Radial shaft seals – general

Radial shaft seals are used between rotating and stationary machine components or between two components in relative motion and consist of two main parts:

- A cylindrical outer covering of sheet steel (case) or an elastomer that has the requisite interference fit to seal statically against the housing bore.
- A sealing lip made of an elastomeric or thermoplastic material that seals dynamically and statically against the shaft. The lip has a sealing edge that is formed by moulding, cutting or grinding. It is normally pressed against the counterface surface of the shaft, with a defined radial load, by a garter spring. The edge of the sealing lip and the shaft counterface surface form the most important functional area of a radial shaft seal. The sealing effect of the lip can be enhanced by designing the contact area of the lip with hydrodynamic features.

Some radial shaft seal designs have an auxiliary lip that protects the primary sealing lip from dust and other contaminants. A suitable lubricant in the space between the primary sealing lip and the auxiliary lip can reduce wear and delay corrosion. Contaminants that have passed the auxiliary lip will eventually cause damage in the counterface surface area. A build-up of heat can also occur between the two lips, resulting in premature wear.

Radial shaft seals are used in a multitude of applications. Because of the importance of radial shaft seals for the operational reliability and service life of machines and equipment, both seal manufacturers and users are equally interested, to some degree, in standardization. This has led to the establishment of national and international standards and guidelines listed in **table 1** on **page 64**. These cover boundary dimensions, tolerances, material specifications, test methods and terminology as well as the basic outside diameter constructions and sealing lip arrangements.

See **figs. 1** and **2** on **page 63** for the terminology used in this publication.

Fig. 1

Metal-cased seal with spring-loaded sealing lip

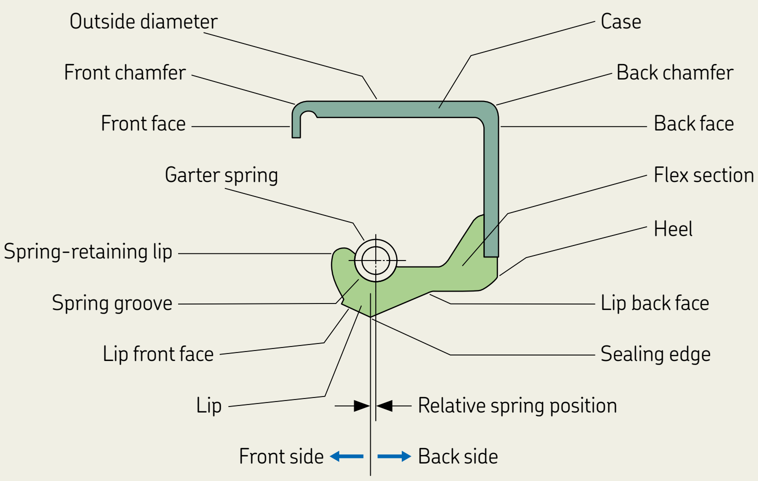


Fig. 2

Rubber outside diameter seal with spring-loaded sealing lip and auxiliary lip

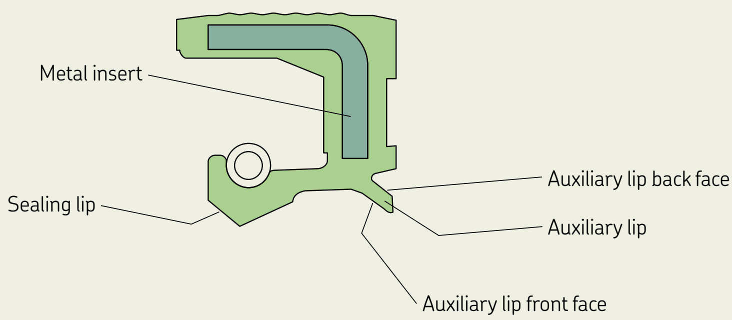


Table 1

Standards and other documents relating to radial shaft seals

Document[1]	Title
ISO 2230	Rubber products – guidelines for storage
ISO 6194-1	Rotary shaft lip-type seals – Nominal dimensions and tolerances
ISO 6194-2	Rotary shaft lip-type seals – Vocabulary
ISO 6194-3	Rotary shaft lip-type seals – Storage, handling and installation
ISO 6194-4	Rotary shaft lip-type seals – Performance test procedures
ISO 6194-5	Rotary shaft lip-type seals – Identification of visual imperfections
SAE J946	Application guide to radial lip seals
RMA OS-1-1	Shaft requirements for rotary shaft seals
RMA OS-4	Application guide for radial lip type shaft seals
RMA OS-7	Storage and handling guide for radial lip type shaft seals
RMA OS-8	Visual variations guide for rotating shaft seals
DIN 3760	Radial-Wellendichtringe (Radial shaft seals)
DIN 3761	Radial-Wellendichtringe für Kraftfahrzeuge (Radial shaft seals for motor vehicles), Parts 1 to 15. This standard covers all aspects including vocabulary, material requirements and test methods.
DIN 7172	Tolerances and limit deviations for sizes above 3 150 mm up to 10 000 mm.
DIN 7716	Rubber products; requirements for storage, cleaning and maintenance.

1) RMA = Rubber Manufacturers Association
SAE = Society of Automotive Engineers
ISO = International Organization for Standardization
DIN = Deutsches Institut für Normung

Outside diameter design

The standard assortment of radial shaft seals manufactured by SKF for general industrial applications covers three different outside diameter executions (→ **figs. 3a** to **3c**).

Seals with a rubber outside diameter (→ **fig. 3a**) are used in a wide range of applications. They maintain a tight fit in the housing bore when the housing material has a higher coefficient of thermal expansion than steel and / or when the housing is split. They are also recommended in all applications where the housing bore surface finish requirements cannot be met.

Metal-cased seals (→ **fig. 3b**) are multi-purpose seals that can be used for most applications. They are relatively easy to install and, provided the housing bore meets the requirements, will fit tightly and centrically in the housing bore.

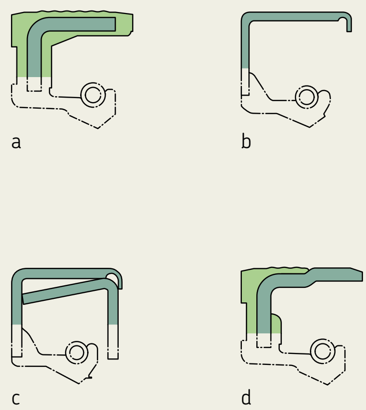
Radial shaft seals designed with a metal case and a secondary reinforcement in the side face (→ **fig. 3c**) offer advantages where operating conditions are severe. They have a higher radial stiffness and are available for shaft diameters ≥ 50 mm *(2 in)*.

Besides these standard outside diameter designs, there is also a half rubber / half metal outside diameter design (→ **fig. 3d**) that is typically used in automotive applications.

In addition to the seal designs for general industrial applications described above, SKF also manufactures seals for heavy industrial applications with special features to meet specific requirements (→ **page 172**).

Fig. 3

Outside diameter designs



SKF Bore Tite Coating

As the static sealing ability between a metal outside diameter and the housing bore is somewhat limited, particularly in the case of low-viscosity fluids and media that can “creep”, most SKF seals with a metal case feature SKF Bore Tite Coating, a water-based acrylic sealant. SKF Bore Tite Coating is green in colour, does not harden and serves to fill small imperfections in the housing bore. For additional details, refer to **page 31**.

Garter springs

SKF radial shaft seals have garter springs made of drawn carbon steel or stainless steel spring wire. Carbon steel springs are standard unless otherwise specified.

Dimensions

SKF radial shaft seals are manufactured for a wide range of shaft diameters, from 5 to 4 600 mm *(0.2 to 181 in)*. The range also includes standard sizes in accordance with ISO 6194-1 and DIN 3760 for shafts ranging from 6 to 500 mm *(0.24 to 19.7 in)*.

Tolerances

SKF radial shaft seals are generally manufactured to the outside diameter tolerances listed in **table 2** on **page 67**, for metric seals, and **table 3** on **page 67** for inch-size seals. These are, where standardized, in accordance with ISO 6194-1, DIN 3760 and RMA OS-4.

Table 2

Outside diameter tolerances for metric seals

Nominal seal outside diameter D over	incl.	Seals with outside diameter of steel: Seal outside diameter tolerance high	low	elastomer[1)]: Seal outside diameter tolerance high	low
mm		mm		mm	
	50	+0,20	+0,08	+0,30	+0,15
50	**80**	+0,23	+0,09	+0,35	+0,20
80	**120**	+0,25	+0,10	+0,35	+0,20
120	**180**	+0,28	+0,12	+0,45	+0,25
180	**300**	+0,35	+0,15	+0,45	+0,25
300	**500**	+0,45	+0,20	+0,55	+0,30
500	**630**	+0,50	+0,22	–	–
630	**800**	+0,50	+0,24	–	–
800	**1 000**	+0,55	+0,25	–	–
1 000	**1 250**	+0,60	+0,27	–	–
1 250	**1 600**	+0,65	+0,30	–	–

1) Seals with beaded outside diameter require different tolerances.
Contact SKF for sizes outside the listed range.

Table 3

Outside diameter tolerances for inch-size seals

Bore diameter[1)] D over	incl.	Tolerance	Seals with outside diameter of steel: Nominal seal outside diameter	Seal outside diameter tolerance	elastomer: Nominal seal outside diameter	Seal outside diameter tolerance
in			in		in	
	2.000	±0.001	+0.005	±0.002	+0.008	±0.003
2.000	**3.000**	±0.001	+0.0055	±0.0025	+0.01	±0.003
3.000	**4.000**	±0.0015	+0.0065	±0.003	+0.0105	±0.003
4.000	**5.000**	±0.0015	+0.0065	±0.003	+0.0105	±0.003
5.000	**7.000**	±0.0015	+0.007	±0.003	+0.012	±0.004
7.000	**9.000**	±0.002	+0.0085	±0.0035	+0.0125	±0.004
9.000	**10.000**	±0.002	+0.0085	±0.0035	+0.0125	±0.004

1) Housing bores made of material other than steel may need a different nominal press-fit tolerance due to differences in thermal coefficients of expansion.
Contact SKF for sizes outside the listed range.

Sealing lip design

Fig. 4

Conventional sealing lip with straight edge

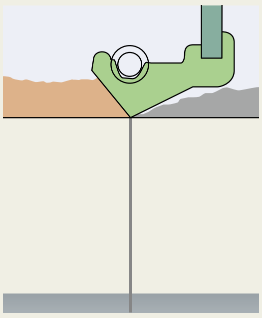
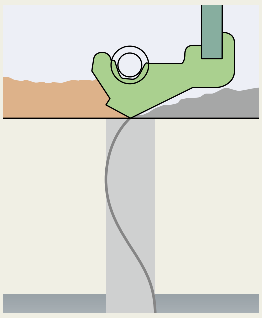


Fig. 5

SKF Wave sealing lip with sinusoidal sealing lip edge



The form and design of a sealing lip is based on knowledge gained through research and development activities as well as wide practical experience obtained by SKF in close cooperation with users. The distance between the lip and the seal back face, the strength of the flex section, the angle of the lip (→ **fig. 1** on **page 63**) and the tension in the spring are all balanced so that the pressure applied by the garter spring provides a satisfactory sealing performance between the sealing lip and counterface.

The sealing lips of SKF radial shaft seals are manufactured from several materials and two different main designs. The various materials are described on **pages 31** to **33**. There are two main sealing lip designs that differ in the execution of the sealing lip edge. The "conventional" sealing lip (→ **fig. 4**) has a straight edge, whereas the SKF Wave lips (→ **fig. 5**) are moulded with a hydrodynamic feature that results in the lip taking a sinusoidal path on its counterface surface.

SKF Wave seals represent one of the most important developments in radial shaft seals. The sealing lip is moulded to a special form, producing a relative movement on the counterface, imparting hydrodynamic properties. SKF Wave seals are suitable for rotation in both directions. They pump the lubricant back into the bearing arrangement and expel contaminants. The sinusoidal form of the sealing lip considerably extends the path (→ **fig. 5**) on the counterface surface and at the same time reduces the specific surface pressure at the sealing lip / counterface contact.

As a consequence, SKF Wave seals produce up to 20% less friction resulting in up to 30% lower temperatures than conventional lip designs (→ **diagrams 1** and **2** on **page 69**). Reduced friction and the sinusoidal path of the sealing lips help prevent the formation of deep tracks in the counterface, resulting in significantly extended service life. SKF Wave seals are recommended where demands for operational reliability and long service life for machines and equipment are high.

SKF seals with conventional spring-loaded sealing lips meet general demands because they are able to provide efficient sealing even under unfavourable operating conditions. To improve sealing performance, some SKF radial shaft seals are designed with hydrodynamic features on the sealing lip. These have either a right-hand twist for shafts that rotate clockwise, or a left-hand twist for shafts that rotate counter-clockwise as seen from the air side. The degree to which the hydrodynamic feature improves the sealing ability depends on the form of the spiral flutes, the circumferential speed, the pressure conditions and the media being sealed. See also paragraph *Oil retention* on **page 21**.

Diagram 1

Temperature rise at sealing lip / counterface contact for conventional and SKF Wave lips as a function of rotational speed for a 76 mm diameter shaft with SAE 30 engine oil

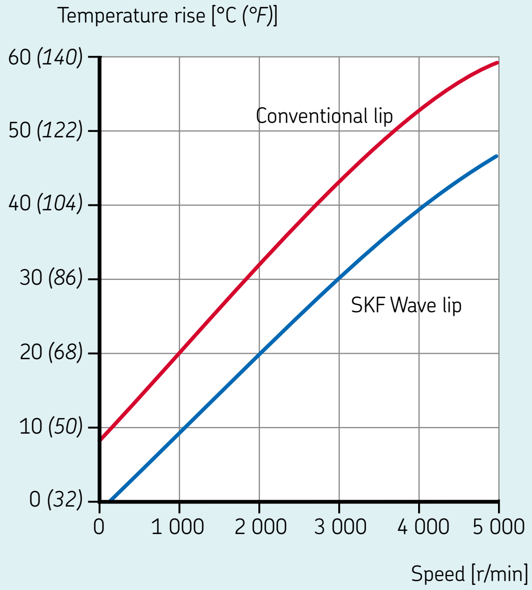
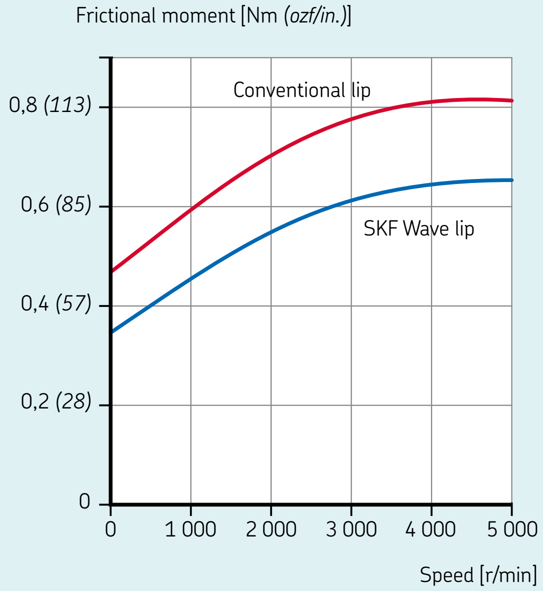


Diagram 2

Frictional moment at sealing lip / counterface contact for conventional and SKF Wave lips as a function of rotational speed for a 76 mm diameter shaft with SAE 30 engine oil



Auxiliary lips

SKF radial shaft seals can also be designed with an auxiliary lip for increased protection against contaminants (→ **fig. 2** on **page 63**). These auxiliary lips are either contacting or non-contacting. Seal designs that incorporate contacting auxiliary lips are used in heavily contaminated environments, with the drawback, however, of creating increased friction and elevated underlip temperatures. The auxiliary lip of HMSA10 and CRWA1 / CRWHA1 seals is non-contacting, which means that these designs normally can be used at the same speeds as the single-lip designs HMS5 and CRW1 / CRWH1.

Coaxiality and runout

Deviation from coaxiality and dynamic runout of the shaft are two of many operating parameters that affect seal performance and service life. They should therefore be kept within narrow limits, particularly when there is a pressure differential across the seal. The total deviation should never exceed 1,3 times the value of the permissible deviation from coaxiality.

Coaxiality

Deviations from coaxiality, i.e. the difference between the centre lines of the shaft and housing bore (shaft-to-bore misalignment, STBM), cause force to be distributed irregularly on the sealing lip (→ **fig. 6**). This means that one section of the sealing lip will be subjected to more force, causing an enlargement of the contact area between lip and counterface surface, whereas the opposite section will be correspondingly unloaded and its sealing effect reduced. Guideline values for the permissible coaxiality deviations for SKF seals can be obtained from **diagram 3** on **page 71**.

Fig. 6

Coaxiality

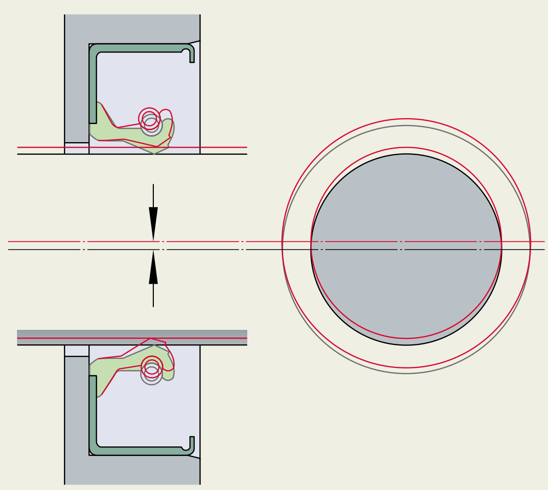
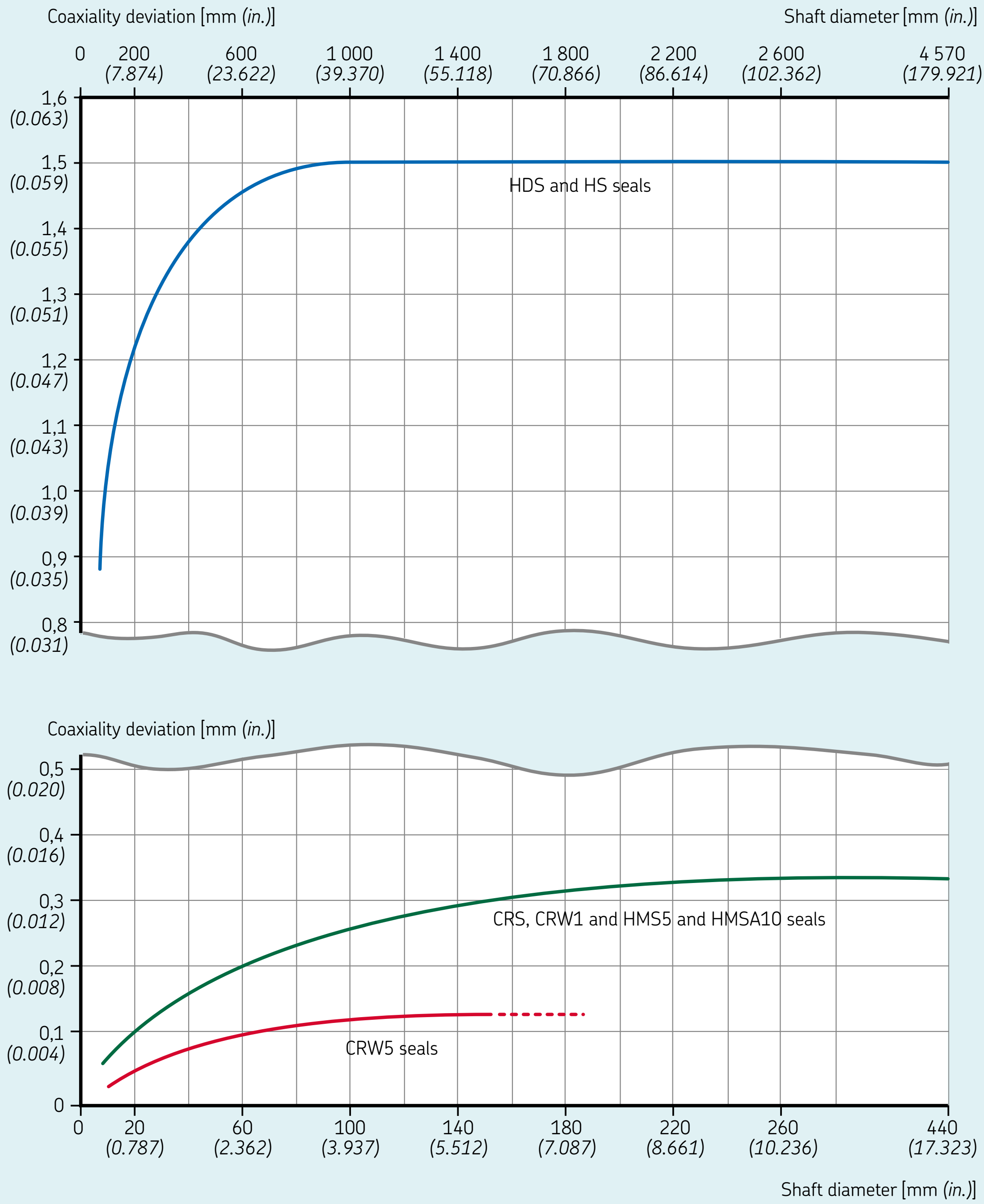


Diagram 3

Maximum permissible deviation from coaxiality as a function of shaft diameter



Runout

Runout (or dynamic runout, DRO) describes the dynamic eccentricity of the shaft. Particularly at high speeds, there is a risk that the sealing lip, because of its inertia, will not be able to follow the shaft surface (→ **fig. 7**). If the eccentricity is such that the distance between the sealing lip and shaft becomes larger than that required to maintain a hydrodynamic lubricant film, the medium to be sealed will escape through the gap. It is therefore advisable to arrange the seal in close proximity to the bearing and to keep bearing operating clearance to a minimum.

Permissible runout values can be obtained from **diagram 4** on **page 73**. These values are normally lower for narrow seals and always depends on seal cross section, sealing lip material and operating temperature.

Fig. 7

Runout

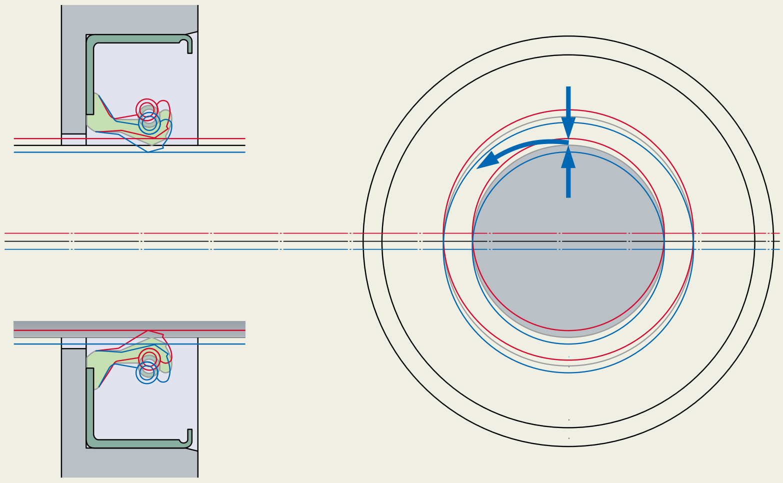
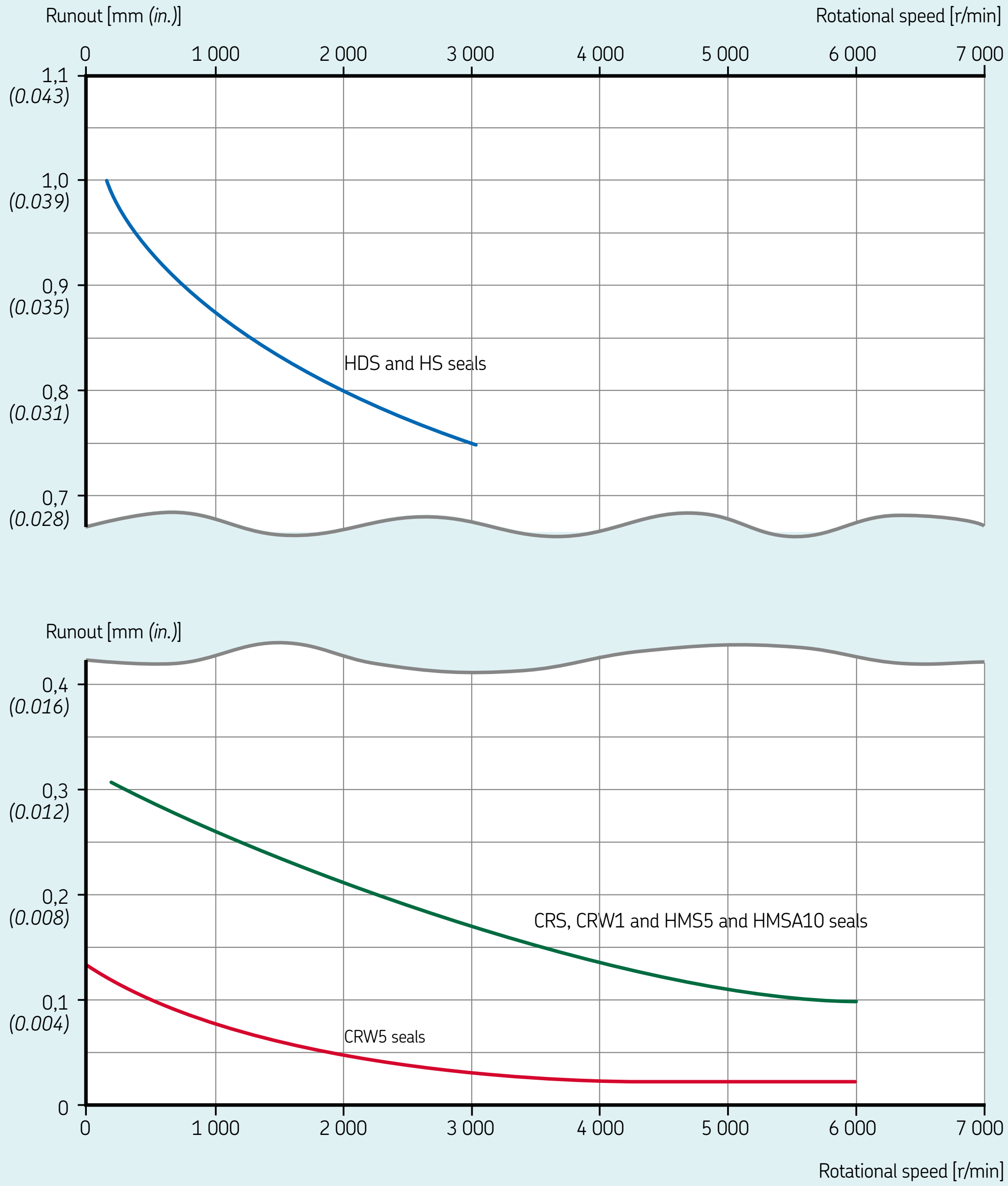


Diagram 4

Maximum permissible runout as a function of rotational speed



Axial movement

Small movements of the shaft relative to the housing in the axial direction do not affect seal performance, provided that the total counterface surface meets the same demands regarding to hardness, accuracy and surface finish.

Permissible speeds

Guideline values for the permissible rotational and circumferential speeds for different seal designs are provided in the seal selection charts (**matrix 2** on **pages 176** to **183**). If the circumferential speeds provided in the matrix are not sufficient for a particular sealing position, **diagram 5** from DIN 3760 on **page 75** may be used. The diagram lists circumferential and rotational speeds related to the material of the sealing lip. The values are valid for spring-loaded sealing lips that are well-lubricated by a mineral oil, where adequate lubricant supply prevents heat build-up and where the pressure is the same on both sides of the seal (pressure differential = 0).

Diagram 5 on **page 75** shows that large diameter shafts can accommodate higher circumferential speeds than shafts with smaller diameters. This is because the cross section of the shaft does not increase linearly with the increase in diameter but by the square of the increase in diameter. Therefore, the heat dissipation of a large shaft is much better than that of a small shaft.

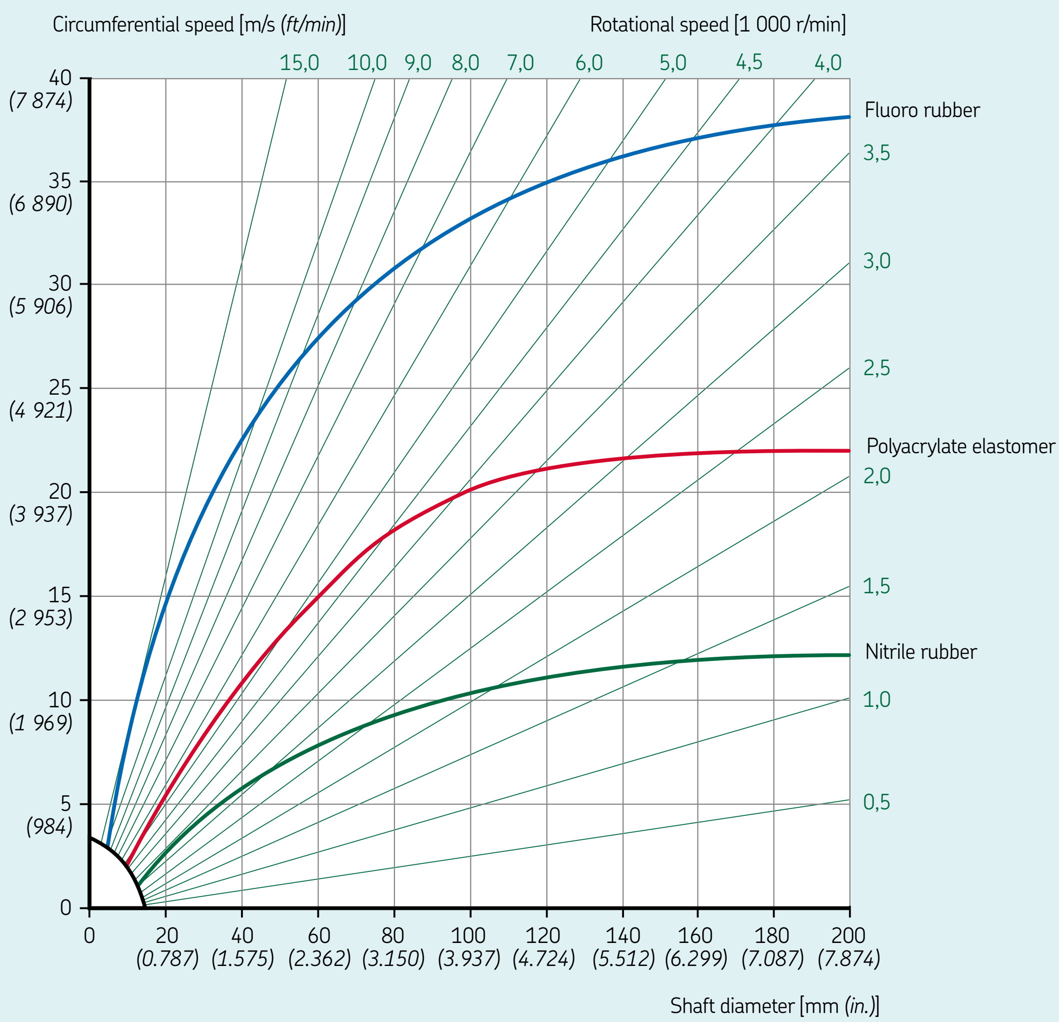
Generally, SKF Wave seals can be operated at higher circumferential speeds than those obtained from **diagram 5** on **page 75** because of the hydrodynamic form of the lip.

The values obtained from **diagram 5** on **page 75** should be reduced if

- radial shaft seals with an auxiliary, contacting lip are used,
- lubrication is inadequate or grease lubrication is used, i.e. when underlip temperatures increase due to poor heat dissipation,
- the counterface does not meet surface finish or running accuracy requirements or
- there is a pressure differential across the seal.

Diagram 5

Permissible speeds for spring-loaded sealing lips where no pressure differential exists across seal in operation
For permissible speeds for seals at shaft diameters > 200 mm, refer to seal selection chart starting on page 104.



Source: DIN standard 3760

Lubrication

To seal efficiently over a long period, the sealing lip of a radial shaft seal must be lubricated. This reduces friction and wear to the sealing lip and shaft. Dry running of sealing lips made of standard materials should always be avoided. To prevent dry running, coat the counterface surface with a suitable lubricant prior to seal installation.

The lubricant not only lubricates the sealing lip to reduce friction and wear, but also dissipates heat generated by the seal. To promote heat dissipation, a sufficient quantity of lubricant needs to reach the sealing lip from start-up.

Some rolling bearings, such as angular contact ball bearings, tapered roller bearings and spherical roller thrust bearings, as well as gears, create a pumping action by virtue of their design. This means that the sealing lip can either be starved of lubricant, or subjected to excessive quantities of lubricant. In either case, steps must be taken during the design stage to make sure that the proper amount of lubricant reaches the sealing lip, as too much or too little can affect seal performance.

To prevent lubricant starvation, lubrication ducts can be provided. If the seal is subjected to excessive amounts of lubricant, a flinger can be installed between the bearing and the seal.

In applications where the sealing lip is not exposed to a lubricant, for example when two seals are installed in tandem, grease or oil must be separately supplied to provide sufficient lip lubrication. In some cases, it may be sufficient to provide an initial grease fill between the two lips.

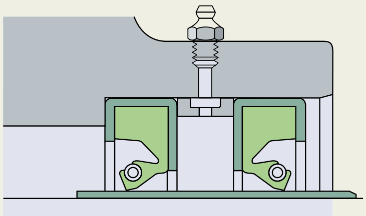
Lubrication of paired arrangements

When two radial shaft seals are installed back-to-back or in tandem, the space between the seals should be filled with a suitable lubricant to eliminate the risk of the sealing lip running dry.

To further prevent dry running, a spacing washer between the seals can also be used. This spacing washer should be provided with lubrication holes or an annular groove and lubrication holes so that grease can be supplied to the space between the seals via a grease fitting (→ **fig. 8**).

Fig. 8

Lubrication of a paired arrangement



Friction

To be effective, the lip of a radial shaft seal must always exert a certain radial load on the counterface. The friction resulting from this radial load is only part of the total contact friction and power loss at the sealing position. Other contributing factors include:

- Type of medium being sealed
- Pressure differential across the seal
- Circumferential speed
- Ambient temperature
- Lubricant and lubrication method
- Condition of the counterface
- Sealing material
- Lip surface roughness
- Shaft roughness

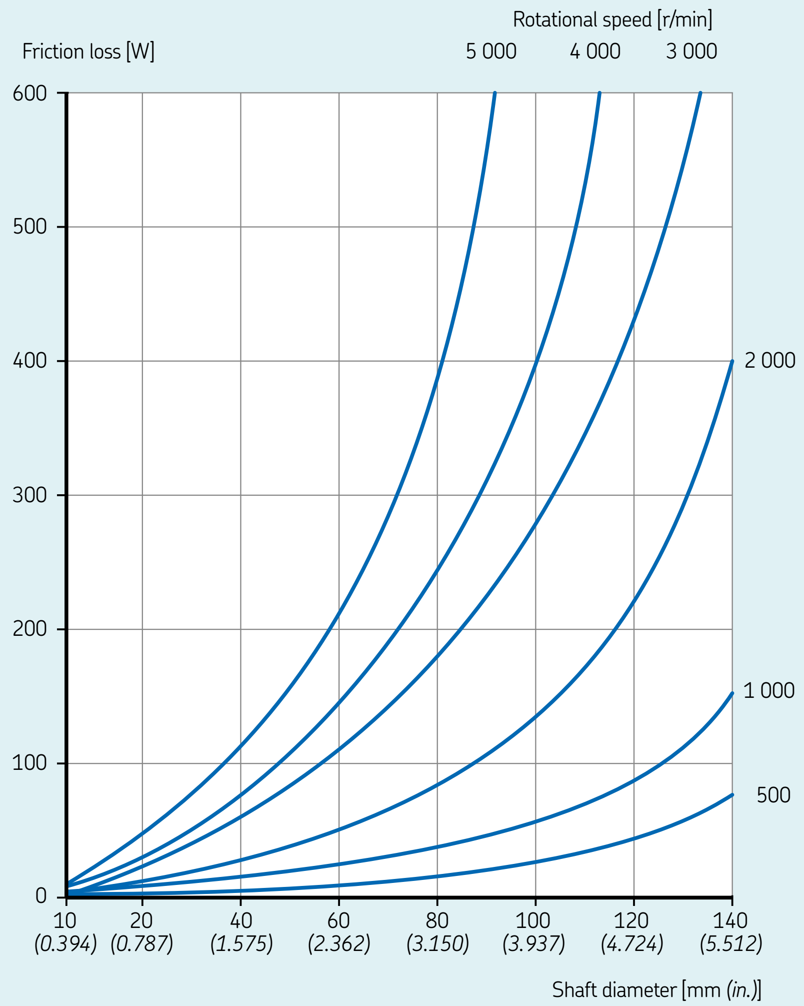
Diagram 6 on **page 77** provides an indication of the friction losses that may be expected when a radial shaft seal with a conventional sealing lip is properly installed and fully lubricated.

The running-in phase of the sealing lip lasts a few hours. During this time, the friction losses are somewhat higher than during normal operation.

Seals intended for applications with high pressure differentials typically have greater losses than specified in the diagram. SKF Wave seals, on the other hand, typically have losses lower than those indicated in the diagram.

Diagram 6

Friction losses of radial shaft seals as a function of rotational speed and shaft diameter



Chemical and thermal resistance

The most important factor when selecting the appropriate elastomer for a radial shaft seal is its chemical resistance to the medium to be sealed or excluded. The operating temperature is another important factor. Heat accelerates ageing of the elastomer and increases the reactivity and aggressiveness of the sealed medium.

Radial shaft seals are mainly used to seal lubricating oils and greases as well as hydraulic fluids (including non-flammable fluids). Guideline values are provided in **table 4** for the permissible operating temperatures, i.e. temperatures at which the SKF seals are still chemically resistant. The temperature range stated for a group of media means that the sealing material is resistant when continuously operated within this particular range.

The ☐ means that, within the group, there are some media that are compatible with the elastomer, but also some that have a detrimental effect on the elastomer.

The ■ means that the seal material is not resistant to media belonging to this group.

For the resistance of sealing materials to media not listed in **table 4**, refer to the section *Chemical resistance* (→ **page 36**) or contact SKF.

Table 4

Chemical and thermal resistance, radial shaft sealing lip materials

Medium to be sealed	**Permissible operating temperatures (continuous) for SKF radial shaft sealing lip materials**[1] R (NBR)		P (ACM)		S (MVQ)		V (FKM)	
–	°C	*°F*	°C	*°F*	°C	*°F*	°C	*°F*
Mineral oil based lubricants								
Motor oils	100	*210*	130	*270*	150	*300*	170	*340*
Gear oils	80	*175*	120	*250*	130	*250*	150	*300*
Hypoid gear oils	80	*175*	120	*250*	■		150	*300*
Automatic transmission fluids (ATF oils)	100	*210*	130	*270*	☐		170	*340*
Greases	90	*195*	☐		☐		☐	
Hydraulic fluids	90	*195*	120	*250*	☐		150	300
Fire-resistant hydraulic fluids								
Oil in water emulsions and aqueous polymer solutions	70	*160*	■		60	*140*	☐	
Anhydrous fluids	■		■		■		150	*300*
Other media								
Fuel oils EL and L	90	*195*	☐		■		N	
Water	90	*195*	■		■		100	*210*
Alkaline washing solutions	90	*195*	■		■		100	*210*
Permissible temperature range								
for sealing lip min.:	–40	*–40*	–40	*–40*	–60	*–75*	–40	*–40*
max.:	+100	*+210*	+150	*+300*	+160	*+320*	+200	*+390*

■ Lip material not resistant
☐ Lip material not resistant to some media in this group

[1] R = nitrile rubber
P = polyacrylate elastomer
S = silicone rubber
V = fluoro rubber

SKF

Seals under pressure

When a seal is exposed to pressure, the radial load of the sealing lip increases. This in turn increases the actual sealing lip / shaft contact area, resulting in additional friction and elevated underlip temperatures. Therefore, the guideline values for speeds provided in **diagram 5** on **page 75** do not apply.

Diagram 7 shows an example of lip distortion of a conventional sealing lip design. System pressure pushes the sealing lip onto the counterface and this leads to sealing lip distortion and increased radial force. This results in higher friction, more frictional heat and consequentially reduced seal service life.

SKF CRW5 and CRWA5 pressure profile seals (→ **fig. 9**) are designed to withstand pressure differentials of 0,34 MPa (*50 psi*) at speeds up to 5 m/s (*1 000 ft/min*).

When there is a pressure differential across the seal, a shoulder or retaining ring should be used at the low-pressure side of the seal to prevent it from being pressed out of the housing bore (→ **fig. 10**).

Fig. 9

Pressure profile seals

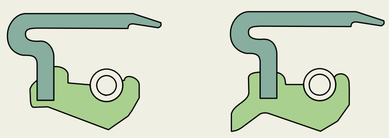


Fig. 10

CRWA5 seal

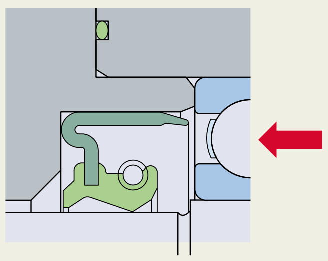
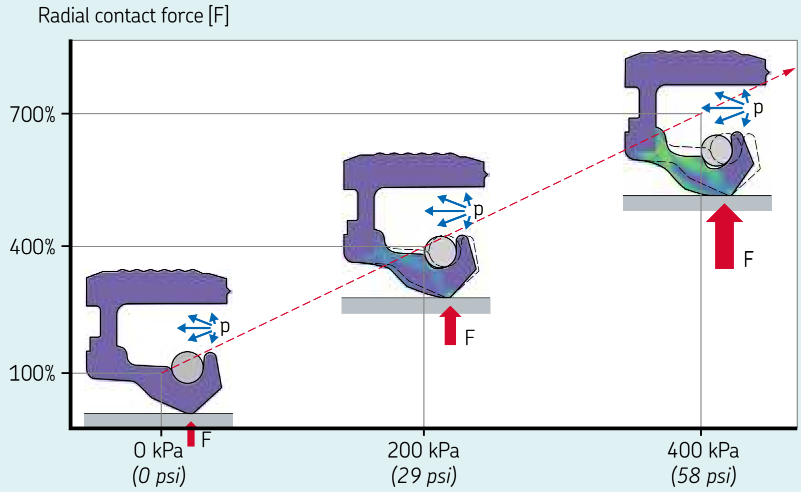


Diagram 7

System pressure pushes the sealing lip onto the counterface and leads to sealing lip distorion and increased radial force. This results in higher friction, more frictional heat and – consequentially – reduced seal service life.



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Shaft requirements

General

To achieve reliable sealing performance and maximum service life, the counterface for a radial shaft seal should meet the requirements outlined below. The seal counterface must be able to accommodate all permissible deviations and movements – surface SL and an additional surface SL' – which may be required in the case of repairs or inspection (→ **fig. 11**).

In cases where a shaft cannot be machined to meet the requirements, SKF recommends the use of SKF Speedi-Sleeve or a wear sleeve for heavy industrial applications (LDSLV). Detailed information about sleeves is provided in the chapter Wear sleeves starting on **page 232**.

Tolerances

The diameter of the shaft d1 at the counterface should be machined to the tolerances provided in **table 6** on **page 81** for metric shafts and **table 7** on **page 81** for inch-size shafts.

Out-of-roundness must be less than 0,005 mm *(0.0002 in)* at a maximum of 2 lobes or less than 0,0025 mm *(0.0001 in)* at a maximum of 7 lobes.

If components with an interference fit will pass over the counterface during installation, the shaft diameter should be reduced by 0,2 mm *(0.008 in)*.

Surface roughness

The surface roughness values of the counterface for radial shaft seals, calculated according to methods described in ISO 4288 (DIN 4768), should be kept within the limits specified in RMA OS-1-1 (→ **table 5**).

The lower value for R_a is a minimum value. Using a lower value will adversely affect the lubricant supply to the sealing lip. The temperature rise caused by inadequate lubrication, particularly at high circumferential speeds, can lead to hardening and cracking of the sealing lip which will eventually lead to premature seal failure. If the counterface is too rough, there will be excessive sealing lip wear and seal service life will be shortened. If the value R_{pm} is exceeded, the seal will leak or excessive sealing lip wear may occur.

Fig. 11

Counterface for radial shaft seals

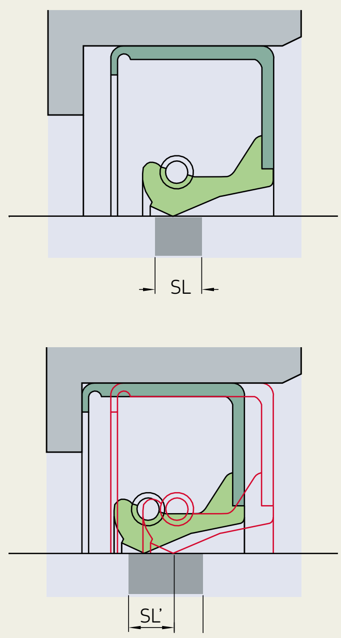


Table 5

Recommended shaft surface roughness values

	ISO		DIN		RMA	
	µm	*µin*	µm	*µin*	µm	*µin*
R_a	0,2–0,5	*8–20*	0,2–0,8	*8–32*	0,2–0,43	*8–17*
R_z	1,2–3	*48–120*	1–5	*40–200*	1,65–2,9	*65–115*
R_{pm}	N/A	*N/A*	N/A	*N/A*	0,5–1,5	*20–50*

Surface finish

Depending on the direction of rotation, directionality on the seal counterface may cause a seal to leak. Plunge grinding is the preferred machining method to minimize directionality (0±0,05°) on the seal counterface. When plunge grinding, whole number ratios of the grinding wheel speed to the work piece speed should be avoided. Run the grinding wheel until it "sparks out" completely, i.e. until there are no more sparks flying from the wheel, to ensure that all lead is removed. The grinding wheel should be dressed using a cluster head dressing tool and the smallest possible lateral feed, or a profile dressing roll without lateral feed. The negative influence of directionality in any particular case can only be ascertained by test running under conditions of alternating rotation.

The seal counterface surface should be free of any damage, scratches, cracks, rust or burrs and should be properly protected until final installation.

Hardness and surface treatment

The surface hardness of the seal counterface should be at least 30 HRC (58 HRC for PTFE lip seals). If the counterface surface could be damaged during transport or installation, this value should be increased to 45 HRC (62 HRC for PTFE lip seals). Under certain conditions, where speeds are low, lubrication is good and contaminants are absent, counterface surfaces having a lower hardness may be suitable. Surfaces that are nitrided, phosphated or have a galvanized coating may also be suitable, but this must be determined for each specific case.

Table 6

Counterface tolerances for metric shafts

Shaft diameter Nominal d_1 over	incl.	**Diameter tolerance (ISO h11)**[1] Deviation high	low
mm		µm	
6	**10**	0	–90
10	**18**	0	–110
18	**30**	0	–130
30	**50**	0	–160
50	**80**	0	–190
80	**120**	0	–220
120	**180**	0	–250
180	**250**	0	–290
250	**315**	0	–320
315	**400**	0	–360
400	**500**	0	–400
500	**630**	0	–440
630	**800**	0	–500
800	**1 000**	0	–560
1 000	**1 250**	0	–660
1 250	**1 600**	0	–780
1 600	**2 000**	0	–920
2 000	**2 500**	0	–1 100
2 500	**3 150**	0	–1 350
3 150	**4 000**	0	–1 650
4 000	**5 000**	0	–2 000

[1] For shaft diameters of 3 150 mm and above, refer to DIN 7172.

Table 7

Counterface tolerances for inch-size shafts

Shaft diameter Nominal d_1 over	incl.	**Diameter tolerance (RMA OS-4)** Deviation high	low
in		in	
–	**4**	+0.003	–0.003
4	**6**	+0.004	–0.004
6	**10**	+0.005	–0.005
10		+0.006	–0.006

Lead-in chamfers

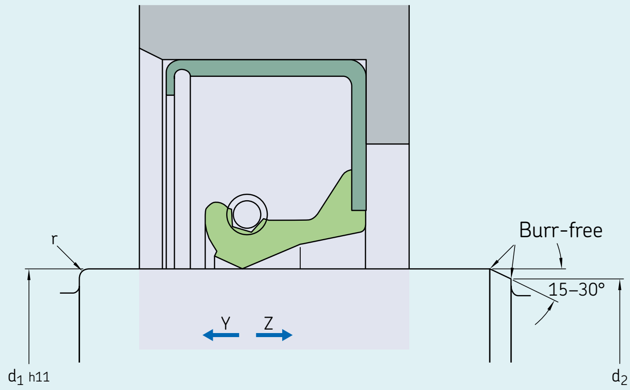
To install radial shaft seals without damaging the sealing lip, SKF recommends chamfering or rounding the shaft ends or shoulders (→ **table 8**).

If the direction of installation is Z, the values ($d_1 - d_2$) provided in table 8 should be adhered to. If the direction of installation is Y, the shaft end could be either rounded (r) or chamfered ($d_1 - d_2$).

To install a seal over a shaft shoulder or end that has not been rounded or chamfered, SKF recommends using an installation sleeve. See section *Seal installation, heavy industrial applications* on **page 89**.

Table 8

Lead-in chamfers and radii



Shaft diameter Nominal d_1 over	incl.	over	incl.	**Diameter** difference[1)] $d_1 - d_2$ min.		**Radii** Seal without auxiliary lip r min.		Seal with auxiliary lip r min.	
mm		*in*		mm	*in*	mm	*in*	mm	*in*
–	**10**	–	*0.394*	1,5	*0.059*	0,6	*0.024*	1	*0.039*
10	**20**	*0.394*	*0.787*	2	*0.079*	0,6	*0.024*	1	*0.039*
20	**30**	*0.787*	*1.181*	2,5	*0.098*	0,6	*0.024*	1	*0.039*
30	**40**	*1.181*	*1.575*	3	*0.118*	0,6	*0.024*	1	*0.039*
40	**50**	*1.575*	*1.968*	3,5	*0.138*	0,6	*0.024*	1	*0.039*
50	**70**	*1.968*	*2.756*	4	*0.157*	0,6	*0.024*	1	*0.039*
70	**95**	*2.756*	*3.740*	4,5	*0.177*	0,6	*0.024*	1	*0.039*
95	**130**	*3.740*	*5.118*	5,5	*0.216*	1	*0.039*	2	*0.079*
130	**240**	*5.118*	*9.449*	7	*0.276*	1	*0.039*	2	*0.079*
240	**500**	*9.449*	*19.685*	11	*0.433*	2	*0.079*	3	*0.118*
500	**–**	*19.685*	–	13	*0.512*	5	*0.197*	5	*0.197*

1) If the corner is blended rather than chamfered, the blended section should not be smaller than the difference in diameters $d_1 - d_2$.

Housing bore requirements

General

To reduce the risk of seal damage during installation, the housing bore should have a 15 to 30° lead-in chamfer. The chamfer should be free of burrs and the transition radius r between the seal seat and shoulder should be in accordance with the recommendations in **table 10** on **page 84**.

In order to facilitate seal removal, holes in the housing shoulder A can be incorporated during the design stage.

Metal-reinforced seals

The depth of a metric housing bore B for metal-cased or metal-inserted seals should be at least 0,3 mm *(0.012 in)* larger than the nominal seal width b (→ **fig. 12**). The corresponding values for an inch housing bore B are 0,4 mm (*0.016 in*).

Seals without metal-reinforcement

Seals without metal reinforcement are manufactured oversized relative to the housing bore diameter and depth to enable proper compression and stability. The actual seal width is approximately 0,4 to 0,8 mm (*0.016 to 0.032 in*) wider than the bore depth B. For all-rubber HS seals, the bore depth tolerance should be ±0,13 mm (*0.005 in*) and ±0,10 mm (*0.004 in*) for all-rubber reinforced HSS seals and fabric-reinforced HSF seals. For seals without metal reinforcement, a cover plate is required for a proper fit (→ **page 94**).

Tolerances

The housing bore diameter D should be machined to tolerance H8 (→ **table 10** on **page 84**). Depending on the operating conditions, out-of-roundness should be 1 to 2 tolerance grades better than H8.

Surface roughness

The surface roughness (to ISO 4288 or DIN 4768) of the housing bore should be kept within the limits specified in **table 9**.

Fig. 12

Housing bore requirements

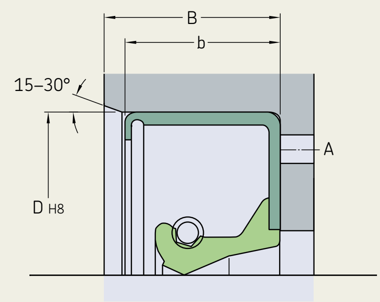


Table 9

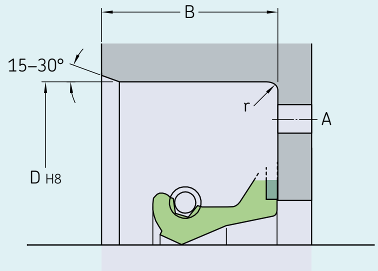
Recommended housing bore surface roughness values

	ISO[1]		DIN		RMA[2)3)]	
	µm	*µin*	µm	*µin*	µm	*µin*
R_a	1,6–3,2	*64–128*	1,6–3,2	*64–128*	1–2,5	*40–100*
R_z	6,3–12,5	*252–500*	10–20	*400–800*	N/A	*N/A*
R_{max}	N/A	*N/A*	N/A	*N/A*	0,5–1,5	*20–50*

1) ISO – The housing bore surface roughness may require lower values when metal-cased seals are used, in which case they should be subject to agreement between the manufacturer and user.
2) RMA – If the bore surface texture is greater than 2,5 µm (*100 µin*) Ra, a sealant should be used.
3) RMA – Turned bores, where a lubricant head of up to 0,20 bar (*3.0 psi*) is present at the seal. If this texture is maintained and tool removal marks or bore defects are not present, no outside diameter leakage should occur.

Table 10

Housing bore tolerances



Housing bore for metric seals (ISO)

Nominal diameter D over	incl.	Housing bore tolerance (ISO tolerance H8) high	low	Fillet radii r max.
mm		µm		mm
–	3	+14	0	0,3
3	6	+18	0	0,3
6	10	+22	0	0,3
10	18	+27	0	0,3
18	30	+33	0	0,3
30	50	+39	0	0,3
50	80	+46	0	0,4
80	120	+54	0	0,8
120	180	+63	0	0,8
180	250	+72	0	0,8
250	315	+81	0	0,8
315	400	+89	0	0,8
400	500	+97	0	0,8
500	630	+110	0	0,8
630	800	+125	0	0,8
800	1 000	+140	0	0,8
1 000	1 250	+165	0	0,8
1 250	1 600	+195	0	0,8
1 600	2 000	+230	0	0,8
2 000	2 500	+280	0	0,8
2 500	3 150	+330	0	0,8
3 150[1]	4 000	+410	0	0,8
4 000[1]	5 000	+500	0	0,8

Housing bore for inch-size seals (RMA)

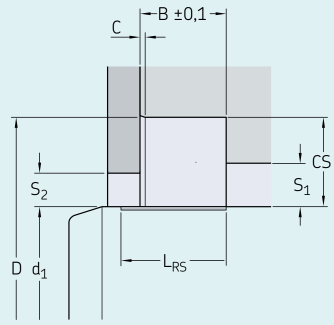
Nominal diameter D over	incl.	Housing bore tolerance high	low	Fillet radii r max.
in		in		in
–	3.000	+0.001	–0.001	0.031
3.000	7.000	+0.0015	–0.0015	0.031
7.000	10.000	+0.002	–0.002	0.031
10.000[2]	12.000	+0.002	–0.002	0.031
12.000[2]	20.000	+0.003	–0.003	0.031
20.000[2]	40.000	+0.004	–0.004	0.031
40.000[2]	60.000	+0.006	–0.006	0.031

1) SKF recommended bore specifications not covered in ISO 286-2
2) SKF recommended bore specifications not covered in RMA OS-4

SKF

Table 11

Shaft and bore requirements for HRS seals



Housing bore for metric seals (ISO)

Range incl. d_1	up to	Tol	Tol D	minimum (recom-mended) CS	HRS1 HRSA B	HRS1 +HRE	S_1	HRS1 S_2	HRSA HRE	HRS1 L_{RS}	HRSA	+HRE	HRS1 HRSA C	HRE
mm														
350	900	–0,4	+0,4	≥ 20 (25)	≥ 20	≥ 25	≤ 12	≤ 12	7-12	≥ 15	≥ 25	≥ B + 10	≤ 10	≤ 1,5
900	1 800	–0,5	+0,5	≥ 25 (32)	≥ 25	≥ 30	≤ 16	≤ 16	7-16	≥ 15	≥ 30	≥ B + 10	≤ 10	≤ 1,5
1 800	3 900	–0,7	+0,7	≥ 28 (32)	≥ 25	≥ 30	≤ 18	≤ 18	7-18	≥ 15	≥ 30	≥ B + 10	≤ 10	≤ 1,5

Surface roughness
The surface roughness values of the counterface for these radial shaft seals, calculated according to methods described in ISO 4288 (DIN 4768), should be:

R_a ≤0.8μm
Material ratio: 50...95% at 50% of R_z,
C_{ref}=0%

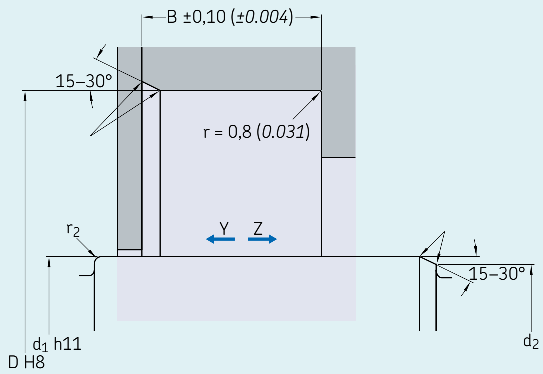
If higher values are used, the seal life may be affected. If the counterface is too rough, there can be excessive sealing lip wear and seal service life might be be shortened.

Surface finish
Depending on the direction of rotation, directionality on the seal counterface may cause a seal to leak. Plunge grinding is the preferred machining method to minimize directionality (0±0,05°) on the seal counterface.
The seal counterface surface should be solid, free of any damage, scratches, cracks, rust or burrs and should be properly protected until final installation.

Hardness and surface treatment
The surface hardness of the seal counterface should be at least 45 HRC. Under certain conditions, such as where speeds are low, lubrication is good and contaminants are absent, counterface surfaces having a lower hardness may be suitable. Surfaces that are nitrided, phosphated or have a galvanized coating may also be suitable, but this must be determined for each specific case.

Table 12

Housing bore requirements for HS/SS seals



Lead-in chamfers and radii

Shaft diameter Nominal d_1 over	incl.	over	incl.	Diameter difference 1) $d_1 - d_2$ min.		Radii r_2 min.	
mm		*in*		mm	*in*	mm	*in*
165	240	*6.500*	*9.499*	7	*0.276*	1	*0.039*
240	500	*9.449*	*19.685*	11	*0.433*	2	*0.079*
500		*19.685*		13	*0.512*	5	*0.197*

1) If the corner is blended rather than chamfered, the blended section should not be smaller than the difference in diameter $d_1 - d_2$.

Table 13

Recommended housing bore surface roughness values

	ISO 1)		DIN		RMA 2) 3)		
	µm	*µin*	µm	*µin*	µm	*µin*	µm
R_a	1,6–3,2	*64–128*	1,6–3,2	*64–128*	1–2,5	*40–100*	0.039
R_z	6,3–12,5	*252–500*	10–20	*400–800*	N/A	*N/A*	0.079
R_{pm}	N/A	*N/A*	25	*1 000*	N/A	*N/A*	0.197

1) ISO – The housing bore surface roughness may require lower values when metal-cased seals are used, in which case they should be subject to agreement between the manufacturer and user.
2) RMA – If the bore surface texture is greater than 2,5 µm (*100 µin*) Ra, a sealant should be used.
3) RMA – Turned bores, where a lubricant head of up to 0,20 bar (*3.0 psi*) is present at the seal. If this texture is maintained and tool removal marks or bore defects are present, no outside diameter leakage should occur.

Lead-in chamfers
To reduce the risk of seal damage during installation, the housing bore should have a 15° to 30° lead-in chamfer. The chamfer should be free of burrs and the transition radius r between the seal seat and shoulder should be in accordance with the recommendations in **table 12.**

Tolerances
For all-rubber HSS seals, the bore depth tolerance should be 0,10 mm (*0.004 in*).

Surface roughness
The surface roughness (to ISO 4288, DIN 4768 or RMA OS-1-1) of the housing bore should be kept within the limits specified in **table 13.**

SKF

Seal installation, general industrial applications

General

To provide effective sealing, radial shaft seals must be installed properly. An experienced installer with suitable tools, working in a clean environment, is recommended to provide proper installation. The shaft counterface surface and housing bore should meet the demands specified under Shaft Housing bore requirements on **pages 83** to **86**.

To facilitate seal installation and to achieve initial lubrication, prior to installation, SKF recommends wiping the shaft and seal with the lubricant that is going to be retained. While the outside diameter of metal-cased seals can be lightly lubricated to ease installation, the outside diameter of rubber covered seals should always be lubricated.

Seals with an auxiliary, contacting lip can also be filled with grease between the sealing lip and auxiliary lip to reduce frictional moment. This does not apply to silicone rubber seals and seals with hydrodynamic features, other than SKF Wave lip designs.

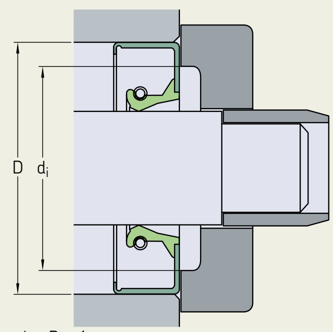
SKF also recommends using a hydraulic press, with suitable tools, to install a seal in its housing bore. Pressure should be applied as close as possible to the outside diameter of the seal.

Seals that are designed to sit flush with the wall of the housing bore must be installed perpendicular to the housing bore axis. The outside diameter of the tool should be larger than the housing bore diameter (→ **fig. 13**).

When pressing seals up against a shoulder or retaining ring, it is advisable to use tools of the type shown in **figs. 14** and **15**. The necessary ring dimensions can be supplied on request.

Fig. 13

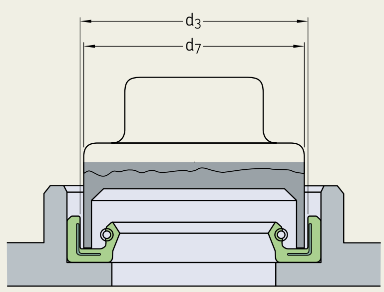
Preferred installation method



$d_i \approx D - 6$ mm

Fig. 14

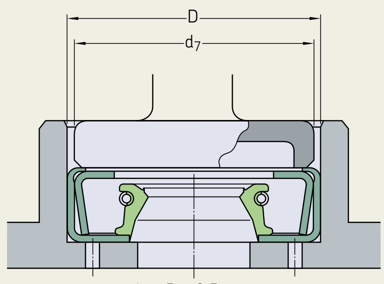
Alternative installation method



$d_7 = d_3 - 0{,}5$ mm

Fig. 15

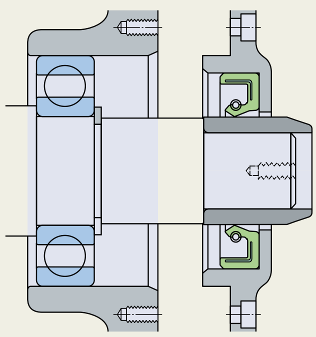
Alternative installation method



$d_7 = D - 0{,}5$ mm

Fig. 16

Installation sleeve



When installing seals on stepped shafts, where the shoulders do not have the recommended chamfer or rounded transition, an installation sleeve as shown in **fig. 17** must be used. If the sealing lip has to pass over grooves, threads or gearing, thin-walled installation sleeves, like those shown in **fig. 18**, can be used to prevent the lip from being damaged. The outside surface of the sleeve should be coated with the same lubricant that is used to lubricate the seal and counterface surface.

Radial shaft seals with a sealing lip made of a sensitive material should always be installed using an installation sleeve.

The tools used to install a seal at a certain distance in a cylindrical opening in a housing
are shown in **figs. 19 and 20**. Instructions for designing the tools can be supplied on request.

Fig. 17

Thin-walled installation sleeve

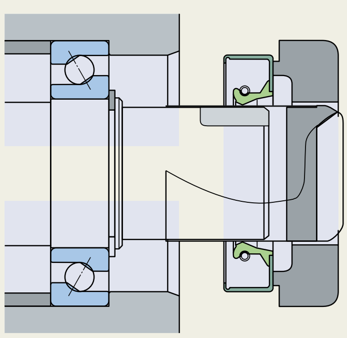
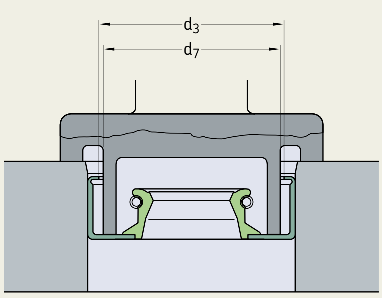


Fig. 18

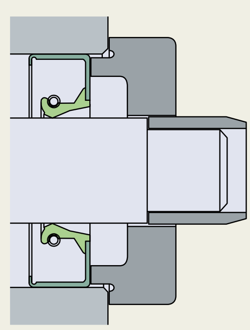
Installation in a cylindrical opening



$d_7 = d_3 - 0,5$ mm

Fig. 19

Installation in a cylindrical opening



Seal installation, heavy industrial applications

General

- **Recommended seal installation temperature +5 to 40 °C**
  Polymeric materials shrink or expand depending on the environment temperature. Installing a seal at very low temperatures might lead to a gap between the ends of the seal. Installing a seal at very high temperatures might lead to a more difficult installation process. If seals have to or are installed in a very cold environment, warming the seals or the surroundings with a heating gun (max. 80 °C) until the cover plates are applied, is recommended.
- **Work clean**
  Before work begins, the cleanliness of the working environment must be checked. Dust and dirt that enters the application, or contaminates the seal or garter spring, during the seal replacement might lead to premature failure replacement.
- **Handle with care**
  Seals are fragile components that have to be handled with care. Dust and abrasive particles, a damaged or bent sealing lip or a carelessly installed spring can cause a service life reduction, leakage or consequential damage. Avoid contact with sharp objects. Do not slide the sealing edge over housing parts.
- **Do not install seal without visibility**
  It is crucial that the sealing lip is visible during the installation and that any installation failure (e.g. sealing lip bending) is avoided by supporting the sealing lip to slide onto the shaft as intended. Make sure that the garter spring stays in the spring groove and that the sealing lip is not damaged or bent backwards during the installation process.

Preparation

Split seals are specially packed for up-tower service. The seals are delivered cut with the ends secured to avoid damage during transport. Prior to installation, the transportation protection must be removed.

Cut the tape with scissors to open the packaging. Avoid touching the seal with sharp tools.

Instructions

Make sure that the necessary equipment is ready:

- Seal and garter spring in their respective package
- Knife or scissors to open the seal packaging
- Flashlight (to check the seal lip right after installation)
- Wood screw to dismount the used seal out of the housing bore
- A cleaning cloth to clean the housing bore during seal replacement
- Tools required to dismount and install the cover plates
- Optional but recommended: adhesive for securing the spring connection (Permabond HM162, Marston-Domsel MD666.620 or Loctite 243)

Metal-cased – HDS seals

When installing metal-reinforced seals, the first step is to check the shaft and housing bore for proper specifications and condition. Next, coat both the seal and bore lightly with a lubricant, preferably the same one that will be used to lubricate the application. For large diameter seals, a special installation tool may not be practical. In these cases, do not hit the seal or seal case directly. Instead, use a wooden block, long enough to span the seal's outside diameter. When using this method, it is important to apply hammer-blows evenly and sequentially to the wood piece around the seal circum ference to prevent the seal from tilting or skewing. SKF also recommends the use of a dead blow hammer for full energy transfer with less impact (→ **fig. 20**).

In some applications, the housing is designed for two seals in tandem, or a seal might have to be recessed further into the bore depth. In those cases, first set the seal flush with the housing using the method described above. Then, use a shorter piece of wood to drive the seal deeper into the bore utilizing a sequential pattern (→ **fig. 21**).

Seals are installed differently depending on whether their main purpose in a specific application is to retain lubricant or to exclude contaminants (→ **fig. 22**).

Fig. 20

Use a dead blow hammer

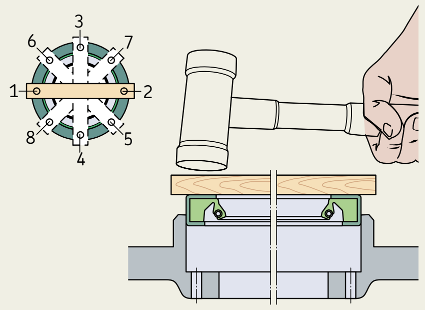


Fig. 21

Installation deeper into the bore

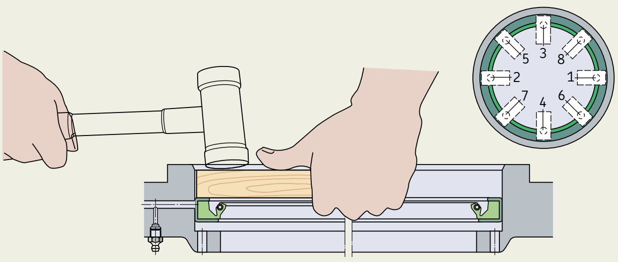
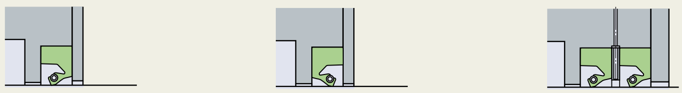


Fig. 22

Ways of installing (e.g. all-rubber HS seals)



All-rubber seal installed to retain lubricant

All-rubber seal installed to exclude foreign material

All-rubber seals in tandem arrangement for maximum lubricant retention

Split seals – HRS

Ensure shaft and housing bore requirements listed in the SKF drawing are met. Clean shaft surface and housing bore and make sure that they meet the specifications.

1 Position the garter spring around the shaft at the installation position (→ **A** in **fig. 23**).

2 Connect the spring (**A**)
  a) Apply adhesive on open spring connection
  b) Back-wind the spring 7 full turns
  c) Screw the spring together leaving no gap

3 Dismount the used seal from the housing bore.

4 Lightly coat the counterface with a lubricant, preferably the same that will be used in the application (**B**).

5 Position the seal joint on the shaft so that it is at the 12 o'clock position (**C**).

6 Insert the garter spring into the groove trying to apply equal tension around the circumference.

7 Compress and push both ends of the joint into the housing bore (**D**).

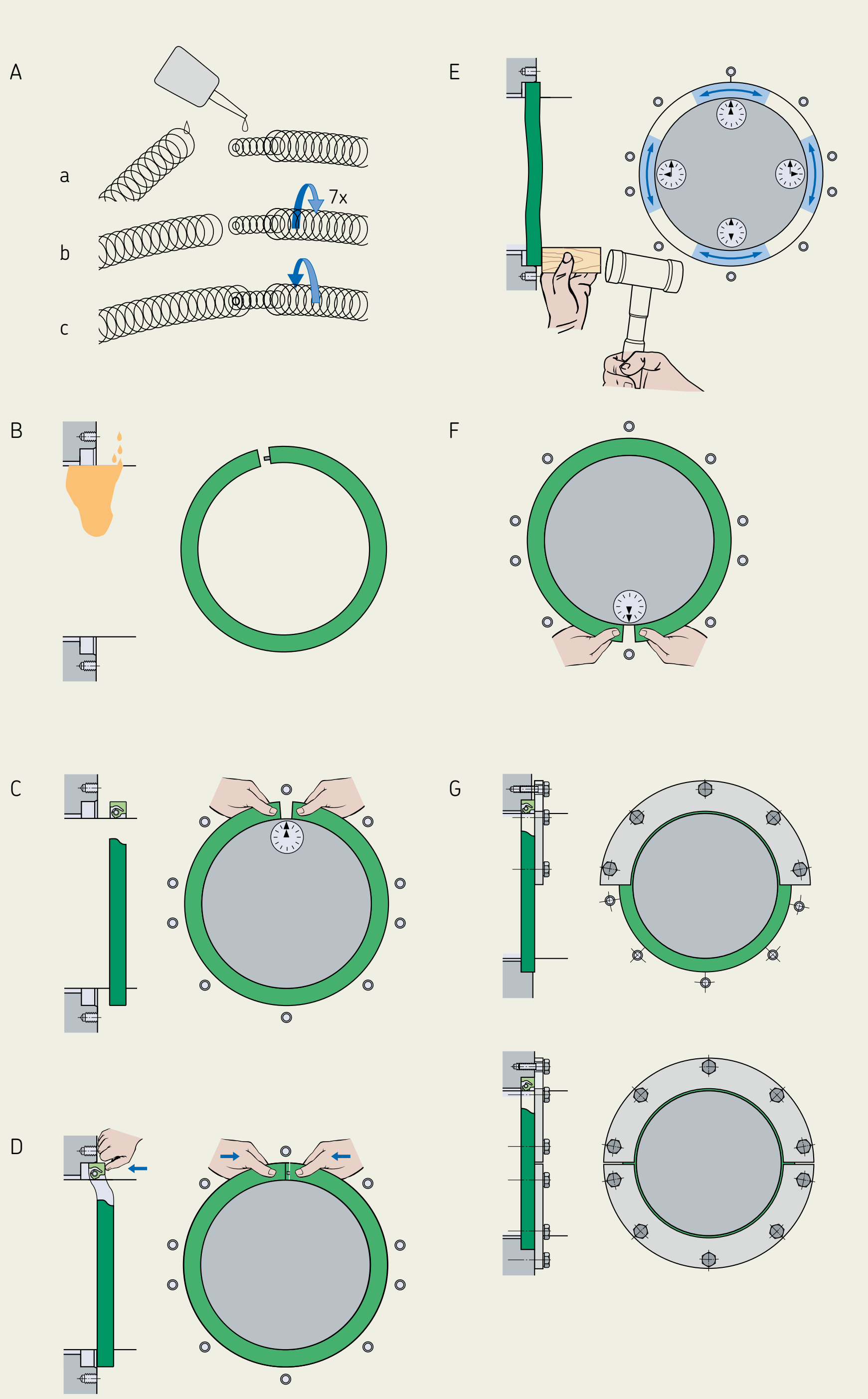
8 Continue at the 6, 3 and 9 o'clock positions, push the rest of the seal into position and finish simultaneously. Use a small block of wood if needed to push the seal in the housing bore until it contacts the housing shoulder (**E**).

9 If an excluder seal HRE1 is used, position it around the shaft and push it against the back of the installed primary seal with the sealing lip facing to the opposite direction. Position the joint at the 6 o'clock position. The excluder seal may try to go out of the housing. Hold it in place until the cover plates are installed (**F**).

10 Check the seal condition, particularly at the joint, to make sure that it has been positioned properly. Install the cover plate on the housing face. Tighten the bolts evenly until the cover plate abuts the housing face (**G**).

Fig. 23

Installing a HRS split seal

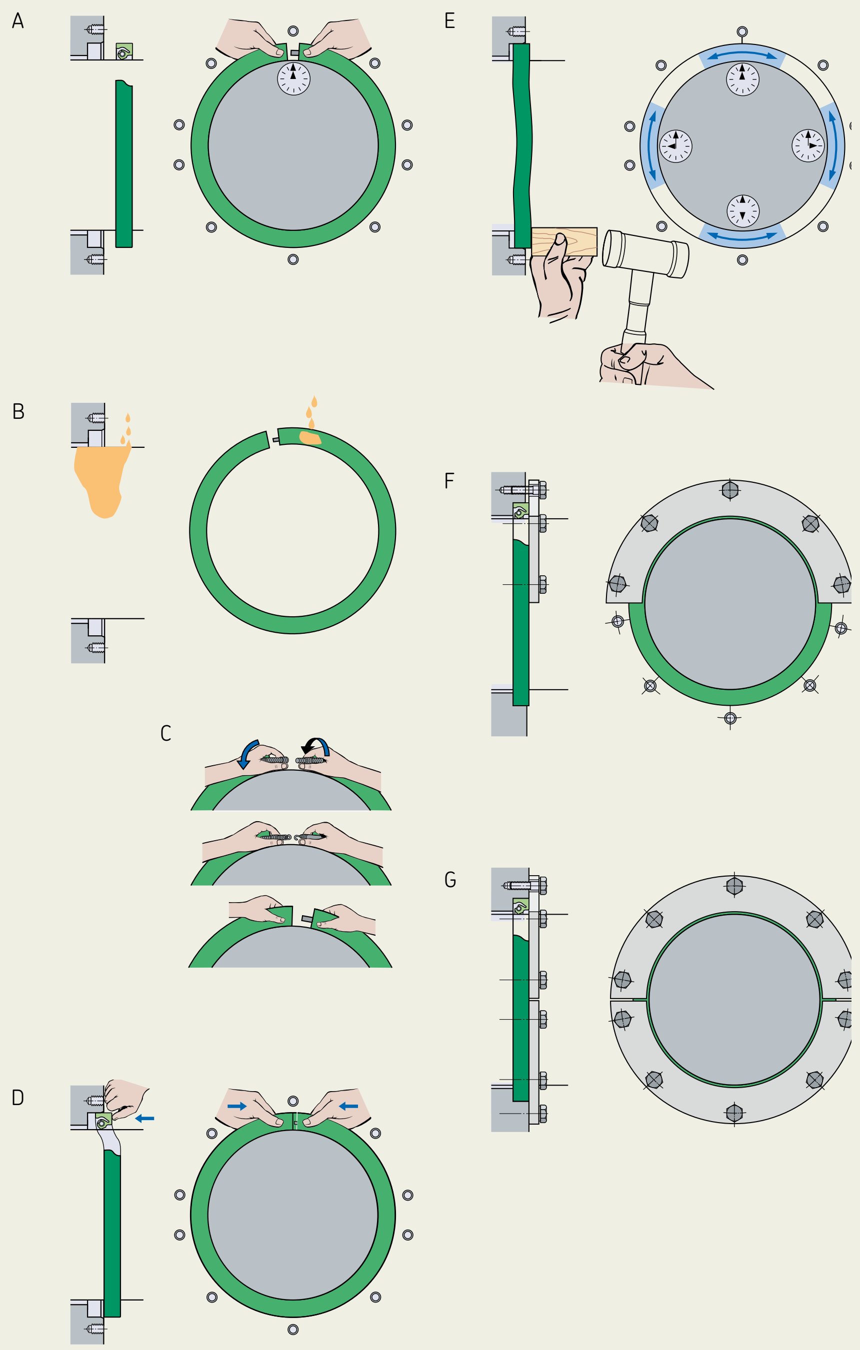


Split seals – HS and HSS

1 Where appropriate, insert the spring in the SKF Springlock groove and position the spring connection, so that it is displaced with regard to the seal joint (→ **A** in **fig. 24**). This is standard with all HS8 seals. Put the seal in the correct position on the shaft.
2 Lightly coat both the seal and counterface surface with a lubricant, preferably the same lubricant that will be used to lubricate the application (**B**).
3 Join the ends of the garter spring by using the spring connector (**C**).
4 For threaded connectors, back-wind the spring a couple of turns before the ends are brought together and allowed to thread into each other. When using a hook-and-eye connector, draw the ends of the spring together and insert the hook into the eye, taking care not to overstretch the spring in the process, as this might impair seal performance. When using a control-wire connector, draw the seal ends together and insert the control wire into the centre of the spring coil.
5 Position the seal joint on the shaft so that it is at the 12 o'clock position and push both ends of the joint into the housing bore (**D**). Do not push only one joint and then work around the shaft as this will create an excess length, making installation difficult or impossible.
6 Continue at the 3 and 9 o'clock positions, push the rest of the seal into position (**E**) and finish simultaneously at the 6 and 12 o'clock positions. For shaft diameters ≥ 1 200 mm *(47 in)*, it is advisable to fix the seal at the 12, 3, 6 and 9 o'clock positions before locating the remaining sections of the seal.
7 Use a small block of wood to push the seal in the housing bore until it contacts the housing shoulder (**E**).

Fig. 24

Installing an all-rubber split seal



8 Check the seal condition, particularly at the joint, to make sure that it has been positioned properly.

9 Install the cover plate (see paragraph *Cover plates* on **page 94**) on the housing face. Tighten the bolts evenly until the end cover abuts the housing face (**F** and **G**).

Installation of HRS and HSS split seals

Video of HRS split seals installation in a wind turbine

Cover plates

Seals without metal reinforcement, split and solid, are manufactured oversized relative to the housing bore diameter and depth to enable proper compression and stability. A cover plate (→ **fig. 25**) provides axial compression of the seal and stabilizes it in the housing bore to achieve maximum seal performance. The cover plate must be dimensioned properly to obtain the required fit. It should be thick enough not to bend or distort. Generally, a thickness of 6,35 to 12,7 mm *(0.25 to 0.50 in)* is sufficient.

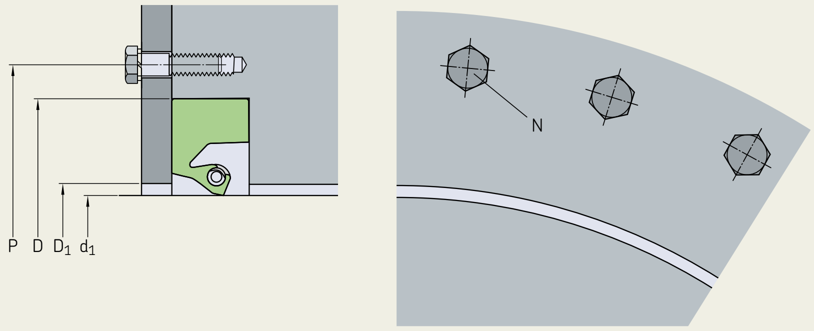
The plate should be fastened with bolts, no more than 150 mm *(6 in)* apart, on a bolt circle located as close to the seal housing bore as practical. The cover plate should be flat and the housing bore depth uniform. Splitting the cover plate at 180° will make seal replacement easier, particularly in confined areas.

To block surges of lubricant toward the seal from the inside and to protect the seal from damage from the outside, SKF recommends dimensioning the inside diameter of the cover plate so that it is 6 to 8 mm *(0.25 to 0.30 in)* greater than the shaft diameter to accommodate shaft-to-bore misalignment and runout (→ **fig. 25**).

In applications where supplementary sealing is necessary, and it is impractical to machine the original housing to provide a seal cavity, a seal cavity can be incorporated into a new plate that is bolted into place as illustrated in **fig. 26** on **page 95**.

Fig. 25

Cover plate recommendations



Inside diameter of cover: D1 ≈ d_1 + 6 .. 8 [mm]
Pitch circle diameter of screws: P ≈ 1,1 D [mm]
No. of attachment screws: N ≈ 0,02 P

Multiple HS seal installations

When installing two split all-rubber HS seals in one cavity, the locations of the split joints should be staggered by 30° to 60° to minimize the risk of leakage through the joints. The splits should be located toward the top of the bore. Grease the cavity between the seals to provide lubricant to the outer sealing lip.

When two HS seals, split or solid, are installed in the same housing bore, a spacing washer must be placed between the two seals (→ **fig. 27**). Suitable washer dimensions can be determined based on the shaft and housing bore diameters, d_1 and D, respectively:

- Washer inside diameter
  = d_1 + 6 to 10 mm *(0.25 to 0.4 in)*

- Washer outside diameter
  = D – 0,5 to 1,5 mm *(0.02 to 0.06 in)*

The width of the washer is determined by the application conditions. There should, however, always be sufficient room for lubrication holes to be provided in the circumference, or lubrication grooves in one side face (→ **fig. 28**). These lubrication provisions must enable grease to be supplied from the housing to the sealing lips via a drilled passage or grease fitting (→ **fig. 29** on **page 96**). When determining what washer width is appropriate for the depth of a housing bore, it is necessary to consider the axial displacement required when clamping the seals.

Fig. 26

Cover plate

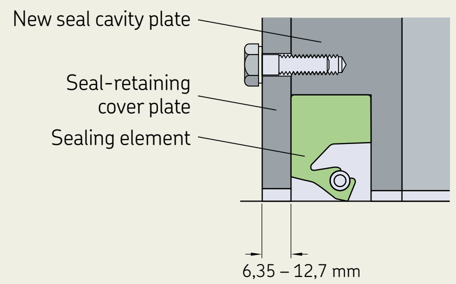


Fig. 27

Spacing washer

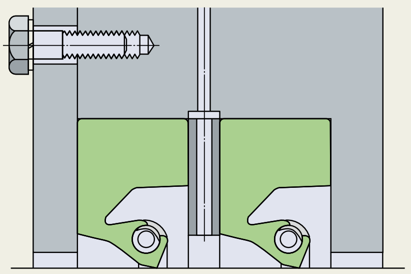


Fig. 28

Details of spacing washer for central lubrication
A separator between two seals can be a slotted washer to promote distribution of the lubricant.

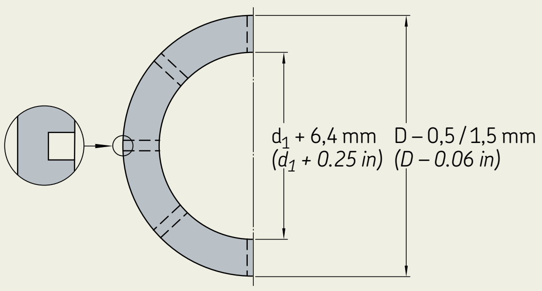


Fig. 29

Spacing washer and grease fitting

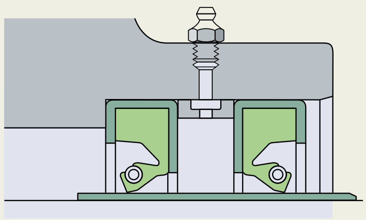
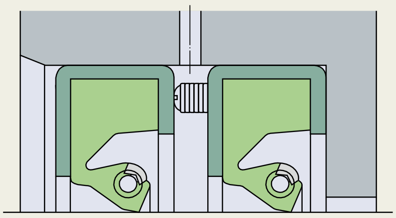


Fig. 30

Spacer lug



Multiple HDS seal installations

When installing two metal-cased radial shaft seals in the same housing bore, either in a tandem or back-to-back arrangement, care must be taken that neither of the sealing lips can run dry at any time. To reduce the risk of dry running, the space between the seals should be filled with a suitable grease.

To avoid dry running, SKF recommends using spacer lugs or a spacing washer between the two seals. The spacing washer should be provided with lubrication holes so that grease can be supplied to the space between the sealing lips via a grease fitting (→ **fig. 29**). No spacing washer is required when using seals that have spacer lugs built into the air side of the metal case (→ **fig. 30**). HDSD and HDSE seals can be supplied from SKF with holes pre-drilled in the metal case to mate with corresponding passages in the housing bore.

PTFE seals

In most cases, small diameter PTFE seals are shipped on a tube that maintains a nominal seal inside diameter (smaller than shaft diameter) during storage. Therefore, they should not be removed from the shipping tube until immediately prior to installation. Also, if quality inspections must be done, SKF recommends that the shipping tube remains in place. The seal inside diameter cannot be accurately measured anyway after manufacturing as the PTFE lip configuration changes over time as it relaxes.

PTFE formulations used for radial lip seals are generally more aggressive and abrasive to the shaft than standard elastomeric materials. Therefore, PTFE sealing lips require a surface hardness value of 58 to 62 HRC. An alternative to a hardened shaft surface is the use of an SKF wear sleeve, manufactured to the same high standards such as the inner rings of SKF needle roller bearings, offering an excellent sealing surface.

In applications where PTFE seals will be retaining a lubricant or be fully flooded with a fluid, the seals should be installed dry. In applications that run dry or will be starved for lubrication, the sealing lip should be pre-lubricated with a grease appropriate for the temperature conditions of the application.

⚠ WARNING

At temperatures above 300 °C (*570 °F*), all PTFE compounds give off dangerous fumes. For additional information, refer to **page 33**.

Installation procedure

PTFE lips do not have the same elastic properties as rubber lips, which makes them more susceptible to damage. Therefore, special care must be taken during installation and handling to prevent damage and help ensure proper operation and function. Shaft features such as keyways and splines, as well as drill holes, ports and sharp-edged shaft steps have the potential to damage PTFE lips. Whenever possible, these obstructions can be covered by using thin-walled installation tools made from plastic or metal.

PTFE lip orientation during installation will determine the installation method. Installation is more difficult when the shaft is installed against the PTFE lip (→ **fig. 31, a** and **c**). This type of installation becomes even more complicated when the hardware is difficult to access or visually obstructed and may not be possible if an installation tool cannot be used. In any case, when the shaft is installed against the PTFE lip, SKF recommends the use of an installation cone or "bullet". SKF can quote and manufacture installation cones if detailed drawings of the shaft and sealing areas are provided. In lieu of installation cones, longer than normal lead-in chamfers on the shaft would be required. However, shaft features that could damage the seal (keyways, etc.) must still be covered, possibly with tape.

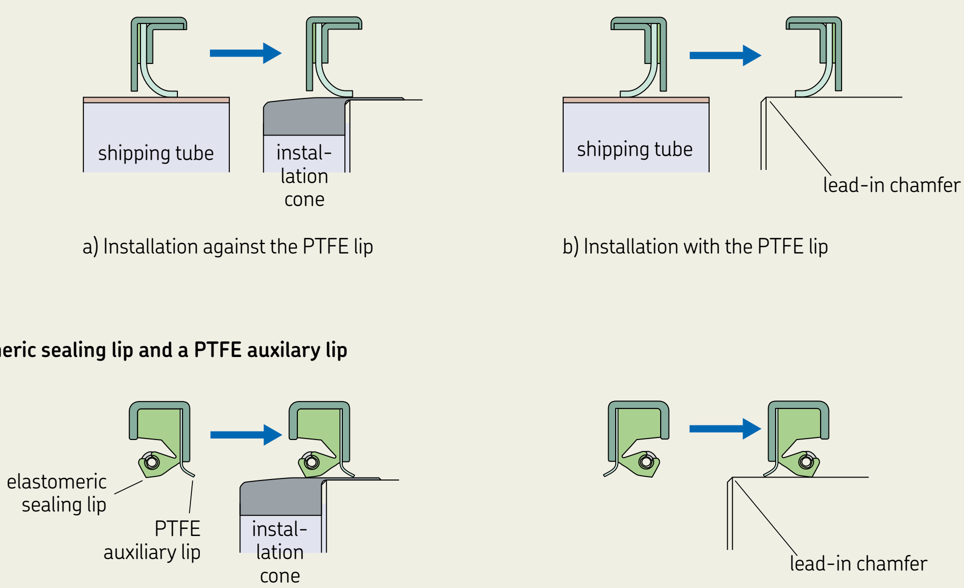
If the shaft is installed with the PTFE lip, a smooth, burr-free radius or chamfer on the shaft end is all that is required, provided that no damaging shaft features are present as noted above (→ **fig. 31, b** and **d).**

Some seals have two PTFE lips facing opposite directions. In this case, installation is always against one of the lips and an installation cone is recommended.

Fig. 31

Seals with a PTFE sealing lip

Seals with an elastomeric sealing lip and a PTFE auxilary lip



a) Installation against the PTFE lip

b) Installation with the PTFE lip

c) Installation against the PTFE lip

d) Installation with the PTFE lip

Protecting the counterface surface against corrosion

The seal counterface surface should be protected from corrosion until the machine is operational. Be sure to use a rust inhibitor that will last for a year, whether or not the shaft is exposed.

The protective coating should be soluble in the medium to be retained and must not cause any chemical separation as this can impair the sealing performance.

When machines are transported, stored under unfavourable conditions, or out of service for extended periods, special rust inhibitors should be used. These rust inhibitors should form a tough, pliable waxy film that can be removed using neutral solvents that leave an oily residue.

Removal

Because radial shaft seals should never be reused, there is no need to worry about damaging the seal when removing it. However, prior to removal, it is advisable to note the direction in which the seal is installed so that the replacement seal can be installed in the same direction. Small seals can generally be removed using a screwdriver, taking care not to damage the shaft surface. The removal of large-size seals is made easier if holes have been provided in the housing shoulder A, see picture in **table 10**, **page 84**, allowing access for a drift.

Replacement

The lip of the replacement seal should not run on the same path as the lip of the old seal. There are several ways to achieve this:

- Install SKF Speedi-Sleeve, see **page 240**.
- Rework or replace the counterface (this may entail removing the shaft).
- Install a spacing ring in the housing bore between the housing shoulder and the seal (→ **fig. 32**).
- Press the new seal to a different depth in a cylindrical opening in the housing, i.e. toward the medium to be sealed.

When choosing a replacement seal, be sure that its design and material correspond to the original seal. In case of doubt, select a seal that meets the operating conditions of the application, and that the seal materials are compatible with the lubricant.

Seals made from a different material should only be used when absolutely necessary. In these cases, the recommendations provided in **table 14** should be followed. The order in which the materials are listed is an indication of their suitability.

If a seal of the same design is not available in the same width as the original, then a somewhat narrower seal can be used, or if the depth of the housing bore allows, a somewhat wider seal can be selected as the replacement.

Fig. 33

Spacing ring

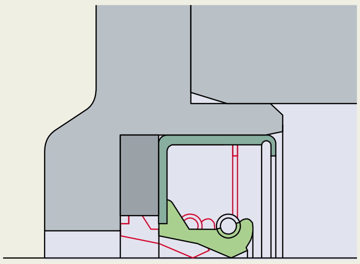


Table 14

Replacement sealing lip materials

Original	Replacement
Felt	Nitrile rubber Polyacrylate elastomer Fluoro rubber
Leather	Nitrile rubber Fluoro rubber
Nitrile rubber	Polyacrylate elastomer Fluoro rubber Silicone rubber
Polyacrylate elastomer	Fluoro rubber Silicone rubber
Silicone rubber	Fluoro rubber