INA FAG

Bearing Solutions for Large Size Machinery

One-bearing solutions
Two-bearing solutions
Three-bearing solutions

SCHAEFFLER GROUP
INDUSTRIAL

"added competence" for your success

With their forward-looking bearing arrangement solutions for feed spindles, main spindles, rotary tables and linear guidance units, INA and FAG have been at the forefront of the world market for decades. Nevertheless, bearing components alone are often no longer the decisive factor for these machine subsystems.

Indeed, our customers are continuing to benefit directly from significant performance improvements and unique selling points thanks to our "ready-to-fit" products, since these follow the efficient basic concept: unpack, screw mount, use. In order to optimise the entire machine tool system, however, it is also becoming ever more important to integrate important functions such as measurement, sealing, lubrication, braking etc. in the components themselves. This intellectual approach is fulfilled comprehensively by the new concept "added competence" in the Business Unit Production Machinery since it attaches central importance to systems solution thinking for the bearing, bearing position and entire system. This means that you can now access a product range that gives optimum coverage for all your applications in the machine tool.

In addition, there is increasingly frequent usage of direct drives and mechatronic solutions in machine tools. We have therefore incorporated IDAM – INA Drives & Mechatronics – as a further strong partner in our provider network. In this way, we can now supply you from a single source with not only bearing elements but also components precisely matched to the drive system.

This opens up completely new technical and economic design possibilities for your requirements as well as significant advantages in the time and process chain.

In terms of products, we can offer you a comprehensive, precisely balanced range, precision technology and top product quality. In order to match the pulse of your developments as closely as possible, we also have a worldwide network of engineers and service and sales technicians working for you and ensuring that we maintain close contact with you in your own location.

We are therefore confident that we have the right product for you, from a robust individual component right through to the defining high end system solution.

Perhaps you would like to talk to us about this?

added
competence

Foreword

Bearing solutions for large size machinery

The general trend towards plant with higher productivity is also apparent in larger production systems. As a result, there is increasing demand for correspondingly high performance components and subassemblies of larger dimensions.
The challenges here are not only technical but also commercial in nature and may vary widely. Components for bearing arrangements are among the machine elements that make a decisive contribution to the overall performance of a system. For bearings in machine tools, the important parameters are not only the load carrying capacity but also the accuracy, rigidity and speed capacity.
On the part of machine manufacturers, this is expanded by the use of complete machining and also process integration.

Individual bearing solutions

In the special case of rotary axes with a vertical axis of rotation, the development partner working on the bearing arrangement has the task of developing concept solutions that make it possible to fulfil the current requirements of the customer. In this product information publication, Schaeffler Group Industrial places the emphasis on realising rotating applications with various table diameters. In addition to the bearing units described in Technical Product Information TPI 120, High Precision Bearings for Combined Loads, bearing solutions are also available for larger bearing diameters that have been configured in accordance with the requirements. These bearing solutions are also known as kingpin bearing arrangements.

Increased requirements

While the predominantly static use of rotary tables represents a non-critical situation for bearing design and operation, rotating applications with longer operating durations and higher speeds require consideration of other influences arising from this operation.

Further information

Technical Product Information TPI 205 is intended both as a reference work and as a template for future designs. It can already present possible solutions for bearing arrangements in such machines in accordance with the applicable requirements.

For detailed design work, we recommend making contact with the application engineers of Schaeffler Group Industrial.

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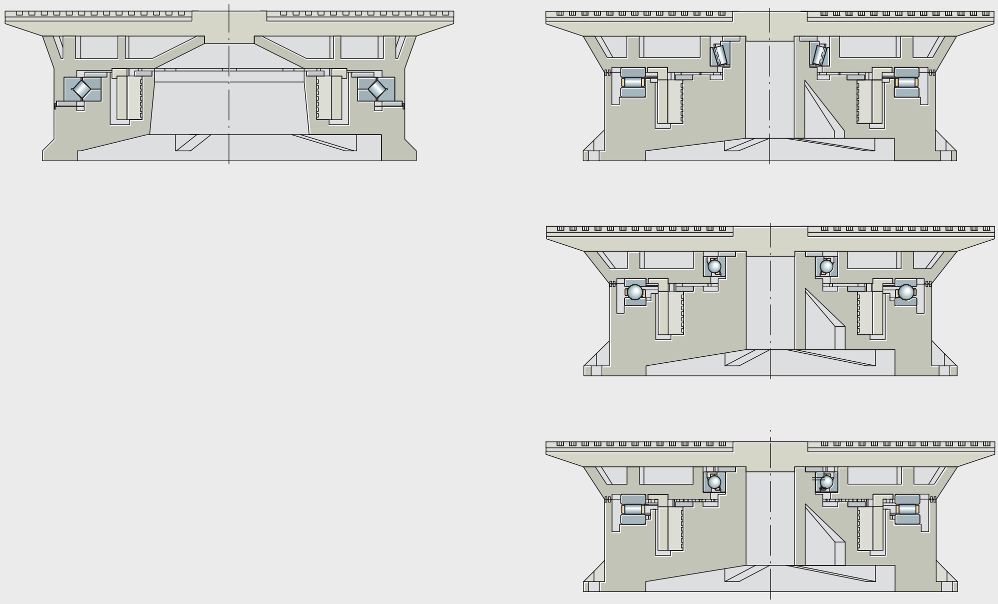

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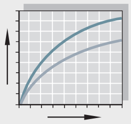
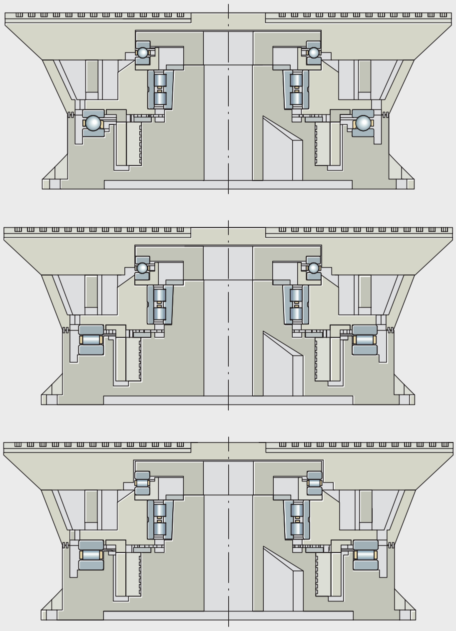


Technical principles



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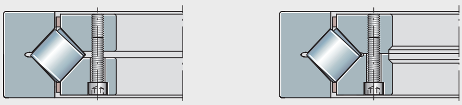

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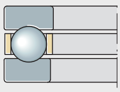
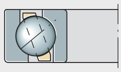
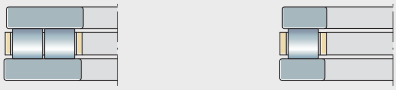


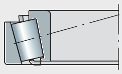
Axial deep groove ball bearings



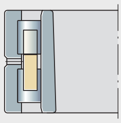
Single row
angular contact ball bearings



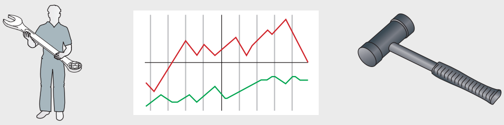
Axial cylindrical roller bearings



Single row tapered roller bearings

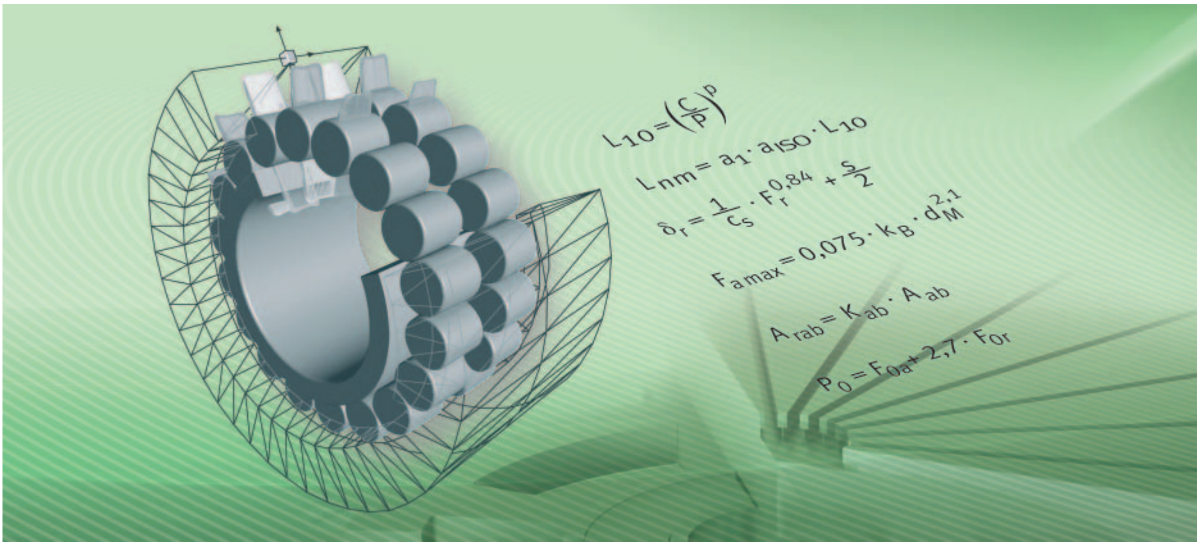


Radial cylindrical roller bearings



Equipment and services for the mounting and maintenance of rolling bearings

Appendix
Addresses
Checklists



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Technical principles

Selection criteria

Procedure for bearing selection

Vertical turret lathes belong to the category of machine tools operating by cutting methods. In order to fulfil the relevant requirements, the bearing arrangement must have the appropriate characteristics.

The most important characteristics are:

- speed capacity
- running accuracy
- operating life
- rigidity.

On the basis of the geometrical boundary conditions, various bearing solutions are used. An overview is given below of the procedure for making a preliminary bearing selection.

In order to make a final determination of bearing types, setting values and operating parameters, please contact the application engineers of Schaeffler Group Industrial. The calculation tool BEARINX® can then be used to perform bearing design in accordance with the design specification and submit recommendations on lubrication.

The data required for this work can be compiled using the template provided in the appendix, see page 158.

Geometrical boundary conditions

The diameter of the faceplate (table diameter) is determined by the range of parts to be clamped. The main support bearing selected should have a diameter approx. $^2/_3$ of the faceplate diameter. In the case of faceplates with a diameter larger than 7 m, bearings with a diameter 50% of the faceplate bearing are permissible.

Speed

With this restriction, the selection can then be continued in relation to the achievable speed. The speed capacity, as a precondition for favourable cutting parameters, is heavily dependent on the bearing type used. The heat generated due to friction is not inconsiderable in some cases and must be dissipated by the lubricant. This is reflected in the type of lubrication required.

Workpiece accuracy

The achievable workpiece accuracy is determined by the running accuracies of the bearings used and this in turn requires an adjacent construction produced to corresponding accuracy.

Rating life

In order to achieve an adequate fatigue life L_h, the bearings must have an appropriate load carrying capacity, expressed in terms of their basic load ratings, that is dependent on the load. This can be influenced on the one hand by the bearing size and also by the bearing type.

Safety factors

For smooth running, the objective should be a factor $f_S \geqq 4$.

It is not normally necessary to factor in any additional safety in calculation.

In special cases, such as approval specifications, internal specifications, requirements stipulated by inspection bodies etc., the appropriate safety factors must be applied.

Dynamic load carrying capacity

Bearings subjected to dynamic load, in other words bearings that undergo predominantly rotary motion, are dimensioned in accordance with their dynamic load carrying capacity.

The size of a bearing under dynamic load can be checked in approximate terms using the basic dynamic load ratings C and the basic rating life L or L_h.

Different loads

In general, different workpieces are produced on one machine type. This means that the bearings are subjected to different loads. The bearing design process must therefore take account of all the load cases in order to ensure that the bearings function acceptably.

If the appropriate preload is selected for the bearing system, the minimum loads required can be ensured in all load cases. Minimum loads are necessary in order to ensure that the rolling elements move without slippage and with low levels of friction and wear. The preload in turn has an influence on the rigidity of the bearing system.

Further guidelines

The performance capacity of the bearing arrangement is strongly influenced by clean, precise mounting and it is therefore important that the necessary care is taken here.

Load carrying capacity and rating life

Basic rating life

The basic rating life L_{10} and L_{10h} is determined as follows:

$$L_{10} = \left(\frac{C}{P}\right)^p$$

$$L_{10h} = \frac{16\,666}{n} \cdot \left(\frac{C}{P}\right)^p$$

L_{10} 10^6 revolutions
The basic rating life in millions of revolutions is the life reached or exceeded by 90% of a sufficiently large group of apparently identical bearings before the first evidence of material fatigue develops

C kN
Basic dynamic load rating

P kN
Equivalent dynamic bearing load for radial and axial bearings

p –
Life exponent;
for roller bearings: p = 10/3
for ball bearings: p =3

L_{10h} h
The basic rating life in operating hours according to the definition for L_{10}

n min^{-1}
Operating speed.

Equivalent dynamic bearing load

The equivalent dynamic load P is a calculated value. This value is constant in magnitude and direction; it is a radial load for radial bearings and an axial load for axial bearings.

A load corresponding to P will give the same rating life as the combined load occurring in practice.

$$P = X \cdot F_r + Y \cdot F_a$$

P kN
Equivalent dynamic bearing load

X –
Radial factor given in the dimension tables or product description

F_r kN
Radial dynamic bearing load

Y –
Axial factor given in the dimension tables or product description

F_a kN
Axial dynamic bearing load.

! This calculation method cannot be applied to axial cylindrical roller bearings. Combined loads are not permissible with these bearings.

Friction and increases in temperature

Friction

The friction in a rolling bearing is made up of several components, see table. Due to the large number of influencing factors, such as dynamics in speed and load, tilting and skewing resulting from mounting and operation, the actual frictional torques and friction values may deviate significantly from the calculated values. If the frictional torque is an important design criterion, please consult the engineering service of the Schaeffler Group.

Frictional component and influencing factor

Frictional component	Influencing factor
Rolling friction	Magnitude of load
Sliding friction of rolling elements, sliding friction of cage	Magnitude and direction of load Speed and lubrication conditions, running-in condition
Fluid friction (flow resistance)	Type and speed Type, quantity and operating viscosity of lubricant
Seal friction	Type and preload of seal

The idling friction is dependent on the lubricant quantity, speed, operating viscosity of the lubricant, seals and the running-in condition of the bearing.

Heat dissipation

Friction is converted into heat. This must be dissipated from the bearing. At lower speeds, this may occur to an adequate extent via the adjacent construction. At higher speeds and with longer operating durations, heat must be dissipated by means of the lubricant.

Heat dissipation by the lubricant

Oil dissipates a portion of the heat. Recirculating oil lubrication with additional cooling is particularly effective. Grease does not give dissipation of heat.

Heat dissipation via the shaft and housing

Heat dissipation via the shaft and housing is dependent on the temperature difference between the bearing and the surrounding structure, *Figure 1*.

! Any additional adjacent sources of heat or thermal radiation must be taken into consideration.

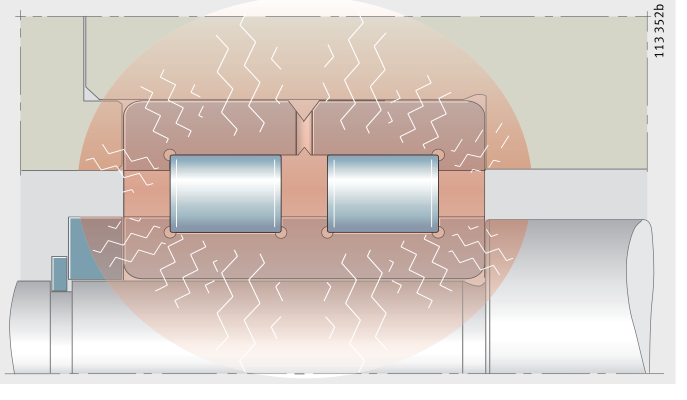


Figure 1
Temperature distribution between bearing, shaft and housing

Friction and increases in temperature

Determining the friction values

For this process, the speed and load must be known.
The type of lubrication, lubrication method and viscosity of lubricant at operating temperature are further important factors in calculation.

Total frictional torque M_R:

$$M_R = M_0 + M_1$$

Frictional power N_R:

$$N_R = M_R \cdot \frac{n}{9\,550}$$

Frictional torque as a function of speed:

$$M_0 = f_0 \cdot \left(\nu \cdot n\right)^{2/3} \cdot d_M{}^3 \cdot 10^{-7}$$

Frictional torque as a function of load for cylindrical roller bearings:

$$M_1 = f_1 \cdot F \cdot d_M$$

Frictional torque as a function of load for ball bearings, tapered roller bearings and spherical roller bearings:

$$M_1 = f_1 \cdot P_1 \cdot d_M$$

M_R Nmm
Total frictional torque

M_0 Nmm
Frictional torque as a function of speed

M_1 Nmm
Frictional torque as a function of load

N_R W
Frictional power

n min^{-1}
Operating speed

f_0 –
Bearing factor for frictional torque as a function of speed, see tables, page 15

ν mm^2s^{-1}
Kinematic viscosity of lubricant at operating temperature.
In the case of grease, the decisive factor is the viscosity of the base oil at operating temperature

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

f_1 –
Bearing factor for frictional torque as a function of load, see tables, page 15

F_r, F_a N
Radial load for radial bearings, axial load for axial bearings

P_1 N
Decisive load value for the frictional torque.
For ball bearings, tapered roller bearings and spherical roller bearings, see table, page 16.

Bearing factors

The bearing factors f_0 and f_1 are mean values derived from series of tests and correspond to the data according to ISO 15312.

The bearing factors f_0 are stated for oil injection lubrication, see tables. The bearing factor f_0 increases, for the same mean bearing diameter d_M, with the size of the balls or the roller length and thus indirectly with the size of the bearing cross-section.

In the tables, the wide series therefore have larger bearing factors f_0 than the narrow series. Where radial bearings operate under radial load on a vertical axis, the actual value must be taken as twice the stated value. This also applies with a large coolant oil throughput or an excessively high grease filling (where there is more grease present than can be laterally displaced).

! In the starting phase, freshly greased bearings have bearing factors f_0 identical to those for bearings with oil bath lubrication. Once grease has been distributed, the bearing factors f_0 are reduced by half.

Bearing factors for cylindrical roller bearings with cage

Series	Bearing factor f_0		Bearing factor f_1
	Grease, oil mist	Oil injection, recirculating oil	
NN30..-K	1,7	3	0,0002 – 0,0004
NNU49..-K	1,7	3	

Bearing factors for axial roller bearings

Series	Bearing factor f_0		Bearing factor f_1
	Grease, oil mist	Oil injection, recirculating oil	
811, K811	2	3	0,0015
812, K812			
893, K893			
894, K894			

Bearing factors for tapered roller bearings

Series	Bearing factor f_0		Bearing factor f_1
	Grease, oil mist	Oil injection, recirculating oil	
302, 303, 320, 329, 330	2	3	0,0004
313, 322, 323, 331, 332	3	4,5	

Bearing factors for angular contact ball bearings

Series	Bearing factor f_0		Bearing factor f_1
	Grease, oil mist	Oil injection, recirculating oil	
70..-B	1,3	2	$0{,}001 \cdot (P_0/C_0)^{0{,}33}$
719..-B			
73..-B	2	3	

Bearing factors for axial deep groove ball bearings

Series	Bearing factor f_0		Bearing factor f_1
	Grease, oil mist	Oil injection, recirculating oil	
511, 512, 513, 514	1	1,5	$0{,}0012 \cdot (F_a / C_0)^{0{,}33}$

Decisive load for ball bearings and tapered roller bearings

Bearing type	Single bearing P_1
Deep groove ball bearings	$3{,}3 \cdot F_a - 0{,}1 \cdot F_r$
Angular contact ball bearings, single row	$F_a - 0{,}1 \cdot F_r$
Tapered roller bearings	$2 \cdot Y \cdot F_a$ or F_r, use the larger value

For $P_1 \leqq F_r$, $P_1 = F_r$.

Speeds

Speeds for bearing combinations

For bearing solutions in vertical turret lathes with combined bearings, the decisive factor for the maximum permissible speed is always the main bearing in the arrangement.

Limiting speed

The limiting speed n_G for oil and grease lubrication is based on practical experience and takes account of additional criteria such as smooth running and centrifugal forces.

The limiting speed must not be exceeded even under favourable operating and cooling conditions.

Lubricant selection

The bearings can in principle be lubricated with either grease or oil. For applications in lathes with longer operating durations and higher speeds, however, oil lubrication should be used in every case in order to dissipate the heat generated in the bearing due to friction.

Oils with a mineral oil base are used most frequently. These mineral oils must fulfil at least the requirements according to DIN 51517, see table.

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, see table. For example, anti-wear protection additives are particularly important for the operation of rolling bearings in the mixed friction range.

Base oils and their typical characteristics

Base oil, abbreviation	Operating temperature		Viscosity/ temperature behaviour	Compatibility with elastomers	Price
	max. °C	min. °C			
Mineral oil[1], Min	+120	−20	100	Good	1
Polyalphaolefin[2], PAO, SHC	+150	−40	160	Good	6

[1] Most frequently used base oil type, "naturally uncontaminated" due to origin as a product of nature.

[2] Widely used synthetic oil type, including use for lubricants with foodstuff approval.

Lubricant additives and their effect

Additive type		Function
Extreme pressure additives	EP	Improved pressure absorption behaviour Reduction in wear through formation of reaction layer
Friction modifier	FM	Modified friction under mixed and boundary friction
Anti-wear protection	AW	Reduction in mild adhesive/abrasive wear under mixed friction
Corrosion inhibitors	KI	Protection of metal surfaces against corrosion
Ageing inhibitors	OI	Delay in oxidation breakdown of lubricant
Adhesion additives		Improved adhesion of lubricant to surface
Detergent and dispersant		Improved contaminant separation and transport behaviour of lubricant
VT improvement agent		Improved (reduced) viscosity/temperature behaviour
Foam inhibitors		Prevention of stable foam formation
Pourpoint reducer		Reduced pourpoint

Recommended oil viscosity

The achievable life and security against wear increase with increasing separation of the contact surfaces by a lubricant film. Since the lubricant film thickness increases with oil viscosity, an oil with a higher operating viscosity ν should be selected where possible.

Very long life can be achieved if the viscosity ratio between the existing and required viscosity is $\kappa = \nu/\nu_1 \geqq 2$. With increasing viscosity, however, the lubricant friction increases. Problems may occur with feed and removal of oil at low and even at normal temperatures.

The oil selected must be sufficiently viscous that, on the one hand, the longest possible fatigue life is achieved but, on the other hand, the power loss due to increased friction is kept as low as possible. It must be ensured that the bearings are provided with sufficient oil at all times.

Operating viscosity

In individual cases, the preferred level of operating viscosity cannot be achieved because:

- the oil selection is determined by other components in the machine, which require a thin-bodied oil
- a sufficiently flowable oil is to be used for recirculating lubrication in order to dissipate contaminants and heat from the bearing
- higher temperatures or very low circumferential viscosity are present at some times and the operating viscosity that can be achieved with the most viscous suitable oil is below the required viscosity.

In such cases, an oil with lower than recommended viscosity may be used. The oil must then, however, contain effective additives and its suitability for lubrication must be demonstrated by means of a rolling bearing test. Depending on the deviation from the nominal value, a reduction in fatigue life and the symptoms of wear on the functional surfaces must then be anticipated, as will be demonstrated by the calculation of the achievable life.

For common viscosity classes in accordance with ISO and SAE, *Figure 1*, page 20 and table, page 20.

Viscosity classes to ISO and SAE

ν_{40} = viscosity at +40 °C
ν_{100} = viscosity at +100 °C

① Gearbox oil to SAE classification
② Engine oil to SAE classification

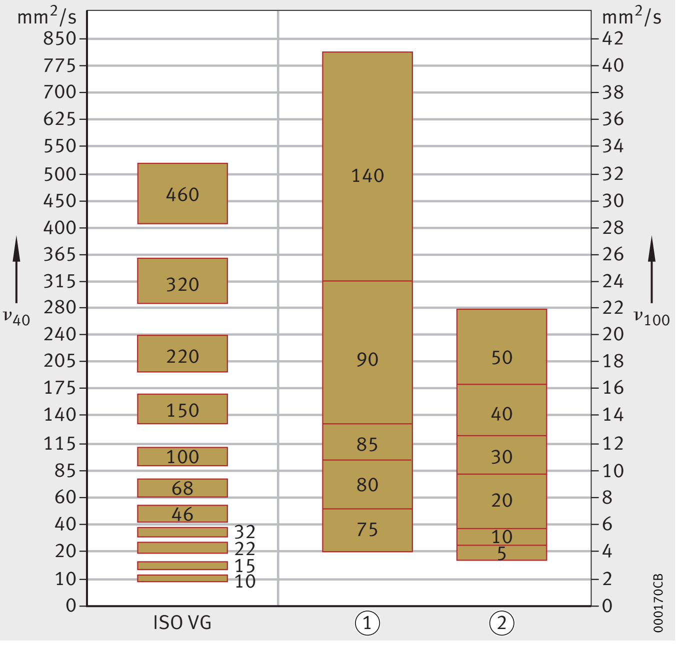


Figure 1
Viscosity classes

Viscosity classes ISO VG

Viscosity class ISO VG	Midpoint viscosity mm^2/s	Limits of kinematic viscosity at +40 °C mm^2/s	
		min.	max.
22	22	19,8	24,2
32	32	28,8	35,2
46	46	41,4	50,6
68	68	61,2	74,8
100	100	90	110
150	150	135	165
220	220	198	242

Oil selection

The oil must be selected in accordance with the specific application. In most cases, the oils used are gearbox or hydraulic oils CLP or HLP of ISO VG 46, ISO VG 68 or ISO VG 100. The selection is dependent on the speed and the load ratio C/P.

High speed parameters

If high circumferental velocities are present, an oil resistant to oxidation with a low foaming tendency and a favourable viscosity/temperature behaviour is advantageous. The maximum permissible speed parameter for axial cylindrical roller bearings is $n \cdot d_M = 250\,000\ \text{min}^{-1} \cdot \text{mm}$, while the maximum for axial deep groove ball bearings is $n \cdot d_M = 440\,000\ \text{min}^{-1} \cdot \text{mm}$.
Suitable synthetic oils with a good V/T behaviour are esters and polyalphaolefins PAO, since the viscosity of these oils shows a smaller reduction in viscosity as the temperature increases.
In the starting phase when the temperature is normally low, high splashing losses and thus an increase in temperature are avoided; once the higher equilibrium temperature is reached, the viscosity is still sufficient to ensure lubrication.

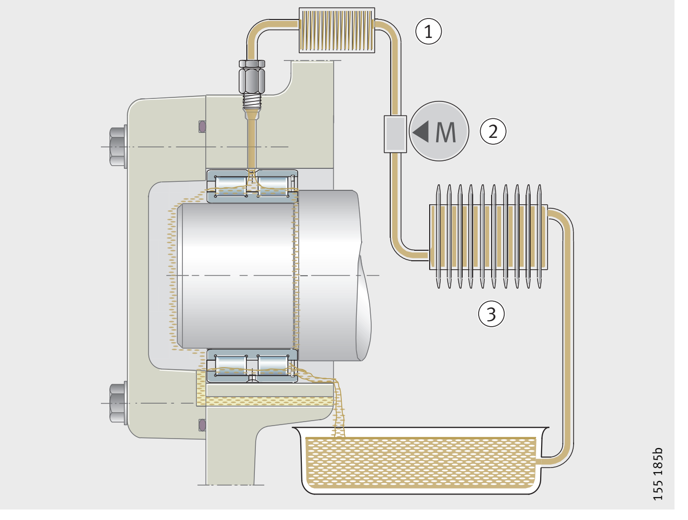
High loads

If the bearings are subjected to high loads ($C/P < 7$) or the operating viscosity ν is lower than the reference viscosity ν_1, oils with anti-wear protection additives should be used (code P to DIN 51502).

Anti-wear protection additives reduce the harmful effects of metallic contact occurring at various points. The suitability of anti-wear protection additives varies and is normally heavily dependent on temperature. Their effectiveness can only be assessed by means of testing in the rolling bearing (for example on our test rig FE 8).

Recirculating lubrication with moderate and larger quantities of oil

In recirculating relubrication, the oil passes through the bearings, is directed into a collection container and is then fed back into the bearings, *Figure 2*. Wear particles and contaminants have a negative effect on the achievable life. It is therefore absolutely essential to provide a filter in order to separate out the wear particles and contaminants. The filter in the feed line should have a retention rate of 6 μm.



① Filter
② Pump
③ Cooling system

Figure 2
Recirculating oil lubrication

Oil recirculation quantity

The recirculation quantities that, at viscosity ratios $\kappa = \nu/\nu_1$ from 1 to 2,5, give a moderate bearing flow resistance can be taken from the diagram, *Figure 3*.

$\dot{V}$ = oil quantity
D = bearing outside diameter

① Increasing oil quantity required for heat dissipation
② No heat dissipation necessary

a = oil quantity sufficient for lubrication
b = upper limit for bearings of symmetrical design
c = upper limit for bearings of asymmetrical design
a_1; b_1; c_1: D/d > 1,5
a_2; b_2; c_2: D/d ≦ 1,5

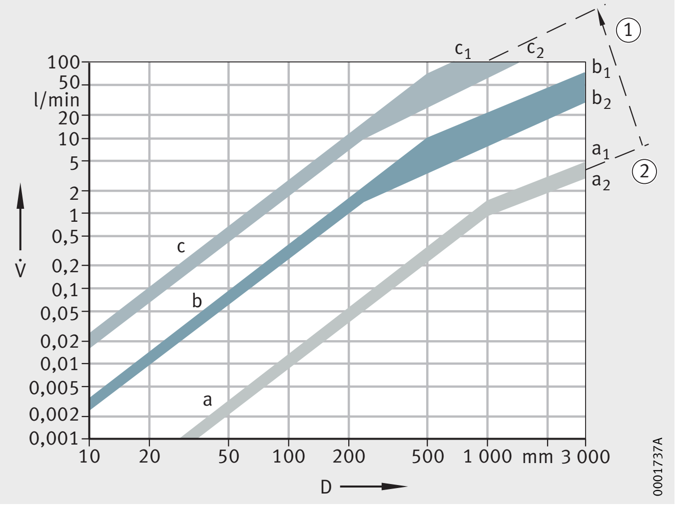


Figure 3
Oil quantities

Operating conditions

The recirculation quantities are matched to the operating conditions:

- Lubrication of the bearing requires only a very small quantity of oil. In comparison, the lubrication quantities stated as sufficient (line a) are large, *Figure 3*, page 22. These oil quantities are recommended in order to ensure that all contact surfaces are completely supplied with oil even if the feed of oil to the bearing is unfavourable. The minimum quantities stated are used for lubrication if a low level of friction is required. The temperature level achieved in this case is comparable with that in oil bath lubrication.
- If heat dissipation is required, larger oil quantities are necessary (line b), *Figure 3*, page 22. Since each bearing provides some resistance to the flow of oil, there are also upper limits for the oil quantities.
- For bearings with an asymmetrical cross-section such as angular contact ball bearings, tapered roller bearings or axial spherical roller bearings, larger throughput quantities are permissible (line c) than for bearings with a symmetrical cross-section, *Figure 3*, page 22. This is due to the fact that bearings with an asymmetrical cross-section provide less resistance to the oil flow due to their pumping action.

At the stated limits, the unpressurised feed and backing-up of oil on the feed side of the bearing as far as just below the shaft is a precondition. The oil quantity that must be provided in individual cases in order to maintain an adequately low bearing temperature is dependent on the conditions of heat input and dissipation. Values higher than those in area c are not advisable, *Figure 3*, page 22. The correct oil quantity can be determined by temperature measurement during initial operation of the machine and then regulated accordingly.

Injection lubrication

With increasing circumferential velocity, bearings with a symmetrical cross-section provide increasing resistance to the oil flow.
If larger recirculation quantities are planned, the oil is injected specifically into the gap between the cage and bearing ring in the case of rolling bearings rotating at high speeds. With oil injection, smaller splashing losses occur.

Normal oil quantities can be determined as a function of the speed parameter and bearing size. In this case, please consult the engineering service of the Schaeffler Group.

The back-up of oil ahead of the bearing is prevented by injecting oil at points that allow free entry into the bearing.
If the outlet ducts ahead of and after the bearing arrangement are adequately dimensioned, this will ensure that the oil not consumed by the bearing and flowing through the bearing can escape without any build-up.

Pressure loss and injection speed

For the range of high circumferential velocities, which is normal with injection lubrication, the oils that have proven effective are oils to specification CLP or HLP that have a viscosity of $\nu = 46\ mm^2/s$ to $68\ mm^2/s$ or $100\ mm^2/s$ in order to achieve $\kappa = 2$. The diagrams give the oil quantity and jet velocity as a function of the pressure drop, nozzle diameter and operating viscosity, *Figure 4*.

These data are derived from tests. The oil flow rate through the rapidly rotating bearing decreases with increasing speed. It increases with increasing injection velocity, for which 30 m/s is the advisable upper limit.

Nozzle length L = 8,3 mm

$\dot{V}$ = volume flow of oil (oil quantity)
Δp = pressure drop
v = jet velocity
D = nozzle diameter

① Operating viscosity $\nu = 7,75\ mm^2/s$
② Operating viscosity $\nu = 15,5\ mm^2/s$

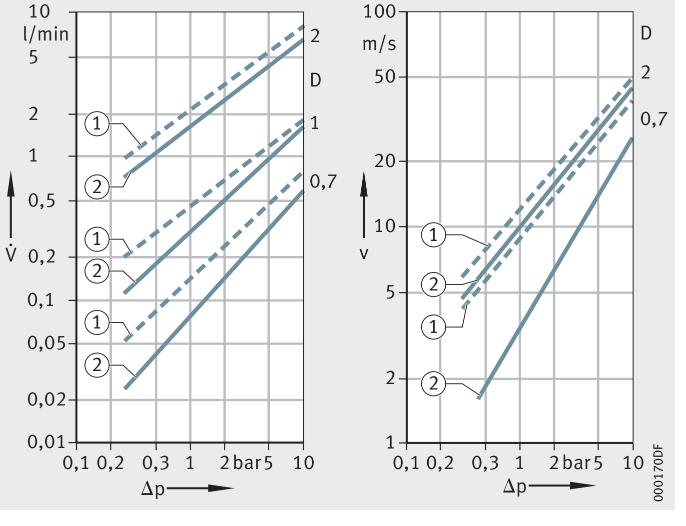


Figure 4
Pressure loss and injection speed

Design considerations

Rolling bearings must be provided with lubricant as soon as the machine is switched on. In the case of recirculating oil lubrication, the pump should therefore start up before the bearing starts to move. An oil sump provided in addition to the recirculating lubrication system also contributes to operational security, since oil can be supplied from the sump for at least a certain period if the pump fails. At low temperatures, the recirculating oil quantity can initially be reduced to the quantity necessary for lubrication until the oil in the container has heated up. The assists in the design of the recirculation system (pump drive, oil return system).

If lubrication is carried out using a larger oil quantity, outlet ducts must be provided in such a way as to prevent oil back-up that leads, mainly at high circumferential velocities, to significant power losses. The required diameter of the outlet line is dependent on the viscosity of the oil and the drop angles of the discharge pipes.

Where there is a combination of several bearings, the appropriate lubricant quantity must be determined for each individual bearing. Lubrication of radial cylindrical roller bearings must be carried out with particular care, see Catalogue SP 1, Super Precision Bearings. In many cases, the radial cylindrical roller bearing is adequately supplied by the oil quantity from the upper bearing.

Diameter of outlet line

For oils with an operating viscosity of up to 500 mm^2/s, the diameter of the outlet line in mm can be approximately stated:

$$d_a = (15...25) \cdot m^{0,5}$$

For more precise dimensioning in the drop region of the outlet line from 1% to 5%, the diameter is as follows:

$$d_a = 11,7 \cdot \left(\frac{m \cdot \nu}{G}\right)^{0,25}$$

d_a mm
Free diameter of outlet line

m l/min
Oil throughput quantity

ν mm^2/s
Operating viscosity

G %
Drop.

Fill quantity of oil container

The fill quantity of the oil container is based on the oil throughput. At a low circulation parameter, contaminants are easily deposited in the oil container, the oil can be cooled and does not age so quickly. At a high circulation parameter, there is a risk of excessive foaming.

In general, the fill quantity is selected such that circulation occurs approx. z = 3 to 8 times per hour:

$$M = m \cdot \frac{60\,\text{min}}{z}$$

M l
Fill quantity of oil container

m l/min
Oil throughput quantity

z –
Circulation parameter.

Dimensional and geometrical tolerances

Unless stated otherwise, the tolerances for radial rolling bearings correspond to DIN 620-2 (ISO 492), the tolerances for axial rolling bearings correspond to DIN 620-3 (ISO 199), *Figure 1*.

The accuracy corresponds to tolerance class PN. For bearings with increased accuracy, the tolerances are restricted to values in the classes P6, P5, P4 and P2. Tolerance tables for the individual tolerance classes, see page 29 to page 32.

High precision bearings

In addition to the standardised tolerance classes, high precision bearings are also produced in the tolerance classes P4S, SP and UP. These tolerances are listed in the product descriptions for the high precision bearings, see TPI 120, High Precision Bearings for Combined Loads.

Measurement methods

Measurement methods according to DIN 620-1 (ISO 1132-2) are valid for the acceptance inspection of rolling bearings.

Further information on the measurement methods is given in TPI 138, Rolling Bearing Tolerances, Definitions and Measurement Principles. This TPI can be ordered via the Internet.

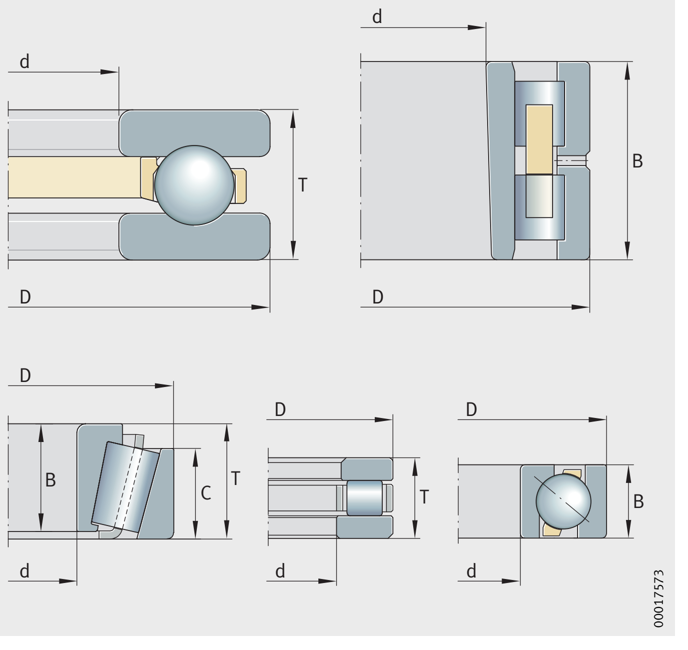


Figure 1
Main dimensions to DIN 620

Tolerance symbols and definitions

Tolerance symbol	Toleranced characteristic to DIN 1132 and DIN 620
d	Nominal bore diameter
Δ_{dmp}	Deviation of mean bore diameter in a single plane
Δ_{d1mp}	Deviation of mean large end diameter in tapered bores
V_{dsp}	Variation of single bore diameter in a single plane
V_{dmp}	Variation of mean bore diameter
D	Nominal outside diameter
Δ_{Dmp}	Deviation of mean outside diameter in a single plane
V_{Dsp}	Variation of single outside diameter in a single plane
V_{Dmp}	Variation of mean outside diameter
B	Nominal inner ring width
Δ_{Bs}	Deviation of a single inner ring width
V_{Bs}	Variation of inner ring width
C	Nominal outer ring width
Δ_{Cs}	Deviation of a single outer ring width
V_{Cs}	Variation of outer ring width
K_{ia}	Radial runout of inner ring of assembled bearing
K_{ea}	Radial runout of outer ring of assembled bearing
S_d	Axial runout of inner ring face to the bore
S_D	Runout of outer ring outside surface generatrix to the face
S_{ia}	Axial runout of inner ring of assembled bearing
S_{ea}	Axial runout of outer ring of assembled bearing
S_i	Variation of washer thickness of shaft locating washer
S_e	Variation of washer thickness of housing locating washer
T	Nominal bearing height of a single direction axial bearing
T	Total width of tapered roller bearing

Radial bearings, excluding tapered roller bearings

The dimensional and geometrical tolerances correspond to tolerance class P5, see tables.

Tolerance class P5
Inner ring
Tolerances in μm

d		Δ_{dmp}		V_{dsp} Diameter series		V_{dmp}	K_{ia}	S_d
mm		Deviation		9	0, 1, 2, 3, 4			
over	incl.	upper	lower	max.	max.	max.	max.	max.
120	180	0	–13	13	10	7	8	10
180	250	0	–15	15	12	8	10	11
250	315	0	–18	18	14	9	13	13
315	400	0	–23	22	18	12	15	15
400	500	0	–27	26	20	14	17	18
500	630	0	–33	32	24	17	19	22
630	800	0	–40	40	30	20	22	26
800	1 000	0	–50	50	38	25	26	32
1 000	1 250	0	–65	64	50	35	30	38
1 250	1 600	0	–80	80	60	40	35	45

Tolerance class P5
Inner ring
Tolerances in μm
continued

d		S_{ia}[1]	Δ_{Bs}		V_{Bs}
mm			Normal deviation		
over	incl.	max.	upper	lower	max.
120	180	10	0	–250	8
180	250	13	0	–300	10
250	315	15	0	–350	13
315	400	20	0	–400	15
400	500	25	0	–450	18
500	630	30	0	–500	22
630	800	35	0	–750	26
800	1 000	40	0	–1 000	32
1 000	1 250	45	0	–1 250	38
1 250	1 600	50	0	–1 600	45

1) Only for deep groove and angular contact ball bearings.

Tolerance class P5
Outer ring[1)]
Tolerances in μm

D		Δ_{Dmp}		V_{Dsp} [2)] Diameter series		V_{Dmp} [3)]	K_{ea}	S_D	S_{ea} [4)]	V_{Cs}
mm		Deviation		9	0, 1, 2, 3, 4					
over	incl.	upper	lower	max.	max.	max.	max.	max.	max.	max.
180	250	0	–15	15	11	8	15	11	15	10
250	315	0	–18	18	14	9	18	13	18	11
315	400	0	–20	20	15	10	20	13	20	13
400	500	0	–23	23	17	12	23	15	23	15
500	630	0	–28	28	21	14	25	18	25	18
630	800	0	–35	35	26	18	30	20	30	20
800	1 000	0	–40	44	34	23	35	25	35	24
1 000	1 250	0	–50	54	40	30	40	30	45	28
1 250	1 600	0	–65	70	54	35	45	35	55	32
1 600	2 000	0	–85	82	64	45	55	40	65	38
2 000	2 500	0	–110	110	84	55	65	50	75	45
2 500	3 150	0	–140	140	104	70	75	60	90	50
3 150	4 000	0	–170	170	130	85	85	70	110	60

1) Δ_{Cs} is identical to Δ_{Bs} for the inner ring of the corresponding bearing, see table Tolerance class P5 Inner ring, page 29.

2) No values are given for radial ball bearings with shields or seals.

3) Applies before assembly of the bearing and after removal of internal and/ or external snap rings.

4) Only for deep groove and angular contact ball bearings.

Axial bearings

The tolerances for shaft locating washers and housing locating washers are based on ISO 199 and DIN 620-3, see tables.

Bore diameter tolerances for shaft locating washers Tolerances in μm

d mm		P5			
		Δ_{dmp} Deviation		V_{dp}	S_i
over	incl.	upper	lower	max.	max.
120	180	0	–25	19	5
180	250	0	–30	23	5
250	315	0	–35	26	7
315	400	0	–40	30	7
400	500	0	–45	34	9
500	630	0	–50	38	11
630	800	0	–75	56	13
800	1 000	0	–100	75	15
1 000	1 250	0	–125	95	18
1 250	1 600	0	–160	120	21
1 600	2 000	0	–200	150	25
2 000	2 500	0	–250	190	30
2 500	3 150	0	–300	224	35

Outside diameter tolerances for housing locating washers Tolerances in μm

D mm		P5			
		Δ_{Dmp} Deviation		V_{Dp}	S_e
over	incl.	upper	lower	max.	
180	250	0	–30	22	5
250	315	0	–35	26	7
315	400	0	–40	30	7
400	500	0	–45	34	9
500	630	0	–50	38	11
630	800	0	–75	55	13
800	1 000	0	–100	75	15
1 000	1 250	0	–125	90	18
1 250	1 600	0	–160	120	21
1 600	2 000	0	–200	150	25
2 000	2 500	0	–250	190	30
2 500	3 150	0	–300	224	35

Tolerances for nominal bearing height

These tolerances are given in the tables. The dimensional symbols correspond to DIN 620, *Figure 1*, page 27.

Tolerances for nominal bearing height
Tolerances in µm

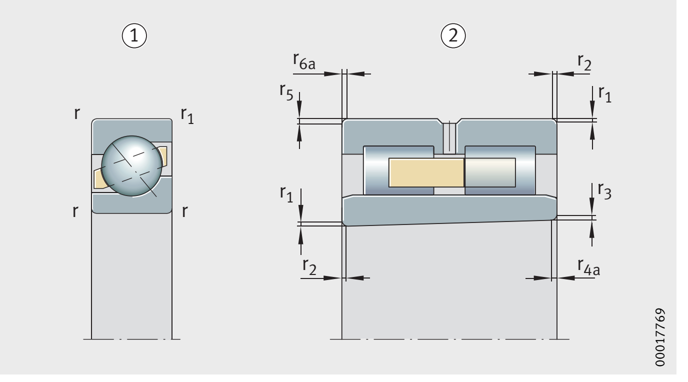
d mm		T Deviation	
over	incl.	upper	lower
120	180	25	−400
180	250	30	−400
250	315	40	−400
315	400	40	−500
400	500	50	−500
500	630	60	−600
630	800	70	−750
800	1 000	80	−1 000
1 000	1 250	100	−1 400

Chamfer dimensions

The chamfer dimensions correspond to DIN 620-6.

Radial bearings, excluding tapered roller bearings

For minimum and maximum bearing values, *Figure 2* and table. For chamfer dimensions of tapered roller bearings see page 34, for axial bearings see page 35.



① Symmetrical ring cross-section with identical chamfers on both rings
② Symmetrical ring cross-section with different chamfers on both rings

Figure 2
Chamfer dimensions for radial bearings excluding tapered roller bearings

Limit values for chamfer dimensions to DIN 620-6
Values in mm

r[1]	d		r_1 to r_{6a}	r_1, r_3, r_5	r_2, r_4, r_6[2]	r_{4a}, r_{6a}
	over	incl.	min.	max.	max.	max.
1	50	–	1	1,9	3	2,2
1,1	120	–	1,1	2,5	4	2,7
1,5	120	–	1,5	3	5	3,5
2	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	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.

Tapered roller bearings

For minumum and maximum values for metric tapered roller bearings, *Figure 3* and table.

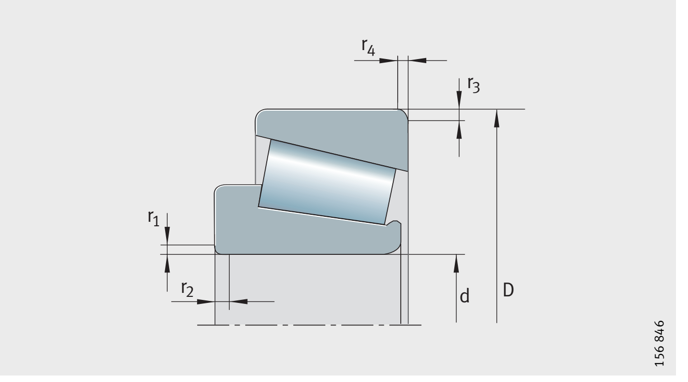


Figure 3
Chamfer dimensions for metric tapered roller bearings

Limit values for chamfer dimensions Values in mm

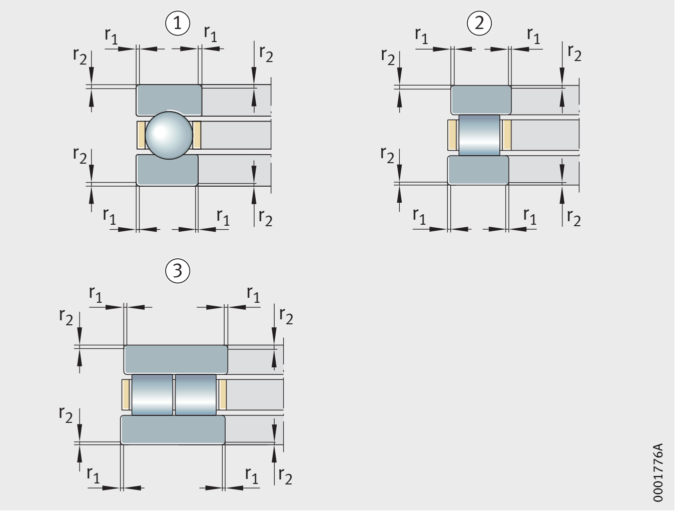
r[1)]	d, D		r_1 to r_4	r_1, r_3	r_2, r_4
	over	incl.	min.	max.	max.
1	50	–	1	1,9	3
1,5	120	250	1,5	2,8	3,5
	250	–	1,5	3,5	4
2	120	250	2	3,5	4,5
	250	–	2	4	5
2,5	120	250	2,5	4	5,5
	250	–	2,5	4,5	6
3	120	250	3	4,5	6,5
	250	400	3	5	7
	400	–	3	5,5	7,5
4	120	250	4	5,5	7,5
	250	400	4	6	8
	400	–	4	6,5	8,5
5	–	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}.

Axial bearings

For minimum and maximum bearing values, *Figure 4* and table. The values in the table correspond to DIN 620-6.

With 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 Single direction axial cylindrical roller bearing, single row

③ Single direction axial cylindrical roller bearing, double row

Figure 4
Chamfer dimensions for axial bearings

Limit values for chamfer dimensions
Values in mm

r[1]	r_1, r_2	
	min.	max.
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}.

Adjacent construction

In order to make full use of the accuracy and rigidity of the bearings in the machine, it must be ensured that the adjacent construction is not only accurate but also has adequate rigidity and load carrying capacity. Particular attention must be paid to the introduction of potentially high axial loads. It is recommended that rigid, geometrically stable abutment is provided in the direction of the machine bed mounting points.

Shaft and housing tolerances

The fit is derived from the ISO tolerances for the shaft and housing (ISO 286) in conjunction with the bore tolerance Δ_{dmp} and the outside diameter tolerance Δ_{Dmp} of the bearings (DIN 620).

Reference to tables of shaft and housing tolerances

The recommendations for selection of shaft and housing tolerances are valid for normal mounting and operating conditions, see tables, page 37.

Shaft tolerances for radial bearings with cylindrical bore

Conditions of rotation	Bearing type	Shaft diameter mm	Displacement facility Load	Tolerance zone
Point load on inner ring	Ball bearings, roller bearings	All sizes	Inner ring easily displaced	g6 (g5)
			Inner ring not easily displaced Angular contact ball bearings and tapered roller bearings with adjusted inner ring	h6 (j6)
Circumferential load on inner ring or indeterminate load direction	Ball bearings	100 to 200	Low loads[1)]	k6 (k5)
			Normal and high loads[2)]	m6 (m5)
		over 200	Low loads	m6 (m5)
			Normal and heavy loads	n6 (n5)
	Roller bearings	60 to 200	Low loads	k6 (k5)
			Normal loads	m6 (m5)
			High loads	n6 (n5)
		200 to 500	Normal loads	m6 (m5)
			High loads, shocks	p6
		over 500	Normal loads	n6 (p6)
			High loads	p6

1) $C/P > 10$.
2) $C/P < 10$.

Shaft tolerances for axial bearings

Load	Bearing type	Shaft diameter	Tolerance zone
Axial load	Axial deep groove ball bearings	All sizes	j6
	Axial cylindrical roller bearings with shaft locating washer		h6 (j6)
	Axial cylindrical roller and cage assembly		h8

Housing tolerances for radial bearings

Conditions of rotation	Displacement facility Load	Operating conditions	Tolerance zone
Point load on outer ring	Outer ring easily displaced Housing unsplit	The tolerance grade is determined by the running accuracy required	H7 (H6)[1]
	Outer ring easily displaced Housing split		H8 (H7)
	Outer ring not easily displaced Housing unsplit	High running accuracy required	H6 (J6)
	Outer ring not easily displaced Angular contact ball bearings and tapered roller bearings with adjusted outer ring, Housing split	Normal running accuracy	H7 (J7)
	Outer ring easily displaced	Heat input via shaft	G7[2]
Circumferential load on outer ring or indeterminate load direction	Low loads Outer ring cannot be displaced	High running accuracy required K6, M6, N6 and P6	K7 (K6)
	Normal loads, shocks Outer ring cannot be displaced		M7 (M6)
	High loads, shocks ($C/P < 6$) Outer ring cannot be displaced		N7 (N6)
	High loads, severe shocks Thin-walled housing, outer ring cannot be displaced		P7 (P6)

1) G7 for housings made from GG if bearing outside diameter $D > 250$ mm and temperature difference between outer ring and housing > 10 K.

2) F7 for housings made from GG if bearing outside diameter $D > 250$ mm and temperature difference between outer ring and housing > 10 K.

Housing tolerances for axial bearings

Load	Bearing type	Operating conditions	Tolerance zone
Axial load	Axial deep groove ball bearings	Normal running accuracy	E8
		High running accuracy	H6
	Axial cylindrical roller bearings with housing locating washer	–	H7 (K7)
	Axial cylindrical roller and cage assembly	–	H10

Mounting

It must be ensured that, at the time of mounting, adequate lubrication of the rolling contact is already present. The adjacent construction must be checked for the necessary accuracy.

For support during initial mounting, we recommend that you consult our experts in Industrial Service, see section Equipment and services for the mounting and maintenance of rolling bearings, page 146.

One-bearing solutions

In one-bearing solutions, a distinction is drawn between the high precision bearings YRTS and ZKLDF of compact design and the solution using crossed roller bearings as presented in this TPI.

High precision bearings

The mounting of high precision bearings in accordance with TPI 120 is described in TPI 103, High Precision Bearings for Combined Loads.

Crossed roller bearings

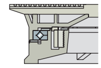
Crossed roller bearings Z-556 are supplied already set to a defined axial preload. In the case of crossed roller bearings Z-549, the axial preload is set during mounting.

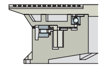
Two-bearing solutions

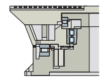
During mounting, it must be ensured that there is good radial running on the one hand between the axial deep groove ball bearing and the angular contact bearing. This can be achieved either by means of the centring devices or by appropriate alignment of the axial washers. On the other hand, the axial preload must be set correctly by means of the angular contact bearing.

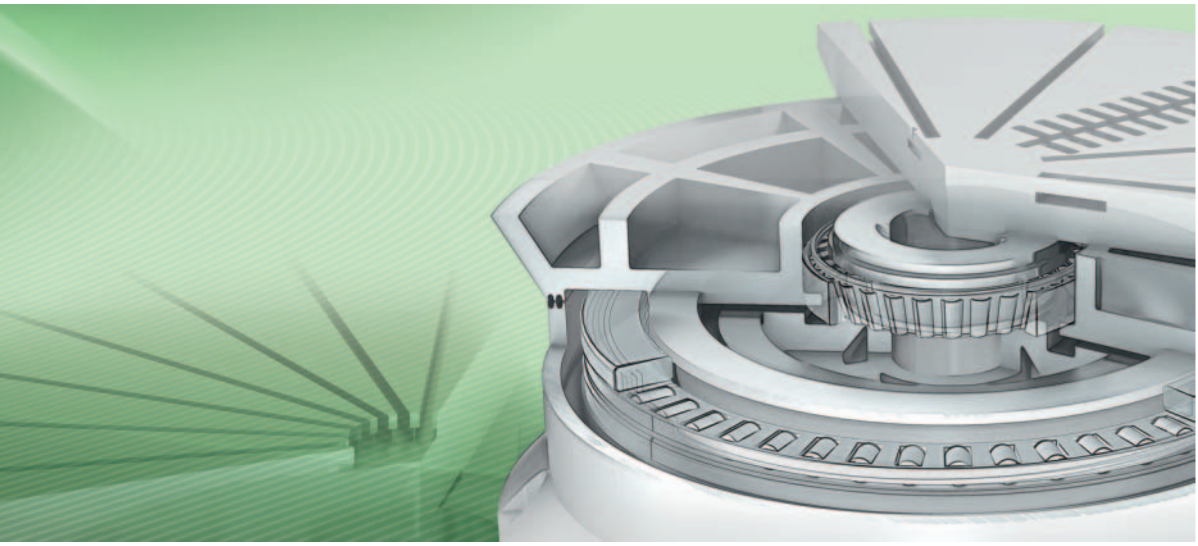
Three-bearing solutions

Good radial running of the axial deep groove ball bearing in relation to the radial cylindrical roller bearing must be ensured. This can be carried out either by means of the centring device or an alignment operation. The radial cylindrical roller bearing must be mounted in accordance with the specified radial preload, see Catalogue SP 1, Super Precision Bearings. Preloading of the axial bearings must be carried out with particular care.









Bearing solutions

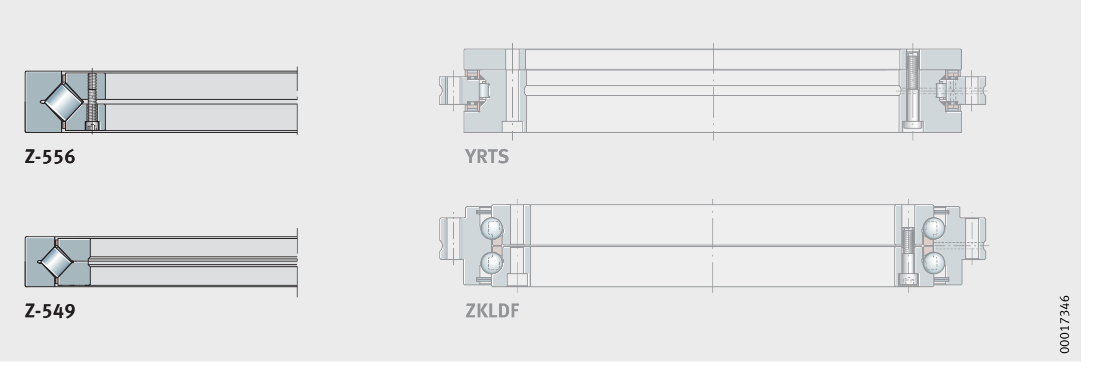
One-bearing solutions
Two-bearing solutions
Three-bearing solutions

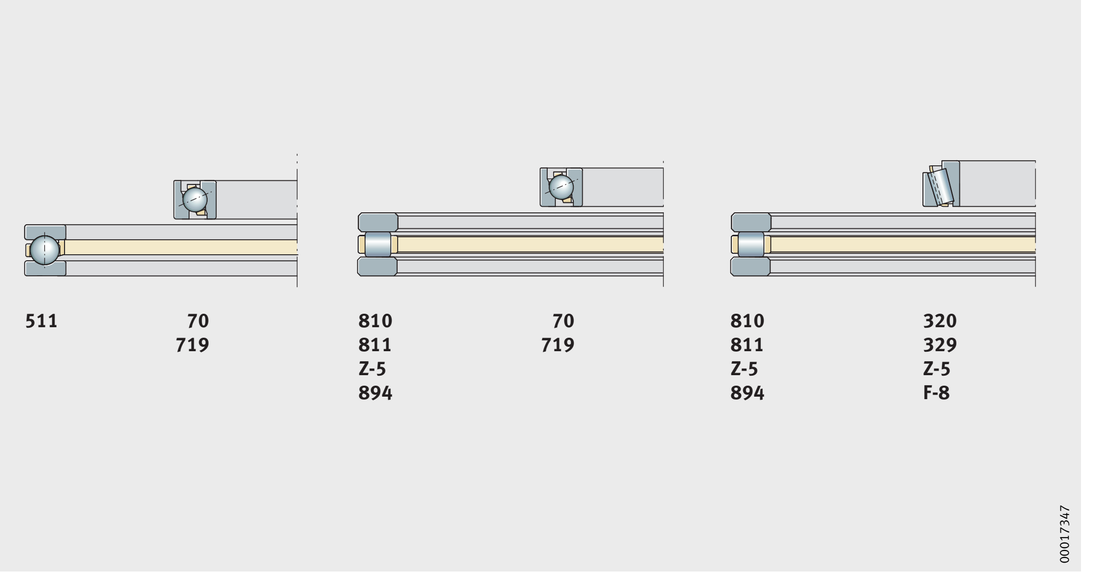
Bearing solutions

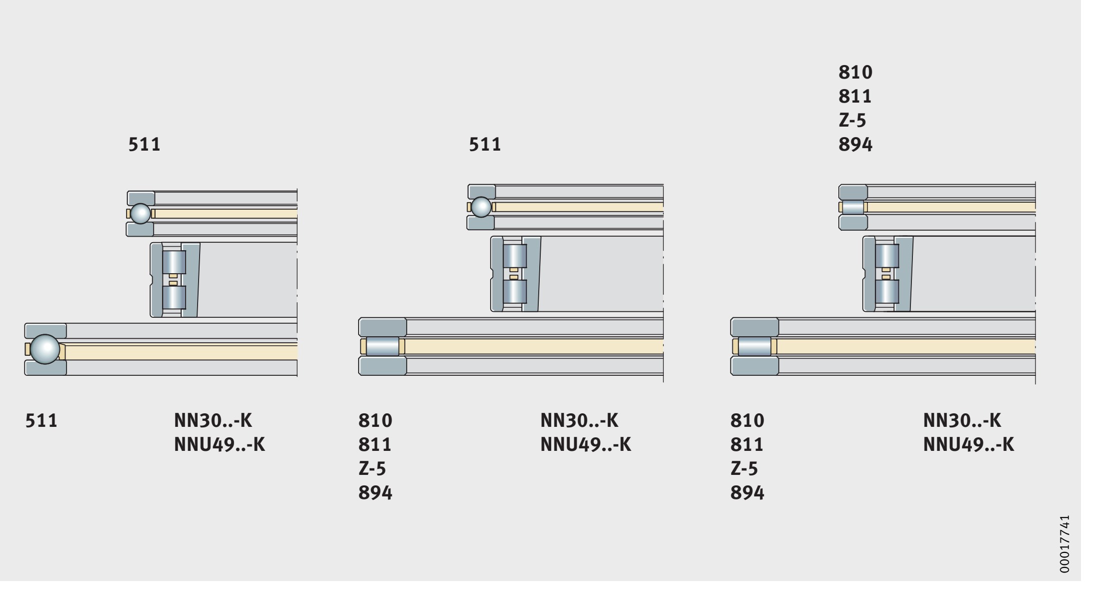
Due to the restricted size range of axial/radial bearings YRTS and axial angular contact ball bearings ZKLDF (see TPI 120, High Precision Bearings for Combined Loads), high precision crossed roller bearings are used here. These bearings are characterised by a simple adjacent construction, very small design envelope and favourable lubrication possibilities.

In the majority of applications, the requirements can be fulfilled by means of a bearing arrangement comprising two bearings. The main bearing arrangement comprises an axial bearing preloaded by the second bearing which also performs the radial guidance function. This bearing solution can fulfil requirements for moderate to high speeds. Angular contact ball bearings and tapered roller bearings are suitable for this role.

Where there are very high requirements not only for accuracy but also for rigidity, bearing arrangements with three individual bearings have significant advantages. The increased amount of work involved in mounting must, however, be taken into consideration.


Z-556
YRTS
Z-549
ZKLDF
00017346


511
70
719
810
811
Z-5
894
70
719
810
811
Z-5
894
320
329
Z-5
F-8
00017347


511
511
810
811
Z-5
894
511
NN30..-K
NNU49..-K
810
811
Z-5
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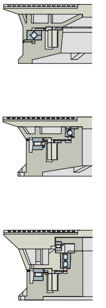
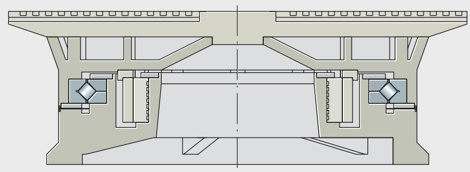
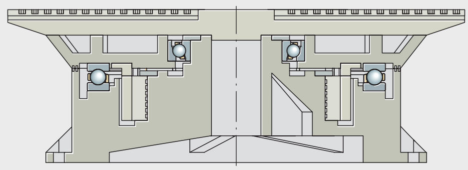
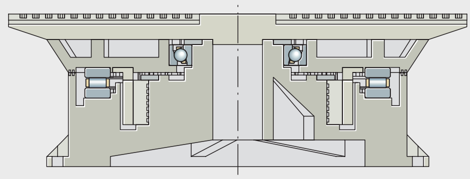
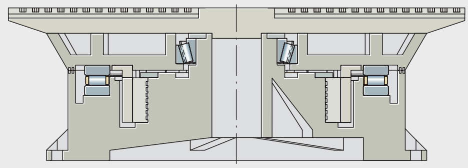
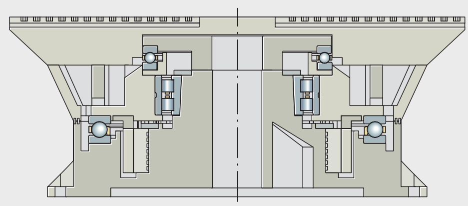
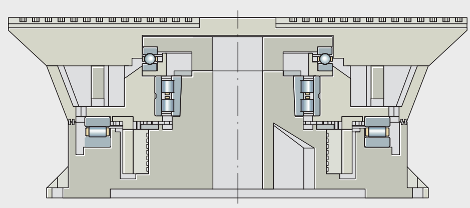
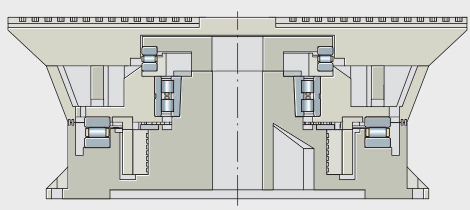
NNU49..-K
810
811
Z-5
894
NN30..-K
NNU49..-K
00017741



Preselection of bearing arrangements

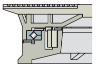
Application	
One-bearing solutions	
Two-bearing solutions	
	
	
Three-bearing solutions	
	
	

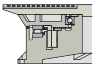
Definition of symbols

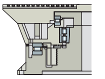
+++ Very good
++ Good
+ Satisfactory
o Adequate

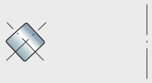
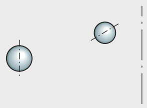
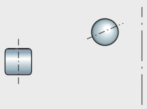
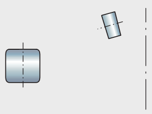
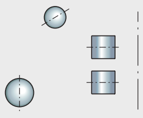
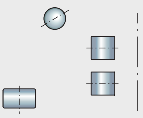
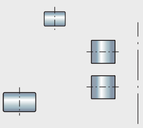
Attention!

This selection matrix is a general overview for making a preliminary assessment as to whether the bearing solutions can be considered for the required purpose. For the specific application, the information given in the product chapters and technical principles must always be taken into consideration.

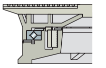
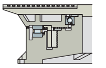
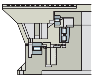






Possible applications of external force	Characteristics									
	Costs	Small design envelope	Axial rigidity	Radial rigidity	Tilting rigidity	Axial runout deviation	Radial runout deviation	Speed	Frictional torque	Complexity of components
	+	+++	+	+	++	o	o	++	++	+++
	+++	++	o	o	+	+	+	+++	+++	+
	++	++	++	o	++	+	+	++	++	+
	++	++	++	+	+++	+	+	+	+	++
	++	+	+	++	+	++	+++	+++	++	++
	o	o	+++	++	++	++	+++	o	o	++
	o	o	++	++	++	++	+++	+	o	+++

One-bearing solutions

One-bearing solutions

Page

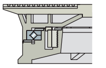
Product overview

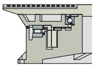
Features

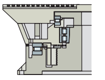
Crossed roller bearing

Z-549, Z-556

One-bearing solutions







Features

In a one-bearing solution, all the loads are supported by a single bearing. This allows a very simple and compact adjacent construction. In addition, there is no need to align individual bearings to each other and the lubrication arrangement can be relatively simple since only one bearing position must be supplied with lubricant.

Crossed roller bearings

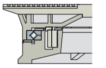
The rollers of these bearings are inclined relative to the bearing axis and are fitted such that rollers are mounted consecutively in a crosswise arrangement. Cage segments made from polyamide are used as spacers.

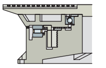
These bearings are produced to accuracy P5 and have a running accuracy better than P4. Crossed roller bearings are supplied with adjustable preload or defined preload.

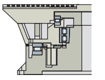
Higher running accuracy

In addition to the crossed roller bearings described here, the axial/radial bearings YRTS and ZKLDF of the diameter range from 200 mm to 460 mm are also suitable for these applications. Axial/radial bearings ZKLDF are also produced by agreement up to a bore diameter of 1030 mm.
These series have higher accuracy than the crossed roller bearings, see TPI 120, High Precision Bearings for Combined Loads.

Two-bearing solutions







Two-bearing solutions

Angular contact ball bearing and axial deep groove ball bearing

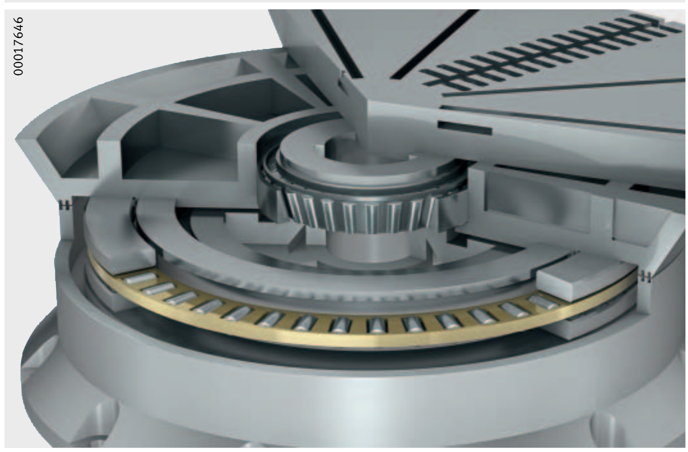
70, 719
511

Angular contact ball bearing and axial cylindrical roller bearing

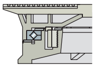
70, 719
810, 811, Z-5, 894

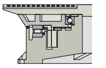
Tapered roller bearing and axial cylindrical roller bearing

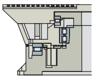
320, 329, Z-5, F-8
810, 811, Z-5, 894



Two-bearing solutions







Features

In contrast with a one-bearing solution, the loads are divided in a two-bearing solution. The axial bearing supports the main load comprising the table mass and the workpiece. The angular contact bearing is used to provide radial support as well as axial preload of the bearing system.

If a roller bearing is used as the axial bearing, very high loads can be supported. Ball bearings are recommended where higher speeds are present. In design and subsequently in mounting, it must be ensured that the required minimum loads are achieved in the various load cases. This also has an influence on the advisable pair arrangements of the bearings.

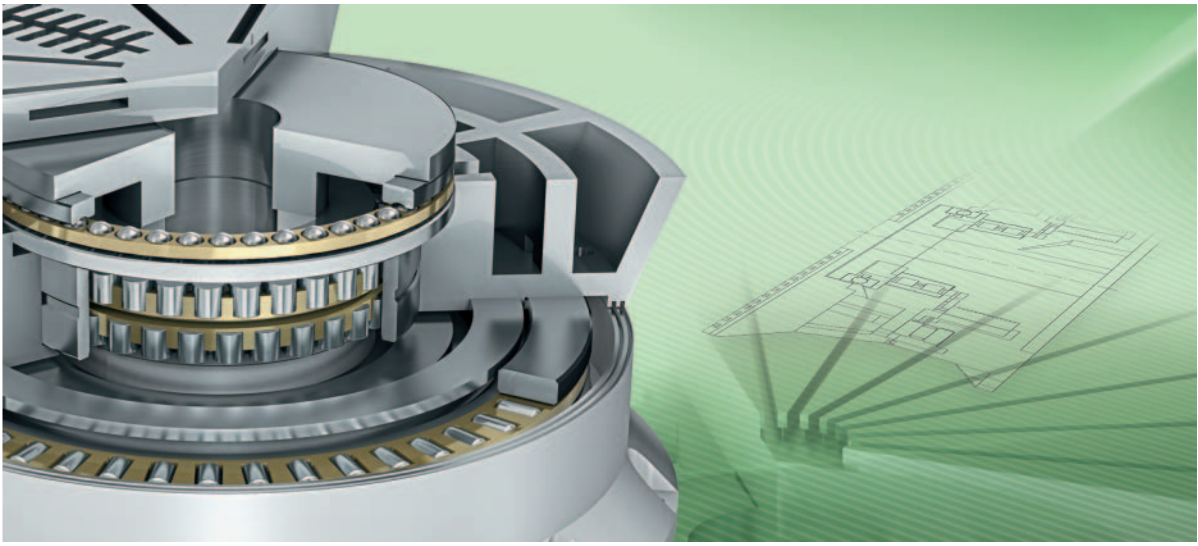
Speeds

In relation to speed capacity, the two-bearing solution using ball bearings offers a good compromise in relation to friction, lubrication requirements and high accuracy.

Accuracy

Dimensional and geometrical tolerances

The accuracy is primarily determined by the larger axial bearing. The influence of the radial runout of the angular contact bearing is, on the other hand, relativised by the smaller diameter of these bearings.

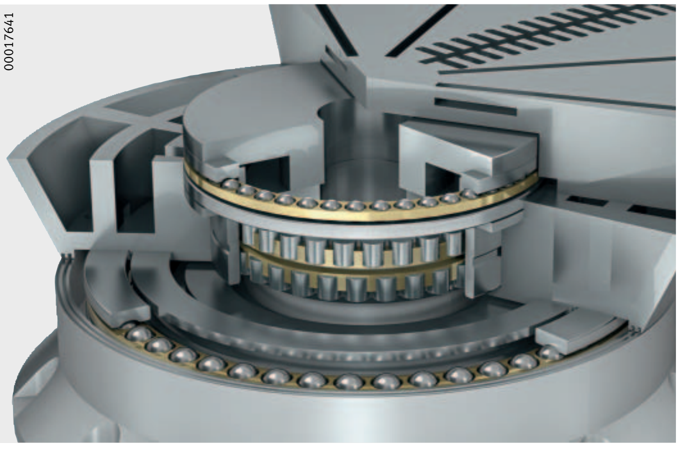


Three-bearing solutions

Three-bearing solutions

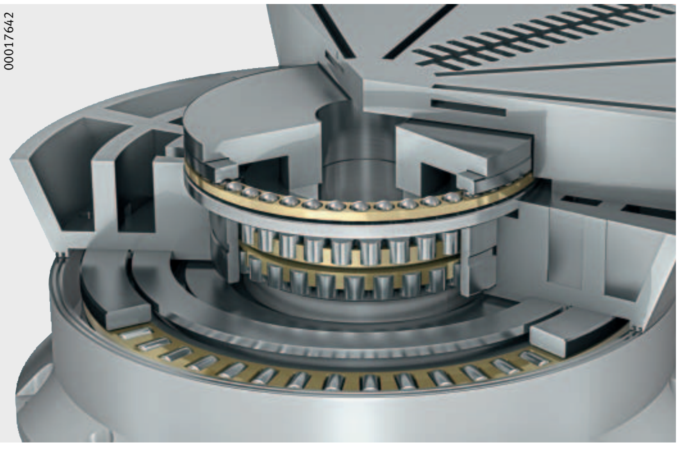
Radial cylindrical roller bearing and two axial deep groove ball bearings

NN30..-K, NNU49..-K
511


00017641

Radial cylindrical roller bearing, axial deep groove ball bearing and axial cylindrical roller bearing

NN30..-K, NNU49..-K
511, 810, 811, Z-5, 894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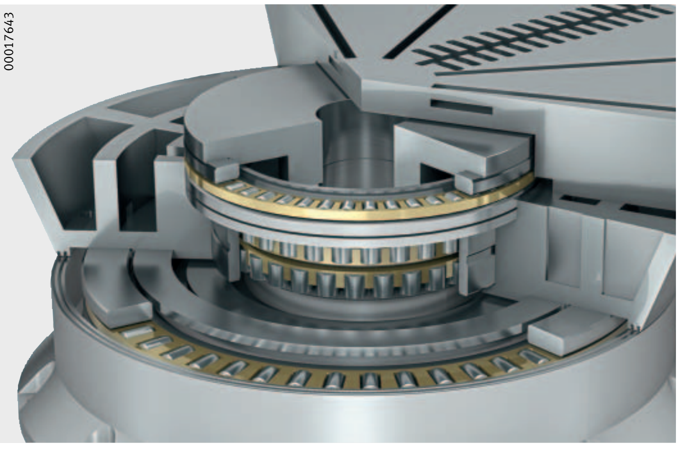
Radial cylindrical roller bearing and two axial cylindrical roller bearings

NN30..-K, NNU49..-K
810, 811, Z-5, 894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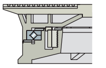
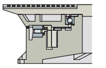
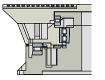
Three-bearing solutions







Features

In this arrangement, the combined loads are divided as appropriate over the two axial bearings and the radial bearing. This allows separate consideration in design work. Selection of the preload to ensure the minimum loads in the axial rows must be determined in accordance with the load cases.

Lubrication

Particular care must be taken on lubrication. While the axial bearings require higher oil throughput for heat dissipation, this is not necessary with the higher speeds occurring in the radial cylindrical roller bearing. Due to the design, the radial bearing can in most cases be supplied with the oil from the smaller axial bearing located above, see page 124.

Rigidity

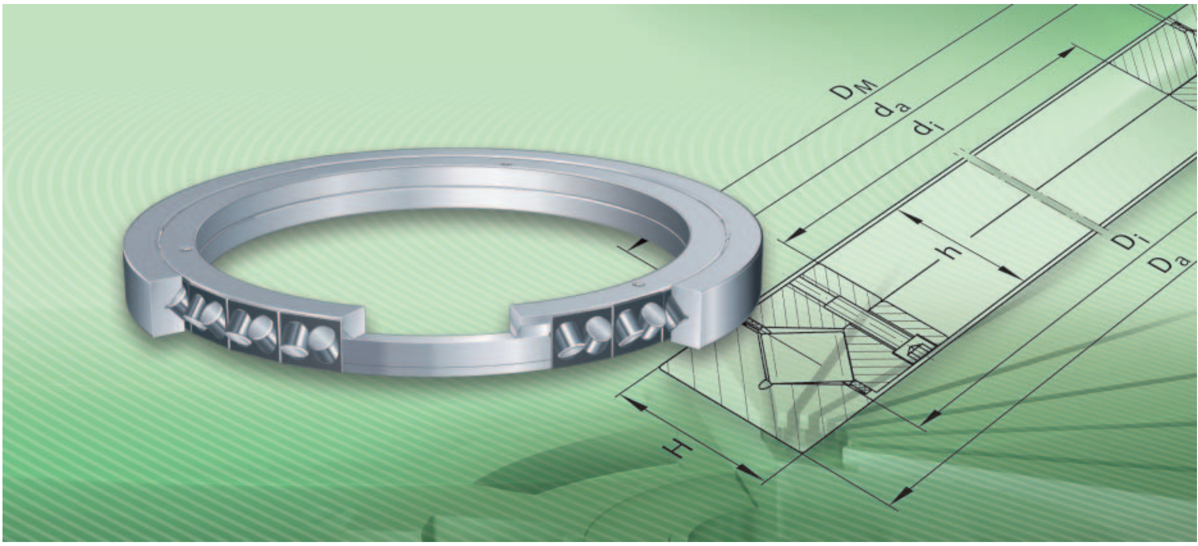
High rigidity of the bearing system can be achieved by defined axial preloading of the two axial bearings relative to each other in addition to radial preloading of the radial bearing to 5 μm, see page 126 and Catalogue SP 1, Super Precision Bearings.

Accuracy

Dimensional and geometrical tolerances

If the individual bearings are correctly combined, this bearing arrangement allows the very highest accuracy to be achieved.

FAG

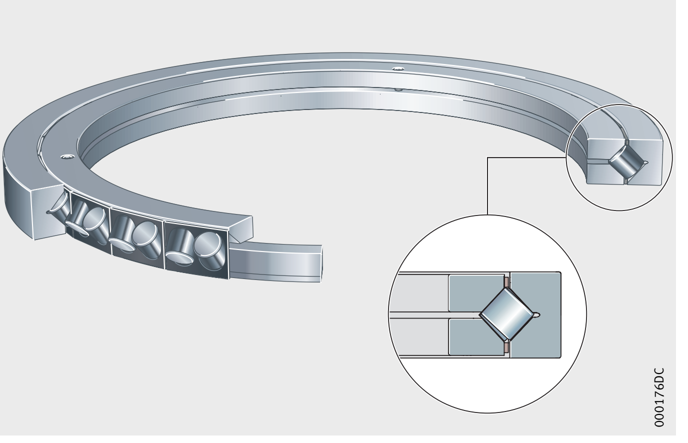


Crossed roller bearings

Crossed roller bearings

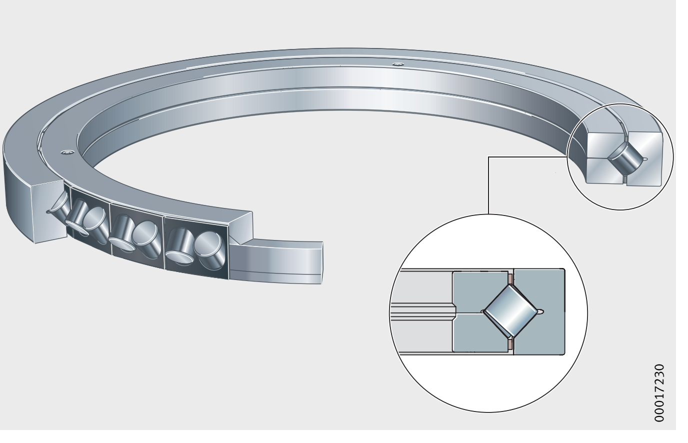
Adjustable axial preload

Z-549



Defined preload

Z-556



Crossed roller bearings

Features

Crossed roller bearings are highly rigid, have a running accuracy better than P4 and the remaining tolerances to P5, and are preloaded.

The bearing outer rings are easily fixed to the adjacent construction using clamping rings.

The crossed roller bearings described here have a special internal construction that is designed for higher speeds and are optimised for use in vertical turret lathes. In comparison with the bearings described in TPI 120, High Precision Bearings for Combined Loads, crossed roller bearings of the same size can offer a significantly higher basic dynamic load rating. Due to the smaller number of rolling elements, they have reduced rigidity.

! The guidelines and values in this chapter relate only to the crossed roller bearings listed in the tables.

The bearings are operated with a rotating outer ring.

For axial, radial and moment loads

Due to the O arrangement of the cylindrical rollers, these bearings can support axial forces in both directions as well as radial forces, tilting moment loads and any combination of loads by means of a single bearing position. As a result, designs involving two bearing positions can be reduced to a single bearing position, *Figure 1* and *Figure 2*.

F_a = axial load
F_r = radial load
M_k = tilting moment load

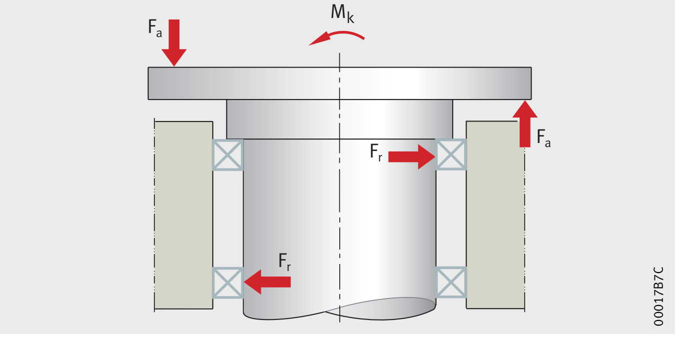


Figure 1
Bearing arrangement with two bearing positions

(1) Crossed roller bearing

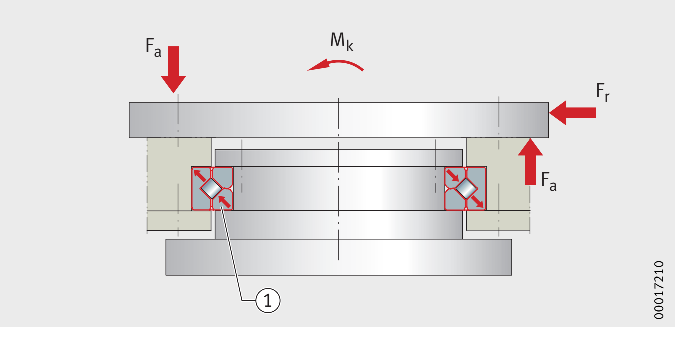


Figure 2
Bearing arrangement with one crossed roller bearing

Limiting speed

The limiting speed is dependent on the lubrication (grease or oil), see dimension tables.

If other limiting speeds are required, please contact the engineering service of the Schaeffler Group.

Preload

In the case of crossed roller bearings Z-556, the preload is set at the manufacturing plant and the bearing rings are located by means of appropriate covers and screw connections.

In the case of crossed roller bearings Z-549, the actual height of the inner rings is stated in the record supplied with the bearing. The required preload of crossed roller bearings with a gap is set by adjustment of the inner rings. This is carried out by means of shims or shim segments that are inserted between the journal and the clamping element on the upper inner ring. It is recommended that the shim thickness is determined according to the following procedure.

Determining the provisional shim thickness

The first step is to produce a thicker shim of approx. 0,25 mm to 0,5 mm, which will then give a measurable axial internal clearance.

The provisional shim thickness X_1 is calculated as follows:

$$X_1 = B_i - L + s$$

X_1 mm
Provisional shim thickness, *Figure 3*

B_i mm
Total width of inner ring according to inspection record

L mm
Measured seat length of shaft

s mm
Thickness of the shim produced,
s = 0,25 mm to 0,5 mm.

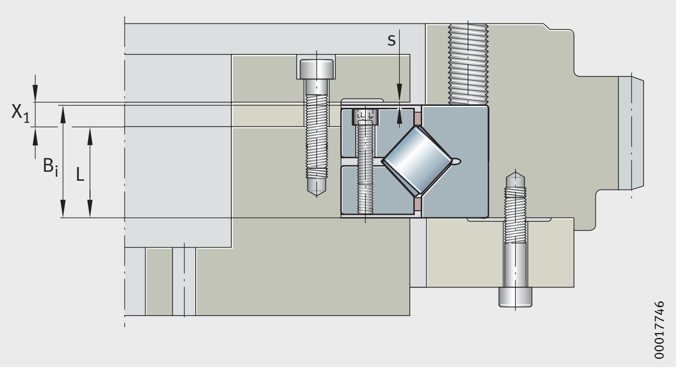


Figure 3
Bearing arrangement with provisional shim thickness X_1

Determining the required shim thickness

After the axial internal clearance has been measured, the final shim thickness X is then determined. The axial internal clearance can be determined by lifting the outer ring together with the adjacent parts.

Determining the required shim thickness:

$$X = X_1 - A - V$$

Determining the preload:

$$V = 2 \cdot \frac{\sqrt[1,08]{F_V}}{C_s}$$

X mm
Required shim thickness, *Figure 4*

X_1 mm
Provisional shim thickness

A mm
Measured axial internal clearance

V mm
Preload

F_V kN
Preload force, recommended value approx. 3,5% of the basic dynamic load rating C

C_S $kN^{0,926}/mm$
Axial spring constant, see dimension table.

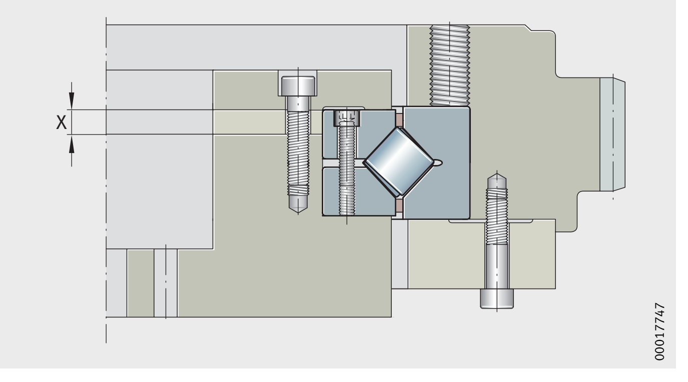


Figure 4
Bearing arrangement with required shim thickness X

Rigidity

Due to the large number of cylindrical rollers, the bearing has a high axial and radial load carrying capacity. The line contact between the rollers and the raceways also gives high rigidity that is increased further by the preload when the bearing is fitted. The axial displacement δ_a of the crossed roller bearings under a concentric axial force K_a can be determined using the following formulae.

Axial deflection for $K_a \leqq 2{,}114 \cdot F_V$:

$$\delta_a = \frac{K_a}{2{,}114 \cdot F_V^{0{,}074} \cdot C_s}$$

Axial deflection for $K_a > 2{,}114 \cdot F_V$:

$$\delta_a = \frac{\sqrt[1{,}08]{K_a} - \sqrt[1{,}08]{F_V}}{C_s}$$

δ_a mm
Axial displacement between shaft locating washer and housing locating washer

K_a kN
Internal axial force

F_V kN
Bearing preload

C_S $kN^{0{,}926}/mm$
Axial rigidity factor.

The calculation result only gives the bearing deflection.
The elasticity of the adjacent construction must additionally be taken into consideration.

Sealing

The bearings are of an open design. The sealing arrangement can be designed anywhere within the adjacent construction.

Lubrication

The crossed roller bearings can be lubricated with oil or grease.

Grease lubrication

For grease lubrication, a high quality lithium soap grease KP2N–20 to DIN 51825 is suitable, such as Arcanol MULTITOP.

For low speeds, and especially for horizontal axes, the simple grease lubrication method should be used. In vertical axes with grease lubrication, a baffle plate should be fitted under the bearing to minimise the escape of grease. We recommend the use of a grease with a lithium soap base and EP additives. When initial greasing is carried out, the space between the rollers should be filled with grease. A relubrication quantity of 20% to 30% of the initial grease quantity is recommended.

Oil lubrication

For oil lubrication, oils CLP to DIN 51 517 or HLP to DIN 51 524 of viscosity classes ISO VG 46 to ISO VG 68 are suitable.

Recirculating oil lubrication

In general, the recirculating oil lubrication for the crossed roller bearings can also be used for the drive system. If lubrication is to provided for the bearing only, a smaller quantity is sufficient.
If the oil must also provide cooling, as is the case at higher speeds, larger quantities of oil are required, *Figure 5*. In each individual case, the oil quantity actually required can be determined by measuring the temperature of the bearing.

$\dot{V}$ = oil quantity
D = bearing outside diameter
a = oil quantity sufficient for lubrication
b = oil quantity required for cooling and lubrication

① Lubrication and cooling
② Lubrication only

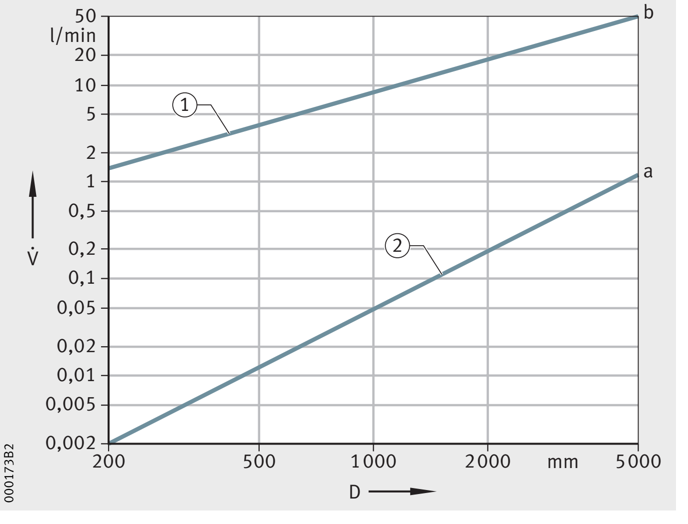


Figure 5
Oil quantities

Reference viscosity for mineral oils

The kinematic oil viscosity required for adequate lubrication is determined from the reference viscosity ν_1. In this case, it is assumed that the operating viscosity ν of the oil (viscosity at operating temperature) is identical to the reference viscosity ν_1. The objective should be to achieve a ratio $\kappa = \nu/\nu_1 = 2$, *Figure 6*.

The reference viscosity is dependent on the bearing diameter $d_M = (D + d)/2$ and the speed. The operating viscosity ν is determined with the aid of the viscosity/temperature diagram, taking account of the assumed operating temperature and the nominal viscosity at +40 °C. An oil with an operating viscosity higher than ν_1 at operating temperature will have a positive effect on the fatigue life of the bearing. In addition, the EP additives give adequate lubricity at low speeds. They are also necessary at low κ values.

n = operating speed
ν_1 = reference viscosity
d_M = mean bearing diameter (d +D)/2
ϑ = operating temperature

① Viscosity mm^2s^{-1} at +40 °C

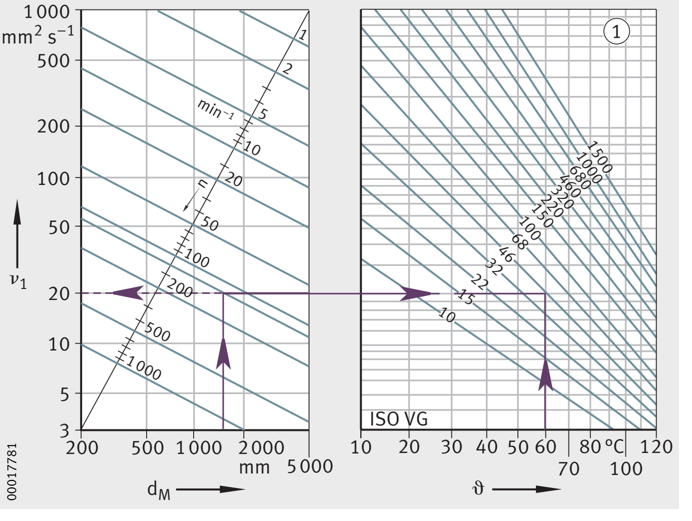


Figure 6
Reference viscosity and V/T diagram for mineral oils

Operating temperature

Crossed roller bearings are suitable for operating temperatures from −30 °C to +80 °C.

Design and safety guidelines

Checking the static load safety factor

The static load safety factor can be checked in approximate terms if the load arrangement is present and all the requirements relating to clamping rings, location, fitting and lubrication are fulfilled, *Figure 2*, page 61.

In order to check the static load carrying capacity, the following equivalent static operating values must be determined:

- bearing load F_{0q}
- tilting moment load M_{0q}.

Checking is possible for applications with or without radial load.

Where load arrangements are more complex or the conditions are not fulfilled, please contact us.

Safety factors

For smooth running, the objective should be a factor $f_S \geqq 4$, see page 11.

Calculation of the rating life

The methods for calculating the rating life are:

- the basic rating life L_{10} and L_{10h} to ISO 281, see page 12
- the simplified form of rating life calculation based on empirical values, see page 68.

Validity

The rating life formulae for L and L_h are only valid:

- with a load arrangement in accordance with *Figure 2*, page 61
- if all the requirements are fulfilled in relation to location (the bearing rings must be rigid or firmly connected to the adjacent construction), fitting, lubrication and sealing
- if the load and speed in the duty cycle can be regarded as constant during operation.

Simplified form of rating life calculation

In order to provide evidence of the rating life, a simplified form of rating life calculation can be selected for crossed roller bearings within a duty cycle. Within such a duty cycle, the speed and load are regarded as constant.

The dynamic factor f_L to be achieved in this calculation is an empirical value against which new designs and proven bearing arrangements are compared.

$$f_L = \frac{C}{P} \cdot f_n$$

f_L –
Dynamic factor, see table, page 70.
For use of crossed roller bearings in machine tools: $3{,}5 \leqq f_L \leqq 5$

C kN
Basic dynamic load rating

f_n –
Speed factor, see table, page 69

P kN
Equivalent dynamic bearing load.

Calculation of the equivalent dynamic load

The equivalent dynamic bearing load P comprises the relevant axial and radial forces, see formulae.

For $F_a/F_r \leqq 1{,}4$:

$$P = 1{,}4 \cdot F_r + 0{,}67 \cdot F_a$$

For $F_a/F_r > 1{,}4$:

$$P = 0{,}93 \cdot F_r + F_a$$

Preload force, decisive axial force for $K_a \leqq 2{,}114 \cdot F_V$:

$$F_a = F_v + 0{,}5 \cdot K_a$$

Preload force, decisive axial force for $K_a > 2{,}114 \cdot F_V$:

$$F_a = K_a$$

Axial preload:

$$V = 2 \cdot \frac{\sqrt[1{,}08]{F_V}}{C_s}$$

P kN
Equivalent dynamic bearing load

F_r, F_a kN
Axial or radial dynamic bearing load

F_V kN
Preload force, recommended value approx. 3% of the basic dynamic load rating C

K_a kN
External axial force

V mm
Preload travel

C_S $kN^{0{,}926}/mm$
Axial rigidity factor, see dimension table.

Speed factor f_n for roller bearings

The speed factor f_n is different for each speed value, see table.
Calculation of the speed factor:

$$f_n = \frac{\sqrt[\frac{10}{3}]{33\frac{1}{3}}}{n}$$

Specified values for f_n

Speed n min^{-1}	Speed factor f_n
1	2,86
2	2,33
3	2,06
4	1,89
5	1,77
6	1,67
7	1,6
8	1,53
9	1,48
10	1,44
15	1,27
20	1,17
30	1,03
40	0,947
50	0,885
60	0,838
70	0,8
80	0,769
90	0,742
100	0,719
150	0,637
200	0,584
300	0,517
400	0,475
500	0,444
600	0,42
700	0,401
800	0,385
900	0,372
1 000	0,36
1 100	0,35
1 200	0,341

Dynamic factor f_L for roller bearings

The rating life L_h can be derived from the dynamic factor, see table.
Calculation of the rating life from the dynamic factor:

$$L_h = 500 \cdot f_L^{10/3}$$

Specified values for f_L

Dynamic factor f_L	Rating life L_h h
1,23	1 000
1,39	1 500
1,52	2 000
1,71	3 000
1,87	4 000
2	5 000
2,11	6 000
2,21	7 000
2,3	8 000
2,38	9 000
2,46	10 000
2,77	15 000
3,02	20 000
3,42	30 000
3,72	40 000
3,98	50 000
4,2	60 000
4,4	70 000
4,58	80 000
4,75	90 000
4,9	100 000

Shaft and housing tolerances

The inner and outer rings should always have a tight fit. In order to give easier mounting and allow setting of the bearing preload, however, the ring under point load has a less tight fit. In the case of crossed roller bearings in machine tools, this is the inner ring. Crossed roller bearings are therefore mounted with a loose fit on the shaft.

When defining the diameters for the shaft and housing bore, the actual dimensions for the bearing bore and outside diameter are used. The actual dimensions are given in the inspection record included with each bearing.

Mounting tolerances for the shaft

Since the inner ring is subjected to point load, it has a loose fit. As a guide value, it is recommended that the shaft should be machined to give a fit clearance, see formula and table.

$$P = \sqrt[3]{d}$$

P µm
Fit, fit clearance
d mm
Shaft diameter.

Mounting tolerances

Nominal dimension range d		Roundness tolerance t_1	Total axial runout tolerance t_2
> mm	≦ mm	µm	µm
–	250	7	4
250	315	7	4
315	400	8	5
400	500	8	6
500	630	9	7
630	800	11	9
800	1 000	12	10
1 000	1 250	14	12
1 250	1 600	16	13
1 600	2 000	20	17
2 000	2 500	23	20
2 500	3 150	28	23
3 150	4 000	34	27

Mounting tolerances for the housing bore

Since the outer ring is subjected to circumferential load, it has a tight fit. When machining the housing bore, this should give the following fit interference, see formula and table.

$$P = 0{,}03 \cdot D$$

P μm
Fit, fit interference
D mm
Housing diameter.

Mounting tolerances

Nominal dimension range D		Roundness tolerance t_1	Total axial runout tolerance t_2
> mm	≦ mm	μm	μm
–	315	10	6
315	400	12	7
400	500	12	9
500	630	13	11
630	800	15	13
800	1 000	18	15
1 000	1 250	20	18
1 250	1 600	23	20
1 600	2 000	27	25
2 000	2 500	33	30
2 500	3 150	39	35
3 150	4 000	47	40
4 000	5 000	57	50

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: see table.

Guide values for roughness of bearing seating surfaces

Diameter of bearing seat d (D) mm		Recommended mean roughness values Ra[1] for ground bearing seats Corresponding diameter tolerance µm		
over	incl.	IT6	IT5	IT4
80	500	1,6 (N7)	0,8 (N6)	0,4 (N5)
500	1 600	1,6 (N7)	1,6 (N7)	0,8 (N6)
1 600	4 000	3,2 (N8)	3,2 (N8)	1,6 (N6)

1) The values in brackets are roughness classes to DIN ISO 1302.

Location using clamping rings

For location of crossed roller bearings, covers or labyrinth covers have proved effective.

Bearing rings must always be rigidly and uniformly supported over their entire circumference and width.

The thickness of the clamping rings and the contact flanges must be matched to the requirements.

Fixing screws

For location of the bearing rings or clamping rings, screws of grade 10.9 are suitable.

Any deviations from the recommended size, grade and quantity of screws will considerably reduce the load carrying capacity and operating life of the bearings.

For screws of grade 12.9, the minimum strength of the clamping rings must be achieved or quenched and tempered seating washers must be used.

Securing of screws

Normally, the screws are adequately secured by the correct preload. If regular shock loads or vibrations occur, however, additional securing of the screws may be necessary.

Not every method of securing screws is suitable for crossed roller bearings.

Never use spring washers or split washers.

General information on securing of screws is given in DIN 25201, and securing by means of adhesive in particular is described in DIN 25203, issue 1992.

If this is to be used, please consult the relevant companies.

Fitting of crossed roller bearings

The bores and edges of the adjacent components must be free from burrs. The support surfaces for the bearing rings must be clean.

The seating and locating surfaces for the bearing rings on the adjacent construction must be lightly oiled or greased.

Lightly oil the thread of the fixing screws in order to prevent varying friction factors (do not oil or grease screws that will be secured by means of adhesive).

! Ensure that all adjacent components and lubrication ducts are free from cleaning agents, solvents and washing emulsions.
The bearing seating surfaces can rust or the raceway system can become contaminated.

Mounting forces must only be applied to the bearing ring to be fitted; they must never be directed through the rolling elements or seals. Avoid direct blows on the bearing rings.

Locate the bearing rings consecutively and without application of any external load.

Mounting

The inner rings must be screwed together using the fixing screws for better transport. These must be loosened during mounting so that preload is no longer present. For easier handling during mounting and dismounting, one inner ring has three threaded holes for eye bolts.

Checking operation

Once mounting is complete, the operation of the fitted crossed roller bearing must be checked.

! If the bearing runs irregularly or roughly, or the temperature in the bearing shows an unusual increase, dismount and check the bearing and mount the bearing again in accordance with the fitting guidelines described.

Accuracy

The running tolerances are based on DIN 620-2 and DIN 620-3 and are in a range better than P4, see tables. The main dimensions are produced to tolerance P5.

Bearings in metric sizes

Tolerances for inner rings and outer rings in metric sizes: see tables.

Inner ring tolerances

Bore d mm		Deviation Δ_{dmp} μm		Width deviation Δ_{Bs} μm		Radial runout K_{ia} μm	Axial runout S_{ia} μm
over	incl.	max.	min.	max.	min.	max.	max.
–	250	0	–20	0	–300	5	5
250	315	0	–23	0	–350	7	7
315	400	0	–25	0	–375	7	7
400	500	0	–27	0	–400	9	9
500	630	0	–30	0	–450	11	11
630	800	0	–35	0	–525	13	13
800	1 000	0	–40	0	–600	15	15
1 000	1 250	0	–46	0	–700	18	18
1 250	1 600	0	–54	0	–800	20	20
1 600	2 000	0	–65	0	–1 000	25	25
2 000	2 500	0	–77	0	–1 200	30	30
2 500	3 150	0	–93	0	–1 400	35	35
3 150	4 000	0	–114	0	–1 700	40	40

Outer ring tolerances

Outside diameter D mm		Deviation Δ_{Dmp}, Δ_{Ds} μm		Width deviation Δ_{Bs} μm		Radial runout K_{ea} μm	Axial runout S_{ea} μm
over	incl.	max.	min.	max.	min.	max.	max.
–	315	0	–20	0	–350	K_{ea} and S_{ea} are identical to the associated values of the inner ring	
315	400	0	–23	0	–375		
400	500	0	–25	0	–400		
500	630	0	–27	0	–450		
630	800	0	–30	0	–525		
800	1 000	0	–35	0	–600		
1 000	1 250	0	–40	0	–700		
1 250	1 600	0	–46	0	–800		
1 600	2 000	0	–54	0	–1 000		
2 000	2 500	0	–65	0	–1 200		
2 500	3 150	0	–77	0	–1 400		
3 150	4 000	0	–93	0	–1 700		

Bearings in inch sizes

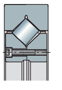
Tolerances for inner rings and outer rings in inch sizes: see tables.

Inner ring tolerances

Bore d mm		Deviation Δ_{dmp}, Δ_{ds} µm		Width deviation Δ_{Bs} µm		Radial runout K_{ia} µm	Axial runout S_{ia} µm
over	incl.	max.	min.	max.	min.	max.	max.
–	304,8	+13	0	Values are identical to those for the metric sizes			
304,8	609,6	+25	0				
609,6	914,4	+38	0				
914,4	1 219,2	+51	0				
1 219,2	–	+76	0				

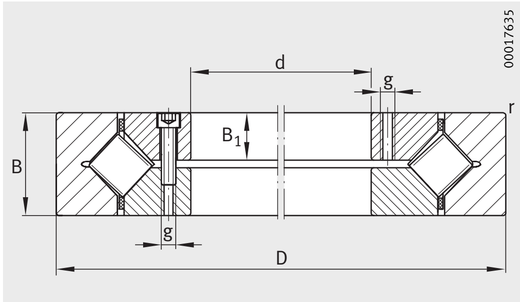
Outer ring tolerances

Outside diameter D mm		Deviation Δ_{Dmp}, Δ_{Ds} µm		Width deviation Δ_{Bs} µm		Radial runout K_{ea} µm	Axial runout S_{ea} µm
over	incl.	max.	min.	max.	min.	max.	max.
–	304,8	+13	0	Values are identical to those for the metric sizes			
304,8	609,6	+25	0				
609,6	914,4	+38	0				
914,4	1 219,2	+51	0				
1 219,2	–	+76	0				



Crossed roller bearings

Adjustable preload
Metric sizes and inch sizes

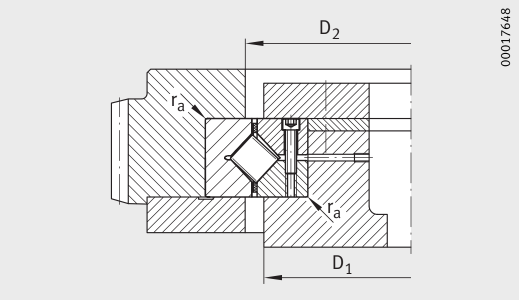


Z-549

Dimension table · Dimensions in mm							
Designation	Mass	Dimensions					
	m	d	D	B	B_1	r	g
	≈kg					min.	
Z-549800[1]	6,1	203,2	279,4	31,75	14,475	1,5	–
Z-549801	14	300	400	38	17,25	1,5	–
Z-549802[1]	33	330,2	457,2	63,5	29,825	4	–
Z-549803	43	380	520	65	30,05	4	–
Z-549804[1]	70	414,95	614,924	65	30,05	4	M8
Z-549805[1]	54	457,2	609,6	63,5	29,3	4	–
Z-549806	101	580	760	80	37	6	M10
Z-549807[1]	152	685,8	914,4	79,375	36,688	4	M10
Z-549808	150	740	940	85	39,5	5	M10
Z-549809[1]	189	901,7	1 117,6	82,55	38,275	4	M12
Z-549810[1]	420	1 028,7	1 327,15	114,3	53,45	5	M16
Z-549811	305	1 100	1 350	95	43,8	4	M16
Z-549812[1]	354	1 270	1 524	95,25	43,925	4	M16
Z-549813	400	1 340	1 600	100	46,3	4	M16
Z-549814[1]	418	1 384,3	1 651	98,425	45,513	4	M16
Z-549815[1]	503	1 549,4	1 828,8	101,6	47,1	4	M16
Z-549816	573	1 580	1 870	110	51,3	4	M16
Z-549817[1]	1 850	1 749,872	2 219,874	190	89,4	7,5	M24
Z-549818[1]	689	1 879,6	2 197,1	101,6	47,1	6	M16
Z-549819	940	2 100	2 430	120	55,8	6	M20
Z-549820[1]	1 125	2 463,8	2 819,4	114,3	53,45	6	M20
Z-549821	1 652	3 000	3 380	130	60,8	6	M24
Z-549822	2 286	3 500	3 920	140	65,45	6	M30
Z-549823	3 161	4 000	4 460	155	72,95	6	M30

[1] Bearings in inch sizes.

[2] The speed limits stated are based on a preload $F_V \approx 3{,}5\%$ of C.
If a higher preload F_V is present, the speed limits are lower.

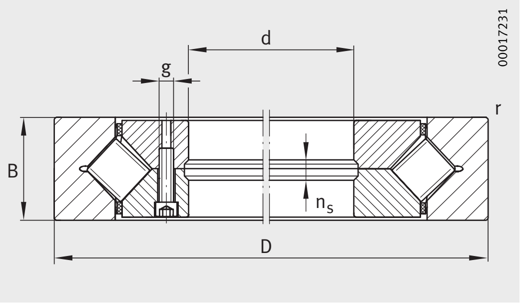


Mounting dimensions

Mounting dimensions			Basic load ratings		Limiting speeds[2)]		Axial spring constant	Grease quantity, initial greasing
D_1 min.	D_2 max.	r_a max.	dyn. C kN	stat. C_0 kN	n_G grease min^{-1}	n_G oil min^{-1}	C_S $kN^{0,926}/mm$	kg
233	253	1,5	116	430	450	900	1 110	0,07
343	367	1,5	190	815	300	630	1 660	0,13
383	417	3	320	1 320	280	560	1 880	0,3
437	477	3	455	1 860	260	530	2 180	0,46
500	540	3	490	2 160	220	450	2 490	0,51
521	562	3	500	2 280	220	430	2 590	0,53
654	704	5	735	3 550	180	360	3 230	0,96
784	839	3	930	4 750	150	300	3 810	1,4
817	871	4	950	4 900	140	280	3 940	1,5
987	1 041	3	1 060	6 000	110	220	4 720	1,7
1 147	1 221	4	1 700	9 300	85	170	5 250	3,8
1 207	1 268	3	1 370	8 150	80	160	5 550	2,7
1 379	1 440	3	1 460	9 300	67	130	6 250	3,1
1 449	1 517	3	1 760	11 000	60	120	6 600	3,9
1 500	1 562	3	1 530	10 200	60	120	6 800	3,3
1 669	1 737	3	1 900	12 700	45	90	7 500	4,5
1 697	1 768	3	2 080	14 000	48	95	7 600	5,5
1 933	2 055	6	4 500	27 000	60	120	8 450	17
1 993	2 088	5	2 080	15 600	36	70	9 050	5,5
2 241	2 322	5	2 850	20 800	34	70	9 900	8,5
2 612	2 686	5	2 600	21 200	28	56	11 100	8,5
3 165	3 252	5	3 600	31 000	24	48	13 200	14
3 685	3 777	5	4 250	38 000	20	43	15 200	18
4 202	4 304	5	5 300	49 000	19	38	17 400	25

Crossed roller bearings

Specified, defined preload
Metric sizes and inch sizes

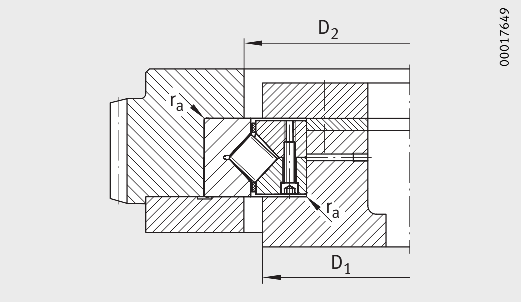


Z-556, Z-562

Dimension table · Dimensions in mm

Designation	Mass	Dimensions					
	m	d	D	B	n_s	r	g
	≈kg					min.	
Z-556904-A[1]	6,1	203,2	279,4	31,75	6	1,5	–
Z-556905-A	14	300	400	38	8	1,5	–
Z-556906-A[1]	33	330,2	457,2	63,5	13	4	–
Z-556907-A	43	380	520	65	13	4	–
Z-562601[1]	70	414,95	614,924	65	13	4	M8
Z-556908-A[1]	54	457,2	609,6	63,5	13	4	–
Z-556910-A	101	580	760	80	16	6	M10
Z-556911-A[1]	152	685,8	914,4	79,375	16	4	M10
Z-556912-A	150	740	940	85	17	5	M10
Z-556913-A[1]	189	901,7	1 117,6	82,55	17	4	M12
Z-562602[1]	420	1 028,7	1 327,15	114,3	23	5	M16
Z-556916-A	305	1 100	1 350	95	19	4	M16
Z-556917-A[1]	354	1 270	1 524	95,25	19	4	M16
Z-556918-A	400	1 340	1 600	100	20	4	M16
Z-556919-A[1]	418	1 384,3	1 651	98,425	20	4	M16
Z-556920-A[1]	503	1 549,4	1 828,8	101,6	20	4	M16
Z-556921-A	573	1 580	1 870	110	22	4	M16
Z-562603[1]	1 850	1 749,872	2 219,874	190	38	7,5	M24
Z-556923-A[1]	689	1 879,6	2 197,1	101,6	20	6	M16
Z-556924-A	940	2 100	2 430	120	24	6	M20
Z-556926-A[1]	1 125	2 463,8	2 819,4	114,3	23	6	M20
Z-556928-A	1 652	3 000	3 380	130	26	6	M24
Z-556929-A	2 286	3 500	3 920	140	28	6	M30
Z-562604	3 161	4 000	4 460	155	31	6	M30

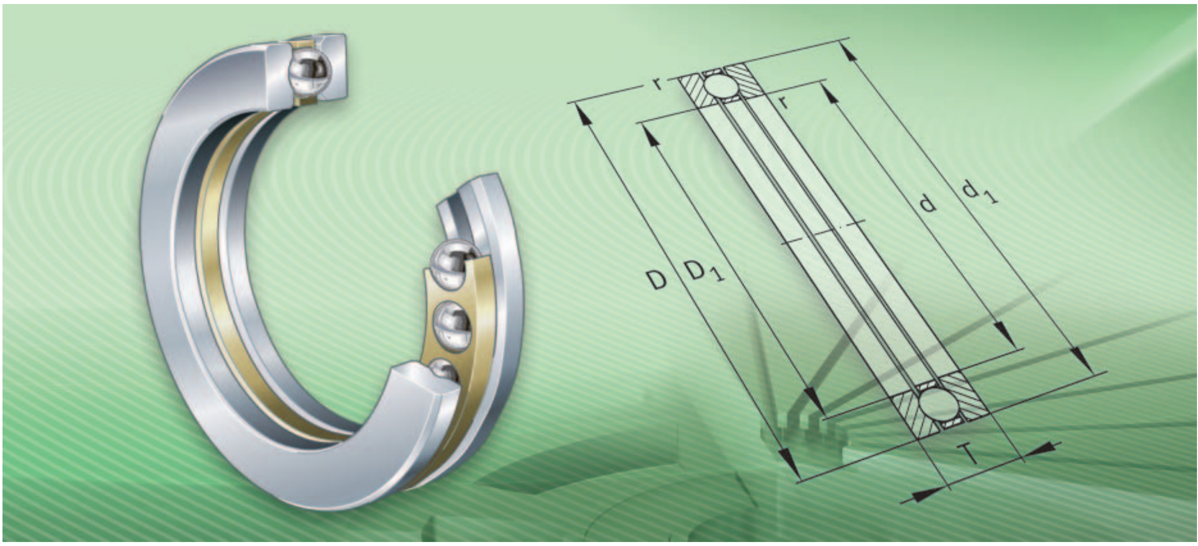
[1] Bearings in inch sizes.



Mounting dimensions

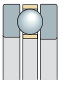
Mounting dimensions			Basic load ratings		Limiting speeds		Axial spring constant	Grease quantity, initial greasing	Preload force
D_1	D_2	r_a	dyn. C	stat. C_0	n_G grease	n_G oil	C_S		F_V
min.	max.	max.	kN	kN	min^{-1}	min^{-1}	$kN^{0,926}/mm$	kg	kN
233	253	1,5	122	455	450	900	1 160	0,07	4,3
343	367	1,5	200	880	300	630	1 770	0,13	7
383	417	3	340	1 400	280	560	1 990	0,3	12
437	477	3	480	2 040	260	530	2 350	0,46	17
500	540	3	520	2 360	220	450	2 580	0,51	18
521	562	3	540	2 450	220	430	2 790	0,53	19
654	704	5	800	3 900	180	360	3 480	0,96	28
784	839	3	1 000	5 100	150	300	4 080	1,4	35
817	871	4	1 020	5 300	140	280	4 220	1,5	36
987	1 041	3	1 140	6 550	110	220	5 050	1,7	40
1 147	1 221	4	1 800	10 000	85	170	5 600	3,8	60
1 207	1 268	3	1 460	9 000	80	160	6 000	2,7	50
1 379	1 440	3	1 560	10 200	67	130	6 750	3,1	55
1 449	1 517	3	1 860	12 000	60	120	7 050	3,9	65
1 500	1 562	3	1 630	11 200	60	120	7 350	3,3	55
1 669	1 737	3	2 000	13 700	45	90	8 050	4,5	70
1 697	1 768	3	2 200	15 000	48	95	8 050	5,5	75
1 933	2 055	6	4 750	29 000	60	120	8 950	17	170
1 993	2 088	5	2 200	17 000	36	70	9 650	5,5	75
2 241	2 322	5	3 000	22 400	34	70	10 500	8,5	110
2 612	2 686	5	2 750	22 800	28	56	11 800	8,5	95
3 165	3 252	5	3 800	33 500	24	48	14 000	14	130
3 685	3 777	5	4 500	41 500	20	43	16 100	18	160
4 202	4 304	5	5 500	53 000	19	38	18 300	25	190

FAG



Axial deep groove ball bearings

Axial deep groove ball bearings



Axial deep groove ball bearings

Brass cage

511, Z-5, F-5, F-8

Axial deep groove ball bearings

Features

Axial deep groove ball bearings comprise a shaft locating washer, a housing locating washer and a ball and cage assembly.
The bearings are not self-retaining; the ball and cage assembly and bearing washers can therefore be fitted separately.

Single direction axial deep groove ball bearings can support axial forces in one direction, but must not be subjected to radial loads.

Operating temperature

Axial deep groove ball bearings can be used at operating temperatures from –30 °C to +150 °C.

Cages

Large axial deep groove ball bearings have ball-guided solid cages made from brass (suffix M or MP) or steel (suffix F or FP), see table.

Suffixes

Suffixes for available designs: see table.

Available designs

Suffix	Description	Design
F	Solid steel cage, ball-guided	Standard
FP	Solid steel window cage, ball-guided	
M	Solid brass cage, ball-guided	
MP	Solid brass window cage, ball-guided	
P5	Higher accuracy to tolerance class P5	Special design
MPB	Solid brass window cage, washer-guided	Special design, available by agreement
M15	With measurement record	
J15	Actual value indication, marking	
J26	Marking of maximum wall thickness variation	

Ordering designation

Axial deep groove ball bearing with measurement record and marking of wall thick variation:

- 511/1320-MP-P5-J26CA-M15EZ
  - CA = shaft locating washer, housing locating washer
  - E = scope of measurements, in this case including d, D, S_i, S_e
  - Z = measurement record included in packaging.

Design and safety guidelines

Axial deep groove ball bearings can support axial forces only.

For calculation of the complete bearing arrangement, advice should be sought from the engineering service of the Schaeffler Group.

Equivalent dynamic bearing load

For bearings under dynamic loading, the following applies:

$$P = F_a$$

P kN
Equivalent dynamic bearing load

F_a kN
Axial dynamic bearing load.

Equivalent static bearing load

For bearings under static loading, the following applies:

$$P_0 = F_{0a}$$

P_0 kN
Equivalent static bearing load

F_{0a} kN
Axial static bearing load.

Minimum axial load

At higher speeds, detrimental sliding movements can occur between the rolling elements and the raceways due to centrifugal forces and gyroscopic moments. In order to prevent slippage, the bearings must be subjected to a minimum load $F_{a\,min}$.

The minimum load factor A is given in the dimension table.
For n_{max}, the maximum operating speed must be used.

$$F_{a\,min} = A \cdot \left(\frac{n_{max}}{1000}\right)^2$$

$F_{a\,min}$ kN
Minimum axial load

A –
Minimum load factor, see dimension table

n_{max} min^{-1}
Maximum operating speed.

Speeds

ISO 15312 does not give thermal reference speeds for axial deep groove ball bearings.

The dimension table gives limiting speeds for oil lubrication.

Design of bearing arrangements

In order to make comprehensive use of the performance capacity of the bearings, the adjacent construction must be of an appropriate design.

Shaft and housing tolerances

For single direction bearings, the shaft tolerance j6 should be selected.

The tolerance of the locating bore is dependent on the running accuracy to be achieved. For normal running accuracy, the tolerance should be in the tolerance zone E8, for high running accuracy it should be in the tolerance zone H6.

Customer-specific solutions are available by agreement.

Adjacent parts

The shoulders on the adjacent construction must be sufficiently high for centring of the shaft and housing that the shaft and housing locating washers are supported over at least half their height.

The abutment shoulders should be rigid, flat and perpendicular to the axis of rotation.

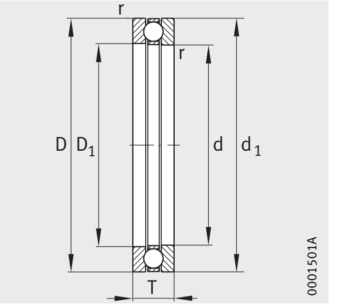
The maximum values for the radii r_a and the diameters of the abutment surfaces d_a, D_a are indicated in the dimension table.

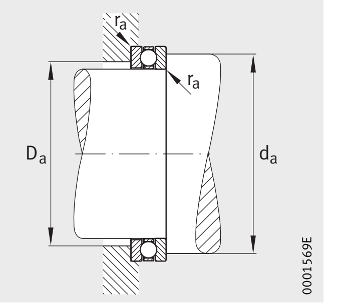
Accuracy

Dimensional and geometrical tolerances

The main dimensions for single direction bearings correspond to ISO 104 or DIN 711, see dimension table.

Axial deep groove ball bearings

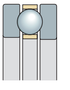




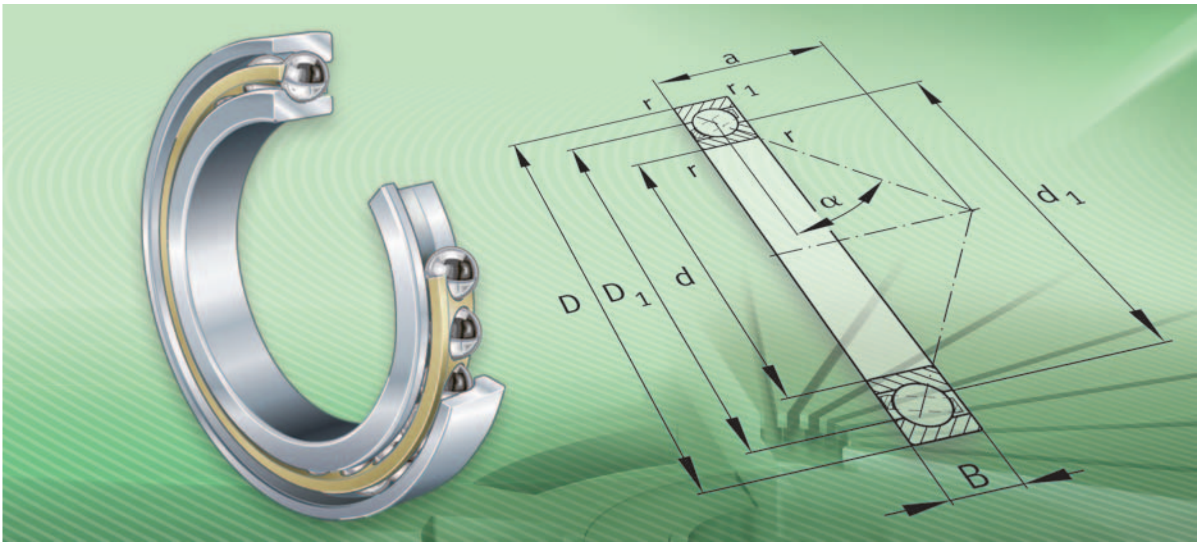
Mounting dimensions

Dimension table · Dimensions in mm

Designation	Dimensions						Mounting dimensions			Basic load ratings		Limiting speed	Axial run-out	Minimum load factor
	d	D	T	D_1	d_1	r	d_a min.	D_a max.	r_a	dyn. C kN	stat. C_0 kN	n_G oil min^{-1}	μm	A
F-574386	500	595	80	500	595	2	550	545	2,1	550	3 350	530	5	58
F-574387	600	705	85	600	705	3	672	633	3	640	4 400	450	5	101
511/630-MP-P5	630	750	95	635	745	3	702	678	2,5	720	5 000	430	11	130
F-573064	800	945	90	800	945	4	894	851	4	750	5 850	360	5	204
F-571056	1 000	1 175	109	1 000	1 175	5	1 091	1 056	5	1 270	11 600	300	5	724
511/1060-MP-P5	1 060	1 250	150	1 065	1 245	5	1 174	1 136	4	1 530	14 600	280	18	1 100
Z-577616	1 250	1 495	150	1 250	1 495	6	1 412	1 337	6	1 660	17 300	220	5	1 600
511/1320-MP-P5	1 320	1 540	175	1 325	1 535	6	1 451	1 406	5	1 760	19 000	200	21	1 900
F-570970	1 700	1 960	170	1 700	1 960	7,5	1 828	1 731	7,5	2 400	30 000	170	5	4 860
F-807089	2 240	2 485	150	2 240	2 485	5	2 399	2 326	5	1 960	28 500	150	10	4 500
Z-546992	3 900	4 100	130	4 100	4 095	3	4 030	3 970	3	1 270	28 000	85	30	9 000



FAG



Single row angular contact ball bearings

Single row angular contact ball bearings

Single row angular contact ball bearings

Single row

70, 719

Single row angular contact ball bearings

Features

Single row angular contact ball bearings are, with a few exceptions, self-retaining units with solid inner and outer rings and ball and cage assemblies with cages. The raceways of the inner and outer rings are offset from each other along the bearing axis. The angular adjustment facility of these bearings is very limited.

Radial and axial load capacity

Single row angular contact ball bearings can support axial forces in one direction and high radial forces. They must be axially adjusted against a second bearing.

The axial load carrying capacity is dependent on the contact angle. Bearings with a contact angle 40° have a higher axial load carrying capacity than those with a contact angle 30°.

Sealing

The bearings are not sealed.

Lubrication

Single row angular contact ball bearings can be lubricated with grease or oil.

Operating temperature

Angular contact ball bearings without seals can be used at operating temperatures from –30 °C to +150 °C.

Bearings with a diameter $D > 240$ mm are dimensionally stable up to +200 °C.

Cages

Angular contact ball bearings with ball-guided solid window cages made from brass have, in the case of bearings of standardised series, the suffix MP.

The suffixes MPA or MPB(S) indicate bearings with a solid window cage made from brass that is guided on the outer ring or inner ring.

Suffixes

Suffixes for available designs of standard bearings: see table.

Available designs

Suffix	Description	Design
B	Modified internal construction	Standard
MP	Solid brass cage	Standard
P5	Bearings in tolerance class P5	Special design
M15	With measurement record	Special design, available by agreement
J15	Actual value indication, marking	

Design and safety guidelines

Equivalent dynamic bearing load

The equivalent dynamic load P is valid for bearings that are subjected to radial and axial dynamic loads. It gives the same rating life as the combined bearing load occurring in practice.

Contact angle 40°

For bearings under dynamic loading, the following applies:

Bearing arrangement	Load ratio	Equivalent dynamic bearing load
Single bearing	$\frac{F_a}{F_r} \leqq 1{,}14$	$P = F_r$
	$\frac{F_a}{F_r} > 1{,}14$	$P = 0{,}35 \cdot F_r + 0{,}57 \cdot F_a$

F_a kN
Axial dynamic bearing load
F_r kN
Radial dynamic bearing load
P kN
Equivalent dynamic bearing load for combined load.

Contact angle 30°

For bearings under dynamic loading, the following applies:

Bearing arrangement	Load ratio	Equivalent dynamic bearing load
Single bearing	$\frac{F_a}{F_r} \leqq 0{,}8$	$P = F_r$
	$\frac{F_a}{F_r} > 0{,}8$	$P = 0{,}39 \cdot F_r + 0{,}76 \cdot F_a$

F_a kN
Axial dynamic bearing load
F_r kN
Radial dynamic bearing load
P kN
Equivalent dynamic bearing load for combined load.

Minimum load

In continuous operation, angular contact ball bearings with cage must therefore be subjected to a minimum load of the order of $P/C_r > 0{,}01$.

Speeds

For the limiting speeds n_G of the bearings, see dimension table.

! The kinematic limiting speeds n_G for the main bearing should not be exceeded.

Design of bearing arrangements

In order to make comprehensive use of the performance capacity of the bearings, the adjacent construction must be of an appropriate design.

Shaft and housing tolerances

Recommended shaft tolerances for radial bearings with cylindrical bore, see table, page 37.

Recommended housing tolerances for radial bearings, see table, page 38.

Mounting dimensions

The bearing table gives the maximum dimension of the radii r_a and r_{a1} and the diameters of the abutment shoulders D_a, D_b and d_a.

Accuracy

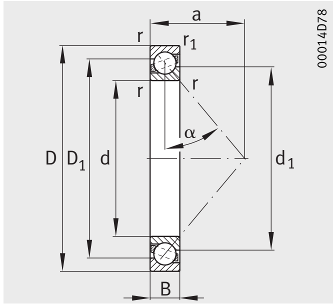
Dimensional and geometrical tolerances

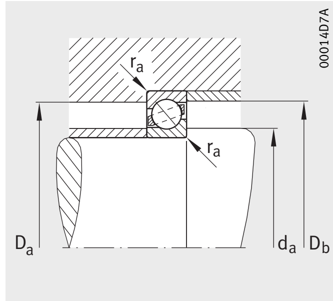
Angular contact ball bearings with standardised main dimensions correspond to DIN 628-1.

The dimensional and geometrical tolerances of the standardised bearings correspond to tolerance class P5 to DIN 620-2.
We can provide the tolerances of the non-standardised bearings by agreement.

Angular contact ball bearings

Single row

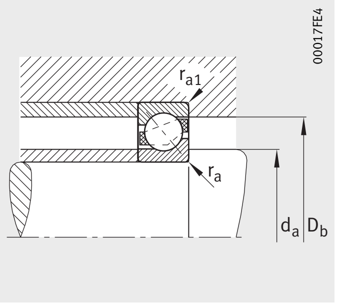




Mounting dimensions

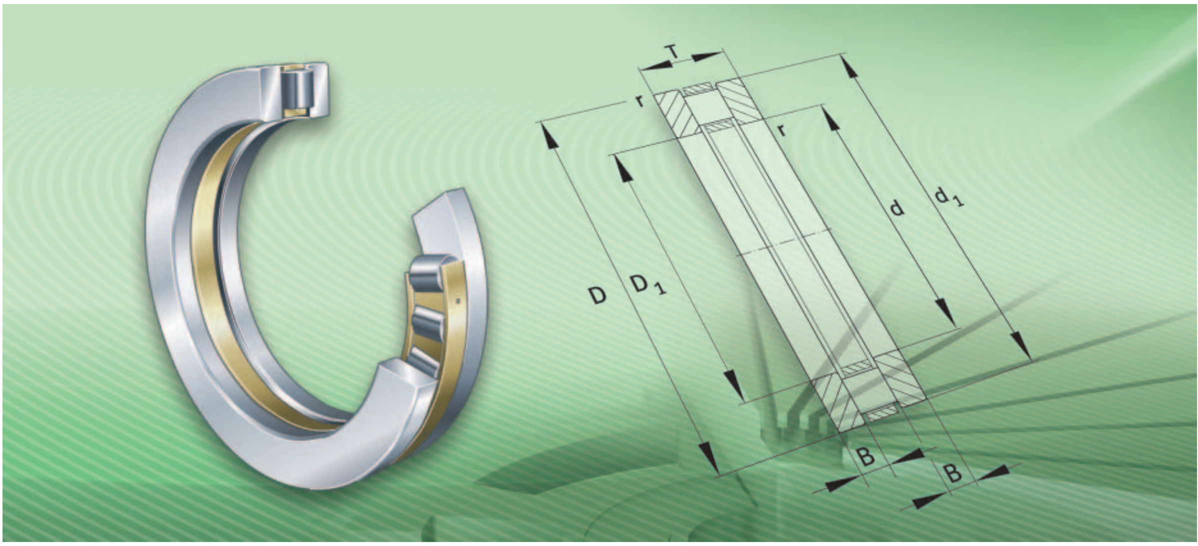
Dimension table · Dimensions in mm

Designation	Dimensions									Mounting dimensions	
	d	D	B	r	r_1	D_1	d_1	a	α	d_a	D_a
				min.	min.	≈	≈	≈	°	min.	max.
7044-B-MP-P5	220	340	56	3	1,1	293,8	269	109	40	232,4	327,6
7060-MP-P5	300	460	74	4	1,5	402,9	360,6	147	30	314,6	445,4
7072-MP-P5	360	540	82	5	2	475,5	428,4	171	30	378	522
71984-MP-P5	420	560	65	4	1,5	508,2	474,6	174	30	434,6	545,4
7088-MP-P5	440	650	94	6	3	566,5	523	204	30	463	627
7092-MP-P5	460	680	100	6	3	600,1	544,5	214	30	483	657
70/670-MPB-P5	670	980	136	7,5	4	869,1	790	306	30	698	952
719/1000-MPB-P5-UL	1 000	1 320	140	7,5	4	1 254	1 122	442	30	1 028	1 392



Mounting dimensions

			Basic load ratings		Calculation factors				Limiting speed	Axial runout	Radial runout
D_b	r_a	r_{a1}	dyn. C_r	stat. C_{0r}	e	X	Y	Y_0	n_G oil	S_{ea}	K_{ea}
max.	max.	max.	kN	kN					min^{-1}	µm	µm
334	2,5	1	255	355	1,14	0,35	0,57	0,26	3 000	20	20
453	3	1,5	430	720	0,8	0,39	0,76	0,33	2 400	23	23
531,2	4	2	530	980	0,8	0,39	0,76	0,33	1 900	25	25
553	3	1,5	415	780	0,8	0,39	0,76	0,33	1 800	25	25
637,6	5	5	655	1 370	0,8	0,39	0,76	0,33	1 500	30	30
667,6	5	2,5	710	1 500	0,8	0,39	0,76	0,33	1 400	30	30
965,4	6	3	1 200	3 200	0,8	0,39	0,76	0,33	1 000	40	35
1 405,4	6	3	1 860	6 200	0,8	0,39	0,76	0,33	700	55	45



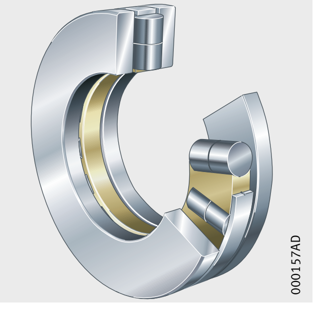
Axial cylindrical roller bearings

Axial cylindrical roller bearings

Product overview Axial cylindrical roller bearings

Single direction

Single row and double row

810, 811, Z-5, F-8	Z-5
	

Axial cylindrical roller bearings

Features Axial cylindrical roller bearings have a low axial section height, high load capacity and high rigidity.

Single direction bearings Single direction axial cylindrical roller bearings comprise an axial cylindrical roller and cage assembly, an externally centred housing locating washer and an internally centred shaft locating washer. The bore diameter, outside diameter and running surface of the housing locating washer and the shaft locating washer are precision machined.

The bearings can support axial forces in one direction.

Bearings 810 and 811 are single row bearings and conform to DIN 722/ISO 104.

Angular contact ball bearings Z-5 and F-8 are special bearings and have non-standardised dimensions and designations.

Operating temperature Axial cylindrical roller bearings and axial cylindrical roller and cage assemblies can be used at operating temperatures from –30 °C to +150 °C.

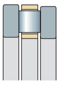
Cages The bearings generally have brass cages. These are indicated in bearings of series 810 and 811 by the suffix M. We can provide information on the cage design in special bearings by agreement.

Suffixes Suffixes for available designs of standardised bearings: see table.

Available designs

Suffix[1)]	Description	Design
M	Brass cage	Standard
MB	Solid brass cage, internally guided	
P5	Improved dimensional and geometrical accuracy	Special design
P4	High dimensional and geometrical accuracy	

1) The design of the bearings with non-standardised designations (Z-5, F-8) is available by agreement from us.



Axial cylindrical roller bearings

Design and safety guidelines

Axial cylindrical roller bearings can support axial forces only.

Equivalent dynamic bearing load

For bearings under dynamic loading, the following applies:

$$P = F_a$$

P kN
Equivalent dynamic bearing load

F_a kN
Axial dynamic bearing load.

Equivalent static bearing load

For bearings under static loading, the following applies:

$$P_0 = F_{0a}$$

P_0 kN
Equivalent static bearing load

F_{0a} kN
Axial static bearing load.

Minimum axial load

In order to ensure reliable operation, the minimum axial load $F_{a\,min}$ in accordance with the formula must be applied:

$$F_{a\,min} = 0{,}0005 \cdot C_{0a} + k_a \left(\frac{C_{0a} \cdot n}{10^8}\right)^2$$

$F_{a\,min}$ N
Minimum axial load

C_{0a} N (observe the dimension)
Basic static load rating

k_a –
Factor for determining the minimum load, see table

n min^{-1}
Speed.

Factor k_a

Series	Factor k_a[1)
810	1,3
811	1,4

1) We can provide k_a values for non-standardised bearings by agreement.

Limiting speed

The limiting speeds given in the dimension tables are valid for oil lubrication.

Design of adjacent parts

Axial bearing washers must be fully supported over their entire surface.

The abutment shoulders should be rigid, flat and perpendicular to the axis of rotation.

Tolerances for shafts and housing bores

Tolerances for shafts and housing bores: see table.

Shaft and housing bore tolerances

Bearing component		Shaft tolerance	Bore tolerance
Cage	Internally guided	h8	–
Housing locating washer	–	–	H7 (K7)
Shaft locating washer	–	h6 (j6)	–

Orientation of washers

The axial bearing washers must be fitted with the raceway side facing the rolling elements.

On housing locating washers, the raceway side is indicated by the smaller chamfer on the outside diameter.

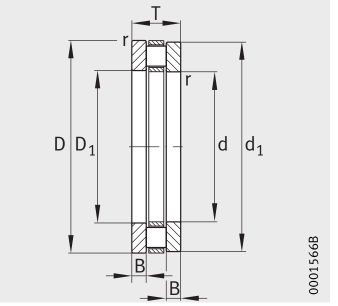
On shaft locating washers, the raceway side is indicated by the smaller chamfer on the bore diameter.

Accuracy

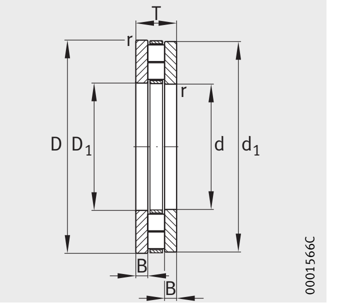
Dimensional and geometrical tolerances

The dimensional and geometrical tolerances of axial bearing washers GS and WS are in accordance with tolerance class P5 or better to DIN 620, see dimension table.

Axial cylindrical roller bearings



Design 1
Single row



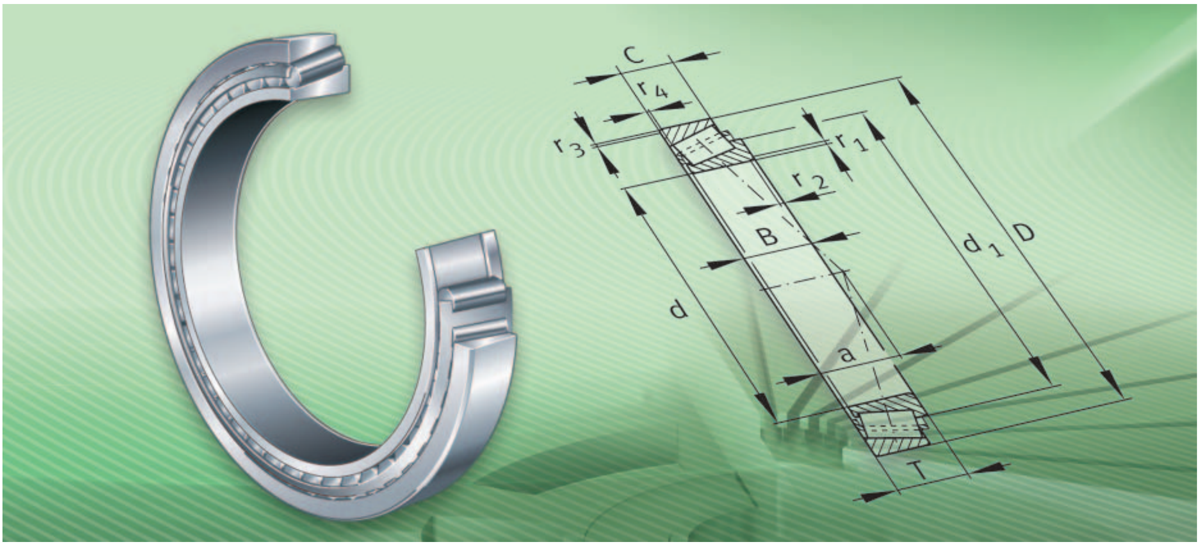
Design 2
Double row

Dimension table · Dimensions in mm

Designation	Dimensions							Basic load ratings		Limiting speed	Axial runout
	d	d_1	D	D_1	T	B	r	dyn. C kN	stat. C_0 kN	n_G oil min^{-1}	μm
811/500-MB-P5	500	595	600	505	80	25	2,5	1 910	9 300	450	11
Z-556947.M48A	610	745	765	635	95	28,5	3	2 350	12 500	380	11 [1] 13 [2]
811/800-MB-P5	800	945	950	805	120	36	4	4 050	21 500	300	15
F-804188	1 000	1 175	1 175	1 000	109	32	5	3 800	24 000	240	45
810/1320-MB-P5	1 320	1 436	1 440	1 324	95	29,5	3	3 250	24 500	190	20
810/1600-MB-P5	1 600	1 726	1 730	1 604	105	32	4	4 150	33 500	160	20
810/1900-MB-P5	1 900	1 904	2 060	2 056	130	40	5	6 100	50 000	130	25
810/2000-MB-P5	2 000	2 156	2 160	2 004	130	40	6	6 300	53 000	120	25
810/2120-MB-P5	2 120	2 296	2 300	2 124	140	43	6	7 200	60 000	120	30
Z-535820	2 350	2 550	2 550	2 350	90	31	6	6 700	90 000	110	20
810/2360-MB-P5	2 360	2 546	2 550	2 364	150	47	5	8 000	69 500	110	30
810/2500-MB-P5	2 500	2 696	2 700	2 504	160	50	5	9 000	78 000	100	30
Z-542346	2 875	3 120	3 125	2 880	110	37	6	8 300	106 000	85	20
Z-524624	3 050	3 300	3 300	3 050	110	37	6	7 800	95 000	80	20
Z-546952	3 280	3 595	3 600	3 285	160	52	3	14 000	156 000	75	20
F-804179	3 650	3 900	3 900	3 655	150	50	6	7 800	78 000	70	20
Z-560532	3 830	4 070	4 070	3 830	160	59	5	10 400	140 000	67	22

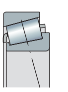
Other sizes by agreement.

[1] Axial runout of shaft locating washer.
[2] Axial runout of housing locating washer.



Single row tapered roller bearings

Single row tapered roller bearings



Single row tapered roller bearings

Single row

320, 329, Z-5, F-8

Single row tapered roller bearings

Features

Single row tapered roller bearings comprise solid inner and outer rings with tapered raceways and tapered rollers with cages made from pressed sheet steel.

The bearings are not self-retaining. As a result, the inner ring with the rollers and the cage can be fitted separately from the outer ring.

In addition to bearings with standardised main dimensions and standardised designations, special bearings in metric and inch sizes are also available, which have the non-standardised designations Z-5 or F-8.

For new designs, bearings in metric sizes should always be used in preference.

Radial and axial load capacity

Single row tapered roller bearings can support axial forces in one direction and high radial forces. They must be axially adjusted against a second bearing.

Contact angle

The axial load carrying capacity is dependent on the contact angle; this means that the larger the angle, the higher the axial load to which the bearing can be subjected.

The size of the contact angle and thus the load carrying capacity is indicated by the bearing-specific value e in the dimension tables.

Compensation of angular misalignments

The modified line contact between the tapered rollers and the raceways ensures optimum stress distribution at the contact points, prevents edge stresses and allows the bearings to undergo angular adjustment.

At a load ratio $P/C_r \leqq 0{,}2$, the tilting of the bearing rings relative to each other must not exceed 4 angular minutes. For higher loads or tilting angles, please contact us.

Sealing

Standard bearings are not sealed.

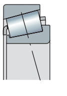
Lubrication

They can be lubricated using oil or grease.

Operating temperature

Single row tapered roller bearings can be used at operating temperatures from –30 °C to +120 °C. For continuous operating temperatures > +120 °C, please contact us.

Bearings with outside diameters of more than 240 mm are dimensionally stable up to +200 °C.



Single row tapered roller bearings

Cages

Single row tapered roller bearings have pressed cages made from sheet steel.

Since these project laterally to a certain extent, the mounting dimensions in the dimension tables and the cage projection, page 111 must be observed.

Suffixes

Suffixes for available designs: see table.

Available designs

Suffix	Description	Design
A	Modified internal construction	Standard
X	External dimensions matched to international standards	
P5	Increased accuracy	Special designs

Design and safety guidelines

Equivalent dynamic bearing load

The equivalent dynamic load P is valid for bearings that are subjected to radial and axial dynamic loads. It gives the same rating life as the combined bearing load occurring in practice.

For bearings under dynamic loading, the following applies:

Single bearings under dynamic load

Load ratio	Equivalent dynamic bearing load
$\frac{F_a}{F_r} \leqq e$	$P = F_r$
$\frac{F_a}{F_r} > e$	$P = 0{,}4 \cdot F_r + Y \cdot F_a$

F_a kN
Axial dynamic bearing load

F_r kN
Radial dynamic bearing load

e, Y –
Factors, see dimension table

P kN
Equivalent dynamic bearing load for combined load.

Equivalent static bearing load

The equivalent static load P_0 is valid for bearings that are subjected to radial and axial static loads. It induces the same load at the centre point of the most heavily loaded contact point between the rolling element and raceway as the combined bearing load occurring in practice.

Single bearings under static load

For single bearings under static load, the following applies:

Load ratio	Equivalent static load
$\frac{F_{0a}}{F_{0r}} \leqq \frac{1}{2 \cdot Y_0}$	$P_0 = F_{0r}$
$\frac{F_{0a}}{F_{0r}} > \frac{1}{2 \cdot Y_0}$	$P_0 = 0,5 \cdot F_{0r} + Y_0 \cdot F_{0a}$

F_{0a} kN
Axial static bearing load

F_{0r} kN
Radial static bearing load

Y_0 –
Factor, see dimension table

P_0 kN
Equivalent static bearing load for combined load.

Minimum load

In order to ensure operation without slippage, the bearings must be subjected to a minimum load $F_{r\ min}$ in a radial direction. This applies particularly in the case of high speeds and high accelerations.
For continuous operation, roller bearings with cage must therefore be subjected to a minimum load of the order of $P/C_r \geqq 0,02$.

Speeds

!

The component limiting the speed is the main bearing.
The kinematic limiting speeds n_G for the main bearings should not be exceeded, see dimension tables.

Design of bearing arrangements

In order to make comprehensive use of the performance capacity of the bearings, the adjacent construction must be of an appropriate design.

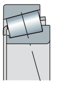
Shaft and housing tolerances

Recommended shaft tolerances for radial bearings with cylindrical bore, see table, page 37.

Recommended housing tolerances for radial bearings, see table, page 38.

Mounting dimensions

The dimension tables give the maximum dimensions of the radii r_a and r_b and the diameters of the abutment shoulders.



Cage projection

!

The cages project laterally to a certain extent. In order to prevent grazing, the lateral minimum distances C_a and C_b in the dimension tables must be taken into consideration in the design of the adjacent construction.

Accuracy
Bearings in metric sizes

The main dimensions of the standardised bearings conform to DIN ISO 355 and DIN 720, the dimensional and running tolerances conform to DIN 620-2.

Tolerance class P5

Tapered roller bearings with restricted tolerances to tolerance class P5 to DIN 620-2, see tables.

Inner ring tolerances

Bore d mm		Bore deviation Δ_{dmp} µm		Variation V_{dsp} µm	Variation V_{dmp} µm	Radial runout K_{ia} µm
over	incl.	max.	min.	max.	max.	max.
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

Inner ring tolerances continued

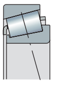
Bore d mm		Axial runout of end face S_d µm	Width deviation Δ_{Bs} µm	
over	incl.	max.	max.	min.
250	315	13	0	−700
315	400	15	0	−800
400	500	17	0	−900
500	630	20	0	−1 100
630	800	25	0	−1 600
800	1 000	30	0	−2 000
1 000	1 250	40	0	−2 000
1 250	1 600	50	0	−2 000

Outer ring tolerances

Outside diameter D mm		Deviation of outside diameter Δ_{Dmp} µm		Variation V_{Dsp} µm	Variation V_{Dmp} µm	Radial runout K_{ea} µm
over	incl.	max.	min.	max.	max.	max.
250	315	0	−25	19	13	18
315	400	0	−28	22	14	20
400	500	0	−33	26	17	23
500	630	0	−38	30	20	25
630	800	0	−45	38	25	30
800	1 000	0	−60	50	30	35
1 000	1 250	0	−80	65	38	52
1 250	1 600	0	−100	90	50	62
1 600	2 000	0	−125	120	65	73

Outer ring tolerances continued

Bore d mm		Runout of outside surface generatrix S_D µm	Width deviation Δ_{Cs} µm	
over	incl.	max.	max.	min.
250	315	13	0	−600
315	400	13	0	−700
400	500	17	0	−800
500	630	20	0	−900
630	800	25	0	−1 100
800	1 000	30	0	−1 600
1 000	1 250	38	0	−2 000
1 250	1 600	50	0	−2 000
1 600	2 000	65	0	−2 000



Bearings in inch sizes

Tapered roller bearings in inch sizes are manufactured as standard with normal tolerances to ANSI/ABMA. The deviation of the width Δ_{Bs} and radial runout correspond to tolerance class Q3 on the basis of ANSI/ABMA.

In contrast to the metric bearings, bearings in inch sizes have plus tolerances on the bore and outside diameter.

Inner ring tolerances

Bore d mm		Bore deviation Δ_{dmp} μm		Width deviation Δ_{Bs} μm	
over	incl.	max.	min.	max.	min.
250	315	13	0	0	–350
315	397	20	0	0	–400
397	500	20	0	0	–400
500	596	25	0	0	–600
596	710	25	0	0	–600
710	800	38	0	0	–800

Inner ring tolerances continued

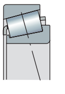
Bore d mm		Width variation V_{Bs} μm	Radial runout K_{ia} μm	Axial runout of end face S_d μm	Axial deviation S_{ia} μm
over	incl.	max.	max.	max.	max.
250	315	5	4	7	8
315	397	7	7	8	10
397	500	7	7	8	10
500	596	10	9	10	13
596	710	10	9	10	13
710	800	15	14	15	19

Outer ring tolerances

Outside diameter D mm		Deviation of outside diameter Δ_{Dmp} µm	
over	incl.	max.	min.
250	315	13	0
315	400	20	0
400	500	20	0
500	630	25	0
630	900	38	0

Outer ring tolerances continued

Outside diameter D mm		Width variation V_{Bs} µm	Radial runout K_{ea} µm	Runout of outside surface generatrix S_D µm
over	incl.	max.	max.	max.
250	315	5	4	7
315	400	7	7	8
400	500	7	7	8
500	630	10	9	10
630	900	20	18	20



Chamfer dimensions

The values for the chamfer dimensions r apply to tapered roller bearings in inch sizes. The values for metric tapered roller bearings are given in Technical Principles, see dimension table.

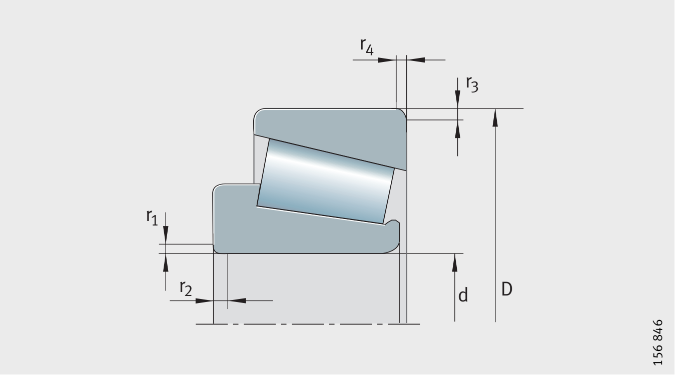


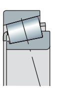
Figure 1
Chamfer dimensions
for inch size tapered roller bearings

Limit values for chamfer dimensions for the inner ring

Nominal bearing bore diameter d mm		Chamfer dimension r_1 mm		Chamfer dimension r_2 mm	
over	incl.	max.	min.	max.	min.
254	355,6	+1,25	0	+2,05	0
355,6	457,2	+2,05	0	+3,05	0
457,2	609,6	+3,05	0	+4,05	0
609,6	914,4	+4,05	0	+5,6	0
914,4	1 219,2	+5,1	0	+6,85	0
1 219,2	–	+6,35	0	+8,9	0

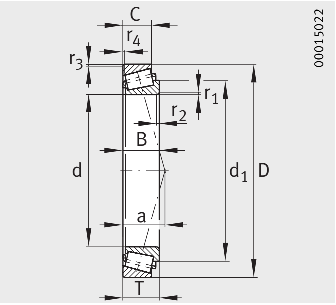
Limit values for chamfer dimensions for the outer ring

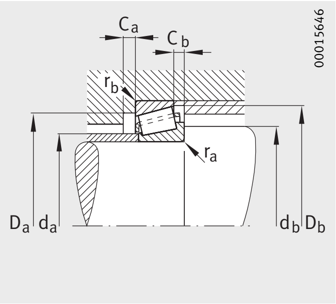
Nominal outside diameter D mm		Chamfer dimension r_3 mm		Chamfer dimension r_4 mm	
over	incl.	max.	min.	max.	min.
266,7	355,6	+1,7	0	+1,7	0
355,6	457,2	+2,05	0	+3,05	0
457,2	609,6	+3,05	0	+4,05	0
609,6	914,4	+4,05	0	+5,6	0
914,4	1 219,2	+5,1	0	+6,85	0
1 219,2	–	+6,35	0	+8,9	0



Tapered roller bearings

Single row



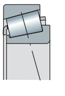


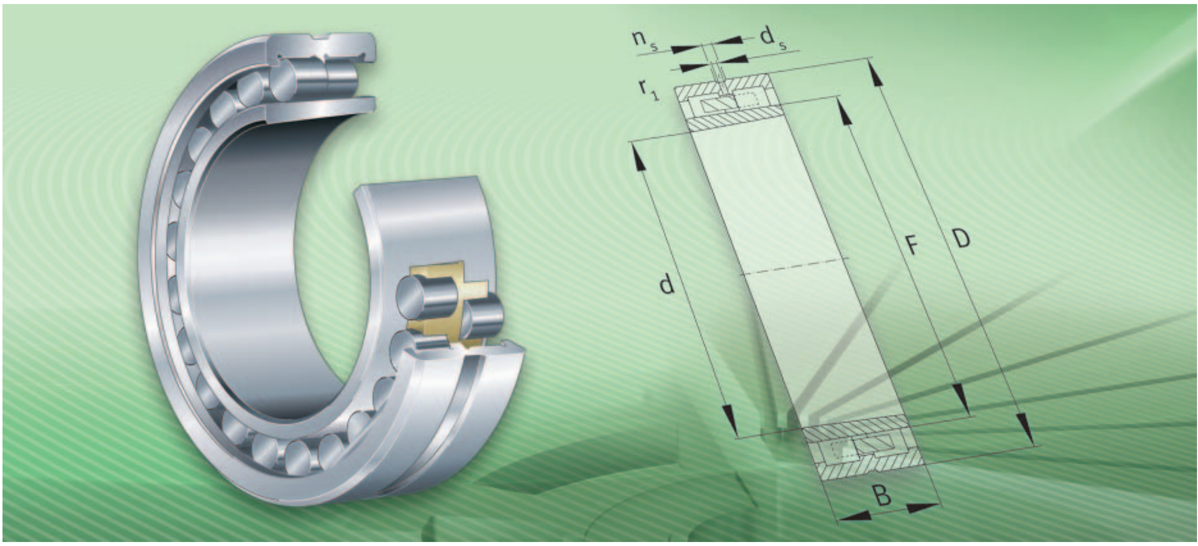
Mounting dimensions

Dimension table · Dimensions in mm

Designation	Dimensions									Mounting dimensions	
	d	D	B	C	T	r_1, r_2 min.	r_3, r_4 min.	a ≈	d_1 ≈	d_a max.	d_b min.
32052-X-P5	**260**	400	87	65	87	5	4	86	331,5	287	278
32960-P5	**300**	420	76	57	76	4	3	80	362	324	314
32064-X-P5	**320**	480	100	74	100	5	4	104	397,5	350	338
F-807078-P5	**460**	600	87	71	87	5	4	110	524,5	482	480
Z-565803-P5	**500**	670	78	60	85	6	5	118	582	533	546
Z-533416-P5	**558,8**	736,6	104,775	81	104,775	6,4	6,4	120,8	645	585	594
Z-523871-P5	**630**	850	108	78	108	7,5	6	145	728	665	700
Z-545093-P5	**850**	1 120	120	90	120	5	5	169	975,2	910	928

D_a		D_b	C_a	C_b	r_a	r_b	Basic load ratings		Calculation factors			Limiting speed
							dyn. C	stat. C_0	e	Y	Y_0	n_G oil
min.	max.	min.	min.	min.	max.	max.	kN	kN				min^{-1}
352	382	383	14	22	5	4	1 150	2 140	0,43	1,38	0,76	1 100
383	406	405	12	19	4	3	990	2 030	0,39	1,52	0,84	950
424	462	461	15	26	5	4	1 560	3 050	0,46	1,31	0,72	850
554	–	583	9	12,5	5	4	1 420	3 250	0,4	1,49	0,82	630
617	–	640	9	25	6	5	1 530	3 300	0,41	1,45	0,8	560
696	–	708	11	19	6,4	6,4	2 270	5 500	0,35	1,73	0,95	500
780	–	815	11	28	7,5	6	2 600	5 800	0,4	1,5	0,83	450
1 034	–	1 064	13	30	5	5	3 600	9 100	0,36	1,68	0,92	360



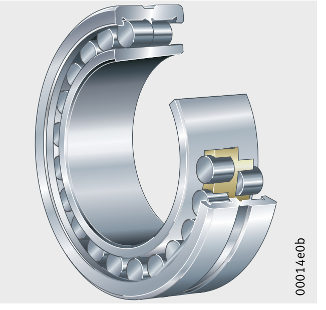


Radial cylindrical roller bearings

Radial cylindrical roller bearings

Double row, tapered bore

NN30..-K, NNU49..-K



Radial cylindrical roller bearings

Features

FAG super precision cylindrical roller bearings comprise solid outer rings, solid inner rings with a tapered bore (taper 1:12) and cylindrical roller and cage assemblies with cages made from brass or polyether ether ketone PEEK. In the case of cylindrical roller bearing NN30, the outer ring is removable and can thus be mounted separately from the rest of the bearing package. In the case of the cylindrical roller bearing NNU49, the inner ring is removable.

The double row bearings are used when very high precision under very high radial load is required. In machine tools, they facilitate bearing arrangements with high accuracy, high radial rigidity and very high load carrying capacity. They provide radial support for the main spindle.

Ideal non-locating bearings

Since variations in length during rotary motion can be compensated between the rollers and the ribless raceway without constraining forces, the cylindrical roller bearings are highly suitable as non-locating bearings. Axial forces are supported by axial bearings.

Bearings with smaller cross-section

Cylindrical roller bearings NNU49 have a smaller cross-section than other cylindrical roller bearings in the FAG super precision range. As a result, smaller centre distances can be achieved in multi-spindle arrangements. In addition, diameter ranges not described in the dimension tables can be supplied by agreement.

Double row cylindrical roller bearings

In the case of cylindrical roller bearing NN30, the rollers are guided on the inner ring. The outer ring is ground cylindrical and is removable, *Figure 1*.

The series NNU49 has a cylindrically ground, separable inner ring. The rollers are guided on the outer ring.

NN30

Figure 1
Double row cylindrical roller bearing

Radial cylindrical roller bearings

Sealing

The cylindrical roller bearings are supplied in an open design.

Lubrication

Due to the high surface quality of the raceways and rollers, FAG cylindrical roller bearings are particularly suitable for grease lubrication.

Oil lubrication

Double row bearings have a lubrication groove and lubrication holes in the outer ring.

When selecting a lubricant, the operating temperature of the lubricant must be taken into consideration. Due to the design, the radial bearing can in most cases be supplied with the oil from the smaller axial bearing located above, see page 57.

Operating temperature

The bearings can be used at operating temperatures from –30 °C to +150 °C.

Cages

Double row bearings have solid cages made from brass (suffix M).

Suffixes

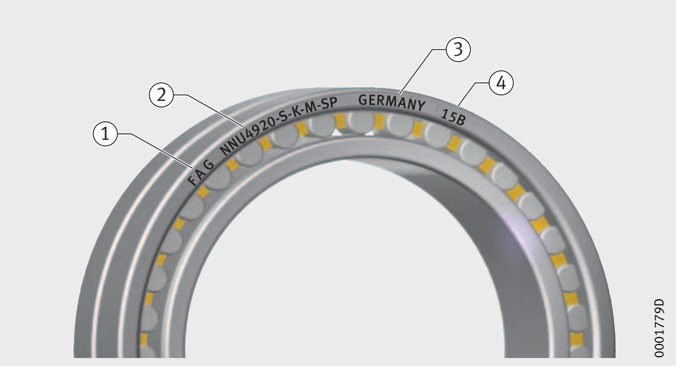
Suffixes for available designs: see table.

Available designs

Suffix	Description	Design
S	Lubrication groove and lubrication holes in outer ring	Standard
AS	Lubrication groove and lubrication holes in outer ring, series NN30	
K	Tapered bore, taper 1:12	
M	Brass cage, guided by rollers	
SP	Accuracy SP and radial internal clearance C1NA	
C2	Radial internal clearance according to standard	Special design, available by agreement
UP	Ultra precision and radial internal clearance C1NA	
R40-50	Individual radial internal clearance	
H74	Higher running accuracy	

Marking of bearings

The bearing rings are marked on the end faces, *Figure 2*.



① Trademark
② Short designation (bearing designation)
③ Country of manufacture
④ Internal code

Figure 2
Marking of double row bearings

Design and safety guidelines

Load carrying capacity and operating life

Bearing arrangements with super precision cylindrical roller bearings are generally designed in accordance with the requirements for load carrying capacity, rigidity and accuracy.

In practice, failure due to fatigue is not significant for these bearings. Calculation of the rating life L_{10} in accordance with DIN ISO 281 in order to determine the operating life is therefore not appropriate.

Equivalent static bearing load

The equivalent static bearing load P_0 is determined from the radial loads acting on the bearing.

Super precision cylindrical roller bearings can support radial forces only.

For bearings under static loading, the following applies:

$$P_0 = F_{0r}$$

P_0 N
Equivalent static bearing load

F_{0r} N
Radial static bearing load.

Static load safety factor

Whether the static load carrying capacity of a bearing is sufficient for a given static load can be checked with the aid of the static load safety factor S_0.

$$S_0 = \frac{C_0}{P_0}$$

S_0 –
Static load safety factor

C_0 N
Basic static load rating

P_0 N
Equivalent static bearing load.

In order to utilise the high accuracy of the bearings, a static load safety factor $S_0 > 3$ is necessary ($S_0 > 8$ = fatigue-resistant).

Clearance adjustment of cylindrical roller bearings

Cylindrical roller bearings with a tapered bore are mounted with clearance, clearance-free or with preload, see table, page 126. For use in vertical turret lathes, an interference of 5 μm has proved effective.

Speeds

The limiting speeds n_G given in the dimension tables are valid for lubrication with grease or for minimal quantity lubrication with oil and must not be exceeded.

In the case of cylindrical roller bearings, the achievable speed is determined by the radial internal clearance in the operational state, see table.

Achievable speeds

Clearance or preload μm	Achievable speed min^{-1}
–5 to 0	$> 0{,}5 \cdot n_G$ grease
$2 \cdot 10^{-5} \cdot d_M$	0,5 to 0,75 $\cdot n_G$ grease
$4 \cdot 10^{-5} \cdot d_M$	0,75 to 1 $\cdot n_G$ grease
$1 \cdot 10^{-4} \cdot d_M$	$1 \cdot n_G$ oil

$d_M = (d + D)/2$

These values are guide values for temperature differences $\Delta T \leqq 5$ K between the inner ring and outer ring. For use in applications with larger temperature differences, please consult the Application Engineering facilities of the Schaeffler Group.

Radial rigidity

The radial rigidity c_r is the quotient of the radial load and radial displacement.

$$c_r = \frac{F_r}{\delta_r}$$

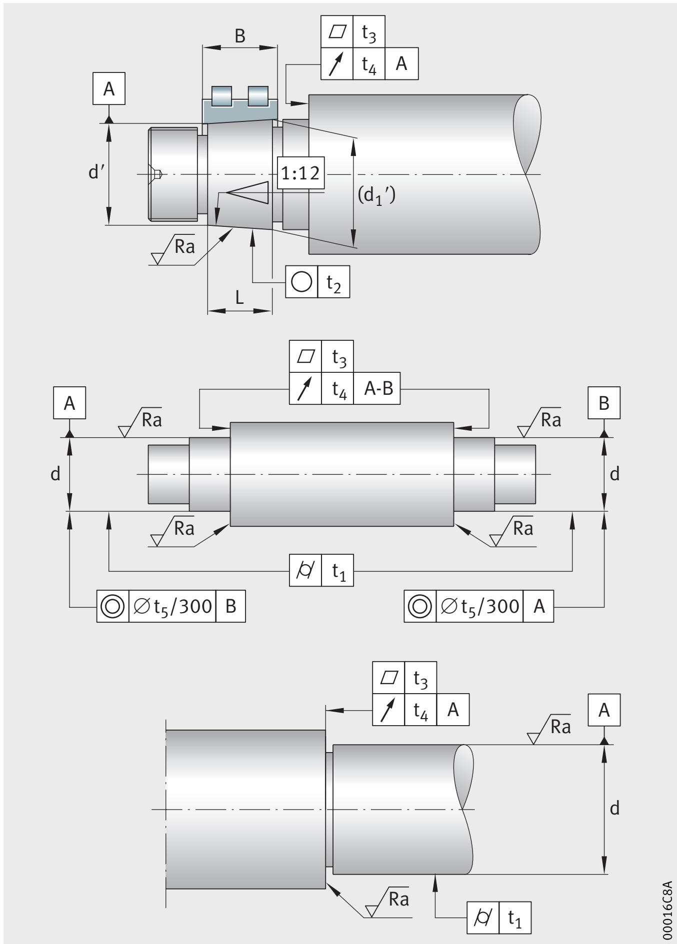
c_r N/μm
Radial rigidity, see dimension tables

F_r N
Radial force

δ_r μm
Radial displacement.

Design of bearing arrangements

In order to make comprehensive use of the performance capacity of the radial cylindrical roller bearings, the adjacent construction must be of an appropriate design, *Figure 3*.



d = nominal shaft diameter
d′ = small taper diameter (= d + lower deviation, see tables, page 129)
d_1′ = large taper diameter $d_1' = d' + 1/12 \cdot L$
L = taper length $L = 0{,}95 \cdot B$ (bearing width)
t_1 = cylindricity tolerance to DIN ISO 1101
t_2 = roundness tolerance to DIN ISO 1101
t_3 = flatness tolerance to DIN ISO 1101
t_4 = axial runout tolerance to DIN ISO 1101
t_5 = coaxiality tolerance to DIN ISO 1101
AT_D = taper angle tolerance to DIN ISO 7178
Ra = mean roughness to DIN ISO 4768

Figure 3
Geometrical tolerances of the shaft

Machining tolerances of the cylindrical shaft

The machining tolerances of the cylindrical shaft for bearings of tolerance class SP or UP are recommendations, see tables.

Tolerances of the cylindrical shaft for tolerance class SP

Nominal shaft diameter d mm		Deviation for d µm		Cylindricity t_1 µm	Flatness t_3 µm	Axial runout t_4 µm	Coaxiality t_5 µm	Mean roughness Ra µm
over	incl.							
18	30	3	–3	1	1	1,5	4	0,2
30	50	3,5	–3,5	1	1	1,5	4	0,2
50	80	4	–4	1,2	1,2	2	5	0,4
80	120	5	–5	1,5	1,5	2,5	6	0,4
120	180	6	–6	2	2	3,5	8	0,4
180	250	7	–7	3	3	4,5	10	0,4
250	315	8	–8	4	4	6	12	0,8
315	400	9	–9	5	5	7	13	0,8
400	500	10	–10	6	6	8	15	0,8
500	630	11	–11	7	7	9	16	0,8
630	800	12	–12	8	8	10	18	0,8

Tolerances of the cylindrical shaft for tolerance class UP

Nominal shaft diameter d mm		Deviation for d µm		Cylindricity t_1 µm	Flatness t_3 µm	Axial runout t_4 µm	Coaxiality t_5 µm	Mean roughness Ra µm
over	incl.							
18	30	2	–2	0,6	0,6	1	2,5	0,2
30	50	2	–2	0,6	0,6	1	2,5	0,2
50	80	2,5	–2,5	0,8	0,8	1,2	3	0,2
80	120	3	–3	1	1	1,5	4	0,2
120	180	4	–4	1,2	1,2	2	5	0,2
180	250	5	–5	2	2	3	7	0,2
250	315	6	–6	2,5	2,5	4	8	0,4
315	400	6,5	–6,5	3	3	5	9	0,4
400	500	7,5	–7,5	4	4	6	10	0,4
500	630	8	–8	5	5	7	11	0,4
630	800	9	–9	5	5	8	12	0,4

Machining tolerances of the tapered shaft

The machining tolerances of the tapered shaft for bearings of tolerance class SP or UP are recommendations, see tables.

Tolerances of the tapered shaft for tolerance class SP

Nominal shaft diameter (bearing bore) d mm		Deviation of small taper diameter[1)] μm		Roundness t_2 μm	Flatness t_3 μm	Axial runout t_4 μm	Mean roughness Ra μm
over	incl.						
18	30	+73	+64	1	1	1,5	0,2
30	40	+91	+80	1	1	1,5	0,2
40	50	+108	+97	1	1	1,5	0,2
50	65	+135	+122	1,2	1,2	2	0,2
65	80	+159	+146	1,2	1,2	2	0,2
80	100	+193	+178	1,5	1,5	2,5	0,2
100	120	+225	+210	1,5	1,5	2,5	0,2
120	140	+266	+248	2	2	3,5	0,2
140	160	+298	+280	2	2	3,5	0,2
160	180	+328	+310	2	2	3,5	0,2
180	200	+370	+350	3	3	4,5	0,2
200	225	+405	+385	3	3	4,5	0,2
225	250	+445	+425	3	3	4,5	0,2
250	280	+498	+475	4	4	6	0,4
280	315	+548	+525	4	4	6	0,4
315	355	+615	+590	5	5	7	0,4
355	400	+685	+660	5	5	7	0,4
400	450	+767	+740	6	6	8	0,4
450	500	+847	+820	6	6	8	0,4
500	560	+928	+900	7	7	9	0,4
560	630	+1008	+980	7	7	9	0,4
630	710	+1092	+1060	8	8	10	0,4

1) In relation to the nominal diameter of the shaft d, see section Calculation example, page 130.

Tolerances of the tapered shaft for tolerance class UP

Nominal shaft diameter (bearing bore) d mm		Deviation of small taper diameter[1) μm		Roundness t_2 μm	Flatness t_3 μm	Axial runout t_4 μm	Mean roughness Ra μm
over	incl.						
18	30	+73	+64	0,6	0,6	1	0,2
30	40	+91	+80	0,6	0,6	1	0,2
40	50	+108	+97	0,6	0,6	1	0,2
50	65	+135	+122	0,8	0,8	1,2	0,2
65	80	+159	+146	0,8	0,8	1,2	0,2
80	100	+193	+178	1	1	1,5	0,2
100	120	+225	+210	1	1	1,5	0,2
120	140	+266	+248	1,2	1,2	2	0,2
140	160	+298	+280	1,2	1,2	2	0,2
160	180	+328	+310	1,2	1,2	2	0,2
180	200	+370	+350	2	2	3	0,2
200	225	+405	+385	2	2	3	0,2
225	250	+445	+425	2	2	3	0,2
250	280	+498	+475	2,5	2,5	4	0,4
280	315	+548	+525	2,5	2,5	4	0,4
315	355	+615	+590	3	3	5	0,4
355	400	+685	+660	3	3	5	0,4
400	450	+767	+740	4	4	6	0,4
450	500	+847	+820	4	4	6	0,4
500	560	+928	+900	5	5	7	0,4
560	630	+1008	+980	5	5	7	0,4
630	710	+1092	+1060	5	5	8	0,4

[1) In relation to the nominal diameter of the shaft d, see section Calculation example.

Calculation example

For cylindrical roller bearings of tolerance class SP, the shaft tolerance of the tapered shaft can be calculated according to the following example:

Bearing bore	d	=	70 mm
Tolerance class			SP
Small taper diameter	d′	=	d + lower deviation
		=	70 mm + 0,146 mm
		=	70,146 mm
Tolerance	t	=	upper deviation – lower deviation
		=	0,159 mm – 0,146 mm
		=	+0,013 mm

Machining tolerances of the taper angle

The taper angle tolerance AT_D applies vertical to the axis and is defined as the differential diameter.

When using FAG taper gauges MGK132, the AT_D values stated should be halved (inclination angle tolerance).

For taper lengths with nominal dimensions between the values stated in the table, the taper angle tolerance AT_D is determined by means of interpolation.

Deviation of taper angle

The deviation of the taper angle of the shaft seat for bearings of tolerance class SP is dependent on the nominal taper length, see table.

Deviation

Nominal taper length mm		Taper angle tolerance µm			
L_U over	L_O incl.	AT_{DU}		AT_{DO}	
16	25	+2	0	+3,2	0
25	40	+2,5	0	+4	0
40	63	+3,2	0	+5	0
63	100	+4	0	+6,3	0
100	160	+5	0	+8	0
160	250	+6,3	0	+10	0

Calculation example

Taper length of shaft seat 50 mm, tolerance class SP.

$$AT_D = \frac{AT_{DO} - AT_{DU}}{L_o - L_u} \cdot L$$

$$AT_D = \frac{5 - 3{,}2}{63 - 40} \cdot 50 = 3{,}91\,\mu m$$

Taper angle tolerance AT_D = +4 µm.

Machining tolerances of the housing

The machining tolerances of the housing for bearings of tolerance class SP or UP are recommendations, see tables.

Housing design for tolerance class SP

Nominal housing bore diameter D mm		Deviation for D µm		Cylindricity t_1 µm	Flatness t_3 µm	Axial runout t_4 µm	Coaxiality t_5 µm	Mean roughness Ra µm
over	incl.							
30	50	+2	−9	1,5	1,5	2,5	4	0,4
50	80	+3	−10	2	2	3	5	0,4
80	120	+2	−13	2,5	2,5	4	6	0,8
120	180	+3	−15	3,5	3,5	5	8	0,8
180	250	+2	−18	4,5	4,5	7	10	0,8
250	315	+3	−20	6	6	8	12	1,6
315	400	+3	−22	7	7	9	13	1,6
400	500	+2	−25	8	8	10	15	1,6
500	630	0	−29	9	9	11	16	1,6
630	800	0	−32	10	10	12	18	1,6
800	1000	0	−36	11	11	14	21	1,6

Housing design for tolerance class UP

Nominal housing bore diameter D mm		Deviation for D µm		Cylindricity t_1 µm	Flatness t_3 µm	Axial runout t_4 µm	Coaxiality t_5 µm	Mean roughness Ra µm
over	incl.							
30	50	+1	−6	1	1	1,5	2,5	0,2
50	80	+1	−7	1,2	1,2	2	3	0,4
80	120	+1	−9	1,5	1,5	2,5	4	0,4
120	180	+1	−11	2	2	3,5	5	0,4
180	250	0	−14	3	3	4,5	7	0,4
250	315	0	−16	4	4	6	8	0,8
315	400	+1	−17	5	5	7	9	0,8
400	500	0	−20	6	6	8	10	0,8
500	630	0	−22	7	7	9	11	1,6
630	800	0	−24	8	8	10	12	1,6
800	1000	0	−27	9	9	11	14	1,6

Accuracy The main dimensions of the bearings conform to DIN 620-1.

The dimensional and geometrical tolerances conform to tolerance class SP.

Super precision cylindrical roller bearings are also available by agreement in the higher tolerance class UP.

The bearings have a cylindrical or tapered bore with the corresponding tolerance of the dimensions, *Figure 4* and tables, page 134.

α = inclination angle at end of taper = 2° 23′ 9,4″

2α = taper angle at end of taper = 4° 46′ 18,8″

B = width of inner ring

d = nominal bearing bore diameter

d_1 = bore diameter at large end of taper

Δ_{dmp} = deviation of bore diameter from nominal dimension in a single radial plane

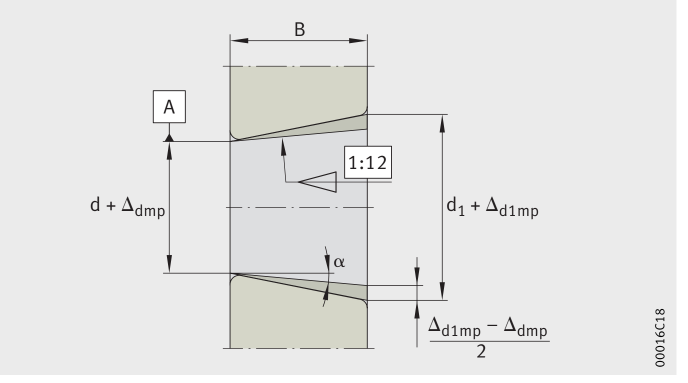


Figure 4
Tolerances for tapered bores

Tolerances of class SP for double row bearings

The following values are valid for the series NN30 and NNU49.

Tolerances of the inner ring (tolerance class SP)

Nominal bore dimension d mm		Deviation of cylindrical bore Δ_{ds}, Δ_{dmp} µm		Deviation of tapered bore Δ_{dmp} µm		Width variation V_{Bs} µm	Width deviation Δ_{Bs} µm	
over	incl.							
18	30	0	–6	10	0	2,5	0	–120
30	50	0	–8	12	0	3	0	–120
50	80	0	–9	15	0	4	0	–150
80	120	0	–10	20	0	4	0	–200
120	180	0	–13	25	0	5	0	–250
180	250	0	–15	30	0	6	0	–300
250	315	0	–18	35	0	8	0	–350
315	400	0	–23	40	0	10	0	–400
400	500	0	–27	45	0	12	0	–450
500	630	0	–30	50	0	14	0	–500
630	800	0	–40	65	0	17	0	–750

Tolerances of the inner ring (tolerance class SP) continued

Nominal bore dimension d mm		Variation (out of roundness) of bore V_{dp} µm		Variation of mean diameter V_{dmp} µm	Deviation $\Delta_{d1mp} - \Delta_{dmp}$ µm		Radial runout K_{ia} µm	Axial runout S_d µm	Axial runout S_{ia} µm
over	incl.	Cylindrical	Tapered						
18	30	3	3	3	4	0	3	4	4
30	50	4	4	4	4	0	4	4	4
50	80	5	5	5	5	0	4	5	5
80	120	5	5	5	6	0	5	5	5
120	180	7	7	7	8	0	6	6	7
180	250	8	8	8	9	0	8	7	8
250	315	9	9	9	11	0	8	8	10
315	400	12	12	12	12	0	10	10	12
400	500	14	14	14	14	0	10	12	15
500	630	15	15	15	15	0	12	14	18
630	800	20	20	20	18	0	15	17	21

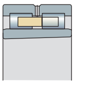
Tolerances of the outer ring (tolerance class SP)

Nominal outside diameter D mm		Deviation of outside diameter Δ_{Ds}, Δ_{Dmp} μm		Variation (out of roundness) V_{Dp} μm
over	incl.			
30	50	0	−7	4
50	80	0	−9	5
80	120	0	−10	5
120	150	0	−11	6
150	180	0	−13	7
180	250	0	−15	8
250	315	0	−18	9
315	400	0	−20	10
400	500	0	−23	12
500	630	0	−28	14
630	800	0	−35	18
800	1000	0	−40	20

The width deviation Δ_{Cs} is identical to Δ_{Bs} of the corresponding inner ring.

Tolerances of the outer ring (tolerance class SP) continued

Nominal outside diameter D mm		Variation of mean diameter V_{Dmp} μm	Width variation V_{Cs} μm	Radial runout K_{ea} μm	Inclination variation S_D μm	Axial runout S_{ea} μm
over	incl.					
30	50	4	2,5	5	4	5
50	80	5	3	5	4	5
80	120	5	4	6	5	6
120	150	6	5	7	5	7
150	180	7	5	8	5	8
180	250	8	7	10	7	10
250	315	9	7	11	8	10
315	400	10	8	13	10	13
400	500	12	9	15	11	15
500	630	14	11	17	13	18
630	800	18	13	20	15	22
800	1000	20	15	23	17	26



Tolerances of class UP for double row bearings

The following values are valid for double row cylindrical roller bearings, see tables.

Tolerances of the inner ring (tolerance class UP)

Nominal bore dimension d mm		Deviation of cylindrical bore Δ_{ds}, Δ_{dmp} µm		Deviation of tapered bore Δ_{dmp} µm		Width variation V_{Bs} µm	Width deviation Δ_{Bs} µm	
over	incl.							
18	30	0	−5	6	0	1,5	0	−25
30	50	0	−6	7	0	2	0	−30
50	80	0	−7	8	0	2,5	0	−40
80	120	0	−8	10	0	3	0	−50
120	180	0	−10	12	0	4	0	−60
180	250	0	−12	14	0	5	0	−75
250	315	0	−15	15	0	5	0	−100
315	400	0	−19	17	0	6	0	−100
400	500	0	−23	19	0	7	0	−100
500	630	0	−26	20	0	8	0	−125
630	800	0	−34	22	0	11	0	−125

Tolerances of the inner ring (tolerance class UP) continued

Nominal bore dimension d mm		Variation (out of roundness) of bore V_{dp} µm		Variation of mean diameter V_{dmp} µm	Deviation $\Delta_{d1mp} - \Delta_{dmp}$ µm		Radial runout K_{ia} µm	Axial runout S_d µm	Axial runout S_{ia} µm
over	incl.	Cylindrical	Tapered						
18	30	2,5	2,5	2,5	2	0	1,5	3	3
30	50	3	3	3	3	0	2	3	3
50	80	3,5	3,5	3,5	3	0	2	4	3
80	120	4	4	4	4	0	3	4	4
120	180	5	5	5	4	0	3	5	6
180	250	6	6	6	5	0	4	6	7
250	315	8	8	8	6	0	4	6	8
315	400	10	10	10	6	0	5	7	9
400	500	12	12	12	7	0	5	8	10
500	630	13	13	13	8	0	6	9	12
630	800	17	17	17	9	0	7	11	18

Tolerances of the outer ring (tolerance class UP)

Nominal outside diameter D mm		Deviation of outside diameter Δ_{Ds}, Δ_{Dmp} µm		Variation (out of roundness) V_{Dp} µm
over	incl.			
30	50	0	–5	3
50	80	0	–6	3
80	120	0	–7	4
120	150	0	–8	4
150	180	0	–9	5
180	250	0	–10	5
250	315	0	–12	6
315	400	0	–14	7
400	500	0	–17	9
500	630	0	–20	10
630	800	0	–25	13
800	1000	0	–30	15

The width deviation Δ_{Cs} is identical to Δ_{Bs} of the corresponding inner ring.

Tolerances of the outer ring (tolerance class UP) continued

Nominal outside diameter D mm		Variation of mean diameter V_{Dmp} µm	Width variation V_{Cs} µm	Radial runout K_{ea} µm	Inclination variation S_D µm	Axial runout S_{ea} µm
over	incl.					
30	50	3	1,5	3	2	3
50	80	3	2	3	2	4
80	120	4	3	3	3	5
120	150	4	4	4	3	5
150	180	5	4	4	3	5
180	250	5	5	5	4	7
250	315	6	5	6	4	7
315	400	7	6	7	5	8
400	500	9	7	8	5	10
500	630	10	8	9	6	12
630	800	13	11	11	7	14
800	1000	15	12	12	10	17

Radial internal clearance

The values in the table are valid for single and double row cylindrical roller bearings with a tapered or cylindrical bore.

The internal clearance groups conform to DIN 620-4.

Radial internal clearance of bearings with tapered bore

Nominal bore dimension d mm		Internal clearance group C1[1)] µm		C2[2)] µm		CN[2)] µm		C3[2)] µm	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.
24	30	15	25	20	45	35	60	45	70
30	40	15	25	20	45	40	65	55	80
40	50	17	30	25	55	45	75	60	90
50	65	20	35	30	60	50	80	70	100
65	80	25	40	35	70	60	95	85	120
80	100	35	55	40	75	70	105	95	130
100	120	40	60	50	90	90	130	115	155
120	140	45	70	55	100	100	145	130	175
140	160	50	75	60	110	110	160	145	195
160	180	55	85	75	125	125	175	160	210
180	200	60	90	85	140	140	195	180	235
200	225	60	95	95	155	155	215	200	260
220	250	65	100	105	170	170	235	220	285
250	280	75	110	115	185	185	255	240	310
280	315	80	120	130	205	205	280	265	340
315	355	90	135	145	225	225	305	290	370
355	400	100	150	165	255	255	345	330	420
400	450	110	170	185	285	285	385	370	470
450	500	120	190	205	315	315	425	410	520
500	560	130	210	230	350	350	470	455	575
560	630	140	230	260	380	380	500	500	620
630	710	160	260	295	435	435	575	565	705

Radial internal clearance without measurement load.

1) Bearings of accuracy SP and UP have the radial internal clearance C1. The bearing rings are not interchangeable (NA).

2) The internal clearance groups C2, CN and C3 can be ordered using suffixes for the accuracy SP and UP. The bearing rings are interchangeable.

Radial internal clearance of bearings with cylindrical bore

Nominal bore dimension d mm		Internal clearance group							
		C1[1] µm		C2[2] µm		CN[2] µm		C3[2] µm	
over	incl.	min.	max.	min.	max.	min.	max.	min.	max.
24	30	5	15	0	25	20	45	35	60
30	40	5	15	5	30	25	50	45	70
40	50	5	18	5	35	30	60	50	80
50	65	5	20	10	40	40	70	60	90
65	80	10	25	10	45	40	75	65	100
80	100	10	30	15	50	50	85	75	110
100	120	10	30	15	55	50	90	85	125
120	140	10	35	15	60	60	105	100	145
140	160	10	35	20	70	70	120	115	165
160	180	10	40	25	75	75	125	120	170
180	200	15	45	35	90	90	145	140	195
200	225	15	50	45	105	105	165	160	220
220	250	15	50	45	110	110	175	170	235
250	280	20	55	55	125	125	195	190	260
280	315	20	60	55	130	130	205	200	275
315	355	20	65	65	145	145	225	225	305
355	400	25	75	100	190	190	280	280	370
400	450	25	85	110	210	210	310	310	410
450	500	25	95	110	220	220	330	330	440
500	560	25	100	120	240	240	360	360	480
560	630	30	110	140	260	260	380	380	500
630	710	30	130	145	285	285	425	425	565

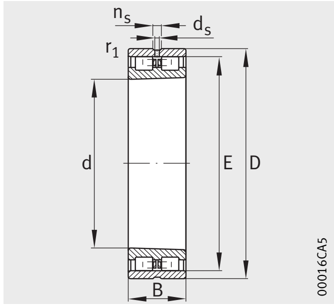
Radial internal clearance without measurement load.

[1] Bearings of accuracy SP and UP have the radial internal clearance C1.
The bearing rings are not interchangeable (NA).

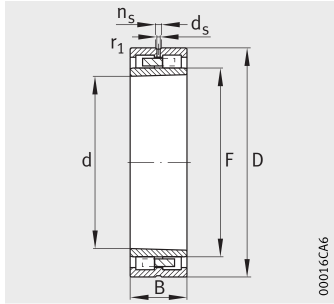
[2] The internal clearance groups C2, CN and C3 can be ordered using suffixes for the accuracy SP and UP. The bearing rings are interchangeable.

Super precision cylindrical roller bearings

Double row



NN30



NNU49

Dimension table · Dimensions in mm

Designation[1]	Mass	Dimensions							
	m	d	D	B	r_1	E	F	n_s	d_s
	≈kg				min.				
NN3006-AS-K-M-SP	0,19	**30**	55	19	1	48,5	–	4,8	3,2
NN3007-AS-K-M-SP	0,25	**35**	62	20	1	55	–	4,8	3,2
NN3008-AS-K-M-SP	0,3	**40**	68	21	1	61	–	4,8	3,2
NN3009-AS-K-M-SP	0,39	**45**	75	23	1	67,5	–	4,8	3,2
NN3010-AS-K-M-SP	0,43	**50**	80	23	1	72,5	–	4,8	3,2
NN3011-AS-K-M-SP	0,63	**55**	90	26	1,1	81	–	4,8	3,2
NN3012-AS-K-M-SP	0,67	**60**	95	26	1,1	86,1	–	4,8	3,2
NN3013-AS-K-M-SP	0,72	**65**	100	26	1,1	91	–	4,8	3,2
NNU4914-S-K-M-SP	0,73	**70**	100	30	1	–	80	4,8	3,2
NN3014-AS-K-M-SP	1,04	**70**	110	30	1,1	100	–	6,5	3,2
NNU4915-S-K-M-SP	0,77	**75**	105	30	1	–	85	4,8	3,2
NN3015-AS-K-M-SP	1,09	**75**	115	30	1,1	105	–	6,5	3,2
NNU4916-S-K-M-SP	0,81	**80**	110	30	1	–	90	4,8	3,2
NN3016-AS-K-M-SP	1,51	**80**	125	34	1,1	113	–	6,5	3,2
NNU4917-S-K-M-SP	1,2	**85**	120	35	1,1	–	96,5	4,8	3,2
NN3017-AS-K-M-SP	1,58	**85**	130	34	1,1	118	–	6,5	3,2
NNU4918-S-K-M-SP	1,26	**90**	125	35	1,1	–	101,5	4,8	3,2
NN3018-AS-K-M-SP	2,05	**90**	140	37	1,5	127	–	6,5	3,2
NNU4919-S-K-M-SP	1,32	**95**	130	35	1,1	–	106,5	4,8	3,2
NN3019-AS-K-M-SP	2,14	**95**	145	37	1,5	132	–	6,5	3,2
NNU4920-S-K-M-SP	1,86	**100**	140	40	1,1	–	113	6,5	3,2
NN3020-AS-K-M-SP	2,23	**100**	150	37	1,5	137	–	6,5	3,2
NNU4921-S-K-M-SP	1,93	**105**	145	40	1,1	–	118	6,5	3,2
NN3021-AS-K-M-SP	2,84	**105**	160	41	2	146	–	6,5	3,2

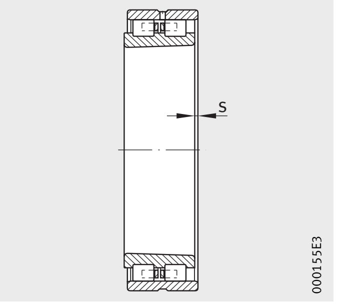
Description of suffixes

AS Lubrication groove and lubrication holes in outer ring (series NN30)
S Lubrication groove and lubrication holes in outer ring
K Tapered bore (taper 1:12)
M Brass cage, guided by rollers
SP Special precision

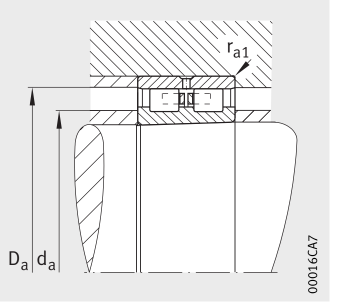
[1] The bearings are also available with a cylindrical bore, example: **NN3006-AS-M-SP**.

[2] Axial displacement of outer ring from central position.

[3] Minimal oil quantity lubrication.



Axial displacement

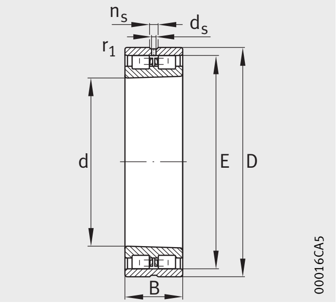


Mounting dimensions

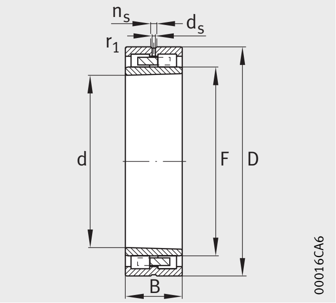
Axial displacement[2)]	Mounting dimensions			Basic load ratings		Limiting speeds		Radial spring rigidity
s	d_a h12	D_a H12	r_{a1} max.	dyn. C_r N	stat. C_{0r} N	n_G grease min^{-1}	n_G oil[3)] min^{-1}	c_r N/μm
1,4	38	50	1	29 000	34 000	16 000	19 000	680
1,4	43	57	1	36 000	44 000	14 000	17 000	790
1,4	48	63	1	45 000	59 000	12 000	15 000	950
1,7	54	69	1	54 000	72 000	11 000	14 000	1 080
1,7	59	74	1	57 000	80 000	10 000	13 000	1 180
1,9	65	83	1,1	72 000	100 000	9 000	11 000	1 300
1,9	70	88	1,1	75 000	110 000	8 500	10 000	1 410
1,9	75	93	1,1	77 000	116 000	8 000	9 500	1 470
1,8	79	92	1	60 000	104 000	7 500	9 000	1 700
2,3	82	102	1,1	98 000	150 000	7 000	8 500	1 660
1,8	84	97	1	63 000	114 000	7 000	8 500	1 870
2,3	87	107	1,1	100 000	156 000	6 700	8 000	1 730
1,8	89	102	1	66 000	122 000	6 700	8 000	1 980
2,5	93	116	1,1	120 000	186 000	6 300	7 500	1 850
2	96	111	1,1	90 000	166 000	6 300	7 500	2 280
2,5	98	121	1,1	125 000	200 000	6 000	7 000	1 990
2	101	116	1,1	93 000	176 000	6 000	7 000	2 420
2,6	105	130	1,5	140 000	224 000	5 600	6 700	2 020
2	106	121	1,1	95 000	186 000	5 600	6 700	2 560
2,6	110	135	1,5	143 000	236 000	5 300	6 300	2 100
2	112	129	1,1	129 000	255 000	5 300	6 300	3 000
2,6	115	140	1,5	146 000	245 000	5 300	6 300	2 170
2	117	134	1,1	129 000	260 000	5 300	6 300	3 080
2,6	120	149	2	190 000	310 000	4 800	5 600	2 320

Super precision cylindrical roller bearings

Double row



NN30



NNU49

Dimension table (continued) · Dimensions in mm

Designation[1]	Mass	Dimensions							
	m	d	D	B	r_1	E	F	n_s	d_s
	≈kg				min.				
NNU4922-S-K-M-SP	2,01	**110**	150	40	1,1	–	123	6,5	3,2
NN3022-AS-K-M-SP	3,61	**110**	170	45	2	155	–	6,5	3,2
NNU4924-S-K-M-SP	2,71	**120**	165	45	1,1	–	134,5	6,5	3,2
NN3024-AS-K-M-SP	3,94	**120**	180	46	2	165	–	6,5	3
NNU4926-S-K-M-SP	3,73	**130**	180	50	1,5	–	146	6,5	3,2
NN3026-AS-K-M-SP	5,79	**130**	200	52	2	182	–	9,5	4,8
NNU4928-S-K-M-SP	4,04	**140**	190	50	1,5	–	156	6,5	3,2
NN3028-AS-K-M-SP	6,22	**140**	210	53	2	192	–	9,5	4,8
NNU4930-S-K-M-SP	6,1	**150**	210	60	2	–	168,5	6,5	3,2
NN3030-AS-K-M-SP	7,58	**150**	225	56	2,1	206	–	9,5	4,8
NNU4932-S-K-M-SP	6,41	**160**	220	60	2	–	178,5	6,5	3,2
NN3032-AS-K-M-SP	9,23	**160**	240	60	2,1	219	–	9,5	4,8
NNU4934-S-K-M-SP	6,73	**170**	230	60	2	–	188,5	6,5	3,2
NN3034-AS-K-M-SP	12,5	**170**	260	67	2,1	236	–	9,5	4,8
NNU4936-S-K-M-SP	9,96	**180**	250	69	2	–	202	9,5	4,8
NN3036-AS-K-M-SP	16,4	**180**	280	74	2,1	255	–	12,2	6,3
NNU4938-S-K-M-SP	10,4	**190**	260	69	2	–	212	9,5	4,8
NN3038-AS-K-M-SP	17,3	**190**	290	75	2,1	265	–	12,2	6,3
NNU4940-S-K-M-SP	14,7	**200**	280	80	2,1	–	225	12,2	6,3
NN3040-AS-K-M-SP	22,2	**200**	310	82	2,1	282	–	12,2	6,3
NNU4944-S-K-M-SP	15,9	**220**	300	80	2,1	–	245	12,2	6,3
NN3044-AS-K-M-SP	29,1	**220**	340	90	3	310	–	15	8
NNU4948-S-K-M-SP	17,1	**240**	320	80	2,1	–	265	12,2	6,3
NN3048-AS-K-M-SP	31,6	**240**	360	92	3	330	–	15	8

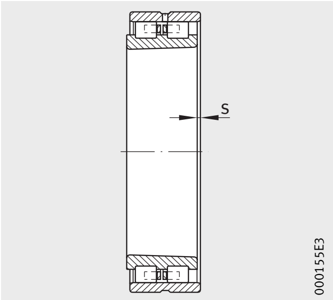
Description of suffixes

AS	Lubrication groove and lubrication holes in outer ring (series NN30)
S	Lubrication groove and lubrication holes in outer ring
K	Tapered bore (taper 1:12)
M	Brass cage, guided by rollers
SP	Special precision

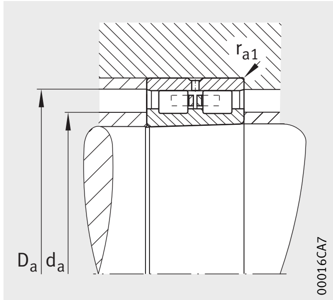
[1] The bearings are also available with a cylindrical bore, example: **NN3022-AS-M-SP**.

[2] Axial displacement of outer ring from central position.

[3] Minimal oil quantity lubrication.



Axial displacement

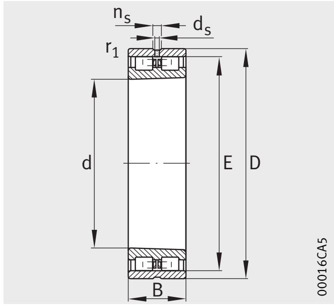


Mounting dimensions

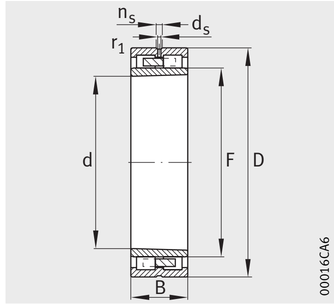
Axial displacement[2)]	Mounting dimensions			Basic load ratings		Limiting speeds		Radial spring rigidity
s	d_a h12	D_a H12	r_{a1} max.	dyn. C_r N	stat. C_{0r} N	n_G grease min^{-1}	n_G oil[3)] min^{-1}	c_r N/μm
2	122	139	1,1	132 000	270 000	5 000	6 000	3 170
2,9	127	158	2	220 000	360 000	4 500	5 300	2 500
2,3	133	155	1,1	176 000	340 000	4 500	5 300	3 200
3,1	137	168	2	232 000	390 000	4 300	5 000	2 700
2,7	145	166	1,5	190 000	390 000	4 000	4 800	3 600
3,1	150	186	2	290 000	500 000	3 800	4 500	2 980
1,8	155	176	1,5	190 000	400 000	3 800	4 500	3 700
3,4	160	196	2	300 000	520 000	3 600	4 300	3 090
2,7	167	197	2	325 000	655 000	3 600	4 300	4 280
3,8	172	210	2,1	335 000	585 000	3 400	4 000	3 300
2,7	177	207	2	335 000	680 000	3 400	4 000	4 420
4,3	183	224	2,1	375 000	670 000	3 200	3 800	3 510
2,7	187	217	2	340 000	695 000	3 200	3 800	4 560
4,6	196	241	2,1	450 000	800 000	3 000	3 600	3 770
3,2	200	232	2	405 000	850 000	3 000	3 600	5 160
4,8	209	260	2,1	570 000	1 000 000	2 800	3 400	4 040
3,2	210	242	2	405 000	880 000	2 800	3 400	5 310
4,8	219	271	2,1	585 000	1 040 000	2 600	3 200	4 190
4,3	223	259	2,1	490 000	1 040 000	2 600	3 200	5 510
5,7	232	288	2,1	655 000	1 200 000	2 400	3 000	4 410
4,3	243	279	2,1	510 000	1 140 000	2 400	3 000	6 000
5,7	254	317	3	800 000	1 460 000	2 200	2 800	4 770
4,3	263	299	2,1	530 000	1 200 000	2 200	2 800	6 320
6,1	274	337	3	850 000	1 560 000	2 000	2 600	5 140

Super precision cylindrical roller bearings

Double row



NN30



NNU49

Dimension table (continued) · Dimensions in mm

Designation[1]	Mass	Dimensions							
	m	d	D	B	r_1	E	F	n_s	d_s
	≈kg				min.				
NNU4952-S-K-M-SP	29,7	**260**	360	100	2,1	–	292	15	8
NN3052-AS-K-M-SP	46,2	**260**	400	104	4	364	–	15	8
NNU4956-S-K-M-SP	31,6	**280**	380	100	2,1	–	312	15	8
NN3056-AS-K-M-SP	49,7	**280**	420	106	4	384	–	15	8
NNU4960-S-K-M-SP	49,1	**300**	420	118	3	–	339	17,7	9,5
NN3060-AS-K-M-SP	68,8	**300**	460	118	4	418	–	17,7	9,5
NNU4964-S-K-M-SP	51,8	**320**	440	118	3	–	359	17,7	9,5
NN3064-AS-K-M-SP	74,2	**320**	480	121	4	438	–	17,7	9
NNU4968-S-K-M-SP	54,5	**340**	460	118	3	–	379	17,7	9,5
NN3068-AS-K-M-SP	99,3	**340**	520	133	5	473	–	17,7	9,5
NNU4972-S-K-M-SP	57,3	**360**	480	118	3	–	399	17,7	9,5
NN3072-AS-K-M-SP	104	**360**	540	134	5	493	–	17,7	9,5
NNU4976-S-K-M-SP	85,8	**380**	520	140	4	–	426	17,7	9,5
NN3076-AS-K-M-SP	110	**380**	560	135	5	513	–	17,7	9,5
NNU4980-S-K-M-SP	89,4	**400**	540	140	4	–	446	17,7	9,5
NN3080-AS-K-M-SP	143	**400**	600	148	5	549	–	17,7	9,5
NNU4984-S-K-M-SP	93,2	**420**	560	140	4	–	466	17,7	9,5
NN3084-AS-K-M-SP	150	**420**	620	150	5	569	–	17,7	9,5
NNU4988-S-K-M-SP	129	**440**	600	160	4	–	490	17,7	9,5
NN3088-AS-K-M-SP	172	**440**	650	157	6	597	–	23,5	12,5
NNU4992-S-K-M-SP	134	**460**	620	160	4	–	510	17,7	9,5
NN3092-AS-K-M-SP	197	**460**	680	163	6	624	–	23,5	12,5
NNU4996-S-K-M-SP	158	**480**	650	170	5	–	534	17,7	9,5
NN3096-AS-K-M-SP	206	**480**	700	165	6	644	–	23,5	12,5
NNU49/500-S-K-M-SP	162	**500**	670	170	5	–	568	17,7	9,5
NN30/500-AS-K-M-SP	214	**500**	720	167	6	664	–	23,5	12

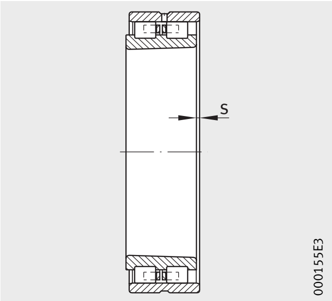
Description of suffixes

AS Lubrication groove and lubrication holes in outer ring (series NN30)
S Lubrication groove and lubrication holes in outer ring
K Tapered bore (taper 1:12)
M Brass cage, guided by rollers
SP Special precision

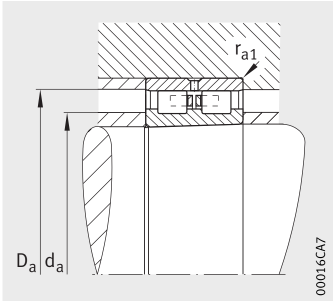
[1] The bearings are also available with a cylindrical bore, example: **NN3052-AS-M-SP**.

[2] Axial displacement of outer ring from central position.

[3] Minimal oil quantity lubrication.



Axial displacement



Mounting dimensions

Axial displacement[2)] s	Mounting dimensions d_a h12	D_a H12	r_{a1} max.	Basic load ratings dyn. C_r N	stat. C_{0r} N	Limiting speeds n_G grease min^{-1}	n_G oil[3)] min^{-1}	Radial spring rigidity c_r N/µm
5,4	289	334	2,1	750 000	1 700 000	2 000	2 600	7 080
6,6	300	372	4	1 060 000	2 000 000	1 900	2 400	5 680
5,4	309	354	2,1	765 000	1 800 000	1 900	2 400	7 480
6,9	320	392	4	1 080 000	2 080 000	1 800	2 200	5 890
6,3	336	389	3	1 040 000	2 400 000	1 700	2 000	8 280
7,5	346	427	4	1 270 000	2 400 000	1 600	1 900	5 930
6,3	356	409	3	1 060 000	2 550 000	1 600	1 900	8 750
8	366	447	4	1 320 000	2 600 000	1 600	1 900	6 440
6,3	376	429	3	1 100 000	2 650 000	1 500	1 800	9 230
8,8	393	483	5	1 630 000	3 250 000	1 400	1 700	7 170
6,3	396	449	3	1 140 000	2 800 000	1 500	1 800	9 700
8,8	413	503	5	1 660 000	3 350 000	1 400	1 700	7 430
7,2	423	482	4	1 430 000	3 600 000	1 400	1 700	10 970
9,1	433	523	5	1 700 000	3 450 000	1 300	1 600	7 690
7,2	443	502	4	1 500 000	3 800 000	1 300	1 600	11 540
9,5	459	560	5	2 160 000	4 500 000	1 200	1 500	8 660
7,2	463	522	4	1 530 000	4 000 000	1 300	1 600	12 120
10	479	580	5	2 120 000	4 500 000	1 200	1 500	8 660
6,8	487	558	4	2 040 000	5 200 000	1 200	1 500	12 690
10,2	501	609	6	2 450 000	5 100 000	1 100	1 400	9 240
6,8	507	578	4	2 120 000	5 500 000	1 100	1 400	13 390
10,9	524	636	6	2 600 000	5 400 000	1 100	1 400	9 430
7,2	531	606	5	2 360 000	6 100 000	1 100	1 400	14 110
11,2	544	656	6	2 700 000	5 850 000	1 000	1 300	10 060
7,2	551	626	5	2 320 000	6 100 000	1 000	1 300	14 110
11,7	564	677	6	2 650 000	5 850 000	1 000	1 300	10 060

Equipment and services for the mounting and maintenance of rolling bearings

Equipment and services for the mounting and maintenance of rolling bearings

Equipment and services

Equipment and services for the mounting and maintenance of rolling bearings

Equipment and services

Competence in maintenance

The service arm of Schaeffler Group Industrial is the specialist contact for the maintenance of rotating components.

The aim is to help customers save on maintenance costs, optimise plant availability and avoid unforeseen machine downtime.
The services are provided irrespective of the brand of the machine components used.

In order to ensure rapid, competent supply of maintenance products and services to customers worldwide, the Schaeffler Group has centres of competence all over the world. All service employees undergo a comprehensive training programme and are audited regularly. This ensures that all services throughout the world conform to a uniformly high standard of quality. Since each customer has a different set of requirements, the Schaeffler Group offers concepts individually tailored to the customer.

Services to industry

The service function has undertaken ongoing expansion of its range in recent years. A small excerpt from the extensive range of products and services can be seen in the following sections.

Detailed information on the equipment and services available can be found in Catalogue IS1, Mounting and Maintenance of Rolling Bearings.

Enquiries

If you have any questions on equipment and services, please address these directly to the service function:

- E-mail: Production-Machinery@schaeffler-iam.com
- Internet: www.schaeffler-iam.com
- Telephone: +49 (0)2407 9149-66

Products for mounting and repair

The product range comprises tools for the mechanical, hydraulic and thermal mounting and dismounting of rolling bearings. Mechanical tools are used predominantly for smaller bearings. Medium-sized and large rolling bearings are mainly mounted and dismounted using hydraulic or thermal tools. The range is logically rounded off by measurement devices and accessories (such as transport tools and gloves).

Products for mechanical mounting and dismounting

For the mechanical mounting and dismounting of small and medium-sized rolling bearings, the Schaeffler Group offers mounting tool sets, various wrenches and mechanical extractors.
Hydraulic extractors are used where higher extraction forces are required.

The following products are available:

- mounting tool sets
- socket wrenches
- hook and pin wrenches
- mechanical extractors
- hydraulic extractors, *Figure 1*
- three-section extraction plates.

Figure 1
Dismounting of a bearing using a hydraulic extractor

Equipment and services for the mounting and maintenance of rolling bearings

Products for hydraulic mounting and dismounting

In order to give easier mounting and dismounting of bearings with a tapered bore, hydraulic nuts are often used. Pressure generation devices available include oil injectors, hand pump sets and high pressure pumps. Selection is aided by the software Mounting Manager.

There is a comprehensive range of accessories, such as manometers, adapters and reduction nipples, high pressure hoses and sleeve connectors:

- hydraulic nuts
- oil injectors
- hand pump sets
- high pressure pumps
- hydraulic systems and units
- connectors, accessories.

Products for thermal mounting and dismounting

Rapid and energy-efficient heating of rolling bearings can be achieved with induction heating devices.

The Schaeffler Group has table top equipment for mobile use as well as high performance standalone equipment:

- electric heating plates
- induction heating devices
- heating rings, heat conducting paste
- electric induction heating devices.

Products for measurement and inspection

Feeler gauges and measuring devices can be used to check the production of bearing seats and the mounting of bearings:

- feeler gauges
- taper gauges
- snap gauges
- enveloping circle gauges.

Accessories for mounting and dismounting

Accessories provide assistance in the storage, transport and mounting of rolling bearings:

- transport and mounting tools
- gloves
- mounting paste
- anti-corrosion oil.

Products for condition monitoring

Condition monitoring helps to achieve high availability and long service life of machinery and plant. FAG products help in planning maintenance work and reducing costs. The range includes devices for the alignment of shafts and belt pulleys. Temperature measuring and sonar devices make it possible to check the operating condition. An important element of the range comprises measuring systems that monitor vibration, torque and lubricants.

Monitoring of operating condition

These devices can be used to manually check the temperature and speed of rolling bearing arrangements:

- temperature measuring devices
- digital hand tachometer.

Vibration diagnosis

Devices for vibration diagnosis:

- Detector III, *Figure 2*
- SmartCheck
- DTECT X1 s
- WiPro s
- ProCheck.

Figure 2
Condition monitoring

Equipment and services for the mounting and maintenance of rolling bearings

Mounting service

The industrial service experts of the Schaeffler Group offer mounting services for rolling bearings that are applicable across industrial sectors, *Figure 3*. We have extensive experience, for example in railways, mining, steel and aluminium and wind power as well as pulp and paper.

Figure 3
Mounting of a large rolling bearing

Condition Monitoring

The malfunction-free and optimised operation of complex machinery and plant can only be achieved by means of condition-based maintenance. The key method used by the Schaeffler Group in condition-based maintenance is vibration diagnosis, *Figure 4*. This method makes it possible to detect incipient damage in machinery at a very early stage.

Above all, vibration diagnosis helps to avoid unplanned downtime and expensive secondary damage, increase productivity and improve plant availability.

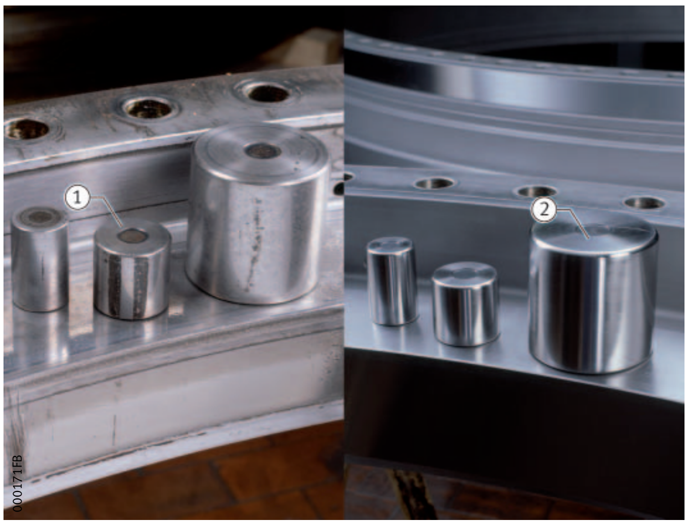
Figure 4
Vibration diagnosis as a service

Rolling bearing reconditioning

During the maintenance of machinery and plant, many rolling bearings are taken out of service and replaced by new ones as a precaution. In some cases, this safety-conscious approach blocks any appreciation of the potential cost savings. The fact is: reconditioned bearings generally give the same performance as new ones.

The reconditioning of rolling bearings and rolling bearing units is one of the core competences of the service arm of Schaeffler Group Industrial and is offered at several certified locations worldwide. Our services for rolling bearings of all types apply irrespective of manufacturer and are not restricted to Schaeffler Group products.

The Schaeffler Group is in a position to recondition and modify rolling bearings with an outside diameter of up to 4 250 mm, *Figure 5*. It is thus an expert partner for customers from a very wide range of industrial sectors such as general and special machine building, steel and aluminium, pulp and paper production, wind power, shipbuilding, private and public railways and mining. Reconditioning of rolling bearings has also proved effective for large bearings in machine tools.



① Before:
Rollers and raceway with corrosion marks and foreign body indentations

② After:
Reground raceway, new rollers with matched oversize

Figure 5
Rollers and raceway

Equipment and services for the mounting and maintenance of rolling bearings

Dimensions

Reconditioning and modification can be carried out on rolling bearings with an outside diameter D of up to 4 250 mm.

Bearings and bearing units are divided into three diameter groups:

- D < 425 mm
- 425 mm < D < 1 250 mm
- 1 250 mm < D < 4 250 mm.

If reconditioning or modification of other bearings is required, please contact the Schaeffler Group.

Reconditioning levels

There are four reconditioning levels, from Level I to Level IV, see table.

Level I to Level IV

Processing steps	Level			
	I	II	III	IV
Removal of fretting corrosion	■	■	■	■
Polishing of raceways	–	■	–	–
Regrinding of raceways	–	–	■	■
Manufacture of rolling elements	–	–	■	■
Replacement of cage	–	–	■	■
Replacement or rework of rolling bearing rings	–	–	–	■
Assembly	■	■	■	■
Preservation or greasing	■	■	■	■
Packing	■	■	■	■
Despatch	■	■	■	■

Further information

Further information on the reconditioning of rolling bearings is given in Technical Product Information TPI 207, Reconditioning of Rolling Bearings.

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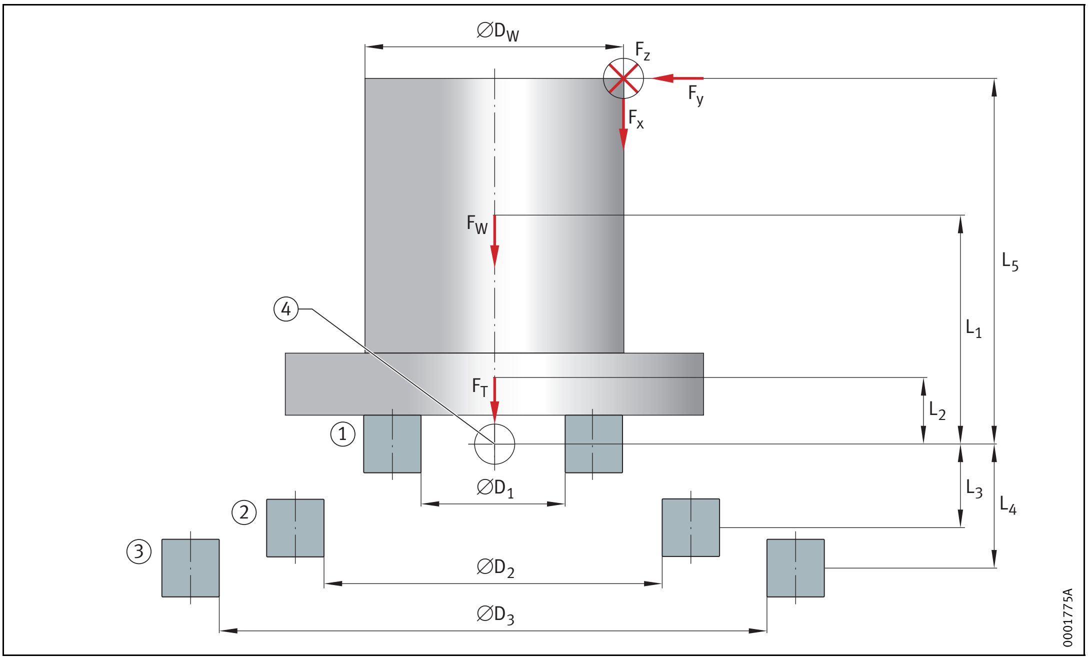
Duty cycle



①, ②, ③ Bearing 1, 2 or 3

④ Zero point, centre of first bearing

Load case	Time proportion	Speed	Workpiece			Machining forces			
			Outside diameter	Weight force		Forces			Overhang
		n	$\varnothing D_W$	F_W	L_1	F_x	F_y	F_z	L_5
	%	min^{-1}	mm	kN	mm	kN	kN	kN	mm
1									
2									
3									
4									
5									

Load case	Table			Bearing solutions				
	Outside diameter	Weight force		Shaft diameter			Distance	
	$\varnothing D_T$	F_T	L_2	$\varnothing D_1$	$\varnothing D_2$	$\varnothing D_3$	L_3	L_4
	mm	kN	mm	mm	mm	mm	mm	mm
1								
2								
3								
4								
5								

Notes

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