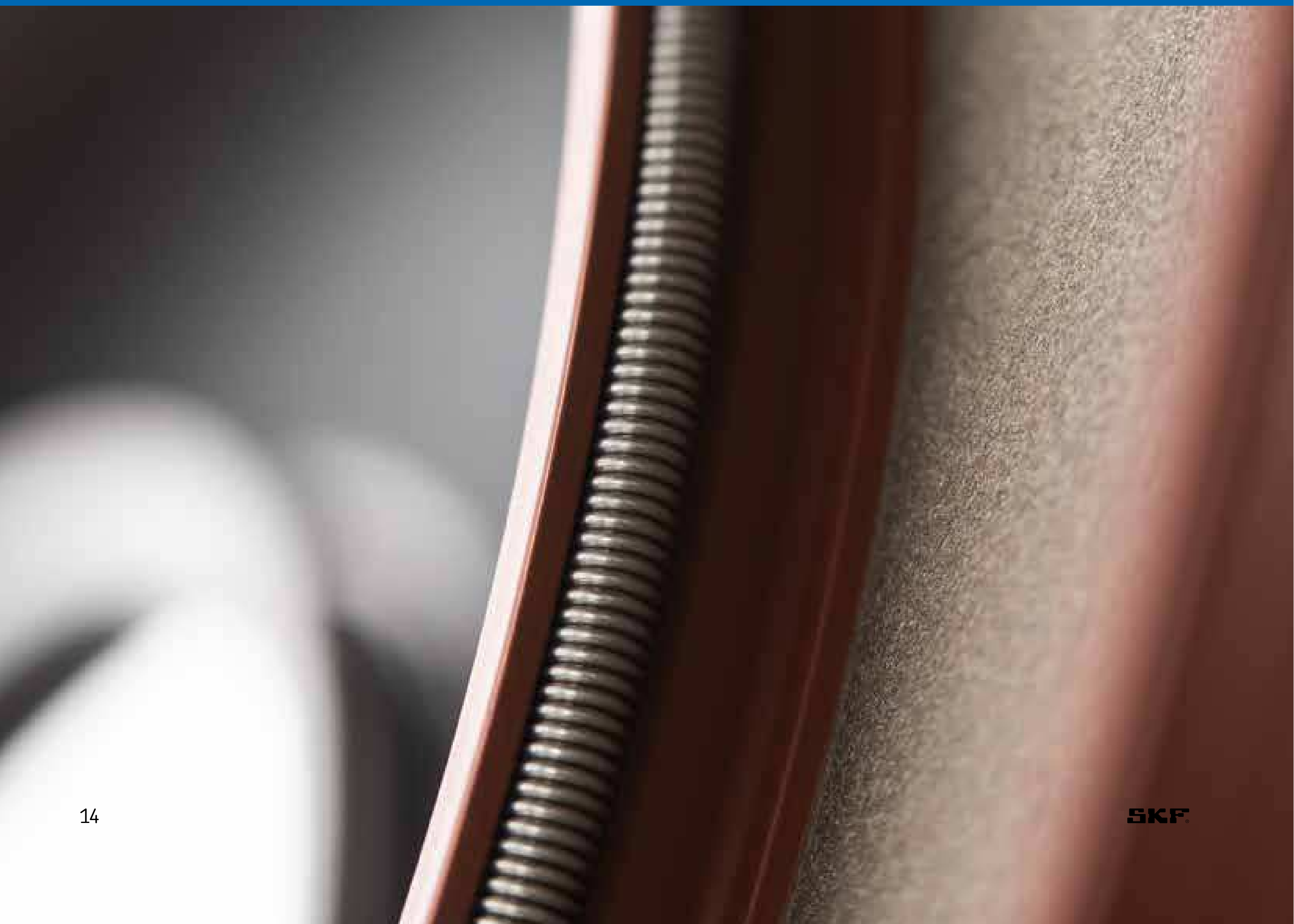
Product data – general



Industrial shaft seals

Industrial shaft seals are used to seal the opening between a rotating and a stationary component, or between two components in relative motion. Primary seal functions include:

- **Retain the lubricant**
- **Exclude contaminants**
- **Separate two different media**
- **Seal under pressure**

To be effective, industrial shaft seals should operate with a minimum of friction and wear, even under unfavourable operating conditions. In order to meet the requirements of a variety of different applications and operating conditions, SKF industrial shaft seals for rotating machine components are manufactured from many different designs, materials and executions. Each of these designs and material combinations has specific properties, making them suitable for a particular application. The main groups of shaft seals and accessories are:

Radial shaft seals
- Seals for general industrial applications
- Seals for heavy industrial applications
- Cassette seals

Axial shaft seals
- Track pin seals
- Metal face seals
- V-ring seals
- Axial clamp seals

Wear sleeves
- SKF Speedi-Sleeve
- Wear sleeves for heavy industrial applications

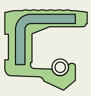
Availability
The SKF assortment of industrial shaft seals comprises hundreds of different designs and material combinations. The products shown in this catalogue and listed in the product tables are the more commonly used seal types and sizes.

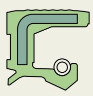
Guidance values
Since several factors simultaneously affect the sealing system and seal performance, all stated values in graphs and tables in this publication should be considered as guidelines only and not as absolute values for practical applications.

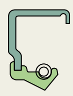
Profile overview selection

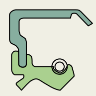
Radial shaft seals

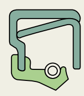
Seals for general industrial applications, elastomeric sealing lip(s)

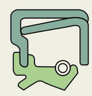

HMS5

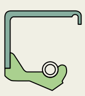

HMSA10


CRS1

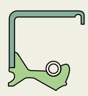

CRSA1


CRSH1

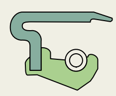

CRSHA1

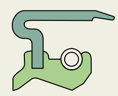

CRW1

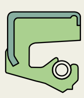

CRWH1

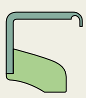

CRWA1

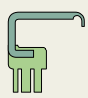

CRWHA1

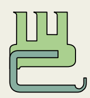

CRW5


CRWA5

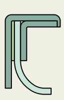

HDW1

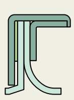

HM14

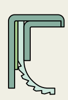

TL7

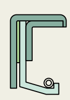

X15

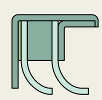
Seals for general industrial applications, PTFE sealing lip(s)

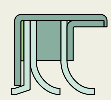

SL

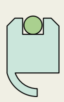

SLA

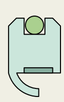

SLX

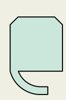

SLS


DL

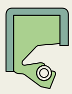

DLA

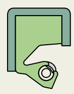

YSLE

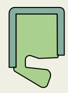

YNSLE

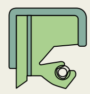

YSL

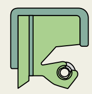
Seals for heavy industrial applications, flex

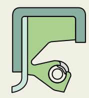

HDS1

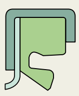

HDS2

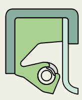

HDS7

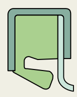

HDSA1

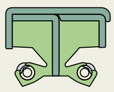

HDSA2

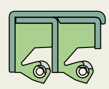

HDSF2


HDSF7

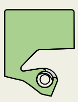

HDSH2

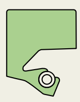

HDSH7

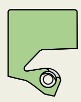

HDSD2

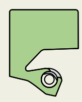

HDSE2


HS4

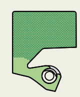

HS5

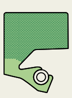

HS6


HS7


HS8

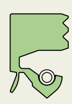

HSS4

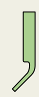

HSS5


HSS6

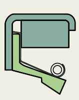

HSS8

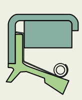

HRS


HRSA

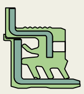

HRE

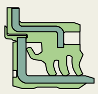
Seals for heavy industrial applications, high speed

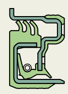

HDL

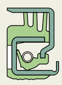

HDLA

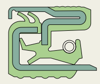
Cassette seals, SKF Mudblock


MUD3

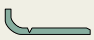

MUD6


MUD7


MUD8


MUD11

Wear sleeves

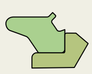


SKF Speedi-Sleeve

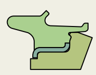
LDSLV4

Axial shaft seals

Track pin seals, SKF Trackstar

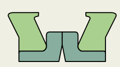


TP



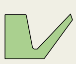
TPM

Metal face seals

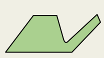


HDDF

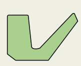
V-ring seals



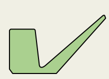
VA / VR1



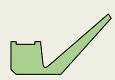
VS / VR2



VL / VR3

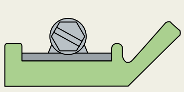


VE / VR4

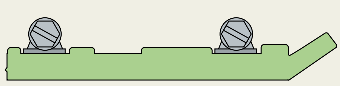


VRME / VR6

Axial clamp seals



CT1



CT4

Selection of seal design and material

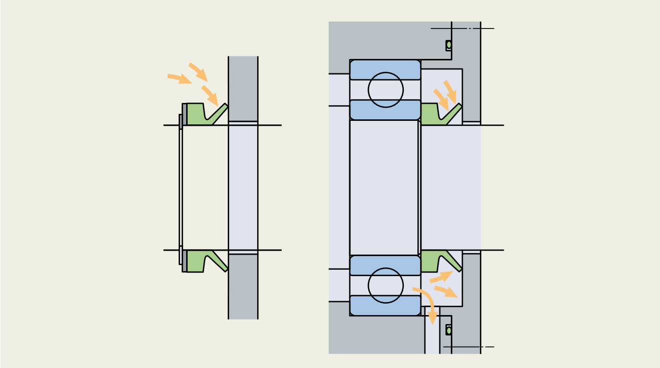


Fig. 1

V-ring

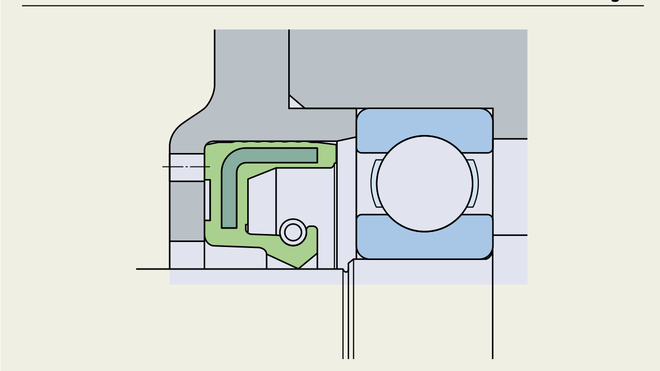


Fig. 2

HMS5 seal

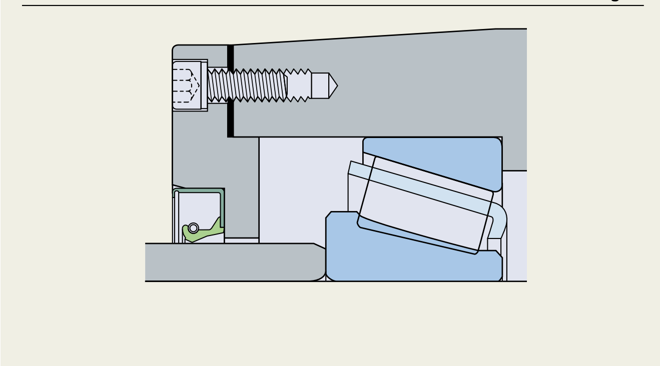


Fig. 3

CRW1 seal

Selecting an appropriate seal design and material depends on the operating conditions of the application such as:

- **Temperature**
- **Speed**
- **Pressure differential**
- **Type of lubricant**
- **Vertical or horizontal orientation**
- **Runout and shaft-to-bore misalignment**

Because the influence of one operating condition typically dominates the seal selection process, there are no universal rules for determining the appropriate seal type or design for a given application. This section describes how operating conditions affect seal performance and service life and provides guidance on selecting the most appropriate seal for a given application.

Pages 103 to **105** and **174** to **183** show the standard SKF radial shaft seals and their main features and permissible operating conditions.

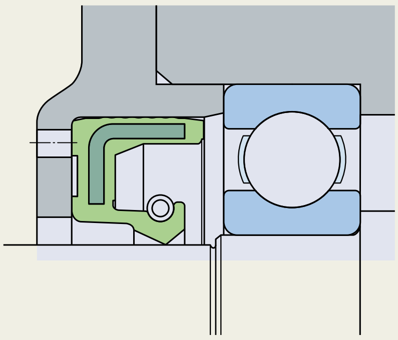
Grease retention

Greases have a relatively high viscosity and are relatively easy to retain in a bearing arrangement. In many grease lubricated applications, a non-spring-loaded sealing lip design or a V-ring can adequately retain the grease (→ **fig. 1**).

However, more demanding applications may require HMS5 or CRW1 spring-loaded radial shaft seals (→ **figs. 2 and 3**).

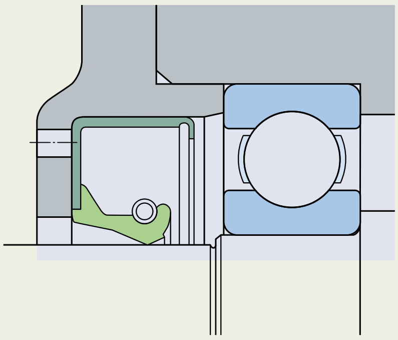
When frequent relubrication is required, the lip of at least one of the seals in the sealing arrangement should be directed toward the air side so that excess grease can escape via the sealing lip (→ **fig. 3**). This avoids grease build-up, which can retain heat and limit heat dissipation. For grease lubricated applications, SKF recommends calculating the permissible circumferential speed for oil and halving the result.

Fig. 4



HMS5 seal

Fig. 5



CRW1 seal

Oil retention

Lubricating oils, particularly relatively low-viscosity oils, are much more difficult to retain than greases. Therefore, HMS5 or CRW1 spring-loaded radial shaft seals (→ **figs. 4** and **5**) are recommended in order to achieve the necessary radial load and resistance to dynamic runout and shaft-to-bore misalignment for a satisfactory sealing performance.

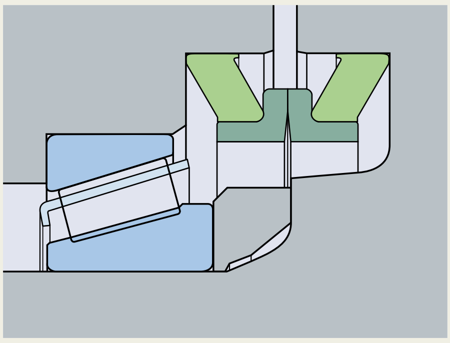
Standard HMS5 seals have a straight lip while CRW1 seals are designed with SKF Wave lips to provide improved pumping ability, regardless of the direction of shaft rotation (→ **fig. 5** on **page 21**). Another way of increasing a seal's pumping ability is to add a helix pattern, i.e. hydrodynamic features, to the sealing lip design.

The rubber outside diameter, like the one found on HMS5 seals, helps compensate for small imperfections in the housing bore surface and is therefore recommended when the required housing bore surface is questionable.

For very tough operating conditions, where circumferential speeds are relatively low, metal face seals, like the HDDF seal (→ **fig. 6**), can be used for both oil or grease retention.

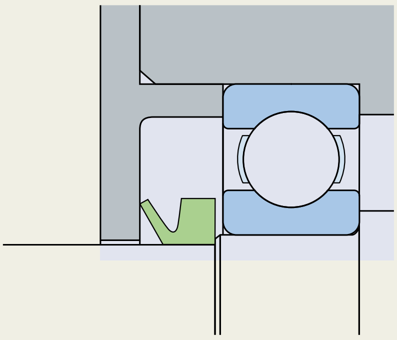
V-rings (→ **fig. 7**) may also be used to retain oil, provided they are installed on the oil side and supported axially on the shaft.

Fig. 6



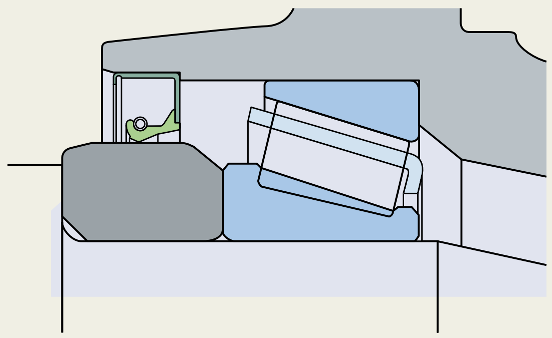
HDDF metal face seal

Fig. 7



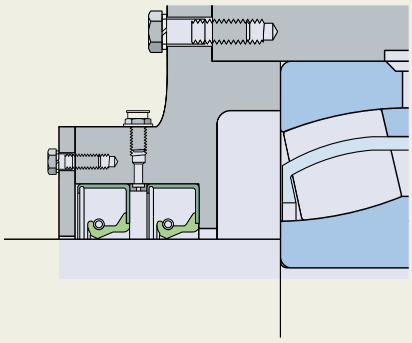
V-ring

Fig. 8



CRW1 seal

Fig. 9



CRW1 seals in tandem

Contaminant exclusion

Radial shaft seals that are primarily used for contaminant exclusion should be installed with the lip pointing outward. When additional protection is needed, SKF recommends a seal design that incorporates an auxiliary lip, for example the HMSA10 or CRWA1 seals.

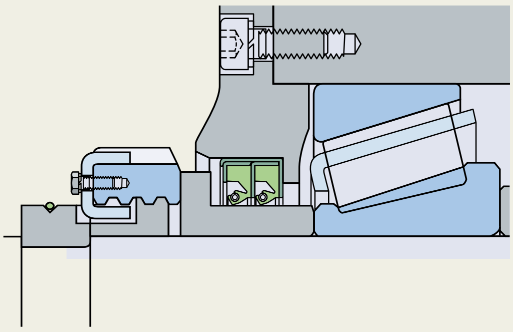
For tough operating conditions, SKF Wave seals (→ **fig. 8**) with hydrodynamic features are recommended. To further enhance sealing efficiency, two single-lip seals can be arranged in tandem (→ **fig. 9**) or a double-lip seal, like the HDSE1 seal, can be used (→ **fig. 10**).

V-rings (→ **fig. 11**) are used primarily to exclude contaminants. These seals, which act as flingers, rotate with the shaft and seal against a surface that is perpendicular to the shaft.

V-rings and axial clamp seals are often used as secondary seals to protect the primary seals from coarse contaminants.

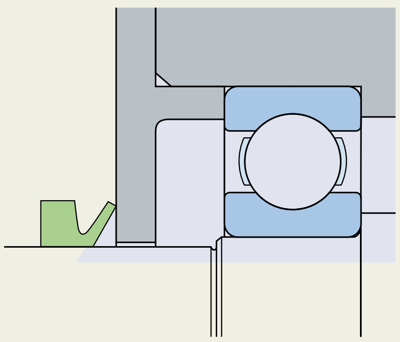
V-ring seal arrangements are not intended for oil retention.

Fig. 10



HDSE1 seal

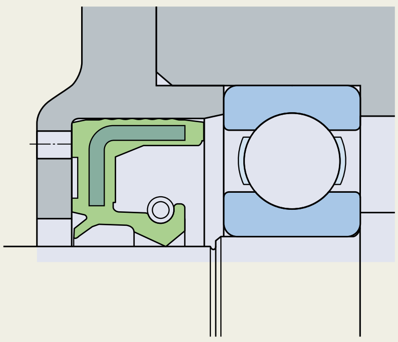
Fig. 11



V-ring

SKF

Fig. 12



HMSA10 seal

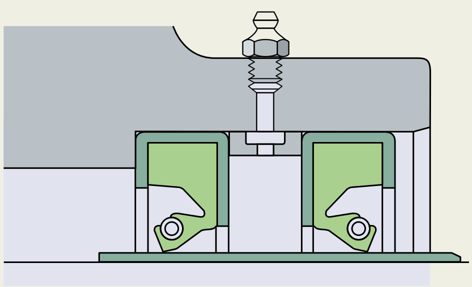
Retention and exclusion

In many applications, the exclusion of contaminants is just as important as lubricant retention. Seals with an auxiliary lip, like the HMSA10 seals (→ **fig. 12**), are appropriate for these applications.

Another option is to use two seals installed in opposite directions (→ **figs. 13** and **14**) or two opposing V-rings (→ **fig. 15**) with a spacing washer.

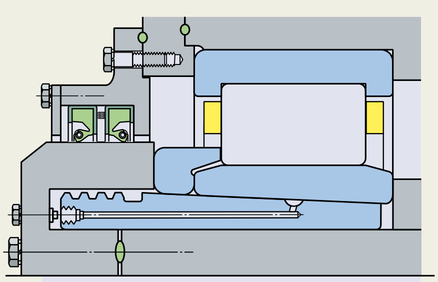
Under extremely tough operating conditions, SKF recommends using HDDF metal face seals (→ **fig. 6** on **page 23**), provided that the sliding velocity of the mating surfaces lies within the permissible range.

Fig. 13



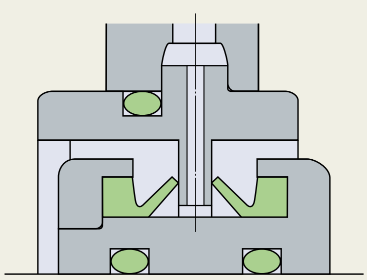
Two seals in opposite direction

Fig. 14



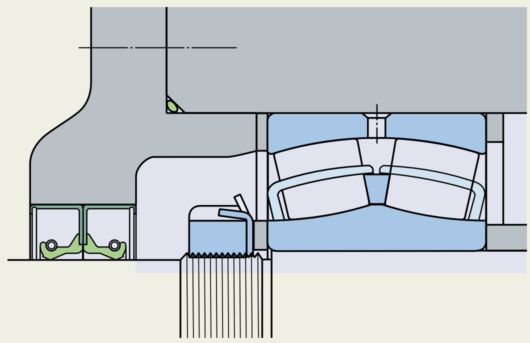
Two seals in opposite direction

Fig. 15



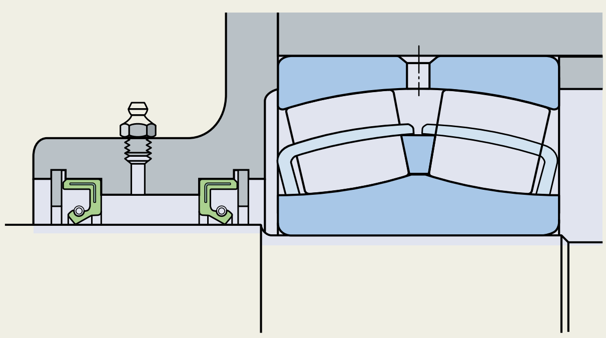
V-ring

Fig. 16



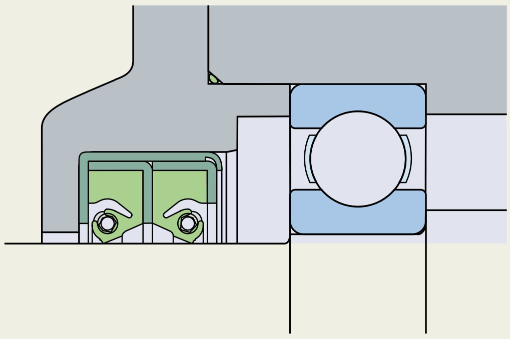
CRW1 seals

Fig. 17



HMS5 seals

Fig. 18



HDSD2 seal

Separating two liquids

When an application has to keep two liquids from coming into contact with each other, there are two suitable solutions. These solutions, which depend on the availability of space and required efficiency, include

- the use of two separate seals (→ **figs. 16** and **17**), positioned with their lips facing in opposite directions or
- the use of HDSD2 double-lip seals (→ **fig. 18**)

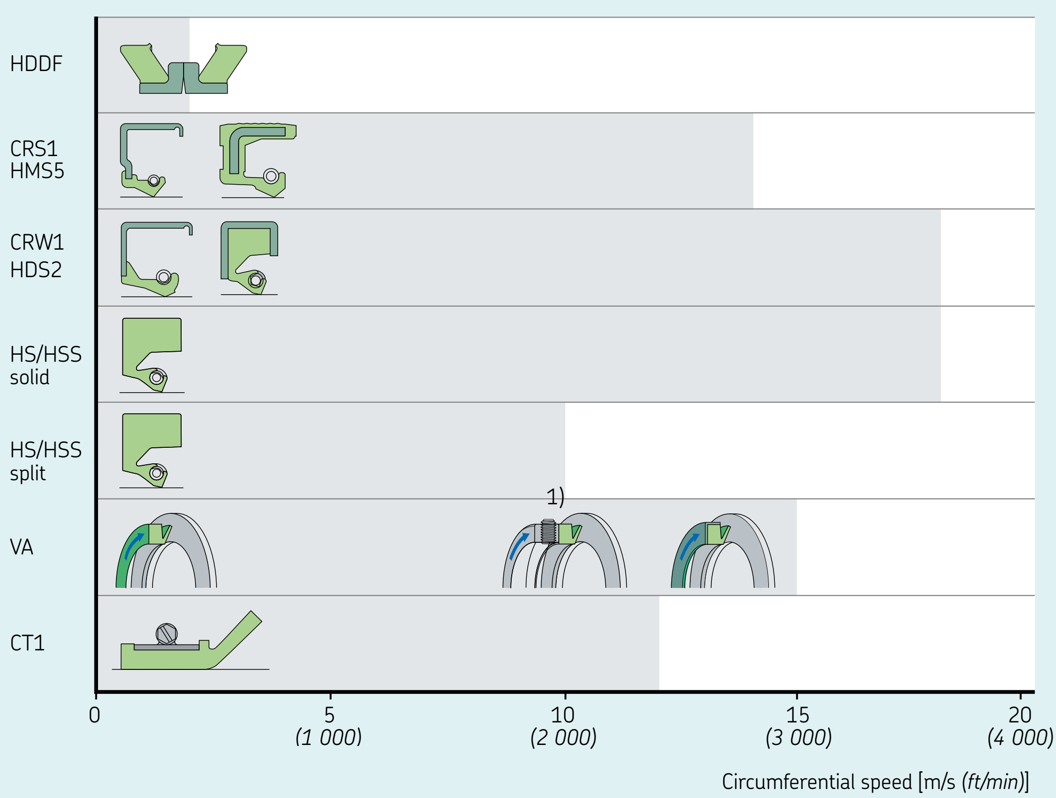
In both alternatives, the sealing lips must be spring-loaded. When using an HDSD seal, it is very important to provide a means to lubricate the sealing lips, i.e. the cavity between the sealing lips must be filled with grease prior to installation.

Circumferential and rotational speed

The permissible speed of a seal is determined by its design and sealing lip material as well as the material and condition of the shaft. All of these factors influence the heat generation at the seal counterface. Lubrication of the sealing lip and the characteristics of the lubricant also have a direct influence on heat generation because they have a direct impact on heat dissipation.

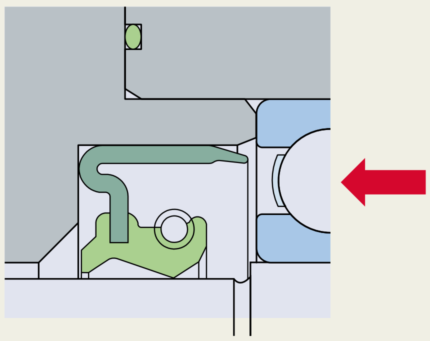
Diagram 1 compares the permissible circumferential speeds for various seal designs assuming normal seal operation, grease or oil retention and no pressure differential across the seal.

Diagram 1



1) Support ring by customer

Fig. 19



CRWA5 seal

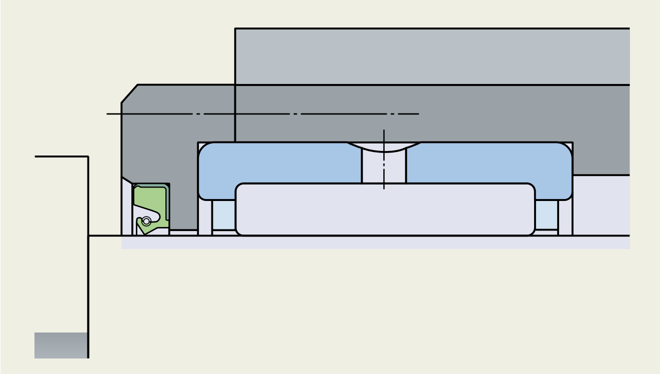
Pressure differentials

When subjected to a pressure differential, the seal must resist the additional radial load generated by the pressure. If the seal is not designed to resist the pressure, it will be forced against the shaft, increasing the radial load, underlip temperature, friction and wear of the seal and the counterface, resulting in shortened service life.

Standard seals are rated for no more than 0,07 MPa at 5 m/s *(10 psi at 1 000 ft/min)*, but SKF offers CRW5 and CRWA5 pressure profile seals that can accommodate 0,34 MPa at 5 m/s *(50 psi at 1 000 ft/min)*. Beyond 0,34 MPa *(50 psi)*, SKF offers a line of special order PTFE seals that can accommodate more than 3,5 MPa *(500 psi)*.

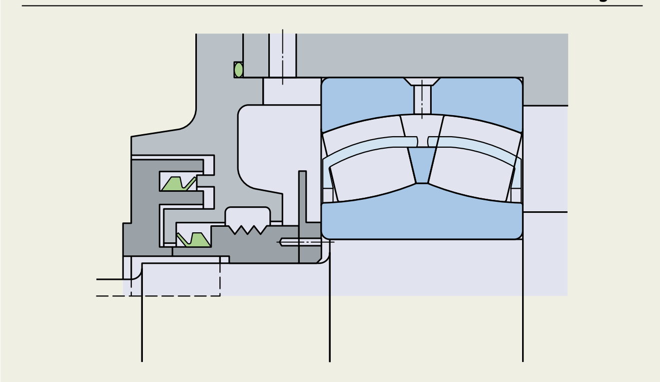
In applications with pressure differentials, shaft seals should be secured axially from the low-pressure side to prevent them from moving axially. This can be accomplished by installing the seal into a counterbore (→ **fig. 19**) or by using a retaining ring.

Fig. 20



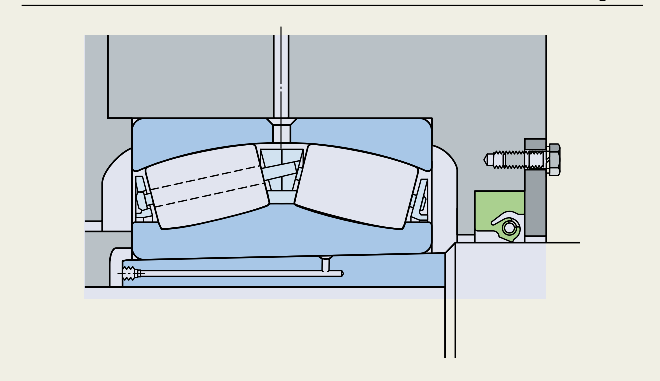
Special seal design

Fig. 21



V-ring seal

Fig. 22



HS8 seal

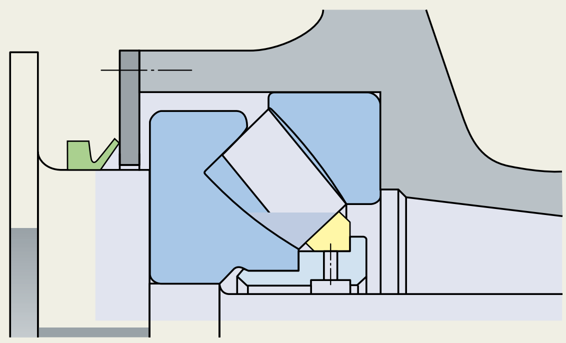
Limited space

In many cases, the available space is insufficient for a radial shaft seal having dimensions in accordance with ISO 6194-1 or DIN 3670. In these situations, special radial shaft seal designs must be used (→ **fig. 20**).

V-rings (→ **fig. 21**) are also suitable for applications with limited space because they can be positioned outside the actual seal position. V-rings seal axially by exerting light pressure against the counterface that can be a stationary or rotating machine component.

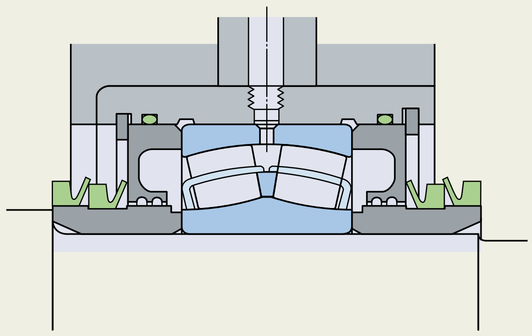
In applications with large shaft diameters, HS8 seals are an appropriate choice when space is limited (→ **fig. 22**).

Fig. 23



V-ring seal

Fig. 24



V-ring seals

Installation restrictions

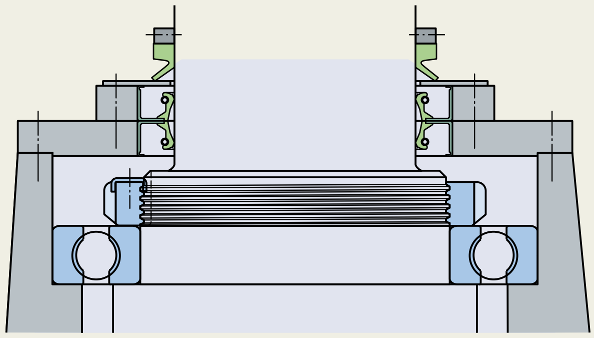
In applications where the seal cannot be installed via the shaft end, a V-ring or any of the split HS, HSS or HRS designs can be used (→ **pages 192** to **199**).

After being positioned on the shaft, HS, HSS and HRS seals are held together by a spring and spring connector. These seals should be retained axially in the housing bore by a one-piece or split cover plate.

Split HS radial shaft seals are suitable for circumferential speeds up to 7,5 or 10 m/s *(1 480 or 1 970 ft/min)*, depending on their design, and are available for shaft diameters up to approximately 4 570 mm *(180 in)*.

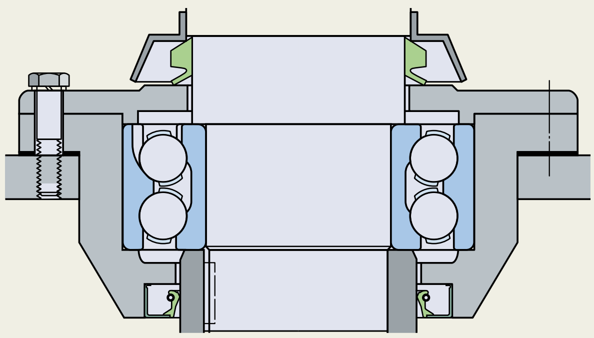
Since V-rings are elastic, they can be stretched and are therefore easy to install, even in applications where they have to be passed over other components (→ **fig. 23**). However, in the event that replacing a V-ring would require the time consuming removal of several components, it is advantageous to install one or two replacement V-rings on the shaft from the outset (→ **fig. 24**). When the time comes to replace a worn V-ring, it can be cut and removed and the replacement V-ring can be pushed into position.

Fig. 25



V-ring seal

Fig. 26



V-ring seal

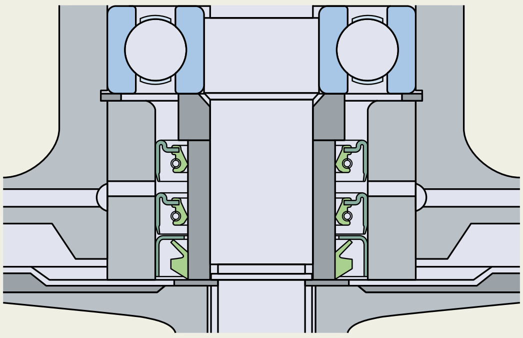
Arrangement

Seals installed on vertical shafts are usually more exposed to contaminants like rain water than seals on horizontal shafts. Oil retention is also more challenging for seals installed on vertical shafts. In general, however, all seals listed in the product tables are suitable for use on both horizontal and vertical shafts.

V-rings (→ **figs. 25** and **26**) have an interference fit on the shaft and rotate with it. They act as flingers and are therefore particularly suitable as both primary and secondary seals on vertical shafts. Highly efficient sealing arrangements, like those found in submersible pumps, can be achieved using radial shaft seals in tandem with a V-ring for additional protection against contaminants (→ **fig. 27**).

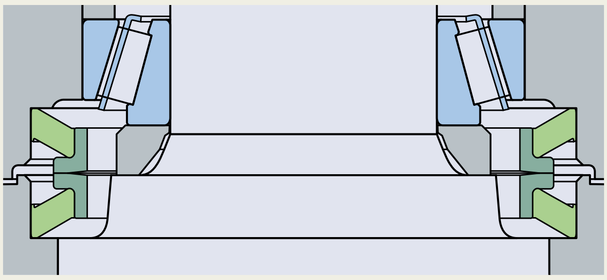
At relatively low speeds, HDDF metal face seals (→ **fig. 28**) effectively retain grease or oil and prevent the ingress of contaminants on vertical shafts.

Fig. 27



CRW5 seals + V-ring seal

Fig. 28



HDDF metal face seal

Counterface design

The service life and performance of a seal are largely influenced by:

- Shaft material and hardness
- Shaft surface finish and tolerance grade
- Dynamic runout and shaft-to-bore misalignment

A shaft surface that is too smooth can lead to lubricant starvation, while a shaft surface that is too rough can accelerate sealing lip wear. The shaft surface should be machined without directionality as directionality can cause leakage depending on the direction of rotation. Dynamic runout and shaft-to-bore misalignment cause an uneven radial load on the circumference of the sealing lip. As a result, the sealing lip, particularly at high speeds, will not be able to follow the shaft. This, in turn, will result in a gap between the sealing lip and the shaft, causing reduced sealing ability.

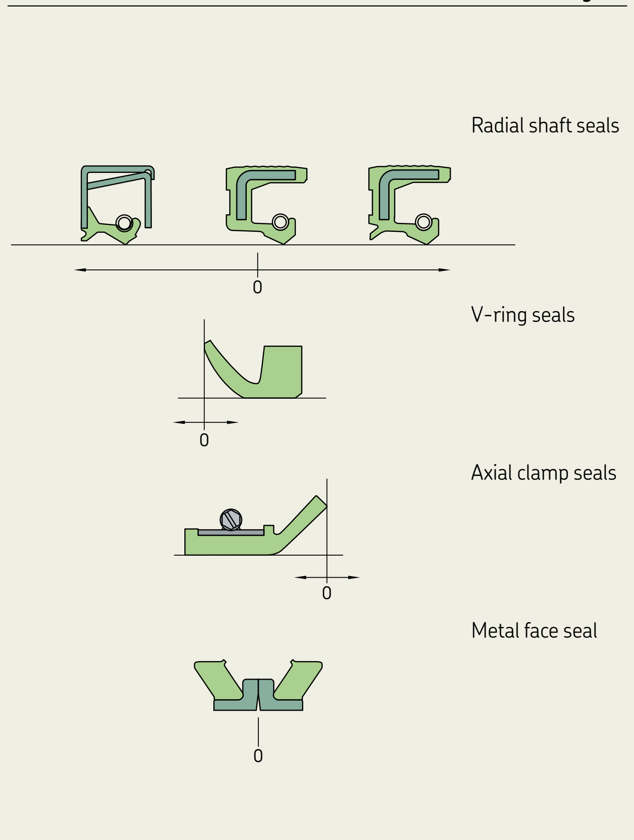
Unlike radial shaft seals, V-rings and axial clamp seals are not affected by normal coaxiality deviations or runout.

Axial movement

Axial movement of the shaft relative to the housing bore does not detract from the sealing ability of radial shaft seals (→ **fig. 29**), provided that the total surface in contact with the lip has the same quality with respect to hardness and surface finish.

The amount of axial movement that can be accommodated by V-rings, axial clamp seals and HDDF seals is limited by the permissible displacement of the seal relative to its counterface.

Fig. 29



Axial movement

Sealing materials

Cases and inserts

Metal cases and reinforcements for SKF radial shaft seals are manufactured standard from deep-drawn carbon sheet steel. The exposed surfaces are treated to protect them from corrosion during normal handling and storage.

SKF radial shaft seals that will be used in corrosive environments can also be designed with a stainless steel case on request.

Garter springs

The garter springs on SKF radial shaft seals are manufactured standard from cold-drawn steel wire. Exceptions are the metal-cased HDS seals, the all-rubber HS seals and the HMS5 / HMSA10 seals made from fluoro rubber that are designed with stainless steel garter springs.

SKF Bore Tite Coating

SKF Bore Tite Coating is a water-based acrylic sealant available on most SKF metal-cased seals. The sealant is used as a coating on the outside diameter of the seal. SKF Bore Tite Coating is pliable with a thickness of 0,03 to 0,07 mm *(0.0012 to 0.0028 in)* to compensate for small imperfections in the housing bore surface. The general guideline in Rubber Manufacturers Association (RMA) is, that if the bore surface texture is greater than 2,5 µm *(100 µin)* R_a, a sealant should be used. This sealant can be used at temperatures up to 200 °C *(390 °F)* and is compatible with most oils, greases, aqueous acids and alkalis, alcohols and glycols. Please note that SKF Bore Tite Coating is not compatible with aromatics, ketones or esters. Contact with these substances will, however, have little or no effect if wiped off quickly.

Adhesives and bonding agents

Adhesives and bonding agents are used to achieve static sealing ability and satisfactory bonding between metal and elastomers in seal designs. Both of them can be solvent or water based depending on the metal and elastomer to be bonded.

Sealing lip materials

In addition to its design, the material of a sealing lip can have a significant impact on sealing performance and reliability. SKF, therefore, manufactures seals using a variety of sealing lip materials to meet the needs of different applications.

The sealing lips of SKF seals are generally made of elastomer materials. However, thermoplastics like polytetrafluoroethylene (PTFE) are gaining in importance. PTFE is mainly used for special seals intended for particular applications where improved thermal or chemical resistance is demanded.

SKF industrial shaft seals are generally manufactured from the materials listed in **table 1** on **page 32**. These materials have characteristics that make them particularly suitable for specific applications.

By changing the actual formulation and blending, it is possible to modify the characteristics of the elastomers relative to:

- Resistance to swelling
- Elasticity
- Chemical resistance
- Thermal resistance
- Behaviour in the cold
- Gas permeability

Details about the chemical resistance of sealing lip materials to various media encountered in operation are provided in the section *Chemical resistance*, **page 37**.

A code is used to identify the sealing lip material of SKF seals (→ **table 1** on **page 32**). The code also appears in the designations of metric radial shaft seals. For seals manufactured from a combination of materials, a combination of code letters is used, like RD (nitrile rubber and SKF Duralip).

Nitrile rubber (R)

The term nitrile rubber is used in this publication for acrylonitrile-butadiene rubber (NBR). This material has very good engineering properties and is a general-purpose sealing lip material. It is a copolymer manufactured from acrylonitrile and butadiene that provides good resistance to the following media:

- Most mineral oils and greases with a mineral oil base
- Normal fuels like gasoline, diesel and light heating oils
- Animal and vegetable oils, fats and hot water

Nitrile rubber also tolerates short-term dry running of the sealing lip. The permissible operating temperature range of nitrile rubber is –40 to +100 °C *(–40 to +210 °F)*. For brief periods, temperatures of up to 120 °C *(250 °F)* can be tolerated.

SKF also offers a special nitrile rubber compound with a temperature range between –55 and +110 °C *(–65 and +230 °F)*.

SKF Duralip (D)

SKF Duralip is a carboxylated nitrile rubber (XNBR) developed by SKF that combines the good technical properties of nitrile rubber with an increased resistance to wear (→ **diagram 2** on **page 34**). It is mainly used for seals for heavy industrial applications. Seals made of this material should be chosen when abrasive contaminants like sand, soil and scale could reach the seal counterface on the shaft.

SKF Duratemp (H)

SKF Duratemp is a hydrogenated nitrile rubber (HNBR) developed by SKF that combines the wear resistance of SKF Duralip with increased high-temperature resistance (→ **diagram 3** on **page 35**). SKF Duratemp is also more resistant to chemical attack, weather, ageing and ozone. However, mixtures of oil in air may have a negative effect. The upper operating temperature limit is 150 °C *(300 °F)*, which is significantly higher than that of ordinary nitrile rubber. SKF Duratemp is mainly used for seals for heavy industrial applications or where extended service life is required.

Table 1

SKF sealing lip materials

Composition of basic material	**Designation according to** SKF	ISO 1629 ISO 1043-1 DIN 7728 Part 1	ASTM[1] D1418 ASTM D1600
Acrylonitrile-butadiene rubber (nitrile rubber)	R, RG	NBR	NBR
Hydrogenated acrylonitrile-butadiene rubber (SKF Duratemp)	H	HNBR	HNBR
Carboxylated nitrile rubber (SKF Duralip)	D	XNBR	XNBR
Polyacrylate elastomer	P	ACM	ACM
Silicone rubber	S	MVQ	VMQ
Fluoro rubber (SKF Duralife[2])	V	FPM	FKM
Polytetrafluoroethylene	T	PTFE	PTFE

1) American Society for Testing and Materials
2) Previously named *LongLife*

SKF Duralife[1] (V)

The fluoro rubber (FPM) compound, SKF Duralife, has been developed by SKF and is characterized by its very good wear, thermal and chemical resistance. Its resistance to weather and ageing from UV light and ozone is also very good and its gas permeability is very slight.

SKF Duralife has exceptional properties even under harsh environmental conditions and can withstand operating temperatures ranging from –20 to +200 °C (*–5 to +390 °F*). In applications with low dynamic runout, the temperature range can be extended down to –40 °C (*–40 °F*). SKF also offers special low-temperature fluoro rubber compounds on request.

SKF Duralife is also resistant to oils and hydraulic fluids, fuels and lubricants, mineral acids and aliphatics as well as aromatic hydrocarbons that would cause many other seal materials to fail. Seals made of SKF Duralife can also tolerate dry running of the lip for short periods. The seals should not be used in the presence of esters, ethers, ketones, certain amines and hot anhydrous hydrofluorides. Because of the compound's valuable properties, SKF manufactures seals with sealing lips made of SKF Duralife for all common shaft diameters.

Polytetrafluoroethylene (PTFE)

PTFE is a thermoplastic polymer that is compatible with a wide assortment of lubricants and features chemical resistance that is far superior to that of any other sealing lip material. PTFE has a smooth, dirt-resistant surface. Seals with PTFE lips can accommodate high surface speeds while offering extended service life. The seals can tolerate dry running and are particularly valuable in highly contaminated applications because of their excellent exclusion ability. PTFE is used for auxiliary sealing elements or for primary sealing lips for special applications. For optimum performance, PTFE sealing elements require a high-quality sealing counterface and extra care during installation. The normal operating temperature range extends from –70 to +200 °C (*–90 to +390 °F*), but may go up to 250 °C (*480 °F*).

Polyacrylate elastomer

Polyacrylate elastomers are more heat resistant than nitrile rubber or SKF Duralip. The operating temperature range for polyacrylate elastomers lies between –40 and +150 °C (*–40 and +300 °F*) and in some fluids the upper limit may be extended to 175 °C (*345 °F*). Seals of polyacrylate are resistant to ageing and ozone and are also suitable for use with lubricants containing EP additives. They should not be used to seal water, acids or alkalis etc. Dry running should be avoided.

Silicone rubber

Silicone rubber is characterized by high thermal resistance and can withstand temperatures ranging from –60 to +200 °C (*–76 to +390 °F*). Silicone rubber absorbs lubricants, thereby minimizing friction and wear. SKF silicone rubber seals are particularly suitable for applications with very low or very high temperatures and for low-friction sealing of bearing arrangements. They are not very resistant to oxidized oils or certain EP additives and should be protected against abrasive substances. Sealing lips made of silicone rubber should not be exposed to dry running.

[1] Previously named *LongLife*

⚠ WARNING

At temperatures above 300 °C (*570 °F*), all fluoro elastomers and PTFE compounds give off dangerous fumes. This can occur, for example, if a welding torch is used when removing a bearing.

Although the fumes are only produced at such high temperatures, once heated, the seals will be dangerous to handle even when they have cooled down. If it is necessary to handle PTFE or fluoro elastomer seals that have been subjected to the high temperatures mentioned above, the following safety precautions should be observed:

- Protective goggles and gloves should always be worn.
- The remains of seals should be put in an airtight plastic container marked “Material will etch”.
- Comply with the safety precautions included in the material safety data that can be provided upon request.

If there is contact with your skin, this should be washed with soap and plenty of water. Wash your eyes with plenty of water if these materials get into your eyes. A doctor should always be consulted. This also applies if the fumes have been inhaled.

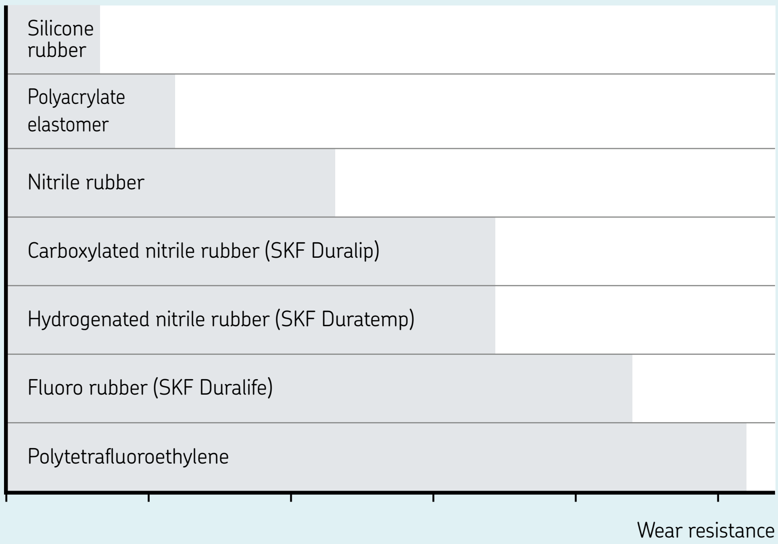
Wear resistance

The wear resistance of a seal depends largely on the sealing lip material, as well as on the shaft surface finish, type of lubricant, circumferential speed, temperature and pressure differentials.

A comparison of wear resistance for various sealing lip materials used by SKF is provided in **diagram 2**. It is valid for seals of the same size, operating under identical conditions.

Diagram 2

Wear resistance for various sealing lip material



Operating temperatures

Both low and high temperatures influence the sealing performance. At low temperatures, the sealing lip loses its elasticity and becomes hard and brittle. Sealing efficiency decreases and the seal becomes more susceptible to mechanical damage.

For applications where temperatures are continuously high, special high-temperature lip materials should be used, for example, PTFE or the SKF fluoro rubber material, compounds like SKF Duralife.

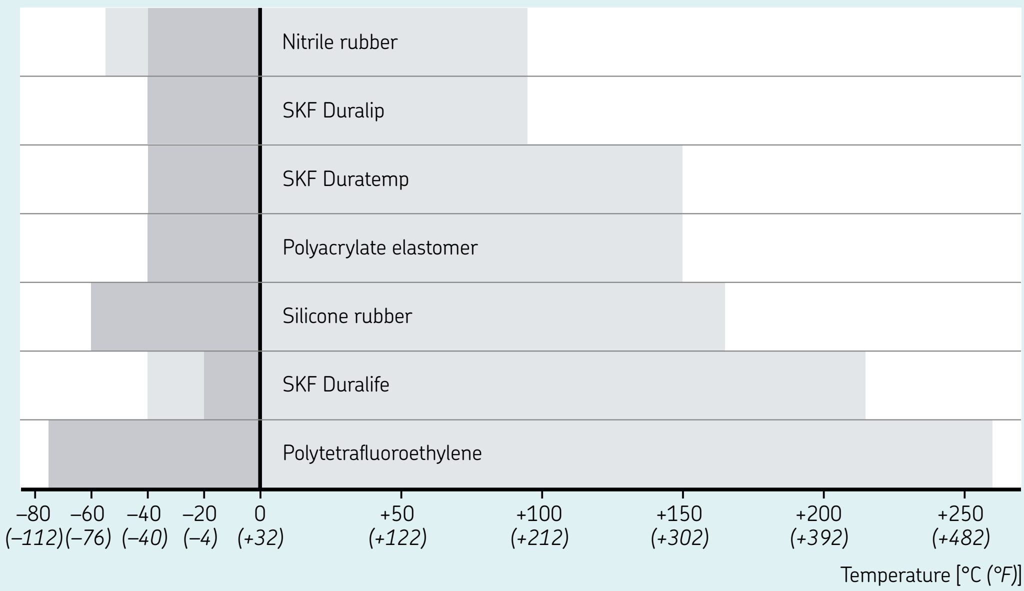
Friction, circumferential speed, viscosity of the medium being sealed as well as the specific heat transfer along the shaft influence the temperature at the sealing position and the temperature between the lip and lubricant film on the counterface. High temperatures generally lead to a breakdown of the lubricant film, resulting in insufficient lubrication, one of the most common causes of premature seal failure.

The static sealing ability between the outside diameter of the seal and the housing bore may also be affected if these components are made of different materials with significantly different coefficients of expansion and shrinkage.

Refer to **diagram 3** to view the permissible operating temperature ranges of sealing lip materials normally used by SKF.

Diagram 3

Permissible operating temperatures



Chemical resistance

In **table 2**, *Chemical resistance* (→ **pages 37** to **46**), information is provided regarding the resistance of SKF sealing lip materials to most of the substances encountered in industrial applications. The information is based on in-house testing and the experience of users, as well as information from the suppliers of the various materials. Unless otherwise stated, the information is valid for media of commercial purity and quality.

The chemical resistance of a seal is influenced by temperature, pressure and the amount of media present. Other important factors to consider when selecting a suitable sealing lip material include:

- Type of service (static or dynamic)
- Circumferential speed of the sealing lip
- Shaft and housing materials
- Surface finish of the seal counterface

Because the above mentioned factors also influence the service life and performance of the seal, the information contained in the table *Chemical resistance* can only be considered as a rough guide.

Explanation for table 2 (→ pages 37 to **46), *Chemical resistance***

RT = room temperature [*20 °C (70 °F)*]
1 = minor effect
2 = moderate effect
3 = static only
4 = not recommended
5 = insufficient data, test before use

Table 2

Chemical resistance

Medium	Temperature	Medium's effect on sealing lip material			
		R, D, H	V	P	S
–	°C (*°F*)	–	–	–	–
A					
Acetaldehycle	RT	4	4	4	2
Acetamide	RT	1	2	4	2
Acetic acid,100% (glacial)	60 (*140*)	3	3	4	2
Acetic acid, 30%	RT	2	2	4	1
Acetic acid, 3% (vinegar)	RT	2	1	4	1
Acetic anhydride	RT / 80 (*175*)	3	4	4	3
Acetone	RT	4	4	4	3
Acetophenone	RT	4	4	4	4
Acetylene	60 (*140*)	1	1	5	2
Acrylonitrile	RT / 60 (*140*)	4	3	4	4
Adipic acid (aq)	RT	1	1	5	5
Alum (aq)	100 (*210*)	1	1	4	1
Aluminium acetate (aq)	RT	2	4	4	4
Aluminium chloride (aq)	RT	1	1	1	2
Aluminium fluoride (aq)	RT	1	1	5	2
Aluminium nitrate (aq)	RT	1	1	5	2
Aluminium phosphate (aq)	RT	1	1	5	1
Aluminium sulphate (aq)	RT / 60 (*140*)	1	1	4	1
Ammonia (anhydrous)	RT	2	4	4	3
Ammonia gas	RT	1	4	4	2
Ammonia gas	*80 (175)* / 100 (*210*)	4	4	4	1
Ammonium carbonate (aq)	RT / 60 (*140*)	2	5	4	5
Ammonium chloride (aq)	RT / 60 (*140*)	1	1	5	5
Ammonium chloride (dry) (sal ammoniac)	RT	1	1	1	2
Ammonium nitrate (aq)	RT	1	5	2	5
Ammonium persulphate (aq)	RT	4	5	4	5
Ammonium phosphate (aq)	RT / 60 (*140*)	1	5	5	1
Ammonium sulphate (aq)	100 (*210*)	1	4	4	5
Amyl acetate	RT	4	4	4	4
Amyl alcohol	60 (*140*)	2	2	4	4
Aniline	60 (*140*) / 100 (*210*)	4	3	4	4
Aniline dyes	RT	4	2	4	3
Aniline hydrochloride	RT	2	2	4	4
Aniline hydrochloride	100 (*210*)	4	5	5	5
Animal fats	80 (*175*)	1	1	1	2
Aqua Regia	RT	4	5	4	4
Arsenic acid	RT / 60 (*140*)	1	1	3	1
Arsenic trichloride (aq)	RT	1	5	5	5
Asphalt (liquid)	100 (*210*)	2	2	4	4
B					
Barium chloride (aq)	RT / 60 (*140*)	1	1	1	1
Barium hydroxide (aq)	RT / 60 (*140*)	1	1	4	1
Barium sulphate	RT / 60 (*140*)	1	1	4	1
Barium sulphide (aq)	RT / 60 (*140*)	1	1	4	1
Beer	RT	1	1	4	1
Benzaldehyde	RT / 60 (*140*)	4	4	4	4
Benzene	RT	4	1	4	4
Benzene sulphonic acid	RT	4	1	4	4
Benzoic acid	RT / 60 (*140*)	4	1	4	4
Benzoyl chloride	RT	4	1	4	5
Benzyl alcohol	RT / 60 (*140*)	4	1	1	2
Benzyl benzoate	50 (*120*) / 60 (*140*)	4	1	4	5
Benzyl chloride	RT	4	1	4	4

Product data – general

con. table 2

Chemical resistance

Medium	Temperature	Medium's effect on sealing lip material			
		R, D, H	V	P	S
–	°C (°F)	–	–	–	–
Blast furnace gas	100 *(210)*	4	1	4	1
Borax (aq)	RT / 60 *(140)*	2	1	5	2
Bordeaux mixture	RT	2	1	4	2
Boric acid	60 *(140)* / 100 *(210)*	1	1	4	1
Brake fluid, ATE	80 *(175)*	4	4	4	1
Brake fluid, glycolether	80 *(175)*	4	5	4	1
Brine (sodiumchloride, aq)	RT / 50 *(120)*	1	1	4	1
Bromine, anhydrous (liquid / gaseous)	RT / 50 *(420)*	4	1	4	4
Bromine trifluoride	RT	4	4	4	4
Bromine water	RT	4	1	4	4
Bromo benzene	RT	4	1	4	4
Bunker oil	60 *(140)*	1	1	1	2
Butadiene (gaseous or liquified)	RT	4	1	4	4
Butane (gaseous or liquified)	RT	1	1	1	4
Butter (animal fat)	RT / 80 *(175)*	1	1	1	2
Butyl acetate	RT	4	4	4	4
Butyl acrylate	RT	4	4	4	5
Butyl alcohol	RT	2	1	4	2
Butyl amines	RT	3	4	4	4
Butylene	RT	2	1	4	4
Butyl stearate	50 *(120)*	2	1	5	5
Butyr aldehyde	RT	4	4	4	4
C					
Calcium acetate (aq)	RT	2	4	4	4
Calcium bisulphite (aq)	RT	1	1	4	1
Calcium chloride (aq)	60 *(140)*	1	1	1	1
Calcium hydroxide (aq)	RT	1	1	4	1
Calcium hypochlorite (aq)	RT / 60 *(140)*	2	1	4	2
Calcium nitrate (aq)	RT / 40 *(105)*	1	1	1	2
Cane sugar liquors	RT / 60 *(140)*	1	1	4	1
Carbon dioxide	RT	1	1	5	2
Carbon disulphide	RT	3	1	3	4
Carbonic acid	RT	2	1	1	1
Carbon monoxide	*60 (140)*	1	1	5	1
Carbon tetrachloride	RT / 60 *(140)*	3	1	4	4
Castor oil	RT	1	1	1	1
Cellosolve (ethyl glycol)	RT	4	3	4	4
Cellosolve acetate (ethyl glycol acetate)	RT	4	4	4	4
Chlorine (dry)	RT	4	1	4	4
Chlorine (wet)	RT	4	1	4	4
Chlorine dioxide	RT	4	1	4	5
Chlorine trifluoride	RT	4	4	4	4
Chloroacetic acid	60 *(140)*	4	4	4	5
Chloroacetone	RT	4	4	4	4
Chlorobenzene	RT	4	1	4	4
Chlorobromomethane	RT	4	1	4	4
Chlorobutadiene	RT	4	1	4	4
Chloroform	RT	4	1	4	4
Chlorosulphonic acid	RT	4	4	4	4
Chlorotoluene	RT	4	1	4	4
Chromic acid	60 *(140)*	4	1	4	3
Citric acid	60 *(140)* / 70 *(160)*	1	1	1	1
Cobalt chloride (aq)	RT	1	1	4	2
Coconut oil	50 *(120)* / 70 *(160)*	1	1	1	1

con. table 2

Chemical resistance

Medium	Temperature	Medium's effect on sealing lip material			
		R, D, H	V	P	S
–	°C (*°F*)	–	–	–	–
Cod liver oil	RT	1	1	1	2
Coke oven gas	80 (*175*)	4	1	4	2
Copper acetate (aq)	RT	2	4	4	4
Copper chloride (aq)	RT	1	1	1	1
Copper sulphate (aq)	60 (*140*)	1	1	4	1
Corn oil	RT / 60 (*140*)	1	1	1	1
Cottonseed oil	RT / 70 (*160*)	1	1	1	1
Cresol	50 (*120*) / 70 (*160*)	4	1	4	4
Cumene (isopropylbenzene)	RT	4	1	4	4
Cyclohexane	RT	1	1	1	4
Cyciohexanol	RT	3	1	5	4
Cyclohexanone	RT	4	4	4	4
p-Cymene	RT	4	1	4	4
D					
Decahydronaphthalene (decalin)	RT / 60 (*140*)	4	1	5	4
Detergent	RT	1	1	4	1
Developing fluids (photography)	RT	1	1	5	1
Diacetone alcohol	RT	4	4	4	2
Dibenzyl ether	RT	4	4	5	5
Dibutyl amine	RT	4	4	4	3
Dibutyl ether	RT	4	3	3	4
Dibutyl phthalate	RT / 60 (*140*)	4	3	4	2
Dibutyl sebacate	RT / 60 (*140*)	4	2	4	2
o-Dichlorobenzene	RT	4	1	4	4
Dicyclohexylamine	RT	3	4	4	5
Diethyl amine	RT	2	4	4	2
Diethyl benzene	RT	4	1	5	4
Diethyl ether	RT	4	4	3	4
Diethyl sebacate	RT	2	2	4	2
Diisopropyl benzene	RT	4	1	5	5
Dimethyl aniline (Xylidine)	RT	3	4	4	4
Dimethyl ether	RT	1	2	4	1
Dimethyl formamide	RT / 60 (*140*)	2	4	4	2
Dimethyl phthalate	RT	4	2	4	5
Dioctyl phthalate	RT / 60 (*140*)	3	2	4	3
Dioctyl sebacate	RT / 60 (*140*)	4	2	4	3
Dioxane	RT / 60 (*140*)	4	4	4	4
Dioxolane	RT	4	4	4	4
Dipentene	RT	2	1	4	4
Diphenyl oxide	RT	4	1	4	3
Dowtherm oils	100 (*210*)	4	1	4	3
Dry cleaning fluids	40 (*105*)	3	1	4	4
E					
Epichlorohydrin	RT	4	4	4	4
Ethane	RT	1	1	1	4
Ethanol (denatured alcohol)	RT	1	1	4	1
Ethanolamine (monoethanolamine)	RT	2	4	4	2
Ethanolamine (di-andtriethanolamine)	50 (*120*)	5	50	-120	5
Ethyl acetate	RT	4	4	4	2
Ethyl acrylate	RT	4	4	4	2
Ethyl benzene	RT	4	1	4	4
Ethyl benzoate	RT	4	1	4	4
Ethyl chloride	RT	1	1	4	4

Product data – general

con. table 2

Chemical resistance

Medium	Temperature	Medium's effect on sealing lip material			
		R, D, H	V	P	S
–	°C *(°F)*	–	–	–	–
Ethylene	RT	1	1	5	5
Ethylene chloride	RT	4	2	4	4
Ethylene chlorohydrin	RT	4	1	4	3
Ethylene diamine	RT	1	4	4	1
Ethylene glycol	RT	1	1	2	1 / 2
Ethylene glycol	100 *(210)*	1	1	3	1 / 2
Ethylene oxide	RT	4	4	4	4
Ethylene trichloride	RT	4	1	4	4
Ethyl ether	RT	3	4	4	4
Ethyl formate	RT	4	1	5	5
Ethyl glycol (Cellosolve)	RT	4	3	4	4
Ethyl glycol acetate (Cellosolve acetate)	RT	4	4	4	4
Ethyl silicate	RT	1	1	5	5
F					
Fatty acids	100 *(210)*	2	1	5	3
Ferric chloride (aq)	RT	1	1	1	2
Ferric nitrate (aq)	RT	1	1	1	3
Ferric sulphate (aq)	RT	1	1	1	2
Fish oil	RT	1	1	5	1
Fluorine (liquified)	RT	4	2	4	4
Fluorobenzene	RT	4	1	4	4
Fluorosilic acid	60 *(140)*	1	1	5	4
Formaldehyde	RT	3	1	4	2
Formaldehyde, 37%	below 100 *(210)*	2	1	4	2
Formic acid	RT / 60 *(140)*	2	3	5	2
Fuels					
– Aeroenginefuels JP:					
– JP3 (MIL-J-5624 G)	RT	1	1	2	4
– JP4 (MIL-J-5624 G)	RT	1	1	2	4
– JP5 (MIL-J-5624 G)	RT	1	1	2	4
– JP6 (MIL-F-25656 B)	RT / 60 *(140)*	1	1	5	4
– ASTM reference fuels:					
– ASTM-A (MIL-S-3136B Typ 1)	RT / 60 *(140)*	1	1	2	4
– ASTM-B (MIL-S-3136B Typ 111)	RT / 60 *(140)*	1	1	5	4
– ASTM-C	RT / 60 *(140)*	2	1	4	4
– Diesel fuel	60 *(140)*	1	1	2	2
– Fuel oil	60 *(140)*	1	1	1	4
– Gasohol (10% ethanol or methanol)	RT	2	3	4	4
– Kerosene	RT	1	1	1	4
– Mineral oil	100 *(210)*	1	1	1	2
– Petrol	RT	1	1	4	4
Fumaric acid	RT	1	1	4	2
Furan	RT	4	5	4	5
Furfural	RT	4	4	4	4
Furfuran	RT	4	5	4	5
G					
Gelatine (aq)	40 *(105)*	1	1	4	1
Glucose	RT	1	1	5	1
Glue	RT	1	1	5	1
Glycerin	100 *(210)*	1	1	3	1
Glycols	100 *(210)*	1	1	4	1 / 2

con. table 2

Chemical resistance

Medium	Temperature	Medium's effect on sealing lip material			
		R, D, H	V	P	S
–	°C (*°F*)	–	–	–	–
H					
n-Hexaldehyde	RT	4	4	5	2
Hexane	RT / 60 *(140)*	1	1	1	4
1-Hexene	RT	2	1	1	4
Hexyl alcohol	RT	1	1	4	2
Hydraulic fluids					
– Hydraulic oils (acc. to DIN 51524)	80 *(175)*	1	1	1	3
– Hydraulic fluids (acc. To DIN 51502)					
– HFA (oil in water emulsion)	55 *(130)*	1	1	5	5
– HFB (water in oil emulsion)	60 *(140)*	1	1	5	5
– HFC (aqueous Polymer solutions)	60 *(140)*	1	1	5	1
– HFD (phosphoric esters)	80 *(175)*	4	2 / 4	4	4
– Skydrol 500	80 *(175)*	4	4	4	3
– Skydrol 7000	80 *(175)*	4	2	4	3
Hydrazine	RT	2	4	5	3
Hydrobromic acid	RT / 60 *(140)*	4	1	4	4
Hydrochloric acid (conc.)	RT	3	1	4	3
Hydrochloric acid (conc.)	80 *(175)*	4	2	4	4
Hydrocyanic acid (Prussic acid)	RT	2	1	4	3
Hydrofluoric acid (conc.)	RT	4	1	4	4
Hydrofluoric acid (conc.)	100 *(210)*	4	3	4	4
Hydrofluoric acid (anhydrous)	100 *(210)*	4	4	4	4
Hydrogen gas	RT	1	1	2	3
Hydrogen peroxide (90%)	RT	4	2	4	2
Hydrogen sulphide (wet)	RT / 100 *(210)*	4	4	4	3
Hydroquinone	RT	4	2	4	5
Hypochlorous acid	RT	4	1	4	5
I					
Iodine pentafluoride	RT	4	4	4	4
Isobutyl alcohol	RT	2	1	4	1
Isooctane	RT	1	1	1	4
Isophorone	RT	4	4	4	4
Isopropyl acetate	RT / 80 *(175)*	4	4	4	4
Isopropyl alcohol	RT 60 *(140)*	2	1	4	1
Isopropyl chloride	RT	4	1	4	4
Isopropyl ether	RT / 60 *(140)*	2	4	3	4
L					
Lactic acid	RT	1	1	4	1
Lactic acid	100 *(210)*	4	1	4	2
Lard	80 *(175)*	1	1	1	2
Lavender oil	RT	2	1	2	4
Lead acetate (aq)	RT / 60 *(140)*	2	2	4	4
Lead nitrate (aq)	RT	1	5	5	2
Linoleic acid	RT	2	2	5	2
Linseed oil	*RT 60 (140)*	1	1	1	1
Lubricants					
– ASTM oil No.1	100 *(210)*	1	1	1	3
– ASTM oil No.2	100 *(210)*	1	1	1	3
– ASTM oil No.3	100 *(210)*	1	1	1	3
– ATF oils, type A	100 *(210)*	1	1	1	4
– ATF oils, type I	100 *(210)*	1	1	1	4
– ATF oils, type II	100 *(210)*	1	1	1	4
– ATF oils, type F	100 *(210)*	1	1	1	4

Product data – general

con. table 2

Chemical resistance

Medium	Temperature	Medium's effect on sealing lip material R, D, H	V	P	S
–	°C *(°F)*	–	–	–	–
– ATF oils, type Mercon	100 *(210)*	1	1	1	4
– EP lubes	100 *(210)*	2	1	1	4
– Fluorolube	100 *(210)*	1	2	5	1
– Grease MIL-G-7118A	80 *(175)*	1	1	3	3
– Grease MIL-G-7711A	80 *(175)*	1	1	1	3
– Lubricating oils (petroleum)	100 *(210)*	1	1	1	4
– Red oil (MIL-H-5606)	100 *(210)*	1	1	1	4
– RJ-1 (MIL-F-25558 B)	100 *(210)*	1	1	1	4
– RJ-1 (MIL-F-25576 C)	100 *(210)*	1	1	1	4
– Motor oil SAE 30	100 *(210)*	1	1	1	1
– Transmission oil SAE 90	100 *(210)*	1	1	1	4
– Transmission oil MIL-L-23699 A	100 *(210)*	1	1	3	3
– Silicone greases	120 *(250)*	1	1	1	3
– Silicone oils	120 *(250)*	1	1	1	3
– Transformer oil (Pyranol)	60 *(140)*	4	1	5	4
– Transformer oil	60 *(140)*	1	1	2	2
– Transmission fluid type A	RT	1	1	1	2
– Turbine oil	100 *(210)*	2	1	1	4
M					
Magnesium chloride (aq)	100 *(210)*	1	1	5	1
Magnesium hydroxide (aq)	100 *(210)*	2	1	4	5
Magnesium sulphate (aq)	100 *(210)*	1	1	4	1
Maleic acid	100 *(210)*	4	1	4	5
Maleic anhydride	*60 (140)*	4	4	4	5
Malic acid	RT	1	1	4	2
Mercury	RT / 60 *(140)*	1	1	5	5
Mercury chloride (aq)	RT / 60 *(140)*	1	1	5	5
Mesityl oxide	RT	4	4	4	4
Methane	RT	1	2	1	4
Methanol (methyl alcohol)	60 *(140)*	1	1	4	4
Methyl acetate	RT	4	4	4	4
Methyl acrylate	RT	4	4	4	4
Methyl aniline	RT	4	2	4	5
Methyl bromide	RT	2	1	3	5
Methyl cellosolve (methyl glycol)	RT	3	4	4	4
Methyl chloride	RT	4	2	4	4
Methyl cyclopentane	RT	4	2	4	4
Methylene chloride	RT	4	2	4	4
Methyl ethyl ketone	RT	4	4	4	4
Methyl formate	RT	4	5	5	5
Methyl glycol (Cellosolve)	RT	3	4	4	4
Methyl isobutyl ketone	RT	4	4	4	4
Methyl methacrylate	RT	4	4	4	4
Methyl salicylate	RT	4	5	5	5
Milk	RT	1	1	4	1
Mustard gas	RT	5	5	5	1
N					
Naphtha	RT	2	1	2	4
Naphthalene	60 *(140)*	4	1	5	4
Naphthalenic acid	RT	2	1	5	4
Natural gas	RT	1	1	2	1
Neat-s-foot oil	RT / 60 *(140)*	1	1	1	2
Nickel acetate (aq)	RT	2	4	4	4

con. table 2

Chemical resistance

Medium	Temperature	Medium's effect on sealing lip material			
		R, D, H	V	P	S
–	°C (*°F*)	–	–	–	–
Nickel chloride	RT	1	1	4	1
Nickel sulphate (aq)	RT / 60 (*140*)	1	1	4	1
Nitric acid (conc.)	RT	4	3	4	4
Nitric acid (fuming)	RT	4	4	4	4
Nitric acid (dilute)	RT	4	1	4	2
Nitrobenzene	*50 (120)*	4	2	4	4
Nitroethane	RT	4	4	4	4
Nitrogen	RT	1	1	1	1
Nitrogen tetroxide	RT	4	4	4	4
Nitromethane	RT	4	4	4	4
O					
Octadecane	RT / 50 (*120*)	1	1	2	4
n-Octane	RT	2	1	4	4
Octyl alcohol	RT	2	1	4	2
Oleic acid	70 (*160*)	1	2	2	4
Olive oil	60 (*140*)	1	1	1	3
Oxalic acid	70 (*160*)	2	1	5	4
Oxygen	RT	2	1	2	1
Oxygen	> 100 (*210*)	4	2	4	2
Ozone	RT	4	1	2	1
P					
Palmitic acid	60 (*140*)	1	1	4	4
Peanut oil	RT / 50 (*120*)	1	1	1	1
Perchloric acid	RT	4	1	4	4
Perchloroethylene	RT / 60 (*140*)	2	1	4	4
Petroleum	below 120 (*250*)	1	1	2	2
Petroleum	above 120 (*250*)	4	2	4	4
Petroleum ether	RT / 60 (*140*)	1	1	1	4
Petroleum gas (liquified)	RT	1	1	3	3
Phenol	60 (*140*) / 100 (*210*)	4	1	4	4
Phenyl ethyl ether	RT	4	4	4	4
Phenyl hydrazine	RT / 60 (*140*)	4	1	4	5
Phoron (diisopropylidene acetone)	60 (*140*)	4	4	4	4
Phosphoric acid, 20%	50 (*120*) / 60 (*140*)	2	1	5	2
Phosphoric acid, 45%	50 (*120*) / 60 (*140*)	4	1	5	3
Phosphorus trichloride	RT	4	1	5	5
Pickling solution	RT	4	2	4	4
Picric acid	RT	4	1	5	4
Pinene	RT	2	1	4	4
Pine oil	RT	4	1	5	4
Piperidine	RT	4	4	4	4
Potassium acetate (aq)	RT	2	4	4	4
Potassium chloride (aq)	RT / 60 (*140*)	1	1	1	1
Potassium cyanide (aq)	RT / 50 (*120*)	1	1	1	1
Potassium dichromate (aq)	RT	1	1	1	1
Potassium hydroxide (aq)	60 (*140*)	2	4	4	4
Potassium nitrate (aq)	RT / 60 (*140*)	1	1	1	1
Potassium sulfate (aq)	RT / 60 (*140*)	1	1	4	1
Propane	RT	1	1	1	4
Propyl acetate	RT	4	4	4	4
Propyl alcohol	RT / 60 (*140*)	1	1	4	1
Propylene	RT	4	1	4	4
Propylene oxide	RT	4	4	4	4

Product data – general

con. table 2

Chemical resistance

Medium	Temperature	Medium's effect on sealing lip material			
		R, D, H	V	P	S
–	°C (*°F*)	–	–	–	–
Prussic acid (hydrocyanic acid)	RT	2	1	4	3
Pyridine	RT	4	4	4	4
Pyroligneous acid	RT	4	4	4	5
Pyrrole	RT	4	4	4	2
R					
Rapeseed oil	RT	2	1	2	4
Refrigerants (acc.to DIN 8962)	RT	2	1	5	4
– R 11	RT	2	1	5	4
– R 12	RT	1	2	1	4
– R 13	RT	1	1	5	4
– R 13 B1	RT	1	1	5	4
– R 14	RT	1	1	5	4
– R 21	RT	4	4	5	4
– R 22	RT	4	4	2	4
– R 31	RT	4	4	5	5
– R 32	RT	1	4	5	5
– R 112	RT	3	1	5	4
– R 113	RT	1	2	5	4
– R 114	RT	1	2	5	4
– R 114 B	RT	2	2	5	4
– R 115	RT	1	2	5	5
– R C 318	RT	1	2	5	5
S					
Salicylic acid	RT	2	1	5	5
Sea water	RT	1	1	4	1
Silver nitrate (aq)	RT	2	1	1	1
Soap solution	RT	1	1	4	1
Sodium acetate (aq)	RT	2	4	4	4
Sodium bicarbonate (aq)	60 (*140*)	1	1	5	1
Sodium bisulphite (aq)	*100 (210)*	1	1	4	1
Sodium carbonate (soda)	RT / 60 (*140*)	1	1	5	1
Sodium chloride (aq)	RT / 100 (*210*)	1	1	5	1
Sodium cyanide (aq)	RT	1	1	5	1
Sodium hydroxide (aq)	RT	2	2	3	2
Sodium hypochlorite (aq)	RT / 50 (*120*)	2	1	4	5
Sodium metaphosphate	RT / 60 (*140*)	1	1	5	2
Sodium nitrate (aq)	RT / 60 (*140*)	2	5	5	4
Sodium phosphate (aq)	RT / 60 (*140*)	1	1	4	4
Sodium silicate (aq)	RT / 60 (*140*)	1	1	5	5
Sodium sulphate (aq) (Glauber's salt)	RT / 60 (*140*)	1	1	4	1
Sodium thiosulphate (aq)	RT / 50 (*120*)	2	1	4	1
Soyabean oil	RT	1	1	1	1
Stannic chloride (aq)	RT / 80 (*175*)	1	1	5	2
Stannous chloride (aq)	RT / 80 (*175*)	1	1	5	2
Steam	below 150 (*300*)	4	4	4	3
Steam	above 150 (*300*)	4	4	4	4
Stearic acid	60 (*140*)	2	2	4	2
Stoddard solvent	RT	1	1	1	4
Styrene	RT	4	2	4	4
Sucrose solution	RT / 60 (*140*)	1	1	4	1
Sulphur	RT / 60 (*140*)	4	1	4	3
Sulphur chloride (aq)	RT	3	1	4	3
Sulphur dioxide (dry)	RT / 60 (*140*)	4	1	4	2

con. table 2

Chemical resistance

Medium	Temperature	Medium's effect on sealing lip material			
		R, D, H	V	P	S
–	°C (*°F*)	–	–	–	–
Sulphur dioxide (liquified)	RT / 60 (*140*)	4	1	4	2
Sulphur dioxide (wet)	RT / 60 (*140*)	4	1	4	2
Sulphur hexafluoride	RT	2	1	4	2
Sulphuric acid (conc.)	RT / 50 (*120*)	4	1	4	4
Sulphuric acid (20%) (battery acid)	60 (*140*)	4	1	4	4
Sulphuric acid (dilute)	RT	3	1	2	4
Sulphurous acid	RT / 60 (*140*)	4	1	4	4
Sulphur trioxide	RT	4	1	4	2
T					
Tannic acid	RT / 60 (*140*)	1	1	4	2
Tar,bituminous	RT	2	1	4	2
Tartaric acid	60 (*140*)	1	1	5	1
Tepineol	RT	2	1	5	5
Tetrabromoethane	RT	4	1	4	4
Tetrabromomethane	RT	4	1	5	4
Tetrabutyl titanate	RT	2	1	5	5
Tetrachloroethylene	60 (*140*)	4	2	4	4
Tetraethyl lead	RT	2	1	5	5
Tetrahydrofuran	RT	4	4	4	4
Tetrahydronaphthalene (Tetralin)	RT	4	1	5	4
Thionyl chloride	RT	4	2	4	5
Titanium tetrachloride	RT	2	1	4	4
Toluene	RT	4	1	4	4
Toluene diisocyanate	RT	4	4	4	4
Triacetin	RT	2	1	4	5
Tributoxy ethyl phosphate	RT	4	1	4	5
Tributyl phosphate	RT / 60 (*140*)	4	4	4	4
Trichloroacetic acid	60 (*140*)	5	4	4	4
Trichloroethane	RT	4	1	4	4
Trichloroethylene	RT	4	1	4	4
Tricresyl phosphate	RT / 60 (*140*)	4	1	4	3
Triethanol amine	RT	2	4	4	5
Triethyl aluminium	RT	4	2	4	5
Triethyl borane	RT	4	1	4	5
Trinitrotoluene	RT	4	2	4	5
Trioctyl phosphate	RT / 60 (*140*)	4	2	4	3
Tung oil (China wood oil)	RT	1	1	1	4
Turpentine	RT	1	1	2	4
V					
Varnish	RT	2	1	4	4
Vegetable oil	60 (*140*)	1	1	1	2
Vinyl acetylene	RT	1	1	5	2
Vinyl chloride	RT	4	1	5	5
W					
Water	100 (*210*)	1	1	4	1
Whisky	RT	1	1	4	1
White oil	RT / 80 (*175*)	1	1	1	4
Wine	RT	1	1	4	1
Wood oil	RT	1	1	1	4

con. table 2

Chemical resistance

Medium	Temperature	Medium's effect on sealing lip material			
		R, D, H	V	P	S
–	°C (°F)	–	–	–	–
X					
Xylene	RT	4	1	4	4
Xylidine (di-methyl aniline)	RT	3	4	4	4
Z					
Zeolites	RT	1	1	5	5
Zinc acetate (aq)	RT	1	1	4	4
Zinc chloride (aq)	RT	1	1	4	1
Zinc sulphate (aq)	RT	1	1	4	1

Storage and handling of seals

General

The following guidelines for the storage and cleaning of seals are valid for natural and synthetic elastomeric materials and are in accordance with ISO 2230 and DIN 7716 standards. The storage guidelines set forth in DIN 7716 are valid for long-term storage.

Unfavourable storage conditions and improper handling can change the physical properties of most products made from natural or synthetic rubber. This can result in hardening or softening, permanent deformation, peeling or cracks, which can lead to a shortened service life or render the products altogether useless. These changes can be brought about by storing the products under stress or load or from the influence of oxygen, ozone, heat, light, moisture or solvents. When stored properly, elastomer products generally retain their properties for several years.

Storage

The storage area should be cool, dry, moderately ventilated and there should be as little dust as possible. Outdoor storage without protection should be avoided.

The appropriate storage temperature depends on the elastomer. The most favourable storage temperature for synthetic rubber seals is 15 to 25 °C *(60 to 80 °F)*.

Elastomers that have been subjected to low temperatures during transport or storage may become stiff. They should therefore be warmed and kept at a temperature of at least 20 °C *(70 °F)* before being unpacked and used in order to prevent exposure to condensation.

In heated storage rooms, the products should be shielded from the heat source. There should be at least 1 m *(3 ft.)* between the packages and the source of heat. In rooms where a heater with a fan is used, the distance should be greater. Storage in damp rooms should be avoided because of the risk of condensation. A storage facility with relative humidity below 65% is excellent.

Seals should be protected from light, particularly direct sunlight or artificial light with a high proportion of UV radiation. Any windows in the store should therefore be covered with a red or orange coating (never blue). Ordinary light bulbs are preferred for illumination.

Seals should be wrapped or stored in airtight containers, protecting them from atmospheric changes and particularly against drafts.

Because ozone is particularly damaging, steps must be taken to make sure that no ozone is produced in the storage facility as the result of using electric motors or other equipment that can produce sparks or other electric discharges. Combustion fumes and vapours that can produce ozone as the result of photochemical processes should be exhausted. For this reason, solvents, fuels, lubricants, chemicals, acids, disinfectants etc. should not be stored in the same room as the seals.

Elastomer products should not be subjected to tension, compression or other forms of load during storage as this can produce permanent deformations and cracks. Seals should therefore not be hung on hooks during storage. Certain metals, especially copper and manganese, damage elastomer products. Contact with these metals should therefore be avoided and the seals should be covered with layers of paper or polyethylene to prevent such contact.

In case it is necessary to repack the seals, packaging and covering materials should not contain substances such as copper or alloys containing copper, petroleum, oil etc. that can cause damage to the seals. The packaging materials should not contain softeners.

If the products are powdered, suitable powders are talcum, chalk, finely divided glimmer and rice starch.

Seals made of different materials should not be in contact with each other. This is particularly important when the seals are different in colour as this will avoid discolouration.

Seals should be stored for the shortest period of time possible. Where long-term storage is involved, care should be taken that newly arrived products are kept separate from those already in storage to enable use of seals on a first in, first out basis.

Cleaning and maintenance

In the event that cleaning is necessary, elastomers should be cleaned with warm, soapy water that does not exceed 30 °C *(85 °F)*, and air dried at room temperature.

Solvents such as trichloroethylene, carbon tetrachloride or hydrocarbons should not be used, nor should sharp-edged objects, wire brushes, emery cloth or sandpaper.

Elastomer / metal combinations can be cleaned using a 1:10 mixture of glycerine and alcohol.

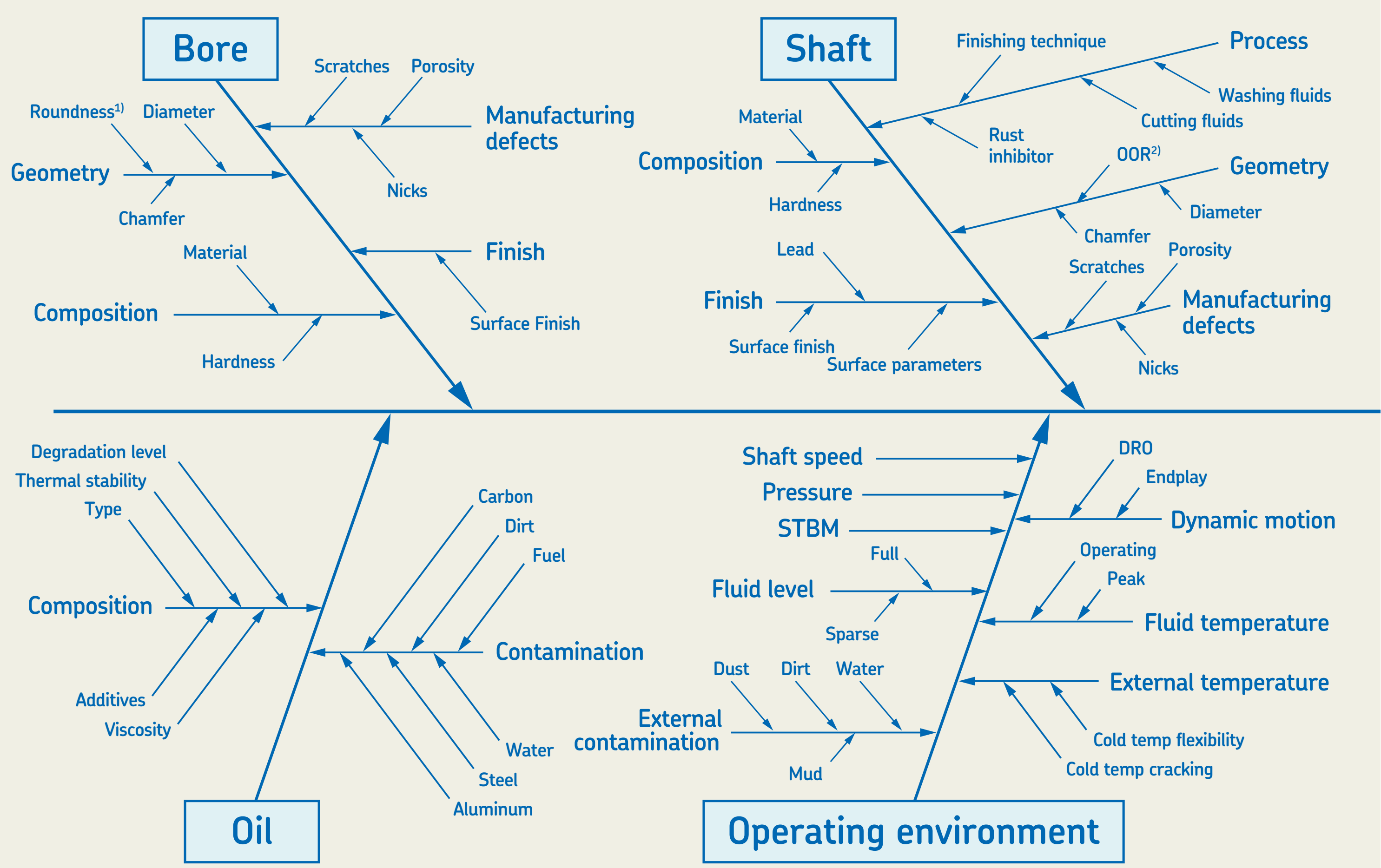
Seal failure analysis

Leaking seals are not inevitable

Attitudes about seal performance are influenced by industry expectations and personal habits. But no matter where you are on the spectrum between vigilance and indifference, understand that there is always a better way. After all, the definition of insanity is doing the same thing and expecting a different result.

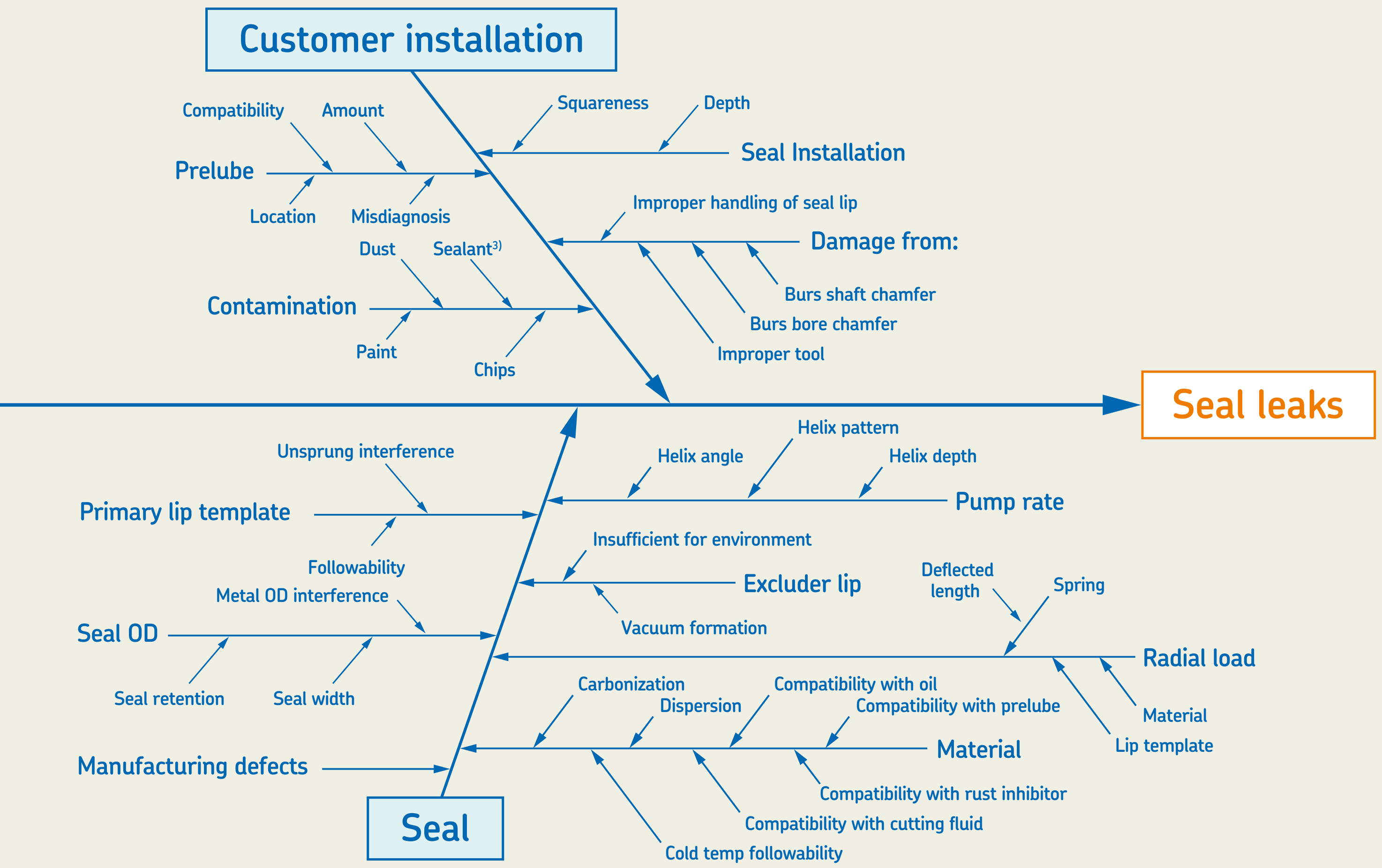
Consider the fishbone

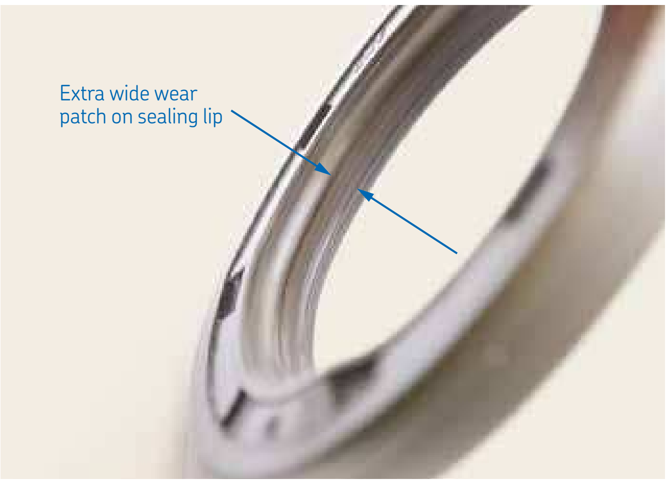
A leaking seal means a defective seal that must be replaced right? As the fishbone diagram below shows, there are several potential causes of a leaking seal, and only one of the six categories involves a problem with the actual seal. SKF is committed to helping you identify the root causes of failure and find a better way. Contact your local SKF application engineer for help with troubleshooting.



1) ODR – Outside Diameter Roundness
2) OOR – Out Of Round
3) RTV – Type of sealant: Room Temperature Vulcanization silicon sealant

SKF


Customer installation
Compatibility
Amount
Squareness
Depth
Seal Installation
Prelube
Location
Misdiagnosis
Improper handling of seal lip
Damage from:
Dust
Sealant3)
Contamination
Burs shaft chamfer
Burs bore chamfer
Improper tool
Paint
Chips
Seal leaks
Unsprung interference
Helix pattern
Helix angle
Helix depth
Primary lip template
Pump rate
Followability
Insufficient for environment
Metal OD interference
Excluder lip
Deflected length
Spring
Seal OD
Vacuum formation
Radial load
Seal retention
Seal width
Carbonization
Dispersion
Compatibility with oil
Compatibility with prelube
Material
Lip template
Manufacturing defects
Material
Compatibility with rust inhibitor
Compatibility with cutting fluid
Cold temp followability
Seal



Excessive wear

Possible root causes

- Elevated internal operating pressure
- External contaminant ingress
- Excessive radial load or interference
- Lack of adequate lubrication
- Internal contaminant ingress
- Incorrect material selected for the application
- Seal reached normal end of life
- Shaft running surface too rough

Potential solutions

- Remove contamination
- Switch to high wear sealing material or increase lubrication at lip interface
- Follow RMA / ISO standards for surface finish
- Reduce radial load

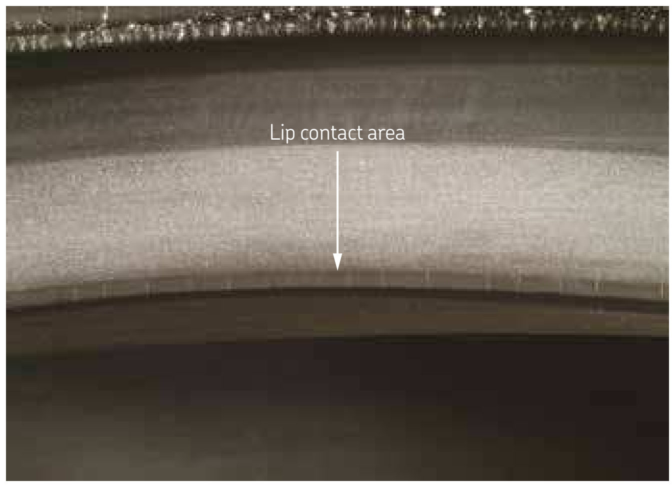
Nicks, scratches, or cuts in lip contact area

Possible root causes

- Installation tool or bullet with sharp edge
- Seal installed over defects in shaft
- Seal installed over shaft through hole, keyway, or splines
- Inconsistent manufacturing trimming operation
- Damage caused during packaging or handling

Potential solutions

- Protect lip by covering splines, keyways and holes with chamfered sleeve or tape
- Keep screwdrivers and other sharp tools away from sealing lip
- Regularly inspect sealing lips before installation



Crosslink carbonization

Possible root causes

- Chemical bond occurs between amines in oil additives and fluorine in FKM compounds
- Penetrates the elastomer and hardens until cracks form
- Generally requires temperatures of 100 °C (*210 °F*) or higher

Potential solutions

- Switch material to HNBR if under-lip temperatures are below 95 °C (*203 °F*)
- Switch material to base-resistant FKM for higher temperatures
- Reduce interference or increase lubrication to decrease under-lip temperature

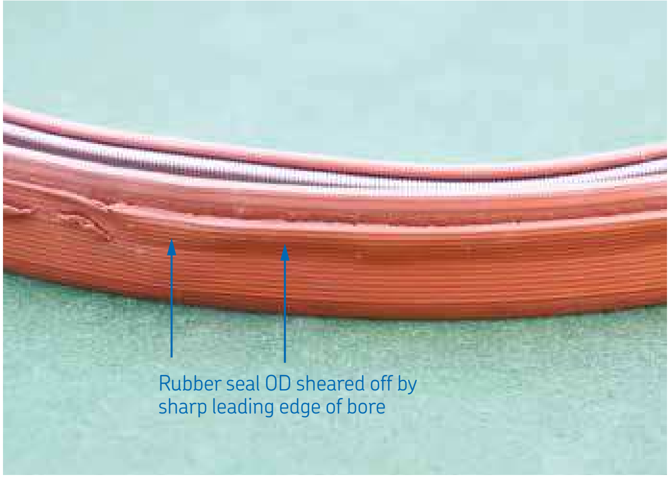
Axial cracking on NBR lip contact area

Possible root causes

- Elevated internal operating pressure
- High shaft speed
- Fluid compatibility
- Excessive under-lip temperature
- Insufficient lubrication at the lip interface

Potential solutions

- Change material to HNBR or FKM
- Increase lubrication
- Reduce radial interference



Inverted sealing lip

Possible root causes

- Poor assembly procedures
- High internal operating pressure

Potential solutions

- Switch to HDS7 springless design, HDS2 garter spring design with spring-cover, or HSS5
- Modify installation tool and / or procedure
- If failure is pressure-induced, use pressure seal

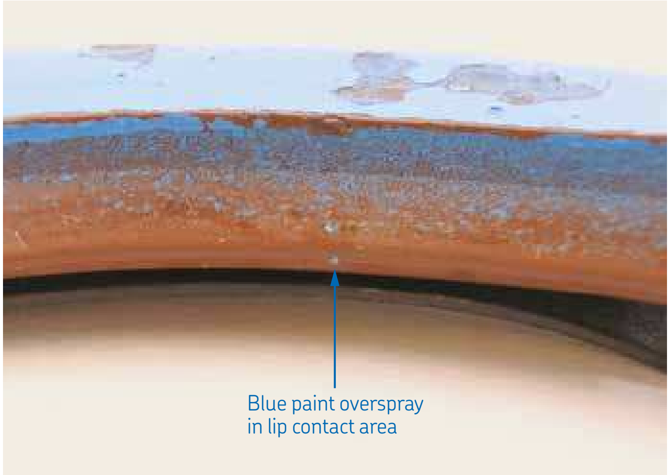
Seal damaged during installation

Possible root causes

- Improper or worn installation tool
- Direct contact with hammer on seal
- Inadequate lead in chamfer on the bore
- Undersized bore

Potential solutions

- Add proper bore chamfer per recommendations and check bore diameter
- Use installation tool designed for the specific installation procedure
- Reevaluate installation procedure



Irregular / damaged shaft surface finish

Possible root causes

- Excessively rough shaft may accelerate lip wear
- Overly smooth shaft may result in early leakage
- Poor shaft grinding process or none at all
- Change in shaft suppliers
- Installation or handling damage prior to assembly
- Contamination ingress
- Shaft hardness too soft for the application
- Hardened outer heat-treat layer too thin

Potential solutions

- Measure surface finish and shaft lead and compare to RMA / ISO standards
- Check for visual damage or irregular surface characteristics
- Reevaluate shaft packaging during handling and transport

Paint overspray on sealing lip or contamination

Possible root causes

- Inadequate seal protection during manufacturing paint process
- Loose paint / contaminants get trapped under sealing lip
- Seal failure caused by contamination ingress

Potential solutions

- Use proper shielding during painting process
- Pack grease on air side to form a barrier from paint overspray
- Use v-ring on metal seal face to protect lip
- Choose seal with a dust lip to reduce contaminant ingression

FEA simulation in SKF

A brief history of FEA

The origins of the finite element method (FEM) date back to the 1940s when the basic principle of dividing complex problems into simpler parts (finite elements) and mathematically describing their interaction was established.

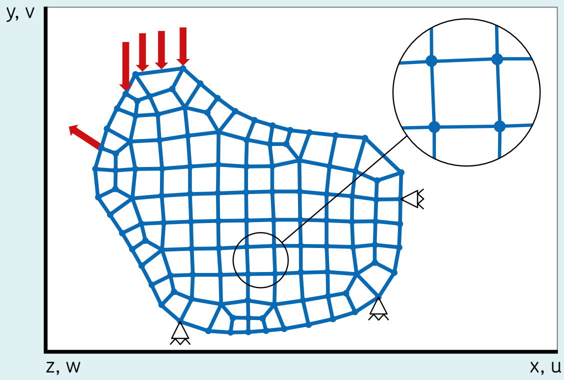
SKF has been using FEA for many years in various engineering disciplines to aid the product development and improve the product quality while optimizing validation and testing costs.

In particular the nonlinear and complex field of sealing technology led SKF to develop its own FEA tools, where available standard tools were impractical, inefficient or not powerful enough.

FEA Software "SAMBA" from SKF

Diagram 4

It's important to consider that a FEA simulation is a tool which needs to be used in the right way to really be of help for the product development and testing departments.



Body divided into finite elements called FE mesh

FEA Simulation

Simulation

Input

In the input phase the engineer feeds the tool with all data that shall be considered for the calculation.

Typical input:

- Models of deformable and rigid components with a suitable mesh
- Interactions and degrees of freedom
- Boundary conditions, loads, pressures, forces, movements and temperatures
- Time and the correct sequence of steps
- The right material data for the component
- Establishment of non-linear material models, especially for elastomeric materials, is key for reliable simulations. Preferably visco-elastic models should be applied for long-term prediction of contact force and strain. SKF uses extensive characterisation methods to establish accurate and close-to-reality models for its own materials

Calculation

The software tool (→ **figure 30**) is solving the equations based on the provided input.

It's important to know the available tools and chose the most fitting one for the task.

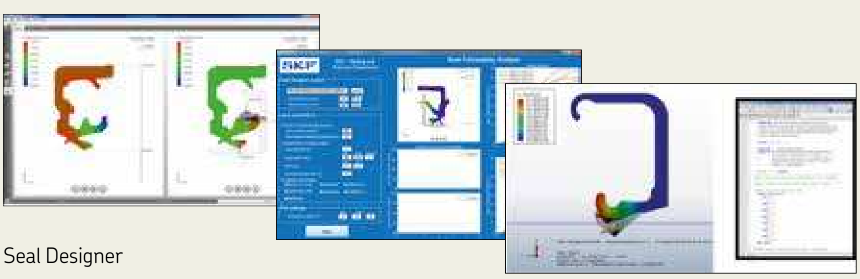
Both SealDesigner and SAMBA are SKF-developed software tools to perform FEA calculations but they serve a different purpose to solve another kind of problem.

Result

The output provided depends on the tool which has been used to perform the calculation.

Usually the results are values for strain and stress as well as element deformations and movements. Modern tools allow a colourful graphical representation of the output but still this is just a visualisation of vectors and values and requires the human mind to process the result, make sense of it and use it to understand and improve the system (→ **figure 31**).

Fig. 30



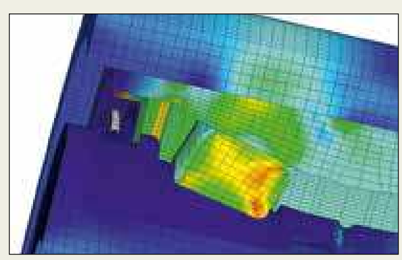
Seal Designer

SAMBA Quick

SAMBA

FEA Software from SKF

Fig. 31



FEA is used to simulate the impact of operating conditions, material selection and seal design on seal behaviour.

Machined seals concept (MSC)

Customized sealing solutions

Manufacturing flexibility

Whether you need a single seal or a high-volume production run, SKF can support your needs. Our flexible seal production model combines moulded and machined manufacturing capabilities to accommodate virtually any demand.

With competencies in compression, injection and transfer moulding technologies, SKF can apply the most appropriate option for your requirements. With the machined seals concept, we are also able to provide machined seals very quickly, without tooling costs.

Meeting unique sealing demands, on-demand

The machined seals concept provides a fast, flexible alternative to moulded seal production. With a unique combination of capabilities, we can deliver polymeric seals in a very short time, in almost any dimension and any design, for virtually any industrial application.

The machined seals concept combines several SKF strengths, including extensive application engineering support, a wide selection of seal profiles and materials, and worldwide availability. Together, these capabilities enable on-demand manufacturing for everything from a single seal to a low-volume series for fluid power, fluid handling and power transmission applications.

Application engineering support

We begin with a consultative process through which our engineers gain an understanding of your particular sealing application challenges. Once we determine your unique requirements, we can develop a solution, choosing from the most appropriate seal profiles and materials.

Profile and materials selection

We select your seal profiles from an array of designs that are pre-programmed in our proprietary machining system, or we can work with you to design a fully customized profile. Our engineers will also determine the optimum sealing material. Our world-class range of standard and special-grade machinable sealing materials includes many that comply with FDA, NSF, NORSOK, NACE, EU1935 and other key industry standards and government regulations.

CNC manufacturing process

Featuring proprietary software and high-precision cutting tools, the SKF SEAL JET manufacturing system uses Computer Numerical Control (CNC) technology to machine polymeric seals quickly. The system machines a seal from a semi-finished tube of your specially selected materials.

Rapid delivery worldwide

The machined seals concept and related services are available globally at selected SKF Solution Factories and machined seals centres. Strategically positioned throughout the world's major industrial markets, these facilities enable rapid manufacturing and delivery.

Sealproduction – SKF machine seals


SKF