

Sealing rings

Single lip and double lip

Sealing rings

The quality of a bearing arrangement is decisively influenced by the components – shaft, housing, seal – that are directly adjacent to the bearing.

Seals play a decisive role in protecting bearings against contamination. If inadequate seals are used, contaminants can penetrate the bearing or an unacceptably large quantity of lubricant may escape from the bearing. Solid contaminants lead to wear and/or fatigue of the raceways and rolling elements.

Bearings that are contaminated or running dry will fail long before they reach their fatigue rating life. When designing the bearing arrangement, the use of seals that are correctly matched to the application is decisive in determining the operating life of the bearings.

INA sealing rings were developed as seals for needle roller bearings and have been available in the market for almost fifty years. During this time, they have proved extremely effective in automotive and engine construction as well as machine and equipment building.


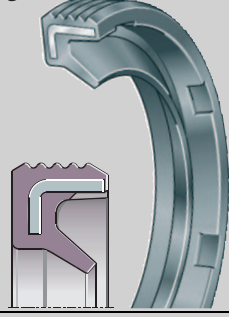
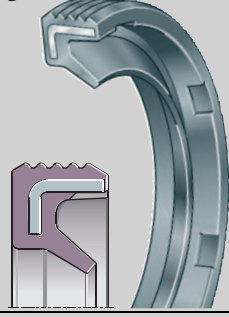
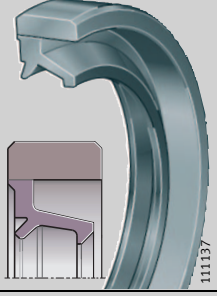
TPI 128 is completely new and replaces publication GSD. Any information in previous editions that does not concur with the data in this edition is therefore invalid.

Sealing rings

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Criteria for selection of sealing rings

		Type				
		GR	G	Special designs		SD
						
		Sealing ring GR	Sealing ring G			Sealing ring SD
Criteria	Page	Single lip	Single lip	G...FPM GR...FPM	G...HNBR GR...HNBR	Double lip
Resistance Mineral oils and greases	20	Normally resistant	Normally resistant	Resistant	Normally resistant	Normally resistant
Highly blended/ synthetic lubricants	20	Conditionally resistant	Conditionally resistant	Normally resistant	Conditionally resistant	Not resistant
Aggressive media	18 20	Consultation necessary	Consultation necessary	Conditionally resistant	Consultation necessary	Not resistant
Weather Light/air	20	Moderate	Moderate	Good	Good	Good
Humidity	–	Good	Good	Good	Good	Good
Contamination resistance (lip facing outwards)	11	Good	Good	Good	Good	Very good
Temperature Minimum/ maximum	20	–30 °C +110 °C	–30 °C +110 °C	–20 °C +160 °C	–30 °C +140 °C	–30 °C +100 °C
Relubrication (lip facing outwards)	–	Good	Good	Good	Good	Satisfactory
Shaft						
Seal integrity	22 to 24	Good	Good	Good	Good	Good
Max. circumferential speed	25	10 m/s	10 m/s	16 m/s	12 m/s	10 m/s
Max. stroke speed	27	3 m/s	3 m/s	3 m/s	3 m/s	3 m/s
Housing						
				Sealing ring		
				GR	G	
Seal integrity	22, 23	Satisfactory	Very good	Satisfactory	Very good	Good
Firm seating	22, 23	Very good	Good	Very good	Good	Good
Press-in force	11, 12	Moderate	Low	Moderate	Low	High
Soft housing material	8	Restricted suitability	Highly suitable	Restricted suitability	Highly suitable	Suitable
High thermal expansion	8	Restricted suitability	Suitable	Restricted suitability	Suitable	Suitable
Roughness of housing bore	–	R _a 3,2	R _a 6,3	R _a 3,2	R _a 6,3	R _a 6,3
Split housing	–	Restricted suitability	Suitable	Restricted suitability	Suitable	Restricted suitability

Caution! Optimum sealing will be achieved if all criteria are carefully weighed and matched.

Product overview Sealing rings

Single lip
Angled reinforcing ring
encased in rubber



External steel reinforcement



Double lip



Sealing rings

Features Sealing rings of series G, GR and SD are matched to the small radial dimensions of INA drawn cup needle roller bearings with open ends and with closed end and of needle roller bearings without an inner ring.

These contact seals protect the sealed area against contamination, spray water and the excessive loss of grease.

In comparison with spring-preloaded rotary shaft seals, they have significantly smaller cross-sectional dimensions, lower friction values and allow space-saving, economical sealing of shafts undergoing rotary and axial motion.

The sealing rings are easy to fit, since they can simply be pressed into the housing bore.

In rotary motion, sealing rings allow high circumferential speeds at the seal lip, depending on the surface quality of the shaft.

Sealing rings G Sealing rings G have a single lip, are made from synthetic NBR elastomer (coloured green) and are suitable for shaft diameters from 8 mm to 80 mm.

They have a rubber-encased angled reinforcing ring made from steel for particular stability. The rubber outer surface has an outside diameter with a wave profile and gives the following advantages:

- improved sealing on the outside diameter
- reduced press-in forces
- fitting with the seal lip facing outwards or inwards, depending on the sealing action required.

The sealing rings are particularly suitable for:

- split housings
- housing materials with high thermal expansion (e. g. aluminium)
- housings with a rough surface ($R_a 6,3$).

Sealing rings GR Sealing rings GR have a single lip, are made from synthetic NBR elastomer (coloured green) and are suitable for shaft diameters from 4 mm upwards.

They have external steel reinforcement for stiffening purposes and in order to increase seating of the sealing ring in the case of small sealing ring widths.

Operating temperature The sealing rings are suitable for operating temperatures from -30 °C to $+110\text{ °C}$, depending on the medium acting on the sealing ring.

Sealing rings

Sealing rings SD

Sealing rings SD have a double lip and are suitable for shaft diameters from 8 mm to 50 mm:

- a contact seal lip essentially prevents the escape of lubricant and unpressurised oil from the bearing arrangement
- a protective lip not in contact with the shaft (marked side) also acts as a gap seal against the ingress of contamination

The space between the seal lip and protective lip must be filled with grease.

The sealing rings comprise two plastic components. The seal carrier is made from reinforced polyamide (coloured black), while the seal lip area is made from thermoplastic PU elastomer (coloured green).

Sealing rings SD are also suitable for use as wipers on shafts undergoing axial motion and allow stroke speeds of up to 3 m/s, depending on the surface quality of the shaft.

Operating temperature

The sealing rings are suitable for operating temperatures from $-30\text{ }^{\circ}\text{C}$ to $+100\text{ }^{\circ}\text{C}$, depending on the medium acting on the sealing ring.

Design and safety guidelines

Tolerances for the housing bore

For firm seating of sealing rings in the housing bore, the housing tolerances should be in accordance with the table Shaft and housing design, page 9.

Chamfers on the housing bore

The housing bore must have a lead chamfer – chamfer dimensions according to *Figure 2*, page 9. The remaining seating length must be at least the nominal width of the sealing rings.

Caution!

If the housing and sealing ring materials have considerably different coefficients of thermal expansion, the firm seating may change under hot or cold conditions.

If the sealing ring GR is fitted with the seal lip facing outwards, it may scrape against the housing bore during fitting, especially where soft housing materials are used, *Figure 1*.

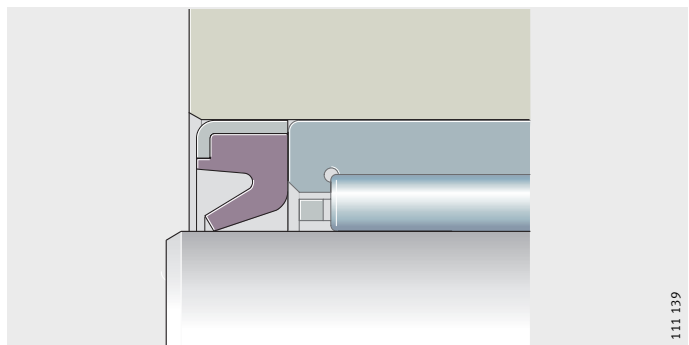


Figure 1
Seal lip facing outwards

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Tolerances and roughness of the shaft surface

For shafts, the tolerances should be in accordance with the table Shaft and housing design. The ISO tolerance class h8 to DIN ISO 286 is also permissible.

The surface roughness must be in accordance with the table Shaft and housing design.

Caution! The sliding surface for the seal lips must be free from score marks and damage such as impact points, scratches, cracks, rust, raised areas.

Chamfers at the end of the shaft

The end of the shaft must have a lead chamfer so that the seal lips are not damaged during fitting – chamfer dimensions according to *Figure 2* and the table Chamfer dimensions or to DIN 3 760.

Hardness of the shaft raceway

The steels normally used in machine building are suitable – raceway hardness according to the table Shaft and housing design. If increased wear is expected, the running surface can be coated. In such cases, please consult Schaeffler KG.

Shaft and housing design

Sealing ring	Shaft movement	Bore tolerance	Shaft	
			Tolerance	Roughness
G, GR, SD	Rotation only	G7 to R7	g7 to k7	$0,2 \leq R_a \leq 0,8$
SD	Axial motion	G7 to R7	g7 to k7	max. $R_a 0,3$
Shaft hardness			min. 55 HRC or 600 HV	

Chamfer dimensions

Chamfer	$D \leq 30$ mm	$D > 30$ mm	$d \leq 30$ mm	$d > 30$ mm
v min.	0,3	1% of D	–	–
w min.	–	–	0,3	0,5

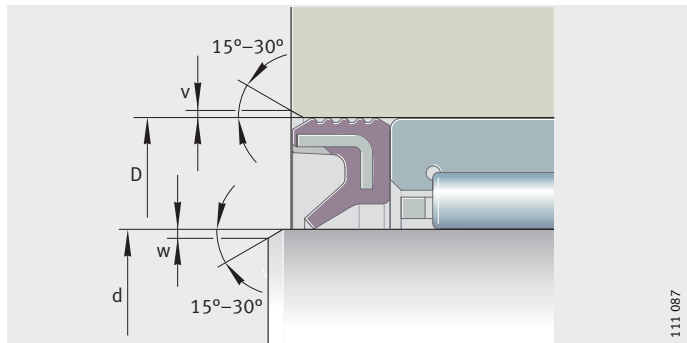


Figure 2
Chamfers on housing bore and shaft end

Sealing rings

Coaxiality and runout

Caution! The coaxiality and runout influence the sealing function and wear at the seal edge.

If the coaxiality between the shaft and housing bore is too large, *Figure 3*, the radial force will be distributed unevenly. This will lead to wear of the seal edge on one side and will reduce the sealing action.

Runout deviations can, especially at high circumferential speeds, increase the seal gap and lead to leakage, *Figure 4*. Do not exceed the limit values for coaxiality and runout, *Figure 5*.

- ① Locating bore
 - ② Centre of bore
 - ③ Shaft
 - ④ Centre of shaft
- T_m = Concentricity deviation
 t_k = Coaxiality tolerance

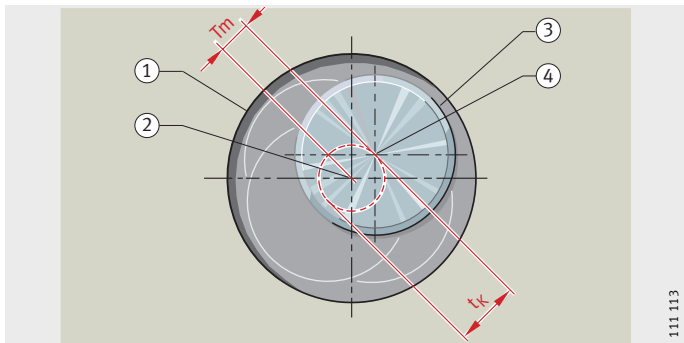


Figure 3
Coaxiality

- ① Locating bore
 - ② Outer limit circle
 - ③ Inner limit circle
 - ④ Shaft
- t_R = Runout tolerance

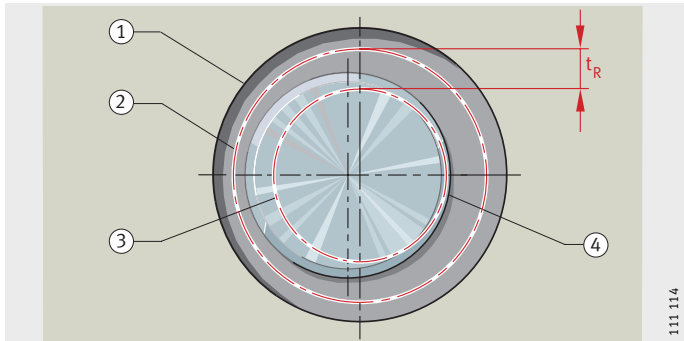


Figure 4
Runout

- ① Coaxiality and runout
- ② Shaft diameter
- ③ Total of coaxiality and runout tolerance $t_k + t_R$
- ④ Coaxiality t_k
- ⑤ Runout t_R

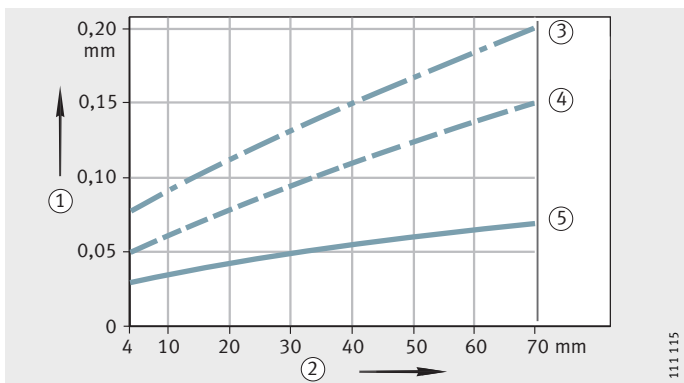


Figure 5
Limit values for coaxiality and runout

Design of the axial adjacent construction

Caution! The adjacent construction should be designed such that the seal lips are not constrained in an axial direction.

Fitting

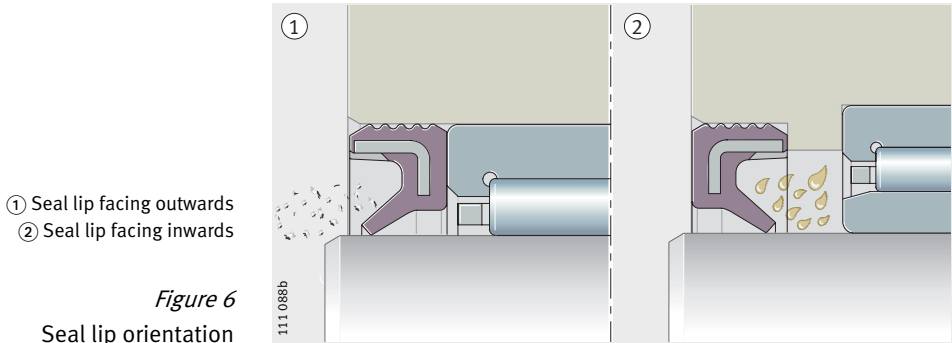
Caution! Sealing rings must be handled and fitted correctly. This is the only way to ensure that they fulfil their sealing function correctly for a long period.

Pay attention to the orientation of the seal lip.

A seal lip facing outwards prevents the ingress of dust and contaminants, *Figure 6, ①*.

A seal lip facing inwards prevents the escape of lubricant, *Figure 6, ②*.

On sealing rings SD, the side with the protective lip is the marked side. If it should be relubricated from inside, the lip must face outwards.



Sealing rings

Oil or grease the running surface of the shaft and seal lip. This reduces the frictional energy during initial movement. In the case of sealing rings with an encased reinforcing ring – sealing ring G – the outer surface should be oiled before the seal is pressed in. This makes it easier to fit the seal in the housing.

Press sealing rings carefully into the housing bore using a pressing device and a suitable pressing tool, *Figure 7*.

Ensure that the seal lip is not damaged. Cover any sharp shaft edges, slots, teeth or threads using fitting sleeves, *Figure 8*.

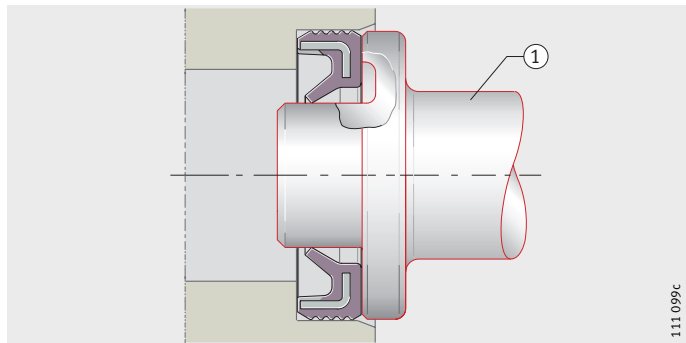
Fit sealing rings in such a way that the pressing-in force is applied as close as possible to the outside diameter.

Sealing rings SD have an oversized outside diameter. This gives firm seating once the rings are pressed into the housing bore. The rings will adopt their correct geometrical form once fitted in the bore.

① Pressing tool

Figure 7

Fitting using a pressing tool

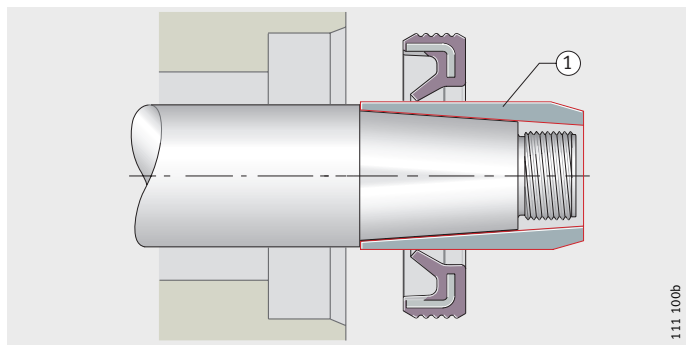


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① Fitting sleeve

Figure 8

Fitting using a fitting sleeve



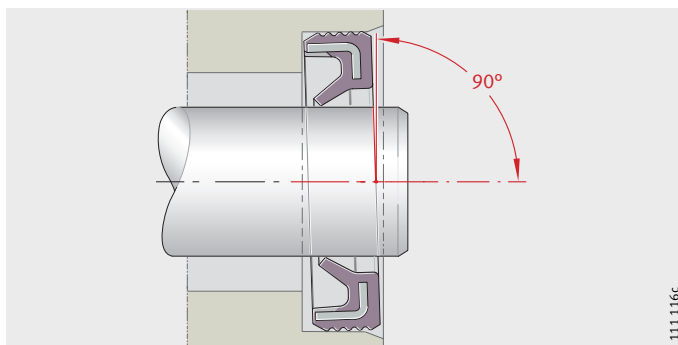
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Caution! Fit sealing rings perpendicular to the shaft axis and the housing bore, *Figure 9*. Do not exceed the maximum perpendicularity between the sealing ring and the shaft axis once fitted, see table Maximum perpendicularity deviation. A larger deviation will influence the sealing action.

Maximum perpendicularity deviation

Shaft diameter d mm	Maximum deviation mm
d < 25	0,1
d ≥ 25	0,2

Figure 9
Perpendicularity – position of sealing ring relative to shaft axis/housing bore



In sealing rings SD, the space between the seal lip and protective lip must be filled with grease, *Figure 10*.

After fitting, allow the sealing rings to run in and check the sealing function. Slight leakage (forming a grease or liquid film) is desirable in order to lubricate the contact surface for the seal lips.

A collar of grease will assist the sealing action, *Figure 11*.

During relubrication, increase the pressure only slowly.

Figure 10
Grease filling between sealing lip and protective lip

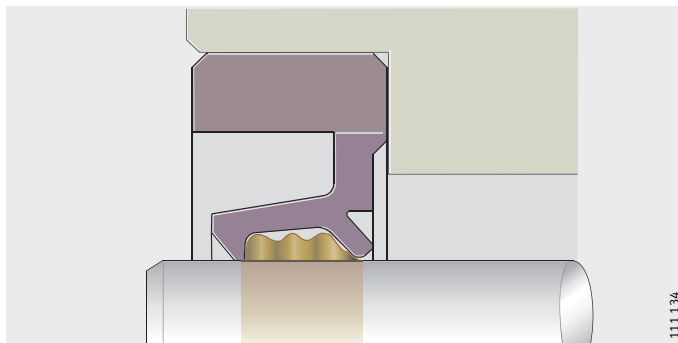
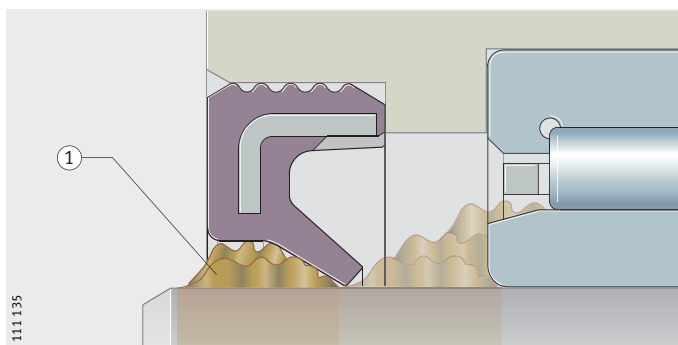


Figure 11
Grease collar



Sealing rings

Storage Sealing rings should be stored in dry, dust-free rooms – relative humidity max. 65%, moderate ventilation, free from draughts. Observe the storage room requirements in accordance with DIN 7 716.

Sealing rings should be stored at an air temperature of $+20\text{ °C} \pm 5\text{ °C}$ free from stress, i.e. without tension, compression or deformation.

Do not allow the rings to come into contact with chemicals such as acids, solvents or fuels.

Protect sealing rings from:

- direct sunlight
- UV light
- ozone (e.g. produced by electrical equipment)
- intense thermal radiation.

Caution! If these conditions are not maintained, this may cause unfavourable changes in the physical characteristics of the sealing rings (e.g. hardening).

Do not remove sealing rings from their original packaging until immediately before fitting.

The maximum storage time from manufacture to fitting is:

- 5 years for NBR
- 10 years for FPM/HNBR.

Cleaning

Caution! Solvents must not be used for cleaning. Observe the guidelines on the cleaning of rubber products according to DIN 7 716.

Sealing rings G and GR can be cleaned using a glycerine/ spirit mixture (1:10 ratio).

Sealing rings SD can be cleaned using a warm soap solution.

Heavily contaminated or greased sealing rings should be cleaned first with a soft cloth – sharp-edged objects must not be used.

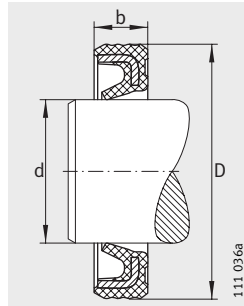
After cleaning, sealing rings should be allowed to dry at room temperature – max. $+40\text{ °C}$.

Special designs

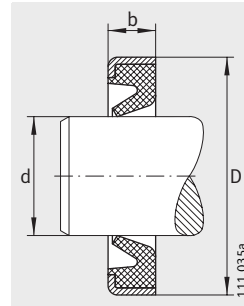
Available by agreement:

- sealing rings G and GR for temperatures from -20 °C to $+160\text{ °C}$ or circumferential speeds up to 16 m/s and 12 m/s respectively; pay attention to compatibility with media
- materials based on fluoro rubber, suffix FPM, HNBR.

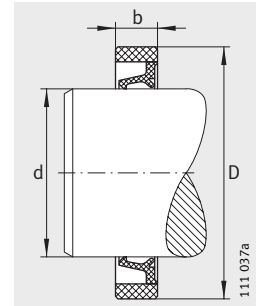
Sealing rings



G



GR



SD

Dimension table · Dimensions in mm

Design			Designation			Mass		
G	GR	SD	d ×	D ×	b ¹⁾	G	GR	SD
						≈ g		
–	2)	–	4	8	2	–	0,2	–
–	2)	–	5	9	2	–	0,2	–
–	2)	–	5	10	2	–	0,2	–
–	2)	–	6	10	2	–	0,2	–
–	2)	–	6	12	2	–	0,4	–
–	2)	–	7	11	2	–	0,3	–
–	2)	–	7	14	2	–	0,5	–
2)	4)	4)	8	12	3	0,4	–	–
2)	4)	2)	8	15	3	0,7	–	0,3
2)	2)	4)	9	13	3	0,5	0,5	–
2)	4)	4)	9	16	3	0,7	–	–
2)	2)	4)	10	14	3	0,5	0,5	–
2)	4)	2)	10	17	3	0,9	–	0,4
2)	2)	4)	12	16	3	0,6	0,6	–
2)	4)	2)	12	18	3	0,9	–	–
2)	2)	2)	12	19	3	1	1	0,5
2)	4)	4)	13	19	3	0,9	–	–
2)	3)	2)	14	20	3	1	1	0,5
2)	4)	4)	14	21	3	1,1	–	–
2)	3)	2)	14	22	3	1,3	1,1	0,7
2)	3)	2)	15	21	3	1	1	0,5
2)	3)	2)	15	23	3	1,3	1,3	0,7
2)	3)	2)	16	22	3	1,3	1,3	0,6
2)	3)	2)	16	24	3	1,3	1,3	0,7
2)	4)	4)	16	25	3	1,6	–	–
2)	3)	2)	17	23	3	1,3	1,3	0,6
2)	4)	2)	17	25	3	1,5	–	0,8
2)	4)	2)	18	24	3	1,2	–	0,6
2)	4)	2)	18	26	4	1,8	–	1,1
2)	4)	2)	19	27	4	2	–	1,1
2)	3)	2)	20	26	4	1,8	1,8	0,8
2)	3)	2)	20	28	4	2,1	2,1	1,1
2)	4)	4)	21	29	4	2,2	–	–
2)	3)	2)	22	28	4	1,8	1,8	0,9
2)	3)	2)	22	30	4	2,2	2,2	1,3

Dimension table (continued) · Dimensions in mm

Design			Designation			Mass		
G	GR	SD	d ×	D ×	b ¹⁾	G	GR	SD
						≈ g		
2)	3)	4)	24	32	4	2,5	2,5	–
2)	3)	2)	25	32	4	2,3	2,3	1,3
2)	4)	2)	25	33	4	2,5	–	1,3
2)	3)	2)	25	35	4	2,6	2,6	1,9
2)	4)	2)	26	34	4	2,6	–	1,4
2)	3)	2)	28	35	4	2,4	2,4	1,3
2)	3)	4)	28	37	4	3,1	3,1	–
2)	4)	4)	29	38	4	3,2	–	–
2)	3)	2)	30	37	4	2,7	2,7	1,3
2)	3)	2)	30	40	4	3,6	3,6	2,1
2)	4)	2)	32	42	4	3,7	–	2,4
2)	4)	4)	32	45	4	5,1	–	–
2)	3)	2)	35	42	4	3	4	1,5
2)	4)	2)	35	45	4	4,1	4,1	2,5
2)	4)	2)	37	47	4	4	–	2,7
2)	4)	2)	38	48	4	4,4	–	2,8
2)	4)	2)	40	47	4	3,3	–	1,7
2)	3)	2)	40	50	4	4,6	4,6	2,9
2)	3)	2)	40	52	5	4,8	4,8	4,5
2)	3)	2)	42	52	4	4,7	4,7	3
2)	4)	4)	43	53	4	4,8	–	–
2)	3)	2)	45	52	4	3,8	3,8	1,9
2)	3)	2)	45	55	4	5,2	5,2	3,2
2)	3)	2)	50	58	4	4,5	4,5	2,4
2)	3)	2)	50	62	5	10,4	10,4	5,5
2)	3)	–	55	63	5	7,1	7,1	–
2)	3)	–	70	78	5	9	9	–
2)	4)	–	80	90	5	13,8	–	–

Special designs available by agreement, see page 14.

1) Width tolerance +0,1/–0,2.

2) **Standard range.**

3) Please enquire on delivery capability.

4) Available by agreement for economically viable batch sizes.

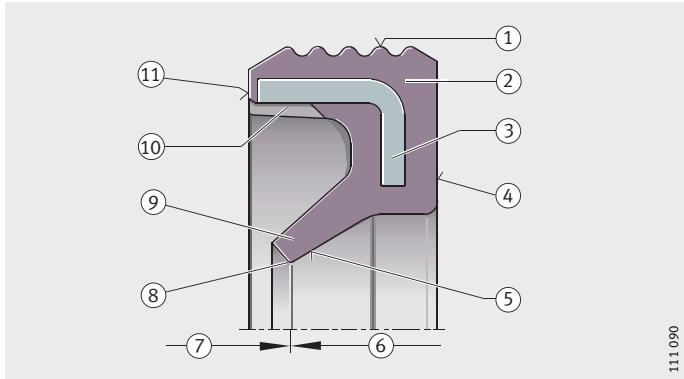
Sealing rings

Structure of sealing rings

Sealing ring terms

- ① Outside surface
- ② Rubber casing
- ③ Angled reinforcing ring
- ④ Back surface (with marking)
- ⑤ Contact surface
- ⑥ Back face
- ⑦ End face
- ⑧ Seal edge
- ⑨ Seal lip
- ⑩ Locating recess
- ⑪ End surface

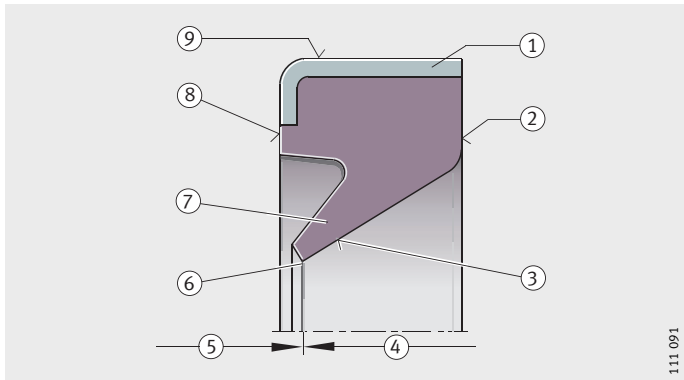
Figure 1
Sealing ring G



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- ① Angled reinforcing ring
- ② Back surface (with marking)
- ③ Contact surface
- ④ Back face
- ⑤ End face
- ⑥ Seal edge
- ⑦ Seal lip
- ⑧ End surface
- ⑨ Outside surface

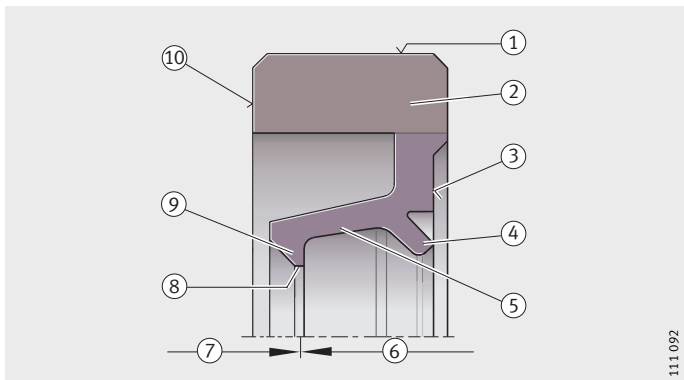
Figure 2
Sealing ring GR



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- ① Outside surface
- ② Carrier
- ③ Back surface (with marking)
- ④ Protective lip
- ⑤ Membrane
- ⑥ Back face
- ⑦ End face
- ⑧ Seal contact surface
- ⑨ Seal lip
- ⑩ End surface

Figure 3
Sealing ring SD



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Materials and characteristics

The selection of sealing ring material is determined by the interaction of the contact media, the mechanical characteristics of the material and the operating temperature.

INA sealing rings are made from elastomer materials. They are manufactured using pressing and injection moulding methods.

Elastomers are wide-mesh, high-polymer materials with rubber-elastic characteristics. They exhibit viscoelastic behaviour, with the elastic influence predominant.

Due to the viscoelasticity, elastomers gradually return to their original condition once stress is relieved.

Elastomers are characterised principally by their hardness and compression or tension set.

Hardness

The hardness is determined using test plates.

The principal test methods used are:

- Shore A for testing of “softer” seal materials (scale 10–90 Shore A)
 - truncated cone, tolerance ± 5 Shore A
- Shore D for testing of “harder” seal materials (scale 30–90 Shore D)
 - cone point, tolerance ± 3 Shore D.

Values in accordance with table Materials, ageing and media resistance, page 20.

The micro ball indentation hardness test according to IRHD (International Rubber Hardness Degree) can be used to determine hardness values for the finished product using a suitable testpiece geometry.

The hardness influences the radial force at the seal edge.

Compression or tension set

The compression and tension set is defined as the permanent deformation of an elastomer testpiece after compression or tension under defined conditions – temperature, time.

The lower the compression or tension set, the longer the elastomer will maintain a constant radial force at the seal edge.

Sealing rings

Sealing ring materials

The sealing ring materials used and their characteristics are listed in the table Materials, ageing and media resistance, page 20. The elastomer materials are specified in a number of technical delivery conditions.

Acrylonitrile butadiene rubber NBR

Sealing rings of series G and GR are based on a high quality synthetic NBR elastomer material.

The acrylonitrile (ACN) content essentially determines the characteristics of the NBR.

As the ACN content increases:

- the resistance to swelling in mineral oils, greases and fuels increases
- cold flexibility and elasticity decreases
- the compression set deteriorates.

These characteristics show the opposite trend as the ACN content decreases.

Sealing rings of series G and GR have a balanced composition and have particularly good resistance to wear and heat due to an active filler material.

Fluoro elastomer FPM, HNBR

Sealing rings of series G and GR made from fluoro elastomer (FPM and HNBR) are also available.

Due to the FPM and HNBR quality, INA sealing rings have particularly good resistance to heat and media (table Materials, ageing and media resistance, page 20).

They are resistant to:

- mineral oils and greases
- fuels
- poorly flammable fluids of type HFD
- aliphatic and aromatic hydrocarbons
- silicone oils and silicone greases.

They are not resistant to:

- polar solvents, brake fluids based on glycol and superheated water vapour.

Thermoplastic polyurethane elastomer TPE-U

Sealing rings of series SD have a lip area made from thermoplastic polyurethane elastomer.

Due to its particular structure, thermoplastic polyurethane elastomer has rubber-elastic characteristics. It is highly wear-resistant and also resistant to environmental influences and many mineral oils.

Polyurethane may change colour due to exposure to light. However, this does not influence the mechanical and chemical characteristics of the material.

Materials for carrier and reinforcing parts

The angled reinforcing rings in sealing rings G and GR are made from formed sheet steel to DIN 1623 and DIN 1624 respectively.

The carrier in sealing rings SD is made from glass fibre reinforced polyamide PA 66 GF. Polyamide is a thermoplastic material and is tough and temperature-resistant due to its hydrogen bonding.

It is highly wear-resistant, resistant to almost all solvents and resistant to mineral oils and mineral greases.

Sealing rings

Materials, ageing and media resistance

Material Resistance	Sealing rings of standard design G, GR
Material	Acrylonitrile butadiene rubber
Designation to DIN 3 760 to ISO 1629	NB NBR
Colour	Green (RAL water blue 5 021)
For temperatures²⁾	From -30 °C to +110 °C
Hardness³⁾	70 to 75 ±5 Shore A
Compression set – DVR³⁾	Very low
Strength³⁾	Very good
Ageing resistance⁴⁾ Light	Satisfactory
Ozone	Satisfactory
Media resistance⁴⁾ Mineral oils Naphthenic-base	Conditionally resistant
Paraffin-base	Resistant
Polyalphaolefins or polyalphaolefin ester (10%) mixture	Resistant
Ester Diester	Not resistant
Polyester	Not resistant
Polyglycols Short-chain mixtures	Not resistant
Long-chain mixtures	Resistant
Alkoxy fluoro ether	Resistant
Poorly flammable fluids HFA (95% water, 5% oil)	Conditionally resistant
HFC (water, glycol)	Conditionally resistant
HFD (chlorinated hydrocarbons, phosphate esters)	Not resistant

¹⁾ With increasing operating temperature, decreasingly resistant under humid conditions.

²⁾ Dependent on the medium (see DIN 3 760).

³⁾ Dependent on temperature and time.

⁴⁾ The data are guide values and are only valid for temperatures up to approx. 80% of the maximum temperature. They cannot be transferred without restriction to all operating conditions. If in doubt, please contact us.

	Sealing rings of special design		Material Resistance
SD	G, GR	HNBR	
Thermoplastic polyurethane elastomer ¹⁾	Fluoro rubber		Material
– AU	FP FPM	HNBR	Designation to DIN 3 760 to ISO 1 629
Green	Brown	Black	Colour
From –30 °C to +100 °C	From –20 °C to +160 °C	From –30 °C to +140 °C	For temperatures²⁾
47 ± 3 Shore D	70 to 75 ± 5 Shore A	70 to 80 ± 5 Shore A	Hardness³⁾
Moderate, increases with temperature	Low	Low	Compression set – DVR³⁾
Very good	Good	Very good	Strength³⁾
Very good	Very good	Very good	Ageing resistance⁴⁾ Light
Good	Very good	Very good	Ozone
			Media resistance⁴⁾
Normally resistant	Resistant	Conditionally resistant	Mineral oils Naphthenic-base
Normally resistant	Resistant	Resistant	Paraffin-base
Conditionally resistant	Resistant	Resistant	Polyalphaolefins or polyalphaolefin ester (10%) mixture
Conditionally resistant	Conditionally resistant	Not resistant	Ester Diester
Conditionally resistant	Conditionally resistant	Not resistant	Polyester
Not resistant	Resistant	Not resistant	Polyglycols Short-chain mixtures
Not resistant	Resistant	Resistant	Long-chain mixtures
Not resistant	Resistant	Resistant	Alkoxy fluoro ether
Not resistant	Conditionally resistant	Not resistant	Poorly flammable fluids HFA (95% water, 5% oil)
Not resistant	Conditionally resistant	Not resistant	HFC (water, glycol)
Not resistant	Resistant	Not resistant	HFD (chlorinated hydrocarbons, phosphate esters)

Sealing rings

Operating behaviour

Sealing rings are normally used with rotating shafts.

Static sealing of the housing bore

The outside surface of the sealing rings gives static sealing of the housing bore. The sealing action is achieved when the sealing ring is pressed into the housing bore with an interference fit, *Figure 4*.

The firm seating and sealing action are decisively influenced:

- by the design and accuracy of the housing bore
- by the outside surface of the sealing ring
- by correct fitting of the sealing rings.

The rubber-encased sealing rings G adapt particularly well to the surface of the housing bore. As a result, they are used in preference for the sealing of fluid media.

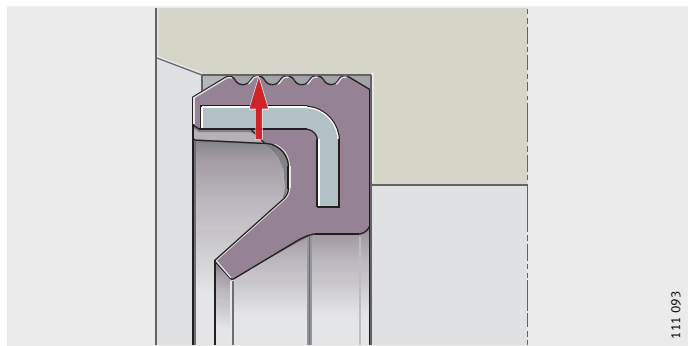


Figure 4

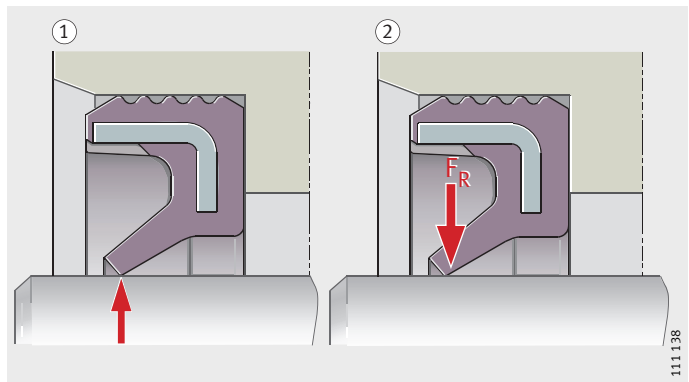
Static sealing of the housing bore

Static/dynamic sealing of the shaft

The diameter of the seal lip in the unfitted seal is smaller than the shaft diameter. As a result, the seal lip in the unfitted seal has interference of the radial force F_R (press-on force). The radial force is the sum of all the component forces from the seal edge of the seal lip that act towards the centre point of the shaft, *Figure 5*.

It is dependent on:

- the deformation values of the seal lip – e.g. compression set, material hardness
- the geometry of the seal lip
- the operating temperature.



① Static/dynamic sealing of the shaft

② Radial force F_R

Figure 5

Sealing of the shaft/radial force F_R

Static sealing With a stationary shaft, the seal integrity is primarily determined by the radial force.

Dynamic sealing With a rotating shaft, the seal integrity is additionally influenced by:

- the shaft surface
- the geometrical tolerances – e.g. coaxiality, runout, perpendicularity
- tribological factors – lubrication, friction, wear
- the speed
- the temperature
- contamination.

Changes in the radial forces

The radial forces change during operation.

Decreases in the forces may be due to:

- thermal expansion of the seal lip ($\alpha_{\text{elastomer}} \approx 10 \times \alpha_{\text{steel}}$) leading to a reduction in interference
- relaxation, defined by the compression set
- wear of the seal edge, especially under dry running and heavy contamination.

Even if the radial forces diminish over time during operation, the lip still gives sufficiently secure sealing.

Increases in the radial forces may be due to:

- contractions of the seal lip towards the inside due to cold and swelling of the elastomer material.

Interference

Assuming that sealing rings are of the same design and made from the same material, the following will apply at the same temperature and in the same mounting position, *Figure 6*:

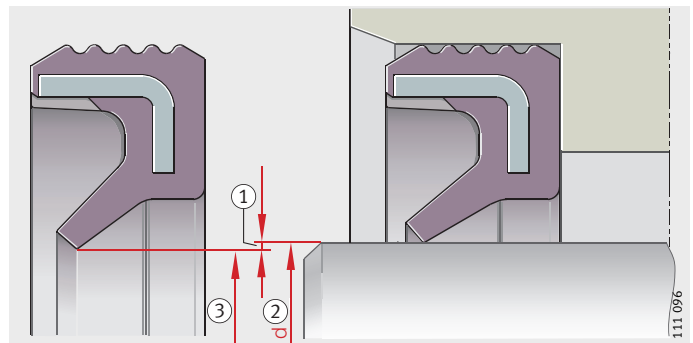
- a large interference between the shaft and seal lip diameter will initially give high radial forces. This will lead to an increase in friction, heat and running-in wear at the contact surface
- a small interference will give low radial forces. In this case, the friction, heat generation and wear will be lower.

If the recommended mounting tolerances are observed, INA sealing rings will give reliable sealing. The radial forces and heat generation at the contact surface will remain at their lowest possible level.

- ① Interference
- ② d = shaft diameter
- ③ d = loose

Figure 6

Interference of shaft and seal lip diameter



Sealing rings

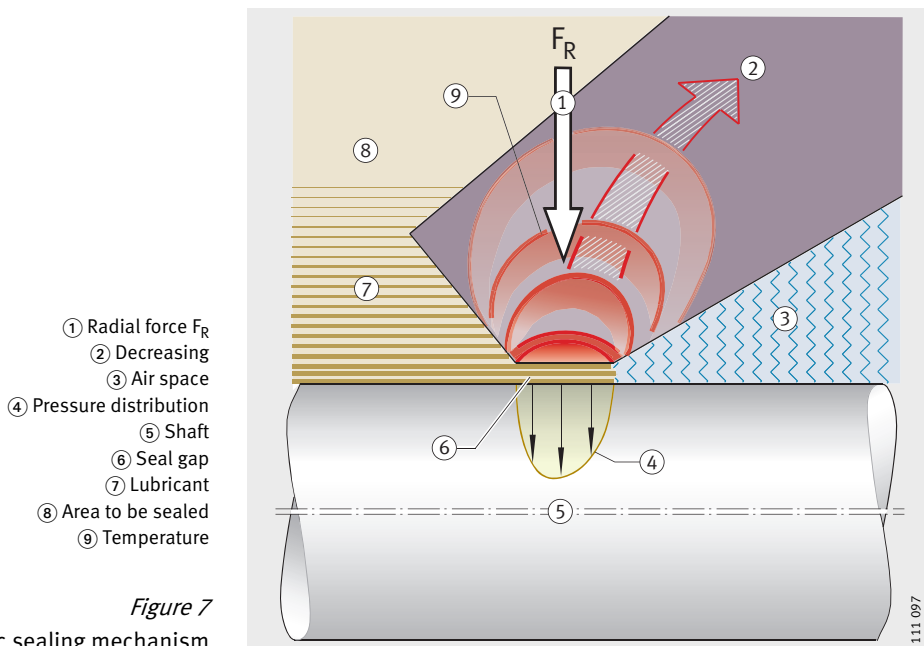
Dynamic sealing mechanism

The seal edge distributes the pressure of the radial force F_R to the shaft. At the contact surface, the adhesive friction present during standstill is converted to sliding friction when movement begins. This reduces the pressure on the seal lip, *Figure 7*.

The lubricant is drawn into the seal gap as far as the seal edge by means of its capillary forces.

The lubricant cools and reduces the pressure on the contact surface.

Once the circumferential speed is reached, a condition of mixed friction generally occurs (solid body and fluid friction). In an ideal situation, only fluid friction is present.



Temperature

The permissible temperature is dependent on the interaction between the medium and the temperature and its effect on the sealing ring material.

Caution! With increasing circumferential speed, the temperature at the contact surface increases as a result of the increasing shear forces in the lubricant and the low thermal conductivity of the elastomer.

If there are internal vibrations in the elastomer, e.g. due to deviations in runout or under inadequate lubrication, the temperature at the seal edge can increase by up to +50 °C, or in extreme cases by up to +80 °C.

If the temperature of the seal edge increases too much, wear and heat cracks may occur that impair the seal integrity.

The suitability of the sealing rings should be checked by tests as the temperature limits are approached.

Circumferential speed

Sealing rings made from the standard materials NBR and TPE-U can be used at circumferential speeds up to 10 m/s.

Sealing rings made from the special materials FPM and HNBR are suitable for circumferential speeds up to 16 m/s and 12 m/s respectively.

Caution! These limit values are only valid if there is no excess pressure in the area towards which the seal lip is facing and if there is adequate lubrication and cooling of the seal edge.

At circumferential speeds close to the limit value, oil lubrication is more beneficial than grease lubrication.

Lubrication

Caution! Sealing rings only function reliably if the seal edge is continually lubricated.

Heat is generated at the seal edge. This is mainly dissipated to the shaft by the moving lubricant.

Since elastomer gives only poor conduction of heat ($\lambda_{\text{steel}} \approx 100 \times \lambda_{\text{elastomer}}$), heat cracks and wear can occur at the seal edge under inadequate lubrication.

With grease lubrication, a grease collar protects the edge from excessive heating.

Friction

The friction is determined by:

- the material pair – elastomer/steel
- the shaft surface
- the interference (radial force F_R)
- the lubrication of the contact surface – shaft/seal edge.

With a rotating shaft, the adhesive friction present during standstill is converted to sliding friction. If lubricant is supplied, mixed friction occurs.

The frictional power of the sealing rings increases with the diameter and the speed of the shaft. With appropriate lubrication, it is between 10 watts and 80 watts ($n = 3\,000 \text{ min}^{-1}$).

When the shaft starts to move, the frictional torque is higher than in normal operation, especially after a long period of standstill.

Wear

The following type of wear can occur at the seal edge:

- adhesive wear, e.g. if the seal lip sticks to the shaft after a long period of standstill
- abrasive wear
 - if the seal edge slides on the contact surface
 - under dry running
 - if there are contaminant particles between the seal edge and the contact surface.

After an extended running time, deposits may build up on the shaft/seal edge contact surface – e.g. comprising carbon and additive residues. These deposits can influence the sealing function and lead to leakage.

Wear grooves may occur on the shaft, especially if a soft shaft material is used or there is a heavy stream of contaminant particles.

The wear can be reduced by using a hardened shaft material or coated shafts.

The abrasion resistance of NBR, FPM and HNBR elastomer is good, the abrasion resistance of TPE-U is very good.

Sealing rings

Leakage In leakage, the medium escapes from the area to be sealed, especially at the seal edge.

Slight leakage cannot be completely prevented with contact seals due to the sealing mechanism – even if the sealing ring is fully functional.

Leakage can occur in the form of gas or vapour leakage and in the form of droplet or drop leakage.

In droplet or drop leakage, a thin film of fluid is formed on the shaft.

Operating life Physical, chemical and mechanical influences determine the operating life of sealing rings, *Figure 8*.

These include:

- ageing; the elastomer structure may undergo thermo-oxidative degradation, further crosslinking or embrittlement
- the medium; media (fluids) may be dispersed within the structure or dissolve elastomer components. The elastomer may swell or contract as a result. If several media are affecting the seal at the same time, volume changes can be superimposed on each other and may be difficult to detect by optical means
- the temperature; high temperatures and/or aggressive media can accelerate the decomposition and ageing processes
- wear and contamination.

The interaction of these influences is very complex. As a result, it is not possible to calculate the operating life of sealing rings; only values based on practical experience can be given.

Under normal operating conditions, seals can achieve a maximum operating life of:

- 10 000 operating hours in continuous operation or 3 to 5 years.

The data in the table Materials, ageing and media resistance, page 20, can be taken as guide values. They cannot be transferred without restriction to all operating conditions.

Caution! If there is any doubt, please consult Schaeffler KG.

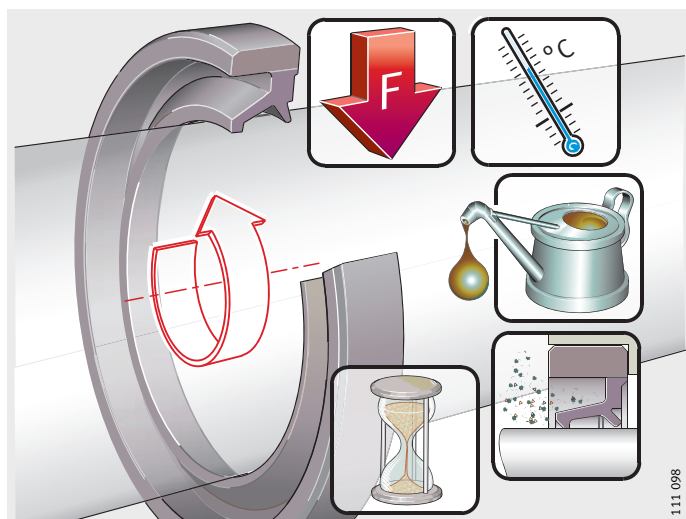


Figure 8
Factors influencing the operating life

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Axial motion of the shaft

In the case of shafts with axial motion, two types of motion may occur:

- pure axial motion
- rotary motion overlaid with axial motion.

Pure axial motion

In this case, the sealing ring acts as a wiper. The seal lip faces outwards.

As in the case of rotating shafts, the sealing ring performs a dual function:

- it retains the lubricant in the area to be sealed
- it prevents contaminants from penetrating the area to be sealed.

The interference of the shaft and seal lip diameter determines the sealing action.

On the entry stroke of the shaft, the sealing ring wipes away the lubricant and contaminant particles. The seal lip slides on the remaining lubricant film. On the counterstroke, lubricant is drawn out through the seal gap. This increases the lubricant film on the shaft again.

If there is a lack of lubricant, the seal lip is not lubricated. The displacement forces increase as a result of dry running. Furthermore, the seal lip is damaged.

Sealing rings SD, G and GR

Sealing rings SD have a harder and stiffer lip material than sealing rings G as well as an additional protective lip. They are therefore particularly suitable for axial motion.

In special cases, two sealing rings G, GR can be fitted adjacent to each other.

Caution! The G sealing rings must be fitted so that one seal lip faces outwards and one seal lip faces inwards.

The sealing function increases, the lower the surface roughness of the shaft.

Stroke speeds of up to 3 m/s are possible.

Rotary motion overlaid with axial motion

Overlaid axial motion can be caused by thermal expansion, stroke motion – e.g. due to axial internal clearance – or axial vibration of the shaft. They are normally small and, in the case of single stroke motion, are within a few tenths of a millimetre or at frequencies up to 10 Hz.

INA sealing rings adapt particularly well to these combined motions. If appropriate lubrication is provided, the seal lip follows the axial motions without stick-slip due to the low radial forces.

Application examples

Truck Kingpin

The bearings perform only small swivel motions, *Figure 1*, ①. Due to uneven road surfaces, however, very high shock type forces can occur during operation. These forces must be supported radially ② and axially ③.

The bearing arrangement for radial load is not encapsulated. It must therefore be effectively protected against contamination, dust, moisture and salt water.

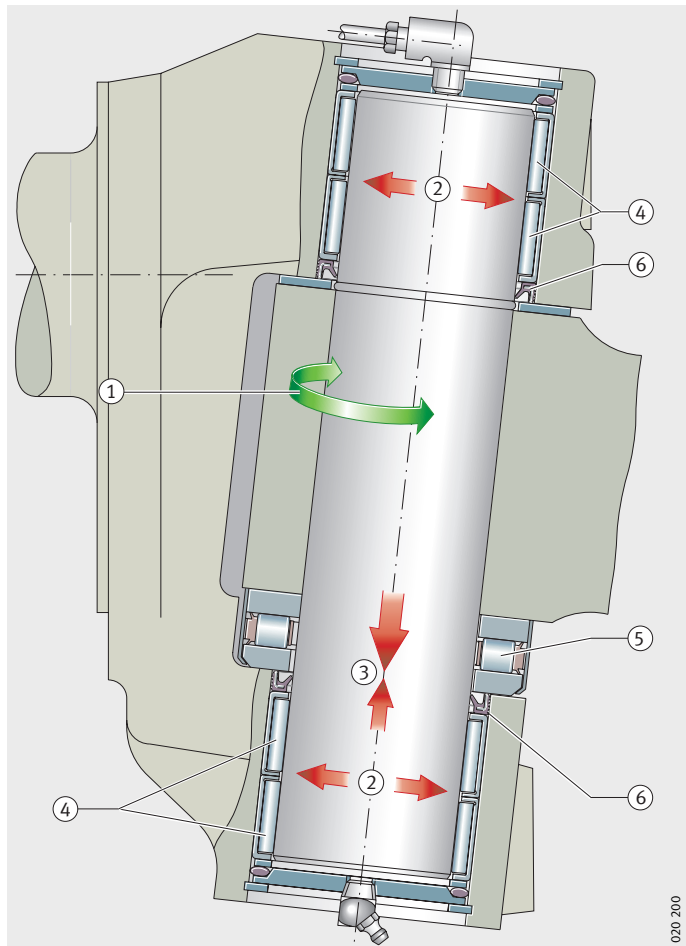
Design solution

The kingpins are supported radially in full complement drawn cup needle roller bearings HN ④. Due to the full complement design, these bearings are particularly compact and have high load carrying capacity and rigidity. The axial forces are supported by encapsulated axial cylindrical roller bearings AR ⑤.

The drawn cup needle roller bearings are supported on the inside by sealing rings G ⑥. The seal lips face outwards and open during lubrication of the bearings. As a result, a grease collar is formed on the seal edge that gives the bearings additional protection against contamination, moisture and water.

- ① Swivel motion
- ② Radial load
- ③ Axial load
- ④ Drawn cup needle roller bearing HN
- ⑤ Encapsulated axial cylindrical roller bearing AR
- ⑥ Sealing ring G

Figure 1
Design solution



Hand drill Work spindle

Due to the two-speed gearbox in this power tool, it is possible to deliver high torque at low speeds for drilling large diameter holes or high speeds for drilling small diameter holes.

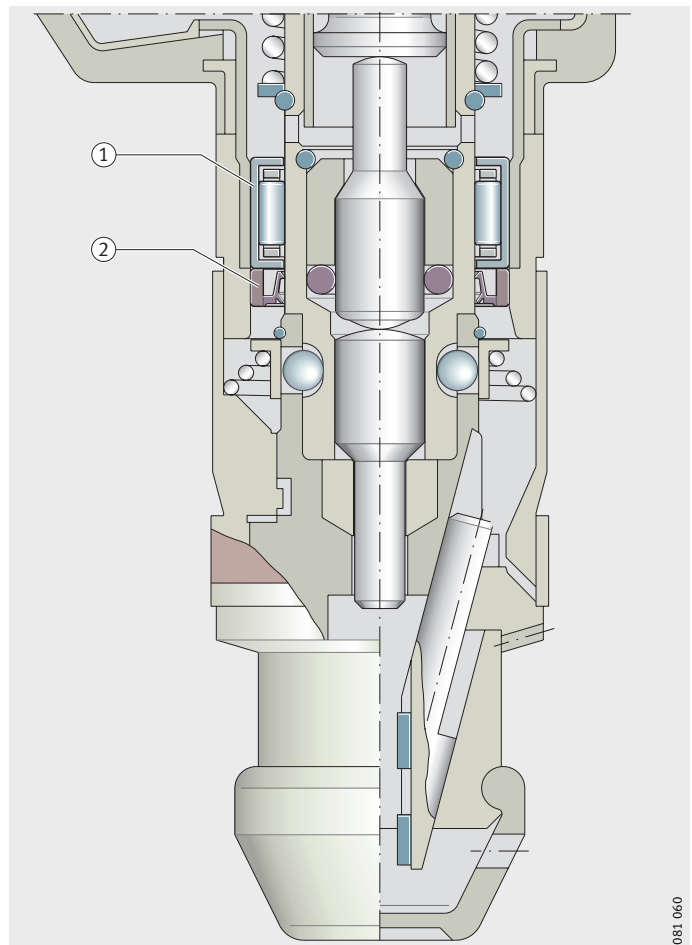
The drills are compact, robust and maintenance-free.

The bearing arrangement of the work spindle must be protected against loss of grease from the inside and fine dust from the outside.

Design solution

The work spindle is supported by a drawn cup needle roller bearing HK, *Figure 2*, ①. This bearing has an extremely small radial and axial design envelope, is very easy to fit and is greased for life.

The drawn cup needle roller bearing is sealed by a double lip seal SD ②. The seal lip faces inwards and is the principal component retaining the grease in the bearing. The additional protective lip gives protection against debris and dust from outside.



- ① Drawn cup needle roller bearing HK
- ② Sealing ring SD

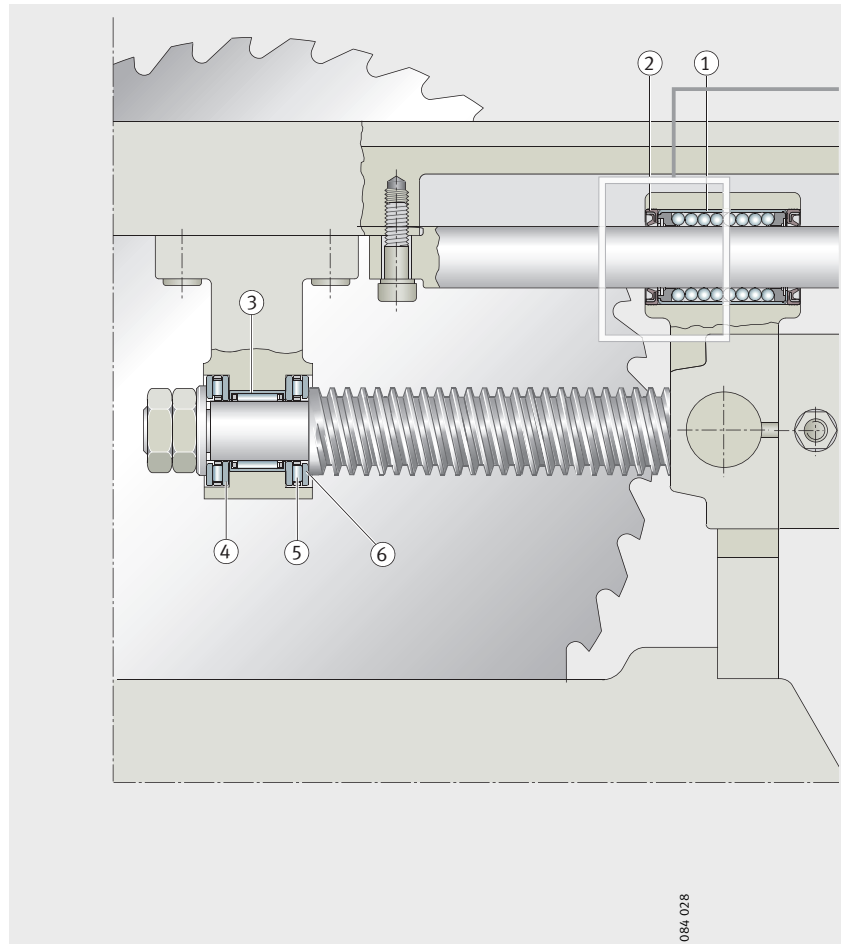
Figure 2
Design solution

Application examples

Circular saw Table guidance system

The circular saw is used to cut profiled sections made from steel, non-ferrous metals and plastics. The profiles are fed to the saw blade by a table. The table is adjusted by a manual rapid adjustment device or the threaded spindle.

The guidance system must be smooth-running, wear-resistant, clearance-free and maintenance-free. The rolling element system must not come into contact with contamination and swarf.



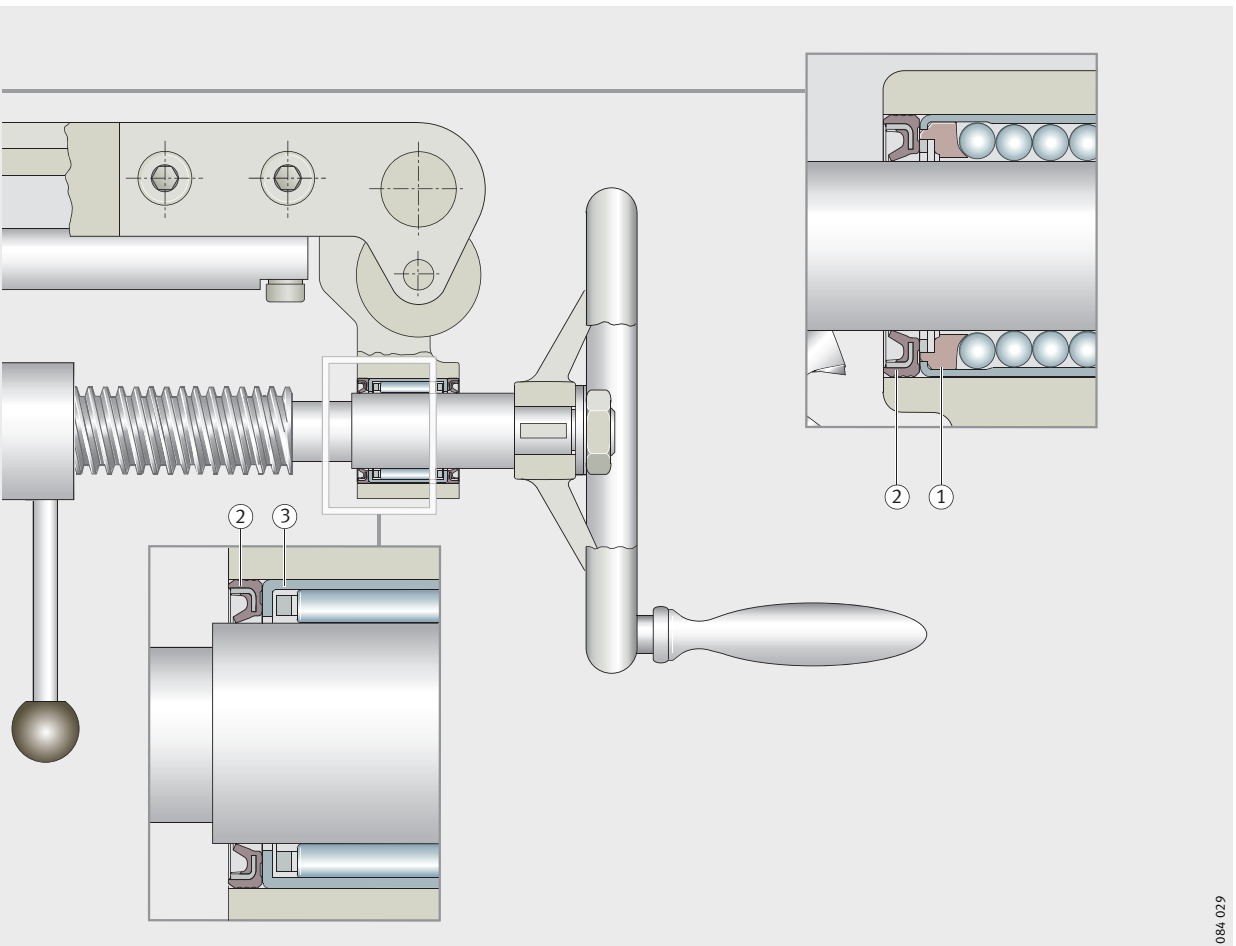
- ① Linear ball bearing KH
- ② Sealing ring G
- ③ Drawn cup needle roller bearing HK
- ④ Axial bearing washer GS
- ⑤ Axial needle roller and cage assembly AXK
- ⑥ Axial bearing washer WS

Figure 3
Design solution

Design solution

The threaded spindle is supported on the locating and non-locating side by drawn cup needle roller bearings HK, *Figure 3*, ③. The axial forces on the locating bearing side are supported by an axial needle roller and cage assembly AXK ⑤. The mating raceways for the needle roller and cage assembly are axial bearing washers GS ④ and WS ⑥. The nuts are guided on hardened and ground rods by linear ball bearings KH ①.

The bearing on the non-locating bearing side and the linear ball bearings are sealed on both sides by sealing rings G ②. The seal lips face outwards and also act as contamination wipers. All the bearings are greased for life.



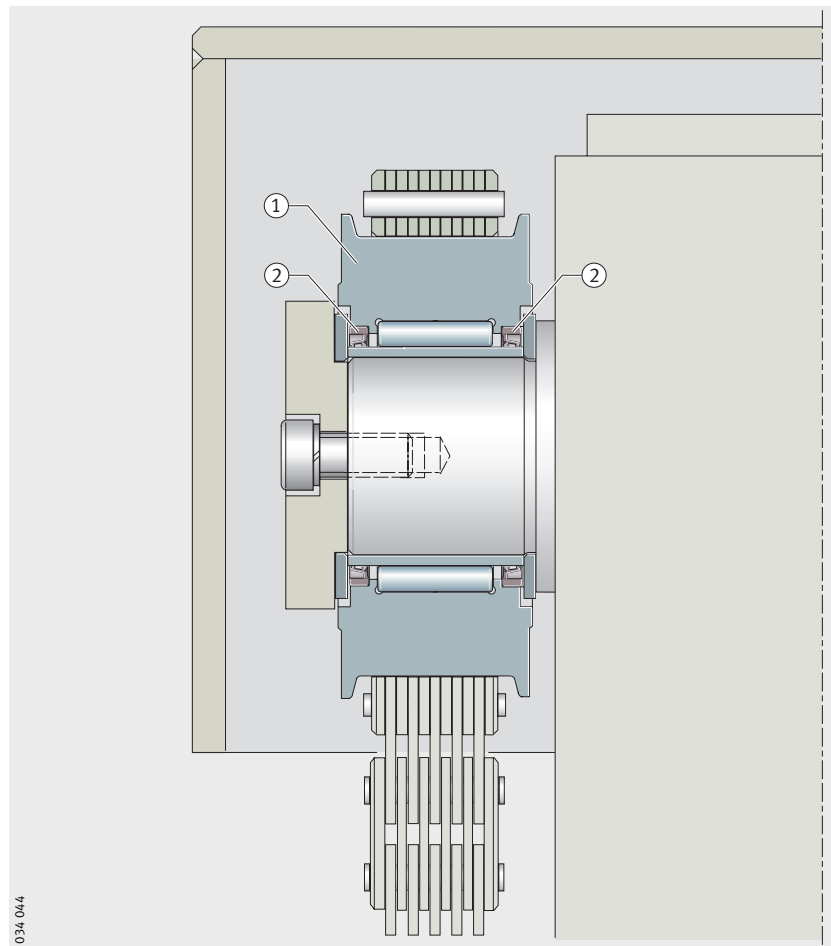
Application examples

Fork lift truck Chain guide roller

Fork lift trucks are mobile, manoeuvrable lifting vehicles for indoor and outdoor operation. A lift mast slide moves the fork vertically between two recirculating chains. For transport, the goods are grasped using the fork and lifted to the necessary height.

The lift mast slide and chain guide rollers must be supported such that the fork moves smoothly, quickly and precisely with or without load.

For operational reliability and a long operating life, the guide rollers must be protected against contamination and moisture.



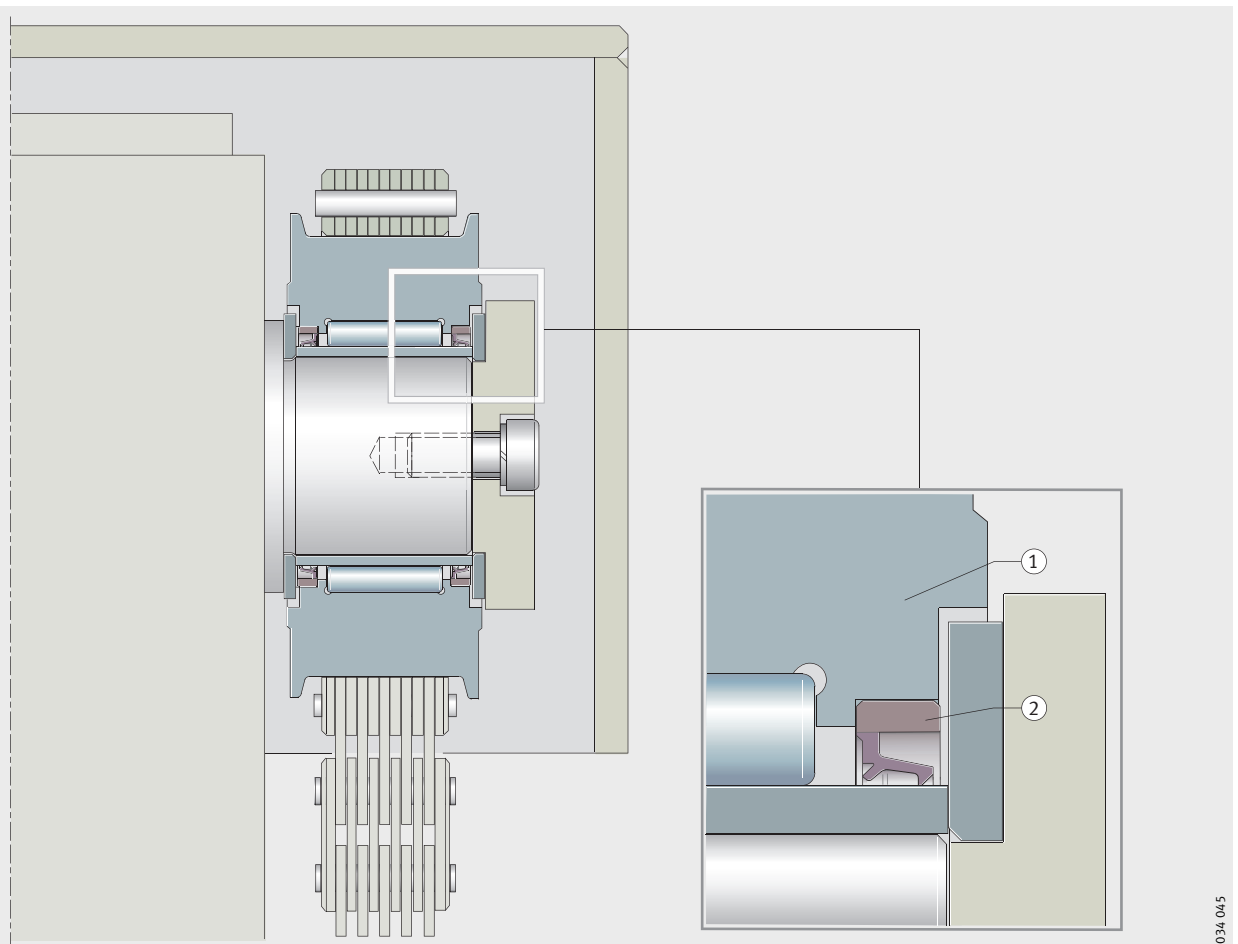
- ① Chain guide roller KTR
- ② Sealing ring SD

Figure 4
Design solution

Design solution

Chain guide rollers KTR adjusted free from clearance transmit the forces to the chains, *Figure 4*, ①. The profile of the outer rings is matched to the cross-section of the chain.

Double lip sealing rings SD ② protect the guide rollers against contamination from outside. The sealing rings are fitted such that the seal lip faces outwards and the protective lip faces inwards. The seal lip facing inwards retains the grease in the bearing.



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