

## 11 Accuracy and Internal Clearance

Accuracy of a ball bearing unit is specified in JIS B 1558 (ball bearings for ball bearing units) and JIS B 1559 (housings for ball bearing units). FYH produces products conforming to these standards.

### 11.1 Accuracy of Bearings

Table 11.1 to Table 11.4 shows the accuracy of a ball bearings for ball bearing units.

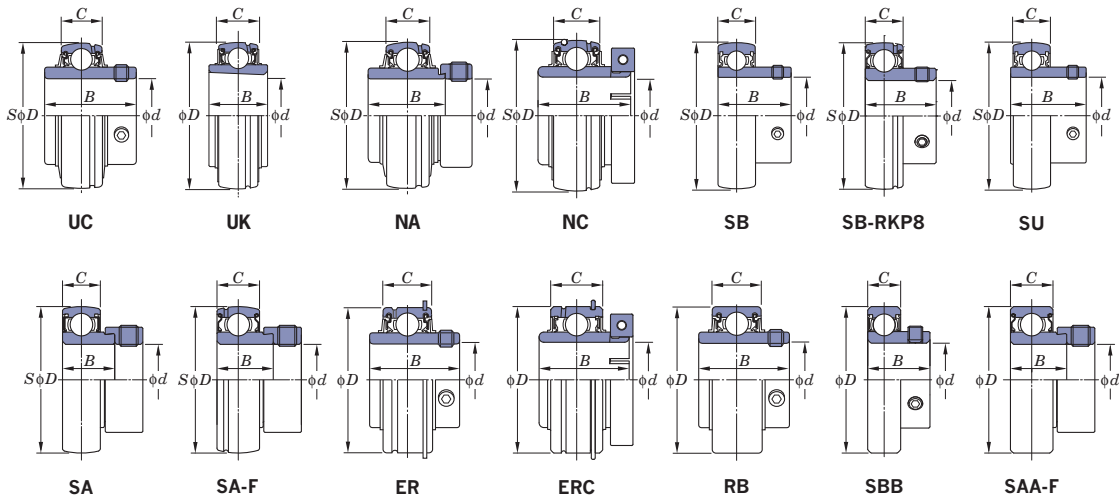
Ball bearings for blowers (special code: S3, S5) are produced with greater accuracy than standard models (see Table 11.3).

Table 11.5 shows the tolerance limitations of inner rings for cylindrical bore bearings.

**Table 11.2 Tolerances and tolerance values of outer rings of ball bearings inserts**

Unit:  $\mu\text{m}$

| Nominal bearing outer dia. $D$ (mm) |       | Variation of tolerance of average outer dia. $\Delta D_m$ |      | Radial runout of outer ring $K_{\text{Ea}}$ |
|-------------------------------------|-------|-----------------------------------------------------------|------|---------------------------------------------|
| Over                                | Incl. | Max.                                                      | Min. | Max.                                        |
| 18                                  | 30    | 0                                                         | -9   | 15                                          |
| 30                                  | 50    | 0                                                         | -11  | 20                                          |
| 50                                  | 80    | 0                                                         | -13  | 25                                          |
| 80                                  | 120   | 0                                                         | -15  | 35                                          |
| 120                                 | 150   | 0                                                         | -18  | 40                                          |
| 150                                 | 180   | 0                                                         | -25  | 45                                          |
| 180                                 | 250   | 0                                                         | -30  | 50                                          |
| 250                                 | 315   | 0                                                         | -35  | 60                                          |



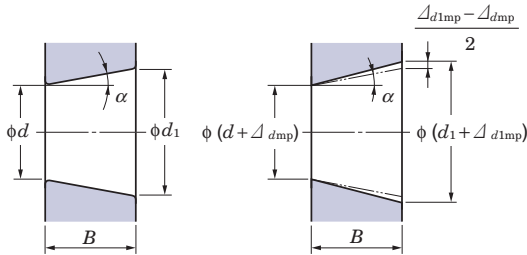
**Table 11.1 Tolerances and tolerance values of inner rings of ball bearings for ball bearing units**

Unit:  $\mu\text{m}$

| Nominal bearing bore dia. $d$ (mm) |       | Variation of tolerance of average bore dia. in plane $\Delta d_{\text{mp}}$ |      | Unequal bore dia. in plane $V_{\text{dsp}}$ | Variation of tolerance of eccentricity on eccentric surface of inner ring and eccentric locking collar $\Delta H_s$ |      | Variation of tolerance of inner ring width $\Delta B_s$ |      | Radial runout of inner ring $K_{\text{ia}}$ |
|------------------------------------|-------|-----------------------------------------------------------------------------|------|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------|------|---------------------------------------------------------|------|---------------------------------------------|
| Over                               | Incl. | Max.                                                                        | Min. | Max.                                        | Max.                                                                                                                | Min. | Max.                                                    | Min. | Max.                                        |
| -                                  | 10    | +15                                                                         | 0    | 10                                          | +100                                                                                                                | -100 | 0                                                       | -120 | 10                                          |
| 10                                 | 18    | +15                                                                         | 0    | 10                                          | +100                                                                                                                | -100 | 0                                                       | -120 | 15                                          |
| 18                                 | 31.75 | +18                                                                         | 0    | 12                                          | +100                                                                                                                | -100 | 0                                                       | -120 | 18                                          |
| 31.75                              | 50.8  | +21                                                                         | 0    | 14                                          | +100                                                                                                                | -100 | 0                                                       | -120 | 20                                          |
| 50.8                               | 80    | +24                                                                         | 0    | 16                                          | +100                                                                                                                | -100 | 0                                                       | -150 | 25                                          |
| 80                                 | 120   | +28                                                                         | 0    | 19                                          | +100                                                                                                                | -100 | 0                                                       | -200 | 30                                          |
| 120                                | 180   | +33                                                                         | 0    | 22                                          | +100                                                                                                                | -100 | 0                                                       | -250 | 35                                          |

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**Table 11.3 Variation of tolerances and tolerance values of tapered bore on bearing with tapered bore**



Theoretical tapered bore

Tapered bore with variation of tolerance of average bore dia. in plane

Unit:  $\mu\text{m}$

| Nominal bearing bore dia. $d$ , mm |       | $\Delta d_{mp}$ |      | $\Delta d_{1mp} - \Delta d_{mp}$ |      | $V_{dsp}^{1)}$ |
|------------------------------------|-------|-----------------|------|----------------------------------|------|----------------|
| Over                               | Incl. | Max.            | Min. | Max.                             | Min. | Max.           |
| 18                                 | 30    | +33             | 0    | +21                              | 0    | 13             |
| 30                                 | 50    | +39             | 0    | +25                              | 0    | 16             |
| 50                                 | 80    | +46             | 0    | +30                              | 0    | 19             |
| 80                                 | 120   | +54             | 0    | +35                              | 0    | 22             |
| 120                                | 180   | +63             | 0    | +40                              | 0    | 40             |

Note <sup>1)</sup> To be applied to all the radial planes of tapered bore

Remarks 1. Applicable range

Applicable to tapered bore of inner ring of tapered bore radial bearing that standard value of taper ratio is 1/12.

2. Amount code

$d_1$ : Standard diameter at theoretical large end of tapered bore

$$\text{Standard diameter } d_1 = d + \frac{1}{12} B$$

$\Delta d_{mp}$ : Variation of tolerance of average bore diameter in plane at theoretical small end of tapered bore

$\Delta d_{1mp}$ : Variation of tolerance of average bore diameter in plane at theoretical large end of tapered bore

$V_{dsp}$ : Unequal bore diameter in plane

$B$ : Nominal inner ring width

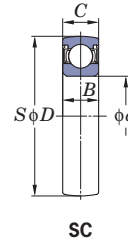
$\alpha$ : 1/2 of nominal taper angle of tapered bore

$$\alpha = 2^\circ 23' 9.4''$$

$$= 2.385 94^\circ$$

$$= 0.041 643 \text{ rad}$$

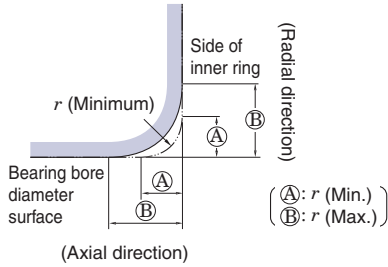
**Table 11.4 Tolerances and tolerance values of inner rings of SC ball bearings**



Unit:  $\mu\text{m}$

| Nominal bearing bore dia. $d$ (mm) |       | Variation of tolerance of average bore dia. in plane $\Delta d_{mp}$ |      | Unequal average bore dia. in plane $V_{dsp}$ | Radial runout of inner ring $K_{ia}$ |
|------------------------------------|-------|----------------------------------------------------------------------|------|----------------------------------------------|--------------------------------------|
| Over                               | Incl. | Max.                                                                 | Min. | Max.                                         | Max.                                 |
| 10                                 | 18    | 0                                                                    | - 8  | 6                                            | 7                                    |
| 18                                 | 31.75 | 0                                                                    | -10  | 6                                            | 8                                    |
| 31.75                              | 50.8  | 0                                                                    | -12  | 10                                           | 10                                   |

**Table 11.5 Tolerance limitations for radius dimensions for the inner ring of cylindrical bore bearings**



Unit: mm

| r (Min.) | r (Max.)         |                 |
|----------|------------------|-----------------|
|          | Radial direction | Axial direction |
| 0.6      | 1                | 2               |
| 1        | 1.5              | 3               |
| 1.1      | 2                | 3.5             |
| 1.5      | 2.3              | 4               |
| 2        | 3                | 4.5             |
| 2.1      | 4                | 6.5             |
| 2.5      | 3.8              | 6               |
| 3        | 5                | 8               |
| 4        | 6.5              | 9               |

**Remark** Though accurate profile of chamfered surface is not specified, the profile on the axial plane should not exceed the virtual arc of radius  $r$  (minimum) that contacts with the side of inner ring and the bearing bore diameter surface.

**11.2 Accuracy of Housings**

This section details the tolerance specifications of the inner diameter of the spherical bore of FYH housings. These values determine how tight or how loose the bearing fits inside the housing.

**Table 11.6** shows the tolerance of the diameter of the spherical bore of housings.

Standard tolerance for mounted units, between the outer diameter of the bearing and the inner diameter of the housing, is a class J7 intermediate fit.

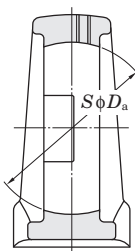
A class H7 tolerance allows greater clearance for applications where minor shaft alignment constantly occurs or in environments where higher temperatures can cause thermal expansion. An anti-rotation pin on the outer ring of the bearing is supplied with these units to prevent the outer ring of the bearing from spinning inside the housing.

A class K7 tolerance allows less clearance and is recommended to prevent the outer ring of the bearing from rotating inside the housing.

**Fig. 11.1** shows examples of housing dimensions relative to installation position with tolerance values.

**Table 11.6 Allowance of spherical bore diameter of housings**

Unit:  $\mu\text{m}$

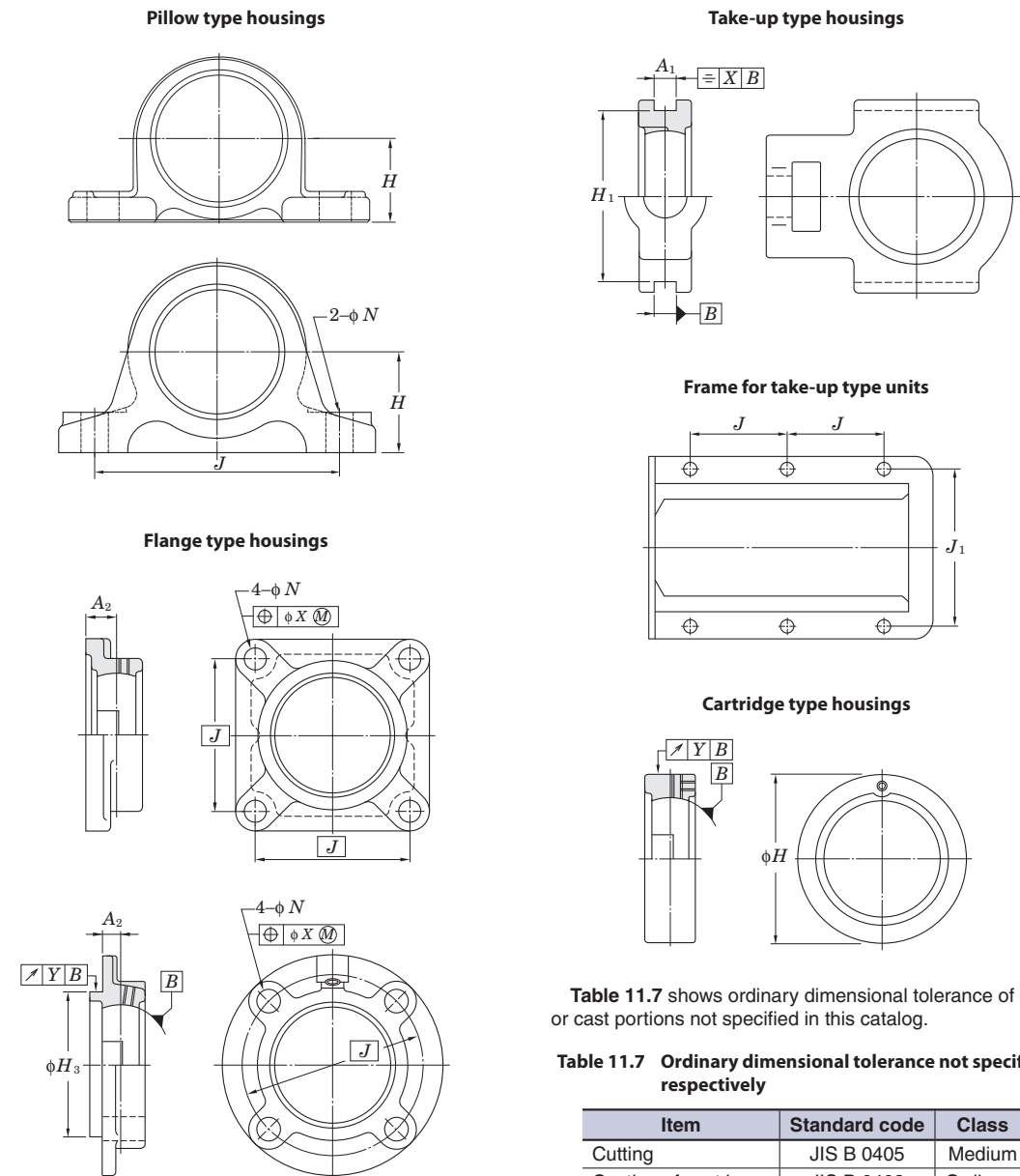


| Nominal dia. of spherical bore $D_a$ (mm) |       | Tolerance class H7                                                    |      | Tolerance class J7                                                    |      | Tolerance class K7                                                    |      |
|-------------------------------------------|-------|-----------------------------------------------------------------------|------|-----------------------------------------------------------------------|------|-----------------------------------------------------------------------|------|
|                                           |       | Variation of tolerance of spherical bore dia. $\Delta D_{\text{dam}}$ |      | Variation of tolerance of spherical bore dia. $\Delta D_{\text{dam}}$ |      | Variation of tolerance of spherical bore dia. $\Delta D_{\text{dam}}$ |      |
| Over                                      | Incl. | Max.                                                                  | Min. | Max.                                                                  | Min. | Max.                                                                  | Min. |
| 18                                        | 30    | +21                                                                   | 0    | +12                                                                   | -9   | +6                                                                    | -15  |
| 30                                        | 50    | +25                                                                   | 0    | +14                                                                   | -11  | +7                                                                    | -18  |
| 50                                        | 80    | +30                                                                   | 0    | +18                                                                   | -12  | +9                                                                    | -21  |
| 80                                        | 120   | +35                                                                   | 0    | +22                                                                   | -13  | +10                                                                   | -25  |
| 120                                       | 180   | +40                                                                   | 0    | +26                                                                   | -14  | +12                                                                   | -28  |
| 180                                       | 250   | +46                                                                   | 0    | +30                                                                   | -16  | +13                                                                   | -33  |
| 250                                       | 315   | +52                                                                   | 0    | +36                                                                   | -16  | +16                                                                   | -36  |

**Remark** FYH selects J, H, or K depending on the applications.

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Fig. 11.1 Dimensions relative to installation of housings with tolerances and tolerance values (representative example)



Remark Respective tolerances and tolerance values for housings are shown in dimensional tables.

Table 11.7 shows ordinary dimensional tolerance of cut or cast portions not specified in this catalog.

Table 11.7 Ordinary dimensional tolerance not specified respectively

| Item                  | Standard code | Class    |
|-----------------------|---------------|----------|
| Cutting               | JIS B 0405    | Medium   |
| Casting of cast iron  | JIS B 0403    | Ordinary |
| Casting of cast steel | JIS B 0403    | Ordinary |



### 11.3 Internal Bearing Clearance

Internal bearing clearance is defined as the allowable space between the bearing balls and the raceways. The degree of internal clearance, referred to as “operation clearance”, greatly influences operational life of the bearing as well as characteristics of heat, noise, and vibration.

If the clearance is exceptionally tight between the shaft and the inner ring of the bearing then expansion of the inner ring must be taken into consideration and the correct ball clearance should be selected. Transmission heat from the shaft is also a factor to consider when determining the correct amount of ball clearance (see “7 Operating temperature and bearing specifications”).

Table 11.8 shows the internal clearance applicable to specific operating conditions and Table 11.9 shows the available options for internal clearance.

**Table 11.8 Internal clearance applicable to specific operating conditions**

| Type                                    | Applicable internal clearance |                           |
|-----------------------------------------|-------------------------------|---------------------------|
|                                         | Bearing with cylindrical bore | Bearing with tapered bore |
| Standard type                           | CN                            | C3                        |
| NC                                      | CN                            | –                         |
| Stainless steel type                    | C3                            | –                         |
| Heat resistant type (suffix code: D1K2) | C4                            | C5                        |
| Heat resistant type (suffix code: D9K2) | C4                            | C5                        |
| Cold resistant type (suffix code: D2K2) | CN                            | C3                        |
| High speed type (suffix code: K3)       | CN                            | C3                        |
| For blower (suffix code: S3)            | CN                            | C3                        |
| For high speed blower (suffix code: S5) | C2                            | C3                        |

Remark For bearings with suffix codes, as those indicated above, the clearance is implied and not indicated in the part number.

**Table 11.9 Available options for internal clearance**

Unit:  $\mu\text{m}$

| Nominal bearing bore dia. $d$ (mm) |       | Internal clearance |      |      |      |      |      |      |      |      |      |      |      |
|------------------------------------|-------|--------------------|------|------|------|------|------|------|------|------|------|------|------|
|                                    |       | C2                 |      | CN   |      | GN   |      | C3   |      | C4   |      | C5   |      |
| Over                               | Incl. | Min.               | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. |
| 6                                  | 10    | 0                  | 7    | 2    | 13   | –    | –    | 8    | 23   | 14   | 29   | 20   | 37   |
| 10                                 | 18    | 0                  | 9    | 3    | 18   | 10   | 25   | 11   | 25   | 18   | 33   | 25   | 45   |
| 18                                 | 24    | 0                  | 10   | 5    | 20   | 12   | 28   | 13   | 28   | 20   | 36   | 28   | 48   |
| 24                                 | 30    | 1                  | 11   | 5    | 20   | 12   | 28   | 13   | 28   | 23   | 41   | 30   | 53   |
| 30                                 | 40    | 1                  | 11   | 6    | 20   | 13   | 33   | 15   | 33   | 28   | 46   | 40   | 64   |
| 40                                 | 50    | 1                  | 11   | 6    | 23   | 14   | 36   | 18   | 36   | 30   | 51   | 45   | 73   |
| 50                                 | 65    | 1                  | 15   | 8    | 28   | 18   | 43   | 23   | 43   | 38   | 61   | 55   | 90   |
| 65                                 | 80    | 1                  | 15   | 10   | 30   | 20   | 51   | 25   | 51   | 46   | 71   | 65   | 105  |
| 80                                 | 100   | 1                  | 18   | 12   | 36   | 24   | 58   | 30   | 58   | 53   | 84   | 75   | 120  |
| 100                                | 120   | 2                  | 20   | 15   | 41   | 28   | 66   | 36   | 66   | 61   | 97   | 90   | 140  |
| 120                                | 140   | 2                  | 23   | 18   | 48   | 33   | 81   | 41   | 81   | 71   | 114  | 105  | 160  |

Remarks 1. Radial internal clearance in this table conforms to JIS B 1558 (ball bearing inserts).

2. Increase in radial internal clearance generated by measured load conforms to the table below. Smaller correction of C2 clearance is applicable to the minimum clearance, while larger correction is applicable to the maximum clearance.

Unit:  $\mu\text{m}$

| Nominal bearing bore dia. $d$ (mm) |       | Measured load | Correction of clearance |    |    |        |    |
|------------------------------------|-------|---------------|-------------------------|----|----|--------|----|
|                                    |       |               | N                       | C2 | CN | GN, C3 | C4 |
| Over                               | Incl. |               |                         |    |    |        |    |
| 2.5                                | 18    | 24.5          | 3 – 4                   | 4  |    |        | 4  |
| 18                                 | 50    | 49            | 4 – 5                   | 5  |    |        | 6  |
| 50                                 | 280   | 147           | 6 – 8                   | 8  |    |        | 9  |