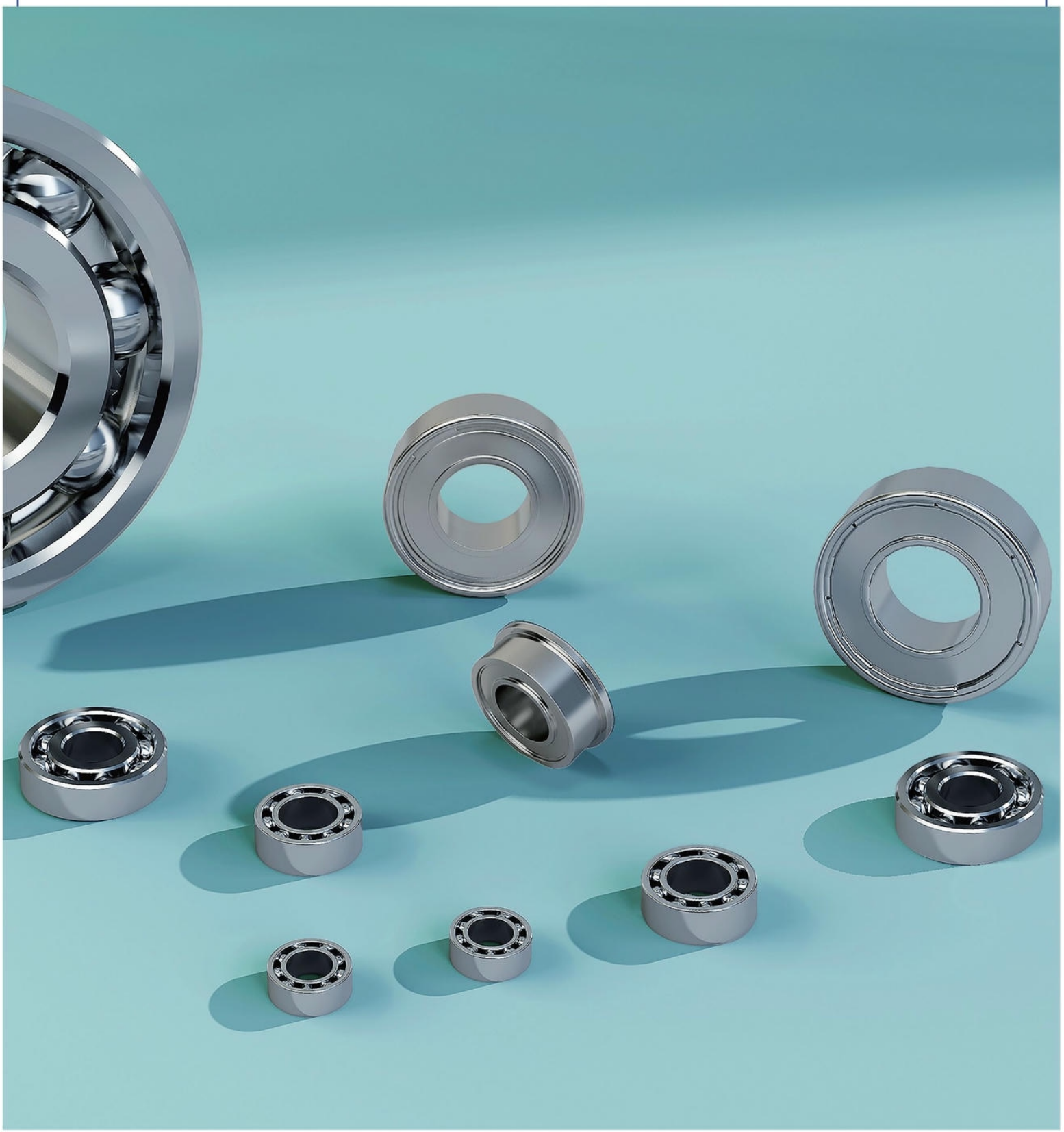
STT

# Miniature Ball Bearings



**STT** Superior/Tenacity/Teamwork



STT Technology has long been dedicated to the R&D of manufacturing processes and technologies for precision-grade extra-miniature deep groove ball bearings, providing customers with precision products widely applied in aerospace, marine, automotive, household appliances, medical equipment, and other fields. In order to meet the ever-changing product demands of different market groups, and also to further reduce the energy consumption of the machines, this catalog has been specially compiled for reference by professionals in their work. The first section of this catalog provides a concise introduction to the types and models of extra-miniature ball bearings; the second section offers certain applications and technical data related to relevant products; and the third section consists of appendix tables.

# FACTORY Overview



**Precision Turning and Machining**

To highlight the distinctiveness of STT bearings, STT Technology begins processing and quality control from the very stage of raw materials. The use of fully automatic CNC lathes ensures that products are machined and formed in a single process, thereby better guaranteeing the stability of subsequent machining from the very source.



**Vacuum Heat Treatment**

Vacuum heat treatment can optimize the metallographic structure of the material, enhance the wear resistance of the material, and greatly extend the service life of the bearing.



**Precision Grinding and Machining**

The first in China to achieve fully automatic grinding of the inner bore of extra-miniature ball bearings with an inner diameter of 1.0 millimeter.



**Fully Automatic Assembly**

The first in China to achieve fully automatic assembly of extra-miniature ball bearings with an outer diameter of 4.0 millimeters.

The first in China to achieve fully automatic vibration measurement of extra-miniature ball bearings with an inner diameter of 2 millimeters.

**Vibration Measurement of Extra-Miniature Ball Bearings**



The company manufactures precision machining equipment in-house to ensure machining accuracy of the equipment.

**Equipment Machining Workshop**



Proprietary precision equipment developed in-house has been granted national patent recognition.

**Patents**



Recognition as a High-Tech Enterprise.

**Certificate of High-Tech Enterprise**



# Content


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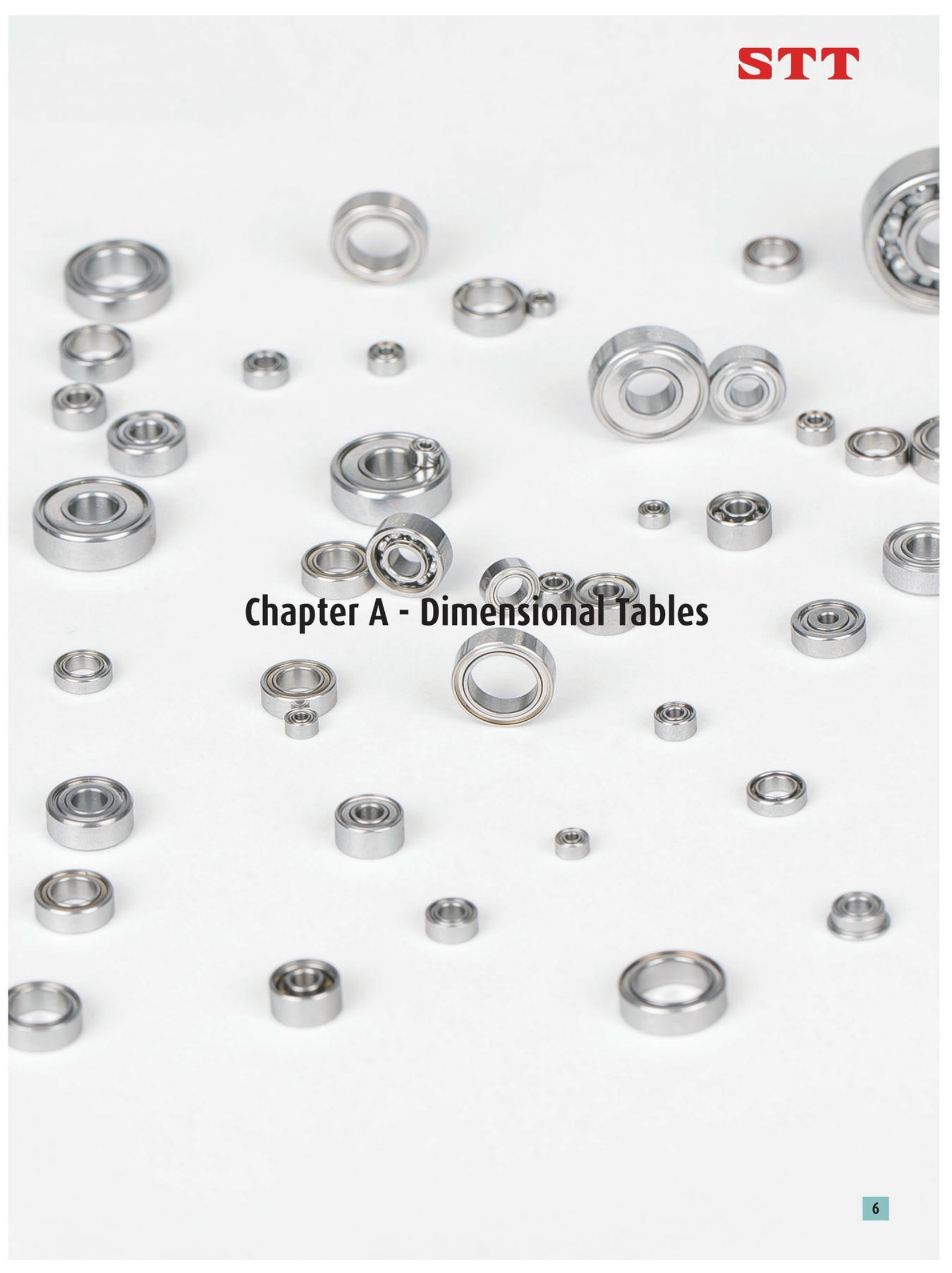
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# Chapter A - Dimensional Tables

# 1. Introduction to Extra-Miniature Deep Groove Ball Bearings

Extra-Miniature Deep Groove Ball Bearings include:
By size: Metric series, inch series, custom series;
By sealing form: Open, Metal shield, Rubber seal;
By shape: Standard type, flanged type, snap ring type.

## Introduction

1) Open



This type of bearing can withstand both radial loads and axial loads acting in two directions simultaneously. It features low frictional torque and is suitable for applications requiring high rotational speed or operation under conditions of low noise and vibration.

2) Metal shield and Rubber seal



In addition to possessing the features of the Open structure, this type of bearing is also equipped with a metal dust cover or a rubber sealing ring to prevent leakage of grease or the entry of foreign matter, thereby extending the service life of the bearing. For outer ring flanged type and outer ring snap ring type bearings, metal dust covers or rubber seals can also be provided according to customer requirements.

3) Outer ring flanged type



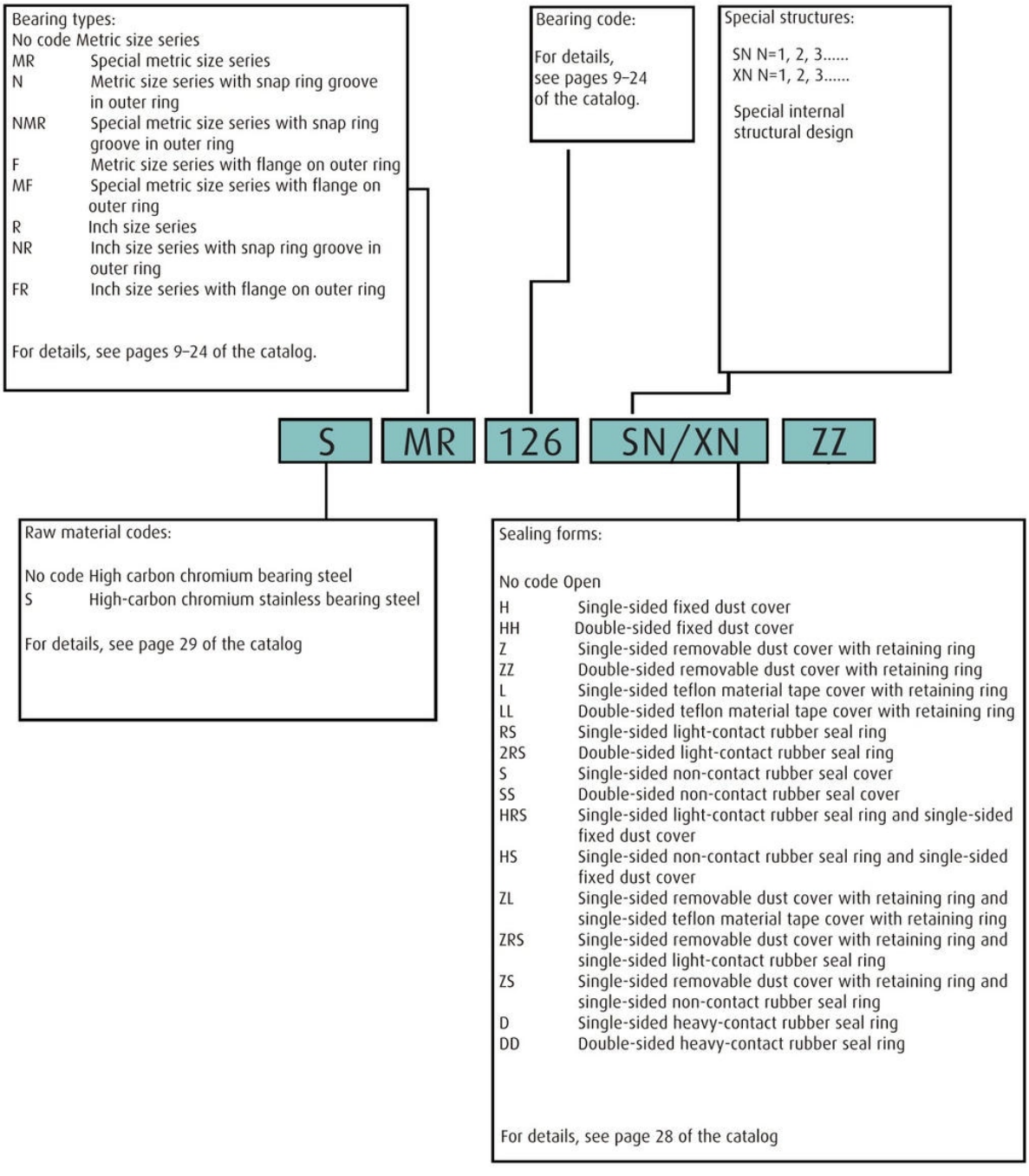
This type of bearing has a flange on one end of the outer surface. Since the side surface of the housing is used as a reference during installation, the bearing can be easily positioned in the axial direction, which facilitates installation.

4) Outer ring snap ring type



This type of bearing has a snap ring for axial positioning, which makes installation within the housing relatively simple.

# 2. Composition of Codes for Extra-Miniature Deep Groove Ball Bearings



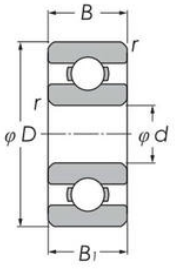

For special specifications, please refer to page 23 or contact us.

# Metric Series

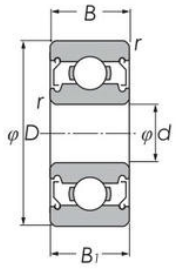
## Standard Structures

Bore diameter

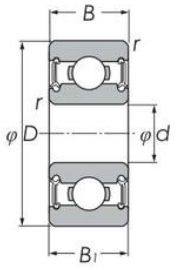
1mm-3.175mm



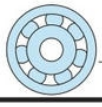
Open

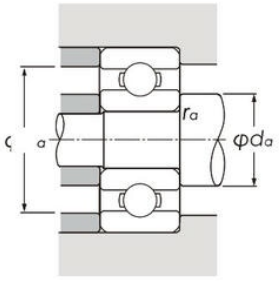


Metal Shield



Rubber Seal

| Actual size | Bearing Number | | | | Bore | OD | Width | | Radius | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Open | Capped | | | | | Open | Capped | | |
| | | Metal shield | Rubber seal | | d | D | B | $B_1$ | ~ $r_{smin}$ | |
| | | ZZ. HH | SS | 2RS | mm | mm | mm | mm | mm | |
|  | 681 | — | — | — | 1 | 3 | 1 | — | 0.05 | |
| | 691 | — | — | — | 1 | 4 | 1.5 | — | 0.10 | |
| | 68/1.5 | 68/1.5ZZ | — | — | 1.5 | 4 | 1.2 | 2 | 0.05 | |
|  | 69/1.5 | 69/1.5ZZ | — | — | 1.5 | 5 | 2 | 2/2.6 | 0.15 | |
| | 60/1.5 | 60/1.5ZZ | — | — | 1.5 | 6 | 2.5 | 3 | 0.15 | |
| | 672/MR42 | 672ZZ(MR42ZZ) | — | — | 2 | 4 | 1.2 | 2 | 0.05 | |
| | 682 | 682ZZ | — | — | 2 | 5 | 1.5 | 2.3 | 0.08 | |
| | MR52 | MR52ZZ | — | — | 2 | 5 | 2 | 2.5/2.6 | 0.10 | |
|  | 692 | 692ZZ | — | — | 2 | 6 | 2.3 | 2.3/3 | 0.15 | |
| | MR62 | MR62ZZ | — | — | 2 | 6 | 2.5 | 2.3/2.5 | 0.15 | |
| | MR72 | MR72ZZ | — | — | 2 | 7 | 2.5 | 3 | 0.15 | |
| | 602 | 602ZZ | — | — | 2 | 7 | 2.8 | 3.5 | 0.15 | |
|  | 69/2.3 | 69/2.3ZZ | — | — | 2.3 | 7 | 2.5 | 3.5 | 0.15 | |
| | 60/2.3 | 60/2.3ZZ | — | — | 2.3 | 8 | 3 | 4 | 0.15 | |
|  | MR9/2.3 | MR9/2.3ZZ | — | — | 2.3 | 9 | 3 | 3 | 0.15 | |
| | MR5/2.5 | MR5/2.5ZZ | — | — | 2.5 | 5 | 1.5 | 2.3 | 0.08 | |
|  | 68/2.5 | 68/2.5ZZ | — | — | 2.5 | 6 | 1.8 | 2.6 | 0.08 | |
| | 69/2.5 | 69/2.5ZZ | — | — | 2.5 | 7 | 2.5 | 3.5 | 0.15 | |
| | MR8/2.5 | MR8/2.5ZZ | — | — | 2.5 | 8 | 2.5 | 2.8 | 0.20 | |
| | 60/2.5 | 60/2.5ZZ | — | — | 2.5 | 8 | 2.8 | 4 | 0.15 | |
| | 673/MR63 | 673ZZ/MR63ZZ | — | — | 3 | 6 | 2 | 3/2.5 | 0.10 | |
| | 683 | 683ZZ | — | — | 3 | 7 | 2 | 3 | 0.10 | |
| | MR83 | MR83ZZ | — | — | 3 | 8 | 2.5 | 3 | 0.15 | |
|  | 693 | 693ZZ | — | — | 3 | 8 | 3 | 4 | 0.15 | |
| | 603 | 603ZZ | — | — | 3 | 9 | 3 | 5 | 0.15 | |
| | 623 | 623ZZ | — | — | 3 | 10 | 4 | 4 | 0.15 | |
|  | 60/3.175 | 60/3.175ZZ | — | — | 3.175 | 12 | 4 | 4 | 0.20/0.15 | |



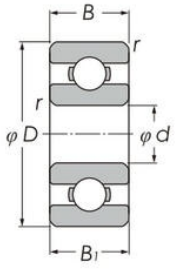

| | Basic dynamic load | | Limit speed | | | Mounting Dimensions | | | Weight |
|---|---|---|---|---|---|---|---|---|---|
| | Dynamic load $C_r$ N | Static load $C_{or}$ N | Oil-lubricated Open 1/min | Grease lubrication ZZ. HH. SS 1/min | 2RS 1/min | $d_{a\ MIN}$ mm | $D_{a\ MAX}$ mm | $r_{a\ MAX}$ mm | (Approx.) g |
| | 72 | 19 | 155 000 | — | — | 1.6 | 2.4 | 0.05 | 0.02 |
| | 161 | 45 | 124 000 | — | — | 2.3 | 3.2 | 0.05 | 0.04 |
| | 125 | 37 | 124 000 | 105 000 | — | 2.3 | 3.2 | 0.05 | 0.07 |
| | 186 | 57 | 111 000 | 94 000 | — | 2.7 | 3.8 | 0.15 | 0.18 |
| | 330 | 99 | 101 000 | 86 000 | — | 2.7 | 4.8 | 0.15 | 0.32 |
| | 113 | 35 | 116 000 | 98 000 | — | 2.5 | 3.5 | 0.05 | 0.05 |
| | 188 | 59 | 111 000 | 94 000 | — | 2.8 | 4.2 | 0.08 | 0.13 |
| | 188 | 59 | 111 000 | 94 000 | — | 2.8 | 4.2 | 0.10 | 0.17 |
| | 331 | 100 | 101 000 | 86 000 | — | 3.2 | 4.8 | 0.15 | 0.28 |
| | 331 | 100 | 101 000 | 86 000 | — | 3.2 | 4.8 | 0.15 | 0.30 |
| | 380 | 126 | 90 000 | 76 000 | — | 3.2 | 5.8 | 0.15 | 0.46 |
| | 380 | 126 | 90 000 | 76 000 | — | 3.2 | 5.8 | 0.15 | 0.50 |
| | 386 | 129 | 75 000 | 63 000 | — | 3.9 | 5.8 | 0.15 | 0.28 |
| | 552 | 177 | 71 000 | 60 000 | — | 3.9 | 6.8 | 0.15 | 0.85 |
| | 571 | 189 | 67 000 | 56 000 | — | 5.3 | 7.4 | 0.20 | 1.15 |
| | 188 | 59 | 82 000 | 70 000 | — | 3.1 | 4.4 | 0.08 | 0.21 |
| | 206 | 75 | 96 000 | 81 000 | — | 3.7 | 4.8 | 0.08 | 0.22 |
| | 380 | 126 | 90 000 | 76 000 | — | 3.7 | 5.8 | 0.15 | 0.42 |
| | 559 | 179 | 82 000 | 70 000 | — | 4.1 | 6.4 | 0.20 | 0.52 |
| | 551 | 175 | 85 000 | 72 000 | — | 3.7 | 6.8 | 0.15 | 0.63 |
| | 206 | 75 | 80 000 | 71 000 | — | 3.6 | 5.4 | 0.08 | 0.22 |
| | 380 | 126 | 75 000 | 63 000 | — | 4.2 | 5.8 | 0.10 | 0.32 |
| | 380 | 126 | 67 000 | 60 000 | — | 4.2 | 6.8 | 0.15 | 0.51 |
| | 552 | 177 | 67 000 | 60 000 | — | 4.2 | 6.8 | 0.15 | 0.60 |
| | 634 | 219 | 67 000 | 56 000 | — | 4.2 | 7.8 | 0.15 | 0.80 |
| | 641 | 226 | 60 000 | 50 000 | — | 4.2 | 8.8 | 0.15 | 1.45 |
| | 911 | 233 | 54 000 | 46 000 | — | 6.4 | 10.4 | 0.20 | 2.30 |

# Metric Series

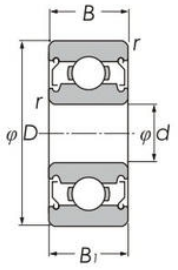
## Standard Structures

Bore diameter

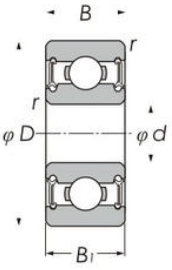
4mm-6mm



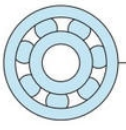
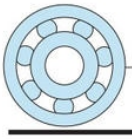
Open

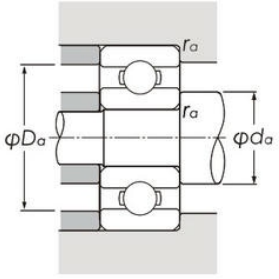


Metal Shield



Rubber Seal

| Actual size | Bearing Number | | | | Bore | OD | Width | | Radius | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Open | Capped | | | | | Open | Capped | | |
| | | Metal shield | Rubber seal | | d | D | B | $B_1$ | ~ $r_{smin}$ | |
| | | ZZ. HH | SS | 2RS | mm | mm | mm | mm | mm | |
|  | 674/MR74 | 674ZZ/MR74ZZ | — | — | 4 | 7 | 2 | 2/2.5/3 | 0.10 | |
| | MR84 | MR84ZZ | — | — | 4 | 8 | 2 | 3 | 0.15/0.10 | |
| | 684 | 684ZZ | SS | — | 4 | 9 | 2.5 | 4 | 0.10 | |
| | 684W30 | 684ZZW30 | — | — | 4 | 9 | 3 | 3 | 0.10 | |
| | MR104 | MR104ZZ | — | — | 4 | 10 | 3 | 4 | 0.20/0.15 | |
|  | 694W30 | 694ZZW50 | — | — | 4 | 11 | 3 | 5 | 0.15 | |
| | 694 | 694ZZ | SS | — | 4 | 11 | 4 | 4 | 0.15 | |
|  | 604 | 604ZZ | SS | 2RS | 4 | 12 | 4 | 4 | 0.20 | |
| | 624 | 624ZZ | SS | 2RS | 4 | 13 | 5 | 5 | 0.20 | |
| | 634 | 634ZZ | SS | 2RS | 4 | 16 | 5 | 5 | 0.30 | |
| | 675/MR85 | 675ZZ/MR85ZZ | — | — | 5 | 8 | 2 | 2/2.5/3 | 0.10 | |
| | MR95 | MR95ZZ | — | — | 5 | 9 | 2.5 | 3 | 0.15 | |
| | MR105 | MR105ZZ | — | — | 5 | 10 | 3 | 4 | 0.15 | |
| | 685 | 685ZZ | SS | — | 5 | 11 | 3 | 5 | 0.15 | |
| | 685W35 | 685ZZW35 | — | — | 5 | 11 | 3.5 | 3.5 | 0.15 | |
| | MR115 | MR115ZZ | — | — | 5 | 11 | 3 | 4 | 0.15 | |
| | 695 | 695ZZ | SS | 2RS | 5 | 13 | 4 | 4 | 0.20 | |
| | 605 | 605ZZ | SS | — | 5 | 14 | 5 | 5 | 0.20 | |
|  | 625 | 625ZZ | SS | 2RS | 5 | 16 | 5 | 5 | 0.30 | |
| | 635 | 635ZZ | SS | 2RS | 5 | 19 | 6 | 6 | 0.30 | |
| | 676/MR106 | 676ZZ/MR106ZZ | — | — | 6 | 10 | 2.5 | 3 | 0.15/0.10 | |
| | MR126 | MR126ZZ | — | — | 6 | 12 | 3 | 4 | 0.20/0.15 | |
| | 686 | 686ZZ | SS | 2RS | 6 | 13 | 3.5 | 5 | 0.15 | |
| | 686W40 | 686ZZW40 | — | — | 6 | 13 | 4 | 4 | 0.15 | |
| | 696 | 696ZZ | SS | 2RS | 6 | 15 | 5 | 5 | 0.20 | |
|  | 606 | 606ZZ | SS | 2RS | 6 | 17 | 6 | 6 | 0.30 | |
| | 626 | 626ZZ | SS | 2RS | 6 | 19 | 6 | 6 | 0.30 | |



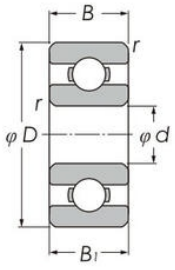

| Basic dynamic load | | Limit speed | | | Mounting Dimensions | | | Weight |
|---|---|---|---|---|---|---|---|---|
| Dynamic load $C_r$ | Static load $C_{or}$ | Oil-lubricated Open | Grease lubrication ZZ. HH. SS | 2RS | $d_{a\ MIN}$ | $D_{a\ MAX}$ | $r_{a\ MAX}$ | (Approx.) |
| N | N | 1/min | 1/min | 1/min | mm | mm | mm | g |
| 251 | 106 | 67 000 | 60 000 | — | 4.6 | 6.4 | 0.08 | 0.23 |
| 392 | 139 | 67 000 | 56 000 | — | 5.2 | 6.8 | 0.15 | 0.39 |
| 644 | 226 | 63 000 | 53 000 | — | 5.2 | 7.8 | 0.10 | 0.65 |
| 608 | 216 | 61 000 | 51 000 | — | 5.2 | 7.8 | 0.10 | 1.00 |
| 714 | 265 | 60 000 | 50 000 | — | 5.6 | 8.4 | 0.20 | 0.96 |
| 911 | 323 | 54 000 | 46 000 | — | 5.2 | 9.8 | 0.15 | 2.00 |
| 714 | 265 | 56 000 | 48 000 | — | 5.2 | 9.8 | 0.15 | 1.6 |
| 958 | 347 | 54 000 | 46 000 | 43 000 | 5.6 | 10.4 | 0.20 | 2.1 |
| 1310 | 488 | 48 000 | 40 000 | 37 000 | 5.6 | 11.4 | 0.20 | 3.1 |
| 1730 | 670 | 43 000 | 36 000 | 33 000 | 6.0 | 14.0 | 0.30 | 5.3 |
| 276 | 131 | 63 000 | 53 000 | — | 5.6 | 7.4 | 0.08 | 0.25 |
| 493 | 06 | 50 000 | — | — | 6.2 | 7.8 | 0.15 | 0.54 |
| 714 | 265 | 60 000 | 50 000 | — | 6.2 | 8.8 | 0.15 | 0.91 |
| 714 | 265 | 53 000 | 45 000 | — | 6.2 | 9.8 | 0.15 | 1.16 |
| 676 | 274 | 51 000 | 43 000 | — | 6.2 | 9.8 | 0.15 | 1.90 |
| 714 | 265 | 56 000 | 48 000 | — | 6.3 | 9.8 | 0.15 | 1.05 |
| 1074 | 423 | 50 000 | 43 000 | 38 000 | 6.6 | 11.4 | 0.20 | 2.4 |
| 1330 | 505 | 50 000 | 40 000 | — | 6.6 | 12.4 | 0.20 | 3 |
| 1730 | 670 | 43 000 | 36 000 | 33 000 | 7.0 | 14.0 | 0.30 | 4.5 |
| 2340 | 885 | 40 000 | 32 000 | 28 000 | 7.0 | 17.0 | 0.30 | 8.5 |
| 457 | 193 | 53 000 | 45 000 | — | 6.6 | 9.2 | 0.10 | 0.55 |
| 832 | 363 | 56 000 | 31 000 | — | 7.6 | 10.4 | 0.20 | 1.25 |
| 1080 | 440 | 50 000 | 40 000 | 35 000 | 7.2 | 11.8 | 0.15 | 1.87 |
| 1029 | 421 | 48 000 | 28 000 | — | 7.2 | 11.8 | 0.15 | 2.70 |
| 1730 | 670 | 45 000 | 40 000 | 35 000 | 7.6 | 13.4 | 0.20 | 3.90 |
| 2260 | 835 | 45 000 | 38 000 | 31 000 | 8.0 | 15.0 | 0.30 | 5.50 |
| 2340 | 885 | 40 000 | 32 000 | 28 000 | 8.0 | 17.0 | 0.30 | 7.80 |

# Metric Series

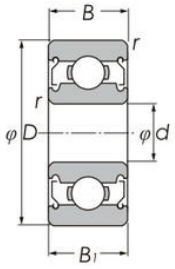
## Standard Structures

Bore diameter

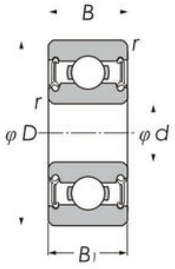
7mm-12mm



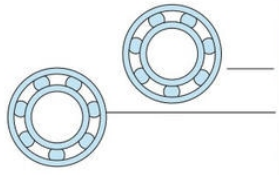
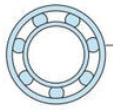
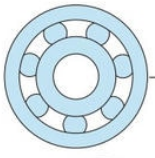
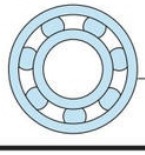
Open

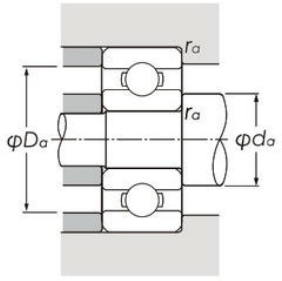


Metal Shield



Rubber Seal

| Actual size | Bearing Number | | | | Bore | OD | Width | | Radius | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Open | Capped | | | | | | | | |
| | | Metal shield | Rubber seal | | d | D | Open B | Capped $B_1$ | ~ $r_{smin}$ | |
| | | ZZ. HH | SS | 2RS | mm | mm | mm | mm | mm | |
|  | 677/MR117 | 677ZZ/MR117ZZ | — | — | 7 | 11 | 2.5 | 3 | 0.15/0.10 | |
| | MR137 | MR137ZZ | — | — | 7 | 13 | 3 | 4 | 0.20/0.15 | |
| | 687 | 687ZZ | SS | 2RS | 7 | 14 | 3.5 | 5 | 0.15 | |
| | 687W40 | 687ZZW40 | — | — | 7 | 14 | 4 | 4 | 0.15 | |
| | 697 | 697ZZ | SS | 2RS | 7 | 17 | 5 | 5 | 0.30 | |
| | 607 | 607ZZ | SS | 2RS | 7 | 19 | 6 | 6 | 0.30 | |
| | 627 | 627ZZ | SS | 2RS | 7 | 22 | 7 | 7 | 0.30 | |
| | 678/MR128 | 678ZZ/MR128ZZ | — | — | 8 | 12 | 2.5 | 3/3.5 | 0.15/0.10 | |
| | MR148 | MR148ZZ | — | — | 8 | 14 | 3.5 | 4 | 0.20/0.15 | |
| | 688W40 | 688ZZW40 | — | — | 8 | 16 | 4 | 4 | 0.20 | |
|  | 688 | 688ZZ | SS | 2RS | 8 | 16 | 4 | 5 | 0.20 | |
| | 698 | 698ZZ | SS | 2RS | 8 | 19 | 6 | 6 | 0.30 | |
| | 608 | 608ZZ | SS | 2RS | 8 | 22 | 7 | 7 | 0.30 | |
| | 679 | 679ZZ | SS | 2RS | 9 | 14 | 3 | 4.5 | 0.10 | |
|  | 689 | 689ZZ | SS | 2RS | 9 | 17 | 4 | 4 | 0.20 | |
| | 699 | 699ZZ | SS | 2RS | 9 | 20 | 6 | 6 | 0.30 | |
| | 6700 | 6700ZZ | SS | 2RS | 10 | 15 | 3 | 4.5 | 0.10 | |
| | 6800 | 6800ZZ | SS | 2RS | 10 | 19 | 5 | 5 | 0.30 | |
|  | 6900 | 6900ZZ | SS | 2RS | 10 | 22 | 6 | 6 | 0.30 | |
| | 6701 | 6701ZZ | SS | 2RS | 12 | 18 | 4 | 4 | 0.20 | |
| | 6801 | 6801ZZ | SS | 2RS | 12 | 21 | 5 | 5 | 0.30 | |



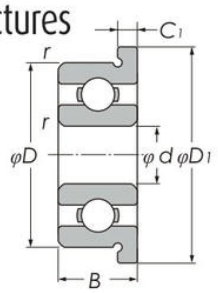

| | Basic dynamic load | | Limit speed | | | Mounting Dimensions | | | Weight |
|---|---|---|---|---|---|---|---|---|---|
| | Dynamic load $C_r$ N | Static load $C_{or}$ N | Oil-lubricated Open 1/min | Grease lubrication ZZ. HH. SS 1/min | 2RS 1/min | $d_{a\ MIN}$ mm | $D_{a\ MAX}$ mm | $r_{a\ MAX}$ mm | (Approx.) g |
| | 448 | 193 | 50 000 | 43 000 | — | 7.8 | 10.2 | 0.10 | 0.59 |
| | 880 | 409 | 48 000 | 40 000 | — | 8.6 | 11.4 | 0.20 | 1.52 |
| | 1170 | 510 | 45 000 | 40 000 | 31 000 | 8.2 | 12.8 | 0.15 | 2.00 |
| | 1170 | 510 | 45 000 | 40 000 | — | 8.2 | 12.8 | 0.15 | 2.00 |
| | 1610 | 715 | 43 000 | 36 000 | 28 000 | 9.0 | 15.0 | 0.30 | 4.80 |
| | 2619 | 1056 | 40 000 | 32 000 | 28 000 | 8.0 | 17.0 | 0.30 | 7.70 |
| | 3297 | 1368 | 40 000 | 34 000 | 28 000 | 10.6 | 18.0 | 0.30 | 13.10 |
| | 506 | 246 | 48 000 | 40 000 | — | 8.8 | 11.2 | 0.10 | 0.70 |
| | 820 | 385 | 45 000 | 38 000 | | 9.6 | 12.4 | 0.20 | 1.90 |
| | 1610 | 711 | 43 000 | 36 000 | — | 9.6 | 14.4 | 0.20 | 3.00 |
| | 1610 | 711 | 43 000 | 36 000 | 27 000 | 9.6 | 14.4 | 0.20 | 3.00 |
| | 2609 | 1056 | 40 000 | 32 000 | 28 000 | 9.0 | 17.0 | 0.30 | 7.40 |
| | 3297 | 1370 | 40 000 | 32 000 | 28 000 | 10.6 | 18.0 | 0.30 | 13.00 |
| | 919 | 469 | 42 000 | 36 000 | 32 000 | 10.4 | 12.6 | 0.10 | 1.57 |
| | 1327 | 668 | 43 000 | 36 000 | 32 000 | 10.3 | 15.6 | 0.20 | 3.85 |
| | 2467 | 1081 | 40 000 | 34 000 | 32 000 | 12.0 | 17.9 | 0.30 | 8.54 |
| | 857 | 435 | 17 000 | 15 000 | 13 500 | 9.0 | 14.0 | 0.10 | 1.90 |
| | 1716 | 840 | 43 000 | 37 000 | 35 000 | 9.0 | 18.0 | 0.30 | 5.60 |
| | 2695 | 1273 | 41 000 | 34 000 | 31 000 | 10.3 | 20.6 | 0.30 | 10.00 |
| | 935 | 528 | 15 000 | 13 000 | 12 000 | 13.0 | 17.0 | 0.20 | 3.10 |
| | 1915 | 1041 | 39 000 | 33 000 | 31 000 | 13.3 | 19.7 | 0.30 | 6.50 |

# Metric Series

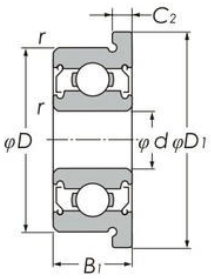
## Outer ring flanged structures

Bore diameter

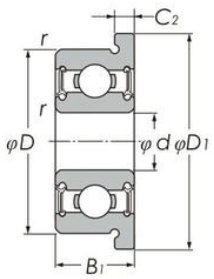
1.5 mm - 4 mm



Open

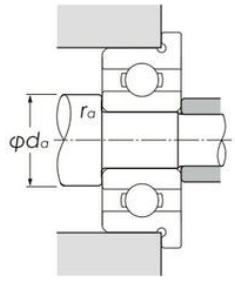


Metal Shield



Rubber Seal

| Actual size | Bearing Number | | | | Bore | OD | Width | | Radius | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Open | Capped | | | | | Open | Capped | | |
| | | Metal shield | Rubber seal | | d | D | B | $B_1$ | ~ $r_{smin}$ | |
| | | ZZ.HH | SS | 2RS | mm | mm | mm | mm | mm | |
| | F68/1.5 | F68/1.5 ZZ | — | — | 1.5 | 4 | 1.2 | 2 | 0.05 | |
| | F69/1.5 | F69/1.5 ZZ | — | — | 1.5 | 5 | 2 | 2.6 | 0.15 | |
| | F60/1.5 | F60/1.5 ZZ | — | — | 1.5 | 6 | 2.5 | 3 | 0.15 | |
| | F682 | F682 ZZ | — | — | 2 | 5 | 1.5 | 2.3 | 0.08 | |
| | MF52 | MF52 ZZ | — | — | 2 | 5 | 2 | 2.5 | 0.10 | |
| | F692 | F692 ZZ | — | — | 2 | 6 | 2.3 | 3 | 0.15 | |
| | MF62 | MF62 ZZ | — | — | 2 | 6 | 2.5 | 2.5 | 0.15 | |
| | MF72 | MF72 ZZ | — | — | 2 | 7 | 2.5 | 3 | 0.15 | |
| | F602 | F602 ZZ | — | — | 2 | 7 | 2.8 | 3.5 | 0.15 | |
| | F68/2.5 | F68/2.5 ZZ | — | — | 2.5 | 6 | 1.8 | 2.6 | 0.08 | |
| | F69/2.5 | F69/2.5 ZZ | — | — | 2.5 | 7 | 2.5 | 3.5 | 0.15 | |
| | MF8/2.5 | — | — | — | 2.5 | 8 | 2.5 | - | 0.20 | |
| | F60/2.5 | F60/2.5 ZZ | — | — | 2.5 | 8 | 2.8 | 4 | 0.15 | |
| | MF63 | MF63 ZZ | — | — | 3 | 6 | 2 | 2.5 | 0.10 | |
| | F683 | F683 ZZ | — | — | 3 | 7 | 2 | 3 | 0.10 | |
| | MF83 | MF83 ZZ | — | — | 3 | 8 | 2.5 | 3 | 0.15 | |
| | F693 | F693 ZZ | — | — | 3 | 8 | 3 | 4 | 0.15 | |
| | MF93 | — | — | — | 3 | 9 | 2.5 | - | 0.20 | |
| | — | MF93 ZZ | — | — | 3 | 9 | - | 4 | 0.15 | |
| | F603 | F603 ZZ | — | — | 3 | 9 | 3 | 5 | 0.15 | |
| | F623 | F623 ZZ | — | — | 3 | 10 | 4 | 4 | 0.15 | |
| | MF74 | MF74 ZZ | — | — | 4 | 7 | 2 | 2.5 | 0.10 | |
| | MF84 | MF84 ZZ | — | — | 4 | 8 | 2 | 3 | 0.15/0.10 | |
| | F684 | F684 ZZ | — | — | 4 | 9 | 2.5 | 4 | 0.15 | |
| | MF104 | — | — | — | 4 | 10 | 3 | - | 0.20 | |
| | — | MF104 ZZ | — | — | 4 | 10 | 3 | 4 | 0.15 | |
| | F694 | F694 ZZ | — | — | 4 | 11 | 4 | 4 | 0.15 | |
| | F604 | F604 ZZ | — | — | 4 | 12 | 4 | 4 | 0.20 | |
| | F624 | F624 ZZ | — | — | 4 | 13 | 5 | 5 | 0.20 | |
| | F634 | F634 ZZ | — | — | 4 | 16 | 5 | 5 | 0.30 | |



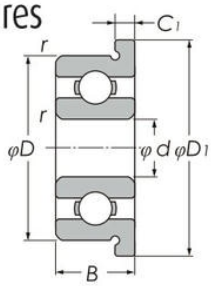

| | Flange dimensions | | | Basic dynamic load ratings | | Limit speed | | | Mounting dimensions | | Weight |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diameter | Width | | Dynamic load | Static load | Oil-lubricated | Grease lubrication | | | | (Approx.) |
| | $D_1$ | $C_1$ | $C_2$ | $C_r$ | $C_{or}$ | Open | ZZ. HH. SS | 2RS | $d_{a\ MIN}$ | $r_{a\ MAX}$ | |
| | mm | mm | mm | N | N | rpm | rpm | rpm | mm | mm | g |
| | 5.0 | 0.4 | 0.6 | 125 | 37 | 100 000 | 88 000 | - | 2.3 | 0.05 | 0.09 |
| | 6.5 | 0.6 | 0.8 | 186 | 57 | 93 000 | 79 000 | - | 2.7 | 0.15 | 0.24 |
| | 7.5 | 0.6 | 0.8 | 330 | 98 | 84 000 | 71 000 | - | 2.7 | 0.15 | 0.42 |
| | 6.1 | 0.5 | 0.6 | 188 | 59 | 87 000 | 74 000 | - | 2.8 | 0.08 | 0.17 |
| | 6.2 | 0.6 | 0.6 | 188 | 59 | 100 000 | 85 000 | - | 2.8 | 0.10 | 0.21 |
| | 7.5 | 0.6 | 0.8 | 331 | 100 | 79 000 | 67 000 | - | 3.2 | 0.15 | 0.35 |
| | 7.2 | 0.6 | 0.6 | 331 | 100 | 90 000 | 75 000 | - | 3.2 | 0.15 | 0.36 |
| | 8.2 | 0.6 | 0.6 | 380 | 126 | 90 000 | 75 000 | - | 3.2 | 0.15 | 0.52 |
| | 8.5 | 0.7 | 0.9 | 380 | 126 | 66 000 | 56 000 | - | 3.7 | 0.15 | 0.83 |
| | 7.1 | 0.5 | 0.8 | 206 | 75 | 76 000 | 65 000 | - | 3.7 | 0.08 | 0.26 |
| | 8.5 | 0.7 | 0.9 | 380 | 126 | 70 000 | 59 000 | - | 3.7 | 0.15 | 0.53 |
| | 9.2 | 0.6 | - | 560 | 179 | 71 000 | 60 000 | - | 4.1 | 0.20 | 0.62 |
| | 9.5 | 0.7 | 0.9 | 550 | 174 | 66 000 | 56 000 | - | 3.7 | 0.15 | 0.83 |
| | 7.2 | 0.6 | 0.6 | 206 | 75 | 71 000 | 60 000 | - | 3.6 | 0.08 | 0.26 |
| | 8.1 | 0.5 | 0.8 | 380 | 126 | 68 000 | 58 000 | - | 4.2 | 0.10 | 0.38 |
| | 9.2 | 0.6 | 0.6 | 380 | 126 | 67 000 | 60 000 | - | 4.2 | 0.15 | 0.56 |
| | 9.5 | 0.7 | 0.9 | 552 | 177 | 67 000 | 60 000 | - | 4.2 | 0.15 | 0.70 |
| | 10.2 | 0.6 | - | 634 | 219 | 67 000 | 56 000 | - | 4.6 | 0.20 | 0.81 |
| | 10.6 | - | 0.8 | 634 | 219 | 67 000 | 56 000 | - | 4.6 | 0.20 | 1.34 |
| | 10.5 | 0.7 | 1.0 | 634 | 219 | 67 000 | 56 000 | - | 4.2 | 0.15 | 1.00 |
| | 11.5 | 1.0 | 1.0 | 641 | 226 | 58 000 | 50 000 | - | 4.2 | 0.15 | 1.80 |
| | 8.2 | 0.6 | 0.6 | 251 | 106 | 63 000 | 54 000 | - | 4.6 | 0.08 | 0.35 |
| | 9.2 | 0.6 | 0.6 | 392 | 139 | 67 000 | 56 000 | - | 5.2 | 0.15 | 0.44 |
| | 10.3 | 0.6 | 1.0 | 644 | 226 | 63 000 | 53 000 | - | 4.8 | 0.10 | 0.70 |
| | 11.2 | 0.6 | - | 714 | 265 | 60 000 | - | - | 5.6 | 0.20 | 1.13 |
| | 11.6 | - | 0.8 | 714 | 265 | - | 50 000 | - | 5.6 | 0.20 | 1.59 |
| | 12.5 | 1.0 | 1.0 | 714 | 265 | 56 000 | 48 000 | - | 5.2 | 0.15 | 2.20 |
| | 13.5 | 1.0 | 1.0 | 958 | 347 | 51 000 | 43 000 | - | 5.6 | 0.20 | 2.30 |
| | 15.0 | 1.0 | 1.0 | 1 310 | 488 | 49 000 | 42 000 | - | 5.6 | 0.20 | 3.50 |
| | 18.0 | 1.0 | 1.0 | 1 730 | 670 | 43 000 | 36 000 | - | 6.0 | 0.30 | 5.70 |

# Metric Series

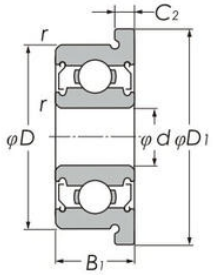
## Outer ring flanged structures

Bore diameter

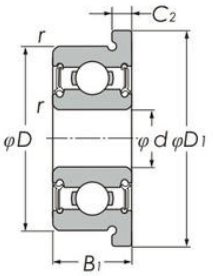
5 mm - 8 mm



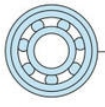
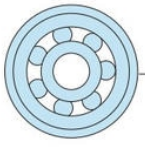
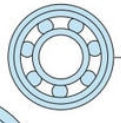
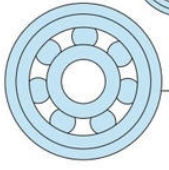
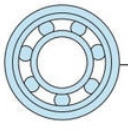
Open

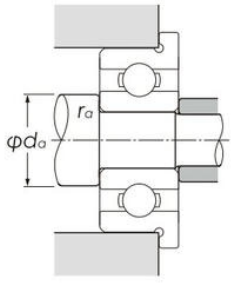


Metal Shield



Rubber Seal

| Actual size | Bearing Number | | | | Bore | OD | Width | | Radius | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Open | Capped | | | | | Open | Capped | | |
| | | Metal shield | Rubber seal | | d | D | B | $B_1$ | ~ $r_{smin}$ | |
| | | ZZ.HH | SS | 2RS | mm | mm | mm | mm | mm | |
| | MF85 | MF85 ZZ | — | — | 5 | 8 | 2 | 2.5 | 0.10 | |
| | MF95 | MF95 ZZ | — | — | 5 | 9 | 2.5 | 3 | 0.15 | |
| | MF105 | — | — | — | 5 | 10 | 3 | - | 0.15 | |
| | — | MF105 ZZ | — | — | 5 | 10 | - | 4 | 0.15 | |
| | MF115 | MF115 ZZ | — | — | 5 | 11 | - | 4 | 0.15 | |
|  | F685 | F685 ZZ | — | — | 5 | 11 | 3 | 5 | 0.15 | |
| | F695 | F695 ZZ | SS | 2RS | 5 | 13 | 4 | 4 | 0.20 | |
|  | F605 | F605 ZZ | — | — | 5 | 14 | 5 | 5 | 0.20 | |
| | F625 | F625 ZZ | SS | 2RS | 5 | 16 | 5 | 5 | 0.30 | |
| | F635 | F635 ZZ | SS | 2RS | 5 | 19 | 6 | 6 | 0.30 | |
| | MF106 | MF106 ZZ | — | — | 6 | 10 | 2.5 | 3 | 0.15/0.10 | |
| | MF126 | — | — | — | 6 | 12 | 3 | - | 0.20 | |
|  | — | MF126 ZZ | SS | 2RS | 6 | 12 | - | 4 | 0.15 | |
| | F686 | F686 ZZ | — | — | 6 | 13 | 3.5 | 5 | 0.15 | |
| | F696 | F696 ZZ | SS | 2RS | 6 | 15 | 5 | 5 | 0.20 | |
|  | F606 | F606 ZZ | SS | 2RS | 6 | 17 | 6 | 6 | 0.30 | |
| | F626 | F626 ZZ | SS | 2RS | 6 | 19 | 6 | 6 | 0.30 | |
| | MF117 | MF117 ZZ | — | — | 7 | 11 | 2.5 | 3 | 0.15/0.10 | |
| | MF137 | — | — | — | 7 | 13 | 3 | - | 0.20 | |
|  | — | MF137 ZZ | — | — | 7 | 13 | - | 4 | 0.15 | |
| | F687 | F687 ZZ | — | — | 7 | 14 | 3.5 | 5 | 0.15 | |
| | F697 | F697 ZZ | — | — | 7 | 17 | 5 | 5 | 0.30 | |
| | MF128 | MF128 ZZ | — | — | 8 | 12 | 2.5 | - | 0.15 | |
| | — | F678 ZZ | — | — | 8 | 12 | - | 3.5 | 0.10 | |
| | MF148 | MF148 ZZ | — | — | 8 | 14 | 3.5 | 4 | 0.20/0.15 | |
| | F688 | F688 ZZ | SS | 2RS | 8 | 16 | 4 | 5 | 0.20 | |



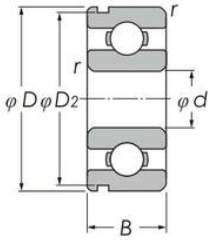

| | Flange dimensions | | | Basic dynamic load ratings | | Limit speed | | | Mounting dimensions | | Weight |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diameter | Width | | Dynamic load | Static load | Oil-lubricated | Grease lubrication | | | | (Approx.) |
| | $D_1$ | $C_1$ | $C_2$ | $C_r$ | $C_{or}$ | Open | ZZ. HH. SS | 2RS | $d_{a\ MIN}$ | $r_{a\ MAX}$ | |
| | mm | mm | mm | N | N | rpm | rpm | rpm | mm | mm | g |
| | 9.2 | 0.6 | 0.6 | 276 | 131 | 63 000 | 53 000 | - | 5.6 | 0.08 | 0.48 |
| | 10.2 | 0.6 | 0.6 | 493 | 206 | 60 000 | 50 000 | - | 6.2 | 0.15 | 0.59 |
| | 11.2 | 0.6 | - | 714 | 265 | 60 000 | - | - | 6.2 | 0.15 | 1.05 |
| | 11.6 | - | 0.8 | 714 | 265 | - | 50 000 | - | 6.2 | 0.15 | 1.46 |
| | 12.6 | - | 0.8 | 714 | 265 | 51 000 | 43 000 | - | 6.2 | 0.15 | 2.00 |
| | 12.5 | 0.8 | 1.0 | 714 | 265 | 53 000 | 45 000 | - | 6.2 | 0.15 | 1.30 |
| | 15.0 | 1.0 | 1.0 | 1 074 | 423 | 50 000 | 43 000 | 38 000 | 6.6 | 0.20 | 2.80 |
| | 16.0 | 1.0 | 1.0 | 1 330 | 505 | 46 000 | 39 000 | - | 6.6 | 0.20 | 3.90 |
| | 18.0 | 1.0 | 1.0 | 1 730 | 670 | 43 000 | 36 000 | 32 000 | 7.0 | 0.30 | 5.40 |
| | 22.0 | 1.5 | 1.5 | 2 340 | 885 | 40 000 | 32 000 | 30 000 | 7.0 | 0.30 | 9.50 |
| | 11.2 | 0.6 | 0.6 | 457 | 193 | 53 000 | 45 000 | - | 6.6 | 0.10 | 0.72 |
| | 13.2 | 0.6 | - | 832 | 363 | 50 000 | - | - | 7.6 | 0.20 | 1.38 |
| | 13.6 | - | 0.8 | 832 | 363 | - | 40 000 | 38 000 | 7.6 | 0.20 | 1.94 |
| | 15.0 | 1.0 | 1.1 | 715 | 292 | 56 000 | 48 000 | - | 7.2 | 0.15 | 2.10 |
| | 17.0 | 1.2 | 1.2 | 1 730 | 670 | 45 000 | 40 000 | 35 000 | 7.6 | 0.20 | 5.05 |
| | 19.0 | 1.2 | 1.2 | 2 260 | 835 | 45 000 | 38 000 | 34 000 | 8.0 | 0.30 | 6.60 |
| | 22.0 | 1.5 | 1.5 | 2 340 | 885 | 40 000 | 32 000 | 30 000 | 8.0 | 0.30 | 9.10 |
| | 12.2 | 0.6 | 0.6 | 448 | 193 | 48 000 | 40 000 | - | 7.8 | 0.10 | 0.77 |
| | 14.2 | 0.6 | - | 880 | 409 | 48 000 | - | - | 8.6 | 0.20 | 1.70 |
| | 14.6 | - | 0.8 | 880 | 409 | - | 40 000 | - | 8.6 | 0.20 | 2.23 |
| | 16.0 | 1.0 | 1.1 | 1 170 | 510 | 45 000 | 40 000 | 31 000 | 8.2 | 0.15 | 2.30 |
| | 19.0 | 1.2 | 1.2 | 1 610 | 710 | 43 000 | 36 000 | 28 000 | 9.0 | 0.30 | 5.70 |
| | 13.2 | 0.6 | - | 506 | 246 | 48 000 | - | - | 8.8 | 0.10 | 0.82 |
| | 13.6 | - | 0.8 | 506 | 246 | - | 40 000 | - | 8.8 | 0.10 | 1.15 |
| | 15.6 | 0.8 | 0.8 | 820 | 385 | 45 000 | 38 000 | - | 9.6 | 0.20 | 2.09 |
| | 18.0 | 1.0 | 1.1 | 1 610 | 710 | 43 000 | 36 000 | 30 000 | 9.6 | 0.20 | 4.50 |

# Metric Series

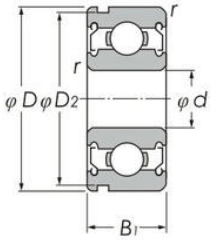
## Outer ring snap ring groove structures

Bore diameter

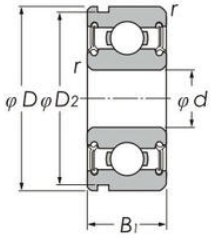
5 mm - 6 mm



Open

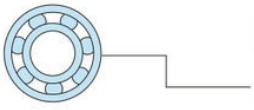


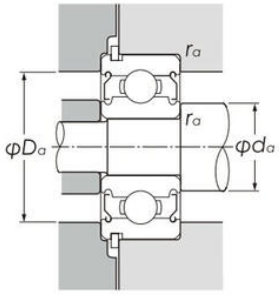
Metal Shield



Rubber Seal




| Actual size | Bearing Number | | | | Bore | OD | Width | | Radius | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Open | Capped | | | | | Open | Capped | | |
| | | Metal shield | Rubber seal | | d | D | B | $B_1$ | ~ $r_{smin}$ | |
| | | ZZ. HH | SS | 2RS | mm | mm | mm | mm | mm | |
|  | N695 | N695 ZZ | — | — | 5 | 13 | 4 | 4 | 0.20 | |
| | N605 | N605 ZZ | — | — | 5 | 14 | 5 | 5 | 0.20 | |
| | NMR126 | NMR126 ZZ | — | — | 6 | 12 | 3 | 4 | 0.20/0.15 | |
| | N686 | N686 ZZ | — | — | 6 | 13 | 3.5 | 5 | 0.15 | |
| | N696 | N696 ZZ | — | — | 6 | 15 | 5 | 5 | 0.20 | |



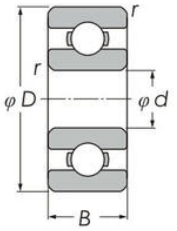

| | Snap ring groove dimensions | | Basic dynamic load ratings | | Limit speed | | | Mounting dimensions | | | Weight |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diameter $D_2$ mm | Width $C_1$ mm | Dynamic load $C_r$ N | Static load $C_{or}$ N | Oil-lubricated Open rpm | Grease lubrication ZZ. HH. SS rpm | 2RS rpm | $d_{a\ MIN}$ mm | $D_{a\ MAX}$ mm | $r_{a\ MAX}$ mm | (Approx.) g |
| | 12.15 | 0.55 | 1 074 | 423 | 47 000 | 40 000 | - | 6.6 | 11.4 | 0.20 | 2.00 |
| | 13.03 | 0.65 | 1 330 | 505 | 46 000 | 39 000 | - | 6.6 | 12.4 | 0.20 | 4.00 |
| | 11.15 | 0.60 | 832 | 363 | 47 000 | 40 000 | - | 7.2 | 10.8 | 0.15 | 1.20 |
| | 12.15 | 0.55 | 1 080 | 440 | 46 000 | 39 000 | - | 7.2 | 11.8 | 0.15 | 2.10 |
| | 14.03 | 0.65 | 1 350 | 530 | 44 000 | 37 000 | - | 7.6 | 13.4 | 0.20 | 4.10 |

# Inch Series

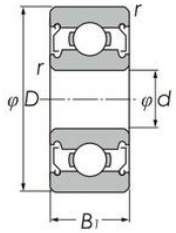
## Standard structures

Bore diameter

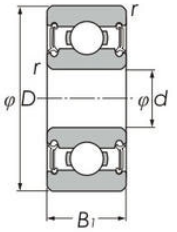
1.397 mm - 6.35 mm



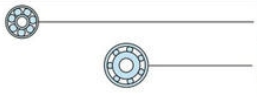
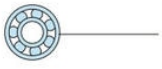
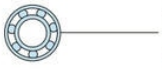
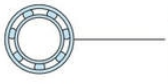
Open

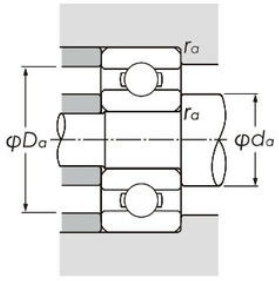


Metal Shield



Rubber Seal

| Actual size | Bearing Number | | | | Bore | OD | Width | | Radius | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Open | Capped | | | d | D | Open B | Capped $B_1$ | ~ $r_{smin}$ | |
| | | Metal | Rubber seal | | | | | | | |
| | | ZZ. HH | SS | 2RS | mm | mm | mm | mm | mm | |
|  | R1 | R1 ZZ | — | — | 1.397 | 4.762 | 1.984 | 2.779 | 0.10 | |
| | R1-4 | R1-4 ZZ | — | — | 1.984 | 6.350 | 2.380 | 3.571 | 0.10 | |
| | R1-5/2.3 | R1-5/2.3ZZ | — | — | 2.3 | 7.938 | 2.779 | 3.571 | 0.15 | |
| | R133 | R133 ZZ | — | — | 2.380 | 4.762 | 1.588 | 2.380 | 0.10 | |
| | R1-5 | R1-5 ZZ | — | — | 2.380 | 7.938 | 2.779 | 3.571 | 0.15 | |
| | R144 | R144 ZZ | — | — | 3.175 | 6.350 | 2.380 | 2.779 | 0.10 | |
|  | R2-5 | R2-5 ZZ | — | — | 3.175 | 7.938 | 2.779 | 3.571 | 0.10 | |
| | R2-6 | R2-6 ZZ | — | — | 3.175 | 9.525 | 2.779 | 3.571 | 0.15 | |
|  | R2 | R2 ZZ | SS | — | 3.175 | 9.525 | 3.967 | 3.967 | 0.30 | |
| | R2A | R2A ZZ | SS | — | 3.175 | 12.700 | 4.366 | 4.366 | 0.30 | |
|  | R155 | R155 ZZ | — | — | 3.9675 | 7.9375 | 2.7788 | 3.175 | 0.10 | |
| | R156 | R156 ZZ | — | — | 4.763 | 7.938 | 2.779 | 3.175 | 0.10 | |
|  | R166 | R166 ZZ | — | — | 4.763 | 9.525 | 3.175 | 3.175 | 0.10 | |
| | R3 | R3 ZZ | SS | — | 4.763 | 12.700 | 3.967 | 4.978 | 0.30 | |
| | R3A | R3A ZZ | SS | — | 4.763 | 15.875 | 4.978 | 4.978 | 0.30 | |
|  | R168 | R168 ZZ | — | — | 6.350 | 9.525 | 3.175 | 3.175 | 0.10 | |
| | R188 | R188 ZZ | — | — | 6.350 | 12.700 | 3.175 | 4.763 | 0.15 | |
| | R4 | R4 ZZ | SS | — | 6.350 | 15.875 | 4.978 | 4.978 | 0.30 | |
| | R4A | R4A ZZ | SS | — | 6.350 | 19.050 | 5.558 | 7.142 | 0.40 | |



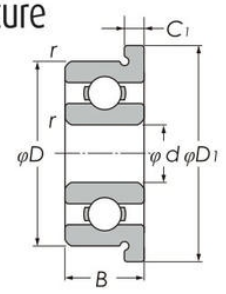

| | Basic dynamic load ratings | | Limit speed | | | Mounting dimensions | | | Weight |
|---|---|---|---|---|---|---|---|---|---|
| | Dynamic load $C_r$ N | Static load $C_{or}$ N | Oil-lubricated Open rpm | Grease lubrication ZZ. HH. SS rpm | 2RS rpm | $d_{a\ MIN}$ mm | $D_{a\ MAX}$ mm | $r_{a\ MAX}$ mm | (Approx.) g |
| | 231 | 66 | 110 000 | 90 000 | - | 2.2 | 3.9 | 0.10 | 0.19 |
| | 310 | 108 | 80 000 | 67 000 | - | 2.8 | 5.5 | 0.10 | 0.50 |
| | 552 | 176 | 71 000 | 60 000 | - | 3.7 | 6.7 | 0.15 | 0.55 |
| | 143 | 52 | 95 000 | 80 000 | - | 3.2 | 3.9 | 0.10 | 0.13 |
| | 550 | 175 | 71 000 | 60 000 | - | 3.6 | 6.7 | 0.15 | 0.72 |
| | 113 | 34 | 80 000 | 67 000 | - | 4.0 | 5.5 | 0.10 | 0.25 |
| | 560 | 179 | 67 000 | 60 000 | - | 4.0 | 7.0 | 0.08 | 0.50 |
| | 640 | 225 | 63 000 | 53 000 | - | 4.0 | 8.7 | 0.10 | 0.96 |
| | 630 | 218 | 67 000 | 56 000 | - | 4.8 | 7.8 | 0.03 | 1.40 |
| | 640 | 225 | 63 000 | 53 000 | - | 4.8 | 11.0 | 0.30 | 3.30 |
| | 360 | 149 | 63 000 | 53 000 | - | 4.8 | 7.0 | 0.08 | 0.51 |
| | 360 | 149 | 63 000 | 53 000 | - | 5.6 | 7.0 | 0.08 | 0.69 |
| | 710 | 270 | 60 000 | 50 000 | - | 5.6 | 8.7 | 0.08 | 0.81 |
| | 1 300 | 485 | 53 000 | 43 000 | - | 6.8 | 10.7 | 0.30 | 2.90 |
| | 1 300 | 485 | 53 000 | 43 000 | - | 6.8 | 13.8 | 0.30 | 2.97 |
| | 375 | 173 | 56 000 | 48 000 | - | 7.2 | 8.7 | 0.08 | 1.01 |
| | 1 080 | 440 | 50 000 | 40 000 | - | 7.6 | 11.5 | 0.15 | 2.03 |
| | 1 480 | 615 | 45 000 | 38 000 | - | 8.4 | 13.8 | 0.30 | 5.02 |
| | 2 340 | 885 | 43 000 | 36 000 | - | 9.4 | 16.0 | 0.40 | 7.00 |

# Inch Series

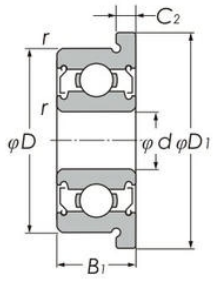
## Outer ring flanged structure

Bore diameter

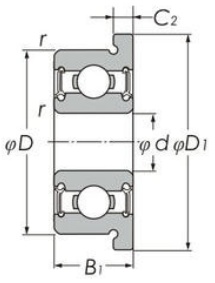
1.397 mm - 9.525 mm



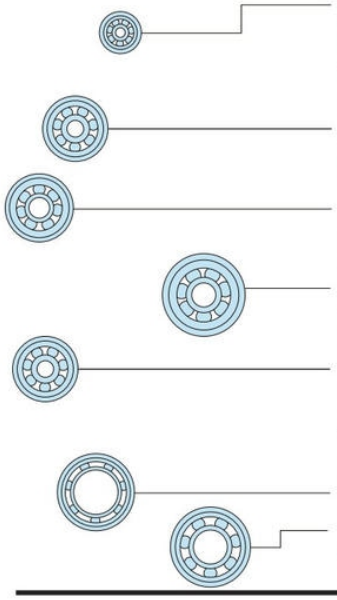
Open



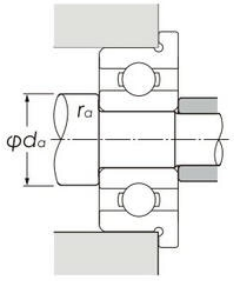
Metal Shield



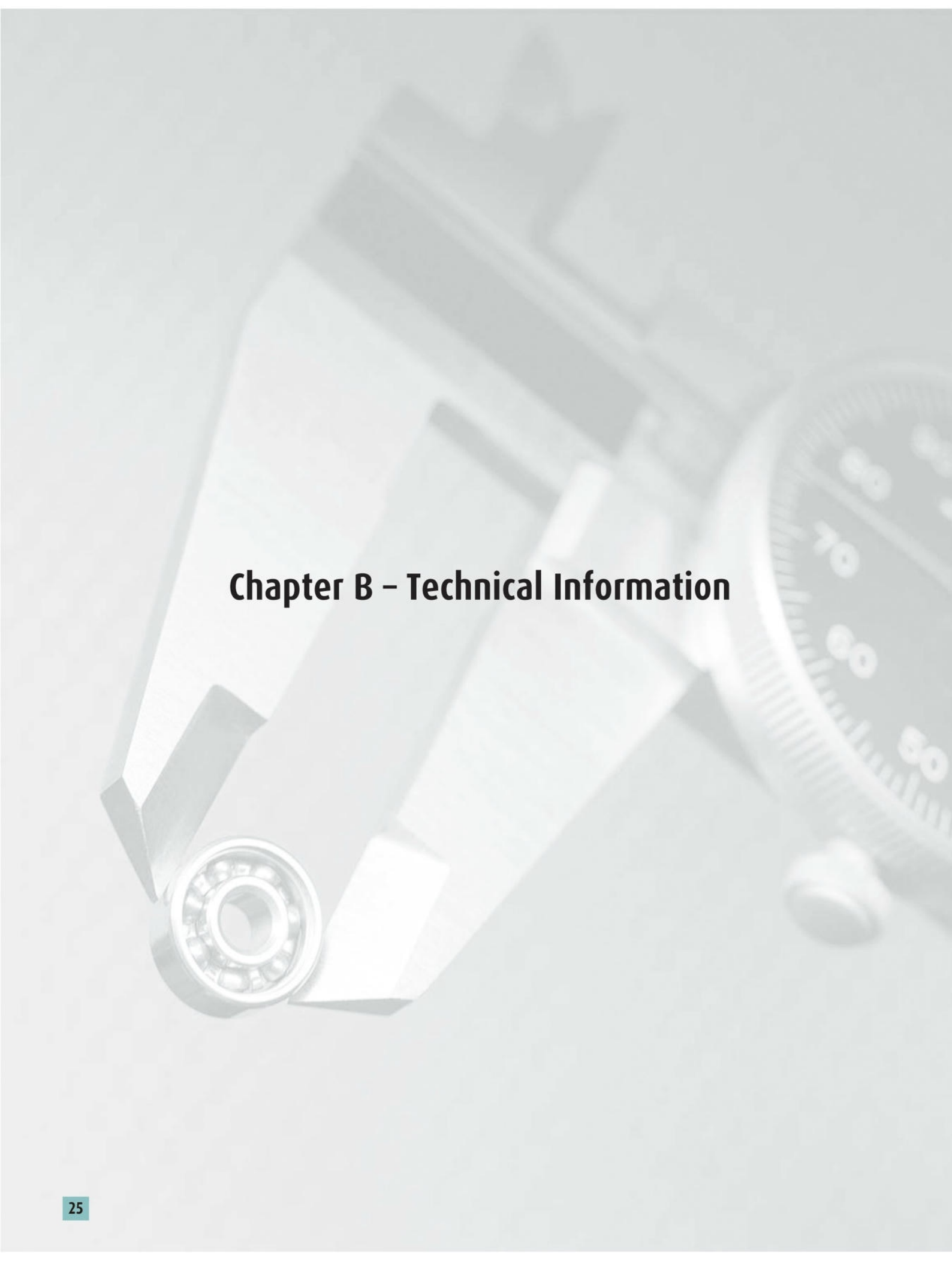
Rubber Seal

| Actual size | Bearing Number | | | | Bore | OD | Width | | Radius | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Open | Capped | | | d | D | Open B | Capped $B_1$ | ~ $r_{smin}$ | |
| | | Metal shield | Rubber seal | | | | | | | |
| | | ZZ. HH | SS | 2RS | mm | mm | mm | mm | mm | |
|  | FR1 | FR1 ZZ | — | — | 1.397 | 4.762 | 1.984 | 2.779 | 0.10 | |
| | FR1-4 | FR1-4 ZZ | — | — | 1.984 | 6.350 | 2.380 | 3.571 | 0.10 | |
| | FR133 | FR133 ZZ | — | — | 2.380 | 4.762 | 1.588 | 2.380 | 0.10 | |
| | FR1-5 | FR1-5 ZZ | — | — | 2.380 | 7.938 | 2.779 | 3.571 | 0.15 | |
| | FR144 | FR144 ZZ | — | — | 3.175 | 6.350 | 2.380 | 2.779 | 0.10 | |
| | FR2-5 | FR2-5 ZZ | — | — | 3.175 | 7.938 | 2.779 | 3.571 | 0.10 | |
| | FR2-6 | FR2-6 ZZ | — | — | 3.175 | 9.525 | 2.779 | 3.571 | 0.15 | |
| | FR2 | FR2 ZZ | — | — | 3.175 | 9.525 | 3.967 | 3.967 | 0.30 | |
| | FR156 | FR156 ZZ | — | — | 4.763 | 7.938 | 2.779 | 3.175 | 0.10 | |
| | FR166 | FR166 ZZ | — | — | 4.763 | 9.525 | 3.175 | 3.175 | 0.10 | |
| | FR3 | FR3 ZZ | — | — | 4.763 | 12.700 | 4.978 | 4.978 | 0.30 | |
| | FR168 | FR168 ZZ | — | — | 6.350 | 9.525 | 3.175 | 3.175 | 0.10 | |
| | FR188 | FR188 ZZ | — | — | 6.350 | 12.700 | 3.175 | 4.763 | 0.15 | |
| | FR4 | FR4 ZZ | — | — | 6.350 | 15.875 | 4.978 | 4.978 | 0.30 | |
| | FR6 | FR6 ZZ | SS | 2RS | 9.525 | 22.225 | 7.142 | 7.142 | 0.40 | |

Due to space constraints, we couldn't list all types, varieties that the company can produce. Please check our website or consult with our engineer for more information.



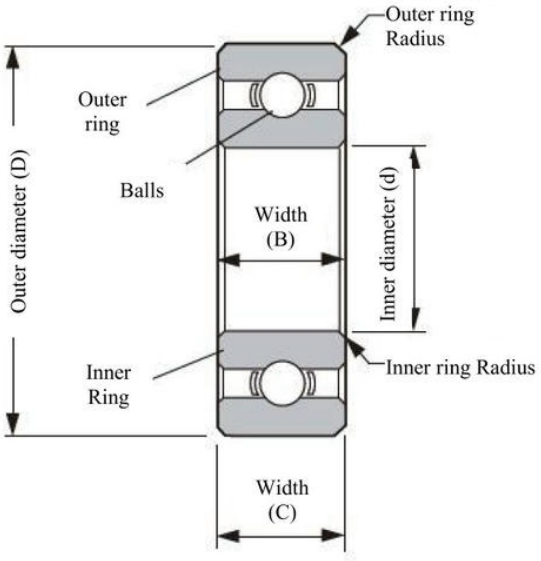

| | Flange Dimensions | | | Basic dynamic load ratings | | Limit speed | | | Mounting dimension | | Weight |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diameter | Width | | Dynamic load | Static load | Oil-lubricated | Grease lubrication | | | | (Approx.) |
| | $D_1$ | $C_1$ | $C_2$ | $C_r$ | $C_{or}$ | Open | ZZ. HH. SS | 2RS | $d_{a\ MIN}$ | $r_{a\ MAX}$ | |
| | mm | mm | mm | N | N | rpm | rpm | rpm | mm | mm | g |
| | 5.944 | 0.584 | 0.787 | 231 | 66 | 111 000 | 90 000 | - | 2.2 | 0.10 | 0.20 |
| | 7.518 | 0.584 | 0.787 | 310 | 108 | 80 000 | 67 000 | - | 2.8 | 0.10 | 0.41 |
| | 5.944 | 0.457 | 0.787 | 124 | 42 | 85 000 | 73 000 | - | 3.2 | 0.08 | 0.16 |
| | 9.119 | 0.584 | 0.787 | 430 | 152 | 66 000 | 56 000 | - | 3.2 | 0.10 | 0.76 |
| | 7.518 | 0.584 | 0.787 | 283 | 95 | 80 000 | 67 000 | - | 4.0 | 0.08 | 0.40 |
| | 9.119 | 0.584 | 0.787 | 560 | 179 | 67 000 | 60 000 | - | 4.0 | 0.08 | 0.62 |
| | 10.719 | 0.584 | 0.787 | 640 | 225 | 63 000 | 53 000 | - | 4.4 | 0.15 | 1.08 |
| | 11.176 | 0.762 | 0.762 | 630 | 218 | 67 000 | 56 000 | - | 5.2 | 0.30 | 1.63 |
| | 9.119 | 0.584 | 0.914 | 362 | 148 | 63 000 | 53 000 | - | 5.6 | 0.10 | 0.82 |
| | 10.719 | 0.584 | 0.787 | 706 | 274 | 60 000 | 50 000 | - | 5.6 | 0.10 | 0.98 |
| | 14.351 | 1.067 | 1.067 | 1 301 | 488 | 53 000 | 43 000 | - | 6.8 | 0.30 | 3.42 |
| | 10.719 | 0.584 | 0.914 | 372 | 176 | 56 000 | 48 000 | - | 7.2 | 0.10 | 1.32 |
| | 13.894 | 0.584 | 1.143 | 1 082 | 442 | 50 000 | 40 000 | - | 7.6 | 0.15 | 2.45 |
| | 17.526 | 1.067 | 1.067 | 1 480 | 621 | 45 000 | 38 000 | - | 8.4 | 0.30 | 6.80 |
| | 24.613 | 1.575 | 1.575 | 3 332 | 1 422 | 40 000 | 34 000 | 32 000 | 11.5 | 0.40 | 13.8 |

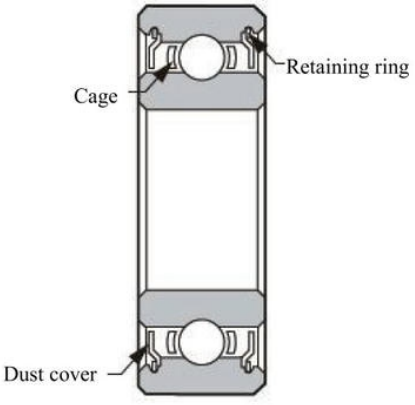


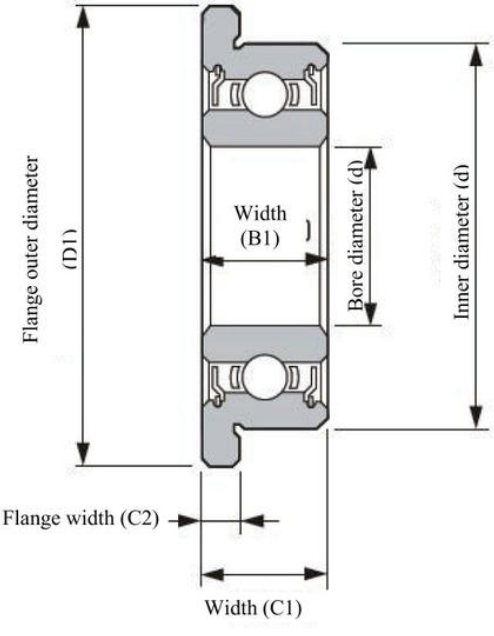
# Chapter B – Technical Information

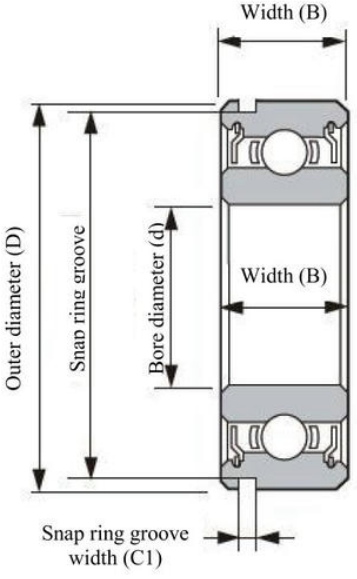
# 1. Names and Codes of Components of Extra-Miniature Deep Groove Ball Bearings

## Component Name



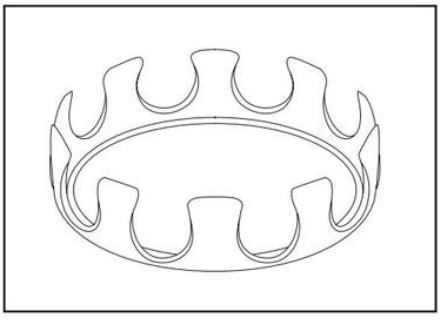



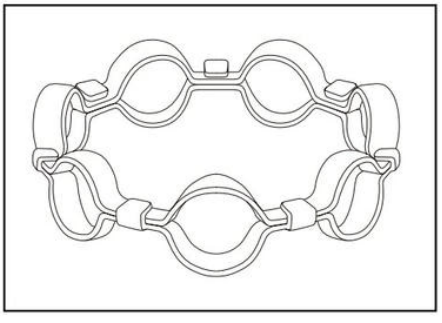
## Types of Cages

The primary function of the cage is to keep the balls inside the ball bearing evenly spaced, preventing direct contact between adjacent balls, thereby keeping heat generated by friction to a minimum.



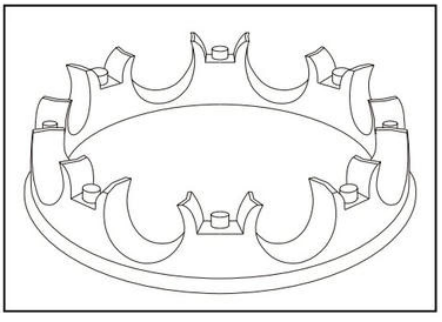
### Crown-type cage

Stamped from stainless steel, suitable for medium and low-speed applications, with very low frictional torque and speed factor, commonly used in miniature and thin-walled deep groove ball bearings.



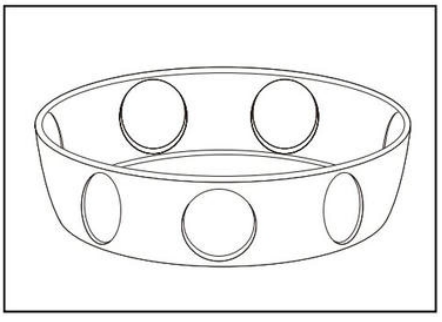
### Wave-type cage

Stamped from steel plate, characterized by low starting and running torque, and capable of withstanding higher loads.



### Resin molded cage

A cage formed by resin injection molding. Resin materials include polyamide, PEEK, and others.
Suitable for high-speed rotation and low-noise applications.



### Resin machined cage

A cage machined from resin, with resin materials including polyamide–imide (e.g. TORLON).
Suitable for ultra-high-speed and low-noise applications.

## Types of Bearing Seals

Extra-miniature deep groove ball bearings are usually equipped with metal dust covers or rubber seals on one or both sides. Extra-miniature deep groove ball bearings with metal dust covers or rubber seals on both sides are lifetime maintenance-free.

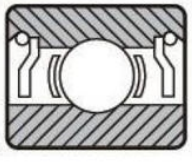
Extra-miniature deep groove ball bearings with metal dust covers are suitable for applications where the outer ring is fixed and the inner ring rotates. If they are applied to conditions where the outer ring rotates, there is a risk of grease leakage at high rotational speed.

Extra-miniature deep groove ball bearings with non-contact rubber seals are suitable for applications requiring high sealing performance and low torque. Since the inner bore of the seal does not come into contact with the outer wall of the bearing' s inner ring, bearings with non-contact rubber seals can reach the same rotational speed as bearings with metal seals.

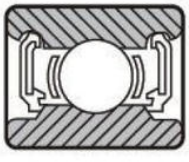
Extra-miniature deep groove ball bearings with contact-type seals are suitable for applications requiring high sealing performance, as the inner bore of the seal comes into contact with the outer wall of the bearing' s inner ring.

Conventional rubber seals consist of a metal framework and NBR, with an operating temperature range of -40 to +120°C. If the working environment or temperature conditions change, please contact us.

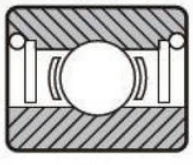
### Classification of Metal and Rubber Seals



2 "Z" dust cover
(Metal removable type)



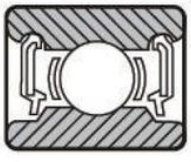
2 "RS" seal ring
(Rubber contact type)



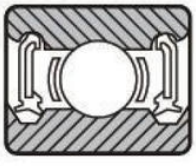
2 "L" dust cover
(Teflon removable type)



2 "H" dust cover
(Metal fixed type)



2 "S" seal ring
(Rubber non-contact type)



2 "SD" seal ring
(Rubber light-contact type)

# 2. Materials of Extra-Miniature Deep Groove Ball Bearings and Components

## Materials of Bearing Rings and Rolling Elements

The material of the outer ring, inner ring, and balls is high-carbon chromium bearing steel treated by vacuum heat treatment, such as the Chinese standard grade GCr15, which ensures long service life. Where resistance to corrosion and high temperatures is required, martensitic stainless steel can be used, such as the Chinese standard grade 9Cr18.

| Material name | Chinese grade | Equivalent grade | | |
|---|---|---|---|---|
| | | USA | German | Japan |
| High carbon chromium bearing steel | GCr15 | SAE52100 | 100Cr6 | SUJ2 |
| Martensitic stainless steel | 9Cr18 (9Cr18Mo) | AISI440C | X102CrMo17 | SUS440C |

## Chemical Composition Table

| Steel grade | Chemical composition | | | | | | |
|---|---|---|---|---|---|---|---|
| | C% | Si% | Mn% | P% | S% | Cr% | Mo% |
| GCr15 | 0.95～1.05 | 0.15～0.35 | 0.25～0.45 | ≤ 0.025 | ≤ 0.025 | 1.40～1.65 | ≤0.10 |
| SUJ2 | 0.95～1.10 | 0.15～0.35 | ≤0.50 | 1.30～1.60 | ≤0.08 | ≤ 0.025 | ≤ 0.025 |
| 100Gr6 | 0.95～1.05 | 0.15～0.35 | 0.25～0.45 | 1.40～1.65 | ≤0.08 | ≤ 0.025 | ≤ 0.025 |
| SAE52100 | 0.95～1.10 | 0.15～0.35 | 0.25～0.45 | 1.30～1.60 | ≤0.10 | ≤ 0.025 | ≤ 0.025 |

| Steel grade | Chemical composition | | | | | | |
|---|---|---|---|---|---|---|---|
| | C% | Si% | Mn% | P% | S% | Cr% | Mo% |
| 9Cr18 | 0.95～1.00 | ≤0.80 | ≤0.80 | ≤0.035 | ≤0.030 | 17.0～19.0 | -- |
| 9Cr18Mo | 0.95～1.10 | ≤0.80 | ≤0.80 | ≤0.035 | ≤0.030 | 16.0～18.0 | 0.40～0.70 |

## Cage Materials

In addition to possessing adequate strength, cage materials must also provide good thermal conductivity, low coefficient of friction, excellent wear resistance, strong impact toughness, low density, and a coefficient of thermal expansion close to that of the rolling elements. Furthermore, stamped cages must withstand complex stamping deformations, which also requires the material to have good processing performance.

### Stamped Steel Plate Cages

| Steel grade | Chemical composition | | | | | | |
|---|---|---|---|---|---|---|---|
| | C% | Si% | Mn% | P% | S% | Ni% | Cr% |
| JISG 3141 SPCC | <0.12 | -- | <0.5 | <0.04 | <0.045 | -- | -- |

## Nylon Cages

Most injection-molded cages are made of Nylon 66, with or without glass fiber reinforcement. This material offers a good balance of strength and elasticity. The mechanical properties of nylon, such as strength and elasticity, depend on temperature. Generally, the operating temperature is below 120 °C, and aging may occur depending on operating conditions. The most important factors influencing this aging process are temperature, duration, and the medium in contact (such as lubricants). For applications requiring higher temperature resistance, cages made of Nylon 46 or PEEK can also be provided.

## Materials of Metal Dust Covers

Unless otherwise specified, we generally use AISI-304 stainless steel.

## Materials of Rubber Seals

| Type | ASTM D1418 Name | Temperature range | Hardness (Shore A) | Features | Limit |
|---|---|---|---|---|---|
| Nitrile rubber | NBR | (-40°C~120° C) | 40-90 | Low compression set, high ductility, and resistance to corrosion, with excellent oil resistance. | Not suitable for high-temperature conditions, and should be protected from direct sunlight and chemical corrosion. |
| Silicone rubber | MQ/PMQ/VMQ / PVMP | (-70°C~200° C) | 25-80 | Resistant to high temperature and dryness, ozone resistance, and ultraviolet resistance. | Poor in surface wear resistance and anti-cracking properties. |
| Hydrogena ted nitrile rubber | HNBR/NEM | (-35°C~165° C) | 50-90 | Resistant to heat, high ductility, and chemical corrosion. | Not suitable for low-temperature conditions; should be protected from direct sunlight and chemical erosion. |
| Fluororubb er | FKM/FPM | (-28°C~200° C) | 50-95 | Hightemperature resistance, remarkable chemical corrosion resistance, and resistance to petroleum products. | Not suitable for low-temperature operating conditions. |
| Polypropyl ene rubber | ACM rubber | (-25°C~175° C) | 40-90 | Strong resistance to hot oil, sunlight, and ozone erosion, while also providing excellent crack resistance. | Poor water resistance, not suitable for ultra-low-temperature operating conditions. |
| EPDM rubber | EPDM | (-55°C~150° C) | 50-90 | Low density with high filling capacity, resistant to aging and corrosion, resistant to steam, and excellent in electrical insulation performance. | Very poor in self-adhesion and mutual adhesion. |

Note: At an operating temperature of 200 °C, fluororubber is safe and harmless. However, if the temperature exceeds 300 °C, equivalent to the heat of cutting steel pipes, fluororubber will release gases and fumes, which may be harmful. Avoid contact with skin.

# 3. Tolerances of Extra-Miniature Deep Groove Ball Bearings

## Definition of Tolerances

Extra-miniature deep groove ball bearings are divided into multiple grades. JIS and ANSI/ABMA specify the permissible deviations and allowable values for each grade. STT follows JIS B 1514-1, -3, ANSI/ABMA Std. 12.2, and ANSI/ABMA Std. 20. The main symbols used in the specifications are as shown below.

## Measurement of Tolerances for Extra-Miniature Deep Groove Ball Bearings

The tolerances of extra-miniature deep groove ball bearings refer to two aspects—dimensional accuracy and rotational accuracy.

## Dimensional Accuracy

Including bore diameter, outside diameter, width, Radius dimension tolerances or permissible values. Dimensional deviations include bore diameter deviation, mean bore diameter variation, outside diameter deviation, mean outside diameter variation, permissible values of face runout or thickness parallelism of the bearing rings.

Dimensions-

d: Nominal bore diameter D: Nominal outside diameter

$D_1$: Nominal flange outside diameter of the outer ring

B: Nominal width of the inner ring C: Nominal width of the outer ring

r: Nominal Radius dimension of the inner ring or outer ring

Dimensional deviations –

$\triangle d_S$: Deviationof the actual measured bore diameter

$\triangle d_{mp}$: Deviation of the mean bore diameter in a single radial plane

$(_{\triangle dm})$: Deviation of the mean bore diameter

$\triangle D_S$: Deviation of the actual measured outside diameter

$\triangle D_{mp}$: Deviation of the mean outside diameter in a single radial plane

$(_{\triangle Dm})$: Deviation of the mean outside diameter

$\triangle B_S$: Deviation of the actual measured width of the inner ring

$\triangle C_S$: Deviation of the actual measured width of the outer ring

$\triangle D_{1S}$: Deviation of the actual measured flange outside diameter of the outer ring

$\triangle C_{1S}$: Deviation of the actual measured flange width of the outer ring

Radius –

rS: Actual measured Radius dimension of the inner ring and outer ring

$rS_{min}$: Minimum value of rS

$rS_{max}$: Maximum value of rS

Variation in dimensions –

$VB_S$: Variation in inner ring width $VC_S$: Variation in outer ring width

$VC_{1S}$: Variation in flange width of the outer ring

## Rotational Accuracy

Rotational accuracy specifies the permissible runout during rotation, including radial and axial runout of the inner ring and outer ring, lateral runout of the inner ring, and the perpendicularity tolerance of the outer diameter surface.

Extra-miniature deep groove ball bearings are divided into multiple grades. JIS and ANSI/ABMA specify the permissible deviations and allowable values for each grade. STT complies with JIS B 1514-1, -3, ANSI/ABMA Std. 12.2, and ANSI/ABMA Std. 20. The main symbols used in the specifications are as follows:

Kia: Radial runout of the inner ring
Sia: Axial runout of the inner ring
Sd: Perpendicularity of the inner ring side face relative to the bore axis [lateral runout of the inner ring]
Kea: Radial runout of the outer ring
Sea: Axial runout of the outer ring
SD: Perpendicularity of the outer diameter surface of the outer ring relative to the side face [tilt of the outer diameter surface]

Sea1: Axial runout of the back face of the outer ring
flange Notes: Symbols in ( ) are based on ANSI/ABMA.
References in [ ] indicate terminology used in the old JIS.
Note: Recorded only for radial ball bearings.

## Conversion Table of Tolerance Standards in Various Countries

| Country | Standard No. | Level | | | | |
|---|---|---|---|---|---|---|
| China | GB/T307 | 0 | 6 | 5 | 4 | 2 |
| International | IS0492 | 0 | 6 | 5 | 4 | 2 |
| Japan | JIS B1514 | JIS0 | JIS 6 | JIS 5 | JIS 4 | JIS 2 |
| German | DIN 620/2 | P0 | P6 | P5 | P4 | P2 |
| USA | ANSI B3.14 | ABEC1 | ABEC3 | ABEC5 | ABEC7 | ABEC9 |

## Permissible Deviations and Allowable Values for Inner Rings d ≤ 18 mm (excerpted from JIS B 1514-1)

Unit: μm

| Level | Bore diameter deviation | | | | Radial runout | Verticality | Axial runout | Width deviation | | Parallelism |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\triangle d_{mp}$ | | $\triangle d_s$ | | $K_{ia}$ | $S_d$ | $S_{ia}$ | $\triangle B_s$ | | $VB_s$ |
| | Upper | Lower | Upper | Lower | Maximum | Maximum | Maximum | Upper | Lower | Maximum |
| Class 0 | 0 | -8 | - | - | 10 | - | - | 0 | -40[1]<br>-120 | 12[1]<br>15[2]<br>20 |
| Class 6 | 0 | -7 | - | - | 5[1]<br>6[2]<br>7 | - | - | 0 | -40[1]<br>-120 | 12[1]<br>15[2]<br>20 |
| Class 5 | 0 | -5 | - | - | 4 | 7 | 7 | 0 | -40[2]<br>-80 | 5 |
| Class 4 | 0 | -4 | 0 | -4 | 2.5 | 3 | 3 | 0 | -40[2]<br>-80 | 2.5 |
| Class 2 | 0 | -2.5 | 0 | -2.5 | 1.5 | 1.5 | 1.5 | 0 | -40[2]<br>-80 | 1.5 |

1) Applicable to bearings with a bore diameter of 2.5 mm or less. 2) Applicable to bearings with a bore diameter of 10 mm or less.

## Permissible Deviations and Allowable Values for Outer Rings D ≤ 30 mm (excerpted from JIS B 1514-1)

Unit: μm

| Level | Bore diameter deviation | | | | Radial runout | Verticality | Axial runout | Width deviation | | Parallelism |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\triangle d_{mp}$ | | $\triangle d_s$ | | $K_{ia}$ | $S_d$ | $S_{ia}$ | $\triangle B_s$ | | $VB_s$ |
| | Upper | Lower | Upper | Lower | Maximum | Maximum | Maximum | Upper | Lower | Maximum |
| Class 0 | 0 | -8[1]<br>-9 | - | - | 15 | - | - | 0 | -40[2]<br>-120 | 12[1]<br>15[3]<br>20 |
| Class 6 | 0 | -7[1]<br>-8 | - | - | 8[1]<br>9 | - | - | 0 | -40[2]<br>-120 | 12[2]<br>15[3]<br>20 |
| Class 5 | 0 | -5[1]<br>-6 | - | - | 5[1]<br>6 | 8 | 8 | 0 | -40[3]<br>-80[4] | 5 |
| Class 4 | 0 | -4[1]<br>-5 | 0 | -4[1]<br>-5 | 3[1]<br>4 | 4 | 4 | 0 | -40[3]<br>-80[4] | 2.5 |
| Class 2 | 0 | -2.5[1]<br>-4 | 0 | -2.5[1]<br>-4 | 1.5[1]<br>2.5 | 1.5 | 1.5[1]<br>2.5 | 0 | -40[3]<br>-80[4] | 1.5 |

1) Applicable to bearings with an outside diameter of 18 mm or less.
2) Applicable to bearings with a bore diameter of 2.5 mm or less.
3) Applicable to bearings with a bore diameter of 10 mm or less.
4) Applicable to bearings with a bore diameter of 18 mm or less.

## Permissible Deviations of Outer Ring Flange Outside Diameter (excerpted from JIS)

Unit: μm

| D1 (mm) | | Column 1 | | Column 2 | |
|---|---|---|---|---|---|
| | | $\triangle D_{1s}$ | | | |
| Greater than | Below | Upper | Lower | | |
| | 10 | +220 | -36 | 0 | -36 |
| 10 | 18 | +270 | -43 | 0 | -43 |
| 18 | 30 | +330 | -52 | 0 | -52 |

Note: When the flange outside diameter surface is used for positioning, Column 2 shall apply.

## Permissible Deviations of Flange Width and Allowable Values of Its Rotational Accuracy (excerpted from JIS)

Unit: μm

| D (mm) | | Class 0, Class 6 | | Class 5, Class 4, Class 2 | | Class 0, Class 6 | Class 5 | Class 4 | Class 2 |
|---|---|---|---|---|---|---|---|---|---|
| | | $\triangle C_{1s}$ | | | | $VC_{1s}$ | | | |
| Greater than | Below | Upper | Lower | | | Maximum | | | |
| 2.5[1] | 30 | 0 | -40[2]<br>-120 | 0 | -40[3]<br>-80 | 12[2]<br>15[3]<br>20 | 5 | 2.5 | 1.5 |

Unit: μm

| D (mm) | | Class 5 | Class 4 | Class 2 | Class 5 | Class 4 | Class 2 |
|---|---|---|---|---|---|---|---|
| | | $SD_1$ | | | $S_{ea1}$ | | |
| Greater than | Below | Maximum | | | Maximum | | |
| 2.5[1] | 18 | 8 | 4 | 1.5 | 11 | 7 | 3 |
| 18 | 30 | 8 | 4 | 1.5 | 11 | 7 | 3 |

1) An outside diameter of 2.5 mm also falls under this dimensional classification.
2) Applicable to bearings with a bore diameter of 2.5 mm or less.
3) Applicable to bearings with a bore diameter of 10 mm or less.

## Permissible Deviations and Allowable Values for Inner Rings d ≤ 18 mm (excerpted from ANSI/ABMA)

Unit: μm

| Level | $\triangle D_{mp}$ Note 1 | | $\triangle D_s$ | | $K_i$ | $S_{di}$ | Si | $\triangle B_s$ | | $VB_s$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ABEC | Upper | Lower | Upper | Lower | Maximum | Maximum | Maximum | Upper | Lower | Maximum |
| 3P | 0 | -5.1 | 2.5 | -7.6 | 5.1[1]<br>7.6 | - | - | 0 | -127 | - |
| 5P | 0 | -5.1 | 0 | -5.1 | 3.8 | 7.6 | 7.6 | 0 | -25.4 | 5.1 |
| 7P | 0 | -5.1 | 0 | -5.1 | 2.5 | 2.5 | 2.5 | 0 | -25.4 | 2.5 |
| 9P | 0 | -2.5 | 0 | -2.5 | 1.3 | 1.3 | 1.3 | 0 | -25.4 | 1.3 |

Note 1: For Class 3P, $\triangle D_m$ is generally specified. 1) Applicable to bearings with a bore diameter of 10 mm or less.

## Permissible Deviations and Allowable Values for Outer Rings D ≤ 30 mm (excerpted from ANSI/ABMA)

Unit: μm

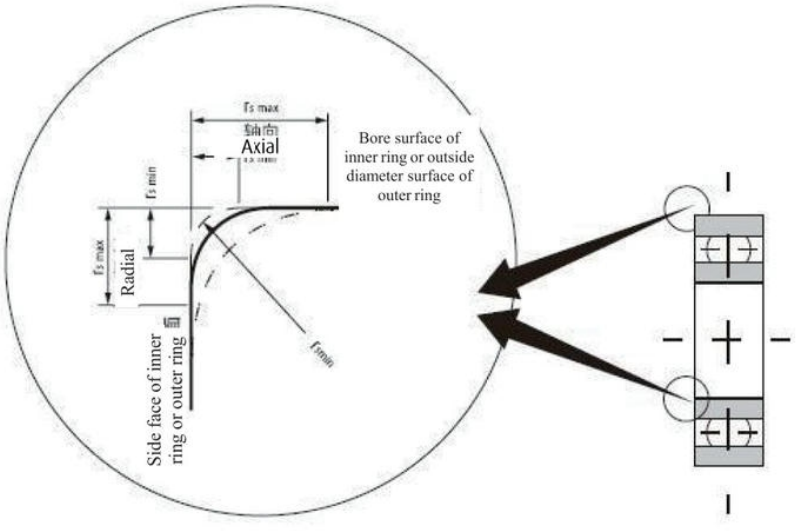
| Level ABEC | $\triangle D_{mp}$ | Note 2 | $\triangle D_s$ | | | | $K_e$ | $C_s$ | $S_e$ | $\triangle C_s$ | | $VC_s$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Open | | Metal and Rubber seal | | | | | | | |
| | Upper | Lower | Upper | Lower | Upper | Lower | Maximum | Maximum | Maximum | Upper | Lower | Maximum |
| 3P | 0 | -7.6 | 2.5 | -10.2 | 5.1 | -12.7 | 10.2 | - | - | 0 | -127 | - |
| 5P | 0 | -5.1 | 0 | -5.1 | 1 | -6.1 | 5.1 | 7.6 | 7.6 | 0 | -25.4 | 5.1 |
| 7P | 0 | -5.1 | 0 | -5.1 | 1 | -6.1 | 3.8 | 3.8 | 5.1 | 0 | -25.4 | 2.5 |
| 9P | 0 | -2.5[1)]<br>-3.8 | 0 | -2.5[1)]<br>-3.8 | - | - | 1.3[1)]<br>2.5 | 1.3 | 1.3[1)]<br>2.5 | 0 | -25.4 | 1.3 |

Note 2: For Class 3P, $\triangle$Dm is generally specified. 1) Applicable to bearings with an outside diameter of 18 mm or less.

## Maximum Permissible Values for Radius Dimensions of Extra-Miniature Deep Groove Ball Bearings

Unit: mm

| $r_{s\,min}$ | d | | $r_{s\,max}$ | |
|---|---|---|---|---|
| | Greater than | Below | Radial | Axial |
| 0.05 | - | - | 0.10 | 0.20 |
| 0.08 | - | - | 0.16 | 0.30 |
| 0.10 | - | - | 0.20 | 0.40 |
| 0.15 | - | - | 0.30 | 0.60 |
| 0.20 | - | - | 0.5 | 0.80 |
| 0.30 | - | 40 | 0.60 | 1 |

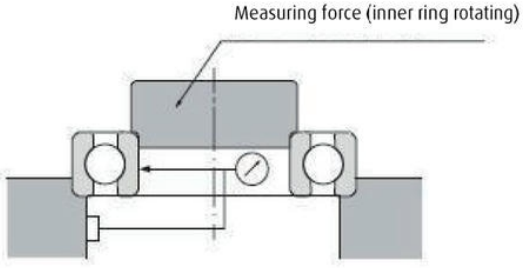


# 4. Measurement Methods for Extra-Miniature Deep Groove Ball Bearings

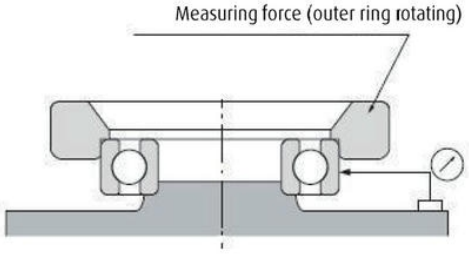
## Introduction

For the general principles related to verifying the dimensions and runout of extra-miniature deep groove ball bearings, please refer to the provisions of ISO 9274. A summary of the measurement methods for actual dimensions and runout is outlined below.

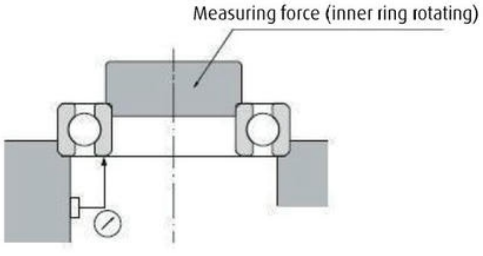
Radial runout of the inner ring
($K_{ia}$)



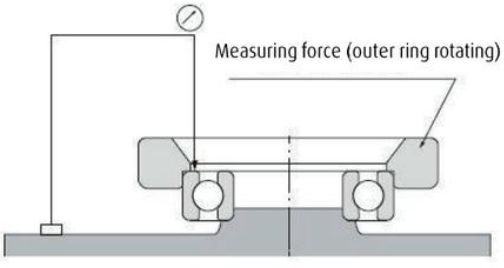

Radial runout of the outer ring
($K_{ea}$)



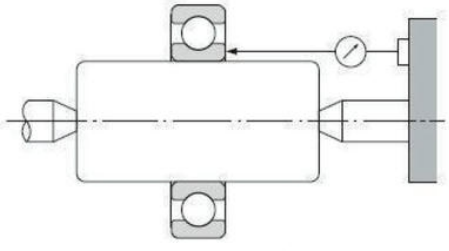

Axial runout of the inner ring
($S_{ia}$)



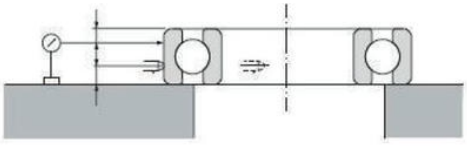

Axial runout of the outer ring
($S_{ea}$)




Perpendicularity of the inner ring side face relative to the bore axis
[ Lateral runout of the inner ring ]
($S_d$)



Perpendicularity of the outer ring outside-diameter surface relative to the side face
[ Tilt of the outside-diameter surface ]
($S_D$)



# 5. Rated Load and Service Life

## Calculation of Rated Service Life

The rated dynamic load and rated static load of bearings are calculated in accordance with ISO standards, and users may apply the same methodology to determine the rated service life of a bearing. The following calculation method applies to deep groove ball bearings made of GCr15 bearing steel. For bearings made of stainless steel 9Cr18, the rated dynamic load is approximately 80% of that of ball bearings manufactured from GCr15 bearing steel, whereas for ball bearings made of beryllium bronze or non-magnetic stainless steel, the rated dynamic load is only about 25% of that of ball bearings made from GCr15 bearing steel.

The relationship between the basic rated service life and the basic dynamic load rating of bearings can be expressed by the following ISO formula.

$L10 = (C_r / P_r)^3$

Representation:
L10 = Basic rated service life (with a reliability of 90%), expressed in millions of revolutions.
Cr = Basic dynamic load rating, unit: N
Pr = Equivalent dynamic bearing load, unit: N
The basic radial dynamic load rating Cr is defined as the constant stationary radial load that the bearing can theoretically withstand, under which the bearing can reach a basic rated service life of one million revolutions.

ISO 281 provides the calculation method and lists the values in the dimensional

tables: $Pr = XF_r + YF_a$

Pr = Equivalent dynamic load
X, Y = X represents the radial load factor, and Y represents the axial load factor. Both values can be obtained from the table below.
Fr = Radial load
Fa = Axial load

Under conditions of constant rotational speed, service life is usually expressed in terms of time. The relationship between the basic rated service life and service life time is as follows.

$$L_{10\ \text{Million revolutions}} \times \frac{1{,}000{,}000}{RPM * 60} = L_{1\text{Hour}}$$

| Axial load ratio | | Fa / Fr ≤ e | | Fa / Fr ≥ e | |
|---|---|---|---|---|---|
| $\frac{Fa}{Z * D_W^2}$ | e | X | Y | X | Y |
| 0.0175 | 0.19 | 1 | 0 | 0.56 | 2.30 |
| 0.0352 | 0.22 | | | | 1.99 |
| 0.0703 | 0.26 | | | | 1.71 |
| 0.105 | 0.28 | | | | 1.55 |
| 0.143 | 0.30 | | | | 1.45 |
| 0.211 | 0.34 | | | | 1.31 |
| 0.352 | 0.38 | | | | 1.15 |
| 0.527 | 0.42 | | | | 1.04 |
| 0.703 | 0.44 | | | | 1 |

Z = Number of balls $D_W$ = Ball diameter (mm)
Step 1: Calculate $Fa / (Z \times DW^2)$ to determine the value of "e."
Step 2: Determine the relationship between Fa / Fr and then refer to obtain the values of X and Y.

In addition to the basic rated service life ($L_{10}$), DIN ISO 281 also introduced the extended modified rated service life ($_{Lnm}$), together with a life modification factor ($a_1$) and an operating condition factor ($_{aISO}$).
Calculation method for the extended modified rated service life Lnm:

$L_{nm}=a_1 \cdot a_{ISO} \cdot L_{10}$

$L_{nm}$: Extended modified rated service life, unit: $10^6$ revolutions
$a_1$: Life modification factor when the reliability is not 90%. Refer to the table: Life Modification Factor
a1 $a_{ISO}$: Life modification factor that takes operating conditions into account
$L_{10}$: Basic rated service life

Life modification factor $a_1$

| Reliability | Extended adjustment parameters | Life modification factors |
|---|---|---|
| % | $L_{nm}$ | $a_1$ |
| 90 | $L10_m$ | 1 |
| 95 | $L5_m$ | 0.64 |
| 96 | $L4_m$ | 0.55 |
| 97 | $L3_m$ | 0.47 |
| 98 | $L2_m$ | 0.37 |
| 99 | $L1_m$ | 0.25 |
| 99.2 | $L0.8_m$ | 0.22 |
| 99.4 | $L0.6_m$ | 0.19 |
| 99.6 | $L0.4_m$ | 0.16 |
| 99.8 | $L0.2_m$ | 0.12 |
| 99.9 | $L0.1_m$ | 0.093 |
| 99.92 | $L0.08_m$ | 0.087 |
| 99.94 | $L0.06_m$ | 0.08 |
| 99.95 | $L0.05_m$ | 0.077 |

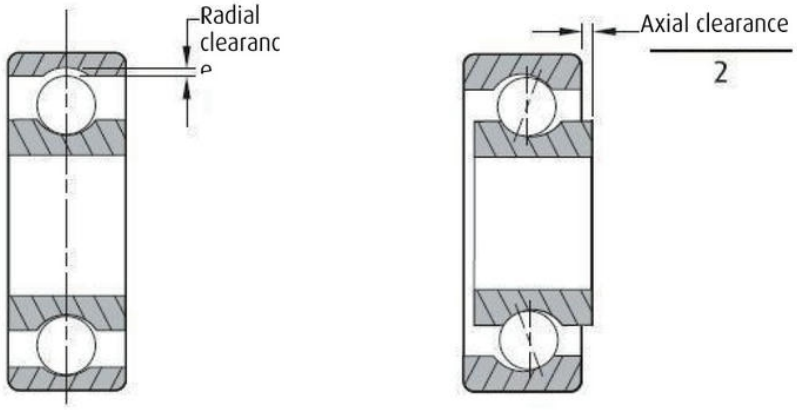
# 6. Internal Clearance of Bearings

## Definition of Internal Clearance

Internal clearance refers to the amount of clearance between the outer ring, inner ring, and balls of the bearing. Generally, when the inner ring is fixed and the outer ring is moved vertically, the amount of movement is referred to as radial clearance. When the outer ring is moved horizontally, the amount of movement is referred to as axial clearance. During bearing operation, the magnitude of internal clearance is a primary factor influencing performance characteristics such as lateral vibration, heat generation, and fatigue life.

Conventional deep groove ball bearings are represented using the normal radial internal clearance. In actual measurement, in order to obtain a stable measured value, a specified load is applied. Due to the elastic deformation of the bearing, the measured value at this time is larger than the actual clearance. Therefore, after correction, the true clearance can be obtained.

Theoretically, the service life of a bearing in operation reaches its maximum only when the clearance is slightly negative. However, it is well known that even a small excess of negative clearance will rapidly shorten the service life. For this reason, the initial clearance is generally selected to be larger than C0, and extra-miniature deep groove ball bearings are most often specified with clearance class C3.




## Radial Internal Clearance for Extra-Miniature Deep Groove Ball Bearings (μm)

| Symbols | C2 | | C0 | | C3 | | C4 | | C5 | | C6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Radial internal clearance | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. |
| | 0 | 5 | 3 | 8 | 5 | 10 | 5 | 13 | 10 | 15 | 13 | 20 |

## Modification Values of Clearance for Extra-Miniature Deep Groove Ball Bearings (μm)

| Clearance code | C2 | C0 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|
| Modification values of clearance | 1 | 1 | 1 | 1 | 2 | 2 |

The test load is as follows:
Miniature ball bearings 2.5 N {0.25 kg}

## ● Relationship Between Radial Internal Clearance and Axial Internal Clearance

The axial internal clearance is determined by the ball diameter, the groove radius of the inner and outer rings, and the value of the radial internal clearance.

When attempting to reduce the axial internal clearance after mounting, selecting a small radial clearance together with a large interference fit is hazardous.

Ga = (8 ~ 10) × Gr

Ga: Axial clearance, unit: μm

Gr: Radial clearance, unit: μm

If axial clearance requirements exist, please specify them at the time of order.

If you wish to know the range of axial clearance for bearings, please contact the technical department of STT.

## ● Reduction of Radial Internal Clearance

During operation, the bearing is subject to external influences, and the radial clearance may either increase or decrease. An increase in radial clearance may result in a larger contact angle, which can in turn cause premature bearing failure. In the worst case, a reduction in radial clearance may lead to accelerated wear of the bearing and premature failure.

The following factors have a direct influence on radial clearance:

Temperature variations inside the bearing

Fit between the bearing and the housing

Centrifugal force

Reduction of radial clearance due to thermal expansion

$\triangle S_{RT} \approx a \times \triangle T \times Da$ (mm)

$\triangle S_{RT}$: Change in radial clearance due to thermal expansion [μm]

a = Coefficient of linear expansion (1/°C); for bearing steel, $a = 12.5 \times 10^{-6}$; for stainless steel, $a = 10.1 \times 10^{-6}$

$\triangle T$ = Temperature difference between inner and outer rings (°C); typically $\triangle T$ = 5–11 °C

Da = Raceway diameter of the outer ring (mm); generally Da = [(4 × D + d) / 5]

Reduction of radial clearance due to interference fit

$\triangle S_{RU} \approx k \cdot u$

$\triangle S_{RU}$: Reduction of radial clearance caused by interference fit

[μm] k: Coefficient steel: 0.7–0.9; aluminum: 0.45–0.65

U: Maximum interference amount [μm]

If both the inner ring and the outer ring adopt an interference fit, the reductions from each must be added together to obtain the total reduction in radial clearance.

Reduction of radial clearance due to centrifugal force

At extremely high rotational speeds or in cases where the inner ring is rotating, centrifugal force increases. The load applied to the outer ring and the balls of the bearing also causes the inner ring to expand, which changes the fit between the shaft and the bearing, resulting in slippage of the bearing on the shaft. Under such conditions, a tighter fit must be selected.

# 7. Vibration and Noise

## Introduction

For assembled deep groove ball bearings, the internal condition cannot be observed from the outside. In addition, the vibration and noise performance of deep groove ball bearings must be inspected under actual rotating conditions. Instruments for detecting bearing vibration and noise are generally divided into acceleration type (such as model S0910) and velocity type (such as model BVT).

Acceleration-type vibration testers, on the one hand, are prone to distortion of the measured signal because the resonance frequency of the sensor falls within the working vibration frequency range of the bearing. On the other hand, since the measuring force of the sensor is 5–10 N, this is equivalent to applying a considerable radial force to the outer diameter of the bearing during testing. When measuring extra-miniature bearings, this alters the structural response of the bearing, leading to inaccurate measurement values. Therefore, they will not be further discussed here.

Velocity-type vibration testers produce less distortion in the measured signal because the resonance frequency of the sensor lies outside the working frequency range. Their readings are therefore more reliable. In addition, the measuring force of the sensor is less than 0.7 N, which makes them suitable for extra-miniature bearings.

The indication units of velocity-type vibration testers are generally of two kinds. One is the arithmetic mean value in μm/s, which is adopted in countries such as Sweden and China. The other is the ANDERON unit, which is used in the United States, Japan, Germany, and others. STT is equipped with different testing instruments and can perform various tests according to customer requirements. A brief description using the BVT instrument as an example is given below:

Using the BVT instrument, with the inner ring rotating and the outer ring stationary, the specified preload for each model is applied for inspection. The inner ring is rotated at a speed of 1800 r/min, and the velocity-type pickup device makes contact with the outer circumference of the outer ring to detect mechanical vibration in the radial direction. The vibration transmitted to the stationary outer ring is converted into an electrical signal and output. Instead of detecting air vibrations, the device directly measures rotational vibration, which eliminates the influence of external vibrations and makes it possible to detect extremely slight vibrations.

The detected vibrations are classified into three zones according to different frequency bands, and the instrument displays the vibration magnitude of each band. In addition to the instrument display, headphones (or loudspeakers) may be used to confirm the sound quality across all frequency bands.

| Frequency band | Frequency range (Hz) |
|---|---|
| L: Low-frequency band | 50～300 |
| M: Mid-frequency band | 300-1800 |
| H: High-frequency band | 1800-10000 |

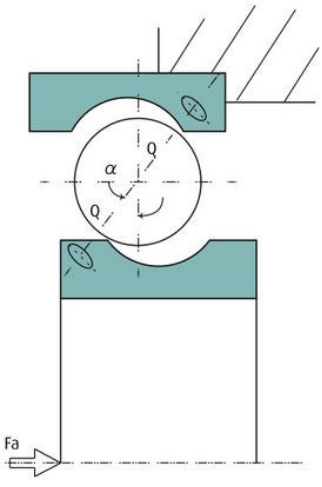


# 8. Preload

## Appropriate Preload

An appropriate preload can be recommended by calculating the "surface pressure". When a preload (Fa) is applied to a deep groove ball bearing, elastic deformation occurs at the contact area between the balls and the raceway groove, creating a minute elliptical contact surface. Surface pressure refers to the value obtained by dividing the vertical component of force (rolling element load) Q at the contact area by the elliptical area.

In the figure below, the contact ellipse formed at the ball–raceway contact area has an area of S = πab, where π is the constant pi, and a and b are the semi-major and semi-minor axes, respectively. If the vertical component of force at the contact area is denoted as Q and the average surface pressure as P, then P = Q / S [MPa].




Method of Calculating "Surface Pressure"

Semi-major axis radius $a$ $e_a \sqrt[3]{\frac{Q}{\sum \rho}}$

Semi-minor axis radius $b$ $e_b \sqrt[3]{\frac{Q}{\sum \rho}}$

$S = \pi ab$

Vertical component of contact force $Q = Fa / (Z \times \sin \alpha)$

Surface pressure $P = Q / S$

Appropriate preload $Fa = P \times S \times Z \times \sin \alpha$

When the applied load used for preloading constitutes the predominant load, the approximate standards for setting the preload amount based on noise life are as follows.

| | |
|---|---|
| For a service life exceeding 10,000 hours, | the preload amount corresponds to an average surface pressure P of less than 800 MPa. |
| 5,000–10,000 hours of service life (standard products): | preload corresponding to an average Surface pressure P of approximately 1000 MPa |
| Less than 5,000 hours of service life (with emphasis on rigidity): | preload corresponding to an average surface pressure P of approximately 1500 MPa |

When setting the preload amount simply on the basis of the basic dynamic load rating (Cr), the following guidelines apply.

For service life exceeding 10,000 hours: 0.5/100 Cr – 1/100 Cr

For service life of 5,000–10,000 hours: 1/100 Cr – 1.5/100 Cr

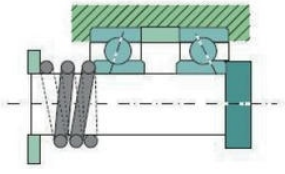
For service life below 5,000 hours: 1.5/100 Cr – 2/100 Cr

## Preload and Rigidity

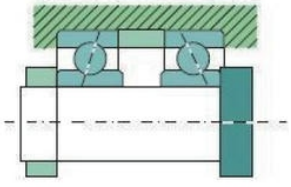
Preloading methods can generally be classified into two categories: constant-pressure preload and fixed-position preload.

- Constant-pressure preload is a method in which preload is applied using components such as coil springs or lock washers. It has the advantage that the preload amount varies little with temperature changes. However, it also has disadvantages, such as an increased number of structural components and relatively lower rigidity.
- Fixed-position preload is a method in which preload is applied based on the positional relationship between components. It offers advantages of having fewer structural parts and higher rigidity. However, it may be affected by thermal expansion or contraction caused by temperature changes, resulting in variations in the preload amount. In addition, component wear may also lead to changes in preload, or even to loss of preload.

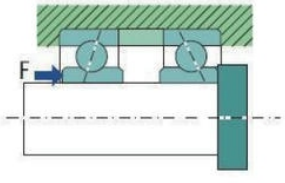
There are generally two preload directions.
"Back-to-back arrangement (DB)" and "Face-to-face arrangement (DF)." The rigidity of the back-to-back arrangement is higher than that of the face-to-face arrangement.



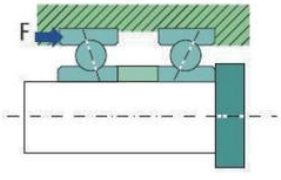
Constant-pressure preload
Preload method



Fixed-position preload
Preload method




Back-to-back arrangement DB
Preload direction




Face-to-face arrangement DF
Preload direction

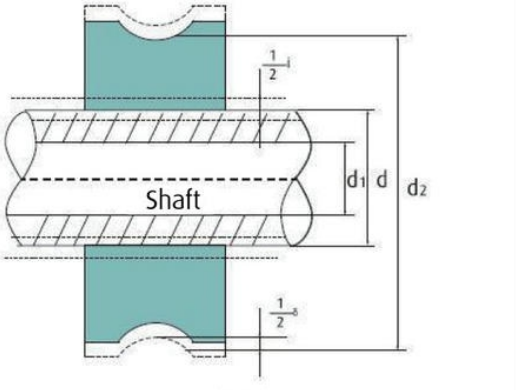
# 9. Fits of Bearings

## Introduction

Deep groove ball bearings are never used alone but always in combination with a shaft and a housing. "Fit" refers to the degree of tightness when the shaft mates with the bore of the inner ring and when the housing mates with the outside diameter of the outer ring. In general, fits are classified into three categories: "clearance fit", "transition fit", and "interference fit."

The purpose of a fit is to suppress runout during rotation, to securely fix the inner ring of the deep groove ball bearing to the shaft, and to fix the outer ring to the housing, thereby preventing harmful slippage (known as creep). If creep occurs, it will result in abnormal heating or the generation of wear particles due to sliding wear.

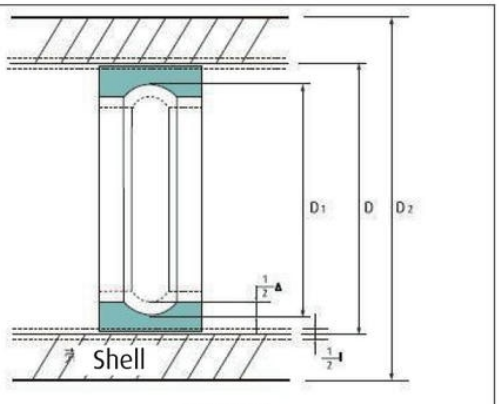
Abnormal heating accelerates the deterioration of grease or the cage, and wear particles entering the bearing will cause vibration or further degradation. If creep occurs, not only will the performance of the deep groove ball bearing fail to be fully realized, but sintering or reduced service life may also result. Therefore, the fit method must be selected according to the intended application. When an interference fit is employed, the radial clearance changes in proportion to the amount of interference. The amount of change in radial clearance with interference can be obtained through the calculation method described previously.




$$\delta = \frac{2i(d_2/d)}{\left\{(d_2/d)^2 - 1\right\}\left[\left\{\frac{(d_2/d)^2+1}{(d_2/d)^2-1} + \frac{1}{m_b}\right\} + \frac{E_b}{E_s}\left\{\frac{(d/d_1)^2+1}{(d/d_1)^2-1} - \frac{1}{m_s}\right\}\right]}$$

The solid line represents the schematic before fitting, and the dashed line represents the schematic after fitting.
When pressed in with an interference amount i, the groove diameter of the inner ring increases by δ.
That is, δ represents the amount of reduction in radial clearance caused by the fit.

δ = Reduction in radial clearance
d = Bore diameter of the inner ring
$d_1$ = Bore diameter of the shaft (taken as 0 for a solid shaft)
$d_2$ = Groove diameter of the inner ring
I = Interference amount
$E_b$ = Young's modulus of the inner ring (or outer ring)
$E_s$ = Young's modulus of the shaft
$m_b$ = Poisson's ratio of the inner ring (or outer ring)
$m_s$ = Poisson's ratio of the shaft




$$\Delta = \frac{2I(D/D_1)}{\left\{(D/D_1)^2 - 1\right\}\left[\left\{\frac{(D/D_1)^2+1}{(D/D_1)^2-1} + \frac{1}{m_b}\right\} + \frac{E_b}{E_h}\left\{\frac{(D_2/D)^2+1}{(D_2/D)^2-1} - \frac{1}{m_h}\right\}\right]}$$

The solid line represents the schematic before fitting, and the dashed line represents the schematic after fitting.
When pressed in with an interference amount I, the groove diameter of the outer ring D1 decreases by △.

△ = Reduction in radial clearance
$D_1$ = Raceway diameter of the outer ring
D = Outside diameter of the outer ring
$D_2$ = Outside diameter of the housing
I = Interference amount
$E_h$ = Young's modulus of the housing
$m_h$ = Poisson's ratio of the housing

## Dimensional Tolerances of Housing Bores for Common Fits

Unit: μm

| Classification of dimensions (mm) | | G | H | | | JS | | | K | | | M | | | N | | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Greater than | Below | G7 | H5 | H6 | H7 | JS5 | JS6 | JS7 | K5 | K6 | K7 | M5 | M6 | M7 | N6 | N7 | P7 |
| - | 3 | +12<br>+2 | +4<br>0 | +6<br>0 | +10<br>0 | ±2 | ±3 | ±5 | 0<br>-4 | 0<br>-6 | 0<br>-10 | -2<br>-6 | -2<br>-8 | -2<br>-12 | -4<br>-10 | -4<br>-14 | -6<br>-16 |
| 3 | 6 | +16<br>+4 | +5<br>0 | +8<br>0 | +12<br>0 | ±2.5 | ±4 | ±6 | 0<br>-5 | +2<br>-6 | +3<br>-9 | -3<br>-8 | -1<br>-9 | 0<br>-12 | -5<br>-13 | -4<br>-16 | -8<br>-20 |
| 6 | 10 | +20<br>+5 | +6<br>0 | +9<br>0 | +15<br>0 | ±3 | ±4.5 | ±7.5 | +1<br>-5 | +2<br>-7 | +5<br>-10 | -4<br>-10 | -3<br>-12 | 0<br>-15 | -7<br>-16 | -4<br>-19 | -9<br>-24 |
| 10 | 18 | +24<br>+6 | +8<br>0 | +11<br>0 | +18<br>0 | ±4 | ±5.5 | ±9 | +2<br>-6 | +2<br>-9 | +6<br>-12 | -4<br>-12 | -4<br>-15 | 0<br>-18 | -9<br>-20 | -5<br>-23 | -11<br>-29 |
| 18 | 30 | +28<br>+7 | +9<br>0 | +13<br>0 | +21<br>0 | ±4.5 | ±6.5 | ±10.5 | +1<br>-8 | +2<br>-11 | +6<br>-15 | -5<br>-14 | -4<br>-17 | 0<br>-21 | -11<br>-24 | -7<br>-28 | -14<br>-35 |

## Dimensional Tolerances of Shafts for Common Fits

Unit: μm

| Classification of dimensions (mm) | | f | g | | h | | | js | | | k | | | m | | n | P | r |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Greater than | Below | f6 | g5 | g6 | h4 | h5 | h6 | js4 | js5 | js6 | k4 | k5 | k6 | m5 | m6 | n6 | P6 | r6 |
| - | 3 | -6<br>-12 | -2<br>-6 | -2<br>-8 | 0<br>-3 | 0<br>-4 | 0<br>-6 | ±1.5 | ±2 | ±3 | +3<br>0 | +4<br>0 | +6<br>0 | +6<br>+2 | +8<br>+2 | +10<br>+4 | +12<br>+6 | +16<br>+10 |
| 3 | 6 | -10<br>-18 | -4<br>-9 | -4<br>-12 | 0<br>-4 | 0<br>-5 | 0<br>-8 | ±2 | ±2.5 | ±4 | +5<br>+1 | +6<br>+1 | +9<br>+1 | +9<br>+4 | +12<br>+4 | +16<br>+8 | +20<br>+12 | +23<br>+15 |
| 6 | 10 | -13<br>-22 | -5<br>-11 | -5<br>-14 | 0<br>-4 | 0<br>-6 | 0<br>-9 | ±2 | ±3 | ±4.5 | +5<br>+1 | +7<br>+1 | +10<br>+1 | +12<br>+6 | +15<br>+6 | +19<br>+10 | +24<br>+15 | +28<br>+19 |

## Fits Relative to the Inner Ring of Deep Groove Ball Bearings [1)]

| Bearing class | Rotating load on the inner ring or load of indeterminate direction | | | | | | | Stationary load on the inner ring | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tolerance grade of the shaft [2)] | | | | | | | | | |
| Class 0, Class 6 | r6 | P6 | n6 | m6<br>m5 | k6<br>k5 | js6<br>js5 | h5 | h6<br>h5 | g6<br>g5 | f6 |
| Class 5 | - | - | - | m5 | k4 | js4 | h4 | h5 | - | - |
| Fit | Interference fit | | | | | Transition fit | | | | Clearance fit |

## Fits Relative to the Outer Ring of Deep Groove Ball Bearings [3)]

| Bearing class | Stationary load on the outer ring | | | | Load of indeterminate direction or rotating load on the outer ring | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Tolerance grade of the bore [2)] | | | | | | | | |
| Class 0, Class 6 | G7 | H7<br>H6 | JS7<br>JS6 | - | JS7<br>JS6 | K7<br>K6 | M7<br>M6 | N7<br>N6 | P7 |
| Class 5 | - | H5 | JS5 | K5 | - | K5 | M5 | - | - |
| Fit | Clearance fit | | Transition fit | | | | | | Interference fit |

1) The permissible deviations of the bearing bore diameter are based on JIS B 1514-1. 2) The representation of tolerance grades follows JIS B 0401.
3) The permissible deviations of the bearing outside diameter are based on JIS B 1514-1.

## Fixing with Adhesives

When fixing deep groove ball bearings to the shaft or housing without interference, but instead using adhesives, please ensure that the clearance selected allows sufficient bonding strength of the adhesive. The appropriate clearance varies depending on the type of adhesive. For details, please consult the respective adhesive manufacturers. In addition, note that the roundness of the raceway ring may deteriorate due to curing stresses of the adhesive.

# 10. Frictional Torque

## The torque of deep groove ball bearings is divided into starting torque and running torque.

- Starting torque refers to the initial torque required to initiate rotation of a stationary deep groove ball bearing. When a deep groove ball bearing is at rest and a load is applied to the shaft through preload or other means, elastic deformation occurs at the contact points between the balls and the raceway grooves (surfaces). To initiate rotation, a force greater than the elastic deformation must be applied. Furthermore, additional force is required to overcome the resistance of the lubricant between the balls and the raceway grooves. These resistances together constitute the starting torque.
- Running torque refers to the resistance generated during rotation by the stirring of lubricant by the balls, raceway grooves, and cage. It also includes friction between the balls and the cage as well as friction between the balls and the raceway grooves. The torque of deep groove ball bearings can cause heat generation and, in applications such as motors, may result in variations in starting current, rated current, rated speed, and current values, or may cause uneven rotation. The following provides examples of such phenomena along with explanations of their causes and countermeasures.

### Failure to Reach Rated Speed

The motor fails to reach its rated speed. Causes include excessive grease filling, the use of a churning-type grease, excessively tight fits, or excessive preload.

### Excessive Starting Current

The reason for excessive motor starting current lies in factors such as the amount of grease, the use of churning-type grease, as well as the influence of preload or fit.

### Uneven Rotation

The speed of a motor in stable rotation suddenly changes and then returns to stable operation. This phenomenon often occurs when grease-filling channels (walls) are damaged, causing grease to enter between the balls and the raceway grooves, resulting in sudden variations in rotational resistance. Torque also changes simultaneously. Improvements can be achieved by reducing the amount of grease applied, switching to grease with better groove performance, or changing to a churning-type grease that does not create reverse channels.

### Rotational Speed and Running Torque

In general, torque increases as rotational speed rises. Preload amount and grease selection must be determined in accordance with the operating speed. With respect to grease filling and running torque, the greater the amount of grease applied, the greater the torque becomes. However, if the amount of grease is reduced solely for the purpose of lowering torque, service life will be adversely affected. Please take due care.

### Temperature and Running Torque

In general, as temperature decreases, running torque increases. This is because the viscosity of the base oil in the grease rises with decreasing temperature.

### Grease Filling Position and Running Torque

The value of running torque also varies depending on the position at which grease is applied. For example, when grease on the cage connects with grease adhering to the outside diameter of the inner ring or the inside diameter of the outer ring and rotates together, torque changes as soon as the connection breaks. This is due to the influence of grease shear force on the torque.

### Load and Running Torque

When a load is applied to deep groove ball bearings, both starting torque and running torque change. For instance, the torque under preload is higher than the torque without preload.

# 11. Bearing Displacement

## Introduction

When deep groove ball bearings are subjected to external loads, deformation occurs at the contact points between the balls and the raceways. This deformation is referred to as displacement.

## Radial Displacement

As shown in the figure below, when a radial load is applied, with the radial load designated as Fr and the maximum load applied to the ball designated as Q, then:

$$Q = \frac{5}{Z} Fr$$

(Z: Number of balls)

The radial displacement $\delta$ at the contact point between the ball and the raceway groove is expressed as follows:

$$\delta = e_{\delta}^{3}\sqrt{\left(\sum\rho\right) Q^{2}}$$

$e_{\delta}$: A coefficient determined by the relationship between the ball and the raceway groove.

$\sum\rho$: The sum of the principal curvatures at the contact point. Since the ball contacts both the inner and outer rings, the total displacement is the sum of the two individual displacements.

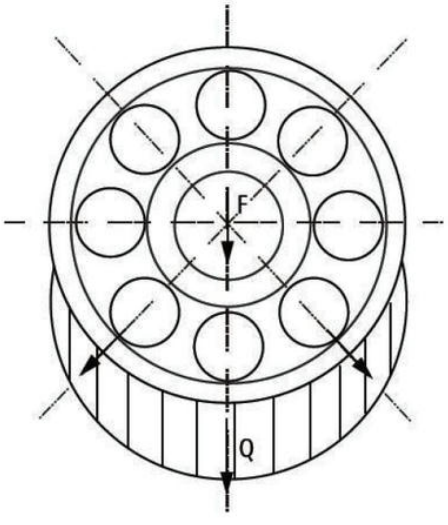
Let: $\delta r$: Total radial displacement

$\delta i$: Radial displacement between the ball and the inner ring raceway groove

$\delta e$: Radial displacement between the ball and the outer ring raceway groove

Then the expression for the total displacement ($\delta r$) is as follows.

$$\delta r = \delta i + \delta e$$



## Axial Displacement

The axial displacement (δt) under axial load (Fa) can be obtained using the following method. Initial contact angle (a0)

$$\alpha_0 = \cos^{-1}\left\{1 - \frac{G_r}{2\left(r_i + r_e - D_W\right)}\right\}$$

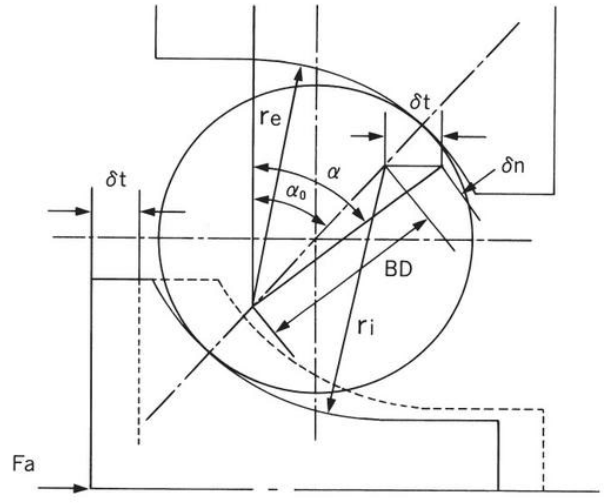
When a single raceway ring is axially shifted so that the bearing clearance (Gr) becomes zero, the initial contact angle generated can be determined by the following equation:

Gr: Radial clearance
$r_i$: Groove radius of the inner ring $r_e$: Groove radius of the outer ring DW: Ball diameter

Relationship between the initial contact angle (a0) and the contact angle (a)

$$\frac{\cos\alpha_0}{\cos\alpha} = 1 + \frac{c \cdot D_W}{\left(r_i + r_e - D_W\right)}\left(\frac{F_a}{Z \cdot D_W{}^2 \cdot \sin\alpha}\right)^{\frac{2}{3}}$$

When an axial load (Fa) is applied under the initial contact condition, the relationship between the contact angle (a) and the initial contact angle (a0) is expressed as follows.




The axial displacement can be obtained from the following equation:

$$\delta_t = \left(r_i + r_e - D_W\right)\left(\sin\alpha - \sin\alpha_0\right) + c \cdot \left(\frac{F_a}{Z}\right)^{\frac{2}{3}}\left(\frac{\sin\alpha}{D_W}\right)^{\frac{1}{3}}$$

where c: Contact elasticity coefficient

# 12. Lubricants

The selection of lubricants is extremely important for deep groove ball bearings and has a significant influence on their performance.

Even when deep groove ball bearings are made of the same material and consist of identical components, their service life, torque, rotational stability, and noise performance may vary depending on the choice of lubricant applied.

Lubricants may be either lubricating oil or grease, and in general the lubricant is not replaced once applied. Typically, the lubrication life of grease is longer than that of oil, and for sealed deep groove ball bearings, grease is adopted as the standard specification.

Grease consists of a thickener and oil (base oil component). Through the fiber-binding or entangled structure of the thickener, grease gradually releases oil in a semi-solid form in a process known as "oil separation", thereby continuously maintaining its lubricating function. A single lubricating oil, by contrast, exhibits high diffusivity and tends to leak easily. In grease, the thickener remains in a solid state, and through oil separation gradually supplies the base oil, thus allowing lubrication performance to be maintained for a longer period compared with oil alone. However, for applications requiring extremely low torque or where torque fluctuation must be prevented, lubricating oil is more suitable than grease. This is because oil, with its higher diffusivity, exerts less influence on torque. Grease, as noted, contains a solid thickener that tends to increase rotational resistance. When using lubricating oil alone as the lubricant, particular attention must be paid to service life.

Additives in grease include antioxidants to prevent base oil oxidation, oiliness agents to enhance boundary lubrication, extreme pressure additives to prevent seizure, and rust inhibitors. Each type of grease has its own specific strengths.

Properties and Characteristics of STT Standard Grease

| Code | Thickener | Base oil | Operating temperature (°C) ❊ | Purpose |
|---|---|---|---|---|
| SL21 | Lithium soap | Diester | -20~+120 | Low temperature, low torque |
| SL01 | Lithium soap | Ester | -40~+150 | Low noise, wide range |
| SL11 | Urea | Synthetic oil | -40~+200 | High speed, high temperature, low noise |
| SL14 | Lithium soap | Synthetic oil | -50~+140 | Low temperature |
| SL12 | Polyurea | Synthetic oil | -50~+120 | Ultra-high speed |
| SL02 | Barium-based | Synthetic hydrocarbon | -60~+170 | High and low temperature |
| SL51 | PTFE | Fluorinated oil | -40~+260 | High temperature |
| SL15 | Polyurea | Ester | -40~+180 | High temperature, low noise |
| L01 | - | Ester | -50~+120 | Low torque, smooth rotation |
| L02 | - | Ester | -50~+100 | Ultra-low torque |

* The numerical values listed are from product catalogs of lubricant manufacturers. They do not represent the operating temperature ranges of bearings.

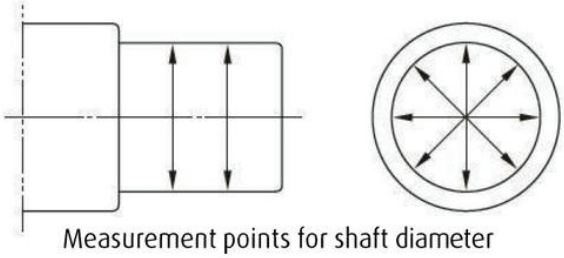
# 13. Installation of Bearings

## Preparation Before Installation

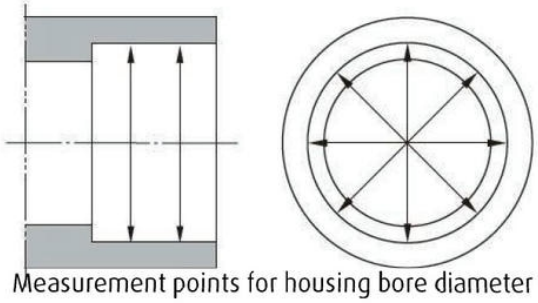
When installing bearings, use clean installation tools and fixtures. Do not open the package until immediately before use. Oils and greases must be stored in sealed containers. The shaft and housing should be cleaned, and it must be confirmed in advance that there are no scratches, indentations, burrs, or similar defects. Do not wash the bearings; they should be used in their original condition.

## Inspection of Shafts and Housings

Confirm whether the dimensions, accuracy, and surface roughness of the shaft and housing meet the specified requirements. If the fitting surfaces are rough, the fit may loosen during operation, sometimes resulting in creep. If the shaft fillet radius is larger than the Radius of the bearing, the shoulder surface may not provide proper support, preventing the bearing from being mounted at a right angle. This will cause torque loads and rotational vibration, thereby shortening service life. When two or more bearings are mounted on the same shaft, temperature variations occur along the shaft length. Therefore, in most cases, one bearing is fixed while the other is allowed axial movement within the shaft. In such cases, it is essential to confirm in advance that there is sufficient axial clearance to permit movement.



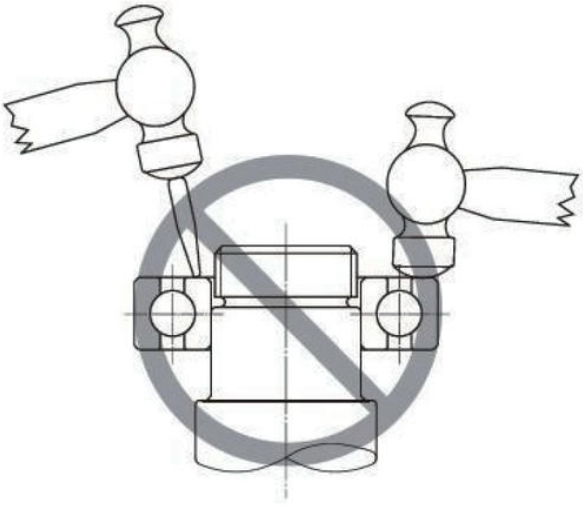
Measurement points for shaft diameter

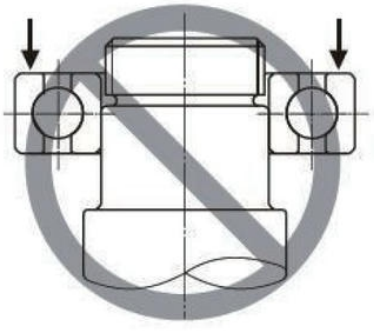


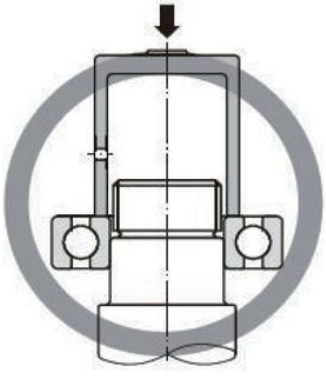
Measurement points for housing bore diameter

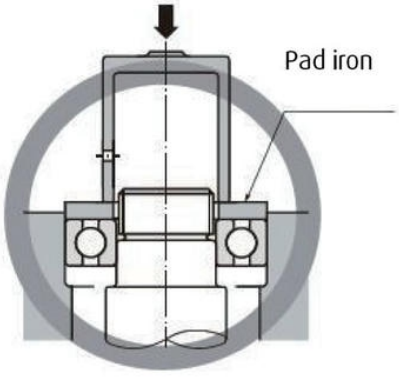
## Installation

When installing bearings, equal pressure must be applied to the circumference of the ring end face to press the ring into place. Do not strike the bearing end face directly with a hammer or similar tool, as this may damage the bearing. Furthermore, if pressure is applied to one ring (for example, the outer ring) and transmitted through the rolling elements to press in the other ring (for example, the inner ring), indentations and scratches may occur on the raceway surface. This method must not be used.









# 14. Handling and Storage of Bearings

## Introduction

Deep groove ball bearings are precision components and must be protected from the ingress of foreign matter. Great importance should be placed on maintaining a clean operating environment.

(1) To prevent rust formation, store bearings in an environment with a temperature of around 20 °C and humidity below 65%. Do not place them directly on the floor; ideally, store them on shelves at least 30 cm above the ground. Avoid locations exposed to direct sunlight or near cold walls.

(2) When bearings are in use, keep the surrounding area clean, and prevent contamination from perspiration or dirt. In addition, handling should follow specified operating requirements and be performed by personnel familiar with bearings. Extra care must be taken to avoid scratches, indentations, and similar damage.

(3) When bearings are stored in acidic air, rust and discoloration may easily occur. Wipe the bearings, shafts, and housings with gloves or cotton yarn. The ingress of dirt into the bearing interior or fitting surfaces can cause abnormalities; therefore, particular caution is required.

# 15. Bearing Damage and Countermeasures

When equipment fitted with deep groove ball bearings fails, or when the bearings are damaged or destroyed, the causes can be identified based on the observed symptoms. By taking corrective measures against such failures, the performance of rolling bearings can be further optimized and maintained. Representative examples of failures and their countermeasures are described as follows.

## Failure Symptoms

| Symptom | | Presumed main causes | Response |
|---|---|---|---|
| Poor rotation | Non-rotation or poor rotation | Effects of lubricants (grease) — quantity, type | Replace the lubricating grease<br>Improvement of driving components (such as motor parts) — increase driving force, etc. |
| | | Contact condition of components | Improvement of operating methods, improvement of design |
| | | Lubrication failure (wear powder) | Replace the lubricant, increase the amount of grease applied, or change the type of grease |
| | | Surface flaking (peeling caused by metal fatigue) | Confirm load conditions and rotational conditions; select a larger-size bearing |
| Noise | Regular noise | Resonance of component parts | Change the dimensions (thickness) of component parts or use alternative materials |
| | | Brinell indentations on the raceway surface | Improve bearing handling, assembly work, and equipment transport operations (check for excessive load or impact load) |
| | | Scars on the raceway surface caused by foreign matter | Improve bearing sealing and working environment |
| | Irregular noise | Insufficient preload | Adjust preload amount based on load and rotational conditions |
| | | Entrapment of foreign matter | Improve bearing sealing and working environment |
| | | Damage to rolling elements | Improve working environment and procedures (prevent foreign matter contamination or excessive load) |
| Excessive vibration | | Excessive internal clearance | Reduce bearing internal clearance |
| | | Improper preload | Adjust preload amount based on load and rotational conditions |
| | | Shaft misalignment | Re-select component dimensional tolerances and cleanliness; improve working procedures |
| | | Raceway deformation | Re-select machining accuracy (roundness) of shaft and housing; replace adhesive; improve bonding operations |
| Temperature rise | | Improper grease type or grease quantity | Re-select grease |
| | | Excessive load | Improve load resistance and enhance “fitting” |
| Grease leakage | | Improper grease type or grease quantity | Re-select grease |
| | | Incorrect selection of dust cover or seal | Re-select dust cover or seal |
| Damage (cracking) of resin materials | | Chemical attack | Improve lubricant, eliminate stress, and re-select resin materials |
| | | Excessive interference fit | Re-select the “fit” |
| | | Weld line | Improve molding conditions, change gate position |

## Examples of Damage

| Damage condition | Presumed cause | Response |
|---|---|---|
| ■ Surface Flaking (Peeling caused by metal fatigue)  | Excessive load | Re-select bearing specifications and load conditions |
| | Poor assembly | Re-select assembly accuracy, and the dimensions and tolerances of shaft and housing |
| | Poor lubrication | Re-select lubricant type and quantity |
| ■ Indentations (Brinell indentations)  | Excessive assembly load | Exercise caution during assembly work |
| | Impact load caused by dropping during handling | Exercise caution during assembly work |
| ■ Raceway Scoring  | Ingress or entrapment of foreign matter | Improve working environment and handling methods |
| | Poor lubrication | Re-select lubricant type and quantity |
| ■ Creep  | Insufficient interference fit | Re-select fitting method and interference fit |
| ■ Electrical Corrosion  | Melting caused by current flow through the bearing | Adopt insulation measures or grounding treatment |

# Chapter C – Supplementary Tables

# Supplementary Table 1: Inch/Metric Conversion Table

| Inch System | | 0" | 1" | 2" | 3" | 4" | 5" | 6" | 7" | 8" | 9" |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Score | Decimal | | | | | | | | | | |
| | | | 25.400 | 50.800 | 76.200 | 101.600 | 127.000 | 152.400 | 177.800 | 203.200 | 228.600 |
| 1/64 | 0.015625 | 0.397 | 25.797 | 51.197 | 76.597 | 101.997 | 127.397 | 152.797 | 178.197 | 203.597 | 228.997 |
| 1/32 | 0.031250 | 0.794 | 26.194 | 51.594 | 76.994 | 102.394 | 127.794 | 153.194 | 178.594 | 203.994 | 229.394 |
| 3/64 | 0.046875 | 1.191 | 26.591 | 51.991 | 77.391 | 102.791 | 128.191 | 153.591 | 178.991 | 204.391 | 229.791 |
| 1/16 | 0.062500 | 1.588 | 26.988 | 52.388 | 77.788 | 103.188 | 128.588 | 153.988 | 179.388 | 204.788 | 230.188 |
| 5/64 | 0.078125 | 1.984 | 27.384 | 52.784 | 78.184 | 103.584 | 128.984 | 154.384 | 179.784 | 205.184 | 230.584 |
| 3/32 | 0.093750 | 2.381 | 27.781 | 53.181 | 48.581 | 103.981 | 129.381 | 154.781 | 180.181 | 205.581 | 230.981 |
| 7/64 | 0.109375 | 2.778 | 28.178 | 53.578 | 78.978 | 104.378 | 129.778 | 155.178 | 180.578 | 205.978 | 231.378 |
| 1/8 | 0.125000 | 3.175 | 28.575 | 53.975 | 79.375 | 104.775 | 130.175 | 155.575 | 180.975 | 206.375 | 231.775 |
| 9/64 | 0.140625 | 3.572 | 28.972 | 54.372 | 79.772 | 105.172 | 130.572 | 155.972 | 181.372 | 206.772 | 232.172 |
| 5/32 | 0.156250 | 3.969 | 29.369 | 54.769 | 80.169 | 105.569 | 130.969 | 156.369 | 181.769 | 207.169 | 232.569 |
| 11/64 | 0.171875 | 4.366 | 29.766 | 55.166 | 80.566 | 105.966 | 131.366 | 156.766 | 182.166 | 207.566 | 232.966 |
| 3/16 | 0.187500 | 4.762 | 30.162 | 55.562 | 80.962 | 106.362 | 131.762 | 157.162 | 182.562 | 207.962 | 233.362 |
| 13/64 | 0.203125 | 5.159 | 30.559 | 55.959 | 81.359 | 106.759 | 132.159 | 157.559 | 182.959 | 208.359 | 233.759 |
| 7/32 | 0.218750 | 5.556 | 30.956 | 56.356 | 81.756 | 107.156 | 132.556 | 157.956 | 183.356 | 208.756 | 234.156 |
| 15/64 | 0.234375 | 5.953 | 31.353 | 56.753 | 82.153 | 107.553 | 132.953 | 158.353 | 183.753 | 209.153 | 234.553 |
| 1/4 | 0.250000 | 6.350 | 31.750 | 57.150 | 82.550 | 107.950 | 133.350 | 158.750 | 184.150 | 209.550 | 234.950 |
| 17/64 | 0.265625 | 6.747 | 32.147 | 57.547 | 82.947 | 108.347 | 133.747 | 159.147 | 184.547 | 209.947 | 235.347 |
| 9/32 | 0.281250 | 7.144 | 32.544 | 57.944 | 83.344 | 108.744 | 134.144 | 159.544 | 184.944 | 210.344 | 235.744 |
| 19/64 | 0.296875 | 7.541 | 32.941 | 58.341 | 83.741 | 109.141 | 134.541 | 159.941 | 185.341 | 210.741 | 236.141 |
| 5/16 | 0.312500 | 7.938 | 33.338 | 58.738 | 84.138 | 109.538 | 134.938 | 160.338 | 185.738 | 211.138 | 236.538 |
| 21/64 | 0.328125 | 8.334 | 33.734 | 59.134 | 84.534 | 109.934 | 135.334 | 160.734 | 186.134 | 211.534 | 236.934 |
| 11/32 | 0.343750 | 8.731 | 34.131 | 59.531 | 84.931 | 110.331 | 135.731 | 161.131 | 186.531 | 211.931 | 237.331 |
| 23/64 | 0.359375 | 9.128 | 34.528 | 59.928 | 85.328 | 110.728 | 136.128 | 161.528 | 186.928 | 212.328 | 237.728 |
| 3/8 | 0.375000 | 9.525 | 34.925 | 60.325 | 85.725 | 111.125 | 136.525 | 161.925 | 187.325 | 212.725 | 238.125 |
| 25/64 | 0.390625 | 9.922 | 35.322 | 60.722 | 86.122 | 111.522 | 136.922 | 162.322 | 187.722 | 213.122 | 238.522 |
| 13/32 | 0.406250 | 10.319 | 35.719 | 61.119 | 86.519 | 111.919 | 137.319 | 162.719 | 188.119 | 213.519 | 238.919 |
| 27/64 | 0.421875 | 10.716 | 36.116 | 61.516 | 86.916 | 112.316 | 137.716 | 163.116 | 188.516 | 213.916 | 239.316 |
| 7/16 | 0.437500 | 11.112 | 36.512 | 61.912 | 87.312 | 112.721 | 138.112 | 163.512 | 188.912 | 214.312 | 239.712 |
| 29/64 | 0.453125 | 11.509 | 36.909 | 62.309 | 87.709 | 113.109 | 138.509 | 163.909 | 189.309 | 214.709 | 240.109 |
| 15/32 | 0.468750 | 11.906 | 37.306 | 62.706 | 88.106 | 113.506 | 138.906 | 164.306 | 189.706 | 215.106 | 240.506 |
| 31/64 | 0.484375 | 12.303 | 37.703 | 63.103 | 88.503 | 113.903 | 139.303 | 164.703 | 190.103 | 215.503 | 240.903 |
| 1/2 | 0.500000 | 12.700 | 38.100 | 63.500 | 88.900 | 114.300 | 139.700 | 165.100 | 190.500 | 215.900 | 241.300 |
| 33/64 | 0.515625 | 13.097 | 38.497 | 63.897 | 89.297 | 114.697 | 140.097 | 165.497 | 190.897 | 216.297 | 241.697 |
| 17/32 | 0.531250 | 13.494 | 38.894 | 64.294 | 89.694 | 115.094 | 140.494 | 165.894 | 191.294 | 216.694 | 242.094 |
| 35/64 | 0.546875 | 13.891 | 39.291 | 64.691 | 90.091 | 115.491 | 140.891 | 166.291 | 191.691 | 217.091 | 242.491 |
| 9/16 | 0.562500 | 14.288 | 39.688 | 65.088 | 90.488 | 115.888 | 141.283 | 166.688 | 192.088 | 217.488 | 242.888 |
| 37/64 | 0.578125 | 14.684 | 40.084 | 65.484 | 90.884 | 116.284 | 141.684 | 167.084 | 192.484 | 217.884 | 243.284 |
| 19/32 | 0.593750 | 15.081 | 40.481 | 65.881 | 91.281 | 116.681 | 142.081 | 167.481 | 192.881 | 218.281 | 243.681 |
| 39/64 | 0.609375 | 15.478 | 40.878 | 66.278 | 91.678 | 117.078 | 142.478 | 167.878 | 193.278 | 218.678 | 244.078 |
| 5/8 | 0.625000 | 15.875 | 41.275 | 66.675 | 92.075 | 117.475 | 142.875 | 168.275 | 193.675 | 219.075 | 244.475 |
| 41/64 | 0.640625 | 16.272 | 41.672 | 67.072 | 92.472 | 117.872 | 143.272 | 168.672 | 194.072 | 219.472 | 244.872 |
| 21/32 | 0.656250 | 16.669 | 42.069 | 67.469 | 92.869 | 118.269 | 143.669 | 169.069 | 194.469 | 219.869 | 245.269 |
| 43/64 | 0.671875 | 17.066 | 42.466 | 67.866 | 93.266 | 118.666 | 144.066 | 169.466 | 194.866 | 220.266 | 245.666 |
| 11/16 | 0.687500 | 17.462 | 42.862 | 68.262 | 93.662 | 119.062 | 144.462 | 169.862 | 195.262 | 220.662 | 246.062 |
| 45/64 | 0.703125 | 17.859 | 43.259 | 68.659 | 94.059 | 119.459 | 144.859 | 170.259 | 195.659 | 221.056 | 246.459 |
| 23/32 | 0.718750 | 18.256 | 43.656 | 69.056 | 94.456 | 119.856 | 145.256 | 170.656 | 196.056 | 221.456 | 246.856 |
| 47/64 | 0.734375 | 18.653 | 44.053 | 69.453 | 94.853 | 120.253 | 145.653 | 171.053 | 196.453 | 221.853 | 247.253 |
| 3/4 | 0.750000 | 19.050 | 44.450 | 69.850 | 95.250 | 120.650 | 146.050 | 171.450 | 196.850 | 222.250 | 247.650 |
| 49/64 | 0.765625 | 19.447 | 44.847 | 70.247 | 95.647 | 121.047 | 146.447 | 171.847 | 197.247 | 222.647 | 248.047 |
| 25/32 | 0.781250 | 19.844 | 45.244 | 70.644 | 96.044 | 121.444 | 146.844 | 172.244 | 197.644 | 223.044 | 248.444 |
| 51/64 | 0.796875 | 20.241 | 45.641 | 71.041 | 96.441 | 121.841 | 147.241 | 172.641 | 198.041 | 223.441 | 248.841 |
| 13/16 | 0.812500 | 20.638 | 46.038 | 71.438 | 96.838 | 122.238 | 147.638 | 173.038 | 198.438 | 223.838 | 249.238 |
| 53/64 | 0.828125 | 21.034 | 46.434 | 71.834 | 97.234 | 122.634 | 148.034 | 173.434 | 198.834 | 224.234 | 249.634 |
| 27/32 | 0.843750 | 21.431 | 46.831 | 72.231 | 97.631 | 123.031 | 148.431 | 173.831 | 199.231 | 224.631 | 250.031 |
| 55/64 | 0.859375 | 21.828 | 47.228 | 72.628 | 98.028 | 123.428 | 148.828 | 174.228 | 199.628 | 225.028 | 250.428 |
| 7/8 | 0.875000 | 22.225 | 47.625 | 73.025 | 98.425 | 123.825 | 149.225 | 174.625 | 200.025 | 225.425 | 250.825 |
| 57/64 | 0.890625 | 22.622 | 48.022 | 73.422 | 98.822 | 124.222 | 149.622 | 175.022 | 200.422 | 225.822 | 251.222 |
| 29/32 | 0.906250 | 23.019 | 48.419 | 73.819 | 99.219 | 124.619 | 150.019 | 175.419 | 200.819 | 226.219 | 251.619 |
| 59/64 | 0.921875 | 23.416 | 48.816 | 74.216 | 99.616 | 125.016 | 150.416 | 175.816 | 201.216 | 226.616 | 252.016 |
| 15/16 | 0.937500 | 23.812 | 49.212 | 74.612 | 100.012 | 125.412 | 150.812 | 176.212 | 201.612 | 227.012 | 252.412 |
| 61/64 | 0.953125 | 24.209 | 49.609 | 75.009 | 100.409 | 125.809 | 151.209 | 176.609 | 202.009 | 227.409 | 252.809 |
| 31/32 | 0.968750 | 24.606 | 50.006 | 75.406 | 100.806 | 126.206 | 151.606 | 177.006 | 202.406 | 227.806 | 253.206 |
| 63/64 | 0.984375 | 25.003 | 50.403 | 75.803 | 101.203 | 126.603 | 152.003 | 177.403 | 202.803 | 228.203 | 253.603 |

# Supplementary Table 2: Hardness Conversion Table (Reference)

| Rockwell hardness | Brinell hardness | Rockwell hardness | | Vickers hardness | | Shore hardness |
|---|---|---|---|---|---|---|
| Class C 1471.0 N {150kgf} | | Standard steel ball | Tungsten carbide ball | Class A 588.4 N {60kgf} | Class B 980.7 N {100kgf} | |
| 68 | 940 | | | 85.6 | | 97 |
| 67 | 900 | | | 85.0 | | 95 |
| 66 | 865 | | | 84.5 | | 92 |
| 65 | 832 | | 739 | 83.9 | | 91 |
| 64 | 800 | | 722 | 83.4 | | 88 |
| 63 | 772 | | 705 | 82.8 | | 67 |
| 62 | 746 | | 688 | 82.3 | | 85 |
| 61 | 720 | | 670 | 81.8 | | 83 |
| 60 | 697 | | 654 | 81.2 | | 81 |
| 59 | 674 | | 634 | 80.7 | | 80 |
| 58 | 653 | | 615 | 80.1 | | 78 |
| 57 | 633 | | 595 | 79.6 | | 76 |
| 56 | 613 | | 577 | 79.0 | | 75 |
| 55 | 595 | — | 560 | 78.5 | | 74 |
| 54 | 577 | — | 543 | 78.0 | | 72 |
| 53 | 560 | — | 525 | 77.4 | | 71 |
| 52 | 544 | 500 | 512 | 76.8 | | 69 |
| 51 | 528 | 487 | 496 | 76.3 | | 68 |
| 50 | 513 | 475 | 481 | 75.9 | | 67 |
| 49 | 498 | 464 | 469 | 75.2 | | 66 |
| 48 | 464 | 461 | 455 | 74.7 | | 64 |
| 47 | 471 | 442 | 443 | 74.1 | | 63 |
| 46 | 458 | 432 | 432 | 73.6 | | 62 |
| 45 | 446 | 421 | 421 | 73.1 | | 60 |
| 44 | 434 | 409 | 409 | 72.5 | | 58 |
| 43 | 423 | 400 | 400 | 72.0 | | 57 |
| 42 | 412 | 390 | 390 | 71.5 | | 56 |
| 41 | 402 | 381 | 381 | 70.9 | | 55 |
| 40 | 392 | 371 | 371 | 70.4 | — | 54 |
| 39 | 382 | 362 | 362 | 69.9 | — | 52 |
| 38 | 372 | 353 | 353 | 69.4 | — | 51 |
| 37 | 363 | 344 | 344 | 68.9 | — | 50 |
| 36 | 354 | 336 | 336 | 68.4 | (109.0) | 49 |
| 35 | 345 | 327 | 327 | 67.9 | (108.5) | 48 |
| 34 | 336 | 319 | 319 | 67.4 | (108.0) | 47 |
| 33 | 327 | 311 | 311 | 66.8 | (107.5) | 46 |
| 32 | 318 | 301 | 301 | 66.3 | (107.0) | 44 |
| 31 | 310 | 294 | 294 | 65.8 | (106.0) | 43 |
| 30 | 302 | 286 | 286 | 65.3 | (105.5) | 42 |
| 29 | 294 | 279 | 279 | 64.7 | (104.5) | 41 |
| 28 | 286 | 271 | 271 | 64.3 | (104.0) | 41 |
| 27 | 279 | 264 | 264 | 63.8 | (103.0) | 40 |
| 26 | 272 | 258 | 258 | 63.3 | (102.5) | 38 |
| 25 | 266 | 253 | 253 | 62.8 | (101.5) | 38 |
| 24 | 260 | 247 | 247 | 62.4 | (101.0) | 37 |
| 23 | 254 | 243 | 243 | 62.0 | 100.0 | 36 |
| 22 | 248 | 237 | 237 | 61.5 | 99.0 | 35 |
| 21 | 243 | 231 | 231 | 61.0 | 98.5 | 35 |
| 20 | 238 | 226 | 226 | 60.5 | 97.8 | 34 |
| (18) | 230 | 219 | 219 | — | 96.7 | 33 |
| (16) | 222 | 212 | 212 | — | 95.5 | 32 |
| (14) | 213 | 203 | 203 | — | 93.9 | 31 |
| (12) | 204 | 194 | 194 | — | 92.3 | 29 |
| (10) | 196 | 187 | 187 | | 90.7 | 26 |
| (8) | 188 | 179 | 179 | | 89.5 | 27 |
| (6) | 180 | 171 | 171 | | 87.1 | 26 |
| (4) | 173 | 165 | 165 | | 85.5 | 25 |
| (2) | 166 | 158 | 158 | | 83.5 | 24 |
| (0) | 160 | 152 | 152 | | 81.7 | 24 |

Quoted from Hardness Conversion Table SAE J417

# Supplementary Table 3: Shaft and Housing Bore Dimensional Tolerance Table

## Shaft Dimensional Tolerances

| Shaft diameter dimensions mm | | a13 | | c12 | | d6 | | e6 | | e13 | | f5 | | f6 | | g5 | | g6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exceeding | Including | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower |
| 3 | 6 | -270 | -450 | -70 | -190 | -30 | -38 | -20 | -28 | -20 | -200 | -10 | -15 | -10 | -18 | -4 | -9 | -4 | -12 |
| 6 | 10 | -280 | -500 | -80 | -230 | -40 | -49 | -25 | -34 | -25 | -245 | -13 | -19 | -13 | -22 | -5 | -11 | -5 | -14 |
| 10 | 18 | -290 | -560 | -95 | -275 | -50 | -61 | -32 | -43 | -32 | -302 | -16 | -24 | -16 | -27 | -6 | -14 | -6 | -17 |
| 18 | 30 | -300 | -630 | -110 | -320 | -65 | -78 | -40 | -53 | -40 | -370 | -20 | -29 | -20 | -33 | -7 | -16 | -7 | -20 |
| 30 | 40 | 310 | 700 | -120 | 370 | -80 | -96 | -50 | -66 | -50 | -440 | -25 | -36 | -25 | -41 | -9 | -20 | -9 | -25 |
| 40 | 50 | 320 | 710 | -130 | 380 | | | | | | | | | | | | | | |
| 50 | 65 | 340 | -800 | -140 | 440 | -100 | -119 | -60 | -79 | -60 | -520 | -30 | -43 | -30 | -49 | -10 | -23 | -10 | -29 |
| 65 | 80 | 360 | -820 | -150 | 450 | | | | | | | | | | | | | | |
| 80 | 100 | 380 | 920 | -170 | 520 | -120 | -142 | -72 | -94 | -72 | -612 | -36 | -51 | -36 | -58 | -12 | -27 | -12 | -34 |
| 100 | 120 | 410 | 950 | -180 | 530 | | | | | | | | | | | | | | |
| 120 | 140 | 460 | -1090 | -200 | -600 | -145 | -170 | -85 | -110 | -85 | -715 | -43 | -61 | -43 | -68 | -14 | -32 | -14 | -39 |
| 140 | 160 | 520 | -1150 | -210 | -610 | | | | | | | | | | | | | | |
| 160 | 180 | -580 | -1210 | -230 | -630 | | | | | | | | | | | | | | |
| 180 | 200 | -660 | -1380 | -240 | -700 | -170 | -199 | -100 | -129 | -100 | -820 | -50 | -70 | -50 | -79 | -15 | -35 | -15 | -44 |
| 200 | 225 | -740 | -1460 | -260 | -720 | | | | | | | | | | | | | | |
| 225 | 250 | -820 | -1540 | -280 | -740 | | | | | | | | | | | | | | |
| 250 | 280 | -920 | -1730 | -300 | -820 | -190 | -222 | -110 | -142 | -110 | -920 | -56 | -79 | -56 | -88 | -17 | -40 | -17 | -49 |
| 280 | 315 | -1050 | -1860 | -330 | -850 | | | | | | | | | | | | | | |
| 315 | 355 | -1200 | -2090 | -360 | 930 | -210 | -246 | -125 | -161 | -125 | -1015 | -62 | -87 | -62 | -98 | -18 | -43 | -18 | -54 |
| 355 | 400 | -1350 | -2240 | -400 | 970 | | | | | | | | | | | | | | |
| 400 | 450 | -1500 | -2470 | -440 | -1070 | -230 | -270 | -135 | -175 | -135 | -1105 | -68 | -95 | -68 | -108 | -20 | -47 | -20 | -60 |
| 450 | 500 | -1650 | -2620 | -480 | -1110 | | | | | | | | | | | | | | |
| 500 | 560 | - | - | - | - | -260 | -304 | -145 | -189 | - | - | - | - | -76 | -120 | - | - | -22 | -66 |
| 560 | 630 | | | | | | | | | | | | | | | | | | |
| 630 | 710 | - | - | - | - | -290 | -340 | -160 | -210 | - | - | - | - | -80 | -130 | - | - | -24 | -74 |
| 710 | 800 | | | | | | | | | | | | | | | | | | |
| 800 | 900 | - | - | - | - | -320 | -376 | -170 | -226 | - | - | - | - | -86 | -142 | - | - | -26 | -82 |
| 900 | 1000 | | | | | | | | | | | | | | | | | | |
| 1000 | 1120 | - | - | - | - | -350 | -416 | -195 | -261 | - | - | - | - | -98 | -164 | - | - | -28 | -94 |
| 1120 | 1,250 | | | | | | | | | | | | | | | | | | |
| 1250 | 1400 | - | - | - | - | -390 | -468 | -220 | -298 | - | - | - | - | -110 | -188 | - | - | -30 | -108 |
| 1400 | 1600 | | | | | | | | | | | | | | | | | | |

| Shaft diameter dimensions mm | | j13 | | js5 | | j6 | | js6 | | j7 | | k4 | | k5 | | k6 | | m5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exceeding | Including | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower |
| 3 | 6 | +3 | -2 | +2.5 | -2.5 | +6 | -2 | +4 | -4 | +8 | -4 | +5 | +1 | +6 | +1 | +9 | +1 | +9 | +4 |
| 6 | 10 | +4 | -2 | +3 | -3 | +7 | -2 | +4.5 | -4.5 | +10 | -5 | +5 | +1 | +7 | +1 | +10 | +1 | +12 | +6 |
| 10 | 18 | +5 | -3 | +4 | -4 | +8 | -3 | +5.5 | -5.5 | +12 | -6 | +6 | +1 | +9 | +1 | +12 | +1 | +15 | +7 |
| 18 | 30 | +5 | -4 | +4.5 | -4.5 | +9 | -4 | +6.5 | -6.5 | +13 | -8 | +8 | +2 | +11 | +2 | +15 | +2 | +17 | +8 |
| 30 | 40 | +6 | -5 | +5.5 | -5.5 | +11 | -5 | +8 | -8 | +15 | -10 | +9 | +2 | +13 | +2 | +18 | +2 | +20 | +9 |
| 40 | 50 | | | | | | | | | | | | | | | | | | |
| 50 | 65 | +6 | -7 | +6.5 | -6.5 | +12 | -7 | +9.5 | -9.5 | +18 | -12 | +10 | +2 | +15 | +2 | +21 | +2 | +24 | +11 |
| 65 | 80 | | | | | | | | | | | | | | | | | | |
| 80 | 100 | +6 | -9 | +7.5 | -7.5 | +13 | -9 | +11 | -11 | +20 | -15 | +13 | +3 | +18 | +3 | +25 | +3 | +28 | +13 |
| 100 | 120 | | | | | | | | | | | | | | | | | | |
| 120 | 140 | +7 | -11 | +9 | -9 | +14 | -11 | +12.5 | -12.5 | +22 | -18 | +15 | +3 | +21 | +3 | +28 | +3 | +33 | +15 |
| 140 | 160 | | | | | | | | | | | | | | | | | | |
| 160 | 180 | | | | | | | | | | | | | | | | | | |
| 180 | 200 | +7 | -13 | +10 | -10 | +16 | -13 | +14.5 | -14.5 | +25 | -21 | +18 | +4 | +24 | +4 | +33 | +4 | +37 | +17 |
| 200 | 225 | | | | | | | | | | | | | | | | | | |
| 225 | 250 | | | | | | | | | | | | | | | | | | |
| 250 | 280 | +7 | -16 | +11.5 | -11.5 | +16 | -16 | +16 | -16 | +26 | -26 | +20 | +4 | +27 | +4 | +36 | +4 | +43 | +20 |
| 280 | 315 | | | | | | | | | | | | | | | | | | |
| 315 | 355 | +7 | -18 | +12.5 | -12.5 | +18 | -18 | +18 | -18 | +29 | -28 | +22 | +4 | +29 | +4 | +40 | +4 | +46 | +21 |
| 355 | 400 | | | | | | | | | | | | | | | | | | |
| 400 | 450 | +7 | -20 | +13.5 | -13.5 | +20 | -20 | +20 | -20 | +31 | -32 | +25 | +5 | +32 | +5 | +45 | +5 | +50 | +23 |
| 450 | 500 | | | | | | | | | | | | | | | | | | |
| 500 | 560 | - | - | - | - | - | - | +22 | -22 | - | - | - | - | - | - | +44 | 0 | - | - |
| 560 | 630 | | | | | | | | | | | | | | | | | | |
| 630 | 710 | - | - | - | - | - | - | +25 | -25 | - | - | - | - | - | - | +50 | 0 | - | - |
| 710 | 800 | | | | | | | | | | | | | | | | | | |
| 800 | 900 | - | - | - | - | - | - | +28 | -28 | - | - | - | - | - | - | +56 | 0 | - | - |
| 900 | 1000 | | | | | | | | | | | | | | | | | | |
| 1000 | 1120 | - | - | - | - | - | - | +33 | -33 | - | - | - | - | - | - | +66 | 0 | - | - |
| 1120 | 1,250 | | | | | | | | | | | | | | | | | | |
| 1250 | 1400 | - | - | - | - | - | - | +39 | -39 | - | - | - | - | - | - | +78 | 0 | - | - |
| 1400 | 1600 | | | | | | | | | | | | | | | | | | |

Unit: μm

| h4 | | h5 | | h6 | | h7 | | h8 | | h9 | | h10 | | h11 | | h13 | | js4 | | Shaft diameter dimensions mm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Exceeding | Including |
| 0 | -4 | 0 | -5 | 0 | -8 | 0 | -12 | 0 | -18 | 0 | -30 | 0 | -48 | 0 | -75 | 0 | -180 | +2 | -2 | 3 | 6 |
| 0 | -4 | 0 | -6 | 0 | -9 | 0 | -15 | 0 | -22 | 0 | -36 | 0 | -58 | 0 | -90 | 0 | -220 | +2 | -2 | 6 | 10 |
| 0 | -5 | 0 | -8 | 0 | -11 | 0 | -18 | 0 | -27 | 0 | -43 | 0 | -70 | 0 | -110 | 0 | -270 | +2.5 | -2.5 | 10 | 18 |
| 0 | -6 | 0 | -9 | 0 | -13 | 0 | -21 | 0 | -33 | 0 | -52 | 0 | -84 | 0 | -130 | 0 | -330 | +3 | -3 | 18 | 30 |
| 0 | -7 | 0 | -11 | 0 | -16 | 0 | -25 | 0 | -39 | 0 | -62 | 0 | -100 | 0 | -160 | 0 | -390 | +3.5 | -3.5 | 30<br>40 | 40<br>50 |
| 0 | -8 | 0 | -13 | 0 | -19 | 0 | -30 | 0 | -46 | 0 | -74 | 0 | -120 | 0 | -190 | 0 | -460 | +4 | -4 | 50<br>65 | 65<br>80 |
| 0 | -10 | 0 | -15 | 0 | -22 | 0 | -35 | 0 | -54 | 0 | -87 | 0 | -140 | 0 | -220 | 0 | -540 | +5 | -5 | 80<br>100 | 100<br>120 |
| 0 | -12 | 0 | -18 | 0 | -25 | 0 | -40 | 0 | -63 | 0 | -100 | 0 | -160 | 0 | -250 | 0 | -630 | +6 | -6 | 120<br>140<br>160 | 140<br>160<br>180 |
| 0 | -14 | 0 | -20 | 0 | -29 | 0 | -46 | 0 | -72 | 0 | -115 | 0 | -185 | 0 | -290 | 0 | -720 | +7 | -7 | 180<br>200<br>225 | 200<br>225<br>250 |
| 0 | -16 | 0 | -23 | 0 | -32 | 0 | -52 | 0 | -81 | 0 | -130 | 0 | -210 | 0 | -320 | 0 | -810 | +8 | -8 | 250<br>280 | 280<br>315 |
| 0 | -18 | 0 | -25 | 0 | -36 | 0 | -57 | 0 | -89 | 0 | -140 | 0 | -230 | 0 | -360 | 0 | -890 | +9 | -9 | 315<br>355 | 355<br>400 |
| 0 | -20 | 0 | -27 | 0 | -40 | 0 | -63 | 0 | -97 | 0 | -155 | 0 | -250 | 0 | -400 | 0 | -970 | +10 | -10 | 400<br>450 | 450<br>500 |
| - | - | - | - | 0 | -44 | 0 | -70 | 0 | -110 | 0 | -175 | 0 | -280 | 0 | -440 | 0 | - | - | - | 500<br>560 | 560<br>630 |
| - | - | - | - | 0 | -50 | 0 | -80 | 0 | -125 | 0 | -200 | 0 | -320 | 0 | -500 | 0 | - | - | - | 630<br>710 | 710<br>800 |
| - | - | - | - | 0 | -56 | 0 | -90 | 0 | -140 | 0 | -230 | 0 | -360 | 0 | -560 | 0 | - | - | - | 800<br>900 | 900<br>1000 |
| - | - | - | - | 0 | -66 | 0 | -105 | 0 | -165 | 0 | -260 | 0 | -420 | 0 | -660 | 0 | - | - | - | 1000<br>1120 | 1120<br>1,250 |
| - | - | - | - | 0 | -78 | 0 | -125 | 0 | -195 | 0 | -310 | 0 | -500 | 0 | -780 | 0 | - | - | - | 1250<br>1400 | 1400<br>1600 |

Unit: μm

| m6 | | n5 | | n6 | | p5 | | P6 | | r6 | | r7 | | Standard accuracy | | | | Shaft diameter dimensions mm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | IT2 | IT3 | IT5 | IT7 | Exceeding | Including |
| +12 | +4 | +13 | +8 | +16 | +8 | +17 | +12 | +20 | +12 | +23 | +15 | +27 | +15 | 1.5 | 2.5 | 5 | 12 | 3 | 6 |
| +15 | +6 | +16 | +10 | +19 | +10 | +21 | +15 | +24 | +15 | +28 | +19 | +34 | +19 | 1.5 | 2.5 | 6 | 15 | 6 | 10 |
| +18 | +7 | +20 | +12 | +23 | +12 | +26 | +18 | +29 | +18 | +34 | +23 | +41 | +23 | 2 | 3 | 8 | 18 | 10 | 18 |
| +21 | +8 | +24 | +15 | +28 | +15 | +31 | +22 | +35 | +22 | +41 | +28 | +49 | +28 | 2.5 | 4 | 9 | 21 | 18 | 30 |
| +25 | +9 | +28 | +17 | +33 | +17 | +37 | +26 | +42 | +26 | +50 | +34 | +59 | +34 | 2.5 | 4 | 11 | 25 | 30<br>40 | 40<br>50 |
| +30 | +11 | +33 | +20 | +39 | +20 | +45 | +32 | +51 | +32 | +60<br>+62 | +41<br>+43 | +71<br>+73 | +41<br>+43 | 3 | 5 | 13 | 30 | 50<br>65 | 65<br>80 |
| +35 | +13 | +38 | +23 | +45 | +23 | +52 | +37 | +59 | +37 | +73<br>+76 | +51<br>+54 | +86<br>+89 | +51<br>+54 | 4 | 6 | 15 | 35 | 80<br>100 | 100<br>120 |
| +40 | +15 | +45 | +27 | +52 | +27 | +61 | +43 | +68 | +43 | +88<br>+90<br>+93 | +63<br>+65<br>+68 | +103<br>+105<br>+108 | +63<br>+65<br>+68 | 5 | 8 | 18 | 40 | 120<br>140<br>160 | 140<br>160<br>180 |
| +46 | +17 | +51 | +31 | +60 | +31 | +70 | +50 | +79 | +50 | +106<br>+109<br>+113 | +77<br>+80<br>+84 | +123<br>+126<br>+130 | +77<br>+80<br>+84 | 7 | 10 | 20 | 46 | 180<br>200<br>225 | 200<br>225<br>250 |
| +52 | +20 | +57 | +34 | +66 | +34 | +79 | +56 | +88 | +56 | +126<br>+130 | +94<br>+98 | +146<br>+150 | +94<br>+98 | 8 | 12 | 23 | 52 | 250<br>280 | 280<br>315 |
| +57 | +21 | +62 | +37 | +73 | +37 | +87 | +62 | +98 | +62 | +144<br>+150 | +108<br>+114 | +165<br>+171 | +108<br>+114 | 9 | 13 | 25 | 57 | 315<br>355 | 355<br>400 |
| +63 | +23 | +67 | +40 | +80 | +40 | +95 | +68 | +108 | +68 | +166<br>+172 | +126<br>+132 | +189<br>+195 | +126<br>+132 | 10 | 15 | 27 | 63 | 400<br>450 | 450<br>500 |
| +70 | +26 | - | - | +88 | +44 | - | - | +122 | +78 | +194<br>+199 | +150<br>+155 | +220<br>+225 | +150<br>+155 | - | - | - | 70 | 500<br>560 | 560<br>630 |
| +80 | +30 | - | - | +100 | +50 | - | - | +138 | +88 | +225<br>+235 | +175<br>+185 | +255<br>+265 | +175<br>+185 | - | - | - | 80 | 630<br>710 | 710<br>800 |
| +90 | +34 | - | - | +112 | +56 | - | - | +156 | +100 | +266<br>+276 | +210<br>+220 | +300<br>+310 | +210<br>+220 | - | - | - | 90 | 800<br>900 | 900<br>1000 |
| +106 | +40 | - | - | +132 | +66 | - | - | +186 | +120 | +316<br>+326 | +250<br>+260 | +355<br>+365 | +250<br>+260 | - | - | - | 105 | 1000<br>1120 | 1120<br>1,250 |
| +126 | +48 | - | - | +156 | +78 | - | - | +218 | +140 | +378<br>+408 | +300<br>+330 | +425<br>+455 | +300<br>+330 | - | - | - | 125 | 1250<br>1400 | 1400<br>1600 |

## • Housing Bore Dimensional Tolerances

| Housing bore dimensions mm | | E7 | | E10 | | E11 | | E12 | | F6 | | F7 | | F8 | | G6 | | G7 | | H6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exceeding | Including | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower |
| 3 | 6 | +32 | +20 | +68 | +20 | +95 | +20 | +140 | +20 | +18 | +10 | +22 | +10 | +28 | +10 | +12 | +4 | +16 | +4 | +8 | 0 |
| 6 | 10 | +40 | +25 | +83 | +25 | +115 | +25 | +175 | +25 | +22 | +13 | +28 | +13 | +35 | +13 | +14 | +5 | +20 | +5 | +9 | 0 |
| 10 | 18 | +50 | +32 | +102 | +32 | +142 | +32 | +212 | +32 | +27 | +16 | +34 | +16 | +43 | +16 | +17 | +6 | +24 | +6 | +11 | 0 |
| 18 | 30 | +61 | +40 | +124 | +40 | +170 | +40 | +250 | +40 | +33 | +20 | +41 | +20 | +53 | +20 | +20 | +7 | +28 | +7 | +13 | 0 |
| 30 | 40 | +75 | +50 | +150 | +50 | +210 | +50 | +300 | +50 | +41 | +25 | +50 | +25 | +64 | +25 | +25 | +9 | +34 | +9 | +16 | 0 |
| 40 | 50 | | | | | | | | | | | | | | | | | | | | |
| 50 | 65 | +90 | +60 | +180 | +60 | +250 | +60 | +360 | +60 | +49 | +30 | +60 | +30 | +76 | +30 | +29 | +10 | +40 | +10 | +19 | 0 |
| 65 | 80 | | | | | | | | | | | | | | | | | | | | |
| 80 | 100 | +107 | +72 | +212 | +72 | +292 | +72 | +422 | +72 | +58 | +36 | +71 | +36 | +90 | +36 | +34 | +12 | +47 | +12 | +22 | 0 |
| 100 | 120 | | | | | | | | | | | | | | | | | | | | |
| 120 | 140 | +125 | +85 | +245 | +85 | +335 | +85 | +485 | +85 | +68 | +43 | +83 | +43 | +106 | +43 | +39 | +14 | +54 | +14 | +25 | 0 |
| 140 | 160 | | | | | | | | | | | | | | | | | | | | |
| 160 | 180 | | | | | | | | | | | | | | | | | | | | |
| 180 | 200 | +146 | +100 | +285 | +100 | +390 | +100 | +560 | +100 | +79 | +50 | +96 | +50 | +122 | +50 | +44 | +15 | +61 | +15 | +29 | 0 |
| 200 | 225 | | | | | | | | | | | | | | | | | | | | |
| 225 | 250 | | | | | | | | | | | | | | | | | | | | |
| 250 | 280 | +162 | +110 | +320 | +110 | +430 | +110 | +630 | +110 | +88 | +56 | +108 | +56 | +137 | +56 | +49 | +17 | +69 | +17 | +32 | 0 |
| 280 | 315 | | | | | | | | | | | | | | | | | | | | |
| 315 | 355 | +182 | +125 | +355 | +125 | +485 | +125 | +695 | +125 | +98 | +62 | +119 | +62 | +151 | +62 | +54 | +18 | +75 | +18 | +36 | 0 |
| 355 | 400 | | | | | | | | | | | | | | | | | | | | |
| 400 | 450 | +198 | +135 | +385 | +135 | +535 | +135 | +765 | +135 | +108 | +68 | +131 | +68 | +165 | +68 | +60 | +20 | +83 | +20 | +40 | 0 |
| 450 | 500 | | | | | | | | | | | | | | | | | | | | |
| 500 | 560 | +215 | +145 | - | - | - | - | - | - | +120 | +76 | +146 | +76 | +186 | +76 | +66 | +22 | +92 | +22 | +44 | 0 |
| 560 | 630 | | | | | | | | | | | | | | | | | | | | |
| 630 | 710 | +240 | +160 | - | - | - | - | - | - | +130 | +80 | +160 | +80 | +205 | +80 | +74 | +24 | +104 | +24 | +50 | 0 |
| 710 | 800 | | | | | | | | | | | | | | | | | | | | |
| 800 | 900 | +260 | +170 | - | - | - | - | - | - | +142 | +86 | +176 | +86 | +226 | +86 | +82 | +26 | +116 | +26 | +56 | 0 |
| 900 | 1000 | | | | | | | | | | | | | | | | | | | | |
| 1000 | 1120 | +300 | +195 | - | - | - | - | - | - | +164 | +98 | +203 | +98 | +263 | +98 | +94 | +28 | +133 | +28 | +66 | 0 |
| 1120 | 1,250 | | | | | | | | | | | | | | | | | | | | |
| 1250 | 1400 | +345 | +220 | - | - | - | - | - | - | +188 | +110 | +235 | +110 | +305 | +110 | +108 | +30 | +155 | +30 | +78 | 0 |
| 1400 | 1600 | | | | | | | | | | | | | | | | | | | | |
| 1600 | 1800 | +390 | +240 | - | - | - | - | - | - | +212 | +120 | +270 | +120 | +350 | +120 | +124 | +32 | +182 | +32 | +92 | 0 |
| 1800 | 2000 | | | | | | | | | | | | | | | | | | | | |

Unit: μm

| Housing bore dimensions mm | | K6 | | K7 | | M6 | | M7 | | N6 | | N7 | | P6 | | P7 | | R6 | | R7 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Exceeding | Including | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower |
| 3 | 6 | +2 | -6 | +3 | -9 | -1 | -9 | 0 | -12 | -5 | -13 | -4 | -16 | -9 | -17 | -8 | -20 | -12 | -20 | -11 | -23 |
| 6 | 10 | +2 | -7 | +5 | -10 | -3 | -12 | 0 | -15 | -7 | -16 | -4 | -19 | -12 | -21 | -9 | -24 | -16 | -25 | -13 | -28 |
| 10 | 18 | +2 | -9 | +6 | -12 | -4 | -15 | 0 | -18 | -9 | -20 | -5 | -23 | -15 | -26 | -11 | -29 | -20 | -31 | -16 | -34 |
| 18 | 30 | +2 | -11 | +6 | -15 | -4 | -17 | 0 | -21 | -11 | -24 | -7 | -28 | -18 | -31 | -14 | -35 | -24 | -37 | -20 | -41 |
| 30 | 40 | +3 | -13 | +7 | -18 | -4 | -20 | 0 | -25 | -12 | -28 | -8 | -33 | -21 | -37 | -17 | -42 | -29 | -42 | -25 | -50 |
| 40 | 50 | | | | | | | | | | | | | | | | | | | | |
| 50 | 65 | +4 | -15 | +9 | -21 | -5 | -24 | 0 | -30 | -14 | -33 | -9 | -39 | -26 | -45 | -21 | -51 | -35 | -54 | -30 | -60 |
| 65 | 80 | | | | | | | | | | | | | | | | | -37 | -56 | -32 | -62 |
| 80 | 100 | +4 | -18 | +10 | -25 | -6 | -28 | 0 | -35 | -16 | -38 | -10 | -45 | -30 | -52 | -24 | -59 | -44 | -66 | -38 | -73 |
| 100 | 120 | | | | | | | | | | | | | | | | | -47 | -69 | -41 | -76 |
| 120 | 140 | +4 | -21 | +12 | -28 | -8 | -33 | 0 | -40 | -20 | -45 | -12 | -52 | -36 | -61 | -28 | -68 | -56 | -81 | -48 | -88 |
| 140 | 160 | | | | | | | | | | | | | | | | | -58 | -83 | -50 | -90 |
| 160 | 180 | | | | | | | | | | | | | | | | | -61 | -86 | -53 | -93 |
| 180 | 200 | +5 | -24 | +13 | -33 | -8 | -37 | 0 | -46 | -22 | -51 | -14 | -60 | -41 | -70 | -33 | -79 | -68 | -97 | -60 | -106 |
| 200 | 225 | | | | | | | | | | | | | | | | | -71 | -100 | -63 | -109 |
| 225 | 250 | | | | | | | | | | | | | | | | | -75 | -104 | -67 | -113 |
| 250 | 280 | +5 | -27 | +16 | -36 | -9 | -41 | 0 | -52 | -25 | -57 | -14 | -66 | -47 | -79 | -36 | -88 | -85-89 | -117 | -74 | -126 |
| 280 | 315 | | | | | | | | | | | | | | | | | | -121 | -78 | -130 |
| 315 | 355 | +7 | -29 | +17 | -40 | -10 | -46 | 0 | -57 | -26 | -62 | -16 | -73 | -51 | -87 | -41 | -98 | -97-103 | -133 | -87 | -144 |
| 355 | 400 | | | | | | | | | | | | | | | | | | -139 | -93 | -150 |
| 400 | 450 | +8 | -32 | +18 | -45 | -10 | -50 | 0 | -63 | -27 | -67 | -17 | -80 | -55 | -95 | -45 | -108 | -113 | -153 | -103 | -166 |
| 450 | 500 | | | | | | | | | | | | | | | | | -119 | -159 | -109 | -172 |
| 500 | 560 | 0 | -44 | 0 | -70 | -26 | -70 | -26 | -96 | -44 | -88 | -44 | -114 | -78 | -122 | -78 | -148 | -150 | -194 | -150 | -220 |
| 560 | 630 | | | | | | | | | | | | | | | | | -155 | -199 | -155 | -225 |
| 630 | 710 | 0 | -50 | 0 | -80 | -30 | -80 | -30 | -100 | -50 | -100 | -50 | -130 | -88 | -138 | -88 | -168 | -175 | -225 | -175 | -225 |
| 710 | 800 | | | | | | | | | | | | | | | | | -185 | -235 | -185 | -265 |
| 800 | 900 | 0 | -56 | 0 | -90 | -34 | -90 | -34 | -124 | -56 | -112 | -56 | -146 | -100 | -156 | -100 | -190 | -210 | -266 | -210 | -300 |
| 900 | 1000 | | | | | | | | | | | | | | | | | -220 | -276 | -220 | -310 |
| 1000 | 1120 | 0 | -66 | 0 | -105 | -40 | -106 | -40 | -145 | -66 | -132 | -66 | -171 | -120 | -186 | -120 | -225 | -250 | -316 | -250 | -355 |
| 1120 | 1,250 | | | | | | | | | | | | | | | | | -260 | -326 | -260 | -365 |
| 1250 | 1400 | 0 | -78 | 0 | -125 | -48 | -126 | -48 | -173 | -78 | -156 | -78 | -203 | -140 | -213 | -140 | -265 | -300 | -378 | -300 | -425 |
| 1400 | 1600 | | | | | | | | | | | | | | | | | -330 | -408 | -330 | -455 |
| 1600 | 1800 | 0 | -92 | 0 | -150 | -58 | -150 | -58 | -208 | -92 | -184 | -92 | -242 | -170 | -262 | -170 | -320 | -370 | -462 | -370 | -520 |
| 1800 | 2000 | | | | | | | | | | | | | | | | | -400 | -492 | -400 | -550 |

Unit: μm

| H7 | | H8 | | H9 | | H10 | | H11 | | H13 | | J6 | | JS6 | | J7 | | JS7 | | K5 | | Shaft diameter dimensions (mm) Exceeding | Including |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | | |
| +12 | 0 | +18 | 0 | +30 | 0 | +48 | 0 | +75 | 0 | +180 | 0 | +5 | -3 | +4 | -4 | +6 | -6 | +6 | -6 | 0 | -5 | 3 | 6 |
| +15 | 0 | +22 | 0 | +36 | 0 | +58 | 0 | +90 | 0 | +220 | 0 | +5 | -4 | +4.5 | -4.5 | +8 | -7 | +7.5 | -7.5 | +1 | -5 | 6 | 10 |
| +18 | 0 | +27 | 0 | +43 | 0 | +70 | 0 | +110 | 0 | +270 | 0 | +6 | -5 | +5.5 | -5.5 | +10 | -8 | +9 | -9 | +2 | -6 | 10 | 18 |
| +21 | 0 | +33 | 0 | +52 | 0 | +84 | 0 | +130 | 0 | +330 | 0 | +8 | -5 | +6.5 | -6.5 | +12 | -9 | +10.5 | -10.5 | +1 | -8 | 18 | 30 |
| +25 | 0 | +39 | 0 | +62 | 0 | +100 | 0 | +160 | 0 | +390 | 0 | +10 | -6 | +8 | -8 | +14 | -11 | +12.5 | -12.5 | +2 | -9 | 30<br>40 | 40<br>50 |
| +30 | 0 | +46 | 0 | +74 | 0 | +120 | 0 | +190 | 0 | +460 | 0 | +13 | -6 | +9.5 | -9.5 | +18 | -12 | +15 | -15 | +3 | -10 | 50<br>65 | 65<br>80 |
| +35 | 0 | +54 | 0 | +87 | 0 | +140 | 0 | +220 | 0 | +540 | 0 | +16 | -6 | +11 | -11 | +22 | -13 | +17.5 | -17.5 | +2 | -13 | 80<br>100 | 100<br>120 |
| +40 | 0 | +63 | 0 | +100 | 0 | +160 | 0 | +250 | 0 | +630 | 0 | +18 | -7 | +12.5 | -12.5 | +26 | -14 | +20 | -20 | +3 | -15 | 120<br>140<br>160 | 140<br>160<br>180 |
| +46 | 0 | +72 | 0 | +115 | 0 | +185 | 0 | +290 | 0 | +720 | 0 | +22 | -7 | +14.5 | -14.5 | +30 | -16 | +23 | -23 | +2 | -18 | 180<br>200<br>225 | 200<br>225<br>250 |
| +52 | 0 | +81 | 0 | +130 | 0 | +210 | 0 | +320 | 0 | +810 | 0 | +25 | -7 | +16 | -16 | +36 | -16 | +26 | -26 | +3 | -20 | 250<br>280 | 280<br>315 |
| +57 | 0 | +89 | 0 | +140 | 0 | +230 | 0 | +360 | 0 | +890 | 0 | +29 | -7 | +18 | -18 | +39 | -18 | +28.5 | -28.5 | +3 | -22 | 315<br>355 | 355<br>400 |
| +63 | 0 | +97 | 0 | +155 | 0 | +250 | 0 | +400 | 0 | +970 | 0 | +33 | -7 | +20 | -20 | +43 | -20 | +31.5 | -31.5 | +2 | -25 | 400<br>450 | 450<br>500 |
| +70 | 0 | +110 | 0 | +175 | 0 | +280 | 0 | +440 | 0 | - | 0 | - | - | +22 | -22 | - | - | +35 | -35 | - | - | 500<br>560 | 560<br>630 |
| +80 | 0 | +125 | 0 | +200 | 0 | +320 | 0 | +500 | 0 | - | 0 | - | - | +25 | -25 | - | - | +40 | -40 | - | - | 630<br>710 | 710<br>800 |
| +90 | 0 | +140 | 0 | +230 | 0 | +360 | 0 | +560 | 0 | - | 0 | - | - | +28 | -28 | - | - | +45 | -45 | - | - | 800<br>900 | 900<br>1000 |
| +105 | 0 | +165 | 0 | +260 | 0 | +420 | 0 | +660 | 0 | - | 0 | - | - | +33 | -33 | - | - | +52.5 | -52.5 | - | - | 1000<br>1120 | 1120<br>1,250 |
| +125 | 0 | +195 | 0 | +310 | 0 | +500 | 0 | +780 | 0 | - | 0 | - | - | +39 | -39 | - | - | +62.5 | -62.5 | - | - | 1250<br>1400 | 1400<br>1600 |
| +150 | 0 | +230 | 0 | +370 | 0 | +600 | 0 | +920 | 0 | - | 0 | - | - | +46 | -46 | - | - | +75 | -75 | - | - | 1600<br>1800 | 1800<br>2000 |

# Supplementary Table 4: Manufacturer Part Number Comparison Table

## Metric Series – Standard Construction

| Inner diameter | STT | | NMB | | NSK/ISC | | NTN | |
|---|---|---|---|---|---|---|---|---|
| ID | Open | Capped | Open | Capped | Open | Capped | Open | Capped |
| 1 | | | L-310 | | 681 | | | |
| 1 | | | | | MR31 | | | |
| 1 | | | R-410 | | 691 | | | |
| 1.2 | | | R-412 | | MR41X | MR41X ZZ | | |
| 1.5 | | | | L-001 ZZ | | | | |
| 1.5 | 68/1.5 | 68/1.5 ZZ | L-415 | L-415 ZZ | 681X | 681X ZZ | 68/1.5 | W68/1.5 SSA |
| 1.5 | 69/1.5 | 69/1.5 ZZ | R-515 | R-515 ZZ | 691X | 691X ZZ | 69/1.5 | W69/1.5 SSA |
| 1.5 | 60/1.5 | 60/1.5 ZZ | R-615 | R-615 ZZ | 601X | 601X ZZ | 60/1.5 | W60/1.5 ZZA |
| 2 | MR42 | MR42 ZZ | | | | | 672 | |
| 2 | 682 | 682 ZZ | L-520 | L-520 ZZ | 682 | 682 ZZ | 682 | W682 SSA |
| 2 | MR52 | MR52 ZZ | | L-520 ZZW52 | MR52B | MR52B ZZ | BC2-5 | WBC2-5 SSA |
| 2 | 692 | 692 ZZ | R-620 | R-620 ZZ | 692 | 692 ZZ | 692 | W692 SSA |
| 2 | MR62 | MR62 ZZ | R-620W52 | R-620 ZZY52 | MR62 | MR62 ZZ | BC2-6 | |
| 2 | MR72 | MR72 ZZ | | R-720 ZZY03 | MR72 | MR72 ZZ | BC2-7A | |
| 2 | 602 | 602 ZZ | R-720 | R-720 ZZ | 602 | 602 ZZ | 602 | W602 ZZA |
| 2.5 | | MR5/2.5 ZZ | | | | | 67/2.5 | W67/2.5 ZZA |
| 2.5 | 68/2.5 | 68/2.5 ZZ | L-625 | L-625 ZZ | 682X | 682X ZZ | 68/2.5 | W68/2.5 SSA |
| 2.5 | 69/2.5 | 69/2.5 ZZ | R-725 | R-725 ZZ | 692X | 692X ZZ | 69/2.5 | W69/2.5 SSA |
| 2.5 | MR8/2.5 | MR8/2.5 ZZ | | | MR82X | | BC2.5-8 | WBC2.5-8 ZZA |
| 2.5 | 60/2.5 | 60/2.5 ZZ | R-825 | R-825 ZZ | 602X | 602X ZZ | 60/2.5 | W60/2.5 ZZA |
| 3 | MR63 | MR63 ZZ | L-630 | L-630 ZZ | MR63 | MR63 ZZ | 673 | WA673 SSA |
| 3 | 683 | 683 ZZ | L-730 | L-730 ZZ | 683A | 683A ZZ | 683 | W683 ZZA |
| 3 | MR83 | MR83 ZZ | | | MR83 | | BC3-8 | WBC3-8 ZZA |
| 3 | 693 | 693 ZZ | R-830 | R-830 ZZ | 693 | 693 ZZ | 693 | W693 ZZ |
| 3 | MR93 | MR93 ZZ | R-930Y52 | R-930 ZZY04 | MR93 | MR93 ZZ | BC3-9 | WBC3-9 ZZA |
| 3 | 603 | 603 ZZ | R-930 | R-930 ZZ | 603 | 603 ZZ | 603 | W603 ZZA |
| 3 | 623 | 623 ZZ | R-1030 | R-1030 ZZ | 623 | 623 ZZ | 623 | 623 ZZA |
| 4 | MR74 | MR74 ZZ | L-740 | L-740 ZZ | MR74 | MR74 ZZ | 674A | WA674A SSA |
| 4 | MR84 | MR84 ZZ | L-840 | L-840 ZZ | MR84 | MR84 ZZ | BC4-8 | WBC4-8 ZZ |
| 4 | 684 | 684 ZZ | L-940 | L-940 ZZ | 684A | 684A ZZ | 684 | W684A ZZ |
| 4 | MR104 | MR104 ZZ | L-1040 | L-1040 ZZ | MR104B | MR104B ZZ | BC4-10 | WBC4-10 ZZ |
| 4 | 694 | 694 ZZ | R-1140 | R-1140 ZZ | 694 | 694 ZZ | 694 | 694 ZZ |
| 4 | 604 | 604 ZZ | R-1240 | R-1240 ZZ | 604 | 604 ZZ | 604 | 604 ZZ |
| 4 | 624 | 624 ZZ | R-1340 | R-1340 ZZ | 624 | 624 ZZ | 624 | 624 ZZ |
| 4 | 634 | 634 ZZ | R-1640 | R-1640HH | 634 | 634 ZZ | 634 | 634 ZZ |
| 5 | MR85 | MR85 ZZ | L-850 | L-850 ZZ | MR85 | MR85 ZZ | 675 | WA675 ZZ |
| 5 | MR95 | MR95 ZZ | L-950 | L-950 ZZ | MR95 | MR95 ZZ | BC5-9 | BC5-9 ZZA |
| 5 | MR105 | MR105 ZZ | L-1050 | L-1050 ZZ | MR105 | MR105 ZZ | BC5-10 | BC5-10 ZZ |
| 5 | MR115 | MR115 ZZ | | L-1150 ZZY04 | | MR115 ZZ | BC5-11 | BC5-11 ZZ |
| 5 | 685 | 685 ZZ | L-1150 | L-1150 ZZ | 685 | 685 ZZ | 685 | W685 ZZA |
| 5 | 695 | 695 ZZ | R-1350 | R-1350 ZZ | 695 | 695 ZZ | 695 | 695 ZZ |

## Metric Series – Standard Construction

| Inner diameter | STT | | NMB | | NSK/ISC | | NTN | |
|---|---|---|---|---|---|---|---|---|
| ID | Open | Capped | Open | Capped | Open | Capped | Open | Capped |
| 5 | 605 | 605 ZZ | R-1450 | R-1450 ZZ | 605 | 605 ZZ | 605 | 605 ZZ |
| 5 | 625 | 625 ZZ | R-1650 | R-1650 HH | 625 | 625 ZZ | 625 | 625 ZZ |
| 5 | 635 | 635 ZZ | R-1950 | R-1950 ZZ | 635 | 635 ZZ | 635 | 635 ZZ |
| 6 | MR106 | MR106 ZZ | L-1060 | L-1060 ZZ | MR106 | MR106 ZZ | 676A | WA676A ZZ |
| 6 | MR126 | MR126 ZZ | L-1260 | L-1260 ZZ | MR126 | MR126 ZZ | BC6-12 | WBC6-12 ZZA |
| 6 | 686 | 686 ZZ | L-1360 | L-1360 ZZ | 686A | 686A ZZ | 686 | W686 ZZ |
| 6 | 696 | 696 ZZ | R-1560 | R-1560 ZZ | 696 | 696 ZZ | 696 | 696 ZZ |
| 6 | 606 | 606 ZZ | R-1760 | R-1760 ZZ | 606 | 606 ZZ | 606 | 606 ZZ |
| 6 | 626 | 626 ZZ | R-1960 | R-1960 ZZ | 626 | 626 ZZ | 626 | 626 ZZ |
| 7 | MR117 | MR117 ZZ | L-1170 | L-1170 ZZ | MR117 | MR117 ZZ | 677 | WA677 ZZA |
| 7 | MR137 | MR137 ZZ | L-1370 | L-1370 ZZ | MR137 | MR137 ZZ | BC7-13 | WBC7-13 ZZA |
| 7 | 687 | 687 ZZ | L-1470 | L-1470 ZZ | 687 | 687 ZZ | 687A | W687A ZZ |
| 7 | 697 | 697 ZZ | | | 697 | 697 ZZ | 697 | 697 ZZ |
| 8 | MR128 | MR128 ZZ | L-1280 | L-1280 ZZ | MR128 | MR128 ZZ | 678A | W678A ZZ |
| 8 | MR148 | MR148 ZZ | L-1480 | L-1480 ZZ | MR148 | MR148 ZZ | BC8-14 | WBC8-14 ZZ |
| 8 | 688 | 688 ZZ | L-1680 | L-1680 ZZ | 688A | 688A ZZ | 688A | W688A ZZ |

## Inch Series – Standard Construction

| AS | STT | | NMB | | NSK/ISC | | NTN | |
|---|---|---|---|---|---|---|---|---|
| ID | Open | Capped | Open | Capped | Open | Capped | Open | Capped |
| 1.016 | | | RI-2 | | R09 | | | |
| 1.191 | | | RI-21/2 | RI-21/2 ZZ | R0 | R0 ZZ | | |
| 1.397 | R1 | R1 ZZ | RI-3 | RI-3 ZZ | R1 | R1 ZZ | | |
| 1.984 | R1-4 | R1-4 ZZ | RI-4 | RI-4 ZZ | R1-4 | R1-4 ZZ | R1-4 | R1-4 ZZA |
| 2.38 | R133 | R133 ZZS | RI-3332 | RI-3332 ZZ | R133 | R133 ZZS | R133 | RA133 ZZA |
| 2.38 | R1-5 | R1-5 ZZ | RI-5 | RI-5 ZZ | R1-5 | R1-5 ZZ | R1-5 | RA1-5 ZZA |
| 3.175 | R144 | R144 ZZ | RI-418 | RI-418 ZZ | R144 | R144 ZZ | R144 | RA144 ZZA |
| 3.175 | R2-5 | R2-5 ZZ | RI-518 | RI-518 ZZ | R2-5 | R2-5 ZZ | R2-5 | RA2-5 ZZA |
| 3.175 | R2-6 | R2-6 ZZ | RI-618 | RI-618 ZZ | R2-6 | R2-6 ZZ | R2-6 | RA2-6 ZZA |
| 3.175 | R2 | R2 ZZ | R-2 | R-2 ZZ | R2 | R2 ZZ | R2 | RA ZZA |
| 3.175 | R2A | R2A ZZ | | | R2A | R2A ZZ | RA2 | RA2 ZZA |
| 3.967 | R155 | R155 ZZ | RI-5532 | RI-5532 ZZ | R155 | R155 ZZ | R155 | R155 ZZA |
| 4.762 | R156 | R156 ZZS | RI-5632 | RI-5632 ZZ | R156 | R156 ZZS | R156 | R156 ZZA |
| 4.762 | R166 | R166 ZZ | RI-6632 | RI-6632 ZZ | R166 | R166 ZZ | R166 | R166 ZZA |
| 4.762 | R3 | R3 ZZ | R-3 | R-3 ZZ | R3 | R3 ZZ | R3 | |
| 4.762 | R3A | R3AZZ | | | | | RA3 | RA3ZZA |
| 6.35 | R168 | R168 ZZ | RI-614 | RI-614 ZZ | R168B | R168B ZZ | R168A | R168A ZZ |
| 6.35 | R188 | R188 ZZ | RI-814 | RI-814 ZZ | R188 | R188 ZZ | R188 | RA188A ZZA |
| 6.35 | R4 | R4 ZZ | R-4 | R-4 ZZ | R4B | R4B ZZ | R4 | R4 ZZ |
| 6.35 | R4A | R4A ZZ | RI-1214 | RI-1214 ZZ | R4AA | R4AA ZZ | RA4A | RA4 ZZ |

## Metric Series – Outer Ring Flange Structure

| Inner diameter | STT | | NMB | | NSK/ISC | | NTN | |
|---|---|---|---|---|---|---|---|---|
| ID | Open | Capped | Open | Capped | Open | Capped | Open | Capped |
| 1 | | | | | F681 | | | |
| 1 | | | | | F691 | | | |
| 1.2 | | | | | MF41X | | | |
| 1.5 | F68/1.5 | F68/1.5 ZZ | | | F681XF | F681X ZZ | FL68/1.5 | FLW68/1.5 SSA |
| 1.5 | F69/1.5 | F69/1.5 ZZ | RF-515 | RF-515 ZZ | F691XF | F691X ZZ | FL69/1.5 | FLW69/1.5 SSA |
| 1.5 | F60/1.5 | F60/1.5 ZZ | RF-615 | RF-615 ZZ | F601XF | F601X ZZ | FL60/1.5 | FLW60/1.5 ZZA |
| 2 | F682 | F682 ZZ | LF-520 | L-520 ZZ | F682 | F682 ZZ | FL682 | FLW682 SSA |
| 2 | MF52 | MF52 ZZ | | | MF52B | MF52B ZZ | FLBC2-5 | FLWBC2-5 SSA |
| 2 | F692 | F692 ZZ | RF-620 | RF-620 ZZ | F692 | F692 ZZ | F692 | FLW692 SSA |
| 2 | MF62 | MF62 ZZ | | | MF62 | MF62 ZZ | FLBC2-6 | |
| 2 | MF72 | MF72 ZZ | | | MF72 | MF72 ZZ | | |
| 2 | F602 | F602 ZZ | RF-720 | RF-720 ZZ | F602 | F602 ZZ | FL602 | FLW602 ZZA |
| 2.5 | F68/2.5 | F68/2.5 ZZ | LF-625 | LF-625 ZZ | F682XF | F682X ZZ | FL68/2.5 | FLW68/2.5 SSA |
| 2.5 | F69/2.5 | F69/2.5 ZZ | RF-725 | RF-725 ZZ | F692XF | F692X ZZ | FL69/2.5 | FLW69/2.5 SSA |
| 2.5 | MF8/2.5 | | | | MF82X | | | |
| 2.5 | F60/2.5 | F60/2.5 ZZ | RF-825 | RF-825 ZZ | F602XF | F602X ZZ | FL60/2.5 | FLW60/2.5 ZZA |
| 3 | MF63 | MF63 ZZ | LF-630 | LF-630 ZZ | MF63 | MF63 ZZ | FL673 | FLWA673 SSA |
| 3 | F683 | F683 ZZ | LF-730 | LF-730 ZZ | F683A | F683A ZZ | FL683 | FLW683 ZZA |
| 3 | MF83 | MF83 ZZ | | | MF83 | | | |
| 3 | F693 | F693 ZZ | RF-830 | RF-830 ZZ | F693 | F693 ZZ | FL693 | FLW693 ZZ |
| 3 | MF93 | MF93 ZZ | | | MF93 | MF93 ZZ | FLBC3-9 | FLWBC3-9 ZZA |
| 3 | F603 | F603 ZZ | RF-930 | RF-930 ZZ | F603 | F603 ZZ | FL603 | FLW603 ZZA |
| 3 | F623 | F623 ZZ | RF-1030 | R-1030 ZZ | F623 | F623 ZZ | FL623 | FL623 ZZA |
| 4 | MF74 | MF74 ZZ | LF-740 | LF-740 ZZ | MF74 | MF74 ZZ | FL674A | FLWA674A SSA |
| 4 | MF84 | MF84 ZZ | LF-840 | LF-840 ZZ | MF84 | MF84 ZZ | FLBC4-8 | FLWBC4-8 ZZ |
| 4 | F684 | F684 ZZ | LF-940 | LF-940 ZZ | F684 | F684 ZZ | FL684 | FLW684A ZZ |
| 4 | MF104 | MF104 ZZ | LF-1040 | LF-1040 ZZ | MF104B | MF104B ZZ | FLBC4-10 | FLWBC4-10 ZZ |
| 4 | F694 | F694 ZZ | RF-1140 | RF-1140 ZZ | F694 | F694 ZZ | FL694 | FL694 ZZ |
| 4 | F604 | F604 ZZ | RF-1240 | RF-1240 ZZ | F604 | F604 ZZ | FL604 | FL604 ZZ |
| 4 | F624 | F624 ZZ | RF-1340 | RF-1340 ZZ | F624 | F624 ZZ | FL624 | FL624 ZZ |
| 4 | MR104 | F634 ZZ | RF-1640 | RF-1640HH | F634 | F634 ZZ | FL634 | FL634 ZZ |
| 5 | MF85 | MF85 ZZ | LF-850 | LF-850 ZZ | MF85 | MF85 ZZ | FL675 | FLWA675 ZZ |
| 5 | MF95 | MF95 ZZ | LF-950 | LF-950 ZZ | MF95 | MF95 ZZ | FLBC5-9 | FLBC5-9 ZZA |
| 5 | MF105 | MF105 ZZ | LF-1050 | LF-1050 ZZ | MF105 | MF105 ZZ | FLBC5-10 | FLBC5-10 ZZ |
| 5 | MF115 | MF115 ZZ | | | | MF115 ZZ | FLBC5-11 | FLBC5-11 ZZ |
| 5 | F685 | F685 ZZ | LF-1150 | LF-1150 ZZ | F685 | F685 ZZ | FL685 | FLW685 ZZA |
| 5 | F695 | F695 ZZ | RF-1350 | RF-1350 ZZ | F695 | F695 ZZ | FL695 | FL695 ZZ |
| 5 | F605 | F605 ZZ | RF-1450 | RF-1450 ZZ | F605 | F605 ZZ | FL605 | FL605 ZZ |
| 5 | F625 | F625 ZZ | RF-1650 | RF-1650HH | F625 | F625 ZZ | FL625 | FL625 ZZ |
| 5 | F635 | F635 ZZ | RF-1950 | RF-1960 ZZ | F635 | F635 ZZ | FL635 | FL635 ZZ |

## Metric Series – Outer Ring Flange Structure

| Inner diameter | STT | | NMB | | NSK/ISC | | NTN | |
|---|---|---|---|---|---|---|---|---|
| ID | Open | Capped | Open | Capped | Open | Capped | Open | Capped |
| | | | | | | | | |
| 6 | MF106 | MF106 ZZ | LF-1060 | LF-1060 ZZ | MF106 | MF106 ZZ | FL676A | FLWA676A ZZ |
| 6 | MF126 | MF126 ZZ | LF-1260 | LF-1260 ZZ | MF126 | MF126 ZZ | FLBC6-12 | FLWBC6-12 ZZA |
| 6 | F686 | F686 ZZ | LF-1360 | LF-1360 ZZ | F686A | F686A ZZ | FL686 | FLW686 ZZ |
| 6 | F696 | F696 ZZ | RF-1560 | RF-1560 ZZ | F696 | F696 ZZ | FL696 | FL696 ZZ |
| 6 | F606 | F606 ZZ | RF-1760 | RF-1760 ZZ | F606 | F606 ZZ | FL606 | FL606 ZZ |
| 6 | F626 | F626 ZZ | RF-1960 | RF-1960 ZZ | F626 | F626 ZZ | FL626 | FL626 ZZ |
| 7 | MF117 | MF117 ZZ | LF-1170 | LF-1170 ZZ | MF117 | MF117 ZZ | FL677 | FLWA677 ZZA |
| 7 | MF137 | MF137 ZZ | LF-1370 | LF-1370 ZZ | MF137 | MF137 ZZ | FLBC7-13 | FLWBC7-13 ZZA |
| 7 | F687 | F687 ZZ | LF-1470 | LF-1470 ZZ | F687 | F687 ZZ | FL687A | FLW687A ZZ |
| 7 | F697 | F697 ZZ | | | F697 | F697 ZZ | FL697 | FL697 ZZ |
| 8 | MF128 | MF128 ZZ | LF-1280 | LF-1280 ZZ | MF128 | MF128 ZZ | FL678A | FLW678A ZZ |
| 8 | MF148 | MF148 ZZ | LF-1480 | LF-1480 ZZ | MF148 | MF148 ZZ | FLBC8-14 | FLWBC8-14 ZZ |
| 8 | F688 | F688 ZZ | LF-1680 | LF-1680 ZZ | F688A | F688A ZZ | FL688A | FLW688A ZZ |

## Inch Series – Outer Ring Flange Structure

| Inner diameter | STT | | NMB | | NSK/ISC | | NTN | |
|---|---|---|---|---|---|---|---|---|
| ID | Open | Capped | Open | Capped | Open | Capped | Open | Capped |
| 1.191 | FR0 | FR0 ZZ | | | FR0 | FR0 ZZ | | |
| 1.397 | FR1 | FR1 ZZ | RIF-3 | RIF-3 ZZ | FR1 | FR1 ZZ | | |
| 1.984 | FR1-4 | FR1-4 ZZ | RIF-4 | RIF-4 ZZ | FR1-4 | FR1-4 ZZ | FLR1-4 | FLR1-4 ZZA |
| 2.38 | FR133 | FR133 ZZS | RIF-3332 | RIF-3332 ZZ | FR133 | FR133 ZZS | FLR133 | FLRA133 ZZA |
| 2.38 | FR1-5 | FR1-5 ZZ | RIF-5 | RIF-5 ZZ | FR1-5 | FR1-5 ZZ | FLR1-5 | FLRA1-5 ZZA |
| 3.175 | FR144 | FR144 ZZ | RIF-418 | RIF-418 ZZ | FR144 | FR144 ZZ | FLR144 | FLRA144 ZZA |
| 3.175 | FR2-5 | FR2-5 ZZ | RIF-518 | RIF-518 ZZ | FR2-5 | FR2-5 ZZ | FLR2-5 | FLRA2-5 ZZA |
| 3.175 | FR2-6 | FR2-6 ZZS | RIF-618 | RIF-618 ZZ | FR2-6 | FR2-6 ZZS | FLR2-6 | FLRA2-6 ZZA |
| 3.175 | FR2 | FR2 ZZ | RF-2 | RF-2 ZZ | FR2 | FR2 ZZ | FLR2 | FLR2 ZZA |
| 3.175 | FR2A | | | | FR2A | FR2A ZZ | FLRA2 | FLRA2 ZZA |
| 3.967 | FR155 | FR155 ZZ | RIF-5532 | RIF-5532 ZZ | FR155 | FR155 ZZ | FLR155 | FLR155 ZZA |
| 4.762 | FR156 | FR156 ZZ | RIF-5632 | RIF-5632 ZZ | FR156 | FR156 ZZ | FLR156 | FLR156 ZZA |
| 4.762 | FR166 | FR166 ZZ | RIF-6632 | RIF-6632 ZZ | FR166 | FR166 ZZ | FLR166 | FLR166 ZZA |
| 4.762 | FR3 | FR3 ZZ | RF-3 | RF-3 ZZ | FR3 | FR3 ZZ | FLR3 | |
| 4.762 | | | | | | | FLRA3 | FLRA3 ZZA |
| 6.35 | FR168B | FR168B ZZ | RIF-614 | RIF-614 ZZ | FR168B | FR168B ZZ | FLR168A | FLR168A ZZ |
| 6.35 | FR188 | FR188 ZZ | RIF-814 | RIF-814 ZZ | FR188 | FR188 ZZ | FLR188 | FLRA188A ZZA |
| 6.35 | FR4B | FR4B ZZ | RF-4 | RF-4 ZZ | FR4B | FR4B ZZ | FLR4 | FLR4 ZZ |
| 6.35 | R4A | R4A ZZ | RIF-1214 | RIF-1214 ZZ | R4AA | R4AA ZZ | | |

# Supplementary Table 5: Weight Conversion

| kgf | | N | kgf | | N | kgf | | N |
|---|---|---|---|---|---|---|---|---|
| 0.1020 | 1 | 9.8066 | 3.4670 | 34 | 333.43 | 6.8321 | 67 | 657.04 |
| 0.2039 | 2 | 19.613 | 3.5690 | 35 | 343.23 | 6.9341 | 68 | 666.85 |
| 0.3059 | 3 | 29.420 | 3.6710 | 36 | 353.04 | 7.0361 | 69 | 676.66 |
| 0.4079 | 4 | 39.227 | 3.7730 | 37 | 362.85 | 7.1380 | 70 | 686.46 |
| 0.5099 | 5 | 49.033 | 3.8749 | 38 | 372.65 | 7.2400 | 71 | 696.27 |
| 0.6118 | 6 | 58.840 | 3.9769 | 39 | 382.46 | 7.3420 | 72 | 706.08 |
| 0.7138 | 7 | 68.646 | 4.0789 | 40 | 392.27 | 7.4440 | 73 | 715.88 |
| 0.8158 | 8 | 78.453 | 4.1808 | 41 | 402.07 | 7.5459 | 74 | 725.69 |
| 0.9177 | 9 | 88.260 | 4.2828 | 42 | 411.88 | 7.6479 | 75 | 735.50 |
| 1.0197 | 10 | 98.066 | 4.3848 | 43 | 421.68 | 7.7499 | 76 | 745.30 |
| 1.1217 | 11 | 107.87 | 4.4868 | 44 | 431.49 | 7.8518 | 77 | 755.11 |
| 1.2237 | 12 | 117.68 | 4.5887 | 45 | 441.30 | 7.9538 | 78 | 764.92 |
| 1.3256 | 13 | 127.49 | 4.6907 | 46 | 451.10 | 8.0558 | 79 | 774.72 |
| 1.4276 | 14 | 137.29 | 4.7927 | 47 | 460.91 | 8.1578 | 80 | 784.53 |
| 1.5296 | 15 | 147.10 | 4.8946 | 48 | 470.72 | 8.2597 | 81 | 794.34 |
| 1.6316 | 16 | 156.91 | 4.9966 | 49 | 480.52 | 8.3617 | 82 | 804.14 |
| 1.7335 | 17 | 166.71 | 5.0986 | 50 | 490.33 | 8.4637 | 83 | 813.95 |
| 1.8355 | 18 | 176.52 | 5.2006 | 51 | 500.14 | 8.5656 | 84 | 823.76 |
| 1.9375 | 19 | 186.33 | 5.3025 | 52 | 509.94 | 8.6676 | 85 | 833.56 |
| 2.0394 | 20 | 196.13 | 5.4045 | 53 | 519.75 | 8.7696 | 86 | 843.37 |
| 2.1414 | 21 | 205.94 | 5.5065 | 54 | 529.56 | 8.8716 | 87 | 853.18 |
| 2.2434 | 22 | 215.75 | 5.6085 | 55 | 539.36 | 8.9735 | 88 | 862.98 |
| 2.3454 | 23 | 225.55 | 5.7104 | 56 | 549.17 | 9.0755 | 89 | 872.79 |
| 2.4473 | 24 | 235.36 | 5.8124 | 57 | 558.98 | 9.1775 | 90 | 882.60 |
| 2.5493 | 25 | 245.17 | 5.9144 | 58 | 568.78 | 9.2794 | 91 | 892.40 |
| 2.6513 | 26 | 254.97 | 6.0163 | 59 | 578.59 | 9.3814 | 92 | 902.21 |
| 2.7532 | 27 | 264.78 | 6.1183 | 60 | 588.40 | 9.4834 | 93 | 912.02 |
| 2.8552 | 28 | 274.59 | 6.2203 | 61 | 598.20 | 9.5854 | 94 | 921.82 |
| 2.9572 | 29 | 284.39 | 6.3223 | 62 | 608.01 | 9.6873 | 95 | 931.63 |
| 3.0592 | 30 | 294.20 | 6.4242 | 63 | 617.82 | 9.7893 | 96 | 941.44 |
| 3.1611 | 31 | 304.01 | 6.5262 | 64 | 627.62 | 9.8913 | 97 | 951.24 |
| 3.2631 | 32 | 313.81 | 6.6282 | 65 | 637.43 | 9.9932 | 98 | 961.05 |
| 3.3651 | 33 | 323.62 | 6.7302 | 66 | 647.24 | 10.0952 | 99 | 970.86 |

(How to use this table) If you want to convert 10 kgf into Newtons, first locate 10 in the middle column and then find the corresponding value in the Newton column: 10 kgf = 98.666 N. Similarly, if you want to convert 10 N into kilogram-force, look in the kgf column for the corresponding value: 10 N = 1.0197 kgf.

1kgf=9.80665N
1N=0.101972kgf




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