---|
| **Drilling mud** | | | | | | | |
| -diesel based | | | + | + | 0 | + | + |
| -ester based | | | 0 | 0 | - | 0 | 0 |
| -mineral oil based | | | + | + | + | + | + |
| -silicate based | | | + | + | 0 | + | + |
| **Glycols -general** | | | 0 | 0 | - | 0 | 0 |
| **Hydraulic fluids** | | | | | | | |
| -mineral oil based (at 23°C/60°C) | | | +/+ | +/+ | +/+ | +/+ | +/+ |
| **-synthetic oils** | | | | | | | |
| -HETG (triglyceride) (at 23°C/60°C) | | | +/+ | +/+ | +/0 | +/+ | +/+ |
| -HEES (synthetic ester) (at 23°C/60°C) | | | +/+ | +/+ | +/0 | +/+ | +/+ |
| -HEPG (polyglycols) (at 23°C/60°C) | | | +/0 | +/0 | 0/- | +/0 | +/0 |
| -HEPR (Polyalphaolefines) (at 23°C/60°C) | | | +/+ | +/+ | +/0 | +/+ | +/+ |
| **-Fire resistant fluids** | | | | | | | |
| **-HFA (water-oil emulsion)** | | | | | | | |
| -HFA-E (at 23°C/60°C) | | | +/+ | +/+ | -/- | +/+ | +/+ |
| -HFA-S (at 23°C/60°C) | | | +/+ | +/+ | -/- | +/+ | +/+ |
| -HFB (oil-water emulsion) (at 23°C/60°C) | | | +/+ | +/+ | -/- | +/+ | +/+ |
| -HFC (water-glycol) (at 23°C/60°C) | | | 0/0 | 0/0 | -/- | 0/0 | +/0 |
| -HFD (water free) | | | | | | | |
| -HFD-R (at 23°C/60°C) | | | -/- | -/- | -/- | -/- | -/- |
| -HFD-S (at 23°C/60°C) | | | -/- | -/- | -/- | -/- | -/- |
| -HFD-T (at 23°C/60°C) | | | -/- | -/- | -/- | -/- | -/- |
| -HFD-U (at 23°C/60°C) | | | +/+ | +/+ | 0/0 | +/+ | +/+ |
| **Hydrocarbons** | | | | | | | |
| -aliphatic | | | + | + | + | + | + |
| -aromatic | | | - | - | - | - | - |
| **Hydrogen sulphide** | | | + | + | - | + | + |
| **Methanol** | | | | | | | |
| -diluted | | | + | + | 0 | + | + |
| -consentrated | | | 0 | 0 | - | 0 | 0 |
| **Natural gas (Methane CH4)** | | | + | + | 0 | + | + |
| **Sea water** | | | + | + | - | + | + |
| **Solvents** | | | | | | | |
| -Toluene | | | - | - | - | - | - |
| -Acetone | | | - | - | - | - | - |
| -MEK (Methyl-Ethyl-Ketone) | | | - | - | - | - | - |
| **Steam** | | | - | - | - | - | - |
| **Water** | | | | | | | |
| -general (at 23°C/60°C) | | | +/+ | +/+ | -/- | +/+ | +/+ |
| -produced | | | + | + | - | + | + |
| -treated | | | 0 | 0 | - | 0 | 0 |
| **UV radiation** | | | + | + | + | + | + |
| **Food contact** | | | F | NA | NA | F | NA |

* All tests performed at 23°C, except when other temperatures are listed.
**(1)** Values for this property are derived from DMA-analysis and are defined as the maximum of the loss modulus curves. **(2)** Test specimens: Type S2.
**(3)** Test speed: 200mm/min. **(4)** Tests were done on discs ø13x6,3mm. Compression rating 20%. Test specimens are stored at elevated temperature in an air circulating oven for defined periods. Compression set represents the percent of deflection that did not return. **(5)** 6,3mm thick test specimens.
**(6)** Electrode configuration: ø25/ø75mm coaxial cylinders; in transformer oil according to IEC 60296: 1mm thick test specimens (natural coloured). It is important to know that the electric strength of black material can be as low as 50% of the value of natural material.
**(7)** Symbolic of the rating: **+** [Excellent] **0** [Moderate/fair] **-** [Not recommended]
**NA** [No data available] **F** [Suitable for food-stuff applications]
This table is a valuable help in choice of a material. The data listed here fall within the normal range of product properties. However, they are not guaranteed and they should not be used to establish material specification limits alone as the basis of design.

| PROPERTIES* | Test method | Unit | RU1 | RU2 | RU3 | RU4 | RU5 | RU6 |
|---|---|---|---|---|---|---|---|---|
| | | | NBR | FKM | EPDM | H-NBR | VMQ | FEPM |
| **Colour** | - | - | black | brown | black | black | reddish brown | black |
| **Density** | DIN 53479 | g/cm$^3$ | 1.31 | 2.3 | 1.22 | 1.22 | 1.52 | 1.6 |
| **THERMAL PROPERTIES** | | | | | | | | |
| **Melting temperature** | - | °C | - | - | - | - | - | |
| **Glass transition temperature (1)** | - | °C | -23 | -12 | -47 | -27 | - | 4 |
| **Max. Service temperature** | - | °C | 100 | 200 | 150 | 150 | 200 | 200 |
| **Min. service temperature** | - | °C | -30 | -20 | -50 | -25 | -60 | 0 |
| **Mechanical Properties at 23°C** | | | | | | | | |
| **Tensile test (2)** | | | | | | | | |
| -Tensile strength (3) | DIN 53504 | MPa | 16 | 8 | 12 | 18 | 7 | 15 |
| -Elongation at break (3) | DIN 53504 | % | 130 | 200 | 110 | 180 | 130 | 200 |
| -100% modulus (3) | DIN 53504 | MPa | 11 | 5 | 9 | 10 | 5 | 8 |
| **Compression set (4)** | | | | | | | | |
| -after 22h at 100°C | DIN 53517 | % | 15 | - | 15 | 22 | - | - |
| -after 22h at 175°C | DIN 53517 | % | - | 20 | - | - | 15 | 30 |
| **Tear strength** | DIN 53515 | N/mm | 20 | 21 | 15 | 30 | 8 | 22 |
| **Rebound resilience** | DIN 53512 | % | 28 | 7 | 38 | 29 | 44 | - |
| **Abrasion** | DIN 53516 | mm | 90 | 150 | 120 | 90 | - | 110 |
| **Durometer hardness Shore A (5)** | DIN 53505 | - | 85 | 85 | 85 | 85 | 85 | 80 |
| **Electrical properties** | | | | | | | | |
| **-Electric strength (6)** | IEC 60243 | kV/mm | - | 20 | - | - | - | - |
| **-Volume resistivity** | IEC 60093 | Ω cm | >$10^{10}$ | >$10^{13}$ | >$10^{16}$ | - | >$10^{16}$ | - |
| **-Relative permittivity ER at 50Hz/1MHz** | IEC 60250 | - | 20/- | -/- | 2.5/2.5 | - | 2.8/- | - |
| **-Dielectric dissipation factor tan d at 50Hz/1MHz** | IEC 60250 | - | 0.2/- | -/- | -/- | - | 0.001/- | - |
| **Chemical & Environmental resistance (7)** | | | | | | | | |
| **Acids** | | | | | | | | |
| -inorganic diluted | | | 0 | + | + | 0 | NA | + |
| -inorganic consentrated | | | - | + | + | - | NA | + |
| -organic diluted | | | + | + | + | + | NA | + |
| -organic consentrated | | | - | - | + | - | NA | 0 |
| **Alkalies -general** | | | 0 | 0 | + | 0 | NA | 0 |
| **Alcohol -general (excl. Methanol)** | | | + | + | + | + | + | + |
| **Biocides** | | | | | | | | |
| -diluted | | | + | + | + | + | NA | + |
| -consentrated | | | - | - | - | - | NA | 0 |
| **Brines -general** | | | 0 | + | + | 0 | NA | + |
| **Carbon dioxide** | | | + | + | 0 | + | 0 | 0 |
| **Corrosion inhibitors** | | | | | | | | |
| -amine based | | | - | - | + | + | NA | + |
| -potassium based | | | - | - | + | 0 | NA | + |
| **Crude oil** | | | | | | | | |
| -sweet | | | + | + | - | + | NA | 0 |
| -sour; up to 5% H2S | | | - | 0 | - | 0 | NA | + |
| -sour; above 5% H2S | | | - | - | - | - | NA | + |
| **Drilling mud** | | | | | | | | |
| -diesel based | | | 0 | 0 | - | + | NA | 0 |
| -ester based | | | - | 0 | - | - | NA | 0 |

| PROPERTIES* | Test method | Unit | RU1 | RU2 | RU3 | RU4 | RU5 | RU6 |
|---|---|---|---|---|---|---|---|---|
| -mineral oil based | | | + | + | - | + | NA | + |
| -silicate based | | | 0 | + | 0 | + | NA | + |
| **Glycols -general** | | | + | + | + | + | NA | + |
| **Hydraulic fluids** | | | | | | | | |
| **-mineral oil based** | | | + | + | - | + | 0 | + |
| **-synthetic oils** | | | | | | | | |
| -HETG (triglyceride) (at 23°C/60°C) | | | 0/0 | +/+ | -/- | 0/0 | NA | +/+ |
| -HEES (synthetic ester) (at 23°C/60°C) | | | 0/0 | +/+ | -/- | 0/0 | NA | +/+ |
| -HEPG (polyglycols) (at 23°C/60°C) | | | +/+ | +/+ | +/+ | +/+ | NA | +/+ |
| -HEPR (Polyalphaolefines) (at 23°C/60°C) | | | +/0 | +/+ | -/- | +/0 | NA | +/+ |
| **-Fire resistant fluids** | | | | | | | | |
| -HFA (water-oil emulsion) | | | + | + | - | + | NA | + |
| -HFA-E (at 23°C/60°C) | | | +/+ | +/0 | -/- | +/+ | NA | +/0 |
| -HFA-S (at 23°C/60°C) | | | +/0 | +/0 | +/0 | +/0 | NA | +/0 |
| -HFB (oil-water emulsion) (at 23°C/60°C) | | | +/+ | +/+ | -/- | +/+ | NA | +/NA |
| -HFC (water-glycol) (at 23°C/60°C) | | | + | -/- | +/+ | +/+ | NA | +/NA |
| -HFD (water free) | | | | | | | | |
| -HFD-R (at 23°C/60°C) | | | -/- | 0/0 | +/+ | -/- | NA | +/NA |
| -HFD-S (at 23°C/60°C) | | | -/- | +/+ | -/- | -/- | NA | 0/NA |
| -HFD-T (at 23°C/60°C) | | | -/- | +/+ | -/- | - | NA | 0/NA |
| -HFD-U (at 23°C/60°C) | | | -/- | +/+ | -/- | -/- | NA | 0/NA |
| **Hydrocarbons** | | | | | | | | |
| -aliphatic | | | + | + | - | + | NA | + |
| -aromatic | | | 0 | + | - | 0 | NA | 0 |
| **Hydrogen sulphide** | | | - | - | + | + | - | + |
| **Methanol** | | | | | | | | |
| -diluted | | | + | + | + | + | + | + |
| -consentrated | | | 0 | - | 0 | + | + | + |
| **Natural gas (Methane CH4)** | | | + | + | - | + | - | + |
| **Sea water** | | | + | + | + | + | + | + |
| **Solvents** | | | | | | | | |
| -Toluene | | | - | + | - | - | - | 0 |
| -Acetone | | | - | - | + | - | 0 | - |
| -MEK (Methyl-Ethyl-Ketone) | | | - | - | + | - | - | - |
| **Steam** | | | - | - | + | - | - | + |
| **Water** | | | | | | | | |
| -general (at 23°C/60°C) | | | +/+ | +/+ | +/+ | +/+ | +/+ | +/+ |
| -produced | | | 0 | 0 | + | + | NA | + |
| -treated | | | 0 | - | + | + | NA | + |
| **UV radiation** | | | - | - | + | - | + | NA |
| **Food contact** | | | NA | F | F | F | F | NA |

* All tests performed at 23°C, except when other temperatures are listed.
**(1)** Values for this property are derived from DMA-analysis and are defined as the maximum of the loss modulus curves. **(2)** Test specimens: Type S. **(3)** Test speed: 200mm/min **(4)** Tests were done on discs ø13x6,3mm. Compression rating 20%. Test specimens are stored at elevated temperature in an air circulating oven for defined periods. Compression set represents the percent of deflection that did not return. **(5)** 6,3mm thick test specimens. **(6)** Electrode configuration: ø25/ø75mm coaxial cylinders; in transformer oil according to IEC 60296: 1mm thick test specimens (natural coloured).
It is important to know that the electric strength of black material can be as low as 50% of the value of natural material.

**(7) Symbolic of the rating:**
+ [Excellent]
0 [Moderate/fair]
- [Not recommended]
NA [No data available]
F [Suitable for food-stuff applications]

This table is a valuable help in choice of a material. The data listed here fall within the normal range of product properties. However, they are not guaranteed and they should not be used to establish material specification limits alone as the basis of design.



| PROPERTIES* | Test method | Unit | FL2 | FL3 | FL5 | FL13 | PA1 | POM1 | PEEK 1 |
|---|---|---|---|---|---|---|---|---|---|
| | | | PTFE w/glass and $MoSo_2$ w/15%glass fibre + 5%MoS2 | PTFE w/40% bronze | Modified PTFE | Modified PTFE w/25% carbon | Polyam-ide | Poly-acetal-copolymer | Poly-Ether-Ether-Ketone |
| **Colour** | - | - | dark grey | bronze | white | black | black | natural/ black | cream |
| **Density** | ISO1183 | g/cm3 | 2.25 | 3.0 | 2.16 | 2.10 | 1.15 | 1.41 | 1.32 |
| **Water absorption:** | | | | | | | | | |
| -after 24/96h immersion in water of 23°C | ISO 62 | mg | - | - | - | - | 44/83 | 20/37 | 5/10 |
| -after 24/96h immersion in water of 23°C | ISO 62 | % | - | - | - | - | 0.65/1.22 | 0.24/0.45 | 0.06/0.12 |
| -at saturation in air of 23°C/ 50% RH | - | % | 0.02 | - | - | - | 2.2 | 0.2 | 0.2 |
| -at saturation in water of 23°C | - | % | <0.15 | - | - | - | 8.5 | 0.85 | 0.45 |
| **Thermal Properties** | | | | | | | | | |
| Melting temperature | - | °C | 327 | 327 | 327 | 327 | 220 | 165 | 340 |
| Glass transition temperature (1) | - | °C | - | - | - | - | - | - | - |
| Thermal conductivity at 23°C | - | W/(m K) | 0.48 | - | 0.35 | - | 0.29 | 0.31 | 0.25 |
| Coefficient of lineær thermal expansion: | | | | | | | | | |
| -average value between 23 and 60°C | - | m/(m K) | - | - | - | - | 80 $10^{-6}$ | 110 $10^{-6}$ | 110 $10^{-6}$ |
| -average value between 23 and 100°C | - | m/(m K) | - | - | - | - | 90 $10^{-6}$ | 60 $10^{-6}$ | 110 $10^{-6}$ |
| -average value above 150°C | - | m/(m K) | 110 $10^{-6}$ | 60 $10^{-6}$ | 120 $10^{-6}$ | - | - | - | 65 $10^{-6}$ |
| **Max. Service temperature in air:** | | | | | | | | | |
| -for short periods (2) | - | °C | 300 | 300 | 300 | 300 | 170 | 140 | 310 |
| -continuously for 5000/20000 h (3) | - | °C | 260/260 | 260/260 | 260/260 | 260/260 | 105/90 | 115/100 | 250/250 |
| **Min. service temperature (4)** | - | °C | -200 | -200 | -200 | -200 | -40 | -50 | -60 |
| **Flammability (5)** | | | | | | | | | |
| **-Oxygen index** | ISO 4589 | % | 95 | - | - | - | 25 | 15 | 35 |
| **-according to UL 94 (thickness 1.5/3 mm)** | - | - | V-O/- | - | - | - | -/HB | -/HB | V-0/V-0 |
| **Mechanical Properties at 23°C** | | | | | | | | | |
| **Tensile test (6)** | | | | | | | | | |
| -Tensile stress at yield (7) (dry /wet) | ISO 527 | MPa | | - | - | - | 85/65 | 68/68 | 110/110 |
| -Tensile stress at break (7) (dry /wet) | ISO 527 | MPa | 18/18 | 22/22 | 30/30 | -/- | - | - | - |
| -Tensile strain at break (7) (dry/wet) | ISO 527 | % | 200/200 | 280/280 | 360/360 | -/- | 25/>50 | 35/35 | 20/20 |
| -Tensile mod. of elasticity (8) (dry/wet) | ISO 527 | MPa | - | - | - | - | 3500/ 1800 | 3100/ 3100 | 4400/ 4400 |
| **Compression test (9)** | | | | | | | | | |
| -compr. Stress at 1/2/5% nominal strain | ISO 604 | MPa | -/14/- | - | - | - | 26/51/92 | 19/35/67 | 29/57/- |
| **Hardness** | | | | | | | | | |
| Charpy impact strength - unnotched (10) | ISO 179/1eU | kJ/m² | - | - | no break | - | no break | 150 | no break |
| Charpy impact strength - notched (11) | ISO 179/1eU | kJ/m² | - | - | - | - | 3.5 | 7 | 3.5 |
| Izod impact strength - notched | ISO 180/2A | kJ/m² | 12 | - | - | - | 3.5 | 7 | 6 |
| Ball intendation hardness (12) | ISO 2039-1 | N/mm² | - | - | - | - | 165 | 140 | 230 |
| Rockwell hardness (12) | ISO 2039-2 | - | - | - | - | - | M88 | M84 | M105 |
| Shore hardness D (Tested 3 sec.) | ISO 868 | - | 60 | 64 | 59 | 65 | 77 | 82 | 86 |
| | | | | | | | | | |
| **Electrical properties (1)** | | | | | | | | | |
| -Electric strength (13) (dry/wet) | IEC 60243 | kV/ mm | -/13 | -/- | -/- | -/- | 25/17 | 20/20 | -/24 |

| PROPERTIES* | Test method | Unit | FL2 | FL3 | FL5 | FL13 | PA1 | POM1 | PEEK 1 |
|---|---|---|---|---|---|---|---|---|---|
| -Volume resistivity (dry/wet) | IEC 60093 | Ω cm | -/$10^{17}$ | -/- | -/- | -/- | $>10^{14}$/ $>10^{12}$ | $>10^{14}$/ $>10^{14}$ | -/$10^{16}$ |
| -Surface resistivity (dry/wet) | IEC 60093 | Ω | -/$10^{16}$ | -/- | -/- | -/- | $>10^{13}$/ $>10^{12}$ | $>10^{13}$/ $>10^{13}$ | -/$10^{16}$ |
| -Relative permittivity ER at 100Hz (dry/wet) / 1MHz (dry/wet) | IEC 60250 | - | 2.6/2.6 | -/- | -/- | -/- | (3.6/3.2)/ (6.6/3.7) | (3.8/3.8)/ (3.8/3.8) | ( -/-)/ (3.2/3.2) |
| -Dielectric dissipation factor tan d at 100Hz (dry/wet) / 1MHz (dry/wet) | IEC 60250 | - | <0.003/ 0.003 | -/- | -/- | -/- | (0.012/0.016)/ (0.14/0.05) | (0.003/0.008)/ (0.003/0.008) | (-/-)/ (0.001/0.002) |
| -Comparative tracking index (CTI) (dry/ wet) | IEC 60112 | - | - | - | - | - | 600/600 | 600/600 | 150 |
| **Chemical & Environmental resistance (14)** | | | | | | | | | |
| **Acids** | | | | | | | | | |
| -inorganic diluted | | | + | + | + | + | 0 | 0 | + |
| -inorganic consentrated | | | - | 0 | + | - | - | - | - |
| -organic diluted | | | + | + | + | + | 0 | 0 | + |
| -organic consentrated | | | + | + | + | + | 0 | 0 | + |
| **Alkalies -general** | | | 0 | 0 | 0 | 0 | 0 | 0 | + |
| **Alcohol -general (except Methanol)** | | | + | + | + | + | + | + | 0 |
| **Biocides** | | | | | | | | | |
| -diluted | | | + | + | + | + | + | + | + |
| -consentrated | | | + | + | + | + | - | 0 | + |
| **Brines -general** | | | + | + | + | + | 0 | + | + |
| **Carbon dioxide** | | | + | + | + | + | + | + | + |
| **Corrosion inhibitors** | | | | | | | | | |
| -amine based | | | + | + | + | + | + | + | + |
| -potassium based | | | + | + | + | + | 0 | + | + |
| **Crude oil** | | | | | | | | | |
| -sweet | | | + | + | + | + | + | + | + |
| -sour; up to 5% H2S | | | + | + | + | + | + | + | + |
| -sour; above 5% H2S | | | 0 | + | + | 0 | 0 | + | + |
| **Drilling mud** | | | | | | | | | |
| -diesel based | | | + | + | + | + | + | + | + |
| -ester based | | | + | + | + | + | + | + | + |
| -mineral oil based | | | + | + | + | + | + | + | + |
| -silicate based | | | + | + | + | + | + | + | + |
| **Glycols -general** | | | + | + | + | + | 0 | + | + |
| **Hydraulic fluids** | | | | | | | | | |
| **-mineral oil based** | | | + | + | + | + | + | + | + |
| **-synthetic oils** | | | | | | | | | |
| -HETG | | | + | + | + | + | + | + | + |
| -HEES | | | + | + | + | + | + | + | + |
| -HEPG | | | + | + | + | + | + | + | + |
| -HEPR | | | + | + | + | + | + | + | + |
| **-Fire resistant fluids** | | | | | | | | | |
| -HFA (HFA-E/HFA-S) (water-oil emulsion) | | | + | + | + | + | + | + | + |
| -HFB (oil-water emulsion) | | | + | + | + | + | + | + | + |
| -HFC (water-glycol) | | | + | + | + | + | + | + | + |
| -HFD (water free) | | | + | + | + | + | | + | + |
| -HFD-R | | | + | + | + | + | + | + | + |
| -HFD-S | | | + | + | + | + | + | + | + |
| -HFD-T | | | + | + | + | + | + | + | + |
| -HFD-U | | | + | + | + | + | + | + | + |
| **Hydrocarbons** | | | | | | | | | |
| -aliphatic | | | + | + | + | + | + | + | + |
| -aromatic | | | + | + | + | + | + | + | + |
| **Hydrogen sulphide** | | | 0 | + | + | + | - | + | + |
| **Methanol** | | | | | | | | | |
| -diluted | | | + | + | + | + | + | + | + |
| -consentrated | | | + | + | + | + | - | + | + |
| **Natural gas (Methane CH4)** | | | + | + | + | + | + | + | + |
| **Sea water** | | | + | + | + | + | 0 | + | + |
| **Solvents** | | | | | | | | | |
| -Toluene | | | 0 | + | + | + | + | + | + |
| -Acetone | | | + | + | + | + | + | + | + |
| -MEK (Methyl-Ethyl-Ketone) | | | + | + | + | + | + | 0 | + |
| **Steam** | | | + | + | + | + | - | - | + |
| **Water** | | | | | | | | | |
| -general | | | + | + | + | + | 0 | + | + |
| -produced | | | + | + | + | + | 0 | + | + |
| -treated | | | + | + | + | + | 0 | 0 | + |
| **UV radiation** | | | + | + | + | + | 0 | - | - |
| **Food contact** | | | NA | NA | F | NA | NA | F | F |

* All tests performed at 23°C, exept when other temperatures listed.
**D** Values referring to dry material
**W** Values referring to material in equilibrium with the standard atmosphere 23°C/ 50% RH (mostly derived from literature)
**(1)** Values for this property are derived from DMA-analysis and are defined as the maximum of the loss modulus curves.
**(2)** Only short time exposure (a few hours) in application where no or only a very low load is applied to the material.
**(3)** Temperature resistance over a period of min. 20.000 hours. After this period of time, there is a decrease in tensile strength of about 50% as compared with the original value. The temperature values given here are thus based on the thermal-oxidative degradation which take place and causes a reduction in properties. Note, however, that, as far as all thermoplastics, the maximum allowable service temperature depends in many cases essentially on the duration and the magnitude of the mechanical stresses to which the material is subjected.
**(4)** Impact strength decreasing with decreasing temperature, the minimum allowable service temperature is practically mainly determined by the extent to which the material is subjected to impact.
The values given here are based on unfavourable impact conditions and may consequently not be considered as being the absolute practical limits.
**(5)** These estimated ratings, derived from raw material supplier data, are not intended to reflect hazards presented by the materials under actual fire conditions. There are no UL-yellow cards available for these stock shapes.
**(6** Test specimens: Type 1B.
**(7)** Test speed: 5mm/min
**(8)** Test speed: 1mm/min
**(9)** Test specimens: cylinders with ø12x30mm
**(10)** Pendulum used: 4 J
**(11)** Pendulum used: 5J
**(12)** 10mm thick test specimens
**(13)** Electrode configuration: ø25/ø75mm coaxial cylinders; in transformer oil according to IEC 60296: 1mm thick natural coloured test specimens.
It is important to know that the electric strength of black material can be as low as 50% of the value for natural material.
**(14)** Symbolic of the rating
**+** Excellent
**0** Moderate / fair
**-** Not recommended
**NA** No data available
**F** Suitable for food-stuff applications

This table is a valuable help in the choice of material. The data listed here fall within the normal range of product properties of dry material. However, they are not guarantied and they should not be used to establish material specification limits nor used alone as basis of the design.It has to be noted that plenty of the products listed in this table are fibre reinforced and/or filled, and consequently they are anisotropic materials (properties differ when measured parallel and perpendicular to the extrusion direction.)

*Table 2*

| Chemical resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ACETALDEHYDE | 23 | 73 | - | - | - | - | + | - | 0 | + | 0 | + |
| ACETAMIDE | 23 | 73 | - | - | + | + | + | + | 0 | + | + | + |
| ACETIC ACID, GLACIAL | 70 | 158 | - | - | 0 | - | + | 0 | 0 | - | - | + |
| ACETIC ACID 10 % | 50 | 122 | 0 | - | - | + | + | - | + | - | -(0) | + |
| ACETIC ACID 50 % | 50 | 122 | - | - | - | - | + | - | 0 | - | - | + |
| ACETIC ANHYDRIDE | 23 | 73 | - | - | - | - | + | - | 0 | - | 0 | + |
| ACETONE (DIMETHYLKETONE) | 23 | 73 | - | - | - | - | + | - | 0 | + | + | + |
| ACETOPHENONE | 23 | 73 | - | - | - | - | + | - | 0 | + | + | + |
| ACETYLCHLORIDE | 23 | 73 | - | - | - | + | - | - | - | - | - | + |
| ACETYLENE | 23 | 73 | + | + | + | + | + | + | - | + | + | + |
| ACETYLENE TETRACHLORIDE | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| ACRYLONITRILE | 23 | 73 | - | - | - | - | - | - | - | + | + | + |
| ADIPIC ACID AQ. SOL. | 23 | 73 | + | 0 | + | + | + | + | 0 | n.a. | 0 | + |
| AEROSHELL FLUID 4 (SHELL) | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| AEROSHELL 7A | 50 | 122 | + | + | + | + | - | + | 0 | + | + | + |
| AEROSHELL 17 | 50 | 122 | + | + | + | + | - | + | 0 | + | + | + |
| AEROSHELL 750 | 50 | 122 | n.a. | - | 0 | + | n.a. | 0 | - | + | + | + |
| AIR, HOT [°C] (LIMITING VALUE) | _ | | 110 | 110 | 80 | 200 | 130 | 130 | 200 | 100 | 100 | 260 |
| AIR, HOT [°F] (LIMITING VALUE) | | _ | 230 | 230 | 176 | 392 | 266 | 266 | 392 | 212 | 212 | 500 |
| AIR, HOT (LONG TIME TEST) | 100 | 212 | + | + | - | + | + | + | + | - | 0 | + |
| AIR, HOT (LONG TIME TEST) | 200 | 392 | - | - | - | + | - | - | + | - | - | + |
| AIR (LONG TIME WEATHERING TEST) | n.a. | n.a. | + | + | 0 | + | + | + | + | (+) | + | + |
| ALCOHOL (DRINKING-ALCOHOL ~40 VOL.%) | 23 | 73 | 0(+) | - | + | + | + | + | + | + | + | + |
| ALUMINIUM ACETATE, AQ. SOL. | 50 | 122 | n.a. | - | + | 0 | + | + | - | + | + | + |
| ALUMINIUM CHLORIDE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | 0 | + | + | + |
| ALUMINIUM FLUORIDE, AQ. SOL. | 50 | 122 | 0(+) | - | + | + | + | + | 0 | + | + | + |
| ALUMINIUM NITRATE, AQ. SOL. | 50 | 122 | 0(+) | - | + | + | + | + | 0 | + | + | + |
| ALUMINIUM PHOSPHATE, AQ. SOL. | 50 | 122 | 0(+) | - | + | + | + | + | + | + | 0 | + |
| AMMONIA GAS, COLD | 23 | 73 | + | 0 | + | - | + | + | + | n.a. | n.a. | + |
| AMMONIA GAS, HOT | 80 | 176 | - | - | 0 | - | 0 | 0 | + | n.a. | n.a. | + |
| AMMONIA SOLUTION 25% | 23 | 73 | 0(+) | - | 0 | 0 | + | 0 | + | + | 0 | + |
| AMMONIUM CARBONATE, AQ. SOL. | 50 | 122 | 0(+) | - | + | + | + | + | 0 | + | 0 | + |
| AMMONIUM CHLORIDE, AQ. SOL. | 50 | 122 | 0(+) | - | + | + | + | + | 0 | + | 0 | + |
| AMMONIUM HYDROXIDE 25% | 23 | 73 | 0(+) | - | + | + | + | + | + | + | 0 | + |
| AMMONIUM PERSULFATE, AQ. SOL. | 50 | 122 | - | - | + | + | + | + | - | + | 0 | + |
| AMMONIUM SULFIDE, AQ. SOL. | 23 | 73 | + | 0 | + | - | + | + | (+) | + | 0 | + |
| AMYL ACETATE | 23 | 73 | - | - | - | - | + | - | - | + | + | + |
| AMYL ALCOHOL (N-AMYL ALCOHOL) | 50 | 122 | (0) | - | + | + | + | + | - | + | + | + |
| AMYL CHLORIDE | 40 | 104 | 0 | - | - | + | - | - | - | - | + | + |
| AMYL CHLORONAPHTHALENE | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| ANILINE | 23 | 73 | - | - | - | + | + | - | + | 0 | 0 | + |
| ANILINE | 100 | 212 | - | - | - | - | + | - | n.a. | 0 | 0 | + |
| ANILINE HYDROCHLORIDE | 23 | 73 | - | - | - | + | + | - | - | n.a. | n.a. | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available

| Chemical resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AQUA REGIA | 23 | 73 | - | - | - | + | 0 | - | - | - | - | + |
| ARAL VITAM GX 32 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| ARAL VITAMOL 3865 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| ARAL VITAMOL 4004 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| ARGON | 23 | 73 | + | + | + | + | + | + | 0 | + | + | + |
| ARSENIC ACID, AQ. SOL. | 50 | 122 | 0 | - | + | + | + | + | + | + | 0 | + |
| ASPHALT / BITUMEN | 100 | 212 | + | 0 | 0 | + | - | 0 | - | + | + | + |
| ASTM-REFERENCE FUEL A | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| ASTM-REFERENCE FUEL B | 23 | 73 | 0 | 0 | 0 | + | - | - | - | + | + | + |
| ASTM-REFERENCE FUEL C | 23 | 73 | 0 | 0 | - | + | - | - | - | + | + | + |
| ASTM-REFERENCE FUEL D | 23 | 73 | + | + | - | + | - | - | - | + | + | + |
| ASTM-REFERENCE NO. 1 OIL | 100 | 212 | + | + | + | + | - | + | + | + | + | + |
| ASTM-REFERENCE NO. 2 OIL | 100 | 212 | + | 0 | + | + | - | + | 0 | + | + | + |
| ASTM-REFERENCE NO. 3 OIL | 100 | 212 | + | 0 | + | + | - | + | - | + | + | + |
| AVIATION FUEL | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| BARIUM CHLORIDE, AQ. SOL. | 50 | 122 | + | - | + | + | + | + | + | + | 0 | + |
| BARIUM HYDROXIDE, AQ. SOL. | 50 | 122 | n.a. | - | + | + | + | + | + | + | 0 | + |
| BEER | 23 | 73 | + | - | + | + | + | + | + | + | + | + |
| BEER WORT | 90 | 194 | n.a. | - | + | + | 0 | + | 0 | n.a. | n.a. | + |
| BENZALDEHYDE | 23 | 73 | - | - | - | - | + | - | 0 | + | 0 | + |
| BENZALDEHYDE | 100 | 212 | - | - | - | - | + | - | - | - | - | + |
| BENZENE | 23 | 73 | - | - | - | + | - | - | - | + | + | + |
| BENZENE SULFONIC ACID | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| BENZOIC ACID, AQ. SOL. | 23 | 73 | - | - | - | + | 0 | - | - | 0 | 0 | + |
| BENZOPHENONE | 40 | 104 | - | - | 0 | + | 0 | 0 | - | n.a. | n.a. | + |
| BENZYL ALCOHOL | 23 | 73 | - | - | - | + | 0 | - | 0 | + | -(0) | + |
| BENZYL CHLORIDE | 23 | 73 | - | - | - | + | - | - | - | + | + | + |
| BIOMIL H (HUNGARY) | 80 | 176 | + | - | - | + | - | - | - | + | + | + |
| BISULFITE WASTE LIQUOR | 23 | 73 | n.a. | - | 0 | + | + | 0 | (+) | + | 0 | + |
| BLAST-FURNACE GAS | 23 | 73 | - | - | - | + | - | - | + | + | + | + |
| BLEACH LIQUOR | 23 | 73 | n.a. | - | - | + | + | - | 0 | - | -(0) | + |
| BONE OIL | 23 | 73 | + | (+) | + | + | - | (+) | 0 | + | + | + |
| BORAX, AQ. SOL. | 50 | 122 | (0) | - | + | + | + | + | 0 | + | 0 | + |
| BORIC ACID 10% | 23 | 73 | + | 0 | + | + | + | + | 0 | + | 0 | + |
| BP BIOHYD 46 | 80 | 176 | + | - | - | + | - | - | - | + | + | + |
| BP BIOHYD SE 46 | 80 | 176 | + | - | - | + | - | - | - | + | + | + |
| BP ENERGOL SF-C 15 | 50 | 122 | 0(+) | - | + | 0 | + | + | 0 | + | 0 | + |
| BP ENERGOL SF-C 15 | 60 | 140 | -(0) | - | + | 0 | + | + | 0 | + | 0 | + |
| BRAKE FLUID (BASED ON GLYCOL, DOT-4) | 50 | 122 | - | - | - | - | + | - | 0 | - | - | + |
| BRAKE FLUID (BASED ON GLYCOL, DOT-4) | 100 | 212 | - | - | - | - | + | - | 0 | - | - | + |
| BRENNTAG TR 32 | 50 | 122 | 0 | - | + | + | - | + | + | + | + | + |
| BRENNTAG TR 32 | 60 | 140 | - | - | + | + | - | + | + | + | + | + |
| BRENNTAG TR 46 | 50 | 122 | + | - | + | + | - | + | + | + | + | + |
| BRENNTAG TR 46 | 60 | 140 | 0 | - | + | + | - | + | + | + | + | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available

| Chemical resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BROMINE, LIQUID | 23 | 73 | - | - | - | + | - | - | - | - | - | + |
| BROMINE PENTAFLUORIDE | 23 | 73 | - | - | - | - | - | - | - | n.a. | n.a. | + |
| BROMINE TRIFLUORIDE | 23 | 73 | - | - | - | - | - | - | - | n.a. | n.a. | + |
| BROMINE WATER | 23 | 73 | - | - | - | + | - | - | - | - | - | + |
| BUNKER OIL | 70 | 158 | + | 0 | + | + | - | + | - | + | + | + |
| BUTADIEN (MONOMER) | n.a. | n.a. | - | - | - | + | - | - | - | + | + | + |
| BUTANE | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| BUTANOL | 23 | 73 | n.a. | - | + | + | + | + | 0 | + | + | + |
| BUTANOL | 50 | 122 | n.a. | - | + | + | + | + | - | + | + | + |
| BUTANOL TERT. | 50 | 122 | - | - | 0 | + | 0 | 0 | 0 | + | + | + |
| BUTTER | 23 | 73 | + | 0 | + | + | - | + | + | + | + | + |
| BUTTER FAT(WITHOUT WATER) | 23 | 73 | + | 0 | + | + | - | + | + | + | + | + |
| BUTYL ACETATE | 23 | 73 | - | - | - | - | 0 | - | - | + | + | + |
| BUTYL ACETYL RICINOLEATE | 23 | 73 | n.a. | - | 0 | + | + | 0 | - | n.a. | n.a. | + |
| BUTYL ACRYLATE | 23 | 73 | - | - | - | - | - | - | + | n.a. | n.a. | + |
| BUTYL AMINE | 23 | 73 | - | - | 0 | - | 0 | 0 | 0 | n.a. | n.a. | + |
| BUTYLENE | 23 | 73 | (+) | (+) | + | + | - | + | - | + | + | + |
| BUTYRALDEHYDE | 23 | 73 | - | - | - | - | 0 | - | - | n.a. | n.a. | + |
| CALCIUM ACETATE, AQ. SOL. | 50 | 122 | n.a. | - | + | - | + | + | - | + | 0 | + |
| CALCIUM CHLORIDE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| CALCIUM HYDROXIDE, AQ. SOL. | 23 | 73 | + | - | + | + | + | + | - | + | 0 | + |
| CALCIUM HYPOCHLORITE 15% | 23 | 73 | (0) | - | - | + | + | - | 0 | + | 0 | + |
| CALCIUM PHOSPHATE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| CAMPHOR OIL | 23 | 73 | + | 0 | + | + | - | + | - | + | + | + |
| CARBOLIC ACID | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| CARBON DIOXIDE, DRY | 23 | 73 | + | + | + | + | 0 | + | 0 | + | + | + |
| CARBON DIOXIDE, WET | 23 | 73 | + | 0 | + | + | 0 | + | 0 | n.a. | n.a. | + |
| CARBON DISULFIDE | 23 | 73 | - | - | - | + | - | - | - | + | + | + |
| CARBONIC ACID | 23 | 73 | + | + | + | + | + | + | + | + | + | + |
| CARBON MONOXIDE, DRY | 23 | 73 | + | + | + | + | + | + | + | + | + | + |
| CASTOR OIL | 80 | 176 | + | + | + | + | 0 | (+) | + | + | + | + |
| CASTROL ALPHA SP 68 | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| CASTROL BIOTEC ALPIN 22 | 80 | 176 | + | 0 | - | + | - | - | - | + | + | + |
| CASTROL BIOTEC HVX | 80 | 176 | + | 0 | - | + | - | - | - | + | + | + |
| CASTROL HYSPIN AWS 32 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| CETANE | 23 | 73 | n.a. | - | + | + | - | + | - | n.a. | n.a. | + |
| CHLORACETIC ACID | 23 | 73 | - | - | - | - | + | - | - | - | - | + |
| CHLORBUTADIENE | n.a. | n.a. | - | - | - | + | - | - | - | n.a. | n.a. | + |
| CHLORINE DIOXIDE | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| CHLORINE, DRY GAS | 23 | 73 | - | - | - | 0 | - | - | - | - | - | + |
| CHLORINE, WET GAS | 23 | 73 | - | - | - | 0 | - | - | - | - | - | + |
| CHLORINE WATER | 23 | 73 | - | - | - | - | 0 | - | - | - | - | + |
| CHLOROACETONE | 23 | 73 | - | - | - | - | + | - | - | n.a. | n.a. | + |
| CHLOROBENZOL | 50 | 122 | - | - | - | + | - | - | - | + | + | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available



| Chemical resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CHLOROFORM | 23 | 73 | - | - | - | + | - | - | - | - | -(0) | + |
| CHLORONAPHTHALENE | 23 | 73 | - | - | (-) | + | - | (-) | - | n.a. | n.a. | + |
| CHLORONITROETHANE | 23 | 73 | - | - | - | - | - | - | - | n.a. | n.a. | + |
| CHLOROPHENOL (O-CHLOROPHENOL) | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| CHLOROSULFONIC ACID 10% | 23 | 73 | - | - | - | - | 0 | - | - | n.a. | n.a. | + |
| CHLOROTOLUENE | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| CHROME PLATING SOLUTIONS | 23 | 73 | - | - | - | + | - | - | 0 | - | -(0) | + |
| CHROMIC ACID, AQ. SOL. | 23 | 73 | n.a. | 0 | - | + | 0 | - | 0 | -(0) | -(0) | + |
| CHROMIUM-POTASSIUM ALUM, AQ. SOL. | 50 | 122 | n.a. | - | + | + | + | + | + | n.a. | n.a. | + |
| CICO H 3000 | 80 | 176 | + | - | - | + | - | 0 | - | + | + | + |
| CITRIC ACID, AQ. SOL.(SATURATED) | 23 | 73 | + | 0 | + | + | + | + | + | + | 0 | + |
| COAL GAS | 23 | 73 | 0 | (-) | - | + | + | - | n.a. | n.a. | n.a. | + |
| COBALT CHLORIDE, AQ. SOL. | 23 | 73 | n.a. | - | + | + | + | + | 0 | + | 0 | + |
| COCA-COLA® | bp. | bp. | n.a. | n.a. | 0 | (-) | + | 0 | + | n.a. | n.a. | + |
| COCONUT FATTY ACID | 80 | 176 | (+) | 0 | + | + | - | + | + | + | + | + |
| COCONUT OIL | 80 | 176 | + | 0 | + | + | 0 | + | + | + | + | + |
| COD-LIVER OIL | 23 | 73 | + | + | 0 | + | + | 0 | 0 | + | + | + |
| COFFEE | 50 | 122 | + | - | + | + | + | + | + | + | 0 | + |
| COPPER ACETATE, AQ. SOL. | 50 | 122 | - | - | 0 | - | + | 0 | - | + | 0 | + |
| COPPER CHLORIDE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| COPPER SULFATE, AQ. SOL. | 50 | 122 | 0(+) | - | + | + | + | + | + | + | + | + |
| COTTAGE CHEESE 60% | 50 | 122 | (+) | (0) | + | + | + | + | + | n.a. | n.a. | + |
| COTTONSEED OIL | 70 | 158 | + | + | + | + | 0 | + | 0 | + | + | + |
| CREAM 30% | 50 | 122 | + | n.a. | + | + | + | + | + | + | (+) | + |
| CREOSOLS | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| CREOSOTE-WOOD TAR | 23 | 73 | n.a. | 0 | + | + | - | + | - | n.a. | n.a. | + |
| CRESOL (O-CRESOL) | 70 | 158 | - | - | - | + | - | - | - | n.a. | - | + |
| CRUDE OIL | 50 | 122 | + | + | + | + | - | + | - | + | + | + |
| CRUDE OIL - AROMATIC BASE | 80 | 176 | + | 0 | + | + | - | + | - | + | + | + |
| CRUDE OIL - PARAFFIN BASE | 80 | 176 | + | 0 | + | + | - | + | - | + | + | + |
| CUMENE | n.a. | n.a. | - | - | - | + | - | - | - | n.a. | n.a. | + |
| CYCLOHEXANE | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| CYCLOHEXANOL | 23 | 73 | - | - | + | + | - | + | - | + | + | + |
| CYCLOHEXANONE | 23 | 73 | - | - | - | - | 0 | - | - | + | + | + |
| DEKALIN | 23 | 73 | n.a. | (0) | - | + | - | - | - | + | + | + |
| DEXTRIN, AQ. SOL. | 23 | 73 | + | + | + | + | + | + | + | + | + | + |
| DIBENZYL ETHER | 23 | 73 | n.a. | 0 | - | - | 0 | - | 0 | n.a. | n.a. | + |
| DIBENZYL SEBACATE | 23 | 73 | n.a. | 0 | - | 0 | 0 | - | - | n.a. | n.a. | + |
| DIBUTYLAMINE | 23 | 73 | - | - | - | - | (0) | - | - | n.a. | n.a. | + |
| DIBUTYL ETHER | 23 | 73 | n.a. | 0 | - | - | 0 | - | - | n.a. | n.a. | + |
| DIBUTYL PHTHALATE | 23 | 73 | n.a. | - | - | 0 | + | - | 0 | + | + | + |
| DIBUTYL SEBACATE | 23 | 73 | n.a. | - | - | + | + | - | 0 | + | n.a. | + |
| DICHLOROBENZENE | 23 | 73 | - | - | - | + | - | - | - | 0 | + | + |
| DICHLOROMETHYL ACETATE | 23 | 73 | - | - | - | - | - | - | - | n.a. | n.a. | + |
| DICHLOROETHYLENE | 23 | 73 | - | - | - | + | - | - | - | + | - | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available

| Chemical resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DICYCLOHEXYLAMINE | 23 | 73 | - | - | 0 | - | - | 0 | - | n.a. | n.a. | + |
| DIESEL FUELS | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| DIETHYLAMINE | 23 | 73 | - | - | - | - | 0 | - | 0 | + | n.a. | + |
| DIETHYLENE GLYCOL | 50 | 122 | - | - | + | + | + | + | 0 | n.a. | n.a. | + |
| DIETHYL ETHER | 23 | 73 | n.a. | 0 | - | - | - | - | - | n.a. | n.a. | + |
| DIETHYL SEBACATE | 23 | 73 | n.a. | (+) | - | + | 0 | - | 0 | n.a. | n.a. | + |
| DIGLYCOLIC ACID, AQ. SOL. | 50 | 122 | - | - | 0 | + | + | 0 | (+) | n.a. | 0 | + |
| DIISOBUTYL KETONE | 23 | 73 | - | - | - | - | + | - | - | n.a. | n.a. | + |
| DIISOPROPYL KETONE | 23 | 73 | - | - | - | - | + | - | - | n.a. | n.a. | + |
| DIMETHYLAMINE | 23 | 73 | - | - | - | - | 0 | - | - | + | n.a. | + |
| DIMETHYLANILINE | 23 | 73 | - | - | - | - | + | - | - | n.a. | n.a. | + |
| DIMETHYLBUTANE | n.a. | n.a. | (+) | (+) | + | + | - | + | - | n.a. | n.a. | + |
| DIMETHYLETHER | 23 | 73 | - | - | - | - | + | - | - | + | n.a. | + |
| DIMETHYLFORMAMIDE | 23 | 73 | - | (-) | - | - | + | - | 0 | + | + | + |
| DIMETHYLHYDRAZINE | 23 | 73 | (-) | (-) | 0 | - | + | 0 | - | n.a. | n.a. | + |
| DIMETHYLPHTHALATE | n.a. | n.a. | (-) | - | - | + | + | - | - | n.a. | n.a. | + |
| DIOCTYL PHTHALATE | n.a. | n.a. | (-) | - | - | + | + | - | - | + | + | + |
| DIOCTYL SEBACATE | 23 | 73 | 0 | 0 | - | 0 | 0 | - | - | n.a. | n.a. | + |
| DIOXANE | 23 | 73 | - | - | - | - | + | - | - | + | + | + |
| DIOXOLANES | 23 | 73 | - | - | - | - | 0 | - | - | n.a. | n.a. | + |
| DIPENTENE (LACQUER SOLVENT) | 23 | 73 | - | - | 0 | + | - | 0 | - | n.a. | n.a. | + |
| DIPHENYL ETHER | 23 | 73 | - | - | - | + | - | - | - | + | + | + |
| DIPHYL | 150 | 302 | - | - | - | + | - | + | - | - | - | + |
| DODECYL ALCOHOL | 23 | 73 | - | - | + | + | + | + | (+) | n.a. | n.a. | + |
| DOW CORNING 550 E | 80 | 176 | + | - | - | + | - | - | - | + | + | + |
| DOWTHERM A | 150 | 302 | - | - | - | + | - | + | - | - | - | + |
| DOWTHERM E | 150 | 302 | - | - | - | + | - | + | - | - | - | + |
| ELECTROPLATING BATH (CHROME) | n.a. | n.a. | n.a. | n.a. | (+) | + | + | (+) | - | - | -(0) | + |
| ELECTROPLATING BATH (NOT CHROME) | n.a. | n.a. | n.a. | n.a. | + | + | + | (+) | - | - | -(0) | + |
| EPICHLOROHYDRIN | 50 | 122 | - | - | - | - | 0 | - | - | n.a. | n.a. | + |
| ERIFON HD 856 | 60 | 140 | + | - | + | 0 | (+) | + | (+) | + | 0 | + |
| ESSO CAZAR K1 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| ESSO ESSTIC 42, 43 | 23 | 73 | + | 0 | + | + | - | + | - | + | + | + |
| ESSO FUEL 208 | 23 | 73 | n.a. | - | + | + | - | + | - | n.a. | n.a. | + |
| ESSO NUTO H 22 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| ESSO NUTO H 68 | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| ESSO SPINESSO 10 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| ESSO THERMALÖL T | 200 | 392 | - | - | - | + | - | - | - | - | - | + |
| ETHANE | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| ETHANOL (ETHYL ALCOHOL) | 60 | 140 | 0 | - | + | 0 | + | + | - | + | 0(+) | + |
| ETHANOLAMINE | 23 | 73 | 0 | - | 0 | - | + | 0 | 0 | n.a. | n.a. | + |
| ETHER | 23 | 73 | 0 | 0 | 0 | - | 0 | 0 | - | n.a. | n.a. | + |
| ETHYL ACETATE | 23 | 73 | 0 | - | - | - | + | - | 0 | + | + | + |
| ETHYL ACRYLATE | 23 | 73 | - | - | - | - | 0 | - | 0 | + | + | + |
| ETHYL BENZENE | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available



| Chemical resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ETHYL CHLORIDE | 23 | 73 | n.a. | (0) | + | + | + | + | - | + | + | + |
| ETHYLENE | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| ETHYLENE CHLORIDE | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| ETHYLENE CHLOROHYDRIN | 23 | 73 | 0 | - | - | + | 0 | - | - | n.a. | n.a. | + |
| ETHYLENE DIAMINE | 23 | 73 | - | - | + | - | + | + | + | + | + | + |
| ETHYLENE DIBROMIDE | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| ETHYLENE GLYCOL | 100 | 212 | - | - | + | + | + | + | + | n.a. | n.a. | + |
| ETHYLENE OXIDE | 23 | 73 | - | - | - | - | 0 | - | - | + | 0(+) | + |
| ETHYL ETHER | 23 | 73 | 0 | 0 | - | - | - | - | - | + | + | + |
| ETHYL FORMIC ESTER | 23 | 73 | n.a. | - | - | - | 0 | - | (-) | n.a. | n.a. | + |
| ETHYL HEXANOL | 23 | 73 | - | - | + | + | + | + | 0 | n.a. | n.a. | + |
| ETHYL MERCAPTAN | 23 | 73 | + | + | - | + | 0 | - | - | n.a. | n.a. | + |
| ETHYL PENTACHLOROBENZENE | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| FAM-REFERENCE FUEL T1 (DIN 51604) | 23 | 73 | - | - | - | + | - | - | - | + | + | + |
| FAM-REFERENCE FUEL T2 (DIN 51604) | 23 | 73 | - | - | - | 0 | - | - | - | + | + | + |
| FAM-REFERENCE FUEL T3 (DIN 51604) | 23 | 73 | - | - | - | 0 | - | - | - | + | + | + |
| FERRIC CHLORIDE, AQ. SOL. | 30 | 86 | + | 0 | + | + | + | + | 0 | 0 | 0 | + |
| FERRIC SULFATE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | 0 | n.a. | 0 | + |
| FISH OIL | 50 | 122 | + | + | + | + | - | + | + | + | + | + |
| FLUORINE, DRY | 23 | 73 | - | - | - | + | 0 | (-) | - | - | - | + |
| FLUORINE, LIQUID | 23 | 73 | - | - | - | 0 | - | - | - | - | - | + |
| FLUOROBENZENE | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| FORMALDEHYDE 40% | 23 | 73 | - | - | + | + | + | (+) | + | + | 0 | + |
| FORMIC ACID CONCENTRATED | 23 | 73 | - | - | - | - | + | - | - | - | - | + |
| FREON / FRIGEN 11 | 23 | 73 | n.a. | 0 | + | 0 | - | + | - | + | + | + |
| FREON / FRIGEN 112 (WITH / WITHOUT OIL) | 23 | 73 | 0 | 0 | + | + | - | + | - | + | + | + |
| FREON / FRIGEN 113 | 23 | 73 | + | + | + | 0 | - | + | - | + | + | + |
| FREON / FRIGEN BF(F112) | 23 | 73 | 0 | 0 | 0 | 0 | - | 0 | - | + | + | + |
| FREON / FRIGEN C 316 | 23 | 73 | (+) | (+) | + | + | + | + | (-) | + | + | + |
| FREON / FRIGEN C 318 | 23 | 73 | (+) | (+) | + | + | + | + | (-) | + | + | + |
| FREON / FRIGEN MF | 23 | 73 | (0) | (0) | + | 0 | - | + | - | + | + | + |
| FREON / FRIGEN PCA | 23 | 73 | + | + | + | 0 | - | + | - | + | + | + |
| FREON / FRIGEN T-P 35 | 23 | 73 | + | + | + | + | + | + | + | + | + | + |
| FREON / FRIGEN T-WD 602 | 23 | 73 | + | + | 0 | + | 0 | 0 | - | + | + | + |
| FREON / FRIGEN TA | 23 | 73 | + | + | + | - | + | + | + | + | + | + |
| FREON / FRIGEN TC | 23 | 73 | + | + | + | + | 0 | + | - | + | + | + |
| FREON / FRIGEN TF | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| FREON / FRIGEN TMC | 23 | 73 | 0 | 0 | 0 | + | 0 | 0 | - | + | + | + |
| FRUIT-JUICE | 23 | 73 | + | 0 | + | + | + | + | + | + | + | + |
| FUEL OIL, HEAVY | 40 | 104 | + | 0 | 0 | + | - | 0 | 0 | + | + | + |
| FUEL OIL, LIGHT | 40 | 104 | + | 0 | + | + | - | + | 0 | + | + | + |
| FURAN | n.a. | n.a. | n.a. | (-) | - | (-) | - | - | (-) | n.a. | n.a. | + |
| FURFURAL | n.a. | n.a. | (-) | (-) | - | - | 0 | - | - | n.a. | n.a. | + |
| FURFUR ALCOHOL | n.a. | n.a. | - | (-) | - | (-) | + | - | - | n.a. | n.a. | + |
| FURFUROL (A-FURFURYLALDEHYDE) | 23 | 73 | (-) | (-) | - | - | + | - | (-) | + | 0(+) | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available

| Chemical resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FYRQUEL LT (AKZO NOBEL) | 80 | 176 | - | - | n.a. | + | - | n.a. | - | n.a. | n.a. | + |
| GAMMA-RAYS | 20 | 68 | + | + | 0 | - | 0 | 0 | 0 | - | 0 | - |
| GAS OIL | 23 | 73 | 0(+) | 0(+) | + | + | - | + | - | + | + | + |
| GASOLINE | 23 | 73 | 0 | 0 | + | + | - | + | - | + | + | + |
| GASOLINE (20% ETHANOL) | 23 | 73 | - | - | 0 | + | - | (0) | - | n.a. | n.a. | + |
| GASOLINE (20% METHANOL) | 23 | 73 | - | - | - | 0 | - | - | - | n.a. | n.a. | + |
| GASOLINE HIGH-OCTANE | 23 | 73 | 0 | 0 | 0 | + | - | 0 | - | + | + | + |
| GASOLINE M-15 (15% METHANOL) | 23 | 73 | - | - | - | 0 | - | - | - | + | + | + |
| GASOLINE, 92 OCTANE | 23 | 73 | 0 | 0 | + | + | - | + | - | + | + | + |
| GASOLINE, 98 OCTANE | 23 | 73 | 0 | 0 | 0 | + | - | - | - | + | + | + |
| GASOLINE, REFINED | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| GEAR LUBES, HYPOID LUBES, ATF | 80 | 176 | n.a. | n.a. | 0 | + | - | + | - | -(0) | + | + |
| GEAR LUBES SAE 80 / SAE 90 | 80 | 176 | n.a. | n.a. | + | + | - | + | 0 | n.a. | n.a. | + |
| GELATINE, AQ. SOL. | 50 | 122 | n.a. | 0 | + | + | + | + | + | + | + | + |
| GENERATOR GAS | 23 | 73 | + | + | + | + | - | + | 0 | + | + | + |
| GLUCOSE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | n.a. | n.a. | + |
| GLUE | n.a. | n.a. | + | + | + | + | + | + | + | + | + | + |
| GLYCERIN (GLYCEROL) | 50 | 122 | (+) | - | + | + | + | + | + | + | + | + |
| GLYSANTINE (ANTIFREEZE) | 60 | 140 | - | - | + | + | + | + | + | n.a. | n.a. | + |
| GLYSANTINE / WATER (40 : 60 VOL%) | 100 | 212 | n.a. | (-) | 0 | + | + | 0 | n.a. | + | 0(+) | + |
| GREASE, ANIMAL BASE | 50 | 122 | + | + | + | + | 0 | + | + | + | + | + |
| GREASE, PETROLEUM BASE | 50 | 122 | + | + | + | + | - | + | - | + | + | + |
| GREASE, VEGETABLE BASE | 50 | 122 | + | + | + | + | - | + | + | + | + | + |
| HALON 1211 (FIRE-EXTINGUISHING MEDIUM) | 23 | 73 | + | + | - | 0 | - | - | - | n.a. | n.a. | + |
| HALON 1301 | 23 | 73 | + | + | + | + | + | + | - | n.a. | n.a. | + |
| HELIUM | 23 | 73 | + | + | + | + | + | + | + | + | + | + |
| HEPTANE (n-HEPTANE) | 23 | 73 | n.a. | + | + | + | - | + | - | + | + | + |
| HEPTANONE | 23 | 73 | - | - | - | - | 0 | - | - | n.a. | n.a. | + |
| HESSOL BIOL HE 46 | 80 | 176 | + | 0 | - | + | - | - | - | + | + | + |
| HESSOL BIOL HR 37 | 80 | 176 | + | 0 | - | + | - | - | - | + | + | + |
| HEXACHLOROCYCLOHEXANE | 23 | 73 | n.a. | 0 | - | + | - | - | - | + | -(0) | + |
| HEXANE (n-HEXANE) | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| HEXYL ALCOHOL | 23 | 73 | - | - | 0 | + | 0 | 0 | 0 | n.a. | + | + |
| HOUGHTO-SAFE 271, 620 | 50 | 122 | 0 | - | + | 0 | + | + | 0 | + | 0 | + |
| HOUGHTO-SAFE 1010, 1055 | 50 | 122 | - | - | - | + | + | - | - | n.a. | n.a. | + |
| HOUGHTO-SAFE 5040 | 50 | 122 | (+) | - | + | + | - | + | - | + | 0 | + |
| HYDRAULIC FLUID HFA (OIL IN WATER) | 50 | 122 | + | - | + | + | - | + | 0 | + | 0 | + |
| HYDRAULIC FLUID HFB (WATER IN OIL) | 50 | 122 | + | - | + | + | - | + | (+) | + | 0 | + |
| HYDRAULIC FLUID HFC (POLYALKYLENE-GLYCOLS) | 60 | 140 | 0 | - | + | 0 | + | + | (+) | + | 0 | + |
| HYDRAULIC FLUID HFD-R (PHOSPHATE ESTER) | 100 | 212 | - | - | - | + | + | - | - | n.a. | n.a. | + |
| HYDRAULIC FLUID HFD-S (CHLOR.HYDROCARB.) | 100 | 212 | - | - | - | + | - | - | (+) | n.a. | n.a. | + |
| HYDRAULIC FLUID HFD-U (SYNTH. ESTER) | 80 | 176 | + | -(0) | - | + | - | 0(+) | (-) | + | + | + |
| HYDRAULIC OIL (PETROLEUM BASE) | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| HYDRA - VIS (HOUGHTON VAUGHAN) | 70 | 158 | - | - | - | - | - | - | - | + | 0 | + |
| HYDRAZINE | 23 | 73 | - | - | 0 | - | + | 0 | - | + | n.a. | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available



| Chemical resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HYDROBROMIC ACID, AQ. SOL. | 50 | 122 | - | - | - | + | + | - | - | - | - | + |
| HYDROCHLORIC ACID 10% | 40 | 104 | 0 | - | 0 | + | + | 0 | 0 | - | - | + |
| HYDROCHLORIC ACID FUMING | 23 | 73 | - | - | - | - | 0 | - | - | - | - | + |
| HYDROFLUORIC ACID 48% | 23 | 73 | - | - | - | + | + | (-) | - | - | - | + |
| HYDROFLUORIC ACID 75% | 23 | 73 | - | - | - | 0 | + | (-) | - | - | - | + |
| HYDROGEN CHLORIDE, GAS | 23 | 73 | - | - | - | + | + | - | - | - | - | + |
| HYDROGEN FLUORIDE, DRY | 23 | 73 | - | - | - | + | 0 | - | - | n.a. | n.a. | + |
| HYDROGEN, GAS | 23 | 73 | + | + | + | + | + | + | - | + | + | + |
| HYDROGEN PEROXIDE 30% | 23 | 73 | + | + | - | + | + | - | 0 | - | - | + |
| HYDROGEN PEROXIDE 90% | 23 | 73 | 0 | - | - | + | 0 | - | 0 | - | - | + |
| HYDROGEN SULFIDE | 23 | 73 | + | - | - | - | + | + | - | + | - | + |
| HYDROLUBRIC 120 B (HOUGHTON VAUGHAN) | 60 | 140 | + | - | + | + | + | + | + | + | 0 | + |
| HYDROQUINONE | 23 | 73 | - | - | - | + | 0 | - | - | n.a. | - | + |
| HYDROXYL-AMINE SULFATE, AQ. SOL. | 23 | 73 | n.a. | - | + | + | + | + | + | + | 0 | + |
| HYPOCHLOROUS ACID | 23 | 73 | - | - | - | + | + | - | - | n.a. | n.a. | + |
| HY-TRANS-PLUS MS 1207 (CASE) | 80 | 176 | + | + | 0 | + | - | + | - | n.a. | n.a. | + |
| H-17(HUNGARY) | 60 | 140 | + | - | + | + | - | + | - | + | 0 | + |
| IODINE PENTAFLUORIDE | 23 | 73 | - | - | - | - | - | - | - | n.a. | n.a. | + |
| IODOFORM | 23 | 73 | - | n.a. | n.a. | n.a. | + | n.a. | n.a. | - | - | + |
| ISOPROPANOL | 23 | 73 | - | - | 0 | + | + | 0 | + | + | + | + |
| ISOPROPYL CHLORIDE | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| ISOPROPYL ETHER | 23 | 73 | n.a. | 0 | 0 | - | - | 0 | - | n.a. | n.a. | + |
| JAM | 23 | 73 | + | 0 | + | + | + | + | + | + | + | + |
| JET FUEL A1 | 80 | 176 | 0(+) | - | + | + | - | + | - | n.a. | n.a. | + |
| KEROSENE | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| KETCHUP | 50 | 122 | + | 0 | + | + | + | + | + | n.a. | n.a. | + |
| KLÜBER SYNTHESO D 220 - EP | 80 | 176 | n.a. | n.a. | 0 | n.a. | n.a. | 0 | n.a. | n.a. | n.a. | n.a. |
| KLÜBER SYNTHESO PROBA 270 | 50 | 122 | + | + | + | + | + | + | n.a. | n.a. | n.a. | + |
| LARD, ANIMAL FAT | 60 | 140 | + | + | + | + | 0 | + | + | + | + | + |
| LAUGHING GAS | 23 | 73 | + | + | + | + | + | + | + | + | + | + |
| LAURYL ALCOHOL | 23 | 73 | - | - | + | 0 | + | + | (+) | n.a. | n.a. | + |
| LAVENDER OIL | 23 | 73 | n.a. | - | 0 | + | - | 0 | - | + | + | + |
| LEAD ACETATE | 50 | 122 | n.a. | - | 0 | - | + | 0 | - | + | + | + |
| LIME SULFUR-WET | 50 | 122 | n.a. | n.a. | - | + | + | (0) | + | n.a. | n.a. | + |
| LINSEED OIL | 23 | 73 | + | + | + | + | - | + | 0 | + | + | + |
| LIQUEUR (MAX. 30% ALCOHOL) | 23 | 73 | (+) | - | + | + | + | + | + | + | 0 | + |
| LITHIUM BROMIDE, AQ. SOL. | 50 | 122 | n.a. | - | + | + | + | + | + | + | 0 | + |
| LUBRICATING OIL | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| MAGNESIUM CHLORIDE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| MAGNESIUM HYDROXIDE, AQ. SOL. | 50 | 122 | (+) | - | + | + | + | + | + | + | 0 | + |
| MAGNESIUM SULFATE (EPSOM SALTS), AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| MAIZE OIL | n.a. | n.a. | + | + | + | + | - | + | + | + | + | + |
| MALEIC ACID, AQ. SOL. | 50 | 122 | 0 | - | 0 | + | + | 0 | - | n.a. | n.a. | + |
| MALIC ACID | 23 | 73 | n.a. | - | + | + | - | + | 0 | + | 0 | + |
| MARGARINE | 40 | 104 | n.a. | - | + | + | - | + | + | + | + | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available

| Chemical resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MARSH GAS | 23 | 73 | n.a. | 0 | + | + | - | + | - | + | + | + |
| MAYONNAISE | 50 | 122 | n.a. | - | + | 0 | - | + | + | + | + | + |
| MERCURY | 23 | 73 | + | + | + | + | + | + | + | + | + | + |
| MERCURY CHLORIDE, AQ. SOL. | 50 | 122 | n.a. | - | + | + | + | + | + | + | - | + |
| MESITYL OXIDE | 23 | 73 | - | - | - | - | + | - | - | + | 0(+) | + |
| METHANE | 23 | 73 | + | 0 | + | + | - | + | - | + | + | + |
| METHANOL | 50 | 122 | 0 | - | 0 | - | 0 | + | + | + | - | + |
| METHYL ACRYLATE | 23 | 73 | - | - | - | - | 0 | - | - | n.a. | n.a. | + |
| METHYL AMINE, AQ. SOL. | 50 | 122 | - | - | 0 | - | + | 0 | (-) | + | + | + |
| METHYL BROMIDE | 23 | 73 | - | - | - | + | - | - | - | + | + | + |
| METHYL BUTYL KETONE | 23 | 73 | - | - | - | - | + | - | - | n.a. | n.a. | + |
| METHYL CHLORIDE | 23 | 73 | - | - | - | + | - | - | - | + | + | + |
| METHYL CYCLOPENTANE | 23 | 73 | - | - | - | + | - | - | 0 | n.a. | n.a. | + |
| METHYLENE CHLORIDE | 23 | 73 | - | - | - | 0 | - | - | - | 0 | -(0) | + |
| METHYLENE DICHLORIDE | 23 | 73 | - | - | - | 0 | - | - | - | 0 | 0 | + |
| METHYL ETHER | 23 | 73 | n.a. | n.a. | + | + | + | + | + | n.a. | n.a. | + |
| METHYL ETHYL KETONE | 23 | 73 | - | - | - | - | + | - | - | 0 | + | + |
| METHYL FORMATE | 23 | 73 | - | - | - | - | 0 | - | 0 | n.a. | n.a. | + |
| METHYL ISOBUTYL KETONE | 23 | 73 | - | - | - | - | 0 | - | - | n.a. | n.a. | + |
| METHYL ISOPROPYL KETONE | 23 | 73 | - | - | - | - | 0 | - | - | n.a. | n.a. | + |
| METHYL METHACRYLATE | 23 | 73 | - | - | - | - | - | - | - | n.a. | n.a. | + |
| METHYL OLEATE | 23 | 73 | n.a. | - | - | + | 0 | - | - | n.a. | n.a. | + |
| MILK | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| MILK ACID, AQ. SOL. | 50 | 122 | + | 0 | 0 | + | 0 | 0 | + | + | + | + |
| MILK, CONDENSED | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| MINERAL OIL | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| MOBIL AMBREX 33 | 80 | 176 | + | 0 | + | + | - | + | - | + | + | + |
| MOBIL AMBREX 830 | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| MOBIL DELVAC 1100, 1110, 1120, 1130 | 70 | 158 | + | 0 | + | + | - | + | - | + | + | + |
| MOBIL DTE 25 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| MOBILOIL SAE 20 | 70 | 158 | + | + | + | + | - | + | - | + | + | + |
| MOBIL THERM 600 | 80 | 176 | n.a. | - | + | + | - | + | - | + | + | + |
| MOBIL VACTRA NR.2 | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| MOLASSES | 23 | 73 | (+) | 0 | + | + | + | + | + | + | + | + |
| MOLYDUVAL MOLYKOTE-GREASE | 50 | 122 | + | + | + | + | - | + | - | + | + | + |
| MONOBROMOBENZENE | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| MONOCHLOROACETIC ACID | 23 | 73 | - | - | - | - | + | - | - | n.a. | n.a. | + |
| MONOCHLOROBENZENE | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| MONOETHANOLAMINE | 23 | 73 | - | - | 0 | - | + | 0 | 0 | n.a. | n.a. | + |
| MORPHOLINE | 23 | 73 | n.a. | - | - | - | - | - | - | n.a. | n.a. | + |
| MOTOR OIL | 80 | 176 | + | 0 | + | + | - | + | 0 | + | + | + |
| MUSTARD | 50 | 122 | + | + | + | + | + | + | + | n.a. | n.a. | + |
| MUSTARD GAS | 23 | 73 | n.a. | n.a. | n.a. | + | + | n.a. | + | n.a. | n.a. | + |
| MUSTARD OIL | 60 | 140 | n.a. | n.a. | + | + | n.a. | + | n.a. | n.a. | n.a. | + |
| NAPHTHALENE | 23 | 73 | n.a. | 0 | - | + | - | - | - | + | + | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available



| Chemical resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NATURAL GAS | 23 | 73 | + | 0 | + | + | - | + | - | + | + | + |
| NEON | 23 | 73 | + | + | + | + | + | + | + | + | + | + |
| NICKEL ACETATE, AQ. SOL. | 50 | 122 | n.a. | - | 0 | - | + | 0 | - | + | 0 | + |
| NICKEL SULFATE, AQ. SOL. | 50 | 122 | (+) | 0 | + | + | + | + | + | + | 0 | + |
| NITRIC ACID 10% | 50 | 122 | 0 | - | - | + | + | - | 0 | - | - | + |
| NITRIC ACID 65% | 23 | 73 | - | - | - | 0 | - | - | - | - | - | + |
| NITRIC ACID FUMING | 23 | 73 | - | - | - | - | - | - | - | - | - | + |
| NITROBENZENE | 50 | 122 | - | - | - | + | + | - | - | 0 | 0 | + |
| NITRO DILUTION | 23 | 73 | - | - | - | - | - | - | - | n.a. | n.a. | + |
| NITROETHANE | 23 | 73 | - | - | - | - | 0 | - | - | n.a. | n.a. | + |
| NITROGEN | 23 | 73 | + | + | + | + | + | + | + | + | + | + |
| NITROGEN TETROXIDE | 23 | 73 | - | - | - | - | 0 | - | - | - | 0 | + |
| NITROMETHANE | 23 | 73 | - | - | - | - | 0 | - | - | n.a. | 0(+) | + |
| 1-NITROPROPANE | 23 | 73 | (0) | - | - | - | 0 | - | - | n.a. | n.a. | + |
| OCEANIC HW 443 (WATER-GLYCOL, CONTROL FLUID) | 60 | 140 | 0 | - | + | 0 | n.a. | + | n.a. | n.a. | n.a. | + |
| OCEANIC HW 443 | 70 | 158 | - | - | + | 0 | n.a. | + | n.a. | n.a. | n.a. | + |
| OCEANIC HW 540 (WATER-GLYCOL, CONTROL FLUID) | 60 | 140 | + | - | + | 0 | n.a. | + | n.a. | n.a. | n.a. | + |
| OCEANIC HW 540 | 70 | 158 | 0 | - | + | 0 | n.a. | + | n.a. | n.a. | n.a. | + |
| O-CHLOROETHYLBENZENE | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| OCTADECANE | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| OCTANE (N-OCTANE) | 23 | 73 | - | - | 0 | + | - | 0 | - | + | + | + |
| OCTYL ALCOHOL | 23 | 73 | n.a. | - | 0 | 0 | 0 | 0 | 0 | n.a. | n.a. | + |
| OCTYL CRESOL | 23 | 73 | n.a. | - | 0 | 0 | - | 0 | - | n.a. | n.a. | + |
| OLEIC ACID | 23 | 73 | (+) | 0 | + | + | - | + | - | + | + | + |
| OLIVE OIL | 50 | 122 | + | + | + | + | - | + | 0 | + | + | + |
| ORANGE ESSENCE | 50 | 122 | n.a. | n.a. | - | 0 | - | - | - | + | + | + |
| OXALIC ACID 25% | 23 | 73 | n.a. | 0 | 0 | + | + | 0 | 0 | n.a. | 0 | + |
| OXYGEN | 23 | 73 | + | + | 0 | + | + | + | + | + | + | + |
| OZONE AIR MIXTURE , 50 PPHM OZONE | 40 | 104 | + | + | - | + | + | 0 | + | 0 | 0 | + |
| PALMITIC ACID | 23 | 73 | + | + | + | + | 0 | + | - | + | + | + |
| PARAFFIN MOLTEN | 55 | 131 | + | + | + | + | - | + | 0 | + | + | + |
| PARAFFIN OIL | 50 | 122 | + | + | + | + | - | + | 0 | + | + | + |
| PEANUT OIL | 23 | 73 | + | 0 | + | + | - | + | + | + | + | + |
| PENTACHLORODIPHENYL | n.a. | n.a. | - | - | - | + | - | - | - | n.a. | n.a. | + |
| PENTANE , N-PENTANE | 23 | 73 | n.a. | n.a. | + | + | - | + | - | n.a. | n.a. | + |
| PENTOSIN CHF 11S | 80 | 176 | + | 0 | + | + | - | + | - | + | + | + |
| PERCHLORIC ACID | 23 | 73 | - | - | - | 0 | 0 | - | - | n.a. | n.a. | + |
| PERCHLOROETHYLENE | 23 | 73 | - | - | - | + | - | - | - | + | 0 | + |
| PETROLEUM | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| PETROLEUM | 100 | 212 | 0 | - | 0 | 0 | - | 0 | - | (+) | + | + |
| PETROLEUM ETHER | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| PHENOL | 23 | 73 | - | - | - | + | - | - | - | - | - | + |
| PHENOL/WATER 70:30 %WEIGHT | 50 | 122 | - | - | - | + | - | - | - | - | - | + |
| PHENYL ETHYL ETHER | 23 | 73 | - | - | - | - | - | - | - | n.a. | n.a. | + |
| PHENYL HYDRAZINE | 23 | 73 | (-) | (-) | - | + | - | - | (-) | n.a. | n.a. | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available

| Chemical resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PHOSGENE GAS | 23 | 73 | - | (-) | - | - | + | - | (-) | n.a. | n.a. | + |
| PHOSGENE LIQUID | 23 | 73 | (-) | (-) | - | - | + | - | (-) | n.a. | n.a. | + |
| PHOSPHORIC ACID 20% | 50 | 122 | 0(+) | - | 0 | + | + | 0 | 0 | - | - | + |
| PHOSPHORIC ACID CONCENTRATED | 50 | 122 | n.a. | - | - | + | + | - | - | - | - | + |
| PHOSPHOROUS OXYLCHLORIDE | 23 | 73 | - | (-) | - | + | + | - | (-) | n.a. | n.a. | + |
| PHOSPHOROUS TRICHLORIDE | 23 | 73 | - | - | - | + | + | - | - | n.a. | n.a. | + |
| PHOTOGRAPHIC DEVELOPER | 23 | 73 | n.a. | - | + | + | + | (+) | + | + | 0 | + |
| PHOTOGRAPHIC FIXER | 23 | 73 | n.a. | - | + | + | + | (+) | + | + | 0 | + |
| PICRIC ACID 10% | 23 | 73 | (+) | (0) | + | + | + | + | - | 0 | n.a. | + |
| PINE NEEDLE OIL | 40 | 104 | + | + | + | + | - | + | - | + | + | + |
| PINE OIL | 40 | 104 | + | + | 0 | + | - | 0 | - | + | + | + |
| PIPERIDINE | 23 | 73 | - | - | - | - | - | - | - | n.a. | n.a. | + |
| PLANTOHYD 40 (GENOL) | 80 | 176 | + | 0 | - | + | - | - | - | + | 0 | + |
| POLYVINYL ACETATE EMULSION | 23 | 73 | n.a. | n.a. | + | 0 | + | + | - | n.a. | n.a. | + |
| POTASH CAUSTIC 10% | 23 | 73 | + | 0 | 0 | 0 | + | 0 | - | + | 0 | + |
| POTASSIUM ACETATE, AQ. SOL. | 50 | 122 | n.a. | (-) | 0 | - | + | 0 | - | + | 0 | + |
| POTASSIUM BORATE, AQ. SOL. | 50 | 122 | n.a. | n.a. | + | + | + | + | + | + | 0 | + |
| POTASSIUM BROMATE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| POTASSIUM BROMIDE, AQ. SOL. | 50 | 122 | 0(+) | - | + | + | + | + | + | + | + | + |
| POTASSIUM CARBONATE, AQ. SOL. | 50 | 122 | n.a. | - | + | + | + | + | 0 | n.a. | n.a. | + |
| POTASSIUM CHLORATE, AQ. SOL. | 50 | 122 | + | 0 | 0 | + | + | 0 | n.a. | n.a. | + | + |
| POTASSIUM CHLORIDE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | + | + |
| POTASSIUM CYANIDE, AQ. SOL. | 50 | 122 | + | 0 | + | 0 | + | + | + | + | n.a. | + |
| POTASSIUM DICHROMATE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| POTASSIUM HYDROXIDE 10 % | 23 | 73 | + | 0 | 0 | 0 | + | 0 | - | + | 0 | + |
| POTASSIUM PERCHLORATE, AQ. SOL. | 50 | 122 | n.a. | n.a. | 0 | + | + | 0 | - | 0 | + | + |
| POTASSIUM PERMANGANATE 25 % | 23 | 73 | 0(+) | - | (-) | 0 | + | (-) | n.a. | + | - | + |
| PROPANE | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| PROPANOL | 23 | 73 | n.a. | - | + | + | + | + | + | + | + | + |
| PROPYL ACETATE | 23 | 73 | - | - | - | - | 0 | - | - | n.a. | n.a. | + |
| PROPYL AMINE | 23 | 73 | - | - | - | - | + | - | - | n.a. | n.a. | + |
| PROPYLENE | 23 | 73 | n.a. | - | - | + | - | - | - | + | + | + |
| PROPYLENE GLYCOL | 23 | 73 | n.a. | 0 | + | + | + | + | + | n.a. | n.a. | + |
| PROPYLENE OXIDE | 23 | 73 | n.a. | - | - | - | 0 | - | - | n.a. | n.a. | + |
| PRUSSIC ACID | 23 | 73 | - | - | 0 | - | + | 0 | - | - | n.a. | + |
| P-TERTIARY BUTYL CATECHOL | 23 | 73 | - | - | - | + | 0 | - | n.a. | n.a. | n.a. | + |
| PYDRAUL 29ELT, 30E, 50E, 65E, 90E | 80 | 176 | (-) | - | - | + | + | - | 0 | n.a. | n.a. | + |
| PYDRAUL 312C, 540C | 80 | 176 | n.a. | - | - | + | - | - | - | n.a. | n.a. | + |
| PYDRAUL F-9 | 80 | 176 | n.a. | - | - | + | 0 | - | n.a. | n.a. | n.a. | + |
| PYRANOL (TRANSFORMER OIL) | 23 | 73 | n.a. | 0 | + | + | - | + | - | n.a. | n.a. | + |
| PYRIDINE | 23 | 73 | - | - | - | - | 0 | - | - | 0(+) | + | + |
| PYRROLE | 23 | 73 | n.a. | - | - | - | - | - | 0 | n.a. | n.a. | + |
| QUINTOLUBRIC N822 - 220 | 80 | 176 | + | - | - | + | - | 0 | (-) | + | + | + |
| QUINTOLUBRIC N822 - 300 | 80 | 176 | + | 0 | - | + | - | 0 | (-) | + | + | + |
| QUINTOLUBRIC N850 | 80 | 176 | + | 0 | - | + | - | 0 | (-) | + | + | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available

| Chemical resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q8 KIRON LT68 (KUWAIT PETROLEUM) | 60 | 140 | + | - | + | + | - | + | - | + | 0 | + |
| RAPE OIL (RAPE SEED OIL) | 80 | 176 | + | 0 | 0 | + | - | 0 | - | + | + | + |
| RARE GAS | n.a. | n.a. | + | + | + | + | + | + | 0 | + | + | + |
| REFERENCE FUEL A (ISO 1817) | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| REFERENCE FUEL B (ISO 1817) | 23 | 73 | 0 | 0 | 0 | + | - | - | - | + | + | + |
| REFERENCE FUEL C (ISO 1817) | 23 | 73 | - | - | - | + | - | - | - | + | + | + |
| REFERENCE FUEL D (ISO 1817) | 23 | 73 | - | - | - | + | - | - | - | + | + | + |
| RENOLIN MR 20 VG 68 (FUCHS) | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| SALT SOLUTION | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| SAUERKRAUT | 23 | 73 | + | - | + | 0 | + | + | + | + | 0 | + |
| SHELL ALVANIA R 2 | 60 | 140 | + | + | + | + | - | + | 0 | + | + | + |
| SHELL DIALA-ÖL D | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| SHELL DROMUS OIL B | 60 | 140 | + | - | + | + | - | + | - | + | 0 | + |
| SHELL FIREGARD 200 | 60 | 140 | 0(+) | - | + | 0 | + | + | (+) | + | 0 | + |
| SHELL HSG 80W/90 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| SHELL HYDROL DO 46 | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| SHELL MACOMA 72 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| SHELL NATURELLE HF-E 15 | 80 | 176 | + | - | - | + | - | - | - | + | + | + |
| SHELL OMALA 68 | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| SHELL TELLUS 27, 33 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| SHELL TELLUS T 37 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| SHELL TELLUS 68 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| SHELL TELLUS 68 + 5% CASTROL CX 23 | 80 | 176 | + | 0 | + | + | - | + | - | + | + | + |
| SHELL TIRENA WA | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| SHELL TMO SW 30 | 80 | 176 | + | - | - | + | - | - | - | + | + | + |
| SIDERLUBRIC 822-200 | 80 | 176 | + | - | - | + | - | 0 | - | + | + | + |
| SILICONE GREASE, SILICONE OIL | 50 | 122 | + | + | 0 | + | 0 | 0 | - | + | + | + |
| SILICONE GREASE, SILICONE OIL | 80 | 176 | + | 0 | - | + | - | - | - | + | + | + |
| SILVER NITRATE, AQ. SOL. | 50 | 122 | + | 0 | 0 | + | + | (+) | + | + | 0 | + |
| SKYDROL 500 B4 (MONSANTO) | 70 | 158 | - | - | - | - | + | - | - | n.a. | + | + |
| SKYDROL LD4 (7000) (MONSANTO) | 70 | 158 | - | - | - | - | + | - | - | n.a. | + | + |
| SODIUM ACETATE, AQ. SOL. | 50 | 122 | n.a. | - | 0 | - | + | 0 | - | + | 0 | + |
| SODIUM BENZOATE, AQ. SOL. | 50 | 122 | n.a. | - | + | + | + | + | + | + | 0 | + |
| SODIUM BISULFITE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | n.a. | 0 | + |
| SODIUM BORATE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| SODIUM CARBONATE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| SODIUM CHLORATE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | - | + | 0 | + |
| SODIUM CHLORIDE(SALT), AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| SODIUM CYANIDE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| SODIUM DICHROMATE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | 0 | n.a. | 0 | + |
| SODIUM HYDROXIDE 10% (CAUSTIC SODA) | 50 | 122 | 0 | - | 0 | 0 | + | 0 | - | 0 | 0 | + |
| SODIUM HYDROXIDE 25% (CAUSTIC SODA) | 50 | 122 | 0 | - | 0 | - | + | 0 | - | 0 | 0 | + |
| SODIUM HYPOCHLORITE, AQ. SOL. | 30 | 86 | (0) | - | - | 0 | 0 | - | 0 | - | -(0) | + |
| SODIUM NITRITE, AQ. SOL. | 50 | 122 | n.a. | - | + | + | + | + | + | + | 0 | + |
| SODIUM PERBORATE, AQ. SOL. | 50 | 122 | + | 0 | 0 | + | + | 0 | 0 | + | n.a. | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available

| Chemical resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SODIUM STEARATE, AQ. SOL. | 50 | 122 | n.a. | n.a. | + | + | + | + | + | n.a. | n.a. | + |
| SODIUM SULFATE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| SODIUM SULFIDE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |
| SODIUM THIOSULFATE, AQ. SOL. | 23 | 73 | + | 0 | + | + | + | + | + | + | 0 | + |
| SOLUBLE OIL | n.a. | n.a. | + | + | + | + | - | + | - | + | + | + |
| SOUP SOLUTION | 50 | 122 | + | - | + | + | + | + | + | + | 0 | + |
| SOUR MILK | 50 | 122 | + | - | + | + | + | + | + | + | 0 | + |
| SOYA OIL | 50 | 122 | + | 0 | + | + | - | + | - | + | + | + |
| SPIRITS, SCHNAPS | 23 | 73 | 0(+) | - | + | + | + | + | + | + | + | + |
| STARCH, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | n.a. | n.a. | + |
| STEAM, UP TO 150°C / 302°F | 150 | 302 | - | - | - | - | + | - | - | - | - | + |
| STEAM, UP TO 180°C / 356°F | 180 | 356 | - | - | - | - | 0 | - | - | - | - | + |
| STEARIC ACID | 50 | 122 | + | 0 | 0 | + | 0 | 0 | - | + | + | + |
| STYRENE, MONOMER | 23 | 73 | (0) | - | - | 0 | - | - | - | + | + | + |
| SULFUR CHLORIDE | 23 | 73 | n.a. | - | - | + | - | - | - | n.a. | n.a. | + |
| SULFUR DIOXIDE, DRY | 50 | 122 | n.a. | - | - | + | + | - | 0 | - | + | + |
| SULFUR DIOXIDE, WET | 50 | 122 | n.a. | - | - | + | + | - | 0 | - | 0(+) | + |
| SULFUR HEXAFLUORIDE | 23 | 73 | n.a. | 0 | 0 | 0 | + | 0 | 0 | + | + | + |
| SULFURIC ACID 10% | 23 | 73 | + | - | - | + | + | 0 | - | 0 | -(0) | + |
| SULFURIC ACID 25% | 23 | 73 | n.a. | - | - | + | + | - | - | n.a. | n.a. | + |
| SULFURIC ACID 50% | 23 | 73 | - | - | - | + | + | - | - | n.a. | n.a. | + |
| SULFURIC ACID 60% | 23 | 73 | - | - | - | + | + | - | - | n.a. | n.a. | + |
| SULFURIC ACID 75% | 100 | 212 | - | - | - | 0 | + | - | - | n.a. | n.a. | + |
| SULFURIC ACID 96% | 23 | 73 | - | - | - | + | + | - | - | - | - | + |
| SULFUR MOLTEN | mp. | mp. | - | - | - | + | + | - | - | + | + | + |
| SULFUROUS ACID | 23 | 73 | n.a. | - | 0 | + | + | 0 | - | - | 0(+) | + |
| SULFUR TRIOXIDE, DRY | 23 | 73 | (+) | - | - | + | 0 | - | 0 | n.a. | n.a. | + |
| SUNFLOWER OIL | 80 | 176 | + | + | + | + | - | + | + | + | + | + |
| SUVA HP 62 | 23 | 73 | + | + | n.a. | n.a. | n.a. | n.a. | n.a. | + | + | + |
| SUVA 134a | 23 | 73 | 0 | 0 | n.a. | n.a. | n.a. | n.a. | n.a. | + | + | + |
| SUVA 9000 | 23 | 73 | 0 | 0 | n.a. | n.a. | n.a. | n.a. | n.a. | + | + | + |
| TANNIC ACID | 23 | 73 | + | + | + | + | + | + | 0 | 0 | n.a. | + |
| TAR , TAR OIL | 23 | 73 | + | 0 | - | + | - | - | - | + | + | + |
| TEBIOL HVI 32 A | 80 | 176 | + | - | - | + | - | - | - | + | + | + |
| TERTIARY BUTYL MERCAPTAN | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| TETRABROMOETHANE | 23 | 73 | n.a. | - | - | + | - | - | - | n.a. | n.a. | + |
| TETRACHLOROETHANE | 23 | 73 | - | - | - | + | - | - | - | n.a. | n.a. | + |
| TETRACHLOROMETHANE | 23 | 73 | (0) | (0) | - | + | - | - | - | 0 | + | + |
| TETRAETHYL LEAD | 23 | 73 | n.a. | 0 | 0 | + | - | 0 | - | n.a. | - | + |
| TETRAHYDROFURAN | 23 | 73 | - | - | - | - | - | - | - | 0 | 0(+) | + |
| TETRALIN (SULFOLANE) | 23 | 73 | - | - | - | + | - | - | - | + | + | + |
| TEXACO REGAL B | 70 | 158 | + | + | + | + | - | + | - | + | + | + |
| TEXACO UNI-TEMP | 23 | 73 | + | + | + | + | - | + | 0 | + | + | + |
| TEXAMATIC "A" TRANSMISSION-OIL | 23 | 73 | n.a. | 0 | + | + | - | + | - | + | + | + |
| THIOKOL TP-90 B | 23 | 73 | n.a. | n.a. | - | + | + | - | n.a. | n.a. | n.a. | + |
| THIOKOL TP-95 | 23 | 73 | n.a. | n.a. | - | + | + | - | n.a. | n.a. | n.a. | + |
| THIONYL CHLORIDE | 23 | 73 | n.a. | - | - | 0 | - | - | - | n.a. | n.a. | + |
| TOLUENE | 23 | 73 | - | - | - | + | - | - | - | + | + | + |
| TOLUYLENE DIISOCYANATE | 23 | 73 | - | - | - | 0 | 0 | - | - | n.a. | n.a. | + |
| TOOTH-PASTE | 50 | 122 | (+) | n.a. | + | + | + | + | + | + | + | + |
| TRANSFORMER OIL | 23 | 73 | + | + | + | + | - | + | 0 | + | + | + |
| TRIACETIN | 23 | 73 | n.a. | - | 0 | - | + | 0 | + | n.a. | n.a. | + |
| TRIBUTYL PHOSPHATE | 23 | 73 | - | - | - | - | + | - | 0 | n.a. | n.a. | + |
| TRICHLOROACETIC ACID | 23 | 73 | - | - | - | - | 0 | - | - | - | - | + |
| TRICHLOROETHANE | 23 | 73 | - | - | - | + | - | - | - | 0 | (+) | + |
| TRICHLOROETHYLENE (TRIAD) | 23 | 73 | - | - | - | + | - | - | - | - | 0(+) | + |
| TRICRESYL PHOSPHATE | 23 | 73 | n.a. | (-) | - | + | + | - | 0 | + | + | + |
| TRIETHANOLAMINE | 23 | 73 | - | - | 0 | - | + | 0 | (-) | + | + | + |
| TRINITROTOLUENE | 23 | 73 | - | - | - | 0 | - | - | - | n.a. | n.a. | + |
| TRIOCTYL PHOSPHATE | 23 | 73 | - | - | - | 0 | + | - | - | n.a. | n.a. | + |
| TURPENTINE | 50 | 122 | n.a. | - | 0 | + | - | 0 | - | + | + | + |
| UNIVIS 40 (ESSO) | 70 | 158 | + | + | + | + | - | + | - | + | + | + |
| UNIVIS J 13 (ESSO) | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| UREA, AQ. SOL. | 50 | 122 | n.a. | 0 | + | + | + | + | 0 | + | + | + |
| VACUUM PUMP OIL N 62 (LEYBOLD) | 80 | 176 | + | + | 0 | + | - | + | + | + | + | + |
| VASELINE | 40 | 104 | + | + | + | + | - | + | + | + | + | + |
| VEGETABLE OIL | 23 | 73 | + | + | + | + | - | + | + | + | + | + |
| VINEGAR 5% | 23 | 73 | + | - | 0 | + | + | 0 | + | + | 0 | + |
| VINYL CHLORIDE | 23 | 73 | - | - | - | + | 0 | - | - | + | + | + |
| WAGNER 21 B | 23 | 73 | - | - | - | - | + | - | 0 | n.a. | n.a. | + |
| WATER, DISTILLED | 100 | 212 | 0 | - | 0 | 0 | + | + | + | (+) | 0 | + |
| WATER, DRINKING (COLD) | 20 | 68 | + | + | + | + | + | + | + | + | 0 | + |
| WATER, DRINKING (HOT) | 80 | 176 | + | - | 0 | 0 | + | + | + | + | 0 | + |
| WATER, DRINKING (HOT) | 100 | 212 | 0 | - | 0 | 0 | + | + | + | (+) | (0) | + |
| WATER, DRINKING (MINERAL) | 50 | 122 | + | - | + | + | + | + | + | + | 0 | + |
| WATER, SEA | 80 | 176 | + | - | + | + | + | + | + | + | 0 | + |
| WATER, WASTE | 50 | 122 | + | - | + | + | 0 | + | 0 | + | 0 | + |
| WATERGLASS | 23 | 73 | + | 0 | + | + | + | + | + | + | + | + |
| WHISKEY | 23 | 73 | 0(+) | - | + | + | + | + | + | + | 0 | + |
| WINE (WHITE, RED) | 23 | 73 | + | - | + | + | + | + | + | + | 0 | + |
| WOOD OIL | 23 | 73 | + | 0 | + | + | - | + | - | + | + | + |
| XENON | 23 | 73 | + | + | + | + | + | + | + | + | + | + |
| XYLENE | 23 | 73 | - | - | - | + | - | - | - | + | + | + |
| YEAST, AQ. SOL. | 30 | 86 | n.a. | - | + | + | + | + | + | + | + | + |
| YOGHURT | 50 | 122 | (+) | - | + | + | + | + | + | + | + | + |
| ZINC ACETATE, AQ. SOL. | 50 | 122 | - | - | 0 | 0 | + | 0 | - | n.a. | n.a. | + |
| ZINC CHLORIDE, AQ. SOL. | 50 | 122 | + | 0 | + | + | + | + | + | + | 0 | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available

All data and recommendations shown in this list are based on many years of experience with the production of seals, testing and on information from the specialised literature. In spite of all the experiences, unknown factors in the application of seals can influence the correctness of a general recommendation tremendously, for which reason the recommendations and proposals resulting from this list cannot be regarded as binding.

*Table 3*

| Pressure fluid resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BRAKE FLUID** | | | | | | | | | | | | |
| WAGNER 21 B | 23 | 73 | - | - | - | - | + | - | 0 | n.a. | n.a. | + |
| **CONTROL FLUID** | | | | | | | | | | | | |
| ERIFON HD 856 (WATER/GLYCOL) | 60 | 140 | + | - | + | 0 | (+) | + | (+) | + | 0 | + |
| OCEANIC HW 443 (WATER/GLYCOL) | 60 | 140 | 0 | - | + | 0 | n.a. | + | n.a. | n.a. | n.a. | + |
| OCEANIC HW 443 | 70 | 158 | - | - | + | 0 | n.a. | + | n.a. | n.a. | n.a. | + |
| OCEANIC HW 540 (WATER/GLYCOL) | 60 | 140 | + | - | + | 0 | n.a. | + | n.a. | n.a. | n.a. | + |
| OCEANIC HW 540 | 70 | 158 | 0 | - | + | 0 | n.a. | + | n.a. | n.a. | n.a. | + |
| **FIRE-EXTINGUISHING MEDIUM** | | | | | | | | | | | | |
| HALON 1211 | 23 | 73 | + | + | - | 0 | - | - | - | n.a. | n.a. | + |
| HALON 1301 | 23 | 73 | + | + | + | + | + | + | - | n.a. | n.a. | + |
| **FUEL** | | | | | | | | | | | | |
| ESSO FUEL 208 | 23 | 73 | n.a. | - | + | + | - | + | - | n.a. | n.a. | + |
| JET FUEL A1 | 80 | 176 | 0(+) | - | + | + | - | + | - | n.a. | n.a. | + |
| **GREASE** | | | | | | | | | | | | |
| AEROSHELL 7A | 50 | 122 | + | + | + | + | - | + | 0 | + | + | + |
| AEROSHELL 17 | 50 | 122 | + | + | + | + | - | + | 0 | + | + | + |
| AEROSHELL 750 | 50 | 122 | n.a. | - | 0 | + | n.a. | 0 | - | + | + | + |
| ESSO CAZAR K1 (MINERAL-GREASE) | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| KLÜBER SYNTHESO PROBA 270 (LITHIUM-GREASE) | 50 | 122 | + | + | + | + | + | + | n.a. | n.a. | n.a. | + |
| MOLYDUVAL MOLYKOTE-FETT (MINERAL-GREASE) | 50 | 122 | + | + | + | + | - | + | - | + | + | + |
| SHELL ALVANIA R 2 (MINERAL-GREASE) | 60 | 140 | + | + | + | + | - | + | 0 | + | + | + |
| **HEAT CARRIER OIL** | | | | | | | | | | | | |
| DOWTHERM A | 150 | 302 | - | - | - | + | - | + | - | - | - | + |
| DOWTHERM E | 150 | 302 | - | - | - | + | - | + | - | - | - | + |
| ESSO THERMALÖL T | 200 | 392 | - | - | - | + | - | - | - | - | - | + |
| **HIGH-TEMPERATURE OIL** | | | | | | | | | | | | |
| MOBIL THERM 600 | 80 | 176 | n.a. | - | + | + | - | + | - | + | + | + |
| **LUBRICANT** | | | | | | | | | | | | |
| TEXACO UNI-TEMP | 23 | 73 | + | + | + | + | - | + | 0 | + | + | + |
| **MINERAL OIL** | | | | | | | | | | | | |
| ARAL VITAM GX 32 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| ARAL VITAMOL 3865 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| ARAL VITAMOL 4004 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| CASTROL ALPHA SP 68 | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| CASTROL HYSPIN AWS 32 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| ESSO ESSTIC 42, 43 | 23 | 73 | + | 0 | + | + | - | + | - | + | + | + |
| ESSO NUTO H 22 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| ESSO NUTO H 68 | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| ESSO SPINESSO 10 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| MOBIL AMBREX 33 | 80 | 176 | + | 0 | + | + | - | + | - | + | + | + |
| MOBIL AMBREX 830 | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| MOBIL DELVAC 1100, 1110, 1120, 1130 | 70 | 158 | + | 0 | + | + | - | + | - | + | + | + |
| MOBIL DTE 25 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| MOBIL VACTRA NR.2 | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| MOBILOIL SAE 20 | 70 | 158 | + | + | + | + | - | + | - | + | + | + |
| PENTOSIN CHF 11S (BRANCH OF AUTOMOBILE) | 80 | 176 | + | 0 | + | + | - | + | - | + | + | + |
| RENOLIN MR 20 VG 68 (FUCHS) | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| SHELL DIALA-ÖL D | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| SHELL HYDROL DO 46 | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| SHELL MACOMA 72 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| SHELL TELLUS 27, 33 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| SHELL TELLUS T 37 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| SHELL TELLUS 68 | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| SHELL TELLUS 68 + 5% CASTROL CX 23 | 80 | 176 | + | 0 | + | + | - | + | - | + | + | + |
| SHELL TIRENA WA | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| TEXACO REGAL B | 70 | 158 | + | + | + | + | - | + | - | + | + | + |
| VACUUM PUMP OIL N 62 (LEYBOLD) | 80 | 176 | + | + | 0 | + | - | + | + | + | + | + |
| **PRESSURE FLUID HEES** | | | | | | | | | | | | |
| BP BIOHYD SE 46 | 80 | 176 | + | - | - | + | - | - | - | + | + | + |
| CICO H 3000 | 80 | 176 | + | - | - | + | - | 0 | - | + | + | + |
| HESSOL BIOL HE 46 | 80 | 176 | + | 0 | - | + | - | - | - | + | + | + |
| SHELL NATURELLE HF-E 15 | 80 | 176 | + | - | - | + | - | - | - | + | + | + |
| SHELL TMO SW 30 | 80 | 176 | + | - | - | + | - | - | - | + | + | + |
| TEBIOL HVI 32 A | 80 | 176 | + | - | - | + | - | - | - | + | + | + |
| BRENNTAG TR 32 | 50 | 122 | 0 | - | + | + | - | + | + | + | + | + |
| BRENNTAG TR 32 | 60 | 140 | - | - | + | + | - | + | + | + | + | + |
| BRENNTAG TR 46 | 50 | 122 | + | - | + | + | - | + | + | + | + | + |
| BRENNTAG TR 46 | 60 | 140 | 0 | - | + | + | - | + | + | + | + | + |
| **PRESSURE FLUID HETG** | | | | | | | | | | | | |
| BIOMIL H (UNGARN) | 80 | 176 | + | - | - | + | - | - | - | + | + | + |
| BP BIOHYD 46 | 80 | 176 | + | - | - | + | - | - | - | + | + | + |
| CASTROL BIOTEC ALPIN 22 | 80 | 176 | + | 0 | - | + | - | - | - | + | + | + |
| CASTROL BIOTEC HVX | 80 | 176 | + | 0 | - | + | - | - | - | + | + | + |
| HESSOL BIOL HR 37 | 80 | 176 | + | 0 | - | + | - | - | - | + | + | + |
| PLANTOHYD 40 (GENOL) | 80 | 176 | + | 0 | - | + | - | - | - | + | 0 | + |
| **PRESSURE FLUID HFA-E** | | | | | | | | | | | | |
| HOUGHTO-SAFE 5040 | 50 | 122 | (+) | - | + | + | - | + | - | + | 0 | + |
| HYDRA - VIS (HOUGHTON VAUGHAN) | 70 | 158 | - | - | - | - | - | - | - | + | 0 | + |
| H-17(UNGARN) | 60 | 140 | + | - | + | + | - | + | - | + | 0 | + |
| SHELL DROMUS OIL B | 60 | 140 | + | - | + | + | - | + | - | + | 0 | + |
| **PRESSURE FLUID HFA-S** | | | | | | | | | | | | |
| HYDROLUBRIC 120 B (HOUGHTON VAUGHAN) | 60 | 140 | + | - | + | + | + | + | + | + | 0 | + |
| **PRESSURE FLUID HFB** | | | | | | | | | | | | |
| Q8 KIRON LT68 (KUWAIT PETROLEUM) | 60 | 140 | + | - | + | + | - | + | - | + | 0 | + |
| **PRESSURE FLUID HFC** | | | | | | | | | | | | |
| BP ENERGOL SF-C 15 | 50 | 122 | 0(+) | - | + | 0 | + | + | 0 | + | 0 | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available

| Pressure fluid resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BP ENERGOL SF-C 15 | 60 | 140 | -(0) | - | + | 0 | + | + | 0 | + | 0 | + |
| HOUGHTO-SAFE 271, 620 | 50 | 122 | 0 | - | + | 0 | + | + | 0 | + | 0 | + |
| SHELL FIREGARD 200 | 60 | 140 | 0(+) | - | + | 0 | + | + | (+) | + | 0 | + |
| **PRESSURE FLUID HFD-R** | | | | | | | | | | | | |
| HOUGHTO-SAFE 1010, 1055 | 50 | 122 | - | - | - | + | + | - | - | n.a. | n.a. | + |
| PYDRAUL 29ELT, 30E, 50E, 65E, 90E | 80 | 176 | (-) | - | - | + | + | - | 0 | n.a. | n.a. | + |
| PYDRAUL 312C, 540C | 80 | 176 | n.a. | - | - | + | - | - | - | n.a. | n.a. | + |
| PYDRAUL F-9 | 80 | 176 | n.a. | - | - | + | 0 | - | n.a. | n.a. | n.a. | + |
| SKYDROL 500 B4 (MONSANTO) | 70 | 158 | - | - | - | - | + | - | - | n.a. | + | + |
| SKYDROL LD4 (7000) (MONSANTO) | 70 | 158 | - | - | - | - | + | - | - | n.a. | + | + |
| **PRESSURE FLUID HFD-U** | | | | | | | | | | | | |
| QUINTOLUBRIC N822 - 220 | 80 | 176 | + | - | - | + | - | 0 | (-) | + | + | + |
| QUINTOLUBRIC N822 - 300 | 80 | 176 | + | 0 | - | + | - | 0 | (-) | + | + | + |
| QUINTOLUBRIC N850 | 80 | 176 | + | 0 | - | + | - | 0 | (-) | + | + | + |
| SIDERLUBRIC 822-200 | 80 | 176 | + | - | - | + | - | 0 | - | + | + | + |
| **PRESSURE FLUID, LOW TEMPERATURE** | | | | | | | | | | | | |
| AEROSHELL FLUID 4 (SHELL) | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| UNIVIS 40 (ESSO) | 70 | 158 | + | + | + | + | - | + | - | + | + | + |
| UNIVIS J 13 (ESSO) | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| **PRESSURE FLUID, REMAINING** | | | | | | | | | | | | |
| FYRQUEL LT (AKZO NOBEL) | 80 | 176 | - | - | n.a. | + | - | n.a. | - | n.a. | n.a. | + |
| **REFRIGERANTS** | | | | | | | | | | | | |
| FREON / FRIGEN 11 | 23 | 73 | n.a. | 0 | + | 0 | - | + | - | + | + | + |
| FREON / FRIGEN 112 (WITH / WITHOUT OIL) | 23 | 73 | 0 | 0 | + | + | - | + | - | + | + | + |
| FREON / FRIGEN 113 | 23 | 73 | + | + | + | 0 | - | + | - | + | + | + |
| FREON / FRIGEN 114 | 23 | 73 | + | + | + | 0 | - | + | - | + | + | + |
| FREON / FRIGEN 114 B2 | 23 | 73 | n.a. | n.a. | 0 | 0 | - | 0 | - | + | + | + |
| FREON / FRIGEN 115 | 23 | 73 | (+) | (+) | + | + | + | + | - | + | + | + |
| FREON / FRIGEN 12 | 23 | 73 | + | + | + | 0 | 0 | + | - | + | + | + |
| FREON / FRIGEN 13 | 23 | 73 | n.a. | - | + | + | + | + | - | + | + | + |
| FREON / FRIGEN 13 B1 | 23 | 73 | + | + | + | + | + | + | - | + | + | + |
| FREON / FRIGEN 134A | 23 | 73 | (+) | (+) | + | 0 | n.a. | + | - | + | + | + |
| FREON / FRIGEN 14 | 23 | 73 | + | + | + | + | + | + | - | + | + | + |
| FREON / FRIGEN 142 B | 23 | 73 | (+) | (+) | + | - | + | + | - | + | + | + |
| FREON / FRIGEN 152 A | 23 | 73 | (+) | (+) | + | - | + | + | (-) | + | + | + |
| FREON / FRIGEN 21 | 23 | 73 | n.a. | - | - | - | - | - | - | + | + | + |
| FREON / FRIGEN 218 | 23 | 73 | (+) | (+) | + | + | + | + | (-) | + | + | + |
| FREON / FRIGEN 22 | 23 | 73 | n.a. | - | - | - | + | - | - | + | + | + |
| FREON / FRIGEN 31 | 23 | 73 | n.a. | - | - | - | + | - | - | + | + | + |
| FREON / FRIGEN 32 | 23 | 73 | + | (+) | + | - | + | + | - | + | + | + |
| FREON / FRIGEN 502 | 23 | 73 | n.a. | n.a. | 0 | 0 | (+) | 0 | - | + | + | + |
| FREON / FRIGEN BF(F112) | 23 | 73 | 0 | 0 | 0 | 0 | - | 0 | - | + | + | + |
| FREON / FRIGEN C 316 | 23 | 73 | (+) | (+) | + | + | + | + | (-) | + | + | + |
| FREON / FRIGEN C 318 | 23 | 73 | (+) | (+) | + | + | + | + | (-) | + | + | + |
| FREON / FRIGEN MF | 23 | 73 | (0) | (0) | + | 0 | - | + | - | + | + | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available



| Pressure fluid resistance | TEMP. [°C] | TEMP. [°F] | HPU | LPU | RU1 (NBR) | RU2 (FKM) | RU3 (EPDM) | RU4 (H-NBR) | RU5 (VMQ) | POM1 | PA1 | FL5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREON / FRIGEN PCA | 23 | 73 | + | + | + | 0 | - | + | - | + | + | + |
| FREON / FRIGEN T-P 35 | 23 | 73 | + | + | + | + | + | + | + | + | + | + |
| FREON / FRIGEN T-WD 602 | 23 | 73 | + | + | 0 | + | 0 | 0 | - | + | + | + |
| FREON / FRIGEN TA | 23 | 73 | + | + | + | - | + | + | + | + | + | + |
| FREON / FRIGEN TC | 23 | 73 | + | + | + | + | 0 | + | - | + | + | + |
| FREON / FRIGEN TF | 23 | 73 | + | + | + | + | - | + | - | + | + | + |
| FREON / FRIGEN TMC | 23 | 73 | 0 | 0 | 0 | + | 0 | 0 | - | + | + | + |
| SUVA HP 62 | 23 | 73 | + | + | n.a. | n.a. | n.a. | n.a. | n.a. | + | + | + |
| SUVA 134a | 23 | 73 | 0 | 0 | n.a. | n.a. | n.a. | n.a. | n.a. | + | + | + |
| SUVA 9000 | 23 | 73 | 0 | 0 | n.a. | n.a. | n.a. | n.a. | n.a. | + | + | + |
| **SILICON OIL** | | | | | | | | | | | | |
| DOW CORNING 550 E | 80 | 176 | + | - | - | + | - | - | - | + | + | + |
| **SOFTENER** | | | | | | | | | | | | |
| THIOKOL TP-90 B (POLYESTER-SOFTENER) | 23 | 73 | n.a. | n.a. | - | + | + | - | n.a. | n.a. | n.a. | + |
| THIOKOL TP-95 | 23 | 73 | n.a. | n.a. | - | + | + | - | n.a. | n.a. | n.a. | + |
| **SYNTHETIC OIL** | | | | | | | | | | | | |
| KLÜBER SYNTHESO D 220 - EP (GLYCOL) | 80 | 176 | n.a. | n.a. | 0 | n.a. | n.a. | 0 | n.a. | n.a. | n.a. | n.a. |
| **TRANSFORMER OIL** | | | | | | | | | | | | |
| PYRANOL | 23 | 73 | n.a. | 0 | + | + | - | + | - | n.a. | n.a. | + |
| **TRANSMISSION LUBRICANT** | | | | | | | | | | | | |
| HY-TRANS-PLUS MS 1207 (CASE) | 80 | 176 | + | + | 0 | + | - | + | - | n.a. | n.a. | + |
| SHELL HSG 80W/90 (BRANCH OF AUTOMOBILE) | 80 | 176 | + | + | + | + | - | + | - | + | + | + |
| SHELL OMALA 68 | 80 | 176 | + | + | + | + | - | + | 0 | + | + | + |
| TEXAMATIC "A" TRANSMISSION-OIL | 23 | 73 | n.a. | 0 | + | + | - | + | - | + | + | + |

**LEGEND:** **+** Excellent **0** Moderate **-** Not recommended **( )** Presumedly **n.a.** not available

All data and recommendations shown in this list are based on many years of experience with the production of seals, testing and on information from the specialised literature. In spite of all the experiences, unknown factors in the application of seals can influence the correctness of a general recommendation tremendously, for which reason the recommendations and proposals resulting from this list cannot be regarded as binding.

# Conversion chart

## Inches – millimeters

| Inches | Decimals | 0″ | 1″ | 2″ | 3″ | 4″ | 5″ | 6″ | 7″ | 8″ | 9″ | 10″ | 11″ | 12″ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0,000 | 25,40 | 50,80 | 76,20 | 101,60 | 127,00 | 152,40 | 177,8 | 203,2 | 228,6 | 254,0 | 279,4 | 304,8 |
| 1/64 | 0,016 | 0,397 | 25,80 | 51,20 | 76,60 | 102,00 | 127,39 | 152,79 | 178,2 | 203,6 | 229,0 | 254,4 | 279,8 | 305,2 |
| 1/32 | 0,031 | 0,794 | 26,19 | 51,59 | 76,99 | 102,39 | 127,79 | 153,19 | 178,6 | 204,0 | 229,4 | 254,8 | 280,2 | 305,6 |
| 3/64 | 0,047 | 1,191 | 26,59 | 51,99 | 77,39 | 102,79 | 128,19 | 153,59 | 179,0 | 204,4 | 229,8 | 255,2 | 280,6 | 307,0 |
| 1/16 | 0,063 | 1,587 | 26,99 | 52,39 | 77,59 | 103,19 | 128,59 | 153,98 | 179,4 | 204,8 | 230,2 | 255,6 | 281,0 | 306,4 |
| 5/64 | 0,078 | 1,984 | 27,38 | 52,78 | 78,18 | 103,58 | 128,98 | 154,38 | 179,8 | 205,2 | 230,6 | 256,0 | 281,4 | 306,8 |
| 3/32 | 0,094 | 2,381 | 27,78 | 53,18 | 78,58 | 103,98 | 129,38 | 154,78 | 180,2 | 205,6 | 231,0 | 256,4 | 281,8 | 307,2 |
| 7/64 | 0,109 | 2,778 | 28,18 | 53,58 | 78,98 | 104,38 | 129,78 | 155,18 | 180,6 | 206,0 | 231,4 | 256,8 | 282,2 | 307,6 |
| 1/8 | 0,125 | 3,175 | 28,57 | 53,97 | 79,37 | 104,77 | 130,17 | 155,57 | 181,0 | 206,4 | 231,8 | 257,2 | 282,6 | 308,0 |
| 9/64 | 0,141 | 3,572 | 28,97 | 54,37 | 79,77 | 105,17 | 130,57 | 155,97 | 181,4 | 206,8 | 232,2 | 257,6 | 283,0 | 308,4 |
| 5/32 | 0,156 | 3,969 | 29,37 | 54,77 | 80,17 | 105,57 | 130,97 | 156,37 | 181,8 | 207,2 | 232,6 | 258,0 | 283,4 | 308,8 |
| 11/64 | 0,172 | 4,366 | 29,77 | 55,16 | 80,56 | 105,96 | 131,36 | 156,76 | 182,2 | 207,6 | 233,0 | 258,4 | 283,8 | 309,2 |
| 3/16 | 0,188 | 4,762 | 30,16 | 55,56 | 80,96 | 106,36 | 131,76 | 157,16 | 182,6 | 208,0 | 233,4 | 258,8 | 284,2 | 309,6 |
| 13/64 | 0,203 | 5,159 | 30,56 | 55,96 | 81,36 | 106,76 | 132,16 | 157,56 | 183,0 | 208,4 | 233,8 | 259,2 | 284,6 | 310,0 |
| 7/32 | 0,219 | 5,556 | 30,96 | 56,36 | 81,75 | 107,15 | 132,55 | 157,95 | 183,4 | 208,8 | 234,2 | 259,6 | 285,0 | 310,4 |
| 15/64 | 0,234 | 5,953 | 31,35 | 56,75 | 82,15 | 107,55 | 132,95 | 158,35 | 183,7 | 209,1 | 234,5 | 259,9 | 285,3 | 310,7 |
| 1/4 | 0,250 | 6,350 | 31,75 | 57,15 | 82,55 | 107,95 | 133,35 | 158,75 | 184,1 | 209,5 | 234,9 | 260,3 | 285,7 | 311,1 |
| 17/64 | 0,266 | 6,747 | 32,15 | 57,55 | 82,95 | 108,34 | 133,74 | 159,14 | 184,5 | 209,9 | 234,3 | 260,7 | 286,1 | 311,5 |
| 9/32 | 0,281 | 7,144 | 32,54 | 57,94 | 83,34 | 108,74 | 134,14 | 159,54 | 184,9 | 210,3 | 235,7 | 261,1 | 286,5 | 311,9 |
| 19/64 | 0,297 | 7,540 | 32,94 | 58,34 | 83,74 | 109,14 | 134,54 | 159,94 | 185,3 | 210,7 | 236,1 | 261,5 | 286,9 | 312,3 |
| 5/16 | 0,313 | 7,937 | 33,34 | 58,74 | 84,14 | 109,54 | 134,94 | 160,33 | 185,7 | 211,1 | 236,5 | 261,9 | 287,3 | 312,7 |
| 21/64 | 0,328 | 8,334 | 33,73 | 59,13 | 84,53 | 109,93 | 135,33 | 160,73 | 186,1 | 211,5 | 236,9 | 262,3 | 287,7 | 313,1 |
| 11/32 | 0,344 | 8,731 | 34,13 | 59,53 | 84,93 | 110,33 | 135,73 | 161,13 | 186,5 | 211,9 | 237,3 | 262,7 | 288,1 | 313,5 |
| 23/64 | 0,359 | 9,128 | 34,53 | 59,93 | 85,33 | 110,73 | 136,13 | 161,53 | 186,9 | 212,3 | 237,7 | 263,1 | 288,5 | 313,9 |
| 3/8 | 0,375 | 9,525 | 34,92 | 60,32 | 85,72 | 111,12 | 136,52 | 161,92 | 187,3 | 212,7 | 238,1 | 263,5 | 288,9 | 314,3 |
| 25/64 | 0,391 | 9,922 | 35,32 | 60,72 | 86,12 | 111,53 | 136,92 | 162,32 | 187,7 | 213,1 | 238,5 | 263,9 | 289,3 | 314,7 |
| 13/32 | 0,406 | 10,319 | 35,72 | 61,12 | 86,52 | 111,92 | 137,32 | 162,72 | 188,1 | 213,5 | 238,9 | 264,3 | 289,7 | 315,1 |
| 27/64 | 0,422 | 10,715 | 36,11 | 61,51 | 86,91 | 112,31 | 137,71 | 163,11 | 188,5 | 213,9 | 239,3 | 264,7 | 290,1 | 315,5 |
| 7/16 | 0,438 | 11,112 | 36,51 | 61,91 | 87,31 | 112,71 | 138,11 | 163,51 | 188,9 | 214,3 | 239,7 | 265,1 | 290,5 | 315,9 |
| 29/64 | 0,453 | 11,509 | 36,91 | 62,31 | 87,71 | 113,11 | 138,51 | 163,91 | 189,3 | 214,7 | 240,1 | 265,5 | 290,9 | 316,3 |
| 15/32 | 0,469 | 11,906 | 37,31 | 62,71 | 88,10 | 113,50 | 138,90 | 164,30 | 189,7 | 215,1 | 240,5 | 265,9 | 291,3 | 316,7 |
| 31/64 | 0,484 | 12,303 | 37,70 | 63,10 | 88,50 | 113,90 | 139,30 | 164,70 | 190,1 | 215,5 | 240,9 | 266,3 | 291,7 | 317,1 |
| 1/2 | 0,500 | 12,700 | 38,10 | 63,50 | 88,90 | 114,30 | 139,70 | 165,10 | 190,5 | 215,9 | 241,3 | 266,7 | 292,1 | 317,5 |
| 33/64 | 0,516 | 13,097 | 38,50 | 63,90 | 89,30 | 114,69 | 140,09 | 165,49 | 190,9 | 216,3 | 241,7 | 267,1 | 292,5 | 317,9 |
| 17/32 | 0,531 | 13,493 | 38,89 | 64,29 | 89,69 | 115,09 | 140,49 | 165,89 | 191,3 | 216,7 | 242,1 | 267,5 | 292,9 | 318,3 |
| 35/64 | 0,547 | 13,890 | 39,29 | 64,69 | 90,09 | 115,49 | 140,89 | 166,29 | 191,7 | 217,1 | 242,5 | 267,9 | 293,3 | 318,7 |
| 9/16 | 0,563 | 14,287 | 39,69 | 65,09 | 90,49 | 115,89 | 141,28 | 166,68 | 192,1 | 217,5 | 242,9 | 268,3 | 293,7 | 319,1 |
| 37/64 | 0,578 | 14,684 | 40,08 | 65,48 | 90,88 | 116,28 | 141,68 | 167,08 | 192,5 | 217,9 | 243,3 | 268,7 | 294,1 | 319,5 |
| 19/32 | 0,594 | 15,081 | 40,48 | 65,88 | 91,28 | 116,68 | 142,08 | 167,49 | 192,9 | 218,3 | 243,7 | 269,1 | 294,5 | 319,9 |
| 39/64 | 0,609 | 15,478 | 40,88 | 66,28 | 91,68 | 117,08 | 142,48 | 167,88 | 193,3 | 218,7 | 244,1 | 269,5 | 294,9 | 320,3 |
| 5/8 | 0,625 | 15,875 | 41,27 | 66,67 | 92,07 | 117,47 | 142,87 | 168,27 | 193,7 | 219,1 | 244,5 | 269,9 | 295,3 | 320,7 |
| 41/64 | 0,641 | 16,272 | 41,67 | 67,07 | 92,47 | 117,87 | 143,27 | 168,67 | 194,1 | 219,5 | 244,9 | 270,3 | 295,7 | 321,1 |
| 21/32 | 0,656 | 16,668 | 42,07 | 67,47 | 92,87 | 118,27 | 143,67 | 169,07 | 194,5 | 219,9 | 245,3 | 270,7 | 296,1 | 321,5 |
| 43/64 | 0,672 | 17,065 | 42,46 | 67,86 | 93,26 | 118,66 | 144,06 | 169,46 | 194,9 | 220,3 | 245,7 | 271,1 | 296,5 | 321,9 |
| 11/16 | 0,688 | 17,462 | 42,86 | 68,26 | 93,66 | 119,06 | 144,46 | 169,86 | 195,3 | 220,7 | 246,1 | 271,5 | 296,9 | 322,3 |
| 45/64 | 0,703 | 17,859 | 43,26 | 68,66 | 94,06 | 119,46 | 144,86 | 170,26 | 195,7 | 221,1 | 246,5 | 271,9 | 297,3 | 322,7 |
| 23/32 | 0,719 | 18,256 | 43,66 | 69,05 | 94,45 | 119,85 | 145,25 | 170,65 | 196,1 | 221,5 | 246,9 | 272,3 | 297,7 | 323,1 |
| 47/64 | 0,734 | 18,653 | 44,05 | 69,45 | 94,85 | 120,25 | 145,65 | 171,05 | 196,4 | 221,8 | 247,2 | 272,6 | 298,0 | 323,4 |
| 3/4 | 0,750 | 19,050 | 44,45 | 69,85 | 95,25 | 120,65 | 146,05 | 171,45 | 196,8 | 222,2 | 247,6 | 273,0 | 298,4 | 323,8 |
| 49/64 | 0,766 | 19,447 | 44,85 | 70,25 | 96,65 | 121,04 | 146,44 | 171,84 | 197,2 | 222,6 | 248,0 | 273,4 | 298,8 | 324,2 |
| 25/32 | 0,781 | 19,843 | 45,24 | 70,64 | 96,04 | 121,44 | 146,84 | 172,24 | 197,6 | 223,0 | 248,4 | 273,8 | 299,2 | 324,6 |
| 51/64 | 0,797 | 20,240 | 45,64 | 71,04 | 96,44 | 121,84 | 147,24 | 172,64 | 198,0 | 223,4 | 248,8 | 274,2 | 299,6 | 325,0 |
| 13/16 | 0,813 | 20,637 | 46,04 | 71,44 | 96,84 | 122,24 | 147,63 | 173,03 | 198,4 | 223,8 | 249,2 | 274,6 | 300,0 | 325,4 |
| 53/64 | 0,828 | 21,034 | 46,43 | 71,83 | 97,23 | 122,63 | 148,03 | 173,43 | 198,8 | 224,2 | 249,6 | 275,0 | 300,4 | 325,8 |
| 27/32 | 0,844 | 21,431 | 46,83 | 72,23 | 97,63 | 123,03 | 148,43 | 173,83 | 199,2 | 224,6 | 250,0 | 275,4 | 300,8 | 326,2 |
| 55/64 | 0,859 | 21,828 | 47,23 | 72,63 | 98,03 | 123,43 | 148,83 | 174,22 | 199,6 | 225,0 | 250,4 | 275,8 | 301,2 | 326,6 |
| 7/8 | 0,875 | 22,225 | 47,62 | 73,02 | 98,42 | 123,82 | 149,22 | 174,62 | 200,0 | 225,4 | 250,8 | 276,2 | 301,6 | 327,0 |
| 57/64 | 0,891 | 22,621 | 48,02 | 73,42 | 98,82 | 124,22 | 149,62 | 175,02 | 200,4 | 225,8 | 251,2 | 276,6 | 302,0 | 327,4 |
| 29/32 | 0,906 | 23,018 | 48,42 | 73,82 | 99,22 | 124,62 | 150,02 | 175,42 | 200,8 | 226,2 | 251,6 | 277,0 | 302,4 | 327,8 |
| 59/64 | 0,922 | 23,415 | 48,81 | 74,21 | 99,61 | 125,01 | 150,41 | 175,81 | 201,2 | 226,6 | 252,0 | 277,4 | 302,8 | 328,2 |
| 15/16 | 0,938 | 23,812 | 49,21 | 74,61 | 100,01 | 125,41 | 150,81 | 176,21 | 201,6 | 227,0 | 252,4 | 277,8 | 303,2 | 328,6 |
| 61/64 | 0,953 | 24,209 | 49,61 | 75,01 | 100,41 | 125,81 | 151,21 | 176,61 | 202,0 | 227,4 | 252,8 | 278,2 | 303,6 | 329,0 |
| 31/32 | 0,969 | 24,606 | 50,01 | 75,40 | 100,80 | 126,20 | 151,60 | 177,00 | 202,4 | 227,8 | 253,2 | 278,6 | 304,0 | 329,4 |
| 63/64 | 0,984 | 25,003 | 50,40 | 75,80 | 101,20 | 126,60 | 152,00 | 177,40 | 202,8 | 228,2 | 253,6 | 279,0 | 304,4 | 329,8 |

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