Principles of slewing bearing selection and application

Selection of slewing bearing type

Each slewing bearing type has different characteristics based on its design, which make it more, or less, appropriate for a given application. For example, single row four-point contact slewing bearings have a simple and sturdy design that makes them cost-effective, while crossed cylindrical roller slewing bearings are used when accuracy and rigidity are key operational parameters or when zero operational clearance or preload is required.

Because several factors have to be considered when selecting a slewing bearing type, no general rules can be provided.

The information provided here are the most important factors to be considered when selecting a standard bearing type. Factors include:

- accuracy
- magnitude and direction of loads
- permissible operating temperature
- vibration
- operating speed
- sealing

A brief overview of the standard slewing bearing types and their suitability for a particular application can be found in **table 1**.

Selecting the appropriate slewing bearing can be a challenge, particularly if there are stringent technical, reliability or economic demands. In these cases, for example, it is advisable to consult the SKF application engineering service during the initial design phase. This service can do much more than help select a bearing. They can also provide expert advice in any of the following areas:

- design optimization
- lubrication systems
- sealing arrangements

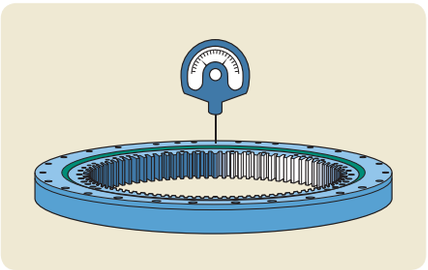
To provide the SKF application engineering service with the information they need to help find the best technical solution for your application, SKF has developed a questionnaire, which can be found on **page 32**.

Table 1

Slewing bearing selection guide

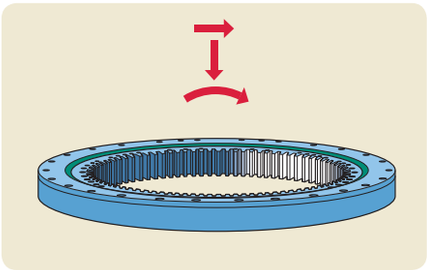
Slewing bearing type	Suitability of bearings for high running accuracy	high speeds	heavy static loads	vibration	long service life
Single row four-point contact ball slewing bearings					
Light series bearings	–	o	o	–	o
Medium size bearings	–	+	+	o	o
Customized bearings	–	+	+	o	o
Single row crossed cylindrical roller slewing bearings					
Medium size bearings	+	–	o	+	+
Customized bearings	+	–	o	+	+

+ Recommended **o** Suitable – Not recommended



Accuracy

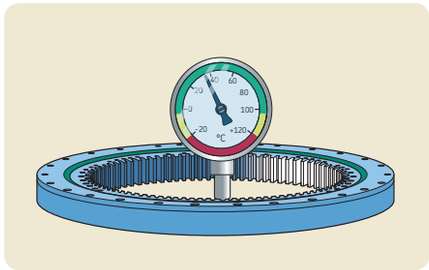
When preloaded, SKF crossed cylindrical roller slewing bearings provide a high degree of stiffness, due to the large roller/raceway contact area. These bearings, which have a high degree of running accuracy, are typically used when accurate positioning is a key operational parameter. Four-point contact ball slewing bearings have a lower degree of stiffness.



Magnitude and direction of loads

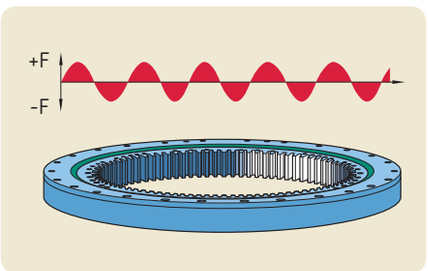
The magnitude of the load is one of the factors that usually determine the size of the bearing to be used. Generally, four-point contact ball slewing bearings are able to withstand heavy loads and shock loads. They can be adapted for slewing applications where heavy loads vary in magnitude and direction.

Using the static limiting load diagram, together with the bearings listed in the product tables, the required bearing size can be estimated using the resulting axial bearing load and the magnitude of the tilting moment.



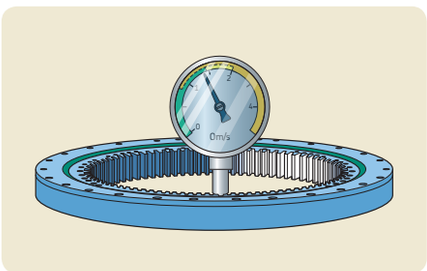
Permissible operating temperature

The permissible operating temperatures for slewing bearings listed in this catalogue are determined primarily by the spacer and seal material and the grease used for lubrication. The permissible operating temperature typically ranges from –25 to +70 °C. If slewing bearings are required to operate outside the reference temperatures, contact the SKF application engineering service. Also contact the SKF application engineering service if the outer ring has a lower temperature in operation than the inner ring, which might lead to reduced internal clearance or increase the preload in the bearing.



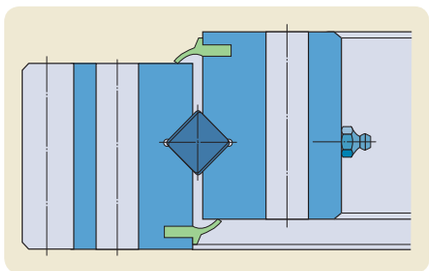
Vibration

For applications subjected to vibrations, preloaded four-point contact ball slewing bearings are typically used. However, crossed cylindrical roller slewing bearings are also suitable. In cases where sufficient experience with a similar bearing arrangement is not available, it is strongly advised to consult the SKF application engineering service.



Operating speed

SKF four-point contact ball slewing bearings generate less friction than crossed cylindrical roller slewing bearings. Consequently, four-point contact ball slewing bearings also have a higher speed capability. These bearings can accommodate tangential operating speeds up to 4 m/s. Crossed cylindrical roller bearings are limited to approximately 1,5 m/s for continuous slewing motion and up to 2 m/s for brief periods.



Sealing

The selection of a seal is vital to the performance of a slewing bearing. The standard seals used in SKF slewing bearings provide good protection against moisture and contaminants and also provide reliable retention of the lubricant.

These integral seals are not intended to protect bearings that operate under extreme conditions where, for example, they are exposed to water, vacuum, high levels of abrasive contaminants, or radiation. For these types of applications, additional external seals must be used to prevent media from entering the bearing cavity.

Selection of slewing bearing size

The size of a slewing bearing can be based initially on the dynamic and static load ratings of the bearing, in relation to the applied loads and the requirements regarding reliability and service life. Values for the axial dynamic load rating C and axial static load rating C_0 are quoted in the product tables.

When determining the most efficient and economical slewing bearing for a specific application, SKF recommends taking the following into consideration:

- loads acting on the bearing
- frequency of oscillating movements
- type of application
- bearing size most suitable for the application
- torque applied to the gear

If it is necessary to calculate the basic rating life*, contact the SKF application engineering service. SKF also recommends confirming the results by contacting the application engineering service once calculations and the selection process are complete.

*) The basic rating life is the result of a calculation that indicates the time a bearing can operate before the first sign of metal fatigue occurs on one of its rings or rolling elements.

Determining bearing loads

The loads and moments acting on a slewing bearing from the inherent weight of the components that it carries, and the other inertia forces, are either known or can be calculated. Assuming the conditions cited in **fig. 1**, the resulting loads and moments applied to the bearing can be estimated, using the following equations:

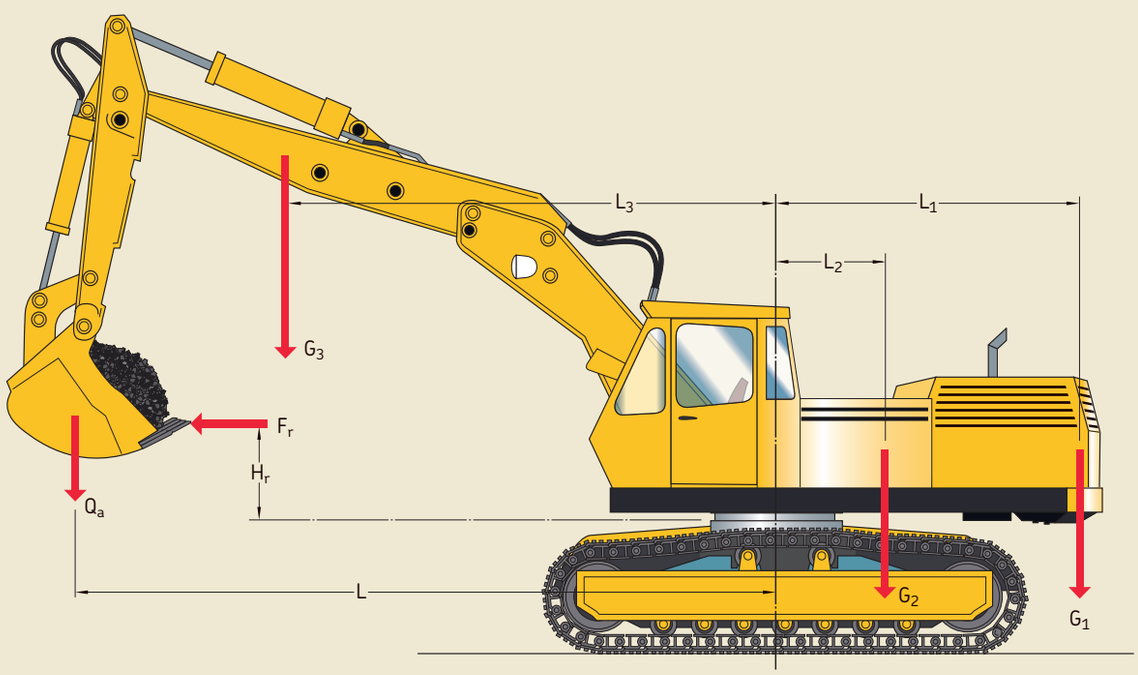
$$F_a = Q_a + G_1 + G_2 + G_3$$

$$M_t = Q_a \times L + F_r \times H_r + G_3 \times L_3 - G_1 \times L_1 - G_2 \times L_2$$

where
F_a = resulting axial load applied to the bearing, kN
F_r = external radial load applied to the bearing, e.g. work/wind force, kN
G_1 = weight fraction 1, e.g the counterweight, kN
G_2 = weight fraction 2, e.g. the weight of the cabin, kN

Load distribution scheme

Fig. 1



G_3 = weight fraction 3, e.g. the weight of the boom, kN
H_r = distance from the bearing centre point to the line of action of the radial force F_r, m
L = distance from the centre of rotation to the centre of the lifting load, m
L_1 = distance from the centre of rotation to the centre of gravity of the weight fraction 1, m
L_2 = distance from the centre of rotation to the centre of gravity of the weight fraction 2, m
L_3 = distance from the centre of rotation to the centre of gravity of the weight fraction 3, m
M_t = resulting tilting moment acting on the bearing, kNm
Q_a = lifting load, kN

In applications where the working radii L and L_3 for the lifting load and the adjustable boom vary, the maximum working radii have to be used to calculate the maximum tilting moment M_t acting on the bearing.

External radial loads F_r may be neglected as long as they are ≤ 5% of the axial load. If these radial loads are acting at any point other than the plane of the bearing, the resulting tilting moment should be calculated and taken into consideration. If the radial loads exceed the ratio F_r/F_a = 0,6, it is advisable to contact the SKF application engineering service.

Determining bearing size

When determining bearing size using the static limiting load diagrams, additional forces should be taken into account. Which forces to consider depend on the type and mode of operation of the machine and operational requirements regarding service life and reliability. This is done by multiplying the resulting axial load and tilting moment by a load factor f_L as listed in **table 1**:

$$F_{ar} = f_L \times F_a$$

$$M_{tr} = f_L \times M_t$$

where
F_{ar} = maximum rated axial load, kN
F_a = resulting axial load applied to the bearing, kN
M_{tr} = maximum rated tilting moment, kNm
M_t = resulting tilting moment acting on the bearing, kNm
f_L = load factor (→ **table 1**)

Using the calculated values for the maximum rated axial load F_{ar} and the maximum rated tilting moment M_{tr}, the requisite slewing bearing size can be obtained from the appropriate static limiting load diagram, shown together with the slewing bearings in the product tables. Each diagram contains two curves per bearing; the solid line shows the raceway capacity and the dotted line shows the bolting capacity (→ **fig. 2**). The points, where the plotlines of rated axial load F_{ar} and the rated tilting moment M_{tr} intersect, must always be below the capacity curves, i.e. inside the green zone. If the points of intersection (red) are above the capacity curves, the bearing is not suitable for the application.

Raceway capacity

The raceway capacity is defined as the maximum static load that can be accommodated by the slewing bearing without detrimental effects on its running behaviour.

Bolting capacity

Bolting capacity applies to the supported bearing and the number of 10.9 strength grade (EN ISO 898) nuts and bolts used to anchor the bearing to its support surface. For these capacities to be valid, the threads of all bolts and nuts must be coated with a thin layer of light oil and tightened according to the recommended values in **table 1** "Tightening torque and preload of attachment bolts" on **page 24**.

Note: All basic load ratings and capacity data specified in this catalogue are valid for supported slewing bearings. In the case of suspended bearing arrangements, contact the SKF application engineering service.

Raceway and bolting capacity

Fig. 2

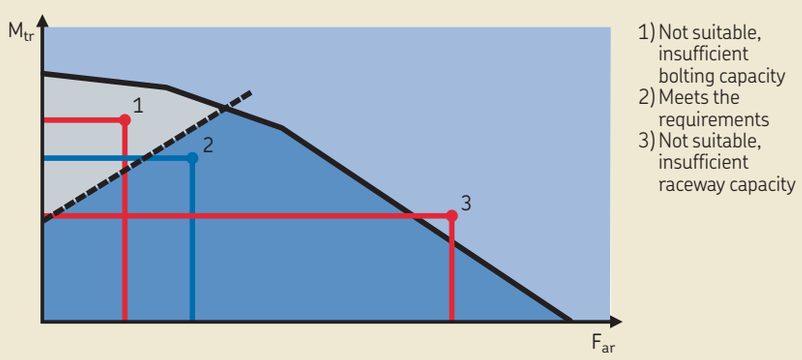


Table 1

Load factor f_L

Application	Load factor f_L
Aerial platforms	1,33
Carrousels	2
Cement mixers	1,33
Compactors	2
Concrete pumps	1,5
Handling workshops	1,15
Mobile cranes	1,5
Mini excavators	1,33
Sedimentation tanks	1,25
Service cranes	1,33
Turntables	1,15
Welding positioners	1,15

Selection example

A slewing bearing with an internal gear has to be selected for a mini excavator, which is exposed to the following operating conditions:

- resulting axial load applied to the bearing F_a = 65 kN
- external radial load applied to the bearing F_r = 12 kN
- resulting tilting moment acting on the bearing M_t = 120 kNm

The following is considered:

- the value for the load ratio F_r/F_a = 12/65 = 0,184 lies within the permissible range $F_r/F_a \leq 0,6$. Therefore, any series of four-point contact ball or crossed cylindrical roller slewing bearing can be used.
- with f_L = 1,33 the maximum rated axial load and maximum rated tilting moment is calculated:

  $F_{ar} = f_L \times F_a = 1,33 \times 65 = 87$ kN

  $M_{tr} = f_L \times M_t = 1,33 \times 120 = 160$ kNm

- using F_{ar} = 87 kN and M_{tr} = 160 kNm, a bearing that adequately meets the needs of the application can be obtained from the product tables:

– medium size four-point contact ball slewing bearing with an internal gear, **page 70**: RKS.062.20.1094
– medium size crossed cylindrical roller slewing bearing with an internal gear, **page 94**: RKS.162.14.1094

In applications where stiffness is important, the crossed cylindrical roller slewing bearing RKS.162.14.1094 is the best choice; otherwise the four-point contact ball slewing bearing RKS.062.20.1094 is suitable for this task.

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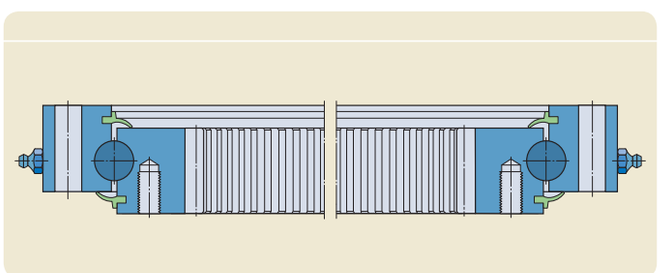
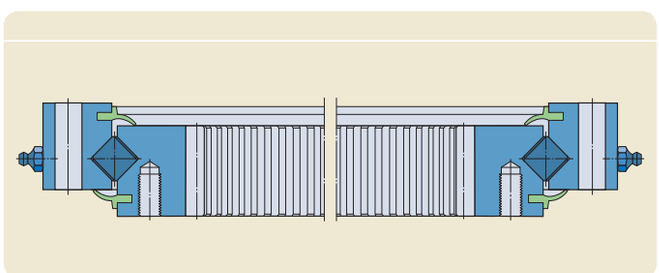


Four-point contact ball slewing bearing with an internal gear RKS.062.20.1094



Crossed cylindrical roller slewing bearing with an internal gear RKS.162.14.1094

Mounting, inspection and storage

General information

It takes skill and experience to maximize bearing performance and reduce the risk of premature failures. Experience means choosing the correct mounting method and using the correct tools for the job.

The information provided in the following section is quite general and primarily identifies the factors that must be considered in order to facilitate the mounting process.
The information is valid for single row slewing bearings used in typical applications. For additional information, contact the SKF application engineering service.

Mounting should, wherever possible, be carried out in a dry, clean environment. When slewing bearings have to be mounted in an unprotected area, which is often the case, steps should be taken to protect the bearing and its associated components until installation is complete.

As is the case with all bearings, never hit the rings or seals directly with a hammer or any other hard object. Also, never apply a mounting force directly through the rolling elements.

Preparations for mounting

Before mounting, all necessary parts, tools, equipment and data need to be on hand. SKF also recommends checking all drawings and instructions to determine that each component is assembled in the correct order.

Bearing handling

To reduce the risk of injury, wear gloves when mounting slewing bearings. Also, use carrying and lifting tools that are specially suited for mounting such bearings.

Slewing bearings should be transported and stored flat on a surface that extends over the whole side face of the bearing (→ **fig. 1**). When the bearing is to be moved or held in position, appropriate lifting tackle should be used (→ **fig. 2**). Eyebolts, for example, should only be subjected to a load in the direction of the shank axis. Also, keep in mind when using eyebolts that the hole size is limited and only designed to accommodate the weight of the bearing. The bearing should never be weighted down with tools or associated components. Slewing bearings should never be suspended from a single point using a sling or one bolt, because the rings are relatively thin-walled and the weight of the bearing could deform the rings.

Like other rolling bearings, slewing bearings should remain in their original, unopened package until immediately before mounting so that they will not be exposed to contaminants like dirt unnecessarily. The preservative coating applied to a new bearing from the factory should be removed from side faces that will be in contact with the support surface.

Bearing markings

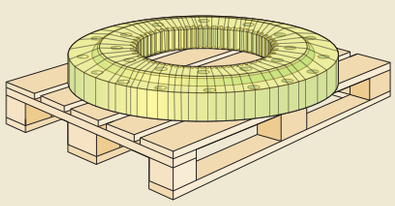
To facilitate correct installation, the inner and outer rings of SKF slewing bearings are marked on one side face according to **fig. 3**.

A **red marking** and the letter "**F**" indicate a small unhardened area in the raceway – the soft zone on the raceway between the beginning and end of induction hardening. Whenever possible, this area coincides with the position of the hole that is needed for ball or roller loading and is closed with a plug.

To facilitate backlash adjustment, a **blue marking** and the letter "**B**" on the geared ring locates the smallest gap between two teeth.

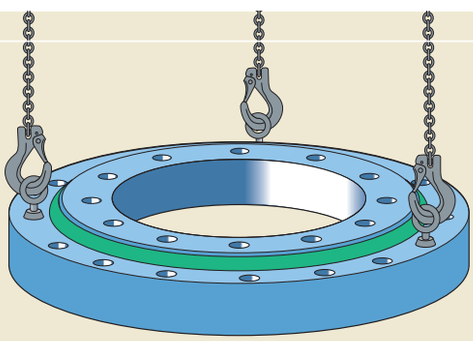
A **black marking** on a bearing with a low sectional height relative to its diameter, indicates the minimum out-of-roundness of the assembled bearing.

Fig. 1



Proper bearing transportation

Fig. 2



Appropriate lifting tackle

Attachment bolts

Only bolts and nuts as specified in the technical documents or mounting instructions should be used. Recommendations are provided in the chapter “Attachment bolts” on **page 22**.

Under normal operating conditions and when the recommended flat washers are used, the recommended bolt torque values provide a reliable and safe connection to the support surface and the application.

Tightening methods

All bolts and nuts should be tightened with a highly accurate torque wrench (→ **fig. 4**) or a hydraulic bolt tensioner (→ **fig. 5**) in at least two stages as described in the section “Mounting recommendations” (→ **fig. 40**). SKF recommends that whenever possible, the bolts should be tightened using an HYDROCAM hydraulic bolt tensioner. This hydraulically operated bolt tensioner enables bolts to be installed accurately without applying torque. The tensioner also enables

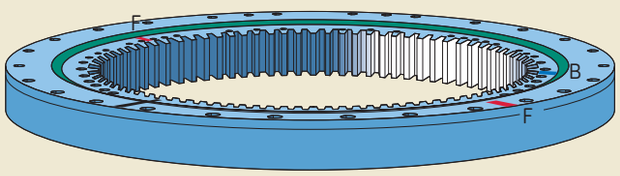
- bolted joints with uniform preload on all bolts
- the optimum exploitation of the yield strength of the bolt
- the use of high-strength bolts.

The HYDROCAM bolt tensioner was designed specifically to install the bolts on slewing bearings. These tensioners are available in four different designs. The standard bolt tensioner (→ **fig. 5**) consists of

- a skirt (**a**)
- a hydraulic body (**b**)
- a brace (**c**)
- a socket for standard nuts (**d**) to hand tighten the nut.

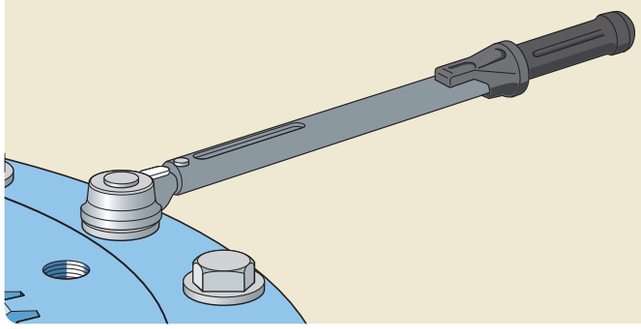
For additional information about HYDROCAM bolt tensioners, contact the SKF application engineering service.

Fig. 3



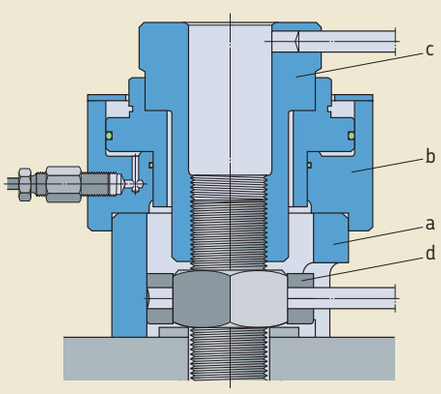
Bearing markings

Fig. 4



Appropriate torque wrench

Fig. 5



HYDROCAM bolt tensioner

Mounting recommendations

Correct mounting of a slewing bearing depends on the design of the application and the type of slewing bearing. The following information is quite general, but provides basic information proven in the field. For additional information, contact the SKF application engineering service.

1 Remove any burrs on the seat surfaces with emery cloth or a honing tool (→ **fig. 1**).
2 Clean the seat surfaces with compressed air. Make sure that the surfaces of the support structure and the bearing are clean and dry (→ **fig. 2**).
3 Check the form accuracy of the support structure (→ **fig. 3**) according to the information in the section "Associated components" starting on **page 21**.
4 Position the bearing on the first support surface. The **red marking F** on the ring must be arranged at a 90° angle to the axis of the maximum loaded zone, provided that the axis can be determined or estimated (→ **fig. 4**).

Fig. 1

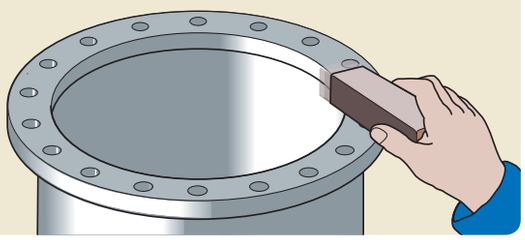


Fig. 2

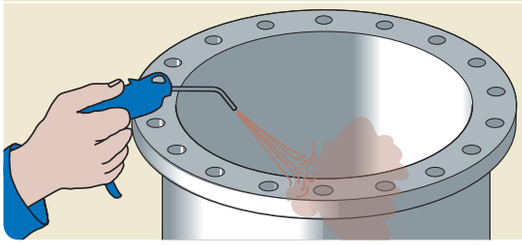


Fig. 3

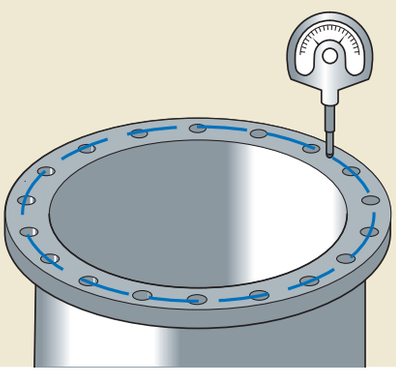
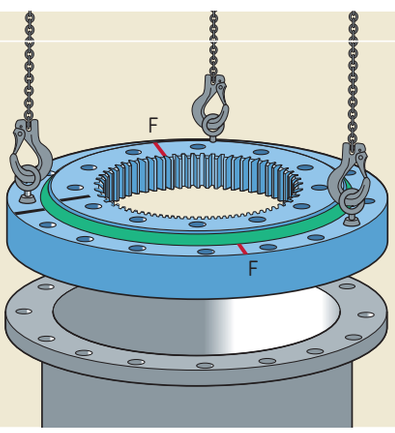


Fig. 4



5 Adjust the bearing so that the bolt holes in the ring coincide with those of the support structure. Check that the bearing is level over the entire seat surface (→ **fig. 5**).
6 Coat the bolt threads with a thin layer of light oil.
7 Fit the bolts, washers and nuts and manually tighten them (→ **fig. 6**).
8 In a first round, tighten the bolts or nuts (→ **fig. 7**) to between 40 and 50 % of the prescribed value, following the tightening pattern (→ **fig. 8**). In a second round, fully tighten the bolts or nuts to the prescribed preload, following the tightening pattern.

Fig. 5

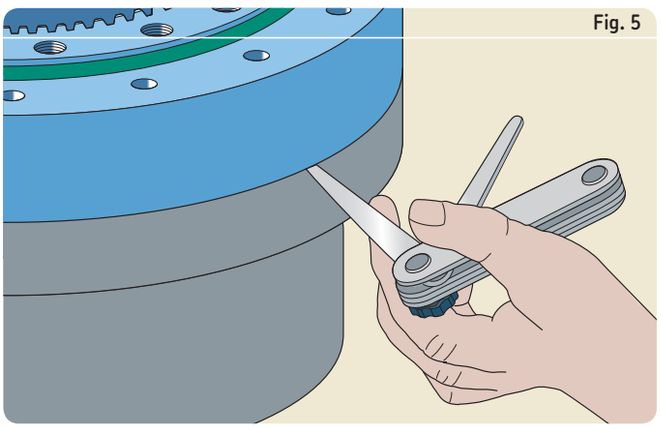


Fig. 6

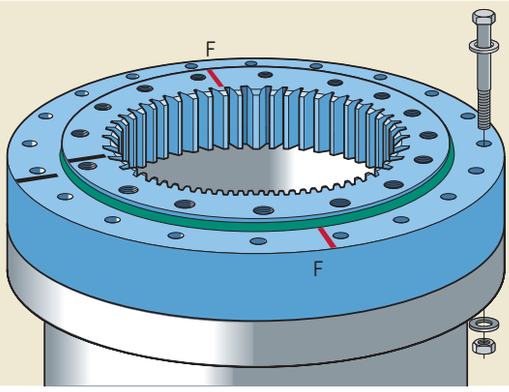


Fig. 7

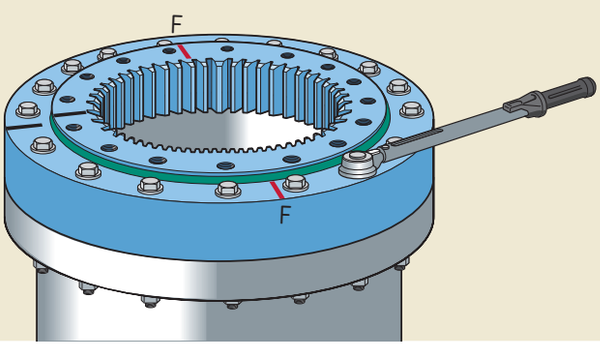
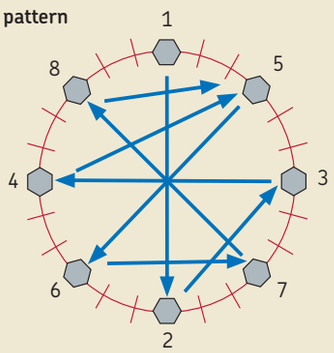


Fig. 8

Bolt tightening pattern



9 Check for correct installation by turning the “free” ring (→ **fig. 9**). The torque, which might be high due to preload, grease and friction of the seals, should not show any excessive variation or “tight spots” during rotation. If the torque varies excessively, check the ovality of the bearing, and correct if necessary.

10 Position the second support structure with its support surface on the free bearing ring. The **red marking F** on this ring must be at 180° from the **red marking F** of the mounted ring (→ **fig. 10**).

11 Adjust the position of the support structure so that the bolt holes coincide with those of the bearing ring.

12 Coat the bolt threads with a thin layer of light oil.

13 Fit the bolts, washers and nuts and tighten them, following **steps 7** and **8**.

14 Check the installation by rotating the assembled bearing arrangement. The torque should not show any excessive variation or “tight spots” during rotation (→ **fig. 11**).

15 Measure the tilting clearance of the installed bearing in the main load line with the aid of a dial gauge by applying a defined tilting moment (→ **fig. 12**). Check 180° from the measuring point to be sure that the radial clearance is virtually zero. Mark the measuring points on the adjacent component and note the measured clearance on the installation report.

Fig. 9

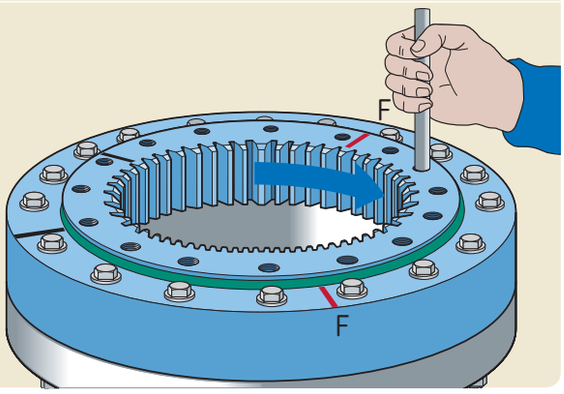


Fig. 10

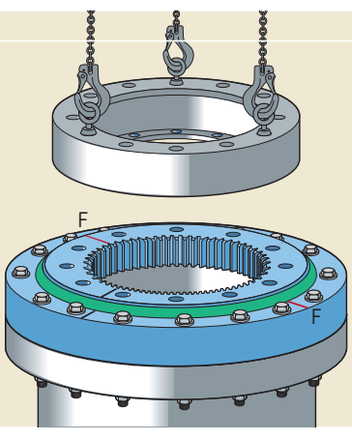


Fig. 11

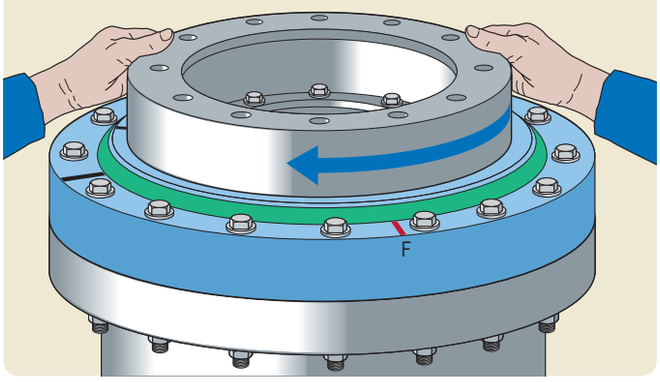
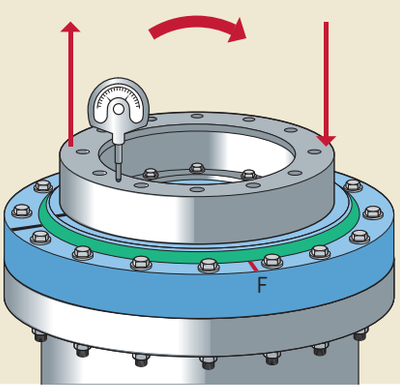


Fig. 12



16 For geared slewing bearings, check the backlash, using a feeler gauge, after positioning the pinion (**fig. 13**). The measurement has to be made at the **blue mark** on the bearing gear, which indicates the point where the backlash is smallest. Required values for backlash are listed in **table 1** on **page 29**. If these values are not attained, correct the backlash by adjusting the distance between the centres of the gear wheels.

17 Supply grease to the raceway via the grease fittings provided in one of the bearing rings (**fig. 14**). If applicable, rotate the bearing during the greasing operation. If a centralized lubricating system will be used, connect the lubricating tubes to the bearing.

18 Lubricate the gear. (→ **fig. 15**)

Fig. 13

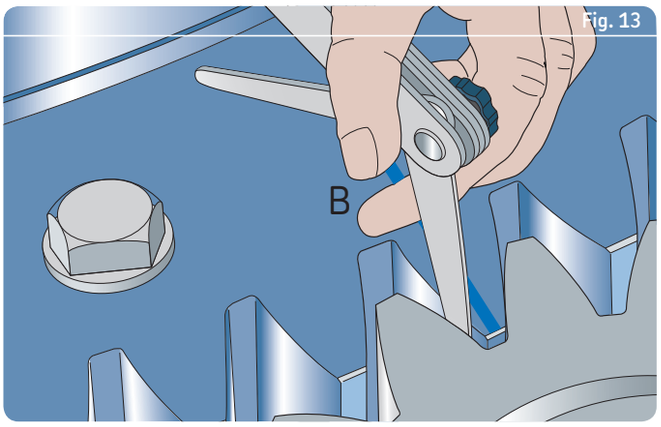


Fig. 14

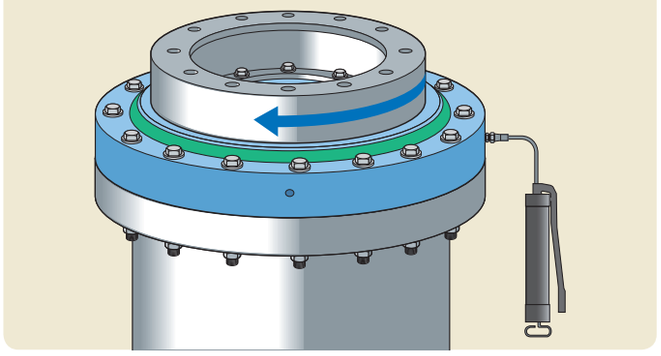
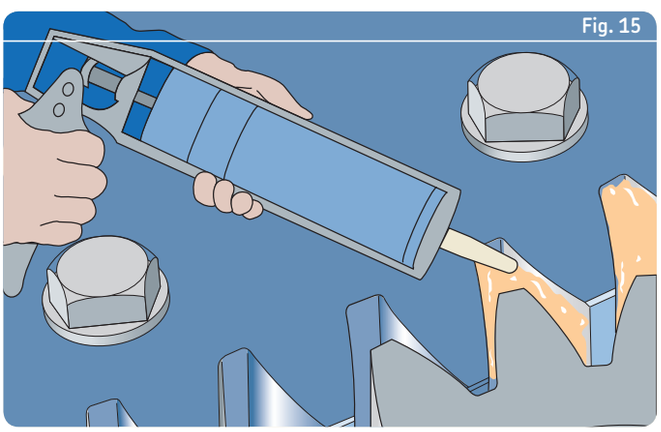


Fig. 15



Trueing up

This section applies only to slewing bearings with a mean raceway diameter above 2 000 mm and having a black marking on each ring.

1 Align the black markings by rotating one of the rings (→ **fig. 16**).
2 Measure the ovality of each ring at 6 points (30° intervals), e.g. on the centring diameters d_{1c}, d_{2c}, D_{1c}, or D_{2c}, respectively (→ **fig. 17**). The ovality of a bearing ring should not exceed 0,5 mm for bearings with a mean raceway diameter between 2 000 and 3 000 mm.
3 Trueing up the bearing is achieved through elastic deformation of the bearing rings. To reduce the ovality, only small adjustments are required, which can be achieved by means of small jacks (→ **fig. 18**) or a star shaped tool.
4 After trueing-up, tighten the bolts of the adjusted ring to the prescribed preload (→ **fig. 4**), following the mounting recommendations starting on **page 40**.
5 Remove the adjustment tool (→ **fig. 19**).
6 Check for correct mounting by turning the "free" ring (→ **fig. 20**). The torque, which might be high due to preload, grease and friction of the seals, should not show any excessive variation or "tight spots" during rotation.

Note: The tools that can be used for trueing-up the bearing are rather simple. They can consist, for example, of a bar with adjustable screws at the ends, to expand the inner ring. Only minimal pressure should be applied against the bearing rings.

Fig. 16

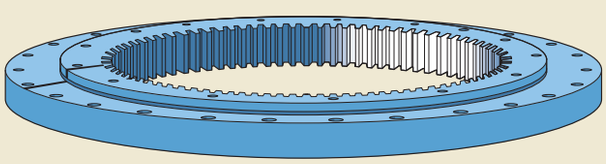


Fig. 17

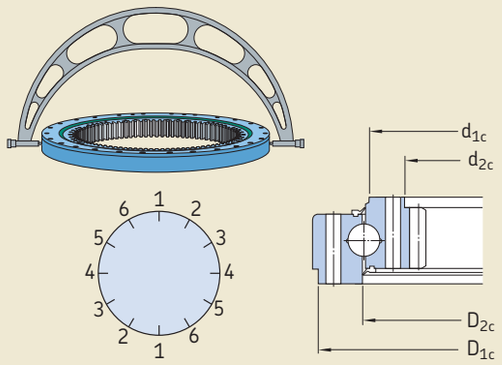


Fig. 18

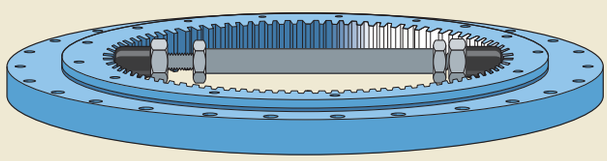


Fig. 19

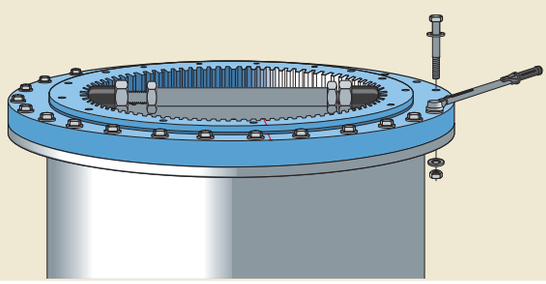
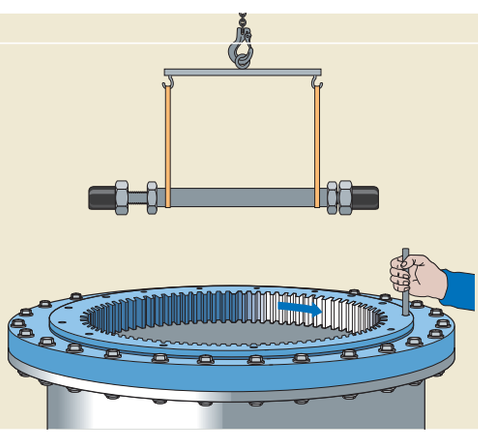


Fig. 20



Inspection

As with all important machine components, slewing bearings should be cleaned and inspected regularly. Maintenance intervals depend entirely on the operating conditions. In applications where there are heavy loads and/or high levels of contamination, decrease the time between inspections.

To avoid accidents or injuries during the inspection process, be sure that the moving part of the slewing bearing arrangement is balanced and that no tilting moments or radial loads are present.

Inspecting axial tilting clearance

To determine and record wear in slewing bearings, SKF recommends checking the axial tilting clearance after 2 000 operating hours, or at least once a year. Since there is a definite relationship between raceway wear and increased axial clearance, measure the axial clearance prior to operation. This is normally done during the bearing installation process (→ **fig. 1**). The results of the first and any subsequent measurements should be noted and recorded as a graph.

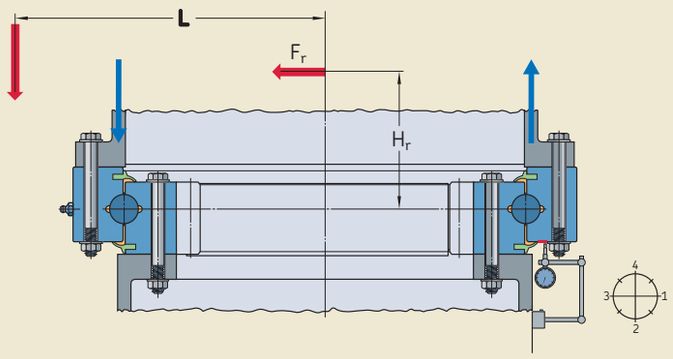
For applications where measurement of the axial tilting clearance is not possible, the bearing height reduction (→ **fig. 2**) can be used to define raceway wear:

$$\Delta_{Hw} = H_{s0} - H_{s1}$$

where
Δ_{Hw} = bearing height reduction, mm
H_{s0} = bearing height after installation, mm
H_{s1} = bearing height after operation, mm

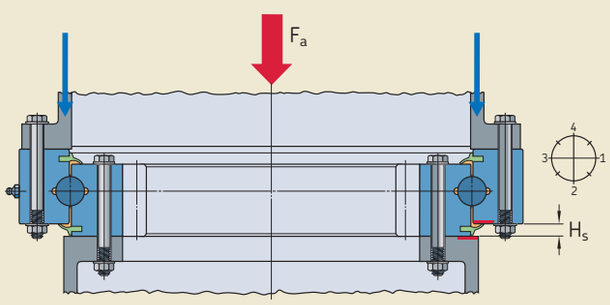
Also, in this case, measurement values of the bearing height are needed after installation and prior to start-up. The procedures used to take measurements should be the same each time. Guideline values for the permissible bearing height reduction as a function of the rolling element diameter are listed in **table 1**. For additional information, contact the SKF application engineering service.

Fig. 1



Inspecting axial tilting clearance

Fig. 2



Measuring the bearing height reduction

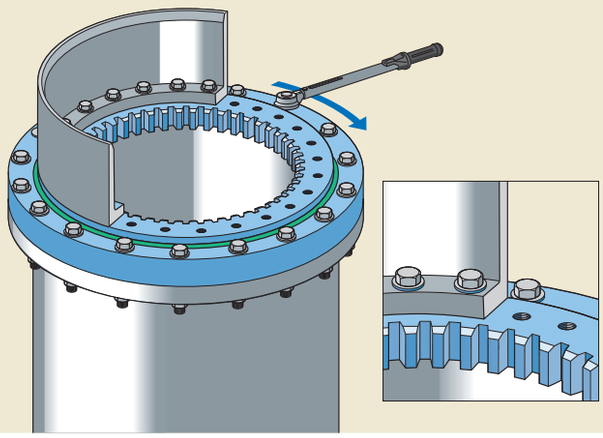
Table 1

Permissible bearing height reduction

Rolling element diameter[1] D_w	Bearing height reduction Δ_{Hw}	Rolling element diameter[1] D_w	Bearing height reduction Δ_{Hw}
mm	mm	mm	mm
14	1	**25**	1,8
16	1,2	30	2,2
20	1,5		

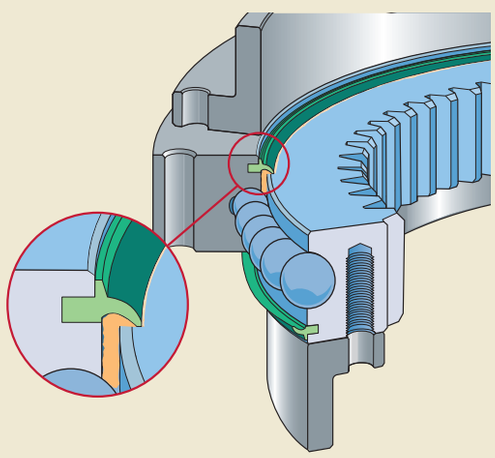
[1] See "Designation system" on **pages 56** and **87**. Light series four-point contact ball slewing bearings incorporate 20 mm diameter balls. Rolling element diameter of customized bearings is supplied on request

Fig. 3



Retightening the bolts

Fig. 4



Seal inspection

Inspecting bolt joints

Special attention must be paid to the bolt joints. Depending on the application, all bolts need to be retightened between the third week and twelve weeks of operation. (→ **fig. 3**).

Before start-up after an extended period of machine downtime, after 2 000 operating hours or at least once a year, all attachment bolts of a slewing bearing arrangement should be retightened. In cases where

- a bolt has lost 20% or more of the prescribed preload, then the actual bolt(s) as well as the two adjacent ones, must be replaced
- at least 20% of the bolts of a single ring are found to have less than 80% of the prescribed preload, then all the bolts must be replaced.

Never loosen or exchange more than one bolt at a time. Use the same tightening method, the same tools and the same type of bolts employed originally.

Seal inspection

The seals or sealing arrangements should be inspected at least every six months during normal maintenance. If necessary, clean the seals and if there are signs of damage, replace the seal to prevent any contaminants from entering the bearing.

Furthermore, check that there is always a sufficient amount of grease around the entire circumference of the sealing lip (→ **fig. 4**).

Note: The instructions for inspecting bolt joints should not be considered as a substitute for standards that may apply in countries where the slewing bearings are operated. When replacing a slewing bearing, always replace the bolts too.

Storage

Slewing bearings can be stored in their original package (→ **fig. 1**) for approximately one year, provided that the relative humidity in the storeroom does not exceed 60% and there is no vibration and no great fluctuation in temperature.

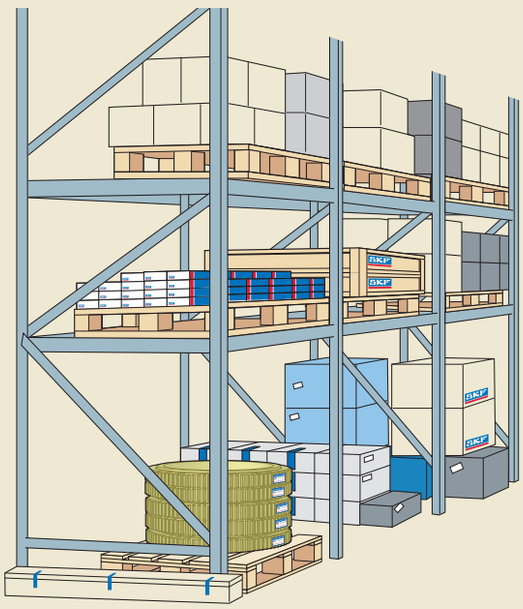
If slewing bearings have to be stored for periods longer than one year, this has to be specified when ordering, because special provisions have to be made during packaging (→ **fig. 3**).

The protection of the bearing enables storage at about 20 °C at a maximum relative humidity of 75% during the time mentioned on the label attached to the packaging.

Slewing bearings should only be stored lying flat on a surface where the entire side face is supported (→ **fig. 2**). If stored in the upright position, the weight of the rings and rolling elements can result in permanent deformation.

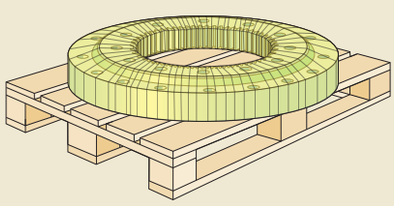
For additional information about storage, contact the SKF application engineering service.

Fig. 1



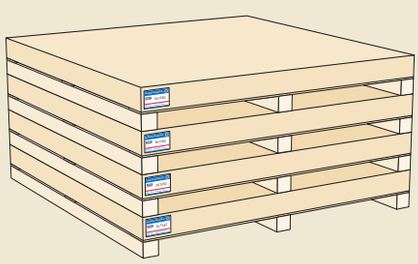
Correct storage of bearings

Fig. 2



Standard wrapping of an SKF slewing bearing

Fig. 3



Wooden package of slewing bearings