Planetary Gear Bearing Arrangements
in Industrial Gearboxes

Technical principles
Products and applications
Foreword

Industrial gearboxes are being designed as increasingly compact with smaller design envelope while their power levels are continually increasing. This increase in power density within a very small space places increasingly high demands on the rolling bearings used. This is particularly true for planetary gearboxes in industrial gearboxes, since such gearboxes must transmit very high power levels with high operational security within a very small design envelope. In more than a few cases, the planetary gears in particular are subjected to loads up to their physical limits. At the same time, the planet carriers and planet pins are subjected to heavy reversed bending loads.

For this demanding area of application, bearing solutions are only accepted if the bearing arrangements not only have a reduced design envelope and give quiet running but also have low friction, extremely high reliability levels, a very long life and are very easy to fit.

For applications in planetary gearboxes, Schaeffler has solutions giving major customer benefits, such as:

- radially very compact, full complement single and double row cylindrical roller bearings RSL without an outer ring, with high dynamic and static load carrying capacity
- cage-guided cylindrical roller bearings RN, especially suitable for high speeds
- needle roller and cage assemblies KZK for high centrifugal and acceleration forces, designed for very high speeds
- full complement needle roller arrangements NRB and VRS with very high load carrying capacity while requiring the very smallest radial design envelope.

In addition, there are a large number of special solutions to fulfil a very wide range of requirements.

Advice on the selection of bearings and the design of bearing arrangements in planetary gear bearing arrangements is available from Schaeffler application engineers and the Schaeffler engineering service worldwide.

Replacement for...

This Technical Product Information TPI 08, Planetary Gear Bearing Arrangements in Industrial Gearboxes, replaces the previous TPI 08, Rolling Bearings in Large Gearboxes. Any information in previous editions which does not concur with the data in this edition is therefore invalid.

TPI 08 is a supplement to Catalogue HR 1, Rolling Bearings. It essentially covers the subjects relating to planetary gear bearing arrangements in industrial gearboxes that are not described in Catalogue HR 1. In the design of the bearing arrangement, however, the relevant information in Catalogue HR 1 must also be observed.
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<td>44</td>
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<td>Full complement cylindrical roller bearings, dimension series 22, without outer ring, single row</td>
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<td>Full complement cylindrical roller bearings, dimension series 23, without outer ring, single row</td>
<td>32</td>
</tr>
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<td>RSL1830..-A</td>
<td>Full complement cylindrical roller bearings, dimension series 30, without outer ring, single row</td>
<td>32</td>
</tr>
<tr>
<td>RSL1850..-A</td>
<td>Full complement cylindrical roller bearings, dimension series 50, without outer ring, double row</td>
<td>32</td>
</tr>
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<td>VRS</td>
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<td>80</td>
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</tr>
<tr>
<td>320</td>
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<td>84</td>
</tr>
</tbody>
</table>
Technical principles

**Planetary gear bearings**
- Full complement cylindrical roller bearings
- Cylindrical roller bearings with cage
- Needle roller and cage assemblies
- Needle rollers
- Full complement needle roller arrangements
- Full complement needle roller sets
- Spherical roller bearings
- Tapered roller bearings

**Special solutions**
- X-life
- Cage design
- Cage for high accelerations
- Bearing arrangements with optimised mass
- Floating planetary gear bearing arrangements
- Axial location of bearings
- Coated bearings

**Applications in planetary gearboxes**
- Pitch and yaw gearbox for wind turbines
- Hydraulic drive unit
- Slewing gear drive for crawler excavators
- Planetary gearbox with front-mounted spur gear stage

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Technical principles

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# Technical principles

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Friction

Catalogue HR 1, Rolling Bearings gives a detailed description, in the chapter Friction and increases in temperature, of the subject of friction and the calculation of frictional torques. The information presented here is supplementary and covers planetary gear bearing arrangements.

The friction in a rolling bearing is made up of several components, see table. Due to the large number of influencing factors, such as dynamics at speed and load, tilting and skewing during mounting, actual frictional torques and frictional energy may deviate significantly from the calculated values.

If the frictional torque is an important design criterion, please consult the Schaeffler engineering service.

Frictional components

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

<table>
<thead>
<tr>
<th>Frictional component</th>
<th>Influencing factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolling friction</td>
<td>Magnitude of load</td>
</tr>
<tr>
<td>Sliding friction of rolling elements of cage</td>
<td>Magnitude and direction of load, Speed and lubrication conditions, running-in condition</td>
</tr>
<tr>
<td>Fluid friction (flow resistance)</td>
<td>Type and speed, Type, quantity and operating viscosity of lubricant</td>
</tr>
</tbody>
</table>
For planetary gear bearing arrangements in industrial gearboxes, the bearing factors $f_0$ and $f_1$ apply, see tables.

### Factor $f_0$, $f_1$

#### for needle roller and cage assemblies and full complement needle roller arrangements

<table>
<thead>
<tr>
<th>Series</th>
<th>Bearing factor $f_0$</th>
<th>Bearing factor $f_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grease, oil mist</td>
<td>Oil bath, recirculating oil</td>
<td></td>
</tr>
<tr>
<td>VRS</td>
<td>$(30 \cdot B)/(33 + d)$</td>
<td>$(45 \cdot B)/(33 + d)$</td>
</tr>
<tr>
<td>K, KZK</td>
<td>$(12 \cdot B)/(33 + d)$</td>
<td>$(18 \cdot B)/(33 + d)$</td>
</tr>
</tbody>
</table>

### Factor $f_0$, $f_1$

#### for full complement cylindrical roller bearings

<table>
<thead>
<tr>
<th>Series</th>
<th>Bearing factor $f_0$</th>
<th>Bearing factor $f_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grease, oil mist</td>
<td>Oil bath, recirculating oil</td>
<td></td>
</tr>
<tr>
<td>RSL1822</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>RSL1823</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>RSL1830</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>RSL1850</td>
<td>9</td>
<td>13</td>
</tr>
</tbody>
</table>

### Factor $f_0$, $f_1$

#### for cylindrical roller bearings with cage

<table>
<thead>
<tr>
<th>Series</th>
<th>Bearing factor $f_0$</th>
<th>Bearing factor $f_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grease, oil mist</td>
<td>Oil bath, recirculating oil</td>
<td></td>
</tr>
<tr>
<td>RN2...E</td>
<td>1.3</td>
<td>2</td>
</tr>
<tr>
<td>RN3...E</td>
<td>1.3</td>
<td>2</td>
</tr>
<tr>
<td>RN22...E</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>RN23...E</td>
<td>2.7</td>
<td>4</td>
</tr>
</tbody>
</table>

**Legend**

- $f_0$ – Bearing factor for frictional torque as a function of speed
- $f_1$ – Bearing factor for frictional torque as a function of load
- B: mm Bearing width
- d: mm Bearing bore diameter.


## Speeds and acceleration

### Limiting speed

The limiting speed $n_G$ is based on practical experience and takes account of additional criteria such as smooth running, sealing function and centrifugal forces.

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

### Thermally safe operating speed

The thermally safe operating speed $n_0$ is calculated according to DIN 732. The basis for the calculation is the heat balance in the bearing, the equilibrium between the frictional energy as a function of speed and the heat dissipation as a function of temperature. When conditions are in equilibrium, the bearing temperature is constant.

The permissible operating temperature determines the thermally safe operating speed $n_0$ of the bearing.

For calculation, it is assumed that normal operating clearance and constant operating conditions are present.

In addition to the thermally safe operating speed, the limiting speed $n_G$ must always be observed.

### Limits of the calculation method

The calculation method is not valid for:
- sealed rolling bearings with contact seals; the maximum speed is restricted by the permissible sliding velocity at the seal lip.

### Permissible radial acceleration

Planetary gear bearing arrangements are subjected to strong normal accelerations in operation. In the design of the bearing arrangement, a distinction must be drawn between a full complement roller bearing arrangement and a cage bearing arrangement.

#### Full complement roller bearing arrangement

In full complement roller and full complement needle roller bearings, the permissible radial acceleration is restricted by the maximum $pv$ value between the rolling elements and the thermal balance in the bearing, *Figure 1*.

#### Cage bearing arrangement

In cage bearing arrangements, the permissible radial acceleration is restricted by the strength of the cage.

---

$r_{st} = \text{distance from centre of rotation}$

$\omega = \text{angular velocity}$

*Figure 1*

Radial acceleration
Radial acceleration

The radial acceleration is described by the acceleration parameter $a$:

$$ a = \frac{1}{g} \cdot r_{sl} \cdot \omega^2 = \frac{1}{g} \cdot r_{sl} \cdot \left(\frac{2 \cdot \pi \cdot r}{60 \cdot n}\right)^2 $$

- $a$ Acceleration parameter
- $g$ Acceleration due to gravity $g = 9.81 \text{ m/s}^2$
- $r_{sl}$ Distance from the centre of rotation, Figure 1, page 12
- $\omega$ Angular velocity, Figure 1, page 12
- $n$ Relative speed of the planetary gear bearing arrangement.

Maximum acceleration

If the acceleration values are high, further advice should be sought from the Schaeffler engineering service.

Maximum acceleration for cage bearings

If bearings with cages are used, the following must be observed:

- Only use cages guided on external ribs.
- For higher accelerations, use solid cages instead of riveted cages.
- For maximum accelerations, use needle roller and cage assemblies KZK. For suitable needle roller and cage assemblies, see page 55.
Lubrication

Functions of the lubricant
The lubricant should:
- form a lubricant film sufficiently capable of supporting loads on the contact surfaces and thus prevent wear and premature fatigue
- dissipate heat in the case of oil lubrication
- reduce the running noise
- give protection against corrosion.

The essential information on lubrication in Catalogue HR 1, Rolling Bearings, chapter Lubrication, must be observed.

Oil flow through the bearing
In order to transfer heat and lubricate the rolling elements and cage, a sufficiently large oil flow through the bearing must be ensured. In order to ensure the outflow of oil, lubrication slots should be provided in the thrust washers where geometrical conditions are tight such as in the case of needle roller bearings, needle roller and cage assemblies and full complement needle roller sets.
Design of bearing arrangements

Arrangement of bearings

The guidance and support of a rotating shaft requires at least two bearings arranged at a certain distance from each other.

Depending on the application, one of the following can be selected:
- locating/non-locating bearing arrangement
- adjusted bearing arrangement
- floating bearing arrangement.

For a bearing arrangement in a planetary gear, only one bearing is used depending on the application. The essential information on the arrangement of bearings in Catalogue HR 1, Rolling Bearings, chapter Technical principles, must be observed.

Floating bearing arrangement

The floating bearing arrangement is a simple and economical design solution for supporting planetary gears. In this type of bearing arrangement, the planetary gear can be displaced relative to the planetary gear carrier by the axial clearance “s”.

The value “s” is defined as a function of the required guidance accuracy such that the bearing is not axially stressed even under unfavourable thermal conditions.

Internal or external bearing arrangement

The following bearing arrangements are possible, Figure 1:
- internal bearing arrangement
- external bearing arrangement.

In the internal bearing arrangement, the planetary gear runs on a pin clamped on one or both sides.

In the external bearing arrangement, the planetary gear pin is supported on both sides in the planetary gear carrier.

Example solutions show the versatile design of bearing arrangements for planetary gears, see page 24 to page 26.
**Design of bearing arrangements**

**Fits**
Rolling bearings are located on the shaft and in the housing in a radial, axial and tangential direction in accordance with their function.

Radial and tangential location is normally achieved by force locking, i.e. by tight fits on the bearing rings.

Axial location of the bearings is normally achieved by form fit.

**Criteria for selection of fits**
The following must be taken into consideration in the selection of fits:

- The bearing rings must be well supported on their circumference in order to allow full utilisation of the load carrying capacity of the bearing.
- The bearings must not creep on their mating parts, otherwise the seats will be damaged.

**Internal bearing arrangement**
If the planetary gear has an internal bearing arrangement, the outer ring of the planetary bearing has circumferential load. This ring must therefore be produced as a tight fit.

**External bearing arrangement**
Due to the circumferential load on the inner ring, the external bearing arrangement requires a fit with a tight seat on the inner ring.

**Conditions of rotation**
The conditions of rotation indicate the motion of one bearing ring with respect to the load direction and are expressed as either circumferential load or point load.

**Point load**
If the ring remains stationary relative to the load direction, there are no forces that displace the ring relative to its seating surface. This type of load is described as point load.

There is no risk that the seating surface will be damaged and a loose fit is possible.

**Circumferential load**
If forces are present that displace the ring relative to its seating surface, every point on the raceway is subjected to load over the course of one revolution of the bearing. This type of load is described as circumferential load.

As damage to the bearing seating surface can occur, a tight fit should be used.

**Shaft and housing tolerances**
The fit is determined by the ISO tolerances for shafts and housings (in accordance with ISO 286) in conjunction with the tolerances for the bore and outside diameter D of the bearings (in accordance with DIN 620).

The type of bearing arrangement (internal or external bearing arrangement) determines the shaft and housing tolerance, see tables, page 17.
**Shaft and housing tolerances for internal bearing arrangement**

<table>
<thead>
<tr>
<th>Condition of rotation</th>
<th>Bearing type</th>
<th>Pin diameter mm</th>
<th>Load</th>
<th>Tolerance zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point load on inner ring</td>
<td>Roller bearings</td>
<td>All</td>
<td>All</td>
<td>g6 (g5)</td>
</tr>
<tr>
<td></td>
<td>Needle roller bearings</td>
<td>All</td>
<td>All</td>
<td>h6 (g6)</td>
</tr>
<tr>
<td>Circumferential load on outer ring</td>
<td>All</td>
<td>All</td>
<td>Low</td>
<td>K7 (K6)</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>All</td>
<td>Normal, shock type</td>
<td>M7 (M6)</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>All</td>
<td>High, shock type (C/P &lt; 6)</td>
<td>N7 (N6)</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>All</td>
<td>High, extreme shock type, thin planetary wall thickness</td>
<td>P7 (P6)</td>
</tr>
</tbody>
</table>

1) For easier fitting.

**Shaft and housing tolerances for external bearing arrangement**

<table>
<thead>
<tr>
<th>Condition of rotation</th>
<th>Bearing type</th>
<th>Pin diameter mm</th>
<th>Load</th>
<th>Tolerance zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circumferential load on inner ring</td>
<td>Roller bearings</td>
<td>up to 60</td>
<td>Low</td>
<td>j6 (j5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Normal to high</td>
<td>k6 (k5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60 to 200</td>
<td>Low</td>
<td>k6 (k5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Normal</td>
<td>m6 (m5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>High</td>
<td>n6 (n5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200 to 500</td>
<td>Normal</td>
<td>m6 (m5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>High, shock type</td>
<td>p6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>over 500</td>
<td>Normal</td>
<td>n6 (p5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>High</td>
<td>p6</td>
</tr>
</tbody>
</table>

Point load on outer ring | All | All | All | H7 |
Design of bearing arrangements

Geometrical tolerances of bearing seating surfaces

The shaft raceway and housing bore must be designed as a function of the selected fit, *Figure 2.*
The degree of accuracy for the bearing seat tolerances on the shaft and in the housing is given in the table.

*Figure 2*  
Dimensional and geometrical tolerances

**IT grades in accordance with DIN ISO 286**

<table>
<thead>
<tr>
<th>Bearing tolerance class</th>
<th>Bearing seating surface</th>
<th>Diameter tolerance</th>
<th>Roundness tolerance $t_1$</th>
<th>Parallelism tolerance $t_2$</th>
<th>Axial runout tolerance of abutment shoulders $t_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>PN P6X</td>
<td>Shaft</td>
<td>IT6 (IT5)</td>
<td>Circumferential load IT4/2</td>
<td>IT4</td>
<td>IT4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Point load IT5/2</td>
<td>IT5</td>
<td></td>
</tr>
<tr>
<td>Housing</td>
<td>IT7 (IT6)</td>
<td></td>
<td>Circumferential load IT5/2</td>
<td>IT5</td>
<td>IT5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Point load IT6/2</td>
<td>IT6</td>
<td></td>
</tr>
</tbody>
</table>
Raceways for bearings without inner and/or outer ring

In rolling bearings which do not have an inner and/or outer ring, the rolling elements run directly on the shaft or in the housing bore.

The bores and shafts must be produced as rolling bearing raceways (hardened and ground).

The raceways must always be free from undulations, precision machined and resistant to wear (grinding).

The mean roughness value Ra indicated in each case for a standard or X-life bearing must not be exceeded, see table. If the Ra value is higher, it is not possible to utilise the full load carrying capacity of the bearing.

Mounting of the bearing will be made easier by chamfers on both sides of the planetary gear bore.

The lateral contact running surfaces must be designed as precision machined and wear-resistant, incorporating axial washers if necessary.

### Design of the rolling bearing raceway

<table>
<thead>
<tr>
<th>Diameter Nominal dimension mm</th>
<th>Roundness μm</th>
<th>Parallelism1) μm</th>
<th>Mean roughness Ra μm</th>
<th>Standard</th>
<th>X-life</th>
</tr>
</thead>
<tbody>
<tr>
<td>over incl.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 18</td>
<td>4</td>
<td>4</td>
<td>0,2</td>
<td>0,1</td>
<td></td>
</tr>
<tr>
<td>18 30</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 50</td>
<td>6</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 80</td>
<td>7</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80 120</td>
<td>8</td>
<td>11</td>
<td>0,3</td>
<td>0,15</td>
<td></td>
</tr>
<tr>
<td>120 150</td>
<td>9</td>
<td>13</td>
<td>0,4</td>
<td>0,2</td>
<td></td>
</tr>
<tr>
<td>150 180</td>
<td>13</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>180 250</td>
<td>15</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>250 315</td>
<td>18</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>315 400</td>
<td>20</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) The parallelism of the guideway is related to the width of the planetary gear.

### Materials for raceway

Through hardening steels and case hardening steels are suitable as materials.

#### Through hardening steels

Steels in accordance with ISO 683-17 (such as 100Cr6) are suitable. These can also be surface layer hardened.

#### Case hardening steels

Case hardening steels must conform to ISO 683-17 (such as 17MnCr5, 16CrNiMo6) or EN 10 084 (such as 16MnCr5).
Design of bearing arrangements

Surface hardness and hardening depth

The values are applicable to raceways. Axial washers and shaft shoulders should be produced as wear-resistant surfaces, for example by hardening. Case, flame or induction hardened steels must have a surface hardness of 670 HV + 170 HV and an adequate hardening depth CHD or SHD.

In accordance with DIN 50190, the hardening depth is the depth of the hardened surface zone at which there is still a hardness of 550 HV. It is measured on the finish ground shaft and must correspond to the stated values, but must in any case be \( \geq 0.3 \) mm.

If the raceways are softer than 650 HV (58 HRC), the bearing arrangement will not achieve its full load carrying capacity. In this case, the basic dynamic load rating \( C_r \) and the basic static load rating \( C_0r \) in the dimension tables must be reduced by the hardness factor \( f_H \) or \( f_{H0} \), Figure 3 and Figure 4.

\[
f_H = \text{dynamic hardness factor}
\]

\[
HV, HRC = \text{surface hardness}
\]

Figure 3
Dynamic hardness factor \( f_H \)

\[
f_{H0} = \text{static hardness factor}
\]

\[
HV, HRC = \text{surface hardness}
\]

Figure 4
Static hardness factor \( f_{H0} \)
**Calculation of the effective load carrying capacity**

The effective load carrying capacity can be calculated using the correction equations:

\[
C_{Hr} = f_H \cdot C_r \\
C_{0Hr} = f_{H0} \cdot C_{0r}
\]

- \(C_{Hr}, C_{0Hr}\) N Effective dynamic or static load rating at reduced hardness
- \(f_H, f_{H0}\) Dynamic or static hardness factor, Figure 3 and Figure 4
- \(C_r, C_{0r}\) N Basic radial dynamic or static load rating.

**Case hardening depth of raceway surfaces**

The minimum case hardening depth \(CHD\) of the raceway can be determined as follows:

\[
CHD \geq 0.078 \cdot \frac{D_w}{n}
\]

- \(CHD\) mm Case hardening depth
- \(D_w\) mm Rolling element diameter.

**Roughness of bearing seating surfaces in bearings with rings**

The roughness of the bearing seats must be matched to the tolerance class of the bearings. The mean roughness value \(Ra\) must not be too high, in order to maintain the interference loss within limits.

Shafts should be ground and bores should be precision turned. Recommended mean roughness \(Ra = 3.2\).

**Wall thickness between raceway and tooth base**

The wall thickness between the raceway and tooth base should be at least 2.5 times the modulus.

Smaller wall thicknesses may be possible once precise calculation has been carried out by the Schaeffler engineering service.
Design of bearing arrangements

Accuracy
The dimensional and running tolerances of the bearings correspond to tolerance class PN to DIN 620.

Tolerance for enveloping circle diameter $E_w$
The following tolerances are determined as a function of the bore diameter $d$ for the enveloping circle diameter $E_w$:
- $d \leq 40\,\text{mm}, E_w = -0.01\,\text{mm}$
- $d \leq 65\,\text{mm}, E_w = -0.015\,\text{mm}$
- $d \leq 120\,\text{mm}, E_w = -0.02\,\text{mm}$
- $d \leq 200\,\text{mm}, E_w = -0.025\,\text{mm}$
- $d \leq 240\,\text{mm}, E_w = -0.03\,\text{mm}$.

The enveloping circle diameters of the bearings are given in the dimension tables.

Radial internal clearance
In bearings without an outer ring, the planetary gear fulfils the function of the outer ring. The radial internal clearance ($C_2, C_N, C_3, C_4$) is therefore determined by the design of the planetary gear bore and as a function of the enveloping circle diameter $E_w$ of the rolling bearing, see tables, page 23.

Determining the diameter of the planetary gear bore as a function of the radial internal clearance (example)
For a planetary gear bearing arrangement with the cylindrical roller bearing RSL183004-A (bore diameter $d = 20\,\text{mm}$), a radial internal clearance $C_N$ should be present.
What is the size required for the planetary gear bore?
Example:
- Cylindrical roller bearing = RSL183004-A, see dimension table, page 34
- Enveloping circle diameter $F_w = 36.81\,\text{mm}$, see dimension table, page 34
- Tolerance for $E_w = -0.01\,\text{mm}$, see page 22
- Tolerance for radial internal clearance $C_N = 20\,\mu\text{m}\text{ to }45\,\mu\text{m}$, see table, page 23
- Bore for planetary gear = $36.81+0.02/+0.035$

-
# Radial internal clearance to C2 and CN

<table>
<thead>
<tr>
<th>Bore diameter ( d ) mm</th>
<th>Bore code ( \overline{\text{over} \ \text{incl.}} )</th>
<th>Tolerance ( \overline{\text{over} \ \text{incl.}} ) ( \mu \text{m} )</th>
<th>C2 radial internal clearance ( \mu \text{m} )</th>
<th>Tolerance ( \overline{\text{over} \ \text{incl.}} ) ( \mu \text{m} )</th>
<th>CN radial internal clearance ( \mu \text{m} )</th>
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# Radial internal clearance to C3 and C4

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<th>Bore code ( \overline{\text{over} \ \text{incl.}} )</th>
<th>Tolerance ( \overline{\text{over} \ \text{incl.}} ) ( \mu \text{m} )</th>
<th>C3 radial internal clearance ( \mu \text{m} )</th>
<th>Tolerance ( \overline{\text{over} \ \text{incl.}} ) ( \mu \text{m} )</th>
<th>C4 radial internal clearance ( \mu \text{m} )</th>
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</table>
Planetary gear bearing arrangements in industrial gearboxes can be designed in a wide variety of ways. Some bearing arrangements with cylindrical roller bearings are shown here, Figure 1 to Figure 6, page 25.

**Figure 1**
Full complement roller set, single row, without outer ring

**Figure 2**
Full complement roller set, single row, without outer ring

**Figure 3**
Full complement roller set, double row, without outer ring
Figure 4
Special bearing, full complement roller set, double row, without outer ring

Figure 5
Bearing with cage, without outer ring

Figure 6
Bearing with cage, without outer ring
Design examples

Needle roller and cage assembly or full complement needle roller set

Depending on the operating conditions, planetary gears can also be supported by needle roller and cage assemblies or full complement needle roller sets, *Figure 7* and *Figure 8*.

Radial needle roller bearings must not be used to transmit axial loads or to provide axial guidance.

---

**K (KZK)**

1. Spacer ring
2. Axial washer

*Figure 7*

Bearing arrangement with double row needle roller and cage assemblies

**NRB, VRS**

1. Axial washer

*Figure 8*

Full complement needle roller arrangement
Planetary gear bearings

Full complement cylindrical roller bearings
Cylindrical roller bearings with cage
Needle roller and cage assemblies
Needle rollers
Full complement needle roller arrangements
Full complement needle roller sets
Spherical roller bearings
Tapered roller bearings
Planetary gear bearings

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Tapered roller bearings

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Comparison of characteristics for bearing preselection

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<thead>
<tr>
<th>Series</th>
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<tr>
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<td>Load carrying capacity</td>
</tr>
<tr>
<td>K</td>
<td>Load carrying capacity</td>
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<td>KZK</td>
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<td>Speed</td>
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<tr>
<td></td>
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</tr>
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</table>
Product overview

Full complement cylindrical roller bearings

Without outer ring
Single row
RSL1822..-A, RSL1823..-A, RSL1830..-A

Double row
RSL1850..-A

Axial washer

Schaeffler Technologies
## Full complement cylindrical roller bearings

### Features

Full complement cylindrical roller bearings without an outer ring have solid inner rings and rib-guided cylindrical rollers. The inner rings are produced with two rigid ribs.

Since these bearings have the largest possible number of rolling elements, they have extremely high radial load carrying capacity, high rigidity and are suitable for particularly compact designs.

Due to the kinematic conditions, however, they do not achieve the high speeds that are possible when using cylindrical roller bearings with cage.

The bearings are available as single row and double row locating bearings. They can support not only high radial forces but also axial forces in both directions and can therefore guide shafts axially in both directions.

The bearings are supplied in an open design. They are not greased and can be lubricated with oil or grease.

The rolling elements are protected against damage and loss during transport by means of a plastic sleeve.

The further information on cylindrical roller bearings in Catalogue HR 1, Rolling Bearings must be observed.

### Ordering designation for two or more bearings

If two or more bearings are located adjacent to each other in a planet (2, 3 or 4 bearings), these must be ordered using the suffix 2S, 3S or 4S so that they are sorted together.

### Design and safety guidelines

#### Minimum radial load

In continuous operation, a minimum radial load $F_{r_{\text{min}}}$ of the order of $C_{0r}/P < 60$ is necessary.

If $C_{0r}/P > 60$, please contact us.

#### Axial location

In order to prevent lateral creep of the bearing rings, they must be located by means of form fit.

The abutment shoulder of the shaft should be sufficiently high and perpendicular to the bearing axis.

The transition from the bearing seat to the abutment shoulder must be designed with rounding to DIN 5418 or an undercut to DIN 509.

### Axial guidance of planet

Cylindrical roller bearings can provide axial guidance of the planet. This can be carried out by means of axial washers and retaining rings arranged on both sides of the rolling element, see section Design examples, page 24. As an alternative, L-section rings BRL can be used, see page 91.
Cylindrical roller bearings
Full complement
Single row

RSL1830...-A

Mounting dimensions

<table>
<thead>
<tr>
<th>Designation</th>
<th>Mass</th>
<th>Dimensions</th>
<th>Mounting dimensions</th>
<th>Basic load ratings</th>
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<td>20 16 0,6 36,81</td>
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</table>

1) Suitable axial washers, see page 35.
2) Internal clearance groups and tolerances, see page 23.
3) Tolerance for enveloping circle diameter Ew, see page 22.
4) The values for the spacing Ba relate to the recommended axial washers from Schaeffler. If other axial washers are used, the condition Ba = X + 2 · Baxial washer + 0,2 must be fulfilled.
The dimension for axial location of the bearings must correspond to at least $B_{tot}$.
The tolerance for the spacing $B_{tot}$ must therefore be $+0.2$ mm.

1) Not included in the scope of delivery.
2) In accordance with DIN 472.

### Dimension table: Dimensions in mm

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<th>Axial washer</th>
<th>Mass $m$ kg</th>
<th>Dimensions</th>
<th>Axial clearance $s$</th>
<th>Width between planet carriers</th>
<th>Retaining ring $1)$</th>
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<td>$D$</td>
<td>$B$</td>
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<td>$s$ max.</td>
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### Dimension table: Dimensions in mm

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<tr>
<th>Designation</th>
<th>Mass $m$ kg</th>
<th>Dimensions</th>
<th>Mounting dimension</th>
<th>Basic load ratings</th>
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<td>$B$ mm</td>
<td>$r$ mm (min.)</td>
<td>$E_{w}$ mm</td>
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1) Suitable axial washers, see page 37.
2) Internal clearance groups and tolerances, see page 23.
3) Tolerance for enveloping circle diameter $E_w$, see page 22.
**Axial washers**

The dimension for axial location of the bearings must correspond to at least $B_{\text{tot}}$. The tolerance for the spacing $B_{\text{tot}}$ must therefore be $+0.2$ mm.

1) If the least favourable combination of tolerances is present, it is possible that one bearing size or a combination of two bearing sizes will have either a gap $x$ or a clearance $s$.

2) Not included in the scope of delivery.

3) In accordance with DIN 472.

### Dimension table - Dimensions in mm

<table>
<thead>
<tr>
<th>Cylindrical roller bearing Designation</th>
<th>Drawing number</th>
<th>Mass $m$ kg</th>
<th>Dimensions $D$</th>
<th>Axial clearance $s$</th>
<th>Width between planet carriers $B_{\text{tot}}$ min.</th>
<th>Retaining ring $2)$</th>
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<td>2.5</td>
<td>60.2</td>
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<td>F-87722</td>
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<td>60.2</td>
<td>JV42</td>
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<td>3.25</td>
<td>69</td>
<td>JV50</td>
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<tr>
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<td>3.25</td>
<td>73</td>
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<td>108X4$^3$</td>
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1) The least favourable combination of tolerances is present, it is possible that one bearing size or a combination of two bearing sizes will have either a gap $x$ or a clearance $s$.

2) Not included in the scope of delivery.

3) In accordance with DIN 472.
Axial washers
For the combination comprising cylindrical roller bearings RSL1850 and RSL1830

The dimension for axial location of the bearings must correspond to at least B_{tot}.
The tolerance for the spacing B_{tot} must therefore be +0,2 mm.

1) If the least favourable combination of tolerances is present, it is possible that one bearing size or a combination of two bearing sizes will have either a gap x or a clearance s.

2) Not included in the scope of delivery.

3) In accordance with DIN 472.

### Dimension table - Dimensions in mm

<table>
<thead>
<tr>
<th>Cylindrical roller bearing designation</th>
<th>Axial washer</th>
<th>Drawing number</th>
<th>Mass ( m ) ( = ) kg</th>
<th>Dimensions</th>
<th>Axial clearance ( s )</th>
<th>Width between planet carriers</th>
<th>Retaining ring ( \text{ring}^{2)} )</th>
</tr>
</thead>
<tbody>
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<td>F-90016</td>
<td>0,005</td>
<td>32</td>
<td>36,8</td>
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</table>

The dimensions for axial location of the bearings must correspond to at least \( B_{tot} \).
The tolerance for the spacing \( B_{tot} \) must therefore be +0,2 mm.

1) If the least favourable combination of tolerances is present, it is possible that one bearing size or a combination of two bearing sizes will have either a gap x or a clearance s.

2) Not included in the scope of delivery.

3) In accordance with DIN 472.
# Cylindrical roller bearings

Full complement  
Single row

### Dimension table - Dimensions in mm

<table>
<thead>
<tr>
<th>Designation1 2)</th>
<th>Mass</th>
<th>Dimensions</th>
<th>Mounting dimensions</th>
<th>Basic load ratings</th>
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<td>r</td>
<td>E_w3)</td>
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</table>

1) Suitable axial washers, see page 41.  
2) Internal clearance groups and tolerances, see page 23.  
3) Tolerance for enveloping circle diameter E_w, see page 22.  
4) The values for the spacing B_a relate to the recommended axial washers from Schaeffler. If other axial washers are used, the condition B_a = X + 2 · B_axial washer + 0,2 must be fulfilled.
Axial washers

For RSL1822...-A

Axial clearance s

### Dimension table - Dimensions in mm

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<tr>
<th>Cylindrical roller bearing Designation</th>
<th>Axial washer</th>
<th>Drawing number</th>
<th>Mass kg</th>
<th>Dimensions</th>
<th>Axial clearance mm</th>
<th>Width between planet carriers mm</th>
<th>Retaining ring</th>
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</table>

The dimension for axial location of the bearings must correspond to at least $B_{tot}$. The tolerance for the spacing $B_{tot}$ must therefore be +0,2 mm.

1) Not included in the scope of delivery.

2) In accordance with DIN 472.
Cylindrical roller bearings
Full complement
Single row

RSL1823...-A

Mounting dimensions

1) Suitable axial washers, see page 43.
2) Internal clearance groups and tolerances, see page 23.
3) Tolerance for enveloping circle diameter $E_w$, see page 22.
4) The values for the spacing $B_a$ relate to the recommended axial washers from Schaeffler.
If other axial washers are used, the condition $B_a = X + 2 \cdot B_{axial\ washer} + 0,2$ must be fulfilled.

### Dimension table - Dimensions in mm

<table>
<thead>
<tr>
<th>Designation</th>
<th>Mass $m$</th>
<th>Dimensions</th>
<th>Mounting dimensions</th>
<th>Basic load ratings</th>
</tr>
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<tr>
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</tbody>
</table>
Axial washers

For RSL1823..-A

Axial clearance $s$

### Dimension table - Dimensions in mm

<table>
<thead>
<tr>
<th>Cylindrical roller bearing Designation</th>
<th>Axial washer</th>
<th>Drawing number</th>
<th>Mass $m$ =kg</th>
<th>Dimensions</th>
<th>Axial clearance $s$</th>
<th>Width between planet carriers</th>
<th>Retaining ring $B_{tot}$ min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSL182305-A</td>
<td>F-92059</td>
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</table>

The dimension for axial location of the bearings must correspond to at least $B_{tot}$.
The tolerance for the spacing $B_{tot}$ must therefore be $+0,2$ mm.

1) Not included in the scope of delivery.
2) In accordance with DIN 472.
### Product overview

#### Cylindrical roller bearings with cage

<table>
<thead>
<tr>
<th>Single row</th>
<th>RN2, RN3</th>
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<td><img src="0001772D" alt="Image" /></td>
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<table>
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<th>RN22, RN23</th>
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<tr>
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<table>
<thead>
<tr>
<th>Axial washer</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="0001772B" alt="Image" /></td>
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</tbody>
</table>
Cylindrical roller bearings with cage

**Features**

Single row cylindrical roller bearings with cage and without an outer ring are units comprising solid inner rings and cylindrical roller and cage assemblies. The inner rings have two rigid ribs. The cage prevents the cylindrical rollers from coming into contact with each other during rolling.

The cage type bearings are very rigid, can support high radial loads and are suitable for higher speeds than the full complement designs. They have a roller set with increased capacity and are thus designed for extremely high load carrying capacity.

The bearings are in the form of single row locating bearings. They can support not only high radial forces but also axial forces in both directions and can therefore guide shafts axially in both directions.

The bearings are supplied in an open design. They are not greased and can be lubricated from the end faces using grease or oil.

The rolling elements are protected against damage and loss during transport by means of a plastic sleeve.

The further information on cylindrical roller bearings in Catalogue HR 1, Rolling Bearings must be observed.

**Ordering designation for two or more bearings**

If two or more bearings are located adjacent to each other in a planet (2, 3, 4 bearings), these must be ordered using the suffix N12BA and the quantity (×2, ×3 or ×4) so that they are sorted together.

**Design and safety guidelines**

**Minimum radial load**

In continuous operation, a minimum radial load \( F_{r \text{min}} \) of the order of \( F_{r \text{min}} = C_{0r}/60 \) is necessary.

If \( C_{0r}/P > 60 \), please contact us.

**Axial location**

In order to prevent lateral creep of the bearing rings, they must be located by means of form fit.

The abutment shoulder of the shaft should be sufficiently high and perpendicular to the bearing axis.

The transition from the bearing seat to the abutment shoulder must be designed with rounding to DIN 5418 or an undercut to DIN 509.

**Axial guidance of planet**

Cylindrical roller bearings can provide axial guidance of the planet.

This can be carried out by means of axial washers and retaining rings arranged on both sides of the rolling element, see section Design examples, page 24. As an alternative, L-section rings BRL can be used, see page 91.
Cylindrical roller bearings
With cage
Single row

**Dimension table** - Dimensions in mm

<table>
<thead>
<tr>
<th>Designation</th>
<th>Mass X-life</th>
<th>Dimensions</th>
<th>Mounting dimensions</th>
<th>Basic load ratings</th>
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<td></td>
<td>m =kg</td>
<td>d</td>
<td>B</td>
<td>r</td>
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<td>72</td>
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</tbody>
</table>

1) Suitable axial washers, see page 47.
2) Internal clearance groups and tolerances, see page 23.
3) Depending on availability, one bearing can also be supplied
   with a cage of matching dimensions and the suffix MP1B.
4) Tolerance for enveloping circle diameter \(E_w\), see page 22.
5) The values for the spacing \(B_a\) relate to the recommended axial washers from Schaeffler.
   If other axial washers are used, the condition \(B_a = X + 2 \times B_{\text{axial washer}} + 0,2\) must be fulfilled.
Axial washers

For RN2...E-MPBX

Axial clearance s

### Dimension table: Dimensions in mm

<table>
<thead>
<tr>
<th>Cylindrical roller bearing Designation</th>
<th>Axial washer</th>
<th>Mass ( m ) in g</th>
<th>Dimensions</th>
<th>Axial clearance ( s )</th>
<th>Width between planet carriers ( B_{\text{tot}} ), min.</th>
<th>Retaining ring (^1)</th>
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</table>

The dimension for axial location of the bearings must correspond to at least \( B_{\text{tot}} \).
The tolerance for the spacing \( B_{\text{tot}} \) must therefore be +0,2 mm.

---

1) Not included in the scope of delivery.
2) This will be determined once an order is placed.
Cylindrical roller bearings

With cage

Single row

RN3..-E-MPBX (-EX-MPBX)

1) Mounting sleeve

<table>
<thead>
<tr>
<th>Designation</th>
<th>Mass m [kg]</th>
<th>X-life</th>
<th>Dimensions</th>
<th>Mounting dimensions</th>
<th>Basic load ratings</th>
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<td>r min.</td>
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</table>

1) Suitable axial washers, see page 49.
2) Internal clearance groups and tolerances, see page 23.
3) Depending on availability, one bearing can also be supplied with a cage of matching dimensions and the suffix MP1B.
4) Tolerance for enveloping circle diameter E_w, see page 22.
5) The values for the spacing B_a relate to the recommended axial washers from Schaeffler.
   If other axial washers are used, the condition B_a = X + 2 · B_axial washer + 0,2 must be fulfilled.
Axial washers

For RN3...-E-MPBX (-EX-MPBX) Axial clearance s

The dimension for axial location of the bearings must correspond to at least $B_{tot}$.
The tolerance for the spacing $B_{tot}$ must therefore be $+0,2$ mm.

1) Not included in the scope of delivery.
2) This will be determined once an order is placed.

**Dimension table** - Dimensions in mm

<table>
<thead>
<tr>
<th>Cylindrical roller bearing</th>
<th>Axial washer</th>
<th>Drawing number</th>
<th>Mass $m$</th>
<th>Dimensions $d$</th>
<th>Axial clearance $s$</th>
<th>Width between planet carriers $B_{tot}$</th>
<th>Retaining ring</th>
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</table>

The dimension for axial location of the bearings must correspond to at least $B_{tot}$.
The tolerance for the spacing $B_{tot}$ must therefore be $+0,2$ mm.

1) Not included in the scope of delivery.
2) This will be determined once an order is placed.
Cylindrical roller bearings
With cage
Single row

RN22...-E-MPBX (-EX-MPBX)

Mounting sleeve

Mounting dimensions

Dimension table: Dimensions in mm

<table>
<thead>
<tr>
<th>Designation 1) 2) 3)</th>
<th>Mass m (kg)</th>
<th>Dimensions</th>
<th>Mounting dimensions</th>
<th>Basic load ratings</th>
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<td></td>
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<td>B</td>
<td>r min.</td>
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<td>240</td>
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<td>4</td>
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</table>

1) Suitable axial washers, see page 51.
2) Internal clearance groups and tolerances, see page 23.
3) Depending on availability, one bearing can also be supplied with a cage of matching dimensions and the suffix MP1B.
4) Tolerance for enveloping circle diameter \( E_w \), see page 22.
5) The values for the spacing \( B_a \) relate to the recommended axial washers from Schaeffler.

If other axial washers are used, the condition \( B_a = X + 2 \cdot B_{axial \, washer} + 0,2 \) must be fulfilled.
### Axial washers

For RN22...-E-MPBX (-EX-MPBX) Axial clearance $s$

#### Dimension table: Dimensions in mm

<table>
<thead>
<tr>
<th>Cylindrical roller bearing Designation</th>
<th>Axial washer</th>
<th>Mass $m$</th>
<th>Dimensions</th>
<th>Axial clearance $s$</th>
<th>Width between planet carriers $B_{tot}$</th>
<th>Retaining ring 1)</th>
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<tbody>
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<td>Drawing number 2)</td>
<td></td>
<td>$d$</td>
<td>$D$</td>
<td>$B$</td>
<td>$s$</td>
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1) Not included in the scope of delivery.
2) This will be determined once an order is placed.

---

The dimension for axial location of the bearings must correspond to at least $B_{tot}$. The tolerance for the spacing $B_{tot}$ must therefore be $+0,2$ mm.
# Cylindrical roller bearings

With cage  
Single row

---

## Dimension table - Dimensions in mm

<table>
<thead>
<tr>
<th>Designation 1) 2) 3)</th>
<th>Mass ( m = \text{kg} )</th>
<th>Dimensions</th>
<th>Mounting dimensions</th>
<th>Basic load ratings</th>
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1) Suitable axial washers, see page 53.  
2) Internal clearance groups and tolerances, see page 23.  
3) Depending on availability, one bearing can also be supplied with a cage of matching dimensions and the suffix MP1B.  
4) Tolerance for enveloping circle diameter \( E_w \), see page 22.  
5) The values for the spacing \( B_a \) relate to the recommended axial washers from Schaeffler.  
   If other axial washers are used, the condition \( B_a = X + 2 \cdot B_{\text{axial washer}} + 0,2 \) must be fulfilled.
Axial washers

For RN23..-E-MPBX (-EX-MPBX)

Axial clearance s

### Dimension table: Dimensions in mm

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<th>Mass m</th>
<th>Dimensions</th>
<th>Axial clearance s</th>
<th>Width between planet carriers B&lt;sub&gt;tot&lt;/sub&gt;</th>
<th>Retaining ring</th>
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</table>

The dimension for axial location of the bearings must correspond to at least B<sub>tot</sub>. The tolerance for the spacing B<sub>tot</sub> must therefore be +0,2 mm.

1) Not included in the scope of delivery.
2) This will be determined once an order is placed.
# Product overview

## Needle roller and cage assemblies

<table>
<thead>
<tr>
<th>Type</th>
<th>Model</th>
<th>Image</th>
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<td>K</td>
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<tr>
<td><strong>Double row</strong></td>
<td>K..-ZW</td>
<td><img src="image" alt="Double row K..-ZW" /></td>
</tr>
<tr>
<td><strong>Single row</strong></td>
<td>KZK</td>
<td><img src="image" alt="Single row KZK" /></td>
</tr>
</tbody>
</table>

**Externally guided**
Needle roller and cage assemblies

**Features**

Needle roller and cage assemblies are single or double row units comprising cages and needle rollers. The single row design is based on DIN 5405-1.

The cages are made from quenched and tempered steel, have good wear resistance, have high strength and their large guidance surfaces are designed for optimum lubrication. Plastic cages are only available for certain sizes. Bearings with these cages have the suffix TV.

Needle roller and cage assemblies require very little radial space since the radial section height corresponds precisely to the diameter of the needle rollers.

Needle roller and cage assemblies give bearing arrangements with high runout accuracy, which is influenced by the geometrical accuracy of the raceways.

The radial internal clearance is dependent on the needle sort as well as the shaft and housing tolerances and can be adjusted by means of the needle roller sort.

Double row needle roller and cage assemblies are only available in particular enveloping circle diameters $f_W$.

The further information on needle roller and cage assemblies in Catalogue HR 1, Rolling Bearings, as well as in Technical Product Information TPI 94, Needle Roller and Cage Assemblies for Crank Pins and Piston Pins must be noted.

**Needle rollers**

Needle roller and cage assemblies are supplied with standard needle roller sorts, see table.

A needle roller and cage assembly contains needle rollers of one sort only. The sort is printed on the packaging and is colour coded.

<table>
<thead>
<tr>
<th>Standard needle roller sorts</th>
<th>Needle roller sort</th>
<th>Colour coding</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sort pair</strong></td>
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</tr>
<tr>
<td><strong>Colour coding</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>0 – 2 / –1 –3</td>
<td>Red</td>
</tr>
<tr>
<td>Blue</td>
<td>–2 –4 / –3 –5</td>
<td>Blue</td>
</tr>
<tr>
<td>White (grey)</td>
<td>–4 –6 / –5 –7</td>
<td>White (grey)</td>
</tr>
</tbody>
</table>

**External guidance**

Needle roller and cage assemblies KZK (for example for crank pins) are externally guided, which means that the cage is radially guided with little clearance by the bore.

The radial movement of the cage relative to the bore and the rolling elements is as small as possible.

**Operating temperature**

Needle roller and cage assemblies with a plastic cage can be used at operating temperatures from $-20 \, ^\circ C$ to $+120 \, ^\circ C$. 
Needle roller and cage assemblies

**Design and safety guidelines**

**Design of adjacent parts**

The bores and pins for the needle roller and cage assemblies must be produced as rolling bearing raceways. The roughness must be Ra 0.2 (Rz 1). The roundness and parallelism of the raceways should be IT3.

The rolling bearing raceways should be designed as follows:
- Case hardened to at least 0.3 mm deep; the surface hardness must be at least 670 HV + 170 HV.
- The lateral running surfaces must be precision machined (Ra 2 recommended) and wear-resistant; axial washers should be fitted if necessary.

Axial washers and shaft shoulders should be produced as wear-resistant surfaces, for example by hardening.

**Raceway width**

The raceway width must be at least equal to the cage width Bc (Bc is produced with a minus (−) tolerance); values for Bc, see dimension tables. The distance between the axial limit surfaces should therefore be tolerated to H12, *Figure 1*. The axial running surfaces for the needle roller and cage assemblies must be precision machined (Ra 2 recommended) and wear-resistant.

![Figure 1](image)

**Axial washer**

Bc = cage width

Ra = surface roughness

*Figure 1*

Raceway width and axial running surfaces
Axial location  Needle roller and cage assemblies must be axially located by means of an appropriate adjacent construction design. If location is by means of snap rings or retaining rings, an axial washer must be arranged in each case between the rings and the needle roller and cage assembly. It must be ensured that there is sufficient interference between the ring and the washer. Planetary gears must be axially located directly on the adjacent construction by means of axial washers, Figure 1, page 56.

Radial internal clearance  The radial internal clearance is dependent on the speed, rigidity and accuracy of the adjacent parts. This can be determined by sorting of the needle sort. For simplification, the mean values of the needle roller sorts can be used.

Example  Determining the radial internal clearance using the mean value of the needle roller sort: needle roller sort 0 –2, mean value –1.
**Needle roller and cage assemblies**

**Single row**

**Dimension table** - Dimensions in mm

<table>
<thead>
<tr>
<th>Designation</th>
<th>Mass m (g)</th>
<th>Dimensions Fw, Ew, Bc</th>
<th>Basic load ratings dyn. Cfr N, stat. Cor N</th>
<th>Fatigue limit load Cr stat. N, Cur N</th>
<th>Limiting speed ng min⁻¹, nB min⁻¹</th>
<th>Reference speed</th>
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### Dimension Table (continued) - Dimensions in mm

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<tr>
<th>Designation</th>
<th>Mass ( m )</th>
<th>Dimensions</th>
<th>Basic Load Ratings</th>
<th>Fatigue Limit Load</th>
<th>Limiting Speed</th>
<th>Reference Speed</th>
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<td>( C_{stat} )</td>
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</table>
## Needle roller and cage assemblies

**Single row**

**Double row**

### Dimension table (continued) - Dimensions in mm

<table>
<thead>
<tr>
<th>Designation</th>
<th>Mass m (g)</th>
<th>Dimensions</th>
<th>Basic load ratings</th>
<th>Fatigue load ratings</th>
<th>Limiting speed</th>
<th>Reference speed</th>
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<tbody>
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### Needle roller and cage assemblies

**Single row**

**Double row**

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## Needle roller and cage assemblies

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**Double row**

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Needle roller and cage assemblies
Single row
Externally guided

1) The needle roller and cage assemblies are available by agreement only.
Production is dependent on economically viable quantities.

2) The designation indicates the dimensions.
For a precise ordering designation, please contact the Schaeffler engineering service.

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<th>Basic load ratings</th>
<th>Fatigue limit load</th>
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</table>

1) The needle roller and cage assemblies are available by agreement only.
Production is dependent on economically viable quantities.

2) The designation indicates the dimensions.
For a precise ordering designation, please contact the Schaeffler engineering service.
Product overview Needle rollers

Needle roller

| NRB | 00010A6C 00010A6C |
Needle rollers

Features
Needle rollers are the basic elements of needle roller bearings. They are made from through hardened rolling bearing steel 100Cr6 to DIN 17230, have a hardness of at least 670 HV and conform to DIN 5402-3/ISO 3096-B with flat end faces.

The ends of the needle rollers are profiled. Due to this profiling, the outside surfaces have a curved transition to the end faces. This reduces the edge stresses at the ends of the rolling elements.

Needle rollers are available in the diameter range from 1 mm to 6 mm, in lengths from 2 mm to 43.8 mm and in grade G2.

The further information on needle rollers in Catalogue HR 1, Rolling Bearings, chapter Rolling Elements must be observed.

Sorts
Needle rollers are divided into sorts with very small diameter and length tolerances. Each sort is packed separately and the lower deviation is marked on the packaging.

One pack contains needle rollers of one sort only. In a delivery comprising several packs, the sort may differ from one pack to another.

Needle rollers of only one sort should be used in one bearing arrangement.

Special designs are available by agreement and for economically viable quantities only.

Accuracy
The dimensional and geometrical accuracy conforms to DIN 5402-3/ISO 3096.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Deviations and tolerances for diameter $D_w$</th>
<th>Roundness</th>
<th>Roughness $R_a$</th>
<th>Length tolerance</th>
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<td>Tolerance of one sort µm max.</td>
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1) The roundness is produced in accordance with DIN 1101. The tolerance values apply at the centre of the needle rollers.
2) Preferred sorts are printed bold.
### Needle rollers

**Designation**: Dimensions in mm

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<th>Mass $^1$</th>
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<td>23.8</td>
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1) In each case for 1000 pieces.

2) Mean values;
   the transition to the profiled outside surface can only be estimated.
Product overview

Full complement needle roller arrangements

Full complement needle roller arrangement
Full complement needle roller arrangements

Features

Full complement needle roller arrangements completely fill the available space with needle rollers. This gives particularly compact bearing arrangements that have very high load carrying capacity and high rigidity. They allow bearing arrangements with high radial runout accuracy and a defined radial internal clearance, dependent on the geometrical accuracy of the raceways.

Such bearing arrangements are particularly suitable for swivel motion and high radial loads.

For permissible speeds, please contact the Schaeffler engineering service.

Design of full complement needle roller arrangements

The following must be taken into consideration in the design of full complement needle roller arrangements:

- the raceway dimensions for the shaft and housing bore
- the rolling element diameter
- the number of rolling elements.

Raceway design

<table>
<thead>
<tr>
<th>Requirements for the bearing arrangement</th>
<th>Tolerance zone</th>
<th>Surface quality</th>
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<td>G7</td>
<td>h6 Ra 0,2 (Ra 1)</td>
</tr>
<tr>
<td>High</td>
<td>G6</td>
<td>g5 Ra 0,2 (Ra 1)</td>
</tr>
</tbody>
</table>

For each bearing arrangement, needle rollers of one sort only should be used.

The shaft and housing bore must be designed for use as rolling bearing raceways, see table.

The axial running surfaces for the needle rollers must be precision machined (Ra 2 recommended) and wear-resistant, Figure 1.

In order to restrict axial movement, a clearance “s” of 0,2 mm to 0,4 mm must be observed, Figure 1.

Figure 1

Axial running surfaces and axial clearance
**Full complement needle roller arrangements**

**Determination of basic load ratings**

The basic load ratings of full complement needle roller arrangements are determined from the following equations:

\[
L_{we} = L_w - 2 \cdot r_{min}
\]

\[
C_r = k_c \cdot L_{we}^{7/6}
\]

\[
C_{0r} = \frac{44}{1 + D_w/F} \cdot D_w \cdot L_{we} \cdot Z
\]

- \(L_{we}\) mm Effective rolling element length
- \(L_w\) mm Rolling element length, nominal dimension
- \(r_{min}\) mm Minimum axial chamfer distance of the rolling element, see page 68
- \(C_r, C_{0r}\) N Basic radial dynamic or static load rating
- \(k_c\) Basic load rating factor, see table
- \(D_w\) mm Rolling element diameter
- \(F\) mm Raceway diameter of shaft
- \(Z\) – Number of rolling elements.

**Example**

The full complement needle roller arrangement in this case comprises 24 needle rollers NRB3×11,8G2.

The raceway dimensions and basic load ratings \(C_r, C_{0r}\) are to be determined.

<table>
<thead>
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<sup>1)</sup> Values from table, page 76.

**Effective rolling element length**

\(L_{we} = 11.8 - 2 \cdot 0.2 = 11.4\)

**Basic dynamic load rating \(C_r\)**

\(C_r = 2 \cdot 2984 \cdot 11.4^{7/6} = 19800\) N

**Basic static load rating \(C_{0r}\)**

\[
C_{0r} = \frac{44}{1 + 3/22,022} \cdot 3 \cdot 11.4 \cdot 24 = 31440\) N
**Determination of circumferential clearance**

The circumferential clearance TES is valid for rolling element diameters $D_W \leq 6$ mm.

The following minimum values must be observed for the TES:
- for $D_W \leq 3,5$ mm $= 0,1$ mm
- for $D_W > 3,5$ mm and at least 0,15 mm.

\[
TES = 5 \cdot 10^{-2} \times Z
\]

**TES mm**
Circumferential clearance, Figure 2

**Z**
Number of rolling elements, Figure 2.

**Determination of raceway dimensions**

The only valid dimensions are given in the table, page 76:

\[
F = \frac{D_W + TES \times Z}{\sin \left( \frac{180}{Z} \right)}
\]

\[
E = F + 2 \times D_W
\]

**F** mm
Raceway diameter of shaft, Figure 2

**$D_W$ mm**
Rolling element diameter, Figure 2

**E** mm
Raceway diameter of housing bore, Figure 2.

---

1. Radial operating clearance

\[ TES = \text{circumferential clearance} \]
\[ D_w = \text{rolling element diameter} \]
\[ Z = \text{number of rolling elements} \]
\[ F = \text{raceway diameter of shaft} \]
\[ E = \text{raceway diameter of housing bore} \]

*Figure 2*

Nominal dimensions and tolerances
Full complement needle roller arrangements

Determination of radial internal clearance

\[ s_{\text{min}} = E_{\text{min}} - F_{\text{max}} - 2 \times D_{W_{\text{max}}} \]

\[ s_{\text{max}} = E_{\text{max}} - F_{\text{min}} - 2 \times D_{W_{\text{min}}} \]

- \( s_{\text{min}}, s_{\text{max}} \) \( \mu m \)
- Minimum and maximum radial internal clearance
- \( E_{\text{min}}, E_{\text{max}} \) \( \text{mm} \)
- Minimum and maximum raceway diameter of housing bore
- \( F_{\text{min}}, F_{\text{max}} \) \( \text{mm} \)
- Minimum and maximum raceway diameter of shaft
- \( D_{W_{\text{min}}}, D_{W_{\text{max}}} \) \( \text{mm} \)
- Minimum and maximum possible diameter of needle roller sort used.

Example

Needle roller sort 0–2

\[ s_{\text{min}} = 26.029 \text{ mm} - 20.022 \text{ mm} - 2 \times 3.000 \text{ mm} = 7 \mu m \]

Needle roller sort –5–7

\[ s_{\text{max}} = 26.050 \text{ mm} - 20.009 \text{ mm} - 2 \times 2.993 \text{ mm} = 55 \mu m \]
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### Full complement needle roller arrangements

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</table>
Product overview

Full complement needle roller sets

Full complement needle roller set
Single row or multiple row with transport sleeve inside and outside

VRS
**Full complement needle roller sets**

**Features**

In the case of full complement needle roller arrangements, Schaeffler supplies the needle rollers and the customer assembles his bearing arrangement himself according to the information in section Full complement needle roller arrangements, see page 71.

In the case of full complement needle roller sets (single row or multiple row), Schaeffler supplies the finished bearing set VRS for mounting. The rolling elements are protected against damage and loss by means of plastic transport sleeves.

For full complement needle roller sets, the following information must be provided by the customer:

- the design envelope
- the basic load ratings required
- the speeds present
- the type of bearing lubrication.

The data relevant to the bearing set and its mounting are described in the customer delivery drawing.

For permissible speeds, please contact the Schaeffler engineering service.
**Product overview**  **Spherical roller bearings**

<table>
<thead>
<tr>
<th>Cylindrical bore</th>
<th>Design E1</th>
</tr>
</thead>
<tbody>
<tr>
<td>223..-E1</td>
<td></td>
</tr>
</tbody>
</table>

![Cylindrical bore diagram](image)
Spherical roller bearings

Features
Spherical roller bearings are double row, self-retaining units comprising solid outer rings with a concave raceway, solid inner rings with a cylindrical bore and barrel rollers with cages. The inner rings have cylindrical bores. The symmetrical barrel rollers orient themselves freely on the concave outer ring raceway. This allows compensation of misalignments and tooth deviations.

Spherical roller bearings can be used in planetary gears where particularly economical solutions are required and low speeds are present. In this case, they are used without an outer ring. Spherical roller bearings can be lubricated with oil or grease. The further information on spherical roller bearings in Catalogue HR 1, Rolling Bearings must be observed.

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

Minimum radial load
In order to achieve slippage-free operation, a minimum radial load \( F_{r\,\text{min}} \) of the order of \( P/C_i > 0.02 \) is necessary.

Figure 1
Gear with spherical roller bearing
Product overview  Tapered roller bearings

Single row

320
Tapered roller bearings

**Features**

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

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

The bearings are supplied in an open design. They can be lubricated with oil or grease.

The further information on tapered roller bearings in Catalogue HR 1, Rolling Bearings must be observed.

**Radial and axial load carrying capacity**

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

They must normally be axially adjusted against a second bearing in a mirror image arrangement. This bearing combination is mounted in an O or X arrangement, *Figure 1*.

**Matched bearings**

These tapered roller bearings are mounted in pairs in an O or X arrangement. They can thus support high axial forces from both directions as well as moment loads.

Tapered roller bearings in an O or X arrangement have the advantage that the bearing arrangement can be set clearance-free if necessary. This solution is applied, for example, in wind turbine gearboxes.

**Minimum radial load**

In order to ensure operation without slippage, the bearings must be subjected to a minimum load $F_{r_{\text{min}}}$ in a radial direction.

In continuous operation, a minimum radial load of the order of $P/C_r > 0.02$ is necessary for roller bearings with cage.
Special solutions
Special solutions

**X-life**
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**Cages for high accelerations**
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**Coated bearings**
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Special solutions

Standard bearings for planetary gearboxes have a wide scope of performance characteristics and are adequate for most applications. If the application places greater requirements on the bearings, Schaeffler can develop special solutions in partnership with the customer. The Schaeffler engineering service should be involved in the design process as early as possible.

Many bearings for planetary gearboxes are available in X-life quality. The use of state of the art manufacturing technologies has resulted in a better, more uniform surface over the whole contact face between the rolling elements and raceway. As a result, under identical load there is a significant reduction in the stress conditions present on the rolling elements and raceway. The improved surface quality gives reduced friction and lower bearing temperatures, running resistance is lower and less strain is placed on the lubricant.

Thanks to such improvements, the basic dynamic load ratings are significantly higher than those of the previous designs. This results in an increased basic rating life. If the previous rating life is still taken as a basic requirement, the bearing arrangement can then be subjected to a higher load.

In the case of bearings without an outer ring, particular requirements must be observed for the design of the raceway in the planetary gear, see section Raceways for bearings without inner and/or outer ring, page 19.

Cage design

The cage has the following functions:

- to separate the rolling elements from each other in order to minimise friction and heat generation
- to maintain the rolling elements at the same distance from each other in order to ensure uniform load distribution
- to guide the rolling elements in the load-free zone of the bearing.

Rolling bearing cages are subdivided into sheet metal and solid cages.

Aluminium cage

If aluminium is used as a material, the mass of these externally guided cages can be reduced, Figure 1. They are suitable for applications with moderate to high accelerations.

Figure 1

Aluminium cage
Steel cage

Steel cages are suitable for high temperatures and are unaffected by synthetic oils and greases, Figure 2. The small cage cross-section gives good oil flow within the bearing.

Figure 2
Steel cage

Cages for high accelerations

High accelerations, such as those occurring in input stages or in centrifuges, require special bearing designs.

Special cages

The suitability of bearings is influenced to a significant degree by the use of a cage as well as its specific version and design. Under extremely high accelerations, needle roller and cage assemblies, bearings with an externally guided cage (KZK) or a special brass cage with optimised stress characteristics are required, Figure 3. In these cases, please consult the Schaeffler engineering service.

Figure 3
Optimised cage for high accelerations
Special solutions

Bearing arrangements with optimised mass

Gearboxes are increasingly compact, with increasing power levels and reduced mass, placing particular requirements on the rolling bearings.

Schaeffler has been a leader in forming technology for many years. This technology can be used for the economical production of bearing rings of extremely small cross-section with high load carrying capacity and rigidity, Figure 4.

Production of these bearings is conditional on sufficiently large quantities.

Bearing rings of very small cross-section

Schaeffler has been a leader in forming technology for many years. This technology can be used for the economical production of bearing rings of extremely small cross-section with high load carrying capacity and rigidity, Figure 4.

Production of these bearings is conditional on sufficiently large quantities.

Floating planetary gear bearing arrangements

In the case of planetary gear pins supported on one side, the transition from the pin to the planet carrier is subjected to bending loads, which are high in some cases.

The fracture sensitivity at this point can be significantly reduced by appropriate radii. For this reason, bearings for these applications have an edge transition with large dimensions on one side of the inside diameter, Figure 5.

Schaeffler has a large number of such special bearings.

Optimised edge radii

The fracture sensitivity at this point can be significantly reduced by appropriate radii. For this reason, bearings for these applications have an edge transition with large dimensions on one side of the inside diameter, Figure 5.

Schaeffler has a large number of such special bearings.
Axial location of bearings

In addition to the design examples on pages 24 to 26, a special solution for the axial location of bearings has also proven successful in particular applications.

Location by means of L-section rings

Axial location in the planet and the guidance of rolling elements can be achieved, instead of two retaining rings and two axial washers, Figure 1, page 24, by using two L-section rings (snap rings BRL). This reduces the number of components and gives easier mounting.

The use of L-section rings can be beneficial for larger quantities, with production carried out by agreement.

Coated bearings

Standard bearings have a high performance capacity, a long operating life and are highly suitable for most bearing arrangement tasks. In order to increase the bearing operating life, coatings of various types may be used in unusual operating conditions.

Black oxide coating

Black oxide coating is a highly effective and economical coating method. This surface coating improves the running-in behaviour and is used where there is a risk of smearing, Figure 6.

If low speeds under high loads are present in planetary sets, black oxide coating gives a significantly higher wear resistance and thus a longer operating life.

Further information can be found in publication TPI 186, Higher Performance Capacity through the Use of Coatings.

Figure 6
Bearing with black oxide coating to prevent smearing

Coated cylindrical roller bearing RSL without outer ring
Applications in planetary gearboxes
### Applications in planetary gearboxes

<table>
<thead>
<tr>
<th>Application</th>
<th>Requirements</th>
<th>Design Solution</th>
<th>Products Used</th>
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<td><strong>Pitch and yaw gearbox for wind turbines</strong></td>
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<td>Requirements</td>
<td>Design solution</td>
<td>Products used</td>
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<td></td>
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<tr>
<td><strong>Slewing gear drive for crawler excavators</strong></td>
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<td></td>
<td></td>
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<td></td>
<td>Requirements</td>
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<td>Products used</td>
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<tr>
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<tr>
<td><strong>Planetary gearbox with front-mounted spur gear stage</strong></td>
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<tr>
<td></td>
<td>Requirements</td>
<td>Design solution</td>
<td>Products used</td>
</tr>
</tbody>
</table>
Pitch and yaw gearbox for wind turbines

The rotatable nacelle of a wind turbine is located at a height of up to 120 m. It contains almost the complete electronic system as well as the drive train and the generator. Since the rotor blades are up to 60 m long, such turbines are subjected to enormous forces in stormy wind conditions.

Ways must be found to manage these forces. The nacelle therefore contains mechanical components that are electronically controlled. This ensures that the rotor and rotor blades are always optimally positioned relative to the wind. In extreme situations, the forces acting on the construction can be reduced by adjustment of the rotor blades.

**Requirements**

Slewing drives have proved successful for aligning the rotor in the direction of the wind. The slewing drive, also known as a “yaw drive”, must be very compact but must also have very high operational security, be of a robust design and require very little maintenance.

The drive has a four-stage planetary gearbox. This type of gearbox is characterised by the space-saving construction with coaxially arranged components in the planetary set.

The planetary sets 1 and 2 transmit high and moderate drive speeds under low load. On the output side, incorporating the planetary sets 3 and 4, moderate and high moments are present at low speeds.

The output bearing on the single-piece output pinion shaft is subjected to high radial forces as a result of the high torques.

<table>
<thead>
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<tr>
<td>Output torque</td>
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<tr>
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<td>15 300 Nm</td>
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<tr>
<td>max.</td>
<td>25 000 Nm</td>
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</table>
**Design solution**

The input shaft is supported by a single row deep groove ball bearing. Due to their low frictional torque, these are suitable for high speeds.

The planetary gears are supported by full complement single row and double row cylindrical roller bearings. The single row bearings in stages 1 and 2 are designed for high speeds at low load, while the double row bearings in stages 3 and 4 are designed for high loads at low speed. The rolling elements then run directly in the bore of the planetary gears. As a result, the bearings require very little space. The full complement design ensures high load carrying capacity.

The output shaft is supported in a cylindrical roller bearing (axially free) and a spherical roller bearing (locating bearing). The cylindrical roller bearing has a roller set with increased capacity and is thus designed for extremely high radial load carrying capacity.

The spherical roller bearing on the pinion side supports axial loads from both directions as well as high radial loads and compensates shaft deflections and misalignment of the bearing seats.

---

**Products used**

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<td>Full complement single row cylindrical roller bearings RSL (special design)</td>
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<td>4, 5</td>
<td>Full complement double row cylindrical roller bearings RSL (special design)</td>
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<td>6</td>
<td>Cylindrical roller bearing NJ220-E.M1 (as non-locating bearing)</td>
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<tr>
<td>7</td>
<td>Spherical roller bearing 23024-E1A-M (locating bearing)</td>
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Hydraulic drive unit

Hydraulic compact drives are used as traction drives in tracklaying and wheeled vehicles.

The drive and integrated hydraulic motor is located opposite the idler wheel and is responsible for driving the chain or wheel. The integrated multi-disc stop brake ensures that the device is stopped securely.

Requirements

The traction drive has a multi-stage planetary gearbox.

The planetary stage 1 transmits high drive speeds under low load while the planetary stage 2 on the output side transmits high moments at low speeds.

The planetary stages transmit the force to the ring gear, which can also serve as the wheel hub of the machine.

Traction drives often work for long periods and under extremely challenging conditions. Nevertheless, they must have very high operational security and require very little maintenance.

Operating data

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<th>Drive moment</th>
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<td>7 000 Nm – 1 300 000 Nm</td>
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Design solution

One of the challenges in relation to traction drives is the limited space. The planetary gears are therefore supported by full complement cylindrical roller bearings without outer rings. The rolling elements thus run directly in the bore of the planetary gears. As a result, the bearings require very little radial space.

The full complement design ensures high load carrying capacity. The bearings are axially located in the planetary gear by means of retaining rings. In order to reduce the notch stresses in the planet pin, the bearing inner rings have a larger radius on one side.

Robust support of the main bearing is made possible by a low-clearance angular contact ball bearing with a cage. In the case of very high loads, angular contact roller bearings preloaded clearance-free or tapered roller bearings in an O arrangement can alternatively be used.

Operation free from clearance improves the load carrying capacity of the tooth set and ensures quiet, uniform running.

Products used

1. Full complement single row cylindrical roller bearing without outer ring RN (special design)
2. Full complement double row cylindrical roller bearing RNN with two axial washers and one snap ring (special design)
3. Double row low-clearance angular contact ball bearing with cage
   Alternatively: two tapered roller bearings 302, 322 in O arrangement

Figure 2
Bearing positions in the traction drive
Slewing gear drive for crawler excavators

The slewing gear drive is used in the latest generation of hydraulic crawler excavators and is arranged between the upper and lower structure. The teeth on the output shaft mesh with the teeth on a slewing ring to give slewing and rotary motion of the upper structure. The drive is powered by a hydraulic motor. The slewing stop mechanism is controlled by a multi-disc holding brake.

Requirements

The slewing ratio is provided by means of a multi-stage planetary gearbox. This type of gearbox is characterised by its highly compact construction with coaxially arranged components in the planetary set.

The planetary stage 1 transmits high drive speeds under low load while the planetary stage 2 on the output side transmits high moments at low speeds.

The output bearing on the single-piece output pinion shaft is subjected to high radial forces as a result of the high torques.

Slewing gear drives operate on a daily basis under extreme conditions. They must have very high operational security and require very little maintenance.

Operating data

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Picture source:
Liebherr-Werke Biberach GmbH

Figure 1
Slewing gear drive
Design solution

The planetary gears are supported by full complement double row cylindrical roller bearings. The rolling elements run directly in the bore of the planetary gears. As a result, the bearings require very little space. The full complement design ensures the necessary high load carrying capacity. In order to reduce the notch stresses in the planet pin, the inner rings have a larger radius on one side. The bearings are axially located in the planetary gear by means of retaining rings.

The output pinion shaft is supported by two tapered roller bearings adjusted clearance-free in an O arrangement. The support base H, the distance between the apexes of the contact cones, is wider in the O arrangement than in an X arrangement. Operation free from clearance improves the load carrying capacity of the pinion/slewing ring tooth arrangement. As semi-locating bearings, the bearings can support axial forces in one direction and high radial forces. The output bearing provides an axial counterstay and supports the high radial loads present at the pinion as a result of the large torques.

The input bearing on the pinion shaft is lubricated by the oil splash lubrication of the planetary gearbox and requires no further maintenance. The output bearing is greased for life.

Products used

- Full complement cylindrical roller bearings without outer ring RNN (special design)
- Tapered roller bearings 302, 322 in O arrangement
Planetary gearbox with front-mounted spur gear stage

Planetary gearboxes with a front-mounted spur gear stage are used in various industrial sectors. When used in roll mill drives, they are not only an effective technical component but also a highly economical design solution.

Such a drive is economical thanks to its modular concept in which numerous basic parts can be standardised. These include not only the planetary stages and housing parts but also input and output components.

Requirements

The output power is provided by the multi-stage planetary gearbox. High manufacturing accuracies and simulation methods such as FEM ensure optimised distribution of load across the planetary gears.

The front-mounted spur gear stage transmits high drive speeds under low load to the preliminary stage. High moments must be transmitted at low speeds in the main stage.

Operating data

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<td>Torque</td>
<td>22 000 Nm – 2 600 000 Nm</td>
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</table>
**Design solution**

The input shaft is supported by a spherical roller bearing as a locating bearing and a cylindrical roller bearing as a non-locating bearing. High speeds under low load are transmitted from a hydraulic motor to the shaft. The spur gear stage with straight teeth comprises the input shaft and the intermediate shaft.

The planetary gears in the preliminary stage are guided by two full complement cylindrical roller bearings RN-2S without outer ring. These bearings offer high rigidity and are easy to mount. An economical alternative would be a spherical roller bearing if the required rigidity of the construction is not too high.

Two full complement single row cylindrical roller bearings SL1830 act as semi-locating bearings and are arranged on the outer sides in the planetary gears of the main stage. These bearings have high load carrying capacity. In order to achieve the maximum possible load carrying capacity and rigidity, double row cylindrical roller bearings SL1850..2S-BR-C3 (sorted as semi-locating bearings) may be used as an alternative. Bearings with the suffix BR have a black oxide coating. This improves the wear resistance of the bearing.

The output shaft is supported by two semi-locating bearings SL1818.

---

**Figure 2**

Bearing positions in the planetary gearbox

**Products used**

1. Spherical roller bearing (locating bearing)
2. Cylindrical roller bearing (non-locating bearing)
3. Cylindrical roller bearing (semi-locating bearing)
4, 5. Full complement cylindrical roller bearings RN-2S, without outer ring, 4 alternatively: spherical roller bearing, 5
6, 7. Full complement single row cylindrical roller bearings SL1830, 6 alternatively: double row cylindrical roller bearing SL1850-2S, 7
8. Cylindrical roller bearing SL1818 (semi-locating bearing)
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