Liebherr large anti-friction bearings.

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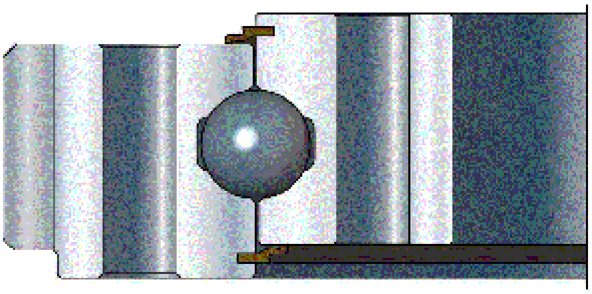
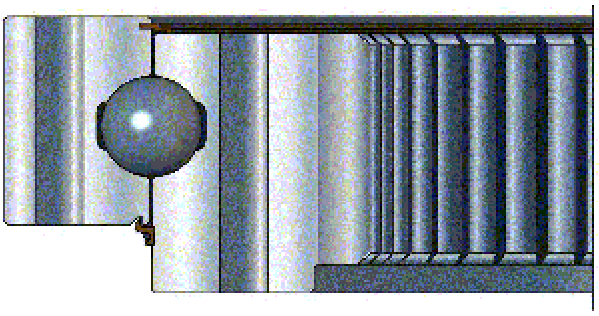
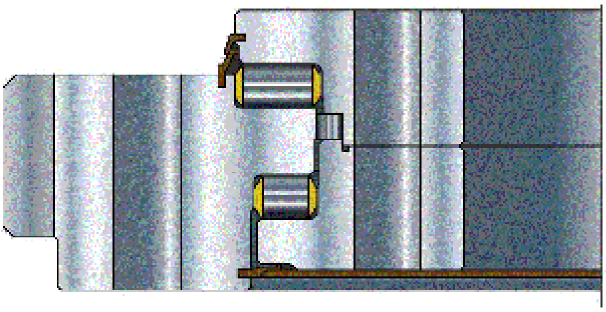


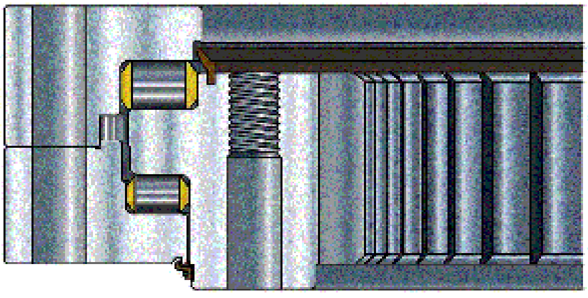
Four-point bearing with internal teeth KUD ... VJ



Roller bearing with external teeth ROD ... DA



Roller bearing with internal teeth ROD ... DJ



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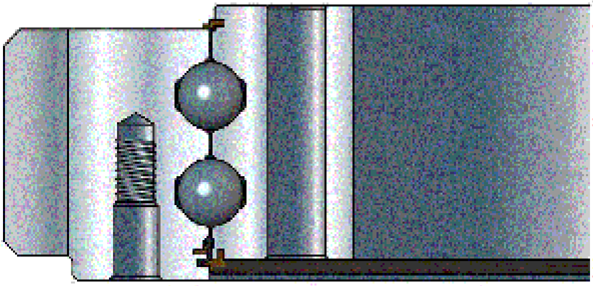
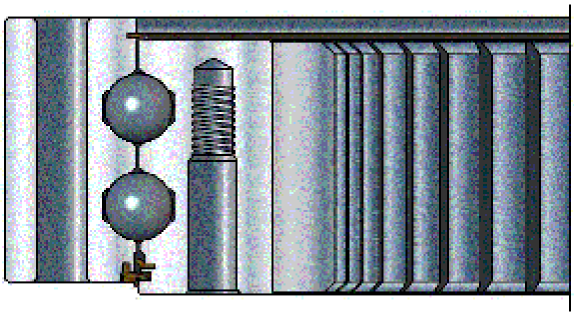
Bearing types - Special models

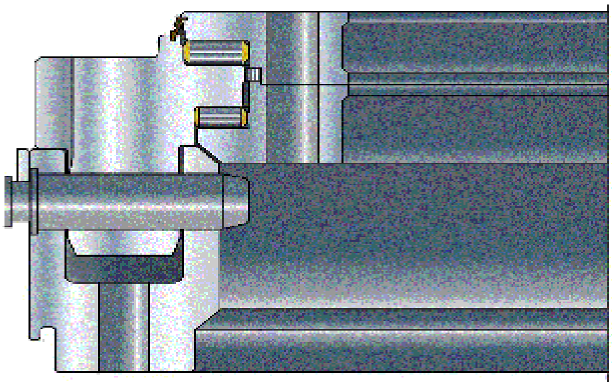
Two row four-point bearing with external teeth KUD ... VA



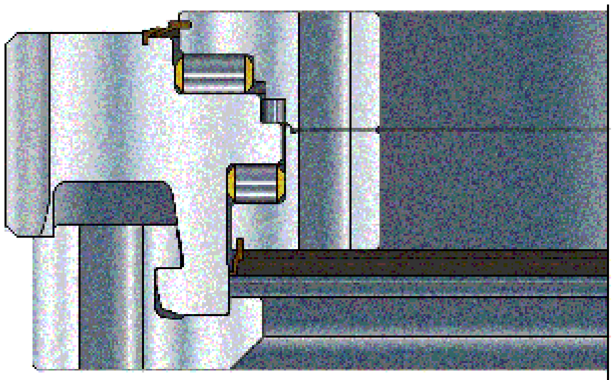
Two row four-point bearing with internal teeth KUD ... VJ



Roller bearing with bolting and external teeth ROD ... BA



Roller bearing with bayonet connection and external teeth ROD ... BA



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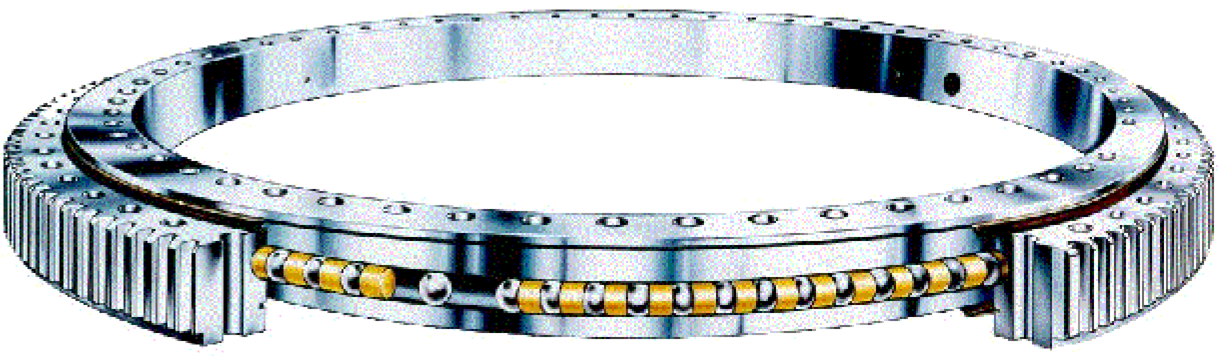
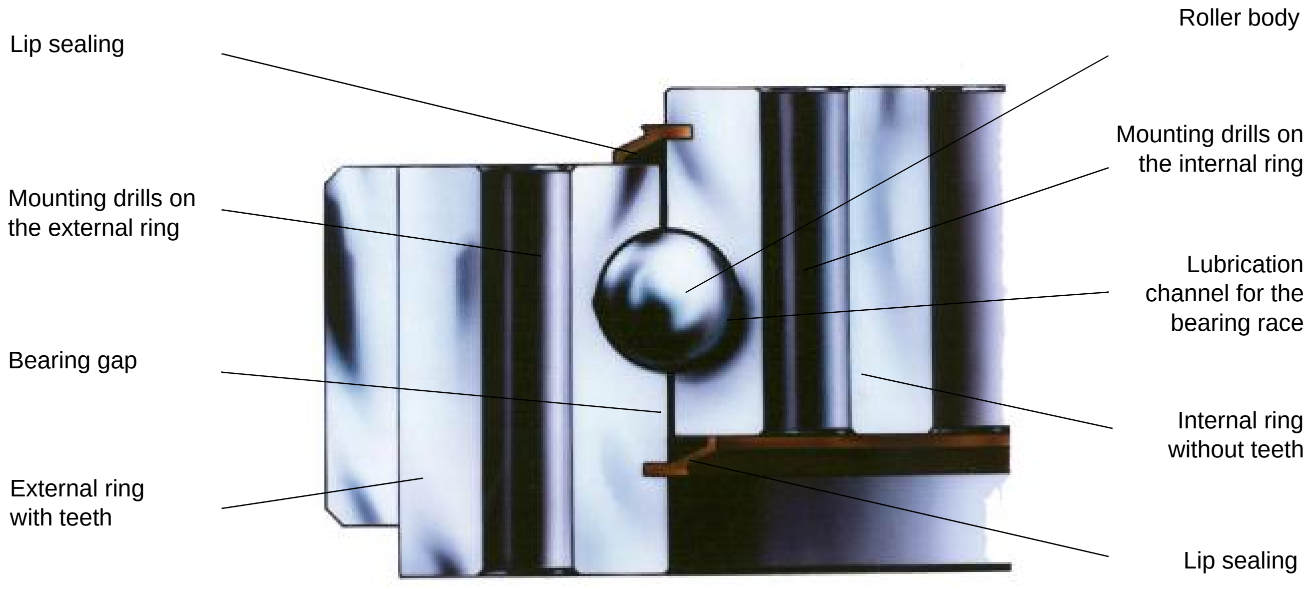
Structure of a four-point bearing



3D-view of a four-point bearing with external teeth



Cross-section of a four-point bearing with external teeth

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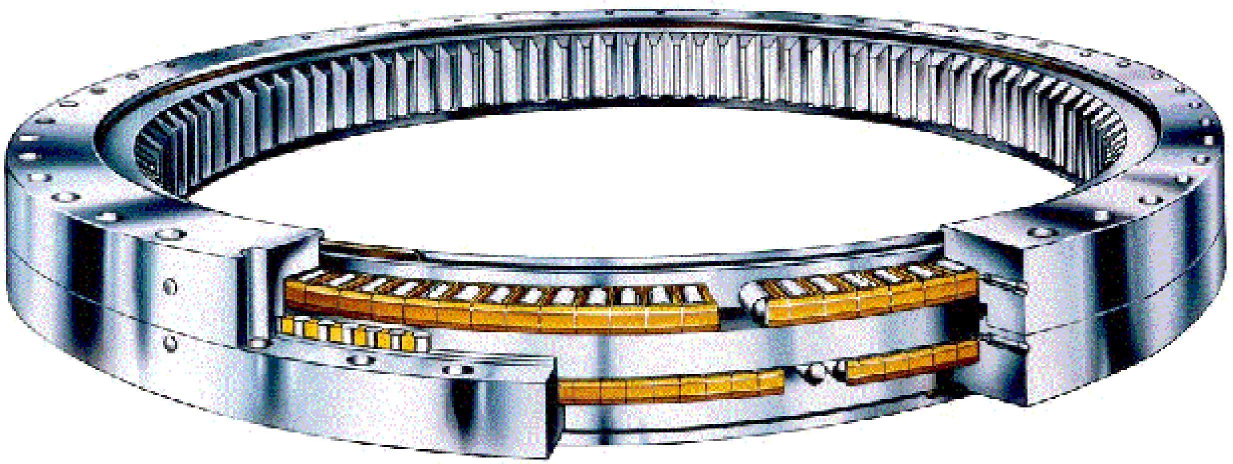
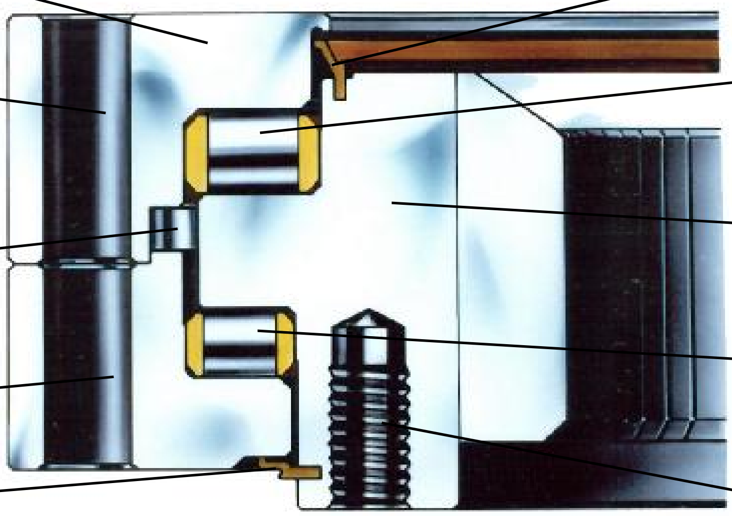
Roller bearing structure



3D-view of a roller bearing with internal teeth



Cross-section of a roller bearing with internal teeth

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Bearing design

Bearing ring materials

Different materials are used according to the application and use of the LIEBHERR large bearing.

The completely seamless rolling rings are manufactured from high-alloy chrome molybdenum steel which corresponds to our plant norms which are similar to DIN 17200 (modified).

These plant norms state and describe the chemical composition, the treatment of the materials during the production of the parts and the mechanical characteristics of the basic materials. The scope of testing and documentation is also set down.

This delivery guideline has been made available to all of our component suppliers. Routine audits of our suppliers ensure that our technical delivery specifications are maintained.

For certain applications or special requirements, LIEBHERR uses special materials such as high-alloy, cryogenic special steel for very low temperatures.

To ensure the quality of the finished products, every individual ring of the roller bearing is checked several times during production. Our quality management system for large bearings certified by the German Technical Standards Authority **(TÜV) according to DIN EN ISO 9001**, ensures that any material faults are detected at the earliest possible stage.

According to requirements for testing and documentation for the component parts, certain certificates can be supplied. For conventional applications in machine and system construction the following certificates will be supplied:

- Plant certification 2.1 or
- Plant certification 2.2 and
- Plant test certificate 2.3

according to EN 10204.

For special requirements **Acceptance Test Certificate 3.1.B or 3.1.C according to EN 10204** will be issued. These are required under the guidelines of the official classification test, for example, by the following classification organisations:

- AMERICAN BUREAU OF SHIPPING,
- DET NORSKE VERITAS,
- GERMANISCHER LLOYD or
- LLOYDS REGISTER OF SHIPPING

These are issued and supplied on request.

Rolling body material

For four-point bearings, the balls used correspond to DIN 5401, for roller bearings the cylinder rollers used are made of hardened rolling bearing steel according to DIN 5402.

Intermediate piece material

The intermediate pieces and rolling cages are made of plastic and serve to guide the rolling bodies and to keep them equidistant from each other. They prevent contact between them and jamming of the rolling bodies.

For special applications, metallic cages or cage belts can be used.

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Bearing design

Sealing types

LIEBHERR large bearings are usually constructed with sealing lips on both sides of the race system. These serve two main purposes:

- to prevent moisture, dust and other foreign bodies from penetrating the bearing gap and
- to retain the lubricant contained in the race system.

Various sealing forms can be supplied. Which form of sealing is used depends on the cross-section and the diameter and the intended use of the bearing and the environmental conditions.

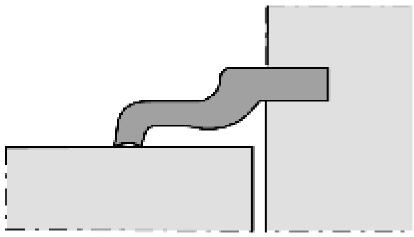
When used in construction machines or in general machine and system manufacture, simple lip sealings have been proven to be most effective.

For special usage purposes, special forms of sealing lips must be used, for example in especially dusty environments or when used in areas where the air may contain sea water. In such cases, special sealings are used to reduce grease leakage, especially in wind power generating systems.

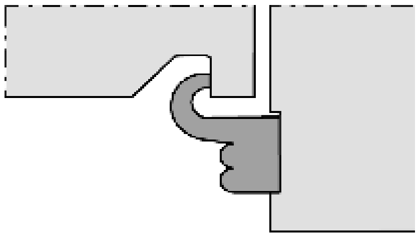
The materials used in our sealings are optimised for the operation conditions. In spite of this the sealing lips are subject to wear caused by the effects of various environmental factors such as exposure to UV light or ozone.

For this reason, they should be checked at regular intervals and replaced if necessary.

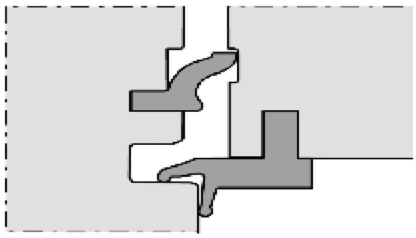
Example of sealing forms



Sealing form for general use



Sealing form for special applications such as in offshore areas



Sealing form for special applications such as in wind power generating systems

Our standard sealings are used in the measurement tables. The use of special forms can have a slight effect on the measurements for the bearing.

The sealing's environment should be constructed in such a manner that damage does not occur either through installation work or through the use of screwdrivers or spanners, as far as this is possible.

During commissioning of the bearing, it is essential to ensure that an even grease collar forms around the sealing.

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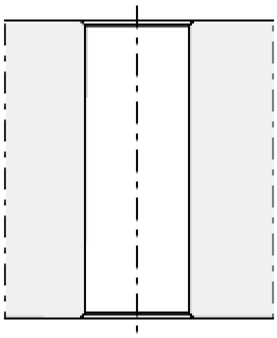
Bearing design

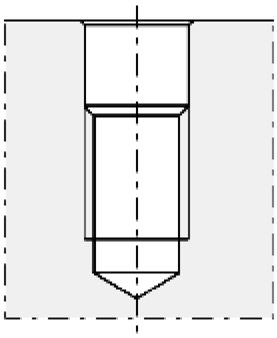
Fixing drill holes

Fixing drill holes are provided for fixing the LIEBHERR large bearing to the assembly construction.

According to use and existing assembly construction, these can either be cylindrical through-holes or threaded pocket-holes with a metric regular thread according to DIN 13 part 1.



Example of through holes



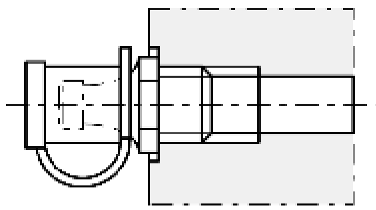
Example of pocket holes

For the fixing in a pocket hole, the thread is drilled clear to ensure the maximum possible length of the rivet grip of the bolt.

Lubrication drill holes

Lubrication drillings are provided for the lubrication of the bearing race. These are arranged either radially on the lower tooth ring or axially depending on the type of construction and have an M10x1 thread as standard.

If desired, a grease nipple corresponding to DIN 71412 form A M10x1 can be fitted in the lubrication drillings at our plant. The grease nipples threads correspond to DIN 158 "M10x1 con. short". If present, the grease nipples are sealed with plastic stoppers to prevent damage.



Example of lubrication drilling with lubrication nipples screwed in

Manual lubrication guns, lubricant supply lines from central lubrication systems or permanent lubricant feeders can be connected to the grease nipples.

Bearing design

Teeth

LIEBHERR large diameter bearings can be manufactured with inner and outer teeth and which mostly takes the form of spur gear teeth.

Special teeth, for example helical gearing can be manufactured on request. Of course, our bearings can also be produced without teeth.

Construction and quality of the teeth

The standard construction for the gearing is with involute gearing corresponding to DIN 867 with a standard angle of pressure $\alpha = 20°$.

In order to optimise the gearing, profile offsetting and modification of the tooth fillets may be required in certain cases. The reference profile according to DIN 3972, I and II is used. Addendum corrections are also possible.

The gearing quality on the large bearing corresponds to the following specifications of DIN 3967:

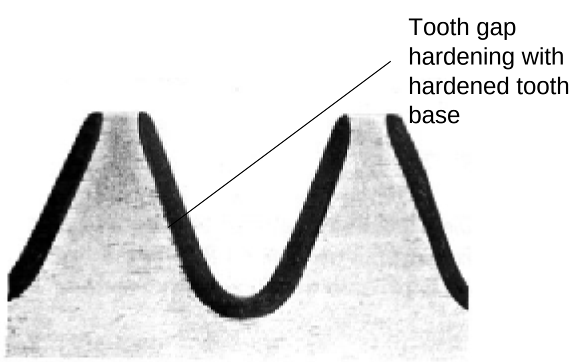
- **Gearing quality 12** (tolerance range values according to function group N) with
- Upper **deviation of tooth thickness** A_{sne} according to DIN 3967 (table 1) corresponding to **row e** and
- **Tooth thickness tolerance** T_{sn} according to DIN 3967 (table 2) corresponding to **tolerance range 28**.

Other qualities or tolerance ranges can be manufactured on request.

Tooth hardness

As a rule, the teeth are left in their tempered condition (mechanical strength of the basic material). Where the teeth are subject to especially high demands on lifetime or durability they can be **inductively hardened**.

Depending on measurement (reference diameter) and tooth module, the gears and treated by either **inductive tooth hardening** or by **circulatory hardening procedure.** The hardening is usually a **tooth gap hardening** with hardened tooth base to avoid metallurgic edges in the intermediate zone between the unhardened material.



Original hardening of a tooth gap hardening

As well as an increased tooth flank capacity this also ensures an increased tooth base capacity.

The hardness of the tooth flanks and the tooth base is usually set slightly below the drive pinion.

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Bearing design

Layout and calculation of the gearing

As a guideline for the bearing layout a ratio from the pinion to the large bearing, of $i_{pinion\ wheel} \approx 9.00...12.00$ can be assumed.

The maximum permissible torque for each bearing in relation to the bearing axis is given in the table. For occasional extreme loads higher values may be permitted depending on our construction.

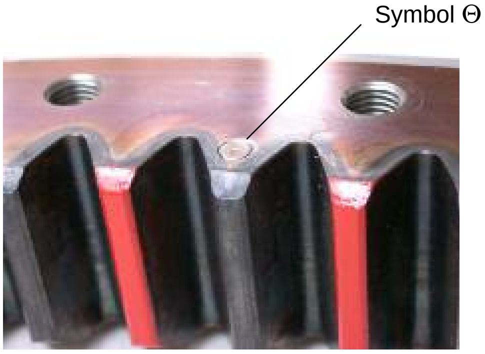
The review of the capacity of the teeth is generally performed by LIEBHERR. To do this we require supplementary technical data such as measurements, number of teeth, profile offset and material of the drive pinion.

Circumferential backlash

The circumferential backlash needs to be set correctly to avoid constrictions of the teeth during operation.

When the bearing is mounted, the circumferential backlash should have a value of at least **0.03...0.04 x module** at the point of the greatest eccentricity. The point of greatest eccentricity is indicated with an imprinted symbol.

- **Outer teeth**: ⊕ symbol
  (Largest existing reference diameter),
- **Inner teeth**: Θ symbol
  (smallest existing reference diameter).



Marking of the point of greatest excentricity

The teeth to the left and right of this point are marked in red.

The circumferential backlash can be set either by moving the large bearing within the tolerance range of the fixings or by the eccentric positioning on the drive pinion by altering the centre distance on these teeth. The setting should be checked after the bolts have been tightened.

Drive pinion

Generally, the number of teeth on the pinion should be not be less than 14 with a recommended profile offset of $v_{A,pinion} = +0,5 \cdot m$.

The pinion gear width should exceed the tooth width of the bearing on both sides by approximately 0.5 x module. This measurement should be at least 5 mm.

The tooth quality of the drive pinion should be adapted to the usage purpose but should not be any worse than tooth quality **Q9** according to DIN 3967 with an upper tooth thickness deviation A_{sne} corresponding to DIN 3967 (table 1) according to **measurement row c...b** and tooth thickness tolerance T_{sn} according to DIN 3967 (table 2) according to **tolerance row 26...27**.

A tip edge on the teeth is absolutey neccessary. We highly reccomend a tip relief.

Bearing design

Measurement tolerance ranges for the Liebherr bearings

Diameter tolerances, general tolerance ranges

Outer and inner diameter	Permissible tolerances according to DIN ISO 2768-m
400 to 1,000 mm	± 0.80 mm
1,000 to 2,000 mm	± 1.20 mm
2,000 to 3,150 mm	± 2.00 mm
3,150 to 4,500 mm	± 2.00 mm

Tolerances to the centring

(if present)

Outer and inner diameter	Permissible measurement deviations
400 to 1,000 mm	+ / - 0.07 mm Œ
1,000 to 2,000 mm	+ / - 0.12 mm Œ
2,000 to 3,150 mm	+ / - 0.17 mm Œ
3,150 to 4,500 mm	+ / - 0.21 mm Œ

Œ Values according to DIN ISO 286 part 2 corresponding to tolerance row IT 8

Position tolerance of the fixing drill holes

Threaded dimension or bore diameter	Permissible measurement deviations according to LIEBHERR plant norm LN 28-1 ⌖
< M10	Ø 0.20 mm
< M16	Ø 0.50 mm
< M24	Ø 0.70 mm
< M42	Ø 1.00 mm
≥ M42	Ø 1.30 mm

Radial run-out of the teeth

(in relation to the races)

Outer and inner reference diameter	Permissible tolerances according to DIN 3962 ↗ for M10 to M16
≥ 500 to 1,000 mm	0.32 mm
≥ 1,000 to 2,500 mm	0.36 mm
≥ 2,500 to 4,500 mm	0.40 mm

Surface quality

(Mean roughness index R_a)

Finished surface	Mean roughness index according to DIN 4768, part 1
Lateral areas	25 µm
Bolt-on surfaces	6.3 µm
Centrings	6.3 µm
Gearing	6.3 µm
Sealing face	1.6 µm

Bearing design

Bearing clearance

The bearing clearance for LIEBHERR large bearings is exactly defined at the plant.

The bearing clearance ensures that the running characteristics are good and that the bearing functions safely.

Narrowly set race systems caused by possible planned deviations of the assembly construction lead to a constriction of the race system. This can lead to stiffness and an impermissibly high load on the rolling body and the race.

The bearing clearance reduces the distortion of the races when they are installed in their assembly constructions. The following bearing clearance is set as standard for LIEBHERR large bearings

Bearing design	Bearing clearance in delivery condition
Four-point bearing	0.00 to 0.50 mm
Roller bearing	0.00 to 0.30 mm

Values for bearing clearance in four-point and roller bearings

During operation, the bearing clearance increases due to mechanical wear of the races and roller bodies. At a certain point, depending on the bearing construction, the bearing size and the application, the wear limit will be reached. The bearing should then be replaced.

Pre-stressing

For special applications, such as hydraulic bulldozers or wind power systems, bearings with slightly pre-stressed bearing races are manufactured.

Bearing clearance resulting low frictional resistance. By pre-stressing the bearing races, the frictional resistance is increased in both the loaded and idle conditions. This should be taken into consideration when designing the drive.

In addition to this, the pre-stressing avoids the formation of grooves. Grooves are mostly formed by constant oscillations when the bearing is at a standstill and leads to a shortening of the material's life span.

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Bearing design

Outer corrosion protection

The purpose of coating the large bearing is to protect the outer metallic surfaces of the rings from corrosion caused by environmental factors.

LIEBHERR large bearings can be coated in several different ways.

Corrosive protection with oil-based agents for temporary protection

The metal surfaces are protected by completely spraying the surfaces with anticorrosive oil. The solvent contained in the spray evaporates leaving a sealed film of oil.

The anticorrosion agent can work for up to **6 weeks** if the large bearing is stored in a closed, temperature-controlled room. Advantage: The anticorrosion agent can be easily removed without solvents before installation in the connector construction.

With simple coating

A thin coating with a water-soluble, environmentally harmless primer makes it possible to install the bearing in its assembly construction without removing the paint off the joint areas.

The bearing can be coated when installed with conventional one-component synthetic lacquer. LIEBHERR should be consulted about the compatibility of the lacquer beforehand.

With lacquer coatings

A wide range of coatings can be used, depending on the area of application and requirements.

Multi-coating systems on a zinc casting-epoxy basis have been proven to be most effective in offshore areas as well as for large bearings in wind power systems.

With zinc flame spraying according to EN 22063

As a base for a further coating, zinc flame spraying according to EN 22063 offers additional protection for the surfaces through the self-healing effect of the zinc coating (for example, if scratches occur during operation or installation).

With a chemical zinc-iron coating

The large bearing can be protected with a thin coat of the exceptionally thin **Zn-Fe coating** according to requirements without an additional coating, thus creating an effective anticorrosive layer.

This type of coating can be used with applications with an external bearing diameter of up to 1,500 mm.

Note for planning:

As a rule we supply an individual suggestion for anticorrosive measures as long as the details for the specific requirements have been entered in the questionnaire.

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Bearing selection

Extreme load capacity

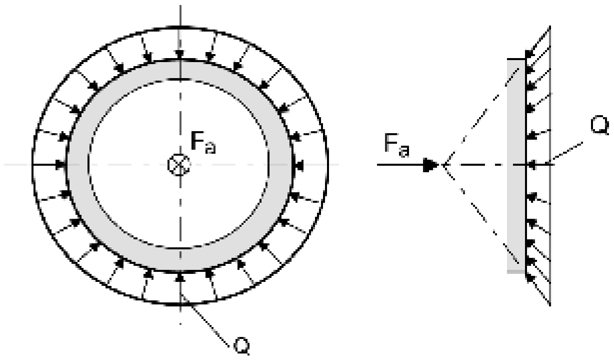
For the selection of large bearings with infrequently occurring rotational movement the extreme load capacity has to be checked.

The extreme load capacity is limited by the maximum of permissible plastic deformations of rolling bodies and the race geometry in the race system under the effects of extreme load.

The extreme load on the bearing is calculated by combination of the tilting moment and the axial force acting on the bearing taking the application-specific shock-load factors and safety aspects into consideration. These may need to be supplied by the user.

Axial force F_a

The direction of the **axial force** runs parallel to the rotary axis of the bearing, The axial force triggers a symmetrical distribution of pressure on the rolling body and the race. The greatness of the rolling body pressure depends on the angle of pressure and the number of rolling bodies.



Central axial force and resulting pressure distribution in a four-point bearing acting under pure axial force

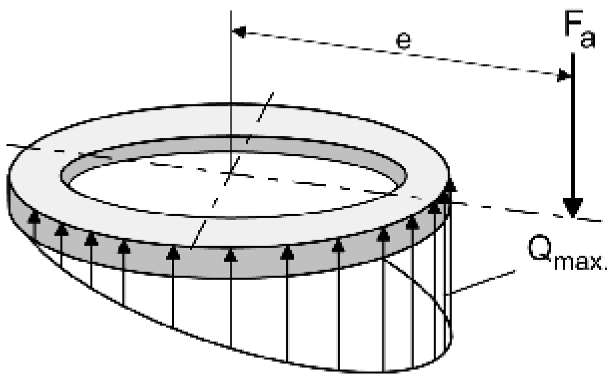
The angle of pressure in the race system is zero with a roller bearing. This results in a purely axial pressure distribution (without radial proportion) on the race and the rolling body.

Tilting moment M_k

An eccentric-acting axial force F_a causes a tilting moment on the bearing through the lever arm ***e***. The resulting moment from all acting eccentric forces is called the **tilting moment**.

The load on various zones of the bearing vary according to the degree of excentricity of the force. The pressure distribution on the rolling body system is asymmetric.

The highest pressure is placed on the rolling body which is currently in the vertex of the pressure distribution.



Eccentric axial force (tilting moment) and resulting pressure distribution

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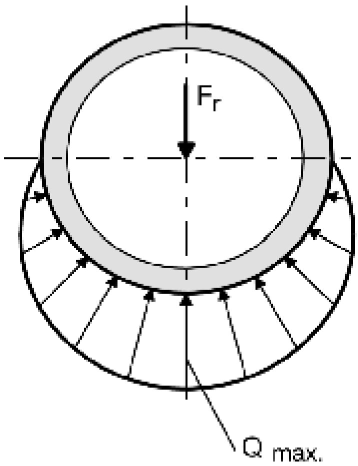
Bearing selection

Effect of radial force F_r

The direction of the radial force runs perpendicular to the rotary axis of the bearing. The level of the direction of force is close to the rolling body centre.



Radial force and resulting pressure distribution

Previous radial bearing loads are taken into consideration when checking the extreme load capacity only if the radial force exceeded

- $F_r = 0,25 \cdot F_a$ for four-point bearings or
- $F_r = 0,10 \cdot F_a$ for roller bearings.

In such cases our construction department will check the extreme load capacity.

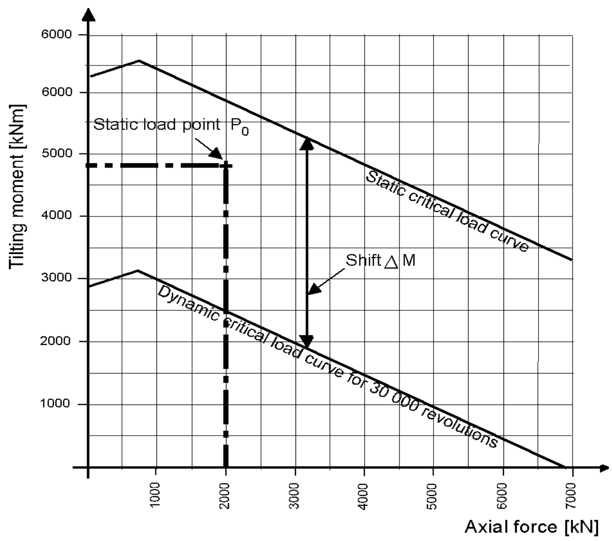
Extreme critical load curve

Every LIEBHERR large bearing has an individual critical load curve which depends on its measurements, race geometry, type and number of rolling bodies and the materials used for manufacturing the ring.

The extreme critical load curve shows the maximum permissible value for a combination of axial force $\boldsymbol{F_a}$ and tilting moment $\boldsymbol{M_k}$. In simplified form this curve is displayed as a line in the extreme critical load diagram (abscissa: $\boldsymbol{F_a}$, ordinate: $\boldsymbol{M_k}$) as equidistant, shifted by $\Delta \boldsymbol{M}$, to the fatigue critical load curve for 30,000 revolutions.

The value for the shift is calculated individually for every bearing and is given in the table for LIEBHERR large bearings.

The calculated value of the existing extreme bearing load is entered in the critical load diagram. The bearing is extremely suitable if the load point $\boldsymbol{P_0}$ ($\boldsymbol{F_a}$, $\boldsymbol{M_k}$) is below the critical load curve of the bearing selected by the user.



Principle of a extreme critical load diagram

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Bearing selection

Selection example

Step 1

A four-point bearing with outer gearing is loaded with a recorded extreme load of

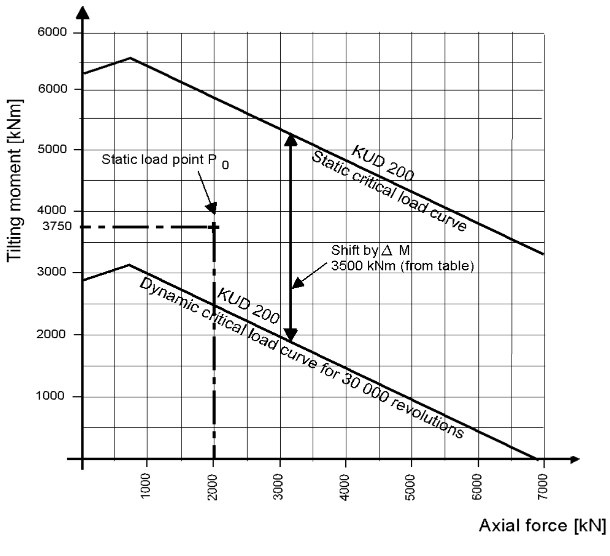
M_k = 3750 kNm

F_a = 2000 N

F_r = 180 N

Step 2

The load combination is entered in the critical load diagram for four-point bearings with outer gearing. The axial force F_a is entered as the abscissa and the tilting moment M_k as the ordinate. The intersection of axial force and tilting moment gives the load point P_0.



Selection example KUD 200 (extreme critical load curve)

Step 3

Checking the radial force:

$$\frac{F_r}{F_a} = \frac{180kN}{2000kN} = 0,09 \le 0,25$$

In the case discussed, F_r<0.25 F_a. An extra check of the radial force by our construction department is therefore not necessary.

Result

The load point found is below the extreme critical load curve for the **KUD 200** bearing. The bearing is suitable for this extreme load and sufficiently proportioned.

The check of bearing capacity and the calculation of safety limits can now be undertaken by our construction team using this data.

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Bearing selection

Fatigue endurance

In addition to the check of the extreme load capacity, the life-expectancy in relation to the demands made by the operating loads are vital for the dimensioning of a large bearing.

The equivalent fatigue load is determined with a combination of the axial force F_a and tilting moment M_k acting on the bearing during operation.

In addition, the individual load components, the existing cumulative load data and the appropriate parts of the total operation time should also be used.

If multi-stage stress or stress resulting from load collectives are present, these can be idealised by adding a one-stage sinusoidal load, taking the largest upper stress and the lowest stress.

Sinusoidal oscillating stress can be attributed to equivalent stress. Various methods can be used to do this, for example the methods devised by

- Palmgren-Miner,
- Corten-Dolan or
- Gnilke,

as well as other established and suitable procedures.

The equivalent fatigue bearing stress is then:

$$P_{äqui} = \left[\frac{\sum P_i^{\,p} \cdot n_i}{n_{ges}}\right]^{1/P}$$

Key:

P_i	Level of stress in the affected stress level ***i***
n_i	Number of load play numbers in stress level ***i***
n_{tot}	Total of load plays
p	Increase in the Wöhler line for ball bearing p = 3 for roller bearing p = 3.33

Effect of the radial force:

Present radial bearing loads are only taken into consideration when checking the fatigue life time only if the radial force exceeded

$F_r = 0,25 \cdot F_a$ for four-point bearings or

$F_r = 0,10 \cdot F_a$ for roller bearings.

In such cases our construction department will check the fatigue lifetime.

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Bearing selection

Fatigue critical load curve

The criteria for the theoretical lifetime from the classical roller bearing theory cannot be simply applied to large bearings.

The basic reason for this is that with the majority of applications the rotary speed of the rolling body is relatively low compared to quick-running rolling bodies.

Smoothness of running and bearing function are therefore not or insignificantly affected by wear.

The fatigue lifetime of a large bearing is therefore mostly limited to material fatigue in the bearing race that occurs during operation.

As well as a extreme critical load curve, every LIEBHERR large bearing has an individual fatigue critical load curve. These can be created for various numbers of load change or revolutions. **In the fatigue critical load diagrams the fatigue critical load curves for a lifetime of 30000 revolutions have been entered.**

In order to estimate the fatigue lifetime of the selected bearing, the recorded values of the fatigue equivalent bearing loads are entered in the critical load diagram for fatigue lifetime. The theoretical lifetime is then calculated as follows.

Step 1

The selected four-point bearing with outer gearing - KUD 200 is stressed with a calculated fatigue equivalent load of

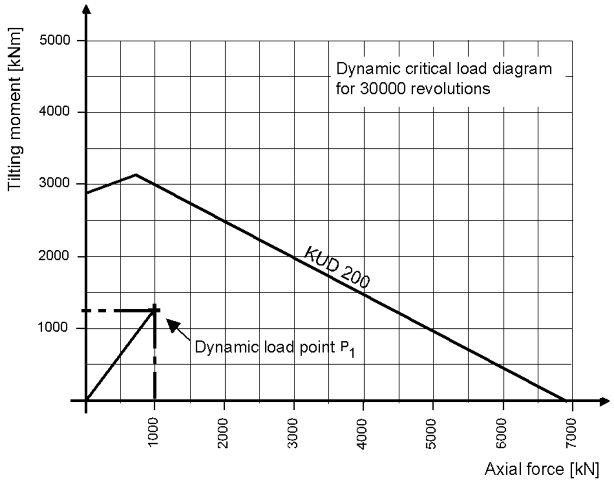
$M_{k,äqui}$ = 1,250 kNm

$F_{a,äqui}$ = 1,000 kN

$F_{r,äqui}$ = 120 kN

Step 2

A line is drawn from the origin of the diagram through the **load point P_1** ($F_{a,equi}$, $M_{k,equi}$) calculated by the same method (as described above).



Calculating the fatigue load point

Step 3

This origin line is extended to the intersection P_2 ($F_{a,theor.}$, $M_{k,theor.}$) with the fatigue critical load curve for 30,000 revolutions for the bearing selected.

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Bearing selection

Step 4

The lifetime factor f_L results

$$f_L = \frac{M_{k,\,theor}}{M_{k,\,equi}} = \frac{F_{a,\,theor}}{F_{a,\,equi}}$$

In the example used:

$$f_L = \frac{M_{k,\,equi}}{M_{k,\,theor}} = \frac{2500}{1250} = 2,00$$

Step 5

The theoretical lifetime is then calculated as

$$L_{theor} = (f_L)^p \cdot 30000[revolutions]$$

with

p for ball bearing = 3

p for roller bearing = 3,33

In the example used:

$$L_{theor} = (f_L)^p \cdot 30000 = (2,00)^3 \cdot 30000$$
$$= 240000(revolutions)$$

Step 6

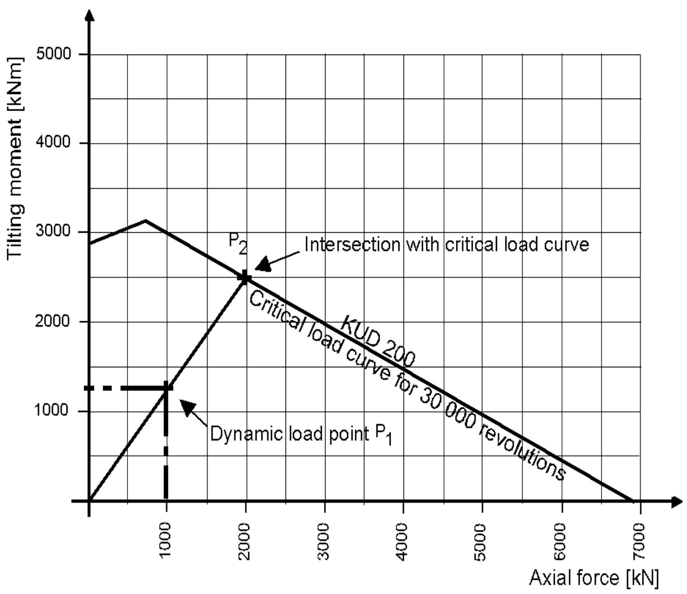
Checking the radial force:

$$\frac{F_r}{F_a} = \frac{120kN}{1000kN} = 0,12 \le 0,25$$

In this example F_r<0.25 F_a. An extra check by our construction department is therefore not necessary.

The user should check now if the calculated lifetime (revolutions) is sufficient for the intended usage.

If necessary a bearing with a longer fatigue lifetime should be selected and checked.



Examples of calculating the fatigue load point

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Bearing selection

Revolution limits

LIEBHERR large roller bearings are suitable for use with forwards and backwards swivelling movement (swivelling operation) or for operation with slow rotating turning movements up to **10 rpm**.

Additionally LIEBHERR large bearings can also be used for continuous turning operation up to certain rotary speeds, however only for short periods of time and without load.

Rolling circle diameter	Briefly permissible rpm without load for four-point bearings
Below 1,000 mm	100 rpm
Below 2,000 mm	50 rpm
Below 3,000 mm	33 rpm
Above 3,000 mm	On request

Revolution limits for four-point bearing

Rolling circle diameter	Briefly permissible rpm without load for roller bearings
Below 1,000 mm	100 rpm
Below 2,000 mm	50 rpm
Below 3,000 mm	33 rpm
Above 3,000 mm	On request

Revolution limits for roller bearing

Every individual case should be checked by our construction department. If necessary, the bearing can be modified to suit the requirements.

Temperature limits

The standard models of LIEBHERR large bearings are suitable for operating temperatures of **between - 30°C and + 60°C.**

If the intended or probable operating or idle temperatures are not within this range then the properties and mechanical strength of the material will have to be checked by our construction department.

Special construction forms

As well as the standard models of the large bearings corresponding to the examples in the tables, we also develop and manufacture special models of our large bearings.

These are produced according to customer specifications and the bearing construction, dimensions, tolerances and sealings are adapted to suit the specific requirements.

Our long-term experience in manufacturing and operating LIEBHERR large bearings in different machines and systems both within and outside of our company applications has given us a broad base of detailed and application-specific expertise.

The technology of our large bearing is constantly improved. Both, the technical development of large bearings and the requirements of our customers are taken into consideration for this process.

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Bearing selection

Friction resistance of the bearing

Like every roller bearing, the large bearing also has a resistance which acts against the rotation of the outer and inner rings. The resistance which acts against a roller bearing is composed of rolling friction, running friction and lubricant friction.

Rolling friction occurs when the rolling body rolls on the races. The friction between the rolling bodies and the race profile increases with load and oscillation.

Running friction occurs on both the contact surfaces of the rolling body in the cage or on the intermediate pieces (with roller bearings also on the rib flanges and the rolling faces) and also on the bearing faces of the sealings.

Under normal operating conditions and with good lubrication, frictional resistance is low. Running friction increases significantly if the lubrication is insufficient or if dirt is present in the system or at high rotary speeds.

Lubricant friction arises from internal lubricant friction and from milling work when the bearing is moved.

Lubricant friction depends entirely on the toughness and quantity of the lubricant. At low speed, lubricant friction is also low.

Friction resistance without load

The following is generally applicable

$$M_{fric} = M_0 + M_1$$

The friction torque of the unloaded bearing is M_0.

M_0 mostly consists of lubricant friction, the friction of the rolling bodies, the friction of the cage and sealings, and depends largely on the size and construction of the bearing.

M_1 indicates the load-dependent proportion of the complete friction torque.

It is largely composed of the material hysterisis and running friction effects. It hardly changes when the revolution speed increases but alters drastically with load i.e. rolling body pressure.

Break-away torque

The break-away torque (starting torque) can lie significantly over the total friction torque M_{fric}. Deviations of ±25 % are judged to be normal and permissible.

The actual values for bearings carrying little or no load can deviate from the calculated values.

The necessary acceleration power and the possible incline of the bearing axle should also be taken into consideration.

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Bearing mounting

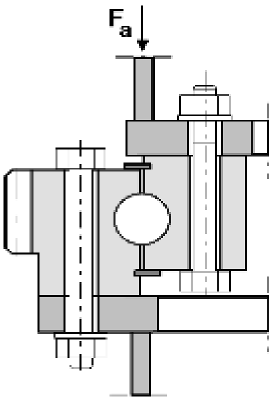
Characteristics of the bolted connection

LIEBHERR large bearings have been manufactured to be bolted to the assembly construction.

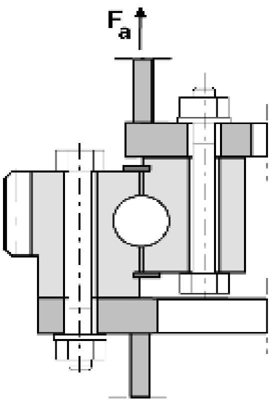
The following parameters must be taken into consideration for the dimensioning of the assembly connection and the bolt parameters:

Installation site of the large bearing

If the bearing is installed in such a way that the axial force takes pressure off the bolts this is known as **supported load**.



Arrangement of the bearing with supported load



Arrangement with suspended installation

If the bearing is mounted in such a way that the axial force increases the load on the bolts, this is known as **suspended installation**.

For the load capacity of the LIEBHERR large bearing, it is assumed, corresponding to the critical load tables (see tables) that a supported load is present.

If suspended installation is selected, the bolted connection should be checked by our construction department.

Tightening procedure and pre-stress force

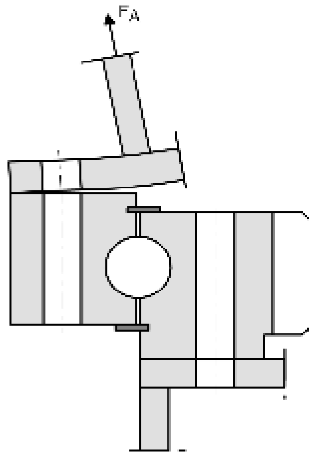
The tightening of the fixing bolts can be performed in various manners [according to VDI 2230/01, Page 64].

The achieved precision for the pre-stress force (minimum clamping force for pressing the bolted parts together) depends greatly on the tightening procedure used. It determines the reliability and load capability of the bolted connection.

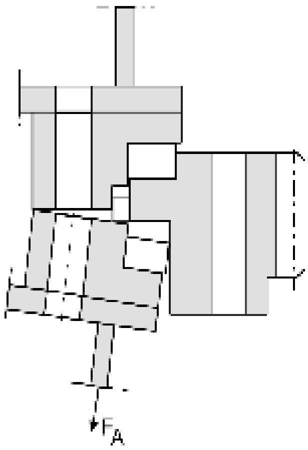
- The setting of the pre-stress force for **hydraulic tightening** is made with a pressure measurement of the system.
- The setting for pre-stress force required for the **torque-controlled pulling** is best done by trial and error of the reference fastening torque on the original bolt-on part, for example, by measuring the length of the bolt.

It has the task of preventing the lifting only partially of the separating joints and safely ensuring the friction contact on the joint surfaces over the entire operating area and for the entire period of operation of the bearing.

Bearing mounting



Example 1: Lifting the assembly construction from the joint surface



Example 2: Gap between the bearing rings underneath each other

The pre-stress force has to be completely present even after long operating times and after permanent deformation setting of the surfaces that are pressed together by the bolts.

The critical load curves for the bearings as entered in the measurement sheets, also cover the complete load capacity range of the screw connections for supported load.

Arrangement of the bolts

The bolts are usually equally distributed around the hole circle circumference. The minimum bolt depth for pocket holes for the "medium" tolerance class is according to VDI 2230/01, table 5.5/4, page 46:

Material of the connection flange / nut	Bolt-in depth for tightness class 10.9 with Ø >9 mm
Construction steel St 37	1.80 * d
St 50	1.20 * d
Hot-treated steel	1.00 * d

Minimum bolt-in depth for pocket threads

Rivet grip

The rivet grip of the bolts should usually be at least $l_K = 5 \cdot d$.

Strength - rating class of the bolts

The strength-rating class for the bolts should correspond to at least class 10.9 according to DIN ISO 898, part 1 (1989). The product and tightness class is the responsibility of the bolt supplier.

Tightness value	Value for tightness class 10.9
Tensile strength R_m	At least 1040 N/mm²
0.2%-elongation limit $R_p0.2$	At least 940 N/mm²

Mechanical properties of bolts according to DIN ISO 898 part 1 (1989)

Bearing mounting

Surface pressing on the bearing area

The surface pressing limit of the bearing area has to be observed. The surface pressing can be roughly calculated according to VDI 2230 as

$$\sigma = \frac{1,1 \cdot F_v}{A_p} \quad \left[\frac{N}{mm^2}\right]$$

F_V = pre-stress force

The supporting bolt-head surface Ap is dependent on the model of the selected bolt. The following values for the surface pressure according to VDI 2230/01, table A9 page 65 may not be exceeded (guideline):

Bearing surface material	Boundary surface pressing
Construction steel St 37	490 N/mm²
Construction steel St 50	710 N/mm²
C45	630 N/mm²
42CrMo4	800 N/mm²
GG 40	700 N/mm²

Boundary surface pressures for bolt-head surfaces (guideline according to VDI 2230)

If the boundary surface pressing is exceeded, larger head surface diameters may be required for example with appropriate **washers** corresponding to DIN 6916.

The **joint surfaces of the bearing** and the bearing surfaces should be bare metal and grease-free. In special cases suitable materials for increasing the friction may be used.

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Bearing mounting

Assembly construction

The cross-section of large bearings is very small in relation to its diameter. The inherent stability is therefore very low compared to the stability and rigidity of the assembly construction.

The bearing rings are, as a rule not able to take and compensate instability and deformations of the assembly constructions.

The assembly construction should therefore be as torsionally rigid as possible. It should transmit external force constantly, if possible, to the bearing. Kinks in the connecting surfaces should be avoided.

Mechanical processing of the connecting surfaces

Therefore the bearing surfaces have to be machine-processed. It should be ensured that surfaces which have already been machine-processed are not damaged or deformed by subsequent machining.

When welding, it should be expected that the heat will lead to distortion. The dimensional accuracy should be inspected after the work is complete and adjusted or reworked as necessary.

Surface coating of the connecting surfaces

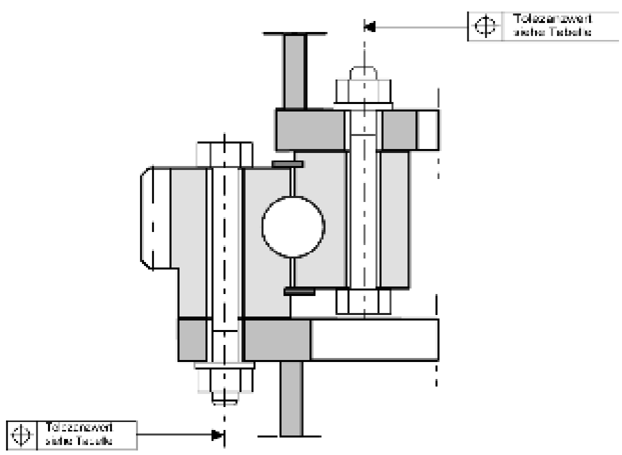
The connection points should be carefully cleaned of paint, impurities, welding beads and grease. The bearing rings must fit tightly on all sides. In special cases, suitable adhesive and / or levelling layers may be necessary.

Assembly and serviceability of the connector construction

The connector construction must be arranged in such a manner that the **lubrication points** of the bearing are easily accessible.

All **fixing bolts** must be easily accessible. Tightening and pre-stressing with suitable equipment must be possible without hindrance. This also applies for inspection during operation.

The alignment of the **hole patterns** for the connecting surfaces and bearings should be inspected. Through holes should be made according to DIN 69.



Size of threads	**Positional tolerance in mm**
M 6	0,2
≤ M 10	0,3
≤ M 16	0,5
≤ M 24	0,7
≤ M 42	1,0
> M 42	1,3

Tolerance ranges on the hole pattern for the connecting surfaces

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Bearing mounting

Accuracy to size of the connecting surfaces

To avoid constrictions and forcing in the race track system, the connection surfaces must have the following accuracy to size.

The **maximum bending of the connection surfaces** on the running circle radius, caused by the highest operating load, may only occur once in a sector of 180°. It may only rise and fall evenly in this area and may not exceed the following values for all bearing types.

Running circle diameter in mm	Maximum bending for four-point and roller bearings in mm
Up to 1,000	0.60
Up to 1,500	0.75
Up to 2,000	1.00
Up to 2,500	1.30
Up to 3,000	1.60
Up to 3,500	2.00
Up to 4,500	2.50

Maximum bending of the assembly construction under maximum conditions

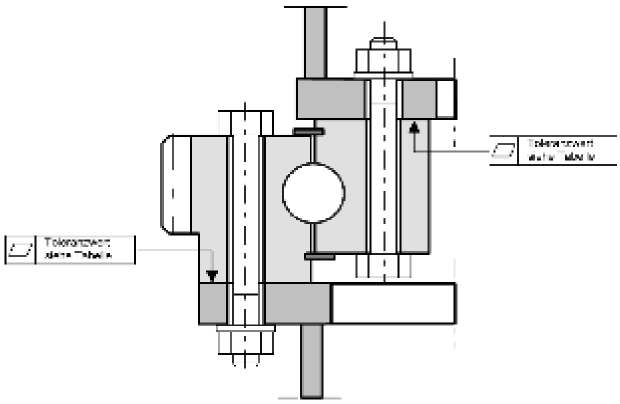
The **evenness of the connecting surfaces** in unloaded condition may not exceed the values given in the following table.

Running circle diameter in mm	Evenness tolerance according to ISO 1101 no. 14.1/ 2 in mm for four-point bearings
Up to 1,000	0.15
Up to 1,500	0.20
Up to 2,000	0.23
Up to 2,500	0.25
Up to 3,000	0.30
Up to 3,500	0.30
Up to 4,500	0.30

Evenness tolerance for four-point bearings

Running circle diameter in mm	Evenness tolerance according to ISO 1101 no. 14.1/ 2 in mm for roller bearings
Up to 1,000	0.10
Up to 1,500	0.13
Up to 2,000	0.15
Up to 2,500	0.18
Up to 3,000	0.20
Up to 3,500	0.20
Up to 4,500	0.20

Evenness tolerance for roller bearings



At a gauge length of 100 mm, a tolerance of 0.05 mm is acceptable, measured at any point of the bearing area.

Illustration of the evenness tolerances of the connecting surfaces

Radial centring

In order to bear higher radial force it can be necessary that the bearing must be held by a radial centring which is able to bear the radial force.

It is, in principle, possible to design the bearings with such radial centrings, however, in certain cases it may be recommended to consult our construction department.

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Lubrication

Bearing race lubrication

Appropriate lubrication is the basic requirement for correct function and lengthy lifetime of the bearing race. The lubricant has the following basic functions:

- Forming a sufficient and load-bearing lubricant film on the contact surfaces to reduce friction between rolling bodies, intermediate pieces and races.
- Sealing the race system against dirt and moisture and thus forming an anticorrosive layer for the race system.

In principle a bearing can be lubricated with either oil or grease. Usually, lubrication of the bearing races is performed by feeding in grease at the lubrication nipples.

Particularly, on Blade Bearings it's essential to **rotate the bearings in regular intervals** to maintain the lubrication and the corrosion protection film on the racetracks. It is highly recommended, that the plant control has a built-in routine for rotating the Blade Bearings about once a day.

Only high-grade lubricants that are suitable for the intended purpose may be used on LIEBHERR large bearings. These must have the following basic properties:

- Sufficient operating temperature range
- Sufficient lubrication capacity of the basic oil
- Sufficient anticorrosive protection properties according to DIN 51802
- Low tendency to absorb water according to DIN 51807
- Sufficient adhesiveness and
- Good aging resistance.

Initial greasing

The initial greasing of the LIEBHERR large bearing takes place at the plant. The grease is a lithium soap-based grease, class KP2K-30 corresponding to DIN 51825. The operating temperature range of the grease covers - 30°C to +120°C.

The filling level for the bearing in the initial greasing is orientated to the requirements of the individual intended purpose and is stated in some cases.

Subsequent bearing race lubrication

The bearing races of the large bearing must be lubricated at regular intervals.

The lubrication intervals basically depend on the operating conditions, the prevailing environmental conditions and the bearing type or the type of sealing. The following intervals can be used to plan the intervals between lubrication:

Operating conditions	Guideline for lubrication intervals
Light	Every 250 Oh
Normal	Every 200 Oh
Heavy	Every 100 Oh

Guidelines for lubrication intervals

Short lubrication intervals should be enforced where special climatic conditions prevail (for example in tropical regions) or in areas where dirt and dust occur in large quantities (for example in mines) or if the bearing is in constant rotary motion.

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Lubrication

Unplanned lubrication

Additional lubrications to those planned as described previously must be undertaken after all of the following events:

- Before and after long stand-still periods (for example, cranes or construction machines),
- After every cleaning with water or steam jets,
- After especially high moisture levels have occurred, for example through splashing or flood water.

Lubrication procedure

The purpose of lubrication is to replace grease that has aged in service with new grease to the highest possible degree.

If no special lubrication instructions have been given, the races should be lubricated via the grease nipples with fresh grease while the equipment is slowly turning. They should be filled until fresh grease emerges evenly around the whole circumference under the sealing lips and forms an even and closed grease collar.

For special applications, such as in wind power systems, special lubrication instructions are issued. They take the special circumstances of use into account.

Lubricant quantity

In certain cases, the quantities of lubricant that are required for the initial greasing and subsequent lubrications are determined by us after the large bearing has been installed.

Lubricants

The selection of the lubricant is based on the load, operating conditions, number of revolutions and the availability of the lubricant.

The lubricants listed in the table have been approved for use with LIEBHERR large bearings and have been tested to check their suitability for the elements of the roller bearing. The suitability and use of other lubricants should be checked and tested by us in certain special cases.

Manufacturer	Lubricant
Agip	Agip Longtime Grease 2 Agip GR MU 2 Agip Grease 30 Autol Top 2000 Bio
Aral	Aral Aralub HLP 2 Aral Aralub BAB EP 2
Avia	Avialith 2 EP Avilub Spezialfett (special grease) CTK Avia Syntogrease 2 Avilub Spezialfett (special grease) 9610
BP	BP Energrease LS-EP 2 BP Langzeitfett (long-term grease) BP Biogrease EP 2
DEA	Glissando EP 2 Paragon EP 2 Dolon EP 2
Elf	Epexelf 2 Elf epexa 2
Esso	Beacon EP 2 Beacon 325
Fina	Marson EPL 2
Mobil	Mobilux EP 2 Mobilgrease HP
Shell	Shell Retinax M Shell Alvania EP (LF) Fett (grease)

Approved lubricants for LIEBHERR large bearings

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Lubrication

Teeth lubrication

The lubricants used for the bearing races of the LIEBHERR large bearing are also suitable for lubricating the teeth (see table). For practical reasons, the same lubricant should be used for both, teeth and racetracks.

In exceptional circumstances, other lubricants are also permissible. Our construction department should check and test this before it is used.

Initial greasing before commissioning

The teeth of the LIEBHERR large bearing are treated at the plant with anticorrosive oil or lacquer primer and must be carefully lubricated before commissioning.

For the initial lubrication, we recommend lubricating grease with EP additives (extreme pressure) for exposed teeth. The VKA (Vier Kugel Apparat - four ball equipment) value of the lubricant should be at least 4000 N according to DIN 51530.

Lubricating the teeth

The length of the lubrication intervals for the bearing teeth depends heavily on the conditions of use and environmental factors.

- For large bearings in systems which turn either only rarely or with a light load, the lubrication intervals can be once a week or even once a month.
- In applications where the bearing revolves intensively and under heavy loads with frequent impacts in normal operation, lubrication should take place on a daily basis and if the bearing is used in multi-shift operation several lubrications a day may be necessary.

Lubrication procedure and quantity

Lubricating grease should be applied or sprayed onto the teeth flanks. The lubricating grease should be spread thinly and evenly. The contact surfaces on the tooth edges of the teeth should have a sufficient film of grease.

Applying too much lubricant is not advantageous. Excess lubricant should be removed with an appropriate tool or device.

Automatic lubricant feed

Automatic lubrication for the teeth using lubricant feeder or lubricating systems linked to a central lubrication system is also possible. Such equipment should be checked and approved by our construction department.

It is advisable to consult us on this matter during the planning procedure

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LIEBHERR

Handling

LIEBHERR large bearings are precise machine elements

They require careful handling in transport and storage.

Packaging and storage

LIEBHERR large bearing rollers normally leave the factory on Euro pallets or stable square-timber constructions.

We believe in the principle of providing simple but adequate packaging materials that result in minimum waste and thus minimum costs for the operator while providing optimum protection during transport.

The packaged large bearing are treated with an anticorrosion agent before delivery. Under normal circumstances, this permits storage up to 6 weeks in covered and temperature-controlled rooms. Prior to installation the anticorrosive agents used can be easily removed from the joint surfaces of the bearing.

Furthermore, LIEBHERR large bearings can be packaged according to special customer needs. This can be necessary, for example, if the equipment is to be transported by sea or air or if it is to be loaded and unloaded several times before it reaches its destination.

If it is planned that the bearing is stored for several months or years before it is commissioned, then **long-term corrosion protection** is necessary.

We have many different solutions available for solving your packaging problems. For this reason we discuss the necessary measures with our customers during the technical consultation stages.

Transport

Large bearings may only be transported horizontally. Exception: Starting at an external diameter of 3,000 mm, LIEBHERR large bearings on are transported on slanting supports or in special devices.

Impacts during transport especially in a radial direction should generally be avoided. Repeated loading and unloading during transport should be avoided as much as possible to prevent any transport damage.

The bearings must be always be lifted at the designated transport holes with the appropriate suspension lugs using only the proper lifting equipment. Number and arrangement of these can be determined during the planning stage.

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Large bearing enquiry data

Please fill out as far as possible and send to:

Abtlg. TVK-K - Postfach 1663 - 88396 Biberach, Germany - Telefax +49 (0)7351 / 41-2717

Customer		Project No.
Application		Date
Equipment description		Contact partner

Loads

Type of load	Des.	Unit	Operational load		Extreme load stat.	Test load
			continuous, normal	seldom, extreme		
Axial load	F_{ax}	kN				
Radial load	F_{rad}	kN				
Resulting bending moment	M_k	kNm				
Teeth load	M_t	kNm				

Dimensions

max outerØ	min innerØ	max height	offset inner / outer ring
connectionØ outer ring	drillingØ outer ring	connectionØ inner ring	drillingØ inner ring

Dimensions must be observed at all times* / should be observed* / bearings must be replaceable (Please attach drawing!)*

Teeth on the large bearing		Teeth on the cog	
outside / inside*	hardened (HRC) / unhardened	number of pinions	hardened (HRC) / unhardened*
module	number of teeth	module	number of teeth min / exact*
tooth width	profile offset xm	tooth width	profile offset factor
speed	lifetime Oh	speed	lifetime required Oh
quality / tolerance range	other specifications	quality / tolerance range	other specifications

Operating conditions

max operating temperature °C	min operating temperature °C	max air humidity %	corrosive substances?
drive unit group according to DIN / FEM	approx. operating hours / year	approx. operating hours / day	normal speed rpm
turning axle position (horiz. / vert.)	strong impacts yes / no	other specifications	maximum speed rpm

Sketch of the installation position / Connection construction enclosed*

Quotation data

planned overall req. / year	number of delivery lots / year	quantity pricing indicated for	desired delivery date (week/year)
Units	delivery lots	Units	

* Underline where applicable.

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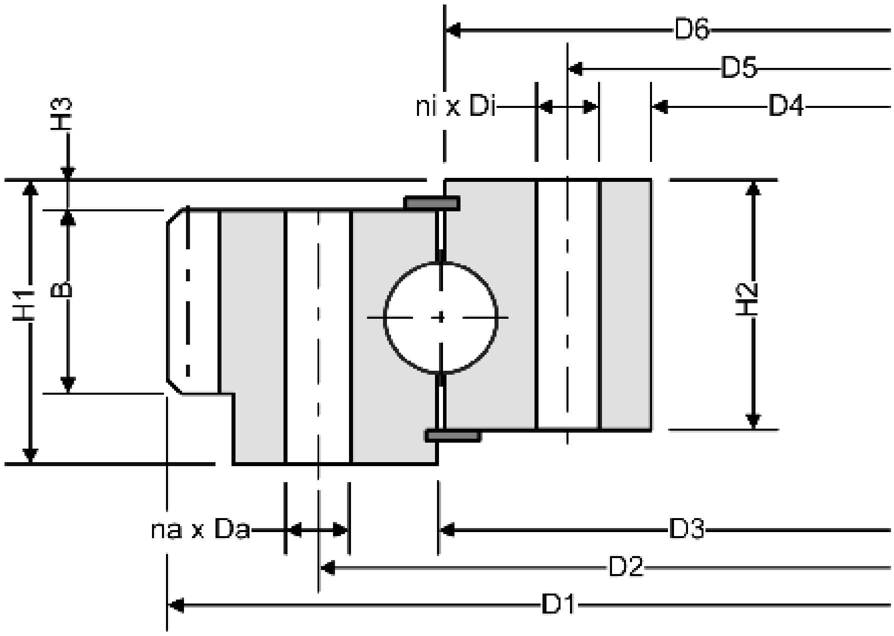
LIEBHERR

Four-point bearing with external teeth



Other dimensions available on request

Our preferred sizes

Designation	D1	D2	D3	D4	D5	D6	H1	H2	H3	B	Na x Da	Ni x Di
KUD 29	1210,5	1140	1087	1000	1035	1085	66	52	16	41	36 x Ø17,5	36 x Ø17,5
KUD 55	1388	1298	1222	1084,5	1146	1222	97	82	12	85	36 x M20	36 x M20
KUD 130	1420	1318	1222	1065	1126	1222	110	100	10	78	60 x Ø26	60 x Ø26
KUD 123	1602	1512	1433,5	1310	1355	1433,5	123	101	22	75	66 x Ø22	66 x Ø22
KUD 138	1808	1690	1608	1450	1525	1608	145	105	27	103	48 x Ø29	48 x Ø29
KUD 190	2088,5	1970	1885,5	1733	1800	1885,5	150	100	25	105	36 x Ø26	36 x Ø26
KUD 215	2307	2190	2106	1977	2021	2106	94	79	9	85	68 x Ø22	68 x Ø22
KUD 200	2088,7	1965	1860	1682	1755	1860	151	122	29	95	48 x Ø33	48 x Ø33
KUD 330	1944,6	1790	1677	1494	1560	1677	165	117	9	156	66 x M30	65 x Ø33
KUD 450	2180	2050	1912	1690	1774	1912	184	171	31	105	48 x Ø36	48 x Ø36

All dimensions are in [mm]

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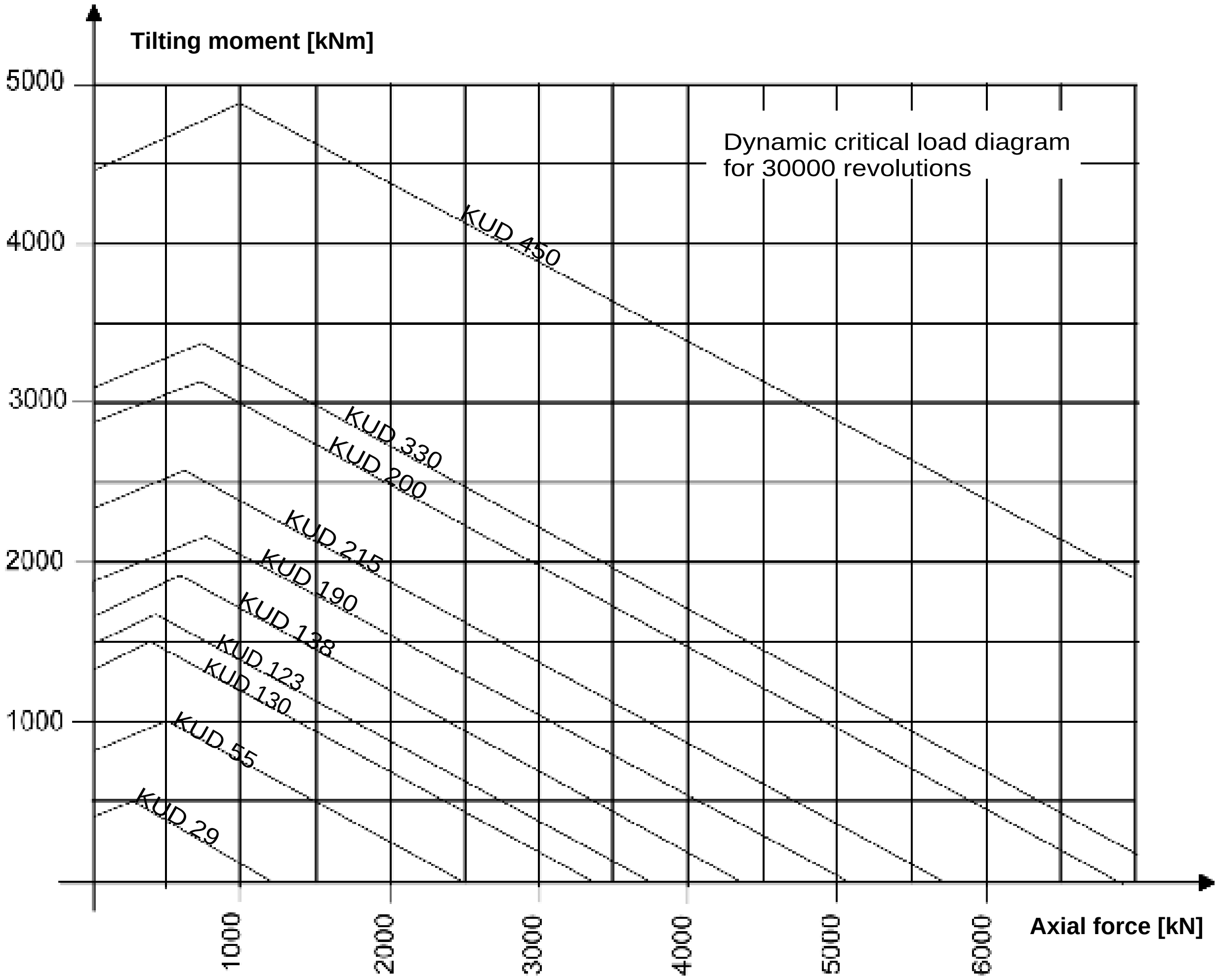
Four-point bearing with external teeth



Load limits

Designation	module	no. of teeth	max. dyn. Torque M_{dyn}	max. stat. Torque M_{stat}	max. tilting moment @ axialload
KUD 29	8 mm	148	2 500 Nm	28 000 Nm	484 kNm @ 256 kN
KUD 55	10 mm	135	23 000 Nm	94 700 Nm	658 kNm @ 246 kN
KUD 130	10 mm	139	14 900 Nm	80 200 Nm	1831 kNm @ 373 kN
KUD 123	9 mm	176	21 700 Nm	89 400 Nm	1940 kNm @ 510 kN
KUD 138	10 mm	177	36 500 Nm	150 400 Nm	2079 kNm @ 476 kN
KUD 190	10 mm	205	43 100 Nm	177 600 Nm	1360 kNm @ 348 kN
KUD 215	14 mm	162	93 500 Nm	231 300 Nm	2000 kNm @ 500 kN
KUD 200	10 mm	205	39 000 Nm	160 700 Nm	3050 kNm @ 573 kN
KUD 330	16 mm	118	184 100 Nm	405 000 Nm	4470 kNm @ 1344 kN
KUD 450	10 mm	216	45 400 Nm	187 100 Nm	4500 kNm @ 696 kN

Design subject to alteration!

This information is supplied without liability.

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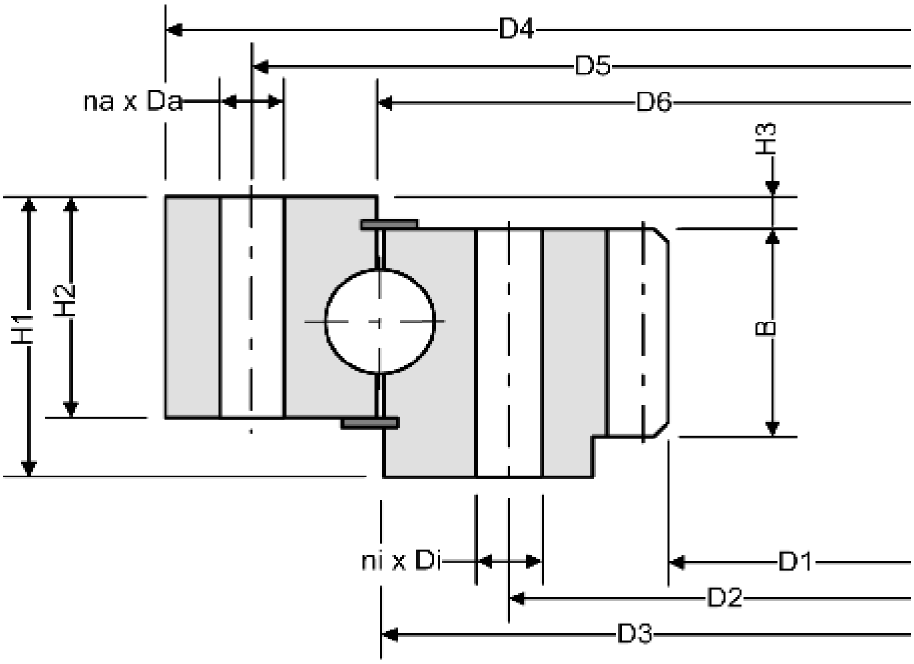
Four-point bearing with internal teeth



Other dimensions available on request

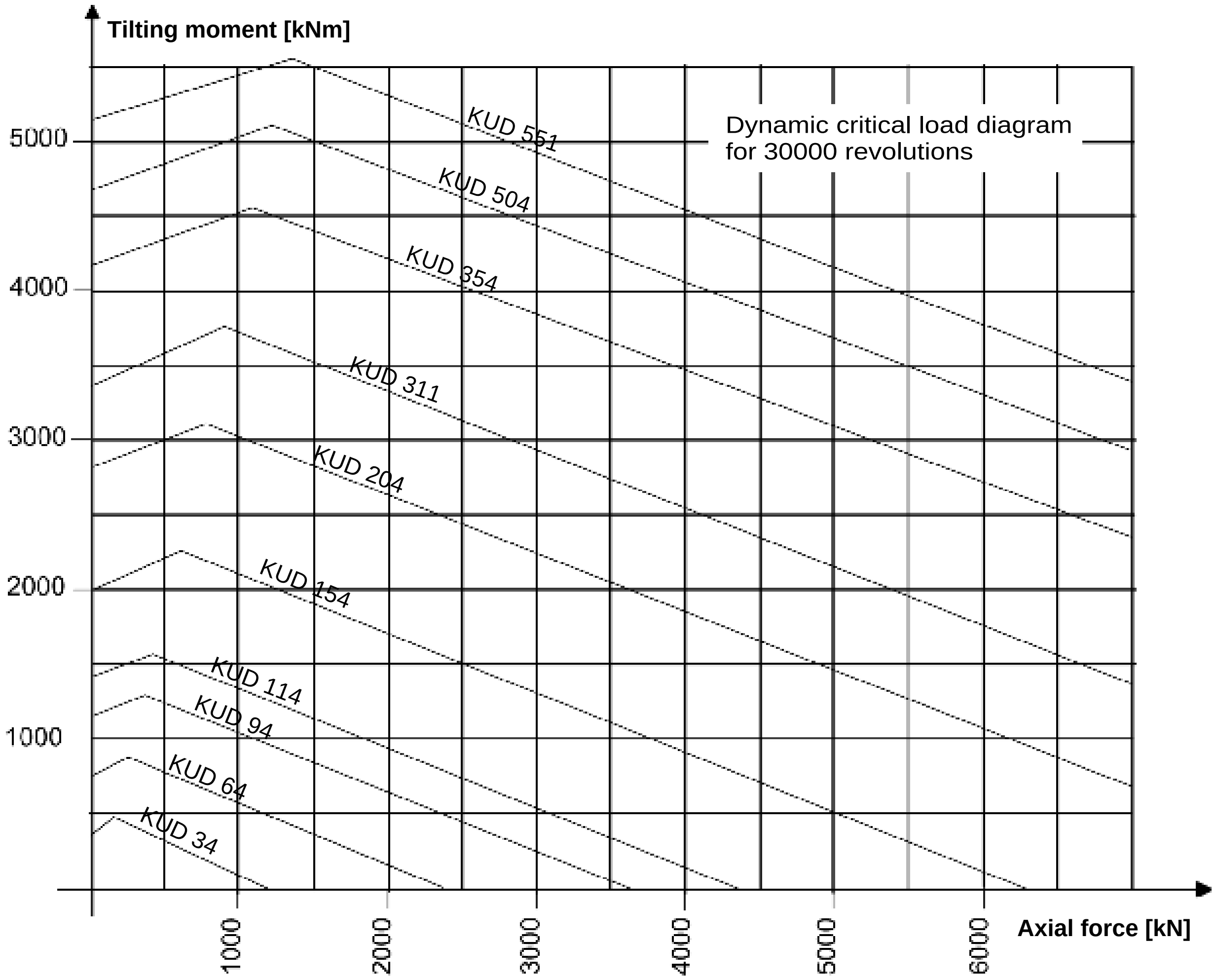
Our preferred sizes

Bezeichnung	D1	D2	D3	D4	D5	D6	H1	H2	H3	B	Na x Da	Ni x Di
KUD 34	962	1045	1085	1185	1145	1090	73	48	8	65	40 x Ø18	40 x M16
KUD 64	939,6	1045	1085	1215	1155	1085	115	72	10	95	48 x Ø22	56 x M20
KUD 94	1011	1145	1198	1355	1285	1198	125	92	10	105	40 x Ø26	48 x M24
KUD 114	1008	1145	1198	1365	1295	1198	150	112	10	115	60 x Ø26	72 x M24
KUD 154	1316	1460	1520	1690	1625	1520	147	110	10	125	56 x Ø30	56 x M27
KUD 204	1503	1665	1725	1910	1840	1725	165	120	10	140	60 x Ø30	60 x M27
KUD 311	1800	1946	2046	2211	2146	2046	155	106	10	145	43 x M27	60 x M27
KUD 354	1728	1880	1970	2160	2080	1970	195	125	15	180	60 x Ø30	60 x M27
KUD 504	2079	2260	2365	2555	2480	2365	215	128	15	200	60 x Ø33	60 x M30
KUD 551	1800	1946	2072	2265	2198	2072	163	142	9	145	79 x M30	80 x M30

All dimensions are in [mm]

LBC/de/01/Ausgabe: 05.05

Four-point bearing with internal teeth



Load limits

Designation	module	no. of teeth	max. dyn. Torque M_{dyn}	max. stat. Torque M_{stat}	max. tilting moment @ axialload
KUD 34	9 mm	106	34 100 Nm	110 100 Nm	829 kNm @ 192 kN
KUD 64	10 mm	94	58 000 Nm	180 800 Nm	938 kNm @ 228 kN
KUD 94	11 mm	92	78 600 Nm	241 700 Nm	1395 kNm @ 400 kN
KUD 114	12 mm	84	95 600 Nm	292 700 Nm	1885 kNm @ 400 kN
KUD 154	14 mm	94	164 500 Nm	497 600 Nm	2409 kNm @ 500 kN
KUD 204	16 mm	94	247 400 Nm	747 500 Nm	3030 kNm @ 890 kN
KUD 311	18 mm	101	204 300 Nm	415 200 Nm	5000 kNm @ 1100 kN
KUD 354	18 mm	96	419 900 Nm	1 259 700 Nm	5100 kNm @ 920 kN
KUD 504	20 mm	104	640 600 Nm	1 892 800 Nm	7200 kNm @ 1220 kN
KUD 551	18 mm	101	204 300 Nm	415 200 Nm	8400 kNm @ 1300 kN

Design subject to alteration!

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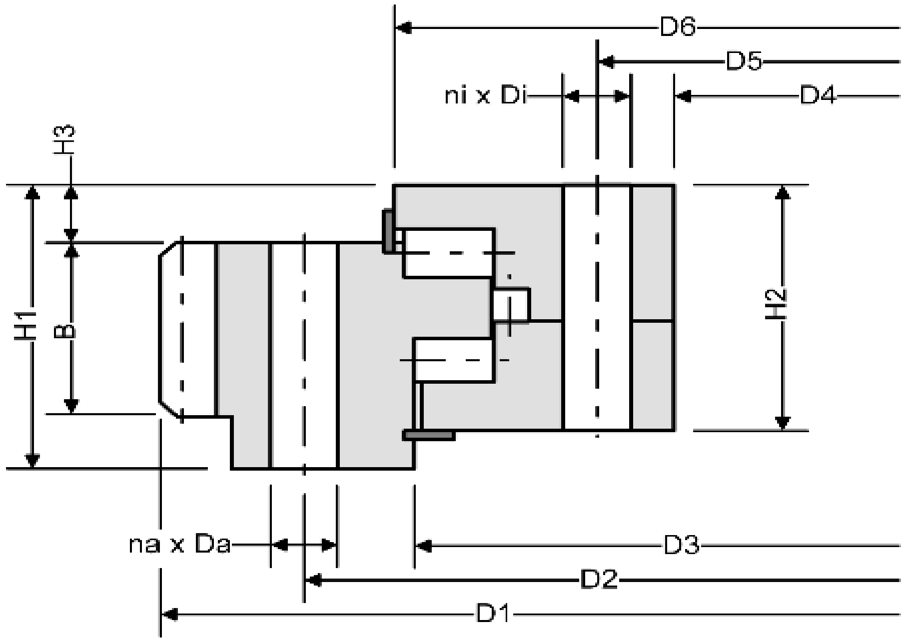
LIEBHERR

Roller bearing with external teeth



Other dimensions available on request

Our preferred sizes

Designation	D1	D2	D3	D4	D5	D6	H1	H2	H3	B	Na x Da	Ni x Di
ROD 173	1812	1702	1623	1468	1520	1622	96	87	21	75	60 x Ø26	60 x Ø26
ROD 243	1716	1605	1514,5	1340	1390	1518	130	122	45	85	56 x Ø30	56 x Ø30
ROD 303	1919	1804	1713,5	1539	1589	1717,3	130	122	31	90	60 x Ø30	60 x Ø30
ROD 413	2178	2071	1985	1792	1861	1990	115	109	25	75	72 x Ø33	70 x Ø33
ROD 493	2338	2193	2085	1840	1915	2085	154	142	54	100	66 x Ø36	66 x Ø36
ROD 671	2275	2130	2016	1790	1860	2035	158	152	34	124	90 x Ø33	90 x Ø33
ROD 771	2560	2404	2290	2046	2130	2309	178	156	36	142	80 x Ø36	80 x Ø36
ROD 900	2408	2228	2085	1770	1882	2105	202,4	191,1	57,4	145	56 x Ø52	56 x Ø52
ROD 1003	2990	2853	2730	2500	2571	2746	160	154	55	100	60 x Ø42	120 x Ø33
ROD 1203	2715	2525	2385,4	2053	2165	2385	225	215	44	130	68 x Ø52	68 x Ø52

All dimensions are in [mm]

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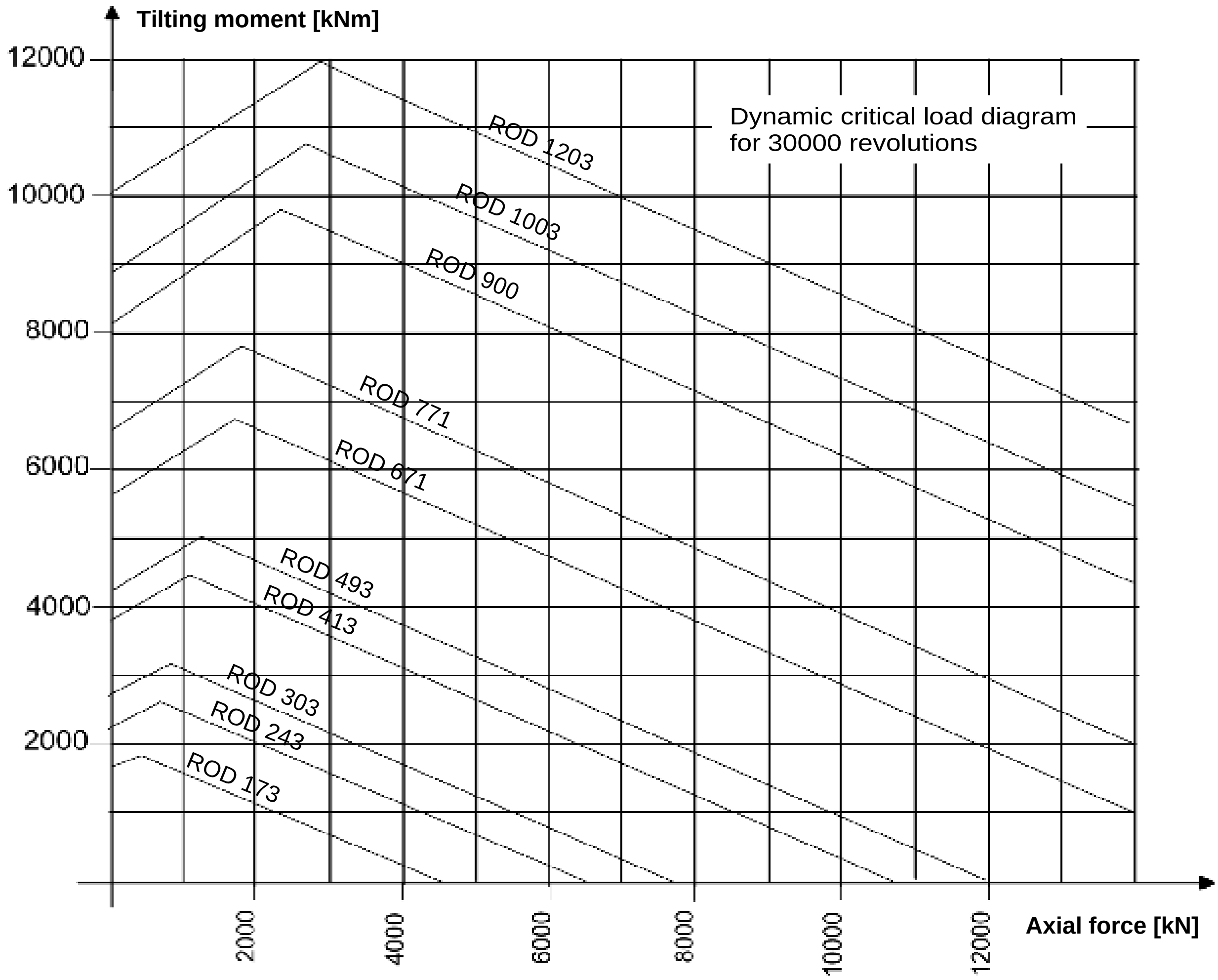
Roller bearing with external teeth



Load limits

Designation	module	no. of teeth	max. dyn. Torque M_{dyn}	max. stat. Torque M_{stat}	max. tilting moment @ axialload
ROD 173	12 mm	149	45 600 Nm	134 100 Nm	2900 kNm @ 480 kN
ROD 243	12 mm	141	48 900 Nm	143 800 Nm	3450 kNm @ 1050 kN
ROD 303	12 mm	157	57 700 Nm	169 600 Nm	4500 kNm @ 1050 kN
ROD 413	9 mm	240	20 300 Nm	109 400 Nm	6250 kNm @ 1250 kN
ROD 493	14 mm	165	112 000 Nm	277 200 Nm	8125 kNm @ 1250 kN
ROD 671	16 mm	139	172 400 Nm	379 200 Nm	9740 kNm @ 2374 kN
ROD 771	16 mm	158	224 400 Nm	493 600 Nm	12000 kNm @ 3600 kN
ROD 900	18 mm	130	263 000 Nm	534 400 Nm	13555 kNm @ 2604 kN
ROD 1003	14 mm	211	143 300 Nm	354 500 Nm	17500 kNm @ 2994 kN
ROD 1203	18 mm	147	266 600 Nm	541 800 Nm	20000 kNm @ 2000 kN

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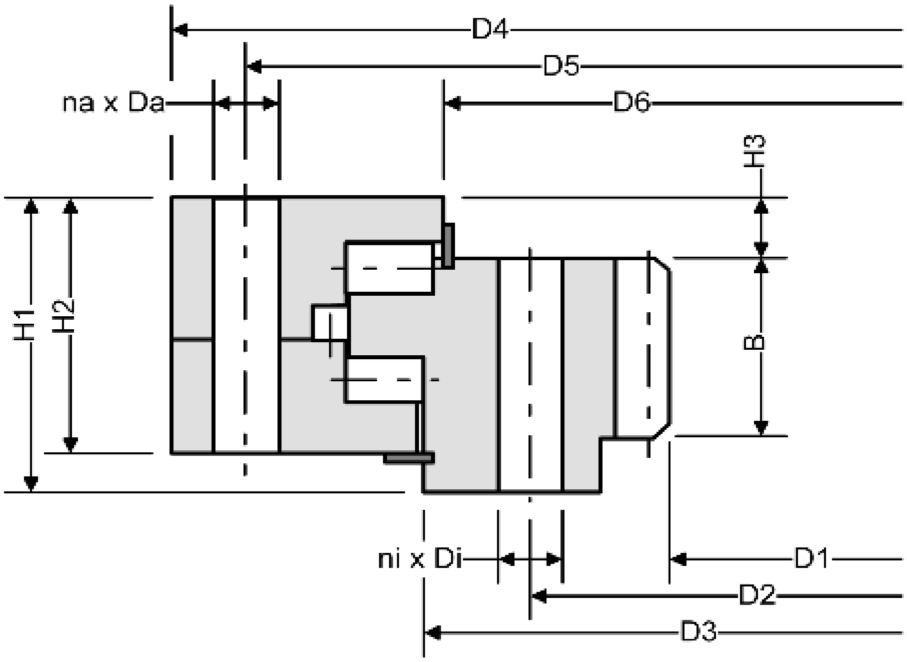
LIEBHERR

Roller bearing with internal teeth



Other dimensions available on request

Our preferred sizes

Designation	D1	D2	D3	D4	D5	D6	H1	H2	H3	B	Na x Da	Ni x Di
ROD 601	1536	1692	1826	2152	2033	1810	220	210	50	170	60 x M36	60 x M36
ROD 721	1776	1936	2024	2317	2224	2016	225	185	38	165	74 x Ø39	74 x M36
ROD 741	1746	1928	2018	2308	2222	1997	220	201	40	145	72 x M36	72 x M36
ROD 991	1744	1912	2030	2320	2228	2004	215	202	35	160	90 x Ø39	64 x M42
ROD 1061	2304	2469	2557	2853	2760	2549	215	185	35	160	90 x Ø39	90 x M36
ROD 1221	2448	2630	2718	3011	2918	2710	245	185	35	145	104 x Ø39	104 x M36
ROD 1321	2624	2800	2888	3181	3088	2880	215	185	35	160	108 x Ø39	108 x M36
ROD 1701	2980	3162	3268	3550	3466	3250	220	205	40	180	74 x M36	100 x M36
ROD 2201	3420	3612	3718	4000	3916	3700	220	205	40	180	120 x M36	120 x M36

All dimensions are in [mm]

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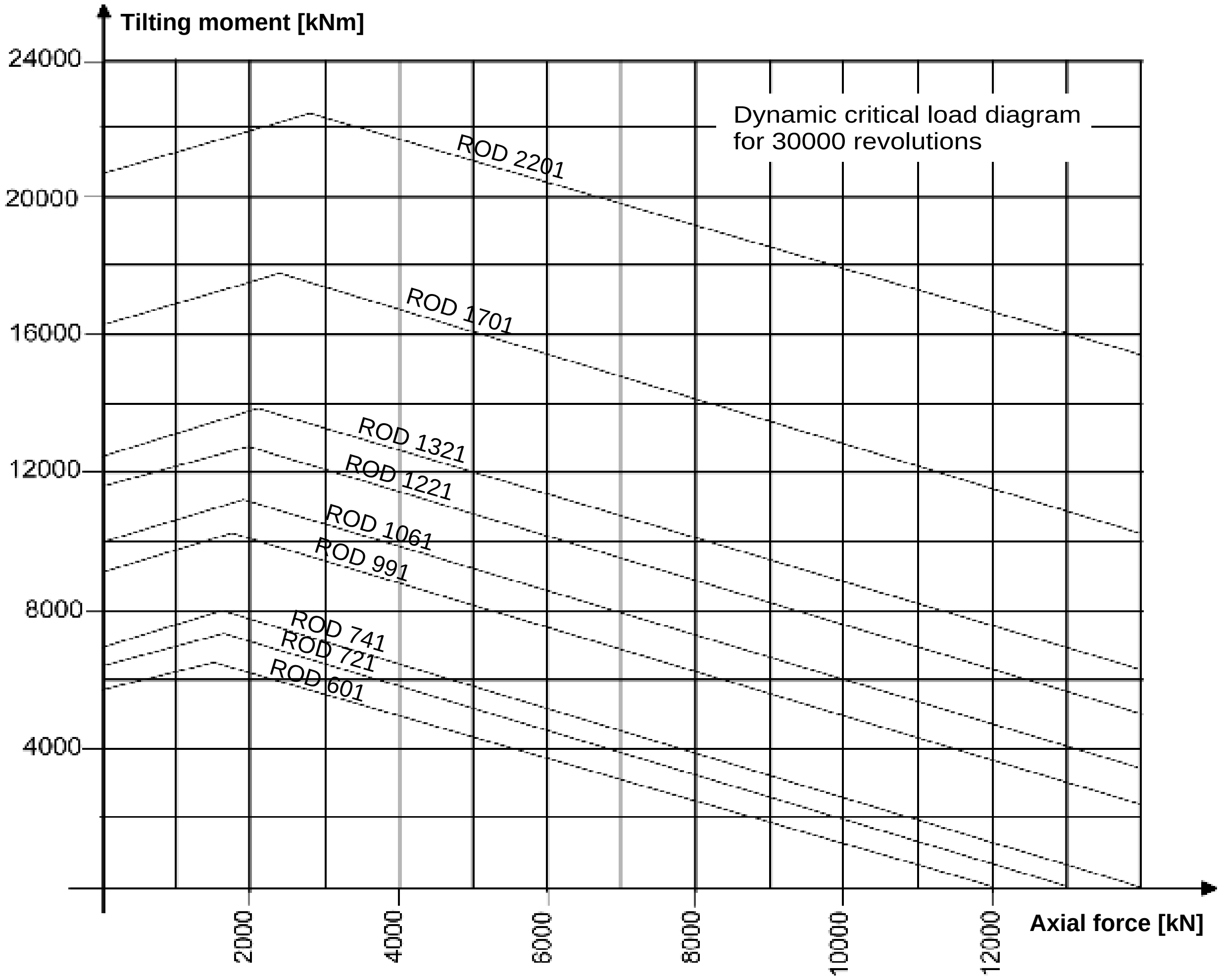
Roller bearing with internal teeth



Load limits

Designation	module	no. of teeth	max. dyn. Torque M_{dyn}	max. stat. Torque M_{stat}	max. tilting moment @ axialload
ROD 601	16 mm	97	164 900 Nm	362 800 Nm	6956 kNm @ 1300 kN
ROD 721	16 mm	112	184 800 Nm	406 600 Nm	12400 kNm @ 900 kN
ROD 741	18 mm	98	198 200 Nm	402 900 Nm	10000 kNm @ 1700 kN
ROD 991	16 mm	110	176 000 Nm	387 200 Nm	14600 kNm @ 1300 kN
ROD 1061	16 mm	145	232 000 Nm	510 400 Nm	17600 kNm @ 990 kN
ROD 1221	18 mm	137	277 100 Nm	563 200 Nm	20150 kNm @ 2910 kN
ROD 1321	16 mm	165	264 000 Nm	580 800 Nm	26500 kNm @ 1200 kN
ROD 1701	20 mm	150	486 000 Nm	945 000 Nm	26500 kNm @ 3600 kN
ROD 2201	20 mm	172	557 300 Nm	1 083 600 Nm	29279 kNm @ 4686 kN

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