Crossed roller bearings

for high precision applications

Publication KSX
This technical publication has been produced with a great deal of care and attention and all data have been checked for their accuracy. However, no liability can be assumed for any incorrect or incomplete data.

⚠️ Product pictures are for illustrative purposes only and must not be used for design work.

Designs must only be prepared in accordance with the technical information, dimension tables and dimension drawings in this edition. In case of doubt, please consult the INA engineering service.

Due to constant development of the product range, we reserve the right to make modifications.

The sales and delivery conditions in force are those which form the basis of the invoices and contracts.

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INA crossed roller bearings SX have long been the optimum solution in technical and economic terms where compact, easy-to-fit bearings with high tilting moment load carrying capacity, rigidity and accuracy are required in a bearing position. These bearings can support radial loads, axial loads from both directions, tilting moments and any combination of loads. As a result, conventional bearing arrangements with radial and axial bearings can generally be reduced to a single bearing position. This reduces, in some cases considerably, the costs and work required in the design of the adjacent construction and the fitting of bearings.

In order to further increase the customer benefits and range of applications for bearing arrangements with crossed roller bearings, INA has expanded the product range for the small and medium diameter range to include the following series:

- crossed roller bearings XSU 08
  - these crossed roller bearings are preloaded and the bearing rings are screw mounted directly on the upper and lower construction

- crossed roller bearings XV
  - in these crossed roller bearings, the bearing clearance is set or the bearing preloaded by means of the split inner ring, while the outer ring is simply screw mounted on the adjacent construction.

These new series allow even more flexible use of crossed roller bearings, for example in machine tools, lifting gear, conveying equipment and vehicle components, precision engineering and medical equipment and particularly in robots and handling systems.

This publication KSX has been completely revised from the previous edition. It gives information on the standard range of proven crossed roller bearings SX and the new series XSU and XV. Any information in previous editions which does not concur with the data in this edition is therefore invalid.

INA-Schaeffler KG
Herzogenaurach (Germany)
## Product range

### Overview/comparison

### Characteristic | Bore diameter | Load carrying capacity | Tilting rigidity | Accuracy | Friction
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<td>Crossed roller bearings</td>
<td>SX</td>
<td>70 mm to 500 mm</td>
<td>radial stat.</td>
<td>radial</td>
<td></td>
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<tr>
<td></td>
<td>XV</td>
<td>30 mm to 110 mm</td>
<td>axial on both sides stat.</td>
<td>axial</td>
<td></td>
</tr>
<tr>
<td></td>
<td>XSU 08</td>
<td>130 mm to 360 mm</td>
<td>tilting moment stat.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>XSU 14</td>
<td>344 mm to 1024 mm</td>
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1) The data refer to the smallest and largest bearing diameters.

2) Design of crossed roller bearing.
### Maximum circumferential speed with grease lubrication

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<td><strong>4 m/s</strong> <em>(n×D_M = 76 400)</em> with standard clearance</td>
<td>8 m/s <em>(n×D_M = 152 800)</em> with standard clearance</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>44</td>
</tr>
<tr>
<td><strong>2 m/s</strong> <em>(n×D_M = 38 200)</em> with preload</td>
<td>4 m/s <em>(n×D_M = 76 400)</em> with preload</td>
<td>4 m/s <em>(n×D_M = 76 400)</em> with preload</td>
<td>■</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2 m/s</strong> <em>(n×D_M = 38 200)</em> with preload</td>
<td>4 m/s <em>(n×D_M = 76 400)</em> with preload</td>
<td>adjustable from clearance-free to preloaded</td>
<td>■</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2 m/s</strong> <em>(n×D_M = 38 200)</em> with preload</td>
<td>4 m/s <em>(n×D_M = 76 400)</em> with preload</td>
<td>■</td>
<td></td>
<td></td>
<td>45</td>
</tr>
<tr>
<td><strong>2 m/s</strong> <em>(n×D_M = 38 200)</em> with preload</td>
<td>4 m/s <em>(n×D_M = 76 400)</em> with preload</td>
<td>■</td>
<td></td>
<td></td>
<td>45</td>
</tr>
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---

2) Determined at 20% of maximum permissible tilting moment, without axial or radial load and with moderate preload.

3) Special design with INA special plating Corrotect®. Available by agreement.
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## Product index

sorted alphanumerically

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<th>Description</th>
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</thead>
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<td>SX</td>
<td>Crossed roller bearing corresponding to dimension series 18 to DIN 616, not sealed, greased, with clearance, reduced clearance or preloaded, outer ring circumferentially split and held together by three retaining rings</td>
</tr>
<tr>
<td>45</td>
<td>XSU</td>
<td>Crossed roller bearing, sealed on both sides, greased, preloaded, centred on the inside and outside diameter, bearing rings can be screw mounted directly on the adjacent construction</td>
</tr>
<tr>
<td>44</td>
<td>XV</td>
<td>Crossed roller bearing, sealed on both sides, greased, with clearance, can be preloaded by locknut, inner ring circumferentially split, outer ring can be screw mounted directly on the adjacent construction</td>
</tr>
</tbody>
</table>
# Index of suffixes

<table>
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<th>Description</th>
</tr>
</thead>
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<td>Low clearance design</td>
</tr>
<tr>
<td>VSP</td>
<td>Bearing with preload</td>
</tr>
<tr>
<td>RR</td>
<td>Corrosion-resistant design with INA special plating Corrotect®</td>
</tr>
</tbody>
</table>
The ordering designation gives an abbreviated description of the crossed roller bearing. It consists of:
- the designation
- suffixes
  - for special bearing features only.

**Designation** (Figure 1)
Every crossed roller bearing has a designation. This is given in the *dimension tables* and describes the standard design of the bearing.
The designation consists of several parts. It indicates, taking the crossed roller bearing SX as an example:
- the type
  - crossed roller bearing SX
- the series
  - series 01
- the dimension series
  - dimension series 18 to DIN 616
- the dimension-specific part
  - size 24.

**Suffix** (Figure 2)
Suffixes are placed after the dimension-specific part. They indicate:
- the bearing clearance or preload
  - e.g. VSP for a preloaded bearing
- the special design
  - e.g. RR for the corrosion-resistant design.

**Ordering example, ordering designation** (Figure 3)
- Crossed roller bearing SX
- Series 01
- Dimension series 18 to DIN 616
- Size 24
- With preload VSP
- Corrosion-resistant RR

**Ordering designation:**
**SX 01 1824 VSP RR**

⚠️ The correct sequence of characters must be observed when ordering!
Unless stated otherwise in the text, the values used in this catalogue have the following symbols, units and definitions.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
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<tr>
<td>C</td>
<td>N</td>
<td>Basic dynamic load rating</td>
</tr>
<tr>
<td>C₀</td>
<td>N</td>
<td>Basic static load rating</td>
</tr>
<tr>
<td>Dₘ</td>
<td>mm</td>
<td>Rolling element pitch circle diameter</td>
</tr>
<tr>
<td>Dₚ</td>
<td>mm</td>
<td>Rolling element diameter</td>
</tr>
<tr>
<td>fₐ</td>
<td>–</td>
<td>Application factor</td>
</tr>
<tr>
<td>fₛ</td>
<td>–</td>
<td>Factor for additional safety</td>
</tr>
<tr>
<td>f₀ᵣ</td>
<td>–</td>
<td>Static radial load factor</td>
</tr>
<tr>
<td>Fₐ</td>
<td>kN</td>
<td>Dynamic bearing load (axial)</td>
</tr>
<tr>
<td>Fₐₜₐₜ</td>
<td>kN</td>
<td>Ultimate axial load</td>
</tr>
<tr>
<td>Fₚ</td>
<td>kN</td>
<td>Dynamic bearing load (radial)</td>
</tr>
<tr>
<td>F₀ₐ</td>
<td>kN</td>
<td>Static bearing load (axial)</td>
</tr>
<tr>
<td>F₀ₐₚ</td>
<td>kN</td>
<td>Equivalent bearing load (static)</td>
</tr>
<tr>
<td>F₀ₚ</td>
<td>kN</td>
<td>Static bearing load (radial)</td>
</tr>
<tr>
<td>kₘ</td>
<td>–</td>
<td>Dynamic load factor</td>
</tr>
<tr>
<td>L</td>
<td>10⁶ rev.</td>
<td>Basic rating life in millions of revolutions</td>
</tr>
<tr>
<td>L₁ₕ</td>
<td>h</td>
<td>Basic rating life in operating hours</td>
</tr>
<tr>
<td>Mₐₜ</td>
<td>Nm</td>
<td>Tightening torque for locknut</td>
</tr>
<tr>
<td>Mₜ</td>
<td>Nm</td>
<td>Breakaway torque with Mₐₜ</td>
</tr>
<tr>
<td>Mₘₘ</td>
<td>kg · cm²</td>
<td>Mass moment of inertia</td>
</tr>
<tr>
<td>Mₚₜ</td>
<td>kNm</td>
<td>Dynamic tilting moment load</td>
</tr>
<tr>
<td>Mₚₜₚ</td>
<td>kNm</td>
<td>Static tilting moment load</td>
</tr>
<tr>
<td>Mₚₜₚₚ</td>
<td>kNm</td>
<td>Equivalent tilting moment load (static)</td>
</tr>
<tr>
<td>n</td>
<td>min⁻¹</td>
<td>Operating speed of crossed roller bearing</td>
</tr>
<tr>
<td>nₜₕ</td>
<td>min⁻¹</td>
<td>Frequency of to and fro movement</td>
</tr>
<tr>
<td>p</td>
<td>–</td>
<td>Life exponent</td>
</tr>
<tr>
<td>Pₚₜₐₜ</td>
<td>kN</td>
<td>Equivalent dynamic axial bearing load</td>
</tr>
<tr>
<td>P₀ₚₜₐₜ</td>
<td>kN</td>
<td>Equivalent static axial bearing load</td>
</tr>
<tr>
<td>S₀</td>
<td>kN</td>
<td>Static load safety factor</td>
</tr>
<tr>
<td>δₜ</td>
<td>mm</td>
<td>Maximum permissible flatness deviation</td>
</tr>
<tr>
<td>ε</td>
<td>–</td>
<td>Load eccentricity parameter</td>
</tr>
<tr>
<td>γ</td>
<td>°</td>
<td>Half of swivel angle</td>
</tr>
</tbody>
</table>
The size of the crossed roller bearing required is dependent on the demands made on its:
- static and dynamic load carrying capacity
- life
- operational reliability.

**Dynamic load carrying capacity**, see page 14.

**Definition of static load carrying capacity**

Crossed roller bearings that undergo rotary motion only infrequently, undergo slow swivel motion, rotate only slowly or are subjected to load while stationary are dimensioned on the basis of their static load carrying capacity since the permissible load in these cases is determined not by material fatigue but by the load-induced deformations at the contact points between the rolling elements and raceways.

The static load carrying capacity is described by:
- the basic static load ratings \( C_0 \) (see *dimension tables*)
- the static limiting load diagrams Raceway and Fixing screws (see *dimension tables* and *calculation example*, page 13).

The size of a statically loaded crossed roller bearing for a particular application can therefore be checked in approximate terms using the basic static load ratings \( C_0 \) and the static limiting load diagrams.

**Checking the static load carrying capacity**

The static load carrying capacity can be checked in approximate terms only when:
- the load arrangement is in accordance with Figure 1
- all the requirements stated in this publication are fulfilled in relation to:
  - clamping rings, flange rings and fastening
  - fitting, lubrication and sealing.

Where load arrangements are more complex or the conditions are not fulfilled, please consult INA.

In order to check the static load carrying capacity, the following equivalent static operating values must be determined:
- the equivalent static bearing load \( F_{0q} \)
- the equivalent static tilting moment load \( M_{0q} \).

Checking is possible for applications with or without radial load.

**Determining the equivalent static bearing load without radial load and checking the static load carrying capacity in the static limiting load diagram Raceway**

If only axial and tilting moment loads are present:

\[
\begin{align*}
F_{0q} & = F_{0a} \cdot f_A \cdot f_S \\
M_{0q} & = M_{0k} \cdot f_A \cdot f_S
\end{align*}
\]

**F** \( F_{0q} \) kN
Equivalent axial bearing load (static)
**F** \( F_{0a} \) kN
Static axial bearing load
- **f** \( f_A \) Application factor (see Table 1, page 12)
- **f** \( f_S \) Factor for additional safety
- **f** \( f_{0r} \) Static radial load factor (see Figure 1)
**M** \( M_{0q} \) kNm
Equivalent tilting moment load (static)
**M** \( M_{0k} \) kNm
Static tilting moment load.

Using the values for \( F_{0q} \) and \( M_{0q} \), determine the load point in the static limiting load diagram Raceway. The load point must be below the raceway curve!

In addition to the raceway, check the dimensioning of the fixing screws as well (see *calculation example*, page 13)!

**Determining the equivalent static bearing load with radial load and checking the static load carrying capacity in the static limiting load diagram Raceway**

Radial loads can only be taken into consideration if the radial load \( F_{0r} \) is smaller than the basic static radial load rating \( C_0 \) according to the *dimension table*!

- Calculate the load eccentricity parameter \( \varepsilon \) using the formula.
- Determine the static radial load factor \( f_{0r} \) as follows:
  - determine the ratio \( F_{0r}/F_{0a} \) in Figure 1
  - from the ratio \( F_{0r}/F_{0a} \) and \( \varepsilon \), determine the static radial load factor \( f_{0r} \) from Figure 1.
- Determine the application factor \( f_A \) according to Table 1, page 12 and the safety factor \( f_S \) if required.
- Calculate the equivalent axial bearing load \( F_{0q} \) and the equivalent tilting moment load \( M_{0q} \) using the formulae.
- Using the values for \( F_{0q} \) and \( M_{0q} \), determine the load point in the static limiting load diagram Raceway (see *calculation example*, page 13). The load point must be below the raceway curve!


\[ \epsilon = \frac{2000 \cdot M_{0k}}{F_{0a} \cdot D_{M}} \]

\[ F_{0q} = F_{0a} \cdot f_A \cdot f_S \cdot f_{0r} \]

\[ M_{0q} = M_{0k} \cdot f_A \cdot f_S \cdot f_{0r} \]

\[ \epsilon \]

Load eccentricity parameter

\[ M_{0k} \quad \text{kNm} \]
Static tilting moment load

\[ F_{0a} \quad \text{kN} \]
Static bearing load (axial)

\[ D_{M} \quad \text{mm} \]
Rolling element pitch circle diameter (dimension tables)

\[ F_{0q} \quad \text{kN} \]
Equivalent bearing load (static)

\[ f_A \]
Application factor (see Table 1, page 12)

\[ f_S \]
Factor for additional safety

\[ f_{0r} \]
Static radial load factor (see Figure 1)

\[ M_{0q} \quad \text{kNm} \]
Equivalent tilting moment load (static).

**Figure 1** - Main load directions and static radial load factor \( f_{0r} \) for crossed roller bearings
Load carrying capacity and life
Static load carrying capacity

Application factors
The application factors \( f_A \) in Table 1 are empirical values. They take account of the most important requirements – e.g. the type and severity of operation, rigidity or running accuracy. If the precise requirements of an application are known, the values may be altered accordingly.

⚠ Application factors < 1 must not be used!
A large proportion of applications can be statically calculated using an application factor of 1 – e.g. bearings for gearboxes and rotary tables.
We recommend that, in addition to static calculation, the life should also always be checked (Dynamic load carrying capacity, page 14).

Table 1 · Application factors \( f_A \) for determining equivalent bearing load (static)

<table>
<thead>
<tr>
<th>Application</th>
<th>Operating/ requirement criteria</th>
<th>Application factor ( f_A )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robots</td>
<td>Rigidity</td>
<td>1.25</td>
</tr>
<tr>
<td>Antennae</td>
<td>Accuracy</td>
<td>1.5</td>
</tr>
<tr>
<td>Machine tools</td>
<td>Accuracy</td>
<td>1.5</td>
</tr>
<tr>
<td>Measuring equipment</td>
<td>Smooth running</td>
<td>2</td>
</tr>
<tr>
<td>Medical equipment</td>
<td>Smooth running</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Safety factors
The factor for additional safety is \( f_S = 1 \).
It is not normally necessary to factor in any additional safety in calculation.

⚠ In special cases – e.g. approval specifications, internal specifications, requirements stipulated by inspection bodies etc. – use the appropriate safety factor!
Calculation example
The static load carrying capacity of the crossed roller bearing SX 01 1860 is to be checked.

Given
- Static bearing load (axial) \( F_{oa} = 70 \text{ kN} \)
- Static bearing load (radial) \( F_{or} = 17.5 \text{ kN} \)
- Static tilting moment load \( M_{ok} = 22.5 \text{ kNm} \)
- Rolling element pitch circle diameter \( D_M = 340 \text{ mm} \)
- Application factor \( f_A = 1.25 \) (Table 1)
- Safety factor \( f_S = 1 \)

Required
- Static load carrying capacity of the bearing.

Solution
\[
\varepsilon = \frac{2000 \cdot M_{ok}}{F_{oa} \cdot D_M} = 1.89
\]
\[
\frac{F_{oz}}{F_{oa}} = \frac{17.5}{70} = 0.25 \quad \text{(Figure 1, page 11)}
\]
\[
f_{or} = 1.2 \quad \text{(Figure 1, page 11)}
\]
\[
F_{0q} = F_{oa} \cdot f_A \cdot f_S \cdot f_{or} = 70 \cdot 1.25 \cdot 1 \cdot 1.2 = 105 \text{ kN}
\]
\[
M_{0q} = M_{ok} \cdot f_A \cdot f_S \cdot f_{or} = 22.5 \cdot 1.25 \cdot 1 \cdot 1.2 = 33.75 \text{ kNm}
\]

Determining the load point in the static limiting load diagram – checking the static load carrying capacity
Using the values for \( F_{0q} \) and \( M_{0q} \), the load point in the static limiting load diagrams Raceway and Fixing screws is determined (see Figure 2 and Figure 3).

The load point is below the raceway and screw curves. The bearing is adequately dimensioned and thus suitable for the application.

Figure 2 · Static limiting load diagram Raceway – compressive load
Figure 3 · Static limiting load diagram Fixing screws – compressive load
Load carrying capacity and life
Dynamic load carrying capacity

Dynamically loaded crossed roller bearings – i.e. bearings undergoing predominantly rotary motion – are dimensioned in accordance with their dynamic load carrying capacity.

Definition of dynamic load carrying capacity
The dynamic load carrying capacity is determined by the fatigue behaviour of the material. The life as a fatigue period depends on the load and operating speed of the bearing and the statistical probability of the first occurrence of failure (for a definition, see also INA Catalogue 307).

The dynamic load carrying capacity is described by:
- the basic dynamic load ratings C (see dimension tables)
- the basic (calculated) rating life L or Lh.

The size of a dynamically loaded crossed roller bearing for a particular application can therefore be checked in approximate terms using the basic dynamic load ratings and the basis rating life.

Definition of basic rating life
The basis for calculation is the theory of probability, according to which a defined percentage of a sufficiently large group of apparently identical bearings achieves or exceeds a particular number of revolutions before the first evidence of material fatigue appears. Calculation is based on a requisite reliability of 90%.

The basic rating life is only an approximate value for guidance and comparative purposes!

Calculation of an adjusted rating life in accordance with ISO 281 is recommended if the nominal viscosity of the lubricant is not achieved for the specific operating load case (see INA Catalogue 307!).

Determining the basic rating life
The life formulae for L and Lh are only valid:
- with a load arrangement in accordance with Figure 1
- if all the requirements stated in this publication are fulfilled in relation to:
  - location (the bearing rings must be rigid or firmly connected to the adjacent construction)
  - fitting, lubrication and sealing
- if the load and speed can be regarded as constant during operation
  - if the load and speed are not constant, equivalent operating values can be determined which will cause the same fatigue conditions as the actual loads (see Equivalent operating values, INA Catalogue 307)
- if the load ratio Fr/Fa is ≥8.

If more complex load arrangements are present, the ratio Fr/Fa is > 8 or the conditions differ from those stated, please consult INA!

Determining the basic rating life for bearings subjected to combined loads
For bearings subjected to combined loads – bearings with axial, radial and tilting moment loads – the life L and Lh is calculated as follows:
- Calculate the load eccentricity parameter ε using the formula.
- Determine the ratio of the dynamic radial bearing load Fr to the dynamic axial bearing load Fa (Fr/Fa).
- Using the values for ε and the ratio Fr/Fa in Figure 1, determine the dynamic load factor kF.
- Calculate the equivalent dynamic axial bearing load Paxial = Fa × kF according to the formula.
- Enter the equivalent dynamic axial bearing load Paxial and the basic dynamic axial load rating Ca in the life formulae for L or Lh and calculate the life. If swivel operation is present, enter the operating speed n calculated using the formula in the life formula Lh.

Determining the basic rating life for bearings subjected to radial loads only
For slewing rings subjected to radial loads only, the following values are entered in the life formulae for L and Lh:
- instead of the equivalent dynamic axial bearing load Paxial, the equivalent dynamic radial bearing load Pradial (i.e. Fr)
- Pradial = Fr
- the basic dynamic radial load rating Cr.
Load eccentricity parameter

$$\epsilon = \frac{2000 \cdot M_k}{F_a \cdot D_M}$$

$$P_{\text{axial}} = k_F \cdot F_a$$

$$L = \left(\frac{C}{P_{\text{axial}}}\right)^p$$

$$L_h = \frac{16.666}{n} \cdot \left(\frac{C}{P_{\text{axial}}}\right)^p$$

$$n = n_{\text{osc}} \cdot \frac{\gamma}{90}$$

**Load eccentricity parameter**

- **M_k** kNm
  Dynamic tilting moment load
- **F_a** kN
  Dynamic bearing load (axial)
- **D_M** mm
  Rolling element pitch circle diameter (dimension tables)
- **P_{axial}** kN
  Equivalent dynamic axial bearing load.
  For slewing rings subjected to radial loads only, enter **P_{radial}**
- **k_F**
  Dynamic load factor (see Figure 1)
- **L** $10^6$ rev.
  Basic rating life in millions of revolutions
- **C_p, C_a** kN
  Basic dynamic axial or radial load rating according to dimension table.
  For slewing rings subjected to radial loads only, enter **C_p**
- **p**
  Life exponent for crossed roller bearings; $p = 10/3$
- **L_h** h
  Basic rating life in operating hours
- **n** min$^{-1}$
  Operating speed of crossed roller bearing
- **n_{osc}** min$^{-1}$
  Frequency of to and fro movement
- **\gamma** 
  Half of swivel angle
- **P_{radial}** kN
  Equivalent dynamic radial bearing load
- **F_r** kN
  Dynamic bearing load (radial).

**Figure 1** - Dynamic load factor $k_F$ for crossed roller bearings
Load carrying capacity and life
Dynamic load carrying capacity

Influences on the operating life of crossed roller bearings

The operating life is the life actually achieved by a crossed roller bearing. This can deviate significantly from the calculated basic rating life due to wear and/or fatigue.

Possible causes include:
- oscillating bearing motion with very small swivel angles – false brinelling
- vibration while the bearing is stationary
- unsuitable design or deformation of the adjacent construction
- excessively high operating temperatures
- incorrect maintenance or lubrication
- contamination
- incorrect fitting
- insufficient preload of the fixing screws.

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

Given
- Crossed roller bearing: SX 01 1820
- Element pitch circle diameter according to dimension table, page 48: \( D_M = 112 \) mm
- Basic dynamic load rating (axial) according to dimension table, page 49: \( C_a = 28 \) kN
- Life exponent for crossed roller bearings: \( p = 10/3 \)
- Dynamic bearing load (axial): \( F_a = 20 \) kN
- Dynamic bearing load (radial): \( F_r = 4 \) kN
- Dynamic tilting moment load: \( M_k = 1 \) kNm

Required
- Basic rating life \( L \) in millions of revolutions.

Solution

\[
\varepsilon = \frac{2000 \cdot M_k}{F_a \cdot D_M}
\]

\[
\varepsilon = \frac{2000 \cdot 1}{20 \cdot 112} = 0.89
\]

\[
\frac{F_r}{F_a} = \frac{4}{20} = 0.2
\]

\[
k_F = 2.1 \text{ (Figure 2)}
\]

\[
P_{\text{axial}} = k_F \cdot F_A
\]

\[
P_{\text{axial}} = 2.1 \cdot 20 \text{ kN} = 42 \text{ kN}
\]

\[
L = \left( \frac{C_a}{P_{\text{axial}}} \right)^{p/3}
\]

\[
L = \left( \frac{28}{42} \right)^{10/3} = 0.26 \cdot 10^6 \text{ revolutions}
\]
Fasteners

Static and dynamic load carrying capacity of fixing screws
INA precision locknuts

In addition to the raceway, the load carrying capacity of the fixing screws must also be checked. This is based on the information in the section Static load carrying capacity.

Conditions for checking load carrying capacity

The load carrying capacity of the fixing screws can be checked if the following conditions are fulfilled:

- the criteria in Static load carrying capacity are fulfilled
- the screws are tightened as specified using a torque wrench – screw tightening factor \( \alpha_A = 1.6 \)
- tightening torques according to Table 1, page 43
- the permissible contact pressure is not exceeded
- screws of the recommended size, quantity and grade are used.

Indicator of load carrying capacity

The load carrying capacity of the screws is described by:

- the curves in the limiting load diagrams Fixing screws (example: see Figure 1)
- the maximum permissible radial load \( F_{\text{perm}} \) (friction locking) in the dimension tables.

Static limiting load diagrams

The screw curves are shown in the static limiting load diagrams Fixing screws. The curves are based on screws of grade 10.9, tightened to 90% of their proof stress including the torsion content.

If screws of grade 8.8 or 12.9 are used, the equivalent static loads \( F_{\text{eq}} \) and \( M_{\text{eq}} \) (see Static load carrying capacity, page 10, must be converted using the following factors:

- grade 8.8 \( F_{\text{eq}} \times 1.65, M_{\text{eq}} \times 1.65 \)
- grade 12.9 \( F_{\text{eq}} \times 0.8, M_{\text{eq}} \times 0.8 \).

Checking the static load carrying capacity

The static load carrying capacity of the screw is limited by its proof stress.

Static load carrying capacity for applications without radial load

Determine the equivalent static bearing loads \( F_{\text{eq}} \) and \( M_{\text{eq}} \) (see: Determining the equivalent static bearing load without radial load, page 10).

Using the values for \( F_{\text{eq}} \) and \( M_{\text{eq}} \), determine the load point in the static limiting load diagram Fixing screws.

The load point must be below the appropriate screw curve (see example, Figure 1)!
Static load carrying capacity for applications with radial load

Determine the equivalent static bearing loads \( F_{0q} \) and \( M_{0q} \) (see: Determining the equivalent static bearing load with radial load, page 10).

Using the values for \( F_{0q} \) and \( M_{0q} \), determine the load point in the static limiting load diagram Fixing screws. The load point must be below the appropriate screw curve!

Influence of radial load on the static load carrying capacity of the fixing screws

If radial loads occur in uncentred bearing rings, the screw connections must prevent displacement of the bearing rings on the adjacent construction.

In order to check this:

- multiply the radial bearing load by an application factor \( f_A \) according to Table 1, page 12
- compare the values determined with the maximum permissible radial load \( F_{r \text{ perm}} \) in the dimension tables.

The maximum radial load \( F_{r \text{ perm}} \) of the fixing screws depends on their friction locking, which is stated for each bearing in the dimension tables and not on the radial load carrying capacity of the bearing!

If the radial load of the bearing is higher than the friction locking of the fixing screws according to the dimension table, or very high radial loads are present \( (F_r/F_d > 4) \), please consult INA!

Checking the dynamic load carrying capacity

The dynamic load carrying capacity corresponds to the fatigue strength of the screw.

Dynamic load carrying capacity

- Based on the dynamic loads present, determine the equivalent loads \( F_{0q} \) and \( M_{0q} \) according to the section
- instead of the application factor \( f_A \), always increase the operating load by the following factors:
  - grade 8.8 (factor 1.8)
  - grade 10.9 (factor 1.6)
  - grade 12.9 (factor 1.5).
- Check the load carrying capacity in the static limiting load diagram Fixing screws. The load point must be below the appropriate screw curve (see example, Figure 1)!

INA precision locknuts

INA precision locknuts of series AM, ZM and ZMA are proven components for setting and fixing bearing clearance or for preloading, see page 46.

- The tightening torques for locknuts according to the technical quotation letter or dimension tables, pages 58 and 59, must be adhered to. The tightening torque required should also be stated in the assembly drawing!

Precision locknuts AM

The locking forces are applied through the segments of the locknut, see page 46.

- Never tighten the locknut using only one segment!
- Tightening should if possible be carried out using an INA socket wrench AMS, which ensures uniform loading of all segments, or the nut must be tightened using a hook wrench to DIN 1810 B!
- Secure the nut using the grub screws in the segments!
- In order to prevent axial deformation of the segments, only tighten the grub screws in a crosswise sequence to the specified tightening torque!
- Ensure that the nut is full screwed onto the shaft thread!

Precision locknuts ZM, ZMA

Locknuts of these series are secured against rotation by means of two locking pegs, see page 46.

- Locknuts should be tightened using a hook wrench to DIN 1810 B!
Correct lubrication and regular maintenance are important preconditions for achieving a long operating life with crossed roller bearings.

The lubricant serves to:
- form a lubricant film capable of supporting loads on all contact surfaces
- seal the bearing against external influences (in the case of grease lubrication) and thus prevent the ingress of solid and liquid contaminants
- reduce the running noise
- protect the bearing against corrosion
- dissipate heat from rolling bearing subjected to heavy loads (in the case of oil lubrication).

**Types of lubrication**

Crossed roller bearings can be lubricated with grease or oil.

The following factors are significant in determining the appropriate type of lubrication and the quantity of lubricant required:
- the design and size of the bearing
- the design of the bearing environment
- the lubricant feed
- the operating conditions.
Criteria for grease selection

Operating temperature range (Figure 1)
The range must correspond to the potential range of temperatures in the rolling bearing.
The possible operating temperatures should not exceed the upper and lower limiting values:
- the maximum operating temperature should be 20 °C less than the upper limit value
- the minimum operating temperature should be 20 °C above the lower limit value. At very low temperatures, greases release very little base oil. This can result in inadequate lubrication.

Type of grease (Figure 2)
The characteristics of a grease depend on:
- the base oil
- the viscosity of the base oil
  - this is important for the speed range
- the thickener
  - the shear strength is important for the speed range
- the additives.

Consistency of greases (Figure 3)
Greases are divided into consistency classes – known as NLGI grades (DIN 51818). Grades 1, 2 and 3 are preferred for rolling bearings.
The greases should not become:
- too soft at high temperatures (NLGI 1)
- too stiff at low temperatures (NLGI 3).
Greases should be selected by their speed parameter \( n \cdot d_M \):
- greases with a high speed parameter should be selected for rolling bearings running at high speeds or with low start-up torques
- greases with a low speed parameter should be used for bearings running at low speeds.

⚠️ The consistency of polycarbamide greases can be altered by shear stresses.

Figure 1 - Operating temperature range
Figure 2 - Type of grease
Figure 3 - Consistency of greases
Lubrication

Grease lubrication

Behaviour in the presence of water (Figure 4)
Water in the grease has a highly detrimental effect on the operating life of the bearing:

- the behaviour of greases in the presence of water is assessed according to DIN 51807 (see Table 1)
- the anti-corrosion characteristics can be checked in accordance with DIN 51802 – information is given in the grease manufacturer’s data sheets.

Pressure properties

- The viscosity must be sufficiently high at the operating temperature for the formation of a lubricant film capable of supporting loads
- At high loads, greases with EP (extreme pressure) characteristics and high base oil viscosity should be used (KP grease to DIN 51502).

⚠️ The load-supporting capability of common greases can change if EP additives containing lead are not used.
Therefore:
- check the grease selection
- consult the lubricant manufacturer.

Figure 4 · Behaviour in the presence of water to DIN 51807

Table 1 · Rolling bearing grease for initial greasing

<table>
<thead>
<tr>
<th>INA designation</th>
<th>Designation to DIN 51825</th>
<th>Type of grease</th>
<th>Temperature range °C</th>
<th>NLGI grade (consistency)</th>
<th>Speed parameter n · dM min⁻¹ mm</th>
<th>Kinematic viscosity at 40 °C (base oil) mm² s⁻¹</th>
<th>Behaviour in the presence of water to DIN 51807</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM03</td>
<td>KP2N–25</td>
<td>Lithium complex soap grease (mineral oil base)</td>
<td>–30¹ to +150</td>
<td>2</td>
<td>500 000</td>
<td>160</td>
<td>1–90</td>
</tr>
</tbody>
</table>

¹ Determined according to IP 186/85.
Miscibility
The preconditions are as follows:
- they must have the same base oil
- they must have compatible thickener types
- they must have similar base oil viscosities
  - the difference must not be more than one ISO VG class
- they must have same consistency – NLGI grade.

⚠️ If greases are to be mixed with each other, contact the grease manufacturer.

Storage (Figure 5)
Lubricants age due to environmental influences. The information provided by the lubricant manufacturer should be adhered to.

INA uses greases with a mineral oil base. Experience shows that these greases can be stored for up to 3 years. This applies under the following conditions:
- closed room or store
- temperatures between 0 °C and +40 °C
- relative atmospheric humidity not more than 65%
- no contact with chemical agents (vapours, gases or fluids)
- the rolling bearings are sealed.

After extended periods of storage, the start-up frictional torque of greased bearings may be temporarily higher than normal. The lubricity of the grease may also have deteriorated.

⚠️ Greases – even those obtained from the same manufacturer – may vary in their characteristics. Therefore, INA does not accept any liability for lubricants and their behaviour during operation.

Initial greasing
INA crossed roller bearings are supplied greased (for the grease used, see Table 1, page 22). The grease is a high quality lithium complex soap grease with a mineral oil base to DIN 51825 KP2N–25.

The free space in the raceway system of the bearing is filled with grease. The grease is suitable for the operating temperature range –30 °C to +150 °C.
Lubrication
Grease lubrication

Lubrication intervals
The lubrication intervals are essentially dependent on:
■ the operating conditions
■ the environmental influences such as contamination, water, etc.
■ the type of crossed roller bearing.

⚠️ The lubrication intervals can only be determined by means of tests under the specific application conditions:
   – sufficiently long observation periods must be allowed
   – the condition of the grease must be checked at regular intervals.

Grease operating life
If relubrication is not possible, the grease operating life becomes the decisive factor.

Based on experience, the guide value for the grease operating life in the majority of applications is higher than the guide value for the lubrication interval by a factor of 2.

At operating temperatures above +70 °C, the lubrication interval and therefore the grease operating life are reduced.

In order to ensure operational reliability, the grease operating life should not exceed 3 years.

Relubrication procedure
During the lubrication procedure, foreign matter such as contaminants, dust, spray water and condensation that have entered the crossed roller bearing are pressed out.

If possible, the grease used for relubrication should be the same as that used in initial operation.

Lubrication should always be carried out on bearings that are warm from operation.

■ Clean the lubrication nipples.

■ Grease should then be pressed into the lubrication nipples until a collar of fresh grease forms around both seals (one bearing ring should be slowly rotated during this process)

   – the old grease must be allowed to flow out unhindered.

Before initial operation, it must be ensured that all the lubricant ducts to the bearing are filled with lubricant.
Lubrication
Oil lubrication

For oil lubrication, INA recommends oils of type CL/CLP to DIN 51 517 or HL/HLP to DIN 51 524 (ISO VG 10 to 100). The oils can be used at operating temperatures from –30 °C to +100 °C.

⚠️ Note the limiting speeds for $n_G$ grease and $n_G$ oil according to the dimension tables!

Selection of the oil
A lubricant film which is capable of supporting loads is required at the contact points between the rolling elements and the raceway.

Depending on the operating speed, at the operating temperature the oil must have:

- at least the nominal viscosity $\nu_1$ (Figure 6).

Nominal viscosity for mineral oils
The guide value for $\nu_1$ is dependent on:
- the mean bearing diameter $d_M$
- the speed $n$.

The guide value takes into consideration:
- the EHD theory on the formation of a lubricant film
- practical experience.

Determining the nominal viscosity $\nu_1$ (Figure 6)
- Assign $\nu_1$ to an ISO VG nominal viscosity grade between 10 and 1500
  - mean viscosity to DIN 51 519.
- Intermediate values should be rounded to the nearest ISO VG grade
  - this is due to the steps between the viscosity groups.

⚠️ This method cannot be used for synthetic oils
- these have different speed/pressure and speed/temperature characteristics.

Influence of temperature on viscosity
As the temperature increases, the viscosity of the oil decreases.

⚠️ When selecting the viscosity, the lowest operating temperature should be taken into consideration:
- increasing viscosity reduces the flowability of the oil and leads to increased power losses.

![Figure 6 - Determining the nominal viscosity $\nu_1$](image-url)
Sealing of the bearing arrangement

INA seal profiles

INA crossed roller bearings SX are supplied without seals. Depending on the requirements and the type of contamination, seals must be provided for the bearing position in the adjacent construction.

INA crossed roller bearings of series XSU and XV are sealed. For severe contamination, spray or flood water etc., however, additional sealing of the bearing arrangement in the adjacent construction may be necessary.

INA seal profiles

For sealing of the bearing arrangement in the adjacent construction, INA supplies various seal profiles by the metre. These profiles fulfil a wide variety of requirements (see Table 1).

⚠ The seal profiles are not suitable for applications requiring leakproof operation – or for grease lubrication! If leakage losses are unacceptable, measures such as rotary shaft seals can be applied!

Seal profile materials

The standard material for the profiles is the synthetic elastomer NBR 70. This material is characterised by:
■ good resistance to oils and greases
■ good wear resistance.

Operating temperature

INA seal profiles can be used at temperatures from –40 °C to +80 °C.

For temperatures lower or higher than this range, extreme environmental influences (e.g. ozone) or high speeds, please consult INA.

Fitting of seal profiles

⚠ The area around the bearing seal must be designed such that the seal profiles are not damaged during operation!

Ensure that the profiles are not damaged while fitting the slewing ring!

Fit the profiles according to the following procedure:
■ Clean the area where the seal is to be fitted.
■ Press the seal profile carefully into the fitting space leaving an excess length of approximately 5% – e.g. with a blunt wooden wedge (Figure 2).
■ Cut the profile to the exact length (Figure 2) – ensure that the joint faces are even.
■ Join the grease-free joint faces using a cyanacrylate adhesive without displacement (Figure 3) – e.g. using Loctite 406.
■ Complete the fitting of the profile (Figure 3).

Figure 1 · Dimensioning of the fitting space and the diameter

Figure 2 · Pressing in and cutting of the profile in the fitting space

Figure 3 · Bonding of the joint faces and final fitting of the profile
Table 1 · Seal profiles – selection scheme and characteristics

<table>
<thead>
<tr>
<th>Profile</th>
<th>Designation</th>
<th>Diameter range$^1$</th>
<th>Fitting space required (guide values)$^1$</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>axial</td>
<td>radial</td>
<td>a</td>
</tr>
<tr>
<td>axial sealing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A/R 0101</td>
<td>A/R 0106</td>
<td>A/R 0207</td>
<td>A/R 0509</td>
<td>100 to 500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>radial sealing</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A/R 0218</td>
<td>A/R 0419</td>
<td>300 to 1000</td>
<td>&gt; 400</td>
<td>300 to 1000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A/R 1025</td>
<td>A/R 1126</td>
<td>A/R 1227</td>
<td>&gt; 200</td>
<td>&gt; 400</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>radial sealing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R 2001</td>
<td>R 2009</td>
<td>–</td>
<td>&gt; 300</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>axial and radial sealing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR 0501</td>
<td></td>
<td>&gt; 400</td>
<td>&gt; 400</td>
<td>19</td>
</tr>
</tbody>
</table>

Installation drawings can be requested for the individual seal profiles.

$^1$ Dimensioning of the fitting space and the diameter: see Figure 1.
INA crossed roller bearings can support high loads. Due to the X arrangement of the rolling elements, these bearings can in a single bearing position (Figure 1) support:

- axial loads from both directions
- radial loads
- tilting moment loads
- any combination of loads.

In order that these advantages can be utilised comprehensively, the adjacent construction must be designed that it is appropriately rigid.

⚠️ Bearing rings must always be rigidly and uniformly supported around their entire circumference and width (Figure 2).

The adjacent construction must be designed only in accordance with the information in this section! Any deviations from the specifications, material strength and adjacent components will considerably reduce the load carrying capacity and operating life of the crossed roller bearings.

**Sealing of the bearing position**

If the bearing arrangement is sealed by means of a seal in the adjacent construction, observe the design guidelines for seal profiles in the section Sealing of the bearing arrangement, page 26.

⚠️ The area around the bearing seal must be designed such that the seal profiles are not damaged during operation!

**Fixing screws**

Screws of grade 10.9 in accordance with Table 2, page 31, are suitable for fixing the bearing rings or clamping rings – the dimensioning and tightening torque are dependent on the bearing size.

⚠️ Any deviations from the recommended size, grade and number of screws will considerably reduce the load carrying capacity and operating life of the bearings!

For screws of grade 12.9, observe the minimum strength of the clamping rings (see page 30) or use quenched and tempered washers!
Crossed roller bearings SX

Depending on the application, the bearing arrangement must fulfill differing requirements for running accuracy.

Fitting tolerances for normal applications

For normal applications, sufficient tolerances are K7 for the housing and h7 for the shaft (see Table 1).

Fitting tolerances for precision applications

In precision applications, the bearing seat in the housing should be designed to tolerance K6 and the bearing seat on the shaft to h6 (see Table 1).

<table>
<thead>
<tr>
<th>Table 1 · Fitting tolerances (deviations in μm)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft Nominal range</td>
<td>Housing bore Nominal range</td>
</tr>
<tr>
<td>Nominal deviations</td>
<td>Nominal deviations</td>
</tr>
<tr>
<td>&gt;</td>
<td>≤</td>
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<tr>
<td>Upper</td>
<td>Lower</td>
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<td>65</td>
<td>80</td>
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</tbody>
</table>
Location using clamping rings

For location of crossed roller bearings SX, clamping rings have proved effective (Figure 3).

The thickness of the clamping rings and mounting flanges must not be less than the minimum thickness $s$ according to Table 2!

Counterbores to DIN 74, type J, for screws to DIN 6912 are permissible. For deeper counterbores, the thickness of the clamping ring $s$ must be increased by the additional counterbore depth.

Mounting dimensions: see Table 2 and Figure 5.

Minimum strength of clamping rings

For screws of grade 10.9, the minimum strength under the screw heads or nuts must be 500 N/mm². Washers are not necessary for these screws.

For fixing screws of grade 12.9, the strength must not be less than the minimum strength of 850 N/mm² or quenched and tempered washers must be used under the screw heads or nuts.

Bearing seat depth

In order that the clamping rings retain the bearing securely, the bearing seat depth $t$ must be in accordance with Table 2 (Figure 4).

The depth of the bearing seat influences the bearing clearance and the rotational resistance.

Preloaded bearings (suffix VSP) have a considerably higher rotational resistance.

If particular requirements for rotational resistance apply, the depth $t$ must be produced to match the relevant height of the bearing ring. It has proved useful to tolerance the depth $t$ to deviations that are the same as or further restricted compared to the dimension $h$ in the dimension tables. For safety, internal tests should in any case be carried out.
Table 2 · Mounting dimensions for the adjacent construction

<table>
<thead>
<tr>
<th>Designation</th>
<th>Mounting dimensions in mm</th>
<th>Fixing screw Grade 10.9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>d₁, h7 (h6)</td>
<td>D₂, K7 (K6)</td>
</tr>
<tr>
<td>SX 01 1814</td>
<td>70</td>
<td>90</td>
</tr>
<tr>
<td>SX 01 1818</td>
<td>90</td>
<td>115</td>
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<td>140</td>
<td>175</td>
</tr>
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<td>SX 01 1832</td>
<td>160</td>
<td>200</td>
</tr>
<tr>
<td>SX 01 1836</td>
<td>180</td>
<td>225</td>
</tr>
<tr>
<td>SX 01 1840</td>
<td>200</td>
<td>250</td>
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<td>300</td>
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<tr>
<td>SX 01 1860</td>
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<td>380</td>
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<td>SX 01 1868</td>
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<td>420</td>
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<td>400</td>
<td>500</td>
</tr>
<tr>
<td>SX 01 18/500</td>
<td>500</td>
<td>620</td>
</tr>
</tbody>
</table>

Note!
- Retaining rings do not support forces!
- Provide grooves, threaded extraction holes, etc. for dismantling!

Figure 5 · Design of bearing arrangements – mounting dimensions
Design of bearing arrangements

Crossed roller bearings XV
Location by means of flange mounting and locknut
Crossed roller bearings XV are screw mounted directly on the housing through the outer ring and centred if necessary (Figure 6).
The inner ring is retained radially by an appropriate fit, abutted axially on a shaft shoulder and located by means of a locknut (Figure 6).
If the bearings are to be lubricated via a lubrication duct \( \odot \) in the adjacent construction (Figure 6), this must be taken into consideration in the design of the housing.

\[ \text{Before fitting, at least one pressed-in lubrication nipple } \odot \text{ must be removed from the bearing.} \]

Housing and shaft design
The accuracy of the bearing seat in the housing and on the shaft and shaft shoulder should correspond to the accuracy of the bearing and the requirements of the application.
The following data for the dimensional and geometrical accuracy and roughness are guide values for standard applications (if there are any deviations, please consult INA):

- for the seating and support surfaces in the housing, accuracy according to Figure 7 is required
- for the seating and support surfaces on the shaft, accuracy according to Figure 8 is required.

Table 3 · Fitting tolerances for shaft and housing

<table>
<thead>
<tr>
<th></th>
<th>Normal applications</th>
<th>Precision applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bore ( \odot D_{ha} ) Figure 7</td>
<td>K6</td>
<td>K5</td>
</tr>
<tr>
<td>Shaft ( \Theta d_{ha} ) Figure 8</td>
<td>h6</td>
<td>h5</td>
</tr>
</tbody>
</table>

INA precision locknuts
For INA precision locknuts of series AM, ZM, ZMA (see dimension tables), the thread on the shaft should have an accuracy in accordance with Table 4.

Table 4 · Accuracy for shaft thread

<table>
<thead>
<tr>
<th>Runout ( \mu \text{m} )</th>
<th>Metric ISO thread of locknut</th>
<th>Shaft thread (Figure 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>“fine”</td>
<td>“medium”</td>
</tr>
<tr>
<td>Normal applications</td>
<td>Precision applications</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>SH DIN 13 Part 21-24</td>
<td>6g DIN 13 Part 21-24</td>
</tr>
</tbody>
</table>

Figure 6 · Radial and axial location of bearing rings – lubricant duct in the adjacent construction

Figure 7 · Housing design

Figure 8 · Shaft design
Crossed roller bearings XSU
Inner and outer ring suitable for flange mounting

Crossed roller bearings XSU are screw mounted directly to the adjacent construction through both bearing rings (Figure 9). The adjacent construction must be flat and uniformly rigid, while the connection between the bearing adjacent components must be by force locking. For the upper and lower adjacent construction, a cylindrical pot with a flange ring has proved effective (Figure 9).

The wall thickness of the pot should be approximately one third of the flange thickness \( s \) and the pot height \( H_T \) should be at least five times the flange thickness \( s \) (Figure 9). For a more uniform rigidity of the bearing arrangement, thicker walls of the pot and flange ring are more favourable than thin walls with ribs.

In order to achieve the most linear force flow possible, arrange the pot precisely above or below the row of rolling elements! Flange rings should be dimensioned such that they support the whole width of the bearing rings!

Permissible flatness and perpendicularity deviation of the adjacent construction

The screw mounting surfaces of the adjacent construction must fulfil the following requirements:

- the flatness deviation must not exceed the permissible value \( \delta_B \) (Figure 10)
- the perpendicularity deviation must not exceed the permissible value \( \delta_W \) (Figure 10).

Permissible flatness deviation (Figure 10)
The flatness deviation \( \delta_B \) is calculated using the following formula and applies in the circumferential and transverse direction:

- in the circumferential direction, it can only be reached once in a sector of 180\(^\circ\). The permissible curve is similar to a slowly rising or slowly falling sine curve.

\[
\delta_B = \frac{D_M + 1000}{20000}
\]

- \( \delta_B \) mm Maximum permissible flatness deviation
- \( D_M \) mm Rolling element pitch circle diameter.

Permissible perpendicularity deviation (Figure 10)
The perpendicularity deviation \( \delta_W \) applies in the transverse direction:

- relative to a flange width of 100 mm, the perpendicularity deviation \( \delta_W \) must not exceed half of the permissible flatness deviation \( \delta_B \) (\( \delta_W \leq 0.5 \delta_B \)).
Crossed roller bearings are precision machine elements. These bearings must be handled very carefully both before and during fitting. Their function and operating life are also dependent on the care taken in fitting.

**Design of the assembly area**

⚠️ Machines, equipment, etc. that produce swarf or generate dust must not be used in the immediate vicinity of the assembly area!

- The bearings must be protected against dust, contamination, swarf, moisture, adhesives, etc.!
- Contamination will impair the function and operating life of the bearings!

Bearsings should be fitted in a workshop if possible. If this is not possible, the fitting position and bearing should be protected against contaminant from the environment.

It must be ensured that work surfaces are bright, clean and free from fibres (e.g. plastic) and that lighting conditions are good.

**Preparing the adjacent construction for fitting of the bearings**

The bores and edges of the adjacent components must be free from burrs

- Any burrs present must be removed using an oilstone (Figure 1).

The support surfaces for the bearing rings must be clean.

Cleaning (Figure 1):

- Apply cleaning agents using a brush or a suitable, lint-free cloth.
- Remove foreign matter and dry the surfaces.

⚠️ Ensure that all adjacent components and lubrication ducts are free from cleaning agents, solvents and washing emulsions!

- The bearing seat surfaces can rust or the raceway system can become contaminated!
Checking the bearing seat and bearing mounting surfaces on the adjacent construction

**Series SX (Figure 2)**
- Check the surface quality and the geometrical accuracy of the screw mounting surfaces in accordance with the section *Design of bearing arrangements* or the assembly drawing.

  The minimum strength of the adjacent components under the screw heads or nuts is 500 N/mm²! If fixing screws of grade 10.9 are used, washers are not necessary.
  If fixing screws of grade 12.9 are used, the minimum strength must not be less than 850 N/mm² or quenched and tempered washers must be used under the screws or nuts.

- Check the fitting tolerances in accordance with the section *Design of bearing arrangements* – Table 1, page 29 and Table 2, page 31 or the assembly drawing.
- Check the bearing seat depth t in accordance with the section *Design of bearing arrangements* – Table 2, page 31 or the assembly drawing.
- Check the minimum thickness s for clamping rings and mounting flange and the depth of the counterbores in accordance with the section *Design of bearing arrangements* – Table 2, page 31 or the assembly drawing.

**Series XV (Figure 3)**
- Check the edge radius at the end of the thread X, the undercut on the shaft shoulder Y and the lead chamfer on the housing bore Z in accordance with the assembly drawing.

- Check the surface quality and the dimensional and geometrical accuracy of the seating and locating surfaces, Figure 7 and 8, page 32.

  Check the shaft and housing seat using a micrometer screw at a minimum of two points.

  The bearing locating surfaces on the shaft shoulder or in the housing bore must be perpendicular to the cylindrical fit surfaces.

  The abutment diameter on the shaft shoulder and the bearing seat depth in the housing must not be less than the minimum values in the section *Design of bearing arrangements*, Figure 7 and 8, page 32, or the assembly drawing.
Fitting
Preparations for fitting

Series XSU (Figure 4)

■ Check the surface quality and the geometrical accuracy of the screw mounting surfaces in accordance with the section Design of bearing arrangements or the assembly drawing.

■ Check the flange thickness s, the flange height H and the flange width t in accordance with the section Design of bearing arrangements, page 33 or the assembly drawing.

■ Check the flatness and perpendicularity deviation of the adjacent construction in accordance with the section Design of bearing arrangements, page 33.

⚠️ The permissible deviations must not be exceeded.

Figure 4 · Surface quality
Delivery condition of crossed roller bearings
Bearings of series SX, XSU and XV are:
■ greased with lithium complex soap grease KP2N–25 to DIN 51825 and dry preserved using VCI paper.

Storage and storage life of crossed roller bearings
⚠ Bearsions should only be stored lying down, never standing up (Figure 5)!
The storage life of the bearings is limited by the storage life of the grease. Experience shows that the greases with a mineral oil base used can be stored for up to 3 years if the following preconditions are met (Figure 6):
■ closed storage room
■ dry, clean rooms with temperatures between 0 °C and +40 °C
■ relative atmospheric humidity not more than 65%
■ no influence by chemical agents such as
  – vapours, gases, fluids.
After long storage periods, the frictional torque may temporarily be higher than that of freshly greased bearings. The lubricity of the grease may also have deteriorated.

Unpacking and transporting crossed roller bearings
Perspiration from handling leads to corrosion. Hands must be kept clean and dry; protective gloves should be worn if necessary.
Bearings should not be removed from their original packaging until immediately before assembly. If the original packaging is damaged, check the condition of the bearing.
Large bearings should be transported lying down if possible. Heavy bearings must only be transported using a hoist attached to the eye bolts or by means of textile slings (Figure 7).
⚠ Bearings must not be wrapped in a chain!

Bearings should never be supported at one point only for lifting!
Fitting
Preparations for fitting

Selection of fasteners

⚠️ The specifications relating to the fasteners must be adhered to!
Any deviations will influence:
- the effectiveness of the screw connection
- the function – e.g. the accuracy and rigidity – as well as the operating life of the bearings!

Fixing screws

Bearings must only be fixed using the screw types specified.
It is essential that the information in the following sources is followed:
- this publication
- the technical quotation documents
- the customer’s assembly drawing.
The sizes, quantity and grades of the screws are given in the dimension tables or in the assembly drawing.

INA precision locknuts

The split inner ring of crossed roller bearing XV can be axially located using a nut. At the same time, this nut sets the bearing clearance or preloads the bearing.
INA precision locknuts of series AM, ZM and ZMA are proven components for locating and setting the bearing clearance or for preloading the bearing (see Fasteners, page 19).

⚠️ Do not under any circumstances exceed the tightening torques M_AL of the locknuts in the dimension table (page 58 to 60). The tightening torque required should also be stated in the assembly drawing.
Precision locknuts must be secured using grub screws after screw mounting.

Securing of screws

Normally, the screws are adequately secured by the correct preload. If regular shock loads or vibrations occur, however, additional securing of the screws may be necessary.

⚠️ Not every method of securing screws is suitable for crossed roller bearings!
Never use spring washers or split washers!

General information on securing of screws is given in DIN 25.201, and securing by means of adhesive in particular is described in DIN 25.203, issued in 1992.
If these are to be used, please consult the relevant companies.

General safety and operating guidelines

⚠️ Assembly forces must only be applied to the bearing ring to be fitted; they must never be directed through the rolling elements or seals! Direct blows on the bearing rings must be avoided.
Bearing rings should be located consecutively and without external load.
Bearings must not be heated using a naked flame!
The material undergoes excessive localised heating, reducing its hardness. Furthermore, this will induce stresses in the bearing.
Do not cool the bearings excessively. The formation of condensation can lead to corrosion in the bearings and on the bearing seat surfaces.

Sequence of operations

The sequence depends on the design of the adjacent construction. The description of fitting is based on applications that have proved successful in practice.
If the adjacent construction is different, fit the bearing appropriately or consult INA.
Fitting of crossed roller bearings SX

⚠️ The outer ring is split and is held together by three retaining rings ☉. Never apply tensile loads to the retaining rings!

Lightly oil or grease the bearing seat and locating surfaces on the adjacent construction.
Lightly oil the thread of the fixing screws in order to prevent varying friction factors (do not oil or grease screws that will be secured by means of adhesive).

Locating the bearing outer ring (Figure 8)
- Insert or press the bearing ☉ into the external adjacent construction ☉ via the outer ring.
- Position the external clamping ring ☉.
- Insert the fixing screws ☉ in the clamping ring and tighten in steps up to the specified tightening torque $M_A$.
  - Tighten the screws in a crosswise sequence ☉ in order to prevent unacceptable fluctuations in the screw tensioning forces.
  - Tightening torques $M_A$ for fixing screws: see Table 1, page 43.

Locating the bearing inner ring (Figure 9)
- Insert the bearing ☉ in the internal adjacent construction ☉.
- Position the internal clamping ring ☉.
- Insert the fixing screws ☉ in the clamping ring and tighten in steps up to the specified tightening torque $M_A$.
  - Tighten the screws in a crosswise sequence ☉ in order to prevent unacceptable fluctuations in the screw tensioning forces.
- Check the function of the bearing (see Checking the function, page 42).
Fitting
Preparations for fitting

Fitting of crossed roller bearings XV
Lightly oil or grease the bearing seat and locating surfaces for the bearing rings on the adjacent construction and the thread on the shaft.

Lightly oil the thread of the fixing screws in order to prevent varying friction factors (do not oil or grease screws that will be secured by means of adhesive).

Locating the bearing outer ring (Figure 10)
- Insert or press the crossed roller bearing $\oplus$ into the locating bore of the adjacent construction $\ominus$ via the outer ring.
- Insert the fixing screws $\varnothing$ – with washers if necessary – in the outer ring and tighten in steps up to the specified tightening torque $M_A$.
  - Tighten the screws in a crosswise sequence $\otimes$, so that the bearing rings are fitted as far as possible without distortion.
  - While the outer ring is being tightened, rotate the inner ring by several times the spacing of several screw pitches.
  - Tightening torques $M_A$ for fixing screws: see Table 1, page 43.

Locating the bearing inner ring (Figure 11)
- Insert the shaft $\odot$ in the inner ring bore as far as the locating shoulder.
- Locate the inner ring $\otimes$ axially using INA precision locknuts $\varnothing$.
- Set the bearing clearance or apply preload by tightening the locknut using a hook wrench. Do not exceed the tightening torque $M_{AL}$.
- In order to secure the locknut, tighten the grub screws $\ominus$ uniformly and alternately $\ominus$ up to the specified tightening torque $M_m$ in accordance with the value in the table.
- Check the function of the bearing (see Checking the function, page 42).
Fitting of crossed roller bearings XSU

lightly oil or grease the bearing seat and locating surfaces for the bearing rings on the adjacent construction.

Lightly oil the thread of the fixing screws in order to prevent varying friction factors (do not oil or grease screws that will be secured by means of adhesive).

Locating the bearing outer ring (Figure 12)
- Position the crossed roller bearing on the screw mounting surface of the adjacent construction via the outer ring.
- Insert the fixing screws – with washers if necessary – in the outer ring and tighten in steps up to the specified tightening torque $M_A$.
  - Tighten the screws in a crosswise sequence in order to prevent distortion of the bearing rings.
  - While the outer ring is being tightened, rotate the inner ring by several times the spacing of several screw pitches.
  - Tightening torques $M_A$ for fixing screws: see Table 1, page 43.

Locating the bearing inner ring (Figure 13)
- Position the crossed roller bearing on the screw mounting surface of the adjacent construction via the inner ring or the adjacent construction on the bearing ring.
- Insert the fixing screws – with washers if necessary – in the inner ring and tighten in steps up to the specified tightening torque $M_A$.
  - Tighten the screws in a crosswise sequence in order to prevent distortion of the bearing rings.
- Check the function of the bearing (see Checking the function, page 42).
Fitting
Checking the function

Once assembly is complete, the operation of the fitted crossed roller bearing must be checked.

⚠️ If the bearing runs irregularly or roughly, or the temperature in the bearing shows an unusual increase, dismantle and check the bearing and reassemble the bearing in accordance with the fitting guidelines in this publication!

Running accuracy
- Check the running accuracy using a dial gauge.
  - For values, see the assembly drawing or the dimension tables.

⚠️ Deviations from the values may be the result of:
  - inaccuracies in the adjacent construction
  - unevenly stressed bearings due to incorrectly tightened clamping rings, fixing screws or locknuts.

Rotational resistance
The rotational resistance is essentially determined by:
- the rolling resistance of the rolling elements
- the bearing clearance or bearing preload
- the friction of the spacers
- the friction of the seals
- the grease
- a deformed or defective adjacent construction
- errors in fitting of the bearings.

⚠️ Due to the preload in the raceway system, the rotational resistance is higher than in a bearing with clearance. At higher speeds, a high preload can lead to generation of significant heat in the bearing; if necessary tests must be carried out with bearings preloaded to various values.

Bearing temperature
After initial operation, the temperature in the bearing can increase – in the case of grease lubrication, for example, until the grease is evenly distributed in the bearing arrangement.

A further increase or unusually high temperatures may be caused by one of the following:
- the bearing is lubricated using an unsuitable grease
- there is excessive lubricant in the bearing
- the load on the bearing is excessively high
- the bearings are fitted unevenly
- the adjacent construction deviates from the specifications.
Fitting

Tightening torques and fitting preload forces

Table 1 · Tightening torques $M_A$ and assembly preload forces $F_M$ for the torque-controlled tightening of fixing screws (set screws)

<table>
<thead>
<tr>
<th>Fixing screw Dimensions</th>
<th>Clamping cross-section $A_s$ mm$^2$</th>
<th>Core cross-section $A_{DG}$ mm$^2$</th>
<th>Tightening torque $M_A^{1)}$ in Nm</th>
<th>Fitting preload $F_M^{2)}$ in kN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Grade 8.8</td>
<td>10.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Grade 8.8</td>
<td>10.9</td>
</tr>
<tr>
<td>M 4</td>
<td>8.78</td>
<td>7.75</td>
<td>2.25</td>
<td>3.31</td>
</tr>
<tr>
<td>M 5</td>
<td>14.2</td>
<td>12.7</td>
<td>4.61</td>
<td>6.77</td>
</tr>
<tr>
<td>M 6</td>
<td>20.1</td>
<td>17.9</td>
<td>7.8</td>
<td>11.5</td>
</tr>
<tr>
<td>M 8</td>
<td>36.6</td>
<td>32.8</td>
<td>19.1</td>
<td>28</td>
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<tr>
<td>M10</td>
<td>58</td>
<td>52.3</td>
<td>38</td>
<td>55.8</td>
</tr>
<tr>
<td>M12</td>
<td>84.3</td>
<td>76.2</td>
<td>66.5</td>
<td>97.7</td>
</tr>
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<td>M14</td>
<td>115</td>
<td>105</td>
<td>107</td>
<td>156</td>
</tr>
<tr>
<td>M16</td>
<td>157</td>
<td>144</td>
<td>168</td>
<td>246</td>
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<td>M18</td>
<td>192</td>
<td>175</td>
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<td>M20</td>
<td>245</td>
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<td>327</td>
<td>481</td>
</tr>
<tr>
<td>M22</td>
<td>303</td>
<td>282</td>
<td>450</td>
<td>661</td>
</tr>
<tr>
<td>M24</td>
<td>353</td>
<td>324</td>
<td>505</td>
<td>830</td>
</tr>
</tbody>
</table>

1) $M_A$ according to VDI Guideline 2230 (July 1986) for $\mu_K = 0.08$ and $\mu_G = 0.12$.
2) $F_M$ according to VDI Guideline 2230 (July 1986) for $\mu_G = 0.12$. 
Crossed roller bearings

with or without seals

Features

Crossed roller bearings

- are complete units comprising an outer ring, inner ring, rolling elements (cylindrical rollers) and spacers
  - depending on the series, the inner ring or outer ring is unsplit or circumferentially split
- can, due to the X arrangement of the rolling elements, support axial loads from both directions as well as radial loads, tilting moment loads and any combination of loads with a single bearing position
  - this allows designs with two bearing positions to be reduced to a single bearing position (see page 45)
- have high rigidity and high running accuracy
- are preloaded and suitable, with grease lubrication, for circumferential speeds up to
  - 2 m/s ($n \cdot D_M = 38 \, 200$)
- are greased, but can alternatively be lubricated using oil
- are particularly easy to fit
- are also available in a corrosion-resistant design with the INA special plating Corrotect®.

Crossed roller bearings SX

- have normal clearance or are preloaded
- are fixed to the adjacent construction using clamping rings
- are suitable with normal clearance for circumferential speeds:
  - with oil lubrication up to 8 m/s ($n \cdot D_M = 152 \, 800$)
  - with grease lubrication up to 4 m/s ($n \cdot D_M = 76 \, 400$)
- are preloaded and suitable, with oil lubrication, for circumferential speeds up to
  - 4 m/s ($n \cdot D_M = 76 \, 400$).

Crossed roller bearings XSU

- are preloaded
- are screw mounted by means of the bearing rings directly on the adjacent construction.

Crossed roller bearings XV

- are screwed mounted through the outer ring to the adjacent construction
  - the inner ring is located by means of a locknut
- can be adjusted very precisely to give clearance or preload by means of the locknut.

Crossed roller bearings

- conform to dimension series 18 to DIN 616
- cylindrical rollers to DIN 5402, spacers made from plastic
- outer ring split in a circumferential direction and held together by three retaining rings
- without seals
- for operating temperatures from –30 °C to +80 °C
- for shaft diameters from 70 mm to 500 mm

SX

- cylindrical rollers to DIN 5402, spacers made from plastic
- sealed on both sides
- for operating temperatures from –30 °C to +80 °C
- for shaft diameters from 30 mm to 10 mm
- two lubrication nipples radially and two lubrication nipples axially
- series XSU 08
  - cylindrical rollers to DIN 5402, spacers made from plastic
  - centring on the inside and outside diameter
  - sealed on both sides
  - for operating temperatures from −30 °C to +80 °C
  - for shaft diameters from 130 mm to 360 mm
  - two lubrication nipples radially and two lubrication nipples axially

- series XSU 14
  - also available with internal or external gear teeth
  - cylindrical rollers to DIN 5402, spacers made from plastic
  - centring on the inside and outside diameter
  - sealed on both sides
  - for operating temperatures from −30 °C to +80 °C
  - for shaft diameters from 344 mm to 1024 mm

Conventional bearing arrangement with two bearing positions

Optimised bearing arrangement with one crossed roller bearing
**Precision locknuts**

**AM**

**ZM, ZMA**

---

**Features**

**Precision locknuts**
- are used for crossed roller bearings XV in order to
  - axially locate the split inner ring
  - set the bearing clearance or preload the bearing
- have a high runout accuracy
- have high rigidity
- can support axial forces.

**Precision locknuts AM**
- are segmented in order to apply the clamping forces:
  - the hexagon socket grub screws are tightened
  - the segments undergo deformation
  - the thread flanks of the segments press against the flanks of the shaft thread
  - the locknut can no longer be loosened
- are secured against rotation by the grub screws in the segments.

**Precision locknuts ZM, ZMA**
- have two radially arranged locking pegs in order to apply the clamping forces:
  - the locking pegs are manufactured together with the internal thread of the locknut
  - they grip like comb teeth in the shaft thread
  - the locking pegs are located by countertensioning grub screws
  - the locknut can no longer be loosened
- are secured against rotation by the locking pegs.

**Breakaway torque and ultimate axial load**

The breakaway torques $M_L$ are given in the *dimension tables* and relate to a locknut that is tightened against a firm shaft collar to the tightening torque $M_{AL}$ and secured; see *Fasteners*, page 19.

The ultimate axial loads $F_{AB}$ are valid for a shaft thread with:
- tolerance 6g or narrower
- a minimum strength of 700 N/mm².

For dynamic loading, the permissible value can be taken as 75% of the ultimate axial load $F_{AB}$.
Dimension tables
Crossed roller bearings
Series SX

Dimension table - Dimensions in mm

<table>
<thead>
<tr>
<th>Designation</th>
<th>No.</th>
<th>Mass</th>
<th>Dimensions</th>
<th>Fixing screws</th>
<th>Running accuracy relative to raceway</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg</td>
<td></td>
<td>D_M</td>
<td>d_t</td>
<td>D_a</td>
</tr>
<tr>
<td>SX 01 1814</td>
<td>1</td>
<td>0.3</td>
<td>80</td>
<td>K6</td>
<td>90-0.022</td>
</tr>
<tr>
<td>SX 01 1818</td>
<td>2</td>
<td>0.4</td>
<td>102</td>
<td>K6</td>
<td>115-0.022</td>
</tr>
<tr>
<td>SX 01 1820</td>
<td>3</td>
<td>0.5</td>
<td>112</td>
<td>K6</td>
<td>120-0.024</td>
</tr>
<tr>
<td>SX 01 1824</td>
<td>4</td>
<td>0.8</td>
<td>135</td>
<td>K6</td>
<td>150-0.024</td>
</tr>
<tr>
<td>SX 01 1828</td>
<td>5</td>
<td>1.1</td>
<td>157</td>
<td>K6</td>
<td>175-0.024</td>
</tr>
<tr>
<td>SX 01 1832</td>
<td>6</td>
<td>1.7</td>
<td>180</td>
<td>K6</td>
<td>200-0.024</td>
</tr>
</tbody>
</table>

1) H: section height of bearing, h: height of individual ring.
2) Lubrication hole: 3 holes spaced evenly about the circumference.
3) Basic load ratings in radial direction: for radial loads only.
4) See static limiting load diagram Raceway and Fixing screws.

Static limiting load diagram Fixing screws – compressive load
<table>
<thead>
<tr>
<th>Standard clearance radial clearance</th>
<th>Low clearance RLO radial clearance</th>
<th>preload VSP radial clearance</th>
<th>Basic load ratings static</th>
<th>Limiting speeds with standard clearance</th>
<th>Limiting speeds with preload</th>
<th>Dimensionally identical to ISO dimension series 18</th>
</tr>
</thead>
<tbody>
<tr>
<td>min.</td>
<td>max.</td>
<td>min.</td>
<td>max.</td>
<td>min.</td>
<td>max.</td>
<td>dyn. ( C_a ) kN</td>
</tr>
<tr>
<td>0,003</td>
<td>0,015</td>
<td>0,006</td>
<td>0,03</td>
<td>0,003</td>
<td>0,006</td>
<td>18</td>
</tr>
<tr>
<td>0,003</td>
<td>0,015</td>
<td>0,006</td>
<td>0,03</td>
<td>0,003</td>
<td>0,015</td>
<td>26</td>
</tr>
<tr>
<td>0,005</td>
<td>0,020</td>
<td>0,010</td>
<td>0,04</td>
<td>0,004</td>
<td>0,008</td>
<td>28</td>
</tr>
<tr>
<td>0,005</td>
<td>0,020</td>
<td>0,010</td>
<td>0,04</td>
<td>0,004</td>
<td>0,008</td>
<td>41</td>
</tr>
<tr>
<td>0,005</td>
<td>0,020</td>
<td>0,010</td>
<td>0,04</td>
<td>0,004</td>
<td>0,008</td>
<td>64</td>
</tr>
<tr>
<td>0,005</td>
<td>0,020</td>
<td>0,010</td>
<td>0,04</td>
<td>0,004</td>
<td>0,008</td>
<td>69</td>
</tr>
</tbody>
</table>

Static limiting load diagram Raceway – compressive load

**INa** 49
Crossed roller bearings
Series SX

### Dimension table - Dimensions in mm

<table>
<thead>
<tr>
<th>Designation</th>
<th>Mass (kg)</th>
<th>Dimensions</th>
<th>Running accuracy relative to raceway</th>
</tr>
</thead>
<tbody>
<tr>
<td>SX 01 1836</td>
<td>2,3</td>
<td>202</td>
<td></td>
</tr>
<tr>
<td>SX 01 1840</td>
<td>3,1</td>
<td>225</td>
<td></td>
</tr>
<tr>
<td>SX 01 1848</td>
<td>5,3</td>
<td>270</td>
<td></td>
</tr>
<tr>
<td>SX 01 1860</td>
<td>12</td>
<td>340</td>
<td></td>
</tr>
<tr>
<td>SX 01 1868</td>
<td>13,5</td>
<td>380</td>
<td></td>
</tr>
<tr>
<td>SX 01 1880</td>
<td>24</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td>SX 01/500</td>
<td>44</td>
<td>560</td>
<td></td>
</tr>
</tbody>
</table>

1) H: section height of bearing, h: height of individual ring.
2) Lubrication hole: 3 holes spaced evenly about the circumference.
3) Basic load ratings in radial direction: for radial loads only.
4) See static limiting load diagram Raceway and Fixing screws.

### Static limiting load diagram Fixing screws – compressive load

![Static limiting load diagram](image_url)

- $M_{0q}$: Equivalent tilting moment load (static)
- $F_{0q}$: Equivalent axial bearing load (static)
### Standard clearance
- **radial clearance**: 0.005 - 0.025
- **axial tilting clearance**: 0.005 - 0.025
- **preload**: 0.005 - 0.025

### Low clearance RLO
- **radial clearance**: 0.005 - 0.025
- **axial tilting clearance**: 0.005 - 0.025
- **preload**: 0.005 - 0.025

### Basic load ratings
- **axial**: dyn. $C_{A}$, stat. $C_{0A}$, kn
- **radial**: dyn. $C_{r}$, stat. $C_{0R}$, kn
- **min. $r_O$**: oil, min–1
- **max. $r_O$**: oil, min–1
- **min. $r_O$**: grease, min–1
- **max. $r_O$**: grease, min–1

### Limiting speeds
- **min. $n$**: 0.005 - 0.010
- **max. $n$**: 0.025

### Dimensionally identical to ISO dimension series 18
- **min. $F_{A}$**: 0.005 - 0.025
- **max. $F_{A}$**: 0.025
- **min. $M_{Q}$**: 0.005 - 0.025
- **max. $M_{Q}$**: 0.025

### Static limiting load diagram
- **Raceway – compressive load**

Static limiting load diagram Raceway – compressive load

- **Raceway - compressive load**
- **Equivalent axial bearing load (static) $F_{Oq}$**
- **Equivalent tilting moment load (static) $M_{Q}$**

*INa* 51
Crossed roller bearings
sealed
Series XV

<table>
<thead>
<tr>
<th>Designation</th>
<th>No.</th>
<th>Mass (kg)</th>
<th>Dimensions</th>
<th>Fixing holes</th>
</tr>
</thead>
<tbody>
<tr>
<td>XV 30</td>
<td>①</td>
<td>0.37</td>
<td>75×0.019</td>
<td>40×0.006</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>30×0.018</td>
<td>42.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14</td>
<td>41.5</td>
</tr>
<tr>
<td>XV 40</td>
<td>②</td>
<td>0.44</td>
<td>85×0.022</td>
<td>50×0.010</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>40×0.020</td>
<td>52.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14</td>
<td>51.5</td>
</tr>
<tr>
<td>XV 50</td>
<td>③</td>
<td>0.67</td>
<td>100×0.022</td>
<td>60×0.023</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>70×0.013</td>
<td>64.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16</td>
<td>63.5</td>
</tr>
<tr>
<td>XV 60</td>
<td>④</td>
<td>0.75</td>
<td>110×0.022</td>
<td>70×0.023</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>80×0.013</td>
<td>74.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16</td>
<td>73.5</td>
</tr>
<tr>
<td>XV 70</td>
<td>⑥</td>
<td>0.84</td>
<td>120×0.022</td>
<td>80×0.023</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>90×0.013</td>
<td>84.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16</td>
<td>83.5</td>
</tr>
<tr>
<td>XV 80</td>
<td>⑧</td>
<td>1.18</td>
<td>135×0.025</td>
<td>100×0.016</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100×0.025</td>
<td>95.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18</td>
<td>94.5</td>
</tr>
<tr>
<td>XV 90</td>
<td>⑩</td>
<td>1.20</td>
<td>145×0.025</td>
<td>110×0.016</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100×0.025</td>
<td>105.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18</td>
<td>104.5</td>
</tr>
<tr>
<td>XV 100</td>
<td>⑫</td>
<td>2.31</td>
<td>170×0.025</td>
<td>120×0.016</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100×0.025</td>
<td>117.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>22</td>
<td>116.5</td>
</tr>
<tr>
<td>XV 110</td>
<td>⑬</td>
<td>2.48</td>
<td>180×0.025</td>
<td>130×0.016</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>110×0.025</td>
<td>127.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>22</td>
<td>126.5</td>
</tr>
</tbody>
</table>

1) Number of holes per ring.
2) See static limiting load diagram Raceway and Fixing screws.

Static limiting load diagram Fixing screws – compressive load
### Fixing screws

<table>
<thead>
<tr>
<th>(d_b)</th>
<th>(d_s)</th>
<th>(t_s)</th>
<th>(F_{p,perm}) (friction locking) (kN)</th>
<th>Basic load ratings</th>
<th>Limiting speeds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>axial</td>
<td>radial</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>dyn. (C_a) (kN)</td>
<td>stat. (C_{0a}) (kN)</td>
</tr>
<tr>
<td>4,6</td>
<td>8</td>
<td>4,6</td>
<td>5</td>
<td>11,6</td>
<td>26</td>
</tr>
<tr>
<td>4,6</td>
<td>8</td>
<td>4,6</td>
<td>5</td>
<td>13,6</td>
<td>34,5</td>
</tr>
<tr>
<td>5,6</td>
<td>10</td>
<td>5,4</td>
<td>8,18</td>
<td>20,6</td>
<td>54</td>
</tr>
<tr>
<td>5,6</td>
<td>10</td>
<td>5,4</td>
<td>10,9</td>
<td>22,6</td>
<td>64</td>
</tr>
<tr>
<td>5,6</td>
<td>10</td>
<td>5,4</td>
<td>10,9</td>
<td>23,6</td>
<td>70</td>
</tr>
<tr>
<td>6,6</td>
<td>11</td>
<td>6,4</td>
<td>15,3</td>
<td>33,5</td>
<td>101</td>
</tr>
<tr>
<td>6,6</td>
<td>11</td>
<td>6,4</td>
<td>15,3</td>
<td>35</td>
<td>111</td>
</tr>
<tr>
<td>9</td>
<td>15</td>
<td>8,5</td>
<td>28,2</td>
<td>54</td>
<td>163</td>
</tr>
<tr>
<td>9</td>
<td>15</td>
<td>8,5</td>
<td>28,2</td>
<td>57</td>
<td>180</td>
</tr>
</tbody>
</table>

---

### Static limiting load diagram

**Raceway – compressive load**

#### Equivalent axial bearing load (static) \(F_{0a}\)

#### Equivalent tilting moment load (static) \(M_{0a}\)

---

**INA** 53
Crossed roller bearings
sealed
Series XSU

<table>
<thead>
<tr>
<th>Designation</th>
<th>No.1,2)</th>
<th>Mass</th>
<th>Dimensions</th>
<th>Fixing holes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><em>=</em></td>
<td>_kg</td>
<td>Holes</td>
</tr>
<tr>
<td>XSU 080168</td>
<td>(1)</td>
<td>3,3</td>
<td>205⁻0,029</td>
<td>205⁻0,029</td>
</tr>
<tr>
<td>XSU 080188</td>
<td>(2)</td>
<td>3,7</td>
<td>225⁻0,029</td>
<td>225⁻0,029</td>
</tr>
<tr>
<td>XSU 080218</td>
<td>(3)</td>
<td>4,3</td>
<td>255⁻0,029</td>
<td>255⁻0,029</td>
</tr>
<tr>
<td>XSU 080258</td>
<td>(4)</td>
<td>5,1</td>
<td>295⁻0,029</td>
<td>295⁻0,029</td>
</tr>
<tr>
<td>XSU 080318</td>
<td>(5)</td>
<td>6,3</td>
<td>335⁻0,036</td>
<td>335⁻0,036</td>
</tr>
<tr>
<td>XSU 080398</td>
<td>(6)</td>
<td>7,8</td>
<td>375⁻0,040</td>
<td>375⁻0,040</td>
</tr>
</tbody>
</table>

1) Number of holes per ring.
2) See static limiting load diagram Raceway and Fixing screws.

Static limiting load diagram Fixing screws – compressive load
<table>
<thead>
<tr>
<th>Fixing screws</th>
<th>Basic load ratings</th>
<th>Limiting speeds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>axial</td>
<td>radial</td>
</tr>
<tr>
<td></td>
<td>dyn. $C_A$ kN</td>
<td>stat. $C_{0A}$ kN</td>
</tr>
<tr>
<td>8.18</td>
<td>66</td>
<td>240</td>
</tr>
<tr>
<td>10.9</td>
<td>71</td>
<td>275</td>
</tr>
<tr>
<td>13.6</td>
<td>77</td>
<td>315</td>
</tr>
<tr>
<td>16.4</td>
<td>84</td>
<td>375</td>
</tr>
<tr>
<td>19.1</td>
<td>93</td>
<td>465</td>
</tr>
<tr>
<td>24.5</td>
<td>106</td>
<td>590</td>
</tr>
</tbody>
</table>

*Static limiting load diagram* Raceway – compressive load
Crossed roller bearings
sealed
Series XSU

**Dimension table - Dimensions in mm**

<table>
<thead>
<tr>
<th>Designation</th>
<th>No.</th>
<th>Mass</th>
<th>Dimensions</th>
<th>Fixing holes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$D_a$</td>
<td>$d_1$</td>
</tr>
<tr>
<td>XSU 14 0414</td>
<td>1</td>
<td>28</td>
<td>484 ±0.06</td>
<td>344 ±0.06</td>
</tr>
<tr>
<td>XSU 14 0544</td>
<td>2</td>
<td>38</td>
<td>614 ±0.07</td>
<td>474 ±0.06</td>
</tr>
<tr>
<td>XSU 14 0644</td>
<td>3</td>
<td>44</td>
<td>714 ±0.08</td>
<td>574 ±0.07</td>
</tr>
<tr>
<td>XSU 14 0744</td>
<td>4</td>
<td>52</td>
<td>814 ±0.09</td>
<td>674 ±0.08</td>
</tr>
<tr>
<td>XSU 14 0844</td>
<td>5</td>
<td>60</td>
<td>914 ±0.09</td>
<td>774 ±0.08</td>
</tr>
<tr>
<td>XSU 14 0944</td>
<td>6</td>
<td>67</td>
<td>1014 ±0.11</td>
<td>874 ±0.09</td>
</tr>
<tr>
<td>XSU 14 1094</td>
<td>7</td>
<td>77</td>
<td>1164 ±0.11</td>
<td>1024 ±0.11</td>
</tr>
</tbody>
</table>

1) Centring lengths: see dimension drawing.
2) Number of holes per ring.
3) See static limiting load diagram Raceway and Fixing screws.

---

**Static limiting load diagram** Fixing screws – compressive load
4 taper type lubrication nipples, DIN 71412 – A M8×1, arranged evenly about the circumference and recessed

<table>
<thead>
<tr>
<th>Fixing screws</th>
<th>Running accuracy relative to raceway</th>
<th>Basic load ratings</th>
<th>Limiting speeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>F_{perm} (friction locking) kN</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>98,3</td>
<td>0,04</td>
<td>0,04</td>
<td>0,06</td>
</tr>
<tr>
<td>131</td>
<td>0,04</td>
<td>0,04</td>
<td>0,07</td>
</tr>
<tr>
<td>147</td>
<td>0,05</td>
<td>0,05</td>
<td>0,08</td>
</tr>
<tr>
<td>164</td>
<td>0,05</td>
<td>0,05</td>
<td>0,09</td>
</tr>
<tr>
<td>164</td>
<td>0,06</td>
<td>0,06</td>
<td>0,09</td>
</tr>
<tr>
<td>180</td>
<td>0,06</td>
<td>0,06</td>
<td>0,11</td>
</tr>
<tr>
<td>197</td>
<td>0,07</td>
<td>0,07</td>
<td>0,11</td>
</tr>
</tbody>
</table>

Static limiting load diagram Raceway – compressive load
## Precision locknuts

Series AM

AM 15 to AM 40

### Dimension table - dimensions in mm

<table>
<thead>
<tr>
<th>Thread d x H</th>
<th>Designation</th>
<th>Mass ~ kg</th>
<th>Dimensions</th>
<th>Set screw</th>
<th>Locknut</th>
<th>Breakaway torque at</th>
<th>Ultimate axial load</th>
<th>Moment of inertia</th>
</tr>
</thead>
<tbody>
<tr>
<td>d x 3</td>
<td></td>
<td></td>
<td>D</td>
<td>h</td>
<td>b</td>
<td>t</td>
<td>d1</td>
<td>c</td>
</tr>
<tr>
<td>M15 x 1</td>
<td>AM 15</td>
<td>0,06</td>
<td>30</td>
<td>18</td>
<td>4</td>
<td>5</td>
<td>23</td>
<td>5</td>
</tr>
<tr>
<td>M17 x 1</td>
<td>AM 17</td>
<td>0,07</td>
<td>32</td>
<td>18</td>
<td>4</td>
<td>5</td>
<td>26</td>
<td>5</td>
</tr>
<tr>
<td>M20 x 1</td>
<td>AM 20</td>
<td>0,13</td>
<td>38</td>
<td>18</td>
<td>4</td>
<td>6</td>
<td>29,5</td>
<td>5</td>
</tr>
<tr>
<td>M25 x 1,5</td>
<td>AM 25</td>
<td>0,16</td>
<td>45</td>
<td>20</td>
<td>5</td>
<td>6</td>
<td>35</td>
<td>6</td>
</tr>
<tr>
<td>M30 x 1,5</td>
<td>AM 30</td>
<td>0,2</td>
<td>52</td>
<td>20</td>
<td>5</td>
<td>7</td>
<td>40</td>
<td>6</td>
</tr>
<tr>
<td>M35 x 1,5</td>
<td>AM 35/58</td>
<td>0,23</td>
<td>58</td>
<td>20</td>
<td>5</td>
<td>7</td>
<td>48</td>
<td>6</td>
</tr>
<tr>
<td>M35 x 1,5</td>
<td>AM 35</td>
<td>0,33</td>
<td>65</td>
<td>22</td>
<td>6</td>
<td>8</td>
<td>48</td>
<td>6</td>
</tr>
<tr>
<td>M40 x 1,5</td>
<td>AM 40</td>
<td>0,3</td>
<td>65</td>
<td>22</td>
<td>6</td>
<td>8</td>
<td>51</td>
<td>6</td>
</tr>
<tr>
<td>M45 x 1,5</td>
<td>AM 45</td>
<td>0,34</td>
<td>70</td>
<td>22</td>
<td>6</td>
<td>8</td>
<td>56</td>
<td>6</td>
</tr>
<tr>
<td>M50 x 1,5</td>
<td>AM 50</td>
<td>0,43</td>
<td>75</td>
<td>25</td>
<td>6</td>
<td>8</td>
<td>62</td>
<td>8</td>
</tr>
<tr>
<td>M60 x 2</td>
<td>AM 60</td>
<td>0,65</td>
<td>90</td>
<td>26</td>
<td>6</td>
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AM 45 to AM 90
### Dimension table - dimensions in mm

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

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<th>Set Screw Tightening Torque (Nm)</th>
<th>Ultimate Axial Load (kN)</th>
<th>Breakaway Torque at Tightening Torque (Nm)</th>
<th>Locknut Mass Moment of Inertia (kg·cm²)</th>
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The lorry-mounted crane has a telescopic jib with a reach of 12.5 m and can lift a mass of 960 kg. By the mounting of additional jibs, it can reach 19.1 m and can lift 270 kg.

The linear motion of the hydraulically driven toothed rack is converted into rotary motion of the crane by means of a pinion. The bearing arrangement must transmit high axial and radial loads as well as large tilting moments. The pedestal bearing arrangement of the crane should be as small as possible. The bearing is subjected to heat, cold and moisture.

INA design solution
The crane rotates in a preloaded crossed roller bearing SX..VSP, so there are no tilting movements. This particularly rigid bearing supports loads from all directions as well as moments. This solution has advantages over conventional bearing arrangements with two bearings: only one bearing seat must be machined and only one bearing must be fitted. There is therefore no need to match two bearings to each other. The crossed roller bearings takes up very little space, so the pedestal bearing arrangement is small.

The bearing is suitable for temperatures from –30 °C to +80 °C. The adjacent construction contains seal profiles A/R 1025 and A/R 0218, which protect the bearing from contaminants and retain the grease in the bearing. The crossed roller bearing is located by means of clamping rings.

The adjacent construction was optimised using the Finite Element Method.

INA products used
1 Crossed roller bearing SX..VSP
2 Seal profile A/R 1025
3 Seal profile A/R 0218

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<td>Resultant radial load ( F_r )</td>
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<td>Resultant tilting moment ( M_k )</td>
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</table>
## Manufacturing Plants

### Australia
INA Bearings Australia Pty. Ltd.
Locked Bag 51
Taren Point 2229
Tel. +61/2/97101100
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56001 Lanskroun
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Fax +420/4653555190

### Germany

<table>
<thead>
<tr>
<th>Location</th>
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</table>
| Höchstadt | INA-Schaeffler KG
91315 Höchstadt (Asch)
Fax +49/1933/80-0 |
| Hörnburg | REGE Motoreniete GmbH & Co. KG
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66406 Homburg (Saar)
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33791 Steinhausen
Fax +49/5420/4999-0 |
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# Crossed roller bearings

**Technical data for processing of quotation (appendix to publication KSX)**

<table>
<thead>
<tr>
<th>Customer</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Load</th>
<th>Max. static operating load</th>
<th>Test load</th>
<th>Dynamic life load</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$F_{oa}$ kN</td>
<td></td>
<td>$F_a$ kN</td>
</tr>
<tr>
<td>2</td>
<td>$F_{or}$ kN</td>
<td></td>
<td>$F_r$ kN</td>
</tr>
<tr>
<td>3</td>
<td>$M_{ok}$ from $F_{oa}$ kNm</td>
<td>$M_{k1}$ kNm</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>$M_{ok}$ from $F_{or}$ kNm</td>
<td></td>
<td>$M_{k2}$ kNm</td>
</tr>
</tbody>
</table>

- **Utilisation life** $B$
- **Mean operating hours per year** $h_a$
- **Load cycles per hour** $L_{sph}$
- **Operating time per day** $h/d$
  - including rotating or swivel time
  - %
- **Required life** $a$
  - in shift operation

**Continuous rotating/swivel motion**
- mean
- maximum

**Speed**
- normal
  - min$^{-1}$
- maximum
  - min$^{-1}$

**Do severe shocks or vibrations occur** yes/no

**Proposal for sealing in adjacent construction required?** yes/no

**Does particular contamination occur** yes/no

**Bearing clearance** yes/no

**Bearing free from clearance and preloaded (VSP)** yes/no

**Particular requirements for rotational resistance**

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1. Including inertia forces (e.g. in cranes).
2. Planned utilisation life of equipment.
3. State not only the medium against which sealing is to be provided but also any aggressive environmental influences or atmospheres.
4. For values see dimension tables.