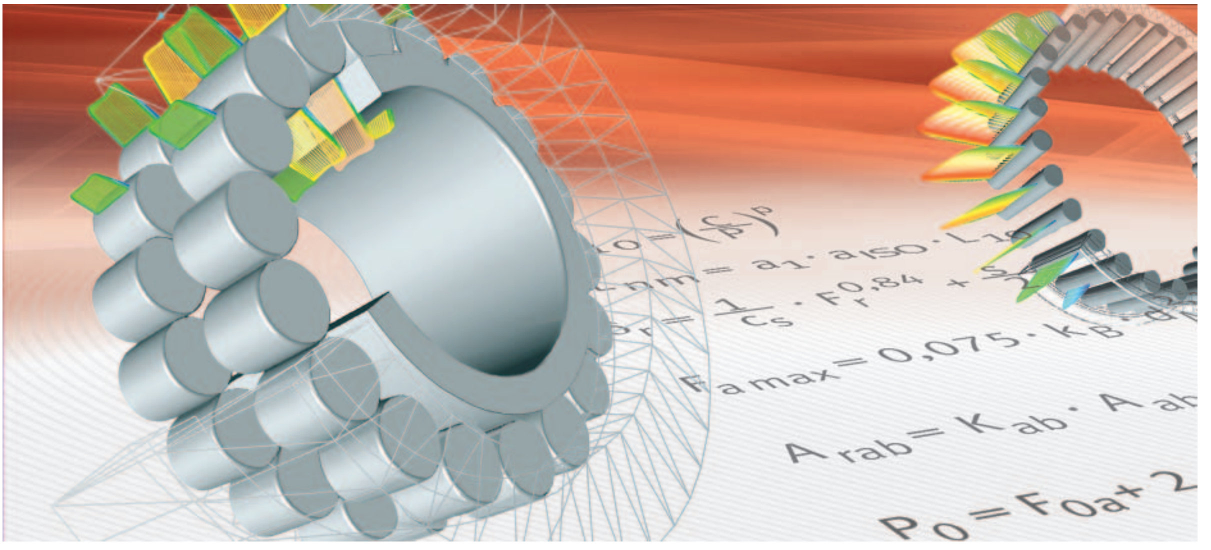


Technical principles

Bearing types
Bearing arrangements
Fits
Internal clearance and operating clearance
Geometrical and positional tolerances
Safety guidelines
Preparations for mounting and dismounting
Dimensional and geometrical inspection
Lubrication
Storage of rolling bearings
Seals
Bearing housings

Technical principles

		Page
Bearing types	Rolling bearings	4
	Principal requirements placed on bearings	4
	Rolling bearing types	5
Bearing arrangements	Bearing arrangements	6
	Locating/non-locating bearing arrangement	6
	Adjusted bearing arrangement	9
	Floating bearing arrangement	12
Fits	Criteria for selection of fits	13
	Seats for axial bearings	13
	Conditions of rotation	14
	Tolerance zones	15
Internal clearance and operating clearance	Radial internal clearance	16
	Enveloping circle	18
	Operating clearance	19
	Operating clearance value	19
	Calculation of operating clearance	19
	Axial internal clearance	21
Geometrical and positional tolerances	Geometrical and positional tolerances of bearing seating surfaces	22
	Accuracy of bearing seating surfaces	22
Safety guidelines	Guidelines on the mounting of rolling bearings	25
	General safety guidelines	25
	Qualification of personnel	25
	Personal protective equipment	25
	Safety specifications	25
	Transport specifications	26
Preparations for mounting and dismounting	Working conditions	27
	Guidelines for mounting	27
	Handling of rolling bearings before mounting	28
	Cleanliness during mounting	28
	Adjacent parts	28
Dimensional and geometrical inspection	Measurement of bearing seat	29
	Cylindrical seating surfaces	29
	Tapered seating surfaces	31
	Enveloping circle	32

Page

Lubrication

Principles 34
Functions of the lubricant 34
Selection of the type of lubrication 34
Design of lubricant feed 35
Greases 36
Initial greasing and new greasing 36
Arcanol rolling bearing greases 38
Oil 38
Further information 38

Storage of rolling bearings

Anti-corrosion protection and packaging 39
Storage conditions 39
Storage periods 39

Seals

Classification of seals 40
Non-contact and contact seals 40
Mounting space and boundary conditions for a sealing position 41
Mounting space 41
Seal running surface 42
Mounting guidelines 42
Mounting of seals 42
Mounting of O rings 45
Dismounting of seals 45

Bearing housings

Housing types 46
Housings in locating bearing design and non-locating bearing design 47
Housings with locating rings 48
Housing seals 48
Mounting 49
Eye bolts 50
Surface quality of the mounting surface 51
Tightening torques for connecting screws 51
Tightening torques for foot screws 52
Horizontal location 53

Bearing types

Rolling bearings

The task (function) of rotary rolling bearings is to guide parts that are movable in relation to each other and support them relative to the adjacent structure. They support forces and transmit these into the adjacent construction. In this way, they perform support and guidance tasks and thus form the connection between stationary and moving machine elements.

The function "Support" comprises the transmission of forces and moments between parts moving relative to each other.

The function "Guidance" principally comprises defining to an appropriate (normally high) accuracy the position of parts moving relative to each other.

Principal requirements placed on bearings

Technical implementation is oriented to the two principal requirements:

- Function must be ensured and fulfilled for as along as possible.
- The resistance to motion (bearing friction) should be as low as possible in order to reduce the energy required for motion (energy efficiency).

Rolling bearing types

An overview of typical bearing types for rotary motion is shown in the following diagram, *Figure 1*.

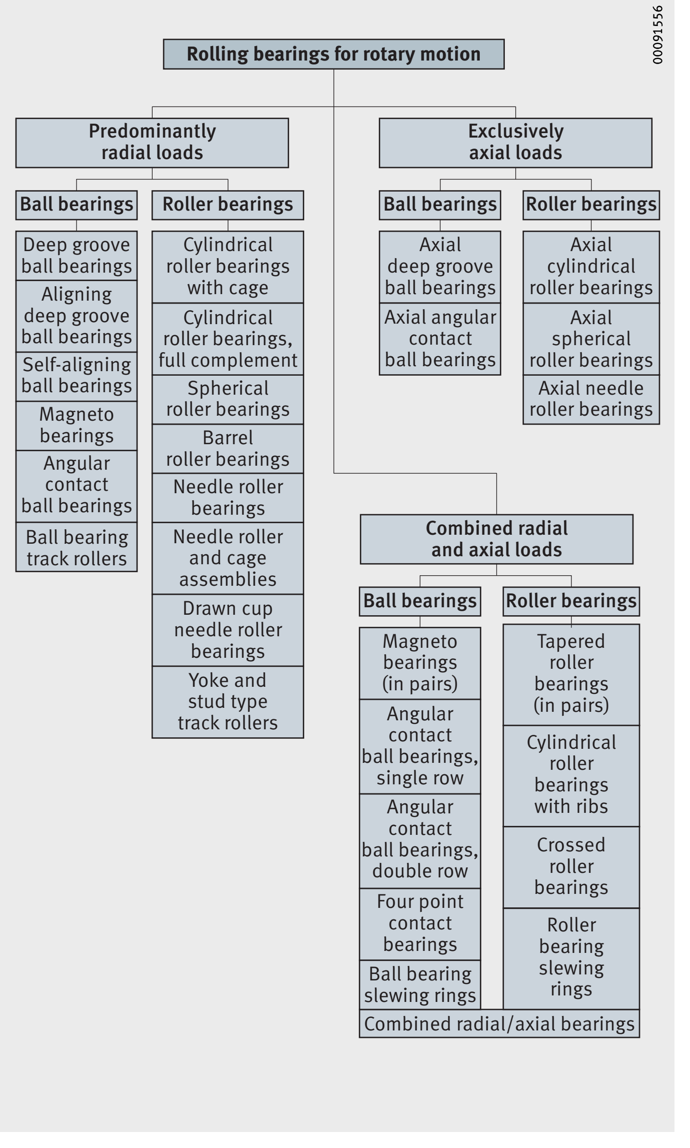


Figure 1
Overview of rolling bearing types

Bearing arrangements

The guidance and support of a rotating shaft requires at least two bearings arranged at a certain distance from each other. Depending on the application, a decision is made between a locating/non-locating bearing arrangement, an adjusted bearing arrangement and a floating bearing arrangement.

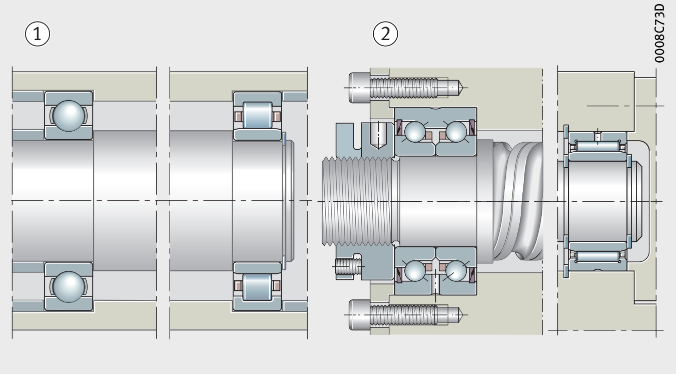
Locating/non-locating bearing arrangement

On a shaft supported by two radial bearings, the distances between the bearing seats on the shaft and in the housing frequently do not coincide as a result of manufacturing tolerances. The distances may also change as a result of temperature increases during operation. These differences in distance are compensated in the non-locating bearing. Examples of locating/non-locating bearing arrangements are shown in *Figure 1* to *Figure 7*, page 9.

Non-locating bearings

Ideal non-locating bearings are cylindrical roller bearings with cage N and NU or needle roller bearings, *Figure 1* ②, ④. In these bearings, the roller and cage assembly can be displaced on the raceway of the bearing ring without ribs.

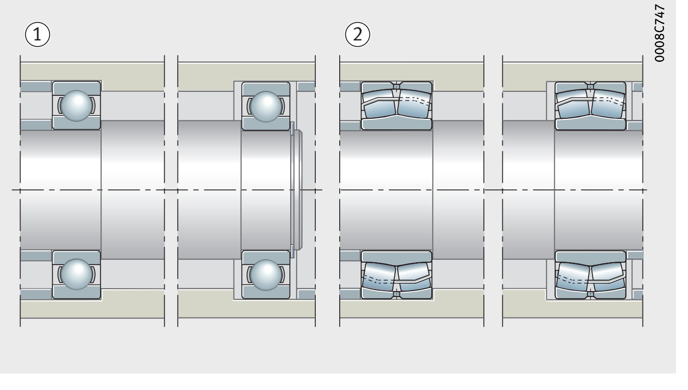
All other bearing types, for example deep groove ball bearings and spherical roller bearings, can only act as non-locating bearings if one bearing ring has a fit that allows displacement, *Figure 2*. The bearing ring subjected to point load therefore has a loose fit; this is normally the outer ring, see page 14.



① Deep groove ball bearing as locating bearing and cylindrical roller bearing NU as non-locating bearing

② Axial angular contact ball bearing ZKLN as locating bearing and needle roller bearing NKIS as non-locating bearing

Figure 1
Locating/non-locating bearing arrangements



① Deep groove ball bearings as locating and non-locating bearings

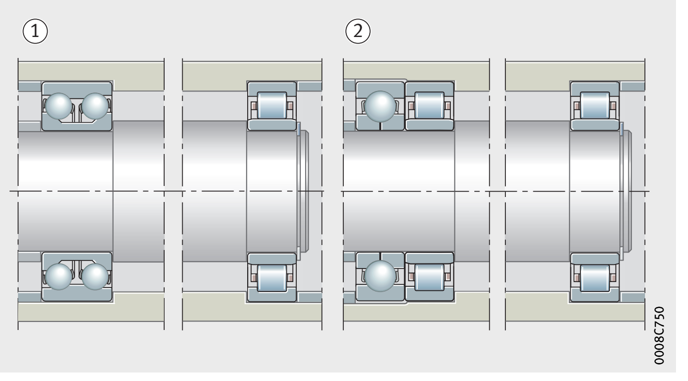
② Spherical roller bearings as locating and non-locating bearings

Figure 2
Locating/non-locating bearing arrangements

Locating bearings

The locating bearing guides the shaft in an axial direction and supports external axial forces. In order to prevent axial preload, shafts with more than two bearings have only one locating bearing. The type of bearing selected as a locating bearing depends on the magnitude of the axial forces and the accuracy with which the shafts must be axially guided.

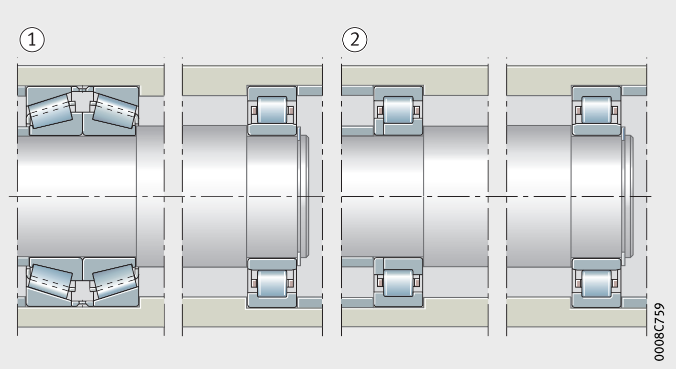
A double row angular contact ball bearing, *Figure 3* ①, for example, will give closer axial guidance than a deep groove ball bearing or a spherical roller bearing. A pair of symmetrically arranged angular contact ball bearings or tapered roller bearings, *Figure 4*, used as locating bearings will provide extremely close axial guidance.



① Double row angular contact ball bearing as locating bearing and cylindrical roller bearing NU as non-locating bearing

② Four point contact bearing and cylindrical roller bearing as locating bearing and cylindrical roller bearing NU as non-locating bearing

Figure 3
Locating/non-locating bearing arrangements



① Two tapered roller bearings as locating bearing and cylindrical roller bearing NU as non-locating bearing

② Cylindrical roller bearing NUP as locating bearing and cylindrical roller bearing NU as non-locating bearing

Figure 4
Locating/non-locating bearing arrangements

There are particular advantages in using angular contact ball bearings of the universal design, *Figure 5*. The bearings can be fitted in pairs in any O or X arrangement without shims. Angular contact ball bearings of the universal design are matched such that, in an X or O arrangement, they have a low axial internal clearance (design UA), zero clearance (UO) or slight preload (UL).

Pair of angular contact ball bearings of universal design
① O arrangement
② X arrangement

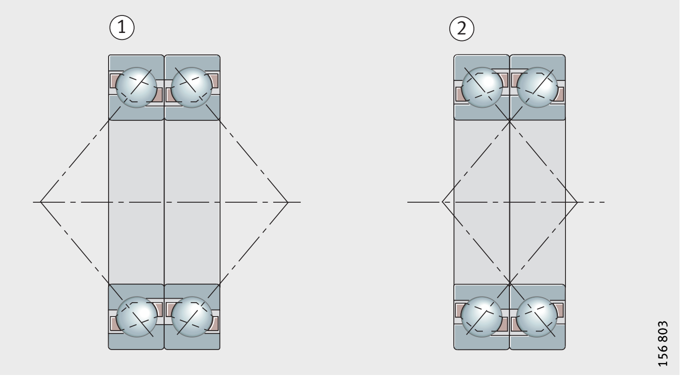


Figure 5
Locating bearing arrangements

Spindle bearings of the universal design UL, *Figure 6*, have slight preload when mounted in an X or O arrangement (designs with higher preload are available by agreement).

In gearboxes, a four point contact bearing is sometimes fitted directly adjacent to a cylindrical roller bearing to give a locating bearing arrangement, *Figure 3* ②, page 7. The four point contact bearing, without radial support of the outer ring, can only support axial forces. The radial force is supported by the cylindrical roller bearing.

If a lower axial force is present, a cylindrical roller bearing with cage NUP can also be used as a locating bearing, *Figure 4* ②, page 7.

Spindle bearings of universal design
① O arrangement
② X arrangement
③ Tandem O arrangement

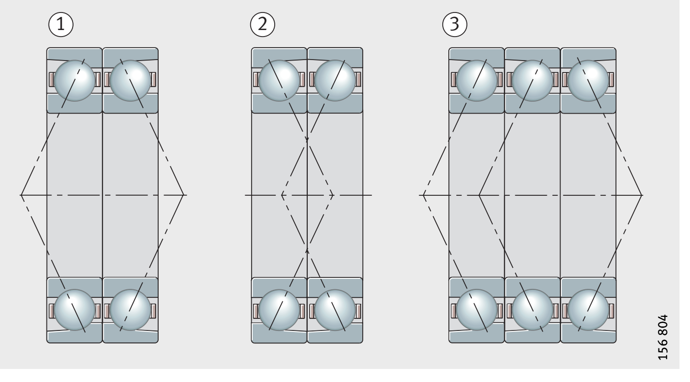
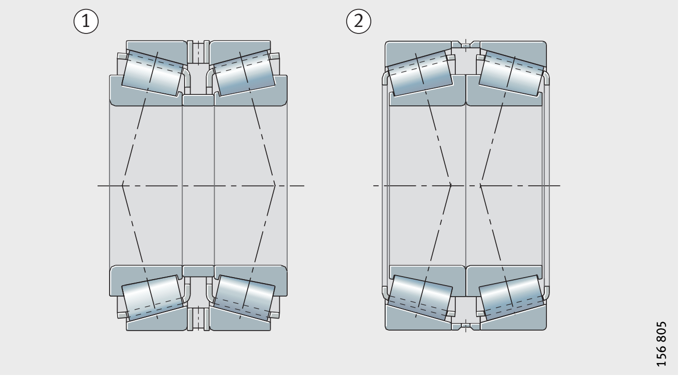


Figure 6
Locating bearing arrangements

No adjustment or setting work with matched pairs of tapered roller bearings

Mounting is also made easier with a matched pair of tapered roller bearings as a locating bearing (313..-N11CA), *Figure 7* ②. They are matched with appropriate axial internal clearance so that no adjustment or setting work is required.



Pair of tapered roller bearings
① O arrangement
② X arrangement

Figure 7
Locating bearing arrangements

Adjusted bearing arrangement

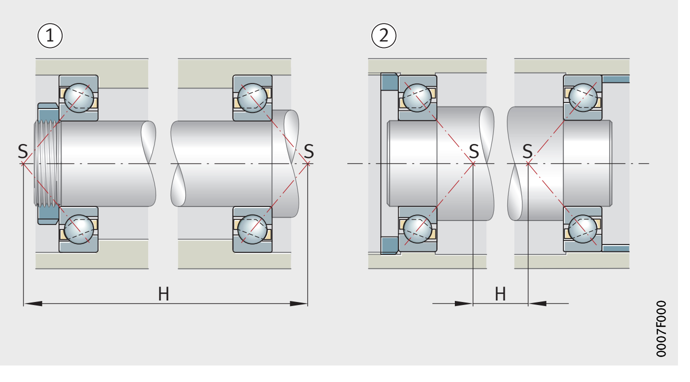
These bearing arrangements normally consist of two symmetrically arranged angular contact ball bearings or tapered roller bearings, *Figure 8*. During mounting, one bearing ring is displaced on its seat until the bearing arrangement achieves the required clearance or the necessary preload.

Area of application

Due to this adjustment facility, the adjusted bearing arrangement is particularly suitable where close guidance is required, for example in pinion bearing arrangements with spiral toothed bevel gears, in spindle bearing arrangements in machine tools or within the rotor bearing arrangement of a wind turbine.

X and O arrangement

A fundamental distinction is drawn between the O arrangement, *Figure 8* ①, and the X arrangement, *Figure 8* ②, of the bearings. In the O arrangement, the cones and their apexes S formed by the pressure lines point outwards; in the X arrangement, the cones point inwards. The support distance H, in other words the distance between the apexes of the contact cones, is larger in the O arrangement than in the X arrangement. The O arrangement therefore gives the lower tilting clearance.



S = apexes of the contact cones
H = support distance

Angular contact ball bearings
① O arrangement
② X arrangement

Figure 8
Adjusted bearing arrangement

Influence of thermal expansion in X and O arrangements

When setting the axial internal clearance, thermal expansion must be taken into consideration. In the X arrangement, *Figure 9*, a temperature differential between the shaft and housing always leads to a reduction in the internal clearance (assuming the following preconditions: shaft and housing of identical material, inner ring and complete shaft at identical temperature, outer ring and complete housing at identical temperature).

S = apexes of the contact cones
R = roller cone apexes

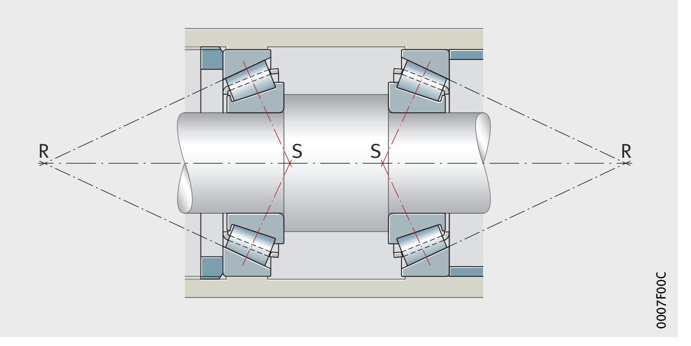


Figure 9
Adjusted tapered roller bearings in X arrangement

In the O arrangement, a distinction is drawn between three cases:

- The roller cone apexes R, i.e. the intersection points of the extended outer ring raceway with the bearing axis, coincide: the internal clearance set is maintained, *Figure 10* ①.
- The roller cone apexes R overlap and there is a short distance between the bearings: the axial internal clearance is reduced, *Figure 10* ②.
- The roller cone apexes R do not meet and there is a large distance between the bearings: the axial internal clearance is increased, *Figure 11*.

S = apexes of the contact cones
R = roller cone apexes

① Intersection points coincide
② Intersection points overlap

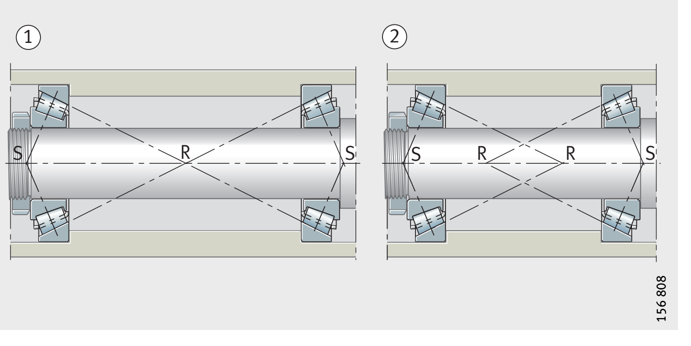


Figure 10
Adjusted tapered roller bearings in O arrangement

S = apexes of the contact cones
R = roller cone apexes

Intersection points do not overlap

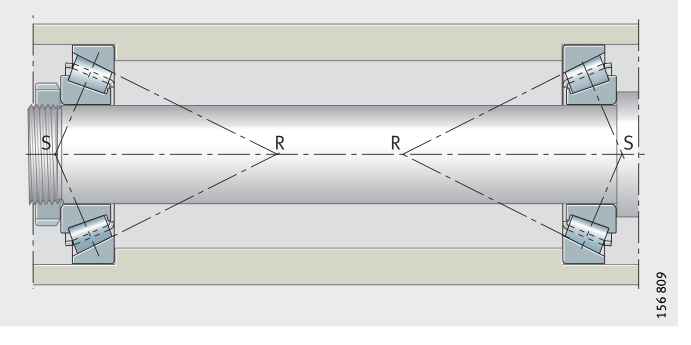
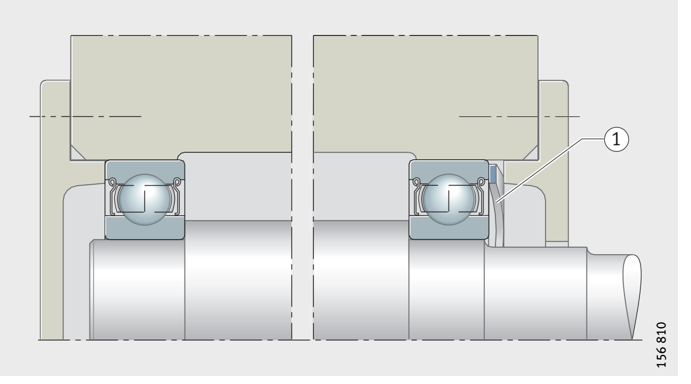


Figure 11
Adjusted tapered roller bearings in O arrangement

Elastic adjustment

Adjusted bearing arrangements can also be achieved by preloading using springs, *Figure 12* ①. This elastic adjustment method compensates for thermal expansion. It can also be used where bearing arrangements are at risk of vibration while stationary.



Deep groove ball bearing preloaded by means of spring washer

① Spring washer

Figure 12
Adjusted bearing arrangement with spring washer

Floating bearing arrangement

The floating bearing arrangement is an economical solution where close axial guidance of the shaft is not required, *Figure 13*. Its construction is similar to that of the adjusted bearing arrangement.

In the floating bearing arrangement, however, the shaft can be displaced in relation to the housing to the extent of the axial clearance s. The value s is defined as a function of the required guidance accuracy such that the bearings are not axially stressed even under unfavourable thermal conditions.

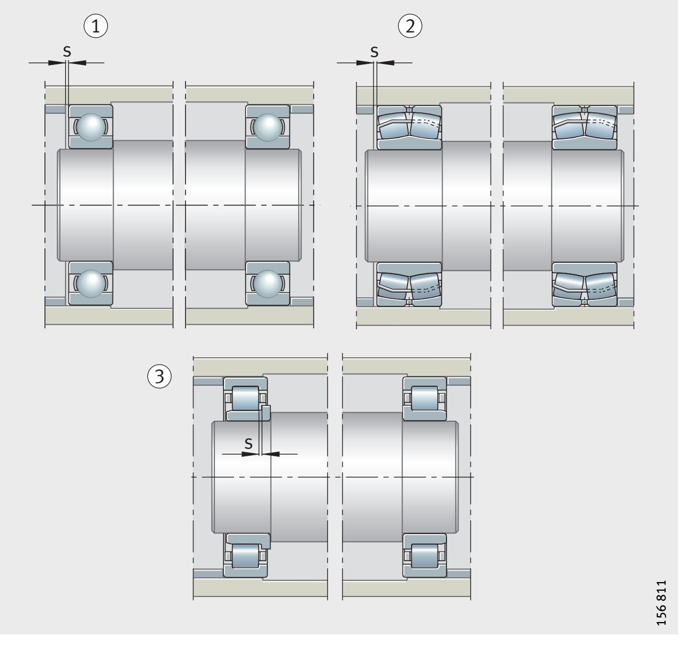
Suitable bearings

Suitable bearing types for the floating bearing arrangement include deep groove ball bearings, self-aligning ball bearings and spherical roller bearings.

In both bearings, one ring, usually an outer ring, has a fit that allows displacement.

In floating bearing arrangements and cylindrical roller bearings with cage NJ, the length compensation takes place within the bearings. The inner and outer rings can have tight fits, *Figure 13* ③.

Tapered roller bearings and angular contact ball bearings are not suitable for a floating bearing arrangement, since they must be adjusted in order to run correctly.



s = axial clearance

① Two deep groove ball bearings
② Two spherical roller bearings
③ Two cylindrical roller bearings NJ

Figure 13
Floating bearing arrangements

Fits

Criteria for selection of fits

Rolling bearings are located on the shaft and in the housing in a radial, axial and tangential direction in accordance with their function. Radial and tangential location is normally achieved by force locking, i.e. by tight fits on the bearing rings. Axial location of the bearings is normally achieved by form fit.

The following must be taken into consideration in the selection of fits:

- The bearing rings must be well supported on their circumference in order to allow full utilisation of the load carrying capacity of the bearing.
- The bearings must not creep on their mating parts, otherwise the seats will be damaged.
- One ring of the non-locating bearing must adapt to changes in the length of the shaft and housing and must therefore be capable of axial displacement.
- The bearings must be easy to mount and dismount.

Good support of the bearing rings on their circumference requires a tight fit. The requirement that rings must not creep on their mating parts also requires firm seating. If non-separable bearings must be mounted and dismounted, a tight fit can only be achieved for one bearing ring.

In cylindrical roller bearings N, NU and needle roller bearings, both rings can have tight fits, since the length compensation takes place within the bearing and since the rings can be fitted separately.

As a result of tight fits and a temperature differential between the inner and outer ring, the radial internal clearance of the bearing is reduced. This must be taken into consideration when selecting the internal clearance.

If materials other than cast iron or steel are used for the adjacent construction, the modulus of elasticity and the differing coefficients of thermal expansion of the materials must also be taken into consideration to achieve rigid seating.

For aluminium housings, thin-walled housings and hollow shafts, a closer fit should be selected if necessary in order to achieve the same force locking as with cast iron, steel or solid shafts.

Higher loads, especially shocks, require a fit with larger interference and narrower geometrical tolerances.

Seats for axial bearings

Axial bearings, which support axial loads only, must not be guided radially (with the exception of axial cylindrical roller bearings which have a degree of freedom in the radial direction due to flat raceways). This degree of freedom is not present in the case of groove-shaped raceways and must be achieved by a loose fit for the stationary washer. A rigid seat is normally selected for the rotating washer.

Where axial bearings also support radial forces, such as in axial spherical roller bearings, fits should be selected in the same way as for radial bearings.

The contact surfaces of the mating parts must be perpendicular to the axis of rotation (axial runout tolerance to IT5 or better), in order to ensure uniform load distribution over all the rolling elements.

Fits

Conditions of rotation

The conditions of rotation indicate the motion of one bearing ring with respect to the load direction and are expressed as either circumferential load or point load, see table.

Point load

If the ring remains stationary relative to the load direction, there are no forces that displace the ring relative to its seating surface. This type of loading is described as point load.

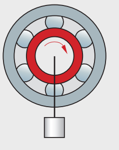
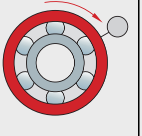
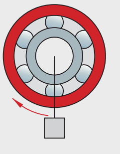
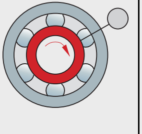
There is no risk that the seating surface will be damaged and a loose fit is possible.

Circumferential load

If forces are present that displace the ring relative to its seating surface, every point on the raceway is subjected to load over the course of one revolution of the bearing. A load with this characteristic is described as a circumferential load.

As damage to the bearing seating surface can occur, a tight fit should be used.

Conditions of rotation

Conditions of motion	Example	Schematic	Load case	Fit
Rotating inner ring Stationary outer ring Constant load direction	Shaft with weight load		Circumferential load on inner ring	Inner ring: tight fit necessary Outer ring: loose fit permissible
Stationary inner ring Rotating outer ring Load direction rotates with outer ring	Hub bearing arrangement with significant imbalance		and Point load on outer ring	
Stationary inner ring Rotating outer ring Constant load direction	Passenger car front wheel, track roller, (hub bearing arrangement)		Point load on inner ring	Inner ring: loose fit permissible Outer ring: tight fit necessary
Rotating inner ring Stationary outer ring Load direction rotates with inner ring	Centrifuge, vibrating screen		and Circumferential load on outer ring	

Tolerance zones

The ISO tolerances are defined in the form of tolerance zones. They are determined by their position relative to the zero line (= tolerance position) and their size (= tolerance grade, see ISO 286-1:1988). The tolerance position is indicated by letters (upper case for housings, lower case for shafts). A schematic illustration of the most common rolling bearing fits is shown in *Figure 1*.

$t_{\Delta Dmp}$ = tolerance for bearing outside diameter

$t_{\Delta dmp}$ = tolerance for bearing bore

1. Zero line
2. Housing bore
3. Shaft diameter
4. Loose fit
5. Transition fit
6. Tight fit

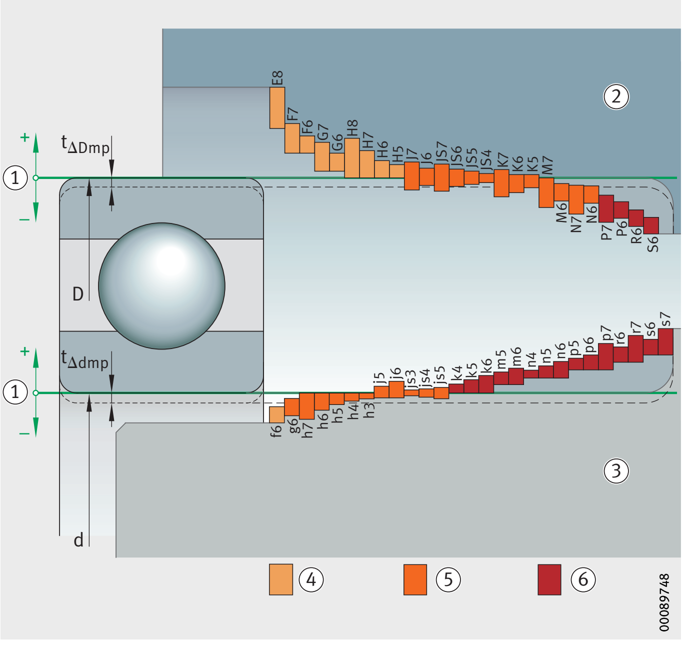


Figure 1
Fits for rolling bearings

The fit interference or fit clearance for shafts and housings is dependent on the specific bore diameter.

Internal clearance and operating clearance

Radial internal clearance

The radial internal clearance applies to bearings with an inner ring and is determined on the unmounted bearing. It is defined as the amount by which the inner ring can be moved in a radial direction from one extreme position to the other in relation to the outer ring, *Figure 1*.

The groups are defined in DIN 620-4 or ISO 5753-1 respectively and are described in DIN 620-4 by means of symbols comprising the letter C and a numeral. ISO 5753-1 designates the groups by means of "Group" and a numeral, *Figure 1* and table.

CN, C2, C3, C4, C5 = radial internal clearance groups in accordance with DIN 620-4

Group N, 2, 3, 4, 5 = radial internal clearance groups in accordance with ISO 5753-1

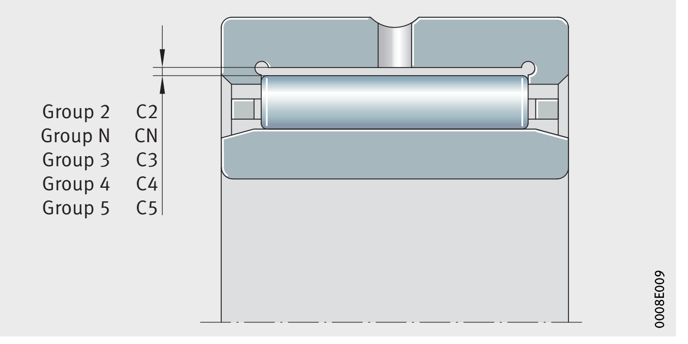


Figure 1
Radial internal clearance

Radial internal clearance groups

Internal clearance group to		Description	Application range
DIN 620-4	ISO 5753-1		
CN	Group N	Normal radial internal clearance Group N is not included in bearing designations	For normal operating conditions with shaft and housing tolerances
C2	Group 2	Internal clearance < Group N	For heavy alternating loads combined with swivel motion
C3	Group 3	Internal clearance > Group N	For bearing rings with press fits and large temperature differential between the inner and outer ring
C4	Group 4	Internal clearance > Group 3	
C5	Group 5	Internal clearance > Group 4	

The radial internal clearance of a bearing is dependent on the specific bore diameter and the type.

The internal clearance of spherical roller bearings, cylindrical roller bearings and toroidal roller bearings is normally determined using feeler gauges in a vertical position. It is important that the rings are centred relative to each other and the rollers within the bearing are correctly aligned. This can be achieved, for example, by rotating the bearing several times.

When the internal clearance is measured before mounting of the bearing, the specified radial internal clearance tolerance of the specific bearing should be obtained. In order to determine the actual internal clearance, a feeler gauge is then passed between the roller and bearing raceway.

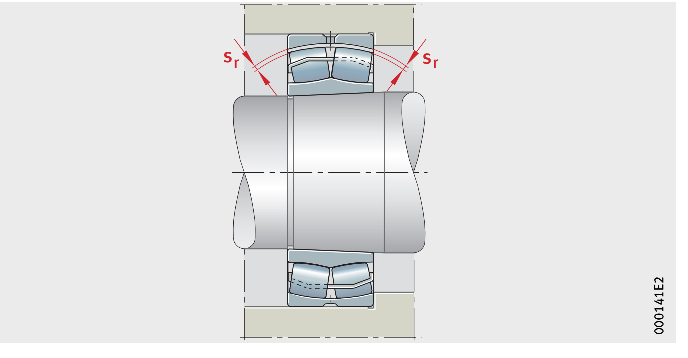
In the case of multiple row bearings, the radial internal clearance must be measured simultaneously over all rows of rollers.

A measurement blade is used first that is somewhat thinner than the minimum value of the initial internal clearance. When passing the blade between the raceway and roller, it must be carefully moved back and forth. This operation must be carried out with measurement blades of increasing thickness until a certain resistance is detected. In the case of particularly large or thin-walled bearings, elastic deformation of the rings can influence the internal clearance determined.

Measurement is always carried out in the load-free zone.
During mounting, the radial internal clearance should be measured continuously until the specified value is achieved.

The radial internal clearance should be determined at approx. +20 °C. In the case of particularly thin-walled bearing rings, elastic deformation of the rings can influence the internal clearance determined.

In spherical roller bearings, the radial internal clearance must be measured simultaneously over both rows of rolling elements, *Figure 2*. It can only be ensured that the inner ring is not laterally offset relative to the outer ring when the internal clearance values are identical for both rows of rollers. Due to the width tolerance of the rings, alignment of the end faces cannot be taken as a reliable indicator.



s_r = radial internal clearance

Figure 2
Radial internal clearance of a spherical roller bearing

In the case of cylindrical roller bearings, the inner ring and outer ring can be mounted individually. If the inner ring can be separated from the bearing, the expansion of the inner ring can be measured using an external micrometer instead of the reduction in radial internal clearance, *Figure 3*.

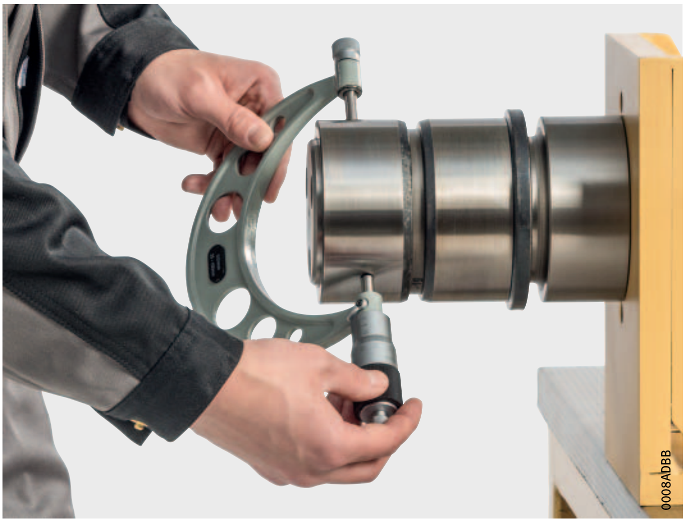
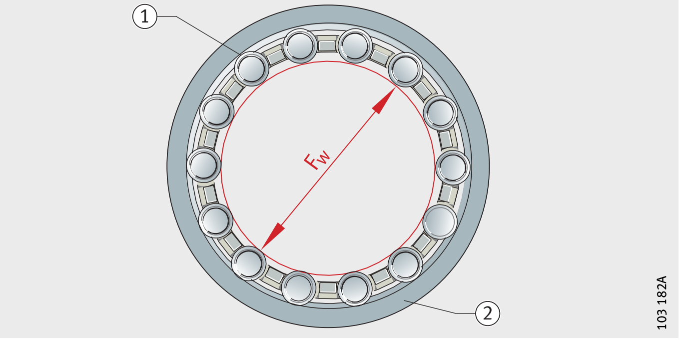


Figure 3
Measurement of expansion using external micrometer

Enveloping circle

For bearings without an inner ring, the enveloping circle F_w is used. This is the inner inscribed circle of the needle rollers in clearance-free contact with the outer raceway, *Figure 4*. When the bearings are unmounted, it is in the tolerance zone F6 (except in the case of drawn cup needle roller bearings).



F_w = enveloping circle diameter

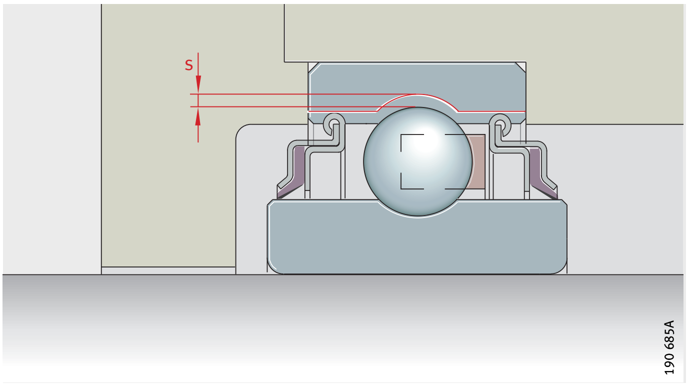
(1) Needle roller
(2) Outer raceway

Figure 4
Enveloping circle

Operating clearance

The operating clearance is determined on a mounted bearing still warm from operation. It is defined as the amount by which the shaft can be moved in a radial direction from one extreme position to the other, *Figure 5*.

The operating clearance is derived from the radial internal clearance and the change in the radial internal clearance as a result of interference fit and thermal influences in the mounted condition.



s = operating clearance

Figure 5
Operating clearance

Operating clearance value

The size of the operating clearance is dependent on the bearing operating and installation conditions. A larger operating clearance is, for example, necessary if heat is transferred via the shaft, the shaft undergoes deflection or if misalignment occurs.

An operating clearance smaller than Group N should only be used in special cases, for example in high precision bearing arrangements.

Normal operating clearance is achieved with an internal clearance of Group N or, for larger bearings, more usually Group 3 if the recommended shaft and housing tolerances are maintained.

Calculation of operating clearance

The operating clearance is derived from:

$$s = s_r - \Delta s_P - \Delta s_T$$

s µm
Radial operating clearance of mounted bearing warm from operation

s_r µm
Radial internal clearance

Δs_P µm
Reduction in radial internal clearance due to fit

Δs_T µm
Reduction in radial internal clearance due to temperature.

Reduction in radial internal clearance due to fit

The radial internal clearance is reduced due to the fit as a result of expansion of the inner ring and contraction of the outer ring:

$$\Delta s_P = \Delta d + \Delta D$$

Δd µm
Expansion of the inner ring

ΔD µm
Contraction of the outer ring.

Expansion of the inner ring

The expansion of the inner ring is calculated as follows:

$$\Delta d \approx 0,9 \cdot U \cdot d/F \approx 0,8 \cdot U$$

U µm
Theoretical interference of the fitted parts with firm seating. The theoretical oversize of the fitted parts with a firm seating is determined from the mean deviations and the upper and lower deviations of the tolerance zones of the fitted parts reduced by $^1/_3$ of their acceptable value. This must be reduced by the amount by which parts are smoothed during fitting

d mm
Bore diameter of the inner ring

F mm
Raceway diameter of the inner ring.

! For very thin-walled housings and light metal housings, the reduction in the radial internal clearance must be determined by mounting trials.

Contraction of the outer ring

The contraction of the outer ring is calculated as follows:

$$\Delta D \approx 0,8 \cdot U \cdot E/D \approx 0,7 \cdot U$$

E mm
Raceway diameter of the outer ring

D mm
Outside diameter of the outer ring.

Reduction in radial internal clearance due to temperature

The radial internal clearance can alter considerably if there is a substantial temperature difference between the inner ring and outer ring.

$$\Delta s_T = \alpha \cdot d_M \cdot 1000 \cdot \left(\vartheta_{IR} - \vartheta_{AR}\right)$$

Δs_T µm
Reduction in radial internal clearance due to temperature

α K^{-1}
Coefficient of thermal expansion of steel: $\alpha = 0,000011\ K^{-1}$

d_M mm
Mean bearing diameter (d + D)/2

ϑ_{IR} °C, K
Temperature of the inner ring

ϑ_{AR} °C, K
Temperature of the outer ring (usual temperature difference between inner and outer ring: 5 K to 10 K).

! Where shafts start up quickly, a larger radial internal clearance should be used since adequate thermal compensation between the bearing, shaft and housing does not occur in this situation.

Δs_T can, in this case, be significantly higher in this case than for continuous operation.

Axial internal clearance

The axial internal clearance s_a is defined as the amount by which one bearing ring can be moved relative to the other, without load, along the bearing axis, *Figure 6*.

s_a = axial internal clearance
s_r = radial internal clearance

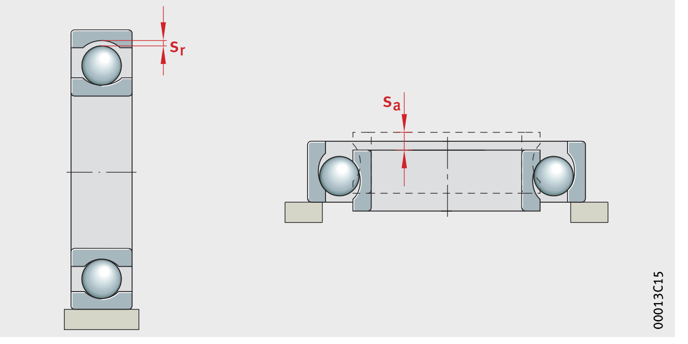


Figure 6
Axial internal clearance in comparison with radial internal clearance

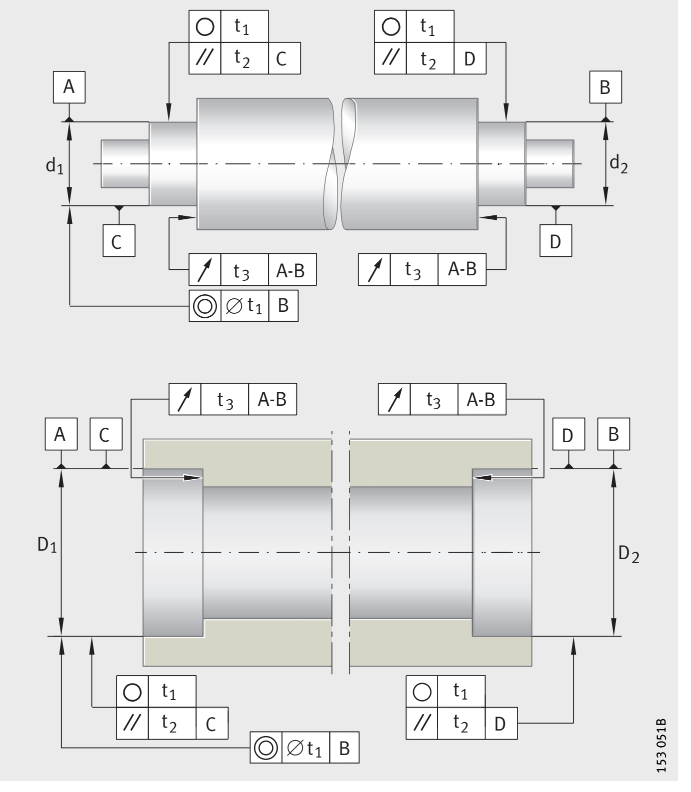
In various bearing types, the radial internal clearance s_r and the axial internal clearance s_a are dependent on each other. Guide values for the correlation between the radial and axial internal clearance are shown for some bearing types in the table.

Correlation between axial internal clearance and radial internal clearance

<table>
<tr><th colspan="3">Bearing type</th><th>Ratio between axial and radial internal clearance s_a/s_r</th></tr>
<tr><td colspan="3">Self-aligning ball bearings</td><td>$2,3 \cdot Y_0$</td></tr>
<tr><td colspan="3">Spherical roller bearings</td><td>$2,3 \cdot Y_0$</td></tr>
<tr><td rowspan="2">Tapered roller bearings</td><td colspan="2">single row, arranged in pairs</td><td>$4,6 \cdot Y_0$</td></tr>
<tr><td colspan="2">matched pairs (N11CA)</td><td>$2,3 \cdot Y_0$</td></tr>
<tr><td rowspan="3">Angular contact ball bearings</td><td rowspan="2">double row</td><td>series 32 and 33</td><td>1,4</td></tr>
<tr><td>series 32..-B and 33..-B</td><td>2</td></tr>
<tr><td>single row</td><td>series 72..-B and 73..-B, arranged in pairs</td><td>1,2</td></tr>
<tr><td colspan="3">Four point contact bearings</td><td>1,4</td></tr>
</table>

Geometrical and positional tolerances of bearing seating surfaces

In order to achieve the required fit, the bearing seats and fit surfaces of the shaft and housing bore must conform to certain tolerances, *Figure 1* and table, page 23.



t_1 = roundness
t_2 = parallelism
t_3 = axial runout of abutment shoulders

Figure 1
Geometrical and positional tolerances

Accuracy of bearing seating surfaces

The degree of accuracy for the bearing seat tolerances on the shaft and in the housing is given in the table, page 23.

Second bearing seat

The tolerances for a second bearing seat on the shaft (d_2) or in the housing (D_2) (expressed in terms of coaxiality to DIN ISO 1101) must be based on the angular adjustment facility of the specific bearing. Misalignments due to elastic deformation of the shaft and housing must be taken into consideration.

Housings

For split housings, the joints must be free from burrs.

The accuracy of the bearing seats is determined as a function of the accuracy of the bearing selected.

Guide values for geometrical and positional tolerances of bearing seating surfaces

Bearing tolerance class		Bearing seating surface	Fundamental tolerance grades			
to ISO 492	to DIN 620		Diameter tolerance	Roundness tolerance t_1	Parallelism tolerance t_2	Total axial runout tolerance of abutment shoulder t_3
Normal 6X	PN (P0) P6X	Shaft	IT6 (IT5)	Circumferential load IT4/2	IT4/2	IT4
				Point load IT5/2	IT5/2	
		Housing	IT7 (IT6)	Circumferential load IT5/2	IT5/2	IT5
				Point load IT6/2	IT6/2	
5	P5	Shaft	IT5	Circumferential load IT2/2	IT2/2	IT2
				Point load IT3/2	IT3/2	
		Housing	IT6	Circumferential load IT3/2	IT3/2	IT3
				Point load IT4/2	IT4/2	
4	P4 P4S[1] SP[1]	Shaft	IT4	Circumferential load IT1/2	IT1/2	IT1
				Point load IT2/2	IT2/2	
		Housing	IT5	Circumferential load IT2/2	IT2/2	IT2
				Point load IT3/2	IT3/2	
	UP[1]	Shaft	IT3	Circumferential load IT0/2	IT0/2	IT0
				Point load IT1/2	IT1/2	
		Housing	IT4	Circumferential load IT1/2	IT1/2	IT1
				Point load IT2/2	IT2/2	

ISO fundamental tolerances (IT grades) to ISO 286-1:1988.

1) Not included in DIN 620.

Geometrical and positional tolerances

Roughness of bearing seats

The roughness of the bearing seats must be matched to the tolerance class of the bearings. The mean roughness value Ra must not be too high, in order to maintain the interference loss within limits. Shafts should be ground and bores should be precision turned. Guide values are given in the table.

The bore and shaft tolerances and permissible roughness values are also given in the design and safety guidelines in the product sections. The guide values for roughness correspond to DIN 5425-1.

Guide values for surface quality of bearing seats

Diameter of bearing seat d (D) mm		Recommended mean roughness value Ra and roughness classes for ground bearing seats Diameter tolerance corresponding to [1)] µm			
over	incl.	IT7	IT6	IT5	IT4
–	80	1,6	0,8	0,4	0,2
80	500	1,6	1,6	0,8	0,4
500	1 250	3,2[2)]	1,6	1,6	0,8

1) Values for IT grades in accordance with DIN ISO 286-1:2010-11.

2) For mounting of bearings using the hydraulic method, a value Ra = 1,6 µm must not be exceeded.

Safety guidelines

Guidelines on the mounting of rolling bearings

In the mounting and dismounting of rolling bearings, important safety guidelines must be observed so that these activities can be carried out safely and correctly. The purpose of this mounting manual is to assist the fitter in mounting rolling bearings safely and correctly.

The objective of the safety guidelines is:

- to prevent personal injury or damage to property that may be caused by errors in mounting
- to facilitate, through correct mounting, a long operating life of the mounted bearing.

Further information

If you have any questions on mounting, please contact the Schaeffler Industrial Service experts:

- mounting-services@schaeffler.com

General safety regulations

The mounting and dismounting of rolling bearings normally involves high forces, pressures and temperatures. Due to these risk factors, mounting and dismounting of rolling bearings should only be carried out by qualified personnel.

Qualification of personnel

A person defined as qualified personnel:

- is authorised to perform mounting of the rolling bearings and adjacent components
- has all the knowledge necessary for mounting and dismounting of the components
- is familiar with the safety regulations.

Personal protective equipment

Personal protective equipment is intended to protect operating personnel against health hazards. This comprises safety shoes, safety gloves and if necessary a protective helmet and these must be used in the interests of personal safety.

Depending on the mounting location and on the machine or equipment in which the rolling bearings are to be mounted, it may be necessary to use additional personal protective equipment.
The applicable regulations relating to occupational safety must be observed.

Safety specifications

In order to prevent the occurrence of personal injury or damage to property during mounting, the following safety specifications must be observed.

Fundamental specifications

The mounting area must be kept free of trip hazards.

Heavy components such as the upper and lower housing sections, seals, covers and rolling bearings must be secured to prevent toppling or falling.

When heavy components are being set down and fitted together, particular attention must be paid to the limbs in order to prevent crushing.

Mounting and maintenance work of all types may only be carried out when the machine or equipment is at a standstill.

Safety guidelines

Lubricants

The lubricants used for greasing may contain components that are hazardous to health. A safety data sheet exists for each lubricant that describes the hazards.

Avoid direct bodily contact with the lubricant and use protective gloves.

Environmental hazards

Depending on the ambient conditions, safety risks may be present at the mounting location that are not associated directly with the rolling bearing but must be taken into consideration in mounting of the rolling bearing. These may include dusts that are hazardous to health or working at a considerable height. Furthermore, the machine or equipment in which the rolling bearing is mounted may be a source of hazards, for example as a result of movable machinery or equipment parts.

Before starting mounting work, a local safety engineer must be consulted. All safety specifications that are applicable to the mounting location and the machine or equipment affected by the mounting work must be observed.

Disposal

Any cloths soaked with grease or solvents, excess grease, packaging material and any other waste generated in connection with mounting and dismounting must be disposed of by environmentally acceptable methods. The applicable legal regulations must be observed.

Transport specifications

In order to prevent the occurrence of personal injury or damage to property during transport, the following transport specifications must be observed.

Before transport, secure rolling bearings against swivelling out or falling apart, *Figure 1*.

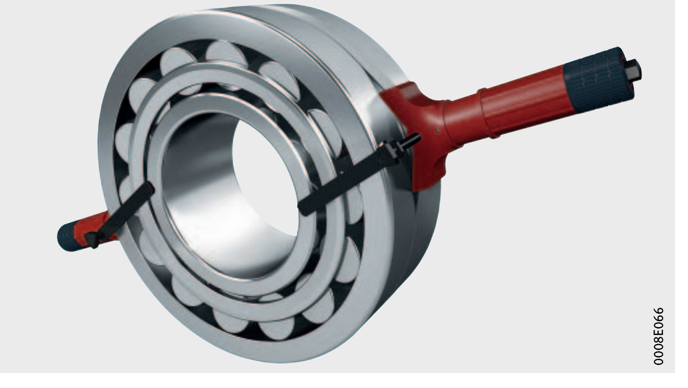


Figure 1
Secure lifting tool with protection against swivelling out

Lifting of heavy components must be carried out using suitable technical accessories. The mounting personnel must be familiar with correct usage of the accessories and must observe all safety specifications relating to the handling of suspended loads.

The following must be observed:

- Do not remain below or within the swivel range of suspended loads.
- Use only lifting gear and tackle that is approved and has sufficient load capacity.
- Do not draw unprotected lifting tackle under load across sharp edges, avoid kinking or twisting.
- Never leave suspended loads unsupervised.

Preparations for mounting and dismounting

Working conditions

Before the mounting and dismounting of rolling bearings, all preparations must be made for a problem-free work process.

Based on the workshop drawing, it is necessary to become familiar with the structure of the design and the sequence in which the individual parts are joined together. Before starting mounting work, a program should be prepared of the individual work operations and clarity should be established on the necessary heating temperatures, the forces for fitting and removal of the bearings and the grease quantity required.

For more extensive work, a mounting manual should be available that precisely describes all relevant work. The manual should also contain details on means of transport, mounting equipment, measurement tools, type and quantity of lubricant and a precise description of the mounting procedure.

Guidelines for mounting

The following guidelines must always be taken into account:

- Keep the mounting area clean and free from dust.
- Protect bearings from dust, contaminants and moisture. Contaminants have a detrimental influence on the running and operating life of rolling bearings.
- Before mounting work is started, familiarise yourself with the design by means of the final assembly drawing.
- Before mounting, check whether the bearing presented for mounting corresponds to the data in the drawing.
- Check the housing bore and shaft seat for dimensional, geometrical and positional accuracy and cleanliness.
- Check that no edges are present which could hamper the mounting of bearing rings on the shaft or in the housing bore. A lead chamfer of 10° to 15° is advantageous in this case.
- Wipe away any anti-corrosion agent from the seating and contact surfaces, wash anti-corrosion agent out of tapered bores.
- Cylindrical seating surfaces of the bearing rings should be rubbed with a very thin layer of Arcanol mounting paste.
- Do not cool the bearings excessively. Moisture due to condensation can lead to corrosion in the bearings and bearing seats.
- After mounting, supply the rolling bearings with lubricant.
- Check the correct functioning of the bearing arrangement.

Preparations for mounting and dismounting

Handling of rolling bearings before mounting

The anti-corrosion agents in bearings with an oil-based preservative are compatible and miscible with oils and greases having a mineral oil base. Compatibility should be checked if synthetic lubricants or thickeners other than lithium or lithium complex soaps are used. If there is an incompatibility, the anti-corrosion oil should be washed out before greasing, especially in the case of lubricants with a PTFE/alkoxyfluoroether base and thickeners based on polycarbamide. If in doubt, please contact the relevant lubricant manufacturer.

Anti-corrosion oil at the seating and locating surfaces should not be wiped away until immediately before mounting.

The anti-corrosion protection should be washed out of tapered bearing bores before mounting in order to ensure a secure, tight fit on the shaft or sleeve.

Prior to mounting, wash used and contaminated bearings carefully with kerosene agent and then oil or grease them immediately afterwards.

Rolling bearings must not be machined subsequently.
For example, it is not permissible to introduce lubrication holes, grooves, ground surfaces or the like, since this can liberate stresses in the rings that lead to premature destruction of the bearing. There is also a risk in this case that swarf or grinding dust will penetrate the bearing.

Cleanliness during mounting

Rolling bearings must be protected under all circumstances against contamination and moisture, since the ingress of even very small particles into the bearing can damage the running surfaces.
For this reason, the mounting area must be dry and free from dust. For example, it must not be located in the vicinity of grinding machines. The use of compressed air must be avoided. Cleanliness of the shaft and housing as well as all other parts must be ensured. Castings must be free from moulding sand. After cleaning, a protective coating should be applied to the inner housing surfaces that will prevent very small particles from coming loose during operation. Any anti-corrosion coatings and colour residues must be carefully removed from the bearing seats on the shaft and in the housing. In the case of turned parts, it must be ensured that burrs are removed and all sharp edges are broken.

Adjacent parts

All parts of the bearing arrangement must be checked for dimensional and geometrical accuracy before assembly.

For example, correct running of a rolling bearing can be impaired by non-compliant bearing seating tolerances, out-of-round housings and shafts and misaligned locating surfaces and this can lead to premature failure.

Measurement of bearing seat

A significant work operation for successful mounting of bearings is the prior measurement of the components used. Various measuring devices are used here. In all measurements, it must be ensured that the measuring device is at approximately the same temperature as the parts to be measured.

Cylindrical seating surfaces

The dimensional accuracy of cylindrical seating surfaces and their roundness should be checked with the aid of micrometers at various measurement points, *Figure 1* and *Figure 4*, page 30.

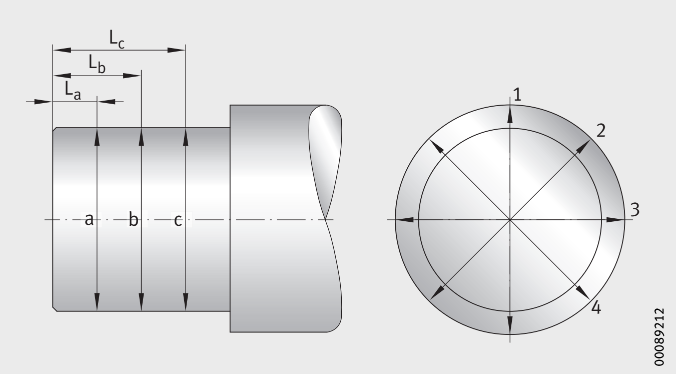
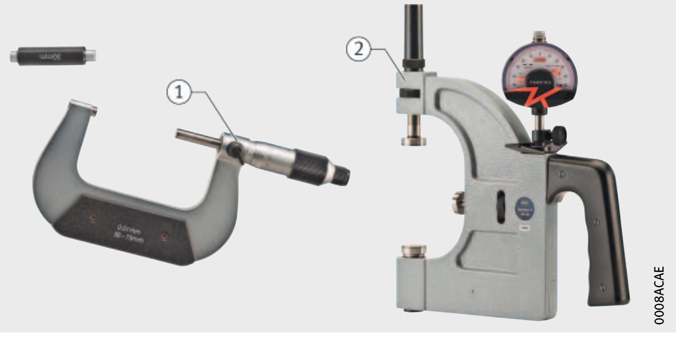


Figure 1
Checking the cylindricity of a shaft

Secure positioning and correct measurement of cylindrical seating surfaces is ensured by the snap gauge, *Figure 2*. The master disc is marked with the diameter to which the gauge must be set.



① External micrometer
② Snap gauge

Figure 2
Gauge for measurement of shaft diameters

Dimensional and geometrical inspection

The measurement of bores is carried out using either conventional internal micrometers or so-called comparator gauges, *Figure 3*. The master ring shown is used for calibration of the measurement tool.

① Internal micrometer
② Comparative gauge with master ring

Figure 3
Gauge for measurement of bores

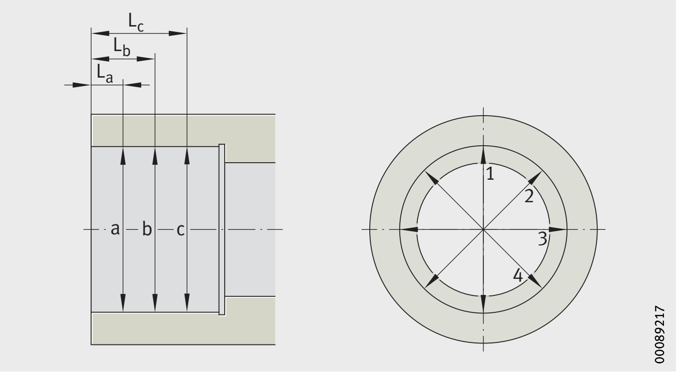


Figure 4
Checking the cylindricity of a housing

Tapered seating surfaces

In order to ensure firm seating of the inner ring on the shaft, the taper of the shaft must match precisely the taper of the inner ring bore.

The taper of rolling bearing rings is standardised. For most bearing series, it is 1:12. Depending on the requirements and the bearing width, bearings with a taper 1:30 are possible.

The simplest gauge for small, tapered bearing seats is the taper ring gauge, *Figure 5*. By means of the touching method, it can be determined whether the shaft and ring gauge match, while corrections are made until the ring gauge is in contact over its whole width.

The inner rings of bearings should not be used as ring gauges.

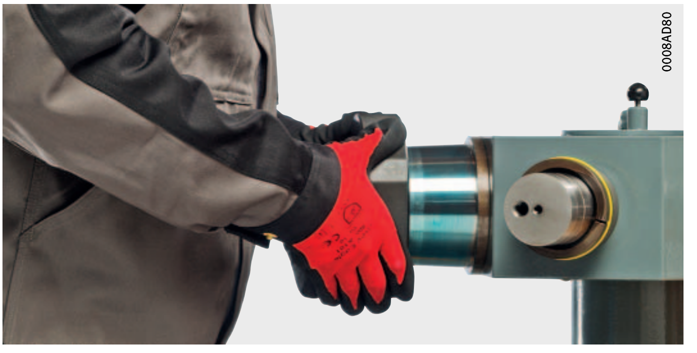
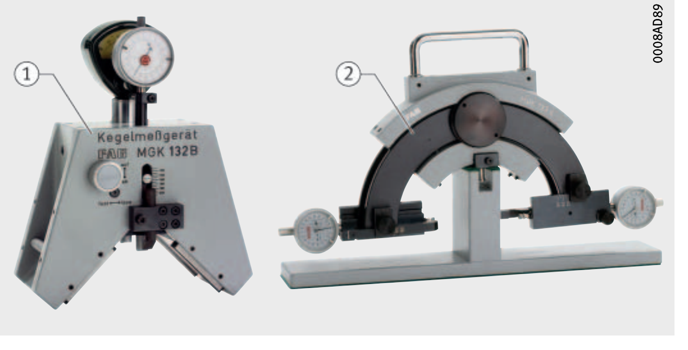


Figure 5
Touching with a taper ring gauge

For precise checking of tapered shaft seating surfaces, Schaeffler has developed the taper gauges FAG MGK 133 and FAG MGK 132, *Figure 6*. The taper and diameter of the bearing seat are measured precisely using a comparator taper or segment. Both devices are easy to use, since it is not necessary to remove the workpiece from the machining equipment for measurement.



(1) Taper gauge FAG MGK 132
(2) Taper gauge FAG MGK 133

Figure 6
Taper gauges FAG MGK 132 and FAG MGK 133

The taper gauge FAG MGK 133 is used to measure tapers shorter than 80 mm. Depending on the device size, the outside diameter of the taper can be between 27 mm and 205 mm.

The taper gauge FAG MGK 132 is suitable for taper lengths of 80 mm or larger and taper diameters from 90 mm to 820 mm.

Enveloping circle

The radial internal clearance of a mounted cylindrical roller bearing is determined by the difference between the roller enveloping circle diameter and the raceway diameter of the ribless ring.

Enveloping circle gauge FAG MGI 21

In the case of cylindrical roller bearings with a separable inner ring NNU49SK, the radial internal clearance or preload is determined by the difference between the diameter of the inner enveloping circle H_i and the raceway F. The internal enveloping circle is defined as the circle inscribed internally by all rollers when they are in contact with the outer ring raceway, *Figure 7*.

H_i = internal enveloping circle
F = raceway diameter

① Rolling elements
② Outer ring

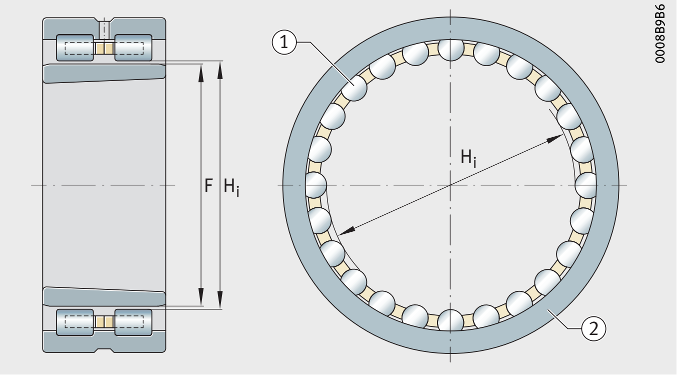


Figure 7
Internal enveloping circle of cylindrical roller bearings NNU49SK (separable inner ring)

The internal enveloping circle is measured using MGI 21; in conjunction with a snap gauge, the radial internal clearance of the mounted bearing can be determined, *Figure 8*. The dimension for the enveloping circle diameter is transferred to the snap gauge. The enveloping circle gauge FAG MGI 21 is used for cylindrical roller bearings with a separable inner ring, such as FAG NNU49SK.

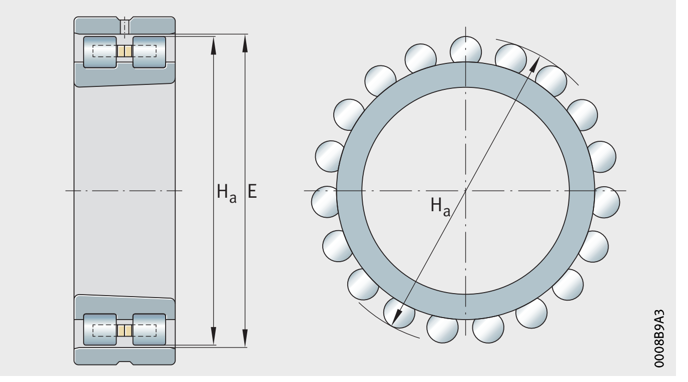
Figure 8
Enveloping circle gauge FAG MGI 21

Enveloping circle gauge FAG MGA 31

In the case of cylindrical roller bearings with a separable outer ring NN30ASK, the radial internal clearance or preload is determined by the difference between the diameter of the raceway E and the external enveloping circle H_a. The external enveloping circle is defined as the circle inscribed externally by all rollers when they are in contact with the inner ring raceway, *Figure 9*, page 33.

E = raceway
H_a = external enveloping circle

Figure 9
External enveloping circle of cylindrical roller bearings NN30ASK (separable outer ring)



The external enveloping circle is measured using MGA 31; in conjunction with a snap gauge, the radial internal clearance of the mounted bearing can be determined, *Figure 10*.

The dimension for the raceway diameter is transferred using the bore gauge to the enveloping circle gauge. The enveloping circle gauge FAG MGA 31 is used for cylindrical roller bearings with a separable outer ring, such as FAG NN30ASK.

Figure 10
Enveloping circle gauge FAG MGA 31

The two opposing steel segments of the enveloping circle gauge are the measuring surfaces. One segment is rigidly attached to the device while the other is capable of radial motion; this motion is transferred to the precision dial indicator.

For measurement, the bearing outer ring must be mounted in the housing. Once the diameter of the outer ring raceway has been determined using the bore gauge, the dimension is transferred to the enveloping circle gauge.

The inner ring, which is held together with the roller and cage assembly by the cage, is first slid onto the tapered shaft seat with form fit. The enveloping circle gauge is then positioned on the roller and cage assembly and the inner ring is pressed into place until the precision dial indicator shows the required dimension.

Plus values indicate preload, while minus values indicate radial internal clearance; the value zero gives a clearance-free bearing.

Lubrication

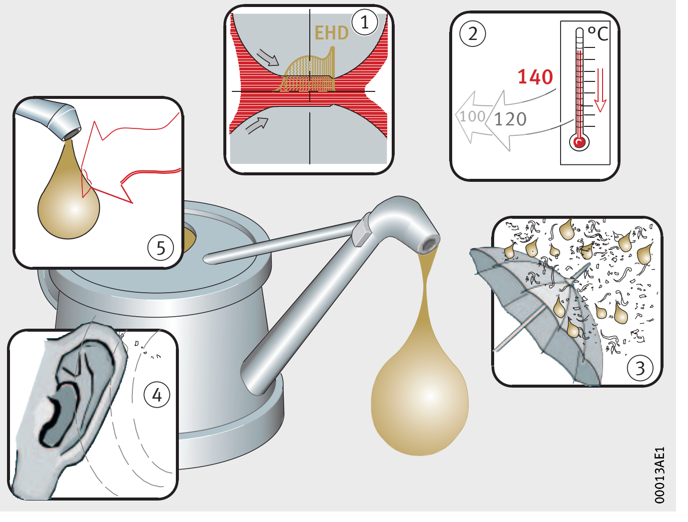
Principles

Lubrication and maintenance are important for the reliable operation and long operating life of rolling bearings.

Functions of the lubricant

The lubricant should, *Figure 1*:

- form a lubricant film on the contact surfaces that is sufficiently capable of supporting loads and thus preventing wear and premature fatigue ①
- dissipate heat in the case of oil lubrication ②
- provide additional sealing for the bearing against external solid and fluid contaminants in the case of grease lubrication ③
- provide damping of running noise ④
- protect the bearing against corrosion ⑤.



① Formation of a lubricant film capable of supporting loads
② Heat dissipation in the case of oil lubrication
③ Sealing of the bearing against external contaminants in the case of grease lubrication
④ Damping of running noise
⑤ Protection against corrosion

Figure 1
Functions of the lubricant

Selection of the type of lubrication

It should be determined as early as possible in the design process whether bearings should be lubricated using grease or oil.

The following factors are decisive in determining the type of lubrication and quantity of lubricant:

- the operating conditions
- the type and size of the bearing
- the adjacent construction
- the lubricant feed.

Criteria for grease lubrication

In the case of grease lubrication, the following criteria must be considered:

- very little design work required
- the sealing action
- the reservoir effect
- long operating life with little maintenance work (lifetime lubrication possible in certain circumstances)
- in the case of relubrication, the provision of collection areas for old grease and feed ducts
- no heat dissipation by the lubricant
- no rinsing out of wear debris and other particles.

Criteria for oil lubrication

In the case of oil lubrication, the following criteria must be considered:

- good lubricant distribution and supply to contact areas
- dissipation of heat possible from the bearing (significant principally at high speeds and/or loads)
- rinsing out of wear debris
- very low friction losses with minimal quantity lubrication
- more demanding requirements in terms of feed and sealing.

Under extreme operating conditions (such as very high temperatures, vacuum, aggressive media), it may be possible to use special lubrication methods such as solid lubricants in consultation with the engineering service.

Design of lubricant feed lines

The feed lines and lubrication holes in the housings and shafts, *Figure 2* and *Figure 3*, must:

- lead directly to the lubrication hole in the rolling bearing
- be as short as possible
- be equipped with a separate feed line for each bearing.

! Ensure that the feed lines are filled, *Figure 2*; the feed line should be bled if necessary.

Follow the guidelines provided by the manufacturers of the lubrication equipment.

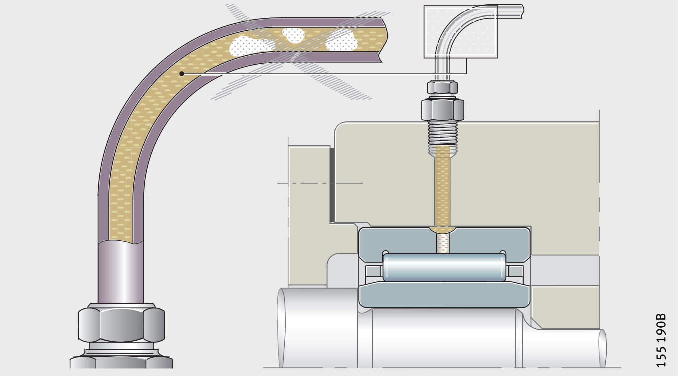


Figure 2
Lubricant feed lines

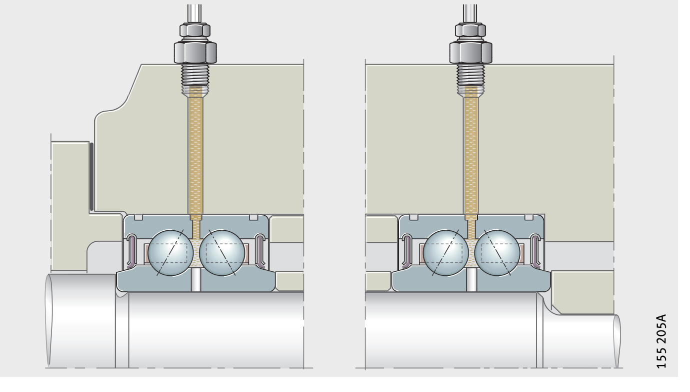


Figure 3
Arrangement of feed lines to more than one bearing on a shaft

Lubrication

Greases

The optimum bearing operating life can be achieved if suitable lubricants are selected. Account must be taken of application-related influencing factors such as bearing type, speed, temperature and load. In addition, attention must be paid to environmental conditions, the resistance of plastics, legal and environmental regulations as well as costs.

Specification according to DIN or the design brief

Greases K standardised in accordance with DIN 51825 should be used in preference. However, this standard only formulates minimum requirements for greases. This means that greases in one DIN class may exhibit differences in quality and may be suitable to varying degrees for the specific application. As a result, rolling bearing manufacturers frequently specify greases by means of design briefs that give a more detailed description of the profile of requirements for the grease.

Initial greasing and new greasing

In the greasing of bearings, the following guidelines must be observed:

- Fill the bearings such that all functional surfaces definitely receive grease.
- Fill any housing cavity adjacent to the bearing with grease only to the point where there is still sufficient space for the grease displaced from the bearing. This is intended to avoid co-rotation of the grease. If a large, unfilled housing cavity is adjacent to the bearing, sealing shields or washers as well as baffle plates should be used to ensure that an appropriate grease quantity (similar to the quantity that is selected for the normal degree of filling) remains in the vicinity of the bearing. A grease filling of approx. 90% of the undisturbed free bearing volume is recommended. This is defined as the volume in the interior of the bearing that does not come into contact with rotating parts (rolling elements, cage).
- In the case of bearings rotating at very high speeds, such as spindle bearings, a smaller grease quantity is generally selected (approx. 60% of the undisturbed free bearing volume or approx. 30% of the total free bearing volume), in order to aid grease distribution during starting of the bearings.
- The sealing action of a gap seal is improved by the formation of a stable grease collar. This effect is supported by continuous relubrication.
- If the correct degree of filling is used, favourable friction behaviour and low grease loss will be achieved.
- If there is a pressure differential between the two sides of the bearing, the flow of air may drive the grease and the released base oil out of the bearing and may also carry contamination into the bearing. In such cases, pressure balancing is required by means of openings and holes in the adjacent parts.
- Bearing rotating at low speeds ($n \cdot d_M < 50\,000\ \text{min}^{-1} \cdot \text{mm}$) and their housings must be filled completely with grease. The churning friction occurring in this case is negligible. It is important that the grease introduced is held in the bearing or vicinity of the bearing by the seals and baffle plates. The reservoir effect of grease in the vicinity of the bearing leads to an increase in the lubrication interval. However, this is conditional on direct contact with the grease in the bearing (grease bridge). Occasional shaking will also lead to fresh grease moving into the bearing from its environment (internal relubrication).

- If a high temperature is expected in the bearing, the appropriate grease should be supplemented by a grease reservoir that has a surface as large as possible facing the bearing and that dispenses oil. The favourable quantity for the reservoir is two to three times the normal degree of filling. The reservoir must be provided either on one side of the bearing or preferably to an identical extent on both sides.
- Bearings sealed on both sides using sealing washers or sealing shields are supplied with an initial greasing. The grease quantity normally introduced fills approx. 90% of the undisturbed free bearing volume. This filling quantity is retained well in the bearing even in the case of high speed parameters ($n \cdot d_M > 400\,000\ \text{min}^{-1} \cdot \text{mm}$). In the case of higher speed parameters, please consult Schaeffler. A higher degree of filling in sealed bearings will lead to higher friction and continuous grease loss until the normal degree of filling is restored. If the egress of grease is hindered, a considerable increase in torque and temperature must be anticipated. Bearings with a rotating outer ring also receive less grease (50% of the normal filling).
- In the case of higher speed parameters, the bearing temperature may settle at a higher value, in some cases over several hours, if the grease quantity during the starting phase has not been set correctly, *Figure 4*. The temperature is higher and the increased temperature is present for longer, the more the bearings and the cavities adjacent to the bearings are filled with grease and the more difficult it is for grease to escape freely. A remedy is a so-called interval running-in process with appropriately determined standstill periods for cooling. If suitable greases and grease quantities are used, equilibrium is achieved after a very short time.

Deep groove ball bearing, freshly greased

M_r = frictional torque
t = time
ϑ = temperature

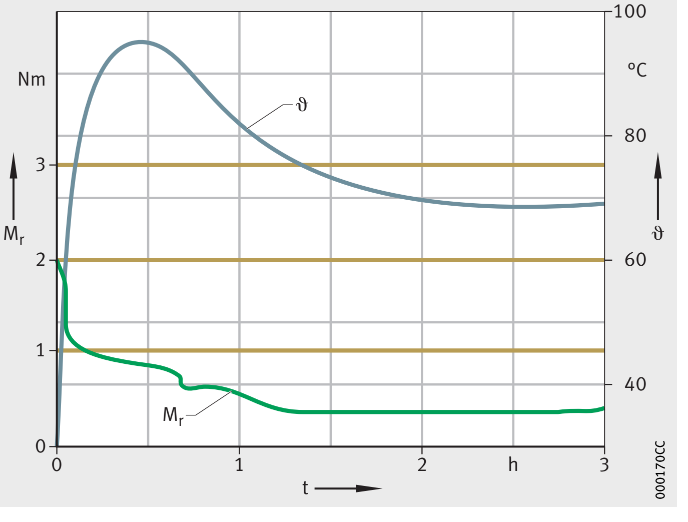


Figure 4
Frictional torque and temperature

Arcanol rolling bearing greases

Rolling bearing greases under the name Arcanol are subjected to 100% quality inspection, *Figure 5*. The inspection methods at Schaeffler are among the most demanding in the market. As a result, Arcanol rolling bearing greases fulfil the highest quality requirements.

The different greases cover almost all applications. They are developed by experienced application engineers and are produced by the best manufacturers in the market. Different greases are used depending on the particular application.

Figure 5
Analysis of the thermal behaviour of greases

Oils

For the lubrication of rolling bearings, mineral oils and synthetic oils are essentially suitable. Oils with a mineral oil base are used most frequently. These mineral oils must fulfil at least the requirements according to DIN 51517 (lubricating oils).

Special oils, which are often synthetic oils, are used where extreme operating conditions are present. The resistance of the oil is subjected to particular requirements under challenging conditions involving, for example, temperature or radiation. The effectiveness of additives in rolling bearings has been demonstrated by well-known oil manufacturers. For example, anti-wear protection additives are particularly important for the operation of rolling bearings in the mixed friction range.

Further information

- Further information on the storage, miscibility and selection of lubricants can be found in TPI 176, Lubrication of Rolling Bearings.

Storage of rolling bearings

Anti-corrosion protection and packaging

The performance capability of modern rolling bearings lies at the boundaries of what is technically achievable. Not only the materials but also the dimensional accuracies, tolerances, surface quality values and lubrication are optimised for maximum function. Even the slightest deviations in functional areas, for example as a result of corrosion, can impair the performance capability.

In order to realise the full performance capability of rolling bearings, it is essential to match the anti-corrosion protection, packaging, storage and handling to each other. Anti-corrosion protection and packaging are components of the product. They are optimised by Schaeffler as part of the process of preserving all the characteristics of the product at the same time. In addition to protection of the surfaces against corrosion, other important characteristics include emergency running lubrication, friction, lubricant compatibility, noise behaviour, resistance to ageing and compatibility with rolling bearing components (brass cage, plastic cage, elastomer seal). Anti-corrosion protection and packaging are matched by Schaeffler to these characteristics. The precondition here is the use of storage that is normal for high quality goods.

Storage conditions

The basic precondition for storage is a closed storage room in which no aggressive media of any sort may have an effect, such as exhaust from vehicles or gases, mist or aerosols of acids, alkalis or salts. Direct sunlight must also be avoided.

The storage temperature should be as constant as possible and the humidity as low as possible. Jumps in temperature and increased humidity lead to condensation.

The following conditions must be fulfilled:

- frost-free storage at a minimum temperature of +5 °C (secure prevention of hoarfrost formation, permissible up to 12 hours per day down to +2 °C)
- maximum temperature +40 °C (prevention of excessive run-off of anti-corrosion oils)
- relative humidity less than 65% (with changes in temperature, permissible up to max. 12 hours per day up to 70%).

! The temperature and humidity must be continuously monitored.

Storage periods

Rolling bearings should not be stored for longer than 3 years. This applies both to open and to greased rolling bearings with sealing shields or washers. In particular, greased rolling bearings should not be stored for too long, since the chemical-physical behaviour of greases may change during storage. Even if the minimum performance capacity remains, the safety reserves of the grease may have diminished. In general, rolling bearings can be used even after their permissible storage period has been exceeded if the storage conditions during storage and transport were observed. If the storage periods are exceeded, it is recommended that the bearing should be checked for corrosion, the condition of the anti-corrosion oil and where appropriate the condition of the grease before it is used.

Seals

Classification of seals

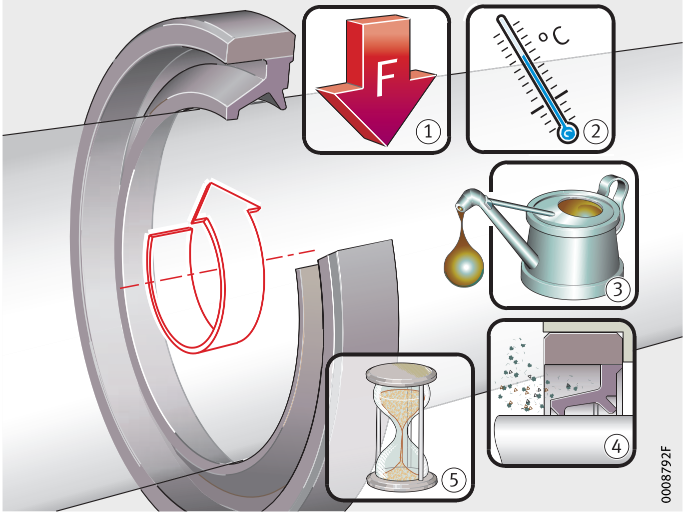
Seals play a decisive role in protecting bearings against contamination. If inadequate seals are used, contaminants can penetrate the bearing or an unacceptably large quantity of lubricant may escape from the bearing. Bearings that are contaminated or running dry will fail long before they reach their fatigue rating life.

Non-contact and contact seals

A basic distinction is made between contact and non-contact seals in the adjacent construction and the bearing.

Non-contact seals

Non-contact seals include gap seals, labyrinth seals, baffle plates and sealing shields. When fitting these types of seal, particular attention must be paid to the size of the seal gap after fitting and during operation. The resulting seal gap in operation is decisively influenced by external factors such as temperature differences, loads and deformations, *Figure 1*.



① Load
② Temperature differences
③ Lubricants
④ Contaminants
⑤ Ageing

Figure 1
Influences
on the operating life of seals

In grease lubrication of the bearing, the seal gaps formed must be filled with the same grease that is used within the bearing arrangement. An additional grease collar on the outside of the seal will protect the bearing against contamination.

Contact seals

Contact seals include felt rings, V rings or rotary shaft seals with one or more lips. They are normally in contact with the running surface under radial contact force. The contact force should be kept small in order to avoid an excessive increase in frictional torque and temperature. The frictional torque and temperature as well as the wear of the seal are also affected by the lubrication condition at the running surface, the roughness of the running surface and the sliding velocity. Correct fitting of the seal has a decisive influence on the possible operating life of the bearing.

Sealed bearings

Sealed rolling bearings are fitted with different seal concepts depending on the specific bearing type and series.

In the case of almost all bearings that are already sealed at the time of delivery, removal of the seal should be avoided. If a prefitted seal does not function correctly, the entire bearing must be replaced.

Sealed bearings must not be heated in an oil bath, and the heating temperature must not exceed +80 °C.

Mounting space and boundary conditions for a sealing position

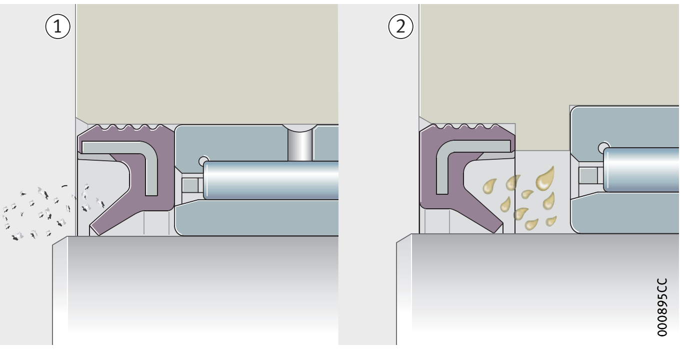
This section describes the mounting space and boundary conditions of sealing rings and rotary shaft seals (RWDR).

Mounting space

In order to achieve the optimum sealing action of a seal, the mounting space must in particular be modelled appropriately. This is carried out using, for example, DIN 3760 Rotary shaft seals and DIN 3761 Rotary shaft seals for vehicles. Design of the shaft and the bore at a sealing position is carried out in particular with the aid of DIN 3761-2. The data on mounting space that relate in this case only to rotary shaft seals, can also be carried over to sealing rings.

In general, the following fundamental rules apply:

- The adjacent construction should be designed such that the seal lips are not constrained in an axial direction.
- Sealing rings must be handled and fitted correctly. It is only in this way that long, problem-free sealing function is ensured.
- The mounting position of the seal lip must be observed, *Figure 2*.



1 Seal lip facing outwards
2 Seal lip facing inwards

Figure 2
Fitting in accordance with the function of the seal

Seal running surface

Seal running surfaces are an important factor for the life of a seal.

Characteristics of seal running surfaces

Seal running surface	Surface roughness	Minimum hardness
Sliding surface for radial seals (sealing for rotary motion)	Ra = 0,2 μm – 0,8 μm	600 HV or 55 HRC
	Rz = 1 μm – 4 μm	
	$Rz_{1\ max} \leqq$ 6,3 μm	
Sliding surface for rods and piston seals (sealing for axial motion)	Ra = 0,05 μm – 0,3 μm	600 HV or 55 HRC
	Rmr(0) 5% Rmr(0,25×Rz) 70%	
	$Rz_{1\ max} \leqq$ 2,5 μm	
Contact surfaces (static sealing)	R $\leqq$ 1,6 μm	–
	Rz $\leqq$ 10 μm	
	$Rz_{1\ max} \leqq$ 16 μm	

Guidelines for mounting

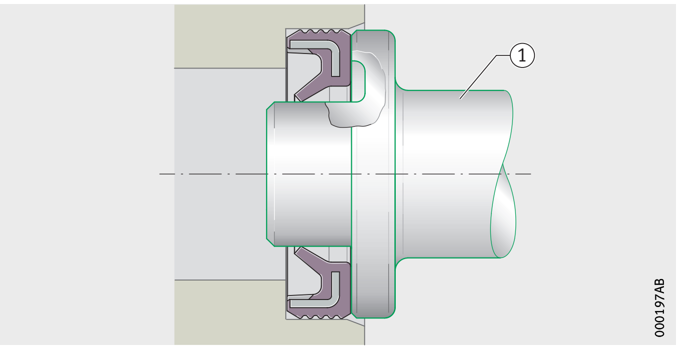
Irrespective of the type or form of the seal, it must always be ensured that it is not damaged during fitting. It must also be ensured in the mounting of directly sealed bearings that the prefitted sealing washer is not damaged or deformed in any way.

Mounting of seals

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

Seals are fitted correctly as follows:

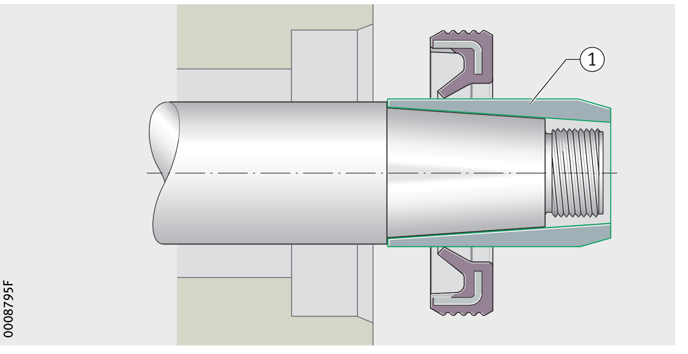
- A seal lip facing outwards protects the bearing against the ingress of dust and contamination, *Figure 2*, 1, page 41.
- A seal lip facing inwards prevents the egress of lubricant from the bearing, *Figure 2*, 2, page 41. In the case of sealing rings SD, the side with the protective lip is the marked side. It should be relubricated from inside, so the lip must face outwards.
- The running surface on the shaft and seal lip must be oiled or greased. This reduces the frictional energy during initial movement. In the case of sealing rings with an encased reinforcing ring – sealing ring G – the outside surface should be oiled before pressing 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 3*.



1 Pressing tool

Figure 3
Fitting using a pressing tool

- Ensure that the seal lip is not damaged. Cover any sharp shaft edges, slots, teeth or threads by means of fitting sleeves, *Figure 4*.
- 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 Fitting sleeve

Figure 4
Fitting using a fitting sleeve

- Fit sealing rings perpendicular to the shaft axis and the housing bore, *Figure 7*.

Do not exceed the maximum perpendicularity between the sealing ring and the shaft axis once fitted, see table. A larger deviation will influence the sealing action.

- In the case of sealing rings SD, the space between the seal lip and protective lip must be filled with grease, *Figure 5*.
- 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.

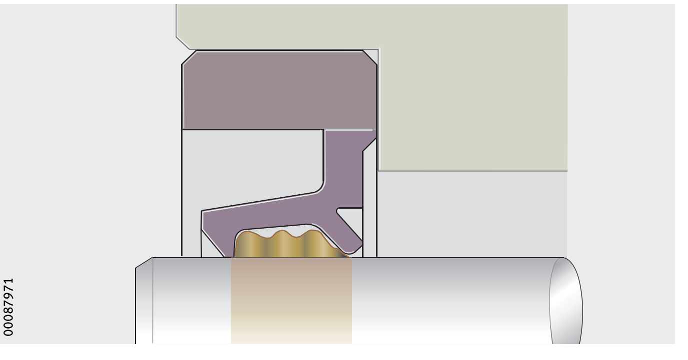


Figure 5
Grease filling between seal lip and protective lip

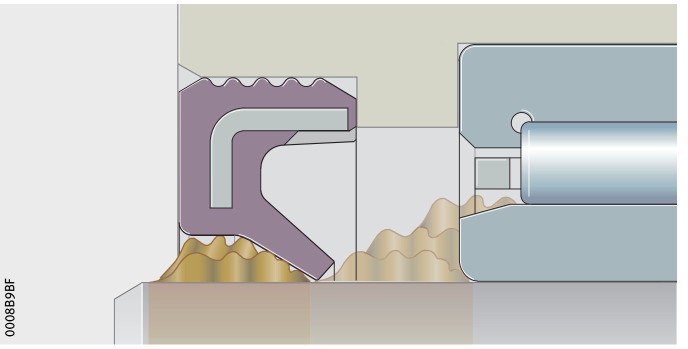


Figure 6
Grease collar
for supporting sealing action

Maximum perpendicularity deviation

Shaft diameter d mm	Maximum deviation mm
$d < 25$	0,1
$d \geqq 25$	0,2

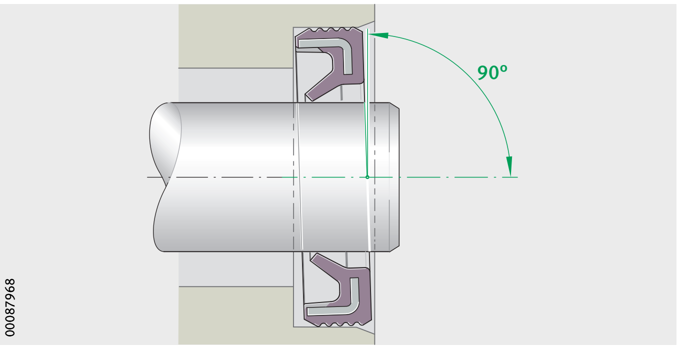


Figure 7
Perpendicularity –
position of sealing ring
relative to shaft axis/housing bore

Fitting of O rings

For an O ring, correct placement in the groove is very important.

In order to prevent damage to the O ring during fitting, sharp edges should be avoided. A lead chamfer will not only eliminate a sharp edge but will also give easier pressing-in of the O ring. The lead chamfer should be in the range between 10° and 20°.

The following guidelines must be observed:

- Before fitting, the cord size and inside diameter of the O ring must be checked.
- The seal position must be clean and free from particles.
- The O ring must not be adhesive bonded in the groove under any circumstances. Alternatively, a fitting grease can be used if chemical compatibility has been established.
- During fitting, the O ring must not be forced over sharp edges, threads, grooves and undercuts.
- The use of sharp or pointed tools is not permitted.
- As a result of fitting, the O ring must not be elongated by more than 5% to 6%.
- During fitting, the inside diameter must not be stretched by more than 50%.
- It must be ensured that the O ring is not fitted in a rotated position during fitting.
- For the removal of an O ring, a special removal tool should always be used.

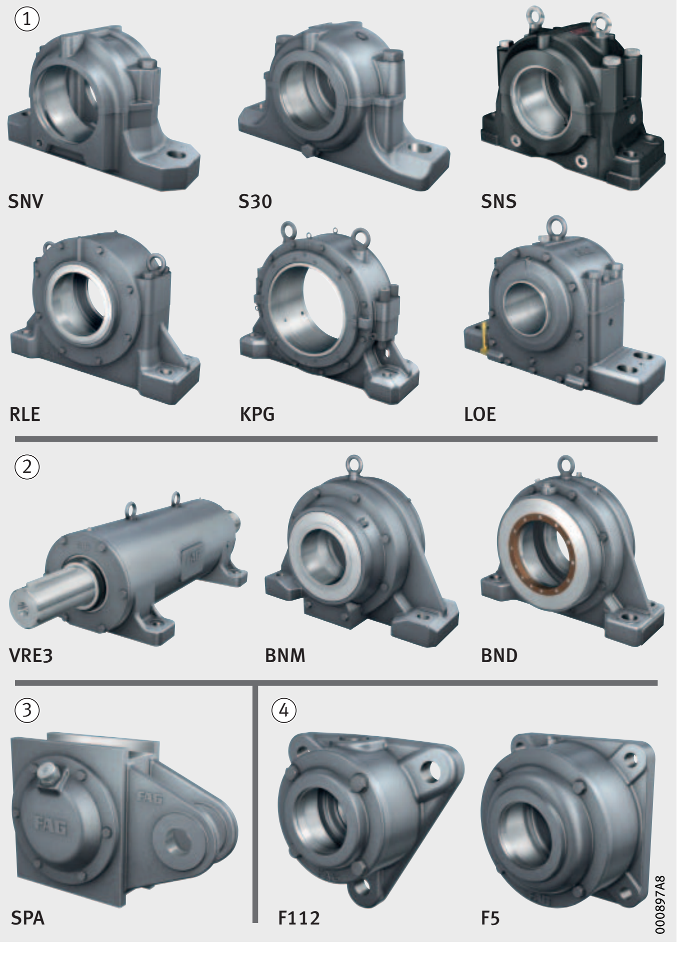
Removal of seals

Once a seal contact has been broken, for example in the removal of a cover or a rotary shaft seal, the seal must be replaced. Since the seal was already in seal contact due to initial fitting and underwent deformation as a result, the integrity of the seal cannot be ensured if it is used again. Furthermore, most seals are in any case heavily deformed or even destroyed during removal. During removal, it must be ensured that the seal running surface is not damaged.

Bearing housings

Housing types

Housings are normally designed as plummer block housings (split or unsplit) or as flanged housings. However, a large number of special housings are also used across a wide range of different applications. They are made predominantly from flake graphite case iron or cast steel and, together with the associated bearing and seals, form a complete unit.



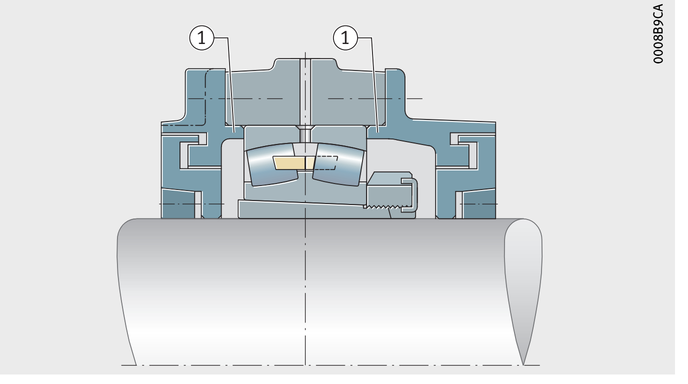
1 Split plummer block housings
2 Unsplit plummer block housings
3 Unsplit SPA housing
4 Flanged housings

Figure 1
Bearing housings

Housings in locating bearing design and non-locating bearing design

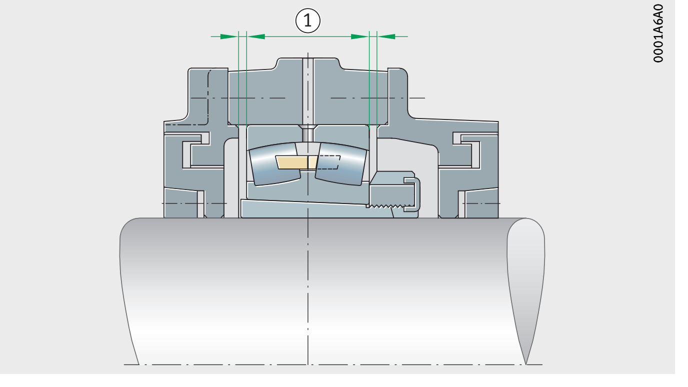
In this housing concept for the implementation of a locating or non-locating bearing arrangement, the housing must be ordered as necessary in a locating bearing design or a non-locating bearing design. This applies to the housings RLE, KPG, KPGZ, LOE, BNM, BND and SPA.

In the case of the locating bearing design, the bearings are axially clamped between the covers on the housings, *Figure 2*. In the case of the non-locating bearing design, the covers have shorter centring collars. As a result, the bearing can be axially displaced, *Figure 3*.



1 Centring collars on covers for axial location of the bearing

Figure 2
Housing
in locating bearing design



1 Bearing can be axially displaced

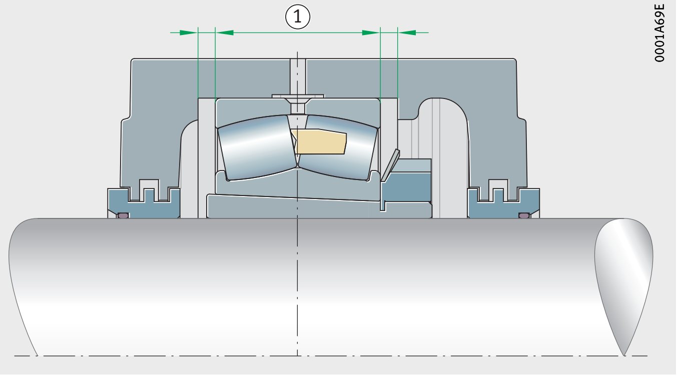
Figure 3
Housing
in non-locating bearing design

Housings with locating rings

In the case of many housings, the bearing seats are designed such that the bearing is capable of axial displacement and therefore acts as a non-locating bearing, *Figure 4*.

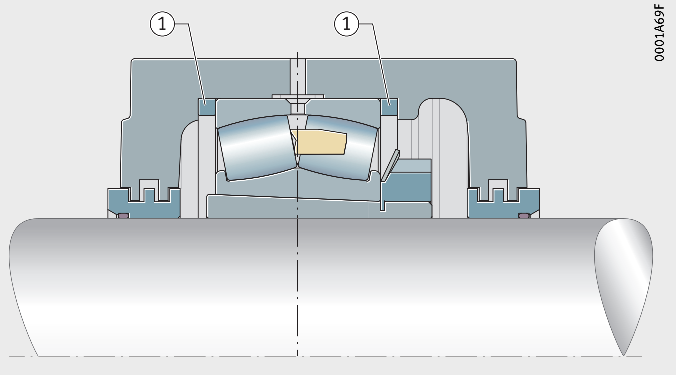
In this housing concept for the implementation of a locating bearing arrangement, a so-called locating ring is used, *Figure 5*. This applies to the housings SNV, S30, SNS and F5.

Once locating rings are inserted, the bearings are axially located. The locating rings are generally inserted in the housing on both sides of the bearing. Normally, an even number of locating rings is specified in order to achieve concentric seating of the bearing in the housing. In some cases, a single locating ring is sufficient.



1 Bearing can be axially displaced

Figure 4
Non-locating bearing arrangement, no locating bearing rings inserted



1 Locating rings give axial location of the bearing

Figure 5
Locating bearing arrangement, as a result of inserted locating rings

Housing seals

The rolling bearings normally used in bearing housings are spherical roller bearings, barrel roller bearings and deep groove ball bearings, which do not have their own sealing arrangement. The bearing position must therefore be sealed by means of the housing. In order to seal the housing against the shaft, contact seals, non-contact seals and combinations of these are available, depending on the operating conditions. These seals can also be ordered in a split or unsplit design.

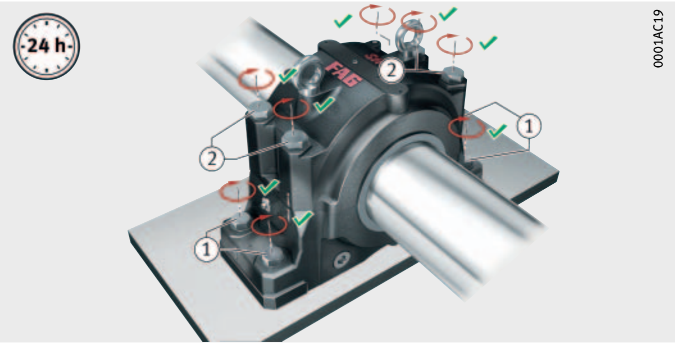
Mounting

For most series of housings from Schaeffler, mounting manuals are available. In some cases, there are also manuals relating to specific applications. Correct mounting has a decisive influence on the achievable bearing life.

Special features in the mounting of housings

In the mounting of housings, attention must be paid to the following:

- The mounting dimensions and critical dimensions must be checked before starting work on mounting.
- The upper and lower sections must not be transposed with parts of other housings.
- Before mounting, all lubrication holes must be cleaned.
- The screws must be dry and free of lubricants.
- A thin coating of mounting paste must be applied to the housing bore.
- In the case of split bearings, first the foot screws and then the cover screws must be tightened to the required torque.
- The specified maximum lubricant quantity must not be exceeded.
- After mounting, precise alignment and the tightening torque of the screws must be checked again and corrected as necessary, *Figure 6*.



① Foot screws
② Connecting screws

Figure 6
Checking of tightening torques

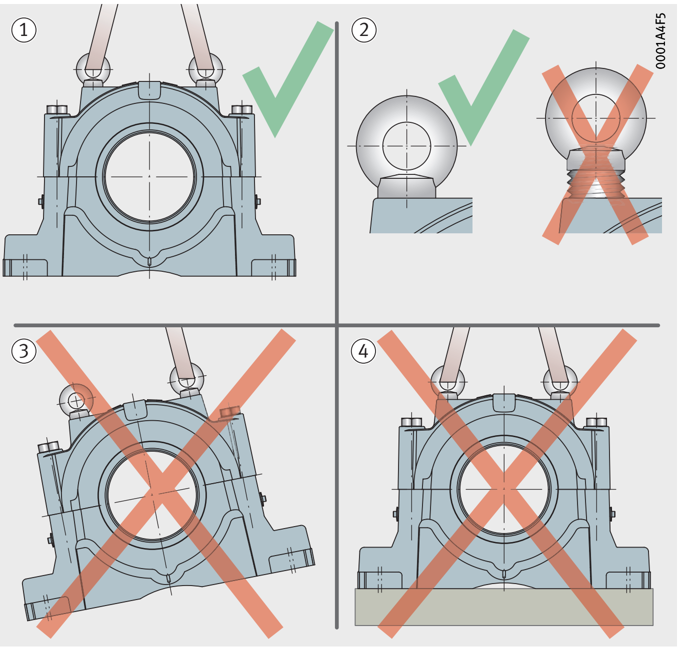
Eye bolts

On many housings, the housing body is provided with one or two eye bolts to DIN 580. These are intended as locating points for mounting and dismounting of the housing. The load carrying capacity of the eye bolts allows lifting of the housing including, in many cases, a bearing fitted in the housing, but without a shaft. Further relevant information is given in the description of the specific housing.

Correct usage of eye bolts on the housing body

Specifications for the use of eye bolts as locating points, *Figure 7*:

- Eye bolts must always be screwed fully into the housing.
- If several eye bolts are provided on the housing body, all the eye bolts must be used simultaneously as locating points.
- Only use eye bolts for lifting the housing and, if permitted for this housing, the bearing fitted in the housing. The eye bolts must not be subjected to additional load as a result of parts attached to the housing.



(1) Correct usage of eye bolts as locating points
(2) Screw in eye bolts completely
(3) Always use all eye bolts simultaneously
(4) Do not apply additional load as a result of attached parts

Figure 7
Correct usage of eye bolts on the housing body

Surface quality of the mounting surface

The requirements for the surface on which the housing is to be mounted are as follows:

- sufficiently robust to withstand the static and dynamic loads occurring in operation over the long term
- surface roughness Ra $\leqq$ 12,5
- flatness tolerance to DIN EN ISO 1101 of IT7, measured across the diagonal
- free from colour.

A difference in level between the mounting surfaces of bearing housings will lead to misalignment of the shaft, *Figure 8*.

ψ = misalignment of shaft
h = difference in level between mounting surfaces

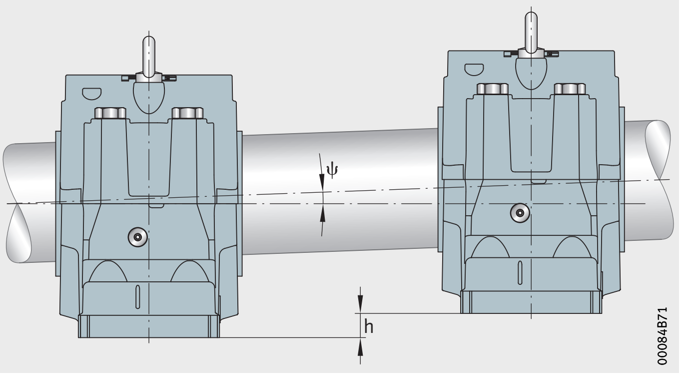


Figure 8
Misalignment of the shaft

The permissible misalignment is dependent on the housing and seal variant. Differences in level must be compensated such that the permissible misalignment is not exceeded. Levelling shims can be used for this purpose.

In addition, it must be ensured that the bearings mounted can compensate the misalignments present.

Tightening torques for connecting screws

In the case of split housings, the necessary tightening torque of the connecting screws for the upper and lower housing section must be determined in accordance with Schaeffler Catalogue GK 1, Bearing Housings. The tightening procedure should be carried out in stages and in a crosswise sequence.

Tightening torques for foot screws

Foot screws are used for screw mounting the housing to the mounting surface. They are not included in the scope of delivery of the housings.

The following table contains tightening torques for metric coarse pitch threads in accordance with DIN 13, DIN 962 and DIN ISO 965-2 as well as head contact dimensions in accordance with DIN EN ISO 4014, DIN EN ISO 4017, DIN EN ISO 4032, DIN EN ISO 4762, DIN 6912, DIN 7984, DIN 7990 and DIN EN ISO 8673.

The maximum tightening torques are valid with 90% utilisation of the yield stress of the screw material 8.8 and a friction factor of 0,14. We recommend that foot screws should be tightened to approx. 70% of these values, see table.

Tightening torques for foot screws with metric thread in accordance with DIN 13, DIN 962 and DIN ISO 965-2

Nominal screw diameter	Maximum tightening torque Nm	Recommended tightening torque Nm
M6	11,3	8
M8	27,3	20
M10	54	35
M12	93	65
M16	230	160
M20	464	325
M24	798	550
M30	1 597	1 100
M36	2 778	1 950
M42	3 991	2 750
M48	6 021	4 250
M56	9 650	6 750
M64	14 416	10 000
M72	21 081	14 500
M80	29 314	20 500
M90	42 525	29 500
M100	59 200	41 000

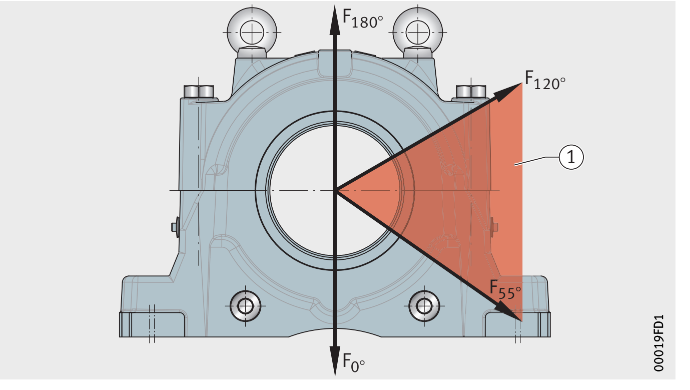
Horizontal location

In the case of plummer block housings, it may be necessary to supplement the foot screws by additional horizontal location of the housing.

Such horizontal location is necessary if one of the following conditions is fulfilled:

- The load angle is between 55° and 120°, *Figure 9*.
- Axial load is present.

Depending on the housing, the location may be implemented by means of stops in the load direction or pins.



1 Load angle range within which horizontal location of the housing is necessary

Figure 9
Load directions on a plummer block housing

Further information

This PDF file is part of “medias” (medias.schaeffler.de). Please also take note of all other information provided there (Internet pages, PDF files), where this information is applicable to your task.?

MH 1 medias / GB-D / published 20160331 / created 20170927 / PDF

Schaeffler Technologies
AG & Co. KG

Industriestraße 1–3
91074 Herzogenaurach
Germany
Internet www.schaeffler.de/en
E-mail info.de@schaeffler.com

In Germany:
Phone 0180 5003872
Fax 0180 5003873

From other countries:
Phone +49 9132 82-0
Fax +49 9132 82-4950

Schaeffler Technologies
AG & Co. KG

Georg-Schäfer-Straße 30
97421 Schweinfurt
Germany
Internet www.schaeffler.de/en
E-mail faginfo@schaeffler.com

In Germany:
Phone 0180 5003872
Fax 0180 5003873

From other countries:
Phone +49 9721 91-0
Fax +49 9721 91-3435

MH 1 GB-D