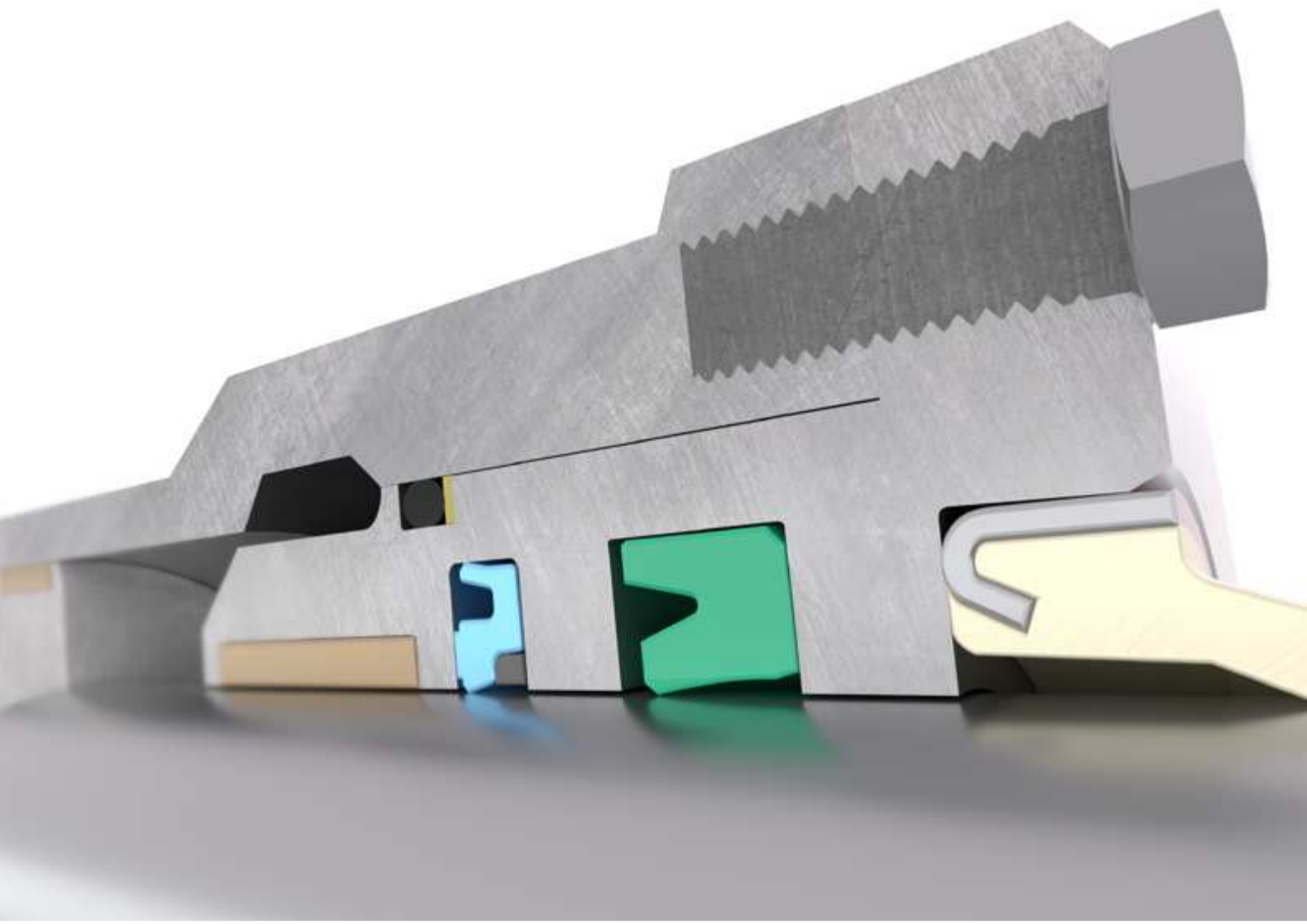
Hydraulic seals



Unit conversions

Quantity	Unit	Conversion			
Length	inch	1 mm	0.03937 in.	1 in.	25,40 mm
	foot	1 m	3.281 ft.	1 ft.	0,3048 m
	yard	1 m	1.094 yd.	1 yd.	0,9144 m
	mile	1 km	0.6214 mi.	1 mi.	1,609 km
Speed, velocity	foot per second	1 m/s	3.28 ft/s	1 ft/s	0,30480 m/s
	foot per minute	1 m/s	196.8504 ft/min	1 ft/min	0,00508 m/s
	mile per hour	1 km/h	0.6214 mph	1 mph	1,609 km/h
Force	pound-force	1 N	0.225 lbf.	1 lbf.	4,4482 N
Pressure, stress	pounds per square inch	1 MPa	145 psi	1 psi	$6{,}8948 \times 10^3$ Pa
		1 N/mm^2	145 psi		
		1 bar	14.5 psi	1 psi	0,068 948 bar
Temperature	degree	Celsius	$t_C = 0.555\ (t_F - 32)$	Fahrenheit	$t_F = 1{,}8\ t_C + 32$

Catalogue overview

Content

Foreword

This catalogue contains the standard assortment of SKF hydraulic seals and guides typically used in hydraulic cylinders. To provide the highest levels of quality and customer service, these products are available worldwide through SKF sales channels. For information about lead times and deliveries, contact your local SKF representative or SKF Authorized Distributor.

This catalogue reflects SKF's state-of-the-art technology and production capabilities as of 2014. The data contained within may differ from that shown in earlier catalogues because of redesign, technological developments, or revised calculation methods. SKF reserves the right to continuously improve its products with respect to materials, design and manufacturing methods, some of which are driven by technological developments.

Getting started

Introduction to fluid power provides an overview over hydraulic cylinder types and classification, a reference to SKF customized solutions and standard assortment of hydraulic seals and guides. The first chapter contains general technical information. Seal counter-surface finish properties, materials, fluid media and gap extrusion are discussed in detail. Furthermore, product storage and installation information is included.

Guidance values

Since several factors simultaneously affect the sealing system and seal performance, all stated values in graphs and tables in this publication should be considered as guidelines only and not as absolute values for practical applications.

How best to use this catalogue

The catalogue follows an easy principle:

- *Introduction to fluid power* **(→ pages 7** to **9)** provides basic information about hydraulic seals.
- Chapter 1 **(→ pages 12** to **33)** provides general technical information, such as counter-surface finish properties, materials, fluid media.
- Chapters 2 to 6 provide product type specific information. If applicable, a profile overview at the beginning shows the different profiles with a brief description and reference to more information inside the chapter. Product type and profile characteristics are discussed in detail. The profile data tables provide product specifications per profile followed by the relevant product tables with dimensions per item. At the end of the chapter more profiles of the specific type are outlined, including examples of the machined seal profiles manufactured with the SKF SEAL JET technology.

Profile overview

- Chapter 7 **(→ pages 146** to **148)** provides some information on other types of fluid power seals used both in hydraulic cylinders and other applications.
- Chapter 8 contains the product index **(→ page 149)** sorted by the profiles.

Find product details quickly

Coloured tabs on each right hand page show the chapter or product table number.

A quick way to access detailed product data is via the QR-Code. They are visible at every profile data page and links directly to our up-to-date online catalogue on skf.com.

Profile data

Colour coding for material

The product illustrations in this catalogue use a colour coding system to indicate the material group, but they do not match the actual material colours. For information about the actual material colours, refer to Materials **(→ page 18)**.

Consistent colour coding for material groups

- Thermoplastic polyurethane elastomers (TPU), moulded articles
- Thermoplastic polyurethane elastomers (TPU), machined articles
- Rubbers
- Rigid thermoplastics
- Unfilled PTFE and other engineered plastics
- Filled PTFE
- Phenolic resins
- Thermoplastic polyesterelastomers (TPC)
- Metals

Units of measurement

This catalogue is for global use. Therefore, the predominant units of measurement are in accordance with ISO 80000-1. Imperial units are used whenever necessary. Unit conversions can be made using the conversion table **(→ page 2).**

For easier use, some values are provided in both metric and imperial values. Values are typically rounded. Therefore, the two values do not always match according to the conversion formula.

Introduction to fluid power

Fluid power systems transfer and utilize mechanical power through a working fluid. Energy is transmitted, stored and used through the transfer and pressure of fluids. There are two main types of fluid power system:

- hydraulic – using liquid, such as oil, for the working fluid
- pneumatic – using gas, such as air, for the working fluid

Hydraulic cylinders

A hydraulic cylinder is a linear actuator used to push or pull a load, or to selectively resist motion under load, by means of fluid pressure. Double-acting cylinders, the most common type, are able to push and pull **(→ fig. 1).** High pressure fluid pumped into the extend chamber (port “A”) acts on the piston to push the piston rod out, thereby extending the length of the cylinder. Inversely, to retract the piston rod and reduce the length of the assembly, high pressure fluid is pumped into the retract chamber (port “B”) and acts on the opposite side of the piston.

Other cylinder types are shown in **figure 2**. A cylinder which can only push but not pull is referred to as a single-acting cylinder. High pressure fluid is pumped into the extend chamber (port “A”) and acts on the piston to push the piston rod out. An external force is required to return the cylinder to the retracted position. A typical application for a single-acting cylinder is a lift truck, where the load of the fork pushes the cylinder back. Multi-stage cylinders (also referred to as telescoping cylinders) have two or more piston rods in a coaxial arrangement to achieve greater extended length compared to the retracted length.

Fig. 1

Double-acting hydraulic cylinder

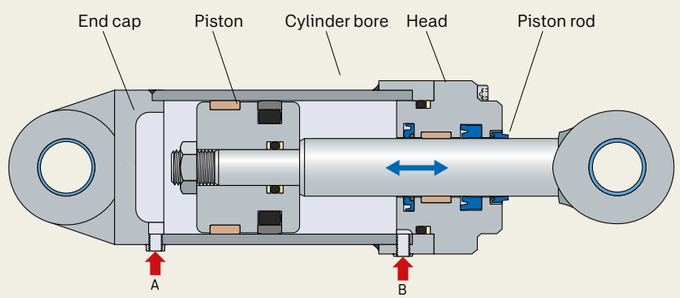
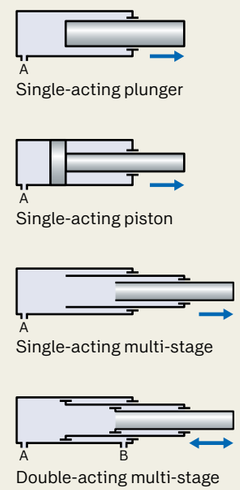


Fig. 2

Cylinder types



Cylinder classification

The type of cylinder and the application in which it is used are two of the main criteria when selecting the appropriate seals and guides. Applications are referred to as light duty, medium duty or heavy duty applications. These classifications are somewhat subjective but the duty levels are typically characterized by the following criteria.

Light duty cylinders

Light duty cylinders, e.g. cylinders used for stationary equipment indoor in a factory environment, may be characterized by:

- system pressures up to 160 bar (2 300 psi)
- temperatures up to 70 °C (160 °F)
- rare pressure peaks in excess of system pressure
- minimal side loads acting on guides
- environment with moderate temperature fluctuations and relatively free of contaminants

Medium duty cylinders

Medium duty cylinders, e.g. cylinders in agriculture off-highway equipment, may be characterized by:

- system pressures up to 250 bar (3 625 psi)
- temperatures up to 90 °C (195 °F)
- moderate pressure peaks in excess of system pressure
- moderate side loads acting on guides
- environment with temperature fluctuations and typical external contaminants such as dust and moisture

Heavy duty cylinders

Heavy duty cylinders, e.g. cylinders in off-highway earthmoving or forestry equipment, may be characterized by:

- system pressures of 400 bar (5 800 psi) or more
- temperatures exceeding 90 °C (195 °F) with peaks in excess of 110 °C (230 °F)
- regular pressure peaks in excess of system pressure
- heavy side loads acting on guides, usually due to heavy components and/or high accelerations
- tough environment with wide temperature fluctuations and typical harsh external contaminants

Hydraulic seals and guides

Hydraulic cylinder seals are used to seal the opening between various components in the hydraulic cylinder. Figure 3 shows an example of the seal and guide components of a heavy duty cylinder. There are two main types of hydraulic seals in the system:

- Dynamic seals
  They seal between components in relative motion. In a hydraulic cylinder the rod sealing system seals dynamic reciprocating motion between the piston rod and head, while the piston sealing system seals dynamic reciprocating motion between the piston and cylinder bore.
- Static seals
  They seal between components fixed together without relative motion. Hydraulic cylinders use static seals in various locations depending on the design and construction. The most common are static seals between the piston and piston rod and between the head and cylinder bore tube.

Each dynamic seal in a hydraulic cylinder has a special function to contribute to the performance of the system:

Piston seal functions

- act as pressure barrier and prevent fluid passing the piston – important for controlling the cylinder motion or maintaining the position when at rest

Rod seal functions

- act as pressure barrier and keep the operating fluid inside the cylinder
- regulate the fluid film which extends with the surface of the piston rod – important to inhibit rod corrosion and to lubricate the wiper seal and the rod seal itself
- accept the lubrication film back into the cylinder when the rod retracts

Buffer seal functions

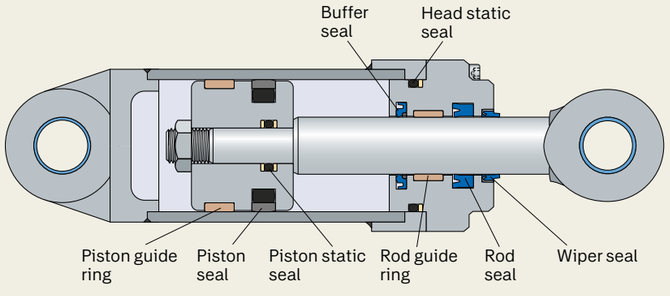
- protect the rod seal from fluid pressure peaks in excess of system pressure
- attenuate the fluctuations in system pressure, thereby improving rod seal performance by allowing the rod seal to deal with more constant or gradually changing pressure
- act as an internal excluder to keep system contaminants, such as metal particles, from damaging the rod seal

Wiper seal functions

- exclude external contaminants from entering the cylinder assembly and the hydraulic system
- accept the lubrication film back into the cylinder when the rod retracts
- Guide rings (rod and piston) functions
- prevent metal-to-metal contact between components
- react the radial load caused by side loads on the cylinder assembly
- keep the piston rod and piston accurately centred in the cylinder assembly – important for performance of the rod sealing system and piston sealing system

The subsequent chapters contain additional information regarding the function of each seal or guide in the system and the selection of them.

Fig. 3



SKF hydraulic seals and guides capabilities

The SKF assortment of hydraulic seals comprises hundreds of different designs and material combinations. The products shown in this catalogue are the more commonly used seal profiles and sizes for hydraulic cylinders. The flexible SKF manufacturing systems and processes, combined with the industry's most agile and comprehensive design and engineering capability, allow additional profiles and sizes to be added on a daily basis. If application requirements are not served by the common profiles or sizes in this catalogue, contact SKF to provide a specific offer.

Customized sealing solutions

In addition to the standard assortment of series-produced seals and sizes listed in this catalogue, SKF designs and manufactures hydraulic seals customized for virtually any requirements.

The design and development of high performance materials combined with testing and failure analysis are vital elements for successful seal development. SKF combines these elements with its extensive application knowledge, to offer solutions that are based on an understanding of sealing systems under various real conditions. SKF continuously develops new customized materials and designs and operates its own testing facilities around the world to provide optimized sealing solutions that meet the sophisticated demands of many industries.

Finite element analysis (FEA)

FEA is used to simulate the impact of operating conditions, material selection and seal design on seal behaviour **(→ fig. 4)**.

SKF SEAL JET system

With the innovative production system SKF SEAL JET virtually any kind of seal for any conceivable application can be manufactured in any dimension and design. SKF operates more than 200 machining centres worldwide and aims to be located as close to the customer as possible. This reduces manufacturing and dispatch time to a minimum. With local and global application engineering teams supported by research and development centres, machined seals **(→ fig. 5)** produced with SKF SEAL JET machines **(→ fig. 6)** can be customized to meet the most stringent sealing requirements of many industries. Key factors of the SKF SEAL JET systems **(→ fig. 7)** are:

- partnership with customers from the design phase to serial production with customized solutions
- prompt manufacturing of seals and components up to 4 000 mm (157 in.) in diameter as one piece and larger with short delivery times
- diameters up to 10 000 mm (395 in.) and larger by using a special welding technique
- virtually unlimited seal designs
- extensive range of sealing materials including materials certified to or complying with a broad range of industry standards and regulations (FDA, NSF, KTW, NORSOK, NACE, etc.)

Fig. 4

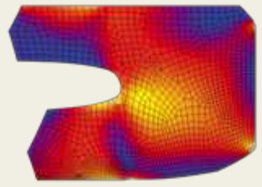


Fig. 5

Machined seals

Fig. 6

SKF SEAL JET machine

Fig. 7

SKF SEAL JET system

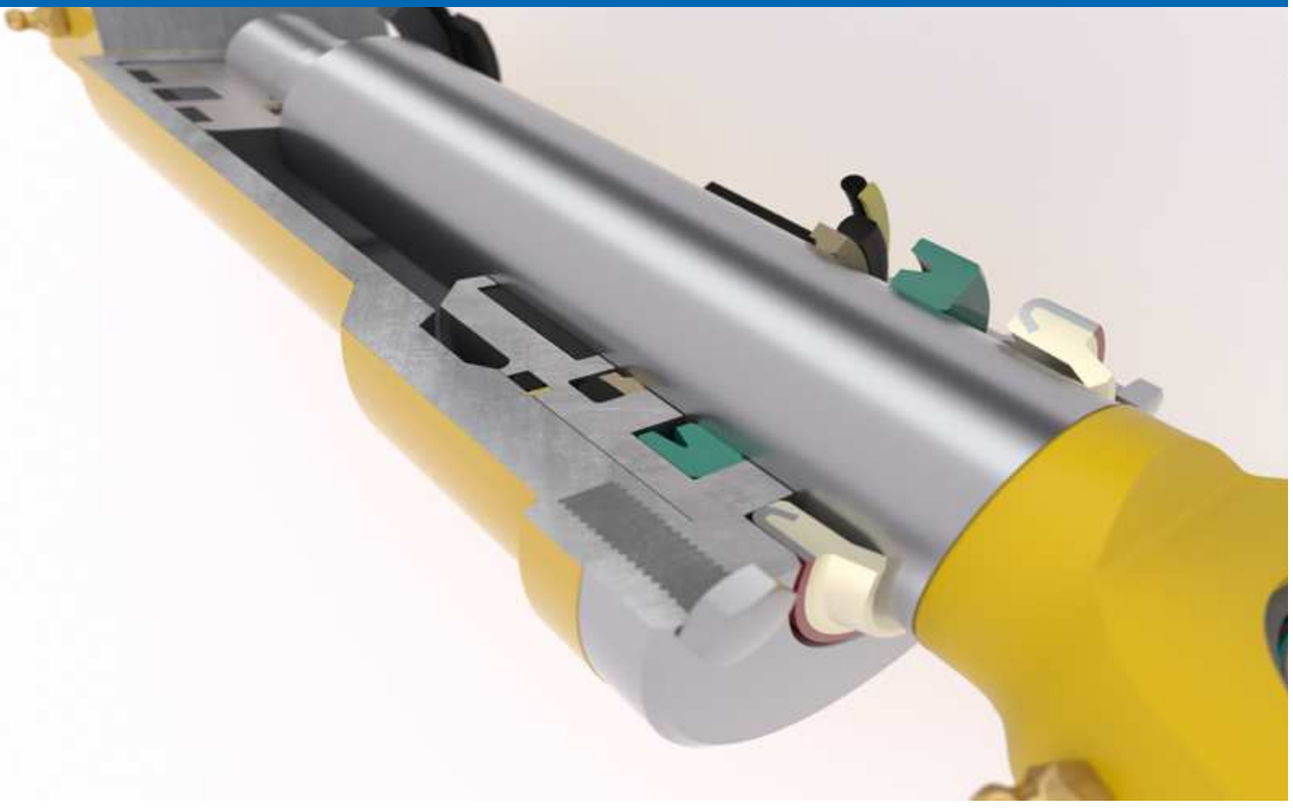
Criteria for seal selection

The selection of the right seal profile and material for a given application requires consideration of many factors. This catalogue supports the selection of the right seal for typical hydraulic seal applications and existing cylinder designs. For any application factors outside of the ordinary, or to specify sealing systems in new hydraulic cylinder designs, a certain amount of expertise, beyond the content of this catalogue, may be required. The hydraulic seal experts at SKF can assist in selecting the right sealing system for new cylinder designs.

Before seals can be selected certain application parameters and information should be collected. The following most common application considerations are nearly always required when selecting hydraulic seals:

- fluid pressure range,
- the range of operating fluid system pressure, as well as frequency and severity of pressure peaks
- temperature range,
- the range of the fluid and cylinder assembly, both when operating and at rest
- speed,
- the stroking speed of the reciprocating
- piston rod
- fluid media,
- the type and viscosity of fluid used in the system
- hardware dimensions,
- the rod and bore diameters, seal groove dimensions and gaps (if already specified), cylinder overall length and stroke length as well as surface finish specifications (if already specified)
- application of the cylinder,
- the type of equipment the cylinder will be used on and how the cylinder will operate in the equipment as well as installation, duty cycles and environmental factors (external temperature, contaminants)

1 SKF hydraulic seals – general technical information



Specifications for effective sealing systems

Designing hydraulic rod and piston sealing systems requires careful attention to the dynamic seal interaction and the principles of tribology to ensure long service life, proper seal function, minimal wear, low friction and smooth operation. Tribology is the study of the design, friction, wear and lubrication of interacting surfaces in relative motion. The most important considerations for tribological properties of a dynamic sealing system are:

- the seal material
- the seal profile design
- the counter-surface material and finish properties
- the hydraulic fluid, which is the lubrication for the dynamic sealing surfaces

For information about seal profile design, see the relevant product chapter.

Counter-surface finish properties

The surface properties of the cylinder bore and the piston rod have a great influence on the function and service life of the seal. Parameters for specifying a surface finish are defined by ISO 4287. The most common surface roughness parameter specified is R_a (in units µm or µin.), i.e. the arithmetic mean deviation of the surface profile. This value does not, however, completely describe how the surface can be expected to affect the seal. The reason for this is that two surfaces with the same values of R_a but with different surface profile characteristics can lead to different lubrication film thickness, resulting in varying seal performance and level of wear.
The material ratio curve (Abbott-Firestone curve) provides more information about the surface profile characteristics. It describes the ratio of the material-filled length to the evaluation length at a given cutting depth expressed in percent (→ **fig. 1**). The slope at the beginning of the curve represents the peaks in the profile, which are causing initial wear on the seal. The slope at the end of the curve represents the valleys in the profile, which serve as lubricant reservoirs.

Fig. 1

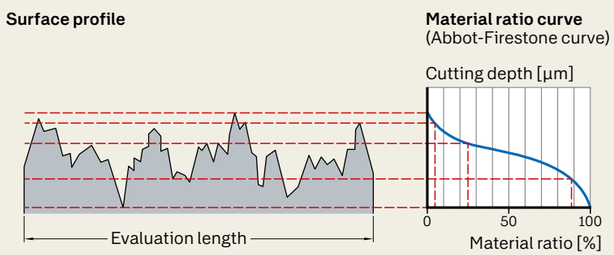


Table 1 shows some surface profiles. To ensure a surface finish with a suitable profile and characteristics for effective dynamic sealing, SKF recommends a defined combination of the following surface parameters:

- R_a – arithmetic mean roughness
- R_z – mean peak-to-valley height
- R_{max} – maximum peak-to-valley height
- R_{mr} – material ratio at a given depth

SKF recommends evaluating R_{mr} at a cutting depth of 0,5 R_z based on c_{ref} = 0% (→ **diagram 1**).

Diagram 1

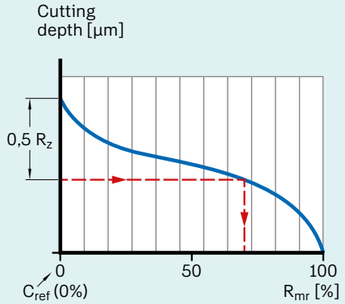


Table 1

Seal counter-surface examples

Surface profile	R_a	R_z	R_{max}	R_{mr}	Material ratio curve
–	µm	µm	µm	%	–
Eroded surface	2,4	7,3	10,4	≈ 40	
Machined surface	2,5	9,5	10,2	≈ 20 ... 25	
Ground and polished surface	0,09	1,2	1,8	≈ 90	

Recommendations for dynamic sealing surfaces

The dynamic sealing surfaces on the piston rod and in the cylinder bore (→ **fig. 2**) require similar, but somewhat different surface finishing.

Piston rod

The recommendations for the piston rod sealing surface (→ **table 2**) assume that typical materials and processes are used to manufacture the piston rod by induction hardening a carbon steel rod, grinding, hard-chromium plating and then polishing it to achieve the specified diameter and finish.
For alternative rod materials and coatings, other surface specifications, finishing methods, seal materials and designs may be required. Examples of such alternative rod coatings include:

- various hard metals applied by high velocity oxygen fuel (HVOF)
- ceramic coatings of various compositions and finishes
- stainless steel
- iron nitride

For recommendations for sealing systems with alternative rod materials and coatings, contact SKF.

Table 2

Recommendations for the dynamic sealing surface on piston rods
(induction hardened and chrome plated rods)

	Thermoplastics and rubbers	PTFE materials
R_a	0,05 to 0,3 µm *(2 to 12 µin.)*	0,05 to 0,2 µm *(2 to 8 µin.)*
R_z	0,4 to 2,5 µm *(15 to 100 µin.)*	0,4 to 2 µm *(15 to 80 µin.)*
R_{max}	0,4 to 2,5 µm *(15 to 100 µin.)*	
R_{mr}	50 to 95% (cutting depth 0,5 R_z based on c_{ref} = 0%)	
Hardness	≥ 50 HRC	
Hardening depth	~1,2 to 2,5 mm *(~0.05 to 0.1 in.)*	
Chromium layer thickness	~20 to 30 µm *(~800 to 1 200 µin.)*	

Fig. 2

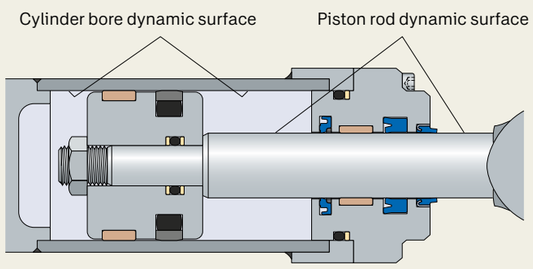


Table 3

Recommendations for the dynamic sealing surface on cylinder bores
(honed or roller burnished tubes)

	Thermoplastics, rubbers and PTFEmaterials
R_a	0,05 to 0,2 µm *(2 to 8 µin.)*
R_z	0,4 to 2 µm *(15 to 80 µin.)*
R_{max}	0,4 to 2,5 µm (15 to 100 µin.)
R_{mr}	50 to 95%

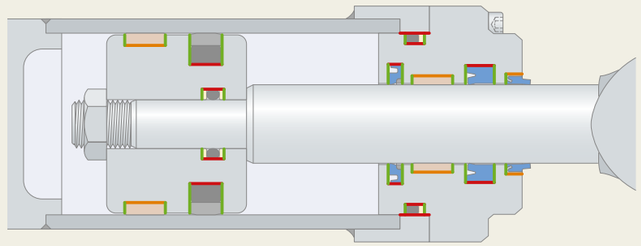
Cylinder bore

The recommendations for the cylinder bore surface (→ **table 3**) assume that typical materials and processes are used to machine the bore by either honing or roller burnishing to achieve the specified diameter and finish.

Recommendations for static sealing surfaces

Static sealing surfaces must also have a proper surface finish to enable the desired sealing performance (→ **fig. 3**).
The counter-surfaces of static seals exposed to pressure, including the static side of dynamic rod and piston seals, should have a roughness $R_a \leq 0{,}8$ µm *(30 µin.)*.
Seat diameters of guide rings and wiper seals should have a roughness of $R_a \leq 1{,}6$ µm *(63 µin.)*. Axial faces of all grooves should have a roughness of $R_a \leq 3{,}2$ µm *(125 µin.)*.

Fig. 3



- Counter-surfaces of static seals exposed to pressure $R_a \leq 0{,}8$ µm *(30 µin.)*
- Seat diameters of guide rings and wiper seals $R_a \leq 1{,}6$ µm *(63 µin.)*
- Axial faces of all grooves $R_a \leq 3{,}2$ µm *(125 µin.)*

Materials

Materials play a major role in the performance and lifetime of seals. Generally, hydraulic seals are exposed to a variety of application and working conditions, such as a wide temperature range, contact with various hydraulic fluids and the outside environment as well as high pressures and contact forces. The appropriate seal materials have to be selected to achieve a reasonable service life and service intervals. A wide variety of seal materials from four major polymeric material groups is available:

- thermoplastic elastomers, such as polyurethane (TPU) and thermoplastic polyester elastomers (TPC)
- rubbers, such as nitrile rubber (NBR) and hydrogenated nitrile rubber (HNBR), fluorocarbon rubbers (FKM, FPM)
- polytetrafluoroethylene (PTFE) and its compounds
- rigid thermoplastics and thermosets and their composites

Many different material properties should be considered to support and maintain the sealing function over the expected seal service life, for example:

- good elasticity over a wide temperature range, especially at low temperatures
- excellent compression set and stress relaxation behaviour to keep the sealing force for the requested operating period
- adequate hardness and flexibility to avoid leakage and allow easy installation
- superior gap extrusion resistance to cover the increased pressures of fluid power equipment
- adequate working temperature range
- good chemical compatibility to cover a wide assortment of hydraulic fluids such as mineral and synthetic oils, biodegradable and water-based fluids or fire-resistant fluids
- excellent tribological properties, i.e. low friction values and high wear resistance to achieve a high efficiency and avoid early failures especially when sealing against rough counter-surfaces

In addition to these considerations, the structure and morphology of polymeric materials make selection and specification of seal materials much more complicated than the standard materials used in mechanical engineering (e.g. aluminium or steel). Mechanical properties of polymeric materials are strongly influenced by time, temperature, load and rate of motion. Highly complex intermolecular processes affect the stress relaxation and retardation phenomena. Furthermore, the tribology conditions of the system (e.g. friction and wear) has a strong influence on the seal material behaviour and vice versa. Therefore, state-of-the-art sealing systems can only be developed by close cooperation between material experts and product designers, supported by advanced design tools like non-linear FEA and extensive seal testing capabilities. SKF has a global material development organization that closely cooperates with the product development and testing functions. SKF is uniquely suited to develop, simulate, test and manufacture tailor-made materials for specific customer needs.

The following tables list the most common materials used by SKF for serial production of hydraulic seals. A wide variety of additional seal materials are available for special hydraulic seals or other seal applications.

Thermoplastic elastomers

SKF has a long history in developing and supplying special polyurethane grades for sealing purposes. SKF manufactures the well-known ECOPUR family of polyurethanes including H-ECOPUR for outstanding chemical and hydrolysis resistance, X-ECOPUR for extrusion resistance or S-ECOPUR for low friction and resistance to wear.

Polyurethanes combine the elastic properties of elastomers with the processability of thermoplastic materials. Seals made of polyurethanes provide excellent wear and pressure resistance and avoid leakage. Due to their elasticity and flexibility, they are easy to install. Special sealing polyurethane grades have a superior compression set and relaxation performance as well as temperature stability compared to commodity industrial grades.

Table 4 (→ **page 20**) lists common thermoplastic elastomers.

Rubbers

Rubbers are widely used in the seals industry for rotary shaft seals, static sealing elements such as O-rings and energizers, as well as dynamic seals in the fluid power industry. Depending on the chemical composition, rubbers can cover a wide temperature range up to 200 °C *(390 °F)* and more and withstand a wide variety of hydraulic fluids. NBR elastomers in a hardness range from 70 to 90 Shore A (shA) are the most commonly used rubbers in the fluid power industry. For higher temperatures and more aggressive hydraulic fluids, SKF recommends HNBR or FKM elastomers.

Table 5 (→ **page 21**) lists common rubbers.

PTFE

PTFE is a polymer with very unique properties. Due to its chemical composition, it is the plastic material with the highest chemical resistance and the lowest coefficient of friction, however, it has some restrictions in terms of mechanical properties and wear. Therefore, PTFE is very often modified by adding various organic and/or inorganic fillers to improve specific properties such as wear or extrusion resistance.

One of the most important characteristics of PTFE is the low coefficient of friction that provides outstanding start-up behaviour as well as minimized stick-slip phenomenon. Therefore, PTFE is the preferred material in applications that require accurate positioning of hydraulic cylinders. Due to the increased modulus of elasticity compared to rubbers and polyurethanes, PTFE seals can usually not be installed by simple snap-in procedures and require special tools and procedures for installation.

Table 6 (→ **page 21**) lists common PTFE materials.

⚠ WARNING

At temperatures above 300 °C (570 °F) all fluoro elastomers and PTFE compounds give off dangerous fumes. If there is contact with your skin or if the vapours are inhaled, seek medical advice immediately.

Rigid thermoplastics and thermosets

Rigid thermoplastics and thermosets and their composites are characterized by much higher hardness and stiffness as well as reduced elasticity compared to polyurethanes, rubbers or PTFE. Therefore, they are used for components where mechanical strength is more important than flexibility, such as guide rings, anti-extrusion rings or special piston seal arrangements for heavy duty applications.

SKF offers rigid thermoplastics and composites in a wide variety of homogenous (un-filled or “virgin”) grades (e.g. polyacetal or polyamide), filled grades (e.g. glass fibre reinforced PA) and fabric-reinforced composites (e.g. phenolic resin with cotton fabric, PF). For extreme conditions, SKF can provide high performance materials such as PEEK (polyetheretherketone).

Table 7 (→ **page 22**) lists common rigid thermoplastic and thermosets.

Table 4

Thermoplastic elastomers (TPU and TPC)

Material code	Material description	Hardness Shore A (shA)	Shore D (shD)	Colour[1]		Example uses
LUBRITHANE U-1003	TPU	95		■	black	Rod seals, piston seals, wiper seals
LUBRITHANE U-1004	TPU		55	■	black	Wiper seals
LUBRITHANE U-1023	TPU	93		■	blue	Rod seals, buffer seals, piston seals, wiper seals
LUBRITHANE U-1029	TPU	94		■	light blue	Rod seals, buffer seals, piston seals, wiper seals
PU54/199	TPU	97	54	■	blue	Piston seal slide rings
W93	TPU	93		■	white	Press-in wiper seals
Y95A	TPU	95		■	yellow	Back-up rings for O-rings
395A	TPU	98		■	black	Back-up rings for O-rings
B93	TPU	93		■	dark blue	Rod seals
ECOPUR	TPU	95	48	■	green	Premium U-cup seals, wiper seals and chevron packings
X-ECOPUR	TPU with increased hardness and extrusion resistance	97	57	■	dark green	Rod and buffer seals
X-ECOPUR PS	TPU with increased hardness and extrusion resistance	98	60	■	green	Piston seals for heavy duty hydraulic applications
H-ECOPUR	TPU with increased chemical resistance against biodegradeable and water based fluids	95	48	■	red	Rod and piston seals for applications requiring hydrolysis resistance, increased chemical resistance or conformance with FDA regulations
XH-ECOPUR	TPU with increased chemical resistance and higher hardness	97	60	■	dark red	Rod and piston seals for applications requiring hydrolysis resistance, increased chemical resistance or conformance with FDA regulations
S-ECOPUR	TPU with improved tribological characteristics	95	48	■	dark grey	Rod and piston seals for water hydraulics, non-lubricated pneumatics or dry-running conditions
FLUOROTREL F-1504	TPC		55	■	turquoise	Energized rod seals, piston seals, anti-extrusion rings
TPC-ET72/075	TPC		72	■	black	Piston seal support rings

[1] The colour examples may deviate from the actual colour of the material.

Table 5

Rubbers

Material code	Material description	Hardness Shore A	Colour[1]		Example uses
A-8501	NBR	70	■	black	Rod seals, piston seals, energizers
A-8504	NBR-LT (low-temperature grade)	70	■	black	Rod seals, piston seals, energizers
A-8526	NBR	90	■	black	Piston seal energizers
C-7021	HNBR	70	■	black	Rod seals, piston seals, energizers
C-7022	HNBR	80	■	black	Rod seals, piston seals, energizers
V-7501	FKM	70	■	black	Piston seals
V-7503	FKM	90	■	black	Rod seals, piston seals, energizers
N70/015	NBR	70	■	black	Piston seal energizers
N70/6052	NBR	70	■	black	O-rings and energizers
N80/047	NBR	80	■	black	Piston seals
N80/198	NBR	80	■	black	Energizers for heavy duty applications
SKF Ecorubber-1	NBR	85	■	black	U-cup seals, chevron packings, machined seals
SKF Ecorubber-2	FKM	85	■	brown	U-cup seals, machined seals, chevron packings, wiper seals
SKF Ecorubber-H	HNBR	85	■	black	U-cup seals, chevron packings, machined seals

[1] The colour examples may deviate from the actual colour of the material.

Table 6

PTFE materials

Material code	Material description	Hardness Shore D	Colour[1]		Example uses
292	PTFE + 40 % bronze + MoS_2	62	■	brown-grey	Piston seal slide rings, guide strips
SKF Ecoflon 1, 100	PTFE unfilled	57	■	white	Anti-extrusion rings, chevron sets, O-rings, food-compatible products (FDA certificate)
SKF Ecoflon 2, 702	PTFE + 15% glass fibres + 5% MoS_2	60	■	grey	Anti-extrusion rings, chevron sets, O-rings
SKF Ecoflon 3, 741	PTFE + 40% bronze	65	■	dark grey	Anti-extrusion rings, chevron sets, O-rings
SKF Ecoflon 4	PTFE + 23% hard carbon + 2% graphite	65	■	black	Anti-extrusion rings, chevron sets, O-rings

[1] The colour examples may deviate from the actual colour of the material.

Table 7

Rigid thermoplastics and thermosets

Material code	Material description	Colour [1]		Example uses
707	PA 6	■	black	Anti-extrusion rings
P-2501	PA 6.6 + 30% glass fibres	■	black	Split piston seal slide rings
P-2506	PA 6.12	■	black	Anti-extrusion rings
P-2518	POM	■	black	Anti-extrusion rings
P-2551	PA 6 + 40% glass fibres	■	dark grey	Guide rings and split piston seal slide rings
P-2552	PA 6 + 40% glass fibres + PTFE	■	black	Guide rings
PA66/011	PA 6.6 + 20% glass fibres	■	black	Split piston seal slide rings
POM/076	POM	■	red	Guide rings in compact sets (light and medium duty cylinders)
PF	Phenolic resin with cotton fabric	■	brown	Guide rings
SKF Ecomid	PA 6	■	black	Anti-extrusion rings, guide rings
SKF Ecotal, 728	POM	■	black	Anti-extrusion rings, guide rings and scraping wiper seals
SKF Ecopaek	PEEK	■	beige	Anti-extrusion rings, guide rings
SKF Ecowear 1000	UHMWPE (ultra-high-molecular-weight polyethylene)	■	white	Anti-extrusion rings, guide rings
SKF Ecotex	Polyester resin with polyester fabric and graphite filler	■	light orange	Guide rings

[1] The colour examples may deviate from the actual colour of the material.

Hydraulic fluids

Fluids used in hydraulic systems serve multiple functions for the system performance:

- transfer power by flow under pressure acting on moveable parts
- lubricate surfaces in contact and relative motion – hydraulic cylinder components and seals, as well as other system components such as pumps and valves
- prevent corrosion of components
- cool the system, by carrying heat from areas of high load, motion or turbulence and spread it to the entire volume of the system including reservoir tanks and cooling equipment
- clean the system by carrying contaminants and wear particles to filter bodies or settling areas

The fluids used in hydraulic systems come in various chemical compositions and viscosity grades as suited to specific applications.

Viscosity is a measurement of the thickness of a fluid or the resistance to flow. Seal performance is affected by the viscosity of the fluid and changes to the viscosity during use. Most typical hydraulic fluids exhibit decreased viscosity with increasing temperature and increased viscosity with increasing pressure.

The most commonly used media in hydraulic systems are mineral oil based fluids with various additives. However, a variety of alternative fluids may be encountered in special applications. For example, biodegradable fluids such as synthetic (HEES) or natural esters (HETG) and polyalphaolefines (PAO) may be used to reduce environmental impact in the event of accidental spills. Flame retardant fluids based on water or synthetic esters may be safely used in confined spaces or where the hydraulic system is used in close proximity to ignition sources. The data, specifications and recommendations in this catalogue are for common mineral oil fluids. For guidance on specifications of sealing systems for alternative fluids, contact SKF.

The chemical composition of hydraulic fluids can impact the seal life and performance depending on compatibility with the seal material(s). Absorption and reaction of the seal material(s) with non-compatible fluids can cause, for example:

- changes in seal material volume – increased “swelling” or decreased “shrinking” and their respective impacts on seal contact force and friction
- hardening and embrittlement of the seal material
- softening, loss of strength or dissolving of the seal material
- degradation of the polymer chains or cross-linking, causing the material to fatigue or lose resilience
- discoloration of the seal material

Generally, these changes are accelerated by higher temperature. To avoid these changes and the resulting damage to seal function and life, careful consideration should be taken to ensure compatibility between the fluid and all seal materials, as well as the temperature and mechanical loads on the seal material. SKF has a long history and extensive database of test results concerning compatibility of various seal materials and fluids, as well as unparalleled expertise in developing materials to meet customers’ needs for chemical resistance of seal materials.

Table 8 (→ **page 24**) summarizes the compatibility rating for the most important fluids and materials used in the fluid power industry. For materials not listed, contact SKF. **Table 8** provides general guidelines for new, clean fluids. Fluids vary by manufacturer, additives and contaminant levels. Materials vary by specific compound. The guidelines cannot substitute for testing the compatibility of a seal in the actual fluid and under actual operating conditions. Temperatures higher than specified in **table 8** can lead to degradation of the basic fluid or its additives. This can cause deterioration of the seal material. For applications where higher temperatures are required, contact SKF.

In addition to the specified hydraulic fluid, seal materials can be attacked by exposure to other fluids from other parts of the machinery (e.g. greases, fuels, coatings), environmental factors (e.g. humidity or radiation) and degradation and reaction with the fluids, additives and contaminants in the system producing additional chemicals.

Table 8

Hydraulic fluids and seal material compatibility

Fluids	Thermoplastic elastomers								Rubbers					Thermoplastics and thermosets			PTFE[2]
	ECOPUR, LUBRITHANE		H-ECOPUR, XH-ECOPUR		Ether-based TPU		TPC (≥ 95 shA)		NBR, HNBR		FKM		EPDM[1]	PA, PF	POM	PEEK	
	Temperature Normal	High	Normal	High	Normal	High	Normal	High	Temperature Normal	High	Normal	High	All	Temperature All	All	All	All
Hydraulic fluids	≤ 60 °C (≤ 140 °F)	≤ 100 °C (≤ 210 °F)	≤ 60 °C (≤ 140 °F)	≤ 100 °C (≤ 210 °F)	≤ 60 °C (≤ 140 °F)	≤ 100 °C (≤ 210 °F)	≤ 60 °C (≤ 140 °F)	≤ 100 °C (≤ 210 °F)	≤ 60 °C (≤ 140 °F)	≤ 100 °C (≤ 210 °F)	≤ 60 °C (≤ 140 °F)	≤ 100 °C (≤ 210 °F)					
Mineral oils HL, HLP, HVLP	A	B	A	A	A	B/C	A	A/B	A	A	A	A	D	A	A	A	A
ATF (automatic transmission fluids)	A	B	A	A	A	B/C	A	B	A	A	A	A	D	A	A	A	A
HETG (triglycerides, rape seed oil)	A	B/C	A	A	A	C	A	B/C	A/B	A/B	A	A	D	A	A	A	A
HEES (synthetic esters)	A	B/C	A	A	A	C	A	B/C	A/B	A/B	A	A	D	A	A	A	A
HEPG (polyalcylene glycols)	B	D	A	C	B/C	D	C	D	A	A/B	A/B	C/D	A	A	A	A	A
HEPR (polyalphaolefines)	A	B	A	A	A	B/C	A	B	A/B	A/B	A	A	D	A	A	A	A
Fire resistant fluids, water-based	≤ 40 °C (≤ 105 °F)	≤ 60 °C (≤ 140 °F)	≤ 40 °C (≤ 105 °F)	≤ 60 °C (≤ 140 °F)	≤ 40 °C (≤ 105 °F)	≤ 60 °C (≤ 140 °F)	≤ 40 °C (≤ 105 °F)	≤ 60 °C (≤ 140 °F)	≤ 40 °C (≤ 105 °F)	≤ 60 °C (≤ 140 °F)	≤ 40 °C (≤ 105 °F)	≤ 60 °C (≤ 140 °F)					
Water	B	D	A	A	A	B	A	B	A	A	A	A	A	C[3]	A	A	A
HFA-fluids (oil in water)	B	D	A	A	B	B/C	A	B	A	A	A	B	D	C[3]	A	A	A
HFB-fluids (water in oil)	B	D	A	A	B	D	A	B	A	A	A	A	D	C[3]	A	A	A
HFC-fluids (water-glycol)	C	D	A	B/C	B	B/C	C	D	A	A	A/B	B/C	A	C[3]	A	A	A
Fire resistant fluids, water-free	≤ 60 °C (≤ 140 °F)	≤ 100 °C (≤ 210 °F)	≤ 60 °C (≤ 140 °F)	≤ 100 °C (≤ 210 °F)	≤ 60 °C (≤ 140 °F)	≤ 100 °C (≤ 210 °F)	≤ 60 °C (≤ 140 °F)	≤ 100 °C (≤ 210 °F)	≤ 60 °C (≤ 140 °F)	≤ 100 °C (≤ 210 °F)	≤ 60 °C (≤ 140 °F)	≤ 100 °C (≤ 210 °F)					
HFD-R fluids	D	D	D	D	D	D	D	D	D	D	A/C[4]	A/C[4]	A	A	A	A	A
HFD-U fluids (polyol and carboxylic esters)	B	D	A	A	B	D	A	B/C	A/B	C	A	A	D	A	A	A	A
Mineral greases	A	B	A	A	A	B	A	A	A	A	A	A	D	A	A	A	A

A Excellent
B Good
C Limited
D Not recommended

[1] Ethylene-propylene rubber for reference only – not common for hydraulic cylinders
[2] For filled PTFE, compatibility of filler must be considered separately (e.g. bronze not recommended for water-based fluids).
[3] Exposure to water-based fluids or moisture causes swelling.
[4] Contact SKF

Gap extrusion

The process by which seal material is forced into the clearances between components is called gap extrusion. The dimension of this clearance gap is referred to as the extrusion gap, or "e-gap" (→ **fig. 4**).

The resistance of a given seal component to gap extrusion is mainly determined by the material composition and quality. Materials of greater hardness and stiffness typically also have improved resistance to extrusion. Therefore, full-face anti-extrusion or back-up rings of materials harder than the seal material may be used to prevent seal extrusion into the e-gap (→ **fig. 5**).

Pressure is the main driver of extrusion, but the e-gap size and application temperature are also major factors. **Diagram 2** shows the pressure resistance of different materials as a function of temperature. The values were measured on an SKF test rig. The tests were carried out with a rectangular sample, dimensions 38,7 x 49 x 5 mm under static pressure and an extrusion gap of 0,3 mm. The pressure values were taken at an extrusion length of 0,5 mm (→ **fig. 4**). While these sample values illustrate the differences in extrusion resistance for standard grades of typical seal materials, there are many variations of each basic composition that impact the extrusion resistance of seals. In addition, the profile design and the seal friction affect extrusion. For maximum allowable pressure, temperature and e-gap of each seal profile, refer to the profile data for each profile in the relevant chapters.
The maximum e-gap in a hydraulic cylinder occurs when the cylinder components are at the maximum radial misalignment of components. This misalignment is affected by:

- external forces acting upon the cylinder assembly (e.g. acceleration forces, frictional moments from rotation of cylinder end connections)
- the weight of the cylinder components (especially when used horizontally)
- deformation of cylinder components (rod flexing, guide ring radial deformation under force)
- the tolerance stack up of multiple cylinder components

Fig. 4

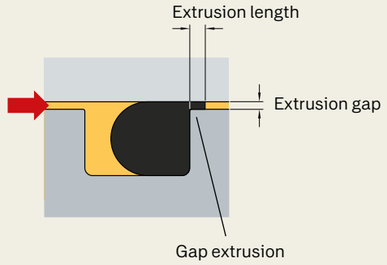


Fig. 5

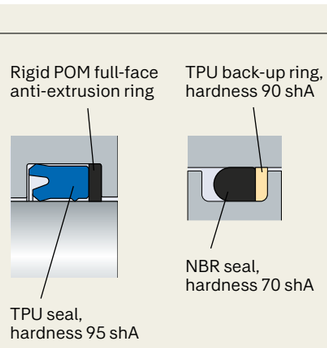
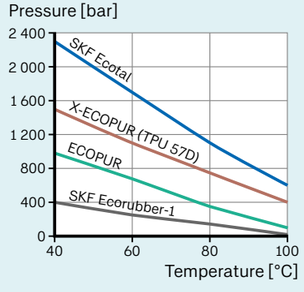


Diagram 2



Therefore, it is necessary to calculate the e-gap at the maximum misalignment at minimum material conditions of the cylinder and guide components.
For rod seals, the maximum e-gap should be calculated with the following conditions (→ **fig. 6**):

- guide ring groove at maximum diameter D
- rod at minimum diameter d
- guide ring cross section at minimum thickness t (considering tolerances and any radial deformation of the guide ring under load)
- rod seal housing throat at maximum diameter h

For piston seals, the maximum e-gap should be calculated with the following conditions (→ **fig. 7**):

- bore at maximum diameter D
- guide ring groove at minimum diameter d
- guide ring cross section at minimum thickness t (considering tolerances and any radial deformation of the guide ring under load)
- piston seal housing at minimum outside diameter OD

The maximum allowable e-gap is provided in the profile data for each rod seal and piston seal profile in the relevant chapter. The e-gap can be kept within these limits by specifying and controlling the tolerances of dimensions described above and shown in **figs. 6** and **7**.

Fig. 6

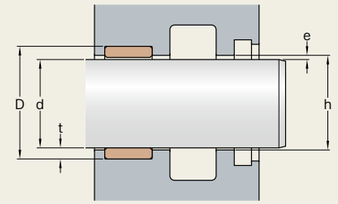


Fig. 7

Storage

During storage, the properties of elastomer products can be damaged either by chemical reactions or by physical processes. Chemical reactions are basically caused by the influence of heat, light, oxygen, ozone or contamination by chemicals. The physical processes, which are called physical ageing, are either due to the influence of external stresses leading to cracks and permanent deformation, or due to the migration of plasticizers, which makes the material more brittle and can lead to deformation of the parts.

Therefore, elastomer products only maintain their characteristics for several years without major changes, if they are properly stored. The ageing behaviour of elastomer products and their reaction on storage conditions depend considerably on their chemical structure. Unsaturated elastomers (e.g. nitrile rubber) age more quickly under improper storage conditions than saturated elastomers (e.g. fluorocarbon rubber).

Storage conditions

Elastomer products should be stored in accordance with the following recommendations, which are in line with the recommendations provided in ISO 2230 or DIN 7716.

- Rubber and plastic products should be stored in a cool and dry room. The relative humidity should be < 65%. Storage temperature should be around 15 °C *(60 °F)* and not exceed 25 °C *(75 °F)*. If the storage temperature is below 15 °C *(60 °F)*, care should be taken during handling of stored products because they may have stiffened. They should be warmed up slowly at ambient temperature.
- The storage room must not contain any ozone-producing devices, such as electric motors or high-voltage devices.
- Rubber and plastic products should not be exposed to direct sunlight or artificial light with a high UV content (bulbs are preferred to neon lamps).
- Rubber products should not be exposed to drafts. They should be stored in airtight packaging. The package material must not contain plasticizers. Polyethylene is the most suitable package material.
- Contact between rubber products of different compositions should be avoided.
- Contact between rubber and plastic products and chemicals or dangerous metals (e.g. copper, manganese) should be avoided.
- Rubber and plastic products should be stored as tension-free as possible, i.e. the parts should not be subject to tension, pressure or bending. Rubber products, especially seals, must not be hung on nails or tightly folded or rolled for reasons of space.

Shelf life

When stored under the conditions mentioned above, elastomer products retain their typical properties for several years (→ **table 9**).

The typical shelf life may be prolonged based on the actual product conditions at the end of the typical shelf life. Trained and experienced experts can approve a prolonged storage period based on a visual inspection of representative samples. The samples should not reveal any permanent distortion, mechanical damage or surface cracking. The material should not show any signs of hardening or softening nor any kind of tackiness.

Table 9

Shelf life recommendations in years

Material	Typical shelf life	Possible prolongation
TPU (standard)	5	2
ECOPUR, LUBRITHANE	5	2
H-ECOPUR, XH-ECOPUR	10	2
TPC	5	2
NBR	6	3
HNBR	8	4
FKM, FPM	10	4
EPDM	8	4
MVQ (silicone)	10	5
PTFE	15	5
PA, POM, PF	8	4
PEEK	15	5
UHMWPE	10	5

Installation and assembly

Seal housing grooves

The type of seal housing determines the method of installation, required equipment and the degree of difficulty. There are four main types of seal housings.

Closed housing grooves

Closed housing grooves are the most common seal housings (→ **fig. 8**). They require the most planning and effort to ensure that the seal is installed properly without damage. Not all seal cross section sizes and material combinations can be installed into this type of seal housing.

Open housing grooves

Open housing grooves allow the seal to be pressed in with minimal deformation and are therefore a good choice when the seal design, material or size prevent installation into a closed or stepped housing. Some seals, such as press-in wiper seals, have a metal sleeve that retains the seal in an open groove by press forces (→ **fig. 9**), whereas other seals may require a snap ring (→ **fig. 10**). Plastic snap rings, such as RI for rods or RR for piston, are available from SKF on request. Open housing grooves require specified edge radii or chamfers to prevent seal damage when the seal enters the housing groove or passes the snap ring groove.

Fig. 8

Closed housing groove

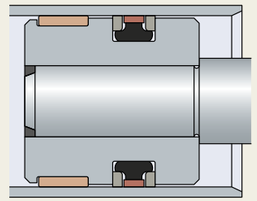


Fig. 9

Open housing groove

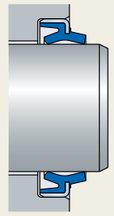
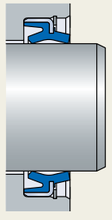


Fig. 10

Open housing groove with snap ring



Split two-piece closed grooves

These grooves incorporate two separable machine components to provide an open groove when the seal is installed and a closed groove when the machine is fully assembled (→ **fig. 11**).

Stepped grooves

Stepped grooves allow seals to be installed with less deformation (→ **fig. 12**). Snap-in wiper seals are a common example in hydraulic cylinder applications.

Corner radii

The corner radii inside the groove should be sized to avoid inadvertent contact with with the adjacent portion of the seal. Static side corner radius recommendations are provided in the product tables of the relevant chapter.

Groove edge radii

All outside groove edges and any other edges that may come into contact with the seal during installation or use should be broken with a small radius. Otherwise, the sharp edge may damage the seal. Unless otherwise specified, all outside groove edges should have a radius of approximately 0,2 mm *(0.008 in.)*.

Fig. 11

Split two-piece closed housing groove

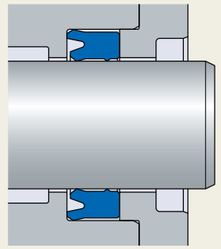


Fig. 12

Stepped housing groove

Installation chamfers

Installation chamfers should be designed into the cylinder bore and onto the assembly end of the piston rod to ensure that the seal can easily transition from its free state diameter into its installed diameter. The installation chamfer should also be blended into the cylinder bore or piston rod diameter with a generous radius. The chamfer angle and minimum length recommendations are provided in the product tables of the relevant chapter.

Installing rod seals

The method of installation and the possible groove types for rod seals depend on the materials, seal design and ratio between the diameter and cross-sectional height. **Table 10** provides general recommendations for profiles made of rubber or TPU with a hardness ≤ 95 shA. PTFE or other harder materials may require a smaller radial depth S or even open grooves. The recommendations in **table 10** are not a substitute for careful installation tests in the particular application.

Installing rod seals in closed grooves

Rod seals can often be installed into closed grooves through carefully bending the profile similar to a kidney shape and then inserting it into the groove. It is very important to avoid sharp bending.

Thin and flexible profiles can be installed by hand (→ **figs. 13 a** and **b**). Installation tools for TPU rod seals help to install profiles of greater section thickness (→ **figs. 14 a** to **f**). After installation, the seal may need to be reshaped to a round form using a cone-shaped tool.

For PTFE seals, small diameter seals or for serial assembly, special assembly tools (→ **fig. 15**, **page 32**) may be required to save time or avoid seal damage. For additional information about such special installation tools, contact SKF.

Fig. 13 a

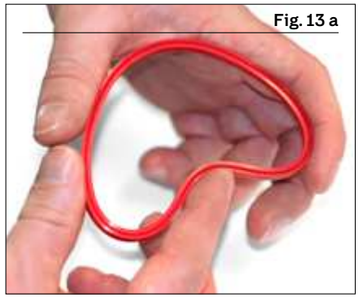


Fig. 13 b

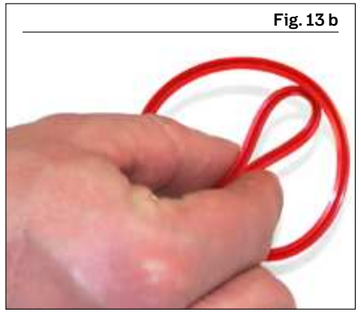
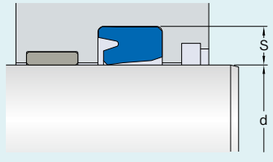


Table 10

General recommendations for selecting the type of installation for rubber and TPU materials
(hardness ≤ 95 shA)



Diameter/radial depth ratio	Type of installation
d/S ≤ 6	Open groove
6 < d/S ≤ 10	Closed groove, installation with tool
d/S > 10	Closed groove, installation by hand


Fig. 14a

Tool, rod seal and housing


Fig. 14b

Tool positioned for grasping the seal

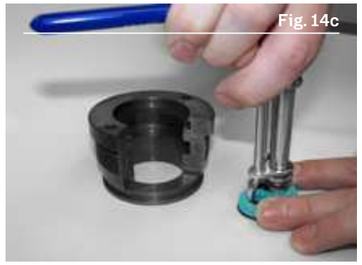


Fig. 14c

Seal properly folded


Fig. 14d

Inserting the seal into the housing


Fig. 14e

Seal positioned for installation


Fig. 14f

Seal properly installed

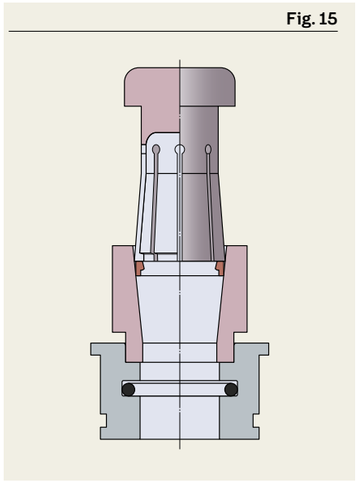


Fig. 15

Installing piston seals

Piston seals installed in closed grooves must be expanded or stretched into position. Seals with step cut slide rings such as CUT or SCP (→ *Piston seals with rigid split slide rings*, **page 42**) are relatively easy to expand into position. Non-split profiles should not be expanded to a material deformation of more than 20% for TPU or 30% for rubbers. Otherwise, the permanent deformation would be too large. Heating the seal, e.g. in an oil bath, decreases the required expansion force, but cannot increase the maximum material deformation.

Piston seals with a TPU slide ring can usually be installed by hand or with simple tools (→ **fig. 16**). PTFE seals or those with thicker radial sections may require special assembly tools to save time or avoid seal damage (→ **fig. 17**). For additional information about such special installation tools, contact SKF.
The recommendations cannot substitute for careful installation tests in the particular application.

Installing wiper seals

Snap-in wiper seals, which are installed in stepped grooves (→ **fig. 12**, **page 30**), are typically of a small radial section per diameter and close to the end of the cylinder head component. Therefore, installation by hand is usually possible. Press-in wiper seals require special equipment and careful planning for ease of installation without damaging the wiper seal or housing. Assembly tools adapted for each press-in wiper seal size should be used in conjunction with appropriate steady force in a hand operated press. Installation by impact (e.g. striking the assembly tool with a hammer) is not advised. The press assembly tool should be configured to stop when the wiper seal has been pressed flush with the groove edge (→ **fig. 18**). Pressing beyond flush can damage the wiper seal.

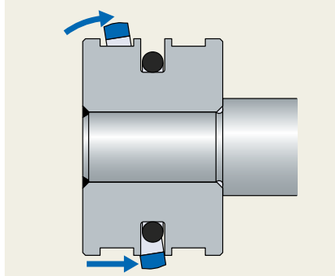


Fig. 16

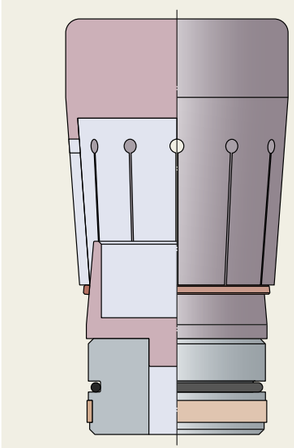


Fig. 17

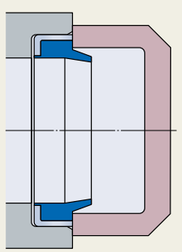
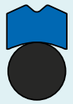


Fig. 18

2 Piston seals

Profile overview

Profile	Description	Additional information → page	Profile data → page
MPV 	Polyurethane slide ring, nitrile rubber energizer; suitable for medium to heavy duty applications	**39**	**44** (metric)
DPV 	Polyurethane slide ring, nitrile rubber energizer; fits O-ring dash-number housings; suitable for medium to heavy duty applications	**39**	**46** (inch)
LPV 	Polyether-based polyurethane slide ring, nitrile rubber energizer; suitable for light to medium duty applications	**40**	**48** (metric)
CPV 	Polyurethane slide ring, nitrile rubber energizer; fits O-ring dash-number housings; suitable for light to medium duty applications	**40**	**50** (inch)
GH 	PTFE slide ring, nitrile rubber energizer; low breakaway friction; suitable for medium duty applications	**40**	**52** (metric and inch)
APR 	PTFE slide ring with incorporated nitrile rubber X-ring for improved sealing performance, nitrile rubber energizer; suitable for medium to heavy duty applications	**40**	**54** (metric and inch)
LCP 	PTFE slide ring supported by polyamide anti-extrusion rings, nitrile rubber energizer; very good gap extrusion resistance; suitable for heavy duty applications and high pressures	**41**	**56** (metric and inch)
LTP 	Sealing ring made of nitrile rubber, supported by polyamide anti-extrusion rings; good gap extrusion resistance; fits O-ring dash-number housings; suitable for medium to heavy duty applications and high pressures	**41**	**58** (inch)

Profile	Description	Additional information → page	Profile data → page
CUT 	Step cut polyamide slide ring, nitrile rubber energizer; suitable for heavy duty applications and high pressures	**42**	**60** (metric)
SCP 	Step cut polyamide slide ring, oval nitrile rubber energizer; fits wide, shallow inch size housings; suitable for heavy duty applications and high pressures	**42**	**62** (inch)
MD-L 	Five-piece compact set consisting of a nitrile rubber sealing ring, integrated polyester elastomer anti-extrusion rings and polyacetal guide rings; suitable for medium duty applications	**42**	**64** (metric)
UNP 	Polyurethane U-cup profile; single-acting; may be used in double-acting cylinders when using two seals in back-to-back arrangement; suitable for medium duty applications	**42**	**66** (metric and inch)

Rod seals that can be used as piston seals

PTB 	These rod seal profiles are designed with similar inside and outside sealing geometry. Therefore, they can also be used as piston seals (→ *Rod seals used as single-acting piston seals*, **page 43**).	→ *Rod and buffer seals*, **page 70**	**86** (metric and inch)
STD 			**88** (inch)
DZ 			**90** (metric and inch)

Basics

Piston seals (→ **fig. 1**) maintain sealing contact between the piston and the cylinder bore. Differential pressures acting on the piston to extend or retract the piston rod can be in excess of 400 bar *(5 800 psi)*. The pressure acting on the piston seal increases contact forces between the piston seal and cylinder surface. Therefore, the surface properties of the sealing surfaces are critical to proper seal performance (→ *Counter-surface finish properties*, **page 14**).

Piston seals are typically classified into single-acting (pressure acting on one side only) and double-acting (pressure acting on both sides) seals.

Materials

Depending on the profile and the required characteristics of its components, a piston seal can consist of one or several materials. Common materials used for piston seals are thermoplastic polyurethane (TPU), polytetrafluoro-ethylene (PTFE), polyamide (PA), and nitrile rubber (NBR). The standard materials used for a specific profile are provided in the *Profile overview* (→ **page 36**) and in the relevant profile sections below.

For additional information, refer to *Materials* (→ **page 18**).

Gap extrusion

External forces acting on the piston rod, reacted by the fluid inside the cylinder, can result in abrupt pressure peaks. These peaks can be far in excess of the system operating pressure and may press a piston seal into the gap between the piston and bore, thereby causing damage to the seal and adversely affecting seal performance and cylinder operation. Seal materials must be carefully chosen to avoid gap extrusion (→ *Gap extrusion*, **page 26**). This risk of gap extrusion can also be minimized by using seals with anti-extrusion rings (→ *Piston seals incorporating anti-extrusion rings*, **page 53**).

Piston guidance

Guide rings avoid sliding metal-to-metal contact between the piston and cylinder bore and accommodate the radial loads of forces acting on the cylinder assembly. Although piston seals are designed to accommodate slight radial motion between the piston and bore, effective guide ring function to accurately centre the piston within the bore is important for piston seal performance. For additional information about piston guidance, refer to *Guide rings and guide strips* (→ **page 118**).

Piston drift

When the piston rod is at rest and held in position by fluid, any amount of flow passing the piston can result in an unintended movement of the piston rod and cause drift. Although piston seal leakage is a possible source of drift, internal valve leakage, external system leakage and flow between the piston and rod static connections should also be carefully checked. In some applications, a minimal amount of flow passing the piston seal within specified limits is permitted. This accepted flow allows the use of piston seals of low friction designs and materials or split slide rings for easy installation.

Sealing between piston and rod

The piston can be welded to the rod (→ **fig. 2**) if the disassembly of the cylinder can be done by removing the rod end attachment. The piston can also be fixed to the rod end by a lock nut (→ **fig. 3**), which enables removing the piston from the rod during complete disassembly of the cylinder. When using a lock nut, static sealing (→ *O-rings and back-up rings*, **page 132**) is required between the piston and the rod end.

Fig. 1

Typical piston seal arrangement for double-acting cylinders

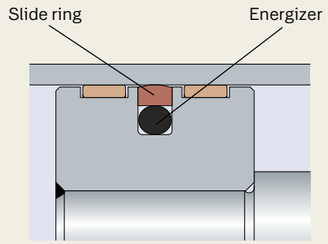


Fig. 2

Piston welded to the rod end tap

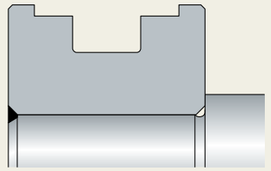
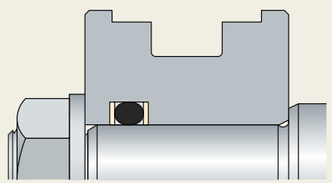


Fig. 3

Piston fixed to the rod by a lock nut and with a static seal and two back-up rings between piston and rod end



More information

Double-acting piston seals

Double-acting cylinders are the most widely used cylinder types. They operate with pressure on both sides and, therefore, require double-acting seal arrangements (→ **fig. 1**, **page 38**).

Double-acting piston seals have a symmetrical profile (cross section) and identical sealing functions in both directions. Typically, double-acting piston seals consist of a slide ring and an energizer. The deformation of the elastomeric energizer when installed provides adequate force to keep the slide ring in dynamic sealing contact with the cylinder bore, while sealing statically against the seal housing groove.

A double-acting cylinder typically has the same fluid on both sides of the piston. Therefore, a relatively thick lubrication film can be permitted between the piston seal and the cylinder bore to minimize friction and wear. The transportation of fluid occurring during dynamic operation is, however, small and insignificant in most applications.

In some older cylinder designs, O-rings were used as piston seals. To allow easy replacement of O-rings with the equivalent piston seals, the housing dimensions for some double-acting piston seals are the same as those for dash-number O-rings. Therefore, these housings are also called O-ring dash-number housings.

SKF supplies double-acting piston seals in many different profiles and in a wide range of series and sizes, which make them appropriate for a wide variety of operating conditions and applications.

Piston seals with polyurethane slide rings

Piston seals with thermoplastic polyurethane (TPU) slide rings have a nitrile rubber (NBR) energizer. The wear-resistant slide ring has a profiled dynamic sealing surface. Its geometry is optimized to reduce friction and resist gap extrusion. Notches in the slide ring edges ensure rapid pressurization of the seal to react to abrupt changes in pressure. These profiles can usually be installed without special equipment and are resistant to damage during installation and cylinder assembly.

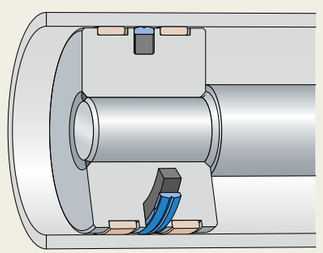
MPV profiles

MPV profiles (→ **fig. 4**) have slide rings made of X-ECOPUR PS (TPU) developed for pressures up to 400 bar *(5 800 psi)*. They are suitable for high fluid temperatures and in medium to heavy duty applications, such as earthmoving equipment. MPV profiles are available in metric sizes and some fit seal housings in accordance with ISO 7425-1.

DPV profiles

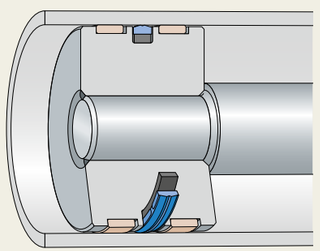
DPV profiles (→ **fig. 5**) have slide rings made of X-ECOPUR PS (TPU) developed for pressures up to 400 bar *(5 800 psi)*. They are suitable for high fluid temperatures and for medium to heavy duty applications such as earthmoving equipment. DPV profiles are available in inch sizes where O-ring dash-number housings are used.

Fig. 4



MPV

Fig. 5



DPV

LPV profiles

LPV profiles (→ **fig. 6**) have a polyether-based polyurethane (EU) slide ring that provides resistance to hydrolysis (attack from moisture) and good low temperature flexibility. The O-ring energizer provides a cost-effective sealing solution. These profiles are developed for pressures up to 250 bar *(3 625 psi)* and suitable for light to medium duty applications, such as agriculture and material handling applications. They are available in metric sizes and some fit seal housings in accordance with ISO 7425-1.

CPV profiles

CPV profiles (→ **fig. 7**) have a polyester-based polyurethane (AU) slide ring. These profiles are developed for pressures up to 345 bar *(5 000 psi)* and suitable for light to medium duty applications. They are available in inch sizes where O-ring dash-number housings are used.

Piston seals with PTFE slide rings

PTFE slide rings may be preferred in applications with demands for low breakaway friction and when it comes to chemical and thermal resistance. Notches in the slide ring edges ensure rapid pressurization of the seal to react to abrupt changes in pressure. PTFE is hard and non-elastic when compared with polyurethane and rubber materials. For additional information about piston seal materials, refer to *Materials* (→ **page 38**).

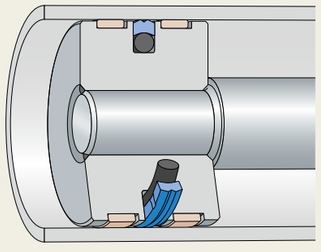
GH profiles

GH profiles (→ **fig. 8**) have a nitrile rubber (NBR) energizer, which is an O-ring as standard. Rectangular energizers are available on request. These profiles are suitable for pressures up to 400 bar *(5 800 psi)* in medium to heavy duty applications. GH profiles are available in metric and inch sizes and some metric sizes fit seal housings in accordance with ISO 7425-1.

APR profiles

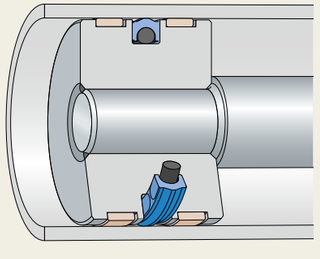
APR profiles (→ **fig. 9**) have a nitrile rubber (NBR) O-ring energizer. The PTFE slide ring incorporates an NBR X-ring to improve sealing performance. They are suitable for pressures up to 350 bar *(5 075 psi)* in medium to heavy duty applications. APR profiles are available in metric and inch sizes and some metric sizes fit seal housings in accordance with ISO 7425-1.

Fig. 6



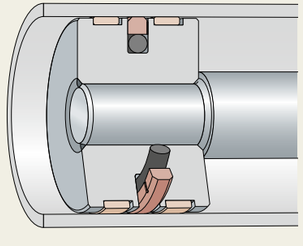
LPV

Fig. 7



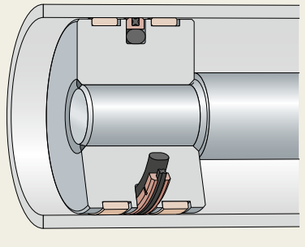
CPV

Fig. 8



GH

Fig. 9



APR

Piston seals incorporating anti-extrusion rings

These SKF piston seals incorporate patented locking anti-extrusion rings made of polyamide (PA). They are split for easy installation. Their snap-in design makes it easy to identify the correct installation direction (→ **fig. 10**), holds them in place when installed and prevents damage during assembly.

Piston seals incorporating anti-extrusion rings have an improved high pressure performance and minimize the risk of gap extrusion at abrupt pressure peaks (→ *Gap extrusion*, **page 26**).

LCP profiles

LCP (→ **fig. 11**) profiles have a PTFE slide ring supported by harder PA anti-extrusion rings (→ **fig. 10**) and a T-shaped nitrile rubber (NBR) energizer. These capped T-seals are suitable for pressures up to 690 bar *(10 000 psi)* and available in metric and inch sizes. Some metric sizes fit seal housings in accordance with ISO 5597.

LTP profiles

LTP profiles (→ **fig. 12**) have a nitrile rubber (NBR) sealing ring supported by harder PA anti-extrusion rings on both sides. These T-seals are suitable for pressures up to 345 bar *(5 000 psi)* in medium to heavy duty applications and are available in inch sizes where O-ring dash-number housings are used.

Fig. 10

Patented locking anti-extrusion rings

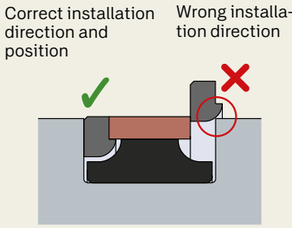
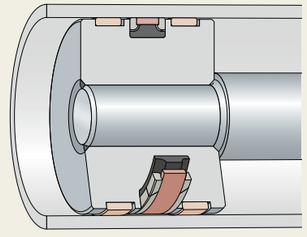
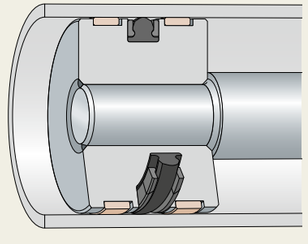


Fig. 11



LCP

Fig. 12



LTP

Piston seals with rigid split slide rings

These SKF piston seals have a rigid split slide ring made of glass fibre reinforced polyamide and a nitrile rubber (NBR) energizer. The rigid slide ring has high resistance to wear and gap extrusion. The slide ring also provides low friction, even at high pressures. The split slide ring design facilitates the installation process into a closed housing.

CUT profiles

CUT profiles (→ **fig. 13**) have a step cut slide ring and a rectangular energizer. They are suitable for pressures up to 500 bar *(7 250 psi)* in heavy duty applications. CUT profiles are available in metric sizes and some fit seal housings in accordance with ISO 7425-1.

They can be used for short pressure pulses and shock loads with proper system design. For additional information, contact SKF.

SCP profiles

SCP profiles (→ **fig. 14**) have a step cut slide ring and an oval energizer. They are suitable for pressures up to 690 bar *(10 000 psi)* in heavy duty applications and are available in inch sizes.

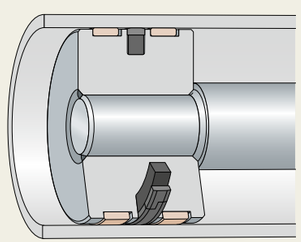
Piston seals with integrated guide rings

These seals are designed as compact sets that incorporate the piston seal and guide rings into one assembly. Typically, they are applied as an all-in-one piston seal solution.

MD–L profiles

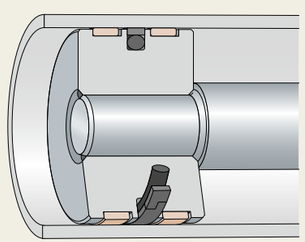
MD-L profiles (→ **fig. 15**) have a nitrile rubber (NBR) sealing ring with thermoplastic polyester elastomer (TPC) anti-extrusion rings on both sides, which incorporate the polyacetal (POM) guide rings. The guide and anti-extrusion rings are split for easy installation. MD-L profiles are suitable for pressures up to 250 bar *(3 625 psi)* in medium duty applications and are available in metric sizes. Some sizes fit seal housings in accordance with ISO 6547.

Fig. 13



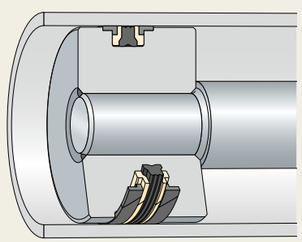
CUT

Fig. 14



SCP

Fig. 15



MD-L

Single-acting piston seals

A single-acting piston seal is designed for cylinders where pressure is applied from one side only. The piston in single-acting cylinders may have oil on the pressure side only, while the opposite side is open to atmosphere. Therefore, the piston seal must leave a minimum of oil film when passing along the cylinder bore since the transportation of oil otherwise would result in a leakage to the exterior.

In single-acting cylinders, the open end may push air out and draw air in as the piston reciprocates. This air may carry moisture and contaminants into the cylinder, which can lead to seal damage. Vent filters may be fitted to the open side of the cylinder to reduce contaminants entering the inside of the cylinder. The cylinder bore may be hard chromium plated to prevent corrosion.

In addition, to prevent damage to the cylinder bore or piston seals, SKF can supply special piston wiper seals on request. For additional information, contact SKF.

UNP profiles

UNP profiles (→ **fig. 16**) are single-acting U-cup seals made of thermoplastic polyurethane (TPU). They are suitable for pressures up to 350 bar *(5 075 psi)* and are available in metric and inch sizes. In case of higher pressures, SKF provides full-face anti-extrusion rings on request. For additional information, contact SKF.

Single-acting piston seals in double-acting cylinders

Two single-acting U-cup profile seals, facing in opposite directions, can be used in a double-acting cylinder. It is important to select seal designs which can relieve reverse pressure for such arrangements to prevent build-up of pressure between the two seals. UNP profiles are suitable for such double-acting arrangements because the dynamic seal lip can flex
to relieve reverse pressure.

Rod seals used as single-acting piston seals

Some rod seal profiles are designed with similar inside and outside sealing geometry and, therefore, can also be used as single-acting piston seals in single- or double-acting cylinders (→ **fig. 17**). PTB, STD and DZ rod seal profiles (→ *Rod and buffer seals*, **page 70**) can be used for those applications.

Rod seals with loaded-lip U-cup profiles may not relieve reverse pressure, but it is possible to remove their energizer (X-ring) from one of the seals to allow reverse pressure relief (→ **fig. 17**).

Fig. 16

UNP profile piston seal with a wiper seal

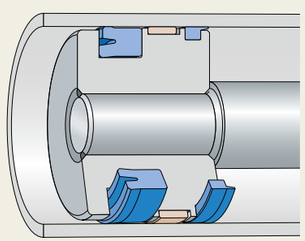
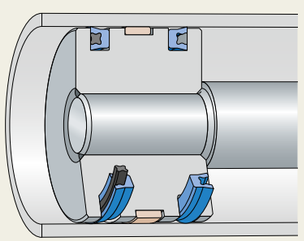


Fig. 17

STD profiles used as piston seals (in a double-acting arrangement)



Profile data

2.1 MPV

Material codes
Slide ring: X-ECOPUR PS
Energizer: N80/198
For additional information → **page 18**

Pressure
Up to 400 bar *(5 800 psi)*

Speed
Up to 1 m/s *(3.2 ft/s)*

Temperature range

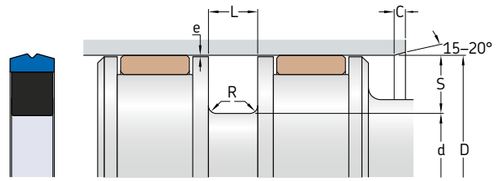
For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Dimension standards
Some sizes fit seal housings in accordance with ISO 7425-1.

Counter-surface
→ **14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

D 50 – 200 mm

Maximum extrusion gap e

Radial depth S	e_{max} at 80 °C *(175 °F)* for pressures 160 bar	250 bar	400 bar
mm	mm		
3,75	0,4	0,4	–
5,5	0,5	0,4	0,3
7,75	0,6	0,45	0,3
10,5	0,7	0,55	0,4

For additional information → **page 26**

For complete product listings see:
https://skf.li/mpv

2.2 DPV

Material codes

Slide ring: X-ECOPUR PS
Energizer: A-8501
For additional information → **page 18**

Pressure

Up to 400 bar *(5 800 psi)*

Speed

Up to 1 m/s *(3.2 ft/s)*

Temperature range

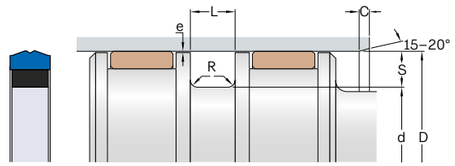
For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Counter-surface

→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Inch sizes

D 1 – 6.002 in.

Maximum extrusion gap e

Radial depth S	**e_{max} at 80 °C *(175 °F)* for pressures** 160 bar	250 bar
mm	**mm**	
3,75	0,3	0,2
5,5	0,4	0,25
7,75	0,4	0,3
10,5	0,5	0,4

For additional information → **page 26**

For complete product listings see:
https://skf.li/dpv

2.3 LPV

Material codes
Slide ring: PU54/199
Energizer: N70/6052
For additional information → **page 18**

Pressure
Up to 250 bar *(3 625 psi)*

Speed
Up to 0,5 m/s *(1.6 ft/s)*

Temperature range

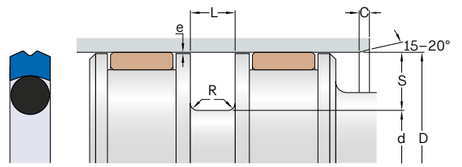
For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Dimension standards
Some sizes fit seal housings in accordance with ISO 7425-1.

Counter-surface
→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

D 25 – 100 mm

Maximum extrusion gap e

Radial depth S		e_{max} at 80 °C *(175 °F)* for pressures 2 300 psi	3 600 psi	5 800 psi
in.	**–**	**in.**		
0.125	**2**	0.012	0.008	–
0.187	**3**	0.018	0.012	0.008
0.25	**4**	0.022	0.016	0.01

For additional information → **page 26**

For complete product listings see:
https://skf.li/lpv

2.4 CPV

Material codes

Slide ring: U-1003
Energizer: A-8501
For additional information → **page 18**

Pressure

Up to 345 bar *(5 000 psi)*

Speed

Pressure ≤ 250 bar *(3 625 psi)* → up to 1 m/s *(3.2 ft/s)*
Pressure > 250 bar *(3 625 psi)* → up to 0,5 m/s *(1.6 ft/s)*

Temperature range

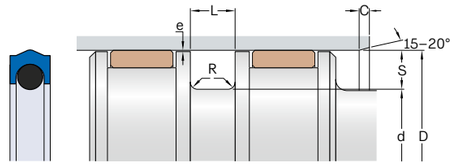
For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Counter-surface

→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Inch sizes

D 1.5 – 9.002 in.

Maximum extrusion gap e

Radial depth S		e_{max} at 80 °C *(175 °F)* for pressures 2 300 psi	3 600 psi	5 800 psi
in.	**–**	**in.**		
0.121	**2**	0.012	0.006	–
0.185	**3**	0.018	0.008	0.004
0.237	**4**	0.022	0.014	0.006

For additional information → **page 26**

For complete product listings see:
https://skf.li/cpv

2.5 GH

Material codes

Slide ring: metric sizes → 292
inch sizes → 741
Energizer: metric sizes → N70/6052
inch sizes → A-8501
For additional information → **page 18**

Pressure

Up to 400 bar *(5 800 psi)*

Speed

Up to 5 m/s *(16.4 ft/s)*

Temperature range

For temperature limits depending on fluid compatibility → **table 8**, **page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

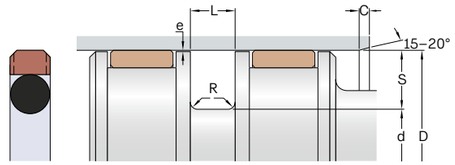
Dimension standards

Some metric sizes fit seal housings in accordance with ISO 7425-1.

Counter-surface

→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

D 14 – 200 mm

Maximum extrusion gap e

Radial depth S	e_{max} at 80 °C *(175 °F)* for pressures 160 bar	250 bar	400 bar
mm –	**mm**		
2,45	0,35	0,25	0,15
3,75	0,35	0,25	0,15
5,5	0,4	0,3	0,2
7,75	0,5	0,35	0,25
10,5	0,6	0,45	0,35

For additional information → **page 26**

For complete product listings see:
https://skf.li/gh

Inch sizes

D 0.5 – 16 in.

Maximum extrusion gap e

Radial depth S		e_{max} at 80 °C *(175 °F)* for pressures 2 300 psi	3 600 psi	5 800 psi
in.	–	**in.**		
0.087	0A	0.014	0.01	0.006
0.13	0D	0.014	0.01	0.006
0.149	1A	0.014	0.01	0.006
0.196	1D	0.015	0.011	0.007
0.212	2A	0.016	0.012	0.008
0.259	2D	0.018	0.013	0.009
0.308	3A	0.02	0.014	0.01
0.415	4A	0.024	0.018	0.014

For additional information → **page 26**

For complete product listings see:
https://skf.li/gh

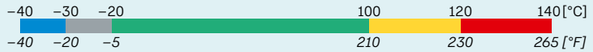
2.6 APR

Material codes
Slide ring: 741
X-ring and energizer: A-8501
For additional information → **page 18**

Pressure
Up to 350 bar *(5 075 psi)*

Speed
Up to 1 m/s *(3.2 ft/s)*

Temperature range



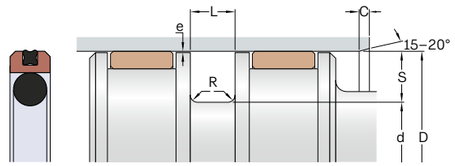
For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Dimension standards
Some metric sizes fit seal housings in accordance with ISO 7425-1.

Counter-surface
→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

D 20 – 190 mm

Maximum extrusion gap e

Radial depth S	e_{max} at 80 °C *(175 °F)* for pressures 70 bar	200 bar	350 bar
mm	**mm**		
5,5	0,46	0,15	0,1
7,75	0,6	0,2	0,13
10,5	0,76	0,25	0,15

For additional information → **page 26**

For complete product listings see: https://skf.li/apr

Inch sizes

D 1 – 14 in.

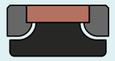
Maximum extrusion gap e

Radial depth S	Series	e_{max} at 80 °C *(175 °F)* for pressures 1 000 psi	3 000 psi	5 075 psi
in.	**–**	**in.**		
0.212	APR2	0.018	0.006	0.004
0.308	APR3	0.024	0.008	0.005
0.42	APR4	0.03	0.01	0.006
0.46	APR5	0.03	0.01	0.006

For additional information → **page 26**

For complete product listings see: https://skf.li/apr

2.7 LCP

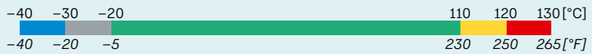


Material codes
Slide ring: 741
Energizer: A-8501
Anti-extrusion rings: P-2506
For additional information → **page 18**

Pressure
Up to 690 bar *(10 000 psi)*

Speed
Up to 1,5 m/s *(4.9 ft/s)*

Temperature range



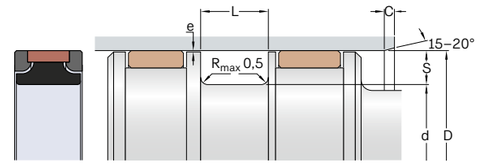
For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Dimension standards
Some metric sizes fit seal housings in accordance with ISO 7425-1.

Counter-surface
→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

D 25 – 290 mm

Maximum extrusion gap e

Radial depth S	e_{max} at 80 °C *(175 °F)* for pressures 70 bar	200 bar	350 bar	
mm	**mm**			
5	0,7	0,45	0,25	0,15
6,15	0,7	0,45	0,25	0,15
7,5	1	0,65	0,4	0,2
9,25	1,4	0,9	0,55	0,25
10	1,4	0,9	0,55	0,25

For additional information → **page 26**

For complete product listings see: https://skf.li/lcp

Inch sizes

D 3– 16 in.

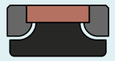
Maximum extrusion gap e

Radial depth S	Series	e_{max} at 80 °C *(175 °F)* for pressures 1 000 psi	3 000 psi	5 075 psi
in.	**–**	**in.**		
0.212	APR2	0.018	0.006	0.004
0.308	APR3	0.024	0.008	0.005
0.42	APR4	0.03	0.01	0.006
0.46	APR5	0.03	0.01	0.006

For additional information → **page 26**

For complete product listings see: https://skf.li/lcp

2.8 LTP



Material codes

Sealing ring: A-8501
Anti-extrusion rings: P-25066
For additional information → **page 18**

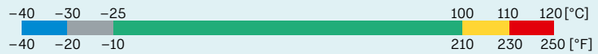
Pressure

Up to 345 bar *(5 000 psi)*

Speed

Pressure ≤ 250 bar *(3 625 psi)* → up to 1 m/s *(3.2 ft/s)*
Pressure > 250 bar *(3 625 psi)* → up to 0,5 m/s *(1.6 ft/s)*

Temperature range



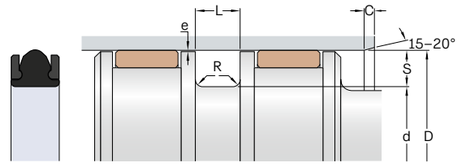
For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Counter-surface

→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Inch sizes

D 0.625– 12.002 in.

Maximum extrusion gap e

Radial depth S	Series	e_{max} at 80 °C *(175 °F)* for pressures 1 000 psi	3 000 psi	5 000 psi
in.	–	**in.**		
0.125	2	0.025	0.008	0.005
0.187	3	0.03	0.012	0.007
0.25	4	0.035	0.017	0.01

For additional information → **page 26**

For complete product listings see:
https://skf.li/ltp

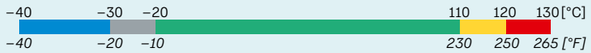
2.9 CUT

Material codes
Slide ring: PA66/011
Energizer: N70/015
For additional information → **page 18**

Pressure
Up to 500 bar *(7 250 psi)*

Speed
Up to 1 m/s *(3.2 ft/s)*

Temperature range



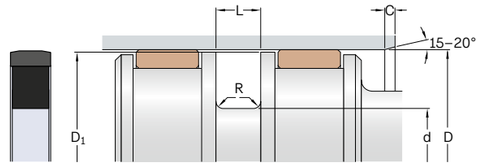
For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Dimension standards
Some sizes fit seal housings in accordance with ISO 7425-1.

Counter-surface
→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

D 40 – 320 mm

For complete product listings see:
https://skf.li/cut

2.10 SCP

Material codes

Slide ring: suffix E5E → P-2501
suffix E5D → P-2551
Energizer: A-8526
For additional information → **page 18**

Pressure

Up to 690 bar *(10 000 psi)*

Speed

Up to 1 m/s *(3.2 ft/s)*

Temperature range

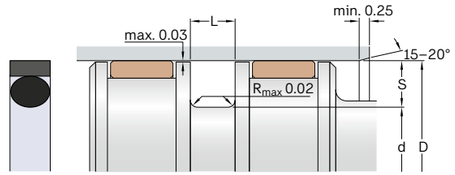
For temperature limits depending on fluid compatibility → **table 8**, **page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Counter-surface

→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Inch sizes

D 2 – 12 in.

For complete product listings see:
https://skf.li/scp

2.11 MD-L

Material codes
Sealing ring: N80/047
Guide rings: POM/076
Support rings: TPC-ET72/075
For additional information → **page 18**

Pressure
Up to 250 bar *(3 625 psi)*

Speed
Up to 1 m/s *(3.2 ft/s)*

Temperature range

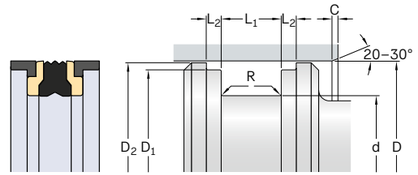
For temperature limits depending on fluid compatibility → **table 8**, **page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Dimension standards
Some sizes fit seal housings in accordance with ISO 7425-1.

Counter-surface
→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

D 25 – 280 mm

For complete product listings see:
https://skf.li/mdl

2.12 UNP

Material codes

Metric sizes → U-1029
Inch sizes → U-1023
For additional information → **page 18**

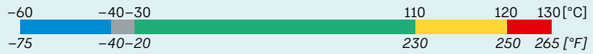
Pressure

Up to 350 bar *(5 075 psi)*

Speed

Pressure ≤ 250 bar (3 625 psi) →up to 1 m/s (3.2 ft/s)
Pressure > 250 bar (3 625 psi) → up to 0,5 m/s (1.6 ft/s)

Temperature range



For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

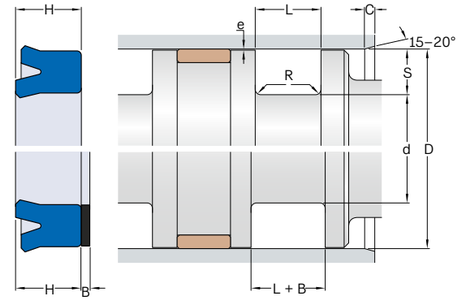
Dimension standards

Some sizes fit seal housings in accordance with ISO 7425-1.

Counter-surface

→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

D 45 –300 mm

Maximum extrusion gap e

Radial depth S	**e_{max} at 80 °C *(175 °F)* for pressures** 160 bar	250 bar	350 bar
mm	**mm**		
5	0,45	0,25	0,1
7,5	0,5	0,3	0,15
10	0,55	0,3	0,15
12,5 to 15	0,6	0,3	0,2

For additional information → **page 26**

For complete product listings see:
https://skf.li/unp

Inch sizes

D 1.125 – 6.5 in.

Maximum extrusion gap e

Radial depth S	**e_{max} at 80 °C *(175 °F)* for pressures** 1 000 psi	3 000 psi	5 075 psi
in.	**in.**		
0.125	0.008	0.004	–
0.187	0.014	0.008	–
0.25	0.018	0.01	0.004
0.375	0.02	0.012	0.006
0.5	0.022	0.012	0.006

For additional information → **page 26**

For complete product listings see:
https://skf.li/unp

More piston seals

The piston seals listed in this catalogue represent the preferred profiles in common sizes. SKF supplies many additional sizes and profiles. The following profiles are also manufactured in series production. SKF can provide customized sealing solutions also for the toughest application conditions. For additional information about these profiles or if the application requires a solution outside of what is provided in this catalogue, contact SKF.

More PTFE slide ring piston seals

Piston seals with PTFE slide rings are available in a wide variety of profiles and materials **(→ fig. 18)**. For additional information about material options, contact SKF.

Customized machined seal profiles

SKF can manufacture a broad variety of piston seal profiles with different materials and sizes with its industry-leading SKF SEAL JET production system **(→ fig. 19)**. For additional information about customized machined profiles, refer to publication Customized machined seals – Product range or contact SKF.

Fig. 18

PTFE slide ring piston seals, profile examples

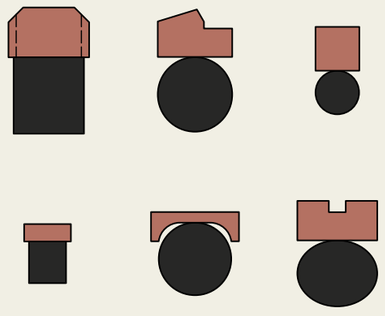


Fig. 19

SKF SEAL JET profile examples

3 Rod and buffer seals

Profile overview

Profile		Description	Additional information → page	Profile data → page
S1S		Single-lip U-cup profile made of polyure-thane; suitable for medium to heavy duty applications	**76**	**80** (metric)
ZBR		Double-lip U-cup profile made of poly-urethane; suitable for medium to heavy duty applications	**76**	**82** (metric and inch)
SIL		Double-lip U-cup profile made of poly-urethane; suitable for low temperatures and light to medium duty applications	**76**	**84** (metric)
PTB		Polyurethane U-cup profile with incorpor-ated nitrile rubber X-ring, which provides good performance even at low pres-sure and temperature; suitable for medium duty applications	**77**	**86** (metric and inch)
STD		Polyurethane U-cup profile with incorpor-ated nitrile rubber X-ring, which provides good performance even at low pres-sure and temperature; fits narrow housings; suitable for medium duty applications	**77**	**88** (inch)
DZ		Nitrile rubber primary sealing ring, polyure-thane secondary sealing ring; low friction; suitable for medium to heavy duty applica-tions	**77**	**90** (metric and inch)

Profile		Description	Additional information → page	Profile data → page
DZR		Nitrile rubber primary sealing ring, polyure-thane secondary sealing ring, integrated triangular polyamide anti-extrusion ring; improved gap extrusion resistance; suitable for heavy duty applications and extreme pressures	**77**	**92** (metric and inch)
RBB		Buffer seal with polyurethane sealing ring, integrated poly-acetal or polyamide anti-extrusion ring; designed to vent pressure back to system side; improved gap extru-sion resist-ance at abrupt pressure peaks; fits narrow housings; suitable for heavy duty applications	**78**	**94** (metric and inch)
S9B		Buffer seal with nitrile rubber O-ring ener-gizer, PTFE slide ring; also available with polyurethane slide ring to improve wear resistance and ease installation; suitable for medium to heavy duty applications	**78**	**96** (metric and inch)
RSB		Buffer seal with PTFE slide ring, nitrile rub-ber energizer; pat-ented and improved de-sign to reduce pressure peaks acting on the rod seal and vent pressure back to system side; improved gap extrusion resistance at abrupt pressure peaks; suitable for medium to heavy duty applications	**79**	**98** (inch)

Basics

Rod sealing systems

Rod and buffer seals maintain sealing contact in sliding motion between the cylinder head and the piston rod. Depending on the application, a rod sealing system can consist of a rod seal and a buffer seal **(→ fig. 1**) or a rod seal only **(→ fig. 2)**. Rod sealing systems for heavy duty applications typically consist of a combination of both seal types, whereas the buffer seal is arranged between the rod seal and the piston in the cylinder head. Rod seals determine the tolerance for the rod diameter d.

In addition to the sealing function, rod seals also provide a thin lubrication film on the piston rod that lubricates themselves and the wiper seals. The lubricant also inhibits corrosion of the piston rod surface. However, the lubrication film must be thin enough so that it returns to the cylinder during the return stroke.

Selecting profiles and materials for a rod sealing system is a complex task, considering all possible cylinder designs and application criteria. SKF supplies rod and buffer seals in many different profiles and in a wide range of materials, series and sizes, which make them appropriate for a wide variety of operating conditions and applications.

Materials

Depending on the profile and the required characteristics of its components, rod and buffer seals can consist of one or several materials. Common materials used for the sealing and energizing elements of rod and buffer seals are thermoplastic polyurethane (TPU), polytetrafluoroethylene (PTFE) or nitrile rubber (NBR). Common materials used for rod seal anti-extrusion rings are polyamide (PA), polyacetal (POM) or PTFE. The materials used for a specific profile are provided in the *Profile overview* **(→ page 72)** and in the relevant profile sections below.

For additional information, refer to *Materials* (**→ page 18**).

Fig. 1

Typical rod seal arrangement for heavy duty hydraulic applications

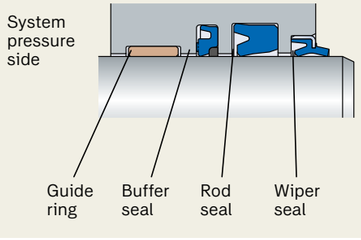
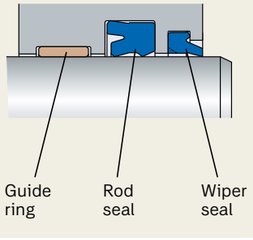


Fig. 2

Typical rod seal arrangement for light to medium duty hydraulic applications



Anti-extrusion rings

External forces acting on the rod can cause pressure peaks. They can be far in excess of the system operating pressure and may press a rod seal into the gap between the piston rod and the cylinder head. This risk of gap extrusion can be avoided for rod and buffer seals by using anti-extrusion rings. These hard and temperature-resistant rings can be integrated in the seal or a separate full-face anti-extrusion ring can be used. This ring can be added to a rod seal by simply extending the housing length **(→ fig. 3)**. Integrated anti-extrusion rings fit into a notch in the rod or buffer seal and do not need an extended housing length.

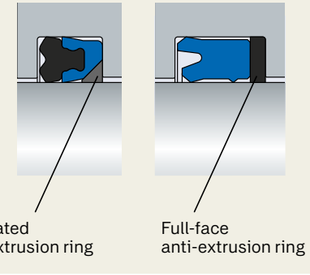
DZR **(→ fig. 10, page 77)** profile rod seals and RBB **(→ fig. 11, page 78)** profile buffer seals incorporate an anti-extrusion ring. Other U-cup and energized U-cup rod seals with an integrated anti-extrusion ring are available on request. For seals without an integrated anti-extrusion ring, SKF provides full-face anti-extrusion rings on request. For additional information, contact SKF.

Rod guidance

Although rod sealing systems are designed to accommodate minor radial motion between the piston rod and cylinder head, effective rod guidance is important to ensure best rod seal performance. Guide rings accurately center the rod within the head, which reduces radial deflection and motion acting on the seals. Guide rings also accommodate the radial loads acting on the cylinder assembly and avoid direct metal-to-metal contact between the piston rod and cylinder head. For additional information about rod guidance, refer to *Guide rings and guide strips* **(→ page 249)**.

Fig. 3

Integrated and full-face anti-extrusion rings



Rod seals

Rod seals are typically single-acting seals, which means that fluid pressure acts from inside the cylinder on one seal side only. Pressures acting on the rod side of the piston can be in excess of 400 bar *(5 800 psi)*, pressure peaks can be even higher. The pressure acting on the rod seal increases contact forces between the rod seal and rod surfaces. Therefore, rod seal materials should be wear resistant and the rod surface needs to be manufactured to the recommended specifications
(→ *Counter-surface finish properties,* **page 14**).

Polyurethane U-cup rod seals

U-cup seals, as their name implies, have a U-shaped profile, including an outside static sealing lip and an inside dynamic sealing lip. The unique combination of resilience and its resistance to gap extrusion and wear makes thermoplastic polyurethane (TPU) the most common material used for U-cup seals in hydraulic applications.

They are available with a single- or double-lip design.

S1S profiles

S1S profiles (→ **fig. 4**) are made of ECOPUR (TPU) and have a single-lip design. The geometry has been optimized using FEA (Finite Element Analysis) to provide the longest possible maintenance-free service. They are suitable for pressures up to 400 bar *(5 800 psi)* in medium to heavy duty applications and are available in metric sizes. Some fit seal housings in accordance with ISO 5597.

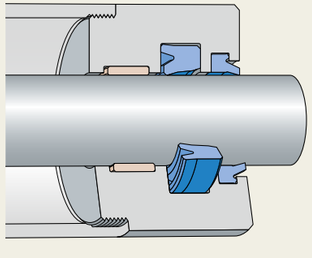
ZBR profiles

ZBR profiles (→ **fig. 5**) are made of LUBRITHANE (TPU) and have a double-lip design. They are suitable for pressures up to 400 bar *(5 800 psi)* in medium to heavy duty applications and are available in metric and inch sizes. Some metric sizes fit seal housings in accordance with ISO 5597.

SIL profiles

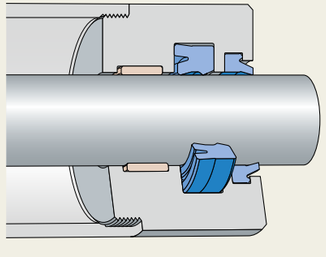
SIL profiles (→ **fig. 6**) are made of ether-based TPU. They have a double-lip design and a secondary dynamic sealing lip. These seals provide good resistance to hydrolysis (attack from moisture) and good low temperature resilience. SIL profiles are suitable for
pressures up to 350 bar *(5 075 psi)* in light to medium duty applications and are available in metric sizes. Some fit seal housings in accordance with ISO 5597.

Fig. 4



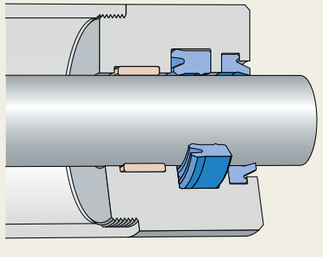
S1S

Fig. 5



ZBR

Fig. 6



SIL

Energized U-cup rod seals

Energized U-cup rod seals incorporate a nitrile rubber (NBR) X-ring in their thermoplastic polyurethane (TPU) U-cup. The X-ring serves as energizer, provides additional sealing force and improves the long-term resilience of the sealing lips. This can be beneficial in applications with low operating pressure or low temperatures.

PTB profiles

PTB profiles (→ **fig. 7**) are made of LUBRITHANE (TPU). They are suitable for pressures up to 400 bar *(5 800 psi)* in medium duty applications and are available in metric and inch sizes. Some metric sizes fit seal housings in accordance with ISO 5597.

STD profiles

STD profiles (→ **fig. 8**) are made of LUBRITHANE (TPU). They are suitable for pressures up to 400 bar *(5 800 psi)* in medium duty applications and can also be used as a heavy duty static seal or a snap-in wiper seal. These profiles are available in inch sizes where narrower seal housings are used. Metric sizes are available on request.

Hybrid rod seals

Hybrid rod seals incorporate dynamic sealing lips of different materials. These material combinations provide a hybrid with the functional benefit of each material and, therefore, a robust rod seal. An example is the sealing ability and resilience of nitrile rubber (NBR) combined with the extrusion and wear resistance of polyurethane (TPU).

DZ profiles

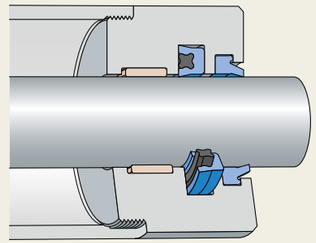
DZ profiles (→ **fig. 9**) combine an NBR primary sealing ring with a LUBRITHANE (TPU) secondary sealing ring into one seal. This combination provides a good low temperature resilience and is suitable for pressures up to 400 bar *(5 800 psi)* in medium to heavy duty applications. DZ profiles are available in metric and inch sizes. They are also available with an elastomer (FLUOROTREL/TPC) secondary sealing ring on request.

These SKF hybrid rod seals have been proven successful in low temperature applications. The NBR primary lips also provide improved long term sealing performance and a greater capability to track larger radial deflections between the rod and the head.

DZR profiles

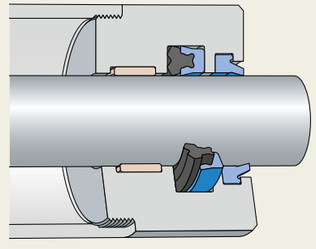
DZR profiles (→ **fig. 10**) combine an NBR primary sealing ring, a LUBRITHANE (TPU) secondary sealing ring and a triangular polyamide (PA) anti-extrusion ring (→ *Anti-extrusion rings*, **page 75**) into one seal. These combinations provide good low temperature resilience, and improved resistance to deformation, wear, and gap extrusion. They are suitable for extreme pressures up to 690 bar *(10 000 psi)* in heavy duty applications. DZR profiles are available in metric and inch sizes.

Fig. 8



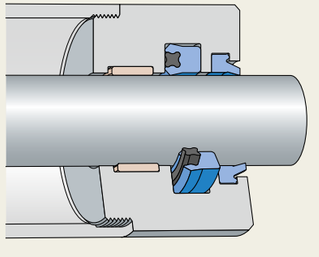
STD

Fig. 9



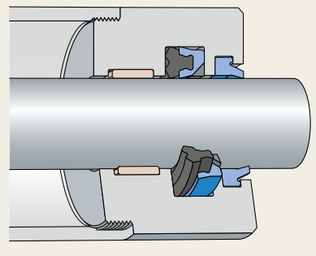
DZ

Fig. 7



PTB

Fig. 10



DZR

Buffer seals

Buffer seals protect the rod seals by reducing the magnitude of pressure peaks. Abrupt pressure peaks can occur by external forces acting on the piston rod, initiated by the fluid inside the cylinder. These pressure peaks can be far in excess of the system operating pressure. Buffer seals in combination with rod seals provide an effective rod sealing system for cylinders in heavy duty applications at high temperature and pressure.

Polyurethane U-cup buffer seals

RBB profiles

RBB profiles (→ **fig. 11**) have a LUBRITHANE (TPU) sealing ring that incorporates a polyamide (PA) or polyacetal (POM) anti-extrusion ring. The flexible outside static sealing lip and notches in the front face ensure that pressure can return to the system side of the buffer and prevent build-up of pressure between the rod and buffer seals. These profiles are suitable for extreme pressure peaks and demanding workloads in heavy duty applications up to 690 bar *(10 000 psi)*. They are available in metric and inch sizes, some metric sizes fit seal housings in accordance with ISO 7425-2.

Buffer seals incorporating slide rings

S9B profiles

S9B profiles (→ **fig. 12**) have a nitrile rubber (NBR) O-ring energizer and a PTFE slide ring as standard. Depending on the application, SKF can manufacture the slide rings from a variety of PTFE materials. On request, SKF can supply these profiles also with X-ECOPUR polyurethane (TPU) slide rings for improved wear resistance and ease of installation compared to PTFE. S9B profiles with a PTFE slide ring are suitable for pressures up to 400 bar *(5 800 psi)*, those with an X-ECOPUR slide ring up to 600 bar *(8 700 psi)*. These profiles are suitable for medium to heavy duty duty applications. Both material combinations are available in metric and inch sizes, some metric sizes fit seal housings in accordance with ISO 7425-2 or ISO 3320.

RSB profiles

RSB profiles (→ **fig. 13**) have a nitrile rubber (NBR) energizer and a PTFE slide ring.

The energizer is designed to hold the slide ring in the proper and permanent sealing position against the rod seal side of the housing. Conventional buffer seal designs can shift axially within the groove and push fluid into the rod seal groove when subjected to abrupt pressure peaks. This ultimately causes rod seal failure. However, the patented design of RSB profiles prevents any axial shifting of the slide ring. Therefore, these profiles protect the rod seal in applications where conventional buffers are not sufficient. In combination with grooves in the energizer outside diameter and notches in the front face of the slide ring (→ **fig. 14**), the protrusions also ensure that pressure can return to the system side.

RSB profiles are suitable for pressures up to 400 bar *(5 800 psi)* in medium to heavy duty applications and are available in inch sizes.

On request, for the most demanding applications of large equipment, SKF can manufacture these profiles with polyamide (PA) slide rings for additional extrusion and wear resistance.

Fig. 11

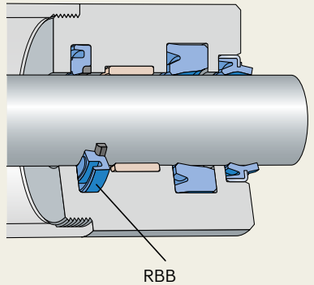


Fig. 12

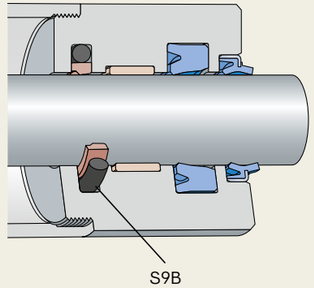


Fig. 13

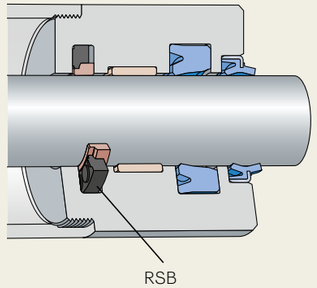
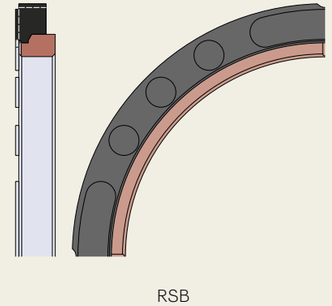


Fig. 14



Profile data

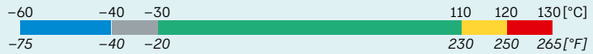
3.1 S1S

Material codes
ECOPU
For additional information → **page 18**

Pressure
Up to 400 bar *(5 800 psi)*

Speed
Up to 1 m/s *(3.2 ft/s)*

Temperature range



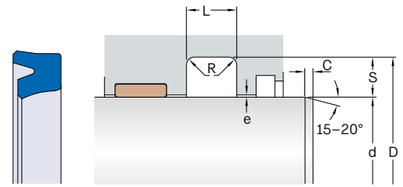
For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Dimension standards
Some sizes fit seal housings in accordance with ISO 7425-1.

Counter-surface
→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

d 18 – 240 mm

Maximum extrusion gap e

Radial depth S	**e_{max} at 80 °C *(175 °F)* for pressures** 160 bar	250 bar	400 bar
mm	**mm**		
4	0,4	0,3	0,15
5	0,5	0,4	0,2
7,5	0,55	0,45	0,25
10	0,6	0,5	0,3

For additional information → **page 26**

For complete product listings see:
https://skf.li/s1s

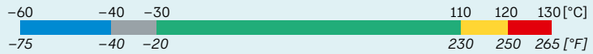
3.2 ZBR

Material codes U-10291
For additional information → **page 18**

Pressure Up to 400 bar *(5 800 psi)*

Speed Up to 1 m/s *(3.2 ft/s)*

Temperature range

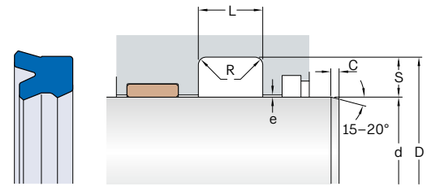


For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Counter-surface → **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

d 14 – 255 mm

Maximum extrusion gap e

Radial depth S	e_{max} at 80 °C *(175 °F)* for pressures 160 bar	250 bar	400 bar
mm	**mm**		
3,5 to 4	0,35	0,2	–
5 to 6,5	0,45	0,25	0,1
7 to 7,5	0,5	0,3	0,15
10	0,55	0,3	0,15
12,5	0,6	0,3	0,2

For additional information → **page 26**

For complete product listings see:
https://skf.li/zbr

Inch sizes

d 0.75– 8 in.

Maximum extrusion gap e

Radial depth S	e_{max} at 80 °C *(175 °F)* for pressures 2 300 psi	3 600 psi	5 800 psi
in.	**in.**		
0.125	0.008	0.004	–
0.187	0.014	0.008	–
0.250	0.018	0.01	0.004
0.312	0.020	0.012	0.006
0.375	0.020	0.012	0.006
0.5	0.024	0.012	0.008

For additional information → **page 26**

For complete produ ct listings see:
https://skf.li/zbr

3.3 SIL

Material codes B93
For additional information → **page 18**

Pressure Up to 350 bar *(5 075 psi)*

Speed Up to 0,5 m/s *(1.6 ft/s)*

Temperature range

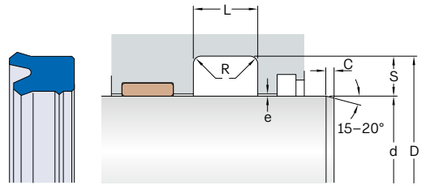
For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Dimension standards Some sizes fit seal housings in accordance with ISO 7425-1.

Counter-surface → **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

d 10 – 150 mm

Maximum extrusion gap e

Radial depth	e_{max} at 80 °C *(175 °F)* for pressures		
S	160 bar	250 bar	350 bar
mm	**mm**		
3	0,2	0,1	–
4	0,35	0,2	–
5	0,45	0,25	0,1
7,5	0,5	0,3	0,15
10	0,55	0,3	0,15

For additional information → **page 26**

For complete product listings see:
https://skf.li/sil

3.4 PTB

Material codes
Slide ring: U-1003
Energizer: A-8501
For additional information → **page 18**

Pressure
Up to 400 bar *(5 800 psi)*

Speed
Up to 1 m/s *(3.2 ft/s)*

Temperature range

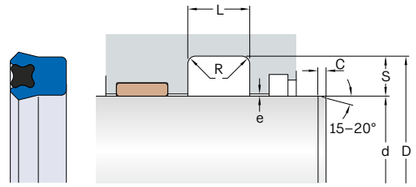
For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Dimension standards
Some metric sizes fit seal housings in accordance with ISO 7425-1.

Counter-surface
→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

d 8 – 205 mm

Maximum extrusion gap e

Radial depth S	e_{max} at 80 °C *(175 °F)* for pressures 160 bar	250 bar	350 bar
mm	**mm**		
3	0,2	0,1	–
3,5 to 4	0,35	0,2	–
4,5 to 6,5	0,45	0,25	0,1
7 to 8	0,5	0,3	0,15
9 to 11,5	0,55	0,3	0,15
12,5	0,6	0,3	0,2
15	0,6	0,3	0,2

For additional information → **page 26**

For complete product listings see: https://skf.li/ptb

Inch sizes

d 0.125 – 35 in.

Maximum extrusion gap e

Radial depth S	e_{max} at 80 °C *(175 °F)* for pressures 2 300 psi	3 600 psi	5 800 psi
in. –	**in.**		
0.125	0.008	0.004	–
0.156 to 0.187	0.014	0.008	–
0.218 to 0.25	0.018	0.010	0.004
0.281 to 0.437	0.020	0.012	0.006
0.5 to 0.562	0.024	0.012	0.008
0.625 to 0.75	0.024	0.012	0.008

For additional information → **page 26**

For complete product listings see: https://skf.li/ptb

3.5 STD

Material codes

Sealing ring: U-1003
X-ring: A-8501
For additional information → **page 18**

Pressure

Up to 400 bar *(5 800 psi)*

Speed

Up to 1 m/s

Temperature range

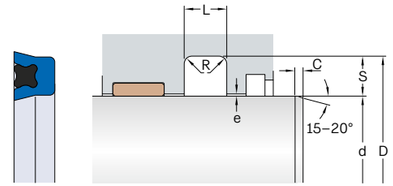
For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Counter-surface

→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Inch sizes

d 0.125 – 45 in.

Maximum extrusion gap e

Radial depth S	**e_{max} at 60 °C *(140 °F)* for pressures** 2 300 psi	3 600 psi	5 800 psi
in. –	**in.**		
0.125	0.008	0.004	–
0.156 to 0.187	0.014	0.008	–
0.218 to 0.25	0.018	0.01	0.004
0.281 to 0.437	0.02	0.012	0.006
0.5 to 0.562	0.024	0.012	0.008
0.625 to 0.75	0.024	0.012	0.008

For additional information → **page 26**

For complete product listings see:
https://skf.li/std

3.6 DZ

Material codes
Primary sealing ring: A-8504
Secondary sealing ring: U-1003
For additional information → **page 18**

Pressure
Up to 400 bar *(5 800 psi)*

Speed
Up to 1 m/s *(3.2 ft/s)*

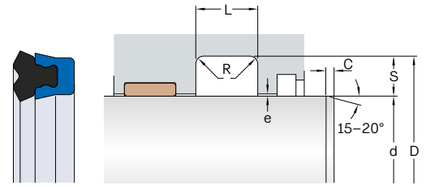
Temperature range

For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Counter-surface
→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

d 25– 105 mm

Maximum extrusion gap e

Radial depth	e_{max} at 60 °C *(140 °F)* for pressures		
S	160 bar	250 bar	400 bar
mm	**mm**		
4	0,35	0,2	–
5	0,45	0,25	0,1
7,5	0,5	0,3	0,15

For additional information → **page 26**

For complete product listings see:
https://skf.li/dz

Inch sizes

d 0.187 – 12 in.

Maximum extrusion gap e

Radial depth	emax at 60 °C (140 °F) for pressures		
S	2 300 psi	3 600 psi	5 800 psi
in.	**in.**		
0.125	0.008	0.004	–
0.156 to 0.187	0.014	0.008	–
0.25	0.018	0.01	0.004
0.312 to 0.375	0.02	0.012	0.006
0.5	0.024	0.012	0.008

For additional information → **page 26**

For complete product listings see:
https://skf.li/dz

3.7 DZR

Material codes

Primary sealing ring: A-8504
Secondary sealing ring: U-1003
Anti-extrusion ring: suffix E2E → P-2506
suffix E2D → 707
For additional information → **page 18**

Pressure

Up to 690 bar *(10 000 psi)*

Speed

Up to 1 m/s *(3.2 ft/s)*

Temperature range

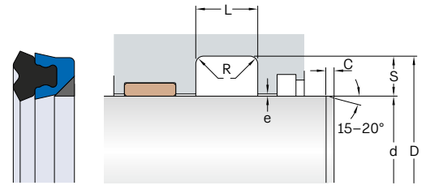
For temperature limits depending on fluid compatibility → **table 8**, **page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Counter-surface

→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

d 4 – 150 mm

Maximum extrusion gap e

Radial depth S	**e_{max} at 80 °C *(175 °F)* for pressures** 160 bar	250 bar	400 bar	690 bar
mm	**mm**			
5	0,55	0,35	0,2	0,1
7,5	0,8	0,5	0,3	0,15
10 to 11	1,1	0,75	0,45	0,2

For additional information → **page 26**

For complete product listings see:
https://skf.li/dzr

Inch sizes

d 1.25 – 12 in.

Maximum extrusion gap e

Radial depth S	**e_{max} at 80 °C *(175 °F)* for pressures** 2 300 psi	3 600 psi	5 800 psi	10 000 psi
in.				
0.187	0.021	0.013	0.008	0.005
0.25	0.028	0.018	0.011	0.007
0.312	0.044	0.028	0.017	0.01
0.375	0.044	0.028	0.017	0.01
0.5	0.059	0.038	0.023	0.014

For additional information → **page 26**

For complete product listings see:
https://skf.li/dzr

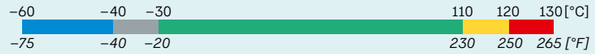
3.8 RBB

Material codes
Sealing ring: metric sizes → U-1029
inch sizes → U-1023
Anti-extrusion ring: metric sizes → P-2518
inch sizes → 707
For additional information → **page 18**

Pressure
Up to 690 bar *(10 000 psi)*

Speed
Up to 1 m/s *(3.2 ft/s)*

Temperature range

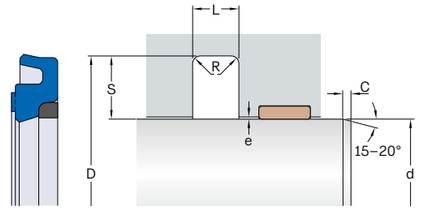


- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Dimension standards
Some metric sizes fit seal housings in accordance with ISO 7425-1.

Counter-surface
→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Metric sizes

d 25– 170 mm

Maximum extrusion gap e

Radial depth S	e_{max} at 80 °C *(175 °F)* for pressures 160 bar	250 bar	400 bar	690 bar
mm				
5,35	0,6	0,4	0,25	0,1
7,55 to 7,75	0,8	0,55	0,35	0,15

For additional information → **page 26**

For complete product listings see:
https://skf.li/rbb

Inch sizes

d 2 – 8 in.

Maximum extrusion gap e

Radial depth S	Series	e_{max} at 80 °C *(175 °F)* for pressures 2 300 psi	3 600 psi	5 800 psi	10 000 psi
in.	–	**in.**			
0.166 to 0.212	RBB2	0.019	0.012	0.008	0.004
0.247 to 0.308	RBB3	0.029	0.019	0.012	0.005
0.32 to 0.415	RBB4	0.037	0.024	0.015	0.007

For additional information → **page 26**

For complete product listings see:
https://skf.li/rbb

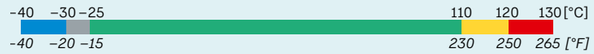
3.9 S9B

Material codes
O-ring energizer: N70/6052 or A-8501
Slide ring: X-ECOPUR or 741
For additional information → **page 18**

Pressure
X-ECOPUR slide ring → up to 600 bar *(8 700 psi)*
PTFE 741 slide ring → up to 400 bar *(5 800 psi)*

Speed
Up to 2 m/s *(6.5 ft/s)*

Temperature range
With X-ECOPUR slide ring:



With X-ECOPUR slide ring:

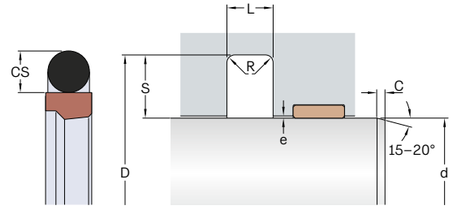
For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Dimension standards
Some metric sizes fit seal housings in accordance with ISO 7425-1.

Counter-surface
→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



For complete product listings see:
https://skf.li/s9b

For complete product listings see:
https://skf.li/s9b

Metric sizes

d 6 – 360 mm

Maximum extrusion gap e with X-ECOPUR slide ring

Radial depth S	e_{max} at 80 °C *(175 °F)* for pressures 160 bar	250 bar	400 bar	600 bar
mm				
2,45 to 2,5	0,3	0,25	0,2	0,1
3,5 to 3,75	0,4	0,3	0,2	0,1
5,35 to 5,5	0,5	0,4	0,3	0,2
7,55 to 7,75	0,5	0,4	0,3	0,2
10,25 to 12,25	0,7	0,5	0,4	0,2

For additional information → **page 26**

Maximum extrusion gap e with 741 slide ring

Radial depth S	e_{max} at 80 °C *(175 °F)* for pressures 160 bar	250 bar	400 bar
mm			
2,45 to 2,5	0,25	0,2	0,15
3,5 to 3,75	0,35	0,25	0,15
5,35 to 5,5	0,4	0,3	0,2
7,55 to 7,75	0,5	0,35	0,25
10,25 to 12,25	0,6	0,45	0,35

For additional information → **page 26**

Inch sizes

d 1 – 10 in.

Maximum extrusion gap e with X-ECOPUR slide ring

Radial depth S	Series	e_{max} at 80 °C *(175 °F)* for pressures 2 300 psi	3 600 psi	5 800 psi	10 000 psi
in.	**–**	**in.**			
0.149	S9B1	0.016	0.012	0.008	0.004
0.212	S9B2	0.02	0.016	0.012	0.008
0.308	S9B3	0.02	0.016	0.012	0.008
0.415	S9B4	0.028	0.02	0.016	0.008

For additional information → **page 26**

Maximum extrusion gap e with 741 slide ring

Radial depth S	Series	e_{max} at 80 °C *(175 °F)* for pressures 2 300 psi	3 600 psi	5 800 psi
in.	**–**	**in.**		
0.149	**S9B1**	0.014	0.01	0.006
0.212	**S9B2**	0.016	0.012	0.008
0.308	**S9B3**	0.02	0.014	0.01
0.415	**S9B4**	0.024	0.018	0.014

For additional information → **page 26**

3.10 RSB

Material codes
Slide ring: 741
Energizer: A-8504
For additional information → **page 18**

Pressure
Up to 400 bar *(5 800 psi)*

Speed
Up to 1 m/s *(3.2 ft/s)*

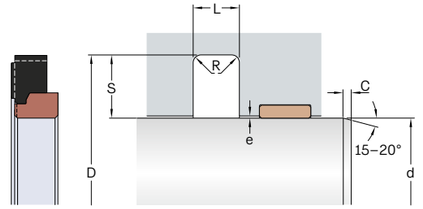
Temperature range

For temperature limits depending on fluid compatibility → **table 8, page 24**

- Extreme low temperature range: may be intermittently exposed (e.g. cold start-up) without seal damage, but seal performance may be compromised while in this range
- Temperatures below the recommended operating range: seal performance depends on system design (precision guiding arrangement recommended)
- **Recommended operating temperature range for this profile and material**
- Temperatures above the recommended operating range: acceptable only with reduced pressure, speed, and/or e-gap
- Extreme high temperature range: only occasional short-term exposure (e.g. cylinder in curing oven of a powder coating process)

Counter-surface
→ **page 14**

Maximum values of application parameters (e.g. pressure, speed, temperature, e-gap) should not be applied continuously nor simultaneously.



Inch sizes

d 1.25– 13 in.

Maximum extrusion gap e

Radial depth S	Series	e_{max} at 80 °C *(175 °F)* for pressures 2 300 psi	3 600 psi	5 800 psi
in.	**–**	**in.**		
0.166 to 0.212	RSB2	0.014	0.01	0.008
0.247 to 0.308	RSB3	0.018	0.012	0.008
0.32 to 0.415	RSB4	0.02	0.014	0.01

For additional information → **page 26**

For complete product listings see:
https://skf.li/rsb

More rod and buffer seals

The rod and buffer seals listed in this catalogue represent the preferred profiles in common sizes. SKF supplies many additional sizes and profiles and provides customized solutions for the toughest application conditions.
The following profiles are also manufactured in series production. For additional information about these profiles or if the application requires a solution not provided in this catalogue, contact SKF.

Rod locking T-seals

LTR profiles **(→ fig. 15)** have a T-shaped rubber sealing ring supported by patented locking anti-extrusion rings on both sides. Therefore, they can be used as double-acting rod seals for special applications. For example, in tandem cylinders that require a rod seal to take pressure from both sides. For additional information about materials and sizes, contact SKF.

TEFLATHANE seals

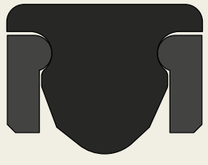
These rod seals of various designs and material combinations incorporate an anti-extrusion ring that is bonded into the body. They are suitable for high temperature and/or short-stroke applications. For example, U-cup seals made of special high-temperature polyurethane bonded to a PTFE anti-extrusion ring in rock hammer applications **(→ fig. 16)**.
For additional information about materials and sizes, contact SKF.

Customized machined seal profiles

SKF can manufacture a wide variety of rod seal profiles with different materials and sizes with its industry-leading SKF SEAL JET production system **(→ fig. 17)**.
For additional information about customized machined profiles, refer to publication Customized machined seals – Product range or contact SKF.

Fig. 15

Rod locking T-seal



LTR

Fig. 16

TEFLATHANE seal example

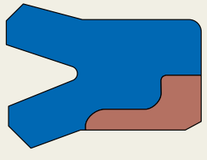
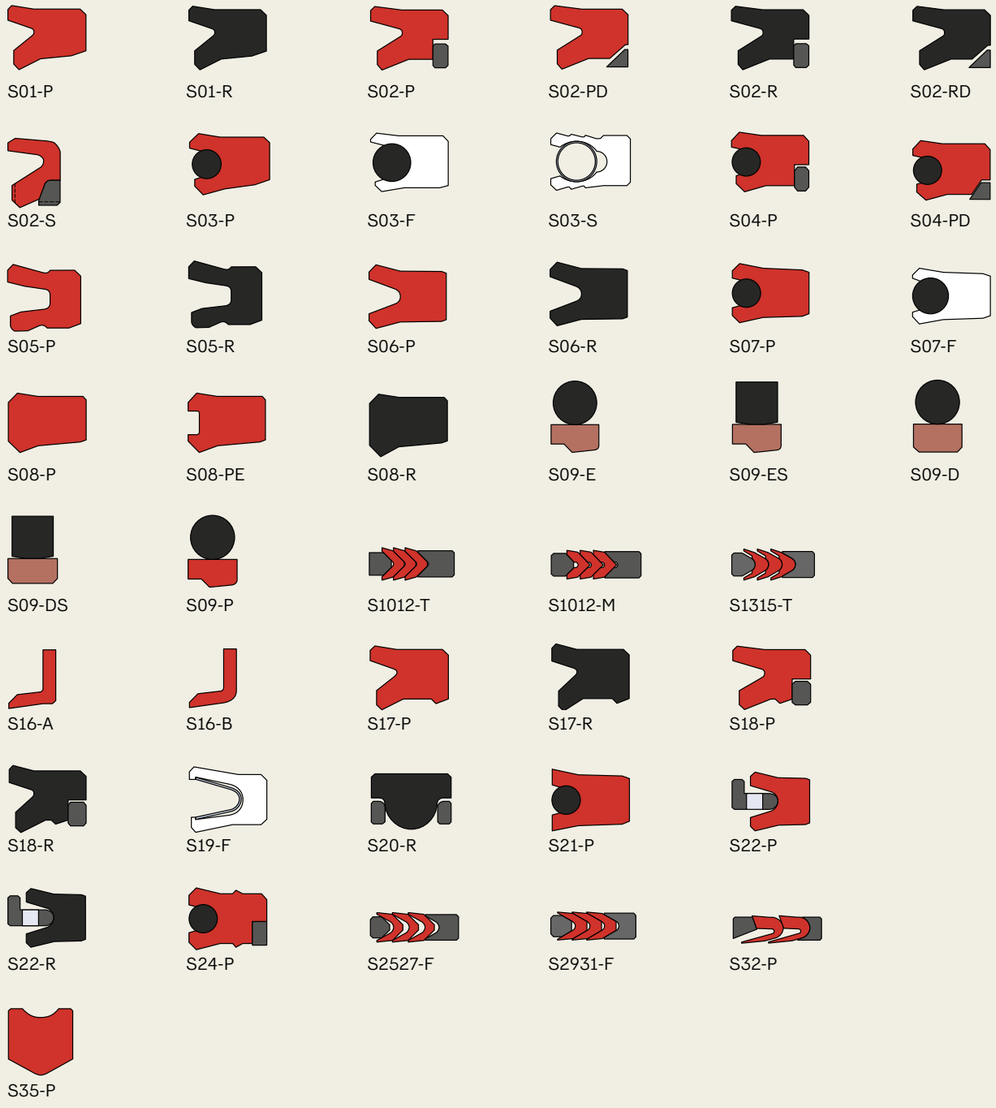
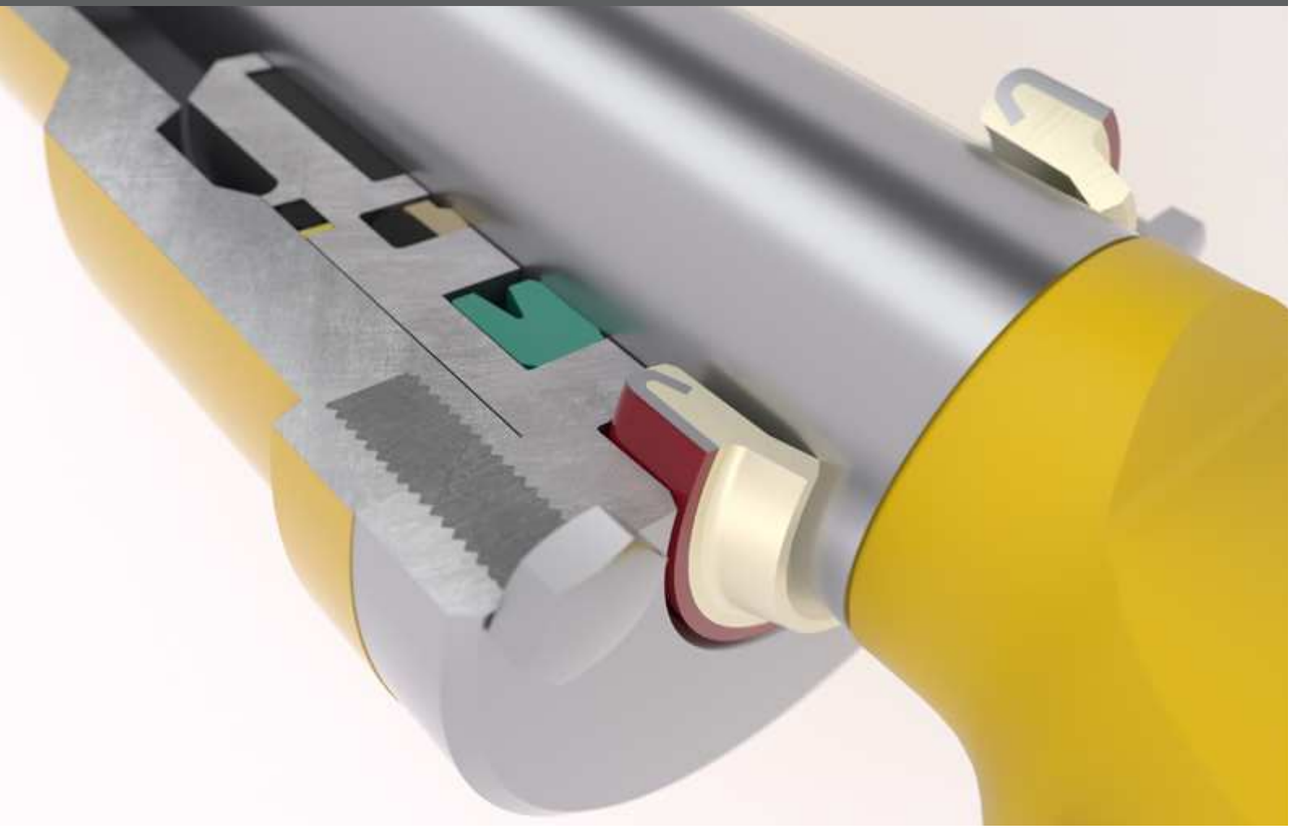


Fig. 17SKF SEAL JET profile examples



4 Wiper seals



Profile overview

Profile	Description	Additional information → page	Profile data → page
PA 	Polyurethane press-in wiper seal; steel retaining ring; single-lip design; lip pro-trudes from head; small radial cross section	**106**	**110** (metric)
MCW 	Polyurethane press-in wiper seal; steel retaining ring; effective single lip design that sits flush with head; suitable for heavy duty applications	**106**	**111** (metric and inch)
PAD 	Polyurethane press-in wiper seal; steel retaining ring; double-lip design im-proves rod sealing system performance	**107**	**112** (metric)
PADV 	PAD design with a vent hole in the in-side-facing lip	**107**	**112** (metric)
DTW 	Polyurethane snap-in wiper seal; single-lip design; static seal lips on the outside surface and outside face; notches on inside edge of heel	**108**	**113** (metric and inch)
DX 	Polyurethane snap-in wiper seal with nitrile rubber O-ring; single-lip design; patented profile for heavy duty appli-cati-ons; notches on inside edge of heel	**109**	**114** (inch)
HW 	Polyurethane snap-in wiper seal; double-lip design improves rod sealing system performance	**109**	**115** (metric and inch)

Basics

Hydraulic cylinders operate in a variety of applications and environmental conditions, including exposure to dust, debris or outside weather conditions. To prevent these contaminants from entering the cylinder assembly and hydraulic system, wiper seals (also known as scrapers, excluders or dust seals) are fitted on the external side of the cylinder head (→ **fig. 1**).

Wiper seals maintain sealing contact to the piston rod when the equipment is stationary (static, no reciprocating motion of rod) and in use (dynamic, reciprocating rod), whereas the tolerance for the rod diameter d is determined by the rod seal. Without a wiper seal, the retracting piston rod could transport contaminants into the cylinder.

The outside static sealing of the wiper seal within the housing is also important to avoid moisture or particles from entering around the outside of the wiper seal.

Installation

Housings for wiper seals are typically designed either as open or stepped housings (→ **fig. 2**).

Wipers for open housings are bonded to a steel retaining ring and pressed into the housing. Therefore, they are called press-in wiper seals.

Wiper seals for stepped housings do not have metal components and can usually be deformed by hand for installation. They "snap" into the groove and, therefore, are called snap-in wiper seal.

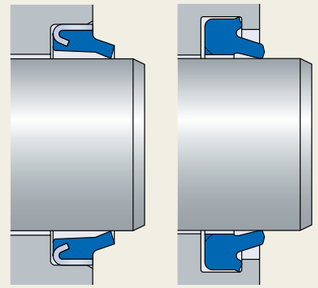
For additional information about installation, refer to *Installing wiper seals* (→ **page 33**).

Materials

Polyurethane (TPU) is the most common material for wiper seals in modern hydraulic seal applications. SKF wiper seals made of TPU are developed for wear resistance and flexibility as well as with the right physical properties to effectively remove contaminants. SKF can supply wiper seals in a wide variety of materials, including rubber elastomers and PTFE (→ *More wiper seals*, **page 116**).

For additional information, refer to *Materials* (→ **page 18**).

Fig. 2

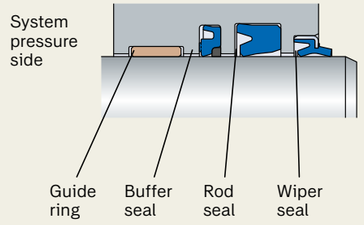


Open housing (press-in wiper seal)

Stepped housing (snap-in wiper seal)

Fig. 1

Wiper seal in typical rod sealing system for medium duty hydraulic applications



Press-in wiper seals

As their name implies, press-in wiper seals are pressed into the housing in the cylinder head. These seals are designed with a steel retaining ring that provides a robust static sealing on the outside surface. The polyurethane (TPU) wiper lip is bonded to the drawn sheet steel retaining ring and maintains a sealing force by tension as well as cantilever action (flexing) to the seal lips. This provides a robust preload of the wiper lips even under minor radial misalignments between the rod and head. Press-in wiper seals are available with a single-lip or double-lip design.

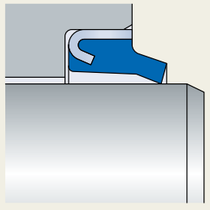
PA profiles

PA profiles (→ **fig. 3**) have an effective single wiping lip that protrudes from the head. This design allows small radial cross sections and reduces the risk of contaminant adherence on the wiper lip. PA profiles are available in metric sizes.

MCW profiles

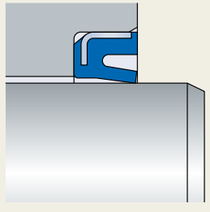
MCW profiles (→ **fig. 4**) have an effective single wiping lip that does not protrude from the head. This allows compact arrangement when the cylinder is retracted. These profiles are available in metric and inch sizes.

Fig. 3



PA

Fig. 4



MCW

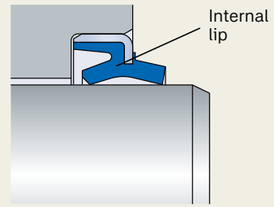
PAD and PADV profiles

PAD profiles (→ **fig. 5**) have a double-lip design with an internal-facing wiper lip that regulates the lubrication film on the rod. The internal lip wipes excess fluid film from the rod on extending stroke and allows this excess fluid to return under the rod seal on the retracting stroke. Double-acting wipers, therefore, improve the performance and extend the service life of rod sealing systems.

However, excess system pressure acting on the internal-facing lip, such as fluid passing a damaged rod seal, could overcome the press force between the housing and the steel retaining ring and push the wiper seal out of the housing. Therefore, SKF recommends using double-acting wiper seals in combination with U-cup rod seals with a single-lip design, such as S1S profile (→ *Rod seals*, **page 76**), to ensure pressurized fluid can return to the hydraulic system. A snap ring may also be required to retain the wiper seal in the housing (→ **fig. 6**) in case of pressure build up.

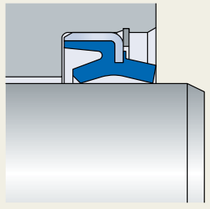
PAD profiles (→ **fig. 7**) are also available with a vent in the internal lip (designation PADV). They do not need extra snap rings in most applications. The vent prevents pressure build-up on the internal-facing lip. PAD and PADV profiles are available in the same metric sizes.

Fig. 5



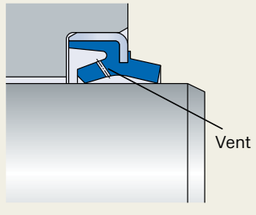
PAD

Fig. 6



PAD with snap ring

Fig. 7



PADV

Snap-in wiper seals

Snap-in wiper seals are designed without any metal component and are easy to install without any special equipment.

A common problem with snap-in wiper seals is that they become loose in the housing resulting in poor static sealing on the outside surface and reduced preload on the dynamic wiper seal lip (→ **fig. 8**). Furthermore, if the inside edge of the wiper seal could contact the rod, it may become an unintended sealing lip (→ **fig. 8**) and could trap pressure between the rod and wiper seal. Therefore, SKF snap-in wiper seals have special sealing and venting features to help ensure proper operation.

DTW profiles

DTW profiles (→ **fig. 9**) have a single-lip design and a radial static seal lip on the outside surface that maintains a positive sealing contact. An axial static seal lip on the external side face keeps the wiper tight in the housing and also serves as an additional static seal. During operation the inside edge of the wiper seal could contact the rod, for example during rod extension. In this case and in the event the rod seal has become damaged or exceeded its service life, notches on the inside edge prevent the wiper seal trapping pressure or being pushed out by pressure. These profiles are available in metric and inch sizes.

DX profiles

DX wiper seals (→ **fig. 10**) have a patented profile with a single external lip design and vented inside edge. These profiles incorporate a rubber O-ring that maintains a robust static sealing contact in the housing. The O-ring also serves as an energizer to provide consistent long term preload on the dynamic lip. In case of radial misalignment, the entire TPU wiper ring follows these radial movements (“floating” design) as the relatively soft and flexible rubber O-ring energizer deforms to compensate.

When the wiper lip encounters resistance from contaminants adhered to the retracting rod (e.g. tree sap or frozen rain), the profile reacts by twisting to increase the preload on the dynamic wiper lip.

Therefore, DX profiles include the functionality of press-in wiper seals as well as the convenience of snap-in wiper seals. These profiles are available in inch sizes.

HW profiles

HW profiles (→ **fig. 11**) have a double-lip design with an internal-facing wiper lip that regulates the lubrication film on the rod. The internal lip wipes any excess fluid film from the rod on the extending stroke and allow this excess fluid to return under the rod seal on the retracting stroke. Double-acting wipers, therefore, improve the performance and extend the service life of rod sealing systems. SKF recommends using double-acting wiper seals in combination with U-cup rod seals with a single-lip design, such as S1S profile (→ *Rod seals*,**page 76**), to ensure pressurized fluid can return to the hydraulic system.

Fig. 8

Snap-in wiper seal loose in the housing

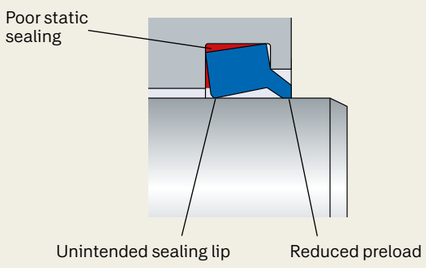


Fig. 9

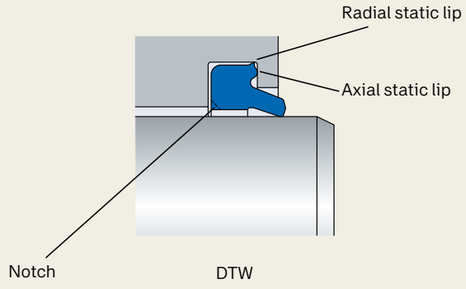
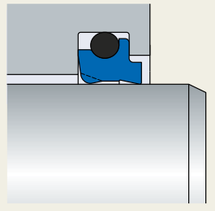
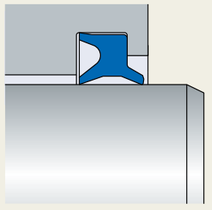


Fig. 10



DX

Fig. 11



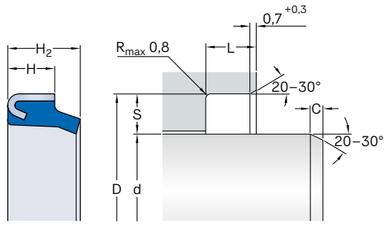
HW

Profile data

4.1 PA

Material codes	W93 For additional information → **page 18**
Speed	Up to 1 m/s *(3.2 ft/s)*
Temperature range	–40 to +110 °C *(–40 to +230 °F)*
Dimension standards	Some sizes fit seal housings in accordance with ISO 7425-1.
Counter-surface	→ **page 14**

Maximum values of application parameters (e.g. speed, temperature) should not be applied continuously nor simultaneously.



Metric sizes

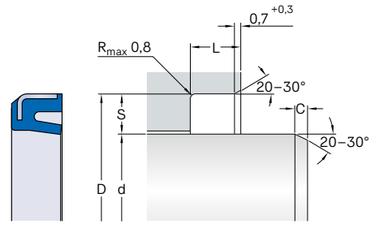
d 12 – 180 mm

For complete product listings see:
https://skf.li/pa

4.2 MCW

Material codes	Metric sizes → U-1029 Inch sizes → U-1023 For additional information → **page 18**
Speed	Up to 1,5 m/s *(4.9 ft/s)*
Temperature range	–40 to +110 °C *(–40 to +230 °F)*
Dimension standards	Some sizes fit seal housings in accordance with ISO 7425-1.
Counter-surface	→ **page 14**

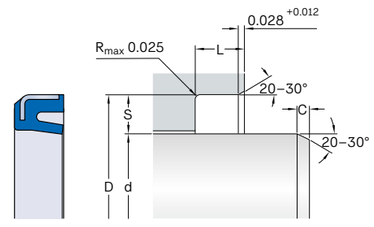
Maximum values of application parameters (e.g. speed, temperature) should not be applied continuously nor simultaneously.



Metric sizes

d 2 – 130 mm

For complete product listings see:
https://skf.li/mcw

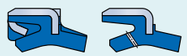


Inch sizes

d 0.5 – 8.5 in.

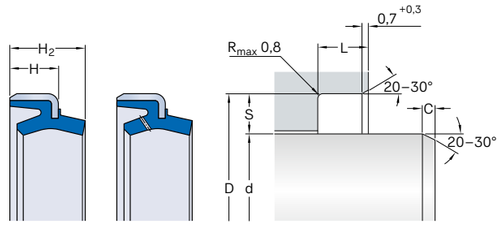
For complete product listings see:
https://skf.li/mcw

4.3 PD and PADVA



Material codes	W93 For additional information → **page 18**
Speed	Up to 1 m/s *(3.2 ft/s)*
Temperature range	–40 to +110 °C *(–40 to +230 °F)*
Counter-surface	→ **page 14**

Maximum values of application parameters (e.g. speed, temperature) should not be applied continuously nor simultaneously.



Metric sizes

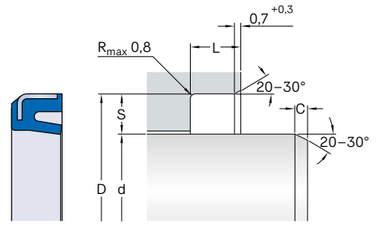
d 30 – 125 mm

For complete product listings see:
https://skf.li/pad_padv

4.4 DTW

Material codes	U-1003 For additional information → **page 18**
Speed	Up to 0,75 m/s *(2.4 ft/s)*
Temperature range	–40 to +120 °C *(–40 to +250 °F)*
Counter-surface	→ **page 14**

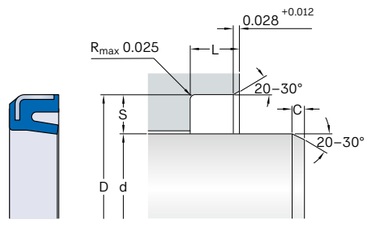
Maximum values of application parameters (e.g. speed, temperature) should not be applied continuously nor simultaneously.



Metric sizes

d 18 – 230 mm

For complete product listings see:
https://skf.li/dtw



Inch sizes

d 0.25 – 15.75 in.

For complete product listings see:
https://skf.li/dtw

4.5 DX

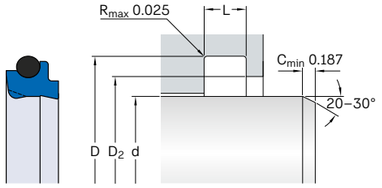
Material codes
Seal ring: suffix J1S → U-1003
suffix J2X → U-1004
Energizer: A-8501
For additional information → **page 18**

Speed
Up to 1 m/s *(3.2 ft/s)*

Temperature range
–40 to +120 °C *(–40 to +250 °F)*

Counter-surface
→ **page 14**

Maximum values of application parameters (e.g. speed, temperature) should not be applied continuously nor simultaneously.



Inch sizes

d 0.75 – 9 in.

For complete product listings see:
https://skf.li/dx

4.6 HW

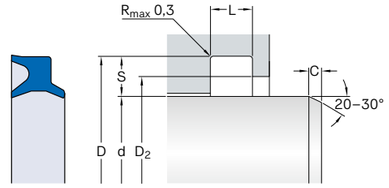
Material codes
U-1003
For additional information → **page 18**

Speed
Up to 0,75 m/s *(2.4 ft/s)*

Temperature range
–40 to +100 °C *(–40 to +210 °F)*

Counter-surface
→ **page 14**

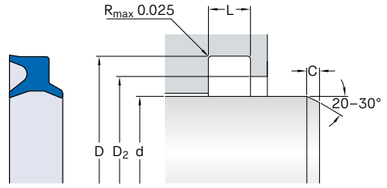
Maximum values of application parameters (e.g. speed, temperature) should not be applied continuously nor simultaneously.



Metric sizes

d 14 – 140 mm

For complete product listings see:
https://skf.li/hw



Inch sizes

d 0.25 – 8 in.

For complete product listings see:
https://skf.li/hw

More wiper seals

PTFE wiper seals

SKF wiper seals made of PTFE (→ **fig. 12**) are intended for applications where there is a demand for low breakaway friction or good chemical resistance. SKF has material for PTFE wiper seals on stock and, therefore, can supply these seals in a wide variety of profiles and different sizes at short notice.

For additional information about PTFE wiper seals, contact SKF.

Rod seals used as wiper seals

STD rod seal profiles (→ *STD profiles*, **page 77**) can also be used as snap-in wiper seals (→ **fig. 13**).

For additional information about rod seals used as wiper seals, contact SKF.

Customized machined seal profiles

SKF can manufacture a wide variety of wiper seal profiles (→ **fig. 14**) with different materials and customized sizes with its industry-leading SKF SEAL JET production system. SKF can supply these customized machined wiper seals in close partnership with customers from the design phase to serial production

For additional information about customized machined profiles, refer to publication *Customized machined seals – Product range* or contact SKF.

Fig. 12

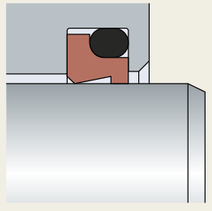


Fig. 13

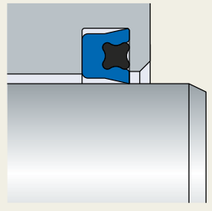


Fig. 14

SKF SEAL JET profile examples

5 Guide rings and guide strips

Basics

In hydraulic cylinders the most commonly used guides are guide rings and guide strips. They accommodate radial loads of forces acting on the cylinder assembly and guide the rod in the cylinder head as well as the piston in the cylinder bore (→ **fig. 1**).

Guides are made of polymer materials and prevent metal-to-metal contact between moving parts in a working hydraulic cylinder. Compared to metal guides, polymer guides provide the following advantages in hydraulic cylinders:

- significantly longer service life
- work more smoothly against the cylinder bore and the sealing surfaces
- avoid wear of cylinder surfaces despite the presence of contamination particles
- high resistance to insufficient lubrication at low speeds
- larger contact area (→ **fig. 2** and **fig. 4**, **page 124**) due to higher degree of elastic deformation distributes the load and reduces stress to counter-surface
- certain self-lubricating properties

SKF supplies different precision machined guide rings with different polymer materials and sizes, which make them appropriate for a wide variety of operating conditions and applications.

Guides of PTFE are also available for applications where start-up friction must be minimized. PTFE guides have limited load carrying capability and should only be used in applications with light loads.

Guide lubrication

The guide must receive ample lubrication at all times. Rod guides are typically placed inward of both the rod and buffer seal and should be lubricated on assembly with the same medium as used in the system. SKF recommends to place guides not outside of the rod seal, means between the wiper and rod seal. However, in certain conditions, PTFE guides may be used outside the rod seal due to their certain self-lubricating properties.

Fig. 2

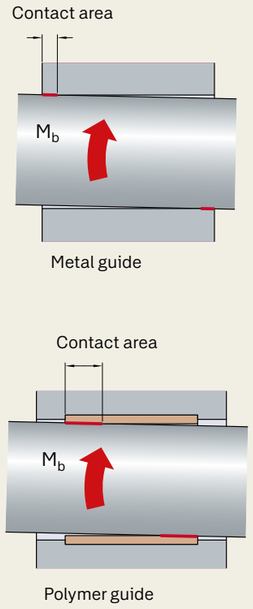
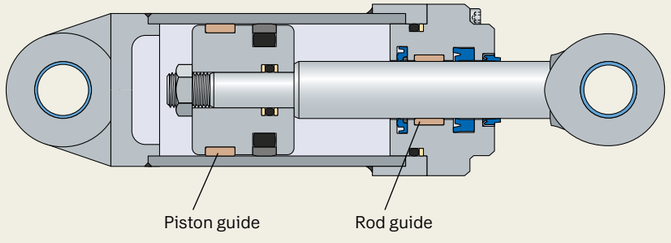


Fig. 1



More information

Materials

The demands on reliability are continuously increasing. At the same time, the service conditions are getting tougher to match the development towards higher effectiveness of the hydraulic systems. Therefore, it is very important to be familiar with the operating conditions and parameters, such as operating temperature and pressure, load, speed, and fluid when choosing the most appropriate guide material. The most common materials for guides listed in this catalogue are:

- glass fibre reinforced polyamide
- fabric reinforced phenolic resin
- PTFE

Polyamide

Glass fibre reinforced polyamide guides are suitable for medium and heavy duty applications and are characterized by the following properties:

- wide temperature range
- wear resistant
- reduce vibrations
- protect seals from particles
- protect components from diesel effect
- easy to install
- tight tolerances
- withstand heavy side loads
- withstand high cycling speed
- prone to moisture swell before installation

P-2551 is the standard polyamide material for guide rings. Technical specifications are provided in **table 1**.

For additional information, refer to *Materials* (→ **page 18**).

Fabric reinforced composites

Fabric reinforced composites consist of cotton fabric bound with thermoset phenolic resin. Its structure and the ability of the fabric fibres to absorb a certain amount of oil make these phenolic guides almost self-lubricating. However, cotton reinforced phenolic guide rings should not be used at high stroke speeds over 0,5 m/s *(1.6 ft/s)*. They are suitable for medium and heavy duty applications and are characterized by the following properties:

- wide temperature range
- wear resistant
- reduce vibrations
- protect seals from particles
- protect components from diesel effect
- low thermal expansion
- easy to install
- tight tolerances
- withstand heavy side loads

Phenolic resin with cotton fabric laminate (PF) is the standard fabric reinforced composite. Technical specifications are provided in **table 1**. SKF also supplies a variety of other thermoset resins and fabrics on request.

For additional information, refer to *Materials* (→ **page 18**).

Table 1

Guide ring material comparison

Material code	Ultimate compressive strength	Maximum recommended linear speed[1]	Maximum recommended operating	Maximum recommended bearing load	Maximum recommended bearing load
–	N/mm² *(psi)*	m/s *(ft/s)*	°C *(°F)*	N/mm² *(psi)*	N/mm² *(psi)*
P-2551	158 *(22 915)*	1 *(3.3)*	120 *(250)*	40 *(5 800)*	30 *(4 350)*
PF	240 *(34 805)*	0,5 *(1.6)*	120 *(250)*	50 *(7 250)*	30 *(4 350)*
292	[2] (depending on time and temperature)	5 *(16.4)* (depending on sealing system)	200 *(390)*	15 *(2 175)*	7,5 *(1 085)*

1) Maximum values are for intermittent exposure and should not be applied simultaneously.
2) PTFE is subject to creep under compression and, therefore, compressive strength depends on time and temperature.

PTFE

PTFE is typically used in guides where low friction and resistance to chemicals, heat or wear are essential. However, PTFE should only be used in applications with low surface pressure. To obtain optimal wear resistance, PTFE materials are available with different fillers, such as bronze or carbon powder. PTFE guides are characterized by the following properties:

- chemical resistance
- wide temperature range
- low friction
- anti-adhesive, low breakaway friction
- good wear resistance
- reduce vibrations
- protect seals from particles
- protect components from diesel effect
- tight tolerance machined guide rings available

292 is the standard PTFE material for guides and strips. Technical specifications are provided in **table 1** (→ **page 121**).
SKF also can supply many other PTFE material compounds on request.

For additional information, refer to *Materials* (→ **page 18**).

Guide rings

SKF guide rings are precision machined according to tight tolerance specifications on the radial section of the guide. Therefore, they optimize guide load distribution and limit radial misalignment of components for best seal performance. SKF supplies the following guide rings:

- WAT rod or piston guide rings
- RGR rod guide rings
- PGR piston guide rings

All of these precision guide rings are split with an angle cut as standard (→ **fig. 8**, **page 128**). Other types and designs or angles of cut are available on request.

WAT rod or piston guide rings

These standard guide rings can operate dynamically either on their outside or inside surfaces and, therefore, can be used in piston or rod applications. WAT guide rings are made of glass fibre reinforced polyamide (P-2551) as standard. On request, SKF can supply WAT guide rings in a variety of materials, including P-2552 (self lubricated rings with PTFE fillers).

RGR rod guide rings

RGR guide rings are developed for guiding rods by operating dynamically on their inside surface. They are made of phenolic resin with cotton fabric laminate (PF) as standard. On request, SKF can supply RGR guide rings in a variety of materials.

They are manufactured and packaged to promote an open split before installation and, therefore, are clamped with their outside surface in the cylinder head. This makes it easier to assemble the cylinder later.

PGR piston guide rings

PGR guide rings are developed for guiding pistons by operating dynamically on their outside surface. They are made of phenolic resin with cotton fabric laminate (PF) as standard. On request, SKF can supply PGR guide rings in a variety of materials.

They are manufactured and packaged to promote a narrow split or even closed ring before installation and, therefore, are clamped with their inside surface on the piston. This makes it easier to assemble the cylinder later.

Design and calculation model

Concentric alignment of cylinder components

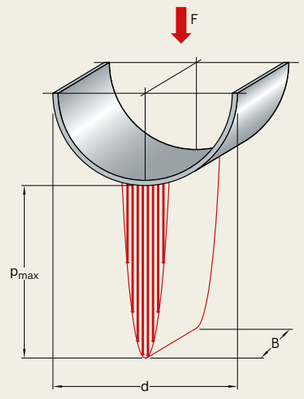
Hydraulic cylinders and all their components are designed to minimize radial movements at load or pressure changes. It is also important that the piston and rod remain in a concentric position during the entire stroke to maintain seal effectiveness, especially at low temperatures, and to minimize the buckling loads on the piston rod. This in turn depends on the combined tolerances of the cylinder bore, the rod, the radial thickness of the guide rings or strips, and the housing diameters.

Guide distance

The bending moment on the cylinder components and the load on guides at any point in the cylinder stroke are a function of the radial loads and the distance between the rod and piston guides. Therefore, the distance between guides should be considered when designing the cylinder and calculating the guide loads.

Fig. 3

Load distribution with metal guide



Load distribution model

With metal guides, the close machining tolerances would cause narrow contact area and high surface pressure (→ **fig. 3**). That could cause damage or wear to the contact surfaces.

The higher degree of elastic deformation of polymer materials provides larger contact surfaces and a better utilization of the guide width (→ **fig. 4**). While the guide ring load is realistically not an even distribution, the guide ring load and width requirements are estimated with the projected area of the full dynamic surface (inside diameter for rod guides or outside diameter for piston guides) assuming the load is carried evenly across the surface (→ **fig. 5**).

Fig. 4

Load distribution with polymer guides

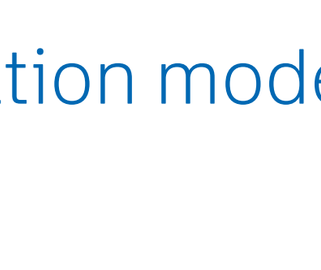
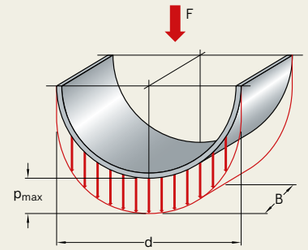


Fig. 5

Theoretical load distribution



Calculation considerations

When calculating the requisite guide housing width L, the above assumption should be taken into consideration by using a safety factor. SKF recommends using a safety factor f of at least 2 for operating temperatures up to 80 °C *(175 °F)*. For operating temperatures above 80 °C *(175 °F)*, the safety factor should be increased. However, at temperatures above 120 °C *(250 °F)*, the selection of guide materials is significantly restricted.

The reduced effective load carrying width B of the guide (→ **fig. 5**) also need to be considered. It is approx. 2 mm *(0.08 in.)* smaller than the housing groove width due to the manufacturing and installation tolerances and the reduction by the chamfers and radii.

Furthermore, dynamic forces, accelerating forces, vibrations and angular forces should be considered when calculating the transverse forces from the rod ends of the cylinders.

For additional information, contact SKF.

Calculating the guide width

The requisite guide width can be calculated for:

- piston guide housing width using

$$L = \frac{F\,f}{p\,D} + 2$$

- rod guide housing width using

$$L = \frac{F\,f}{p\,d} + 2$$

where
L = requisite guide housing width [mm]
D = cylinder bore diameter [mm]
d = rod diameter [mm]
F = radial load [N]
f = safety factor (→ *Calculation considerations*)
p = maximum recommended bearing load pressure [N/mm²]
table 1 (→ **page 121**)

Calculation example

What is the required guide housing width L for a PGR piston guide ring made of phenolic resin with cotton fabric laminate (PF), a cylinder bore diameter of D = 100 mm, considering a radial load of 20 000 N and an operating temperature of 80 °C (normal conditions)?

From **table 1** (→ **page 121**), the maximum recommended bearing load pressure p = 30 N/mm². The safety factor is chosen with 2. The requisite guide housing width L is

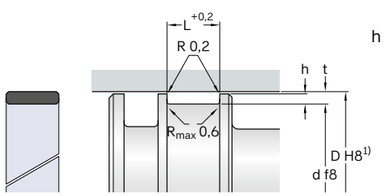
$$L = \frac{20\,000 \times 2}{30 \times 100} + 2 = 15{,}3 \text{ mm}$$

The requisite guide housing width is 15,3 mm. However, choose a 20 mm housing width, which is the nearest larger housing and guide width L, such as guide ring PGR 100x94x20-PF (→ **page 127**).

Profile data

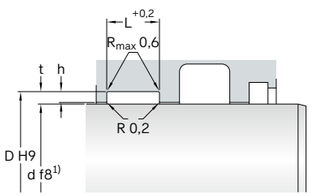
5.1 WAT rod or piston guide rings, metric sizes

D 28 – 260 mm



Piston application
(dynamic on the outside surface)

h ≥ t/2

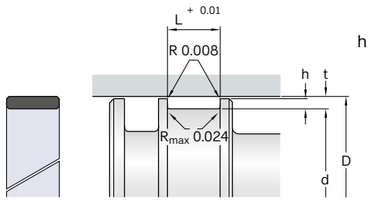


Rod application
(dynamic on the inside surface)

For complete product listings see:
www.skf.com/wat

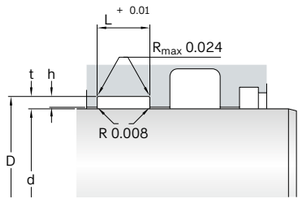
5.2 WAT rod or piston guide rings, inch sizes

D 1 – 10.5 in.



Piston application
(dynamic on the outside surface)

h ≥ t/2



Rod application
(dynamic on the inside surface)

For complete product listings see:
www.skf.com/wat

Diameter tolerances

Cylinder bore	Tolerances[1]	
D	D	d
in.		
1 to 4.875	+0.002	−0.003
5 to 7.75	+0.004	−0.004
8 to 10.5	+0.006	−0.006

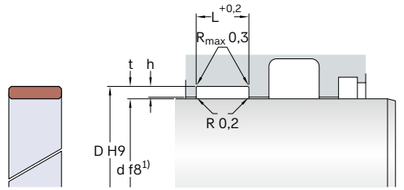
Diameter tolerances

Cylinder bore	Tolerances[1]	
D	D	d
in.		
1 to 5.625	+0.003	−0.002
5.75 to 10.5	+0.005	−0.004

[1] Adjustments according to tolerances provided for rod or piston seals are possible, however, the maximum e-gap also need to be considered (→ Gap extrusion, page 26)

5.3 RGR rod guide rings, metric sizes

d 12 – 365 mm

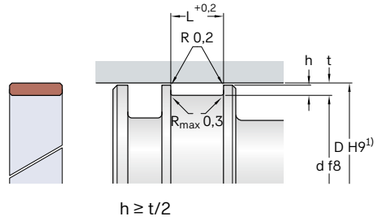


h ≥ t/2

For complete product listings see:
https://skf.li/rgr

5.4 PGR piston guide rings, metric sizes

D 16 – 400 mm



h ≥ t/2

For complete product listings see:
https://skf.li/pgr

Guide strips

SKF guide strips are made of PTFE as standard and should only be used in light duty applications or when fluid, temperature, friction, or speed do not allow any other material. They are typically used with PTFE sealing systems (→ **fig. 6**). At system operating pressures over 200 bar *(2 900 psi)*, contact SKF.

PTFE guide strips are available with different designs (→ **fig. 7**) and can be cut with
different configurations (→ **fig. 8**).

Guide strips cut to length

Based on the hardware dimensions, SKF can supply guide strips with specified lengths. They are designated according to a system that states the type and design, dynamic diameter, housing groove diameter, housing groove width, type of cut and material (→ **table 2**, **page 129**).

For additional information and order assistance, contact SKF.

Fig. 6

PTFE sealing system

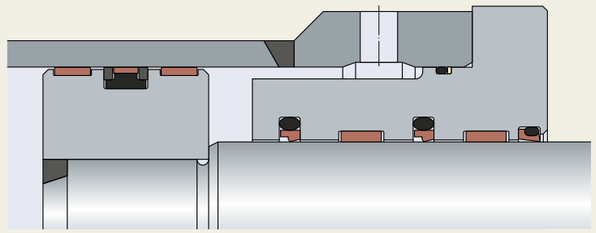


Fig. 7

Guide strip types and designs

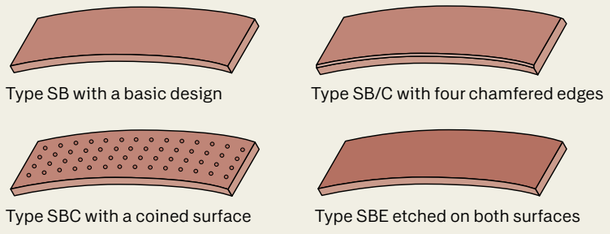
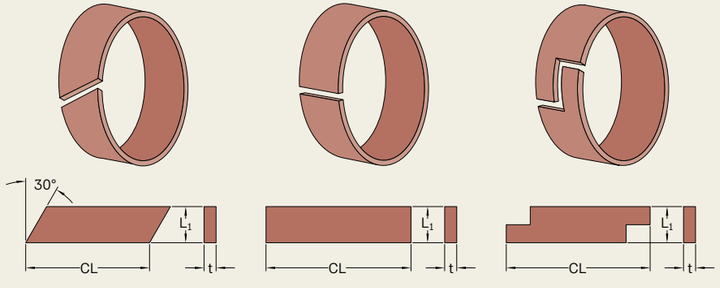


Fig. 8

Guide strips cut configurations



Guide strips uncut

SKF can also supply uncut guide strips. They are designated by the type and design (→ **fig. 7**, **page 128**), guide strip thickness t and housing groove width in millimetres, material code, and length in metres, such as SB 2x8,1-292 / 25 m.

For additional information and order assistance, contact SKF.

Calculating the guide strip length

The individual guide strip length CL can be calculated using the formulas provided in **table 3**.

Table 2

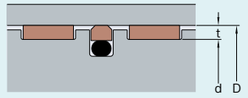
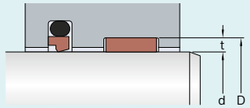
Designation system for guide strips with individual length

SB 200×195×12×45-292

- SB 200×195×12×45-292 — Type and design
- SB **200**×195×12×45-292 — Dynamic diameter [mm]
- SB 200×**195**×12×45-292 — Housing groove diameter [mm]
- SB 200×195×**12**×45-292 — Housing groove width [mm]
- SB 200×195×12×**45**-292 — Type of cut
  - no value = 30° angle cut (→ **fig. 8**)
  - value = angle cut (other than 30°)
  - 0 = straight cut (→ **fig. 8**)
  - S = stepped cut (→ **fig. 8**)
- SB 200×195×12×45-**292** — Material code (→ **table 6**, **page 21**)

Table 3

Guide strip length CL

Material code	Guide strip for piston applications	Guide strip for rod applications
		
PTFE 292	CL = 3,11 (D – t) – 0,8	CL = 3,11 (d + t) – 0,8

CL = guide strip length [mm]
D = cylinder bore diameter or guide ring groove diameter in the head [mm]
d = guide ring groove diameter in the piston or rod diameter [mm]
t = guide strip thickness [mm]

More guides

Spark rings

Spark rings (also known as contamination rings, (→ **fig. 9**) are not technically guide rings, as they are not intended to accommodate radial loads. They rather protect the guides and piston seals from damage due to contamination particles or combustion of gases in the fluid media (diesel effect). SKF supplies spark rings in a variety of PTFE materials.

Customized machined guide profiles

SKF can manufacture a wide variety of guide profiles (→ **fig. 10**) with different materials and customized sizes with its industry-leading SKF SEAL JET production system. SKF can supply customized machined guide rings in close partnership with customers from the design phase to serial production.

For additional information about customized machined profiles, contact SKF.

Fig. 9

Guide rings combined with spark rings

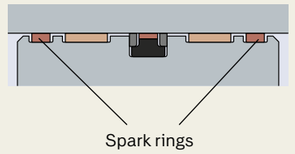
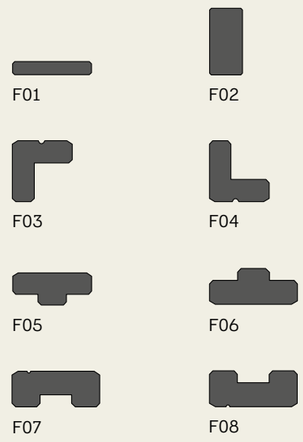


Fig. 10

Examples of SKF SEAL JET guide profiles



5 O-rings and back-up rings

Basics

O-rings are one of the most common sealing solutions. SKF supplies O-rings in a wide range of sizes and different materials, which make them appropriate for a wide variety of operating conditions and applications. They are easy to install and they enable a simple and cost-effective seal housing design.

O-rings maintain sealing contact force by radial or axial deformation in the seal housing between two machine components. The most important criteria that influence the maximum operating pressure at which O-rings in static radial sealing can be used are the following:

- extrusion gap (→ **fig. 2**, **page 140**)
- material (→ *Materials*, **page 18**)
- sealed fluid
- temperature

Under specific conditions, there is a risk for gap extrusion (→ *Extrusion gaps and back-up rings*, **page 298**). Back-up rings prevent O-rings from gap extrusion in static radial sealing.

O-rings are used in a wide variety of applications sealing various media. This catalogue focuses on sealing systems for hydraulic cylinders. Therefore, this chapter and provided recommendations apply to static sealing of common mineral-based hydraulic fluids (→ *Hydraulic fluids*, **page 23**).

Designations

The designations of SKF O-rings (→ **table 1**) in both metric and inch sizes contain their dimensions in metric units.

The designations of SKF back-up rings (→ **table 2**) in metric sizes contain their dimensions in metric units, whereas those in inch sizes contain their dash-number.

The product tables for both are provided in inch and metric sizes. If applicable, the unique dash-numbers for O-ring sizes in accordance with standards AS586 and ISO 3601 are also listed there.

Materials

The O-rings listed in this catalogue are made of nitrile rubber (NBR) with 70 shA hardness as standard. This is the most common O-ring material and hardness used in hydraulic cylinder applications. On request, SKF can supply alternative hardnesses such as 80 shA or 90 shA. However, SKF generally recommends choosing O-rings with 70 shA and combining them with one or two back-up rings (→ *Extrusion gaps and back-up rings*, **page 140**). At operating temperatures above 100 °C *(210 °F)*, fluorocarbon rubber (FKM) or hydrogenated nitrile rubber (HNBR) can be an appropriate materials, depending on the fluid.

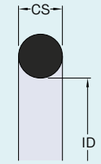
SKF back-up rings listed in this catalogue are made of polyurethane (TPU). On request, SKF can supply alternative materials and various hardness grades. Common back-up ring materials are listed in the designation system (→ **table 2**).

For additional information about O-ring and back-up ring materials, refer to *Materials* (→ **page 18**).

More information

Table 1

Designation system for SKF O-rings



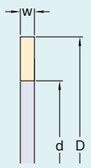
OR 99.1×5.7-N70

- O-ring
- Inside diameter ID [mm]
- Cross section diameter CS [mm]
- Material code (→ **table 5, page 29**)

Table 2

Designation system for SKF back-up rings

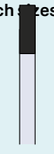
Metric sizes



STR 90×100×1.7-Y95A

- Back-up ring
- Inside diameter d [mm]
- Outside diameter D [mm]
- Width w [mm]
- Material code*)

Inch sizes with a dash-number



STR 19-342-Y95A

- Back-up ring dash-number series
- Dash-number
- Material code*)

*) **Material codes**
Y95A Polyurethane 95 shA (yellow)
395A Polyurethane 98 shA (black)
100 Unfilled PTFE (white)

Standards and sizes

Dimension standards

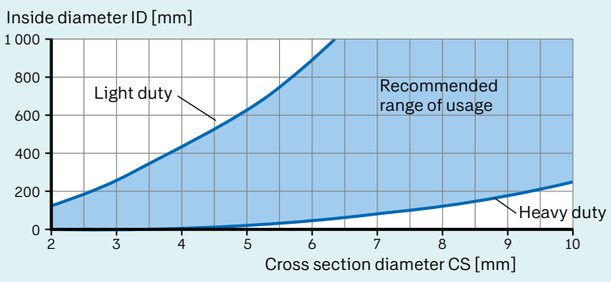
SKF can supply O-rings in a wide range of sizes in accordance with various O-ring standards. **Table 3** provides the most common national and international O-ring standards and their relevant sizes.

Inside diameter/cross section proportion

O-rings used in more demanding applications, such as those with higher operating pressures or larger misalignments, may require larger cross sections. SKF recommends inside diameter ID and cross section proportions as provided in **diagram 1**.

Diagram 1

O-ring inside diameter/cross section proportion



Tolerance standard

SKF supplies all O-rings with dimensional tolerances in accordance with ISO 3601-1 Class B (**→ table 4, page 137**). They are suitable for any elastomer material provided that appropriate tooling is used, whereas the tooling most commonly used is based upon the shrinkage of nitrile rubber (NBR) with 70 shA hardness.

Table 3

O-ring standards and relevant sizes

Standard	DIN 3771:1984		ISO 3601-1 Class B, AS568		BS 4518		JIS 240 P+G		SMS 1586	
Cross section diameter CS	Inside diameter ID_{min}	ID_{max}	Cross section diameter CS	Inside diameter ID_{min}	ID_{max}	Cross section diameter CS	Inside diameter ID_{min}	ID_{max}	Cross section diameter CS	Inside diameter ID_{min}	ID_{max}	Cross section diameter CS	Inside diameter ID_{min}	ID_{max}
mm	mm		mm			mm			mm			mm		
1,8	1,8	17	**1,78**	1,78	133,07	**1,6**	3,1	37,1	**1,9**	2,8	9,8	**1,6**	3,1	37,1
2,65	14	38,7	**2,62**	1,24	247,32	**2,4**	3,6	69,6	**2,4**	9,8	21,8	**2,4**	3,3	17,3
3,55	18	200	**3,53**	4,34	456,06	**3**	19,5	249,5	**3,1**	24,4	144,4	**3**	19,2	44,2
									3,5	21,7	49,7			
5,3	40	400	**5,33**	10,46	658,88	**5,7**	44,3	499,3	**5,7**	47,6	299,3	**5,7**	44,2	144,3
7	206	670	**6,99**	113,67	658,88	**8,4**	144,1	249,1	**8,4**	149,5	399,5	**8,4**	144,1	249,1

Surface standard

SKF supplies O-rings that all have surfaces in accordance with ISO 3601-3 (**→ table 5, page 138**). This standard provides maximum acceptable imperfections and quality criteria for O-ring surfaces.

Table 4

Tolerances in accordance with ISO 3601-1 Class B

Inside diameter ID

The tolerance ΔID can be calculated using

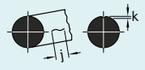
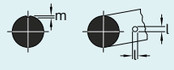
Calculation example:
What is the tolerance ΔID of an O-ring with ID = 94,5 mm?

$\Delta ID = \pm[(94{,}5^{0{,}95} \times 0{,}009) + 0{,}11]$
$= \pm[(75{,}277 \times 0{,}009) + 0{,}11]$
$= \pm[0{,}677 + 0{,}11]$
$= \pm 0{,}79$ mm

Cross section diameter CS over	incl.	Tolerance
mm		mm
0,8	**2,25**	± 0,08
2,25	**3,15**	± 0,09
3,15	**4,5**	± 0,1
4,5	**6,3**	± 0,13
6,3	**8,4**	± 0,15
N		

Table 5

Maximum acceptable surface imperfections in accordance with ISO 3601-3

Surface imperfection category Schematic illustration	Letter symbol	Maximum acceptable limits Grade N O-rings Cross section diameter CS >0,8 ≤2,25	>2,25 ≤3,15	>3,15 ≤4,50	>4,50 ≤6,30	>6,30 ≤8,40	Grade S O-rings Cross section diameter CS >0,8 ≤2,25	>2,25 ≤3,15	>3,15 ≤4,50	>4,50 ≤6,30	>6,30 ≤8,40
–		mm					mm				
Offset (off register and mismatch)											
	e	0,08	0,1	0,13	0,15	0,15	0,08	0,08	0,1	0,12	0,13
Combined flash, offset and parting line projection											
	f	0,1	0,12	0,14	0,16	0,18	0,1	0,1	0,13	0,15	0,15
Backrind											
	g	0,18	0,27	0,36	0,53	0,7	0,1	0,15	0,2	0,2	0,3
	h	0,08	0,08	0,1	0,1	0,13	0,05	0,08	0,1	0,1	0,13
Excessive trimming											
	–	Departure from a circular cross section due to trimming is allowed provided that the resultant surface is smoothly blended and is within the size tolerance limits for CS.									
Flow marks (radial orientation of flow marks is not permissible)											
	j	1,5[1]	1,5[1]	6,5[1]	6,5[1]	6,5[1]	1,5[1]	1,5[1]	5[1]	5[1]	5[1]
	k	0,08	0,08	0,08	0,08	0,08	0,05	0,05	0,05	0,05	0,05
Non-fills and indentations (including parting line indentation)											
	l	0,6	0,8	1	1,3	1,7	0,15	0,25	0,4	0,63	1
	m	0,08	0,08	0,1	0,1	0,13	0,08	0,08	0,1	0,1	0,13
Foreign material	–	Not permitted					Not permitted				

Housing design and dimensions

Housing dimensions for static radial sealing

O-rings for static (non-moving) sealing can be used in a wide variety of applications and arrangements. The most common arrangement in hydraulic cylinder applications is static radial sealing between coaxial cylindrical parts. The O-ring is installed in a housing that is machined either as an outside or inside groove (→ **fig. 1**) in one of the two cylindrical parts.

The housing dimensions for static radial sealing O-rings are listed in the product tables.

Housing groove edges

All housing groove edges should be smoothed and rounded off (→ **fig. 1**) to r = 0,1 to 0,2 mm *(0.004 to 0,008 in.)*.

Lead-in chamfers

All edges and openings through which the O-ring has to pass during the assembly should have appropriate lead-in chamfers and should be well rounded off (→ **table 6**). The chamfers facilitate assembly and protect the O-ring from damage during the installation process. The O-ring and all surrounding parts should be well lubricated before assembly, preferably with the same fluid as used in the hydraulic system, ensuring compatibility with seals and cylinder components.

Fig. 1

Static radial sealing arrangements

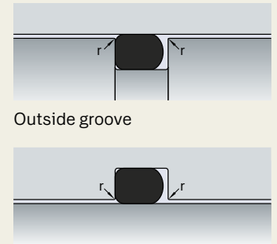
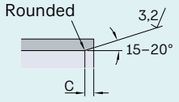


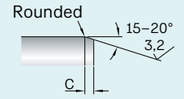
Table 6

Lead-in chamfers for O-rings

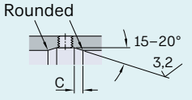
Inside



Outside



Hole



Cross section diameter CS from	incl.	Chamfer length C min.
mm		mm
1	1,5	1,5
1,6	2	2
2,4	3	2,5
3,53	4,5	3,5
5	5,7	4,5
6	8,4	5,5

Extrusion gaps and back-up rings

The size of the permissible extrusion gap (→ *Gap extrusion*, **page 26**) depends mainly on the seal material, temperature and operating pressure. Harder materials (→ *Materials*, **page 18**) provide a certain resistance to gap extrusion. When the permissible extrusion gap for the pressure and temperature in application is exceeded, back-up rings may be used to prevent the seal pressing into the gap and causing extrusion damage and possibly even premature failure. **Figure 2** shows the O-ring behaviour at different operating pressures and conditions. In applications where the O-ring is exposed to pressure from one side only, the back-up ring is installed at the zero pressure side. For an O-ring exposed to pressure from both sides, a back-up ring is installed on both sides.

For the extrusion gaps, SKF recommends machining the fits according to the following tolerance classes:

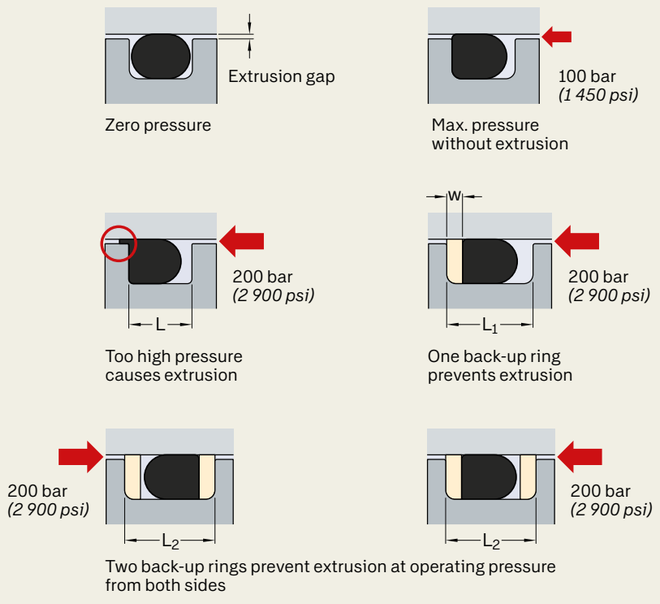
- f8 Ⓔ and H9 Ⓔ for diameters up to 120 mm
- f7 Ⓔ and H8 Ⓔ for diameters larger than 120 mm

Diagrams 2 to **4** provide guideline values for the maximum extrusion gap in relation to the operating pressure for standard O-rings without back-up ring (→ **diagram 2**) and different back-up ring materials and sizes (→ **diagrams 3** and **4**). These guideline values are based on extensive tests conducted in SKF laboratories at 90 °C *(195 °F)* and 100 000 pressure pulses. However, other factors such as temperature and fluid can influence these guideline values and should be considered.

For additional information about O-ring and back-up ring materials, refer to *Materials* (→ **page 134**) and about extrusion, refer to *Gap extrusion* (→ **page 26**).

Fig. 2

O-ring behaviour at different operating pressures and conditions



Housing groove width

To accommodate the additional back-up rings, the O-ring groove width L needs to be increased to L_1 for one back-up ring or L_2 for two back-up rings (→ **fig. 2**). The groove width dimensions are listed in the product tables.

Diagram 2

Guideline limit values for NBR O-rings, 70 shA

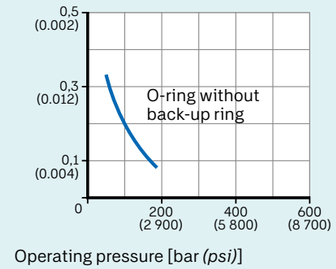


Diagram 3

Guideline limit values from test with OR 89.5×3-N70 and STR 90×95×1.3

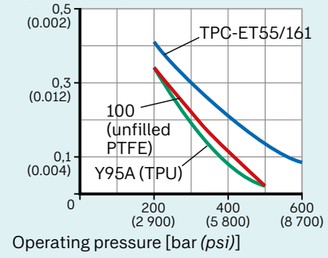
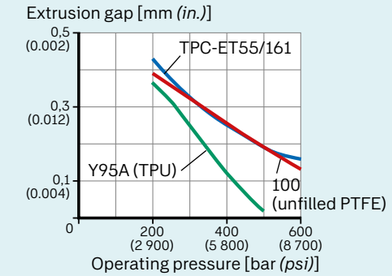


Diagram 4

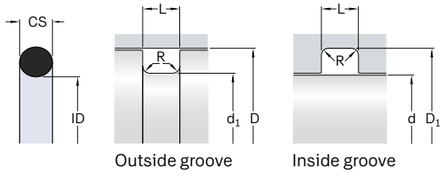
Guideline limit values from test with OR 89.1×5.7-N70 and STR 90×100×1.7



Profile data

6.1 OR O-rings in static radial sealing, metric sizess

ID 2,9 – 499,3 mm



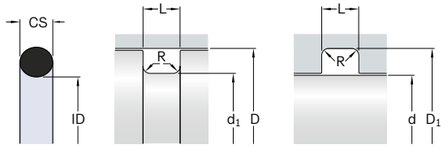
Outside groove Inside groove

SKF recommends designing O-ring housings according to ISO 3601.
This table is a reference to O-ring sizes for common housing dimensions.

For complete product listings see:
https://www.skf.com/group/products/industrial-seals/hydraulic-seals/o-rings-and-back-up-rings

6.2 OR O-rings in static radial sealing, inch sizes

Dash-number 004 – 475



Outside groove Inside groove

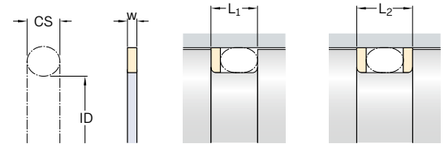
SKF recommends designing O-ring housings according to ISO 3601.
This table is a reference to O-ring sizes for common housing dimensions.

For complete product listings see:
https://www.skf.com/group/products/industrial-seals/hydraulic-seals/o-rings-and-back-up-rings

[1] Adjustments according to tolerances provided for rod or piston seals are possible, however, the maximum e-gap also need to be considered (→ Gap extrusion, page 26)

6.3 STR Back-up rings in static radial sealing, metric sizes

ID 9,3 – 269,3 mm

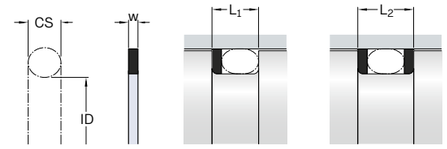


Back-up rings are selected by the corresponding O-ring dimensions.

For complete product listings see:
https://www.skf.com/group/products/industrial-seals/hydraulic-seals/o-rings-and-back-up-rings

6.4 STR Back-up rings in static radial sealing, inch sizes by dash-number, metric dimensions

Dash-number 013 – 449

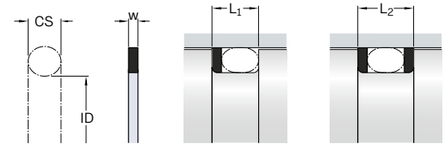


Back-up rings are selected by the corresponding O-ring dimensions.

For complete product listings see:
https://www.skf.com/group/products/industrial-seals/hydraulic-seals/o-rings-and-back-up-rings

6.5 STR Back-up rings in static radial sealing, inch sizes by dash-number

Dash-number 013 – 449



Back-up rings are selected by the corresponding O-ring dimensions.

For complete product listings see:
https://www.skf.com/group/products/industrial-seals/hydraulic-seals/o-rings-and-back-up-rings

Other O-ring sealing and ring materials

Dynamic radial sealing

Under certain conditions, O-rings can be used for dynamic sealing with relative motion between the coaxial parts. These sealing arrangements are limited to slow reciprocating or oscillating motions. The radial depth S should be increased to S1 using

$$S1 = \frac{CS + S}{2}$$

where
S1 = increased radial depth [mm]
CS = cross section [mm] (→ **product tables**)
S = radial depth [mm]
= (D – d1) / 2 for outside grooves
= (D1– d) / 2 for inside grooves

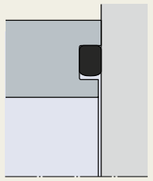
For additional dimensions, refer to the relevant standards (→ **table 3, page 136**).
For additional information, contact SKF.

Static axial sealing

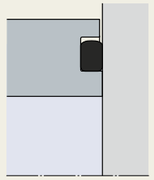
O-rings can also be used for static axial sealing between two opposing parts. Although, static axial sealing arrangements are not common in hydraulic cylinder applications, some examples are shown in **figure 3**.
For additional information, contact SKF.

Fig. 3

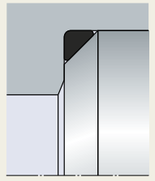
Static axial sealing examples



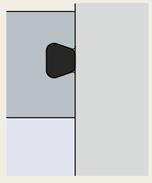
Rectangular groove, inside pressure



Rectangular groove, outside pressure



Triangular groove



Trapezoidal groove

PTFE encapsulated O-rings

SKF also supplies O-rings type ECOR that are encapsulated with PTFE materials (FEP or PFA). These O-rings have a core made of silicone or fluorocarbon rubber. The seamless and uniform PTFE encapsulation protects the core material against fluids and air.
ECOR O-rings are preferred for static sealing and not appropriate for continuously dynamic applications due to its thin and soft encapsulation. They are characterized by the following properties:

- chemical resistant
- wide temperature range
- anti-adhesive, low breakaway friction
- good resistance to wear
- good resistance to UV light
- can be sterilized in accordance with FDA (Food and Drug Administration) requirements
- low steam permeability
- low water absorption

For available sizes and additional information, contact SKF.

Back-up rings made of thermoplastic polyester elastomer

SKF also supplies back-up rings made of thermoplastic polyester elastomer (TPC).
For additional information, contact SKF.

Back-up rings made of PTFE

SKF back-up rings made of PTFE are suitable in applications with high temperatures or aggressive fluids. PTFE back-up rings are available unfilled or with an appropriate filler. Back-up rings made of unfilled PTFE can be machined from tube blanks with outside diameters ranging from 1 to 1 500 mm *(0.039 to 59 in.)*. Therefore, they can easily be adapted to customer specific installations and delivered on short notice.
For additional information, contact SKF.

6 Other fluid power applications

This catalogue contains the standard assortment of SKF hydraulic seals and guides typically used in hydraulic cylinders. Furthermore, SKF provides a wide range of standard and customized sealing solutions for a variety of other fluid power applications. In this chapter, you find some examples of these capabilities. For a solution that best meets the demands of your application, contact SKF.

Hydraulic rock breaker hammers

Hydraulic rock breaker hammers are a demanding application requiring hydraulic reciprocating seals working in short strokes and extreme high velocity.

SKF has many special solutions for rock hammers, including TEFLATHANE seals with a special high-temperature polyurethane U-cup seal that is bonded to a low-friction PTFE anti-extrusion ring to extend service life for significant maintenance savings.

Hydraulic presses

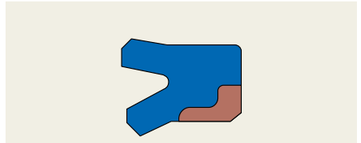
Each hydraulic press application is unique and should work reliably for many years without costly downtime or expensive repairs. SKF has decades of experience developing and manufacturing customized press sealing solutions for original equipment manufacturers, as well as retrofit assemblies for existing equipment.

With moulding and machining capabilities and virtually unlimited diameter range, SKF can customize and manufacture sealing solutions to optimize system performance and decrease operating costs.

Hinge pin joints

Hinge pin seals retain pin joint bearing lubricants and exclude contaminants on off highway equipment that operates in harsh outdoor environments across all climates and weather conditions.

PAK-L press-in seals are optimized for demanding pin joint applications. The wear resistant polyurethane seal materials reduce relubrication intervals and extend both seal and hinge joint bearing life. In addition, SKF has experience developing customized pin joint seal solutions.



Product index

[1)] Starting page of the product table

skf.com | skf.com/seals

PUB SE/P1 12393/3 EN · July 2025