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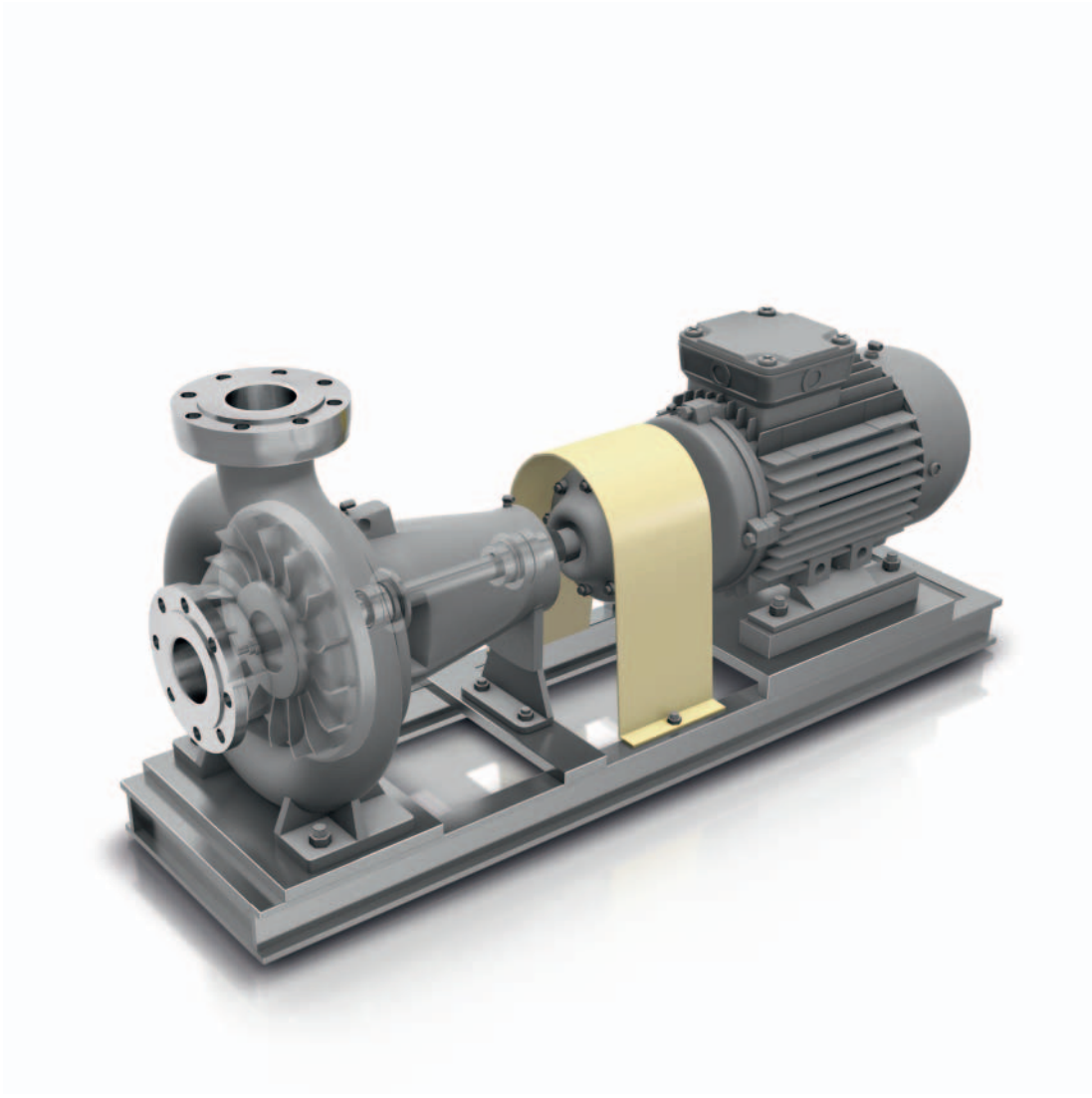


Schaeffler Solutions for Fluid Pumps

Design, maintenance and servicing

Foreword

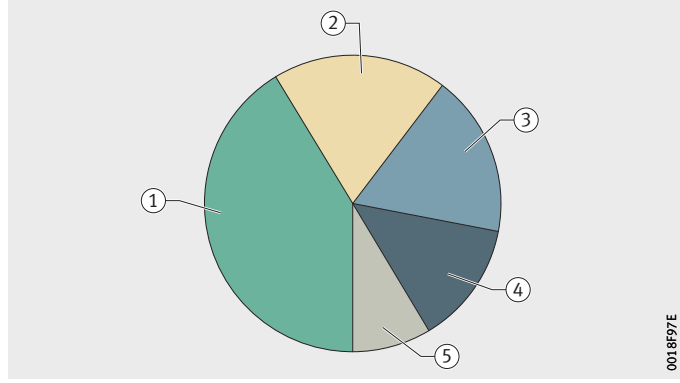
Schaeffler is a leading worldwide supplier of rolling bearings (standard and special bearings), spherical plain bearings, accessories specific to bearings and comprehensive maintenance products and services. Schaeffler offers solutions based on approximately 225 000 products for more than 40 000 customers and has an extremely wide portfolio that gives secure coverage of applications from more than 60 industrial market sectors.

Economical solutions

Products from Schaeffler stand for economy, energy efficiency and a long service life. Schaeffler offers both manufacturers and operators of fluid pumps an extensive range with high availability. Innovative and economical solutions are required as early as the design stage. In particular, it is not just the product and unit costs, but also the total cost of ownership (TCO) which is of considerable interest to plant operators. For this very reason, it is becoming increasingly important to find precisely matched system solutions based on high quality standard bearings. The continuous development of our product portfolio in the area of friction-optimised rolling bearings will also prove advantageous to you in operation.

Industry sectors

Pumps must work reliably and efficiently – irrespective of their application! The appropriate bearing arrangement plays a key role here. The rolling bearings are subject to special requirements, including those from applicable standards, according to their area of use, application and design. As a result, their selection and arrangement play a decisive role in supporting the forces acting in the pump in a reliable and continuous manner and with low friction.



① Water and waste water
② General industry
③ Oil and gas
④ Chemicals industry
⑤ Power plants

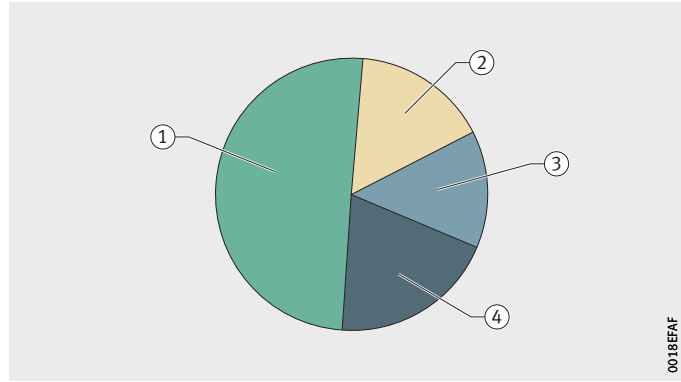
Figure 1
Industry sectors
(source: Oxford Economics, Global Pump Market Prognose 2019)

Foreword

Pump designs

Pumps essentially differ in terms of their functional principle, *Figure 2*. The energy generated by the pump motor is transferred to the fluids in the form of pressure and volume flow.

The corresponding pump designs are derived from the application-specific requirements. **Centrifugal pumps** account for the largest share.



① Centrifugal pumps
② Reciprocating piston pumps
③ Rotary pumps
④ Other

Figure 2
Pump designs
(source: Oxford Economics, Global Pump Market Prognose 2019)

Bearing selection and design

The criteria for the design of the bearing arrangement are the operating data, primarily the effective bearing forces, speeds and lubrication conditions, from which the required bearing design, the bearing arrangement and the basic load rating are then derived. Schaeffler's free online calculation programs enable you to perform rating life calculations of individual bearings or shaft models yourself, in order to select the optimal design. This publication focuses on the rolling bearings in **centrifugal pumps** and on the electric motors which are sometimes integrated in the pump. Detailed information on rolling bearings in electric motors can be found in our separate publication TPI 274, Rolling Bearings in Electric Motors.

Development partners

The engineers in our Application Engineering and External Sales functions are available to support you as a development partner worldwide, so that your pumps operate more effectively, more reliably and also more economically.

This publication gives an overview of various rolling bearings that can be fitted in an application-oriented sense in centrifugal pumps. Fluid pumps themselves are subjected to widely varying operating conditions in their different areas of application. In addition to the pump design and associated operating conditions, there are many other factors that are of particular importance for optimal bearing selection.

Maintenance and servicing

The perfect system should have maximum availability and be maintenance-free throughout. The services and maintenance products provided by Schaeffler ensure all-round support during operation. This begins with the premium lubricants, which are optimally tailored to the machine, continues with the intelligent lubricators, which ensure that all rolling bearings installed in the machines are supplied with lubricant as required, and extends to condition monitoring devices, which identify faults long before they be detected through changes in sound or through an increase in temperature.

Product information

Both the ***medias*** product catalogue and Catalogue HR 1, Rolling Bearings, describe all rolling bearings in accordance with DIN ISO the specific bearing accessories and further rolling bearing types and design variants.

They shows which products can be considered for a bearing arrangement, the factors that must be taken into consideration in the design, the tolerances required on the adjacent construction and how the bearing arrangement is sealed.

They also gives detailed information on the calculation of bearing rating life, on temperatures and loads, on suitable lubricants and, last but not least, on how the products are correctly fitted and maintained.

All information can also be found at www.schaeffler.com under the heading Products & Solutions in the ***medias*** product catalogue.

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Calculation example
Lubrication of rolling bearings and lubricants for pumps and electric motors

Principles and requirements

Principles

A distinction is made between radial, axial and semi-axial pumps based on the design of the impeller. The design therefore has a significant influence on the direction and magnitude of the acting forces. The operating data, primarily the effective bearing forces, speeds and lubrication conditions, form the basis for the mathematical design of the bearing. In order to determine the bearing forces, the axial and radial thrust of the pump must be determined as part of the bearing design. The axial and radial thrust are the forces acting on the pump rotor, which, in turn, are composed of hydraulic, drive, weight and inertia forces.

Axial force

The hydraulic forces, particularly in axial and semi-axial centrifugal pumps, predominantly act as axial forces on the impeller, whereby the influence of various components must be taken into account.

The difference in pressure between the suction and pressure side induces an axial force on the rotor, which is composed of the following:

- The pressure on the suction side of the impeller is related to the area of the impeller plate on the suction side and results in an axial force in the direction of the pressure side.
- The pressure on the pressure side of the pump is related to the area of the cover plate on the pressure side and results in an opposing axial force.

Similarly, the pressure difference at the shaft seal is related to the area of the shaft cross section. The overall result is the axially acting hydrostatic force. The design of the impeller as an open, semi-open or closed impeller therefore has a major influence on the magnitude and direction of the acting axial force. The hydrostatic pressure force can be reduced by means of compensating holes in the impeller and a throttle gap at the cover plates. The load on the bearing arrangement can be relieved but with detrimental effects on pump efficiency and manufacturing costs.

In radial centrifugal pumps, the pumped medium enters the volute casing through the axially arranged suction nozzle, but exits in a tangential direction through the discharge nozzle. An impulse acts on the rotor in an axial direction. The impulse force is determined from the differences in the axial components of the flow velocity between the inlet and outlet and taking into account the flow and density of the pumped medium. The impulse force can be reduced by means of diffusors provided in the design.

During start-up, turbulence can occur in the lateral impeller space. The resulting axial forces can lead to axial load changes during start-up.

Radial force

The radial hydraulic force is created from an interaction of the impeller with the volute housing. Due to the tangential arrangement of the discharge nozzle, the centrifugal flow is not uniform. There are differences in the flow velocities over the circumference of the housing, which fluctuate according to the operating point of the pump. As a result, radial hydraulic forces act on the impeller. By providing a double volute housing with two spiral ducts offset by 180°, which merge into one discharge nozzle, more even flows can be formed with a lower hydraulic radial thrust.

Imbalance forces generated by the rotor act in a radial direction in the centre of mass. Depending on the pump arrangement, the weight forces generated by the rotor act axially on a vertical axis and radially on a horizontal axis.

Other driving forces

Depending on the design of the drive train, various driving forces such as coupling forces, belt pull or magnetic pull must be taken into account.

The effective bearing forces required for dimensioning the bearings can be calculated on the basis of the appropriate bearing arrangement from the axial and radial thrust.

There are also various other requirements which must be taken into account when selecting the bearing arrangements.

Shaft seals

In addition to the rolling bearings and their arrangement, the shaft seals also have a major effect on the design of the pump and bearing arrangement as a result of being a central component. Shaft seals ensure that the pump housing is sealed against the egress of pumped medium and the ingress of air and contaminants. The sealing of the bearing is often realised by means of separate seals in the bearing housing. The stuffing boxes, radial seals or mechanical seals used to seal against pressure can be technically very complex and are a significant cost factor in the design. As wear parts, seals are often critical components and have a major impact on the maintenance strategy and dimensioning of bearings.

For low-wear operation of the seal, the bearing arrangement must ensure good shaft guidance with limited shaft deflection. This can be verified as early as the design phase using the BEARINX-online module Easy Pump.

More complex mechanical seals require additional installation space and involve increased bearing distances from the impeller as well as additional moment loading for the bearings.

Requirements

Requirements to be taken into consideration in the selection of bearing arrangements:

Requirements for pump bearing arrangements

- support of radial and axial loads and of vibrations and shocks
- long operating life with low maintenance outlay
- use of cost-effective standard rolling bearings, also with regard to sealing and greasing
- type reduction and standardisation
- conformity with norms and standards
- low total cost of ownership (TCO)

Requirements for electric motor bearing arrangements

Electric motors are used in preference as drive units in fluid pumps, for which the bearing arrangement must take account of the following factors:

- operating conditions such as load, speed, temperature
- rating life requirements
- shaft arrangement and design envelope
- vibration and noise behaviour
- friction-optimised design with optimum sealing
- lubrication (temperature, noise, grease operating life)
- current insulation

Further application-specific requirements for rolling bearings

- longer relubrication intervals, moving towards lifetime lubrication
- corrosion resistance
- energy-efficient, friction-optimised rolling bearings and complete solutions
- suitability for higher temperature range
- media lubrication
- products and services for maintenance and mounting
- automatic relubrication systems, for example with Schaeffler CONCEPT
- cost-effect condition monitoring, for example with Schaeffler OPTIME

Requirements for rolling bearings in fluid pumps

Requirements for rolling bearings in fluid pumps	Rolling bearing types			
	Deep groove ball bearings Generation C	Cylindrical roller bearings X-life	Angular contact ball bearings X-life	Double row angular contact ball bearings X-life
Low noise	++	+	++	++
Low friction	++	+	++	++
High speed[1]	++	+	++	++
Current insulation by means of ceramic rolling elements (HC)	++[3]	■	■	■
Current insulation by means of coating, e.g. J20AB	++	++	+	+
Radial load	+	++	+	+
Unilateral axial load	+	+[5]	++	+
Support of axial load in both directions	+	+[6]	–	++
High temperature[2]	■	■	■?	■
High sealing action	++	■	++	++
for-life lubrication	++	■	++	++
Long relubrication intervals, grease operating life	++	+	++	++

– not suitable + suitable ++ particularly suitable ■ not relevant

1) Speed parameter $n \times D_m > 500\,000$.

2) Temperature > +80 °C.

3) Especially in smaller diameter range OD < 110 mm.

4) Material-specific temperature limits must be observed.

5) NJ or NUP design only.

6) NUP design only.

					Seal		Cage		Grease lubrication			Internal clearance
Spherical roller bearings X-life	Tapered roller bearings X-life	Four point contact bearings X-life	Needle roller bearings X-life	Ceramic rolling elements X-life	Non-contact e.g. 2Z	Contact e.g. 2HRS	Metal	Plastic	Standard grease	Special grease	Relubrication with Arcanol	C3
–	–	++	+	++	+	■	+	++	+	++	+	■
–	–	++	+	++	+	■	+	++	+	++	+	■
–	+	+	+	++	+	–	++	++	+	++	+	++
■	■	■	■	++	■	■	■	■	■	■	■	■
+	+	+	+	■	■	■	■	■	■	■	■	■
++	++	–	++	■	■	■	■	■	+	+	+	■
+	++	++	–	■	■	■	■	■	+	+	+	■
+	–	++	–	■	■	■	■	■	+	+	+	■
■	■	■	■	++	+[4)]	+[4)]	■	■	–	++	+	++
■	■	■	■	■	+	++	■	■	■	■	■	■
■	■	■	■	++	++	++	+	++	+	++	■	■
–	+	+	+	++	–	–	+	++	+	++	++	■

Further information

- TPI 165, Deep Groove Ball Bearings Generation C
- TPI 206, Current-insulating Bearings
- KXL, X-life Premium Quality
- TPI 176, Lubrication of Rolling Bearings
- MH 1, Mounting Handbook
- FOT General, Condition Monitoring with Schaeffler OPTIME
- FEP, Online calculation of fluid pumps
- PEE, Online calculation of electric motors and generators
- QWT, Product training on rolling and plain bearings

Conformity with norms and standards

Pump standards have been established for various bearing designs and applications, for example DIN 24255 for standardised water pumps or ISO 2858 for standardised chemical pumps. The aim of normalisation is primarily to standardise mounting dimensions, components and performance data in order to simplify the planning, operation and maintenance of systems to the greatest possible extent. Specifications relating to bearing design are also generated in the design of pump bearing arrangements, as the standardised shaft determines, for example, the number of holes in the rolling bearings used.

Other standards, such as ISO 9905, ANSI B73.1 or API 610, also seek to establish a uniformly reliable quality standard and good operational reliability. The design and construction of the pump is also regulated by the design of the pump bearing arrangement. In some cases, detailed specifications are defined, which relate, for example, to the requisite minimum life, design of the bearing seats, bearing supports and seals, but also in part to the bearing arrangements, bearing designs, cage designs and relubrication intervals.

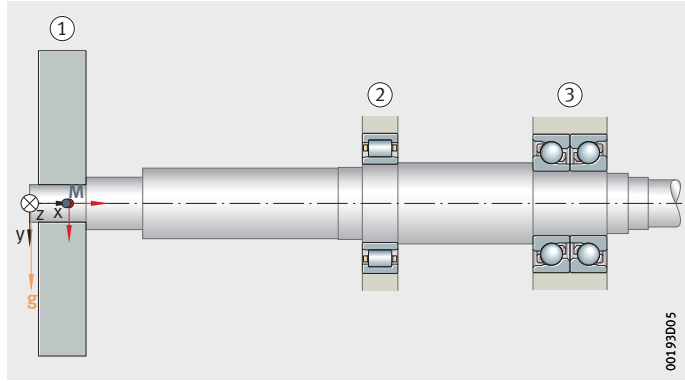
In addition, there are some specifications that can be influenced by the appropriate design of the bearings, including permissible shaft deflection, radial runout accuracies, vibrations and temperature ranges.

Common bearing arrangements for centrifugal pumps

In principle, the pump design of a centrifugal pump differs in terms of how the bearings are arranged relative to the impeller.
If the impeller is located to the side of the locating and non-locating bearing arrangement, this is referred to as a overhung bearing arrangement or “overhanging bearing pump”. By contrast, the impeller in the so-called “between bearings pump” is arranged between the locating and non-locating bearing.

Overhung impeller arrangement (“overhanging bearing pump”)

The majority of centrifugal pumps are designed with an overhung impeller arrangement. In this case, the impeller sits on the side of the locating and non-locating bearing arrangement and only one of the complex shaft seals in the pump housing is required. Savings on installation space and components can also be achieved. The radial forces acting on the impeller subject the overhung bearing arrangement to considerable tilting moments, while the axial forces present must be supported by the locating bearing. The resulting load distribution at the two bearing positions is uneven. The inner bearing on the output side supports most of the radial force. This has an influence on the dimensioning of the bearing and on the calculated rating life.



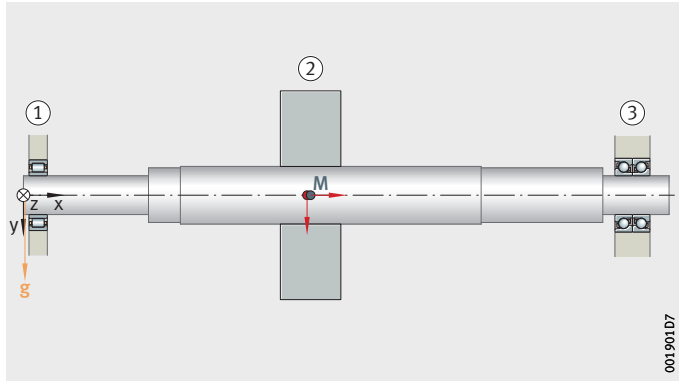
① Impeller
② Non-locating bearing
③ Locating bearing

Figure 1
Overhung bearing arrangement

The example shows a cylindrical roller bearing (non-locating bearing) for the exclusive support of radial loads acting on the pump side. The axial loads are supported by a matched pair of angular contact ball bearings of UB design in an O arrangement.

Impeller between the bearings (“between bearings pump”)

In contrast to the overhung bearing arrangement, the impeller in the so-called “between bearings pump” is arranged between the locating and non-locating bearing.



① Non-locating bearing
② Impeller
③ Locating bearing

Figure 2
Bearing arrangement

Types of bearing arrangements

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

Adjusted bearing arrangement

The simplest bearing arrangement is an adjusted bearing arrangement. The support width, rigidity and deflection of the pump shaft are largely determined by the bearing spacing. An O arrangement of angular contact ball or tapered roller bearings is preferred in order to achieve greater rigidity and thus reduced shaft deflection through an increased support distance.

An adjusted bearing arrangement with deep groove ball bearings is axially spring-adjusted in order to reduce the shaft clearance. A larger operating contact angle for better support of axial loads can be set using internal clearance C3. For higher load carrying capacity requirements, the adjusted bearing arrangement can be designed with single row angular contact ball bearings. Angular contact ball bearings have a ball set with more rolling elements than comparable deep groove ball bearings and are characterised by a contact angle of 40° due to a high axial load carrying capacity.

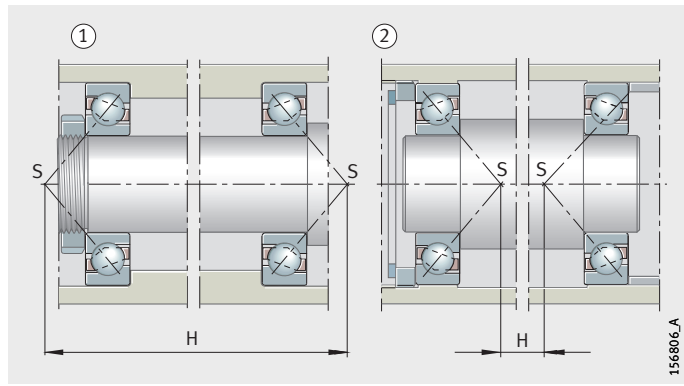
These bearing arrangements normally consist of two symmetrically arranged angular contact ball bearings or tapered roller bearings. During mounting, one bearing ring is displaced on its seat until the bearing arrangement achieves the required clearance or the necessary preload.

Due to this adjustment facility, the adjusted bearing arrangement is particularly suitable where close axial guidance is required.

X and O arrangement

A fundamental distinction is drawn between the O arrangement, *Figure 3*, and the X arrangement, *Figure 3*, of the bearings. In the O arrangement, the cones and their apexes S formed by the contact lines point outwards; in the X arrangement, the cones point inwards. The support distance H, in other words the distance between the apexes of the contact cones, is larger in the O arrangement than in the X arrangement. The O arrangement therefore gives the lower tilting clearance.

When setting the axial internal clearance, thermal expansion must be taken into consideration.



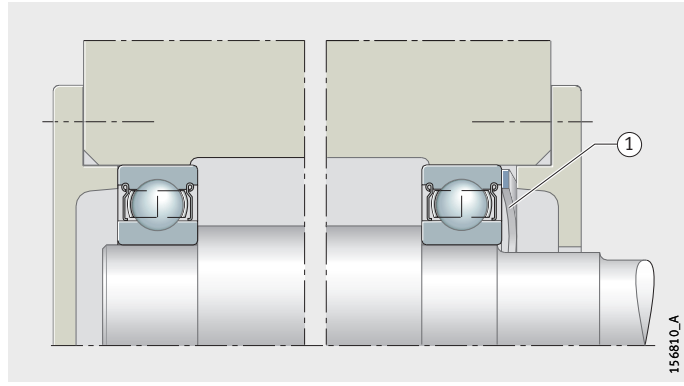
S = apexes of the contact cones
H = support distance

Angular contact ball bearings:
① O arrangement
② X arrangement

Figure 3
Adjusted bearing arrangement

Elastic adjustment

Adjusted bearing arrangements can also be achieved by preloading using springs *Figure 4*. This elastic adjustment method compensates for thermal expansion, for which a loose bearing fit on the outer ring is necessary. It can also be used where bearing arrangements are at risk of vibration while stationary or during operation.



Deep groove ball bearing preloaded by means of spring washer

① Spring washer

Figure 4
Adjusted bearing arrangement

This bearing arrangement is customary, for example, in electric motors. The spring preload not only permits the implementation of a minimum load to avoid slippage in the bearing, particularly in the case of deep groove ball bearings that are subjected to very low loads, but also has a noise-reducing effect.

Floating bearing arrangement

The floating bearing arrangement is an economical solution where close axial guidance of the shaft is not required, *Figure 5*. Apart from the spring preload, its construction is similar to that of the adjusted bearing arrangement.

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

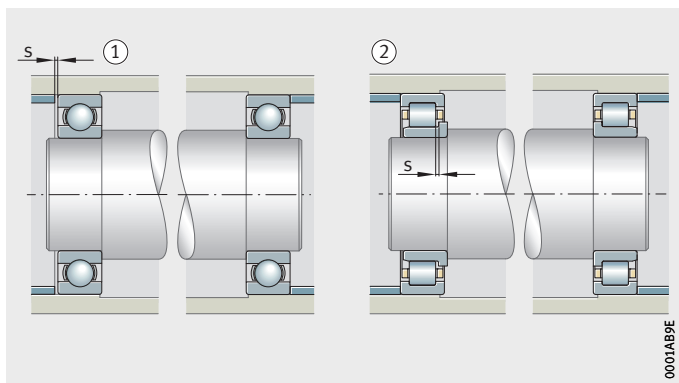
Suitable bearings

Suitable bearing types for the floating bearing arrangement include deep groove ball bearings or even spherical roller bearings.

In order to ensure length compensation which is free from axial forces, one ring each, usually an outer ring, has a fit that allows displacement.

In floating bearings arrangements with cylindrical roller bearings, for example the type NJ shown, the length compensation takes place within the bearings, *Figure 5*. The inner and outer rings can have tight fits.

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



s = axial clearance

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

Figure 5
Floating bearing arrangements

Locating/non-locating bearing arrangement

On a shaft supported by two radial bearings, the distances between the bearing seats on the shaft and in the housing frequently do not coincide as a result of manufacturing tolerances. The distances may also change as a result of temperature increases during operation. These differences in distance are compensated in the non-locating bearing. Examples of locating/non-locating bearing arrangements are shown in *Figure 6* and *Figure 7*, page 20.

Non-locating bearings

The non-locating bearing supports radial load only and enables axial displacement of the shaft to compensate for thermal expansion. In an overhung arrangement, the bearing position on the impeller side is preferably designed as a non-locating bearing. As a result, the axial load support is shifted to the bearing position on the drive side, which is subjected to less radial load. The optimum non-locating bearing function can be achieved with cylindrical roller bearings, such as designs N or NU with cage. In this instance, the roller and cage assembly is displaced with little friction on the raceway of the bearing ring without ribs. Cylindrical roller have higher basic load ratings than ball bearings and are therefore suitable for high radial loads.

It should be noted that this bearing type is prone to slippage if the specified minimum load is not reached. After just a short period of load-free operation, slippage damage to the raceways can occur in the form of wear, which in the least favourable case, in combination with suboptimal lubrication, can lead to an extreme reduction in the operating life. The minimum load ($C_0/P > 60$ must be ensured.

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

Locating bearings

The locating bearing guides the shaft in an axial direction and is thus mainly subjected to axial load. The type of bearing selected as a locating bearing depends on the magnitude of the axial forces and the accuracy with which the shafts must be axially and radially guided. For higher demands on basic load rating and rigidity, double row angular contact ball bearings or a pair of single row angular contact ball bearings in universal design are commonly used.

Single row angular contact ball bearings in an O arrangement with an optimised support width are particularly suitable for higher requirements. Compared with double row angular contact ball bearings, a pair of bearings offers advantages in terms of basic load ratings due to the ball set with a higher number of rolling elements and is also better suited to supporting axial loads due to the larger contact angle of 40°.

The bearings can be fitted in pairs in any O or X arrangement without shims. Angular contact ball bearings of the universal design are matched so that, in an X or O arrangement, they have a defined axial internal clearance. Common designs are UO (without clearance), UB (low axial internal clearance) or UA (slightly higher axial internal clearance).

An alternative for lower requirements is available in the form of four point contact bearings. Four point contact bearings QJ must not be subjected to radial or combined radial/axial loads. For this reason, they are generally used as locating bearings where separate radial bearings are already required in the design, such as in vertical immersion pumps with radial plain bushes for example.

Examples of locating/non-locating bearing arrangements

Deep groove ball bearing:
① Locating bearing
Cylindrical roller bearing NU:
② Non-locating bearing
Deep groove ball bearing:
③ Locating bearing
④ Non-locating bearing

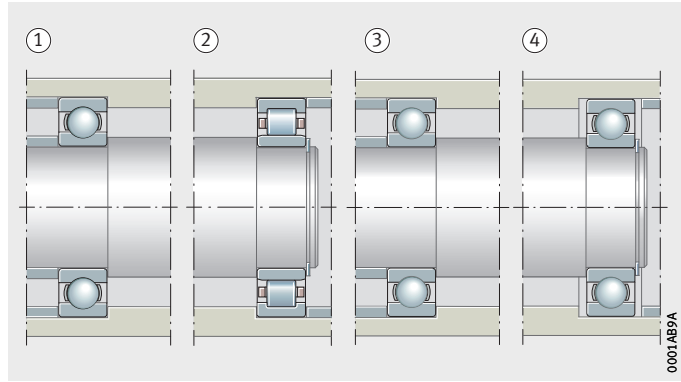


Figure 6
Locating/non-locating bearing arrangements

Double row angular contact ball bearing:
① Locating bearing
Cylindrical roller bearing NU:
② Non-locating bearing
Four point contact bearing and cylindrical roller bearing:
③ Locating bearing
Cylindrical roller bearing NU:
④ Non-locating bearing

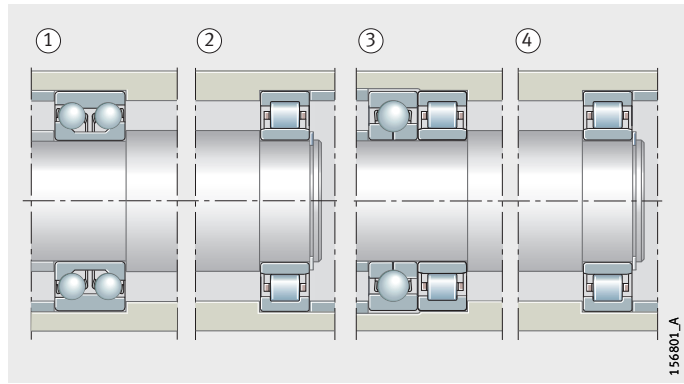


Figure 7
Locating/non-locating bearing arrangements

Axial location of bearings

Axial location of the bearing rings is matched to the specific bearing arrangement (locating bearings, non-locating bearings, bearings in adjusted and floating arrangements).

Design guidelines

The shoulders on the mating parts must be large enough to provide a sufficiently wide contact surface even with the largest chamfer dimension of the bearing (DIN 5418).

The bearing rings must be located by force locking or form fit in order to prevent lateral creep. The bearing rings must only be in contact with the shaft or housing shoulder, but not with the fillet.

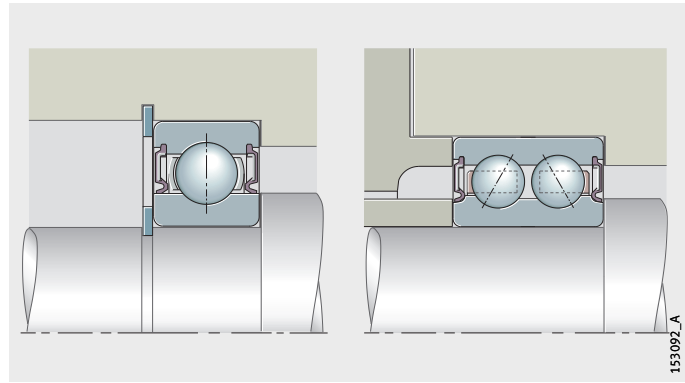
Locating bearings support axial forces. The retaining element must be matched to these axial forces. Shoulders on the shaft and housing, snap rings, housing covers, shaft covers, nuts and spacer rings are suitable, *Figure 8* and *Figure 9*.

In non-separable bearings, one bearing ring must have a tight fit, while the other ring is retained by the rolling elements.

Since bearings in adjusted and floating arrangements support axial forces in one direction only, the bearing rings only need to be supported on one side. Counterguidance is performed by a second, symmetrically arranged bearing. Shaft nuts, ring nuts, covers or spacer washers are suitable as adjustment elements.

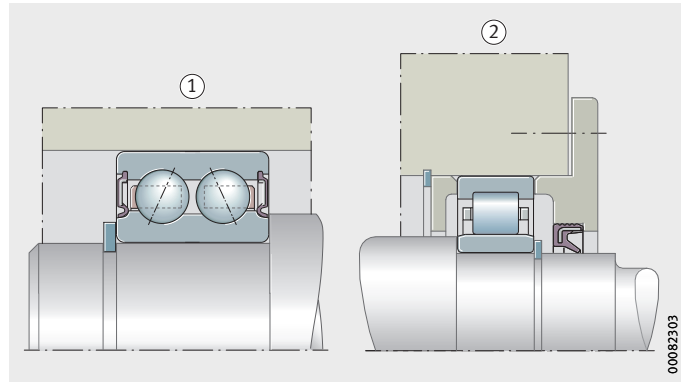
In floating bearing arrangements, lateral movement of the rings is prevented by shaft or housing shoulders, covers, snap rings.

Examples of retaining elements



Axial location by form fit on the inner and outer ring

Figure 8
Locating bearings



① Axial location by form fit on the inner ring

② Axial location by form fit on the inner and outer ring

Figure 9
Non-locating bearings

Shaft tolerances

The following recommendations can be given for the tolerancing of the shaft under normal mounting and operating conditions on the basis of the conditions of rotation.

Shaft tolerances

Condition of rotation	Bearing type	Shaft diameter mm	Displacement facility Load	Tolerance zone
Circumferential load on inner ring or indeterminate load direction	Ball bearings	up to 50	Normal loads[1]	j6 (j5)
		50 to 100	Low loads[2]	j6 (j5)
			Normal and high loads[3]	k6 (k5)
		100 to 200	Low loads[1]	k6 (m6)
			Normal and high loads[4]	m6 (m5)
		over 200	Low loads	m6 (m5)
			Normal and high loads	n6 (n5)
	Roller bearings	up to 60	Low loads	j6 (j5)
			Normal and high loads	k6 (k5)
		60 to 200	Low loads	k6 (k5)
			Normal loads	m6 (m5)
			High loads	n6 (n5)
		200 to 500	Normal loads	m6 (n6)
			High loads, shocks	p6
		over 500	Normal loads	n6 (p6)
			High loads	p6

[1] $\overline{C/P > 10}$.

[2] $C/P > 12$.

[3] $C/P < 12$.

[4] $C/P < 10$.

Deviations are possible if particular requirements apply, for example in relation to running accuracy, smooth running or operating temperature. Increased running accuracies thus require closer tolerances such as tolerance grade 5 instead of 6. If the inner ring is warmer than the shaft during operation, the seating may loosen to an impermissible extent. A tighter fit must then be selected, for example m6 instead of k6.

In such cases, the question of fits can only be resolved by a compromise. The individual requirements must be weighed against each other and those selected that give the best overall solution.

Radial and axial internal clearance

The radial internal clearance is determined on the dismounted bearing. This is the amount by which the inner ring can be moved in a radial direction from one extreme position to the other in relation to the outer ring. The axial internal clearance s_a is defined as the amount by which one bearing ring can be moved relative to the other, without load, along the bearing axis.

Operating clearance

The operating clearance, on the other hand, is determined on a fitted bearing still warm from operation. This is the amount by which the shaft can be moved in a radial direction from one extreme position to the other. It is derived from the radial internal clearance and the change in the radial internal clearance as a result of interference fit and thermal influences in the fitted condition. This is therefore largely defined by the operating and installation conditions of the bearing, which must be taken into account when selecting the bearing: for radial bearings, for example, with C3 radial internal clearance values or for axial bearings by spring preloads.

A lower preload has proved to be advantageous in relation to the rating life of ball bearings, in particular angular contact ball bearings, since the load is then distributed over several rolling elements and the rigidity of the bearing arrangement can be increased. However, this preload must not be increased above an optimum value, since a significant reduction in the rating life must then be anticipated due to the higher contact stresses, *Figure 10*.

Preload during operation must be avoided with roller bearings.

In contrast to a slight preload, an excessively large operating clearance can lead to sliding effects, unfavourable load distribution and unsatisfactory running behaviour.

① Rating life
② Operating clearance
③ Preload
④ Clearance

Figure 10
Operating clearance

Dimensioning of rolling bearings

The required design and size of a rolling bearing is largely dependent on the following requirements:

- application
- adjacent construction and requirements from applicable standards
- required rating life of the rolling bearings and the system
- load carrying capacity
- operational reliability

Calculation of the rating life

The dynamic load carrying capacity of the rolling bearing is determined by the fatigue behaviour of the material. The dynamic load carrying capacity is described in terms of the basic dynamic load rating, which is based on DIN ISO 281. This, in turn, has been broken down further and specified in ISO/TS 16281 and DIN 26281 (formerly DIN ISO 281, Appendix 4), in order to take account of the corresponding influences from operation and thus further improve the calculation results.

Calculation methods

Methods and variations, particularly in relation to the relevant influences from operation, for calculating the fatigue life include the following:

- basic rating life L_{10} and L_{10h} according to ISO 281
- expanded rating life L_{nm} and L_{nmh} according to ISO 281

Basic rating life L_{10} and L_{10h}

The basic rating life L_{10} and L_{10h} in accordance with ISO 281:2007 take account of the following:

- bearing type
- load
- speed

The rating life is determined by means of comparison with reference conditions, essentially the basic load rating and design (ball or roller bearings).

Basic reference rating life L_{nr}

The basic reference rating life L_{hr} in accordance with ISO/TS 16281 and DIN 26281 (formerly DIN ISO 281 Appendix 4) also takes account of the following influences:

- exact internal load distribution
- fatigue limit of the material
- spatial load and tilting of the bearing
- operating clearance

Adjusted reference rating life L_{nmr}

The adjusted reference rating life L_{hmr} in accordance with ISO/TS 16281 and DIN 26281 (formerly DIN ISO 281 Appendix 4) additionally takes account of the following:

- the extent to which the surfaces are separated by the lubricant
- the cleanliness in the lubrication space
- the additive package in the lubricant

A number of influencing factors must be taken into account in the design and dimensioning of the bearing concept. BEARINX-online Easy Pump from Schaeffler, which is available free of charge, is the ideal tool for carrying out an uncomplicated, yet detailed expanded rating life calculation.

Further information

- Detailed information on the rating life calculation of rolling bearings can be found in our main catalogue HR1 or online at https://medias.schaeffler.de/de/knowledge-center
- https://bearinx-online-easy-pump.schaeffler.com

Operating life

The operating life is defined as the life actually achieved by the bearing. It may differ significantly from the calculated value. In practice, the operating life is often significantly higher than the calculated rating life, however, it may also be lower.

This may be due to wear or fatigue as a result of:

- deviations in the operating data
- misalignment between the shaft and housing
- insufficient or excessive operating clearance
- contamination
- corrosion
- lubricant supply
- grease operating life, particularly in the case of sealed bearings lubricated for life
- inadequate lubrication
- excessive operating temperature
- oscillating bearing motion with very small swivel angles (false brinelling)
- high vibration and false brinelling
- very high shock loads (static overloading)
- prior damage during mounting
- current passage

Due to the wide variety of possible mounting and operating conditions, it is not possible to precisely predetermine the operating life. The most reliable way of arriving at a close estimate is by comparison with similar applications.

Making *medias* product information easy to find

What is *medias*?

medias combines the Schaeffler product catalogue, consultation tools and an implemented eCommerce solution in a single platform. On ***medias*** you will find key information on industrial products, receive technical advice and obtain information about the availability of our products and the associated prices.

Buttons

	Technical advice and support, engineering tools and extensive product information such as CAD models and calculation tools.
	Check current product price and availability. An overview of current or past orders and quantity details is also displayed.
	Find a sales partner in your area and request a quotation.

Finding *medias*

medias is accessed as follows:

- https://medias.schaeffler.de
- enter the search query “Schaeffler medias” using any Internet search engine

medias Business

medias Business has an extended range of functions compared with ***medias***. Registration is required to use ***medias*** Business.

Navigation

The options for signing in, registering and selecting languages can be found in the header on the ***medias*** homepage, together with the search function. The search function can be used to navigate directly to a known product. Here, you will find the wish list function and basket in the top right-hand corner. Below the header are the three navigation tabs “Products”, “Engineering Tools” and “Knowledge & Support”, where the relevant information can be called up with just a few clicks.

Products

Product searches can either be performed using the Products navigation tab or directly via the search function. The main dimensions and performance data are stored under the respective product and a data sheet is available for downloading. This data sheet contains the main dimensions and performance data, the mounting dimensions, calculation factor, temperature range and material number. This page also contains further technical information on the corresponding bearing design, as well as the facility to start an individual bearing calculation and download the CAD model of the bearings or instructions on mounting and dismounting.

Knowledge and Support

The “Knowledge & Support” navigation tab opens a field with various functions, including a knowledge database and a lexicon, which contains basic technical knowledge about rolling bearings.

Engineering Tools

In addition to providing product information, ***medias*** also offers a variety of engineering tools, ranging from selection of the correct bearing through to calculation of the rolling bearing life at system level. These tools can be easily accessed via the “Engineering Tools” navigation tab on the ***medias*** home page.

Bearing selection assistant

The bearing selection assistant helps with selection of the optimal bearing. Currently known information or requirements can be entered here, such as which loads occur, which dimensions the bearing should have or which basic load ratings are required. The bearing selection assistant will then you the suitable rolling bearings.

Bearing frequency calculator

Depending on the kinematic frequencies, conspicuous frequency models can be allocated to a single component of a bearing (inner ring, outer ring, rolling element and cage). With the aid of the bearing frequency calculator, this can be determined by inputting the geometrical data.

Heating Manager

The Heating Manager enables you to select the optimal HEATER heating device for your products.

Grease selection guide

Here you will find properties and recommendations for our Arcanol rolling bearing greases.

***medias* interchange**

medias interchange assists with the conversion of competitor rolling bearing designations into INA or FAG designations.

Single bearing calculation

If you have a potential bearing that meets requirements, you can use the calculator symbol to run an immediate online single bearing calculation in order to verify the life requirements.

Shaft calculations

The BEARINX-online module Easy Pump permits the calculation of bearing arrangements for fluid pumps at system level.

Only a single initial registration process is required in order to be able to use BEARINX-online Easy Pump. The program can then be used free of charge for your calculations.

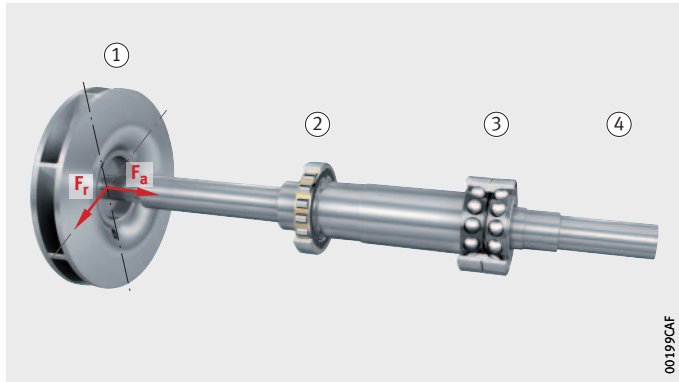
Further information

- FEP, Online calculation of fluid pumps
- PEE, Online calculation of electric motors and generators

BEARINX-online Easy Pump

During calculation, you are guided step by step through the program by self-explanatory dialog pages. This allows rapid, easy input of data for the model structure of the pump shaft, impeller and bearing arrangement, *Figure 1*.

Alternatively, the examples can be used as templates for your design and adapted accordingly. For this purpose, one data set each is available to download for a centrifugal pump, a double flow pump and a submersible pump. This is followed by bearing selection and entry of the operating and load case data.



① Impeller
② Non-locating bearing
③ Locating bearing
④ Motor

Figure 1
Shaft calculation

Calculation results

The internal load distribution in the bearing is calculated precisely, taking into account the actual rolling bearing and raceway profile. The fatigue life in accordance with DIN ISO is output for the evaluation of the bearing arrangement concept. Calculation results for operating clearance, lubrication, tilting or the maximum contact pressure of the individual bearings are also available. In addition, the program outputs guide values for the selective displacement of the shaft during operation and the associated equivalent stress.

Radial displacement

The radial deflection or the displacement at the position of the shaft seal or impeller, for example, can be displayed. This information can therefore be incorporated quickly and easily when configuring the shaft and bearing rigidity.

All input data, project data and calculation results are available to you in a detailed PDF document once the calculation has been completed.

Further information

- For information on BEARINX-online Easy Pump, see the calculation example in the chapter “Dynamic load carrying capacity ad life”
- FEP, Online calculation of fluid pumps
- PEE, Online calculation of electric motors and generators

Calculation example

Calculation example BEARINX-online Easy Pump

https://bearinx-online-easy-pump.schaeffler.com/files/beispiele.htm

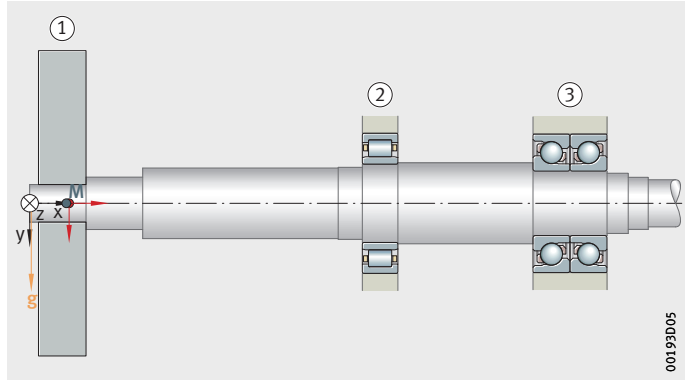
Design examples

Three template files are stored in the program:

- centrifugal pump
- double flow pump
- submersible pump

Bearing arrangement in a centrifugal pump

The impeller is overhung. The weight is calculated in accordance with the modelling from the shaft geometry. The position of the deflection measuring point was set to the impeller's centre of gravity, but alternatively can be selected at will, for example to the position of the seal. On the drive side of the pump shaft, two angular contact ball bearings are used as locating bearings in an O arrangement. The suffix UB indicates that the bearings can be combined as necessary in a tandem, O or X arrangement. The bearing pair supports the axial thrust and a proportionate radial load. A cylindrical roller bearing is installed close to the impeller as a non-locating bearing, which is used solely to support the radial load and for guidance.



① Impeller
② Non-locating bearing
③ Locating bearing

Figure 1
Overhung bearing arrangement

Operating conditions

Speed:	3 000 min^{-1}
Loads on impeller:	F_a = 9 000 N, F_r = 7 000 N
Load cases:	100%. Average operation
Temperatures:	Impeller: 70 °C
	Non-locating bearing: 80 °C
	Locating bearing: 80 °C
Oil bath lubrication:	Viscosity: 32 mm^2/s
Oil cleanliness code:	17 in accordance with ISO 4406
	14 in accordance with ISO 16889

Calculation example

Non-locating bearing

- rolling bearing: NU2218-E-XL-TVP2
- internal clearance: CN
- shaft fit: k6
- housing fit: H7
- mean roughness depth Rz: shaft: 6,3 µm, housing: 12 µm

Locating bearings

- rolling bearings: 2 x 7315-B-XL-TVP-UB in O arrangement
- internal clearance: UB = 27 µm to 39 µm
- shaft fit: k6
- housing fit: H7
- mean roughness depth Rz: Shaft: 6,3 µm, housing: 12 µm

Calculation results

All project data, entries and results for the corresponding documentation are displayed in a clearly arranged results view.

In addition to the basic rating life $L_{10h(xy)}$, the corresponding, significantly more detailed results of the expanded rating life L_h (without the influence of lubrication) and L_{hmr} (with influence of lubrication) in accordance with ISO TS 16281 are also displayed.

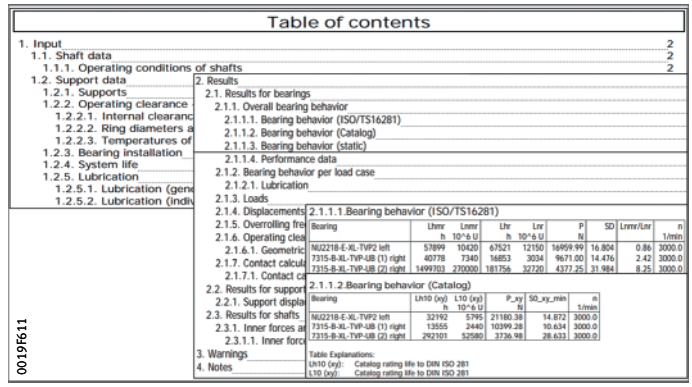


Figure 2
Display of the calculation results

Lubrication of rolling bearings and lubricants for pumps and electric motors

Principles

The main function of the lubrication of rolling bearings is to prevent or reduce contact between rolling and sliding surfaces. As a result, friction and wear are kept to a low level. Lubricant is conveyed into the contact areas of rolling bearings and adheres to the surfaces of parts rolling against each other. The lubricant thus separates the contact surfaces and prevents metal-to-metal contact. If a lubricant film is not formed that can fully support loads, some areas of the surfaces are not separated by the lubricant film. Operation with low levels of wear is possible even in such cases if tribomechanical reaction layers are formed between the additives in the lubricant and the rolling element or bearing ring.

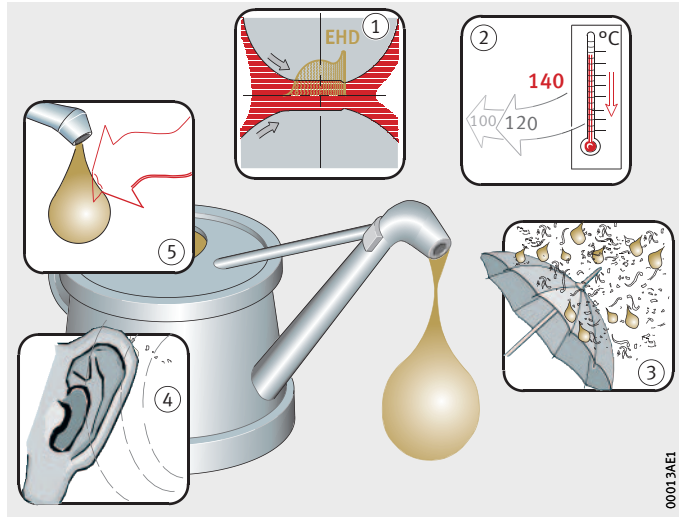


Figure 1
Functions of the lubricant

Legend to *Figure 1*

The lubricant fulfils important functions in the rolling bearing:

① Forms a lubricant film sufficiently capable of supporting loads on the contact surfaces and thus prevent wear and premature fatigue

② Dissipates heat in the case of oil lubrication

③ Provides additional sealing for the bearing against external solid and fluid contaminants in the case of grease lubrication

④ Damping of running noise

⑤ Gives protection against corrosion

Lubrication of rolling bearings and lubricants for pumps and electric motors

Selection of the type of lubrication

A fundamental distinction is made between oil and grease lubrication, with grease lubrication being used for the most part, particularly with smaller pumps.

Oil lubrication

Oil lubrication presents itself as a sensible option if adjacent machine elements are already supplied with oil or if heat is to be dissipated by the lubricant. Heat dissipation may be necessary if high speeds or loads are present or if the bearing arrangement is subjected to heating by an external source.

The advantages of oil lubrication include:

- cleaning of the lubricant in recirculating oil lubrication by means of filters and oil replacement in oil sump lubrication
- reduction in operating temperatures

Grease lubrication

Under normal operating and environmental conditions, lifetime lubrication (lubrication for-life) is often possible for deep groove ball bearings. However, attention must be paid to the grease operating life in design of the bearing and particularly when selecting the grease. We hold a special stock range of the usual bearing types that are greased with standard and high-temperature grease.

If high demands are present, for example in terms of speed, temperature and load, it will be necessary to plan for relubrication at appropriate time intervals. In this case, it is necessary to provide inlet and outlet ducts for grease as well as a collection chamber for used grease. The CONCEPT lubricators are suitable for short relubrication intervals, as they deliver the correct quantity fully automatically in a defined time interval. Detailed information can be found in the chapter Maintenance and servicing.

The advantages of grease lubrication include:

- very little design work required
- sealing action supported by the grease
- long operating life with maintenance-free lubrication

Grease operating life

The grease operating life describes the period over which the grease is capable, without relubrication, of lubricating the bearing to an adequate extent. Once the grease operating life has been reached, function of the bearing is only conditionally possible and the bearing will fail relatively quickly as a result of lubricant failure. The grease operating life is therefore a decisive value if it is shorter than the calculated bearing life. It is particularly relevant to function if the rolling bearings cannot be relubricated.

Influencing factors

The factors influencing the grease operating life are:

- the grease quantity and distribution
- the type of grease (thickener, base oil, additives)
- the production process of the grease
- the bearing type and size
- the magnitude and type of load
- the speed parameter
- the bearing temperature
- the mounting conditions

Grease selection

Correct grease lubrication is particularly important in the case of bearings with high proportions of sliding motion and bearings subjected to heavy loads. Under high load, the lubrication capability of the thickener and the additive package are of particular importance. In grease lubrication, the amount of lubricant playing an active role in the lubrication process is very small. Grease of normal consistency is largely displaced from the rolling contact and is deposited laterally or exits the bearing arrangement through the seals. The grease remaining on the raceway surfaces and laterally in or on the bearing continuously releases the nominal small quantity of oil and, in some cases, thickener as well for lubrication of the functional surfaces. The effective lubricant quantity between the rolling contact surfaces is sufficient for lubrication under moderate load over an extended period.

Influencing factors

The factors influencing grease selection are:

- the bearing type and size
- the operating conditions, for example speed, temperature
- the magnitude and type of load

Lubrication of rolling bearings and lubricants for pumps and electric motors

Lubricating greases

Lubricating greases for deep groove ball bearings greased for-life	
Grease designation	Properties
Standard greases according to defined grease specifications	Standard grease for D ≦ 62 mm Low-noise ball bearing grease for D ≦ 62 mm
	Standard grease for D ≧ 62 mm Low-noise ball bearing grease for D > 62 mm
Preferred high temperature greases that are interchangeable in pumps and electric motor applications	
L069	Low-noise high temperature grease High speeds
L207	Low-noise high temperature grease High speeds
Lubricating greases for sealed, greased for-life, double row angular contact ball bearings	
e.g. L285	Low noise
Arcanol lubricating greases for relubrication of all rolling bearings (all designs) using Schaeffler lubricators CONCEPT	
Arcanol MULTITOP	Universal high performance grease
Arcanol TEMP90	Low-noise high temperature grease

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

Thickener	Base oil	Operating temperature range °C		Speed parameter n×mm min^{-1}·mm	Kinematic viscosity at +40 °C mm^2/s		NLGI class
		from	up to		from	up to	
Lithium soap	Mineral oil	–20	120	500 000	68	150	2
Lithium soap	Mineral oil	–20	120	500 000	68	150	3
Polycarbamide	Ester oil	–40	180	1 000 000	80	–	2, 3
Polycarbamide	Ester oil	–40	180	900 000	70	–	2, 3
Lithium soap	Mineral oil	–20	120	500 000	68	150	3
Lithium soap	Mineral oil PAO	–50[1)]	140	800 000	82	–	2
Polycarbamide	Mineral oil PAO	–40	160	700 000	148	–	3

Further information

- TPI 168, Rolling Bearing Greases Arcanol
- TPI 176, Lubrication of Rolling Bearings
- TPI 252, Automatic Lubricators

SCHAEFFLER

Maintenance and servicing

Condition monitoring
Relubrication with CONCEPT
Relubrication with OPTIME C1
Mounting and servicing of rolling bearings
Typical damage patterns and remedial measures

Condition monitoring

Features

Intelligent Service Solutions not only reduce costs, working time and risks, but also enable user-friendly and safe working conditions. As a competent partner, Schaeffler offers comprehensive solutions for the entire life cycle of rolling bearings in fluid pumps, from intelligent condition monitoring and automatic lubricators to Expert Services. The Service Solutions are essential building blocks for future competitive production. Use the operating life of your bearings to its full potential and avoid unplanned downtime with the help of innovative solutions, even for units where preventive or predictive measures have previously been too costly.

To help you operate your rolling bearings for fluid pumps at optimal costs, Schaeffler offers:

- monitoring systems:
  - Schaeffler OPTIME
    (the inexpensive and wireless solution specifically for ancillary equipment with constant operating conditions)
  - Schaeffler SmartCheck and ProLink CMS
    (the solutions specifically for units with more demanding requirements)
- lubrication systems:
  - CONCEPT1
    (continuously lubricating single-point lubricators)
  - OPTIME C1
    (inexpensive and wireless solution for monitoring single-point lubricators)
  - CONCEPT of series 2 bis 8
    (piston-driven multi-point lubricators)
- Expert Services:
  - temporary offline measurements
  - cause and damage analyses including recommended actions
  - customer training

Figure 1
Overview of monitoring systems

Schaeffler OPTIME

- comprehensive and automated condition monitoring
- wireless IoT solution that can be extended at any time
- several hundred units can be integrated without issue in one day
- up to 50% lower costs compared with manual offline measurement

The monitoring system Schaeffler OPTIME is a complete solution for the straightforward condition monitoring of a large number of machines. The concept also renders condition-based maintenance economical for ancillary equipment, as unplanned downtime can be avoided. The system detects damage to the respective components, for example pumps, electric motors and fans, as well as imbalances, misalignment and stops, with a lead time of several weeks.

During the development of the system particular attention was paid to ensuring very simple start-up, easy scalability and a diverse range of potential uses. Every single process step was designed to be as user-friendly as possible.

The concept features special wireless sensors which combine with the OPTIME gateway to form a mesh network. A further key component of the system are the associated services in the cloud, which use special algorithms based on Schaeffler know-how to automatically evaluate the data.

Figure 2
Concept Schaeffler OPTIME

Figure 3
Schaeffler OPTIME

The results can then be displayed for the specific user in the OPTIME app and assist the user in prioritising notifications and recommended actions.

The results are also available via the web-based dashboard, which can be used to conduct further analyses of time signals or spectra, for example, if required. Furthermore, the entire installation can be managed in the dashboard.

Further information

- Service Info, What is OPTIME and how does it work?
- CSS 0145, Reliable monitoring around the clock – with OPTIME from Schaeffler
- FOT General, Condition Monitoring with Schaeffler OPTIME
- BA 68, User Manual OPTIME
- FEP, Online calculation of fluid pumps
- PEE, Online calculation of electric motors and generators

Schaeffler SmartCheck

The Schaeffler SmartCheck is a compact online measuring system for continuous machine monitoring, *Figure 4*.

Figure 4
Schaeffler SmartCheck

Despite its compact size, Schaeffler SmartCheck is a complete monitoring device and includes an acceleration sensor and full electronic evaluation system.

The device can be mounted very easily on the unit to be monitored. With the pre-installed measurement task and learning mode, simple units such as pumps, motors or fans can be monitored without further configuration. This measurement task can be adjusted and expanded to accommodate changing requirements at any time.

Schaeffler SmartCheck facilitates the following:

- correlation of machine and process parameters
- condition-based maintenance
- increased plant availability

The optional interface in accordance with the OPC UA standard (Open Platform Communication Unified Architecture) allows all measurement data and alarm information to be easily transferred or integrated into the customer infrastructure. For example, the alarm system can be displayed in the system visualisation or work orders can be triggered in a maintenance planning system.

As an additional option, a status e-mail can also be sent to the maintenance engineer, on either a cyclical or alarm-controlled basis. Measurement data can also be added to the e-mail and sent directly to Schaeffler Monitoring Services GmbH for precise analysis.

The characteristic value set thus generated allows highly precise monitoring of the pump.

Further information

- TPI 214, SmartCheck
- Industry 4.0 Service Solutions
- TPI 214, Schaeffler SmartCheck or at www.Schaeffler-SmartCheck.de

ProLink condition monitoring system (CMS)

The ProLink condition monitoring system (CMS) from Schaeffler is a multi-channel system for monitoring complex machines or entire systems.

The ProLink CMS has a modular structure and consists of a main processor module for signal processing and up to four vibration modules for signal acquisition of machine vibrations.

Machine vibration is recorded using up to 16 acceleration sensors, digitalised in the vibration modules and sent to the processor module for evaluation.

Figure 5
ProLink CMS

Thanks to separate sensors, the ProLink CMS can be used wherever the use of OPTIME sensors or Schaeffler SmartCheck is not possible on account of the environment.

As on Schaeffler SmartCheck, a measurement task is also automatically pre-installed for each sensor. The learning module makes it easy to get started in condition monitoring.

As integration in the customer infrastructure is particularly useful for a multi-channel system, optional functionalities such as OPC UA or e-mail are also available in ProLink CMS.

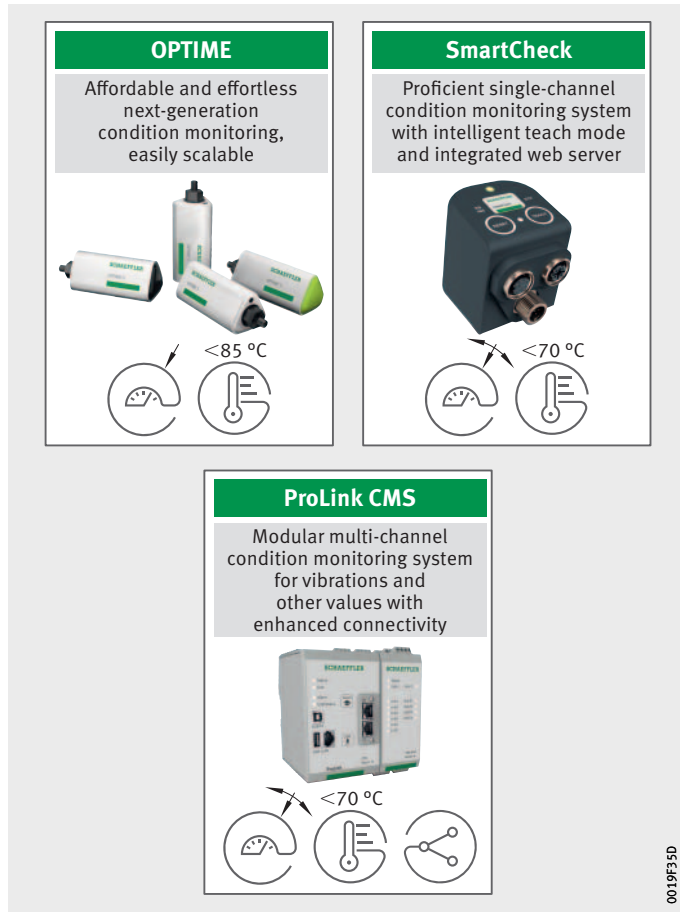


Figure 6
Overview of Schaeffler OPTIME, Schaeffler SmartCheck and Schaeffler ProLink CMS

Further information

- OPL, ProLink CMS – Systematic Condition Monitoring
- User Manual, Schaeffler ProLink CMS
- Technical paper, ProLink – Condition Monitoring System (CMS), Technical presentation
- GTS 0129, Integrated condition monitoring system for a water treatment facility

Features
Automatic lubricators

Almost 80% of bearing damage can be traced back to problems with lubrication. The most common causes are grease ageing, unsuitable grease quantities or grease grades as well as the ingress of contaminants.

With lubricators or lubrication systems, these causes can usually be avoided and the bearings automatically supplied with the correct quantity of lubricant at the right intervals. This significantly increases the life of rolling bearings. Automatic lubricators convey fresh lubricant in the defined quantity at the correct time to the contact points of the rolling bearing. The devices adhere to the lubrication intervals and prevent undersupply or oversupply of grease. Plant downtime and maintenance costs are reduced as a result.

For lubrication points that are difficult to access, work is made easier than with manual lubrication and occupational safety is increased. The lubricators are matched to the bearing positions. They have a wide range of applications, for example on electric motors, gearboxes, compressors and fans, in linear systems, conveying equipment, machine tools and in fluid pumps.

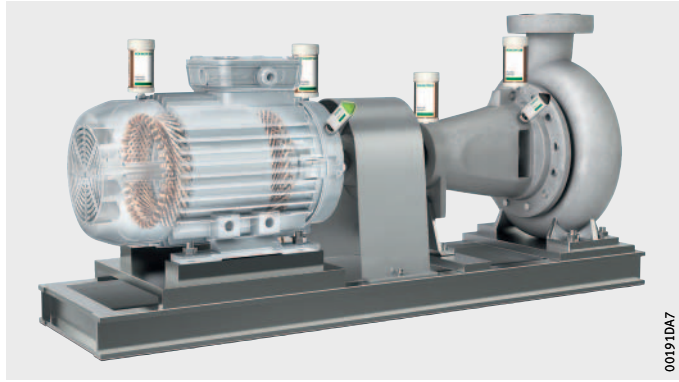


Figure 1
Lubricator on a centrifugal pump

Lubricators are:

- ideally suited for difficult to access locations or ancillary equipment
- economical, as they offer an optimal price/performance ratio
- ready for immediate use due to simple installation
- flexible, as they are available prefilled with Arcanol rolling bearing greases or as an empty device for in-house filling

The portfolio ranges from the CONCEPT1 lubricator with a lubrication connector (single-point) through to the CONCEPT8 lubricator with 8 lubrication connectors (multi-point).

① CONCEPT1
② CONCEPT2
③ CONCEPT4
④ CONCEPT8

Figure 2
Lubricator range

Advantages and functions of the lubricators

- device variants with up to 8 lubrication line outlets (expandable by means of sub-distributors)
- continuous or piston-driven dispensing quantities as required
- increased bearing life by avoiding over- and underlubrication and the resulting temperature increases in the bearing
- increased plant availability and thus reduced maintenance costs
- reduced personnel costs compared to manual lubrication
- battery- or mains-operated variants (DC 24 V) or with integrated gas-powered unit
- wide operating temperature range
- reduced risk of contaminant ingress or of incorrect lubricant selection in comparison with manual lubrication

Further information

- TPI 252, Lubricators for grease and oil lubrication
- FBS, Systematic Lubrication
- ICA, ARCALUB CONCEPT1 – The lubrication system that gets straight to the point
- ICB, CONCEPT2 – The lubrication system that gets straight to the point
- ICC, CONCEPT4 – The lubrication system that gets straight to the point
- ICD, CONCEPT8 – The lubrication system that gets straight to the point

Arcanol rolling bearing greases

Selection of the correct lubricant also plays a decisive role. With the MULTITOP rolling bearing grease, our Arcanol range contains a high-quality standard lubricant which has proven effective for a variety of pumps. Our Arcanol TEMP90 or TEMP110 greases, which guarantee longer relubrication intervals at high temperatures, are suitable for increased temperature requirements.

Figure 3
Arcanol rolling bearing greases

Further information

- TPI 168, Rolling Bearing Greases Arcanol
- TPI 176, Lubrication of Rolling Bearings
- FAS, Arcanol datasheet
- TPI 252, Lubricators for grease and oil lubrication

Relubrication with OPTIME C1

Features

OPTIME C1 is a simple, easy-to-use and cost-effective solution for automatic single-point lubrication. OPTIME C1 expands the Schaeffler OPTIME system developed for the condition monitoring of rolling bearings and integrates the lubricators of the CONCEPT1 series.

During the development of the system, particular attention was paid to ensuring very simple start-up, easy scalability and a diverse range of potential uses. Every single process step was designed to be as user-friendly as possible. These features make Schaeffler OPTIME particularly suitable for the automated and cost-effective monitoring and lubrication of a large number of machines.

Advantages

Advantages of OPTIME C1:

- cost-effective and reliable relubrication
- reduced number of failures and downtimes as a result of reliable lubrication
- hidden costs are avoided, as regular maintenance checks and inspections are no longer required
- extended bearing life due to optimised and controlled lubrication
- guided and easy installation, commissioning and maintenance

Figure 1
OPTIME C1 provided with cartridge, gateway and digital service

Relubrication with OPTIME C1

Schaeffler OPTIME

The OPTIME system is a complete solution for the straightforward condition monitoring and lubrication of a large number of machines. This concept makes automatic lubrication in maintenance even more cost-effective, as unplanned downtimes caused by overlubrication or lubricant starvation can be avoided and regular trips to check the lubricators are no longer necessary. The system warns the user if a lubricator is malfunctioning or if the CONCEPT1 lubricant cartridge needs replacing.

During the development of the system particular attention was paid to ensuring very simple start-up, easy scalability and a diverse range of potential uses. Every single process step was designed to be as user-friendly as possible.

The system features wireless OPTIME C1 lubricators, which are used with a CONCEPT1 cartridge, and combine with the gateway to form mesh network. OPTIME sensors can also be easily integrated, thereby expanding the network. A further key component of the system are the associated services in the cloud, which allow the condition of the lubricators and machines to be checked from any location using a suitable end device via an app or dashboard.

Characteristics of Schaeffler OPTIME:

- comprehensive and automated lubrication
- wireless IoT solution that can be extended at any time
- several hundred units can be integrated without issue in one day
- up to 50% lower costs compared with manual lubrication

Figure 2
OPTIME concept with OPTIME C1, OPTIME sensors, gateway and digital service

Further information

- TPI 271, OPTIME C1
- Customer Success Stories CSS 0179, No surprises with the lubricators
- OPTIME C1 – website at https://www.schaeffler.de/optime-c1

Features

Mounting made simple

Using the right mounting tools not only saves time but also reduces the risk of mounting errors to a minimum. For this reason, we offer a wide selection of mounting and dismounting tools, induction heating devices and devices for optimally aligning your pumps, as a well a mounting service for particularly challenging projects.

Figure 1
Mounting tools

Further information

- MH 1, Mounting Handbook
- TPI 195, Hydraulic Pumps
- TPI 196 Hydraulic Nuts HYDNUT
- TPI 200, Induction Heating Devices HEATER
- TPI 216, Tools for the Mechanical Mounting and Dismounting of Rolling Bearings
- PDB 31, Products for Maintenance
- QWT, Product training on rolling and plain bearings
- OOS, e-learning training on ***medias***-campus

Services

In addition to innovative solutions and products relating to rolling and plain bearings, Schaeffler also offers a wide range of customer-specific services in the area of plant maintenance and quality assurance, from routine measurements and inspections, and professional installations of difficult measurement technology, through to troubleshooting and rectification of faults on complex industrial systems and extensive full-service packages. Always with the aim of helping customers save on maintenance costs, optimise plant availability and avoid unforeseen machine downtime, our service experts support customers worldwide using state-of-the-art technology, for example by remote diagnosis via augmented reality. Where personal intervention is required, support is available from highly qualified technicians and engineers. Countless customers worldwide are already benefitting from the fast, reliable and professional service provided in close customer proximity.

The close cooperation with in-house rolling bearing design and direct access to the expert, application-specific know-how of the application engineering service, also allow condition analyses and condition diagnoses to be performed at a level that is unique to the market. This represents a considerable advantage for our customers with regard to the accuracy of results. Based on many years' experience and qualified experts, Schaeffler is the competent partner for customer-oriented solutions relating to the life cycle of rolling bearings.

Figure 2
Services

Training

Schaeffler's training programme also offers a large selection of product and analysis training courses that specifically strengthen your internal skills with practical first-hand experience.

Our training courses start with basic knowledge and an overview of the products that can be used. Further training courses enhance theoretical know-how and are supplemented by practical exercises. This training also prepares you for having your knowledge of condition monitoring tested and certified at various levels in our certification courses to DIN ISO 18426-2.

Further information

- QWT, Product training on rolling and plain bearings

Typical damage patterns and remedial measures

Features

In terms of high reliability and long life, rolling bearings are among the most important components of a pump, along with the sealing systems. The end of the service life is reached when material fatigue, wear, thermal strain or changes in the lubricant have an increasingly negative effect on the operation of the rolling bearings over time and ultimately lead to a loss of function.

Correct bearing selection and dimensioning is fundamental and leads to a calculated rating life through the incorporation of operating parameters such as adjacent construction, fits, radial and axial load, speed, temperature and lubricant. As not all factors involved in the operation of rolling bearings are fully incorporated into this calculation, the service life actually achieved may deviate from the calculated rating life. An extreme deviation indicates premature bearing damage, which requires the cause to be identified and a suitable remedial measure to be implemented.

Root causes of bearing damage

The following causes can result in corresponding damage to the rolling bearings:

- inadequate, unsuitable or aged lubricant
- inadequate cleanliness, caused by particles or undesirable media
- excessive operating temperatures have a negative impact on the lubricant and material, particularly on the plastic cage or sealing material for example
- temperature differences in the bearing rings affect the operating clearance
- incorrect mounting
- shock loads and vibrations
- material fatigue
- electrical passage of current
- defective bearing location in the housing or on the shaft
- overload
- minimum load not reached

Typical damage patterns and remedial measures

Types of bearing damage

Bearing damage occurring in fluid pumps can include the following:

- fatigue below and on the surface
- wear (abrasive, adhesive)
- corrosion due to moisture or frictional corrosion (fretting corrosion, false brinelling)
- electrical erosion due to stray current or current passage
- plastic deformation due to overloading or indentations (indentations due to particles or handling errors)
- fracture (forced rupture, fatigue fracture) or hot cracking

In order to improve the overall service life of the pump, premature bearing failure should not only be regarded as a total failure of the rolling bearing, but rather as a reduction in the performance capability of the system. A bearing arrangement can only run flawlessly if all operating and design influences are appropriately coordinated. In order to identify the cause and, in particular, to implement suitable remedial measures, all criteria such as lubrication, temperature, sealing, adjacent construction and materials must be taken into account.

The following table is intended to provide an overview of possible influences and relationships, in order that possible causes can be derived from damage patterns of failed bearings and, for example, to permit a closer analysis of these causes. As it is usually difficult to clearly assign the actual applicable damage hypothesis from a bearing that has been removed but not dismantled, a systematic approach should be taken to establish the cause of the failure.

Further information

- Detailed information on typical causes associated with operating or mounting conditions, environmental influences, sealing or lubrication can be found in our publication WL 82 102/2 Rolling Bearing Damage. Appropriate remedial measures are to be derived from this for problem-free operation.

Sealing

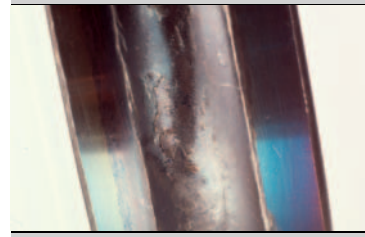
Contaminants	Corrosion
	
Characteristics	
Particle indentations on rolling elements and raceways. These become apparent during further operation in the form of increased noise, vibrations or surface-induced damage.	Red or brown spots or deposits on the rolling elements, raceways or rings. Increased vibrations following by wear.
Cause	
Dust, contamination or abrasive substances present in the air from contaminated working areas, contaminated hands or tools, foreign bodies in lubricants or cleaning solutions.	Damage to the bearings due to aggressive media or environmental influences, formation of condensate due to temperature changes.
Remedy	
Filtration of the lubricant, cleaning of working areas and retention of the bearings in their original packaging until the time of mounting. In the case of contaminated operating environments, possibilities for sealing should be taken into consideration.	Protect the bearing against aggressive media; use of bearings with integral seals and possibly external seals in particularly harsh environments.

Typical damage patterns and remedial measures

Current passage

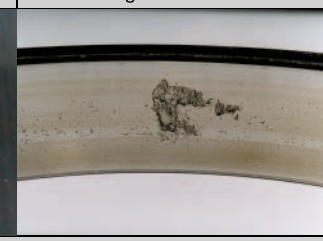
Matting of the raceway	False brinelling
	
Characteristics	
Microscopically small melt craters on the raceway produce a greyish matt raceway.	Indentations running parallel to the axis in the single-digit µm range at seemingly regular intervals. In the application, these flutes lead to increased noise and a rise in temperature.
Cause	
Depending on the motor, frequency converter and operating conditions, different types of unwanted parasitic electric currents can occur in the electric motor. If these currents flow over the rolling bearing, the grease, rolling elements and raceways may become damaged above a certain current intensity.	Depending on the motor, frequency converter and operating conditions, different types of unwanted parasitic electric currents can occur in the electric motor. If these currents flow over the rolling bearing, the grease, rolling elements and raceways may become damaged above a certain current intensity. Flutes only form above a certain current intensity.
Remedy	
Depending on the type of electrical current involved (drive train system), discharge, earthing or insulation should be used to reduce or prevent the passage of current through the bearing. Current-insulating bearings such as hybrid bearings with ceramic balls (prefix HC) or Insutect-coated bearings with a ceramic coating on the outside ring surfaces (e.g. suffix J20AB) provide an easily implementable insulation option.	Depending on the type of electrical current (drive train system), discharge, earthing or insulation should be used to reduce or prevent the passage of current through the bearing. Current-insulating bearings with ceramic balls (prefix HC) or Insutect-coated bearings with a ceramic coating on the outside ring surfaces (e.g. suffix J20AB or J20AA with double layer thickness) provide an easily implementable insulation option.

Lubrication

Failure of lubricant	Micropitting
	
Characteristics	
Dry running due to insufficient, unsuitable or aged lubricant.	Areas of the raceway surface exhibit a large number of extremely small and very flat material ruptures, which give the raceway a partially stained appearance. This is also described as grey staining.
Cause	
Restricted lubricant flow or excessive temperatures, leading to deterioration of the lubricant.	Inadequate lubrication condition (type, quantity, contamination, particularly water) at moderate to low loads, with simultaneously occurring sliding motion.
Remedy	
Use of a suitable lubricant in the correct quantity, prevention of grease loss and compliance with suitable relubrication intervals, for example with CONCEPT lubricators and Arcanol rolling bearing greases. Maintenance of the correct bearing seat and checking of the preload in order to reduce the bearing temperature.	Ensure separating lubricant film; prevent contamination; suitable surface coatings, for example suffix J30PE (Durotect B).

Typical damage patterns and remedial measures

Excessive load

Overload	Material fatigue
	
Characteristics	
Often starting with pressure-polished running marks. Conchiform peeling initially occurring at the most heavily loaded points, which can spread over the entire running surface during further operation.	Often referred to as peeling, emanating from cracks on or under the running surfaces; removal of material particles (usually starting with the inner ring); rapidly propagating damage during further operation, significantly increasing vibrations and running noise.
Cause	
Bearing overload; sometimes in combination with insufficient cleanliness or lubrication.	Overloading, excessive preload, excessively tight fits; fatigue life of the bearing is reached.
Remedy	
Bearings with a higher basic load rating; design change; reduction of the load; rolling bearings to X-life quality.	Rolling bearings to X-life quality; optimisation of lubrication and sealing as well as review or adjustment of the load situation.

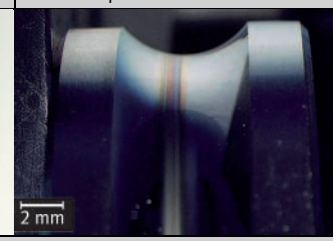
Inadequate load

Slippage marks

Characteristics
Patchy smearing or deep scratches in the material combined with micropitting of the rolling elements or raceways.
Cause
If the load is too low, the rolling elements do not roll on the raceways, but slide over them, which is particularly critical in combination with poor lubrication. Strong acceleration of the rolling elements on entering the load zone. Rapid changes in speed can also lead to slippage and consequently to surface-induced damage.
Remedy
Selection of bearings with lower load carrying capacity; reduction of bearing clearance; improved lubrication; bearings with ceramic rolling elements (prefix HC); coating of rolling elements, for example Triondur C (suffix J48BB).

Typical damage patterns and remedial measures

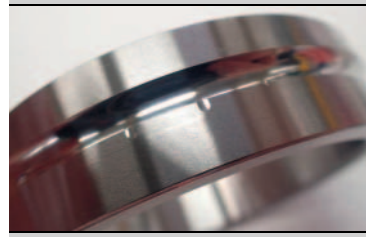
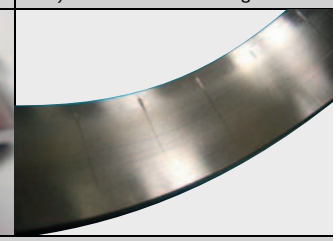
Design

Hot running	Excessive preload
	
Characteristics	
Discolouration of the rings, rolling elements and cages from gold to blue. Temperatures over +150 °C can change the ring and rolling element material, resulting in a reduction in the bearing load carrying capacity and possible premature failures. An increase in temperature also impacts negatively on lubrication.	Distinct running mark due to forced guidance on the raceway floor. This can lead to overheating and consequently cause the bearing to jam.
Cause	
Tight fits, insufficient radial internal clearance or operating clearance, excessive speeds or loads; inadequate heat dissipation (lubrication problem).	Preload in the bearing, too tight a fit; insufficient radial internal clearance; housing problems (roundness/ rigidity).
Remedy	
Sufficient radial internal clearance; suitable bearing selection in terms of speeds and loads; suitable heat dissipation.	Change of fits; higher radial internal clearance.

Fretting corrosion	Co-rotating rings
	
Characteristics	
Reddish or black spots on the outside surface, bore or lateral faces of the bearing. These are oxidised wear particles. Leads to uneven seating conditions, possibly to fatigue fractures and malfunction of non-locating bearing function.	Incipient to severe wear on the seating surface of the inner and outer ring.
Cause	
Micromovements between the matched parts, with moisture and fits which are too loose relative to the acting forces.	Too loose a fit or insufficient consideration of the operating conditions.
Remedy	
Compliance with mounting specifications and fit recommendations (tighter fit where appropriate).	Modification of fits on the shaft or house (tighter fit where appropriate). The radial internal clearance may need to be adjusted under certain circumstances.

Typical damage patterns and remedial measures

Mounting

Rolling element indentations on ball bearings	Mounting-induced score marks on cylindrical roller bearings
	
Characteristics	
Mounting marks appear as plastic deformations, corresponding to the spacing of the rolling elements, in the raceways; these result in increased bearing vibrations (noise). Severe indentations can lead to premature failure as a result of fatigue or fractures.	Score marks running parallel to the axis, mostly on the inner ring; preliminary damage prior to commissioning.
Cause	
Static overloading of the bearing or significant application of force to the bearing, such as the use of a hammer during fitting, dropping or knocking the mounted parts or pressing a bearing onto the shaft by applying force to the inner ring.	Incorrect mounting of the loose ring in the cylindrical roller bearing.
Remedy	
Installation of the bearings using suitable devices, application of force solely to the ring that is to be pressed in.	Mounting of the loose ring under rotation; heating of bearing components where appropriate.

Typical damage patterns and remedial measures

Rolling bearing damage

Characteristics	Damaged areas of the bearing				
	Seating surfaces	Raceways	Rib and roller end face	Cage	Seal
Abnormalities in operating behaviour					
Irregular running	–	–	–	–	–
Unusual noise	–	–	–	–	–
Disturbed temperature behaviour	–	–	–	–	–
Appearance of dismantled bearing parts					
Foreign body indentations	–	■	–	–	–
Fatigue damage	–	■	–	–	–
False brinelling	–	■	–	–	–
Melt craters and fluting	–	■	–	–	–
Slippage damage	–	■	–	–	–
Rolling element indentations, score marks	–	■	■	–	–
Fretting marks	–	■	■	■	–
Wear damage	–	■	■	■	■
Corrosion damage	–	■	■	■	■
Hot air damage	■	■	■	■	■
Fractures	■	■	■	■	–
Frictional corrosion damage (fretting corrosion)	■	–	–	–	–

– not relevant ■ may influence the damage characteristic

	Typical causes of rolling bearing damage															
	Installation						Operating loads			Environmental influences				Lubrication		
	Incorrect mounting methods or tools	Contamination	Fit too tight, preload too high	Fit too loose, preload too low	Inadequate ring support	Misalignments or shaft deflection	Excessive or insufficient loading	Vibrations	High speeds	Dust, dirt	Aggressive media, water	External heat	Current passage	Unsuitable lubricant	lubricant starvation	Overlubrication
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SCHAEFFLER

Rolling bearings for fluid pumps

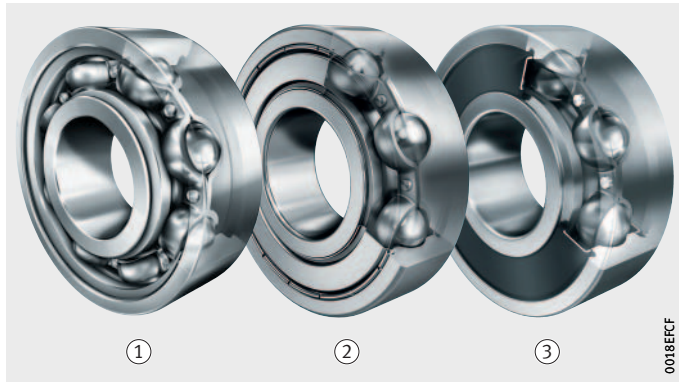
Single row deep groove ball bearings
Single row angular contact ball bearings
Double row angular contact ball bearings
Single row cylindrical roller bearings
Spherical roller bearings
Axial spherical roller bearings
Tapered roller bearings
Four point contact bearings
Needle roller bearings
Coatings for rolling bearings

Single row deep groove ball bearings

Features

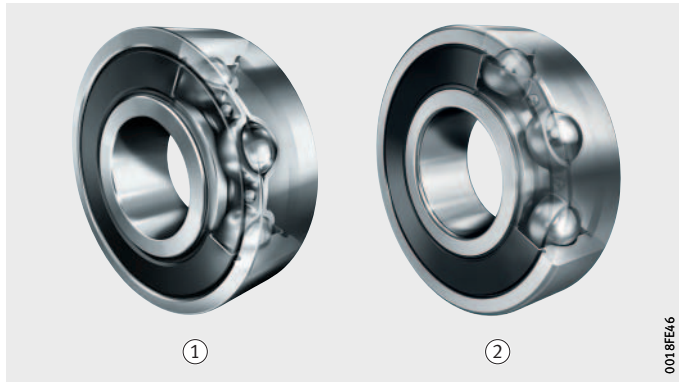
Single row deep groove ball bearings are versatile, self-retaining bearings with solid outer rings, inner rings and ball and cage assemblies. They are of a simple design, robust in operation and easy to maintain. They are available in open and sealed designs.

Deep groove ball bearings of Generation C were specially developed and, as a result of the optimised design, offer lower noise levels, better sealing and higher cost-efficiency, *Figure 1*.



① Open
② Sealing shields on both sides (suffix 2Z)
③ Non-contact seals on both sides (suffix 2BRS)

Figure 1
Single row deep groove ball bearings, Generation C, open or with non-contact seals



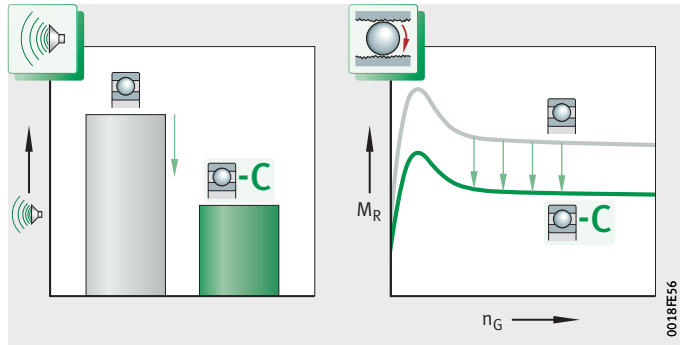
① Contact seals on both sides (suffix 2HRS)
② Contact seals on both sides (suffix 2ELS)

Figure 2
Single row deep groove ball bearings, Generation C, contact seals

The bearing is significantly quieter in operation due to the improved raceway surface, the higher quality of the balls, the optimised internal bearing construction, the higher stability of the cage and higher production accuracy. The frictional torque, which is already very low, is further reduced, resulting in lower energy consumption. Overall, these optimisations lead to a 50% reduction in noise and 35% less friction with Generation C.

C = bearings of Generation C
M_R = frictional torque
n_G = limiting speed

Figure 3
Comparison
of standard deep groove bearings
with bearings of Generation C:
running noise, frictional torque



Radial and axial load carrying capacity

Due to the raceway geometry and the use of balls, deep groove ball bearings can support axial forces in both directions as well as radial forces.

Operating temperature

Open deep groove ball bearings up to an outside diameter of 90 mm can be used up to an operating temperature of +120 °C; for an outside diameter over 90 mm and up to 240 mm, they can be used up to +150 °C.

Deep groove ball bearings with elastomer seals, for example BRS or HRS, can be used at operating temperatures of –30 °C to +110 °C, restricted by the grease and sealing ring material.

Bearings with sealing shield Z can be used from –30 °C to +120 °C.

Lubrication

Bearings sealed on both sides are greased with a high quality grease and are lubricated for life. Special grease applications are also available for individual requirements, for example higher temperatures. These are identified, for example, by the suffixes L069 or L207.

Bearing designation

The structure for single row deep groove ball bearings is shown in *Figure 4*.

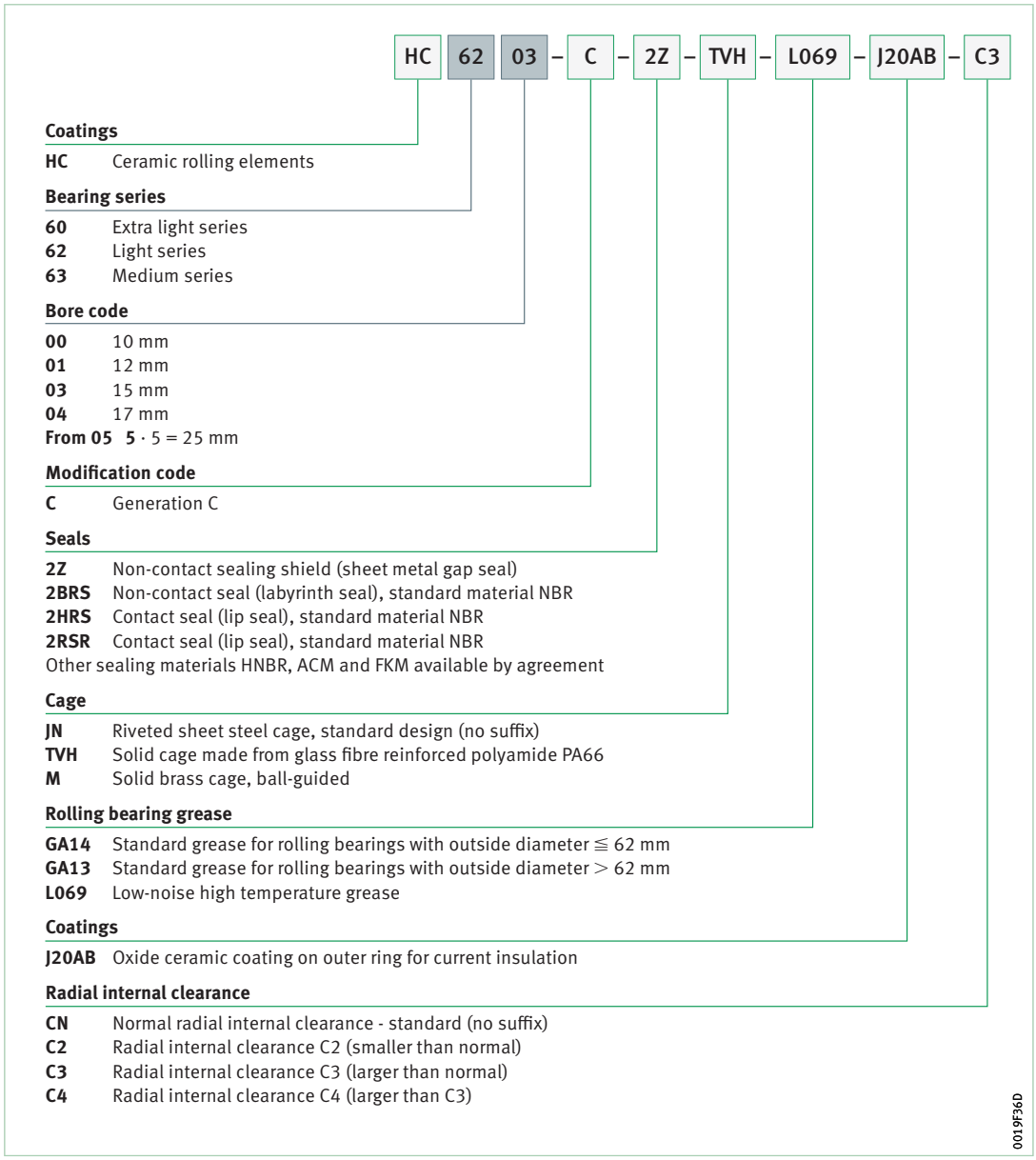


Figure 4
Bearing designation

Further information

- TPI 165, Deep Groove Ball Bearings Generation C
- www.FAG-GenerationC.com
- Product catalogue ***medias***
- Catalogue HR 1, Rolling Bearings,
  see chapter Technical principles and dimension tables

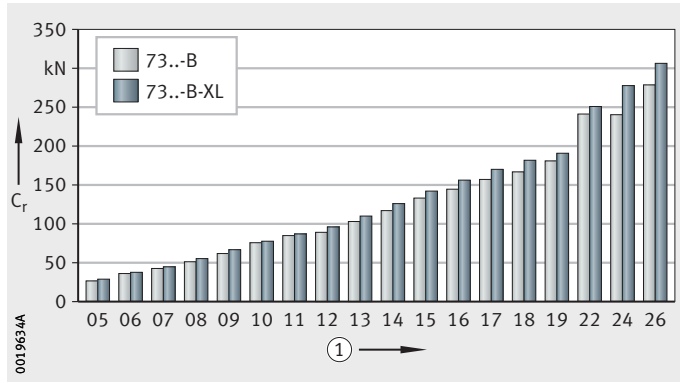
Features

Single row angular contact ball bearings are self-retaining units with solid inner and outer rings and ball and cage assemblies with polyamide, sheet metal or brass cages, *Figure 1*. The raceways of the inner and outer rings are offset from each other along the bearing axis. The bearings are available in open and sealed designs. Their angular adjustment facility is limited.

Figure 1
Single row angular contact ball bearing

X-life

X-life stands for optimised roughness and geometrical accuracy of the raceways. The resulting higher load carrying capacity allows longer operating lives and maintenance intervals to be achieved. Many sizes of single row angular contact ball bearings are classified as X-life products. Other variants can be supplied by agreement.



C_r = basic dynamic load rating

① Bore code

Figure 2
Comparison of basic dynamic load rating C_r – bearing series 73..-B-XL, bore code 05 to 26, with a bearing which is not of X-life quality (73..-B)

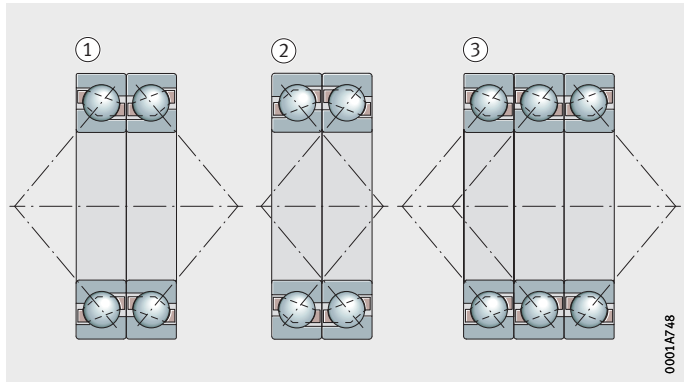
Radial and axial load carrying capacity

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 fitted in a mirror image arrangement.

Due to the contact angle of 40°, these bearings can support high axial loads.

Universal design

Single row angular contact ball bearings of universal design are intended for fitting in pairs in an X, O or tandem arrangement or fitting in groups. These bearings can be mounted in any arrangement required, *Figure 3*.



① O arrangement
② X arrangement
③ Tandem O arrangement

Figure 3
Variants of bearing arrangements

The mounted bearing pair then has a precisely defined axial clearance according to the design selected, for example UO – freedom from clearance, UB – small axial internal clearance, UA – slightly higher axial internal clearance.

Mounting in tandem arrangement

If single row angular contact bearings are mounted in a tandem arrangement, it must be ensured that the end faces of the outer rings in contact with each other have sufficient overlap.

If in doubt, please contact the Schaeffler engineering service.

Operating temperature

Open angular contact ball bearings can be used at operating temperatures from –30 °C to +150 °C.

Angular contact ball bearings with cages made from glass fibre reinforced polyamide are suitable for operating temperatures up to +120 °C.

Bearings with seals are suitable for operating temperatures from –30 °C to +110 °C.

Lubrication

Bearings with lip seals on both sides are greased with a high quality grease and are lubricated for life.

Open bearings and bearings with seals on one side are not greased. They can be lubricated with grease or oil. We recommend the use of our automatic lubricators in the event of grease relubrication.

Bearing designation

The structure for single row angular contact ball bearings is shown in *Figure 4*.

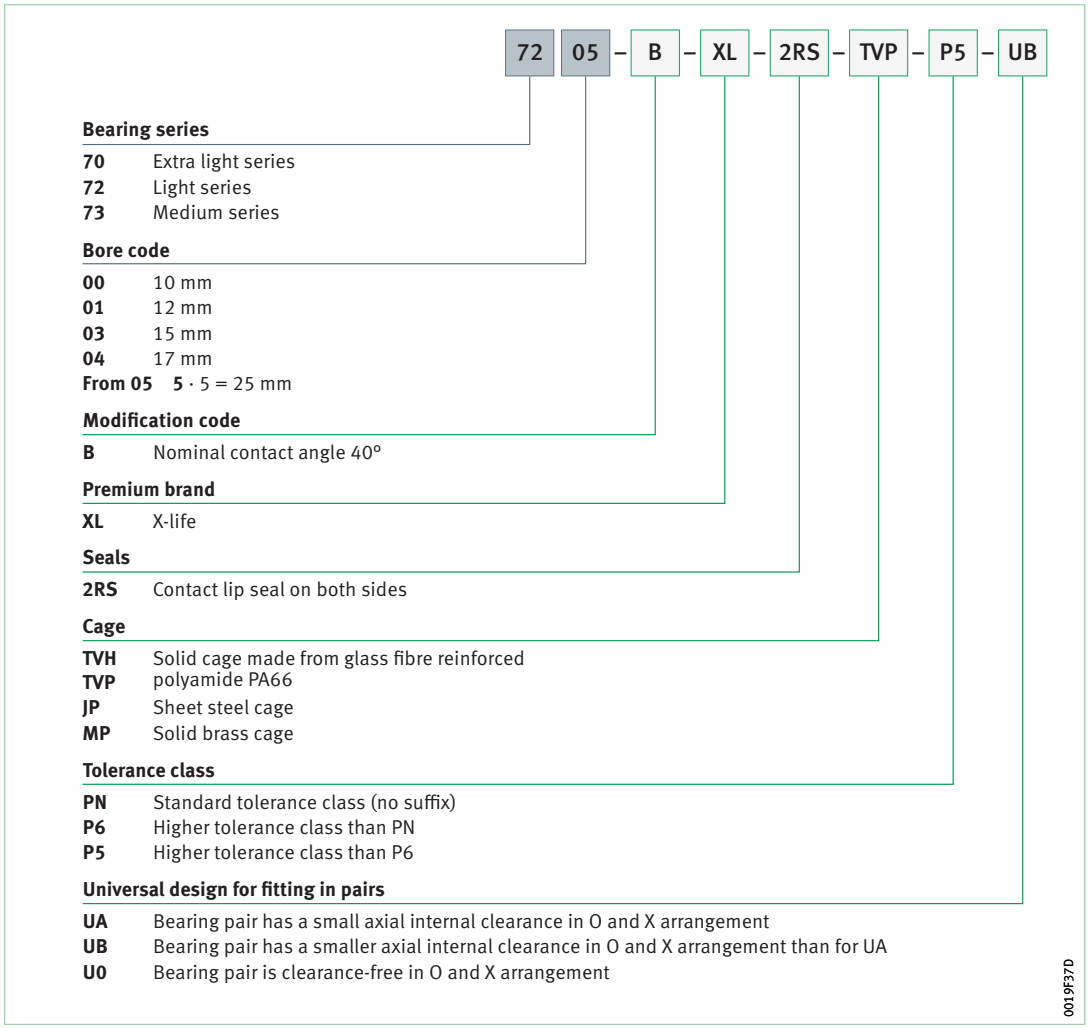


Figure 4
Bearing designation

Further information

- Product catalogue ***medias***
- Catalogue HR 1, Rolling Bearings,
  see chapter Technical principles and dimension tables

Features

Double row angular contact ball bearings are units with solid inner and outer rings and ball and cage assemblies with polyamide, brass or sheet steel cages, *Figure 1*. Their construction is similar to single row angular contact ball bearings arranged in pairs in an O arrangement but they are narrower to a certain extent. They differ in the size of the contact angle and the design of the bearing rings.

Due to the raceway geometry and the two rows of balls, the bearing can support in both radial and axial directions. They are therefore particularly suitable for use in pumps.

The angular adjustment facility of the double row angular contact ball bearings is limited.

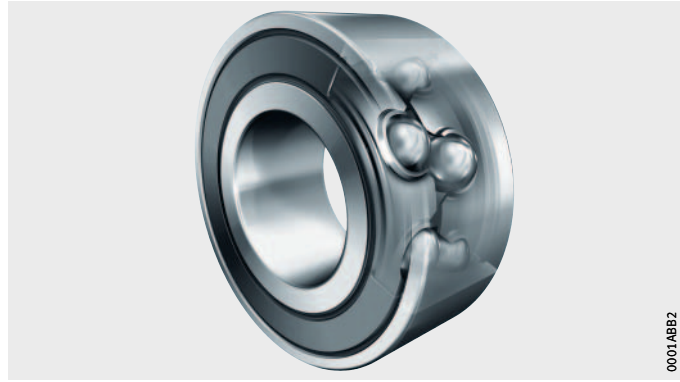
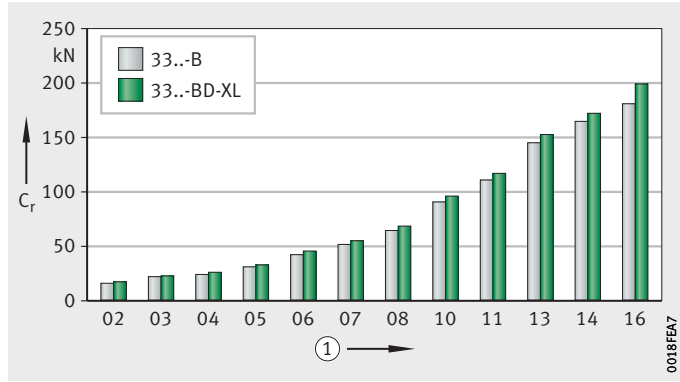


Figure 1
Double row angular contact ball bearing

X-life

X-life stands for quieter bearings with higher basic load ratings. The reduced friction leads to lower temperatures and, in the case of bearings lubricated for life, to a longer grease operating life. Many sizes of double row angular contact ball bearings are classified as X-life products. Other variants can be supplied by agreement.



C_r = basic dynamic load rating

① Bore code

Figure 2
Comparison of basic dynamic load rating C_r – bearing series 33..-BD-XL, bore code 02 to 16, with a bearing which is not of X-life quality (33..-B)

Radial and axial load carrying capacity

Double row angular contact ball bearings can support axial loads in both directions and high radial loads. They are particularly suitable for bearing arrangements where rigid axial guidance is required.

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

Double row angular contact ball bearings are available with contact angles of 25°, 35° and 45°, while double row angular contact ball bearings of X-life quality have a contact angle of 30°.

Bearings with a contact angle of 45° have a split inner ring. In addition, the larger number of balls gives a significant increase in basic load ratings. The brass cage also gives an improvement in the emergency running characteristics of the bearing.

Operating temperature

Double row angular contact ball bearings with elastomer contact seals RSR- or HRS can be used up to 110 °C. The non-contact sealing shield Z, like the glass fibre reinforced polyamide cage TVP, is suitable for temperatures up to 120 °C. For temperatures which exceed this value, we recommend open bearings with suitable lubrication.

Lubrication

Open double row angular contact ball bearings are not greased. They can be lubricated with grease or oil. We recommend the use of our automatic lubricators in the event of grease relubrication.

Sealed bearings are greased with a standard high-quality grease and are lubricated for life. Premium greasing, which is identified by the suffixes L140 or L285 is also available for application-specific requirements.

Bearing designation

The structure for double row angular contact ball bearings is shown in *Figure 3*.

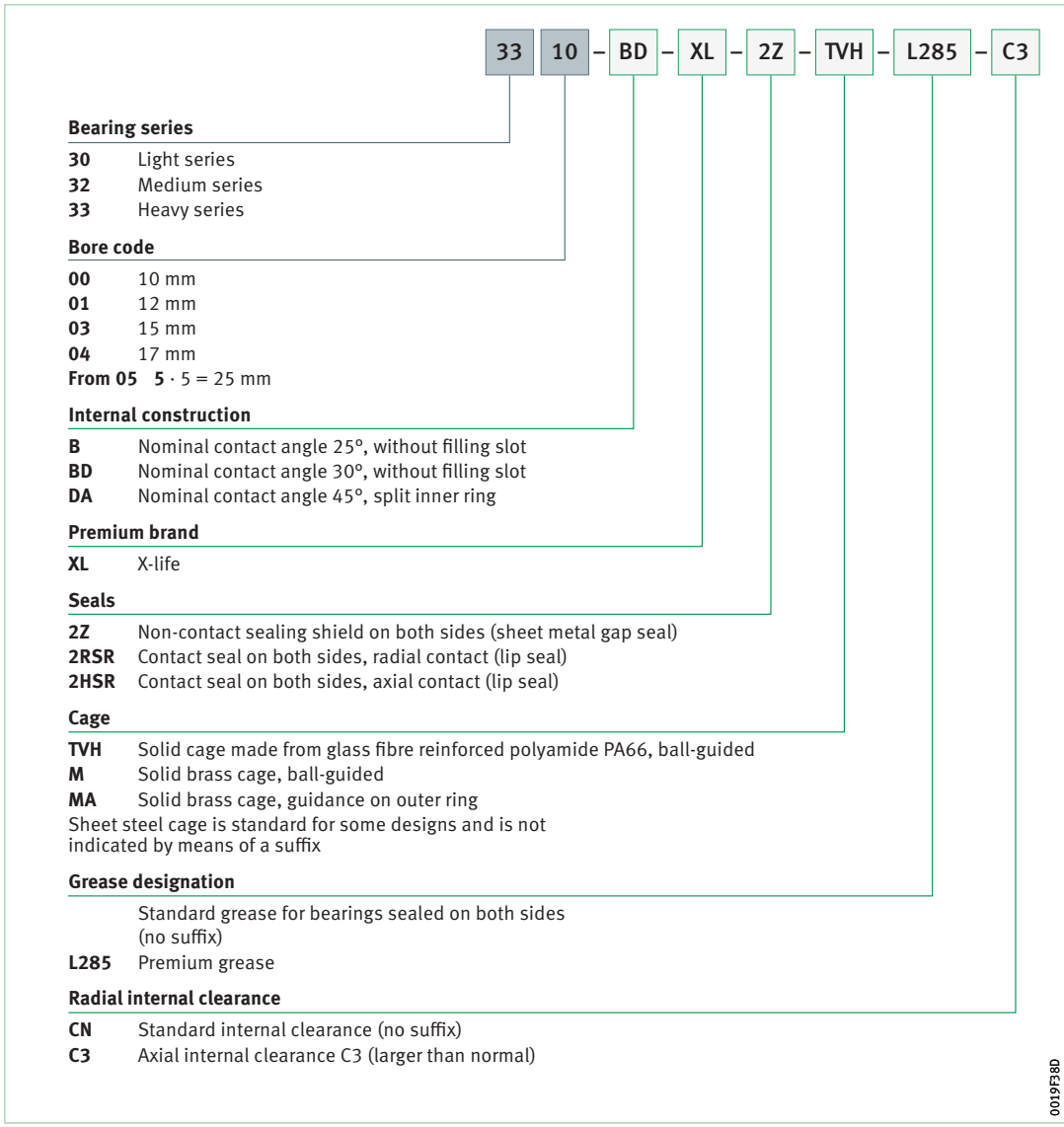


Figure 3
Bearing designation

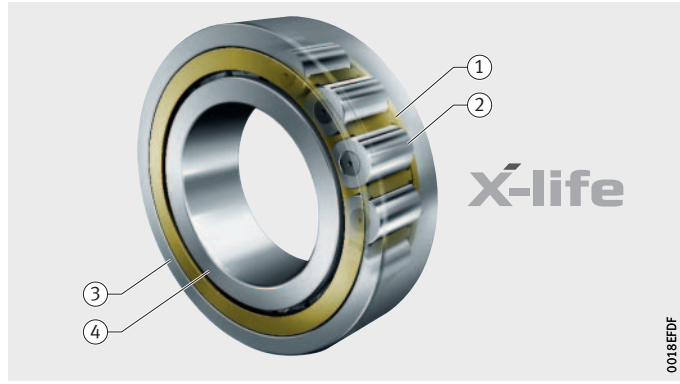
Further information

- TPI 213, Double Row Angular Contact Ball Bearings, X-life quality
- Product catalogue ***medias***
- Catalogue HR 1, Rolling Bearings, see chapter Technical principles and dimension tables

Single row cylindrical roller bearings

Features

Single row cylindrical roller bearings with cage are units comprising solid inner and outer rings and cylindrical roller and cage assemblies, *Figure 1*. The outer rings have rigid ribs on both sides or no ribs, the inner rings have one or two rigid ribs or are designed without ribs. The cage type bearings are very rigid, can support high radial loads and are suitable for higher speeds than the full complement designs. The bearings are separable and are therefore easy to fit and dismantle. Due to the tight fit, both bearing rings are tightly fitted. Depending on the requirements and corresponding design, single row cylindrical roller bearings with cage can be used as non-locating, semi-locating and locating bearings.



① Brass cage
② Cylindrical roller, honed
③ Outer ring, honed
④ Inner ring, honed

Figure 1
Single row cylindrical roller bearings of X-life design

The advantages of cylindrical roller bearings with cage take effect precisely where ball bearings are not sufficient due to higher pump loads. These bearings have significantly higher basic load ratings to support radial loads and are ideal non-locating bearings. As a result of the radial rigidity which is inherent to their design, small gap dimensions in the pump geometry can be reliably maintained.

As the shafts in pumps are often generously dimensioned to meet the requirements for deflection and high strength, narrower series are usually sufficient. Series NU10 can be used in the event of conflicts with minimum load and possible slippage problems. NU10 is not designed as a reinforced version with suffix E, so the small rollers are less prone to slippage.

X-life

Single row cylindrical roller bearings of X-life quality exhibit considerably higher performance than comparable standard cylindrical roller bearings. This is achieved, for example, through the modified internal construction, the optimised contact geometry between the rollers and raceways, the better surface quality and the optimised roller guidance and lubricant film formation. The optimisations lead to significantly reduced heat generation and a measurable increase in the rating life of the rolling bearings.

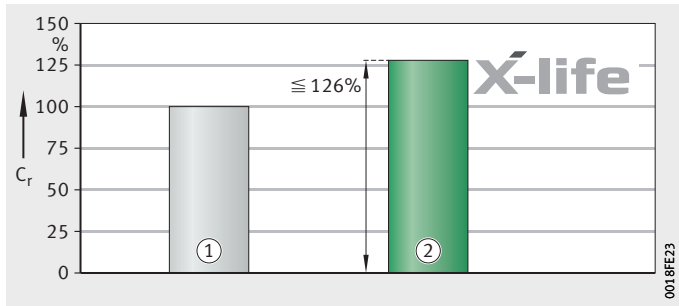


Figure 2
Cylindrical roller bearing with cage: comparison of basic dynamic load rating C_r with bearings without X-life quality

Non-locating bearings

Cylindrical roller bearings NU and N are non-locating bearings and can support radial forces only. In series NU, the outer ring has two ribs, while the inner ring has no ribs. Bearings of type N have two ribs on the inner ring and an outer ring without ribs.

Axial displacement

The outer and inner ring can be axially displaced relative to each other from the central position by the value “s”.

Operating temperature

Single row cylindrical roller bearings with cage can be used at operating temperatures from –30 °C to +120 °C (plastic cage) or up +150 °C (metal cage).

For continuous operating temperatures higher than +120 °C, please contact us.

Sealing

The bearings are supplied without seals.

Lubrication

They can be lubricated from the end faces using grease or oil.

Bearing designation

The structure for single row cylindrical roller bearings is shown in *Figure 3*.

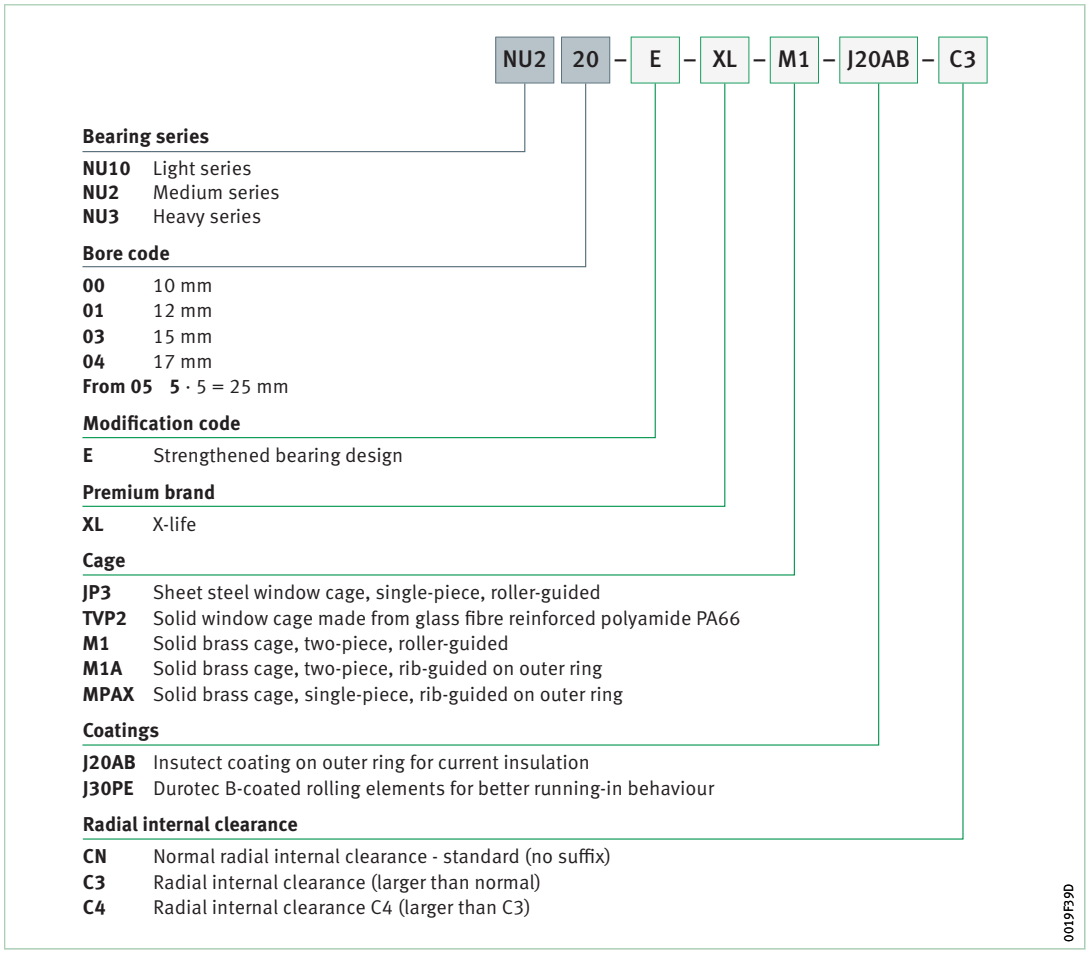


Figure 3
Bearing designation

Further information

- Product catalogue ***medias***
- Catalogue HR 1, Rolling Bearings,
  see chapter Technical principles and dimension tables

Spherical roller bearings

Features

Spherical roller bearings are double row, self-retaining units comprising solid outer rings with a concave raceway, solid inner rings and barrel rollers with cages. The inner rings have cylindrical or tapered bores, *Figure 1*.

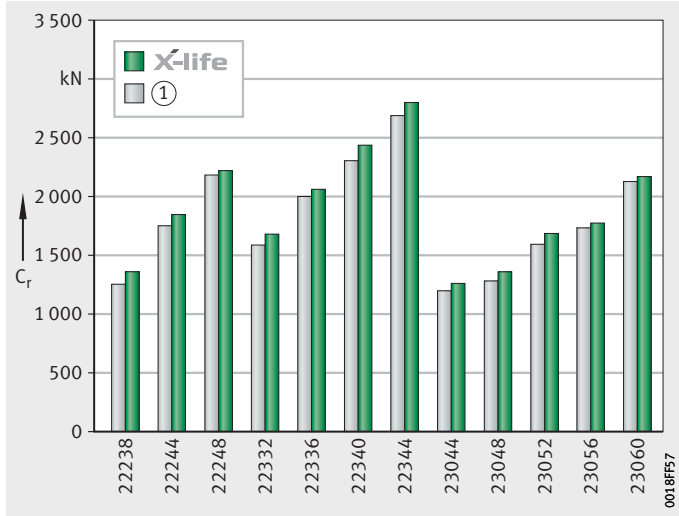
The symmetrical barrel rollers orient themselves freely on the concave outer ring raceway. As a result, shaft flexing and misalignment of the bearing seats are compensated.

With regard to use in large, heavily loaded centrifugal pumps the combination of high basic load rating, angular adjustment facility and support of radial and axial force is of interest.

Figure 1
Spherical roller bearings

X-life

Many sizes of spherical roller bearings are classified as X-life products, with an optimised internal construction giving a higher load carrying capacity, and a reduced friction and bearing temperature due to improved surface quality and contact geometry. Other variants can be supplied by agreement.



① Competitor benchmark (premium product)

Figure 2
Comparison of basic dynamic load ratings series 222, 223 and 230

Radial and axial load carrying capacity

Spherical roller bearings can support axial loads in both directions and high radial loads. They are designed for very high load carrying capacity and, since they have the maximum possible number of large and particularly long barrel rollers, are also suitable for the heaviest loads.

Compensation of angular misalignments

Spherical roller bearings compensate for angular misalignments. The permissible adjustment angle is stated for loads $P < 0{,}1 \cdot C_r$.

These adjustment angles are permissible in the following cases:

- constant angular deviation (static angular misalignment)
- rotating inner ring

Operating temperature

Bearings with metal cages can be used at operating temperatures from –30 °C to +200 °C.

Bearings with cages made from glass fibre reinforced polyamide are suitable up to +120 °C. The selection of a suitable lubricant is also crucial.

Sealing

Sealed and greased bearings can be supplied by agreement.

Lubrication

Open spherical roller bearings can be lubricated with oil or grease.

Bearing designation

The structure for spherical roller bearings is shown in *Figure 3*.

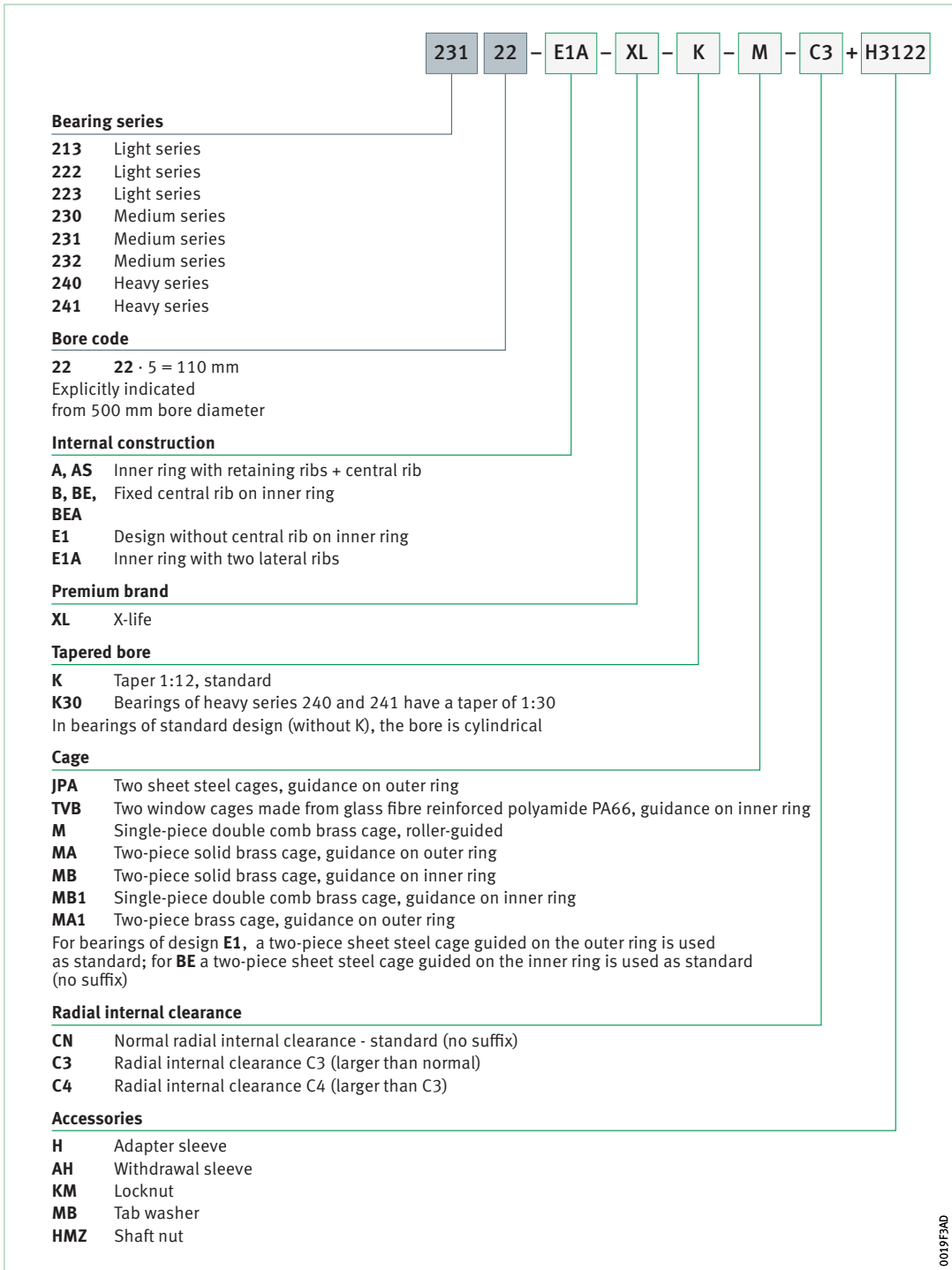


Figure 3
Bearing designation

Further information

- TPI 218, Sealed Spherical Roller Bearings
- Product catalogue ***medias***
- Catalogue HR 1, Rolling Bearings,
  see chapter Technical principles and dimension tables
- ORP, X-life Proven To Be Better
- Film, Hydraulic mounting of a spherical roller bearing with a tapered bore
- TPI 250, Split Spherical Roller Bearings
- WL 80384, Split Spherical Roller Bearings
- MON 90, Mounting instructions for Split Spherical Roller Bearings Lubricated with Grease

Axial spherical roller bearings

Features

Axial spherical roller bearings are single row, non-self-retaining bearings. The inner and outer rings comprise solid shaft and housing locating washers with corresponding raceways for the rolling elements. Cages guide the large number of asymmetrical barrel rollers. The raceways are arranged oblique to the bearing axis, whereby the raceway in the housing locating washer is of a concave design.

Axial spherical roller bearings are suitable, for example, for large, vertically arranged bearing arrangements with high axial loads. Dynamic or static misalignments of the shaft relative to the housing, or deflections of the shaft, can also be compensated by the bearing. Radial loads up to a maximum of 55% of F_a can, however, also be supported in addition to large axial forces. In addition, relatively high speeds or shock type loads do not pose a problem for the bearings.

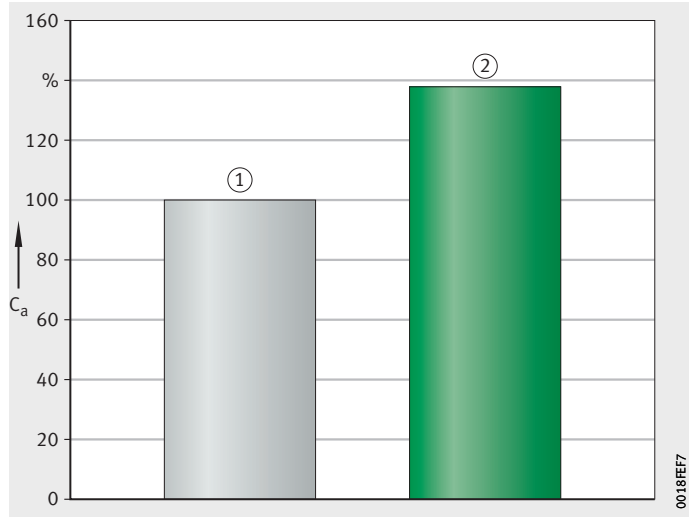
① Cage
② Barrel roller
③ Housing locating washer
④ Shaft locating washer

Figure 1
Axial spherical roller bearings of X-life quality

X-life

X-life bearings exhibit considerably higher performance than conventional axial spherical roller bearings. This is achieved, for example, through the modified internal construction, the optimised contact geometry between the rollers and raceways, the new cage design, a higher steel quality, better surface quality and optimised roller guidance and lubricant film formation.

- optimised load distribution and higher basic load rating
- reduced friction and bearing temperature due to improved surface quality and contact geometry
- better suited for higher speeds



① Competitor benchmark (premium product) – 100%
② X-life – up to 138%

Figure 2
Comparison of basic dynamic load rating C_a

Capable of supporting radial and axial loads

Since the raceways are inclined relative to the bearing axis, axial spherical roller bearings can support very high axial loads in one direction and radial loads simultaneously. The radial load (F_r, F_{0r}) must not, however, exceed 55% of the axial load. They are designed for very axial load carrying capacity and, since they have the maximum possible number of large and long barrel rollers, are also suitable for the heaviest loads.

Compensation of angular misalignments

Due to the concave rolling element raceway in the housing locating washer, axial spherical roller bearings are capable of angular adjustment.

Permissible skewing under static angular misalignment

Bearing series	Permissible skewing	
	D < 320 mm	D > 320 mm
292..-E1	1,5°	1°
293..-E1	2,5°	1,5°
294..-E1	3°	2°

Operating temperature

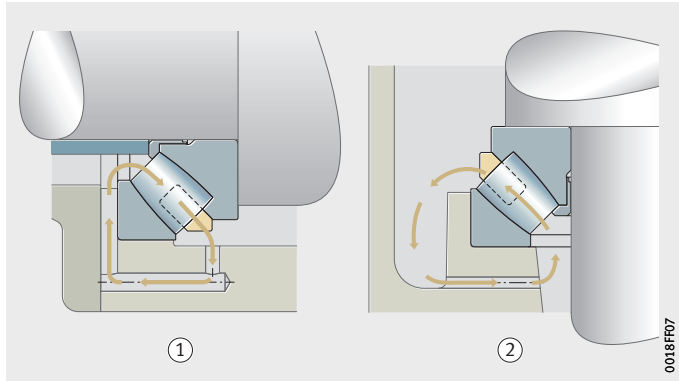
Bearings with metal cages can be used at operating temperatures from –30 °C to +200 °C.

Sealing

Axial spherical roller bearings are supplied without seals.
The required sealing of the bearing position must be carried out in the adjacent construction.

Lubrication

The bearings are not greased. They are generally lubricated using oil. Due to their internal construction, a pumping action occurs in bearings with an asymmetrical cross-section, which must be taken into account accordingly.



① Bearing arrangement with horizontal shaft
② Bearing arrangement with vertical shaft

Figure 3
Oil recirculation by means of pumping action, ducts for the purposes of oil return

In some cases, lubrication with greases containing EP additives is also possible. In this instance, however, it must be ensured that the contact points between the rollers and the guidance rib are always adequately supplied with grease. This is best achieved with our CONCEPT series of automatic lubricators.

Cages

Depending on the bearing series and bore size, axial spherical roller bearings are supplied with either sheet steel or sold brass cages.

Cage, cage suffix, bore code

Bearing series	Sheet steel cage	Solid brass cage MB
	Bore code	
292..-E1	–	30 to /1180
293..-E1-XL	17 to 64	68 to /800
293..-E1	–	/850 to /1600
294..-E1-XL	12 to 68	72 to /710
294..-E1	–	/750 to /1060

Bearing designation

The structure for axial spherical roller bearings is shown in *Figure 4*.

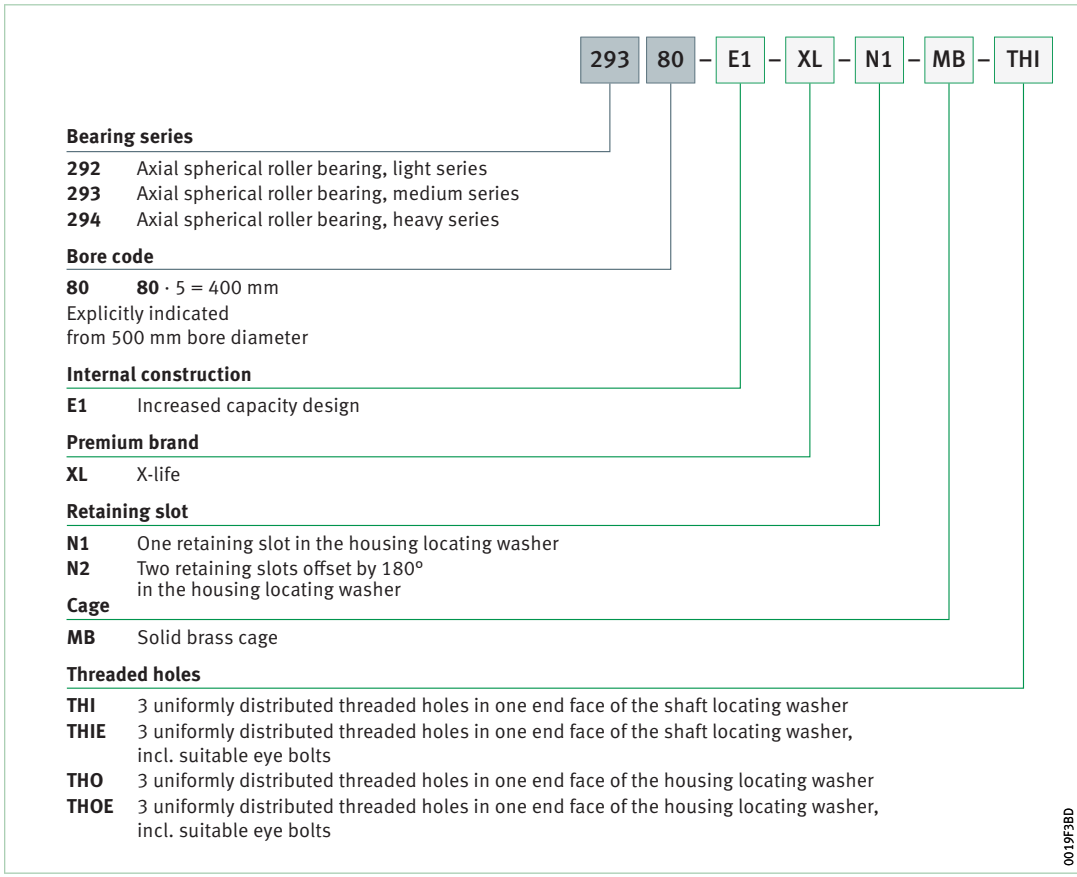


Figure 4
Bearing designation

Further information

- Product catalogue ***medias***
- OAP, X-life Proven To Be Better
- PAX, The most powerful bearings on the market
- MH1, Mounting Handbook

Tapered roller bearings

Features

Tapered roller bearings comprise solid inner and outer rings with tapered raceways and tapered rollers in a window cage, *Figure 1*.

The bearings are available as a standard design, as open variants matched in pairs and as integral designs sealed on one side JKOS.

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

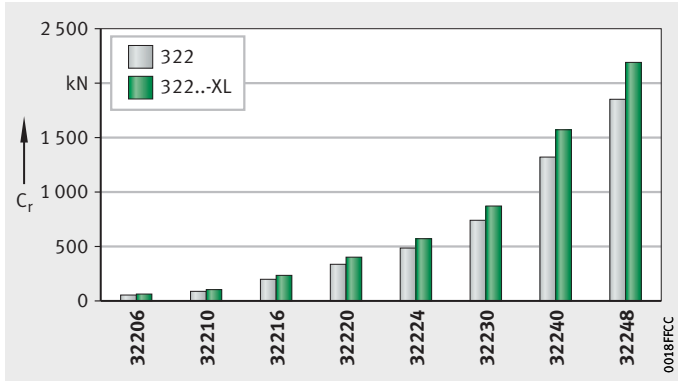
The advantages of the design lie in the higher basic load rating compared with angular contact ball bearings. and precisely why they are of particular interest for larger pumps with higher forces. High radial or axial loads can be supported. An adjusted bearing arrangement (locating bearing) provides a highly rigid and well-guided bearing support with high running accuracy in an axial direction.

Figure 1
Tapered roller bearing

X-life

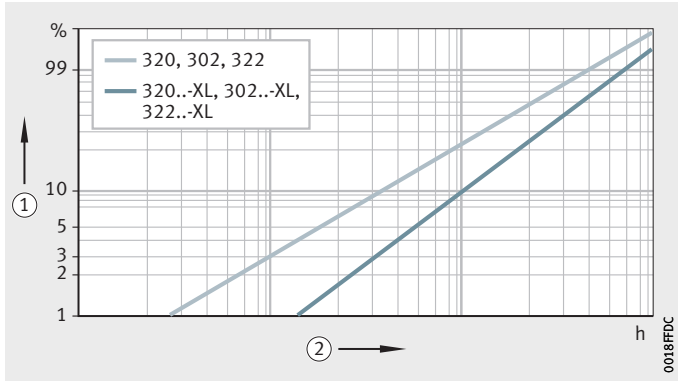
Many sizes of tapered roller bearings are classified as X-life products. Other variants can be supplied by agreement.

The optimised internal construction with up to 20% higher basic dynamic load ratings is demonstrated by a significant increase in the calculated rating life. The reduction in friction of up to 50% achieved through improved surface quality and contact geometry results in a reduced bearing temperature, for example, which in turn has a positive effect on the lubrication. Higher speeds are possible as a result of the improved running accuracy.



C_r = basic dynamic load rating

Figure 2
Comparison of basic dynamic load rating C_r of X-life tapered roller bearings with bearings without X-life performance



① Probability of failure
② Running time in hours

Figure 3
Comparison of fatigue running time in Weibull diagram of X-life tapered roller bearings and bearings without X-life performance

Radial and axial load carrying capacity

Tapered roller bearings can support axial loads in one direction and high radial loads.

However, they must always be axially adjusted against a second bearing fitted in a mirror image arrangement. This bearing combination is then fitted in an O or X arrangement.

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.

If the load ratio $P/C_{0r} < 0,2$, the tilting of the bearing rings relative to each other must not exceed 4 angular minutes. This is, however, subject to the position of the shaft and housing axis remaining constant (no dynamic movements).

Operating temperature

Open tapered roller bearings can be used at operating temperatures from –30 °C to +120 °C.

Bearings with contact lip seals can be used at operating temperatures of –30 °C to +110 °C, restricted by the seal material and lubricant.

Sealing

Tapered roller bearings of standard design and matched in pairs are not sealed. Integral tapered roller bearings JKOS have a lip seal on one side.

Lubrication

Tapered roller bearings of standard design and matched in pairs can be lubricated with oil or grease.

Integral tapered roller bearings JKOS are filled with a high-quality standard grease.

Cages

Tapered roller bearings are available with the following cage designs:

- sheet steel cages (open tapered roller bearings)
- cages made from glass fibre reinforced polyamide (integral bearings JKOS)

Suffixes

The structure for tapered roller bearings is shown in *Figure 4*.

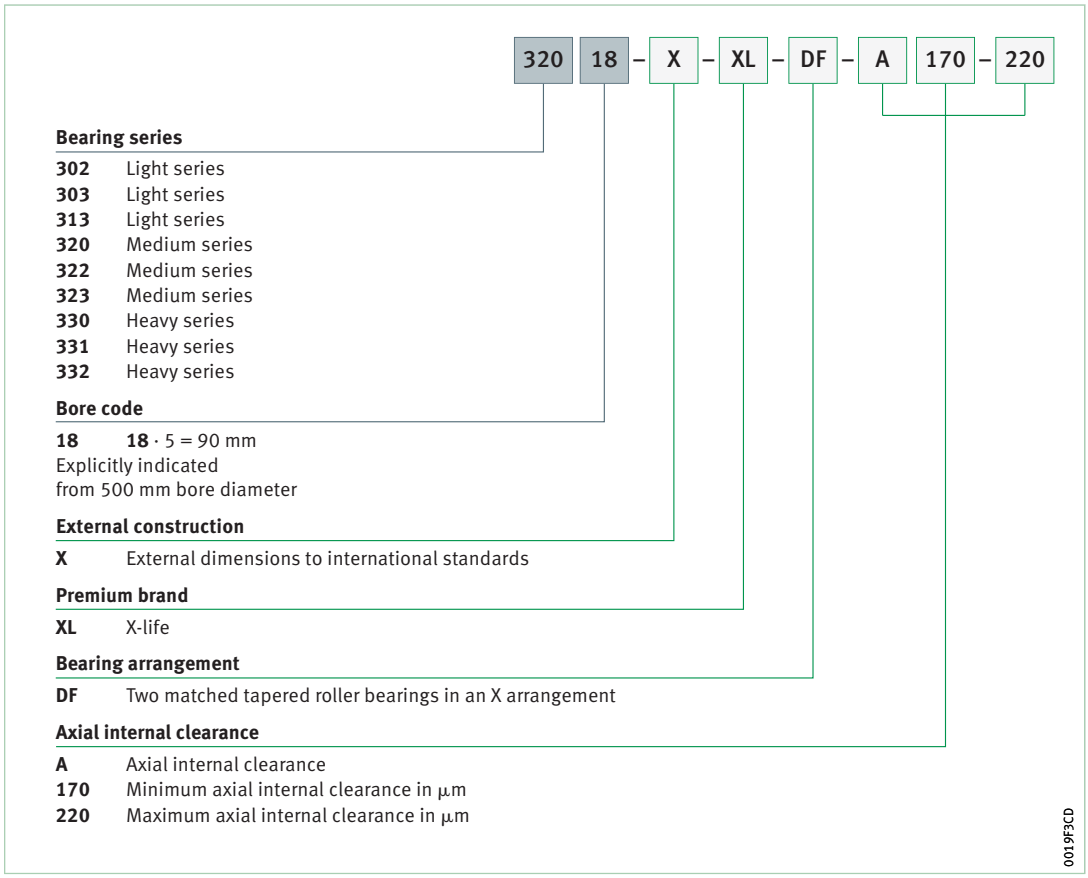


Figure 4
Bearing designation

Further information

- Product catalogue ***medias***
- Catalogue HR 1, Rolling Bearings,
  see chapter Technical principles and dimension tables
- TPI 241, Tapered Roller Bearings in X-life Design
- TPI 245, Tapered Roller Bearings, Matched pairs
- PKE, Tapered Roller Bearings
- OKL, X-life Proven To Be Better

Four point contact bearings

Features

Four point contact bearings are single row angular contact ball bearings and therefore require significantly less space in an axial direction than double row designs, *Figure 1*.

The bearings comprise solid outer rings, split inner rings and ball and cage assemblies with brass or polyamide cages. The two-piece inner rings allow a large complement of balls to be accommodated. The inner ring halves are matched to the particular bearing and must not be interchanged with inner ring halves of other bearings of the same size. The outer ring with the ball and cage assembly can be mounted separately from the two inner ring halves.

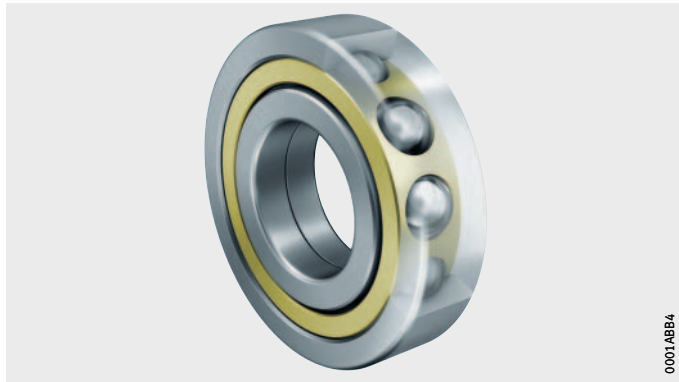
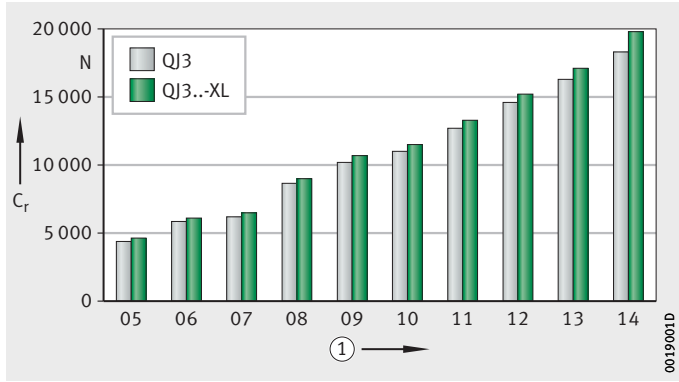


Figure 1
Four point contact bearing

X-life

Many sizes of four point contact bearings are classified as X-life products. Other variants can be supplied by agreement.

The optimised load distribution in the bearing combined with higher basic load ratings results in a operational reliability and longer operating life. X-life bearings have optimised friction characteristics, thus enabling high speeds at lower bearing temperatures.



C_r = basic dynamic load rating

① Bore code

Figure 2
Comparison of basic dynamic load rating C_r of bearing series QJ3..-XL, bore code 5 to 14, with a bearing which is not of X-life quality

Axial load capacity in both directions

Due to the design of the rolling element raceways with their high raceway shoulders, the contact angle of 35° and the large number of rolling elements, four point contact bearings can support high axial loads with an alternating load direction.

Operating temperature

Bearings with solid brass cages can be used at operating temperatures from –30 °C to +150 °C.

Bearings with cages made from glass fibre reinforced polyamide are suitable for operating temperatures up to +120 °C.

Sealing

Four point contact bearings are not sealed.

Lubrication

They are not greased and can be lubricated with grease or oil.

Bearing designation

The structure for four point contact bearings is shown in *Figure 3*.

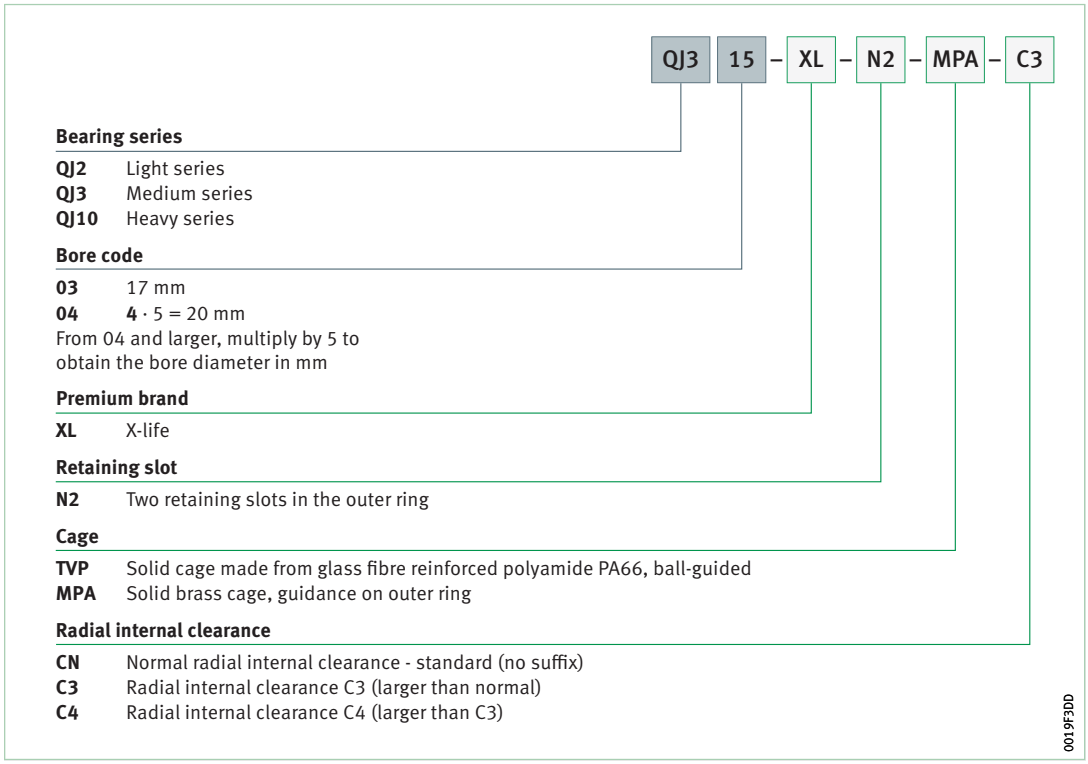


Figure 3
Bearing designation

Further information

- Product catalogue ***medias***
- Catalogue HR 1, Rolling Bearings, see chapter Technical principles and dimension tables
- KXL, X-life – Premium Quality
- OVL, X-life Proven To Be Better

Features

Needle roller bearings are rolling bearings with a low radial section height and high load carrying capacity, which are used as non-locating bearings and are part of the group of radial needle roller bearings. These bearings comprise machined outer rings, needle roller and cage assemblies and removable inner rings. This means that they can be supplied with or without an inner ring in accordance with the application. In contrast to the outer cups of drawn cup needle roller bearings, which are produced by forming methods, the bearing rings are machined. Due to their non-locating bearing function, the bearings cannot guide the shaft axially in either direction.

Figure 1
Needle roller bearing

X-life

Many sizes of needle roller bearings are classified as X-life products. This stands for an optimised internal construction giving a basic load rating which is up to 25% higher, and a reduced friction and bearing temperature due to improved surface quality and contact geometry.

L_{nm} = adjusted reference rating life

① Bearing without X-life quality
② Calculated rating life
③ Rating life verified in tests

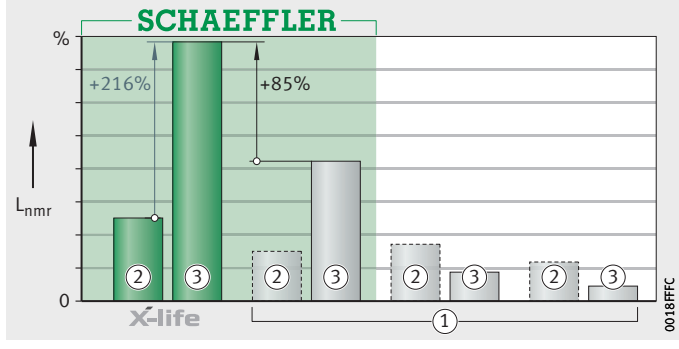


Figure 2
Calculated rating life and rating life verified in tests of X-life needle roller bearings in a comparison with bearings without X-life quality

Capable of supporting radial loads

Radial needle roller bearings support very high radial forces due to the presence of line contact, but may only be subjected to purely radial load. If the bearing position is also required to support axial forces, the needle roller bearings can, for example, be combined with axial needle roller bearings AXW . An extensive range of combined needle roller bearings is also available for combined loads.

Compensation of angular misalignments

Needle roller bearings are not suitable for the compensation of angular misalignments.

Operating temperature

Open bearings can be used at operating temperatures from –30 °C to +120 °C.

Sealed bearings and designs with a plastic cage can be used at operating temperatures from –20 °C to +120 °C.

Sealing

Needle roller bearings are available open or sealed. Under normal operating conditions, contact seals give protection against contamination, spray water and the loss of lubricant. The sealing material used is the oil-resistant and wear-resistant elastomer material NBR.

Bearing designation

The structure for needle roller bearings is shown in *Figure 3*.

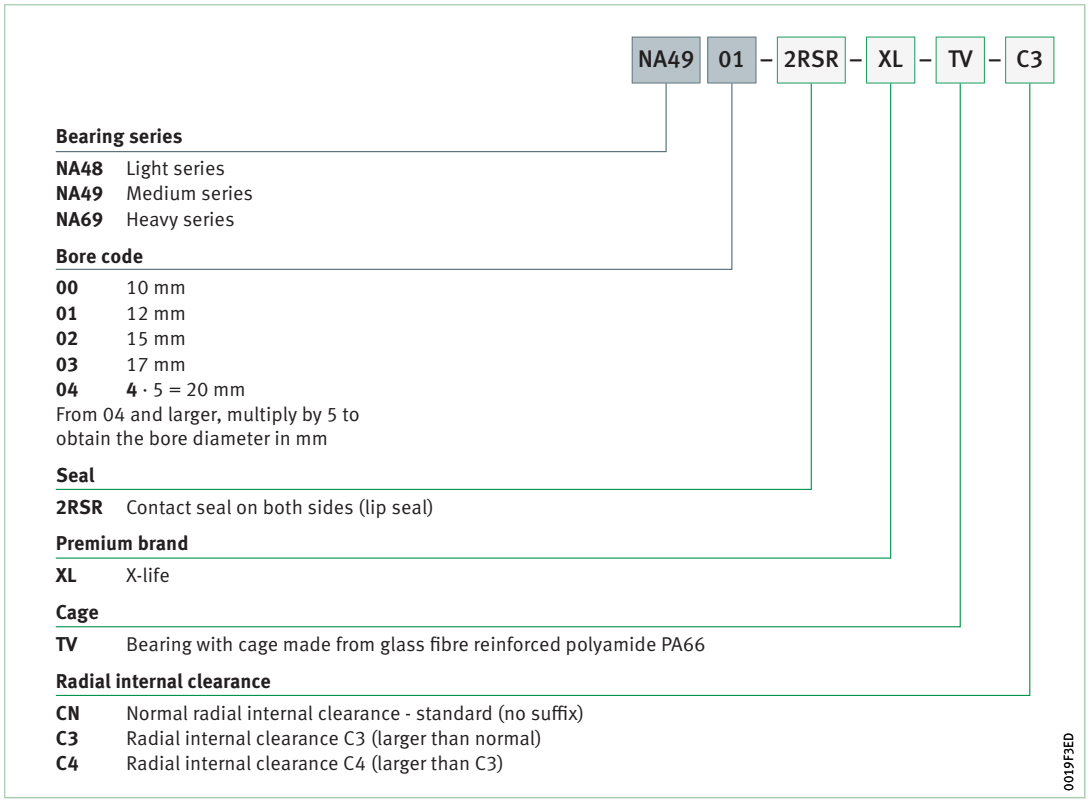


Figure 3
Bearing designation

Further information

- Product catalogue ***medias***
- Catalogue HR 1, Rolling Bearings, see chapter Technical principles and dimension tables
- OMN, Machined Needle Roller Bearings – X-life Proven To Be Better

Coatings for rolling bearings

Features

Bearings and precision components from Schaeffler offer high performance capacity and a long operating life, thus enabling thoroughly developed and economical solutions to be achieved for the majority of requirements. Nevertheless, operating conditions sometimes occur that are beyond the limits of the standard designs. In such cases, one of the very wide range of coatings available can be a solution to the task of increasing the operating life of a component.

Coatings are applied to the surfaces of components without thermo-chemical diffusion taking place between the coating and the base material. At Schaeffler, a large number of coatings are used. They are applied by a wide variety of methods and give widely differing advantages for the component. They should always be individually matched to the mounting situation. In many cases, it is sufficient to coat only one of the components in rolling contact or only a part thereof.

Coatings can give a significant increase in the performance capacity of rolling or plain bearings. Under extreme conditions or in special applications in particular, the use of rolling bearings is only possible by means of coatings, *Figure 1*.

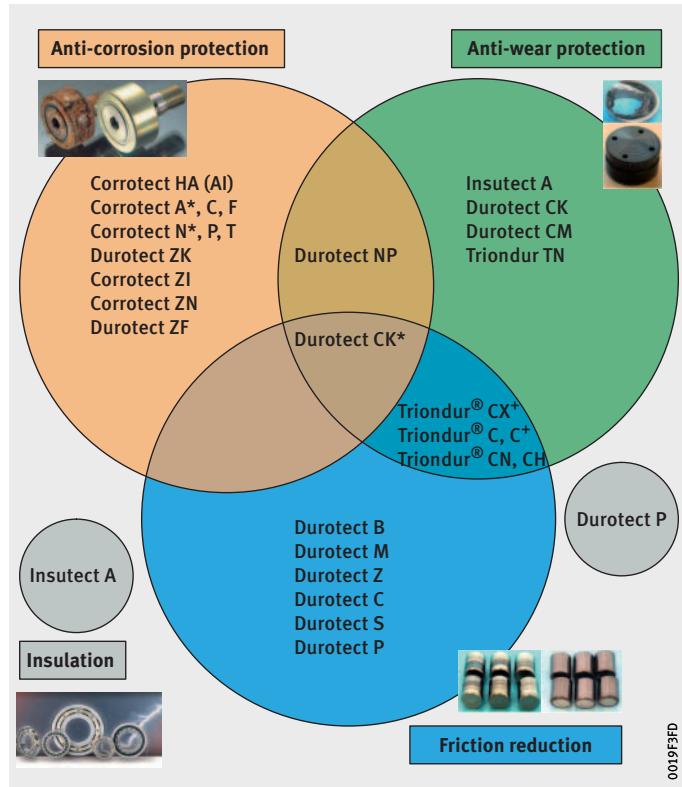


Figure 1
Coatings

Coatings can be used for the following purposes:

- to ensure electrical insulation where there is a risk of current passage
- to minimize friction (energy efficiency)
- to increase protection against corrosion
- to reduce wear under conditions of dry running

Depending on the intended purpose, Schaeffler can supply finish coated products. For example, a significant reduction in friction can be achieved by the use of rolling bearings with the Triondur coating. In order to fulfil increasing requirements, our surface technology centre is continuously developing new coatings and the appropriate deposition methods. At present, a range of more than 40 different surface coatings is available.

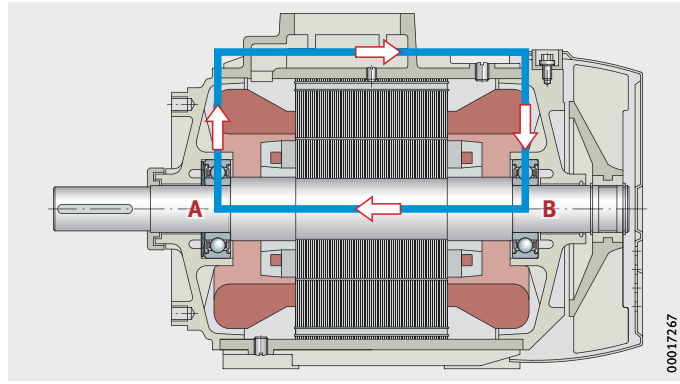
Current-insulating bearings as a preventive measure

Depending on the motor, frequency converter and operating conditions, different types of unwanted electric currents can occur in the electric motor. Remedial measures should also be selected according to the cause. Particularly good results have been obtained with discharge elements, improved earthing and insulating rolling bearings. A general distinction is made between coated bearings, which have an insulating ceramic oxide coating on the inner or outer ring and hybrid bearings with ceramic rolling elements. A brief explanation of which rolling bearing design is the optimal choice for reducing parasitic bearing currents is provided below.

Induced voltage along a shaft

An induced voltage along a shaft leads to a circular current that is completed via bearing 1, the housing and bearing 2, *Figure 2*.

In the case of very large motors or generators with a small number of poles, the cause of such a shaft voltage is the magnetic asymmetries and, in the case of motors operated with frequency converters (from a shaft height of 100), the housing ground current. With these circular currents, the Insutect rolling bearings from Schaeffler with their ceramic oxide layer, constitute an effective solution which is easy to implement. The bearing on the non-driven side is often insulated.



A = bearing 1 (driven side)
B = bearing 2 (non-driven side)

Figure 2
Current flow due to induced voltage along a shaft

Current flow between shaft and housing

In the case of electric motors that are operated with frequency converters, so-called common mode voltage occurs unintentionally. This voltage, which is present between the shaft and housing, can cause electrical currents to flow in the same direction through each of the two bearings, particularly in the case of small electric motors (shaft height < 280), *Figure 3*. The most reliable way of eliminating these currents permanently is through the use of hybrid bearings, which must be applied to both sides.

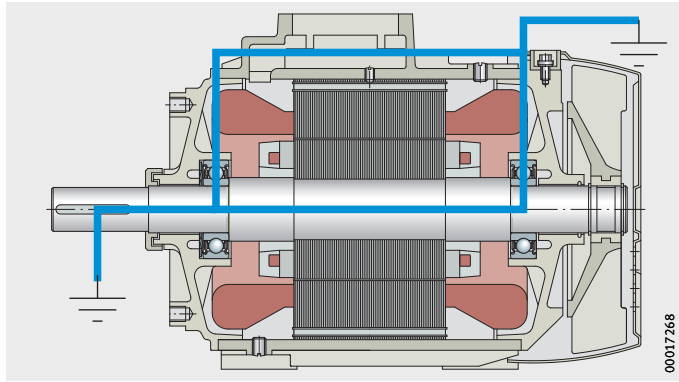


Figure 3
Current flow between shaft and housing

Insutect-coated bearings

The very hard oxide ceramic coating with good thermal conductivity is usually applied to the outer ring of the bearings. A distinction is made regarding the requisite dialectric breakdown strength based on the defined insulation protection of the corresponding coating thicknesses. The external dimensions of the current-insulated rolling bearings correspond to the standardised dimensions in accordance with DIN 616 (ISO 15) and are thus interchangeable with standard bearings. For use in pumps, the Insutect A coating with 100 µm layer thickness, suffix J20AB, has proved effective. Due to a special sealing process, this achieves an insulating effect even in damp environments. The insulation which is also applied to the outer ring with designation J20AA is twice as thick as the J20AB coating, which gives additional security even at higher frequency currents.

Advantages

- high insulation protection due to oxide ceramic coating
- Insutect A J20AB coating thickness 100 µm up to DC 1 000 V
- Insutect A J20AAcoating thickness 200 µm up to DC 3 000 V
- Insutect coatings are established for open and sealed deep groove ball bearings as well as for cylindrical roller bearings.

Example

- ordering designation 6316-J20AB-C3

Hybrid bearings

In the smaller diameter range, hybrid bearings are the best remedial measure against damage from current passage. The rings of the hybrid bearings are made from rolling bearing steel, while the rolling elements are made from ceramic. Here, the ceramic rolling elements take on the function of current insulation. In addition, hybrid bearings offer other advantages over bearings with steel rolling elements.

Advantages

- optimum insulation as a result of very high resistance to current passage
- higher speeds with lower friction and temperatures in operation
- better emergency running characteristics than standard bearings
- ceramic rolling elements which are extremely resistant to wear

Hybrid bearings are identified by the prefix HC.

Example

- ordering designation HC6305-C-2Z-C3

Further information

- TPI 67, Special Coating Corrotect
- TPI 133, Special Coatings
- TPI 186, Higher Performance Capacity Through the Use of Coatings
- TPI 206, Current-insulating Bearings
- PEC, Increased Efficiency for Electric Motors

SCHAEFFLER

Application examples

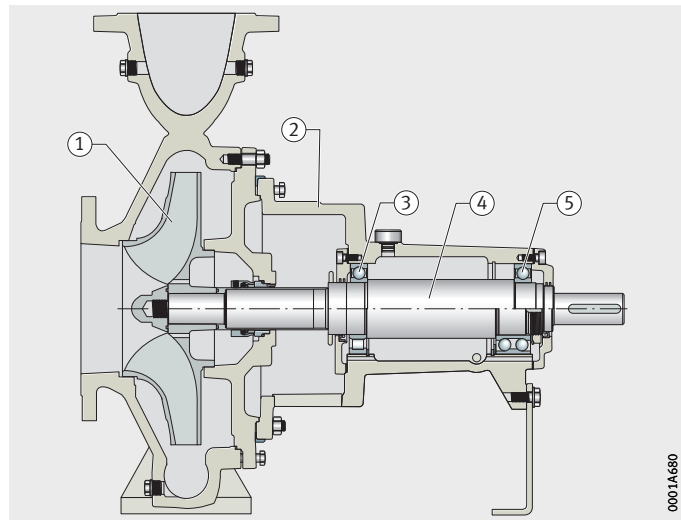
Standardised chemical pump
Process pump in accordance with API 610
Submersible pump
Double flow pump
Multi-stage centrifugal pump
Inline pump
Shaft-driven submersible pump
Multi-stage borehole pump
Solids handling pump
Electric motor

Standardised chemical pump

Features

The designation “standardised chemical pump” refers principally not to the fluid conveyed but to the fact that the pumps correspond to the requirements for dimensions and power ratings in the standard ISO 2858. However, standardised chemical pumps must in many cases additionally fulfil other standards such as ISO 5199 (EN 25199). Due to these specifications, pumps from different manufacturers can be fitted and interchanged without problems within an existing pipework system.

The widely varying areas of application include not only the chemical and petrochemical industry but also, for example, the food industry. The fluids conveyed thus vary considerably and, in some cases, differ significantly in their characteristics. The structure of the pump corresponds to a single stage, single flow centrifugal pump, *Figure 1*.



① Impeller
② Housing
③ Non-locating bearing
④ Shaft
⑤ Locating bearing

Figure 1
Standardised chemical pump

The standardisation of these chemical pumps results in certain requirements and restrictions that differ as a function of the power and size of the pumps. The specifications in the standards also affect the bearing positions where, for example, ISO 2858 specifies the diameter of the shaft end and thus the minimum bearing diameter as a function of the power rating.

In addition to the operating forces, no additional shocks or similar phenomena normally occur. Standardised chemical pumps are operated at speeds up to 3 600 min^{-1}. However, the speed can also be matched to the current requirements by means of an optional frequency inverter.

Standards such as EN 22858, for example, focus on mounting dimensions, interchangeability and availability of replacement parts. Other standards also provide detailed specifications on the design of the pump bearing arrangement. ISO 5199, Technical specifications for centrifugal pumps – Class II, and the American ASME/ANSI B73.1 standard, Specification for Horizontal End Suction Centrifugal Pumps for Chemical Process, are similar in terms of design specifications for the adjacent construction and sealing of the bearing arrangement.

Specifications that must be taken into account in relation to rolling bearing design and the design of the adjacent construction:

- basic rating life $L_{10\,h} > 17\,500$ h
- adherence to limit values for shaft deflection and shaft runout by means of a suitable bearing arrangement
- The bearings are to be axially secured in the corresponding housing or adjacent construction using shaft nuts, shaft shoulders and bearing covers.

The bearing position is protected against the ingress of contaminants by labyrinth seals.

A locating/non-locating bearing arrangement is normally used in the standardised chemical pump.

The radial loads on the non-locating bearing can be supported by a deep groove ball bearing without axial retention. In many cases, a cylindrical roller bearing of the NU design is used, which has no rib on the inner ring and thus ensures an axial displacement facility. The remaining radial forces and additionally the axial forces are supported by the locating bearing on the drive side.

This can be achieved by means of double row or matched pairs of single row angular contact ball bearings. In addition to this bearing arrangement, special solutions such as a floating bearing arrangement with two deep groove ball bearings can also be considered. The use of this arrangement is generally more economical but also gives less accurate guidance of the shaft.

Lubrication of the bearing positions can be carried out with either oil or grease lubrication.

The bearings used in standardised chemical pumps are:

- single row deep groove ball bearings
- single and double row angular contact ball bearings
- cylindrical roller bearings

Process pump in accordance with API 610 for use in the petrochemical industry

Features

Against the background of heavy-duty operation and high-temperature application, API 610 places extensive, tight and high demands on the design of rolling bearings.

- As no leaks can be tolerated in the transport of, in part, hazardous media, special sealing solutions are used.
- In terms of sealing, labyrinth seals are stipulated for the bearing housings and mechanical seals for the pump housings.
- The demanding and, in some cases, very large mechanical seals result in a larger bearing distance to the impeller and thus in an increasing moment load.
- system life $>$ 25 000 h for nominal load (rated)
- system life $>$ 16 000 h for maximum load

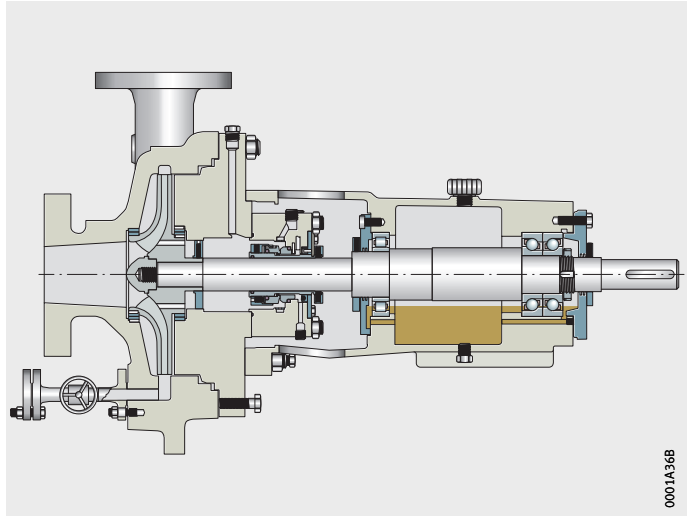


Figure 1
Standardised chemical pump in accordance with API 610

The example provided shows the non-locating bearing on the pump side. Cylindrical roller bearings of width series NU2 or NU3 are used due to the high load carrying capacity and rigid bearing design. As metal cages are stipulated and solid designs are recommended, solid brass cages are used. The standard-compliant locating bearing is shown on the drive side. This comprises a matched pair of angular contact ball bearings in O arrangement (stipulated in the standard!) produced to internal clearance class UA or UB, which is highly suitable for supporting axial forces as a result of the 40° contact angle.

Submersible pump

Features

Submersible pumps are centrifugal pumps that are either transportable or installed in a fixed location. They convey the maximum amount of fluid but build up only a low pressure level.

The area of applications lies principally in the removal and transport of water and contaminated water, for example in drainage of buildings or removal of water from rivers and containers. This involves submerging the entire unit in the liquid, thereby eliminating the need for a suction line.

Submersible pumps differ from the basic design of a centrifugal pump in that they are normally fitted with a vertical shaft on which the drive motor is mounted directly (block construction), *Figure 1*. The electric motor is encapsulated in the design. The drive train is designed without a coupling and the rotor of the electric motor runs on the pump shaft.

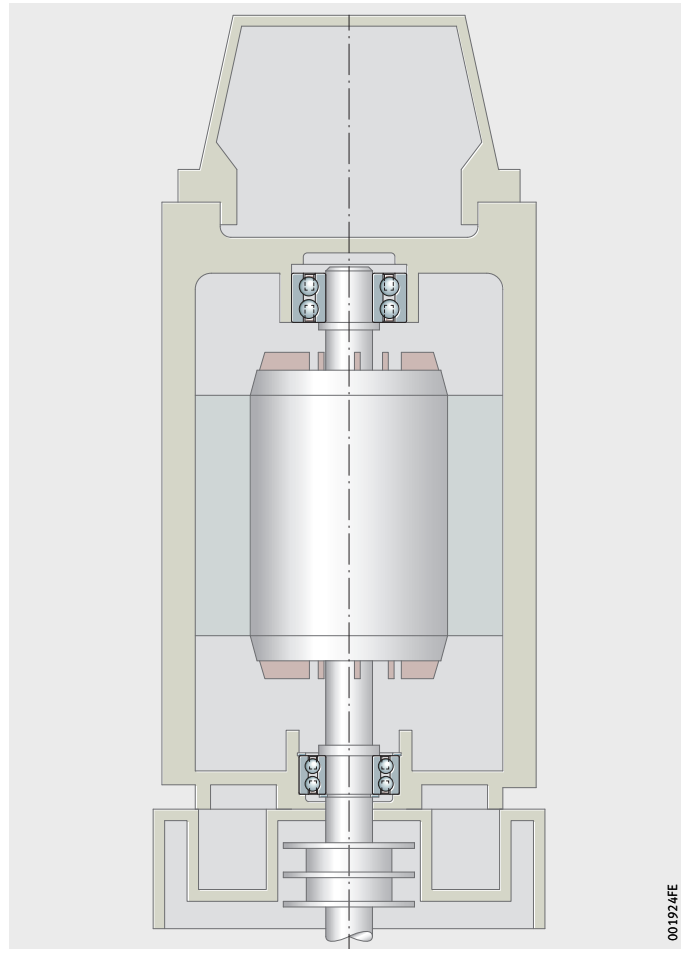


Figure 1
Cross-section
of a submersible pump

Submersible pump

Requirements for rolling bearing design or execution:

- The rigidity of the shaft and bearing arrangement is subject to higher requirements due to the motor gap.
- In order to achieve optimum rotor support, the rotor is arranged between the two bearing positions.

The relevant forces for the bearing arrangement in a submersible pump are determined not only by operation of the pump but also by its design. During operation, loads are generated by pressure generation and slight shocks may occur as a result of waste water containing solid particles.

As a result of the design structure, axial loads occur due to the mass forces of the vertical shaft and the rotor mounted on the shaft. The speed range of such units is normally up to 3 600 min^{-1}.

In order to achieve an efficient, reliable and maintenance-free bearing arrangement of the shaft, a locating/non-locating bearing arrangement comprising robust, sealed bearings lubricated for life is normally used.

In the example shown, the locating bearing in the lower bearing position is designed as a double row angular contact ball bearing. The small manufacturing tolerances of the bearings ensure particularly precise guidance of the impeller, leading to small gap dimensions and thus also to reduced losses. Due to the contact angle of the angular contact ball bearing, it is highly suitable for the support of the axial loads.

The function of the non-locating bearing is also performed by a double row angular contact ball bearing that, however, is not axially retained. This lack of axial retention gives the displacement facility of the bearing where there is thermal expansion of the shaft.

The identical bearing design gives advantages in terms of standardisation. An alternative to a perfect non-locating bearing function would be a cylindrical roller bearing, however the low radial load should be noted here. A narrow series should be selected to avoid the risk of slippage. Series NU10 is highly suitable here due to the non-reinforced version corresponding to suffix -E.

In smaller pumps, the bearings in these applications are sealed and lubricated for life, while the bearing positions in larger units must have relubrication facilities. Due to the vertical shaft, oil lubrication is not normally possible.

Common rolling bearing types for submersible pumps are:

- single row deep groove ball bearings
- single and double row angular contact ball bearings
- cylindrical roller bearings

Double flow pump

Features

The double flow pump contains two single flow impellers arranged back to back and this symmetry improves the suction behaviour of the pump, *Figure 1*. The conveying height remains constant due to parallel switching but the volume flow is doubled.

In comparison with a single flow pump, a double flow pump can be operated at significantly lower supply pressures. This design is used, for example, in pipelines for drinking water supply, in cooling water supply as well as in district heating networks or fire protection systems.

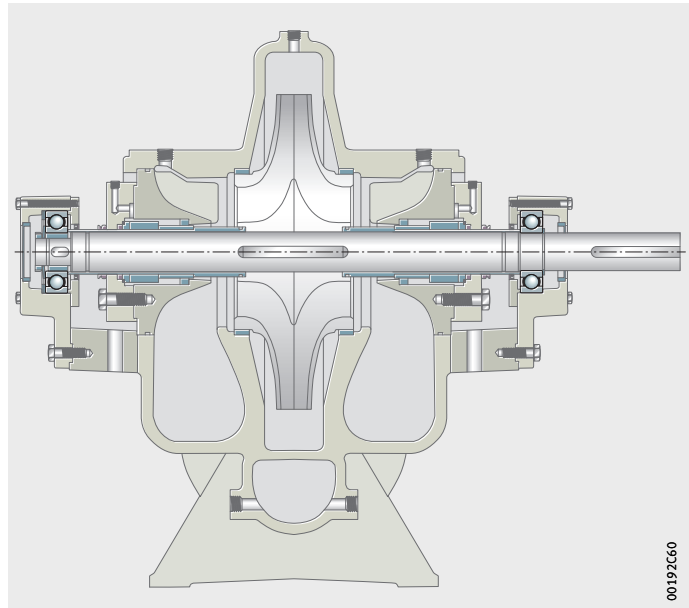


Figure 1
Cross-section
of a double flow pump

Requirements for pump and rolling bearing design:

- very high demands on operational reliability
- minimal maintenance work
- double volute housing to minimise radial hydraulic forces
- longitudinally split housing for efficient maintenance, to allow opening without dismantling the drive train, bearing arrangement and pipework
- impeller supported on both sides for minimal shaft deflection
- minimal seal wear
- high rolling bearing life

Double flow pump

Due to the symmetrical design of the impeller, the axial forces compensate each other almost completely. The higher impeller mass can lead to increased shaft deflection, particularly in larger pumps.

The use of a double volute housing in the example shown ensures reduced deflection of the shaft and reduces the radial loads occurring. If the units are correctly installed, the pumps can be expected to give uniform, shock-free operation.

In contrast to the overhung bearing arrangement of the submersible pump and standardised chemical pump, the impeller in the double flow pump is normally located between the two bearing positions.

The radial loads occurring are therefore distributed more uniformly over the relevant bearings. Due to the symmetry of the impeller described above, the axial loads are almost zero. The bearing arrangement suitable for double flow pumps is a combination of locating bearing and non-locating bearing.

The locating bearing can, due to the low axial load, be mounted on the drive side as well as on the pump side.

For lower loads, single row deep groove ball bearings can be used at both bearing positions, as they have sufficient basic load ratings over the specified bore diameter due to the generously dimensioned shafts. In order to ensure a displacement facility on the non-locating bearing side, the corresponding bearing must be free of axial retention at this point. Where larger forces occur, single or double row angular contact ball bearings are used as locating bearings.

With regard to lubrication, oil sumps with ring oil or grease lubrication are commonly used, for which a relubrication facility is provided. The Schaeffler CONCEPT lubricators are particularly suitable for use here.

Common rolling bearing types for double flow pumps are:

- single row deep groove ball bearings
- single and double row angular contact ball bearings

In addition to these rolling bearings, it is possible to use other bearing solutions, for example with split bearing rings to allow easier mounting in the case of large pumps. These are matched to the relevant requirements and are designed especially for these cases. In this case, please contact Schaeffler External Sales.

Multi-stage centrifugal pump

Features

Multi-stage centrifugal pumps are used in process technology to achieve extremely high pressures. For this purpose, several stages are connected in series in single flow, arranged on a modular basis on a pump shaft and connected using tie rods. As the hydraulic forces of the individual stages mount up, an axial bearing arrangement is no longer capable of supporting them above a certain ratio. This is avoided in the design by arranging the impellers of successive stages back-to-back, which, however, necessitates a more elaborate system for directing the current. Alternatively, a compensating mechanism can be provided to equalize the axial forces on the bearings.

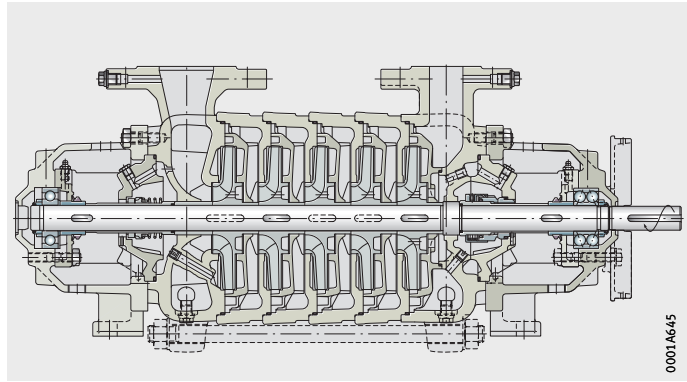


Figure 1
Cross-section
of a multi-stage centrifugal pump

In the example, this is resolved in the design by a sealing gap in the lateral impeller space on the pressure side and by compensating holes in the impeller, *Figure 1*. With good thrust compensation, the demands on the bearings are manageable. The long pump shaft, however, calls for a bearing arrangement on both sides, which is designed as a locating/non-locating bearing arrangement with a deep groove ball bearing and two angular contact ball bearings.

For the non-locating bearing, in the example on the left, which comprises a deep groove ball bearing of series 63 or 62 with the outer ring sliding in the housing, it must be ensured that a suitable fit is selected.

Depending on the requirements, double row angular contact ball bearings or single row angular contact ball bearings in an adjusted design can be used for the locating bearing. The double row angular contact ball bearings shown can be operated with CN clearance in a tight fit with slight bearing clearance through to light preload and thus enable close axial guidance of the impellers in the housing.

Inline pump

Features

In inline pumps, the suction and discharge nozzles lie in a straight line of piping. They are used as pipeline pumps in building technology or industry.

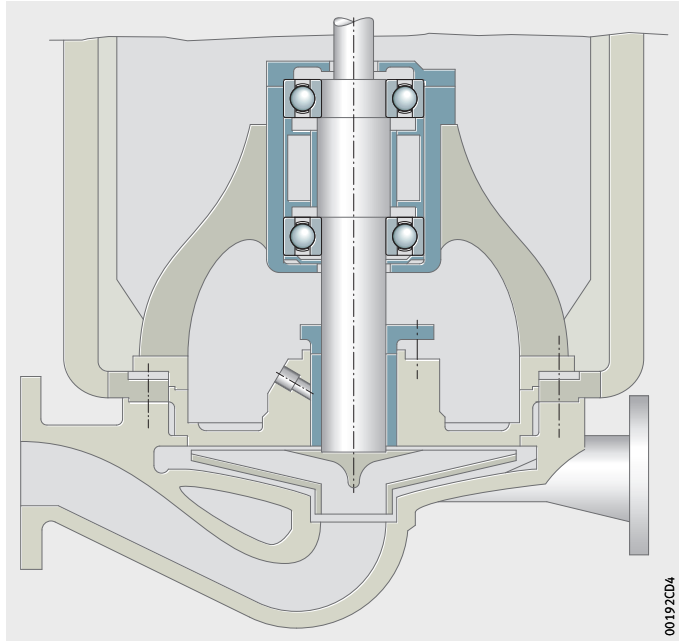


Figure 1
Bearing arrangement of an inline pump

Requirements for the rolling bearing design:

- Pumps with a rigid coupling use the electric motor bearing arrangement, where necessary in a reinforced design, to give better support of axial load or transverse forces.
- When using a flexible coupling, API-class OH3 vertical inline pump, a dedicated pump bearing arrangement is required.
- Suitability for flexible installation of the pump in both a horizontal and vertical arrangement.

The example shows a bearing arrangement with two deep groove ball bearings of series 63. Both the non-locating bearing with the outer ring sliding in the housing and the locating bearing for supporting the axial forces are greased for-life and sealed with 2Z seals. This design is usually sufficient for standard requirements. Grease lubrication, in contrast to oil lubrication, also offers the advantage of enabling either horizontal or vertical installation without the need for design changes. A spring adjustment is provided for the bearing to the impeller, in order that this can be set clearance-free during installation.

Shaft-driven submersible pump

Features

The pump shaft, which is longer in vertical immersion pumps, allows the impeller to be immersed in the fluid, while the pump itself is mounted far above, for example on a shaft. As the pump is not completely submerged, there is no need for complex shaft seals to prevent penetration of the medium.

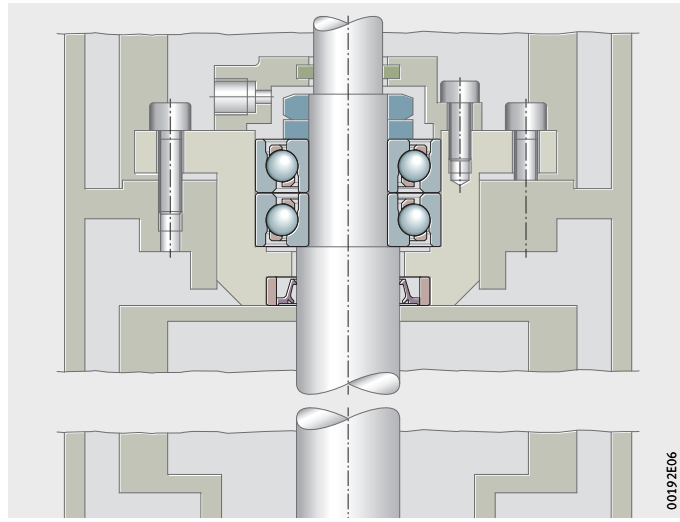


Figure 1
Bearing arrangement
of a shaft-driven submersible pump

Requirements for pump and rolling bearings:

- transport of aggressive media
- reinforced, generously dimensioned pump shaft due to high tilting moments

The example shows the locating bearing on the drive side (upper position). The angular contact ball bearings of series 73 in universal design and O arrangement with clearance class UA or UB are highly suitable for supporting axial forces due to the 40° contact angle. In addition to the radial rigidity provided by its design, the non-locating bearing – cylindrical roller bearing NU10 in the lower position – also offers a non-locating bearing function which is free of axial forces.

Due to the vertical arrangement, the bearing arrangements are lubricated with grease and require the provision of an appropriate relubrication facility. The Schaeffler CONCEPT lubricators are particularly suitable for use here.

Multi-stage borehole pump

Features

Borehole pumps are multi-stage, shaft-driven submersible pumps for a pump sump located deep underground. They are used in irrigation, water extraction, cooling towers and other similar applications.

Requirements for pump and rolling bearings:

- The long pump shaft requires intermediate support of the radial force, which is fulfilled by the design in the form of water-lubricated plain bushes.
- A rigid coupling on the drive is standard.
- Both the high axial weight force of the rotor and the axial hydraulic force are generally supported by the motor bearing arrangement.

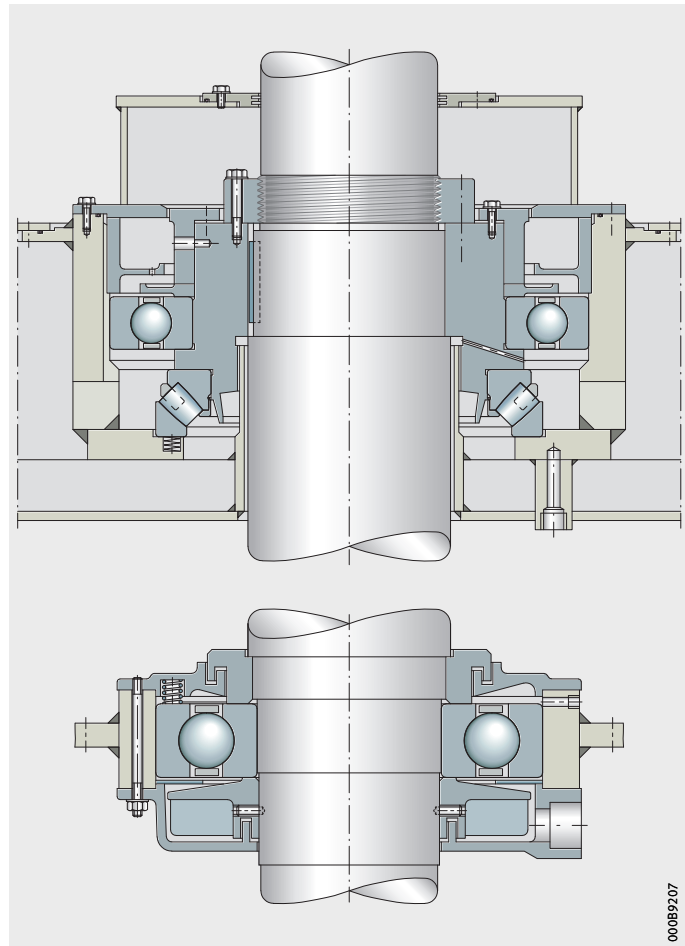


Figure 1
Bearing arrangement of a borehole pump

The motor bearing arrangement shown is designed in flanged housing units on the motor housing. In order that the high axial forces occurring in the main load direction can be reliably supported, axial spherical roller bearings with a very high axial load carrying capacity are mounted in the upper position. A deep groove ball bearing is also required in order to achieve the radial guidance accuracy. Axial spherical roller bearings offer many advantages, however, due to their kinematics, oil lubrication is required, which necessitates a complex housing design in order to seal and supply oil to both bearings in this bearing position. Spring-adjusted deep groove ball bearings are used in the lower position for axial counterguidance as well as for radial guidance of the motor forces. Spring adjustment is required here for clearance-free operation.

Schaeffler supplies manufacturers of electric machines with oil-lubricated, flanged housing units, which are designed for specific projects. These offer the advantage of a holistic concept, as the rolling bearings, lubrication and sealing solution are also considered in addition to the housing.

Further information

- TPI 152, Flanged Housing Units for Large Electrical Machinery

Solids handling pump

Features

Some solids handling pumps are designed as very large units, in order to achieve high delivery volumes for fluids containing solids. Areas of application include dredging, conveying equipment and mining.

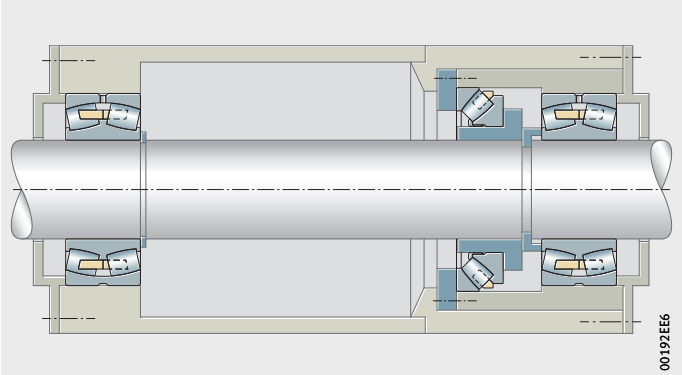


Figure 1
Bearing arrangement of a solids handling pump

Requirements for pump and rolling bearings:

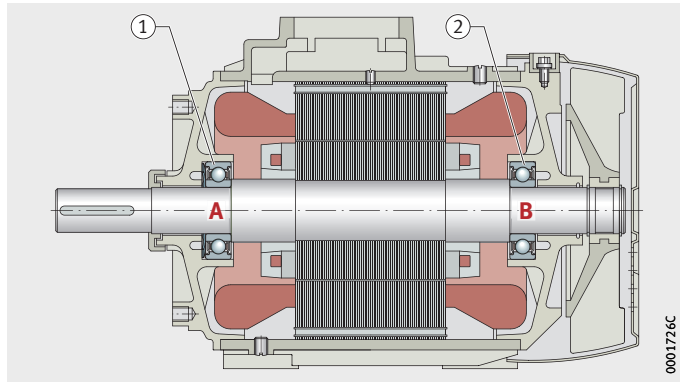
- high imbalance forces due to weight and wear as well as shock loads
- robust bearing arrangement in a dedicated bearing housing

As a result of the and high radial loads and overhung bearing arrangement, the locating/non-locating bearing arrangement is designed using two radial spherical roller bearings, with the non-locating bearing mounted in a radially free position in the housing. The locating bearing position with separate, spring preloaded axial bearing arrangement is realised using axial spherical roller bearings in the main load direction. The preload is required to ensure the minimum load in load-free operation. Axial counterguidance during load changes is assumed by the radial spherical roller bearing. Double row tapered roller bearings with combined axial and radial loads can be used as an alternative.

Electric motor

Features

A current-insulated deep groove ball bearing FAG 6316-J20AB-C3 is fitted on the ventilation side of threephase motor with current direction feed and a deep groove ball bearing FAG 6320-C3 is fitted on the drive side, *Figure 1*. The current-insulated deep groove ball bearing interrupts the flow of current that is generated by the induced voltage along the shaft. Both bearings are lubricated using grease. In the example shown, a relubrication device is provided, for which our CONCEPT lubricators are particularly suitable.



A = drive side
B = fan side

① Deep groove ball bearing FAG 6320-C3
② Deep groove ball bearing FAG 6316-J20AB-C3

Figure 1
Threephase motor

In this example, the topic of current-insulating bearings is examined. A large proportion of the bearing arrangements used in electric motors are achieved using sealed, ball bearings of series 60 and 62 with for-life lubrication in combination with a C3 radial internal clearance and special grease application. As the current-insulating designs with suffix J20AB and J20AA are also part of the Schaeffler Store portfolio, availability must be ensured even for smaller requirements and particularly in the aftermarket.

Schaeffler Technologies AG & Co. KG
Georg-Schäfer-Straße 30
97421 Schweinfurt
Germany
www.schaeffler.de/en
info.de@schaeffler.com

In Germany:
Phone 0180 5003872
From other countries:
Phone +49 9721 91-0

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