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

17. Technical data

17.1 Radial internal clearances vs. axial internal clearances

17.1.1 Deep groove ball bearings

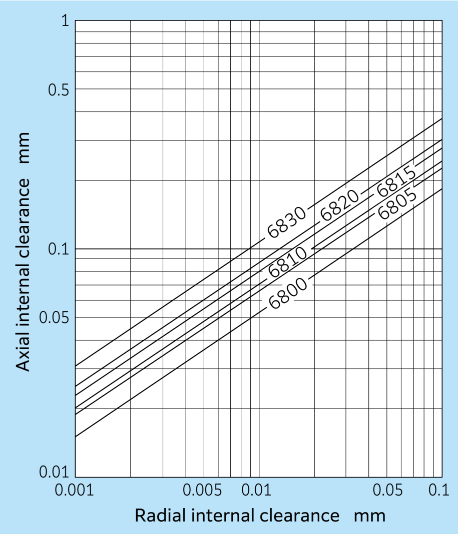


Fig. 17.1.1 Series 68 radial internal/axial internal clearances

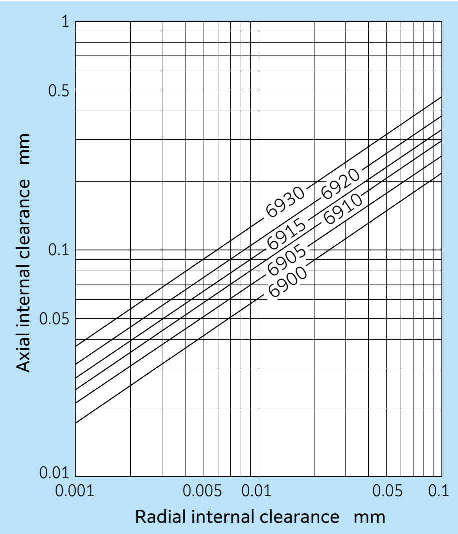


Fig. 17.1.2 Series 69 radial internal/axial internal clearances

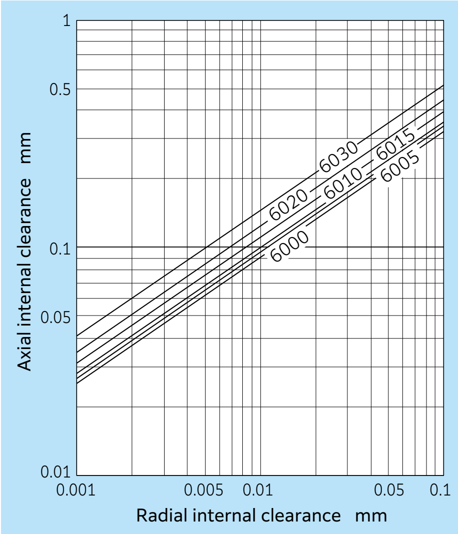


Fig. 17.1.3 Series 60 radial internal/axial internal clearances

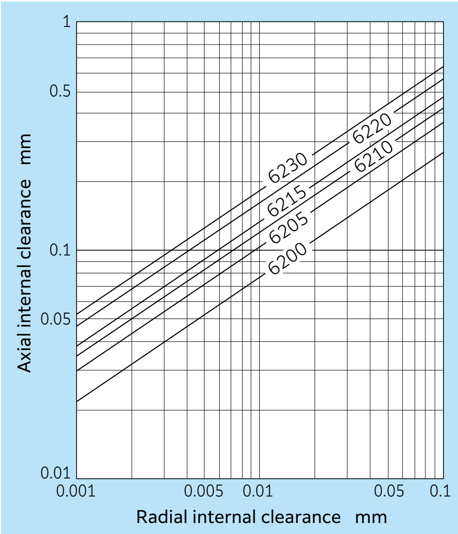


Fig. 17.1.4 Series 62 radial internal/axial internal clearances

Note: 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.

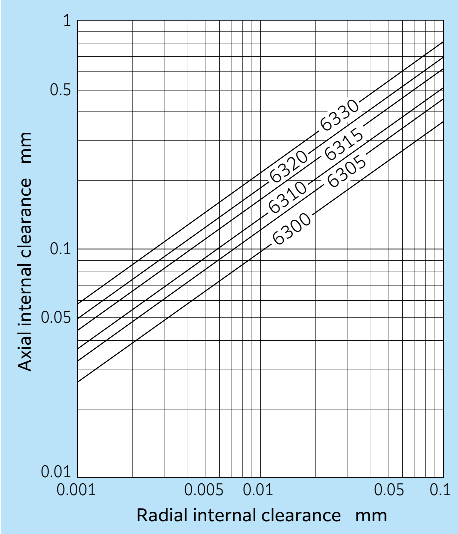


Fig. 17.1.5 Series 63 radial internal/axial internal clearances

Note: Please consult **NTN** Engineering for other types and sizes.

Technical Data

NTN

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

17.1.2 Double-row angular contact ball bearings

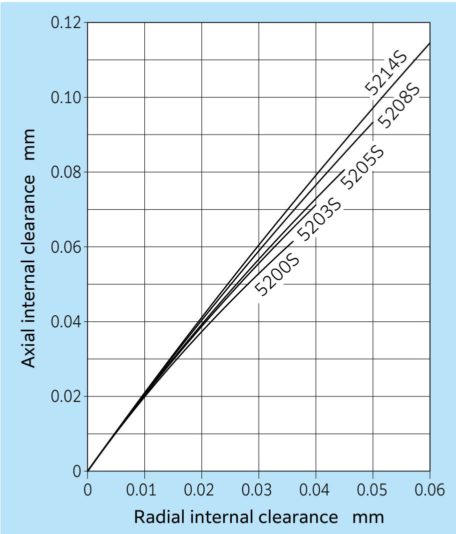


Fig. 17.1.6 Series 52S radial internal/axial internal clearances

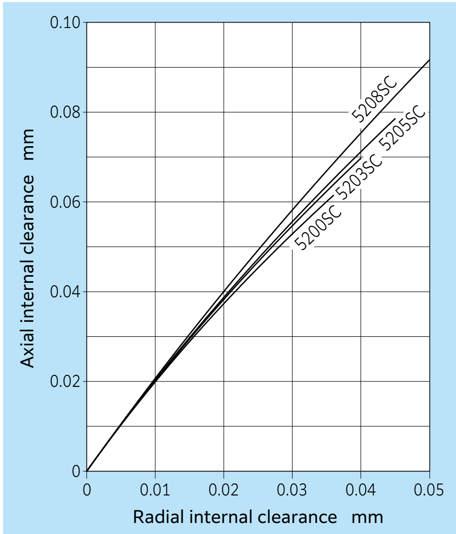


Fig. 17.1.8 Series 52SC radial internal/axial internal clearances

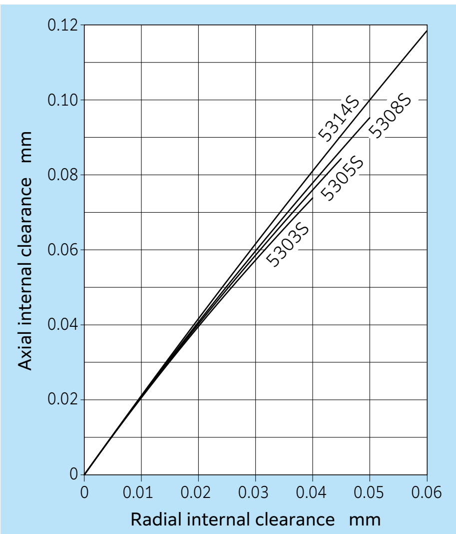


Fig. 17.1.7 Series 53S radial internal/axial internal clearances

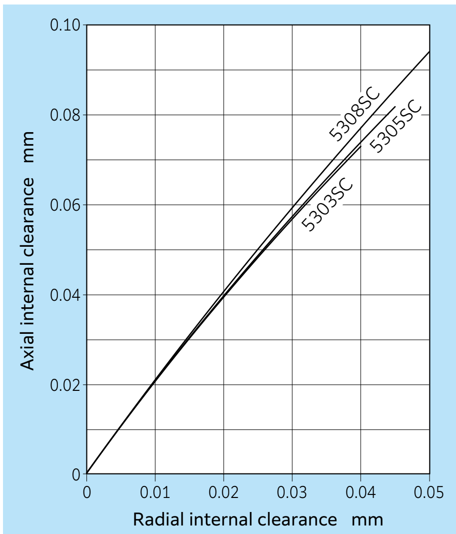


Fig. 17.1.9 Series 53SC radial internal/axial internal clearances

Note: Please consult **NTN** Engineering for other types and sizes.

Technical Data

NTN

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

17.1.3 Spherical roller bearings

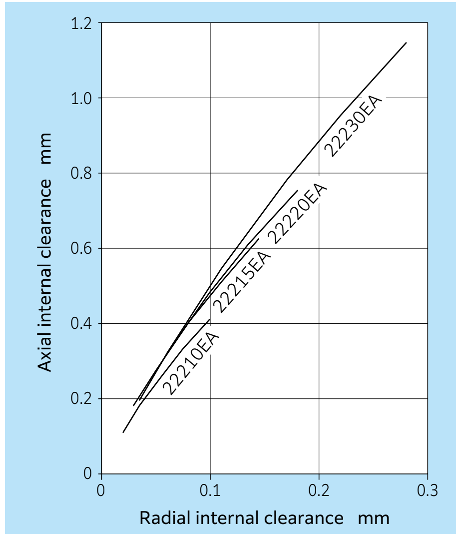


Fig. 17.1.10 Series 222 radial internal/axial internal clearances

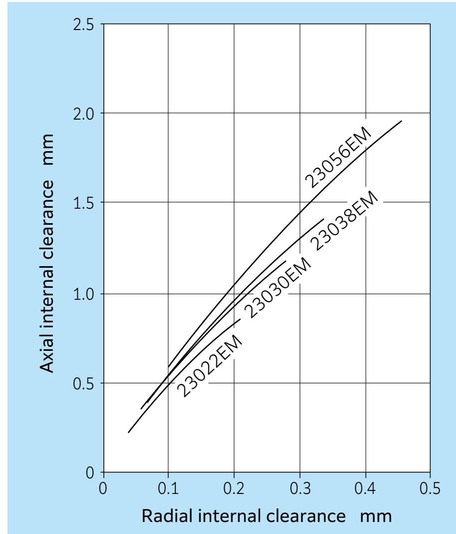


Fig. 17.1.12 Series 230 radial internal/axial internal clearances

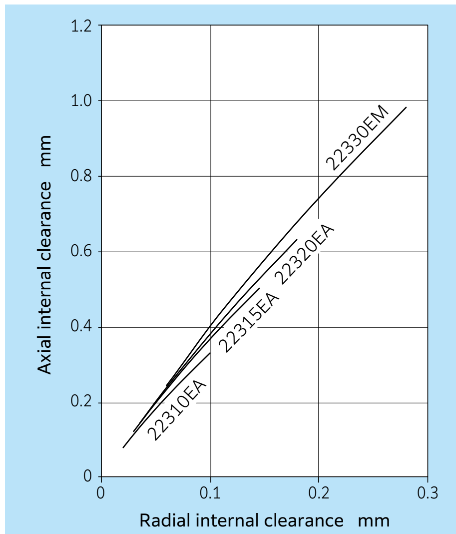


Fig. 17.1.11 Series 223 radial internal/axial internal clearances

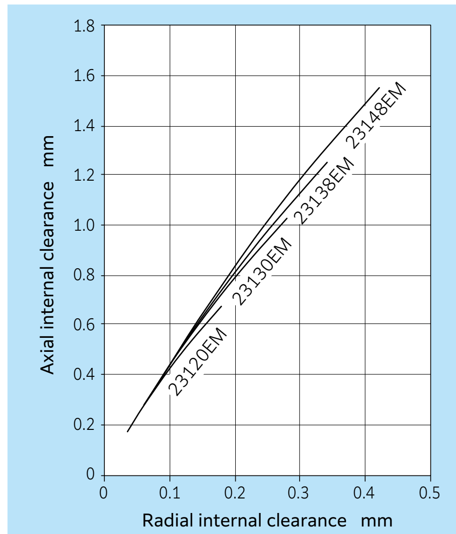


Fig. 17.1.13 Series 231 radial internal/axial internal clearances

Note: Please consult **NTN** Engineering for other types and sizes.

Technical Data

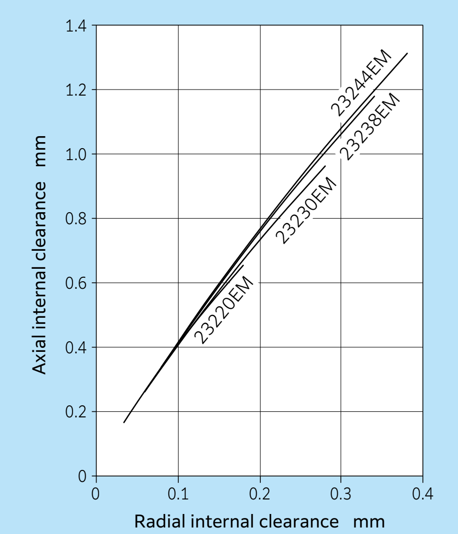


Fig. 17.1.14 Series 232 radial internal/axial internal clearances

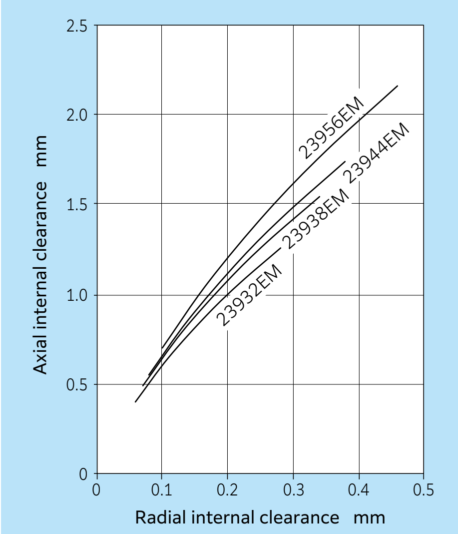


Fig. 17.1.15 Series 239 radial internal/axial internal clearances

Note: Please consult **NTN** Engineering for other types and sizes.

Technical Data

*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

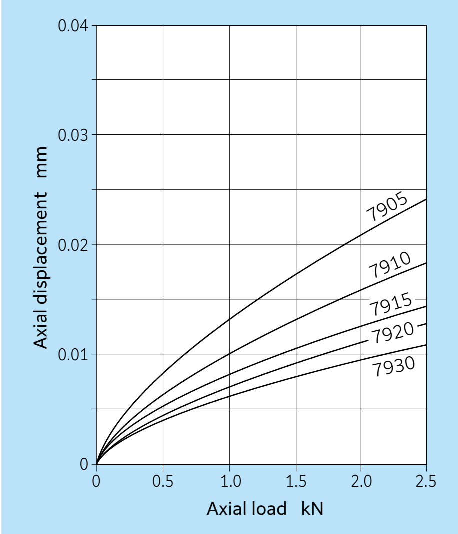


Fig. 17.2.1 Series 79 axial load vs. axial displacement

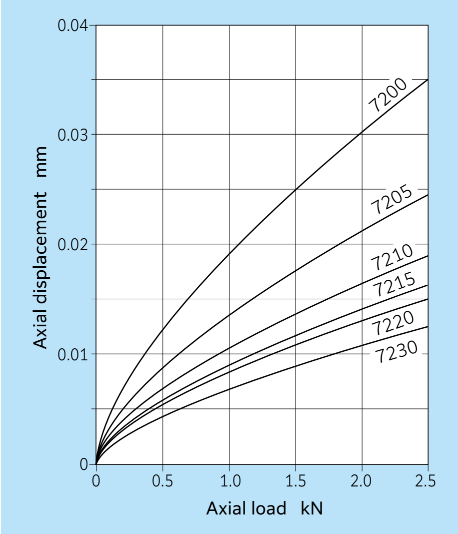


Fig. 17.2.3 Series 72 axial load vs. axial displacement

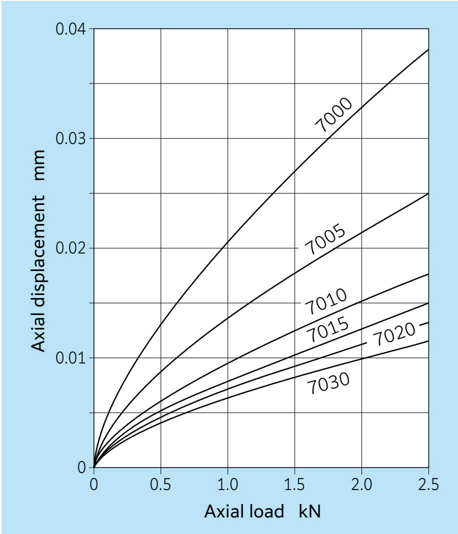


Fig. 17.2.2 Series 70 axial load vs. axial displacement

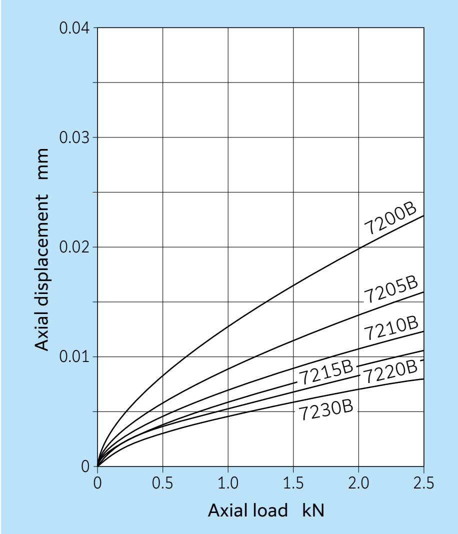


Fig. 17.2.4 Series 72 B axial load vs. axial displacement

Note: Please consult **NTN** Engineering for other types and sizes.

Technical Data

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

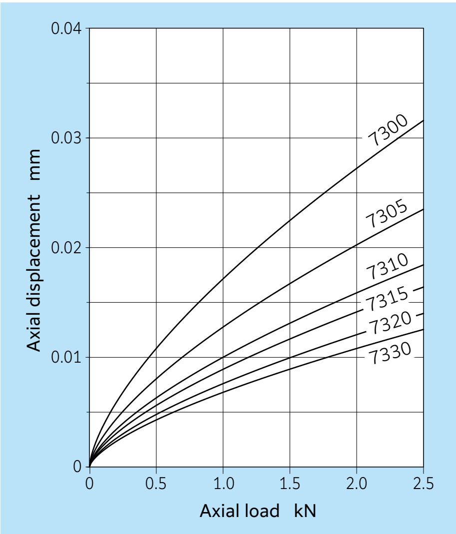


Fig. 17.2.5 Series 73 axial load vs. axial displacement

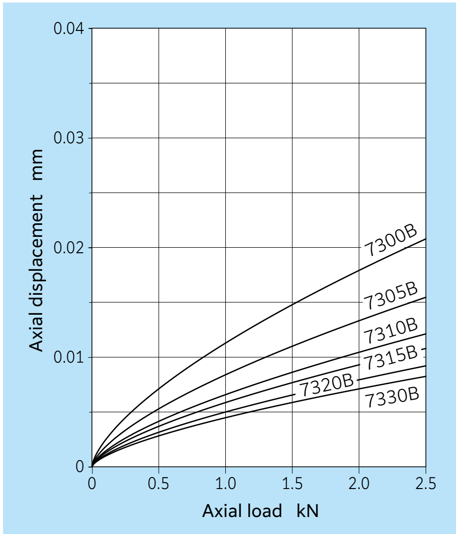


Fig. 17.2.6 Series 73B axial load vs. axial displacement

Note: Please consult **NTN** Engineering for other types and sizes.

Technical Data

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

17.2.2 Tapered roller bearings

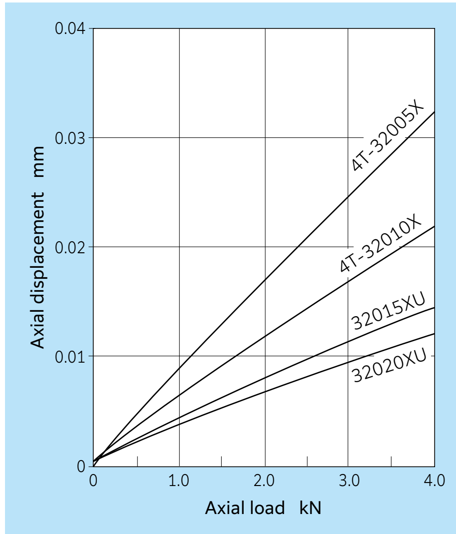


Fig. 17.2.7 Series 320 axial load vs. axial displacement

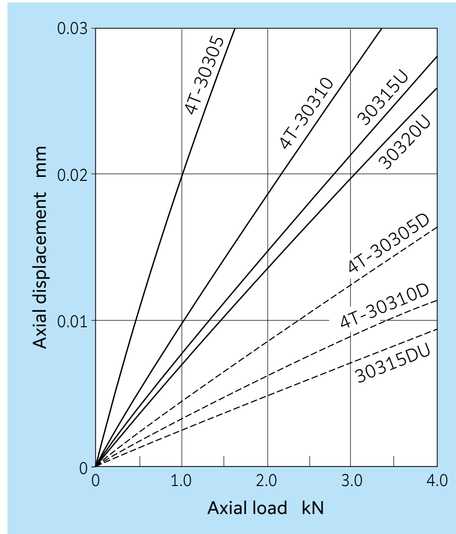


Fig. 17.2.9 Series 303/303 D axial load vs. axial displacement

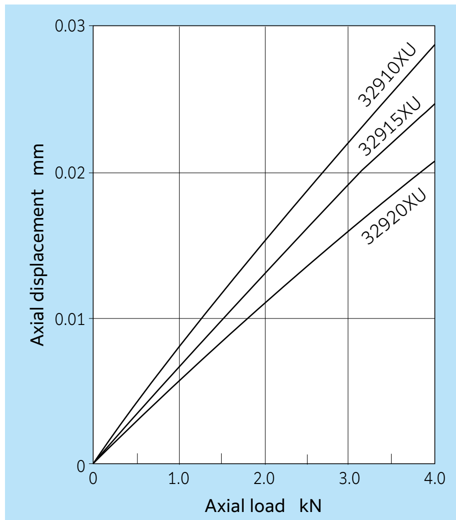


Fig. 17.2.8 Series 329 axial load vs. axial displacement

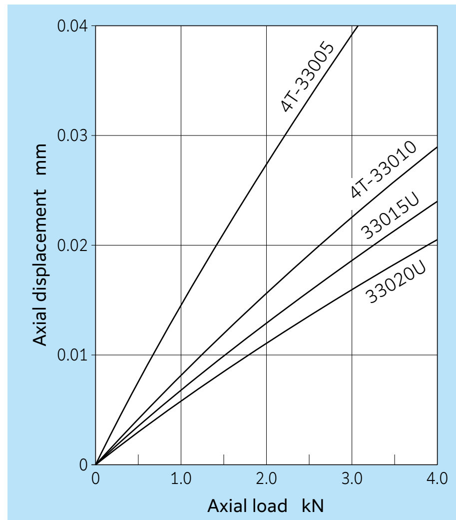


Fig. 17.2.10 Series 330 axial load vs. axial displacement

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.

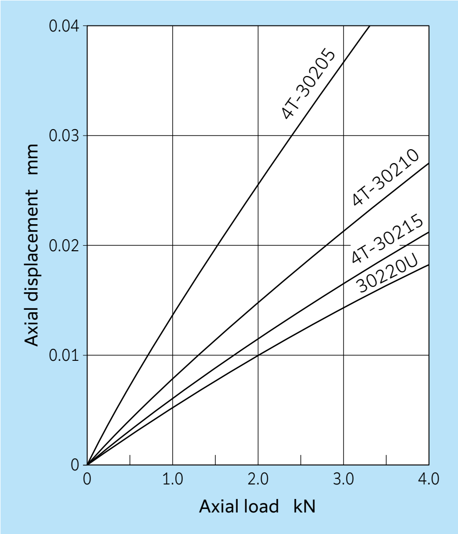


Fig. 17.2.11 Series 302 axial load vs. axial displacement

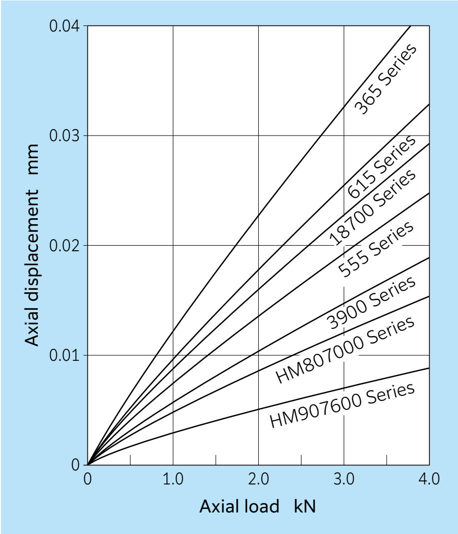


Fig. 17.2.12 Inch series axial load vs. axial displacement

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.

17.3 Allowable axial load

17.3.1 Deep groove ball bearings

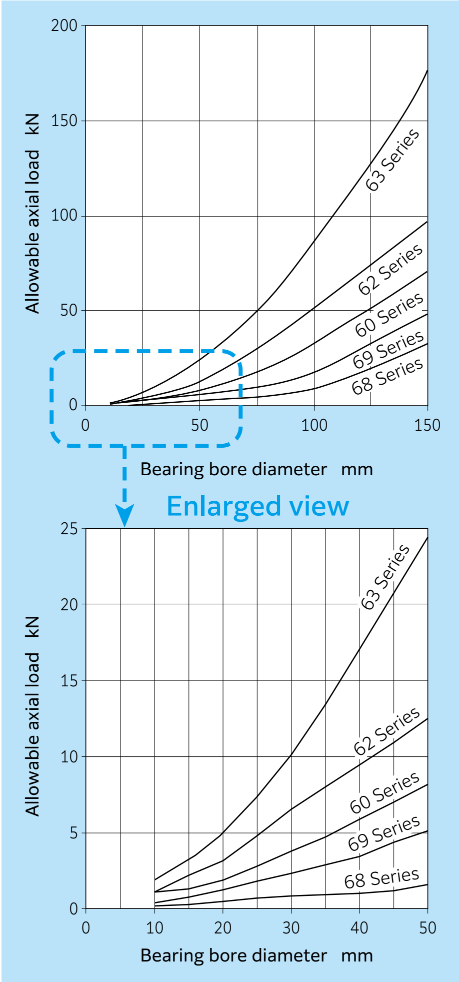


Fig. 17.3.1 Allowable axial load for deep groove ball bearings

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.

17.3.2 Angular contact ball bearings

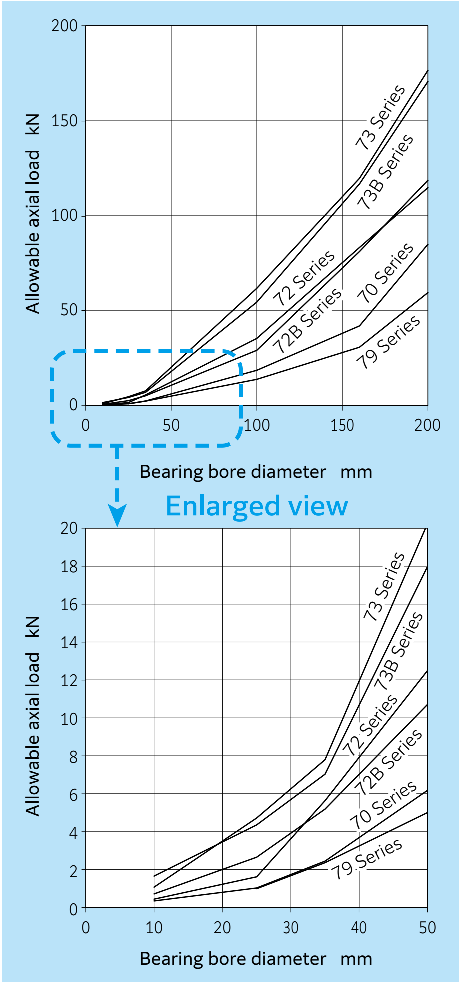


Fig. 17.3.2 Allowable axial load for angular contact ball bearings

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 Δd_{eff} after fitting, is smaller than the apparent interference Δd derived from the measured values for the bearing bore diameter 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 μm

For lathed shafts: 5.0 to 7.0 μm

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_i = 0.8) are fit.

Table 17.4.1 Fitting surface pressure and maximum stress

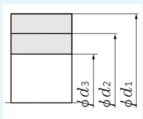
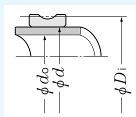
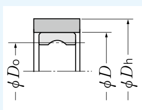
Fit condition		Calculation formula	Symbol (Unit: N, mm)
Fitting surface pressure MPa	Two cylinders General type	$P = \frac{E_1 E_2}{E_2\left\{\frac{(d_1^2+d_2^2)}{(d_1^2-d_2^2)}+\nu_1\right\}+E_1\left\{\frac{(d_2^2+d_3^2)}{(d_2^2-d_3^2)}-\nu_2\right\}}\cdot\frac{\Delta d_e}{d_2}$	P : Fitting surface pressure E_1, E_2 : Young's modulus of outer and inner cylinders ν_1, ν_2 : Poisson's ratio of outer and inner cylinders Δd_e : Effective interference of two cylinders 
	Solid steel shaft/ inner ring fit	$P = \frac{E}{2}\frac{\Delta d_{eff}}{d}\left[1-\left(\frac{d}{D_i}\right)^2\right]$	d : Shaft diameter, inner ring bore diameter d_o : Hollow shaft inner diameter D_i : Inner ring average groove diameter Δd_{eff} : Effective interference E : Longitudinal elasticity factor = 208,000 MPa 
	Hollow steel shaft/ inner ring fit	$P = \frac{E}{2}\frac{\Delta d_{eff}}{d}\frac{[1-(d/D_i)^2]\,[1-(d_o/d)^2]}{[1-(d_o/D_i)^2]}$	
	Steel housing/ outer ring fit	$P = \frac{E}{2}\frac{\Delta D_{eff}}{D}\frac{[1-(D_o/D)^2]\,[1-(D/D_h)^2]}{[1-(D_o/D_h)^2]}$	D : Housing inner diameter, bearing outer diameter D_o : Outer ring average groove diameter D_h : Housing outer diameter ΔD_{eff} : Effective interference 
Maximum stress MPa	Shaft/ inner ring fit	$\sigma_{t\,max} = P\frac{1+(d/D_i)^2}{1-(d/D_i)^2}$	Inner ring bore diameter maximum circumferential stress.
	Housing/ outer ring fit	$\sigma_{t\,max} = P\frac{2}{1-(D_o/D)^2}$	Outer ring outer diameter maximum circumferential stress.

Table 17.4.2 Average groove diameter (approximate expression)

Bearing type		Average groove diameter: Inner ring	Average groove diameter: Outer ring
Deep groove ball bearings	All types	$1.05\frac{4d+D}{5}$	$0.95\frac{d+4D}{5}$
Self-aligning ball bearings	12	$1.03\frac{3d+D}{4}$	$0.97\frac{d+2D}{3}$
	13, 22	$1.03\frac{3d+D}{4}$	$0.97\frac{d+3D}{4}$
	23	$1.03\frac{4d+D}{5}$	$0.97\frac{d+4D}{5}$
Cylindrical roller bearing 1)	All types	$1.05\frac{3d+D}{5}$	$0.98\frac{d+3D}{4}$
Spherical roller bearings	Type B, type C, type 213	$\frac{2d+D}{3}$	$0.97\frac{d+4D}{5}$
	ULTAGE	$\frac{3d+D}{4}$	$0.98\frac{d+5D}{6}$
Tapered roller bearings	All types	$\frac{3d+D}{4}$	$\frac{d+3D}{4}$

Note: d: inner ring bore diameter (mm) D: outer ring outer diameter (mm)
1) Average groove diameter values shown for double-flange type.

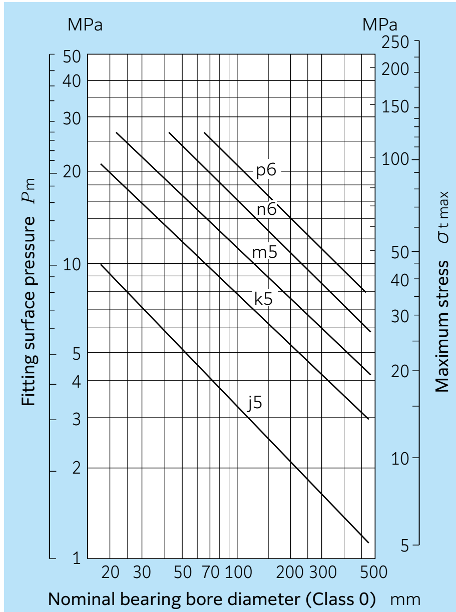


Fig. 17.4.1 Average fit interference as it relates to surface pressure P_m and maximum stress $\sigma_{t\,max}$

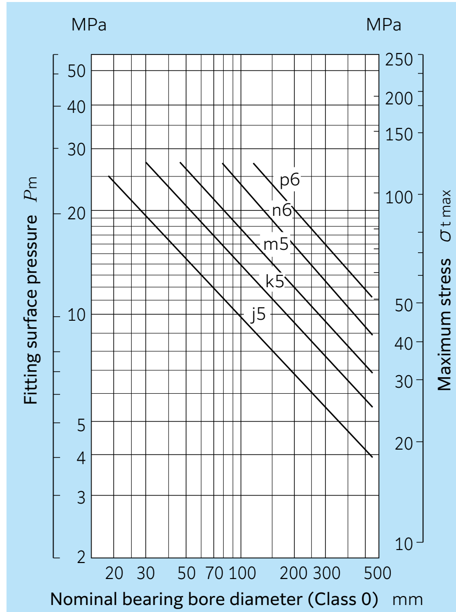


Fig. 17.4.2 Maximum fit interference as it relates to surface pressure P_m and maximum stress $\sigma_{t\,max}$

Note: For the recommended fitting, see the section of "7.3.2 Recommended fitting."

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:

$$K_d = \mu \cdot P \cdot \pi \cdot d \cdot B \quad \cdots\cdots\cdots\cdots\cdots (17.1)$$

For housing and outer rings:

$$K_D = \mu \cdot P \cdot \pi \cdot D \cdot B \quad \cdots\cdots\cdots\cdots\cdots (17.2)$$

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
μ : Sliding friction coefficient (see **Table 17.5.1**)

Table 17.5.1 Press fit and pullout sliding friction coefficient

Concern	μ
Inner (outer) ring press fit onto cylindrical shaft (bore)	0.12
Inner (outer) ring pullout from cylindrical shaft (bore)	0.18
Inner ring press fit onto tapered shaft or sleeve	0.17
Inner ring pullout from tapered shaft	0.14
Sleeve press fit onto shaft/bearing	0.30
Sleeve pullout from shaft/bearing	0.33

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