17. Technical data

17.1 Radial internal clearances vs. axial internal clearances

17.1.1 Deep groove ball bearings

Note: Please consult NTN Engineering for other types and sizes.
17.1.2 Double-row angular contact ball bearings

17.1.3 Spherical roller bearings

*This technical data shows calculated values based on representative values, NTN does not guarantee these values.*
17.2 Axial load vs. axial displacement
17.2.1 Angular contact ball bearings

Note: Please consult NTN Engineering for other types and sizes.
17.2.2 Tapered roller bearings

Note: 1. Values when the shaft and the housing are rigid bodies.
2. Axial displacement may increase depending on the shape of the shaft/housing and fitting conditions.
3. Please consult NTN Engineering for other types and sizes.

*This technical data shows calculated values based on representative values, NTN does not guarantee these values.*
17.3 Allowable axial load

17.3.1 Deep groove ball bearings

Note: 1. Calculation of the allowable axial load uses the median of the radial clearance CN.
2. When an axial load is applied, the allowable axial load is the load whereby the contact ellipse exceeds the shoulder of the raceway.
3. Please consult NTN Engineering for other types and sizes.

Fig. 17.3.1 Allowable axial load for deep groove ball bearings

Fig. 17.2.12 Inch series axial load vs. axial displacement

Note: 1. Values when the shaft and the housing are rigid bodies.
2. Axial displacement may increase depending on the shape of the shaft/housing and fitting conditions.
3. Please consult NTN Engineering for other types and sizes.

Fig. 17.3.2 Allowable axial load for angular contact ball bearings

Note: 1. When an axial load is applied, the allowable axial load is the load whereby the contact ellipse exceeds the shoulder of the raceway.
2. Please consult NTN Engineering for other types and sizes.
17.4 Fitting surface pressure

Table 17.4.1 lists equations for calculating the pressure and maximum stress between fitting surfaces.

Table 17.4.2 can be used to determine the approximate average groove diameter for bearing inner and outer rings.

The effective interference, in other words the actual interference \( \Delta _{\text{eff}} \) after fitting, is smaller than the apparent interference \( \Delta _{\text{app}} \) derived from the measured values for the bearing bore and shaft. This difference is due to the roughness or variations of the finished surfaces to be fitted. Due to this, it is necessary to assume the following reductions in effective interference:

- For ground shafts: 1.0 to 2.5 \( \mu \)m
- For lathed shafts: 5.0 to 7.0 \( \mu \)m

Figure 17.4.1 and Figure 17.4.2 show the root approximate values of the fitting surface pressure and the maximum stress when the solid steel shaft and the inner ring of 0 class bearings (\( d/D_1 = 0.8 \)) are fit.

Table 17.4.1 Fitting surface pressure and maximum stress

<table>
<thead>
<tr>
<th>Fit condition</th>
<th>Calculation formula</th>
<th>Symbol (Unit: ( N , \text{mm} ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two cylinders</td>
<td>( P = \frac{E_1}{E_i} \left( \frac{d_2 + D_2}{d_2 - d_1} \right) )</td>
<td>( \Delta _{\text{eff}} )</td>
</tr>
<tr>
<td>General type</td>
<td>( P = \frac{E_1}{E_i} \left( \frac{d_2 + D_2}{d_2 - d_1} \right) )</td>
<td>( \Delta _{\text{eff}} )</td>
</tr>
<tr>
<td>Solid steel shaft/inner ring fit</td>
<td>( P = \frac{E_1}{d} \Delta _{\text{eff}} \left( 1 - \frac{d}{D_2} \right)^2 )</td>
<td>( d )</td>
</tr>
<tr>
<td>Hollow steel shaft/inner ring fit</td>
<td>( P = \frac{E_1}{d} \Delta _{\text{eff}} \left( 1 - \frac{d}{D_2} \right)^2 \left( 1 - \frac{d}{d_1} \right)^2 )</td>
<td>( D_1 )</td>
</tr>
<tr>
<td>Steel housing/outer ring fit</td>
<td>( P = \frac{E_1}{D} \Delta _{\text{eff}} \left( 1 - \frac{D_1}{D} \right)^2 \left( 1 - \frac{D_1}{D_2} \right)^2 )</td>
<td>( D_2 )</td>
</tr>
<tr>
<td>Maximum stress</td>
<td>( \sigma _{\text{max}} = P )</td>
<td>( \sigma _{\text{max}} )</td>
</tr>
<tr>
<td>Housing/outer ring fit</td>
<td>( \sigma _{\text{max}} = P )</td>
<td>( \sigma _{\text{max}} )</td>
</tr>
</tbody>
</table>

### Table 17.4.2 Average groove diameter (approximate expression)

<table>
<thead>
<tr>
<th>Bearing type</th>
<th>Average groove diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner ring</td>
<td>Outer ring</td>
</tr>
<tr>
<td>Deep groove ball bearings</td>
<td>All types</td>
</tr>
<tr>
<td>Self-aligning ball bearings</td>
<td>12</td>
</tr>
<tr>
<td>Cylindrical roller bearings</td>
<td>13, 22</td>
</tr>
<tr>
<td>Spherical roller bearings</td>
<td>Type B, type C, type 213</td>
</tr>
<tr>
<td>Tapered roller bearings</td>
<td>All types</td>
</tr>
</tbody>
</table>

Note: \( d \) inner ring bore diameter (\( \mu \)m) \( D \) outer ring outer diameter (\( \mu \)m)

1 Average groove diameter values shown for double-flange type.
17.5 Necessary press fit and pullout force

Equations (17.1) and (17.2) below can be used to calculate the necessary pullout force for press fits on inner rings and shafts or outer rings and housings. The force obtained by the equations only serves as an approximation, and a larger load may be required for the actual installation and removal.

For shaft and inner rings:

\[ K_d = \mu \cdot P \cdot \pi \cdot d \cdot B \]  \hspace{1cm} (17.1)

For housing and outer rings:

\[ K_D = \mu \cdot P \cdot \pi \cdot D \cdot B \]  \hspace{1cm} (17.2)

Where:
- \( K_d \): Inner ring press fit or pullout force N
- \( K_D \): Outer ring press fit or pullout force N
- \( P \): Fitting surface pressure MPa
  (see Table 17.4.1)
- \( d \): Shaft diameter, inner ring bore diameter mm
- \( D \): Housing inner diameter, outer ring outer diameter mm
- \( B \): Inner or outer ring width mm
- \( \mu \): Sliding friction coefficient
  (see Table 17.5.1)

### Table 17.5.1 Press fit and pullout sliding friction coefficient

<table>
<thead>
<tr>
<th>Concern</th>
<th>( \mu )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner (outer) ring press fit onto cylindrical shaft (bore)</td>
<td>0.12</td>
</tr>
<tr>
<td>Inner (outer) ring pullout from cylindrical shaft (bore)</td>
<td>0.18</td>
</tr>
<tr>
<td>Inner ring press fit onto tapered shaft or sleeve</td>
<td>0.17</td>
</tr>
<tr>
<td>Inner ring pullout from tapered shaft</td>
<td>0.14</td>
</tr>
<tr>
<td>Sleeve press fit onto shaft/bearing</td>
<td>0.30</td>
</tr>
<tr>
<td>Sleeve pullout from shaft/bearing</td>
<td>0.33</td>
</tr>
</tbody>
</table>

17.6 Bearing technique calculation tool

The following calculations can be performed by using the bearing technique calculation tool on the **NTN** website (https://www.ntnglobal.com).

- Basic rating life calculation of single bearing
- Basic rating life calculation of gear load and bearing
- Basic rating life calculation of bearing load and bearing
- Calculation of operating clearance
- Calculation of bearing vibration frequency