Bearing mounting and the design of surrounding components

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Summary

- After calculation and selection of the bearing arrangement, the design of surrounding components must be carefully considered.
- Rolling bearings are secured with the aid of mechanical elements such as locknuts, circlips (snap rings) or adapter sleeves.
- The choice of the correct fits with shaft and housing depend on the operating conditions
- In the context of bearing abutment dimensions, shoulder height and fillet radii are important

Generally speaking, a bearing is only as good as its environment. Who can perform at their best if they don't feel comfortable in their surroundings? Have you already read our article on fixed and floating bearings? This chapter provides a good basis for bearing mounting and surrounding component design.

Shaft and housing design

After the correct bearings and bearing arrangement have been selected, the surroundings must now be considered. The most important criteria that need to be taken into account are listed below.

- Selection of the bearing arrangement

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- Correct bearing mounting
- Ensuring the mountability of the bearing (Important if you don’t want to make enemies during mounting).
- Choosing the right fit
- Determination of the correct bearing abutment dimensions (shoulder heights and corner radii)
- Geometric accuracy of shaft and housing (Attention: The more accurate, the higher the costs!)
- Determination of the maximum bearing misalignment in comparison to the permissible misalignment

At all times, the rolling bearing manufacturer’s specifications should be observed with regard to these criteria.

Securing of rolling bearings with mechanical elements

Information on choosing the right bearing arrangement can be found in the corresponding article. Let’s start with the correct mounting of the bearings on the shaft and in the housing. Rolling bearings can be secured with the help of various mechanical elements, including, for example, the use of lock nuts or retaining bolts or the use of a retaining ring (snap ring). For bearings with tapered bores, other bearing-specific accessories such as adapter sleeves and withdrawal sleeves can be used.

Inner ring lock	Outer ring lock	Snap ring

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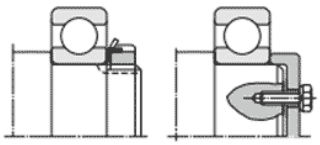
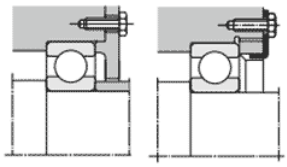
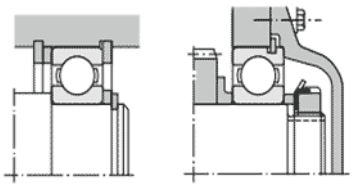
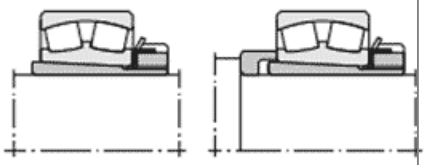
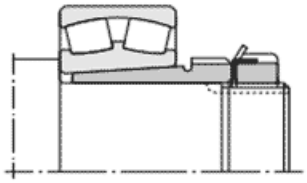
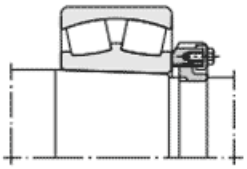
		
Rolling bearings can be fixed with the help of lock nuts or retaining bolts.		Above is a classic fastening with lock nut, lock washer, snap ring, bearing cover and spacer ring.

In this table you will see the fastening methods of rolling bearings that are generally in use.

With regard to the use of a retaining ring (snap ring), special attention must be paid to potential sources of error such as limit radii and bearing connection dimensions. Circlips simplify the construction. It is also important to know that retaining rings (snap rings) have certain disadvantages. They are not suitable for precision applications and equally unsuitable for absorbing high axial loads.

Mounting with adapter sleeve	Mounting with withdrawal sleeve	Mounting with tapered shaft
		
Adapter sleeves and withdrawal sleeves are used for axial location of the bearing on cylindrical shafts.		A split ring inserted into a groove on the shaft holds the rolling bearing in position with a split ring nut.

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Further mounting options for rolling bearings are shown here for you.

The adapter sleeve is fixed by the frictional force between the shaft and the inner diameter of the sleeve. In addition, the position of the bearing on a cylindrical shaft can be freely selected when mounting with an adapter sleeve or withdrawal sleeve; both mounting variants are considered simple and process-safe. Mounting bearings with a tapered shaft is also an option. In this case, the split retaining ring is secured with a locknut or screw. The bearings (such as the spherical roller bearing in the illustration) can also be mounted easily and reliably by hydraulic means. According to the manufacturer's instructions, the displacement path must be measured and, at the same time, always checked, just like the bearing clearance.

Selection of the correct tolerances for shaft and housing

After this brief overview of the various fixing options, we now come to the importance of tolerances for the shaft and housing. On the subject of bearing clearance and preload, terms such as bearing clearance and operating clearance have already been mentioned and it has also been explained how to calculate them. This chapter is now about choosing the right fits. The choice of the "right" fit depends on the following considerations:

- Shaft and housing material
- Wall thickness
- Surface texture
- Operating conditions of the machine

So, let's get straight to the first important question: Tight fit or loose fit?

Load visualisation	Bearing ring rotation	Bearing ring load	Bearing seat fit

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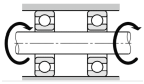
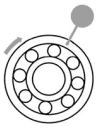
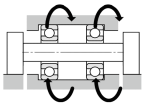
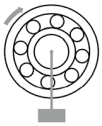
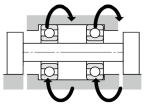
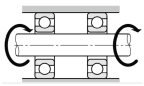
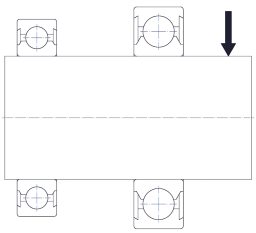
Fixed load 	 Inner ring rotates Outer ring static	Circumferential load for the inner ring Point load for the outer ring	Inner ring: Tight fit Outer ring: Loose fit
Circulating load 	 Inner ring static Outer ring rotates		
Fixed load 	 Inner ring static Outer ring rotates	Point load for the inner ring Circumferential load for the outer ring	Inner ring: Loose fit Outer ring: Tight fit
Circulating load 	 Inner ring rotates Outer ring static		

This table shows you under what circumstances a fixed or loose fit is necessary.

First it has to be clarified which of the two rings is rotating and which is static. Then it is checked which load is applied to the inner ring and which to the outer ring. An

example: For the bearing unit shown, the fits for the two roller bearings are to be selected. Finally, the pulley is mounted on the shaft. The two bearings in question are a 6320C4 and a 6318C4 (manufacturer NTN).

You can visualise the bearing block in the example given like this.



Example bearing arrangement.

Which ring rotates? Correct, both inner rings. The outer rings, on the other hand, should not rotate. Does the inner ring have a point load? No, it has a circumferential load. Circumferential load means that the direction of the radial load acting on the inner ring is circumferential for the ring. Point load is present on both outer rings and means that the load only acts on a small point of the outer ring. The recommended fit is therefore: Inner ring = tight fit and outer ring = loose fit. Suggestions for suitable fits can be found in the catalogues of the rolling bearing manufacturers, for example at NTN. For the current case, for example, taking into account a “normal load“, both shaft seats should have a k5 tolerance and an H7 tolerance should be selected for the housing seats.

Meaning of the bearing abutment dimensions

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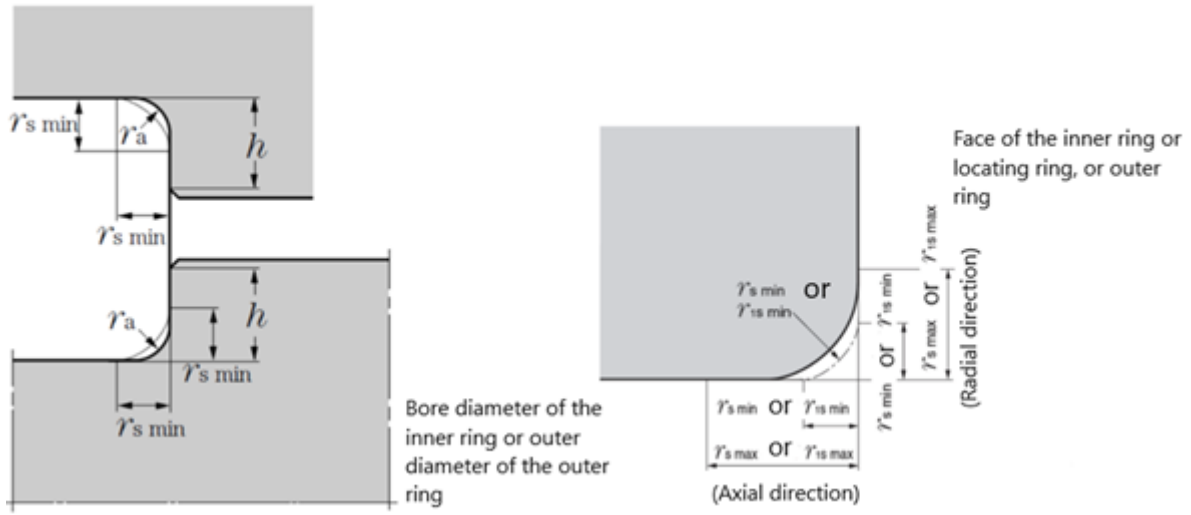
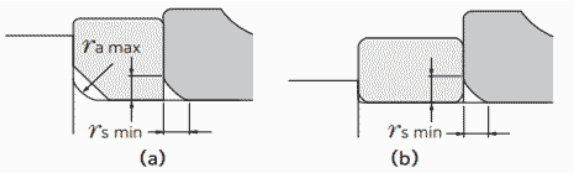
In addition to the bearing mounting itself, attention to the bearing abutment dimensions is crucial, with the shoulder height and corner radii playing a particularly important role.



Shoulder height and corner radius are important parts of the bearing abutment dimensions.

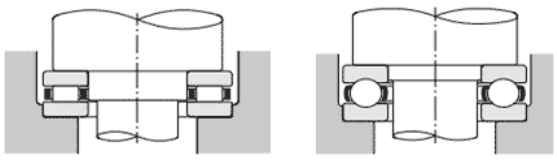
It is important that the height *h* of the bearing ring against the shaft and housing (left side of the illustration) is greater than the maximum permissible edge radius r_s max of the bearing (right side of the illustration). Otherwise, the support of the bearing on the shaft and housing is not sufficient. It must also be taken into account that the fillet radius r_a has a smaller value than the smallest permissible edge radius of the rolling bearing r_s min.

There are situations in which the corner radius r_a max is larger than the edge radii of the bearing. Among other things, this occurs when the shaft is to be strengthened or the contact height is not sufficient as a support surface for the bearing. In such cases it is appropriate to use spacer rings. Spacer rings



In the illustration you can see technical drawings of a spacer ring. This is drawn in light grey.

are individually manufactured in such a way that correct contact between the ring and the rolling bearing on the shoulder of the shaft or housing is guaranteed.



The general rule for shafts and housing abutment heights is that both are always designed to be greater for axial bearings than for radial bearings.

When using thrust bearings, it must be ensured that the supporting surfaces of the bearing rings are sufficiently wide, taking into account the criteria of load and rigidity. For this purpose, there are corresponding dimension tables, for example, in NTN's catalogue.

Accuracy of the shaft and housing bearing seats

Another key area for design of surrounding parts is the accuracy of the mating surfaces for the shaft and housing. In addition, the surface roughness and the perpendicularity of the bearing shoulders are taken into account.

Property	Shaft	Housing
Dimensional accuracy	IT6 (IT5)	IT7 (IT5)
Roundness (max.) Cylindricity	IT3	IT4

Abutment squareness		IT3	IT3
Fitting surface roughness R_a	Small bearings	0,8 µm	1,6 µm
	Medium ~ large bearings	1,6 µm	3,2 µm

In the table you will find useful specifications regarding shaft and housing tolerances. This table applies to normal operating conditions. (IT = basic tolerances).

Permitted inclination and misalignment

Shaft deflections, deviations in the finishing of shaft and housing as well as the smallest installation errors lead to a certain misalignment between the inner and outer ring of a rolling bearing. It is therefore important that in applications where misalignments can be comparatively high, adjustable-angle bearings such as self-aligning ball bearings, spherical roller bearings or insert bearings are used. Basically, it should be noted that the permissible misalignment depends on factors such as the bearing type, load conditions and operating clearance and thus varies depending on the application. The specified guide values should not be exceeded, otherwise there is a risk of bearing damage or problems with the cage.

Allowable bearing misalignment			
Deep groove ball bearing	1/1 000 ~ 1/300	Tapered roller bearing: Single-row (standard) Single-row (Ultage)	 1/2 000 1/600

Angular contact ball bearing Single-row	1/1 000	Needle bearing	1/2 000
Cylindrical roller bearing Bearing series 10, 2, 3, 4 Bearing series 22, 23 Ultage Double-row	1/1 000 1/2 000 1/500 1/2 000		

The permissible misalignment of various types of rolling bearings.

Permissible bearing inclination			
Self-aligning ball bearing Normal load	1/15	Thrust spherical roller bearing Normal load	1/60 to 1/30
Spherical roller bearing Normal load or more Light load	1/115 1/30	Insert bearing	1/60 to 1/30

Self aligning bearings are used in applications with relatively high misalignments.

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