



## Main Spindle Bearings

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## 9. Angular Contact Ball Bearings for Radial Loads

The angular contact ball bearings for radial loads used in machine tools are non-separable bearings whose inner and outer rings cannot be separated. This type of bearing includes the types 78, 79U, 70U, 72, HSE9, HSE0, BNS9, BNS0, BNT9, BNT0 and BNT2. For angular contact ball bearings, the imaginary straight line connecting the contact points between the balls and inner and outer rings forms an angle in the radial direction. The optimal contact angle can be selected to meet the required functionality, such as high speed capability or rigidity. The selectable contact angles are 15° (contact angle symbol "C"), 20° (no symbol), 25° ("AD"), and 30° (no symbol). (Fig. 9.1)

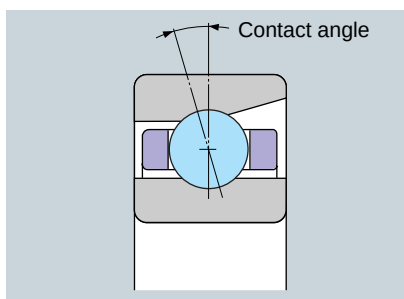


Fig. 9. 1 Contact angle of angular contact ball bearing

### ① Features of various types

#### Open type

#### ■Standard angular contact ball bearings (78, 79, 70 and 72 Types)

The bearing series of standard angular contact ball bearings is available in four types: 78, 79, 70 and 72. Types 79 and 70 include the 79U and 70U Types ULTAGE Series, which accommodate high speed and low temperature rise thanks to optimized specifications for the inner structure. For these types, three contact angles are available: 15° (contact angle symbol "C"), 25° ("AD"), and 30° (no symbol). The contact angle of 25°, however, is available only with 79U and 70U types. This bearing has an accuracy of JIS class 5 or better. The features of this bearing are high speed, high rigidity, and high load capacity. Some models incorporate ceramic balls.

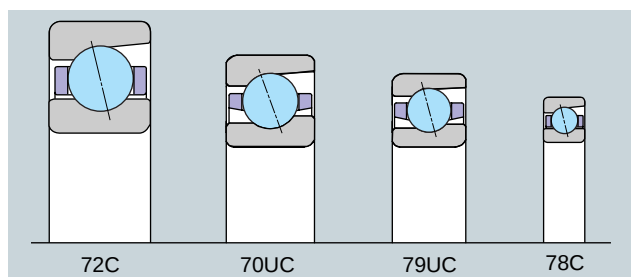


Fig. 9 2. Standard angular contact ball bearings

#### ■High-speed angular contact ball bearings (HSE type)

The bearing series of high-speed angular contact bearings is available in two types: HSE9 and HSE0. The boundary dimensions of this bearing series are determined according to the JIS dimension series (9, 0), and three types of contact angles are available: 15° (contact angle symbol "C"), 20° (no symbol), and 25° ("D"). The accuracy of this ball bearing series is JIS class 5 or better, and the ball diameter is smaller than that of the standard angular contact ball bearing in order to accommodate high speeds. The outer surface of the inner ring and the bore of the outer ring are relieved on one side, and this bearing series employs an air-oil lubrication system to ensure smooth oil flow. In addition, it employs special materials, and its surface is modified to protect the bearing from wear and seizure more positively. The HSE type bearing is available with either steel balls or ceramic balls.

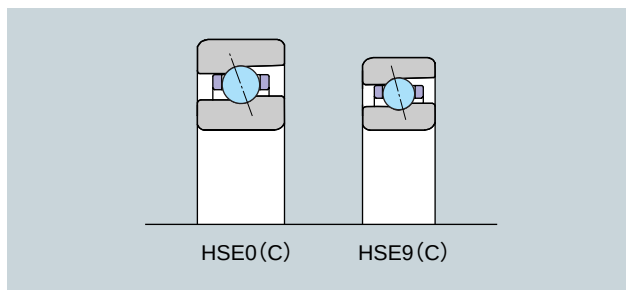


Fig. 9.3 High-speed angular contact ball bearing

#### ■Ultra-high-speed angular ceramic ball bearings (HSF type)

The HSF0 type ultra-high-speed angular contact ceramic ball bearing employs smaller balls than the HSE0C type to ensure rigidity and prevent temperature rise. In addition, it employs a contact angle of 25° to accommodate the change in contact angle caused by centrifugal force during operation.

As a result, it has enabled the air-oil lubrication system ( $d_{mn}$  value  $< 260 \times 10^4$ ) to be introduced in a speed region that was previously possible only with a conventional jet lubrication system.

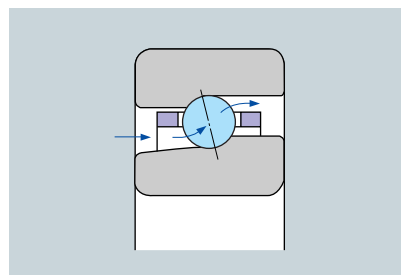


Fig. 9.4 Ultra-high-speed angular contact ball bearing

### ■Eco-friendly air-oil lubricated angular ball bearing (HSL and HSFL types)

For eco-friendly air-oil lubricated angular contact ball bearings (HSL and HSFL types), the angle of the inner ring outer surface (counterbore area) is optimized compared with that of the types HSE and HSF. In addition, these angular contact ball bearing types are dedicated to air-oil lubrication by adopting a circumferential groove and an eco-friendly nozzle. They accommodate the same high speed as types HSE and HSF while they are more eco-friendly because they generate less noise and energy conserving as they consume less air and oil. The accuracies of these bearing types are JIS class 5 or better. For HSL type, three contact angles [15° (contact angle symbol "C"), 20° (no symbol), and 25° ("AD")] are available. For HSFL type, however, only one contact angle (25°) is available. The HSFL type utilizes an eco-friendly nozzle designed especially for it.

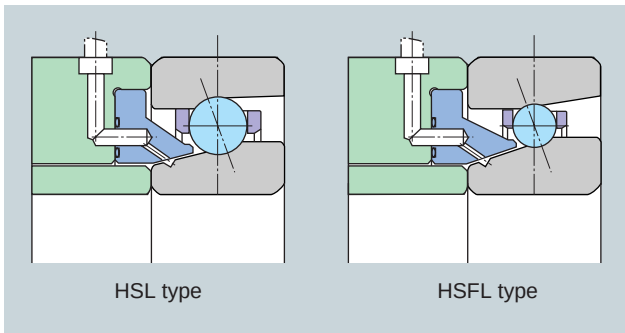


Fig. 9.5 Eco-friendly angular contact ball bearing

### ■High-speed angular contact ball bearings for grinding machines/motors (BNT type)

The boundary dimensions of high-speed angular ball bearings for grinding machines/motors (BNT type) are determined according to the JIS dimension series (9, 0, 2). For this bearing type, only one contact angle (15°, no symbol) is adopted, and the bearing accuracies are JIS class 5 or better. Mainly air-oil lubrication and oil mist lubrication are employed for this bearing. The features of this bearing are its high speed capability and high load capacity. This type of bearing is available with either steel balls or ceramic balls.

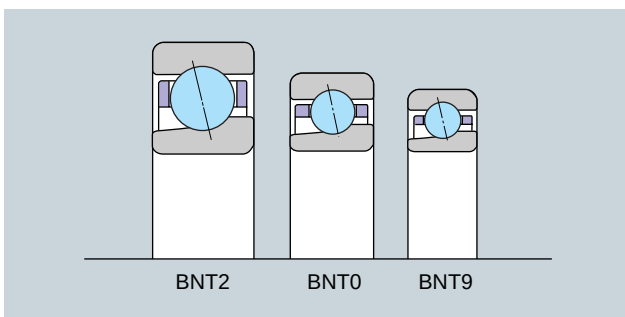


Fig. 9.6 High-speed angular contact ball bearing for grinding machines/motors

### With seal

### ■Standard grease-lubricated sealed angular contact ball bearings (79CD, AD/70CD and AD types)

The standard grease-lubricated sealed angular contact ball bearings (79CD, AD/70CD and AD types) are available in the boundary dimensions of 79 and 70 types. For these bearing types, non-contact rubber seals are mounted on both bearing ends to optimize the inner structure. In addition, special grease is filled in these bearings. As a result, these bearings accommodate high speed, offer prolonged service life, and help to maintain a comfortable working environment. These bearings are available in contact angles of 15° (contact angle symbol "CD") and 25° ("AD") and with a special accuracy of P42 (JIS class 4 dimensional accuracy and JIS class 2 running accuracy). Since they are prefilled with grease, these bearings require no cleaning before use and are therefore easy to handle. Being eco-friendly, they are available with either steel balls or ceramic balls.

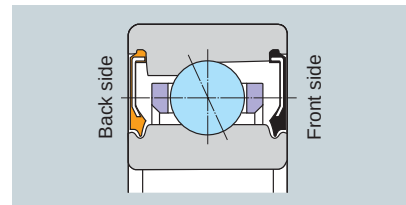


Fig. 9.7 Standard grease-lubricated sealed angular contact ball bearing

### ■High-speed grease-lubricated sealed angular contact ball bearing (BSN type)

The high-speed grease-lubricated sealed angular contact ball bearings (BSN type) are available with the boundary dimensions of HSE type. The non-contact rubber seals of this bearing type are incorporated in both bearing ends, its inner structure is optimized, and it is prefilled with a special grease to achieve high speed capability, inhibit temperature rise, extend service life and realize a comfortable working environment. This bearing type is available in contact angles of 15° (contact angle symbol "CD"), 20° (no symbol), and 25° ("AD"). Bearing accuracy is JIS class 4 or better. The bearing ring is made of a special material, and the surface of this bearing type is modified to protect the bearing from wear and seizure. Since this type is prefilled with grease, it requires no cleaning before use and is therefore easy to handle. Being eco-friendly, it is available with either steel balls or ceramic balls.

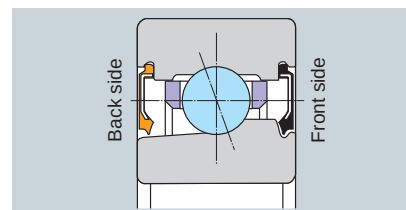


Fig. 9.8 High-speed grease-lubricated sealed angular contact ball bearing

## ② Standard cage design

**Table 9.1 Standard cages of angular contact ball bearings for radial loads**

| Bearing series           | Resin molding cage    | Phenol resin machined cage | High tensile brass casting machined cage |
|--------------------------|-----------------------|----------------------------|------------------------------------------|
| 78C                      | —                     | 7805C ~ 7824C              | 7826C ~ 7834C                            |
| 79U (15°, 25°, 30°), 79C | 7900U ~ 7926U         | —                          | 7928C ~ 7934C                            |
| 70U (15°, 25°, 30°), 70C | 7000U ~ 7026U         | —                          | 7028C ~ 7040C                            |
| 72C                      | 7200C ~ 7220C         | 7221C ~ 7228C              | 7226C                                    |
| HSE9 (15°, 20°, 25°)     | —                     | HSE910 ~ HSE934            | —                                        |
| HSE0 (15°, 20°, 25°)     | HSE010 ~ HSE032       | HSE034                     | —                                        |
| HSF                      | —                     | HSF010 ~ HSF020            | —                                        |
| HSL9 (15°, 20°, 25°)     | —                     | HSL910 ~ HSL934            | —                                        |
| HSL0 (15°, 20°, 25°)     | HSL010 ~ HSL032       | HSL034                     | —                                        |
| HSFL0                    | —                     | HSFL010 ~ HSFL020          | —                                        |
| 79AD/CD                  | 7900AD/CD ~ 7909AD/CD | —                          | —                                        |
| 70AD/CD                  | 7000AD/CD ~ 7009AD/CD | —                          | —                                        |
| BNS9 (15°, 20°, 25°)     | —                     | BNS910 ~ BNS920            | —                                        |
| BNS0 (15°, 20°, 25°)     | —                     | BNS010 ~ BNS020            | —                                        |
| BNT9                     | —                     | BNT900 ~ BNT909            | —                                        |
| BNT0                     | —                     | BNT000 ~ BNT009            | —                                        |
| BNT2                     | —                     | BNT200 ~ BNT209            | —                                        |

Note: Cage design is subject to change without notice. For detailed information, contact NTN Engineering.

## ③ Bearing designations

**78, 79, 70, 72, BNT type**

**5S- 7 0 20 U AD T1 DB /GL P4**

### Accuracy class

P5: JIS class 5, P4: JIS class 4, P2: JIS class 2

### Internal clearance code

GL: Low preload, GN: Normal preload, GM: central preload,  
Gxx: Special preload, CSxx: Special clearance

### Matching code

DB: Back-to-back (double-row)  
DT: Tandem (double-row)  
DTBT: Tandem back-to-back (quad-row)

### Cage code

T1: Laminated phenol resin cage  
T2: Polyamide resin molding cage  
L1: High tensile brass casting machined cage

### Contact angle code

C: 15°, AD: 25°, No symbol: 20°

### Bearing type (ULTAGE Series)

Bore diameter number (See dimension table)

### Dimension series code

### Bearing type

### Material code

5S: Ceramic rolling element  
No code: Bearing steel

### HSE type

**5S- 2LA-HSE 0 20 AD DB /GL P4**

- Contact angle code**  
C: 15°, AD: 25°, No symbol: 20°
- Bore diameter number (See dimension table)**
- Dimension series code**
- Bearing type**
- 2LA : Special material with improved surface treatment**

### HSL type

**5S- 2LA-HSL 0 20 DB +xx Dn /GL P4 +TKZ**

- Spacer code**  
(Locate beside bearings)
- Spacer code**  
(Locate between bearings)
- Spacer width dimension**
- Bearing type**

(notes) HSL : Bearing series code

xxDn : Eco-friendly nozzle, or Spacer with Eco- friendly nozzle locate between bearings (In case of HSL Type)

TKZ : Eco-friendly nozzle, or Spacer with Eco- friendly nozzle locate beside bearings (In case of HSL Type)

### 79CD, AD / 70CD, AD type

**5S- 7006 CD LLB DB /GL P42 /L448**

- Accuracy class**  
P42: Dimensional accuracy = JIS class 4,  
running accuracy = JIS class 2
- Bearing type (ULTAGE Series)**  
CD : Contact angle 15°  
AD : Contact angle 25°

### BNS type

**5S- 2LA-BNS 0 20 LLB DB /GL P4 /L448**

- Grease code**  
/L448 : SDpecial grease (MP-1)
- Seal code**  
LLB: Non-contact rubber seal on both sides
- Bearing type**

## ④ Bearing accuracy

**Table 9.2 Inner rings**

| Nominal bore diameter<br>$d$ |       | Single plane mean bore diameter deviation<br>$\Delta d_{mp}$ |      |           |      |           |       | Single radial plane bore diameter variation<br>$V_{dp}$ |         |         |                      |         |         | Mean bore diameter deviation<br>$V_{dmp}$ |         |         | Inner ring radial runout<br>$K_{ia}$ |         |         |
|------------------------------|-------|--------------------------------------------------------------|------|-----------|------|-----------|-------|---------------------------------------------------------|---------|---------|----------------------|---------|---------|-------------------------------------------|---------|---------|--------------------------------------|---------|---------|
|                              |       |                                                              |      |           |      |           |       |                                                         |         |         |                      |         |         |                                           |         |         |                                      |         |         |
|                              |       | Class 5                                                      |      | Class 4 ① |      | Class 2 ① |       | Diameter series 9                                       |         |         | Diameter series 0, 2 |         |         | Class 5 Class 4 Class 2                   |         |         | Class 5 Class 4 Class 2              |         |         |
| mm over                      | incl. | high                                                         | low  | high      | low  | high      | low   | Class 5                                                 | Class 4 | Class 2 | Class 5              | Class 4 | Class 2 | Class 5                                   | Class 4 | Class 2 | Class 5                              | Class 4 | Class 2 |
| 2.5                          | 10    | 0                                                            | − 5  | 0         | − 4  | 0         | − 2.5 | 5                                                       | 4       | 2.5     | 4                    | 3       | 2.5     | 3                                         | 2       | 1.5     | 4                                    | 2.5     | 1.5     |
| 10                           | 18    | 0                                                            | − 5  | 0         | − 4  | 0         | − 2.5 | 5                                                       | 4       | 2.5     | 4                    | 3       | 2.5     | 3                                         | 2       | 1.5     | 4                                    | 2.5     | 1.5     |
| 18                           | 30    | 0                                                            | − 6  | 0         | − 5  | 0         | − 2.5 | 6                                                       | 5       | 2.5     | 5                    | 4       | 2.5     | 3                                         | 2.5     | 1.5     | 4                                    | 3       | 2.5     |
| 30                           | 50    | 0                                                            | − 8  | 0         | − 6  | 0         | − 2.5 | 8                                                       | 6       | 2.5     | 6                    | 5       | 2.5     | 4                                         | 3       | 1.5     | 5                                    | 4       | 2.5     |
| 50                           | 80    | 0                                                            | − 9  | 0         | − 7  | 0         | − 4   | 9                                                       | 7       | 4       | 7                    | 5       | 4       | 5                                         | 3.5     | 2       | 5                                    | 4       | 2.5     |
| 80                           | 120   | 0                                                            | − 10 | 0         | − 8  | 0         | − 5   | 10                                                      | 8       | 5       | 8                    | 6       | 5       | 5                                         | 4       | 2.5     | 6                                    | 5       | 2.5     |
| 120                          | 150   | 0                                                            | − 13 | 0         | − 10 | 0         | − 7   | 13                                                      | 10      | 7       | 10                   | 8       | 7       | 7                                         | 5       | 3.5     | 8                                    | 6       | 2.5     |
| 150                          | 180   | 0                                                            | − 13 | 0         | − 10 | 0         | − 7   | 13                                                      | 10      | 7       | 10                   | 8       | 7       | 7                                         | 5       | 3.5     | 8                                    | 6       | 5       |
| 180                          | 250   | 0                                                            | − 15 | 0         | − 12 | 0         | − 8   | 15                                                      | 12      | 8       | 12                   | 9       | 8       | 8                                         | 6       | 4       | 10                                   | 8       | 5       |

① The tolerance of bore diameter deviation  $\Delta d_s$ , applicable to classes 4 and 2, is the same as the tolerance of mean bore diameter deviation  $\Delta d_{mp}$ . This applies to the diameter series 0.2 for class 4, and all the diameter series for class 2.

② Applicable to individual bearing rings manufactured for duplex bearings.

**Table 9.3 Outer rings**

| Nominal outside diameter<br>$D$ |       | Single plane mean outside diameter deviation<br>$\Delta D_{mp}$ |      |           |      |           |     | Single radial plane outside diameter variation<br>$V_{Dp}$ |         |         |                      |         |         | Mean single plane outside diameter variation<br>$V_{Dmp}$ |         |         | Outer ring radial runout<br>$K_{ea}$ |         |         |
|---------------------------------|-------|-----------------------------------------------------------------|------|-----------|------|-----------|-----|------------------------------------------------------------|---------|---------|----------------------|---------|---------|-----------------------------------------------------------|---------|---------|--------------------------------------|---------|---------|
|                                 |       |                                                                 |      |           |      |           |     |                                                            |         |         |                      |         |         |                                                           |         |         |                                      |         |         |
|                                 |       | Class 5                                                         |      | Class 4 ② |      | Class 2 ② |     | Diameter series 9                                          |         |         | Diameter series 0, 2 |         |         | Class 5 Class 4 Class 2                                   |         |         | Class 5 Class 4 Class 2              |         |         |
| mm over                         | incl. | high                                                            | low  | high      | low  | high      | low | Class 5                                                    | Class 4 | Class 2 | Class 5              | Class 4 | Class 2 | Class 5                                                   | Class 4 | Class 2 | Class 5                              | Class 4 | Class 2 |
| 18                              | 30    | 0                                                               | − 6  | 0         | − 5  | 0         | − 4 | 6                                                          | 5       | 4       | 5                    | 4       | 4       | 3                                                         | 2.5     | 2       | 6                                    | 4       | 2.5     |
| 30                              | 50    | 0                                                               | − 7  | 0         | − 6  | 0         | − 4 | 7                                                          | 6       | 4       | 5                    | 5       | 4       | 4                                                         | 3       | 2       | 7                                    | 5       | 2.5     |
| 50                              | 80    | 0                                                               | − 9  | 0         | − 7  | 0         | − 4 | 9                                                          | 7       | 4       | 7                    | 5       | 4       | 5                                                         | 3.5     | 2       | 8                                    | 5       | 4       |
| 80                              | 120   | 0                                                               | − 10 | 0         | − 8  | 0         | − 5 | 10                                                         | 8       | 5       | 8                    | 6       | 5       | 5                                                         | 4       | 2.5     | 10                                   | 6       | 5       |
| 120                             | 150   | 0                                                               | − 11 | 0         | − 9  | 0         | − 5 | 11                                                         | 9       | 5       | 8                    | 7       | 5       | 6                                                         | 5       | 2.5     | 11                                   | 7       | 5       |
| 150                             | 180   | 0                                                               | − 13 | 0         | − 10 | 0         | − 7 | 13                                                         | 10      | 7       | 10                   | 8       | 7       | 7                                                         | 5       | 3.5     | 13                                   | 8       | 5       |
| 180                             | 250   | 0                                                               | − 15 | 0         | − 11 | 0         | − 8 | 15                                                         | 11      | 8       | 11                   | 8       | 8       | 8                                                         | 6       | 4       | 15                                   | 10      | 7       |
| 250                             | 315   | 0                                                               | − 18 | 0         | − 13 | 0         | − 8 | 18                                                         | 13      | 8       | 14                   | 10      | 8       | 9                                                         | 7       | 4       | 18                                   | 11      | 7       |

② The tolerance of outside diameter deviation  $\Delta D_s$ , applicable to classes 4 and 2, is the same as the tolerance of mean outside diameter deviation  $\Delta D_{mp}$ . This applies to the diameter series 0.2 for class 4, and all the diameter series for class 2.

Unit:  $\mu\text{m}$

| Face runout with bore<br>$S_d$ |         |         | Axial runout<br>$S_{ia}$ |         |         | Width deviation |         |         |     |                             |         | Width variation |         |         |
|--------------------------------|---------|---------|--------------------------|---------|---------|-----------------|---------|---------|-----|-----------------------------|---------|-----------------|---------|---------|
|                                |         |         |                          |         |         | $\Delta B_s$    |         |         |     |                             |         |                 |         |         |
|                                |         |         |                          |         |         | Single bearing  |         |         |     | Duplex bearing <sup>②</sup> |         |                 |         |         |
| Class 5                        | Class 4 | Class 2 | Class 5                  | Class 4 | Class 2 | Class 5         | Class 4 | Class 2 |     | Class 5                     | Class 4 | Class 5         | Class 4 | Class 2 |
| max                            |         |         | max                      |         |         | high            | low     | high    | low | high                        | low     | max             |         |         |
| 7                              | 3       | 1.5     | 7                        | 3       | 1.5     | 0               | —       | 40      | 0   | —                           | 40      | 0               | —       | 250     |
| 7                              | 3       | 1.5     | 7                        | 3       | 1.5     | 0               | —       | 80      | 0   | —                           | 80      | 0               | —       | 250     |
| 8                              | 4       | 1.5     | 8                        | 4       | 2.5     | 0               | —       | 120     | 0   | —                           | 120     | 0               | —       | 250     |
| 8                              | 4       | 1.5     | 8                        | 4       | 2.5     | 0               | —       | 120     | 0   | —                           | 120     | 0               | —       | 250     |
| 8                              | 5       | 1.5     | 8                        | 5       | 2.5     | 0               | —       | 150     | 0   | —                           | 150     | 0               | —       | 250     |
| 9                              | 5       | 2.5     | 9                        | 5       | 2.5     | 0               | —       | 200     | 0   | —                           | 200     | 0               | —       | 380     |
| 10                             | 6       | 2.5     | 10                       | 7       | 2.5     | 0               | —       | 250     | 0   | —                           | 250     | 0               | —       | 380     |
| 10                             | 6       | 4       | 10                       | 7       | 5       | 0               | —       | 250     | 0   | —                           | 300     | 0               | —       | 380     |
| 11                             | 7       | 5       | 13                       | 8       | 5       | 0               | —       | 300     | 0   | —                           | 350     | 0               | —       | 500     |

Unit:  $\mu\text{m}$

| Outside surface inclination<br>$S_b$ |         |         | Axial runout<br>$S_{ea}$ |         |         | Width deviation<br>$\Delta C_s$                                   | Width variation<br>$VC_s$ |         |         |
|--------------------------------------|---------|---------|--------------------------|---------|---------|-------------------------------------------------------------------|---------------------------|---------|---------|
|                                      |         |         |                          |         |         | All types                                                         |                           |         |         |
| Class 5                              | Class 4 | Class 2 | Class 5                  | Class 4 | Class 2 |                                                                   | Class 5                   | Class 4 | Class 2 |
| max                                  |         |         | max                      |         |         |                                                                   | max                       |         |         |
| 8                                    | 4       | 1.5     | 8                        | 5       | 2.5     | Identical to of $\Delta B_s$ relative to $d$ of the same bearing. | 5                         | 2.5     | 1.5     |
| 8                                    | 4       | 1.5     | 8                        | 5       | 2.5     |                                                                   | 5                         | 2.5     | 1.5     |
| 8                                    | 4       | 1.5     | 10                       | 5       | 4       |                                                                   | 6                         | 3       | 1.5     |
| 9                                    | 5       | 2.5     | 11                       | 6       | 5       |                                                                   | 8                         | 4       | 2.5     |
| 10                                   | 5       | 2.5     | 13                       | 7       | 5       |                                                                   | 8                         | 5       | 2.5     |
| 10                                   | 5       | 2.5     | 14                       | 8       | 5       |                                                                   | 8                         | 5       | 2.5     |
| 11                                   | 7       | 4       | 15                       | 10      | 7       |                                                                   | 10                        | 7       | 4       |
| 13                                   | 8       | 5       | 18                       | 10      | 7       |                                                                   | 11                        | 7       | 5       |

## ⑤ Internal clearance and standard preload of duplex angular contact ball bearings

For duplex angular contact ball bearings, the initial internal clearance or initial preload is determined with consideration for two factors: temperature rise during operation; and the rigidity and accuracy required after assembly or during operation.

The internal clearance of the bearing may be significantly reduced during operation due to three factors: the reduction in clearance caused by fits; the temperature difference between the inner and outer rings during operation; and the effects of centrifugal force. Depending on an initial internal clearance selected, a significantly reduced clearance may result in extreme temperature rise, vibration, noise, and short service life. In addition, seizure may result in some cases. For this reason, it is important to determine the optimal initial internal clearance and initial preload for the required operation functions. When using a duplex angular contact ball bearing as the main spindle bearing of a machine tool, determine the preload by considering the type, main spindle configuration, lubrication system, drive system, intended functions, and other factors. The preload is generally determined according to the  $d_{mn}$  value ( $d_{mn}$ : pitch circle diameter across rolling elements [mm] multiplied by speed [ $\text{min}^{-1}$ ]), as shown below:

$$\begin{aligned} d_{mn} \leq 50 \times 10^4 & \cdots \cdots \cdots \text{Normal preload (GN)} \\ 50 \times 10^4 < d_{mn} \leq 65 \times 10^4 & \cdots \cdots \cdots \text{Light preload (GL)} \\ d_{mn} > 65 \times 10^4 & \cdots \cdots \cdots 0 \text{ to initial clearance} \end{aligned}$$

For detailed information, contact NTN Engineering.

**Table 9.4 Radial internal clearance with duplex angular contact ball bearings**

Unit:  $\mu\text{m}$

| Nominal bore diameter $d$ mm |       | C1  |     | C2  |     | CN (normal) |     |
|------------------------------|-------|-----|-----|-----|-----|-------------|-----|
| over                         | incl. | min | max | min | max | min         | max |
| —                            | 10    | 3   | 8   | 6   | 12  | 8           | 15  |
| 10                           | 18    | 3   | 8   | 6   | 12  | 8           | 15  |
| 18                           | 30    | 3   | 10  | 6   | 12  | 10          | 20  |
| 30                           | 50    | 3   | 10  | 8   | 14  | 14          | 25  |
| 50                           | 80    | 3   | 11  | 11  | 17  | 17          | 32  |
| 80                           | 100   | 3   | 13  | 13  | 22  | 22          | 40  |
| 100                          | 120   | 3   | 15  | 15  | 30  | 30          | 50  |
| 120                          | 150   | 3   | 16  | 16  | 33  | 35          | 55  |
| 150                          | 180   | 3   | 18  | 18  | 35  | 35          | 60  |
| 180                          | 200   | 3   | 20  | 20  | 40  | 40          | 65  |

For duplex angular contact ball bearings, NTN recommends the initial radial clearances and standard preloads shown in **Tables 9.4** through **9.19**. Select the optimal radial internal clearance and initial preload for your application. When ordering a duplex angular ball bearing, please specify the desired preload and clearance. If these are not specified in the order, we will ship a bearing with standard clearance. However, the standard clearance is not available for some product types. In this case, we will inform you of the available clearances.

### ■ Standard preloads of angular contact ball bearings (DB and DF arrangements) Unit:N

**Table 9.5 Standard angular contact ball bearings (78C type)**

| Nominal bore diameter $d$ (mm) | Contact angle: 15° |                     |                     |
|--------------------------------|--------------------|---------------------|---------------------|
|                                | 78xxU              |                     |                     |
|                                | Light preload (GL) | Normal preload (GN) | Medium preload (GM) |
| 25                             | 10                 | 29                  | 78                  |
| 30                             | 10                 | 29                  | 78                  |
| 35                             | 10                 | 29                  | 78                  |
| 40                             | 10                 | 29                  | 78                  |
| 45                             | 20                 | 49                  | 98                  |
| 50                             | 20                 | 49                  | 98                  |
| 55                             | 29                 | 98                  | 196                 |
| 60                             | 29                 | 98                  | 196                 |
| 65                             | 29                 | 98                  | 196                 |
| 70                             | 29                 | 98                  | 196                 |
| 75                             | 29                 | 98                  | 196                 |
| 80                             | 29                 | 98                  | 196                 |
| 85                             | 49                 | 147                 | 294                 |
| 90                             | 49                 | 147                 | 294                 |
| 95                             | 49                 | 147                 | 294                 |
| 100                            | 49                 | 147                 | 294                 |
| 105                            | 49                 | 147                 | 294                 |
| 110                            | 78                 | 196                 | 490                 |
| 120                            | 78                 | 196                 | 490                 |
| 130                            | 98                 | 294                 | 590                 |
| 140                            | 98                 | 294                 | 590                 |
| 150                            | 147                | 390                 | 785                 |
| 160                            | 147                | 390                 | 785                 |
| 170                            | 147                | 490                 | 980                 |

**Table 9.6 Standard angular contact ball bearings (79 type)**

| Nominal bore diameter<br>$d$<br>(mm) | Contact angle: 15° |                     |                     | Contact angle: 25° |                     |                     | Contact angle: 30° |                     |                     |
|--------------------------------------|--------------------|---------------------|---------------------|--------------------|---------------------|---------------------|--------------------|---------------------|---------------------|
|                                      | 79xxUC/5S-79xxUC   |                     |                     | 79xxUAD/5S-79xxUAD |                     |                     | 79xxU/5S-79xxU     |                     |                     |
|                                      | Light preload (GL) | Normal preload (GN) | Medium preload (GM) | Light preload (GL) | Normal preload (GN) | Medium preload (GM) | Light preload (GL) | Normal preload (GN) | Medium preload (GM) |
| 10                                   | —                  | 20                  | 39                  | —                  | 29                  | 59                  | —                  | 39                  | 78                  |
| 12                                   | —                  | 20                  | 39                  | —                  | 29                  | 69                  | —                  | 39                  | 78                  |
| 15                                   | —                  | 29                  | 59                  | —                  | 49                  | 98                  | 20                 | 59                  | 118                 |
| 17                                   | —                  | 29                  | 69                  | 20                 | 49                  | 98                  | 20                 | 69                  | 127                 |
| 20                                   | 20                 | 49                  | 88                  | 20                 | 69                  | 147                 | 29                 | 88                  | 186                 |
| 25                                   | 20                 | 49                  | 98                  | 20                 | 78                  | 157                 | 29                 | 98                  | 196                 |
| 30                                   | 20                 | 49                  | 108                 | 20                 | 78                  | 167                 | 29                 | 98                  | 206                 |
| 35                                   | 29                 | 78                  | 167                 | 39                 | 127                 | 255                 | 49                 | 167                 | 325                 |
| 40                                   | 29                 | 88                  | 177                 | 39                 | 137                 | 275                 | 49                 | 167                 | 345                 |
| 45                                   | 39                 | 108                 | 216                 | 49                 | 167                 | 345                 | 69                 | 216                 | 420                 |
| 50                                   | 39                 | 118                 | 226                 | 49                 | 177                 | 355                 | 69                 | 226                 | 450                 |
| 55                                   | 39                 | 118                 | 236                 | 59                 | 186                 | 375                 | 69                 | 235                 | 460                 |
| 60                                   | 39                 | 127                 | 245                 | 59                 | 196                 | 380                 | 78                 | 245                 | 480                 |
| 65                                   | 39                 | 127                 | 245                 | 59                 | 196                 | 390                 | 78                 | 245                 | 490                 |
| 70                                   | 59                 | 177                 | 365                 | 88                 | 284                 | 560                 | 108                | 355                 | 695                 |
| 75                                   | 59                 | 177                 | 365                 | 88                 | 284                 | 570                 | 108                | 355                 | 705                 |
| 80                                   | 59                 | 186                 | 365                 | 88                 | 284                 | 580                 | 108                | 365                 | 715                 |
| 85                                   | 78                 | 245                 | 490                 | 118                | 390                 | 770                 | 147                | 480                 | 970                 |
| 90                                   | 88                 | 255                 | 500                 | 118                | 390                 | 780                 | 147                | 490                 | 980                 |
| 95                                   | 88                 | 255                 | 510                 | 118                | 400                 | 795                 | 157                | 500                 | 990                 |
| 100                                  | 108                | 325                 | 655                 | 157                | 510                 | 1 020               | 196                | 635                 | 1 270               |
| 105                                  | 108                | 335                 | 655                 | 157                | 520                 | 1 040               | 196                | 645                 | 1 300               |
| 110                                  | 108                | 335                 | 665                 | 157                | 530                 | 1 060               | 206                | 655                 | 1 310               |
| 120                                  | 137                | 410                 | 835                 | 196                | 655                 | 1 300               | 245                | 815                 | 1 620               |
| 130                                  | 167                | 510                 | 1 020               | 235                | 800                 | 1 600               | 305                | 990                 | 1 990               |
|                                      | 79xxC              |                     |                     |                    |                     |                     |                    |                     |                     |
| 140                                  | 196                | 490                 | 980                 |                    |                     |                     |                    |                     |                     |
| 150                                  | 245                | 685                 | 1 470               |                    |                     |                     |                    |                     |                     |
| 160                                  | 245                | 685                 | 1 470               |                    |                     |                     |                    |                     |                     |
| 170                                  | 245                | 685                 | 1 470               |                    |                     |                     |                    |                     |                     |

**Table 9.7 Standard angular contact ball bearings (70 type)**

| Nominal bore diameter<br><i>d</i><br>(mm) | Contact angle: 15°    |                        |                        | Contact angle: 25°    |                        |                        | Contact angle: 30°    |                        |                        |
|-------------------------------------------|-----------------------|------------------------|------------------------|-----------------------|------------------------|------------------------|-----------------------|------------------------|------------------------|
|                                           | 70xxUC/5S-70xxUC      |                        |                        | 70xxUAD/5S-70xxUAD    |                        |                        | 70xxU/5S-70xxU        |                        |                        |
|                                           | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) |
| 10                                        | —                     | 29                     | 59                     | 20                    | 49                     | 108                    | 20                    | 69                     | 127                    |
| 12                                        | —                     | 39                     | 69                     | 20                    | 59                     | 108                    | 20                    | 69                     | 137                    |
| 15                                        | —                     | 39                     | 78                     | 20                    | 59                     | 127                    | 29                    | 78                     | 157                    |
| 17                                        | 20                    | 49                     | 98                     | 20                    | 78                     | 157                    | 29                    | 98                     | 196                    |
| 20                                        | 20                    | 69                     | 137                    | 29                    | 108                    | 216                    | 39                    | 137                    | 265                    |
| 25                                        | 29                    | 78                     | 147                    | 39                    | 118                    | 235                    | 49                    | 147                    | 294                    |
| 30                                        | 29                    | 98                     | 186                    | 49                    | 147                    | 305                    | 59                    | 186                    | 375                    |
| 35                                        | 39                    | 118                    | 235                    | 59                    | 186                    | 380                    | 69                    | 235                    | 480                    |
| 40                                        | 39                    | 127                    | 255                    | 59                    | 206                    | 400                    | 78                    | 255                    | 510                    |
| 45                                        | 49                    | 147                    | 300                    | 69                    | 245                    | 480                    | 88                    | 305                    | 600                    |
| 50                                        | 49                    | 157                    | 325                    | 78                    | 255                    | 510                    | 98                    | 325                    | 635                    |
| 55                                        | 69                    | 216                    | 420                    | 98                    | 335                    | 665                    | 127                   | 420                    | 845                    |
| 60                                        | 69                    | 216                    | 430                    | 108                   | 345                    | 680                    | 127                   | 430                    | 855                    |
| 65                                        | 78                    | 226                    | 460                    | 108                   | 365                    | 725                    | 137                   | 450                    | 900                    |
| 70                                        | 98                    | 294                    | 580                    | 137                   | 460                    | 920                    | 177                   | 580                    | 1 150                  |
| 75                                        | 98                    | 294                    | 600                    | 137                   | 470                    | 940                    | 177                   | 590                    | 1 180                  |
| 80                                        | 118                   | 365                    | 725                    | 177                   | 580                    | 1 150                  | 216                   | 715                    | 1 430                  |
| 85                                        | 127                   | 375                    | 750                    | 177                   | 590                    | 1 180                  | 226                   | 735                    | 1 470                  |
| 90                                        | 147                   | 440                    | 890                    | 206                   | 705                    | 1 400                  | 265                   | 875                    | 1 750                  |
| 95                                        | 157                   | 460                    | 910                    | 216                   | 715                    | 1 430                  | 275                   | 900                    | 1 790                  |
| 100                                       | 157                   | 460                    | 930                    | 226                   | 740                    | 1 470                  | 284                   | 920                    | 1 830                  |
| 105                                       | 186                   | 550                    | 1 090                  | 255                   | 860                    | 1 720                  | 335                   | 1 070                  | 2 140                  |
| 110                                       | 206                   | 630                    | 1 250                  | 294                   | 990                    | 1 980                  | 380                   | 1 230                  | 2 460                  |
| 120                                       | 216                   | 635                    | 1 270                  | 305                   | 1 010                  | 2 020                  | 380                   | 1 260                  | 2 510                  |
| 130                                       | 265                   | 800                    | 1 600                  | 380                   | 1 270                  | 2 530                  | 480                   | 1 570                  | 3 150                  |
| 70xxC                                     |                       |                        |                        |                       |                        |                        |                       |                        |                        |
| 140                                       | 294                   | 785                    | 1 960                  |                       |                        |                        |                       |                        |                        |
| 150                                       | 294                   | 785                    | 1 960                  |                       |                        |                        |                       |                        |                        |
| 160                                       | 490                   | 980                    | 2 450                  |                       |                        |                        |                       |                        |                        |
| 170                                       | 490                   | 980                    | 2 450                  |                       |                        |                        |                       |                        |                        |
| 180                                       | 490                   | 980                    | 2 450                  |                       |                        |                        |                       |                        |                        |
| 190                                       | 590                   | 1 470                  | 3 450                  |                       |                        |                        |                       |                        |                        |
| 200                                       | 590                   | 1 470                  | 3 450                  |                       |                        |                        |                       |                        |                        |

**Table 9.8 Standard angular contact ball bearings (72C type)**

| Nominal bore diameter<br><i>d</i><br>(mm) | Contact angle: 15°    |                        |                        |
|-------------------------------------------|-----------------------|------------------------|------------------------|
|                                           | 72xxU                 |                        |                        |
|                                           | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) |
| 10                                        | 20                    | 49                     | 98                     |
| 12                                        | 20                    | 49                     | 98                     |
| 15                                        | 20                    | 49                     | 147                    |
| 17                                        | 20                    | 49                     | 147                    |
| 20                                        | 49                    | 98                     | 294                    |
| 25                                        | 49                    | 98                     | 294                    |
| 30                                        | 49                    | 98                     | 294                    |
| 35                                        | 78                    | 196                    | 490                    |
| 40                                        | 78                    | 196                    | 490                    |
| 45                                        | 98                    | 294                    | 590                    |
| 50                                        | 98                    | 294                    | 590                    |
| 55                                        | 147                   | 390                    | 785                    |
| 60                                        | 147                   | 390                    | 785                    |
| 65                                        | 147                   | 390                    | 785                    |
| 70                                        | 196                   | 490                    | 980                    |
| 75                                        | 196                   | 490                    | 980                    |
| 80                                        | 196                   | 490                    | 980                    |
| 85                                        | 294                   | 685                    | 1 470                  |
| 90                                        | 294                   | 685                    | 1 470                  |
| 95                                        | 294                   | 685                    | 1 960                  |
| 100                                       | 294                   | 685                    | 1 960                  |
| 105                                       | 390                   | 980                    | 2 450                  |
| 110                                       | 390                   | 980                    | 2 450                  |
| 120                                       | 390                   | 980                    | 2 450                  |
| 130                                       | 490                   | 1 470                  | 2 940                  |

**Table 9.9 High-speed angular contact ball bearings (HSE9 type)**

| Nominal bore diameter<br><i>d</i><br>(mm) | Contact angle: 15° |                     |                     | Contact angle: 20° |                     |                     | Contact angle: 25°   |                     |                     |
|-------------------------------------------|--------------------|---------------------|---------------------|--------------------|---------------------|---------------------|----------------------|---------------------|---------------------|
|                                           | HSE9xxC/5S-HSE9xxC |                     |                     | HSE9xx/5S-HSE9xx   |                     |                     | HSE9xxAD/5S-HSE9xxAD |                     |                     |
|                                           | Light preload (GL) | Normal preload (GN) | Medium preload (GM) | Light preload (GL) | Normal preload (GN) | Medium preload (GM) | Light preload (GL)   | Normal preload (GN) | Medium preload (GM) |
| 50                                        | 29                 | 78                  | 167                 | 39                 | 118                 | 235                 | 39                   | 157                 | 305                 |
| 55                                        | 39                 | 108                 | 206                 | 49                 | 147                 | 305                 | 49                   | 196                 | 390                 |
| 60                                        | 39                 | 108                 | 216                 | 49                 | 157                 | 315                 | 49                   | 196                 | 400                 |
| 65                                        | 39                 | 108                 | 216                 | 49                 | 157                 | 315                 | 49                   | 206                 | 410                 |
| 70                                        | 59                 | 137                 | 275                 | 59                 | 196                 | 400                 | 69                   | 255                 | 520                 |
| 75                                        | 59                 | 137                 | 284                 | 59                 | 206                 | 410                 | 69                   | 265                 | 530                 |
| 80                                        | 59                 | 147                 | 294                 | 59                 | 216                 | 420                 | 69                   | 275                 | 550                 |
| 85                                        | 69                 | 177                 | 345                 | 78                 | 255                 | 510                 | 78                   | 325                 | 655                 |
| 90                                        | 69                 | 177                 | 355                 | 78                 | 265                 | 520                 | 88                   | 335                 | 665                 |
| 95                                        | 69                 | 186                 | 365                 | 78                 | 265                 | 540                 | 88                   | 345                 | 685                 |
| 100                                       | 98                 | 255                 | 510                 | 108                | 375                 | 755                 | 118                  | 480                 | 970                 |
| 105                                       | 108                | 265                 | 530                 | 118                | 380                 | 775                 | 127                  | 500                 | 1 000               |
| 110                                       | 108                | 265                 | 530                 | 118                | 390                 | 785                 | 127                  | 500                 | 1 000               |
| 120                                       | 127                | 315                 | 630                 | 137                | 460                 | 910                 | 147                  | 590                 | 1 180               |
| 130                                       | 147                | 375                 | 745                 | 157                | 550                 | 1 090               | 177                  | 695                 | 1 390               |
| 140                                       | 147                | 375                 | 745                 | 157                | 550                 | 1 090               | 177                  | 695                 | 1 390               |
| 150                                       | 206                | 520                 | 1 040               | 226                | 755                 | 1 520               | 245                  | 980                 | 1 960               |
| 160                                       | 216                | 540                 | 1 070               | 226                | 785                 | 1 560               | 255                  | 1 000               | 2 000               |
| 170                                       | 216                | 550                 | 1 090               | 235                | 795                 | 1 590               | 255                  | 1 020               | 2 040               |

**Table 9.10 High-speed angular contact ball bearings (HSE0 type)**

| Nominal bore diameter<br><i>d</i><br>(mm) | Contact angle: 15° |                     |                     | Contact angle: 20° |                     |                     | Contact angle: 25°   |                     |                     |
|-------------------------------------------|--------------------|---------------------|---------------------|--------------------|---------------------|---------------------|----------------------|---------------------|---------------------|
|                                           | HSE0xxC/5S-HSE0xxC |                     |                     | HSE0xx/5S-HSE0xx   |                     |                     | HSE0xxAD/5S-HSE0xxAD |                     |                     |
|                                           | Light preload (GL) | Normal preload (GN) | Medium preload (GM) | Light preload (GL) | Normal preload (GN) | Medium preload (GM) | Light preload (GL)   | Normal preload (GN) | Medium preload (GM) |
| 50                                        | 59                 | 157                 | 315                 | 69                 | 235                 | 460                 | 78                   | 305                 | 600                 |
| 55                                        | 69                 | 177                 | 345                 | 78                 | 255                 | 510                 | 78                   | 325                 | 645                 |
| 60                                        | 69                 | 186                 | 365                 | 78                 | 265                 | 530                 | 88                   | 345                 | 685                 |
| 65                                        | 69                 | 186                 | 365                 | 78                 | 265                 | 540                 | 88                   | 345                 | 695                 |
| 70                                        | 88                 | 226                 | 450                 | 98                 | 325                 | 655                 | 108                  | 420                 | 845                 |
| 75                                        | 98                 | 235                 | 480                 | 108                | 355                 | 695                 | 118                  | 450                 | 900                 |
| 80                                        | 108                | 275                 | 550                 | 118                | 400                 | 805                 | 127                  | 520                 | 1 030               |
| 85                                        | 108                | 275                 | 560                 | 118                | 400                 | 815                 | 127                  | 520                 | 1 040               |
| 90                                        | 127                | 325                 | 645                 | 137                | 470                 | 940                 | 157                  | 610                 | 1 220               |
| 95                                        | 127                | 325                 | 645                 | 147                | 480                 | 960                 | 157                  | 620                 | 1 240               |
| 100                                       | 137                | 345                 | 675                 | 147                | 490                 | 990                 | 157                  | 635                 | 1 270               |
| 105                                       | 157                | 390                 | 775                 | 167                | 570                 | 1 140               | 186                  | 725                 | 1 450               |
| 110                                       | 196                | 480                 | 960                 | 206                | 695                 | 1 400               | 226                  | 900                 | 1 800               |
| 120                                       | 196                | 480                 | 960                 | 216                | 705                 | 1 410               | 226                  | 910                 | 1 820               |
| 130                                       | 275                | 695                 | 1 380               | 305                | 1 020               | 2 030               | 325                  | 1 300               | 2 610               |
| 140                                       | 284                | 715                 | 1 430               | 315                | 1 050               | 2 090               | 345                  | 1 350               | 2 710               |
| 150                                       | 294                | 735                 | 1 470               | 325                | 1 080               | 2 150               | 345                  | 1 380               | 2 770               |
| 160                                       | 345                | 865                 | 1 730               | 375                | 1 260               | 2 520               | 410                  | 1 630               | 3 250               |
| 170                                       | 390                | 990                 | 1 980               | 430                | 1 450               | 2 900               | 470                  | 1 860               | 3 750               |

**Table 9.11 Eco-friendly air-oil lubricated angular contact ball bearings (HSL9 type)**

| Nominal bore diameter<br><i>d</i><br>(mm) | Contact angle: 15°    |                        |                        | Contact angle: 20°    |                        |                        | Contact angle: 25°    |                        |                        |
|-------------------------------------------|-----------------------|------------------------|------------------------|-----------------------|------------------------|------------------------|-----------------------|------------------------|------------------------|
|                                           | HSL9xxC/5S-HSL9xxC    |                        |                        | HSL9xx/5S-HSL9xx      |                        |                        | HSL9xxAD/5S-HSL9xxAD  |                        |                        |
|                                           | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) |
| 50                                        | 29                    | 78                     | 167                    | 39                    | 118                    | 235                    | 39                    | 157                    | 305                    |
| 55                                        | 39                    | 108                    | 206                    | 49                    | 147                    | 305                    | 49                    | 196                    | 390                    |
| 60                                        | 39                    | 108                    | 216                    | 49                    | 157                    | 315                    | 49                    | 196                    | 400                    |
| 65                                        | 39                    | 108                    | 216                    | 49                    | 157                    | 315                    | 49                    | 206                    | 410                    |
| 70                                        | 59                    | 137                    | 275                    | 59                    | 196                    | 400                    | 69                    | 255                    | 520                    |
| 75                                        | 59                    | 137                    | 284                    | 59                    | 206                    | 410                    | 69                    | 265                    | 530                    |
| 80                                        | 59                    | 147                    | 294                    | 59                    | 216                    | 420                    | 69                    | 275                    | 550                    |
| 85                                        | 69                    | 177                    | 345                    | 78                    | 255                    | 510                    | 78                    | 325                    | 655                    |
| 90                                        | 69                    | 177                    | 355                    | 78                    | 265                    | 520                    | 88                    | 335                    | 665                    |
| 95                                        | 69                    | 186                    | 365                    | 78                    | 265                    | 540                    | 88                    | 345                    | 685                    |
| 100                                       | 98                    | 255                    | 510                    | 108                   | 375                    | 755                    | 118                   | 480                    | 970                    |

**Table 9.12 Eco-friendly air-oil lubricated angular contact ball bearings (HSL0 type)**

| Nominal bore diameter<br><i>d</i><br>(mm) | Contact angle: 15°    |                        |                        | Contact angle: 20°    |                        |                        | Contact angle: 25°    |                        |                        |
|-------------------------------------------|-----------------------|------------------------|------------------------|-----------------------|------------------------|------------------------|-----------------------|------------------------|------------------------|
|                                           | HSL0xxC/5S-HSL0xxC    |                        |                        | HSL0xx/5S-HSL0xx      |                        |                        | HSL0xxAD/5S-HSL0xxAD  |                        |                        |
|                                           | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) |
| 50                                        | 59                    | 157                    | 315                    | 69                    | 235                    | 460                    | 78                    | 305                    | 600                    |
| 55                                        | 69                    | 177                    | 345                    | 78                    | 255                    | 510                    | 78                    | 325                    | 645                    |
| 60                                        | 69                    | 186                    | 365                    | 78                    | 265                    | 530                    | 88                    | 345                    | 685                    |
| 65                                        | 69                    | 186                    | 365                    | 78                    | 265                    | 540                    | 88                    | 345                    | 695                    |
| 70                                        | 88                    | 226                    | 450                    | 98                    | 325                    | 655                    | 108                   | 420                    | 845                    |
| 75                                        | 98                    | 235                    | 480                    | 108                   | 355                    | 695                    | 118                   | 450                    | 900                    |
| 80                                        | 108                   | 275                    | 550                    | 118                   | 400                    | 805                    | 127                   | 520                    | 1 030                  |
| 85                                        | 108                   | 275                    | 560                    | 118                   | 400                    | 815                    | 127                   | 520                    | 1 040                  |
| 90                                        | 127                   | 325                    | 645                    | 137                   | 470                    | 940                    | 157                   | 610                    | 1 220                  |
| 95                                        | 127                   | 325                    | 645                    | 147                   | 480                    | 960                    | 157                   | 620                    | 1 240                  |
| 100                                       | 137                   | 345                    | 675                    | 147                   | 490                    | 990                    | 157                   | 635                    | 1 270                  |

**Table 9.13 Grease-lubricated sealed angular contact ball bearings (79CD and AD types)**

| Nominal bore diameter<br><i>d</i><br>(mm) | Contact angle: 15°    |                        |                        | Contact angle: 25°    |                        |                        |
|-------------------------------------------|-----------------------|------------------------|------------------------|-----------------------|------------------------|------------------------|
|                                           | 79xxCD/5S-79xxCD      |                        |                        | 79xxAD/5S-79xxAD      |                        |                        |
|                                           | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) |
| 10                                        | 10                    | 29                     | 78                     | —                     | 39                     | 78                     |
| 12                                        | 10                    | 29                     | 78                     | —                     | 39                     | 78                     |
| 15                                        | 10                    | 29                     | 78                     | —                     | 49                     | 147                    |
| 17                                        | 10                    | 29                     | 78                     | —                     | 49                     | 147                    |
| 20                                        | 20                    | 49                     | 98                     | 29                    | 98                     | 196                    |
| 25                                        | 20                    | 49                     | 98                     | 29                    | 98                     | 196                    |
| 30                                        | 20                    | 49                     | 98                     | 29                    | 98                     | 196                    |
| 35                                        | 29                    | 78                     | 196                    | 49                    | 147                    | 294                    |
| 40                                        | 29                    | 78                     | 196                    | 49                    | 147                    | 294                    |
| 45                                        | 39                    | 98                     | 245                    | 49                    | 196                    | 390                    |
| 50                                        | 39                    | 98                     | 245                    | 49                    | 196                    | 390                    |

**Table 9.14 Grease-lubricated sealed angular contact ball bearings (70CD and AD types)**

| Nominal bore diameter<br><i>d</i><br>(mm) | Contact angle: 15°    |                        |                        | Contact angle: 25°    |                        |                        |
|-------------------------------------------|-----------------------|------------------------|------------------------|-----------------------|------------------------|------------------------|
|                                           | 70xxCD/5S-70xxCD      |                        |                        | 70xxAD/5S-70xxAD      |                        |                        |
|                                           | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) |
| 10                                        | 20                    | 29                     | 98                     | 29                    | 78                     | 147                    |
| 12                                        | 20                    | 29                     | 98                     | 29                    | 78                     | 147                    |
| 15                                        | 20                    | 29                     | 98                     | 29                    | 78                     | 147                    |
| 17                                        | 20                    | 29                     | 98                     | 29                    | 78                     | 147                    |
| 20                                        | 29                    | 78                     | 147                    | 49                    | 147                    | 294                    |
| 25                                        | 29                    | 78                     | 147                    | 49                    | 147                    | 294                    |
| 30                                        | 29                    | 78                     | 147                    | 49                    | 147                    | 294                    |
| 35                                        | 49                    | 147                    | 294                    | 78                    | 294                    | 590                    |
| 40                                        | 49                    | 147                    | 294                    | 78                    | 294                    | 590                    |
| 45                                        | 49                    | 147                    | 294                    | 78                    | 294                    | 590                    |
| 50                                        | 49                    | 147                    | 294                    | 78                    | 294                    | 590                    |

**Table 9.15 High-speed grease-lubricated sealed angular contact ball bearings (BNS9 type)**

| Nominal bore diameter<br><i>d</i><br>(mm) | Contact angle: 15°    |                        |                        | Contact angle: 20°    |                        |                        | Contact angle: 25°    |                        |                        |
|-------------------------------------------|-----------------------|------------------------|------------------------|-----------------------|------------------------|------------------------|-----------------------|------------------------|------------------------|
|                                           | BNS9xxC/5S-BNS9xxC    |                        |                        | BNS9xx/5S-BNS9xx      |                        |                        | BNS9xxAD/5S-BNS9xxAD  |                        |                        |
|                                           | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) |
| 50                                        | 29                    | 78                     | 167                    | 39                    | 118                    | 235                    | 39                    | 157                    | 305                    |
| 55                                        | 39                    | 108                    | 206                    | 49                    | 147                    | 305                    | 49                    | 196                    | 390                    |
| 60                                        | 39                    | 108                    | 216                    | 49                    | 157                    | 315                    | 49                    | 196                    | 400                    |
| 65                                        | 39                    | 108                    | 216                    | 49                    | 157                    | 315                    | 49                    | 206                    | 410                    |
| 70                                        | 59                    | 137                    | 275                    | 59                    | 196                    | 400                    | 69                    | 255                    | 520                    |
| 75                                        | 59                    | 137                    | 284                    | 59                    | 206                    | 410                    | 69                    | 265                    | 530                    |
| 80                                        | 59                    | 147                    | 294                    | 59                    | 216                    | 420                    | 69                    | 275                    | 550                    |
| 85                                        | 69                    | 177                    | 345                    | 78                    | 255                    | 510                    | 78                    | 325                    | 655                    |
| 90                                        | 69                    | 177                    | 355                    | 78                    | 265                    | 520                    | 88                    | 335                    | 665                    |
| 95                                        | 69                    | 186                    | 365                    | 78                    | 265                    | 540                    | 88                    | 345                    | 685                    |
| 100                                       | 98                    | 255                    | 510                    | 108                   | 375                    | 755                    | 118                   | 480                    | 970                    |

**Table 9.16 High-speed grease-lubricated sealed angular contact ball bearings (BNS0 type)**

| Nominal bore diameter<br><i>d</i><br>(mm) | Contact angle: 15°    |                        |                        | Contact angle: 20°    |                        |                        | Contact angle: 25°    |                        |                        |
|-------------------------------------------|-----------------------|------------------------|------------------------|-----------------------|------------------------|------------------------|-----------------------|------------------------|------------------------|
|                                           | BNS0xxC/5S-BNS0xxC    |                        |                        | BNS0xx/5S-BNS0xx      |                        |                        | BNS0xxAD/5S-BNS0xxAD  |                        |                        |
|                                           | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) |
| 45                                        | 49                    | 118                    | 235                    | 49                    | 177                    | 345                    | 59                    | 226                    | 450                    |
| 50                                        | 59                    | 157                    | 315                    | 69                    | 235                    | 460                    | 78                    | 305                    | 600                    |
| 55                                        | 69                    | 177                    | 345                    | 78                    | 255                    | 510                    | 78                    | 325                    | 645                    |
| 60                                        | 69                    | 186                    | 365                    | 78                    | 265                    | 530                    | 88                    | 345                    | 685                    |
| 65                                        | 69                    | 186                    | 365                    | 78                    | 265                    | 540                    | 88                    | 345                    | 695                    |
| 70                                        | 88                    | 226                    | 450                    | 98                    | 325                    | 655                    | 108                   | 420                    | 845                    |
| 75                                        | 98                    | 235                    | 480                    | 108                   | 355                    | 695                    | 118                   | 450                    | 900                    |
| 80                                        | 108                   | 275                    | 550                    | 118                   | 400                    | 805                    | 127                   | 520                    | 1 030                  |
| 85                                        | 108                   | 275                    | 560                    | 118                   | 400                    | 815                    | 127                   | 520                    | 1 040                  |
| 90                                        | 127                   | 325                    | 645                    | 137                   | 470                    | 940                    | 157                   | 610                    | 1 220                  |
| 95                                        | 127                   | 325                    | 645                    | 147                   | 480                    | 960                    | 157                   | 620                    | 1 240                  |
| 100                                       | 137                   | 345                    | 675                    | 147                   | 490                    | 990                    | 157                   | 635                    | 1 270                  |

**Table 9.17 High-speed sealed angular contact ball bearings (BNT9 type)**

| Nominal bore diameter<br><i>d</i><br>(mm) | Contact angle: 15°    |                        |                        |
|-------------------------------------------|-----------------------|------------------------|------------------------|
|                                           | BNT9xx/5S-BNT9xx      |                        |                        |
|                                           | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) |
| 10                                        | 10                    | 29                     | 78                     |
| 12                                        | 10                    | 29                     | 78                     |
| 15                                        | 10                    | 29                     | 78                     |
| 17                                        | 10                    | 29                     | 78                     |
| 20                                        | 20                    | 49                     | 98                     |
| 25                                        | 20                    | 49                     | 98                     |
| 30                                        | 20                    | 49                     | 98                     |
| 35                                        | 29                    | 78                     | 196                    |
| 40                                        | 29                    | 78                     | 196                    |
| 45                                        | 39                    | 98                     | 245                    |
| 50                                        | 39                    | 98                     | 245                    |
| 55                                        | 49                    | 118                    | 294                    |
| 60                                        | 49                    | 118                    | 294                    |
| 65                                        | 49                    | 118                    | 294                    |

**Table 9.18 High-speed sealed angular contact ball bearings (BNT0 type)**

| Nominal bore diameter<br><i>d</i><br>(mm) | Contact angle: 15°    |                        |                        |
|-------------------------------------------|-----------------------|------------------------|------------------------|
|                                           | BNT0xx/5S-BNT0xx      |                        |                        |
|                                           | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) |
| 10                                        | 20                    | 29                     | 98                     |
| 12                                        | 20                    | 29                     | 98                     |
| 15                                        | 20                    | 29                     | 98                     |
| 17                                        | 20                    | 29                     | 98                     |
| 20                                        | 29                    | 78                     | 147                    |
| 25                                        | 29                    | 78                     | 147                    |
| 30                                        | 29                    | 78                     | 147                    |
| 35                                        | 49                    | 147                    | 294                    |
| 40                                        | 49                    | 147                    | 294                    |
| 45                                        | 49                    | 147                    | 294                    |
| 50                                        | 49                    | 147                    | 294                    |
| 55                                        | 98                    | 196                    | 490                    |
| 60                                        | 98                    | 196                    | 490                    |
| 65                                        | 98                    | 196                    | 490                    |
| 70                                        | 98                    | 294                    | 685                    |

**Table 9.19 High-speed sealed angular contact ball bearings (BNT2 type)**

| Nominal bore diameter<br><i>d</i><br>(mm) | Contact angle: 15°    |                        |                        |
|-------------------------------------------|-----------------------|------------------------|------------------------|
|                                           | BNT2xx/5S-BNT2xx      |                        |                        |
|                                           | Light preload<br>(GL) | Normal preload<br>(GN) | Medium preload<br>(GM) |
| 10                                        | 20                    | 49                     | 98                     |
| 12                                        | 20                    | 49                     | 98                     |
| 15                                        | 20                    | 49                     | 147                    |
| 17                                        | 20                    | 49                     | 147                    |
| 20                                        | 49                    | 98                     | 294                    |
| 25                                        | 49                    | 98                     | 294                    |
| 30                                        | 49                    | 98                     | 294                    |
| 35                                        | 78                    | 196                    | 490                    |
| 40                                        | 78                    | 196                    | 490                    |
| 45                                        | 98                    | 294                    | 590                    |
| 50                                        | 98                    | 294                    | 590                    |
| 55                                        | 147                   | 390                    | 785                    |
| 60                                        | 147                   | 390                    | 785                    |
| 65                                        | 147                   | 390                    | 785                    |
| 70                                        | 196                   | 490                    | 980                    |
| 75                                        | 196                   | 490                    | 980                    |
| 80                                        | 196                   | 490                    | 980                    |

## ⑥ Recommended fit for angular contact ball bearings

If the  $d_{mn}$  value is in the range of  $d_{mn} \leq 75 \times 10^4$  ( $d_m$ : pitch circle diameter across rolling elements [mm],  $n$ : speed [ $\text{min}^{-1}$ ]), the fit values shown in **Tables 9.20** and **9.21** are recommended to ensure high accuracies of precision bearings.

If the  $d_{mn}$  value is in the range of  $d_{mn} > 75 \times 10^4$ , it is necessary to consider expansion of inner ring caused by centrifugal force. In this case, contact NTN Engineering and ask for the recommended fit. As for the fit of the outer ring with the housing, consider the influence of the ambient temperature (such as heat buildup on a built-in motor or the cooling effect of jacket). For a technical assistance in detailed consideration, contact NTN Engineering.

**Table 9.20 Shaft fit**

Unit:  $\mu\text{m}$

| Nominal bore diameter<br>$d$ mm |           | Fit of inner ring with housing |
|---------------------------------|-----------|--------------------------------|
| More than                       | Less than |                                |
| 2.5                             | 10        | 0~2T                           |
| 10                              | 18        | 0~2T                           |
| 18                              | 30        | 0~2.5T                         |
| 30                              | 50        | 0~3T                           |
| 50                              | 80        | 0~3.5T                         |
| 80                              | 120       | 0~4T                           |
| 120                             | 180       | 0~5T                           |
| 180                             | 250       | 0~6T                           |

Notes:

- The mean value should be the target value.
- If the  $d_{mn}$  value of the high-speed machine is in the range of  $d_{mn} > 75 \times 10^4$ , it is necessary to increase the interference fit amount. In this case, contact NTN Engineering for technical assistance.

T: Interference fit

**Table 9.21 Housing fit**

Unit:  $\mu\text{m}$

| Nominal outside diameter<br>$D$ mm |           | Fit of outer ring with housing |                      |
|------------------------------------|-----------|--------------------------------|----------------------|
| More than                          | Less than | Bearing on fixed side          | Bearing on free side |
| 18                                 | 30        | 0~3L                           | 6L~10L               |
| 30                                 | 50        | 0~3L                           | 6L~10L               |
| 50                                 | 80        | 0~4L                           | 6L~12L               |
| 80                                 | 120       | 0~5L                           | 8L~13L               |
| 120                                | 150       | 0~6L                           | 10L~16L              |
| 150                                | 180       | 0~7L                           | 11L~17L              |
| 180                                | 250       | 0~8L                           | 13L~20L              |
| 250                                | 315       | 0~9L                           | 15L~23L              |

Notes:

- The mean value should be the target value.
- If the  $d_{mn}$  value of the high-speed machine or the built-in motor is in the range of  $d_{mn} > 75 \times 10^4$ , it is necessary to increase the fit clearance. In this case, contact NTN Engineering for technical assistance.

L: Loose fit

## ⑦ Duplex angular contact ball bearings

Duplex angular contact ball bearings can be combined in rows of two, three or four bearings to accommodate required specifications.

Back-to-back duplex (DB) arrangement and face-to-face duplex (DF) arrangement accommodate the application of both radial loads and axial loads in both directions. The DB arrangement accommodates a wide interaction space and can handle large moment loads. For this reason, this type of duplex arrangement is preferable for use on the main spindles of machine tools.

DF arrangement cannot handle large moment loads, but their allowable inclination angle is greater than that of DB arrangement. Tandem duplex (DT) arrangement can handle both a radial load and large axial load, but this bearing can handle the axial load in one direction only. The 4-row duplex (type DTBT) arrangement ensures high rigidity in the radial and axial directions and accommodates high-speed operation. For this reason, this type of duplex bearing is preferably used for the main spindles of machining centers.

To enable adjustment of the preload and clearance, each duplex angular contact ball bearing is manufactured as a set. For this reason, combine only duplex bearings of the same product number.

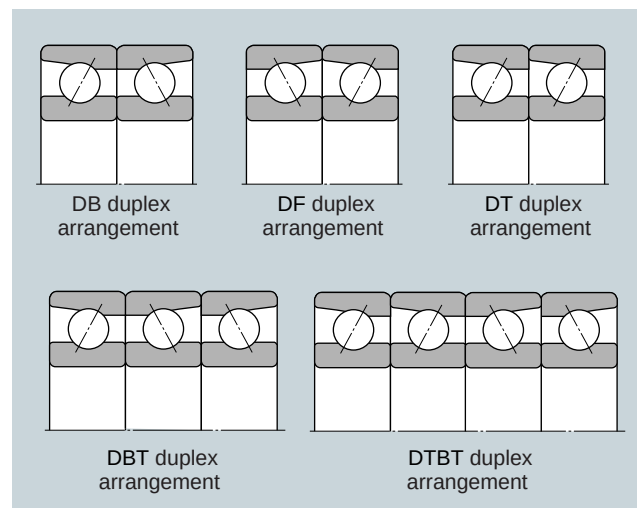


**Fig. 9.5**

## ⑧ Duplex arrangement codes of duplex angular contact ball bearings

Each duplex ball bearing has a product number and duplex arrangement code photo-etched on its end face. On a duplex angular contact ball bearing of triple-row or greater, each matching bearing has a "<" mark on its outside surface. Be sure to align the "<" marks when assembling the bearing unit.

Note that duplex angular contact ball bearing types DB and DF lack the "<" marks. To match them, align the duplex arrangement codes.

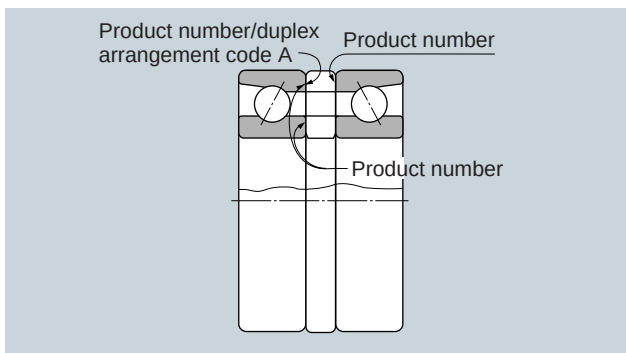


Fig. 9.10

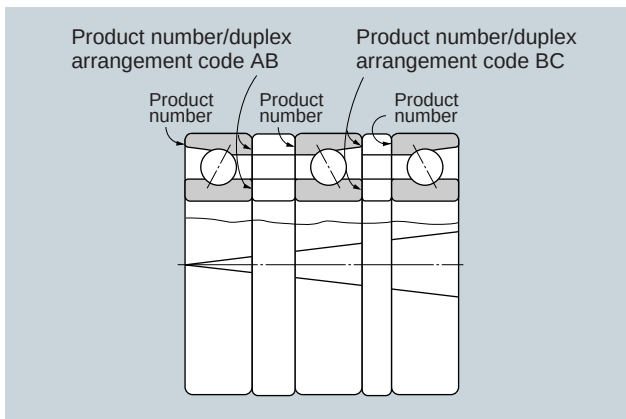


Fig. 9.11

## ⑨ Flush grinding and universal matching

Duplex angular contact ball bearings should be combined according to an intended purpose. Face-to-face duplex (DF) arrangement, back-to-back duplex (DB) arrangement and tandem duplex (DT) arrangement may be combined in rows of two or more. When combining a plurality of bearings, it is important to control the accuracies of the bearings and to align their faces height in a common plane.

### ■ Flush grinding

"Flush grinding" is a finishing technique in which the front and back end faces of the inner and outer rings are aligned with each other to eliminate faces height differences in level (Fig. 9.12). Such alignment can ensure the specified clearance and preload for DF, DB, and DT sets, but it is possible only if the combined bearings have the same clearance/preload symbols. The flush grinding technique is employed for standard BNT series, 0 series, and 2 series bearings designed for main spindles of machine tools, and for 2A-BST thrust angular contact ball bearings designed to support ballscrews.

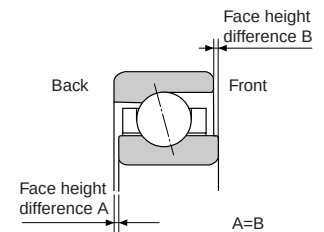


Fig. 9.12 Flush grinding

Note: The flush grinding technique is also adopted for other types of angular contact ball bearings. When ordering a bearing, append "G" to the product number to specify the flush ground type. **Example: 7010C G/GNP4**

### ■ Universal Matching

In addition to the flush grinding technique, universal matching is employed for duplex angular contact ball bearings. Universal matching controls the bearing-to-bearing dimensional differences in the bore and outside diameters.

NTN can control the bearing-to-bearing difference in the bore and outside diameters to no more than one-third the tolerance (a minimum of 2 μm). Universal matching is adopted for duplex angular contact ball bearings of JIS class 5 or better. When ordering a bearing, specify the desired number of duplex bearings to be used in combination ("D2" for DB, DF or DT; and "D3" for DBT, DFT or DTT).

Alternately, indicate the basic combination and specify universal matching.

If two duplex bearings are combined, "D2" is appended to the product number.

**Example: 7010C G D2/GNP4**

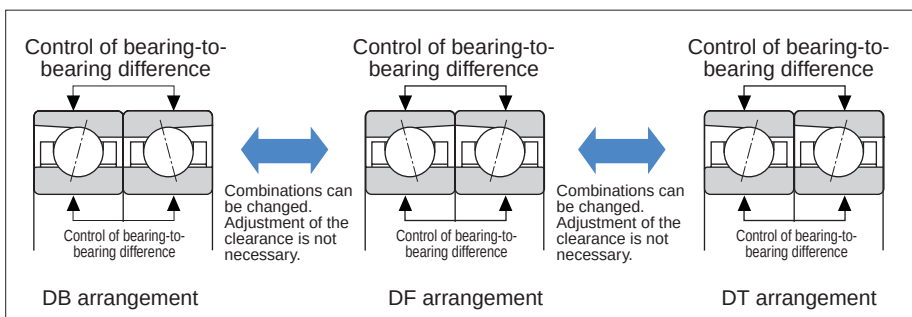


Fig. 9.13 Universal matching

## ⑩ Angular contact ball bearings with ceramic balls

Recently, the main spindles of machining centers, NC machines and other machine tools have been required to operate at much higher speeds. Bearings for main spindles therefore must meet the requirements of high speed and rigidity as well as accuracy. To meet such requirements, many of our customers want the rolling element made of ceramic material. The features of angular contact ball bearings with ceramic balls are described below:

### ■ A bearing with a limited temperature rise that are capable of ultra-high speeds

The specific gravity of ceramic material is one-half that of bearing steel. In addition, the ball diameter of 5S-HSE type is smaller than that of the standard 70 type. For this reason, use of this type of ceramic balls bearing greatly reduces the influence of centrifugal force (ball sliding and spinning caused by gyratory moment).

As a result, these angular contact ball bearings inhibit temperature buildup and ensure ultra-high speed.

### ■ High bearing rigidity for high accuracy of manufactured products

The Young's modulus of ceramic material is approximately 1.5 times that of bearing steel. The rigidity of these angular contact ball bearings is therefore greatly increased.

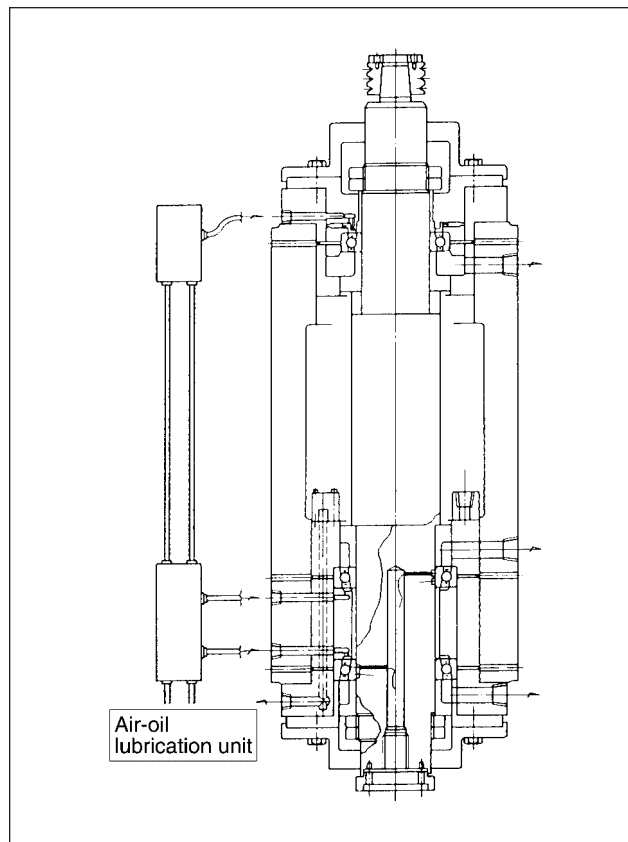


Fig. 9.15 Test rig for measuring temperature rise

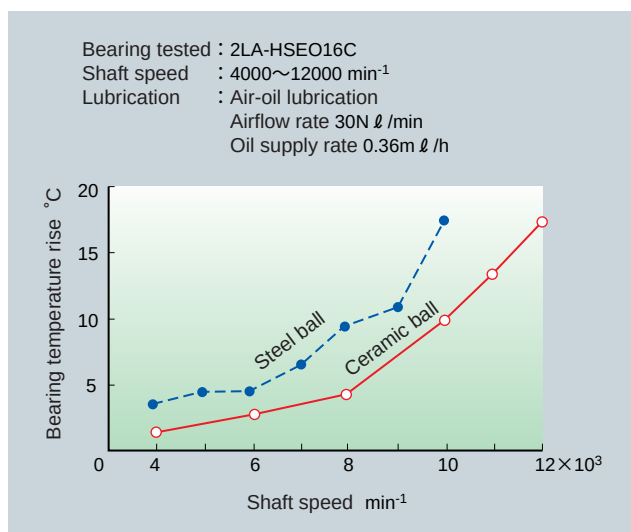


Fig. 9.14 Comparison of temperature rise between bearings with ceramic balls and those with steel balls

Table 9.22 Comparison of physical properties between ceramic and steel balls

| Item                                      | Ceramic (Si <sub>3</sub> N <sub>4</sub> ) | Bearing steel (SUJ2) |
|-------------------------------------------|-------------------------------------------|----------------------|
| Density (g/cm <sup>3</sup> )              | 3.304                                     | 7.8                  |
| Young's modulus (GPa)                     | 315                                       | 210                  |
| Poisson's ratio                           | 0.25                                      | 0.3                  |
| Thermal expansion (×10 <sup>-6</sup> /°C) | 3.2                                       | 12.5                 |
| Thermal conductivity ratio (Cal/cm·s·°C)  | 0.07                                      | 0.1~0.12             |

## ⑪ Operating life of bearings with ceramic balls

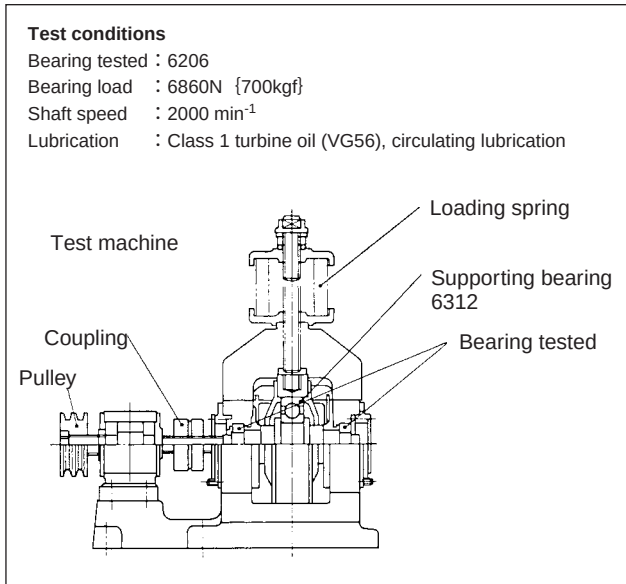


Fig. 9.16 Radial loaded-type bearing life tester

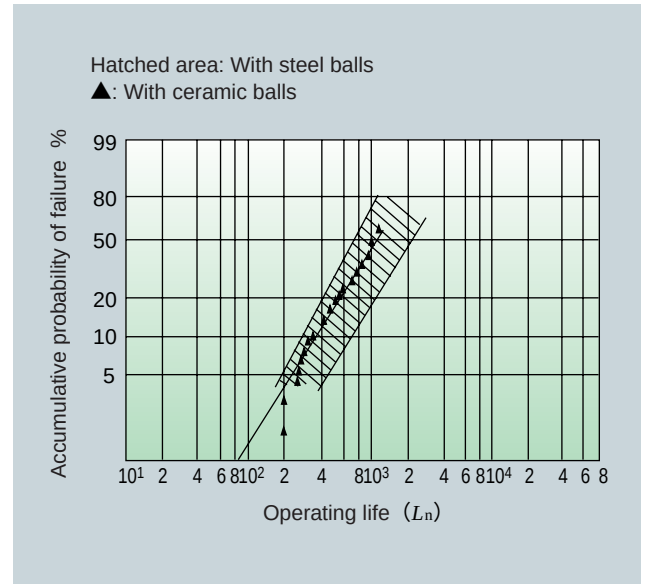


Fig. 9.17 Operating life of ball bearing with ceramic balls

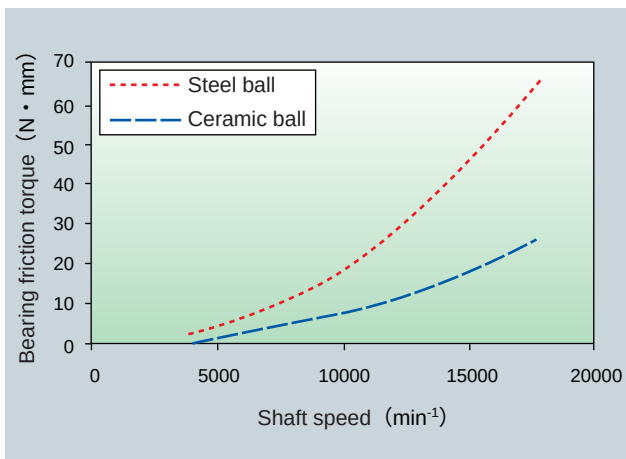


Fig. 9.18 Frictional torque

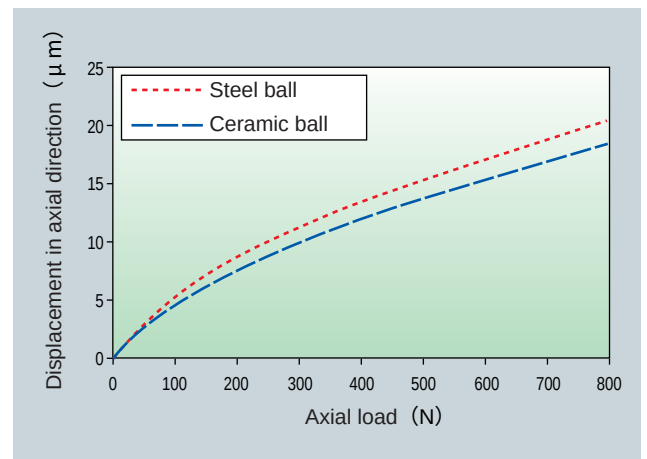


Fig. 9.19 Displacement in axial direction

## 12 Recommended lubrication specifications

Angular contact ball bearings for radial load are usually used together with grease lubrication or air-oil lubrication. Recommended lubrication specifications are described below.

### ■ Grease lubrication

#### ● Recommended brand of grease

Refer to 7. Lubrication of Bearings, 7-1 Grease lubrication in the Technical Data section.

#### ● Recommended grease filling amount

$d_{mn} \text{ value} \leq 65 \times 10^4$

15% of the capacities shown in the dimensions tables

$d_{mn} > 65 \times 10^4$

12% of the capacities shown in the dimensions tables

#### ● Recommended grease filling method

Refer to 6. Handling of Bearings, 6-1 Cleaning of bearings and filling with grease in the Technical Data section.

#### ● Notes

Grease-lubricated sealed angular contact ball bearings (79CD, AD/70CD, AD type, and BNS type bearings) have been in advance appropriately prefilled with long-life grease MP-1.

Wipe rust preventive oil away from the outside of bearing with a clean cloth.

### ■ Air-oil lubrication

#### ● Recommended location of nozzle

Refer to 7. Lubrication of Bearings, 7-2 Air-oil lubrication in the Technical Data section.

#### ● Recommended specifications of nozzle

Nozzle bore dia.: 1 to 1.5 mm

Number of nozzles: One nozzle per bearing, depth of nozzle bore should be four to six times as large as the bore diameter.

#### ● Recommended specifications of air-oil

Oil type: Spindle oil

Viscosity grade: ISO VG from 10 to 32 (32 is preferable)

Table. 9.23 Air and oil amount

| Bearing type     | $d_{mn}$ value<br>( $\times 10^4$ ) |       | Oil amount<br>per shot<br>$\text{cm}^3$ | Lubrication<br>intervals | Oil<br>consumption<br>$\text{cm}^3/\text{h}$ | Recommended<br>air consumption<br>* $\text{N l / min}$ |
|------------------|-------------------------------------|-------|-----------------------------------------|--------------------------|----------------------------------------------|--------------------------------------------------------|
|                  | Over                                | Incl. |                                         | min                      |                                              |                                                        |
| 78C,79U,70U, 72C | ~ 100                               |       | 0.03                                    | 8                        | 0.23                                         | 20~40                                                  |
| HSE9, HSE0       | 100                                 | ~ 150 |                                         | 5                        | 0.36                                         |                                                        |
| HSF              | 150                                 | ~ 260 |                                         | 2                        | 0.90                                         |                                                        |
| HSL<br>HSFL      | ~ 260                               |       |                                         | 10                       | 0.18                                         |                                                        |

\*  $\text{N} \ell / \text{min}$  (Normal liter/minute) ...  $\text{N} \ell$  means the volume of air at  $0^\circ\text{C}$  and 1 atmosphere.