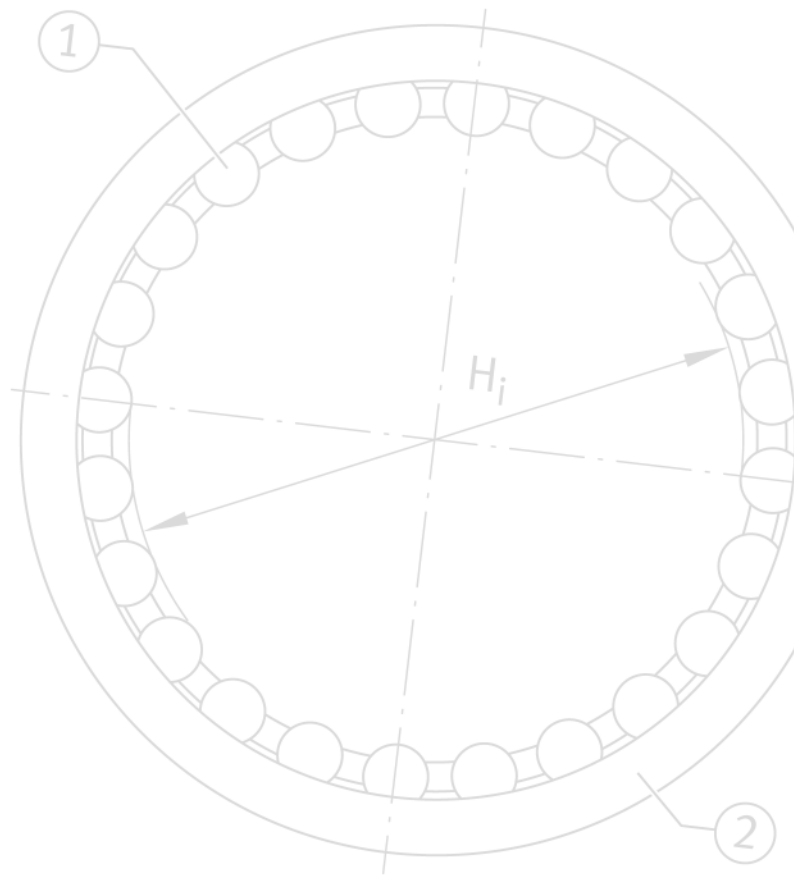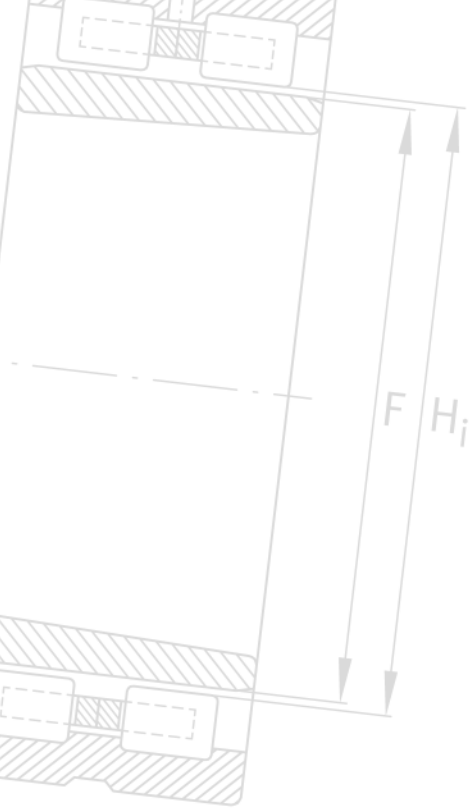SCHAEFFLER

Mounting Handbook

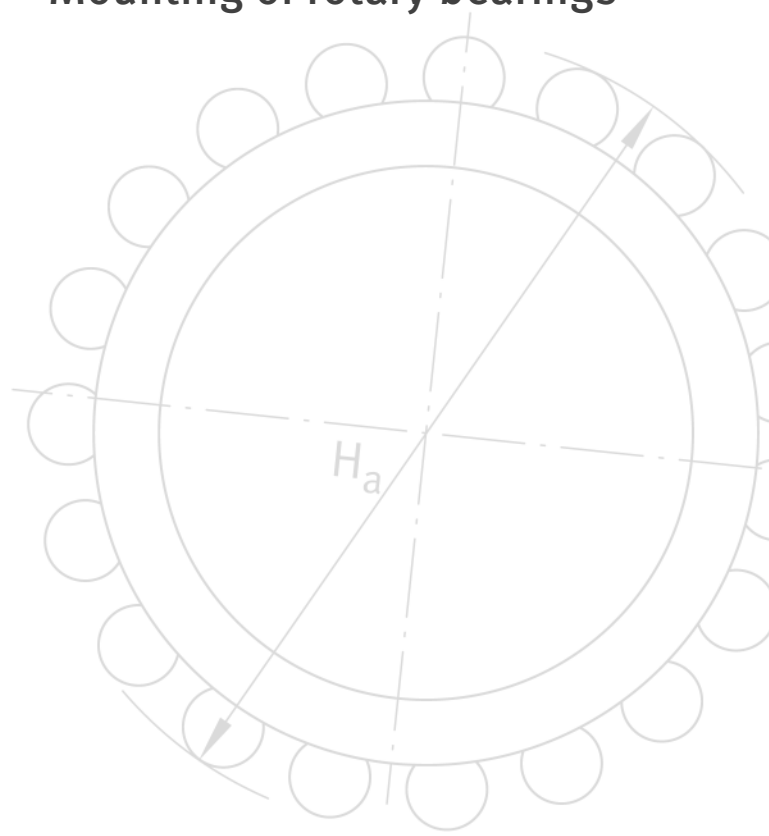Mounting of rotary bearings

Mounting Handbook

Mounting of rotary bearings

Foreword

Schaeffler is a leading worldwide supplier of rolling bearings, accessories specific to bearings and comprehensive maintenance products and services. Schaeffler has approximately 100 000 catalogue products manufactured as standard, providing an extremely wide portfolio that gives secure coverage of applications from all existing industrial market sectors.

Catalogue MH 1, Mounting Handbook

Rolling bearings are high quality goods and must therefore be handled with care. The use of suitable equipment as well as care and cleanliness in mounting and dismounting make a significant contribution to increasing the availability and lifetime of rolling bearings. With the aid of the diverse portfolio of products and services, operating life and performance capability of production plant can be increased and overall costs can be reduced.

This Catalogue MH 1 gives important guidelines on the correct handling of rotary bearing arrangements in mounting, dismounting and maintenance. Further information on the various bearing types, tools and methods can be found in the corresponding product brochures. If you have any other questions on the subject of bearing arrangements, the employees of Schaeffler worldwide will be pleased to assist you.

Catalogue HR 1, Rolling Bearings

Catalogue HR 1 describes the rolling bearings in accordance with DIN ISO that are required for original equipment manufacture, distribution and the aftermarket, specific rolling bearing accessories and further rolling bearing types and design variants.

It shows which products can be considered for a bearing arrangement, the factors that must be taken into consideration in the design, the tolerances required on the adjacent construction and how the bearing arrangement is sealed. It gives detailed information on the calculation of bearing rating life, on temperatures and loads, on the lubricants that are most suitable for the bearing arrangement and, last but not least, on the correct mounting and maintenance of the products.

Catalogue IS 1, Mounting and Maintenance

Catalogue IS1 is aimed principally at maintenance managers and operators of plant in which rolling bearings and other rotating machine components play a critical role in detemining the quality of products and processes. Those responsible for maintenance and production processes must be able to rely every day on the quality of their tools and the expertise of their service providers.

This catalogue gives an overview of the portfolio:
- mounting
- lubrication
- condition monitoring
- services.

Foreword

Global Technology Network

Schaeffler offers its diverse portfolio of products and services worldwide. In the Global Technology Network, Schaeffler combines its local competence in the regions with the knowledge and innovative strength of its experts worldwide under one philosophy. With our local centres of competence under the name "Schaeffler Technology Center", we bring our portfolio of services and our engineering and service expertise directly to your area. Through this combination, you will experience optimum support anywhere in the world and, thanks to our bundled knowledge, innovative and customised solutions of the highest quality. This makes it possible to achieve sustainable reductions in the overall costs of your machinery and plant and thus improvements in efficiency and competitiveness.

Figure 1
Our portfolio

Further information

- www.schaeffler.com/gtn
- ***medias***.

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Storage of rolling bearings
Seals
Bearing housings

Technical principles

Technical principles

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).

Bearing types

Rolling bearing types

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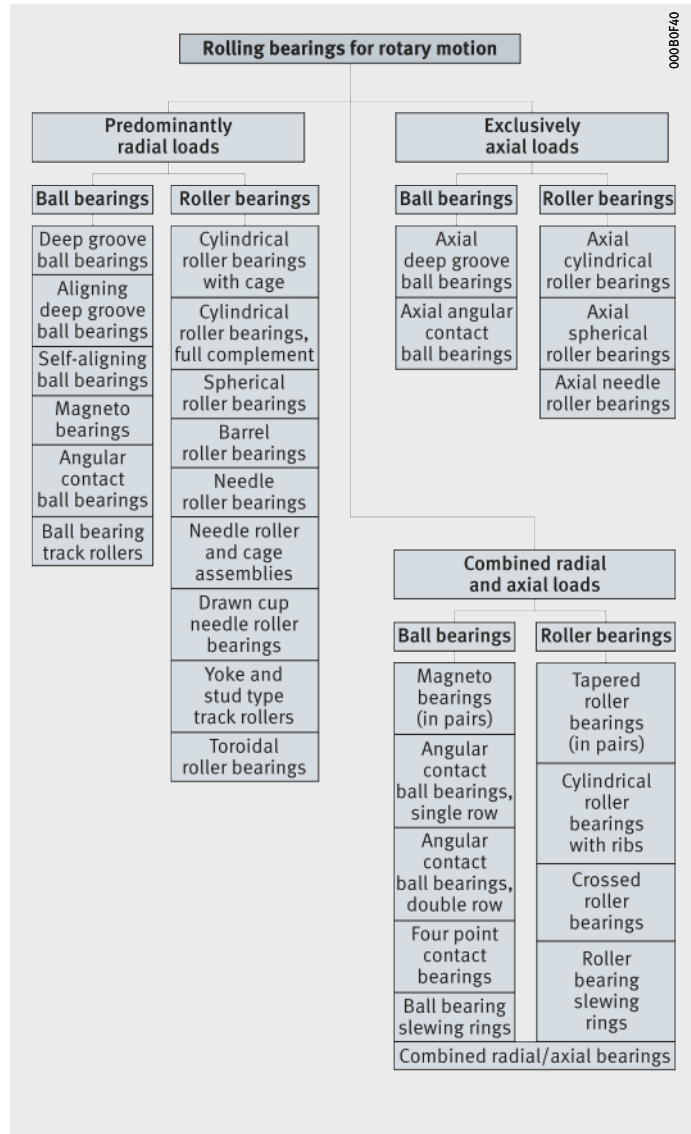
Figure 1
Overview
of rolling bearing types

Bearing arrangements

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 14.

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 20.

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
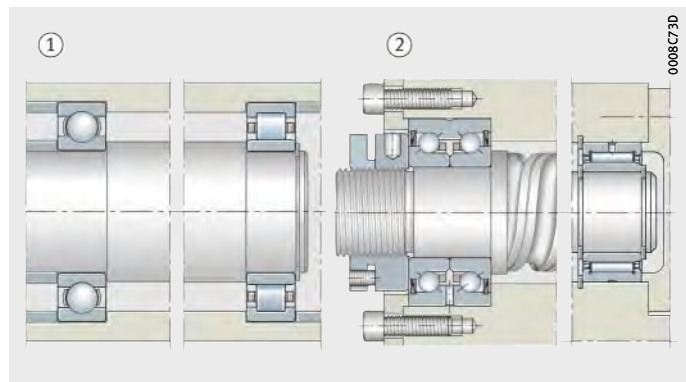
Figure 1
Locating/non-locating bearing arrangements

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

② Spherical roller bearings as locating and non-locating bearings
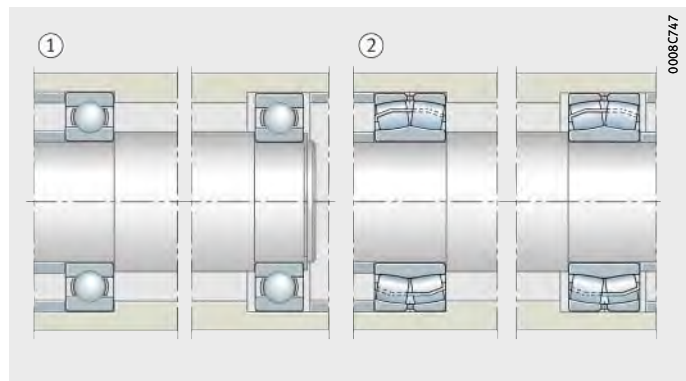
Figure 2
Locating/non-locating bearing arrangements

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.

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. The four point contact bearing, without radial support by the outer ring, can only support axial forces. The radial force is supported by the cylindrical roller bearing.

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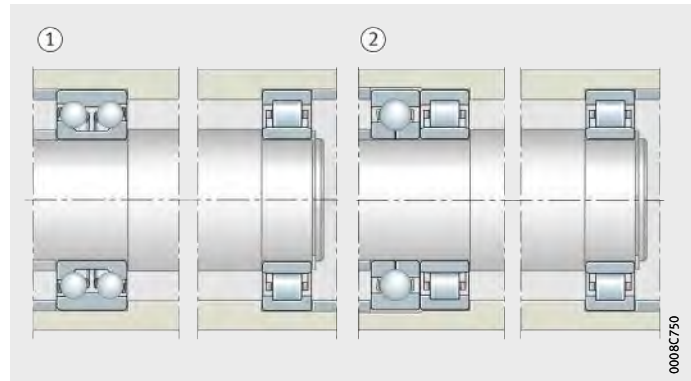
If a lower axial force is present, a cylindrical roller bearing with cage NUP can also be used as a locating bearing, *Figure 4* ②.

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
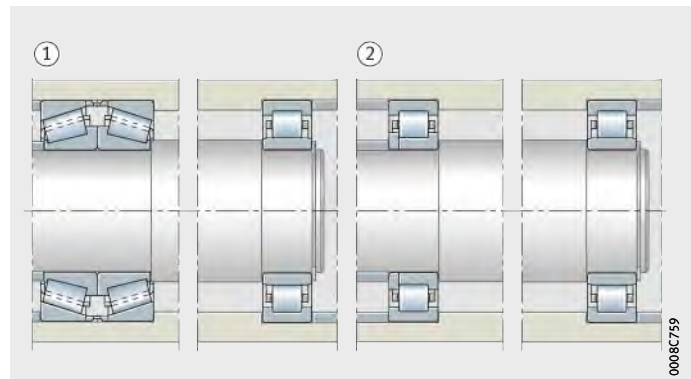
There are particular advantages in using angular contact ball bearings of the universal design, *Figure 5*. The bearings can be fitted in pairs in any O or X arrangement without shims. Angular contact ball bearings of the universal design are matched such that, in an X or O arrangement, they have a low 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
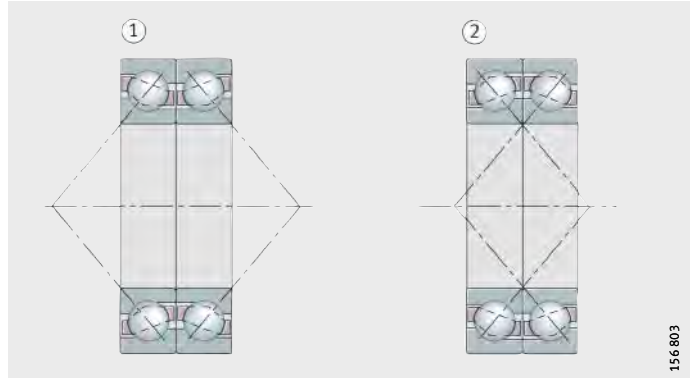
Figure 5
Locating bearing arrangements

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).

Spindle bearings of universal design
① O arrangement
② X arrangement
③ Tandem O arrangement
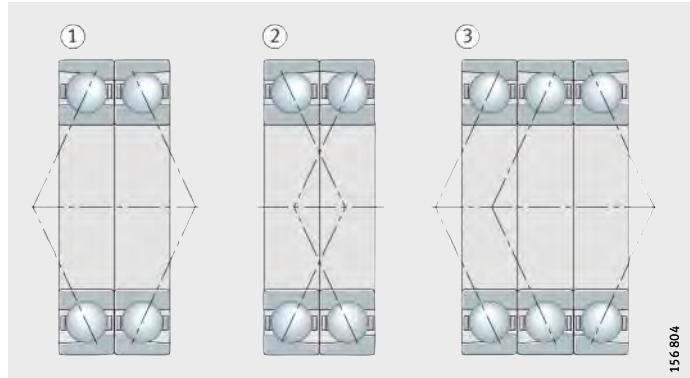
Figure 6
Locating bearing arrangements

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
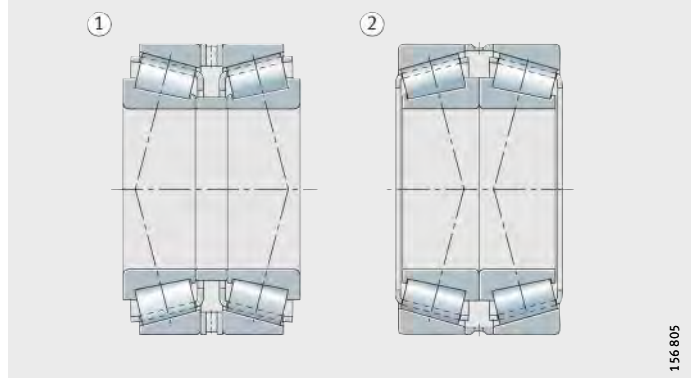
Adjusted bearing arrangement

These bearing arrangements normally consist of two symmetrically arranged angular contact ball bearings or tapered roller bearings, *Figure 8*, page 15. 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
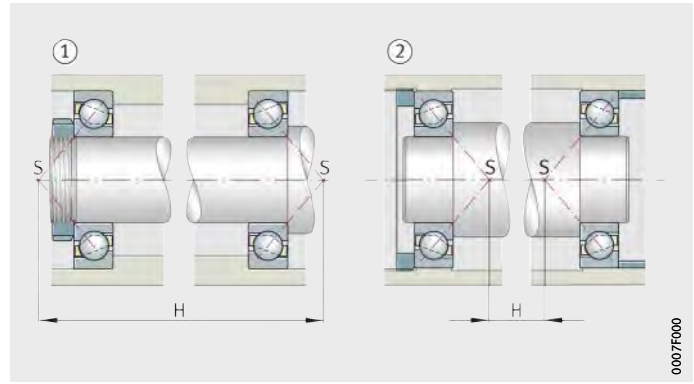
Figure 8
Adjusted bearing arrangement

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
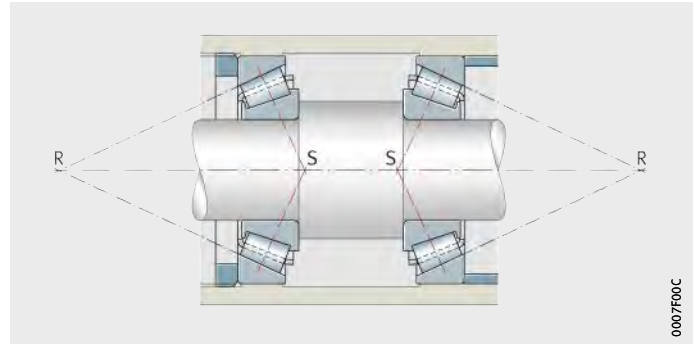
Figure 9
Adjusted tapered roller bearings
in X arrangement

Bearing arrangements

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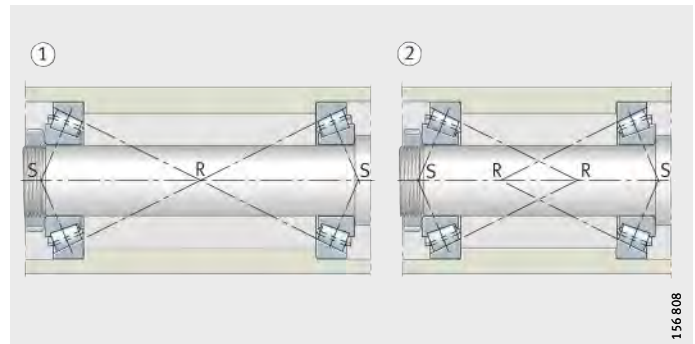
S = apexes of the contact cones
R = roller cone apexes

Intersection points do not overlap

Figure 11
Adjusted tapered roller bearings
in O arrangement
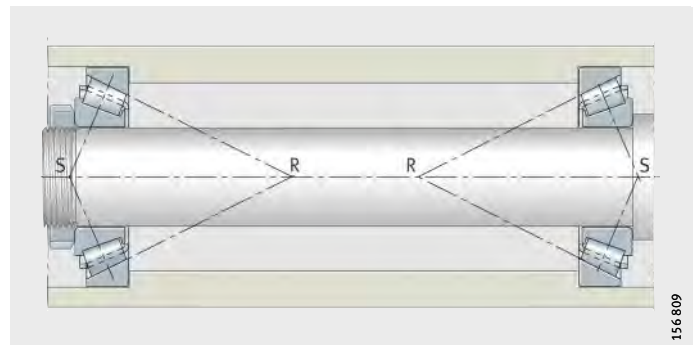
Elastic adjustment

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
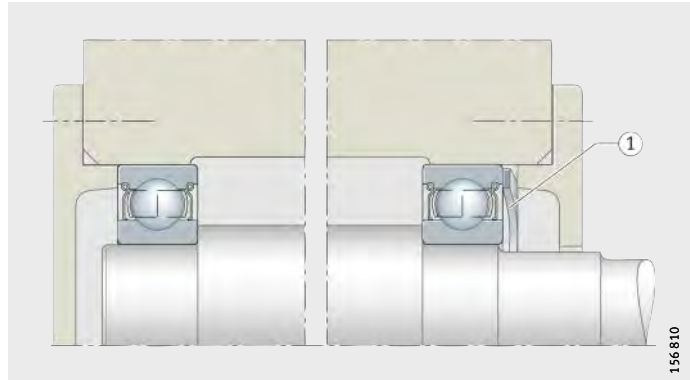
Bearing arrangements

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.
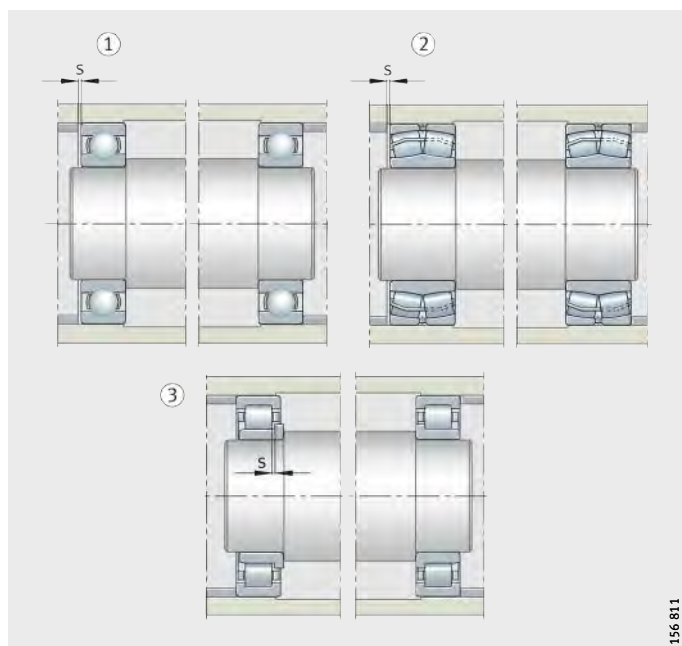
s = axial clearance

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

Figure 13
Floating bearing arrangements

156 811

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.
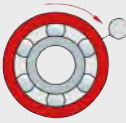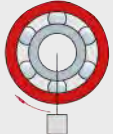
Circumferential load

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
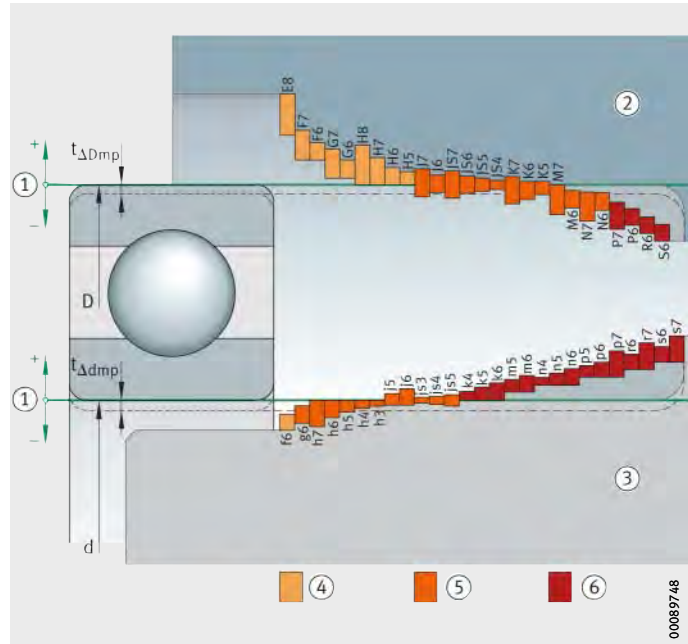
Figure 1
Fits for rolling bearings

The fit interference or fit clearance for shafts and housings is dependent on the specific bore diameter, see table, page 138, and table, page 146.

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
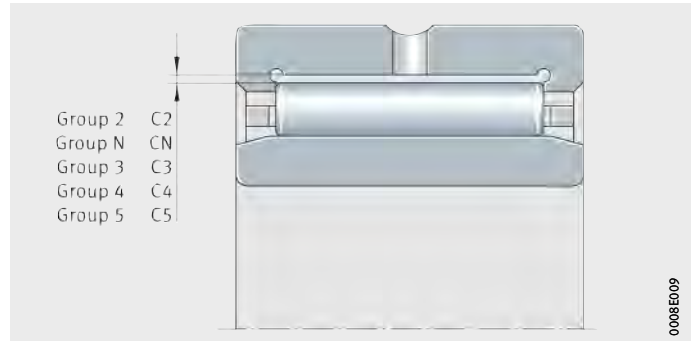
Figure 1
Radial internal clearance

Radial internal clearance groups

Internal clearance group to		Description	Application
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, see page 138
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, see tables starting on page 172.

The internal clearance of spherical roller bearings, cylindrical roller bearings and toroidal roller bearings is normally determined using feeler gauges in a vertical position, *Figure 7*, page 73. 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
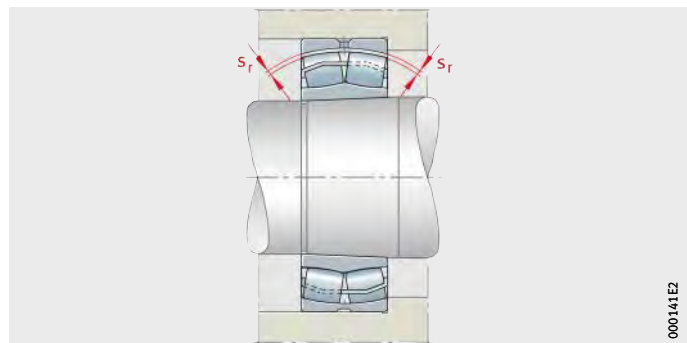
Internal clearance and operating clearance

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
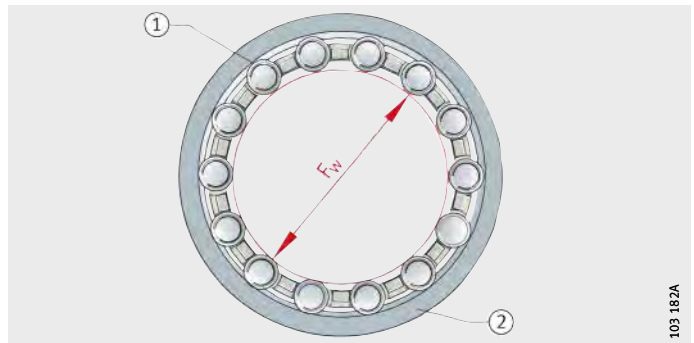
Operating clearance

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
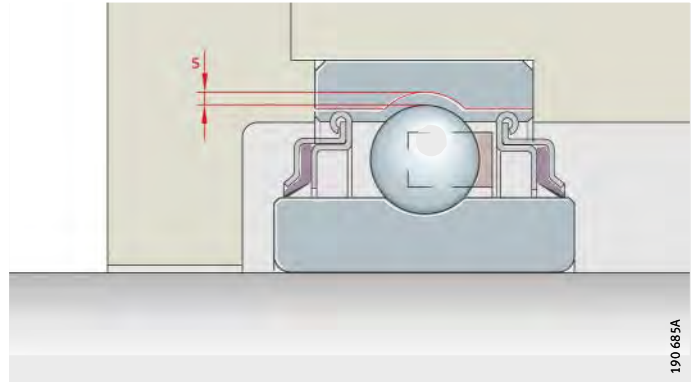
Operating clearance value

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.

The normal operating clearance is achieved with the internal clearance Group N or, in the case of larger bearings, predominantly with Group 3 if the recommended shaft and housing tolerances are observed, see page 138.

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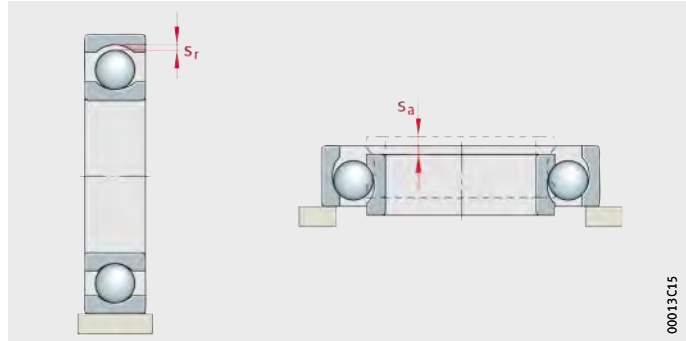
In various bearing types, the radial internal clearance s_r and the axial internal clearance s_a are dependent on each other. Guide values for the correlation between the radial and axial internal clearance are shown for some bearing types in the table.

Correlation between axial internal clearance and radial internal clearance

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

Axial internal clearance for double row FAG angular contact ball bearings and FAG four point contact bearings, see tables starting on page 182.

Geometrical and positional tolerances

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 29.

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

Figure 1
Geometrical and positional tolerances
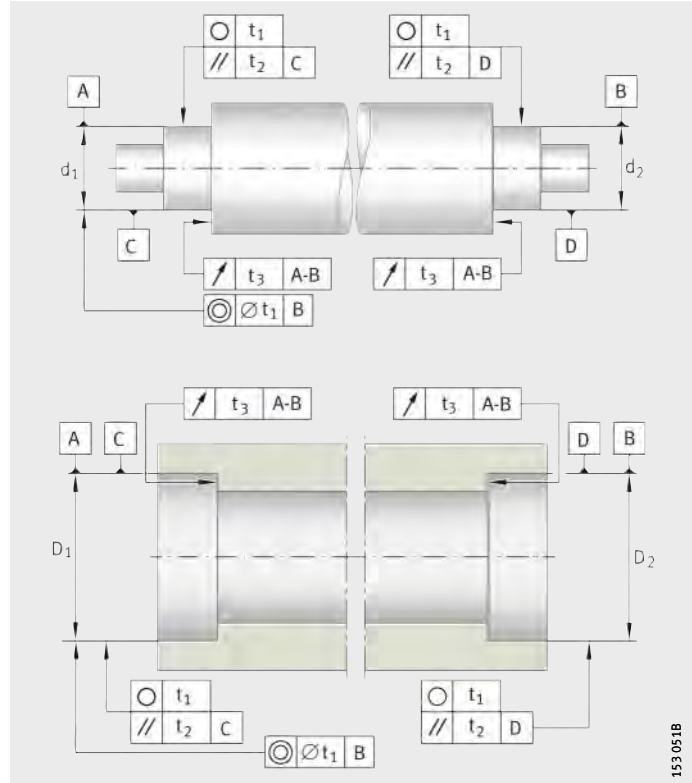
Accuracy of bearing seating surfaces

The degree of accuracy for the bearing seat tolerances on the shaft and in the housing is given in the table, page 29.

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 guidelines

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.

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*.
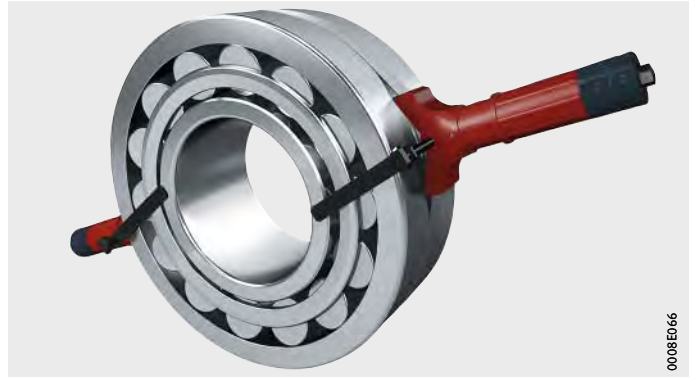
Figure 1
Secure lifting tool with protection against swivelling out

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.

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. In washing out, there is a risk that contamination will be introduced into the bearing.

The anti-corrosion oil should be washed off the seating and locating surfaces (especially in the case of tapered bearing bores) before mounting in order to ensure a secure fit.

In the thermal mounting of bearings, the maximum permissible temperature of the anti-corrosion agent must be observed.

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.

⚠ When washing out bearings, the highest possible cleanliness must be ensured.

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.

Dimensional and geometrical inspection

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 37.
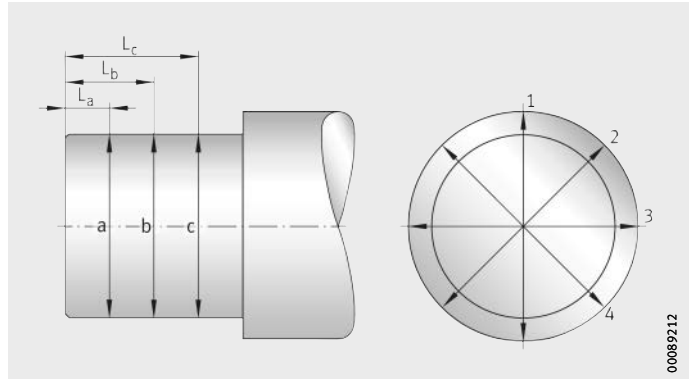
Figure 1
Checking the cylindricity of a shaft

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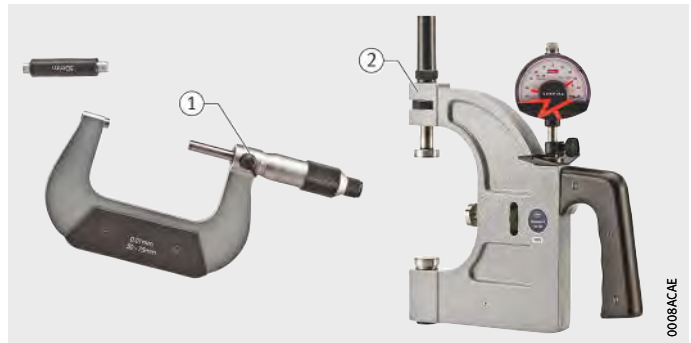
The measurement of bores is carried out using either conventional internal micrometers or so-called comparator gauges, *Figure 3*. The master ring shown is used for calibration of the measurement tool.

① Internal micrometer
② Comparative gauge with master ring

Figure 3
Gauge for measurement of bores
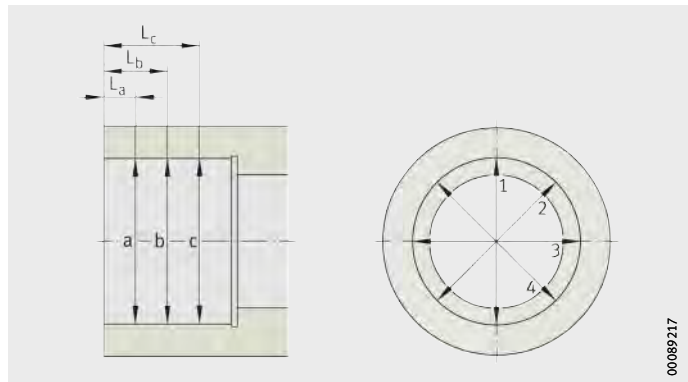
Figure 4
Checking the cylindricity of a housing

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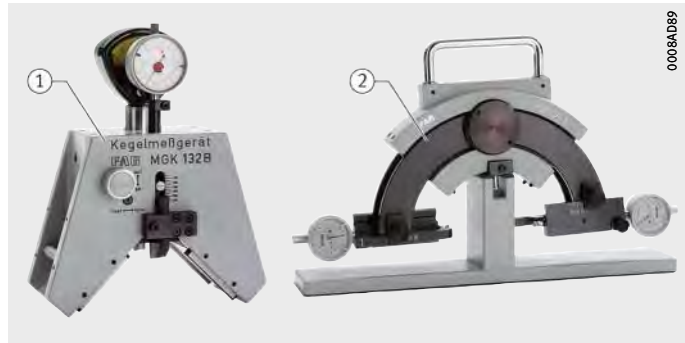
The taper gauge FAG MGK 133 is used to measure tapers shorter than 80 mm. Depending on the device size, the outside diameter of the taper can be between 27 mm and 205 mm.

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.

Dimensional and geometrical inspection

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 = inner enveloping circle
F = raceway diameter

① Rolling element
② Outer ring

Figure 7
Inner enveloping circle of
cylindrical roller bearings NNU49SK
(separable inner ring)
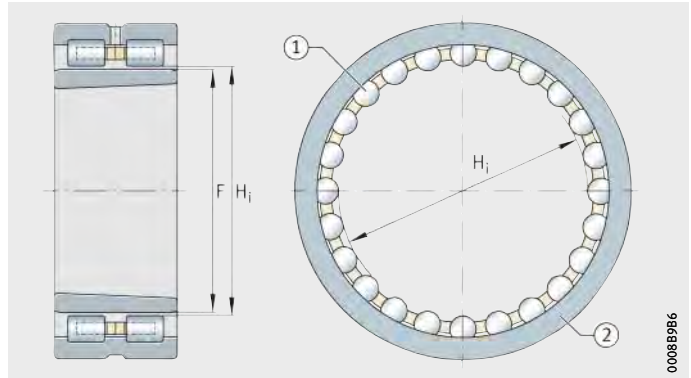
The internal enveloping circle is measured using MGI 21; in conjunction with a snap gauge, the radial internal clearance of the mounted bearing can be determined, *Figure 8*. The dimension for the enveloping circle diameter is transferred to the snap gauge. The enveloping circle gauge FAG MGI 21 is used 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 outer enveloping circle H_a. The outer enveloping circle is defined as the circle inscribed externally by all rollers when they are in contact with the inner ring raceway, *Figure 9*.

E = raceway
H_a = external enveloping circle

Figure 9
External enveloping circle of
cylindrical roller bearings NN30ASK
(separable outer ring)
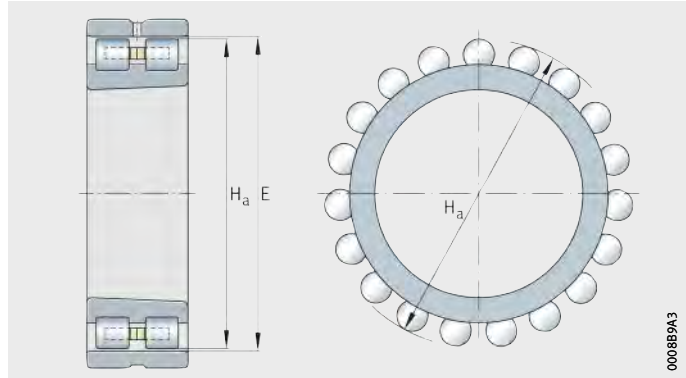
The external enveloping circle is measured using MGA 31; in conjunction with a snap gauge, the radial internal clearance of the mounted bearing can be determined, *Figure 10*.

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

Dimensional and geometrical inspection

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
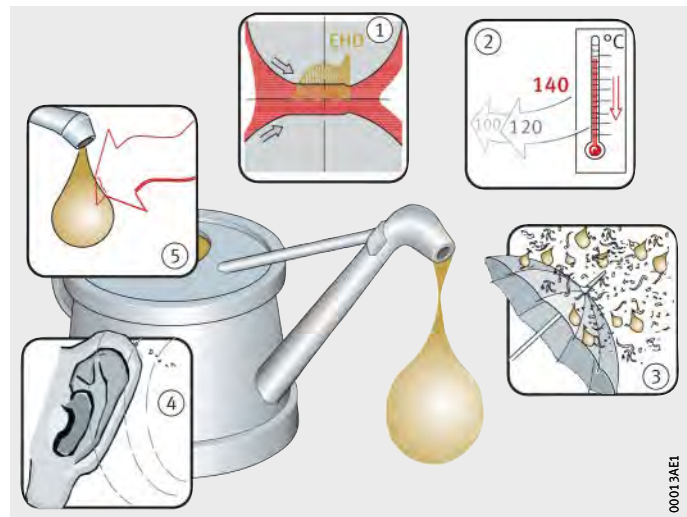
Figure 1
Functions of the lubricant

Lubrication

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.
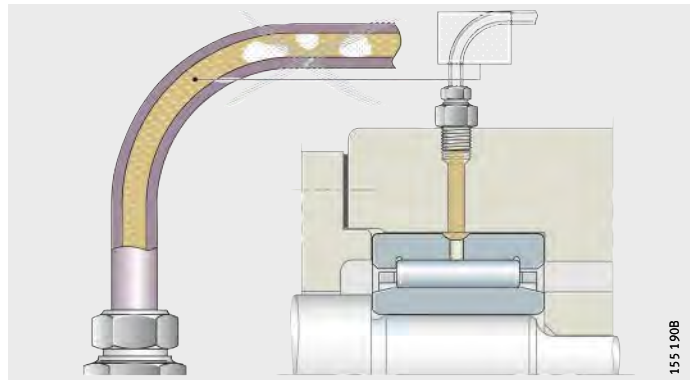
Figure 2
Lubricant feed lines
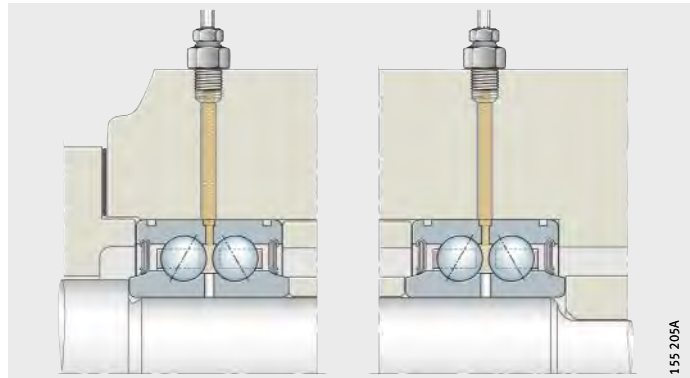
Figure 3
Arrangement of feed lines to more than one bearing on a shaft

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 ($n \cdot d_M < 50\,000$ min$^{-1} \cdot$ 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 ($n \cdot d_M > 400\,000$ min$^{-1} \cdot$ 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).

Lubrication

▪ 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
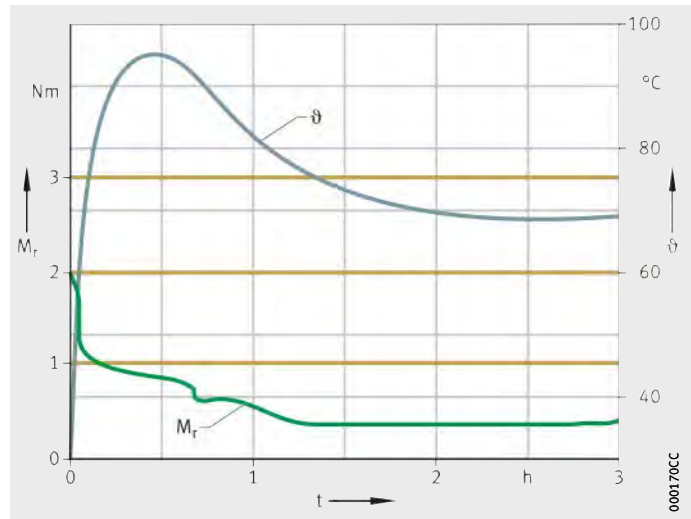
Arcanol rolling bearing greases

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, see table, page 190.

Figure 5
Analysis of the thermal behaviour of greases

Oils

For the lubrication of rolling bearings, mineral oils and synthetic oils are essentially suitable, see table, page 190. 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, 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

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 corrosion protection, packaging, storage and handling to each other. 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). Corrosion protection and packaging are matched by Schaeffler to these characteristics. The bearings must be stored in their original packaging for as long as possible.

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 bearings must be stored lying flat, not standing.

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, up to 70% permissible for up to 12 hours per day).

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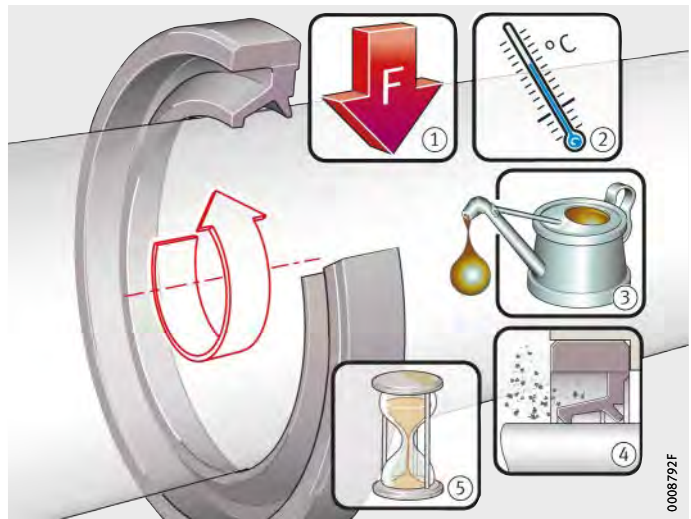
In grease lubrication of the bearing, the seal gaps formed must be filled with the same grease that is used within the bearing arrangement. An additional grease collar on the outside of the seal will protect the bearing against contamination.

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. |

Seals

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.
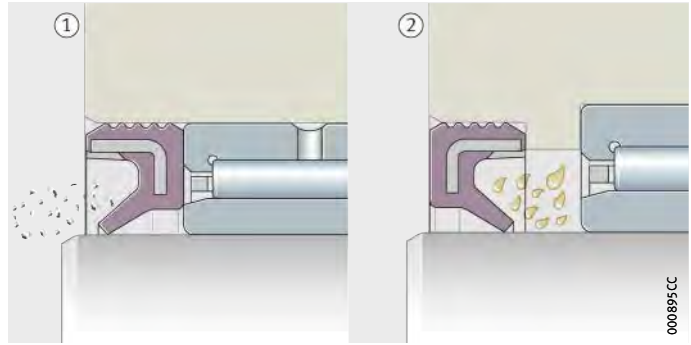
Characteristics of seal running surfaces

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

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 54.

- ■ A seal lip facing inwards prevents the egress of lubricant from the bearing, *Figure 2*, ②, page 54. 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
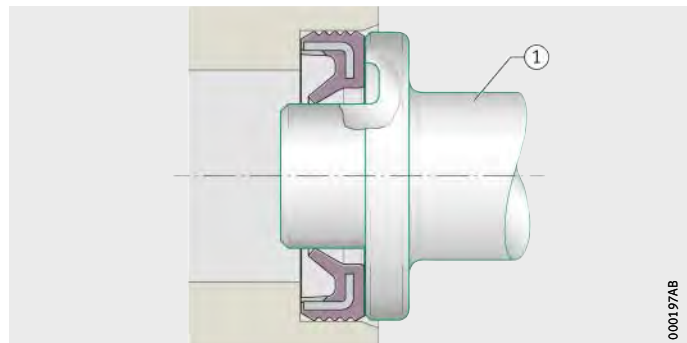
Seals

- 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
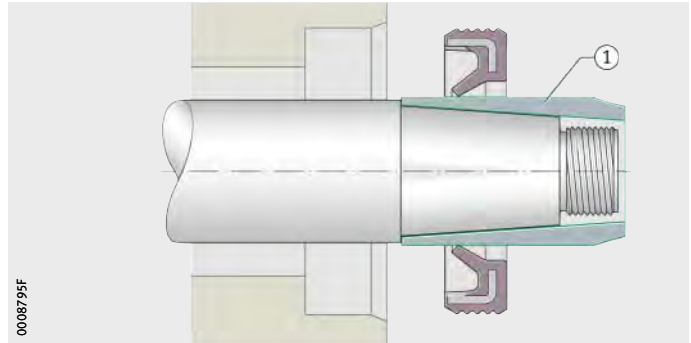
- Fit sealing rings perpendicular to the shaft axis and the housing bore, *Figure 5*.

Figure 5
Perpendicularity –
position of sealing ring
relative to shaft axis/housing bore
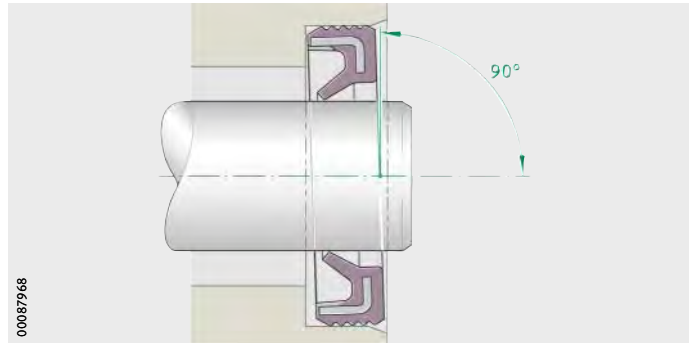
⚠️ Do not exceed the maximum perpendicularity between the sealing ring and the shaft axis once fitted, see table. A larger deviation will influence the sealing action.

■ In the case of sealing rings SD, the space between the seal lip and protective lip must be filled with grease, *Figure 6*.

■ 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 6
Grease filling between seal lip and protective lip

00087971
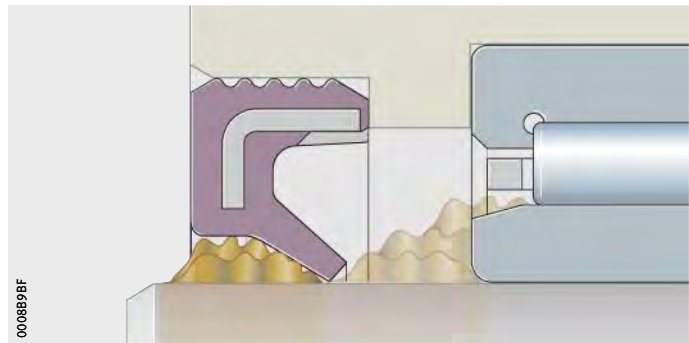
Figure 7
Grease collar
for supporting sealing action

0008B9BF

Maximum perpendicularity deviation

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

Seals

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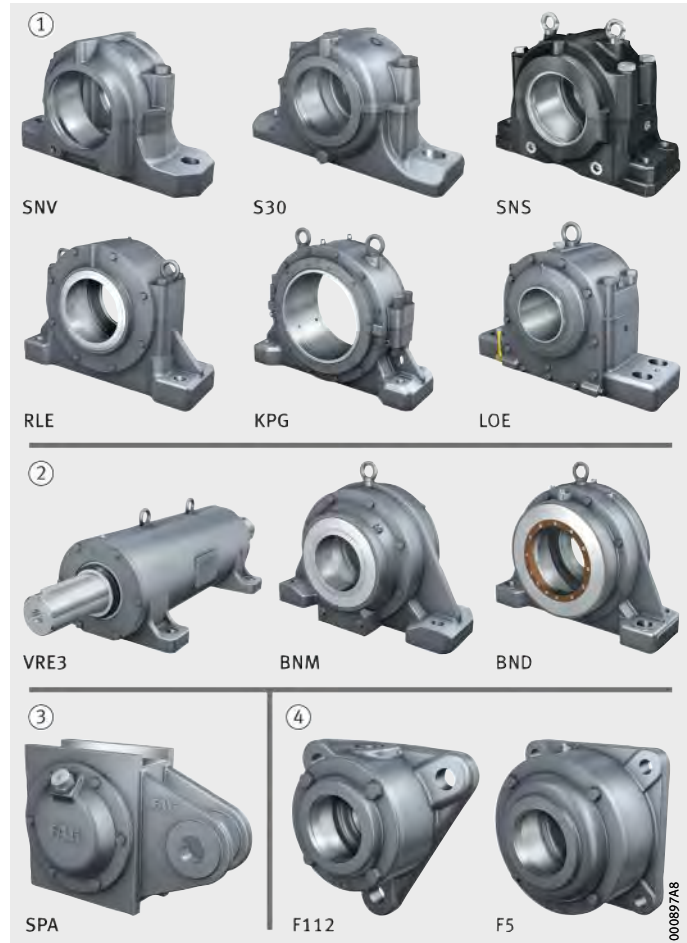
① Split plummer block housings
② Unsplit plummer block housings
③ Unsplit SPA housing
④ Flanged housings

Figure 1
Bearing housings

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
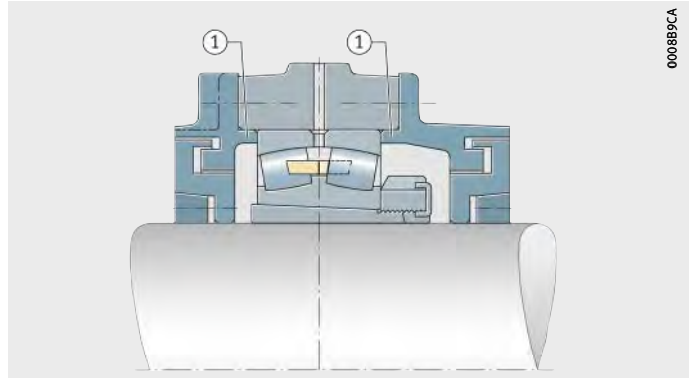
① Bearing can be axially displaced

Figure 3
Housing
in non-locating bearing design
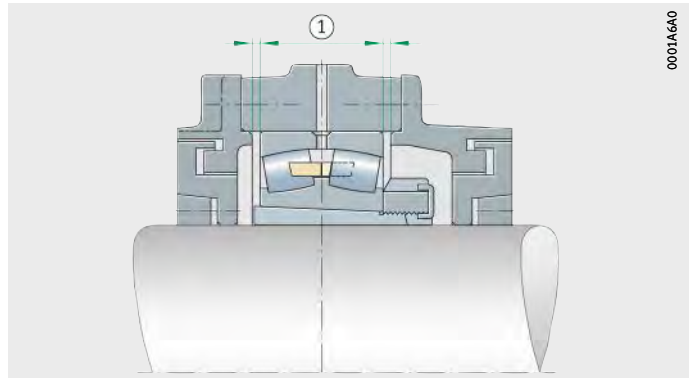
Housings with locating rings

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
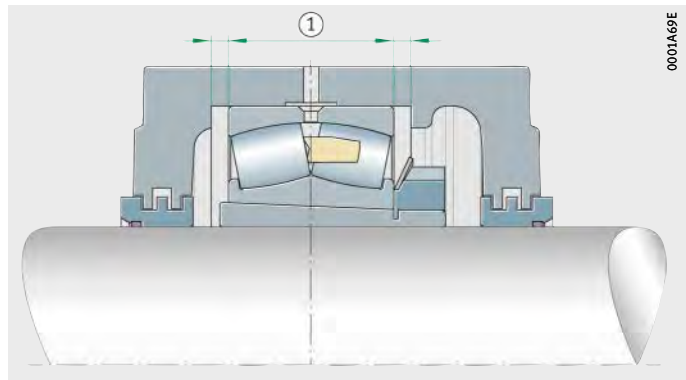
① Locating rings give axial location
of the bearing

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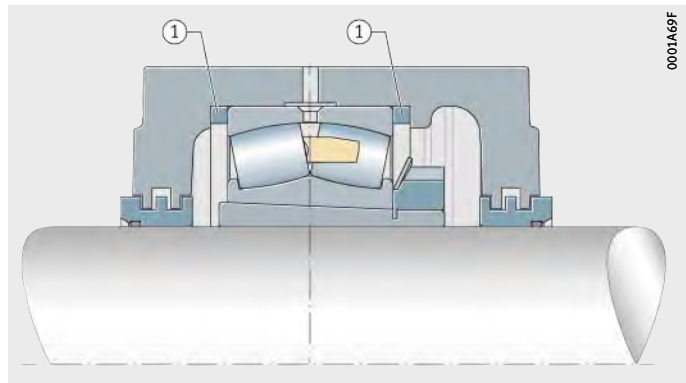
Housing seals

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.

Bearing housings

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
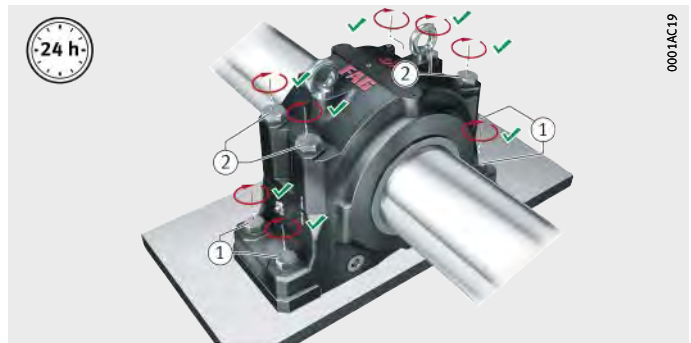
Eye bolts

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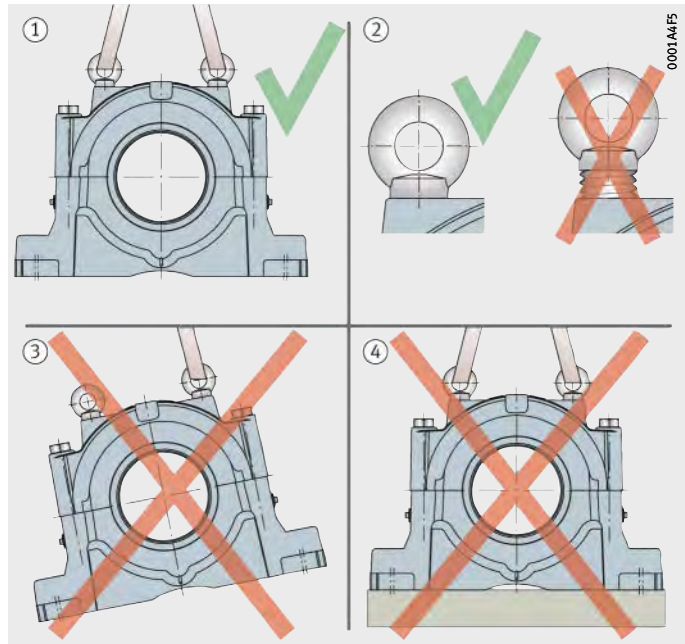
① Correct usage of eye bolts
as locating points
② Screw in eye bolts completely
③ Always use all eye bolts simultaneously
④ Do not apply additional load
as a result of attached parts

Figure 7
Correct usage
of eye bolts on the housing body

Bearing housings

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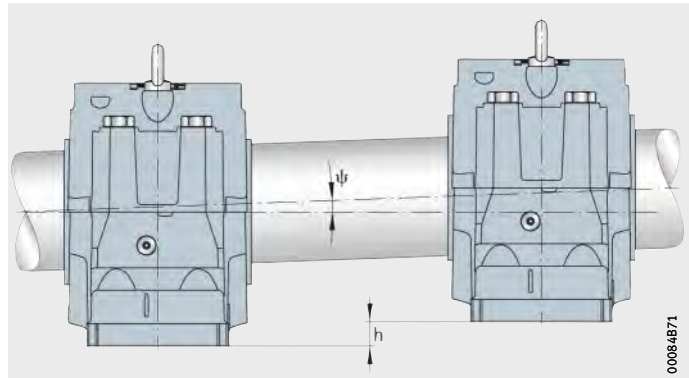
The permissible misalignment is dependent on the housing and seal variant. Differences in level must be compensated such that the permissible misalignment is not exceeded. Levelling shims can be used for this purpose.

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

Bearing housings

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
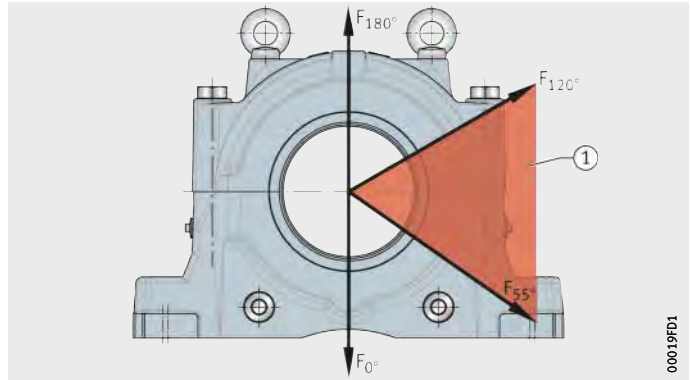
Mounting of rolling bearings

Mounting methods
Mounting of special types

Mounting of rolling bearings

Mounting methods

Due to the different types and sizes of rolling bearings, they cannot all be mounted using the same method. A distinction is made between mechanical, hydraulic and thermal methods.

In the mounting of non-separable bearings, *Figure 1*, the mounting forces must always be applied to the ring with a tight fit. Any forces applied to the ring with a loose fit would be transmitted by the rolling elements, which could cause damage to the raceways and rolling elements. Heating of the housing causes expansion of the bearing seat and thus makes the mounting process considerably easier.
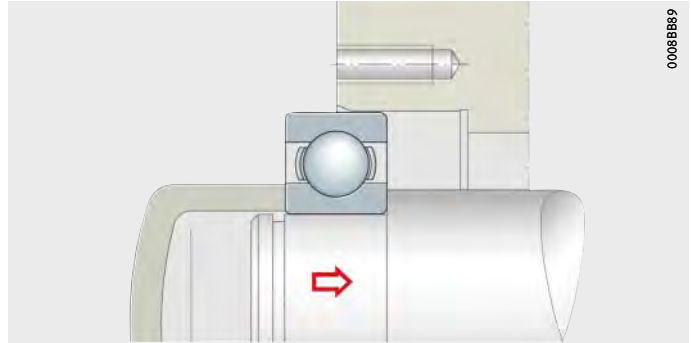
Figure 1
Mounting
of a non-separable bearing

In the case of separable bearings, *Figure 2*, mounting is simpler; both rings can be mounted individually. Rotating the ring during mounting gives a screwdriver effect that will help to avoid scraping marks.
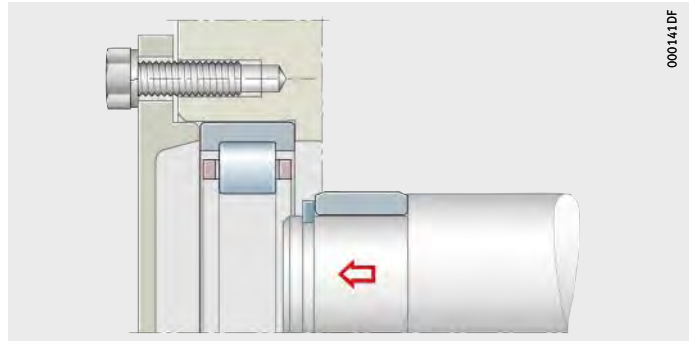
Figure 2
Mounting
of a separable bearing

Mechanical mounting

Smaller rolling bearings can often be mounted by purely mechanical means if the bearing seat is not too tight. It must be ensured, however, that the forces applied in this case do not cause damage to the bearings or their seating surfaces. The use of suitable tools and compliance with certain specifications is helpful in avoiding this.

**Mounting
of cylindrical seats**

Bearings up to a bore diameter of approx. 80 mm can be pressed onto the shaft where a cylindrical seat is present. It is recommended that a mechanical or hydraulic press is used in this case, *Figure 3*.
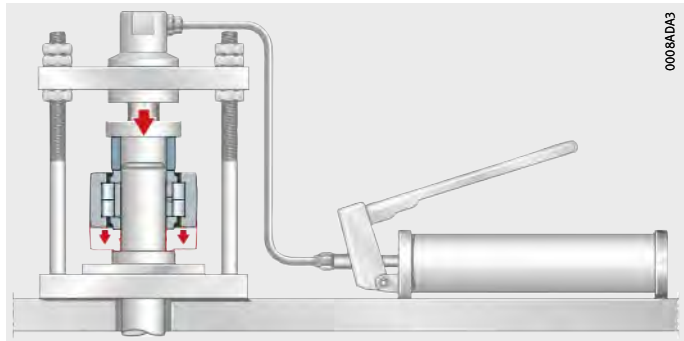
Figure 3
Mounting
by means of a hydraulic press

If a press is not available, bearings with a bore diameter up to 50 mm can also be driven onto the shaft by means of light hammer blows if the fits are not too tight. Since the hardened bearing rings are sensitive to impact load, it is recommended that aluminium mounting sleeves and plastic mounting rings are used, in which case the mounting forces are transmitted by means of form fit. This method can also be used for the mounting of sleeves, intermediate rings, seals and similar parts, *Figure 4*.
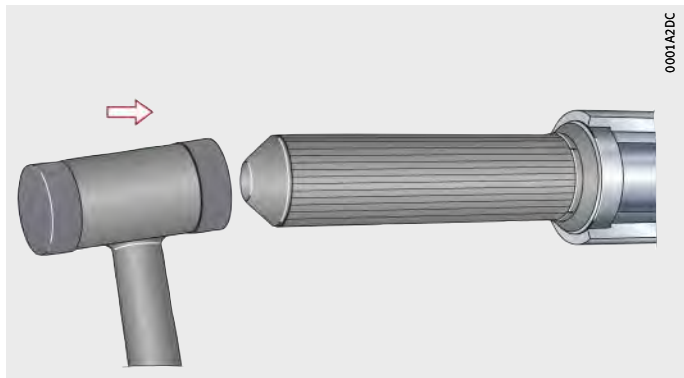
Figure 4
Mounting
using mounting sleeve

Mounting methods

When selecting the dimensions of the mounting sleeve or mounting ring, it must be ensured that the mounting forces are applied over the largest possible circumference but without creating any risk that the cage or rolling elements will be damaged.

If a bearing is to be simultaneously pressed onto the shaft and into the housing, a disc must be used that is in contact with both bearing rings; this prevents tilting of the outer ring in the housing, *Figure 5*.

① Mounting disc

Figure 5
Simultaneous pressing into place
using mounting disc
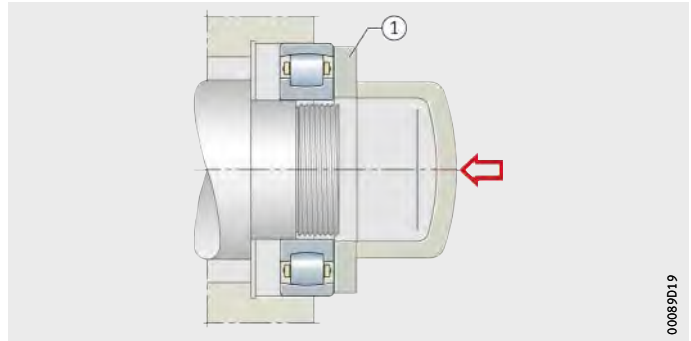
In some bearings, the rolling elements or bearing cage project at the sides. In this case, a recess must be produced in the disc by means of turning, *Figure 6*.

① Mounting disc

Figure 6
Pressing into place
of self-aligning ball bearings
with adapted mounting disc
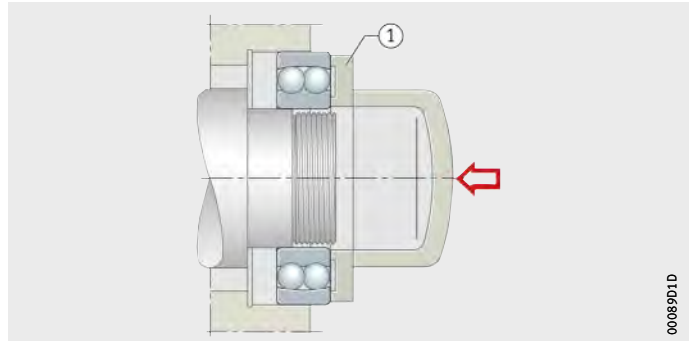
If very tight fits are specified, even small bearings should be heated for mounting, see page 78.

In the case of housings made from light metal or with a press fit, the seating surfaces can be damaged if the outer ring is pressed into the housing bore. In this case, the housing must be heated.

Mounting of tapered seats

Bearings with a tapered bore are mounted either directly on the tapered shaft or journal or by means of an adapter sleeve or withdrawal sleeve on the cylindrical shaft.

Before mounting, the bearing bore and the seating surfaces on the shaft and sleeve must be cleaned. No mounting paste or similar lubricant should be used. A layer of lubricant would reduce the friction and thus facilitate mounting; in operation, however, the lubricant is gradually squeezed out of the fit joint. As a result, the tight fit is lost and the ring or sleeve begins to creep, causing fretting of the surfaces.

When the bearing is slid onto the taper, the inner ring is expanded and the radial internal clearance is thus reduced. The reduction in radial internal clearance is therefore valid as a measure of the seating of the inner ring.

The reduction in radial internal clearance is determined by the difference in the radial internal clearance before and after mounting of the bearing. The radial internal clearance must first be measured before mounting; during pressing onto the taper, the radial internal clearance must be checked continuously until the required reduction in internal clearance and thus the necessary tight fit is achieved, *Figure 7*.

Figure 7
Measurement
of radial internal clearance
using feeler gauges

Mounting methods

In the case of sealed bearings, the radial internal clearance is not measured.

Instead of the reduction in radial internal clearance, the axial drive-up distance on the taper can be measured. In the case of the normal taper 1:12 of the inner ring bore, the drive-up distance corresponds to approximately fifteen times the reduction in radial internal clearance. The factor 15 takes into consideration that the interference of the fit surfaces acts only to the extent of 75% to 80% as expansion of the inner ring raceway.

If neither the reduction in radial internal clearance nor the drive-up distance can be reliably determined, the bearing should if possible be mounted outside the housing. The bearing may only be pressed into place so far that it can still be rotated easily and the outer ring can easily be swivelled by hand. The fitter must be able to sense when the located bearing still runs freely.

If a dismounted bearing is mounted again, it is not sufficient to move the retaining nut to its earlier position. After longer periods of operation, the fit loosens again since the thread undergoes settling and the seating surfaces become smoothed. The reduction in radial internal clearance, the drive-up distance or the expansion must therefore also be measured in this case.

In order to press the bearing onto the tapered seat or press in a withdrawal sleeve, mechanical or hydraulic presses are used. The type of mounting to be selected in the individual case is dependent on the mounting conditions.

Hook wrenches

Hook wrenches can be used to tighten and loosen locknuts (precision locknuts) on shafts, adapter sleeves or withdrawal sleeves, *Figure 8*. Hook wrenches can be used to mount small and medium-sized rolling bearings on tapered shaft seats, adapter sleeves or withdrawal sleeves. If no torque value is specified, jointed hook wrenches, jointed pin wrenches and jointed face wrenches can be used for locknuts and precision locknuts.

Figure 8
Hook wrench

Small bearings with an adapter sleeve are slid onto the tapered seat of the sleeve by means of the adapter sleeve nut and a hook wrench, Figure 9.
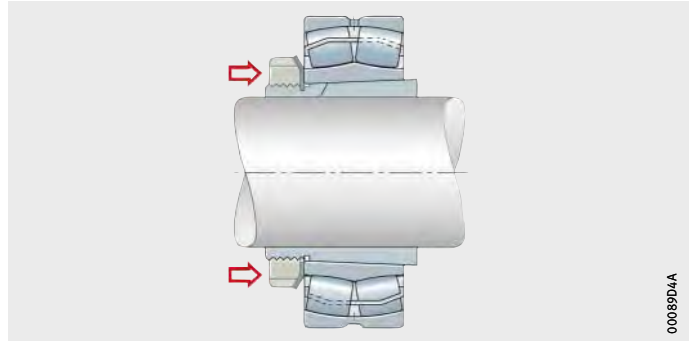
Figure 9
Pressing a spherical roller bearing onto an adapter sleeve using the adapter sleeve nut

Small withdrawal sleeves are pressed into the gap between the shaft and inner ring bore using a locknut, Figure 10.
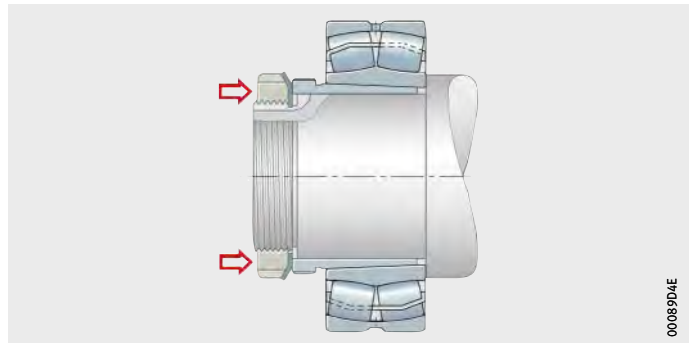
Figure 10
Pressing into place a withdrawal sleeve using the shaft nut

Mounting methods

Double hook wrenches

Double hook wrenches are intended for the mounting of smaller self-aligning ball bearings and spherical roller bearings on adapter sleeves. They contain torque wrenches for precisely determining the initial mounting position before the bearing is pushed into place.

Each double hook wrench is engraved with torsion angles so that the drive-up distance and reduction in radial internal clearance can be precisely set, *Figure 11*.

Measurement of the radial internal clearance is difficult especially in the case of smaller self-aligning ball bearings and spherical roller bearings. If the bearing is mounted in a housing, it is not possible to measure the radial internal clearance in some cases.

As a result, measurement is often dispensed with and the radial internal clearance is estimated in approximate terms by means of the method normally used in the past. In this case, the rolling bearing is pressed onto the adapter sleeve until the outer ring can still be freely rotated and slight resistance is felt under swivelling.

With the method we recommend, the radial internal clearance can be set very accurately. The radial internal clearance is reduced in two stages. First, the locknut is lightly tightened to a specified tightening torque. This gives a precisely defined initial position and the radial internal clearance is then set very accurately in the second stage.

The locknut is then tightened by a defined angle. The radial internal clearance has now been reduced by the recommended 60% to 70%.

Figure 11
Mounting
by means of double hook wrench

Shaft nuts with pressure screws

In the case of larger bearings, considerable forces are required in order to tighten the nuts. In such cases, mounting is made easier by means of the shaft nut with pressure screws shown in *Figure 12*. A spacer ring should be inserted between the nut and sleeve in order to prevent damage to the sleeve.
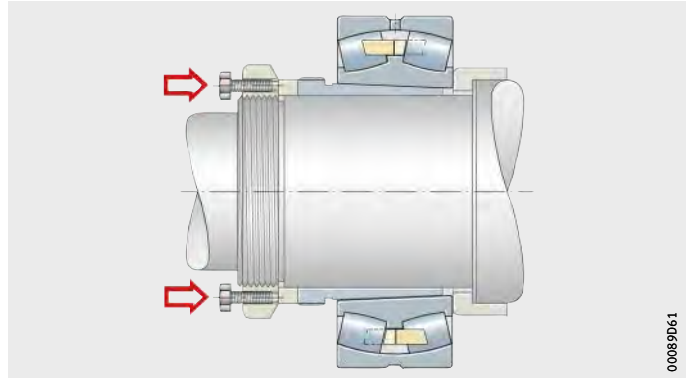
Figure 12
Mounting by means of shaft nut with pressure screws

In order to prevent tilting of the bearing or sleeve, the nut is first tightened only to the point where the nut and mounting ring are fully in contact. The pressure screws are made from quenched and tempered steel and uniformly distributed over the circumference – their quantity is based on the forces required – and are tightened uniformly in a circular sequence until the necessary reduction in radial internal clearance is achieved. Since the taper connection is self-locking, the device can then be removed and the bearing secured by means of its own retaining nut. The principle can also be applied to bearings that are located on an adapter sleeve or directly on a tapered journal.

For the mounting of large bearings, it is advisable to use hydraulic methods in order to slide the bearing into place or press in the sleeve. Further information on this procedure can be found on page 83.

Mounting methods

Thermal mounting

Bearings with a cylindrical bore should be heated before mounting if a tight fit on the shaft is intended and the effort required for pressing into place by mechanical means is too great. The temperature required for mounting is shown in *Figure 13*. The data are valid for maximum fit interference, a room temperature of +20 °C and an excess temperature safety margin of 30 K.

ϑ = heating temperature
d = bearing diameter

① Shaft tolerance

Figure 13
Temperature
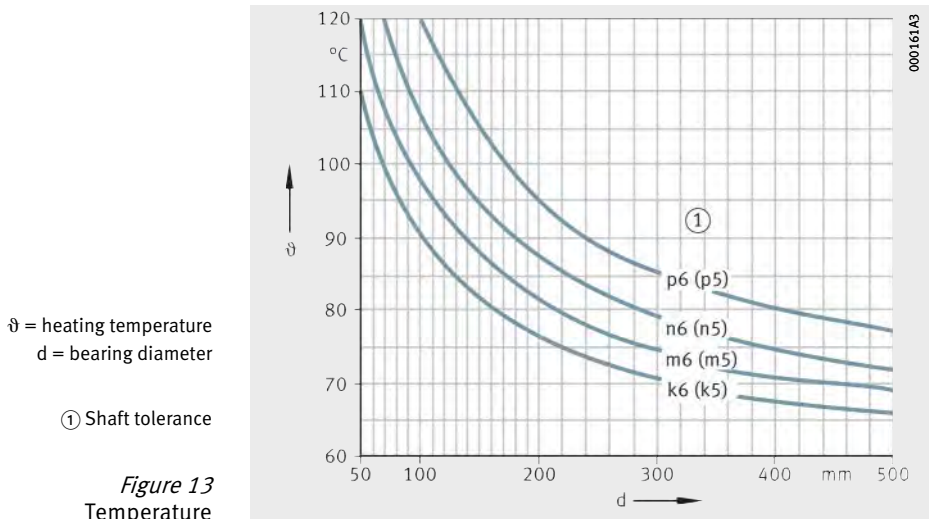
When heating the bearings, the temperature must be precisely monitored. An excessive temperature differential between the individual components can lead to distortion with the bearing and thus to damage. In the case of all non-separable rolling bearings, such as spherical roller bearings, it must be noted that the radial internal clearance present is taken up relatively quickly by the temperature difference between the bearing components and the rolling elements may be pressed into the raceway of the colder components. In addition, the heating must not normally exceed +120 °C, in order to prevent changes to the structure and hardness of the bearing. Furthermore, the maximum temperature of the preservative must be observed.

Bearings with cages made from glass fibre reinforced polyamide and bearings that are sealed or have already been greased can be heated to max. +80 °C but not, however, in an oil bath.

After heating, the parts are slid in a single movement, rapidly and without tilting, up to the stop on the seat. While sliding onto the shaft, slight rotation to give a screwdriver effect helps to achieve prompt mounting. Protective gloves should be worn when mounting the heated parts, *Figure 14*.

Where tight fits are present in the housing, in other words where there is circumferential load on the outer ring, the housing can also be heated for the purposes of support.

Figure 14
Sliding into place
of heated bearing parts

Once the inner ring has been slid in place, it must immediately be secured against its axial abutment point and held under tension until it has cooled, so that it then remains in full contact. There must not be any gap between two rings positioned adjacent to each other.

Mounting methods

Induction heating device

Rolling bearings can be brought to mounting temperature quickly, safely and above all cleanly by the use of induction heating devices operating by the transformer principle. The devices are used mainly in batch mounting work.

The heating devices can be used to heat rolling bearings of all types, including greased and sealed bearings. The smallest heating device is used for bearings with a bore of 10 mm or larger, *Figure 15*. The maximum bearing mass for the heating device shown here, for example, is 50 kg.

Figure 15
Small heating device

The operating range of the largest heating device starts at a bore of 90 mm, *Figure 16*. The heaviest workpiece mass can be up to 1 600 kg.

Figure 16
Large heating device

After the heating process, the bearing is automatically demagnetised. Further details on induction heating devices are given in TPI 200, FAG Heating Devices for Mounting of Rolling Bearings.

Heating plate	Heating plates are used to heat rolling bearings or small machine parts by means of contact heat. It must be ensured, however, that the entire bearing is heated uniformly.
	A ring or disc is placed between a heating plate without temperature control and the inner ring of a bearing with a polyamide cage.
Oil bath	With the exception of sealed, greased bearings and high precision bearings, rolling bearings of all sizes and types can be heated in an oil bath. For heating, a clean oil with a flash point above +250 °C must be used. A thermostatic controller is advisable (temperature +80 °C to +120 °C). In order that the bearings are heated uniformly and no deposits of contamination occur within them, they should be laid on a grid or suspended in the oil bath. After heating, the oil must be allowed to drain off thoroughly and all fit and locating surfaces must be carefully wiped.
	With this method, please note the risk of accidents, environmental pollution by oil vapour and flammability of hot oil.
Heating cabinet	Safe, clean heating of rolling bearings can be carried out in a heating cabinet. The temperature is controlled by means of a thermostat and is therefore precisely maintained. There is almost no possibility of bearing contamination. The disadvantage is that heating by means of hot air takes a relatively long time and is comparatively intensive in terms of time and energy.
Medium frequency technology	With the aid of FAG devices using medium frequency technology, it is possible to heat very large and heavy bearings as well as other components of shrink fit connections by inductive means in order to achieve joining and loosening. Due to its compact construction, the device can also be used for mobile operation.
	The heating device comprises the medium frequency generator and an inductor, *Figure 17*, page 82. Depending on the application, this can be of a flexible or rigid design. The flexible version is similar to a cable that is placed either within the bore or on the outside of the workpiece. Flexible inductors are suitable for workpieces of various sizes and various shapes and can be used for long periods, depending on their design, at heating temperatures up to +180 °C or +300 °C.

Mounting methods

Figure 17
FAG medium frequency
heating device

In batch production applications, where large quantities of identical components are mounted, flexibility is less important than reduced setup times and increased process reliability. Rigid inductors are suitable for this task. In this design, the coil is fitted in a housing matched to the workpiece and can thus be placed quickly and easily in the heating zone. Rigid inductors are also suitable, in contrast to the flexible variant, for small components.

! In the heating of non-separable bearings, the outer ring must be heated first so that the internal clearance is maintained and damage to the bearing is prevented.

! The devices are designed for the specific application. Please contact the application experts at Schaeffler.

Advantages
- Versatile application possibilities by means of flexible inductors.
- Ease of transport – usable anywhere.
- Rapid, energy-efficient operation.
- Short heating times and high productivity.

Further information
- TPI 217, Induction Units with Medium Frequency Technology.

Hydraulic mounting   Hydraulic tools can be used to apply large forces. These methods are therefore particularly suitable for the mounting of large bearings with a tapered bore. Hydraulic nuts are used as a mounting tool. Pressure can be generated using oil injectors, hand pumps or hydraulic units.

Hydraulic nuts   Hydraulic nuts are used to press components with a tapered bore onto their tapered seat, *Figure 18* and *Figure 19*, page 84. These tools are mainly used if the drive-up forces required cannot be applied using other accessories, e.g. shaft nuts or pressure screws. Hydraulic nuts comprise a press ring and an annular piston. Depending on size, the nut thread is a metric precision thread or a trapezoidal thread. Inch size designs are also available. The oil connector, irrespective of size, is always designed as $G^{1}/_{4}$. The necessary drive-up distance is checked by means of a dial gauge.

① Mounting on a tapered seat

Figure 18
Mounting
of a spherical roller bearing
using a hydraulic nut
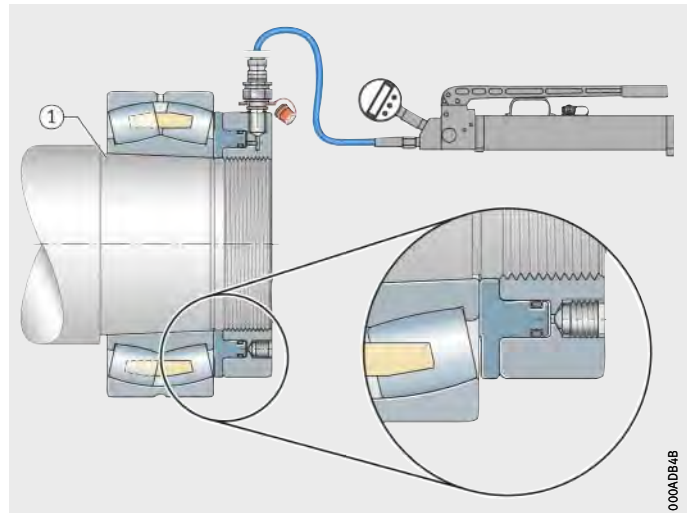
Mounting methods

① Pressing into place
on an adapter sleeve
② Pressing into place
of a withdrawal sleeve

Figure 19
Mounting
of a spherical roller bearing
using a hydraulic nut

000ADB5D
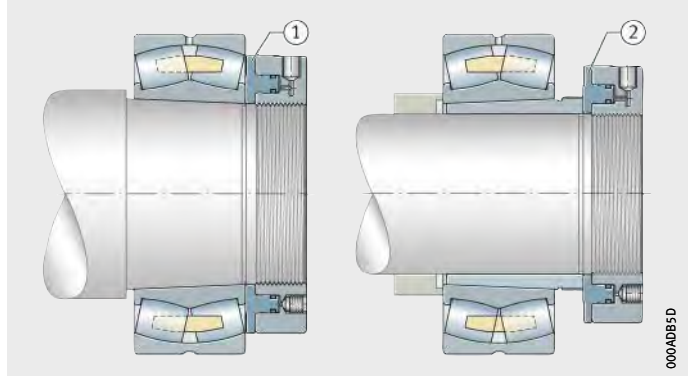
Figure 20
Mounting
of a spherical roller bearing
with a withdrawal sleeve and
pressure plate
(using the hydraulic method)

000ADAF9
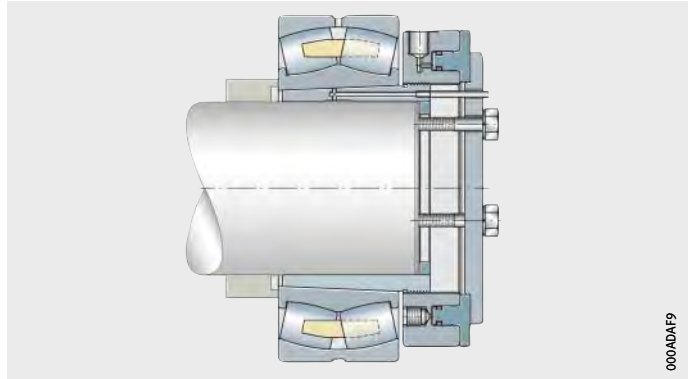
Figure 21
Mounting
of a spherical roller bearing
with a withdrawal sleeve and
support ring
(using the hydraulic method)

000ADAFA
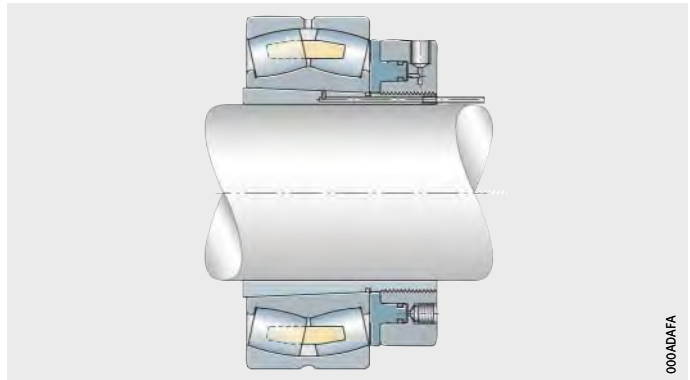
Oil pressure method

In the oil pressure method, oil is pressed between the fit surfaces, *Figure 22*. This method is particularly suitable for the mounting of large bearings with a tapered bore on a conical shaft or on an adapter or withdrawal sleeve. The oil film substantially neutralises the contact between the fit parts, so they can be displaced relative to each other with the application of little force and without the risk of surface damage. Fretting corrosion is loosened by means of paraffin or rust-dissolving additives in the oil.

① Cylindrical seating surface
② Tapered seating surface

Figure 22
Principle of hydraulic mounting: creation of a fluid film between the fit surfaces
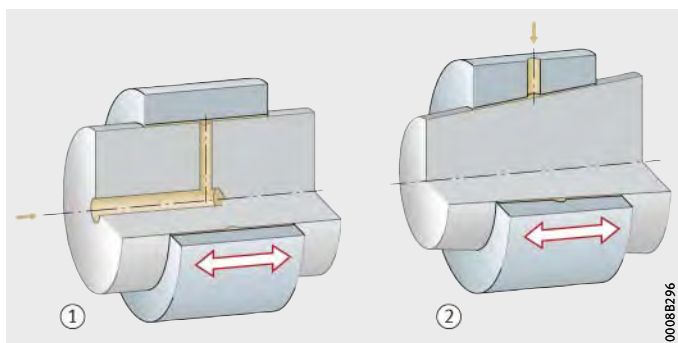
In both cases, oil grooves and feed ducts as well as threaded connectors for the pressure generation devices must be provided. The width of the oil groove is dependent on the bearing width, *Figure 23*, page 86. Further design guidelines are given in the FAG publication WL 80102, Hydraulic Method for the Mounting and Dismounting of Rolling Bearings. Hydraulic nuts are used as a mounting tool. Pressure can be generated using hand pumps and hydraulic units. In isolated cases, oil injectors can also be used.

A mounting plate prevents damage to the sleeve or bearing ring. When pressing in the withdrawal sleeve, *Figure 25*, page 86, the oil connector is guided by the shaft nut. The drive-up distance of the bearing or withdrawal sleeve is determined in accordance with the necessary reduction in radial internal clearance. In order to measure the radial internal clearance, the bearing must be disconnected from the oil pressure.

Once the oil pressure has been disconnected, it will take between 10 minutes and 30 minutes until the oil has completely escaped from the fit joint. During this time, the axial preload must continue to act. After this point, the mounting device (nut with pressure screws or hydraulic nut) is removed and the shaft or sleeve nut is screwed into place and secured.

Mounting methods

B = bearing width

Figure 23
Recommended width for oil grooves
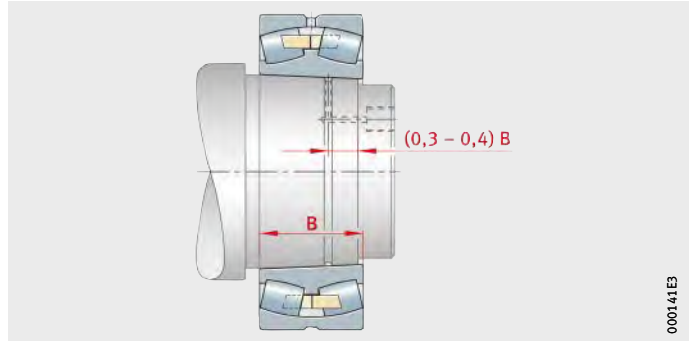
Tapered shaft If the bearing is seated directly on a tapered shaft, the oil is pressed between the fit surfaces, while the bearing is simultaneously pressed onto the taper by means of screws or a nut. The reduction in radial internal clearance or the axial drive-up distance is measured at this time, *Figure 24*.

Figure 24
Bearing seat
on the shaft
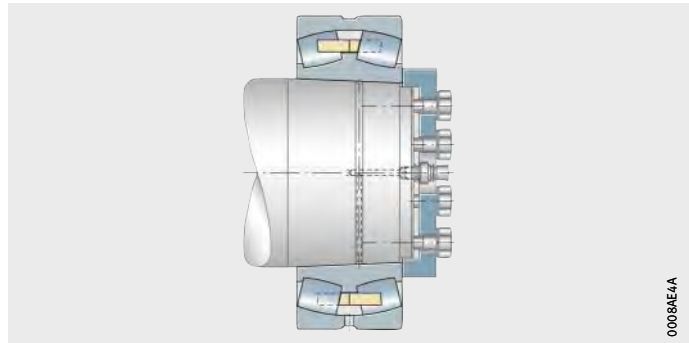
Withdrawal sleeve If the bearing is seated on the withdrawal sleeve, the oil is pressed between the fit surfaces, while the withdrawal sleeve is pressed into the bearing bore by means of screws or a nut. The oil is fed through the shaft nut. The reduction in radial internal clearance is measured at this time, *Figure 25*.

Figure 25
Bearing seat
on the withdrawal sleeve
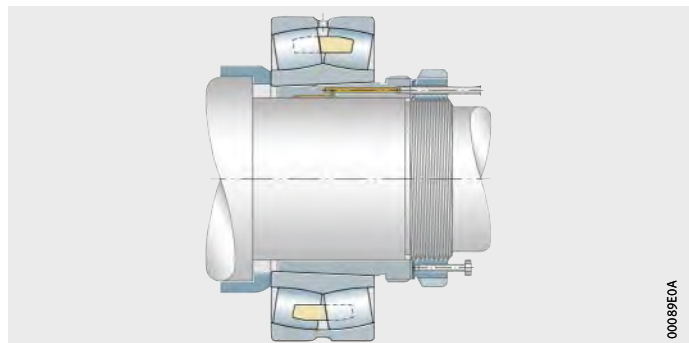
Adapter sleeve If the bearing is seated on the adapter sleeve, the oil is pressed between the fit surfaces, while the bearing is pressed onto the adapter sleeve by means of screws or a nut. The reduction in radial internal clearance is measured at this time, *Figure 26*.

① Oil connector on threaded side
② Oil connector on taper side

Figure 26
Bearing seat
on the adapter sleeve
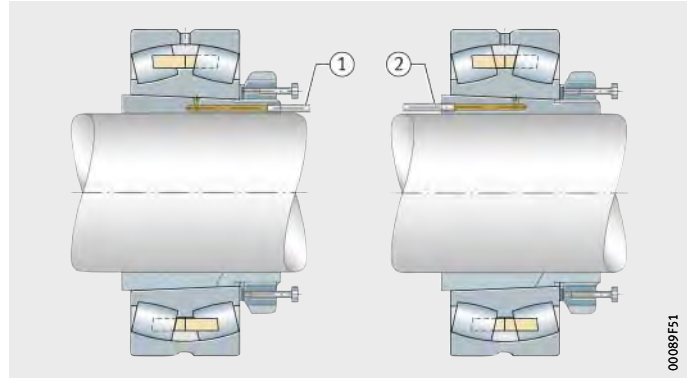
Hand pump In hydraulic mounting, the oil pressure is normally built up by means of a hand pump, *Figure 27*.

A machine oil of moderate viscosity is used as a pressure fluid. For mounting, it is recommended that the oil used should be as thin-bodied as possible and have a viscosity of ≈ 75 mm^2/s at +20 °C (nominal viscosity 32 mm^2/s at +40 °C), in order that the oil can easily escape from the fit joint without leaving a residue after mounting.

Figure 27
FAG hand pump set

Mounting of special types

Features   Selection of the suitable mounting method is based not only on the bearing type but also on the adjacent construction and the relevant dimensions, see page 194. In the case of some rolling bearing types, attention must be paid during mounting to particular features or a particular procedure must be applied, which is discussed in detail below. Further details are given in the product-specific catalogues and brochures. The decisive factor for correct mounting is, however, the mounting manual relating to the application.

Mounting of angular contact ball bearings and tapered roller bearings   Angular contact ball bearings and tapered roller bearings are always mounted in pairs. The axial internal clearance and thus also the radial internal clearance of two bearings adjusted against each other is set at the time of mounting. The magnitude of the internal clearance or preload is based on the operational requirements. Angular contact ball bearings of the universal design can be mounted directly adjacent to each other in any arrangement required.

High loads and high speeds lead to an increase in temperature in the bearing position. As a result of thermal expansion, the internal clearance set at the time of mounting may change during operation. Whether the internal clearance will increase or decrease depends on the arrangement and size of the bearings, the materials of the shaft and housing and the spacing between the two bearings.

If the shaft requires the closest possible guidance, the internal clearance is set in steps. A test run must be carried out after each new adjustment and the temperature must be checked.
This ensures that the internal clearance does not become too small, leading to an excessive increase in running temperature.
During the test runs, the bearing arrangement will "settle" such that the internal clearance undergoes hardly any further change.

The guide value for the correct bearing temperature at moderate to high speed and moderate load can be taken as follows: if there is no heating due to an external source, a correctly adjusted bearing arrangement may reach a temperature of approx. +60 °C to +70 °C during the test run; the temperature should decrease after between two and three hours of operation, however, especially in the case of grease lubrication, once the excess grease has been driven out of the bearing interior and the churning work has decreased.

Bearings exposed to vibrations at low speed, are mounted free from clearance or even with preload, otherwise there is a risk that the rolling bearings will impact against the roller raceways. Angular contact ball bearings and tapered roller bearings are adjusted against each other on the shaft by means of locknuts, *Figure 1*, shims, *Figure 2*, or ring nuts in the housing.

Figure 1
Adjustment
of tapered roller bearings
of a freewheel
using the kingpin nut
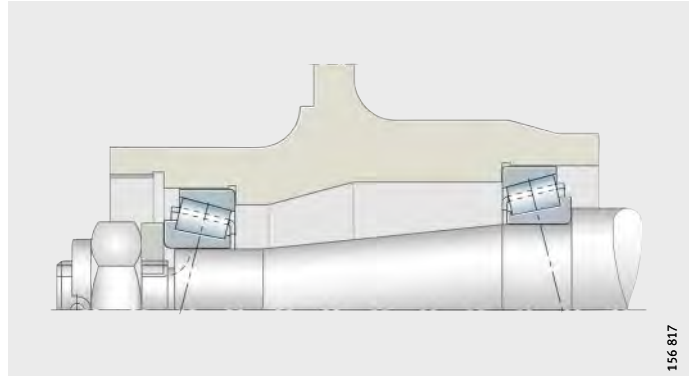
Figure 2
Axial location of an angular
contact ball bearing pair – setting
of internal clearance using shim
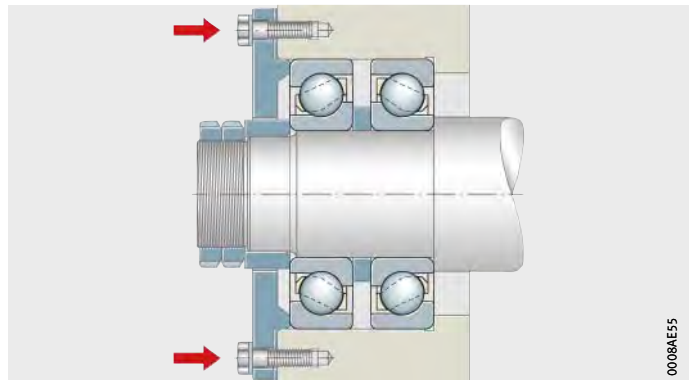
The axial internal clearance or preload of an adjustable bearing arrangement is set – starting from a clearance-free state – by loosening or tightening of the locknut or by insertion of calibrated plates. The axial internal clearance and preload can be converted into revolutions of the locknut with the aid of the thread pitch.

Mounting of special types

The transition from internal clearance to preload is sought during the adjustment process by rotating the shaft continuously by hand and simultaneously checking the possible movement of the shaft by means of a dial gauge.

The correct setting can be found more easily using a torque wrench. The locknut is tightened to the specified torque as a function of the bearing size. The necessary internal clearance is then achieved by reversing the locknut by approx. $1/_{12}$ of a revolution.

In the case of tapered roller bearings, it must be ensured that the rolling elements are in contact with the guide rib during mounting. This prevents any increase in the operating clearance of the rolling bearing due to subsequent settling effects. In order to achieve this, the bearing must be screwed in by several revolutions during mounting. As a result, the rolling elements creep out of their unde-fined initial position into their required contact position on the guide rib. This process is known as "screwing in". After this process, contact between the rollers and the rib must be checked, for example with the aid of a feeler gauge.

Tilting of the rings relative to each other must be avoided.

① Section height before screwing in
② Section height after screwing in
③ Gap

Figure 3
Screwing-in process
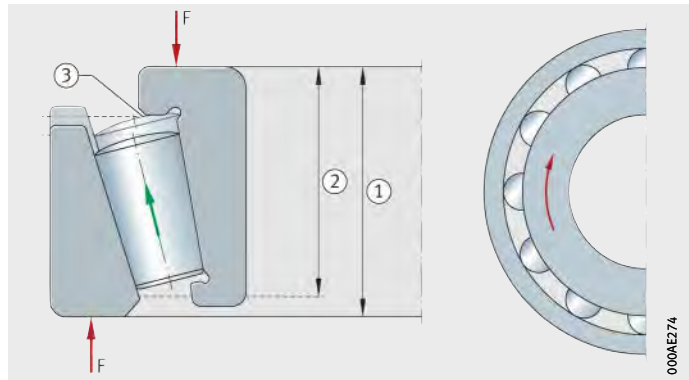
In the case of matched pairs and multiple-row tapered roller bearings, *Figure 4* and *Figure 5*, the axial internal clearance is determined by the width of the intermediate ring.
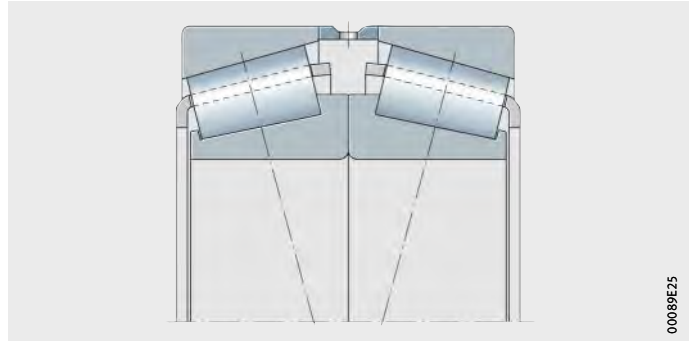
Figure 4
Matched tapered roller bearings
in X arrangement (suffix N11CA)
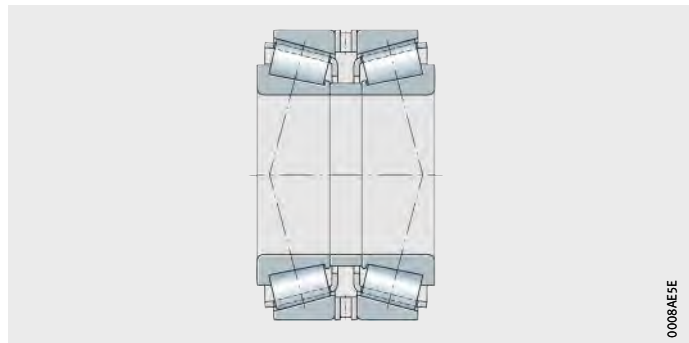
Figure 5
Double row tapered roller bearing
in O arrangement

Mounting of axial bearings

In the case of axial bearings, the shaft locating washers have a transition fit normally and a tight fit only in exceptional cases, while the housing locating washers always have a loose fit.
In double direction axial bearings, the central washer is axially clamped, *Figure 6*.

① Double direction axial deep groove ball bearing adjusted free from clearance
② Axial cylindrical roller bearing preloaded by means of shim S

Figure 6
Axial bearings adjusted free
from clearance
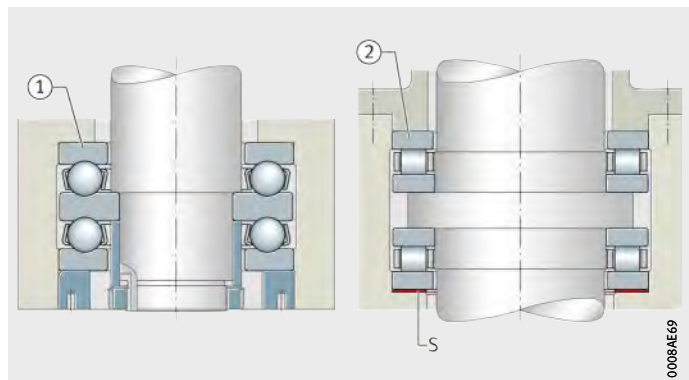
Mounting of special types

Mounting of machine tool bearing arrangements

In the case of machine tool spindles, setting the correct internal clearance is particularly important since the quality of workpieces produced on the machine are dependent on this factor. In order that the operating clearance or preload required by the designer can be precisely set during mounting of the bearings, Schaeffler has developed its own gauges.

Super precision bearings

Super precision bearings include:
- spindle bearings
- super precision cylindrical roller bearings
- axial angular contact ball bearings.

Matching operations

In order to maintain optimum performance or achieve precise positioning of the spindle in relation to the housing, it is often necessary to carry out special matching operations on the components.
This applies, for example, to the covers used to clamp the bearings. Before clamping, a gap should be present, *Figure 7*.

Matching of the intermediate rings may be advisable in the case of high speed spindles, in order to compensate the influence of fit and ring expansion on the preload.

① Gap before tightening of end cover screws
Bearing bore d $\leqq$ 100 mm: 0,01 mm to 0,03 mm
Bearing bore d $>$ 100 mm: 0,02 mm to 0,04 mm

Figure 7
Matching of end cover (recommendation)
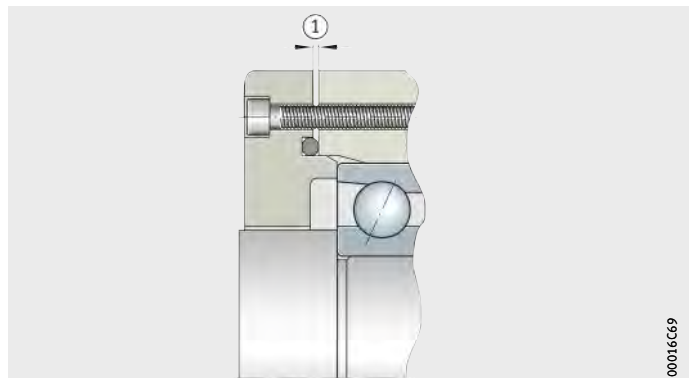
| Greasing | The preservative applied to FAG super precision bearings is such that it is not necessary to wash out the bearings before greasing. The setting of the grease quantity places high requirements on the greasing and measurement equipment used. It is recommended that bearings already greased and sealed from Schaeffler are used. |

Greasing must be carried out under extremely clean conditions.

In the case of bearings with grease lubrication, a grease distribution cycle must be carried out on the bearings before the test run on the spindle.

| Axial clamping of inner rings | Spindle bearing sets are generally clamped on the shaft using shaft nuts. Nuts with axial bores are to be used in preference over locknuts for tightening on the shaft, since they minimise the air turbulence that occurs at high speeds. |

The contact faces of the nuts should be ground in a single clamping operation together with the thread. The recommended maximum axial runout tolerance is 2 μm.

In order to prevent impairment of the runout during the clamping operation, the clamping inserts should be ground together with the thread and the axial face.

Values for axial clamping of inner rings on the shaft using a precision nut are given in Catalogue SP 1, Super Precision Bearings.

In order to eliminate or reduce settling effects, the nut should first be tightened to three times the stated torque, loosened and then finally tightened to the nominal torque. The retaining screws should then be fully tightened in accordance with the manufacturer's data.

| Mounting procedure for cylindrical roller bearings | Cylindrical roller bearings with a tapered bore are mounted with clearance, clearance-free or with preload. |

The precise procedure for the mounting and dismounting of super precision bearings is given in the relevant mounting and maintenance manual for the specific bearing and in Catalogue SP 1, Super Precision Bearings.

Mounting of special types

Mounting of rotary table bearings

Axial/radial bearings as well as axial angular contact ball bearings are ready-to-fit high precision bearings for high precision applications with combined loads. They can support radial loads, axial loads from both sides and tilting moments without clearance and are particularly suitable for bearing arrangements with high requirements for running accuracy, such as rotary tables, face plates, milling heads and reversible clamps.

Mounting of these units is very simple due to the fixing holes in the bearing rings. The bearings are radially and axially preloaded after mounting.

High precision bearings for combined loads include:
- axial/radial bearings YRT, RTC, YRT$_{Speed}$
- axial angular contact ball bearings ZKLDF
- axial/radial bearings YRT with integral angular measuring system YRTM.

Further information

- TPI 103, High Precision Bearings for Combined Loads, Mounting and Maintenance Manual
- MON 36, Series YRTSM and YRTM
- MON 20, High Precision Bearings for Combined Loads, Mounting and Maintenance Manual.

Mounting of screw drive bearings ZKLF, ZKLN, ZKRN, ZARF, ZARN

Bearings for screw drives include:
- double row axial angular contact ball bearings for screw mounting ZKLF
- double row axial angular contact ball bearings not for screw mounting ZKLN
- single row axial angular contact ball bearings BSB, 7602, 7603
- angular contact ball bearing unit TZKLR
- double row and triple row axial angular contact ball bearings ZKLFA, DKLFA
- needle roller/axial cylindrical roller bearings for screw mounting DRS, ZARF
- needle roller/axial cylindrical roller bearings not for screw mounting ZARN.

Mounting of these bearings is described in detail in TPI 100, Bearings for Screw Drives.

Mounting of toroidal roller bearings

For toroidal roller bearings, the procedure is fundamentally the same as for other standard bearings. An overview of the methods and tools recommended as a function of the bearing diameter is given in the table Mounting and dismounting methods for rolling bearings, page 194, in this Mounting Handbook. Further details are given below on recommendations for mounting and dismounting.

Measurement of radial internal clearance

The tight, tapered fit of a ring is often determined by the change in the radial internal clearance. Before and after mounting of the bearing, the radial internal clearance of the bearing must be determined by means of feeler gauges. It must be ensured in this case that the two bearing rings are concentrically aligned to each other. The operating clearance required is generally set by means of the axial displacement of the two rings relative to each other.

Free space on end faces and mounting dimensions

In the axial location of FAG toroidal roller bearings, the degrees of freedom in relation to axial displacement and tilting must be taken into consideration. Any possible contact with retainers or the bearing environment must be avoided. On the one hand, the requisite value for the depth of the free space $C_{a\,req}$ must be maintained, which ensures axial displacement of the shaft in the housing, *Figure 8*.

$$C_{a\,req} = C_a + 0,5 \cdot \left(\delta_{ax} + s_\varphi\right)$$

$C_{a\,req}$ mm
Requisite value for the depth of the free space

C_a mm
Minimum value for depth of free space in the case of bearing rings without offset, see TPI 232, Toroidal Roller Bearings TORB

δ_{ax} mm
Change in shaft length due to temperature

s_φ mm
Reduction in axial displacement facility as a result of tilting.
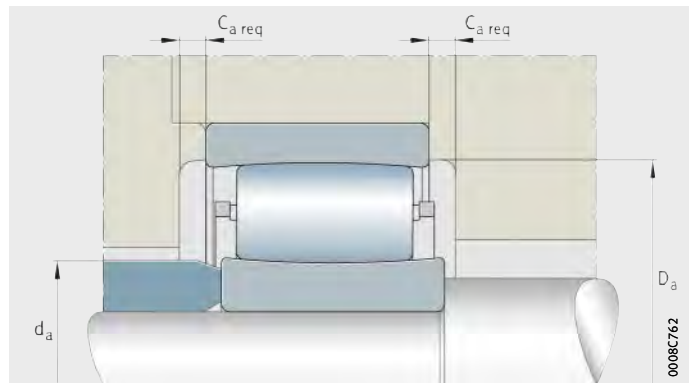
Figure 8
Free spaces in the housing

On the other hand, the appropriate mounting dimensions D_a and d_a must be observed. In those cases where the axial retainers or mounting nuts on the outside diameter do not match the specified mounting dimensions, the use of spacer nuts is necessary.

Mounting of special types

Axial positioning of the bearing

Toroidal roller bearings are normally mounted with the inner and outer ring centred relative to each other, where these are used to set the required internal clearance. Since the radial internal clearance in the bearing is reduced by axial displacement of the rings relative to each other, the required radial clearance can be achieved by offset of the rings. More detailed information on calculation of the reduction in radial internal clearance is given in TPI 232, Toroidal Roller Bearings TORB. Larger axial displacements, which are caused by large temperature fluctuations or other influences, must be counteracted by positioning of the rings relative to each other during mounting. In the case of oscillating bearing arrangement systems, it must be ensured that the axial displacement caused by the oscillation always occurs on the same side relative to the centre of the bearing. Crossing the centre of the bearing is only permissible when starting up an application.

Guidelines for mounting

During mounting, it must be ensured that the two bearing rings are not offset relative to each other. Horizontal mounting is recommended in all cases. If vertical mounting is absolutely necessary, appropriate devices must be used that hold the two bearing rings concentric to each other.

If the bearing is mounted both on a shaft and in a housing at the same time, the mounting pressure must be applied via both the bearing inner ring and the bearing outer ring, in order to prevent tilting.

Mounting of TAROL bearings

The tapered roller bearing units TAROL are used for the bearing arrangements of wheelsets on rail vehicles such as freight wagons and passenger carriages, *Figure 9*. These are compact, ready to fit, greased, sealed and axially adjusted rolling bearings that are pressed onto the shaft journal in a single operation. If the shaft journal diameter is within the specified tolerance, the press fit of the bearing will give the required axial internal clearance.
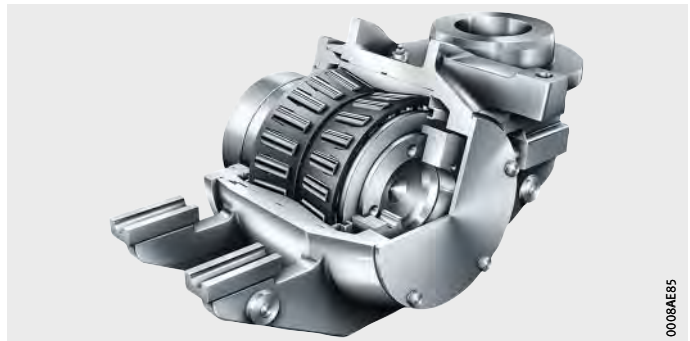
Figure 9
Wheelset bearing for rail vehicles

For the mounting and dismounting of these bearings, Schaeffler recommends the use of a mobile hydraulic unit, *Figure 10*. This unit has a valve-controlled, height-adjustable and double direction pressure cylinder driven by a motor pump. The relevant tool sets are matched to the bearing and the mounting situation. Comprehensive information on the product described and the precise procedure for mounting and dismounting is given in TPI 156, Tapered Roller Bearing Units TAROL – Mounting, maintenance, repair.

Figure 10
Mobile hydraulic unit

The mounting of bearings is subject not only to the specification of the Association of American Railroads (AAR) but also to the mounting specifications of the AAR in their valid issue. These can be found mainly in the Sections G, G-II, H and H-II of the "Manual of Standards and Recommended Practices".

Mounting of special types

Mounting of four-row tapered roller bearings

Four-row tapered roller bearings are special bearings for rolling mills and comprise solid bearing rings and tapered roller and cage assemblies, *Figure 11*. These bearings are separable and are generally mounted in the chock. The chock with the bearing is then slid onto the journal. This requires either a loose cylindrical fit of the inner ring on the journal or a bearing with a tapered bore that is mounted on a tapered shaft journal.

Figure 11
Four-row tapered roller bearing

Comprehensive information on the mounting and dismounting of four-row tapered rolling bearings is given in publication WL 80154, Four-Row Tapered Roller Bearings, Mounting Manual.

Mounting of needle roller bearings

Needle roller bearings with machined rings are mounted in accordance with the same perspectives as cylindrical roller bearings. Bearings mounted adjacent to each other must have the same radial internal clearance so that the load is distributed uniformly.

Needle roller bearings with ribs

Needle roller bearings with ribs are single or double row units comprising machined outer rings with ribs, needle roller and cage assemblies and removable inner rings.

Replacement of inner rings

In the case of the standard bearings, the inner rings are matched to the enveloping circle tolerance F6 and can be interchanged with each other (mixed use) within the same accuracy class.

! In needle roller bearings with ribs, the inner ring is not self-retaining.

Radial and axial location

Needle roller bearings with an inner ring are radially located by means of a fit on the shaft and in the housing. In order to prevent axial creep of the bearing rings, they must be located by means of form fit, *Figure 12*.

The abutment shoulders (shaft, housing) should be sufficiently high and perpendicular to the bearing axis. The transition from the bearing seat to the abutment shoulder must be designed with rounding to DIN 5418 or an undercut to DIN 509. The minimum values for the chamfer dimensions r in the dimension tables must be observed.

The overlap between the snap rings and the end faces of the bearing rings must be sufficiently large, *Figure 12*.

The maximum chamfer dimensions for the inner rings in accordance with DIN 620-6 must be taken into consideration.

NA49

① Snap rings
② Abutment shoulders

Figure 12
Axial location of bearing rings
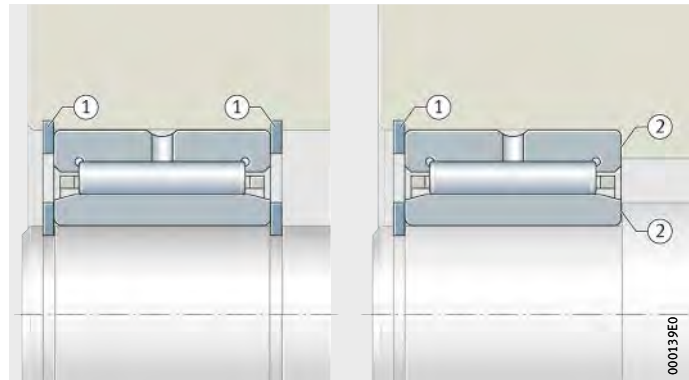
Mounting of special types

Needle roller bearings without ribs

These single or double row units comprise machined outer rings without ribs, needle roller and cage assemblies and removable inner rings. Since the bearings are not self-retaining, the outer ring, needle roller and cage assembly and inner ring can be mounted separately from each other.

Replacement of inner rings

⚠️ In needle roller bearings without ribs, the inner ring is not self-retaining.

The outer ring and the needle roller and cage assembly are matched to each other and must not be interchanged during fitting with components from other bearings of the same size.

In the standard bearings, the inner rings are matched to the enveloping circle tolerance F6 and can be interchanged with each other (mixed use) within the same accuracy class.

Radial and axial location

Needle roller bearings with an inner ring are radially located by means of a fit on the shaft and in the housing. In order to prevent axial creep of the bearing rings, they must be located by means of form fit, *Figure 13*.

The abutment shoulders (shaft, housing) should be sufficiently high and perpendicular to the bearing axis. The transition from the bearing seat to the abutment shoulder must be designed with rounding to DIN 5418 or an undercut to DIN 509. The minimum values for the chamfer dimensions r in the dimension tables must be observed.

The overlap between the snap rings and the end faces of the bearing rings must be sufficiently large, *Figure 13*.

The maximum chamfer dimensions for the inner rings in accordance with DIN 620-6 must be observed.

NAO..-ZW-ASR1
RNAO

① Snap rings
② Abutment shoulders
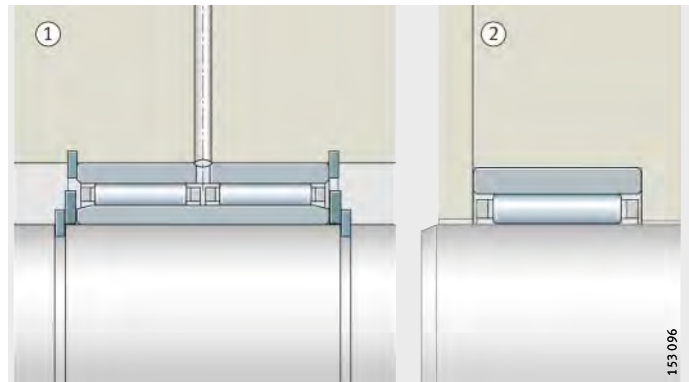
Figure 13
Axial location of bearing rings

153 096

| Aligning needle roller bearings | The bearings comprise drawn outer cups, plastic support rings with a concave inner profile, outer rings with a spherical outside surface, needle roller and cage assemblies and removable inner rings. |

Radial and axial location — Aligning needle roller bearings are firmly seated in the housing bore. No further axial location is required. The bore can therefore be produced easily and economically.

Replacement of inner rings — In the standard bearings, the inner rings are matched to the enveloping circle tolerance F6 and can be interchanged with each other (mixed use) within the same accuracy class.

! In aligning needle roller bearings, the inner ring is not self-retaining.

Mounting using pressing mandrel — Due to the drawn outer cup, the bearings must be mounted using a special pressing mandrel, see page 103. The marked side of the bearing should be in contact with the flange of the mandrel. A toroidal ring on the mandrel holds the bearing securely on the mandrel.

Combined needle roller bearings — These series comprise radial needle roller bearings and a rolling bearing component capable of supporting axial loads. They can support high radial forces as well as axial forces in one direction, while NKIB can support axial forces from both directions, and are used as locating or semi-locating bearings.

The bearings are available in the following designs:
- needle roller/axial deep groove ball bearings
- needle roller/axial cylindrical roller bearings
- needle roller/angular contact ball bearings.

The tight fits of combined needle roller bearings lead to relatively large press-in forces. This must be noted especially in the case of needle roller/axial deep groove ball bearings and needle roller/axial cylindrical roller bearings with dust caps, where the roller and cage assembly of the axial bearing must not be removed. These bearings must be pressed in. It is advantageous to heat the housing.

Combined needle roller bearings must be pressed into the housing, *Figure 14*.
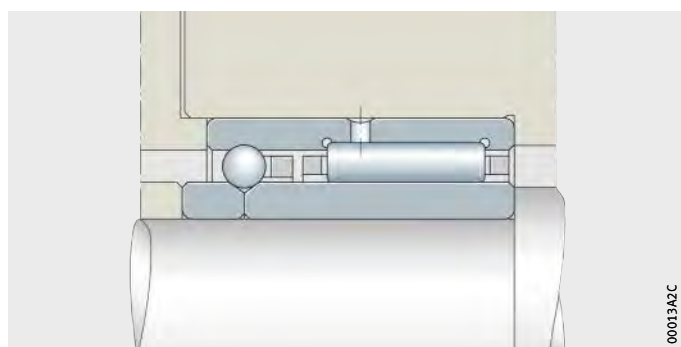
Figure 14
Mounting
of combined needle roller bearings
(needle roller/
angular contact ball bearing)

Mounting of special types

Replacement of inner rings	In the standard bearings of series NKIA and NKIB, the inner rings are matched to the enveloping circle tolerance F6 and can be interchanged with each other (mixed use) within the same accuracy class.

! Combined needle roller bearings are not self-retaining.

Radial and axial location Bearings with an inner ring are radially located by means of a fit on the shaft and in the housing. The axial abutment shoulders (shaft, housing) should be sufficiently high and perpendicular to the bearing axis. The transition from the bearing seat to the abutment shoulder must be designed with rounding to DIN 5418 or an undercut to DIN 509. The minimum values for the chamfer dimensions r in the dimension tables must be observed.

The overlap between the snap rings and the end faces of the bearing rings must be sufficiently large.

The maximum chamfer dimensions for the inner rings in accordance with DIN 620-6 must be taken into consideration.

! In order to prevent lateral creep of the bearing rings, they must be located by means of form fit. For locating bearings and for bearings with a split inner ring, axial abutment of the bearing rings on both sides is particularly important.

Mounting of drawn cup needle roller bearings

Due to their thin-walled outer ring, drawn cup needle roller bearings adopt their exact form as a result of tight housing fits, eliminating the need for lateral location.

Special mounting mandrels are used for pressing in drawn cup needle roller bearings. The mandrel normally rests against the stamped end face of the bearing, which is hardened in the case of smaller bearings. Even if the bearing is pressed in via an unhardened rib, this will not lead to deformations or jamming of the needle roller and cage assembly as long as the mandrel is correctly dimensioned.

Radial and axial location Drawn cup needle roller bearings are located in the housing bore by means of a press fit. They are pressed into the bore and require no further axial retainers.

Mounting using pressing mandrel

The bearings should be installed using a special pressing mandrel, *Figure 15*. The shoulder of the pressing mandrel must rest against the end face of the bearing. This is indicated by the designation.

A toroidal ring should be used to retain the bearing. The length and oversize of the ring must be matched by the customer to the dimensions and mass of the bearing.

If grease lubrication is to be used, the bearings should be lubricated with grease before mounting.

! Drawn cup bearings must not be tilted while they are being pressed in.

The forces occurring during pressing-in are dependent on several factors. Mounting must be carried out so that the bearing rib on the end face is not deformed.

If the application requires a mounting procedure different from the one described, mounting trials must be carried out in order to ensure that the bearings can be mounted correctly and without causing damage.
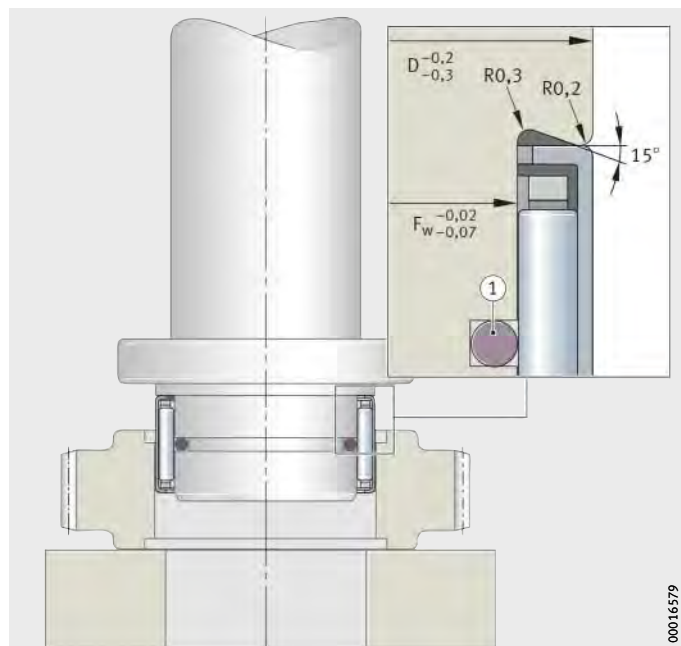
① Toroidal ring

Figure 15
Mounting using pressing mandrel

Mounting of special types

Mounting of needle roller and cage assemblies

Needle roller and cage assemblies are either slid onto the shaft and the parts are then inserted together into the housing, or needle roller and cage assemblies are slid into the housing and the shaft is then inserted. Mounting is carried out without load and using a screw-driver type motion.

Needle roller and cage assemblies can be laterally guided on the shaft or on the housing, *Figure 16*.

① Guidance on housing
② Guidance on shaft

Figure 16
Guidance of needle roller and cage assemblies
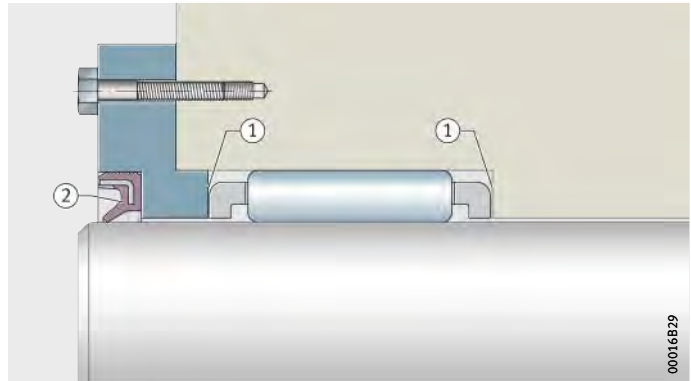
The spacing between the lateral contact running surfaces of the cage must be sufficiently large (tolerance H11), in order to avoid jamming of the needle roller and cage assemblies.

The radial internal clearance of a bearing arrangement with needle roller and cage assemblies is based on the machining tolerances of the hardened and ground raceways on the shaft and in the housing. Needle roller and cage assemblies arranged adjacent to each other must contain needle rollers of the same grade.

Mounting of rope sheave bearings

Before the bearing is pressed into the rope sheave, it is recommended that the bearing seating surfaces should be lightly oiled or alternatively rubbed or sprayed with dry lubricant. In order to prevent bearing damage and inaccurate seating of the bearings, the pressing-in operation should be carried out on a suitable device with control of force and travel.

In order to facilitate the pressing-in operation, the rope sheave can be heated. Appropriate tools for steel rope sheaves are available from Schaeffler.

Guidelines for mounting

During the mounting of cylindrical roller bearings SL04, the mounting forces should be applied only to the bearing ring to be mounted, *Figure 17*.
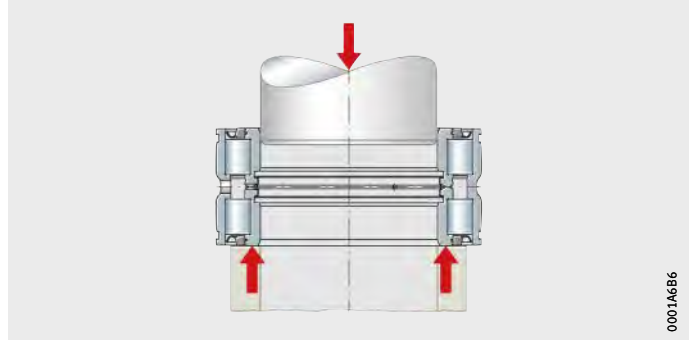
Figure 17
Application of mounting forces

Mounting forces must not be directed through the cylindrical rollers, *Figure 18*. During dismounting of the bearings, the dismounting forces must not be directed through the fasteners on the split inner ring.
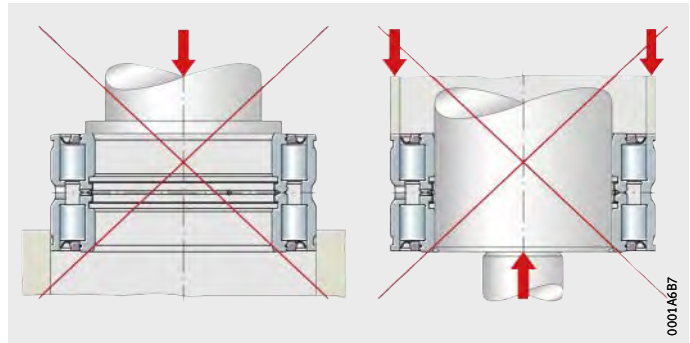
Figure 18
Impermissible mounting or dismounting methods

Mounting with a premounted retaining ring

If bearings with a premounted retaining ring are pressed into the rope sheave, this must be always carried out with monitoring of force (or alternatively with monitoring of travel), *Figure 19*.

① Retaining ring
② Rope sheave
③ Surface for support of mounting forces

Figure 19
Mounting
with a premounted retaining ring
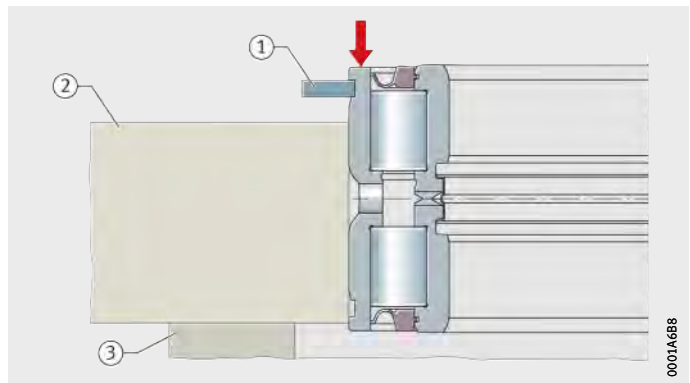
Mounting of special types

Mounting of track rollers

Track rollers are precision machine elements. These products must be handled very carefully before and during mounting. Their trouble-free operation depends largely on the care taken during mounting.

The seating surfaces of the bearing rings must be lightly oiled or rubbed with solid lubricant.

After mounting, the bearings must be supplied with lubricant. Finally, the correct functioning of the bearing arrangement must be checked.

Mounting of yoke type track rollers

If the tolerances are unfavourable, the yoke type track roller should be pressed onto the shaft using a mounting press, *Figure 20*. The inner ring must be mounted such that the pressing-in force is distributed uniformly over the end face of the inner ring.

⚠️ Yoke type track rollers RSTO and STO are not self-retaining. The outer ring and the needle roller and cage assembly are matched to each other and must not be interchanged during mounting with components from other bearings of the same size.

Lubrication hole

The bearings must be mounted such that the lubrication hole is positioned in the unloaded zone. For yoke type track rollers PWTR and NNTR, there is no need for defined positioning of the lubrication hole.

① Mounting press

Figure 20
Mounting of yoke type track roller
using a mounting press
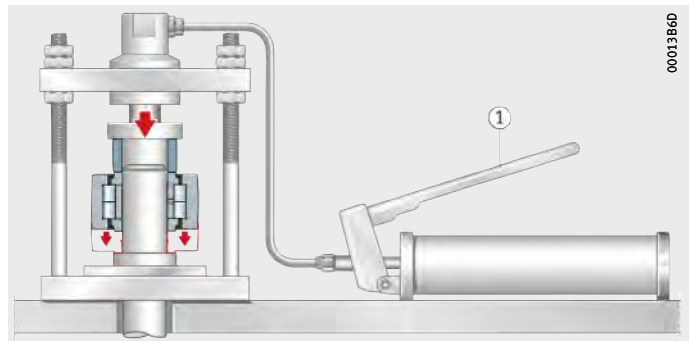
Axial location

Yoke type track rollers NUTR, PWTR and NNTR must be axially clamped in place, *Figure 21*.

① Hexagon nut

Figure 21
Axial location
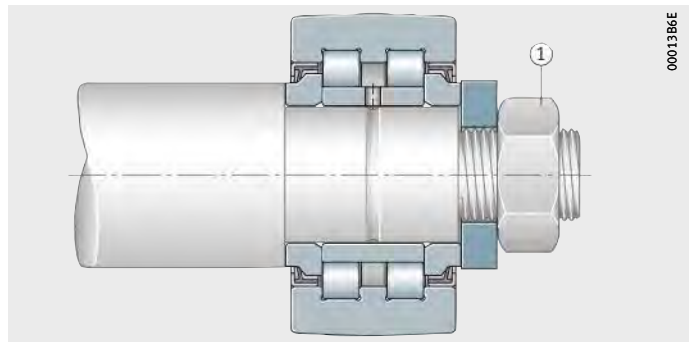
Mounting of stud type track rollers

Stud type track rollers should be mounted using a mounting press if possible (similar to *Figure 20*, page 106).

! Blows on the flange of the roller stud must be avoided.

Drive fit lubrication nipples for stud type track rollers

Stud type track rollers are supplied with loose drive fit lubrication nipples that must be pressed in correctly before mounting of the bearings, *Figure 22*.

! Only the lubrication nipples supplied may be used, see table.

If relubrication is to be carried out via the locating bore, the axial lubrication holes in the stud type track roller must be closed off using the lubrication nipples before mounting, *Figure 22*.
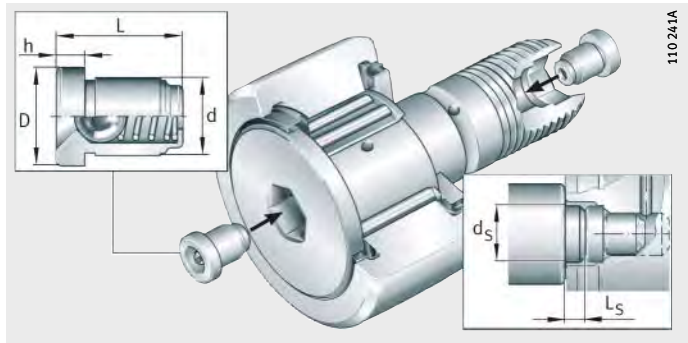
KR..-PP

Figure 22
Stud type track roller
with drive fit lubrication nipple and
dimensions for pressing mandrel

Drive fit lubrication nipples

Lubrication nipple	Dimensions in mm						Suitable for outside diameter D
	D	d	L	h	d_S $\pm 0,1$	L_S	
NIPA1	6	4	6	$1,5^{1)}$	–	–	16, 19
NIPA1×4,5	4,7	4	4,5	1	4,5	5	22 – 32
NIPA2×7,5	7,5	6	7,5	2	7,5	6	35 – 52
NIPA3×9,5	10	8	9,5	3	10	9	62 – 90

[1] Projection of lubrication nipple.

Mounting of special types

Axial location of stud type track rollers

Stud type track rollers must be axially secured using a hexagon nut.

The slot or hexagonal socket on the end of the roller stud can be used to hold the bearing by means of a key while tightening the fixing nut and to adjust the eccentric collar, *Figure 23*.

If heavy vibration occurs, self-locking nuts to DIN 985 or special locking washers can be used.

! The tightening torque stated for the fixing nuts must be observed. It is only in this way that the permissible radial load can be ensured. If this cannot be adhered to, an interference fit is required.

For self-locking nuts, a higher tightening torque must be observed; the advice given by the nut manufacturer must be followed.
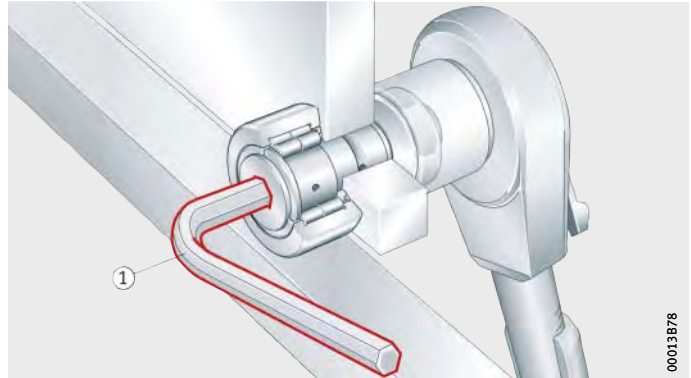
① Allen key

Figure 23
Holding the bearing
using an Allen key

Stud type track rollers with eccentric collar

The highest point on the eccentric collar is indicated on the roller stud side.

Commissioning and relubrication

Stud type track rollers have a lubrication hole for relubrication:
- on the flange side of the roller stud
- on the thread-side end face,
  from an outside diameter of 22 mm
- on the shank of the roller stud,
  from an outside diameter of 30 mm with an additional lubrication groove.

! Stud type track rollers with an eccentric collar cannot be relubricated via the stud. The eccentric collar covers the lubrication hole.

For lubrication, only grease guns with needle point nozzles may be used that have an opening angle $\leqq 60°$, *Figure 24*.

Before commissioning, the lubrication holes and feed pipes must be filled with grease in order to ensure protection against corrosion; lubrication can be carried out at the same time.

Lubrication will be more difficult if a rolling element is located over the radial lubrication hole. Relubrication should therefore be carried out with the bearing still warm from operation and rotating if safe to do so, before the bearing comes to rest if safe to do so and before extended breaks in operation.

The grease used for relubrication must be the same as that used for initial greasing. If this is not possible, the miscibility and compatibility of the greases must be checked.

Relubrication should continue until a fresh collar of grease appears at the seal gaps. The old grease must be able to leave the bearing unhindered.

① Needle point nozzle, opening angle $\leqq 60°$

Figure 24
Relubrication using grease gun
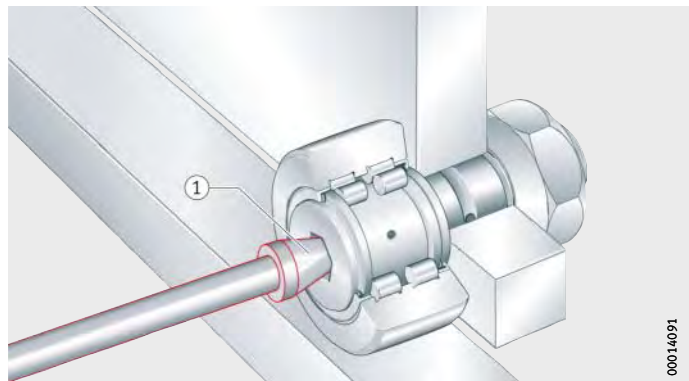
Dismounting of rolling bearings

Dismounting methods

Dismounting of rolling bearings

Dismounting of rolling bearings

Dismounting methods

In order to prevent damage during the dismounting of bearings, various dismounting methods are used depending on the bearing size and type of application that facilitate the reuse of components. In general, a distinction is made in the dismounting of bearings between mechanical, thermal and hydraulic methods. Before dismounting is actually carried out, the mounting drawings and any instructions for mounting and dismounting must be carefully checked. In case of doubt, the Schaeffler expert team is available to provide advice and assistance.

Mechanical dismounting

In the mechanical method, special extractors are normally used. It must be ensured above all that the extraction tool is positioned on the ring that has the tighter fit, otherwise the rolling elements will press into the raceways of the bearing, *Figure 1*. Furthermore, there is a risk of fracture in the case of thin-walled outer rings. In the case of non-separable bearings with a sliding seat on the shaft or housing, this adjacent component should if possible be removed before dismounting of the bearing. The force that must be used in pressing the ring off is normally considerably greater than the force used in pressing the ring on, since the ring becomes fixed in place over the course of time. Dismounting can be difficult even in the case of rings with a loose fit if fretting corrosion has formed after long periods of operation.

The following must therefore be observed:
- Avoid direct blows on the bearing rings.
- Do not direct dismounting forces through the rolling elements.

Figure 1
Dismounting
by means of extraction device

If it is not possible to avoid carrying out extraction via the rolling elements, a collar made from unhardened steel is placed around the outer ring (its thickness should be greater than $1/4$ of the height of the bearing cross-section). This applies in particular to rolling bearings with a small cross-sectional height and small contact angle, such as tapered and spherical roller bearings.
However, the bearings cannot be subsequently reused.

The rings of separable bearings can be dismounted individually.

Dismounting of cylindrical seats

The extraction of small bearings is normally carried out using mechanical extraction devices, *Figure 2*, or hydraulic presses, *Figure 3*, that are in contact either with the ring with a tight fit itself or with the contact parts, such as those on the labyrinth ring. These are available with a mechanical spindle and hydraulic cylinder if higher forces are required.

① Extraction process using a trisection plate
② Extraction device with three adjustable arms and extraction slot in inner ring

Figure 2
Extraction device for rolling bearings
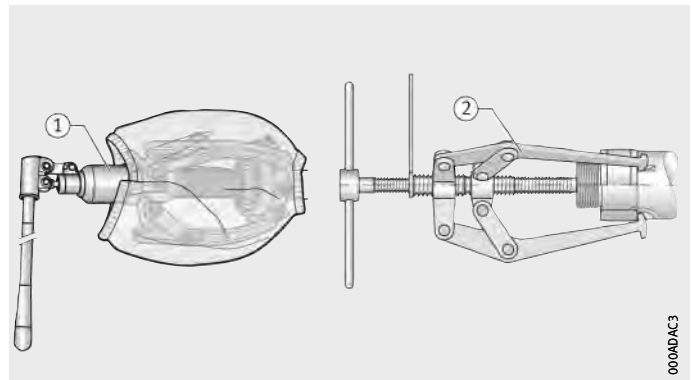
A press can also be used to assist in dismounting. It must be ensured in this case that the bearing is abutted on its inner ring in order to avoid damage. In the pressing operation, the shaft is withdrawn from the bearing.

Figure 3
Dismounting using a press
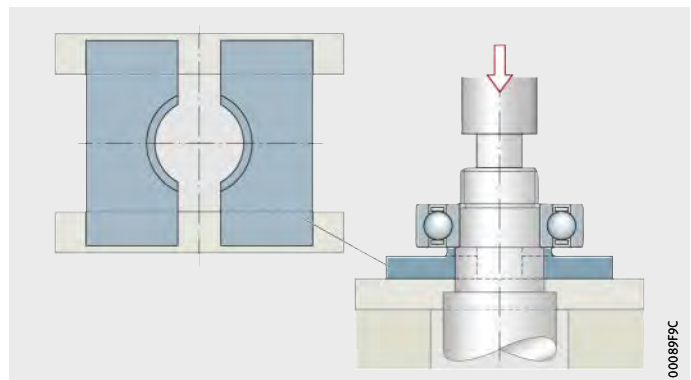
Dismounting of rolling bearings

Dismounting is made much easier if the design includes extraction slots so that the extraction tool can be applied directly to the bearing ring with a tight fit. A further alternative to dismounting of bearings is the use of extraction screws, *Figure 10*, page 119.

Internal extractors

If the shaft has already been dismounted, the bearing can also be removed from the housing by means of an internal extractor.
The gripping segments of the extractor are spread when the threaded spindle is tightened. The lip of the jaws is pressed against the back of the bearing inner ring bore. With the aid of a countersupport or an impact extractor, the bearing is then withdrawn using the internal extractor. As a result, it is not generally possible to reuse the bearing.

Dismounting of tapered seats

If bearings are mounted directly on a tapered shaft seat or on an adapter sleeve, the locking action of the shaft or adapter sleeve nut must be loosened first. The nut must then be unscrewed by at least the amount of the drive-up distance. The inner ring is then driven off the sleeve or shaft, for example using a metal drift or impact block, *Figure 4* ①, ②. An impact block avoids the risk of slipping.

Bearings located using withdrawal sleeves are dismounted using a withdrawal nut, *Figure 4* ③.

① Metal drift
② Impact block
③ Withdrawal nut
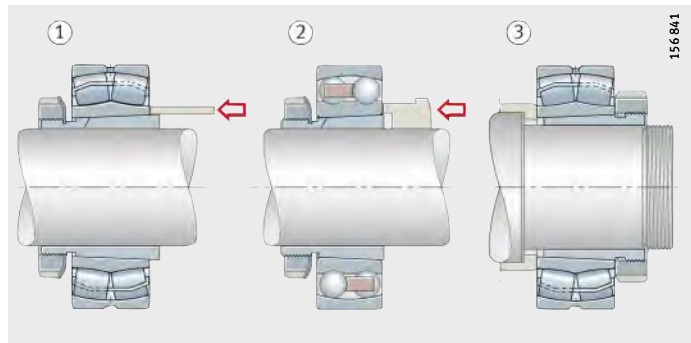
Figure 4
Dismounting of bearings

The dismounting of large bearings located using a withdrawal sleeve requires considerable force. In this case, locknuts with additional pressure screws can be used, *Figure 4*. A disc must be inserted between the inner ring and the pressure screws in order to prevent damage to the bearing.

Thermal dismounting

In thermal dismounting, the bearing ring to be dismounted is heated within a very short space of time, leading to its expansion.
As a result, the fit on the bearing seat is neutralised and any possible adhesion as a result of fretting corrosion is overcome.

! Heating of the bearing ring should not be carried out using a direct flame, since this can cause damage to the components.

Heating rings Heating rings made from light metal can be used for dismounting the inner rings of cylindrical roller bearings that have no ribs or only one rigid rib. The rings are heated on an electric heating plate, depending on their tight fit or interference, to between +200 °C and +300 °C pushed over the bearing ring to be removed and clamped in place. Once the press fit on the shaft has been neutralised, both rings are removed together.

! After removal, the bearing ring must immediately be released from the heating ring in order to prevent overheating.

Heating rings are particularly advantageous for the occasional extraction of medium-sized bearing rings. Each bearing size requires a specific heating ring.

Medium frequency technology With the aid of FAG devices using medium frequency technology, it is possible to heat very large bearings and components of shrink fit connections by inductive means in order to achieve loosening.

The FAG medium frequency heating device comprises the medium frequency generator and an inductor. Depending on the application, this can be of a flexible or rigid design. The flexible version is similar to a cable. It must be ensured in this case that the winding is applied directly to the component with fit.

Where a rolling bearing has a tight fit on a shaft, for example, the inductor must be applied directly to the inner ring.
Through energy-efficient heating, the workpiece to be loosened is heated very quickly and undergoes expansion, so the press fit can be loosened. Flexible inductors are suitable for workpieces of various sizes and various shapes and can be used for long periods at heating temperatures up to +150 °C.

Figure 5
Dismounting of bearing inner rings
using flexible inductor

Dismounting of rolling bearings

In the batch dismounting of identical components such as wheelset bearings on rail vehicles, flexibility is less important than reduced setup times and increased process reliability. Rigid inductors are suitable for this task. In this design, the coil is fitted in a housing matched to the workpiece and can thus be placed quickly and easily in the heating zone. Rigid inductors are also suitable, in contrast to the flexible variant, for small components.

The devices are designed for the specific application. Please contact the application experts at Schaeffler.

Advantages   Advantages in the loosening of shrink fit connections:
- batch dismounting of bearing rings and labyrinth rings
- rapid dismounting of gears and couplings
- simple heating of large and heavy components
  (such as machine supports, housings, shafts, …).

Figure 6
Dismounting of bearing inner rings of wheelset bearings (rail vehicles) using rigid inductor

Further information   ■ TPI 217, Induction Units with Medium Frequency Technology.

Hydraulic dismounting

In the oil pressure method, oil is pressed between the fit surfaces. The oil film substantially neutralises the contact between the fit parts, so they can be displaced relative to each other with the application of little force and without the risk of surface damage, see page 83.

The oil pressure method is suitable for dismounting in the case of both tapered and cylindrical seats. In both cases, oil grooves and feed ducts as well as threaded connectors for the pressure generation devices must be provided. Large adapter and withdrawal sleeves have appropriate grooves and holes.

For the dismounting of bearings with a tapered bore that are located directly on the shaft, injectors are sufficient as pressure generation devices. For bearings with cylindrical bores and where adapter and withdrawal sleeves are present, a pump must be used, *Figure 27*, page 87.

For dismounting, the same oils are used as for mounting, which means oils with a viscosity of approx. 75 mm^2/s at +20 °C (nominal viscosity 32 mm^2/s at +40 °C). Fretting corrosion can be dissolved by rust-dissolving additives in the oil.

Dismounting of cylindrical bearing bore

In the dismounting of bearings with a cylindrical bore, the oil pressure method is normally only used in a supporting function for mechanical tools. The specific extraction device is first placed on the ring with fit and oil under pressure is then pumped into the oil grooves, *Figure 7*.

This neutralises the fit and the bearing can be removed, for example by means of a mechanical extractor.
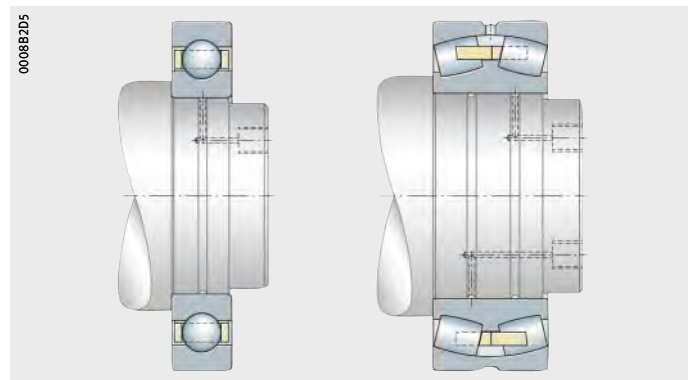
Figure 7
Hydraulic dismounting
of cylindrical seat

Dismounting of rolling bearings

If there are no grooves and ducts in the shaft, for example for reasons of strength, the oil can be pressed between the fit surfaces from the end face of the inner ring. A sealed contact ring is located at the front end of the interference fit, through which the oil is pressed into the fit joint. A container fixed to the end of the shaft makes it possible to press oil between the fit surfaces until the end of the extraction process. If it is not possible to fit such a container, a very stiff oil with a viscosity of 320 mm^2/s (cSt) at +40 °C must be used. With an oil of such stiffness, the oil film remains in the fit joint for up to 5 minutes. This time is sufficient for extraction of the bearing.
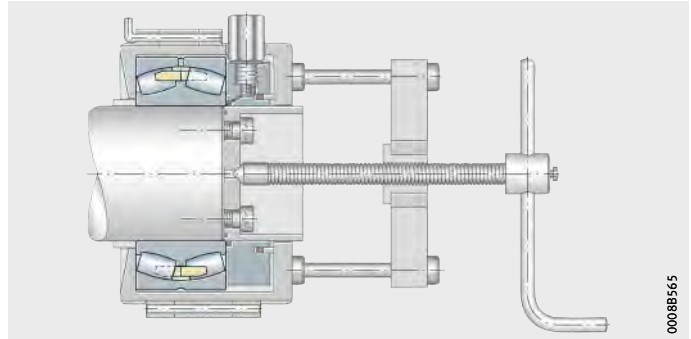
Figure 8
Special device for extraction from a shaft without oil grooves

Dismounting of tapered bore

In the extraction of bearings located on a tapered shaft journal, a withdrawal sleeve or an adapter sleeve, it is only necessary to press oil between the fit surfaces.

The interference fit becomes loose abruptly. Due to the risk of accidents, axial movement of the rolling bearing or withdrawal sleeve during dismounting must be restricted by a shaft nut, adapter sleeve nut or a stop, *Figure 9*.

Figure 9
Hydraulic dismounting of tapered seat

Dismounting is sometimes made more difficult by fretting corrosion. The use of a rust-dissolving hydraulic fluid is recommended, especially in the case of bearings that are dismounted after a long period of operation. In difficult cases, removal of the withdrawal sleeve can be supported by the extraction nut, *Figure 10*. If pressure screws are present in the withdrawal sleeve nut, an intermediate ring must be inserted in order that the extraction forces do not act directly on the rib of the rolling bearing ring.

Dismounting of a withdrawal sleeve:
① Using a nut and pressure screws
② Using a hydraulic nut

Dismounting of a spherical roller bearing from the withdrawal sleeve:
③ Using the hydraulic method

Dismounting of a spherical roller bearing on an adapter sleeve:
④ Using the hydraulic method

Figure 10
Dismounting
of a withdrawal sleeve and
spherical roller bearing

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Services

Services

Services

Features

Schaeffler offers, irrespective of manufacturer, a wide range of services relevant to the lifecycle of a rolling bearing: starting with mounting and progressing through maintenance to the reconditioning of rolling bearings.

During the operational phase, the Schaeffler experts provide support through services in the fields of condition monitoring and corrective maintenance. Companies that wish to build up their knowledge in the areas of rolling bearings and condition monitoring also have access to the Schaeffler training and consultancy portfolio on site, centrally or online. Our e-learning portfolio on the Internet provides the first steps into this field. In this way, customers benefit from the expertise of a leading supplier of rolling and plain bearings.

Mounting and dismounting

The Schaeffler Industrial Service experts offer mounting and dismounting services for rolling bearings that are applicable across industrial sectors. They have detailed knowledge and extensive experience in all industrial sectors, *Figure 1*.

Figure 1
Mounting service
provided by Schaeffler experts

The experts in the Industrial Service function are trained and skilled personnel who can provide reliable, rapid and competent assistance. The services are provided either at the customer's location or in the Schaeffler workshop facilities.

The mounting and dismounting services include:

- mounting and dismounting of rolling bearings and bearing systems of all types
- measurement and condition analyses
- problem solving and preparation of concept solutions
- design and manufacture of special tools
- rental of tools
- emergency service
- training courses on products and mounting
- certification of mounting and dismounting processes.

Advantages

The mounting services give the following advantages:

- rapid availability worldwide of experts in bearing arrangement technology with extensive experience in almost every application
- rapid mounting or dismounting by means of professional preparation and implementation
- increased plant availability and productivity as a result of reduced unplanned downtime
- optimisation of mounting and dismounting processes
- professional mounting and dismounting using special high-quality tools
- training and awareness measures for employees relating to the correct handling of bearings of all types.

Rental of tools

Customers who require special mounting and dismounting tools or measuring equipment only infrequently can rent these from Schaeffler for a fee.

Our service includes:

- prompt rental in Europe
- free-of-charge, rapid delivery to the installation site
- checked quality products in keeping with the latest technological developments
- delivery of the tools, including all add-on parts
- user manuals available in several languages.

If one of our qualified experts in the Industrial Service function is commissioned to carry out the particular activity, rental costs are not generally incurred.

Services

Approximately 25 percent of all premature bearing failures can be attributed to mounting errors. In order to achieve a long bearing operating life, it is particularly important to have not only basic knowledge of rolling bearings but also theoretical and practical knowledge of their correct mounting and dismounting. In order to ensure that the training received by mounting personnel is as close to reality as possible, Schaeffler offers certification of individual mounting and dismounting processes, *Figure 2*.

Figure 2
Theoretical training

Here, information on the correct handling of rolling bearings and the avoidance of mounting errors is imparted by our rolling bearing experts. This is carried out with direct reference to the specific application and the individual circumstances of the customer.

A practical demonstration of the mounting and dismounting process is then provided, which also covers adherence to the necessary processes and regulations.

Finally, the training participants must put their acquired knowledge to the test. Only then do they receive application-specific certification from Schaeffler.

Reconditioning of rolling bearings

It is often the case that new rolling bearings are fitted although the existing bearings could be restored to as-new condition by means of appropriate reconditioning. In many cases, reconditioning of rolling bearings is significantly more cost-effective than using new rolling bearings, *Figure 3*.

① Before reconditioning
② After reconditioning
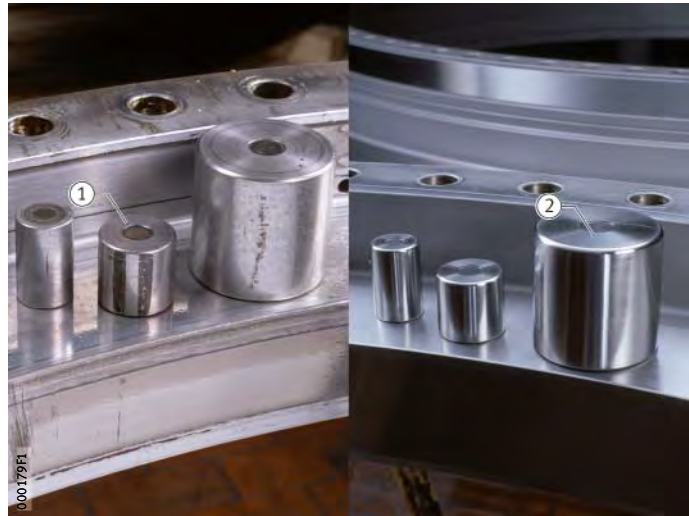
Figure 3
Rolling bearing raceway and rollers
before and after reconditioning

Advantages

The advantages for the customer are as follows:

- reductions in life cycle costs (LCC = Life Cycle Costs)
- increases in operating life
- savings in material and energy costs
- reductions in inventory costs
- high flexibility through short lead times
- feedback on the characteristics and frequencies of damage.

Services

The operations necessary in reconditioning are dependent on the condition of the rolling bearing. In order to allow a reliable statement of the work required, the rolling bearing must be disassembled, cleaned and then carefully examined. Beyond this requalifying process (Level I), which is always necessary, there are three further reconditioning levels, *Figure 4*.
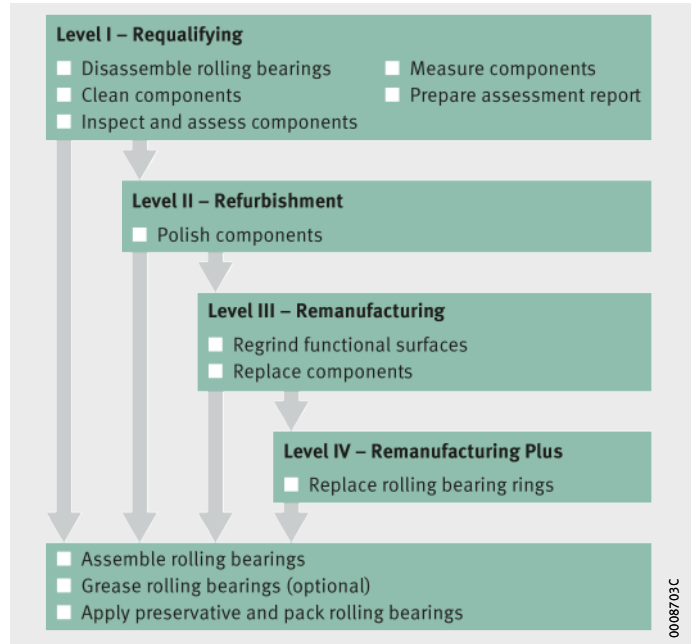
Figure 4
Reconditioning levels

Level I – Requalifying
- Disassemble rolling bearings
- Clean components
- Inspect and assess components
- Measure components
- Prepare assessment report

Level II – Refurbishment
- Polish components

Level III – Remanufacturing
- Regrind functional surfaces
- Replace components

Level IV – Remanufacturing Plus
- Replace rolling bearing rings

- Assemble rolling bearings
- Grease rolling bearings (optional)
- Apply preservative and pack rolling bearings

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Quality	Schaeffler performs reconditioning of rolling bearings to uniform standards throughout the world. All sites apply identical processes and guidelines. Schaeffler rolling bearings are processed in accordance with the original drawings. In the case of all bearings, work is carried out using only original components and original replacement parts. High quality reconditioning is achieved as a result of our comprehensive knowledge of rolling bearings.
Market sectors	Reconditioning is carried out irrespective of manufacturer and is thus not restricted to products of Schaeffler Technologies. Before reconditioning, the condition of the bearings can be assessed on site in consultation with experts from the Global Technology Network.
	Reconditioning of rolling bearings is of particular interest if these are used in machinery or vehicles in the following market sectors:
	■ raw material extraction and processing
	■ metal extraction and processing
	■ pulp and paper
	■ railways.
Dimensions	Reconditioning and, where required, modification can be carried out on rolling bearings with an outside diameter D of 100 mm to 4 500 mm. Please contact us for information on reconditioning or modification of bearings with other outside diameters.
Further information	■ For detailed information, see TPI 207, Reconditioning and Repair of Rolling Bearings
	■ Enquiries: support.is@schaeffler.com, tel. +49 9721 91-1919, fax +49 9721 91-3639.

Services

Training courses

The operating life of rolling bearings is determined to a substantial degree by their correct mounting and dismounting. Appreciating the use of rolling bearings, linear guidance systems and plain bearings as indispensable elements in thousands of applications requires the necessary understanding of these machine elements. Schaeffler has its own training centres worldwide certified to ISO 9001, *Figure 5*.

Figure 5
Training course at the Eltmann site

Training courses on mounting and dismounting generally comprise a theoretical part and a practical part. Thorough knowledge is communicated, for example, on the mounting and dismounting of rolling bearings using the optimum tools and on the condition monitoring of bearing arrangements, especially through the use of noise, vibration and torque measurements.

In general, the initial steps are provided by basic training covering the different characteristics, features and types of rolling bearings, plain bearings and linear guidance systems as well as their combination to form systems, extending all the way to mechatronic units. Application examples reflect the selection criteria and the customer benefits achieved. These product-oriented training courses are followed by modules covering rolling bearing theory as well as selected applications. Rolling bearing theory conveys the necessary knowledge on subjects such as bearing clearance, load distribution in the bearing, rating life and lubrication. In workshops, the participants concentrate on applications, for example the bearing arrangements in a machine tool or a shaft bearing arrangement. All process steps are covered, from bearing selection and bearing calculation through to mounting, *Figure 6*, page 129. We also offer workshops in the field of mechatronics.

Figure 6
Training course on mounting
of rolling bearings

Several training modules cover the mounting and dismounting of rolling bearings and linear guidance systems. Based on perception and exercises, the participant gains the mounting knowledge and skills that he will require in practice. Our training courses on mounting cover a large number of applications. Mounting exercises on individual products are followed by work on more complex systems such as gearboxes, rail wheelsets or machine tools. The possibilities for plannable and economical design of maintenance work on machines, plant and rolling bearings are communicated to the training participant in appropriate courses.

Mounting cabinet Literature on the correct mounting of bearings is readily available, however there is a general lack of appropriate equipment on which apprentices can practise in as practical a sense as possible. The trainers from the Schaeffler training workshops therefore compiled a basic course, *Figure 7*, page 130.

Services

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The aim of this rolling bearing course is to communicate knowledge on the selection of the correct bearing, correct mounting and dismounting and the maintenance of bearing positions. It is divided into two parts.

The theoretical part communicates basic knowledge on rolling bearing technology, illustrating the subject areas of technical drawing, technical calculation and technical theory by means of state-of-the-art media. In the practical part, the basic skills in the mounting and dismounting of common types of bearings are practised with the aid of exemplary simplified mating parts (shafts, housings).
Various methods and tools are used here.

The learning content comprises smaller learning stages and is available in various languages. They correspond in their full scope to the degree of difficulty that is currently required in vocational training. On the basis of this basic course, training can also be given on individual content by means of various mounting sets, *Figure 8*.

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Mounting cross

In order to provide professional training courses on the correct mounting and dismounting of rolling bearings, Schaeffler has developed the so-called mounting cross, *Figure 9*. This piece of equipment allows the skilled trainer to communicate the correct handling procedure visually, using a variety of different bearings, and under realistic conditions. The degree of difficulty corresponds to the basic training of persons who work on a regular basis with rolling bearings.

Figure 9
Training equipment:
Mounting cross

The mounting cross is of a modular structure and can be supplemented and expanded by a large number of different exercises. The initial configuration contains the basic tools required, the mounting cross itself and four different exercises on the most frequently used bearing types. Each one of the exercises contains the bearings, adjacent parts and tools required. Mechanical, thermal and hydraulic methods are communicated.

The training documents enclosed give precise explanations of the correct procedure and the correct use of bearings and tools. The necessary safety measures and alternative procedures are also explained.
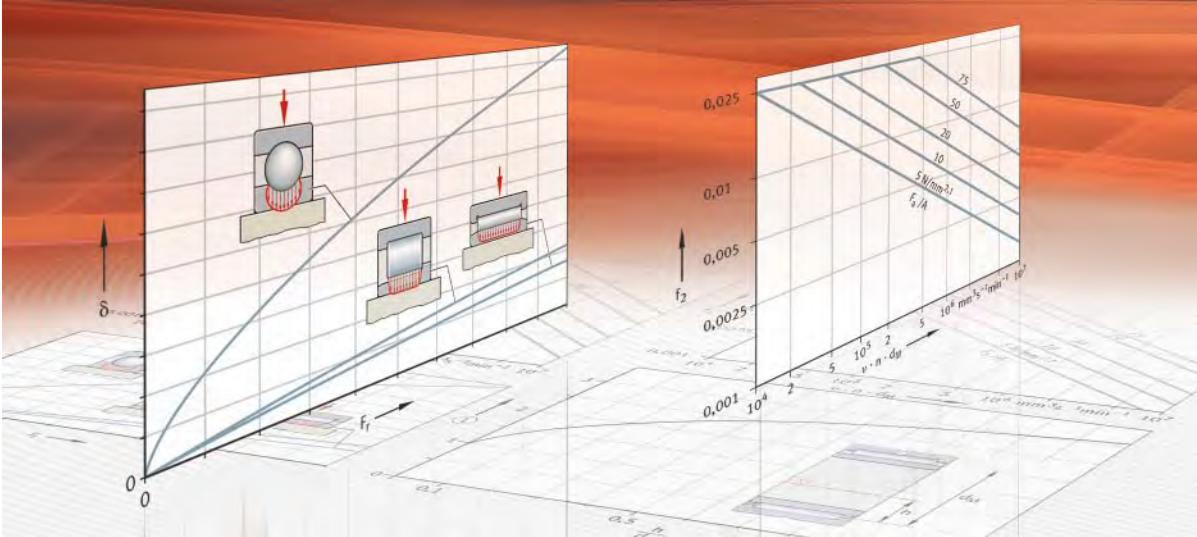
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Axial internal clearance
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FAG rolling bearing greases Arcanol –
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Guidelines for use

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Dimension and tolerance symbols

Dimension and tolerance symbols
for radial rolling bearings
in accordance with ISO 492:2014

Dimension symbol	Tolerance symbol	Description for radial bearings in accordance with ISO 492:2014	Old term in accordance with ISO 1132-1:2000
		Width	
B	–	Nominal inner ring width	Nominal inner ring width
	t_{VBs}	**Symmetrical rings** range of two-point sizes of inner ring width	Variation of inner ring width
		Asymmetrical rings range of minimum circumscribed sizes of inner ring width, between two opposite lines, obtained from any longitudinal section which includes the inner ring bore axis	
	$t_{\Delta Bs}$	**Symmetrical rings** deviation of a two-point size of inner ring width from its nominal size	Deviation of a single inner ring width
		Asymmetrical rings, upper limit deviation of a minimum circumscribed size of inner ring width, between two opposite lines, in any longitudinal section which includes the inner ring bore axis, from its nominal size	
		Asymmetrical rings, lower limit deviation of a two-point size of inner ring width from its nominal size	
C	–	Nominal outer ring width	Nominal outer ring width
	t_{VCs}	**Symmetrical rings** range of two-point sizes of outer ring width	Variation of outer ring width
		Asymmetrical rings range of minimum circumscribed sizes of outer ring width, between two opposite lines, obtained from any longitudinal section which includes the outer ring outside surface axis	
	$t_{\Delta Cs}$	**Symmetrical rings** deviation of a two-point size of outer ring width from its nominal size	Deviation of a single outer ring width
		Asymmetrical rings, upper limit deviation of a minimum circumscribed size of outer ring width, between two opposite lines, in any longitudinal section which includes the outer ring outside surface axis, from its nominal size	
		Asymmetrical rings, lower limit deviation of a two-point size of outer ring width from its nominal size	
C_1	–	Nominal outer ring flange width	Nominal outer ring flange width
	t_{VC1s}	Range of two-point sizes of outer ring flange width	Variation of outer ring flange width
	$t_{\Delta C1s}$	Deviation of a two-point size of outer ring flange width from its nominal size	Deviation of a single outer ring flange width

Dimension and tolerance symbols
for radial rolling bearings
in accordance with ISO 492:2014
(continued)

Dimension symbol	Tolerance symbol	Description for radial bearings in accordance with ISO 492:2014	Old term in accordance with ISO 1132-1:2000
Diameter			
d	–	Nominal bore diameter of a cylindrical bore or at the theoretical small end of a tapered bore	Nominal bore diameter
	t_{Vdmp}	Range of mid-range sizes (out of two-point sizes) of bore diameter obtained from any cross-section of a cylindrical bore	Variation of mean bore diameter
	$t_{\Delta dmp}$	**Cylindrical bore** deviation of a mid-range size (out of two-point sizes) of bore diameter in any cross-section from its nominal size	Deviation of mean bore diameter in a single plane
		Tapered bore deviation of a mid-range size (out of two-point sizes) of bore diameter at the theoretical small end from its nominal size	
	t_{Vdsp}	Range of two-point sizes of bore diameter in any cross-section of a cylindrical or tapered bore	Variation of single bore diameter in a single plane
	$t_{\Delta ds}$	Deviation of a two-point size of bore diameter of a cylindrical bore from its nominal size	Deviation of a single bore diameter
d_1	–	Nominal diameter at the theoretical large end of a tapered bore	Diameter at the theoretical large end of a basically tapered bore
	$t_{\Delta d1mp}$	Deviation of a mid-range size (out of two-point sizes) of bore diameter at the theoretical large end of a tapered bore from its nominal size	Deviation of mean bore diameter in a single plane at the theoretical large end of a basically tapered bore
D	–	Nominal outside diameter	Nominal outside diameter
	t_{VDmp}	Range of mid-range sizes (out of two-point sizes) of outside diameter obtained from any cross-section	Variation of mean outside diameter
	$t_{\Delta Dmp}$	Deviation of a mid-range size (out of two-point sizes) of outside diameter in any cross-section from its nominal size	Deviation of mean outside diameter in a single plane
	t_{VDsp}	Range of two-point sizes of outside diameter in any cross-section	Variation of outside diameter in a single plane
	$t_{\Delta Ds}$	Deviation of a two-point size of outside diameter from its nominal size	Deviation of a single outside diameter
D_1	–	Nominal outside diameter of outer ring flange	Nominal outside diameter of outer ring flange
	$t_{\Delta D1s}$	Deviation of a two-point size of outside diameter of outer ring flange from its nominal size	Deviation of a single outside diameter of outer ring flange
Tapered bore			
SL	–	Taper slope is the difference between nominal diameters at the theoretical large end and small end of a tapered bore ($SL = d_1 - d$)	–
	$t_{\Delta SL}$	Deviation of taper slope of a tapered inner ring bore from its nominal size ($\Delta SL = \Delta d1mp - \Delta dmp$)	–
α	–	Frustum angle of tapered inner ring bore (description based on ISO 1119)	–

Dimension and tolerance symbols

Dimension symbol	Tolerance symbol	Description for radial bearings in accordance with ISO 492:2014	Old term in accordance with ISO 1132-1:2000
Width of assembled bearing			
T	–	Nominal assembled bearing width	Assembled bearing width
	$t_{\Delta Ts}$	Deviation of minimum circumscribed size of assembled bearing width from its nominal size	Deviation of the actual (assembled) bearing width
T_1	–	Nominal effective width of inner subunit assembled with a master outer ring	Effective width of the inner subunit assembled with a master outer ring
	$t_{\Delta T1s}$	Deviation of minimum circumscribed size of effective width (inner subunit assembled with a master outer ring) from its nominal size	Nominal effective width of outer ring assembled with a master inner subunit
T_2	–	Effective width of outer ring assembled with a master inner subunit	Effective nominal width size of the outer ring, paired with an inner master unit
	$t_{\Delta T2s}$	Deviation of minimum circumscribed size of effective width (outer ring assembled with a master inner subunit) from its nominal size	Deviation of the actual effective width of outer ring assembled with a master inner subunit
T_F	–	Nominal assembled flanged bearing width	–
	$t_{\Delta TFs}$	Deviation of minimum circumscribed size of assembled flanged bearing width from its nominal size	–
T_{F2}	–	Nominal effective width of flanged outer ring assembled with a master inner subunit	–
	$t_{\Delta TF2s}$	Deviation of minimum circumscribed size of effective width (flanged outer ring assembled with a master inner subunit) from its nominal size	–
Running accuracy			
	t_{Kea}	Circular radial run-out of outer ring outside surface of assembled bearing with respect to datum, i.e. axis, established from the inner ring bore surface	Radial run-out of outer ring of assembled bearing
	t_{Kia}	Circular radial run-out of inner ring bore of assembled bearing with respect to datum, i.e. axis, established from the outer ring outside surface	Radial run-out of inner ring of assembled bearing
	t_{Sd}	Circular axial run-out of inner ring face with respect to datum, i.e. axis, established from the inner ring bore surface	Perpendicularity of inner ring face with respect to the bore
	t_{SD}	Perpendicularity of outer ring outside surface axis with respect to datum established from the outer ring face	Perpendicularity of outer ring outside surface with respect to the face
	t_{SD1}	Perpendicularity of outer ring outside surface axis with respect to datum established from the outer ring flange back face	Perpendicularity of outer ring outside surface with respect to the flange back face
	t_{Sea}	Circular axial run-out of outer ring face of assembled bearing with respect to datum, i.e. axis, established from the inner ring bore surface	Axial run-out of outer ring of assembled bearing
	t_{Sea1}	Circular axial run-out of outer ring flange back face of assembled bearing with respect to datum, i.e. axis, established from the inner ring bore surface	Axial run-out of outer ring flange back face of assembled bearing
	t_{Sia}	Circular axial run-out of inner ring face of assembled bearing with respect to datum, i.e. axis, established from the outer ring outside surface	Axial run-out of inner ring of assembled bearing

Dimension and tolerance symbols
for axial rolling bearings
in accordance with ISO 199:2014

Dimension symbol	Tolerance symbol	Description for axial bearings in accordance with ISO 199:2014	Old term in accordance with ISO 1132-1:2000
		Diameter	
d	–	Nominal bore diameter of shaft washer, single-direction bearing	Nominal bore diameter of shaft washer
	$t_{\Delta dmp}$	Deviation of a mid-range size (out of two-point sizes) of shaft washer bore diameter in any cross-section from its nominal size	Deviation of mean bore diameter in a single plane
	t_{Vdsp}	Range of two-point sizes of shaft washer bore diameter in any cross-section	Variation of single bore diameter in a single plane
d_2	–	Nominal bore diameter of central shaft washer, double-direction bearing	Nominal bore diameter of central shaft washer
	$t_{\Delta d2mp}$	Deviation of a mid-range size (out of two-point sizes) of central shaft washer bore diameter in any cross-section from its nominal size	Deviation of mean bore diameter in a single plane
	t_{Vd2sp}	Range of two-point sizes of central shaft washer bore diameter in any cross-section	Variation of single bore diameter in a single plane
D	–	Nominal outside diameter of housing washer	Nominal outside diameter of housing washer
	$t_{\Delta Dmp}$	Deviation of a mid-range size (out of two-point sizes) of housing washer outside diameter in any cross-section from its nominal size	Deviation of mean outside diameter in a single plane
	t_{VDsp}	Range of two-point sizes of housing washer outside diameter in any cross-section	Variation of outside diameter in a single plane
		Height	
T	–	Nominal assembled bearing height, single-direction bearing	Nominal bearing height
	$t_{\Delta Ts}$	Deviation of minimum circumscribed size of assembled bearing height from its nominal size, single-direction bearing	Deviation of the actual bearing height
T_1	–	Nominal assembled bearing height, double-direction bearing	Nominal bearing height
	$t_{\Delta T1s}$	Deviation of minimum circumscribed size of assembled bearing height from its nominal size, double-direction bearing	Deviation of the actual bearing height
	t_{Se}	**Axial cylindrical roller bearings:** range of two-point sizes of thickness between housing washer raceway and the back face **Axial ball bearings:** range of minimum spherical sizes between the raceway and the opposite back face of the housing washer	Variation in thickness between housing washer raceway and back face
	t_{Si}	**Axial cylindrical roller bearings:** range of two-point sizes of thickness between shaft washer raceway and the back face **Axial ball bearings:** range of minimum spherical sizes between the raceway and the opposite back face of the shaft washer	Variation in thickness between shaft washer raceway and back face
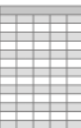
Shaft and housing fits

Shaft fits

	Nominal shaft diameter in mm				
over incl.	**3** **6**	**6** **10**	**10** **18**	**18** **30**	**30** **50**
Deviation of bearing bore diameter in μm (normal tolerance)					
Δ_{dmp}	0 −8	0 −8	0 −8	0 −10	0 −12
Shaft deviation, fit interference or fit clearance in μm					
e7	−20 −32	−25 −40	−32 −50	−40 −61	−50 −75
e8	−20 −38	−25 −47	−32 −59	−40 −73	−50 −89
f6	−10 −18	−13 −22	−16 −27	−20 −33	−25 −41
f7	−10 −22	−13 −28	−16 −34	−20 −41	−25 −50
g5	−4 −9	−5 −11	−6 −14	−7 −16	−9 −20
g6	−4 −12	−5 −14	−6 −17	−7 −20	−9 −25
h5	0 −5	0 −6	0 −8	0 −9	0 −11
h6	0 −8	0 −9	0 −11	0 −13	0 −16
j5	+3 −2	+4 −2	+5 −3	+5 −4	+6 −5
j6	+6 −2	+7 −2	+8 −3	+9 −4	+11 −5
js3	+1,25 +1,25	+1,25 +1,25	+1,5 +1,5	+2 −2	+2 −2
js4	+2 −2	+2 −2	+2,5 +2,5	+3 −3	+3,5 +3,5
js5	+2,5 −2,5	+3 −3	+4 −4	+4,5 −4,5	+5,5 −5,5
js6	+4 −4	+4,5 −4,5	+5,5 −5,5	+6,5 −6,5	+8 −8
k3	+2,5 0	+2,5 0	+3 0	+4 0	+4 0
k4	+5 +1	+5 +1	+6 +1	+8 +2	+9 +2
k5	+6 +1	+7 +1	+9 +1	+11 +2	+13 +2
k6	+9 +1	+10 +1	+12 +1	+15 +2	+18 +2

50 65	65 80	80 100	100 120	120 140	140 160	160 180	180 200	200 225	225 250	250 280	280 315
0 −15	0 −15	0 −20	0 −20	0 −25	0 −25	0 −25	0 −30	0 −30	0 −30	0 −35	0 −35
−60 −90	−60 −90	−72 −107	−72 −107	−85 −125	−83 −125	−85 −125	−100 −146	−100 −146	−100 −146	−110 −162	−110 −162
−60 −106	−60 −106	−72 −126	−72 −126	−85 −148	−85 −148	−85 −148	−100 −172	−100 −172	−100 −172	−110 −191	−110 −191
−30 −49	−30 −49	−36 −58	−36 −58	−43 −68	−43 −68	−43 −68	−50 −79	−50 −79	−50 −79	−56 −88	−56 −88
−30 −60	−30 −60	−36 −71	−36 −71	−43 −83	−43 −83	−43 −83	−50 −96	−50 −96	−50 −96	−56 −108	−56 −108
−10 −23	−10 −23	−12 −27	−12 −27	−14 −32	−14 −32	−14 −32	−15 −35	−15 −35	−15 −35	−17 −40	−17 −40
−10 −29	−10 −29	−12 −34	−12 −34	−14 −39	−14 −39	−14 −39	−15 −44	−15 −44	−15 −44	−17 −49	−17 −49
0 −13	0 −13	0 −15	0 −15	0 −18	0 −18	0 −18	0 −20	0 −20	0 −20	0 −23	0 −23
0 −19	0 −19	0 −22	0 −22	0 −25	0 −25	0 −25	0 −29	0 −29	0 −29	0 −32	0 −32
+6 −7	+6 −7	+6 −9	+6 −9	+7 −11	+7 −11	+7 −11	+7 −13	+7 −13	+7 −13	+7 −16	+7 −16
+12 −7	+12 −7	+13 −9	+13 −9	+14 −11	+14 −11	+14 −11	+16 −13	+16 −13	+16 −13	+16 −16	+16 −16
+2,5 +2,5	+2,5 +2,5	+3 −3	+3 −3	+4 −4	+4 −4	+4 −4	+5 −5	+5 −5	+5 −5	+6 −6	+6 −6
+4 −4	+4 −4	+5 −5	+5 −5	+6 −6	+6 −6	+6 −6	+7 −7	+7 −7	+7 −7	+8 −8	+8 −8
+6,5 −6,5	+6,5 −6,5	+7,5 −7,5	+7,5 −7,5	+9 −9	+9 −9	+9 −9	+10 −10	+10 −10	+10 −10	+11,5 −11,5	+11,5 −11,5
+9,5 −9,5	+9,5 −9,5	+11 −11	+11 −11	+12,5 −12,5	+12,5 −12,5	+12,5 −12,5	+14,5 −14,5	+14,5 −14,5	+14,5 −14,5	+16 −16	+16 −16
+5 0	+5 0	+6 0	+6 0	+8 0	+8 0	+8 0	+10 0	+10 0	+10 0	+12 0	+12 0
+10 +2	+10 +2	+13 +3	+13 +3	+15 +3	+15 +3	+15 +3	+18 +4	+18 +4	+18 +4	+20 +4	+20 +4
+15 +2	+15 +2	+18 +3	+18 +3	+21 +3	+21 +3	+21 +3	+24 +4	+24 +4	+24 +4	+27 +4	+27 +4
+21 +2	+21 +2	+25 +3	+25 +3	+28 +3	+28 +3	+28 +3	+33 +4	+33 +4	+33 +4	+36 +4	+36 +4

Shaft and housing fits

Nominal shaft diameter in mm				
over incl.	**315** **355**	**355** **400**	**400** **450**	**450** **500**
Deviation of bearing bore diameter in μm (normal tolerance)				
Δ_{dmp}	0 −40	0 −40	0 −45	0 −45
Shaft deviation, fit interference or fit clearance in μm				
e7	−125 −182	−125 −182	−135 −198	−135 −198
e8	−125 −214	−125 −214	−135 −232	−135 −232
f6	−62 −98	−62 −98	−68 −108	−68 −108
f7	−62 −119	−62 −119	−68 −131	−68 −131
g5	−18 −43	−18 −43	−20 −47	−20 −47
g6	−18 −54	−18 −54	−20 −60	−20 −60
h5	0 −25	0 −25	0 −27	0 −27
h6	0 −36	0 −36	0 −40	0 −40
j5	+7 −18	+7 −18	+7 −20	+7 −20
j6	+18 −18	+18 −18	+20 −20	+20 −20
js3	+6,5 −6,5	+6,5 −6,5	+7,5 −7,5	+7,5 −7,5
js4	+9 −9	+9 −9	+10 −10	+10 −10
js5	+12,5 −12,5	+12,5 −12,5	+13,5 −13,5	+13,5 −13,5
js6	+18 −18	+18 −18	+20 −20	+20 −20
k3	+13 0	+13 0	+15 0	+15 0
k4	+22 +4	+22 +4	+25 +5	+25 +5
k5	+29 +4	+29 +4	+32 +5	+32 +5
k6	+40 +4	+40 +4	+45 +5	+45 +5

500 560	560 630	630 710	710 800	800 900	900 1 000	1 000 1 120	1 120 1 250
0 −50	0 −50	0 −75	0 −75	0 −100	0 −100	0 −125	0 −125
−145 −215	−145 −215	−160 −240	−160 −240	−170 −260	−170 −260	−195 −300	−195 −300
−145 −255	−145 −255	−160 −285	−160 −285	−170 −310	−170 −310	−195 −360	−195 −360
−76 −120	−76 −120	−80 −130	−80 −130	−86 −142	−86 −142	−98 −164	−98 −164
−76 −146	−76 −146	−80 −160	−80 −160	−86 −176	−86 −176	−98 −203	−98 −203
−22 −51	−22 −51	−24 −56	−24 −56	−26 −62	−26 −62	−28 −70	−28 −70
−22 −66	−22 −66	−24 −74	−24 −74	−26 −82	−26 −82	−28 −94	−28 −94
0 −29	0 −29	0 −32	0 −32	0 −36	0 −36	0 −42	0 −42
0 −44	0 −44	0 −50	0 −50	0 −56	0 −56	0 −66	0 −66
–	–	–	–	–	–	–	–
+22 −22	+22 −22	+25 −25	+25 −25	+28 −28	+28 −28	+33 −33	+33 −33
–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–
+14,5 −14,5	+14,5 −14,5	+16 −16	+16 −16	+18 −18	+18 −18	+21 −21	+21 −21
+22 −22	+22 −22	+25 −25	+25 −25	+28 −28	+28 −28	+33 −33	+33 −33
–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–
+29 0	+29 0	+32 0	+32 0	+36 0	+36 0	+42 0	+42 0
+44 0	+44 0	+50 0	+50 0	+56 0	+56 0	+66 0	+66 0

Shaft and housing fits

Shaft fits
(continued)

Nominal shaft diameter in mm					
over incl.	**3** **6**	**6** **10**	**10** **18**	**18** **30**	**30** **50**
Deviation of bearing bore diameter in μm (normal tolerance)					
Δ_{dmp}	0 −8	0 −8	0 −8	0 −10	0 −12
Shaft deviation, fit interference or fit clearance in μm					
m5	+9 +4	+12 +6	+15 +7	+17 +8	+20 +9
m6	+12 +4	+15 +6	+18 +7	+21 +8	+25 +9
n5	+13 +8	+16 +10	+20 +12	+24 +15	+28 +17
n6	+16 +8	+19 +10	+23 +12	+28 +15	+33 +17
p6	+20 +12	+24 +15	+29 +18	+35 +22	+42 +26
p7	+24 +12	+30 +15	+36 +18	+43 +22	+51 +26
r6	+23 +15	+28 +19	+34 +23	+41 +28	+50 +34
r7	+27 +15	+34 +19	+41 +23	+49 +28	+59 +34
s6	+27 +19	+32 +23	+39 +28	+48 +35	+59 +43
s7	+31 +19	+38 +23	+46 +28	+56 +35	+68 +43
Shaft tolerances for adapter sleeves and withdrawal sleeves					
h7/$\frac{IT5}{2}$	0 −12 *2,5*	0 −15 *3*	0 −18 *4*	0 −21 *4,5*	0 −25 *5,5*
h8/$\frac{IT5}{2}$	0 −18 *2,5*	0 −22 *3*	0 −27 *4*	0 −33 *4,5*	0 −39 *5,5*
h9/$\frac{IT6}{2}$	0 −30 *4*	0 −36 *4,5*	0 −43 *5,5*	0 −52 *6,5*	0 −62 *8*
h10/	0 −48 *6*	0 −58 *7,5*	0 −70 *9*	0 −84 *10,5*	0 −100 *12,5*

The cylindricity tolerance t_1 (values printed in *italic*) relates to the radius
(DIN ISO 1101).
When measuring the shaft diameter, the tolerance values should be doubled.
For general machine building, the values h7 or h8 should be used in preference.

50 65	65 80	80 100	100 120	120 140	140 160	160 180	180 200	200 225	225 250	250 280	280 315
0 −15	0 −15	0 −20	0 −20	0 −25	0 −25	0 −25	0 −30	0 −30	0 −30	0 −35	0 −35
+24 +11	+24 +11	+28 +13	+28 +13	+33 +15	+33 +15	+33 +15	+37 +17	+37 +17	+37 +17	+43 +20	+43 +20
+30 +11	+30 +11	+35 +13	+35 +13	+40 +15	+40 +15	+40 +15	+46 +17	+46 +17	+46 +17	+52 +20	+52 +20
+33 +20	+33 +20	+38 +23	+38 +23	+45 +27	+45 +27	+45 +27	+51 +31	+51 +31	+51 +31	+57 +34	+57 +34
+39 +20	+39 +20	+45 +23	+45 +23	+52 +27	+52 +27	+52 +27	+60 +31	+60 +31	+60 +31	+66 +34	+66 +34
+51 +32	+51 +32	+59 +37	+59 +37	+68 +43	+68 +43	+68 +43	+79 +50	+79 +50	+79 +50	+88 +56	+88 +56
+62 +32	+62 +32	+72 +37	+72 +37	+83 +43	+83 +43	+83 +43	+96 +50	+96 +50	+96 +50	+108 +56	+108 +56
+60 +41	+62 +43	+73 +51	+76 +54	+88 +63	+90 +65	+93 +68	+106 +77	+109 +80	+113 +84	+126 +94	+130 +98
+71 +41	+73 +43	+86 +51	+89 +54	+103 +63	+105 +65	+108 +68	+123 +77	+126 +80	+130 +84	+146 +94	+150 +98
+72 +53	+78 +59	+93 +71	+101 +79	+117 +92	+125 +100	+133 +108	+151 +122	+159 +130	+169 +140	+190 +158	+202 +170
+83 +53	+89 +59	+106 +71	+114 +79	+132 +92	+140 +100	+148 +108	+168 +122	+176 +130	+186 +140	+210 +158	+222 +170
0 −30 *6,5*	0 −30 *6,5*	0 −35 *7,5*	0 −35 *7,5*	0 −40 *9*	0 −40 *9*	0 −40 *9*	0 −46 *10*	0 −46 *10*	0 −46 *10*	0 −52 *11,5*	0 −52 *11,5*
0 −46 *6,5*	0 −46 *6,5*	0 −54 *7,5*	0 −54 *7,5*	0 −63 *9*	0 −63 *9*	0 −63 *9*	0 −72 *10*	0 −72 *10*	0 −72 *10*	0 −81 *11,5*	0 −81 *11,5*
0 −74 *9,5*	0 −74 *9,5*	0 −87 *11*	0 −87 *11*	0 −100 *12,5*	0 −100 *12,5*	0 −100 *12,5*	0 −115 *14,5*	0 −115 *14,5*	0 −115 *14,5*	0 −130 *16*	0 −130 *16*
0 −120 *15*	0 −120 *15*	0 −140 *17,5*	0 −140 *17,5*	0 −160 *20*	0 −160 *20*	0 −160 *20*	0 −185 *23*	0 −185 *23*	0 −185 *23*	0 −210 *26*	0 −210 *26*

Shaft and housing fits

Shaft fits
(continued)

Nominal shaft diameter in mm				
over incl.	**315** **355**	**355** **400**	**400** **450**	**450** **500**
Deviation of bearing bore diameter in μm (normal tolerance)				
Δ_{dmp}	0 −40	0 −40	0 −45	0 −45
Shaft deviation, fit interference or fit clearance in μm				
m5	+46 +21	+46 +21	+50 +23	+50 +23
m6	+57 +21	+57 +21	+63 +23	+63 +23
n5	+62 +37	+62 +37	+67 +40	+67 +40
n6	+73 +37	+73 +37	+80 +40	+80 +40
p6	+98 +62	+98 +62	+108 +68	+108 +68
p7	+119 +62	+119 +62	+131 +68	+131 +68
r6	+144 +108	+150 +114	+166 +126	+172 +132
r7	+165 +108	+171 +114	+189 +126	+195 +132
s6	+226 +190	+244 +208	+272 +232	+292 +252
s7	+247 +190	+265 +208	+295 +232	+315 +252
Shaft tolerances for adapter sleeves and withdrawal sleeves				
h7/ $\frac{IT5}{2}$	0 −57 *12,5*	0 −57 *12,5*	0 −63 *13,5*	0 −63 *13,5*
h8/ $\frac{IT5}{2}$	0 −89 *12,5*	0 −89 *12,5*	0 −97 *13,5*	0 −97 *13,5*
h9/ $\frac{IT6}{2}$	0 −140 *18*	0 −140 *18*	0 −155 *20*	0 −155 *20*
h10/	0 −230 *28,5*	0 −230 *28,5*	0 −250 *31,5*	0 −250 *31,5*

The cylindricity tolerance t_1 (values printed in *italic*) relates to the radius (DIN ISO 1101).
When measuring the shaft diameter, the tolerance values should be doubled.
For general machine building, the values h7 or h8 should be used in preference.

500 / 560	560 / 630	630 / 710	710 / 800	800 / 900	900 / 1 000	1 000 / 1 120	1 120 / 1 250
0 / −50	0 / −50	0 / −75	0 / −75	0 / −100	0 / −100	0 / −125	0 / −125
+55 / +26	+55 / +26	+62 / +30	+62 / +30	+70 / +34	+70 / +34	+82 / +40	+82 / +40
+70 / +26	+70 / +26	+80 / +30	+80 / +30	+90 / +34	+90 / +34	+106 / +40	+106 / +40
+73 / +44	+73 / +44	+82 / +50	+82 / +50	+92 / +56	+92 / +56	+108 / +66	+108 / +66
+88 / +44	+88 / +44	+100 / +50	+100 / +50	+112 / +56	+112 / +56	+132 / +66	+132 / +66
+122 / +78	+122 / +78	+138 / +88	+138 / +88	+156 / +100	+156 / +100	+186 / +120	+186 / +120
+148 / +78	+148 / +78	+168 / +88	+168 / +88	+190 / +100	+190 / +100	+225 / +120	+225 / +120
+194 / +150	+199 / +155	+225 / +175	+235 / +185	+266 / +210	+276 / +220	+316 / +250	+326 / +260
+220 / +150	+225 / +155	+255 / +175	+265 / +185	+300 / +210	+310 / +220	+355 / +250	+365 / +260
+324 / +280	+354 / +310	+390 / +340	+430 / +380	+486 / +430	+526 / +470	+586 / +520	+646 / +580
+350 / +280	+380 / +310	+420 / +340	+460 / +380	+520 / +430	+560 / +470	+625 / +520	+685 / +580
0 / −70 / *14,5*	0 / −70 / *14,5*	0 / −80 / *16*	0 / −80 / *16*	0 / −90 / *18*	0 / −90 / *18*	0 / −105 / *21*	0 / −105 / *21*
0 / −110 / *14,5*	0 / −110 / *14,5*	0 / −125 / *16*	0 / −125 / *16*	0 / −140 / *18*	0 / −140 / *18*	0 / −165 / *21*	0 / −165 / *21*
0 / −175 / *22*	0 / −175 / *22*	0 / −200 / *25*	0 / −200 / *25*	0 / −230 / *28*	0 / −230 / *28*	0 / −260 / *33*	0 / −260 / *33*
0 / −280 / *35*	0 / −280 / *35*	0 / −320 / *40*	0 / −320 / *40*	0 / −360 / *45*	0 / −360 / *45*	0 / −420 / *52,5*	0 / −420 / *52,5*
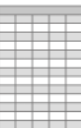
Shaft and housing fits

Housing fits

	Nominal housing bore diameter in mm				
over incl.	**6** **10**	**10** **18**	**18** **30**	**30** **50**	**50** **80**
Deviation of bearing outside diameter in μm (normal tolerance)					
Δ_{Dmp}	0 −8	0 −8	0 −9	0 −11	0 −13
Housing deviation, fit interference or fit clearance in μm					
D10	+98 +40	+120 +50	+149 +65	+180 +80	+220 +100
E8	+47 +25	+59 +32	+73 +40	+89 +50	+106 +60
F7	+28 +13	+34 +16	+41 +20	+50 +25	+60 +30
G6	+14 +5	+17 +6	+20 +7	+25 +9	+29 +10
G7	+20 +5	+24 +6	+28 +7	+34 +9	+40 +10
H5	+6 0	+8 0	+9 0	+11 0	+13 0
H6	+9 0	+11 0	+13 0	+16 0	+19 0
H7	+15 0	+18 0	+21 0	+25 0	+30 0
H8	+22 0	+27 0	+33 0	+39 0	+46 0
J6	+5 −4	+6 −5	+8 −5	+10 −6	+13 −6
J7	+8 −7	+10 −8	+12 −9	+14 −11	+18 −12
JS4	+2 −2	+2,5 −2,5	+3 −3	+3,5 −3,5	+4 −4
JS5	+3 −3	+4 −4	+4,5 −4,5	+5,5 −5,5	+6,5 −6,5
JS6	+4,5 −4,5	+5,5 −5,5	+6,5 −6,5	+8 −8	+9,5 −9,5
JS7	+7,5 −7,5	+9 −9	+10,5 −10,5	+12,5 −12,5	+15 −15

80 120	120 150	150 180	180 250	250 315	315 400	400 500	500 630	630 800	800 1 000	1 000 1 250	1 250 1 600
0 −15	0 −18	0 −25	0 −30	0 −35	0 −40	0 −45	0 −50	0 −75	0 −100	0 −125	0 −160
+260 +120	+305 +145	+305 +145	+355 +170	+400 +190	+440 +210	+480 +230	+540 +260	+610 +290	+680 +320	+770 +350	+890 +390
+126 +72	+148 +85	+148 +85	+172 +100	+191 +110	+214 +125	+232 +135	+255 +145	+285 +160	+310 +170	+360 +195	+415 +220
+71 +36	+83 +43	+83 +43	+96 +50	+108 +56	+119 +62	+131 +68	+146 +76	+160 +80	+176 +86	+203 +98	+235 +110
+34 +12	+39 +14	+39 +14	+44 +15	+49 +17	+54 +18	+60 +20	+66 +22	+74 +24	+82 +26	+94 +28	+108 +30
+47 +12	+54 +14	+54 +14	+61 +15	+69 +17	+75 +18	+83 +20	+92 +22	+104 +24	+116 +26	+133 +28	+155 +30
+15 0	+18 0	+18 0	+20 0	+23 0	+25 0	+27 0	–	–	–	–	–
+22 0	+25 0	+25 0	+29 0	+32 0	+36 0	+40 0	+44 0	+50 0	+56 0	+66 0	+78 0
+35 0	+40 0	+40 0	+46 0	+52 0	+57 0	+63 0	+70 0	+80 0	+90 0	+105 0	+125 0
+54 0	+63 0	+63 0	+72 0	+81 0	+89 0	+97 0	+110 0	+125 0	+140 0	+165 0	+195 0
+16 −6	+18 −7	+18 −7	+22 −7	+25 −7	+29 −7	+33 −7	–	–	–	–	–
+22 −13	+26 −14	+26 −14	+30 −16	+36 −16	+39 −18	+43 −20	–	–	–	–	–
+5 −5	+6 −6	+6 −6	+7 −7	+8 −8	+9 −9	+10 −10	–	–	–	–	–
+7,5 −7,5	+9 −9	+9 −9	+10 −10	+11,5 −11,5	+12,5 −12,5	+13,5 −13,5	–	–	–	–	–
+11 −11	+12,5 −12,5	+12,5 −12,5	+14,5 −14,5	+16 −16	+18 −18	+20 −20	+22 −22	+25 −25	+28 −28	+33 −33	+39 −39
+17,5 −17,5	+20 −20	+20 −20	+23 −23	+26 −26	+28,5 −28,5	+31,5 −31,5	+35 −35	+40 −40	+45 −45	+52 −52	+62 −62

Shaffler and housing fits

Shaft and housing fits
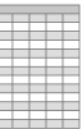
Housing fits
(continued)

Nominal housing bore diameter in mm					
over	**6**	**10**	**18**	**30**	**50**
incl.	**10**	**18**	**30**	**50**	**80**
Deviation of bearing outside diameter in μm (normal tolerance)					
Δ_{Dmp}	0	0	0	0	0
	−8	−8	−9	−11	−13
Housing deviation, fit interference or fit clearance in μm					
K4	+0,5	+1	0	+1	+1
	−3,5	−4	−6	−6	−7
K5	+1	+2	+1	+2	+3
	−5	−6	−8	−9	−10
K6	+2	+2	+2	+3	+4
	−7	−9	−11	−13	−15
K7	+5	+6	+6	+7	+9
	−10	−12	−15	−18	−21
M6	−3	−4	−4	−4	−5
	−12	−15	−17	−20	−24
M7	0	0	0	0	0
	−15	−18	−21	−25	−30
N6	−7	−9	−11	−12	−14
	−16	−20	−24	−28	−33
N7	−4	−5	−7	−8	−9
	−19	−23	−28	−33	−39
P6	−12	−15	−18	−21	−26
	−21	−26	−31	−37	−45
P7	−9	−11	−14	−17	−21
	−24	−29	−35	−42	−51
R6	−16	−20	−24	−29	−35
	−25	−31	−37	−45	−54
S7	−20	−25	−31	−38	−47
	−29	−36	−44	−54	−66

	80 120	120 150	150 180	180 250	250 315	315 400	400 500	500 630	630 800	800 1 000	1 000 1 250	1 250 1 600
	0 −15	0 −18	0 −25	0 −30	0 −35	0 −40	0 −45	0 −50	0 −75	0 −100	0 −125	0 −160
	+1 −9	+1 −11	+1 −11	0 −14	0 −16	0 −17	0 −20	–	–	–	–	–
	+2 −13	+3 −15	+3 −15	+2 −18	+3 −20	+3 −22	+2 −25	–	–	–	–	–
	+4 −18	+4 −21	+4 −21	+5 −24	+5 −27	+7 −29	+8 −32	0 −44	0 −50	0 −56	0 −66	0 −78
	+10 −25	+12 −28	+12 −28	+13 −33	+16 −36	+17 −40	+18 −45	0 −70	0 −80	0 −90	0 −105	0 −125
	−6 −28	−8 −33	−8 −33	−8 −37	−9 −41	−10 −46	−10 −50	−26 −70	−30 −80	−34 −90	−40 −106	−48 −126
	0 −35	0 −40	0 −40	0 −46	0 −52	0 −57	0 −63	−26 −96	−30 −110	−34 −124	−40 −145	−48 −173
	−16 −38	−20 −45	−20 −45	−22 −51	−25 −57	−26 −62	−27 −67	−44 −88	−50 −100	−56 −112	−66 −132	−78 −156
	−10 −45	−12 −52	−12 −52	−14 −60	−14 −66	−16 −73	−17 −80	−44 −114	−50 −130	−56 −146	−66 −171	−78 −203
	−30 −52	−36 −61	−36 −61	−41 −70	−47 −79	−51 −87	−55 −95	−78 −122	−88 −138	−100 −156	−120 −186	−140 −218
	−24 −59	−28 −68	−28 −68	−33 −79	−36 −88	−41 −98	−45 −108	−78 −148	−88 −168	−100 −190	−120 −225	−140 −265
	−44 −66	−56 −81	−61 −86	−68 −97	−85 −117	−97 −133	−113 −153	−150 −194	−175 −225	−210 −266	−250 −316	−300 −378
	−64 −86	−85 −110	−101 −126	−113 −142	−149 −181	−179 −215	−219 −259	–	–	–	–	–

Normal tolerances

Normal tolerances for FAG radial bearings, excluding tapered roller bearings.

Inner ring tolerances

| Bore | | Bore deviation $t_{\Delta dmp}$ μm Deviation | | Variation t_{Vdsp} μm Diameter series | | | t_{Vdmp} μm | Runout t_{Kia} μm | Deviation of inner ring width $t_{\Delta Bs}$ μm Deviation | | | | Vari-ation t_{VBs} μm |
| | | | | | | | | | normal | | modified[1] | | |
over	incl.	upper	lower	9 max.	0, 1 max.	2, 3, 4 max.	max.	max.	upper	lower	upper	lower	max.
0,6[2]	2,5	0	−8	10	8	6	6	10	0	−40	0	−	12
2,5	10	0	−8	10	8	6	6	10	0	−120	0	−250	15
10	18	0	−8	10	8	6	6	10	0	−120	0	−250	20
18	30	0	−10	13	10	8	8	13	0	−120	0	−250	20
30	50	0	−12	15	12	9	9	15	0	−120	0	−250	20
50	80	0	−15	19	19	11	11	20	0	−150	0	−380	25
80	120	0	−20	25	25	15	15	25	0	−200	0	−380	25
120	180	0	−25	31	31	19	19	30	0	−250	0	−500	30
180	250	0	−30	38	38	23	23	40	0	−300	0	−500	30
250	315	0	−35	44	44	26	26	50	0	−350	0	−500	35
315	400	0	−40	50	50	30	30	60	0	−400	0	−630	40
400	500	0	−45	56	56	34	34	65	0	−450	0	−	50
500	630	0	−50	63	63	38	38	70	0	−500	0	−	60
630	800	0	−75	−	−	−	−	80	0	−750	0	−	70
800	1 000	0	−100	−	−	−	−	90	0	−1 000	0	−	80
1 000	1 250	0	−125	−	−	−	−	100	0	−1 250	0	−	100
1 250	1 600	0	−160	−	−	−	−	120	0	−1 600	0	−	120
1 600	2 000	0	−200	−	−	−	−	140	0	−2 000	0	−	140

[1] Only for bearings manufactured specifically for use as matched pairs.

[2] This diameter is included in the group.

Outer ring tolerances[1]

Outside diameter D mm		Deviation of outside diameter $t_{\Delta Dmp}$ μm Deviation		Variation t_{VDsp} μm				t_{VDmp}[2] μm	Runout t_{Kea} μm
				Open bearings Diameter series			Bearings with sealing shields or sealing washers		
over	incl.	upper	lower	9	0, 1	2, 3, 4			
				max.	max.	max.	max.	max.	max.
2,5[3]	6	0	−8	10	8	6	10	6	15
6	18	0	−8	10	8	6	10	6	15
18	30	0	−9	12	9	7	12	7	15
30	50	0	−11	14	11	8	16	8	20
50	80	0	−13	16	13	10	20	10	25
80	120	0	−15	19	19	11	26	11	35
120	150	0	−18	23	23	14	30	14	40
150	180	0	−25	31	31	19	38	19	45
180	250	0	−30	38	38	23	−	23	50
250	315	0	−35	44	44	26	−	26	60
315	400	0	−40	50	50	30	−	30	70
400	500	0	−45	56	56	34	−	34	80
500	630	0	−50	63	63	38	−	38	100
630	800	0	−75	94	94	55	−	55	120
800	1 000	0	−100	125	125	75	−	75	140
1 000	1 250	0	−125	−	−	−	−	−	160
1 250	1 600	0	−160	−	−	−	−	−	190
1 600	2 000	0	−200	−	−	−	−	−	220
2 000	2 500	0	−250	−	−	−	−	−	250

[1] Δ_{Cs}, Δ_{C1s}, V_{Cs} and V_{C2s} are identical to Δ_{Bs} and V_{Bs} for the inner ring of the corresponding bearing (table Tolerance class Normal Inner ring, page 152).

[2] Applies before assembly of the bearing and after removal of internal and/or external snap rings.

[3] This diameter is included in the group.
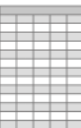
Normal tolerances

**Normal tolerances
for FAG tapered roller bearings
in metric sizes**

The main dimensions conform to ISO 355 and DIN 720,
the dimensional and running tolerances conform to ISO 492:2014.
These values are only valid for bearings in metric sizes.

**Width tolerance
to tolerance class Normal**

Single row tapered roller bearings 302, 303, 313, 322, 323, T2EE,
T4CB, T4DB, T5ED and T7FC correspond to the tolerance
class Normal.

Bearings 320, 329, 330, 331 and 332 for shaft diameters over
200 mm have width tolerances to the tolerance class Normal.
Bearings for shaft diameters $<$ 200 mm have width tolerances
to the tolerance class 6X, see table, page 157.

Inner ring tolerances

Bore d mm		Bore deviation $t_{\Delta dmp}$ μm		Variation t_{Vdsp} μm	t_{Vdmp} μm	Runout t_{Kia} μm
over	incl.	max.	min.	max.	max.	max.
–	10	0	−12	12	9	15
10	18	0	−12	12	9	15
18	30	0	−12	12	9	18
30	50	0	−12	12	9	20
50	80	0	−15	15	11	25
80	120	0	−20	20	15	30
120	180	0	−25	25	19	35
180	250	0	−30	30	23	50
250	315	0	−35	35	26	60
315	400	0	−40	40	30	70
400	500	0	−45	45	34	80
500	630	0	−60	60	40	90
630	800	0	−75	75	45	100
800	1 000	0	−100	100	55	115
1 000	1 250	0	−125	125	65	130
1 250	1 600	0	−160	160	80	150
1 600	2 000	0	−200	200	100	170

Width tolerances

Bore		Deviation of inner ring width		Width deviation					
d		$t_{\Delta Bs}$		$t_{\Delta Ts}$		$t_{\Delta T1s}$		$t_{\Delta T2s}$	
mm		μm		μm		μm		μm	
over	incl.	max.	min.	max.	min.	max.	min.	max.	min.
–	10	0	−120	+200	0	+100	0	+100	0
10	18	0	−120	+200	0	+100	0	+100	0
18	30	0	−120	+200	0	+100	0	+100	0
30	50	0	−120	+200	0	+100	0	+100	0
50	80	0	−150	+200	0	+100	0	+100	0
80	120	0	−200	+200	−200	+100	−100	+100	−100
120	180	0	−250	+350	−250	+150	−150	+200	−100
180	250	0	−300	+350	−250	+150	−150	+200	−100
250	315	0	−350	+350	−250	+150	−150	+200	−100
315	400	0	−400	+400	−400	+200	−200	+200	−200
400	500	0	−450	+450	−450	+225	−225	+225	−225
500	630	0	−500	+500	−500	–	–	–	–
630	800	0	−750	+600	−600	–	–	–	–
800	1 000	0	−1 000	+750	−750	–	–	–	–
1 000	1 250	0	−1 250	+900	−900	–	–	–	–
1 250	1 600	0	−1 600	+1 050	−1 050	–	–	–	–
1 600	2 000	0	−2 000	+1 200	−1 200	–	–	–	–
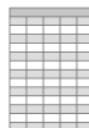
Normal tolerances

Outer ring tolerances

Outside diameter		Deviation of outside diameter		Variation		Runout
D		$t_{\Delta Dmp}$		t_{VDsp}	t_{VDmp}	t_{Kea}
mm		μm		μm	μm	μm
over	incl.	max.	min.	max.	max.	max.
–	18	0	−12	12	9	18
18	30	0	−12	12	9	18
30	50	0	−14	14	11	20
50	80	0	−16	16	12	25
80	120	0	−18	18	14	35
120	150	0	−20	20	15	40
150	180	0	−25	25	19	45
180	250	0	−30	30	23	50
250	315	0	−35	35	26	60
315	400	0	−40	40	30	70
400	500	0	−45	45	34	80
500	630	0	−50	60	38	100
630	800	0	−75	80	55	120
800	1 000	0	−100	100	75	140
1 000	1 250	0	−125	130	90	160
1 250	1 600	0	−160	170	100	180
1 600	2 000	0	−200	210	110	200
2 000	2 500	0	−250	265	120	220

The width tolerance Δ_{Cs} is identical to Δ_{Bs} for the inner ring
of the same bearing.

Width tolerance to tolerance class 6X

Tapered roller bearings 320, 329, 330, 331 and 332 for shaft diameters up to 200 mm and inch size bearings with the code KJ have restricted width tolerances to the tolerance class 6X.

Width tolerances

Bore		Deviation of inner ring width		Width deviation								
d		$t_{\Delta Bs}$		$t_{\Delta Cs}$		$t_{\Delta Ts}$		$t_{\Delta T1s}$		$t_{\Delta T2s}$	
mm		μm		μm		μm		μm		μm	
over	incl.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
–	10	0	−50	0	−100	+100	0	+50	0	+50	0
10	18	0	−50	0	−100	+100	0	+50	0	+50	0
18	30	0	−50	0	−100	+100	0	+50	0	+50	0
30	50	0	−50	0	−100	+100	0	+50	0	+50	0
50	80	0	−50	0	−100	+100	0	+50	0	+50	0
80	120	0	−50	0	−100	+100	0	+50	0	+50	0
120	180	0	−50	0	−100	+150	0	+50	0	+100	0
180	250	0	−50	0	−100	+150	0	+50	0	+100	0
250	315	0	−50	0	−100	+200	0	+100	0	+100	0
315	400	0	−50	0	−100	+200	0	+100	0	+100	0
400	500	0	−50	0	−100	+200	0	+100	0	+100	0
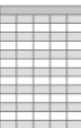
Normal tolerances

Restricted tolerance class 5

Tapered roller bearings with restricted tolerances correspond
to the tolerance class 5 to ISO 492:2014.

Inner ring tolerances
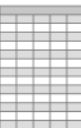
Bore d mm		Bore deviation $t_{\Delta dmp}$ μm		Variation t_{Vdsp} μm	t_{Vdmp} μm	Runout t_{Kia} μm
over	incl.	max.	min.	max.	max.	max.
–	10	0	−7	5	5	5
10	18	0	−7	5	5	5
18	30	0	−8	6	5	5
30	50	0	−10	8	5	6
50	80	0	−12	9	6	7
80	120	0	−15	11	8	8
120	180	0	−18	14	9	11
180	250	0	−22	17	11	13
250	315	0	−25	19	13	13
315	400	0	−30	23	15	15
400	500	0	−35	28	17	20
500	630	0	−40	35	20	25
630	800	0	−50	45	25	30
800	1 000	0	−60	60	30	37
1 000	1 250	0	−75	75	37	45
1 250	1 600	0	−90	90	45	55

Width tolerances

Bore d mm		Deviation of inner ring width $t_{\Delta Bs}$ μm		Deviation of bearing width $t_{\Delta Ts}$ μm	
over	incl.	max.	min.	max.	min.
–	10	0	−200	+200	−200
10	18	0	−200	+200	−200
18	30	0	−200	+200	−200
30	50	0	−240	+200	−200
50	80	0	−300	+200	−200
80	120	0	−400	+200	−200
120	180	0	−500	+350	−250
180	250	0	−600	+350	−250
250	315	0	−700	+350	−250
315	400	0	−800	+400	−400
400	500	0	−900	+450	−450
500	630	0	−1 100	+500	−500
630	800	0	−1 600	+600	−600
800	1 000	0	−2 000	+750	−750
1 000	1 250	0	−2 000	+750	−750
1 250	1 600	0	−2 000	+900	−900

Outer ring tolerances

Outside diameter		Deviation of outside diameter		Variation		Runout
D		$t_{\Delta Dmp}$		t_{VDsp}	t_{VDmp}	t_{Kea}
mm		μm		μm	μm	μm
over	incl.	max.	min.	max.	max.	max.
−	18	0	−8	6	5	6
18	30	0	−8	6	5	6
30	50	0	−9	7	5	7
50	80	0	−11	8	6	8
80	120	0	−13	10	7	10
120	150	0	−15	11	8	11
150	180	0	−18	14	9	13
180	250	0	−20	15	10	15
250	315	0	−25	19	13	18
315	400	0	−28	22	14	20
400	500	0	−33	26	17	24
400	500	0	−38	30	20	30
500	630	0	−45	38	25	36
630	800	0	−60	50	30	43
800	1 000	0	−80	65	38	52
1 000	1 250	0	−100	90	50	62
1 250	1 600	0	−125	120	65	73

Normal tolerances

Normal tolerances for FAG tapered roller bearings to ANSI/ABMA

Tapered roller bearings of series K are manufactured as standard with normal tolerances based on ANSI/ABMA.
Exception: series KJ = 6X.
The width Δ_{Bs} and radial runout correspond to the tolerance class Normal to ISO 492:2014.
The bore and outside diameters of bearings in inch sizes have plus tolerances.

Inner ring tolerances

Bore d mm		Bore deviation $t_{\Delta dmp}$ μm		Runout t_{Kia} μm
over	incl.	max.	min.	
10	18	13	0	15
18	30	13	0	18
30	50	13	0	20
50	81	13	0	25
81	120	25	0	30
120	180	25	0	35
180	305	25	0	50
305	400	50	0	50

Width tolerances

Bore d mm		Deviation of inner ring width (in relation to bore) $t_{\Delta Bs}$ μm		Deviation of bearing width $t_{\Delta Ts}$ μm	
over	incl.	max.	min.	max.	min.
10	50	0	−120	+200	0
50	81	0	−150	+200	0
81	102	0	−200	+200	0
102	120	0	−200	+350	−250
120	180	0	−250	+350	−250
180	250	0	−300	+350	−250
250	305	0	−350	+350	−250
305	315	0	−350	+375	−375
315	400	0	−400	+375	−375
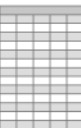
Outside diameter D mm		Deviation of outside diameter $t_{\Delta Dmp}$ µm		Runout t_{Kea} µm
over	incl.	max.	min.	
18	30	+25	0	18
30	50	+25	0	20
50	81	+25	0	25
81	120	+25	0	35
120	150	+25	0	40
150	180	+25	0	45
180	250	+25	0	50
250	305	+25	0	50
305	400	+50	0	50

Normal tolerances for axial bearings

The normal tolerances for axial bearings correspond to ISO 199, DIN 620-3.

Bore diameter tolerances for shaft locating washers

Bore d mm		Bore deviation $t_{\Delta dmp}$ µm Tolerance class				Variation t_{Vdp} µm Tolerance class	
		Normal, 6 and 5 Deviation		4 Deviation		Normal, 6 and 5	4
over	incl.	upper	lower	upper	lower	max.	max.
–	18	0	−8	0	−7	6	5
18	30	0	−10	0	−8	8	6
30	50	0	−12	0	−10	9	8
50	80	0	−15	0	−12	11	9
80	120	0	−20	0	−15	15	11
120	180	0	−25	0	−18	19	14
180	250	0	−30	0	−22	23	17
250	315	0	−35	0	−25	26	19
315	400	0	−40	0	−30	30	23
400	500	0	−45	0	−35	34	26
500	630	0	−50	0	−40	38	30
630	800	0	−75	0	−50	56	–
800	1 000	0	−100	0	–	75	–
1 000	1 250	0	−125	0	–	95	–

Normal tolerances

Outside diameter tolerances for housing locating washers

Outside diameter D mm		Deviation of outside diameter $t_{\Delta Dmp}$ μm Tolerance class				Variation t_{VDp} μm Tolerance class	
		Normal, 6 and 5 Deviation		4 Deviation		Normal, 6 and 5	4
over	incl.	upper	lower	upper	lower	max.	max.
10	18	0	−11	0	−7	8	5
18	30	0	−13	0	−8	10	6
30	50	0	−16	0	−9	12	7
50	80	0	−19	0	−11	14	8
80	120	0	−22	0	−13	17	10
120	180	0	−25	0	−15	19	11
180	250	0	−30	0	−20	23	15
250	315	0	−35	0	−25	26	19
315	400	0	−40	0	−28	30	21
400	500	0	−45	0	−33	34	25
500	630	0	−50	0	−38	38	29
630	800	0	−75	0	−45	55	34
800	1 000	0	−100	–	–	75	–
1 000	1 250	0	−125	–	–	75	–
1 250	1 600	0	−160	–	–	120	–

Variation of washer thickness for shaft and housing locating washers

Bore d mm		Variation				
		t_{Si} μm				t_{Se} μm
		Tolerance class Normal	Tolerance class 6	Tolerance class 5	Tolerance class 4	Tolerance class Normal, 6, 5, 4
over	incl.	max.	max.	max.	max.	
–	18	10	5	3	2	Identical to t_{Si} for the shaft locating washer of the corresponding bearing
18	30	10	5	3	2	
30	50	10	6	3	2	
50	80	10	7	4	3	
80	120	15	8	4	3	
120	180	15	9	5	4	
180	250	20	10	5	4	
250	315	25	13	7	5	
315	400	30	15	7	5	
400	500	30	18	9	6	
500	630	35	21	11	7	
630	800	40	25	13	8	
800	1 000	45	30	15	8	
1 000	1 250	50	35	18	9	

Normal tolerances

Tolerances: see table. The corresponding dimension symbols are shown in *Figure 1*.
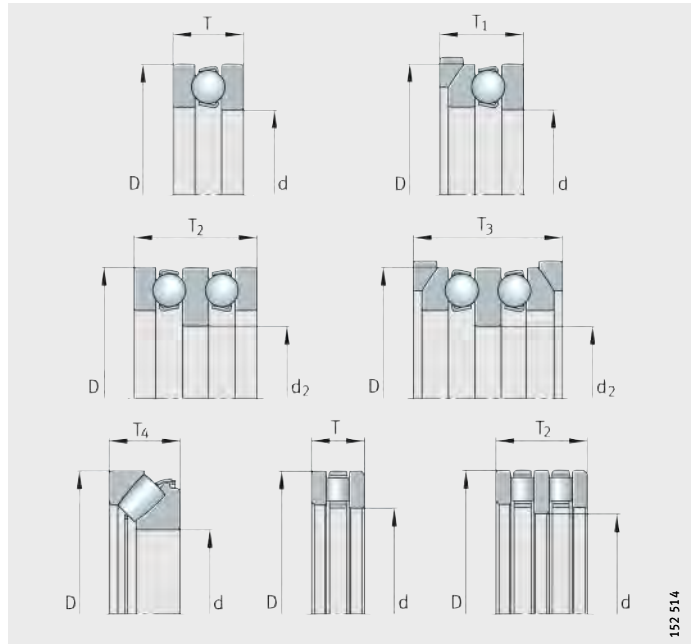
Figure 1
Tolerances
for nominal bearing height

**Tolerances
for nominal bearing height**

Bore d mm		T Deviation μm		T_1 Deviation μm		T_2 Deviation μm		T_3 Deviation μm		T_4 Deviation μm	
over	incl.	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower
–	30	20	−250	100	−250	150	−400	300	−400	20	−300
30	50	20	−250	100	−250	150	−400	300	−400	20	−300
50	80	20	−300	100	−300	150	−500	300	−500	20	−400
80	120	25	−300	150	−300	200	−500	400	−500	25	−400
120	180	25	−400	150	−400	200	−600	400	−600	25	−500
180	250	30	−400	150	−400	250	−600	500	−600	30	−500
250	315	40	−400	200	−400	350	−700	600	−700	40	−700
315	400	40	−500	200	−500	350	−700	600	−700	40	−700
400	500	50	−500	300	−500	400	−900	750	−900	50	−900
500	630	60	−600	350	−600	500	−1 100	900	−1 100	60	−1 200
630	800	70	−750	400	−750	600	−1 300	1 100	−1 300	70	−1 400
800	1 000	80	−1 000	450	−1 000	700	−1 500	1 300	−1 500	80	−1 800
1 000	1 250	100	−1 400	500	−1 400	900	−1 800	1 600	−1 800	100	−2 400

Chamfer dimensions

Chamfer dimensions for radial bearings (excluding tapered roller bearings)

The chamfer dimensions correspond to DIN 620-6.

The minimum and maximum values for the bearings are given in the table, page 166.

In the case of drawn cup needle roller bearings with open ends HK, drawn cup needle roller bearings with closed end BK and aligning needle roller bearings PNA and RPNA, the chamfer dimensions deviate from DIN 620-6.

Chamfer dimensions for tapered roller bearings: see table, page 167, for axial bearings see table, page 171.

① Symmetrical ring cross-section with identical chamfers on both rings
② Symmetrical ring cross-section with different chamfers on both rings
③ Asymmetrical ring cross-section
④ Annular slot on outer ring, bearing with rib washer
⑤ L-section ring

Figure 1
Chamfer dimensions for radial bearings excluding tapered roller bearings
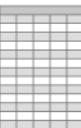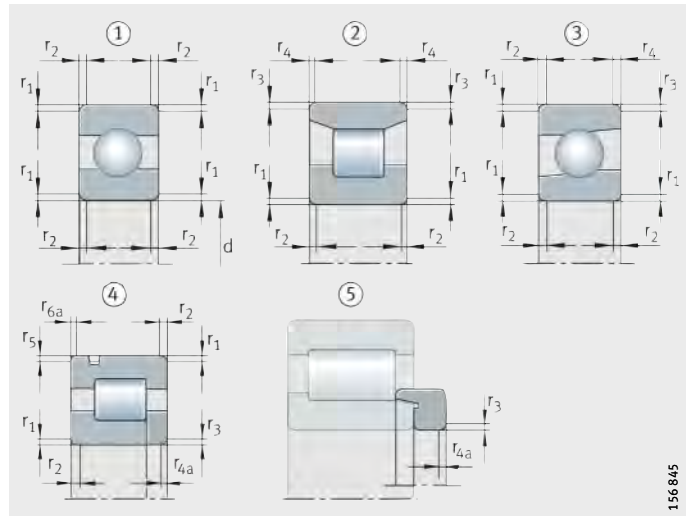
Chamfer dimensions

Limit values for chamfer dimensions of radial bearings to DIN 620-6 (excluding tapered roller bearings)

Nominal chamfer dimension r [1] mm	Nominal bearing bore diameter d mm		Chamfer dimension			
	over	incl.	r_1 to r_{6a} mm	r_1, r_3, r_5 mm	r_2, r_4, r_6 [2] mm	r_{4a}, r_{6a} mm
			min.	max.	max.	max.
0,05	–	–	0,05	0,1	0,2	0,1
0,08	–	–	0,08	0,16	0,3	0,16
0,1	–	–	0,1	0,2	0,4	0,2
0,15	–	–	0,15	0,3	0,6	0,3
0,2	–	–	0,2	0,5	0,8	0,5
0,3	–	40	0,3	0,6	1	0,8
	40	–	0,3	0,8	1	0,8
0,5	–	40	0,5	1	2	1,5
	40	–	0,5	1,3	2	1,5
0,6	–	40	0,6	1	2	1,5
	40	–	0,6	1,3	2	1,5
1	–	50	1	1,5	3	2,2
	50	–	1	1,9	3	2,2
1,1	–	120	1,1	2	3,5	2,7
	120	–	1,1	2,5	4	2,7
1,5	–	120	1,5	2,3	4	3,5
	120	–	1,5	3	5	3,5
2	–	80	2	3	4,5	4
	80	220	2	3,5	5	4
	220	–	2	3,8	6	4
2,1	–	280	2,1	4	6,5	4,5
	280	–	2,1	4,5	7	4,5
2,5	–	100	2,5	3,8	6	5
	100	280	2,5	4,5	6	5
	280	–	2,5	5	7	5
3	–	280	3	5	8	5,5
	280	–	3	5,5	8	5,5
4	–	–	4	6,5	9	6,5
5	–	–	5	8	10	8
6	–	–	6	10	13	10
7,5	–	–	7,5	12,5	17	12,5
9,5	–	–	9,5	15	19	15
12	–	–	12	18	24	18
15	–	–	15	21	30	21
19	–	–	19	25	38	25

[1] The nominal chamfer dimension r is identical to the smallest permissible chamfer dimension r_{min}.

[2] For bearings with a width of 2 mm or less, the values for r_1 apply.

Chamfer dimensions
for tapered roller bearings
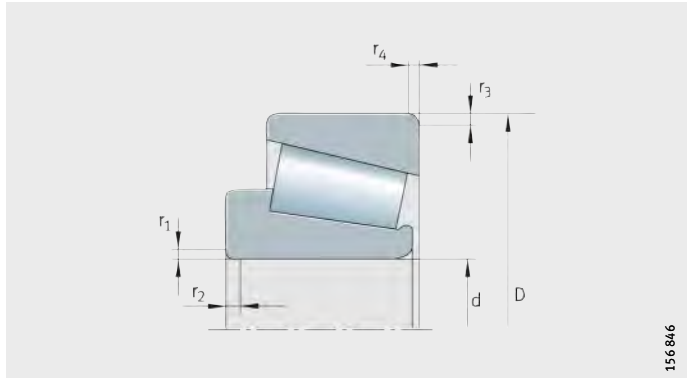
156 846

Figure 2
Chamfer dimensions
for metric tapered roller bearings

Limit values for chamfer dimensions
of tapered roller bearings

Nominal chamfer dimension r[1] mm	Nominal dimension of bearing bore, outside diameter d, D mm		Chamfer dimension		
			r_1 to r_4 mm	r_1, r_3 mm	r_2, r_4 mm
	over	incl.	min.	max.	max.
0,3	–	40	0,3	0,7	1,4
	40	–	0,3	0,9	1,6
0,6	–	40	0,6	1,1	1,7
	40	–	0,6	1,3	2
1	–	50	1	1,6	2,5
	50	–	1	1,9	3
1,5	–	120	1,5	2,3	3
	120	250	1,5	2,8	3,5
	250	–	1,5	3,5	4
2	–	120	2	2,8	4
	120	250	2	3,5	4,5
	250	–	2	4	5
2,5	–	120	2,5	3,5	5
	120	250	2,5	4	5,5
	250	–	2,5	4,5	6
3	–	120	3	4	5,5
	120	250	3	4,5	6,5
	250	400	3	5	7
	400	–	3	5,5	7,5
4	–	120	4	5	7
	120	250	4	5,5	7,5
	250	400	4	6	8
	400	–	4	6,5	8,5
5	–	180	5	6,5	8
	180	–	5	7,5	9
6	–	180	6	7,5	10
	180	–	6	9	11

[1] The nominal chamfer dimension r is identical to the smallest permissible chamfer dimension r_{min}.

Chamfer dimensions

The limit values for chamfer dimensions r are only valid for tapered roller bearings in metric sizes to ISO 582:1995.

Limit values
for chamfer dimensions

Nominal chamfer dimension $r^{1)}$ mm	Nominal dimension of bearing bore, outside diameter d, D mm		Chamfer dimension		
			r_1 to r_4 mm	r_1, r_3 mm	r_2, r_4 mm
	over	incl.	min.	max.	max.
0,3	–	40	0,3	0,7	1,4
	40	–	0,3	0,9	1,6
0,6	–	40	0,6	1,1	1,7
	40	–	0,6	1,3	2
1	–	50	1	1,6	2,5
	50	–	1	1,9	3
1,5	–	120	1,5	2,3	3
	120	250	1,5	2,8	3,5
	250	–	1,5	3,5	4
2	–	120	2	2,8	4
	120	250	2	3,5	4,5
	250	–	2	4	5
2,5	–	120	2,5	3,5	5
	120	250	2,5	4	5,5
	250	–	2,5	4,5	6
3	–	120	3	4	5,5
	120	250	3	4,5	6,5
	250	400	3	5	7
	400	–	3	5,5	7,5
4	–	120	4	5	7
	120	250	4	5,5	7,5
	250	400	4	6	8
	400	–	4	6,5	8,5
5	–	180	5	6,5	8
	180	–	5	7,5	9
6	–	180	6	7,5	10
	180	–	6	9	11

[1] The nominal chamfer dimension r is identical to the smallest permissible chamfer dimension r_{min}.

Chamfer dimensions for FAG tapered roller bearings to ANSI/ABMA

The limit values for chamfer dimensions r are only valid for tapered roller bearings based on ANSI/ABMA.

Limit values for chamfer dimensions r_{max} for the inner ring

Nominal bearing bore diameter d mm		Chamfer dimension r_1 mm	r_2 mm
over	incl.		
–	50,8	+0,4	+0,9
50,8	101,6	+0,5	+1,25
101,6	254	+0,65	+1,8

Limit values for chamfer dimensions r_{max} for the outer ring

Nominal outside diameter D mm		Chamfer dimension r_3 mm	r_4 mm
over	incl.		
–	101,6	+0,6	+1,05
101,6	168,3	+0,65	+1,15
168,3	266,7	+0,85	+1,35
266,7	355,6	+1,7	+1,7

Chamfer dimensions

Chamfer dimensions for axial bearings

Minumum and maximum values for metric tapered roller bearings: *Figure 3* and table. The table corresponds to DIN 620-6.

In the case of axial deep groove ball bearings, the tolerances for the chamfer dimensions are identical in both axial and radial directions.

① Single direction axial deep groove ball bearing with flat housing locating washer

② Double direction axial deep groove ball bearing with spherical housing locating washers and seating washers

③ Single direction axial cylindrical roller bearing

④ Single direction axial spherical roller bearing

Figure 3
Chamfer dimensions for axial bearings
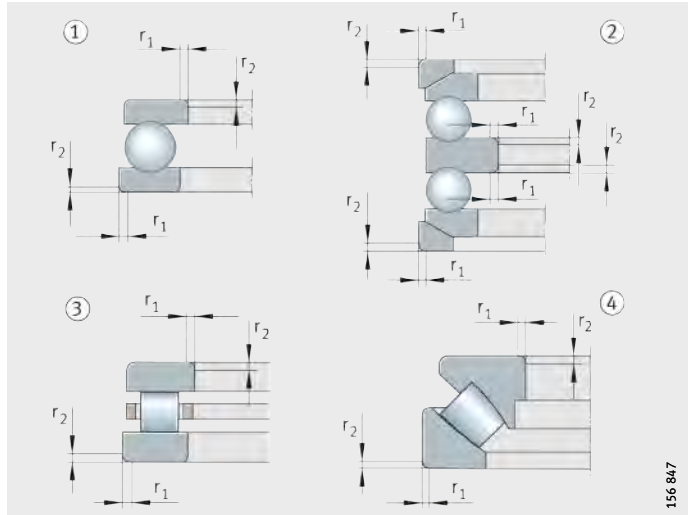
Limit values for chamfer dimensions of axial bearings

Chamfer dimension		
r [1]	r_1, r_2	
mm	mm	
	min.	max.
0,05	0,05	0,1
0,08	0,08	0,16
0,1	0,1	0,2
0,15	0,15	0,3
0,2	0,2	0,5
0,3	0,3	0,8
0,6	0,6	1,5
1	1	2,2
1,1	1,1	2,7
1,5	1,5	3,5
2	2	4
2,1	2,1	4,5
3	3	5,5
4	4	6,5
5	5	8
6	6	10
7,5	7,5	12,5
9,5	9,5	15
12	12	18
15	15	21
19	19	25

[1] The nominal chamfer dimension r is identical to the smallest permissible chamfer dimension r_{min}.
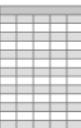
Radial internal clearance

Radial internal clearance of FAG deep groove ball bearings

The radial internal clearance corresponds to the internal clearance group Group N to ISO 5753-1, DIN 620-4.

Standardised bearings with increased internal clearance have the suffix C3. Special bearings with the radial internal clearance Group 3 or Group 4 are indicated in the dimension tables.

Radial internal clearance of FAG deep groove ball bearings with cylindrical bore

Bore d mm		Radial internal clearance							
		Group 2 µm		Group N µm		Group 3 µm		Group 4 µm	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.
1,5	6	0	7	2	13	8	23	–	–
6	10	0	7	2	13	8	23	14	29
10	18	0	9	3	18	11	25	18	33
18	24	0	10	5	20	13	28	20	36
24	30	1	11	5	20	13	28	23	41
30	40	1	11	6	20	15	33	28	46
40	50	1	11	6	23	18	36	30	51
50	65	1	15	8	28	23	43	38	61
65	80	1	15	10	30	25	51	46	71
80	100	1	18	12	36	30	58	53	84
100	120	2	20	15	41	36	66	61	97
120	140	2	23	18	48	41	81	71	114
140	160	2	23	18	53	46	91	81	130
160	180	2	25	20	61	53	102	91	147
180	200	2	30	25	71	63	117	107	163
200	225	2	35	25	85	75	140	125	195
225	250	2	40	30	95	85	160	145	225
250	280	2	45	35	105	90	170	155	245
280	315	2	55	40	115	100	190	175	270
315	355	3	60	45	125	110	210	195	300
355	400	3	70	55	145	130	240	225	340
400	450	3	80	60	170	150	270	250	380
450	500	3	90	70	190	170	300	280	420
500	560	10	100	80	210	190	330	310	470
560	630	10	110	90	230	210	360	340	520
630	710	20	130	110	260	240	400	380	570
710	800	20	140	120	290	270	450	430	630
800	900	20	160	140	320	300	500	480	700
900	1 000	20	170	150	350	330	550	530	770
1 000	1 120	20	180	160	380	360	600	580	850
1 120	1 250	20	190	170	410	390	650	630	920
1 250	1 400	30	200	190	440	420	700	680	990
1 400	1 600	30	210	210	470	450	750	730	1 060

Radial internal clearance of FAG self-aligning ball bearings

The radial internal clearance is Group N to ISO 5753-1, DIN 620-4.

Radial internal clearance of FAG self-aligning ball bearings with cylindrical bore

Bore d mm		Radial internal clearance			
		Group N μm		Group 3 μm	
over	incl.	min.	max.	min.	max.
–	6	5	15	10	20
6	10	6	17	12	25
10	14	6	19	13	26
14	18	8	21	15	28
18	24	10	23	17	30
24	30	11	24	19	35
30	40	13	29	23	40
40	50	14	31	25	44
50	65	16	36	30	50
65	80	18	40	35	60
80	100	22	48	42	70
100	120	25	56	50	83
120	140	30	68	60	100
140	160	35	80	70	120

Bearings with a tapered bore have the internal clearance group Group 3 to ISO 5753-1, DIN 620-4.

Radial internal clearance of FAG self-aligning ball bearings with tapered bore

Bore d mm		Radial internal clearance			
		Group N μm		Group 3 μm	
over	incl.	min.	max.	min.	max.
18	24	13	26	20	33
24	30	15	28	23	39
30	40	19	35	29	46
40	50	22	39	33	52
50	65	27	47	41	61
65	80	35	57	50	75
80	100	42	68	62	90
100	120	50	81	75	108
120	140	60	98	90	130
140	160	65	110	100	150
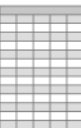
Radial internal clearance

Radial internal clearance of FAG barrel roller bearings

The radial internal clearance corresponds to the internal clearance group Group N to ISO 5753-1, DIN 620-4.

Bearings with a tapered bore have the internal clearance group Group 3 to ISO 5753-1, DIN 620-4.

Radial internal clearance of FAG barrel roller bearings with cylindrical bore

Bore d mm		Radial internal clearance							
		Group 2 μm		Group N μm		Group 3 μm		Group 4 μm	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.
–	30	2	9	9	17	17	28	28	40
30	40	3	10	10	20	20	30	30	45
40	50	3	13	13	23	23	35	35	50
50	65	4	15	15	27	27	40	40	55
65	80	5	20	20	35	35	55	55	75
80	100	7	25	25	45	45	65	65	90
100	120	10	30	30	50	50	70	70	95
120	140	15	35	35	55	55	80	80	110
140	160	20	40	40	65	65	95	95	125
160	180	25	45	45	70	70	100	100	130
180	225	30	50	50	75	75	105	105	135
225	250	35	55	55	80	80	110	110	140
250	280	40	60	60	85	85	115	115	145
280	315	40	70	70	100	100	135	135	170
315	355	45	75	75	105	105	140	140	175

Radial internal clearance of FAG barrel roller bearings with tapered bore

Bore d mm		Radial internal clearance							
		Group 2 μm		Group N μm		Group 3 μm		Group 4 μm	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.
–	30	9	17	17	28	28	40	40	55
30	40	10	20	20	30	30	45	45	60
40	50	13	23	23	35	35	50	50	65
50	65	15	27	27	40	40	55	55	75
65	80	20	35	35	55	55	75	75	95
80	100	25	45	45	65	65	90	90	120
100	120	30	50	50	70	70	95	95	125
120	140	35	55	55	80	80	110	110	140
140	160	40	65	65	95	95	125	125	155
160	180	45	70	70	100	100	130	130	160
180	225	50	75	75	105	105	135	135	165
225	250	55	80	80	110	110	140	140	170
250	280	60	85	85	115	115	145	145	175
280	315	70	100	100	135	135	170	170	205
315	355	75	105	105	140	140	175	175	210

Radial internal clearance

Radial internal clearance of FAG cylindrical roller bearings

The radial internal clearance of bearings with a cylindrical bore normally corresponds to the internal clearance group Group N to ISO 5753-1, DIN 620-4.

Radial internal clearance of FAG cylindrical roller bearings with cylindrical bore

Bore d mm		Radial internal clearance							
		Group 2 μm		Group N μm		Group 3 μm		Group 4 μm	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.
−	10	0	25	20	45	35	60	50	75
10	24	0	25	20	45	35	60	50	75
24	30	0	25	20	45	35	60	50	75
30	40	5	30	25	50	45	70	60	85
40	50	5	35	30	60	50	80	70	100
50	65	10	40	40	70	60	90	80	110
65	80	10	45	40	75	65	100	90	125
80	100	15	50	50	85	75	110	105	140
100	120	15	55	50	90	85	125	125	165
120	140	15	60	60	105	100	145	145	190
140	160	20	70	70	120	115	165	165	215
160	180	25	75	75	125	120	170	170	220
180	200	35	90	90	145	140	195	195	250
200	225	45	105	105	165	160	220	220	280
225	250	45	110	110	175	170	235	235	300
250	280	55	125	125	195	190	260	260	330
280	315	55	130	130	205	200	275	275	350
315	355	65	145	145	225	225	305	305	385
355	400	100	190	190	280	280	370	370	460
400	450	110	210	210	310	310	410	410	510
450	500	110	220	220	330	330	440	440	550
500	560	120	240	240	360	360	480	480	600
560	630	140	260	260	380	380	500	500	620
630	710	145	285	285	425	425	565	565	705
710	800	150	310	310	470	470	630	630	790
800	900	180	350	350	520	520	690	690	860
900	1 000	200	390	390	580	580	770	770	960
1 000	1 120	220	430	430	640	640	850	850	1 060
1 120	1 250	230	470	470	710	710	950	950	1 190
1 250	1 400	270	530	530	790	790	1 050	1 050	1 310
1 400	1 600	330	610	610	890	890	1 170	1 170	1 450
1 600	1 800	380	700	700	1 020	1 020	1 340	1 340	1 660
1 800	2 000	400	760	760	1 120	1 120	1 480	1 480	1 840

Radial internal clearance of FAG cylindrical roller bearings with tapered bore

Bore d mm		Radial internal clearance							
		Group 2 μm		Group N μm		Group 3 μm		Group 4 μm	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.
–	10	5	15	30	55	40	65	50	75
10	24	5	15	30	55	40	65	50	75
24	30	5	15	35	60	45	70	55	80
30	40	5	15	40	65	55	80	70	95
40	50	5	18	45	75	60	90	75	105
50	65	5	20	50	80	70	100	90	120
65	80	10	25	60	95	85	120	110	145
80	100	10	30	70	105	95	130	120	155
100	120	10	30	90	130	115	155	140	180
120	140	10	35	100	145	130	175	160	205
140	160	10	35	110	160	145	195	180	230
160	180	10	40	125	175	160	210	195	245
180	200	15	45	140	195	180	235	220	275
200	225	15	50	155	215	200	260	245	305
225	250	15	50	170	235	220	285	270	335
250	280	20	55	185	255	240	310	295	365
280	315	20	60	205	280	265	340	325	400
315	355	20	65	225	305	290	370	355	435
355	400	25	75	255	345	330	420	405	495
400	450	25	85	285	385	370	470	455	555
450	500	25	95	315	425	410	520	505	615
500	560	25	100	350	470	455	575	560	680
560	630	30	110	380	500	500	620	620	740
630	710	30	130	435	575	565	705	695	835
710	800	35	140	485	645	630	790	775	935
800	900	35	160	540	710	700	870	860	1 030
900	1 000	35	180	600	790	780	970	960	1 150
1 000	1 120	50	200	665	875	865	1 075	1 065	1 275
1 120	1 250	60	220	730	970	960	1 200	1 200	1 440
1 250	1 400	60	240	810	1 070	1 070	1 330	1 330	1 590
1 400	1 600	70	270	920	1 200	1 200	1 480	1 480	1 760
1 600	1 800	80	300	1 020	1 340	1 340	1 660	1 660	1 980
1 800	2 000	100	320	1 120	1 480	1 480	1 840	1 840	2 200

Bearings with a tapered bore frequently have a radial internal clearance Group 3 or Group 4 to DIN 620-4 (ISO 5753-1).

Radial internal clearance

Radial internal clearance of FAG toroidal roller bearings

The radial internal clearance of toroidal roller bearings corresponds to the internal clearance groups in accordance with ISO 5753-1.

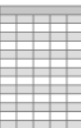**Radial internal clearance of FAG toroidal roller bearings with cylindrical bore**

Bore d mm		Radial internal clearance Group 2 μm	
over	incl.	min.	max.
18	24	15	30
24	30	15	35
30	40	20	40
40	50	25	45
50	65	30	55
65	80	40	70
80	100	50	85
100	120	60	100
120	140	75	120
140	160	85	140
160	180	95	155
180	200	105	175
200	225	115	190
225	250	125	205
250	280	135	225
280	315	150	240
315	355	160	260
355	400	175	280
400	450	190	310
450	500	205	335
500	560	220	360
560	630	240	400
630	710	260	440
710	800	300	500
800	900	320	540
900	1 000	370	600
1 000	1 120	410	660
1 120	1 250	450	720
1 250	1 400	490	800
1 400	1 600	570	890
1 600	1 800	650	1 010

	Group N µm		Group 3 µm		Group 4 µm		Group 5 µm	
	min.	max.	min.	max.	min.	max.	min.	max.
	25	40	35	55	50	65	65	85
	30	50	45	60	60	80	75	95
	35	55	55	75	70	95	90	120
	45	65	65	85	85	110	105	140
	50	80	75	105	100	140	135	175
	65	100	95	125	120	165	160	210
	80	120	120	160	155	210	205	260
	100	145	140	190	185	245	240	310
	115	170	165	215	215	280	280	350
	135	195	195	250	250	325	320	400
	150	220	215	280	280	365	360	450
	170	240	235	310	305	395	390	495
	185	265	260	340	335	435	430	545
	200	285	280	370	365	480	475	605
	220	310	305	410	405	520	515	655
	235	330	330	435	430	570	570	715
	255	360	360	485	480	620	620	790
	280	395	395	530	525	675	675	850
	305	435	435	580	575	745	745	930
	335	475	475	635	630	815	810	1 015
	360	520	510	690	680	890	890	1 110
	390	570	560	760	750	980	970	1 220
	430	620	610	840	830	1 080	1 070	1 340
	490	680	680	920	920	1 200	1 200	1 480
	530	760	750	1 020	1 010	1 330	1 320	1 660
	590	830	830	1 120	1 120	1 460	1 460	1 830
	660	930	930	1 260	1 260	1 640	1 640	2 040
	720	1 020	1 020	1 380	1 380	1 800	1 800	2 240
	800	1 130	1 130	1 510	1 540	1 970	1 970	2 460
	890	1 250	1 250	1 680	1 680	2 200	2 200	2 740
	1 010	1 390	1 390	1 870	1 870	2 430	2 430	3 000

Radial internal clearance

Radial internal clearance of FAG toroidal roller bearings with tapered bore

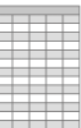| Bore d mm		Radial internal clearance Group 2 µm	
over	incl.	min.	max.
18	24	15	35
24	30	20	40
30	40	25	50
40	50	30	55
50	65	40	65
65	80	50	80
80	100	60	100
100	120	75	115
120	140	90	135
140	160	100	155
160	180	115	175
180	200	130	195
200	225	140	215
225	250	160	235
250	280	170	260
280	315	195	285
315	355	220	320
355	400	250	350
400	450	280	385
450	500	305	435
500	560	330	480
560	630	380	530
630	710	420	590
710	800	480	680
800	900	520	740
900	1 000	580	820
1 000	1 120	640	900
1 120	1 250	700	980
1 250	1 400	770	1 080
1 400	1 600	870	1 200
1 600	1 800	950	1 320

| Group N | | Group 3 | | Group 4 | | Group 5 | |
| μm | | μm | | μm | | μm | |
min.	max.	min.	max.	min.	max.	min.	max.
30	45	40	55	55	70	65	85
35	55	50	65	65	85	80	100
45	65	60	80	80	100	100	125
50	75	70	95	90	120	115	145
60	90	85	115	110	150	145	185
75	110	105	140	135	180	175	220
95	135	130	175	170	220	215	275
115	155	155	205	200	255	255	325
135	180	180	235	230	295	290	365
155	215	210	270	265	340	335	415
170	240	235	305	300	385	380	470
190	260	260	330	325	420	415	520
210	290	285	365	360	460	460	575
235	315	315	405	400	515	510	635
255	345	340	445	440	560	555	695
280	380	375	485	480	620	615	765
315	420	415	545	540	680	675	850
350	475	470	600	595	755	755	920
380	525	525	655	650	835	835	1 005
435	575	575	735	730	915	910	1 115
470	640	630	810	800	1 010	1 000	1 230
530	710	700	890	880	1 110	1 110	1 350
590	780	770	990	980	1 230	1 230	1 490
670	860	860	1 100	1 100	1 380	1 380	1 660
730	960	950	1 220	1 210	1 530	1 520	1 860
810	1 040	1 040	1 340	1 340	1 670	1 670	2 050
890	1 170	1 160	1 500	1 490	1 880	1 870	2 280
970	1 280	1 270	1 640	1 630	2 060	2 050	2 500
1 080	1 410	1 410	1 790	1 780	2 250	2 250	2 740
1 200	1 550	1 550	1 990	1 990	2 500	2 500	3 050
1 320	1 690	1 690	2 180	2 180	2 730	2 730	3 310

Axial internal clearance

Axial internal clearance of double row FAG angular contact ball bearings

The main dimensions of the bearings conform to DIN 628-3.

The dimensional and running tolerances of the bearings correspond to tolerance class 6 to DIN 620-2, ISO 492:2014.

Double row angular contact ball bearings of the basic design have the normal axial internal clearance (CN). Bearings are available by agreement with an axial internal clearance larger (C3) or smaller (C2) than normal.

Bearings with a split inner ring are intended for higher axial loads. In general, they have a tighter fit than unsplit bearings. Their normal internal clearance corresponds approximately to the internal clearance group C3 for unsplit bearings.

Axial internal clearance to DIN 628-3 of FAG angular contact ball bearings with unsplit inner ring

Bore d mm		Axial internal clearance							
		C2 µm		CN µm		C3 µm		C4 µm	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.
–	10	1	11	5	21	12	28	25	45
10	18	1	12	6	23	13	31	27	47
18	24	2	14	7	25	16	34	28	48
24	30	2	15	8	27	18	37	30	50
30	40	2	16	9	29	21	40	33	54
40	50	2	18	11	33	23	44	36	58
50	65	3	22	13	36	26	48	40	63
65	80	3	24	15	40	30	54	46	71
80	100	3	26	18	46	35	63	55	83
100	120	4	30	22	53	42	73	65	96
120	140	4	34	25	59	48	82	74	108

Axial internal clearance of FAG angular contact ball bearings with split inner ring

Bore d mm		Axial internal clearance					
		C2 µm		CN µm		C3 µm	
over	incl.	min.	max.	min.	max.	min.	max.
24	30	8	27	16	35	27	46
30	40	9	29	18	38	30	50
40	50	11	33	22	44	36	58
50	65	13	36	25	48	40	63
65	80	15	40	29	54	46	71

Axial internal clearance of FAG four point contact bearings

The axial internal clearance corresponds to the internal clearance group CN to DIN 628-4.

Axial internal clearance of FAG four point contact bearings

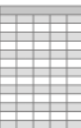| Bore d mm		Axial internal clearance							
		C2 μm		CN μm		C3 μm		C4 μm	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.
18	40	30	70	60	110	100	150	140	190
40	60	40	90	80	130	120	170	160	210
60	80	50	100	90	140	130	180	170	220
80	100	60	120	100	160	140	200	180	240
100	140	70	140	120	180	160	220	200	260
140	180	80	160	140	200	180	240	220	280
180	220	100	180	160	220	200	260	240	300
220	260	120	200	180	240	220	300	280	360
260	300	140	220	200	280	260	340	320	400
300	355	160	240	220	300	280	360	–	–
355	400	180	270	250	330	310	390	–	–
400	450	200	290	270	360	340	430	–	–
450	500	220	310	290	390	370	470	–	–
500	560	240	330	310	420	400	510	–	–
560	630	260	360	340	450	430	550	–	–
630	710	280	390	370	490	470	590	–	–
710	800	300	420	400	540	520	660	–	–
800	900	330	460	440	590	570	730	–	–
900	1 000	360	500	480	630	620	780	–	–

Reduction in radial internal clearance

Reduction
in radial internal clearance
of FAG cylindrical roller bearings
with tapered bore

Nominal bearing bore diameter		Radial internal clearance before mounting Internal clearance group					
d		Group N		Group 3		Group 4	
mm		mm		mm		mm	
over	incl.	min.	max.	min.	max.	min.	max.
24	30	0,035	0,06	0,045	0,07	0,055	0,08
30	40	0,04	0,065	0,055	0,08	0,07	0,095
40	50	0,045	0,075	0,06	0,09	0,075	0,105
50	65	0,05	0,08	0,07	0,1	0,09	0,12
65	80	0,06	0,095	0,085	0,12	0,11	0,145
80	100	0,07	0,105	0,095	0,13	0,12	0,155
100	120	0,09	0,13	0,115	0,155	0,14	0,18
120	140	0,1	0,145	0,13	0,175	0,16	0,205
140	160	0,11	0,16	0,145	0,195	0,18	0,23
160	180	0,125	0,175	0,16	0,21	0,195	0,245
180	200	0,14	0,195	0,18	0,235	0,22	0,275
200	225	0,155	0,215	0,2	0,26	0,245	0,305
225	250	0,17	0,235	0,22	0,285	0,27	0,335
250	280	0,185	0,255	0,24	0,31	0,295	0,365
280	315	0,205	0,28	0,265	0,34	0,325	0,4
315	355	0,225	0,305	0,29	0,37	0,355	0,435
355	400	0,255	0,345	0,33	0,42	0,405	0,495
400	450	0,285	0,385	0,37	0,47	0,455	0,555
450	500	0,315	0,425	0,41	0,52	0,505	0,615
500	560	0,35	0,47	0,455	0,575	0,56	0,68
560	630	0,38	0,5	0,5	0,62	0,62	0,74
630	710	0,435	0,575	0,565	0,705	0,695	0,835
710	800	0,485	0,645	0,63	0,79	0,775	0,935
800	900	0,54	0,71	0,7	0,87	0,86	1,03
900	1 000	0,6	0,79	0,78	0,97	0,96	1,15
1 000	1 120	0,665	0,875	0,865	1,075	1,065	1,275
1 120	1 250	0,73	0,97	0,96	1,2	1,2	1,44
1 250	1 400	0,81	1,07	1,07	1,33	1,33	1,59

[1] Valid only for solid steel shafts and hollow shafts with a bore no larger than half the shaft diameter.
The following applies: Bearings with a radial internal clearance before mounting in the upper half of the tolerance range are mounted using the larger value for the reduction in radial internal clearance or the axial drive-up distance, while bearings in the lower half of the tolerance range are mounted using the smaller value for the reduction in radial internal clearance or the axial drive-up distance.

[2] The actual value of the radial internal clearance must not be smaller than the control value. In the case of bearings with a small diameter, this may be difficult to determine.

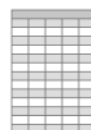| Reduction in radial internal clearance[1]		Drive-up distance on taper 1:12[1]				Control value for radial internal clearance after mounting[2]		
		Shaft		Sleeve		Group N	Group 3	Group 4
mm		mm		mm		mm	mm	mm
min.	max.	min.	max.	min.	max.	min.	min.	min.
0,015	0,02	0,3	0,35	0,3	0,4	0,02	0,025	0,035
0,02	0,025	0,35	0,4	0,35	0,45	0,02	0,025	0,04
0,025	0,03	0,4	0,45	0,45	0,5	0,02	0,03	0,045
0,03	0,035	0,45	0,55	0,5	0,65	0,02	0,035	0,05
0,035	0,04	0,55	0,6	0,65	0,7	0,025	0,04	0,07
0,04	0,045	0,6	0,7	0,65	0,8	0,03	0,05	0,075
0,045	0,055	0,7	0,85	0,8	0,95	0,045	0,065	0,085
0,055	0,065	0,85	1	0,95	1,1	0,045	0,07	0,095
0,06	0,075	0,9	1,2	1,1	1,3	0,05	0,075	0,105
0,065	0,085	1	1,3	1,3	1,5	0,06	0,08	0,11
0,075	0,095	1,2	1,5	1,4	1,7	0,065	0,09	0,125
0,085	0,105	1,3	1,6	1,6	1,8	0,07	0,1	0,14
0,095	0,115	1,5	1,8	1,7	2	0,075	0,105	0,155
0,105	0,125	1,6	2	1,9	2,3	0,08	0,125	0,17
0,115	0,14	1,8	2,2	2,2	2,4	0,09	0,13	0,185
0,13	0,16	2	2,5	2,5	2,7	0,095	0,14	0,195
0,14	0,17	2,2	2,6	2,6	2,9	0,115	0,165	0,235
0,15	0,185	2,3	2,8	2,8	3,1	0,135	0,19	0,27
0,16	0,195	2,5	3	3,1	3,4	0,155	0,215	0,31
0,17	0,215	2,7	3,4	3,5	3,8	0,18	0,24	0,345
0,185	0,24	2,9	3,7	3,6	4,2	0,195	0,26	0,38
0,2	0,26	3,1	4,1	3,9	4,7	0,235	0,305	0,435
0,22	0,28	3,4	4,4	4,3	5,3	0,26	0,35	0,495
0,24	0,31	3,7	4,8	4,8	5,5	0,3	0,39	0,55
0,26	0,34	4,1	5,3	5,2	6,2	0,34	0,44	0,62
0,28	0,37	4,4	5,8	5,7	7	0,385	0,5	0,7
0,31	0,41	4,8	6,4	6,3	7,6	0,42	0,55	0,79
0,34	0,45	5,3	7	0,3	8,3	0,47	0,62	0,85

Reduction in radial internal clearance

Reduction
in radial internal clearance
of FAG spherical roller bearings
with tapered bore

Nominal bearing bore diameter		Radial internal clearance before mounting Internal clearance group					
d		Group N		Group 3		Group 4	
mm		mm		mm		mm	
over	incl.	min.	max.	min.	max.	min.	max.
24	30	0,03	0,04	0,04	0,055	0,055	0,075
30	40	0,035	0,05	0,05	0,065	0,065	0,085
40	50	0,045	0,06	0,06	0,08	0,08	0,1
50	65	0,055	0,075	0,075	0,095	0,095	0,12
65	80	0,07	0,095	0,095	0,12	0,12	0,15
80	100	0,08	0,11	0,11	0,14	0,14	0,18
100	120	0,1	0,135	0,135	0,17	0,17	0,22
120	140	0,12	0,16	0,16	0,2	0,2	0,26
140	160	0,13	0,18	0,18	0,23	0,23	0,3
160	180	0,14	0,2	0,2	0,26	0,26	0,34
180	200	0,16	0,22	0,22	0,29	0,29	0,37
200	225	0,18	0,25	0,25	0,32	0,32	0,41
225	250	0,2	0,27	0,27	0,35	0,35	0,45
250	280	0,22	0,3	0,3	0,39	0,39	0,49
280	315	0,24	0,33	0,33	0,43	0,43	0,54
315	355	0,27	0,36	0,36	0,47	0,47	0,59
355	400	0,3	0,4	0,4	0,52	0,52	0,65
400	450	0,33	0,44	0,44	0,57	0,57	0,72
450	500	0,37	0,49	0,49	0,63	0,63	0,79
500	560	0,41	0,54	0,54	0,68	0,68	0,87
560	630	0,46	0,6	0,6	0,76	0,76	0,98
630	710	0,51	0,67	0,67	0,85	0,85	1,09
710	800	0,57	0,75	0,75	0,96	0,96	1,22
800	900	0,64	0,84	0,84	1,07	1,07	1,37
900	1 000	0,71	0,93	0,93	1,19	1,19	1,52
1 000	1 120	0,78	1,02	1,02	1,3	1,3	1,65
1 120	1 250	0,86	1,12	1,12	1,42	1,42	1,8
1 250	1 400	0,94	1,22	1,22	1,55	1,55	1,96

[1] Valid only for solid steel shafts and hollow shafts with a bore no larger than half the shaft diameter.
The following applies: Bearings with a radial internal clearance before mounting in the upper half of the tolerance range are mounted using the larger value for the reduction in radial internal clearance or the axial drive-up distance, while bearings in the lower half of the tolerance range are mounted using the smaller value for the reduction in radial internal clearance or the axial drive-up distance.

[2] The actual value of the radial internal clearance must not be smaller than the control value. In the case of bearings with a small diameter, this may be difficult to determine.

Reduction in radial internal clearance[1]		Drive-up distance on taper 1:12[1]				Drive-up distance on taper 1:30[1]				Control value for radial internal clearance after mounting[2]		
		Shaft		Sleeve		Shaft		Sleeve		Group N	Group 3	Group 4
mm		mm		mm		mm		mm		mm	mm	mm
min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	min.	min.
0,015	0,02	0,3	0,35	0,3	0,4	–	–	–	–	0,015	0,02	0,035
0,02	0,025	0,35	0,4	0,35	0,45	–	–	–	–	0,015	0,025	0,04
0,025	0,03	0,4	0,45	0,45	0,5	–	–	–	–	0,02	0,03	0,05
0,03	0,04	0,45	0,6	0,5	0,7	–	–	–	–	0,025	0,035	0,055
0,04	0,05	0,6	0,75	0,7	0,85	–	–	–	–	0,025	0,04	0,07
0,045	0,06	0,7	0,9	0,75	1	1,7	2,2	1,8	2,4	0,035	0,05	0,08
0,05	0,07	0,7	1,1	0,8	1,2	1,9	2,7	2	2,8	0,05	0,065	0,1
0,065	0,09	1,1	1,4	1,2	1,5	2,7	3,5	2,8	3,6	0,055	0,08	0,11
0,075	0,1	1,2	1,6	1,3	1,7	3	4	3,1	4,2	0,055	0,09	0,13
0,08	0,11	1,3	1,7	1,4	1,9	3,2	4,2	3,3	4,6	0,06	0,1	0,15
0,09	0,13	1,4	2	1,5	2,2	3,5	4,5	3,6	5	0,07	0,1	0,16
0,1	0,14	1,6	2,2	1,7	2,4	4	5,5	4,2	5,7	0,08	0,12	0,18
0,11	0,15	1,7	2,4	1,8	2,6	4,2	6	4,6	6,2	0,09	0,13	0,2
0,12	0,17	1,9	2,6	2	2,9	4,7	6,7	4,8	6,9	0,1	0,14	0,22
0,13	0,19	2	3	2,2	3,2	5	7,5	5,2	7,7	0,11	0,15	0,24
0,15	0,21	2,4	3,4	2,6	3,6	6	8,2	6,2	8,4	0,12	0,17	0,26
0,17	0,23	2,6	3,6	2,9	3,9	6,5	9	5,8	9,2	0,13	0,19	0,29
0,2	0,26	3,1	4,1	3,4	4,4	7,7	10	8	10,4	0,13	0,2	0,31
0,21	0,28	3,3	4,4	3,6	4,8	8,2	11	8,4	11,2	0,16	0,23	0,35
0,24	0,32	3,7	5	4,1	5,4	9,2	12,5	9,6	12,8	0,17	0,25	0,36
0,26	0,35	4	5,4	4,4	5,9	10	13,5	10,4	14	0,2	0,29	0,41
0,3	0,4	4,6	6,2	5,1	6,8	11,5	15,5	12	16	0,21	0,31	0,45
0,34	0,45	5,3	7	5,8	7,6	13,3	17,5	13,6	18	0,23	0,35	0,51
0,37	0,5	5,7	7,8	6,3	8,5	14,3	19,5	14,8	20	0,27	0,39	0,57
0,41	0,55	6,3	8,5	7	9,4	15,8	21	16,4	22	0,3	0,43	0,64
0,45	0,6	6,8	9	7,6	10,2	17	23	18	24	0,32	0,48	0,7
0,49	0,65	7,4	9,8	8,3	11	18,5	25	19,6	26	0,34	0,54	0,77
0,55	0,72	8,3	10,8	9,3	12,1	21	27	22,2	28,3	0,36	0,59	0,84

Reduction in radial internal clearance

Reduction
in radial internal clearance
of FAG toroidal roller bearings
with tapered bore

Nominal bearing bore diameter		Radial internal clearance before mounting Internal clearance group					
d		Group N		Group 3		Group 4	
mm		mm		mm		mm	
over	incl.	min.	max.	min.	max.	min.	max.
24	30	0,035	0,055	0,050	0,065	0,065	0,085
30	40	0,045	0,065	0,060	0,080	0,080	0,100
40	50	0,050	0,075	0,070	0,095	0,090	0,120
50	65	0,060	0,090	0,085	0,115	0,110	0,150
65	80	0,075	0,110	0,105	0,140	0,135	0,180
80	100	0,095	0,135	0,130	0,175	0,170	0,220
100	120	0,115	0,155	0,155	0,205	0,200	0,255
120	140	0,135	0,180	0,180	0,235	0,230	0,295
140	160	0,155	0,215	0,210	0,270	0,265	0,340
160	180	0,170	0,240	0,235	0,305	0,300	0,385
180	200	0,190	0,260	0,260	0,330	0,325	0,420
200	225	0,210	0,290	0,285	0,365	0,360	0,460
225	250	0,235	0,315	0,315	0,405	0,400	0,515
250	280	0,255	0,345	0,340	0,445	0,440	0,560
280	315	0,280	0,380	0,375	0,485	0,480	0,620
315	355	0,315	0,420	0,415	0,545	0,540	0,680
355	400	0,350	0,475	0,470	0,600	0,595	0,755
400	450	0,380	0,525	0,525	0,655	0,650	0,835
450	500	0,435	0,575	0,575	0,735	0,730	0,915
500	560	0,470	0,640	0,630	0,810	0,800	1,010
560	630	0,530	0,710	0,700	0,890	0,880	1,110
630	710	0,590	0,780	0,770	0,990	0,980	1,230
710	800	0,670	0,860	0,860	1,100	1,100	1,380
800	900	0,730	0,960	0,950	1,220	1,210	1,530
900	1 000	0,810	1,040	1,040	1,340	1,340	1,670
1 000	1 120	0,890	1,170	1,160	1,500	1,490	1,880
1 120	1 250	0,970	1,280	1,270	1,640	1,630	2,060
1 250	1 400	1,080	1,410	1,410	1,790	1,780	2,250
1 400	1 600	1,200	1,550	1,550	1,990	1,990	2,500
1 600	1 800	1,320	1,690	1,690	2,180	2,180	2,730

[1] Valid only for solid steel shafts and hollow shafts with a bore no larger than half the shaft diameter.
The following applies: Bearings with a radial internal clearance before mounting in the upper half of the tolerance range are mounted using the larger value for the reduction in radial internal clearance or the axial drive-up distance, while bearings in the lower half of the tolerance range are mounted using the smaller value for the reduction in radial internal clearance or the axial drive-up distance.

[2] The actual value of the radial internal clearance must not be smaller than the control value. In the case of bearings with a small diameter, this may be difficult to determine.

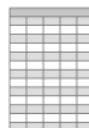| Reduction in radial internal clearance[1]		Drive-up distance on taper 1:12[1]		Drive-up distance on taper 1:30[1]		Control value for radial internal clearance after mounting[2]		
		Shaft		Shaft		Group N	Group 3	Group 4
mm		mm		mm		mm	mm	mm
min.	max.	min.	max.	min.	max.	min.	min.	min.
0,010	0,017	0,24	0,29	0,61	0,72	0,025	0,035	0,048
0,014	0,021	0,30	0,34	0,76	0,84	0,031	0,041	0,059
0,018	0,028	0,37	0,42	0,91	1,04	0,033	0,046	0,062
0,024	0,035	0,46	0,50	1,14	1,24	0,036	0,054	0,075
0,030	0,046	0,55	0,61	1,37	1,53	0,045	0,065	0,090
0,040	0,056	0,67	0,73	1,68	1,83	0,056	0,080	0,114
0,049	0,069	0,79	0,89	1,98	2,23	0,066	0,093	0,131
0,060	0,083	0,91	1,05	2,29	2,62	0,075	0,105	0,147
0,072	0,095	1,04	1,21	2,59	3,02	0,083	0,123	0,170
0,081	0,107	1,16	1,36	2,90	3,41	0,089	0,137	0,193
0,090	0,121	1,28	1,52	3,20	3,81	0,100	0,150	0,204
0,101	0,134	1,43	1,68	3,58	4,20	0,109	0,162	0,226
0,113	0,151	1,59	1,88	3,96	4,69	0,123	0,177	0,249
0,126	0,168	1,77	2,08	4,42	5,19	0,129	0,186	0,273
0,142	0,188	1,98	2,31	4,95	5,78	0,138	0,203	0,292
0,160	0,211	2,23	2,59	5,56	6,47	0,155	0,221	0,329
0,180	0,238	2,50	2,90	6,25	7,26	0,170	0,251	0,357
0,203	0,268	2,81	3,26	7,01	8,15	0,178	0,279	0,382
0,225	0,300	3,11	3,66	7,78	9,14	0,210	0,300	0,430
0,250	0,335	3,48	4,05	8,69	10,13	0,220	0,325	0,465
0,285	0,375	3,90	4,52	9,76	11,31	0,245	0,355	0,505
0,320	0,420	4,39	5,08	10,98	12,69	0,270	0,380	0,560
0,360	0,475	4,94	5,71	12,35	14,27	0,310	0,425	0,625
0,405	0,535	5,55	6,42	13,88	16,05	0,325	0,460	0,675
0,450	0,605	6,16	7,21	15,40	18,03	0,360	0,490	0,735
0,505	0,670	6,89	8,00	17,23	20,00	0,385	0,545	0,820
0,565	0,750	7,69	8,95	19,21	22,37	0,410	0,580	0,880
0,630	0,840	8,60	9,98	21,50	24,94	0,450	0,640	0,940
0,720	0,940	9,82	11,16	24,55	27,90	0,480	0,685	1,050
0,810	1,070	11,04	12,74	27,60	31,85	0,510	0,705	1,110

FAG rolling bearing greases Arcanol – chemical/physical data

Grease		Characteristic applications	Operating temperature °C		Continuous limit temperature °C	Thickener
			from	to		
Multi-purpose greases	MULTITOP	Ball and roller bearings in rolling mills Construction machinery Spinning and grinding spindles Automotive engineering	−50[1]	+140	+80	Lithium soap
	MULTI2	Ball bearings up to an outside diameter of 62 mm in small electric motors Agricultural and construction machinery Household appliances	−30	+120	+75	Lithium soap
	MULTI3	Ball bearings with an outside diameter of or more than 62 mm in large electric motors Agricultural and construction machinery Fans	−30	+120	+75	Lithium soap
High loads	LOAD150	Ball, roller and needle roller bearings Linear guidance systems in machine tools	−20	+140	+95	Lithium complex soap
	LOAD220	Ball and roller bearings in rolling mill plant Paper machinery Rail vehicles	−20	+140	+80	Lithium/calcium soap
	LOAD400	Ball and roller bearings in mining machinery Construction machinery Wind turbine main bearings	−40	+130	+80	Lithium/calcium soap
	LOAD460	Ball and roller bearings Wind turbines Bearings with pin cage	−40[1]	+130	+80	Lithium/calcium soap
	LOAD1000	Ball and roller bearings in mining machinery Construction machinery Cement plant	−30[1]	+130	+80	Lithium/calcium soap
High temperatures	TEMP90	Ball and roller bearings in couplings Electric motors Automotive engineering	−40	+160	+90	Polycarbamide
	TEMP110	Ball and roller bearings in electric motors Automotive engineering	−35	+160	+110	Lithium complex soap
	TEMP120	Ball and roller bearings in continuous casting plant Paper machinery	−30	+180	+120	Polycarbamide
	TEMP200	Ball and roller bearings in guide rollers for baking machinery Kiln trucks and chemical plant Piston pins in compressors	−30	+260	+200	PTFE

Continued on next page.

+++ Extremely suitable. ++ Highly suitable. + Suitable. − Less suitable. −− Not suitable.

[1] Measurement values according to Schaeffler FE8 low temperature test.

Base oil	Consist-ency NLGI	Base oil viscosity at +40 °C mm²/s	Temperatures		Low friction, high speed	High load, low speed	Vibrations	Support for seals	Relubrication facility
			Low	High					
Partially synthetic oil	2	82	+++	++	++	+++	++	+	+++
Mineral oil	2	110	++	+	+	+	+	+	+++
Mineral oil	3	80	++	+	+	+	++	++	++
Mineral oil	2	160	+	++	−	+++	++	++	++
Mineral oil	2	245	+	+	−	+++	++	++	++
Mineral oil	2	400	+	+	−	+++	++	++	++
Mineral oil	1	400	++	+	−	+++	++	−	++
Mineral oil	2	1 000	+	+	−−	+++	++	++	++
Partially synthetic oil	3	148	+++	++	+	+	+	++	++
Partially synthetic oil	2	130	+++	+++	++	+	+	+	+
Synthetic oil	2	400	++	+++	−	+++	+	++	+
Alkoxyfluoro oil	2	550	++	+++	−−	++	+	+	+

FAG rolling bearing greases Arcanol – chemical/physical data

| Grease		Characteristic applications	Operating temperature °C		Continuous limit temperature °C	Thickener
			from	to		
Special requirements	SPEED2,6	☐ Ball bearings in machine tools ☐ Spindle bearings ☐ Rotary table bearings ☐ Instrument bearings	−40	+120	+80	Lithium complex soap
	VIB3	☐ Ball and roller bearings in rotors for wind turbines (blade adjustment) ☐ Packaging machinery ☐ Rail vehicles	−30	+150	+90	Lithium complex soap
	FOOD2	☐ Ball and roller bearings in applications with food contact (NSF-H1 registration, kosher and halal certification)	−30	+120	+70	Aluminium complex soap
	CLEAN-M	☐ Ball, roller and needle roller bearings as well as linear guidance systems in clean room applications	−30	+180	+90	Polycarbamide
	MOTION2	☐ Ball and roller bearings in oscillating operation ☐ Slewing rings in wind turbines	−40	+130	+75	Lithium soap

+++ Extremely suitable. ++ Highly suitable. + Suitable. − Less suitable. −− Not suitable.

Base oil	Consist-ency NLGI	Base oil viscosity at +40 °C mm^2/s	Temperatures		Low friction, high speed	High load, low speed	Vibrations	Support for seals	Relubrication facility
			Low	High					
Synthetic oil	2 – 3	25	+++	+	+++	−−	−	+	+
Mineral oil	3	170	++	++	−	++	+++	++	−
Synthetic oil	2	150	++	−	+	+	+	+	+++
Ether oil	2	103	+++	+++	+	+	+	+	++
Synthetic oil	2	50	+++	+	−	++	+++	++	+

Guidelines for use

Mounting and dismounting methods for rolling bearings

Bearing type		Bearing bore	d mm
Deep groove ball bearings	Tapered roller bearings	Cylindrical	< 80
Angular contact ball bearings Spindle bearings	Barrel roller bearings		80 – 200
Four point contact bearings	Spherical roller bearings		
Self-aligning ball bearings	Toroidal bearings		> 200
Cylindrical roller bearings		Cylindrical	< 80
Needle roller bearings			80 – 200
			> 200
Axial deep groove ball bearings		Cylindrical	< 80
Axial angular contact ball bearings			80 – 200
Axial cylindrical roller bearings			
Axial spherical roller bearings			> 200
Self-aligning ball bearings Self-aligning ball bearings with adapter sleeve		Tapered	< 80
Toroidal bearings			
Barrel roller bearings Barrel roller bearings with adapter sleeve			80 – 200
Spherical roller bearings Spherical roller bearings with adapter sleeve Spherical roller bearings with withdrawal sleeve			
Adapter sleeve	Withdrawal sleeve		> 200
Cylindrical roller bearings, double row		Tapered	< 80
			80 – 200
			> 200

Symbols

	Induction heating device		Heating cabinet		Heating ring
	Heating plate		Medium frequency technology		

Mounting			Dismounting		
Thermal	Mechanical	Hydraulic	Thermal	Mechanical	Hydraulic

Legend:
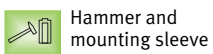
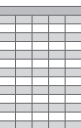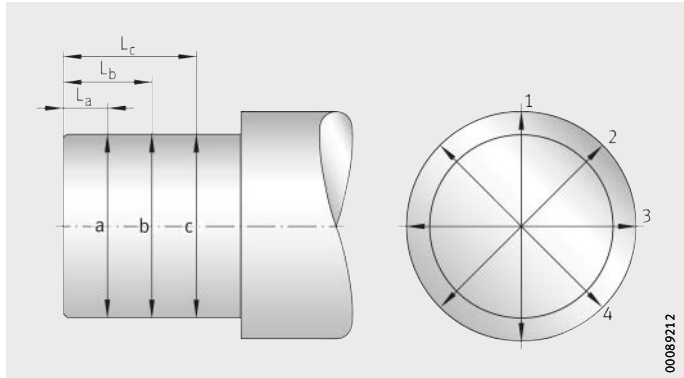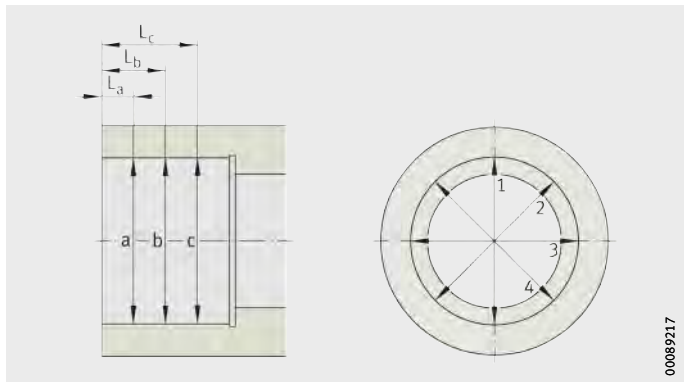|				
Hammer and mounting sleeve	Double hook wrench	Socket	End cap	Hydraulic nut
Mechanical and hydraulic presses	Nut and hook wrench	Nut and mounting wrench	Extraction device	Hydraulic method

Measurement record

Figure 1
Shaft

Figure 2
Housing

Measurement record for shaft

Spacing [mm]	L_a	L_b	L_c
Diameter [mm]	a	b	c
1			
2			
3			
4			
Mean value $(1 + 2 + 3 + 4)/4$			

Measurement record for housing

Spacing [mm]	L_a	L_b	L_c
Diameter [mm]	a	b	c
1			
2			
3			
4			
Mean value $(1 + 2 + 3 + 4)/4$			

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