# 8. Bearing Internal Clearance and Preload

## 8.1 Bearing internal clearance

Bearing internal clearance (initial clearance) is the amount of internal clearance a bearing has before being installed on a shaft or in a housing.

As shown in Fig. 8.1, when either the inner ring or the outer ring is fixed and the other ring is free to move, displacement can take place in either an axial or radial direction. This amount of displacement (radially or axially) is termed the internal clearance and, depending on the direction, is called the radial internal clearance or the axial internal clearance.

When the internal clearance of a bearing is measured, a slight measurement load is applied to the raceway so the internal clearance may be measured accurately. However, at this time, a slight amount of elastic deformation of the bearing occurs under the measurement load, and the clearance measurement value (measured clearance) is slightly larger than the true clearance. This discrepancy between the true bearing clearance and the increased amount due to the elastic deformation must be compensated for. These compensation values are given in Table 8.1. For roller bearings the amount of elastic deformation can be ignored.

The internal clearance values for each bearing class are shown in Tables 8.3 through 8.10.

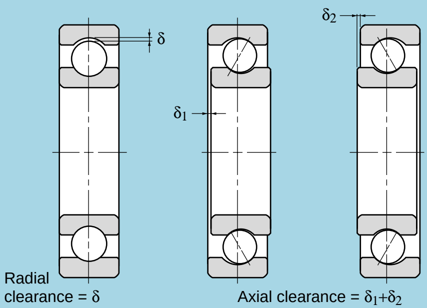



**Fig. 8.1 Internal clearance**

Table 8.1 Adjustment of radial internal clearance based on measured load  Unit $\mu$m

| Nominal Bore Diameter *d* (mm) over | incl. | Measuring Load (N) | Radial Clearance Increase C2 | Normal | C3 | C4 | C5 |
|---|---|---|---|---|---|---|---|
| 10 | 18 | 24.5 | 3~4 | 4 | 4 | 4 | 4 |
| 18 | 50 | 49 | 4~5 | 5 | 6 | 6 | 6 |
| 50 | 200 | 147 | 6~8 | 8 | 9 | 9 | 9 |

## 8.2 Internal clearance selection

The internal clearance of a bearing under operating conditions (effective clearance) is usually smaller than the same bearing's initial clearance before being installed and operated. This is due to several factors including bearing fit, the difference in temperature between the inner and outer rings, etc. As a bearing's operating clearance has an effect on bearing life, heat generation, vibration, noise, etc.; care must be taken in selecting the most suitable operating clearance.

Effective internal clearance:

The initial clearance differential between the initial clearance and the operating (effective) clearance (the amount of clearance reduction caused by interference fits, or clearance variation due to the temperature difference between the inner and outer rings) can be calculated by the following formula:

$$\delta_{\mathrm{eff}} = \delta_{\mathrm{o}} - (\delta_{\mathrm{f}} + \delta_{\mathrm{t}}) \cdots\cdots (8.1)$$

where,

$\delta_{\mathrm{eff}}$ : Effective internal clearance mm
$\delta_{\mathrm{o}}$ : Bearing internal clearance mm
$\delta_{\mathrm{f}}$ : Reduced amount of clearance due to interference mm
$\delta_{\mathrm{t}}$ : Reduced amount of clearance due to temperature differential of inner and outer rings mm

Reduced clearance due to interference:

When bearings are installed with interference fits on shafts and in housings, the inner ring will expand and the outer ring will contract; thus reducing the bearings' internal clearance. The amount of expansion or contraction varies depending on the shape of the bearing, the shape of the shaft or housing, dimensions of the respective parts, and the type of materials used. The differential can range from approximately 70% to 90% of the effective interference.

$$\delta_{\mathrm{f}} = (0.70 \sim 0.90) \bullet \Delta_{deff} \cdots\cdots (8.2)$$

where,

$\delta_{\mathrm{f}}$ : Reduced amount of clearance due to interference mm
$\Delta_{deff}$ : Effective interference mm

Reduced internal clearance due to inner/outer ring temperature difference:

During operation, normally the outer ring will be from 5° to 10° cooler than the inner ring or rotating parts. However, if the cooling effect of the housing is large, the shaft is connected to a heat source, or a heated substance is conducted through the hollow shaft; the temperature difference between the two rings can be even greater. The amount of internal clearance is thus further reduced by the differential expansion of the two rings.

$$\delta_t = \alpha \bullet \Delta_T \bullet D_o \cdots\cdots\cdots (8.3)$$

where,

- $\delta_t$ : Amount of reduced clearance due to heat differential mm
- $\alpha$ : Bearing steel linear expansion coefficient $12.5\times10^{-6}$/°C
- $\Delta_T$ : Inner/outer ring temperature differential °C
- $D_o$ : Outer ring raceway diameter mm

Outer ring raceway diameter, $D_o$, values can be approximated by using formula (8.4) or (8.5).

For ball bearings and self-aligning roller bearings,

$$D_o = 0.20(d + 4.0D) \cdots\cdots\cdots (8.4)$$

For roller bearings (except self-aligning),

$$D_o = 0.25(d + 3.0D) \cdots\cdots\cdots (8.5)$$

where,

- $d$ : Bearing bore diameter mm
- $D$ : Bearing outside diameter mm

## 8.3 Bearing internal clearance selection standards

Theoretically, to maximize life, the optimum operating internal clearance for any bearing would be a slight negative clearance after the bearing had reached normal operating temperature.

Unfortunately, under actual operating conditions, maintaining such optimum tolerances is often difficult at best. Due to various fluctuating operating conditions this slight negative clearance can quickly become a further negative, greatly lowering the life of the bearing and causing excessive heat to be generated. Therefore, an initial internal clearance which will result in a slightly greater than negative internal operating clearance should be selected.

Under normal operating conditions (e.g. normal load, fit, speed, temperature, etc.), a standard internal clearance will give a very satisfactory operating clearance.

Table 8.2 lists non-standard clearance recommendations for various applications and operating conditions.

Table 8.2 Examples of applications where bearing clearances other than normal clearances are used

| Operating conditions | Applications | Selected clearance |
|---|---|---|
| With heavy or shock load, clearance is great. | Railway vehicle axles | C3 |
| | Vibration screens | C3 |
| With direction indeterminate load, both inner and outer rings are tight-fitted. | Railway vehicle traction motors | C4 |
| | Tractors and final speed regulators | C4 |
| Shaft or inner ring is heated. | Paper making machines and driers | C3, C4 |
| | Rolling mill table rollers | C3 |
| Clearance fit for both inner and outer rings. | Rolling mill roll necks | C2 |
| To reduce noise and vibration when rotating. | Micromotors | C2 |
| To reduce shaft runout, clearance is adjusted. | Main spindles of lathes (Double-row cylindrical roller bearings) | C9NA, C0NA |

Table 8.3 Radial internal clearance of deep groove ball bearings Unit μm

| Nominal bore diameter *d* mm | | C2 | | Normal | | C3 | | C4 | | C5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| over | incl. | min | max | min | max | min | max | min | max | min | max |
| — | 2.5 | 0 | 6 | 4 | 11 | 10 | 20 | — | — | — | — |
| 2.5 | 6 | 0 | 7 | 2 | 13 | 8 | 23 | — | — | — | — |
| 6 | 10 | 0 | 7 | 2 | 13 | 8 | 23 | 14 | 29 | 20 | 37 |
| 10 | 18 | 0 | 9 | 3 | 18 | 11 | 25 | 18 | 33 | 25 | 45 |
| 18 | 24 | 0 | 10 | 5 | 20 | 13 | 28 | 20 | 36 | 28 | 48 |
| 24 | 30 | 1 | 11 | 5 | 20 | 13 | 28 | 23 | 41 | 30 | 53 |
| 30 | 40 | 1 | 11 | 6 | 20 | 15 | 33 | 28 | 46 | 40 | 64 |
| 40 | 50 | 1 | 11 | 6 | 23 | 18 | 36 | 30 | 51 | 45 | 73 |
| 50 | 65 | 1 | 15 | 8 | 28 | 23 | 43 | 38 | 61 | 55 | 90 |
| 65 | 80 | 1 | 15 | 10 | 30 | 25 | 51 | 46 | 71 | 65 | 105 |
| 80 | 100 | 1 | 18 | 12 | 36 | 30 | 58 | 53 | 84 | 75 | 120 |
| 100 | 120 | 2 | 20 | 15 | 41 | 36 | 66 | 61 | 97 | 90 | 140 |
| 120 | 140 | 2 | 23 | 18 | 48 | 41 | 81 | 71 | 114 | 105 | 160 |
| 140 | 160 | 2 | 23 | 18 | 53 | 46 | 91 | 81 | 130 | 120 | 180 |
| 160 | 180 | 2 | 25 | 20 | 61 | 53 | 102 | 91 | 147 | 135 | 200 |
| 180 | 200 | 2 | 30 | 25 | 71 | 63 | 117 | 107 | 163 | 150 | 230 |
| 200 | 225 | 2 | 35 | 25 | 85 | 75 | 140 | 125 | 195 | 175 | 265 |
| 225 | 250 | 2 | 40 | 30 | 95 | 85 | 160 | 145 | 225 | 205 | 300 |
| 250 | 280 | 2 | 45 | 35 | 105 | 90 | 170 | 155 | 245 | 225 | 340 |
| 280 | 315 | 2 | 55 | 40 | 115 | 100 | 190 | 175 | 270 | 245 | 370 |
| 315 | 355 | 3 | 60 | 45 | 125 | 110 | 210 | 195 | 300 | 275 | 410 |
| 355 | 400 | 3 | 70 | 55 | 145 | 130 | 240 | 225 | 340 | 315 | 460 |
| 400 | 450 | 3 | 80 | 60 | 170 | 150 | 270 | 250 | 380 | 350 | 510 |
| 450 | 500 | 3 | 90 | 70 | 190 | 170 | 300 | 280 | 420 | 390 | 570 |
| 500 | 560 | 10 | 100 | 80 | 210 | 190 | 330 | 310 | 470 | 440 | 630 |
| 560 | 630 | 10 | 110 | 90 | 230 | 210 | 360 | 340 | 520 | 490 | 690 |
| 710 | 800 | 20 | 140 | 120 | 290 | 270 | 450 | 430 | 630 | 600 | 840 |
| 800 | 900 | 20 | 160 | 140 | 320 | 300 | 500 | 480 | 700 | 670 | 940 |
| 900 | 1000 | 20 | 170 | 150 | 350 | 330 | 550 | 530 | 770 | 740 | 1040 |
| 1000 | 1120 | 20 | 180 | 160 | 380 | 360 | 600 | 580 | 850 | 820 | 1150 |
| 1120 | 1250 | 20 | 190 | 170 | 410 | 390 | 650 | 630 | 920 | 890 | 1260 |

Table 8.5 Radial internal clearance of double row and duplex angular contact ball bearings Unit μm

| Nominal bore diameter *d* mm | | C1 | | C2 | | Normal | | C3 | | C4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| over | incl. | min | max | min | max | min | max | min | max | min | max |
| — | 10 | 3 | 8 | 6 | 12 | 8 | 15 | 15 | 22 | 22 | 30 |
| 10 | 18 | 3 | 8 | 6 | 12 | 8 | 15 | 15 | 24 | 30 | 40 |
| 18 | 30 | 3 | 10 | 6 | 12 | 10 | 20 | 20 | 32 | 40 | 55 |
| 30 | 50 | 3 | 10 | 8 | 14 | 14 | 25 | 25 | 40 | 55 | 75 |
| 50 | 80 | 3 | 11 | 11 | 17 | 17 | 32 | 32 | 50 | 75 | 95 |
| 80 | 100 | 3 | 13 | 13 | 22 | 22 | 40 | 40 | 60 | 95 | 120 |
| 100 | 120 | 3 | 15 | 15 | 30 | 30 | 50 | 50 | 75 | 110 | 140 |
| 120 | 150 | 3 | 16 | 16 | 33 | 35 | 35 | 55 | 80 | 130 | 170 |
| 150 | 180 | 3 | 18 | 18 | 35 | 35 | 60 | 60 | 90 | 150 | 200 |
| 180 | 200 | 3 | 20 | 20 | 40 | 40 | 65 | 65 | 100 | 180 | 240 |

Note: The clearance group in the table is applied only to contact angles in the table below.

| Contact angle symbol | Nominal contact angle | Applicable clearance group |
|---|---|---|
| C | 15° | C1, C2 |
| A[1] | 30° | C2, Normal, C3 |
| B | 40° | Normal, C3, C4 |

1) Usually not to be indicated

Table 8.6 Radial internal clearance of cylindrical roller bearings, needle roller bearings

Table 8.6 (1) Cylindrical Bore Interchangeable Radial Clearance ISO Cylindrical Roller Bearings ONLY — Unit μm

| Nominal bore diameter *d* mm | | C2 | | Normal | | C3 | | C4 | | C5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| over | incl. | min | max | min | max | min | max | min | max | min | max |
| 0 | 10 | 0 | 25 | 20 | 45 | 35 | 60 | 50 | 75 | — | — |
| 10 | 24 | 0 | 25 | 20 | 45 | 35 | 60 | 50 | 75 | 65 | 90 |
| 24 | 30 | 0 | 25 | 20 | 45 | 35 | 60 | 50 | 75 | 70 | 95 |
| 30 | 40 | 5 | 30 | 25 | 50 | 45 | 70 | 60 | 85 | 80 | 105 |
| 40 | 50 | 5 | 35 | 30 | 60 | 50 | 80 | 70 | 100 | 95 | 125 |
| 50 | 65 | 10 | 40 | 40 | 70 | 60 | 90 | 80 | 110 | 110 | 140 |
| 65 | 80 | 10 | 45 | 40 | 75 | 65 | 100 | 90 | 125 | 130 | 165 |
| 80 | 100 | 15 | 50 | 50 | 85 | 75 | 110 | 105 | 140 | 155 | 190 |
| 100 | 120 | 15 | 55 | 50 | 90 | 85 | 125 | 125 | 165 | 180 | 220 |
| 120 | 140 | 15 | 60 | 60 | 105 | 100 | 145 | 145 | 190 | 200 | 245 |
| 140 | 160 | 20 | 70 | 70 | 120 | 115 | 165 | 165 | 215 | 225 | 275 |
| 160 | 180 | 25 | 75 | 75 | 125 | 120 | 170 | 170 | 220 | 250 | 300 |
| 180 | 200 | 35 | 90 | 90 | 145 | 140 | 195 | 195 | 250 | 275 | 330 |
| 200 | 225 | 45 | 105 | 105 | 165 | 160 | 220 | 220 | 280 | 305 | 365 |
| 225 | 250 | 45 | 110 | 110 | 175 | 170 | 235 | 235 | 300 | 330 | 395 |
| 250 | 280 | 55 | 125 | 125 | 195 | 190 | 260 | 260 | 330 | 370 | 440 |
| 280 | 315 | 55 | 130 | 130 | 205 | 200 | 275 | 275 | 350 | 410 | 485 |
| 315 | 355 | 65 | 145 | 145 | 225 | 225 | 305 | 305 | 385 | 455 | 535 |
| 355 | 400 | 100 | 190 | 190 | 280 | 280 | 370 | 370 | 460 | 510 | 600 |
| 400 | 450 | 110 | 210 | 210 | 310 | 310 | 410 | 410 | 510 | 565 | 665 |
| 450 | 500 | 110 | 220 | 220 | 330 | 330 | 440 | 440 | 550 | 625 | 735 |
| 500 | 560 | 120 | 240 | 240 | 360 | 360 | 480 | 480 | 600 | — | — |
| 560 | 630 | 140 | 260 | 260 | 380 | 380 | 500 | 500 | 620 | — | — |
| 630 | 710 | 145 | 285 | 285 | 425 | 425 | 565 | 565 | 705 | — | — |
| 710 | 800 | 150 | 310 | 310 | 470 | 470 | 630 | 630 | 790 | — | — |
| 800 | 900 | 180 | 350 | 350 | 520 | 520 | 690 | 690 | 860 | — | — |
| 900 | 1000 | 200 | 390 | 390 | 580 | 580 | 770 | 770 | 960 | — | — |
| 1000 | 1120 | 220 | 430 | 430 | 640 | 640 | 850 | 850 | 1060 | — | — |
| 1120 | 1250 | 230 | 470 | 470 | 710 | 710 | 950 | 950 | 1190 | — | — |
| 1250 | 1400 | 270 | 530 | 530 | 790 | 790 | 1050 | 1050 | 1310 | — | — |

Table 8.6 (2) Tapered Bore Interchangeable Radial Clearance — Unit μm

| Nominal bore diameter *d* mm | | C2 | | Normal | | C3 | | C4 | | C5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| over | incl. | min | max | min | max | min | max | min | max | min | max |
| 0 | 24 | 15 | 40 | 30 | 55 | 40 | 65 | 50 | 75 | — | — |
| 24 | 30 | 20 | 45 | 35 | 60 | 45 | 70 | 55 | 80 | — | — |
| 30 | 40 | 20 | 45 | 40 | 65 | 55 | 80 | 70 | 95 | — | — |
| 40 | 50 | 25 | 55 | 45 | 75 | 60 | 90 | 75 | 105 | — | — |
| 50 | 65 | 30 | 60 | 50 | 80 | 70 | 100 | 90 | 120 | — | — |
| 65 | 80 | 35 | 70 | 60 | 95 | 85 | 120 | 110 | 145 | — | — |
| 80 | 100 | 40 | 75 | 70 | 105 | 95 | 130 | 120 | 155 | — | — |
| 100 | 120 | 50 | 90 | 90 | 130 | 115 | 155 | 140 | 180 | — | — |
| 120 | 140 | 55 | 100 | 100 | 145 | 130 | 175 | 160 | 205 | — | — |
| 140 | 160 | 60 | 110 | 110 | 160 | 145 | 195 | 180 | 230 | — | — |
| 160 | 180 | 75 | 125 | 125 | 175 | 160 | 210 | 195 | 245 | — | — |
| 180 | 200 | 85 | 140 | 140 | 195 | 180 | 235 | 220 | 275 | — | — |
| 200 | 225 | 95 | 155 | 155 | 215 | 200 | 260 | 245 | 305 | — | — |
| 225 | 250 | 105 | 170 | 170 | 235 | 220 | 285 | 270 | 335 | — | — |
| 250 | 280 | 115 | 185 | 185 | 255 | 240 | 310 | 295 | 365 | — | — |
| 280 | 315 | 130 | 205 | 205 | 280 | 265 | 340 | 325 | 400 | — | — |
| 315 | 355 | 145 | 225 | 225 | 305 | 290 | 370 | 355 | 435 | — | — |
| 355 | 400 | 165 | 225 | 255 | 345 | 330 | 420 | 405 | 495 | — | — |
| 400 | 450 | 185 | 285 | 285 | 385 | 370 | 470 | 455 | 555 | — | — |
| 450 | 500 | 205 | 315 | 315 | 425 | 410 | 520 | 505 | 615 | — | — |

Table 8.7 Radial internal clearance of cylindrical roller bearings, needle roller bearings (Non-interchangeable)

| Nominal bore diameter *d* mm | | Bearing with cylindrical bore | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C1NA | | C2NA | | NA[1)] | | C3NA | | C4NA | | C5NA | |
| over | incl. | min | max | min | max | min | max | min | max | min | max | min | max |
| — | 10 | 5 | 10 | 10 | 20 | 20 | 30 | 35 | 45 | 45 | 55 | — | — |
| 10 | 18 | 5 | 10 | 10 | 20 | 20 | 30 | 35 | 45 | 45 | 55 | 65 | 75 |
| 18 | 24 | 5 | 10 | 10 | 20 | 20 | 30 | 35 | 45 | 45 | 55 | 65 | 75 |
| 24 | 30 | 5 | 10 | 10 | 25 | 25 | 35 | 40 | 50 | 50 | 60 | 70 | 80 |
| 30 | 40 | 5 | 12 | 12 | 25 | 25 | 40 | 45 | 55 | 55 | 70 | 80 | 95 |
| 40 | 50 | 5 | 15 | 15 | 30 | 30 | 45 | 50 | 65 | 65 | 80 | 95 | 110 |
| 50 | 65 | 5 | 15 | 15 | 35 | 35 | 50 | 55 | 75 | 75 | 90 | 110 | 130 |
| 65 | 80 | 10 | 20 | 20 | 40 | 40 | 60 | 70 | 90 | 90 | 110 | 130 | 150 |
| 80 | 100 | 10 | 25 | 25 | 45 | 45 | 70 | 80 | 105 | 105 | 125 | 155 | 180 |
| 100 | 120 | 10 | 25 | 25 | 50 | 50 | 80 | 95 | 120 | 120 | 145 | 180 | 205 |
| 120 | 140 | 15 | 30 | 30 | 60 | 60 | 90 | 105 | 135 | 135 | 160 | 200 | 230 |
| 140 | 160 | 15 | 35 | 35 | 65 | 65 | 100 | 115 | 150 | 150 | 180 | 225 | 260 |
| 160 | 180 | 15 | 35 | 35 | 75 | 75 | 110 | 125 | 165 | 165 | 200 | 250 | 285 |
| 180 | 200 | 20 | 40 | 40 | 80 | 80 | 120 | 140 | 180 | 180 | 220 | 275 | 315 |
| 200 | 225 | 20 | 45 | 45 | 90 | 90 | 135 | 155 | 200 | 200 | 240 | 305 | 350 |
| 225 | 250 | 25 | 50 | 50 | 100 | 100 | 150 | 170 | 215 | 215 | 265 | 330 | 380 |
| 250 | 280 | 25 | 55 | 55 | 110 | 110 | 165 | 185 | 240 | 240 | 295 | 370 | 420 |
| 280 | 315 | 30 | 60 | 60 | 120 | 120 | 180 | 205 | 265 | 265 | 325 | 410 | 470 |
| 315 | 355 | 30 | 65 | 65 | 135 | 135 | 200 | 225 | 295 | 295 | 360 | 455 | 520 |
| 355 | 400 | 35 | 75 | 75 | 150 | 150 | 225 | 255 | 330 | 330 | 405 | 510 | 585 |
| 400 | 450 | 45 | 85 | 85 | 170 | 170 | 255 | 285 | 370 | 370 | 455 | 565 | 650 |
| 450 | 500 | 50 | 95 | 95 | 190 | 190 | 285 | 315 | 410 | 410 | 505 | 625 | 720 |

1) For bearings with normal clearance, only NA is added to bearing numbers. Ex. NU310NA, NN03020KNAP5

Table 8.4 Radial internal clearance of self-aligning ball bearings

| Nominal bore diameter *d* mm | | Bearing with cylindrical bore | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C2 | | Normal | | C3 | | C4 | | C5 | |
| over | incl. | min | max | min | max | min | max | min | max | min | max |
| 2.5 | 6 | 1 | 8 | 5 | 15 | 10 | 20 | 15 | 25 | 21 | 33 |
| 6 | 10 | 2 | 9 | 6 | 17 | 12 | 25 | 19 | 33 | 27 | 42 |
| 10 | 14 | 2 | 10 | 6 | 19 | 13 | 26 | 21 | 35 | 30 | 48 |
| 14 | 18 | 3 | 12 | 8 | 21 | 15 | 28 | 23 | 37 | 32 | 50 |
| 18 | 24 | 4 | 14 | 10 | 23 | 17 | 30 | 25 | 39 | 34 | 52 |
| 24 | 30 | 5 | 16 | 11 | 24 | 19 | 35 | 29 | 46 | 40 | 58 |
| 30 | 40 | 6 | 18 | 13 | 29 | 23 | 40 | 34 | 53 | 46 | 66 |
| 40 | 50 | 6 | 19 | 14 | 31 | 25 | 44 | 37 | 57 | 50 | 71 |
| 50 | 65 | 7 | 21 | 16 | 36 | 30 | 50 | 45 | 69 | 62 | 88 |
| 65 | 80 | 8 | 24 | 18 | 40 | 35 | 60 | 54 | 83 | 76 | 108 |
| 80 | 100 | 9 | 27 | 22 | 48 | 42 | 70 | 64 | 96 | 89 | 124 |
| 100 | 120 | 10 | 31 | 25 | 56 | 50 | 83 | 75 | 114 | 105 | 145 |
| 120 | 140 | 10 | 38 | 30 | 68 | 60 | 100 | 90 | 135 | 125 | 175 |
| 140 | 160 | 15 | 44 | 35 | 80 | 70 | 120 | 110 | 161 | 150 | 210 |

Table 8.7 (Cont.) Radial internal clearance of cylindrical roller bearings, needle roller bearings (Non-interchangeable) Unit μm

| Bearing with tapered bore | | | | | | | | | | | | Nominal bore diameter *d* mm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C9NA | | C0NA[2)] | | C1NA[2)] | | C2NA | | NA[1)] | | C3NA | | | |
| min | max | min | max | min | max | min | max | min | max | min | max | over | incl. |
| 5 | 5 | 7 | 17 | 10 | 20 | 20 | 30 | 35 | 45 | 45 | 55 | — | 10 |
| 5 | 10 | 7 | 17 | 10 | 20 | 20 | 30 | 35 | 45 | 45 | 55 | 10 | 18 |
| 5 | 10 | 7 | 17 | 10 | 20 | 20 | 30 | 35 | 45 | 45 | 55 | 18 | 24 |
| 5 | 10 | 10 | 20 | 10 | 25 | 25 | 35 | 40 | 50 | 50 | 60 | 24 | 30 |
| 5 | 12 | 10 | 20 | 12 | 25 | 25 | 40 | 45 | 55 | 55 | 70 | 30 | 40 |
| 5 | 15 | 10 | 20 | 15 | 30 | 30 | 45 | 50 | 65 | 65 | 80 | 40 | 50 |
| 5 | 15 | 10 | 20 | 15 | 35 | 35 | 50 | 55 | 75 | 75 | 90 | 50 | 65 |
| 10 | 20 | 15 | 30 | 20 | 40 | 40 | 60 | 70 | 90 | 90 | 110 | 65 | 80 |
| 10 | 25 | 20 | 35 | 25 | 45 | 45 | 70 | 80 | 105 | 105 | 125 | 80 | 100 |
| 10 | 25 | 20 | 35 | 25 | 50 | 50 | 80 | 95 | 120 | 120 | 145 | 100 | 120 |
| 15 | 30 | 25 | 40 | 30 | 60 | 60 | 90 | 105 | 135 | 135 | 160 | 120 | 140 |
| 15 | 35 | 30 | 45 | 35 | 65 | 65 | 100 | 115 | 150 | 150 | 180 | 140 | 160 |
| 15 | 35 | 30 | 45 | 35 | 75 | 75 | 110 | 125 | 165 | 165 | 200 | 160 | 180 |
| 20 | 40 | 30 | 50 | 40 | 80 | 80 | 120 | 140 | 180 | 180 | 220 | 180 | 220 |
| 20 | 45 | 35 | 55 | 45 | 90 | 90 | 135 | 155 | 200 | 200 | 240 | 200 | 225 |
| 25 | 50 | 40 | 65 | 50 | 100 | 100 | 150 | 170 | 215 | 215 | 265 | 225 | 250 |
| 25 | 55 | 40 | 65 | 55 | 110 | 110 | 165 | 185 | 240 | 240 | 295 | 250 | 280 |
| 30 | 60 | 45 | 75 | 60 | 120 | 120 | 180 | 205 | 265 | 265 | 325 | 280 | 315 |
| 30 | 65 | 45 | 75 | 65 | 135 | 135 | 200 | 225 | 295 | 295 | 360 | 315 | 355 |
| 35 | 75 | 50 | 90 | 75 | 150 | 150 | 225 | 255 | 330 | 330 | 405 | 355 | 400 |
| 45 | 85 | 60 | 100 | 85 | 170 | 170 | 255 | 285 | 370 | 370 | 455 | 400 | 450 |
| 50 | 95 | 70 | 115 | 95 | 190 | 190 | 285 | 315 | 410 | 410 | 505 | 450 | 500 |

2) C9NA, C0NA and C1NA are applied only to precision bearings of class 5 and higher.

Unit μm

| Bearing with tapered bore | | | | | | | | | | Nominal bore diameter *d* mm | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C2 | | Normal | | C3 | | C4 | | C5 | | | |
| min | max | min | max | min | max | min | max | min | max | over | incl. |
| — | — | — | — | — | — | — | — | — | — | 2.5 | 6 |
| — | — | — | — | — | — | — | — | — | — | 6 | 10 |
| — | — | — | — | — | — | — | — | — | — | 10 | 14 |
| — | — | — | — | — | — | — | — | — | — | 14 | 18 |
| 7 | 17 | 13 | 26 | 20 | 33 | 28 | 42 | 37 | 55 | 18 | 24 |
| 9 | 20 | 15 | 28 | 23 | 39 | 33 | 50 | 44 | 62 | 24 | 30 |
| 12 | 24 | 19 | 35 | 29 | 46 | 40 | 59 | 52 | 72 | 30 | 40 |
| 14 | 27 | 22 | 39 | 33 | 52 | 45 | 65 | 58 | 79 | 40 | 50 |
| 18 | 32 | 27 | 47 | 41 | 61 | 56 | 80 | 73 | 99 | 50 | 65 |
| 23 | 39 | 35 | 57 | 50 | 75 | 69 | 98 | 91 | 123 | 65 | 80 |
| 29 | 47 | 42 | 68 | 62 | 90 | 84 | 116 | 109 | 144 | 80 | 100 |
| 35 | 56 | 50 | 81 | 75 | 108 | 100 | 139 | 130 | 170 | 100 | 120 |
| 40 | 68 | 60 | 98 | 90 | 130 | 120 | 165 | 155 | 205 | 120 | 140 |
| 45 | 74 | 65 | 110 | 100 | 150 | 140 | 191 | 180 | 240 | 140 | 160 |

Table 8.8 Axial internal clearance of metric double row and duplex tapered roller bearings

(Except series 329X, 322C, 323C)

| Nominal bore diameter *d* mm | | Contact angle α≤27° (*e*≤0.76) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | C2 | | Normal | | C3 | | C4 | |
| over | incl. | min | max | min | max | min | max | min | max |
| 18 | 24 | 25 | 75 | 75 | 125 | 125 | 170 | 170 | 220 |
| 24 | 30 | 25 | 75 | 75 | 125 | 145 | 195 | 195 | 245 |
| 30 | 40 | 25 | 95 | 95 | 165 | 165 | 235 | 210 | 280 |
| 40 | 50 | 20 | 85 | 85 | 150 | 175 | 240 | 240 | 305 |
| 50 | 65 | 20 | 85 | 110 | 175 | 195 | 260 | 280 | 350 |
| 65 | 80 | 20 | 110 | 130 | 220 | 240 | 325 | 325 | 410 |
| 80 | 100 | 45 | 150 | 150 | 260 | 280 | 390 | 390 | 500 |
| 100 | 120 | 45 | 175 | 175 | 305 | 350 | 480 | 455 | 585 |
| 120 | 140 | 45 | 175 | 175 | 305 | 390 | 520 | 500 | 630 |
| 140 | 160 | 60 | 200 | 200 | 340 | 400 | 540 | 520 | 660 |
| 160 | 180 | 80 | 220 | 240 | 380 | 440 | 580 | 600 | 740 |
| 180 | 200 | 100 | 260 | 260 | 420 | 500 | 660 | 660 | 820 |
| 200 | 225 | 120 | 300 | 300 | 480 | 560 | 740 | 720 | 900 |
| 225 | 250 | 160 | 360 | 360 | 560 | 620 | 820 | 820 | 1020 |
| 250 | 280 | 180 | 400 | 400 | 620 | 700 | 920 | 920 | 1140 |
| 280 | 315 | 200 | 440 | 440 | 680 | 780 | 1020 | 1020 | 1260 |
| 315 | 355 | 220 | 480 | 500 | 760 | 860 | 1120 | 1120 | 1380 |
| 355 | 400 | 260 | 560 | 560 | 860 | 980 | 1280 | 1280 | 1580 |
| 400 | 500 | 300 | 600 | 620 | 920 | 1100 | 1400 | 1440 | 1740 |

Note: Radial internal clearance is approximately obtained from:

$$\Delta r = \frac{e}{1.5}\Delta_a$$

where $\Delta r$ =radial internal clearance, $\mu$m
$\Delta_a$ =axial internal clearance, $\mu$m
$e$ =constant, see bearing tables

Table 8.8 (Cont.) Axial internal clearance of metric double row and duplex tapered roller bearings
(Except series 329X, 322C, 323C) Unit μm

| Contact angle α>27° (*e*>0.76) | | | | | | | | Nominal bore diameter *d* mm | |
|---|---|---|---|---|---|---|---|---|---|
| C2 | | Normal | | C3 | | C4 | | | |
| min | max | min | max | min | max | min | max | over | incl. |
| 10 | 30 | 30 | 50 | 50 | 70 | 70 | 90 | 18 | 24 |
| 10 | 30 | 30 | 50 | 60 | 80 | 80 | 100 | 24 | 30 |
| 10 | 40 | 40 | 70 | 70 | 100 | 90 | 120 | 30 | 40 |
| 10 | 40 | 40 | 70 | 80 | 110 | 110 | 140 | 40 | 50 |
| 10 | 40 | 50 | 80 | 90 | 120 | 130 | 160 | 50 | 65 |
| 10 | 50 | 60 | 100 | 110 | 150 | 150 | 190 | 65 | 80 |
| 20 | 70 | 70 | 120 | 130 | 180 | 180 | 230 | 80 | 100 |
| 20 | 70 | 70 | 120 | 150 | 200 | 210 | 260 | 100 | 120 |
| 20 | 70 | 70 | 120 | 160 | 210 | 210 | 260 | 120 | 140 |
| 30 | 100 | 100 | 160 | 180 | 240 | 240 | 300 | 140 | 160 |
| — | — | — | — | — | — | — | — | 160 | 180 |
| — | — | — | — | — | — | — | — | 180 | 200 |
| — | — | — | — | — | — | — | — | 200 | 225 |
| — | — | — | — | — | — | — | — | 225 | 250 |
| — | — | — | — | — | — | — | — | 250 | 280 |
| — | — | — | — | — | — | — | — | 280 | 315 |
| — | — | — | — | — | — | — | — | 315 | 355 |
| — | — | — | — | — | — | — | — | 355 | 400 |
| — | — | — | — | — | — | — | — | 400 | 500 |

Table 8.10 Radial internal clearance of bearings for electric motor
Unit μm

| Nominal bore diameter *d* mm | | Radial internal clearance CM[1] | | | |
|---|---|---|---|---|---|
| | | Deep groove ball bearings | | Cylindrical[2] roller bearings | |
| over | incl. | min | max | min | max |
| 10[3] | 18 | 4 | 11 | — | — |
| 18 | 24 | 5 | 12 | — | — |
| 24 | 30 | 5 | 12 | 15 | 30 |
| 30 | 40 | 9 | 17 | 15 | 30 |
| 40 | 50 | 9 | 17 | 20 | 35 |
| 50 | 65 | 12 | 22 | 25 | 40 |
| 65 | 80 | 12 | 22 | 30 | 45 |
| 80 | 100 | 18 | 30 | 35 | 55 |
| 100 | 120 | 18 | 30 | 35 | 60 |
| 120 | 140 | 24 | 38 | 40 | 65 |
| 140 | 160 | 24 | 38 | 50 | 80 |
| 160 | 180 | — | — | 60 | 90 |
| 180 | 200 | — | — | 65 | 100 |

1) Suffix CM is added to bearing numbers.
2) Non-interchangeable clearance.
3) This diameter is included in the group.

Table 8.9 Radial internal clearance of spherical roller bearings

| Nominal bore diameter *d* mm | | Bearing with cylindrical bore | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C2 | | Normal | | C3 | | C4 | | C5 | |
| over | incl. | min | max | min | max | min | max | min | max | min | max |
| 14 | 18 | 10 | 20 | 20 | 35 | 35 | 45 | 45 | 60 | 60 | 75 |
| 18 | 24 | 10 | 20 | 20 | 35 | 35 | 45 | 45 | 60 | 60 | 75 |
| 24 | 30 | 15 | 25 | 25 | 40 | 40 | 55 | 55 | 75 | 75 | 95 |
| 30 | 40 | 15 | 30 | 30 | 45 | 45 | 60 | 60 | 80 | 80 | 100 |
| 40 | 50 | 20 | 35 | 35 | 55 | 55 | 75 | 75 | 100 | 100 | 125 |
| 50 | 65 | 20 | 40 | 40 | 65 | 65 | 90 | 90 | 120 | 120 | 150 |
| 65 | 80 | 30 | 50 | 50 | 80 | 80 | 110 | 110 | 145 | 145 | 180 |
| 80 | 100 | 35 | 60 | 60 | 100 | 100 | 135 | 135 | 180 | 180 | 225 |
| 100 | 120 | 40 | 75 | 75 | 120 | 120 | 160 | 160 | 210 | 210 | 260 |
| 120 | 140 | 50 | 95 | 95 | 145 | 145 | 190 | 190 | 240 | 240 | 300 |
| 140 | 160 | 60 | 110 | 110 | 170 | 170 | 220 | 220 | 280 | 280 | 350 |
| 160 | 180 | 65 | 120 | 120 | 180 | 180 | 240 | 240 | 310 | 310 | 390 |
| 180 | 200 | 70 | 130 | 130 | 200 | 200 | 260 | 260 | 340 | 340 | 430 |
| 200 | 225 | 80 | 140 | 140 | 220 | 220 | 290 | 290 | 380 | 380 | 470 |
| 225 | 250 | 90 | 150 | 150 | 240 | 240 | 320 | 320 | 420 | 420 | 520 |
| 250 | 280 | 100 | 170 | 170 | 260 | 260 | 350 | 350 | 460 | 460 | 570 |
| 280 | 315 | 110 | 190 | 190 | 280 | 280 | 370 | 370 | 500 | 500 | 630 |
| 315 | 355 | 120 | 200 | 200 | 310 | 310 | 410 | 410 | 550 | 550 | 690 |
| 355 | 400 | 130 | 220 | 220 | 340 | 340 | 450 | 450 | 600 | 600 | 750 |
| 400 | 450 | 140 | 240 | 240 | 370 | 370 | 500 | 500 | 660 | 660 | 820 |
| 450 | 500 | 140 | 260 | 260 | 410 | 410 | 550 | 550 | 720 | 720 | 900 |
| 500 | 560 | 150 | 280 | 280 | 440 | 440 | 600 | 600 | 780 | 780 | 1000 |
| 560 | 630 | 170 | 310 | 310 | 480 | 480 | 650 | 650 | 850 | 850 | 1100 |
| 630 | 710 | 190 | 350 | 350 | 530 | 530 | 700 | 700 | 920 | 920 | 1190 |
| 710 | 800 | 210 | 390 | 390 | 580 | 580 | 770 | 770 | 1010 | 1010 | 1300 |
| 800 | 900 | 230 | 430 | 430 | 650 | 650 | 860 | 860 | 1120 | 1120 | 1440 |
| 900 | 1000 | 260 | 480 | 480 | 710 | 710 | 930 | 930 | 1220 | 1220 | 1570 |
| 1000 | 1120 | 290 | 530 | 530 | 780 | 780 | 1020 | 1020 | 1330 | 1330 | 1720 |
| 1120 | 1250 | 320 | 580 | 280 | 860 | 860 | 1120 | 1120 | 1460 | 1460 | 1870 |
| 1250 | 1400 | 350 | 640 | 640 | 950 | 950 | 1240 | 1240 | 1620 | 1620 | 2080 |

Table 8.9 (Cont.) Radial internal clearance of spherical roller bearings

Unit $\mu$m

| Bearing with tapered bore | | | | | | | | | | Nominal bore diameter $d$ mm | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C2 | | Normal | | C3 | | C4 | | C5 | | | |
| min | max | min | max | min | max | min | max | min | max | over | incl. |
| — | — | — | — | — | — | — | — | — | — | 14 | 18 |
| 15 | 25 | 25 | 35 | 35 | 45 | 45 | 60 | 60 | 75 | 18 | 24 |
| 20 | 30 | 30 | 40 | 40 | 55 | 55 | 75 | 75 | 95 | 24 | 30 |
| 25 | 35 | 35 | 50 | 50 | 65 | 65 | 85 | 85 | 105 | 30 | 40 |
| 30 | 45 | 45 | 60 | 60 | 80 | 80 | 100 | 100 | 130 | 40 | 50 |
| 40 | 55 | 55 | 75 | 75 | 95 | 95 | 120 | 120 | 160 | 50 | 65 |
| 50 | 70 | 70 | 95 | 95 | 120 | 120 | 150 | 150 | 200 | 65 | 80 |
| 55 | 80 | 80 | 110 | 110 | 140 | 140 | 180 | 180 | 230 | 80 | 100 |
| 65 | 100 | 100 | 135 | 135 | 170 | 170 | 220 | 220 | 280 | 100 | 120 |
| 80 | 120 | 120 | 160 | 160 | 200 | 200 | 260 | 260 | 330 | 120 | 140 |
| 90 | 130 | 130 | 180 | 180 | 230 | 230 | 300 | 300 | 380 | 140 | 160 |
| 100 | 140 | 140 | 200 | 200 | 260 | 260 | 340 | 340 | 430 | 160 | 180 |
| 110 | 160 | 160 | 220 | 220 | 290 | 290 | 370 | 370 | 470 | 180 | 200 |
| 120 | 180 | 180 | 250 | 250 | 320 | 320 | 410 | 410 | 520 | 200 | 225 |
| 140 | 200 | 200 | 270 | 270 | 350 | 350 | 450 | 450 | 570 | 225 | 250 |
| 150 | 220 | 220 | 300 | 300 | 390 | 390 | 490 | 490 | 620 | 250 | 280 |
| 170 | 240 | 240 | 330 | 330 | 430 | 430 | 540 | 540 | 680 | 280 | 315 |
| 190 | 270 | 270 | 360 | 360 | 470 | 470 | 590 | 590 | 740 | 315 | 355 |
| 210 | 300 | 300 | 400 | 400 | 520 | 520 | 650 | 650 | 820 | 355 | 400 |
| 230 | 330 | 330 | 440 | 440 | 570 | 570 | 720 | 720 | 910 | 400 | 450 |
| 260 | 370 | 370 | 490 | 490 | 630 | 630 | 790 | 790 | 1000 | 450 | 500 |
| 290 | 410 | 410 | 540 | 540 | 680 | 680 | 870 | 870 | 1100 | 500 | 560 |
| 320 | 460 | 460 | 600 | 600 | 760 | 760 | 980 | 980 | 1230 | 560 | 630 |
| 350 | 510 | 510 | 670 | 670 | 850 | 850 | 1090 | 1090 | 1360 | 630 | 710 |
| 390 | 570 | 570 | 750 | 750 | 960 | 960 | 1220 | 1220 | 1500 | 710 | 800 |
| 440 | 640 | 640 | 840 | 840 | 1070 | 1070 | 1370 | 1370 | 1690 | 800 | 900 |
| 490 | 710 | 710 | 930 | 930 | 1190 | 1190 | 1520 | 1520 | 1860 | 900 | 1000 |
| 530 | 770 | 770 | 1030 | 1030 | 1300 | 1300 | 1670 | 1670 | 2050 | 1000 | 1120 |
| 570 | 830 | 830 | 1120 | 1120 | 1420 | 1420 | 1830 | 1830 | 2250 | 1120 | 1250 |
| 620 | 910 | 910 | 1230 | 1230 | 1560 | 1560 | 2000 | 2000 | 2470 | 1250 | 1400 |

## 8.4 Preload

Normally, bearings are used with a slight internal clearance under operating conditions. However, in some applications, bearings are given an initial load; this means that the bearings' internal clearance is negative before operation. This is called "preload" and is commonly applied to angular ball bearings and tapered roller bearings.

### 8.4.1 Purpose of preload

Giving preload to a bearing results in the rolling element and raceway surfaces being under constant elastic compressive forces at their contact points. This has the effect of making the bearing extremely rigid so that even when load is applied to the bearing, radial or axial shaft displacement does not occur. Thus, the natural frequency of the shaft is increased, which is suitable for high speeds.

Preload is also used to prevent or suppress shaft runout, vibration, and noise; improve running accuracy and locating accuracy; reduce smearing, and regulate rolling element rotation. Also, for thrust ball and roller bearings mounted on horizontal shafts, preloading keeps the rolling elements in proper alignment.

The most common method of preloading is to apply an axial load to two duplex bearings so that the inner and outer rings are displaced axially in relation to each other. This preloading method is divided into fixed position preload and constant pressure preload.

### 8.4.2 Preloading methods and amounts

The basic pattern, purpose and characteristics of bearing preloads are shown in Table 8.11. The definite position preload is effective for positioning the two bearings and also for increasing the rigidity. Due to the use of a spring for the constant pressure preload, the preload force can be kept constant, even when the distance between the two bearings fluctuates under the influence of operating heat and load.

Also, the standard preload for the paired angular contact ball bearings is shown in Table 8.12. Light and normal preload is applied to prevent general vibration, and medium and heavy preload is applied especially when rigidity is required.

### 8.4.3 Preload and rigidity

The increased rigidity effect preloading has on bearings is shown in Fig. 8.5. When the offset inner rings of the two paired angular contact ball bearings are pressed together, each inner ring is displaced axially by the amount $\delta_o$ and is thus given a preload, $F_o$, in the direction shown. Under this condition, when external axial load $F_a$ is applied, bearing I will have an increased displacement by the amount $\delta a$ and bearing II's displacement will decrease. At this time the loads applied to bearing I and II are $F_i$ and $F_{ii}$, respectively.

Under the condition of no preload, bearing I will be displaced by the amount $\delta_b$ when axial load $F_a$ is applied. Since the amount of displacement, $\delta_a$, is less than $\delta_b$, it indicates a higher rigidity for $\delta_a$.

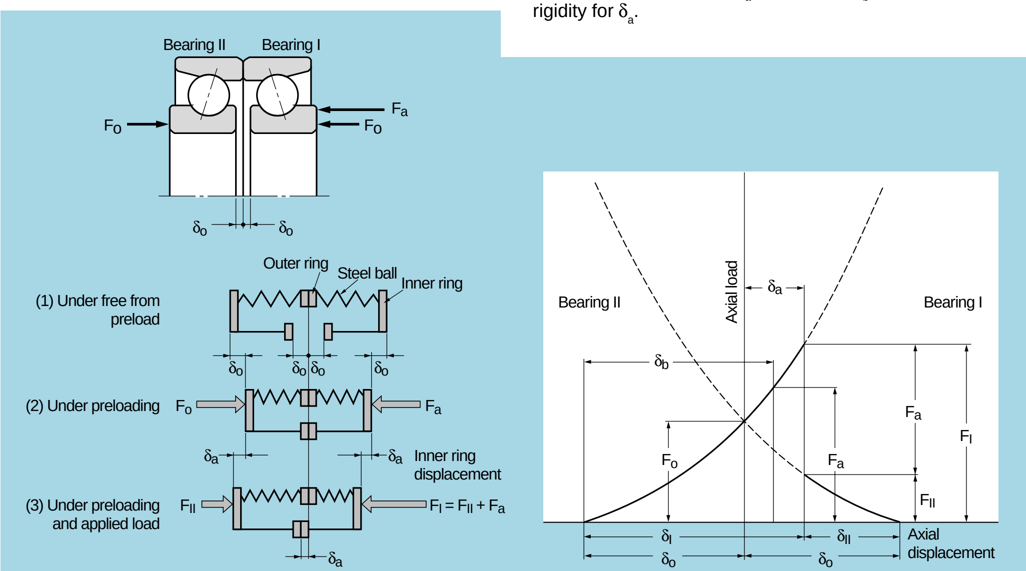
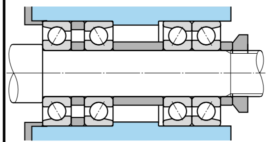
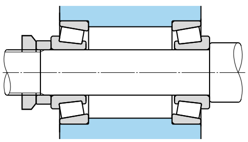
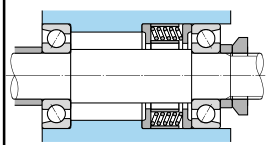
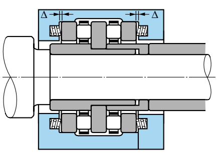



**Fig. 8.5 Fixed position preload versus axial displacement**

Table 8.11 Preloading methods and characteristics

| Method | Basic pattern | Applicable bearings | Object | Characteristics | Applications |
|---|---|---|---|---|---|
| Fixed position preload |  | Precision angular contact ball bearings | Maintaining accuracy of rotating shaft, preventing vibration increasing rigidity | Preload is accomplished by a predetermined offset of the rings or by using spacers. For the standard preload see Table 8.12 | Grinding machines, lathes, milling machines, measuring instruments |
| |  | Tapered roller bearings, thrust ball bearings angular contact ball bearings | Increasing bearing rigidity | Preload is accomplished by adjusting a threaded screw. The amount of preload is set by measuring the starting torque or axial displacement. Relationship between the starting torque M and preload T is approximately given by the following formulas: for duplex angular contact ball bearings: $M = \dfrac{d_p \bullet T}{330 \sim 430}$ N • mm[1)] for duplex tapered roller bearings: $M = \dfrac{d_p^{0.8} \bullet T}{54 \sim 107}$ N • mm[1)] | Lathes, milling machines, differential gears of automotives, printing machines, wheel axles |
| Constant pressure preload |  | Angular contact ball bearings, deep groove ball bearings, precision tapered roller bearings | Maintaining accuracy and preventing vibration and noise with a constant amount of preload without being affected by loads or temperature | Preloading is accomplished by using coil or belleville springs. Recommended preloads are as follows: for deep groove ball bearings: (4 to 8) *d* N for angular contact ball bearings: see Table 8.12 | Internal grinding machines, electric motors, high speed shafts in small machines, tension reels |
| |  | Tapered roller bearings with steep angle, spherical roller thrust bearings, thrust ball bearings | Preventing smearing on raceway of non-loaded side under axial loads | Preload is accomplished by using coil or belleville springs. Recommended preloads are as follows: for thrust ball bearings: $T = 0.42(n \bullet C_{oa})^{1.9} \times 10^{-13}$ N[2)] $T = 0.00083\ C_{oa}$ N[2)] whichever is greater for spherical roller thrust bearings: $T = 0.025\ C_{oa}^{0.8}$ N[2)] | Rolling mills, extruding machines |

Note: In the above formulas,
$d_p$=pitch diameter of bearing, mm
$d_p$=(Bore+Outside dia)/2
$T$=preload, N
$d$=bearing bore, mm
$n$=number of revolutions, r/min
$C_{oa}$=basic static axial load rating, N

The starting torque *M* however, is greatly influenced by lubricants and a period of run-in time.

Table 8.12 Standard preloads for angular contact ball bearings Units: (N)

| Nominal bore diameter *d* mm | | Bearing series | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 78C | | | | 79C, HSB9C | | | | 70C, BNT0, HSBOC | | | | 72C, BNT2 | | | |
| over | incl. | Light | Normal | Medium | Heavy | Light | Normal | Medium | Heavy | Light | Normal | Medium | Heavy | Light | Normal | Medium | Heavy |
| — | 12 | — | — | — | — | — | — | — | — | 20 | 30 | 100 | 150 | 20 | 50 | 100 | 200 |
| 12 | 18 | — | — | — | — | — | — | — | — | 20 | 30 | 100 | 200 | 20 | 50 | 150 | 300 |
| 18 | 32 | 10 | 30 | 80 | 150 | 20 | 50 | 100 | 200 | 30 | 80 | 150 | 300 | 50 | 100 | 300 | 500 |
| 32 | 40 | 10 | 30 | 80 | 150 | 30 | 80 | 200 | 300 | 50 | 150 | 300 | 600 | 80 | 200 | 500 | 800 |
| 40 | 50 | 20 | 50 | 100 | 200 | 40 | 100 | 250 | 500 | 50 | 150 | 300 | 700 | 100 | 300 | 600 | 1000 |
| 50 | 65 | 30 | 100 | 200 | 400 | 50 | 120 | 300 | 600 | 100 | 200 | 500 | 1000 | 150 | 400 | 800 | 1500 |
| 65 | 80 | 30 | 100 | 200 | 400 | 80 | 200 | 400 | 800 | 100 | 300 | 700 | 1500 | 200 | 500 | 1000 | 2000 |
| 80 | 90 | 50 | 150 | 300 | 600 | 100 | 250 | 500 | 1000 | 150 | 400 | 1000 | 2000 | 300 | 700 | 1500 | 3000 |
| 90 | 95 | 50 | 150 | 300 | 600 | 100 | 250 | 500 | 1000 | 150 | 400 | 1000 | 2000 | 300 | 700 | 2000 | 4000 |
| 95 | 100 | 50 | 150 | 300 | 600 | 120 | 300 | 700 | 1500 | 150 | 400 | 1000 | 2000 | 300 | 700 | 2000 | 4000 |
| 100 | 105 | 50 | 150 | 300 | 600 | 120 | 300 | 700 | 1500 | 200 | 600 | 1500 | 2500 | 400 | 1000 | 2500 | 5000 |
| 105 | 110 | 80 | 200 | 500 | 1000 | 120 | 300 | 700 | 1500 | 200 | 600 | 1500 | 2500 | 400 | 1000 | 2500 | 5000 |
| 110 | 120 | 80 | 200 | 500 | 1000 | 150 | 400 | 900 | 2000 | 200 | 600 | 1500 | 2500 | 400 | 1000 | 2500 | 5000 |
| 120 | 140 | 100 | 300 | 600 | 1300 | 200 | 500 | 1000 | 2500 | 300 | 800 | 2000 | 4000 | 500 | 1500 | 3000 | 6000 |
| 140 | 150 | 150 | 400 | 800 | 1500 | 250 | 700 | 1500 | 3000 | 300 | 800 | 2000 | 4000 | 500 | 1500 | 3000 | 6000 |
| 150 | 160 | 150 | 400 | 800 | 1500 | 250 | 700 | 1500 | 3000 | 500 | 1000 | 2500 | 6000 | 700 | 2000 | 4500 | 8000 |
| 160 | 170 | 150 | 500 | 1000 | 2000 | 250 | 700 | 1500 | 3000 | 500 | 1000 | 2500 | 6000 | 700 | 2000 | 4500 | 8000 |
| 170 | 180 | 150 | 500 | 1000 | 2000 | 300 | 900 | 2000 | 4000 | 500 | 1000 | 2500 | 6000 | 700 | 2000 | 4500 | 8000 |
| 180 | 190 | 200 | 600 | 1300 | 2500 | 300 | 900 | 2000 | 4000 | 600 | 1500 | 3500 | 7000 | 800 | 2500 | 5000 | 10000 |
| 190 | 200 | 200 | 600 | 1300 | 2500 | 500 | 1300 | 3000 | 6000 | 600 | 1500 | 3500 | 7000 | 800 | 2500 | 5000 | 10000 |

Note: Symbols /GL, /GN, /GM and GH are suffixes on NTN bearing part numbers indicating Light, Normal, Medium and Heavy preloads, respectively.