MOTION & CONTROL™
NSK

SUPER PRECISION BEARINGS

Introduction

As technologies evolve, all manufacturers share a global responsibility to respect and protect the environment.

NSK Motion and Control products reflect our corporate commitment to being environmentally responsible. While our products improve the performance of machines in a variety of industries, they also save energy and conserve resources because of our superior precision machining technologies.

In order to meet the needs of the highly specialized machine tool industry, we have enhanced every and all aspects of our R & D capability at our Technology Centers. As a result, NSK's precision bearings are also used in a wide variety of industries, such as semiconductor production and industrial robots, and have earned a reputation for excellent performance.

NSK's purchase of RHP (Europe) allowed us to combine our collective experience and expertise, and to unify our strengths in design. As a result, our bearings are known for their exceptional accuracy and reliability.

This catalog explains technical materials including our latest research and experimental data, various applications, the types of precision bearings available, and the proper utilization of each specific type of bearing.

SUPER PRECISION BEARINGS

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Global Network

NSK's global network is the key to our ability to develop innovative products that incorporate the latest technologies.

The network connects each sales branch, distribution center, production facility, and technology center and enables us to gather the latest information from each location. Data is instantly accessible to every part of the network, resulting in products of the highest quality.

Our global system also includes activities such as receiving and processing orders, shipping products, and supplying technical support.

No matter how difficult or complex the challenge, NSK is able to respond immediately.

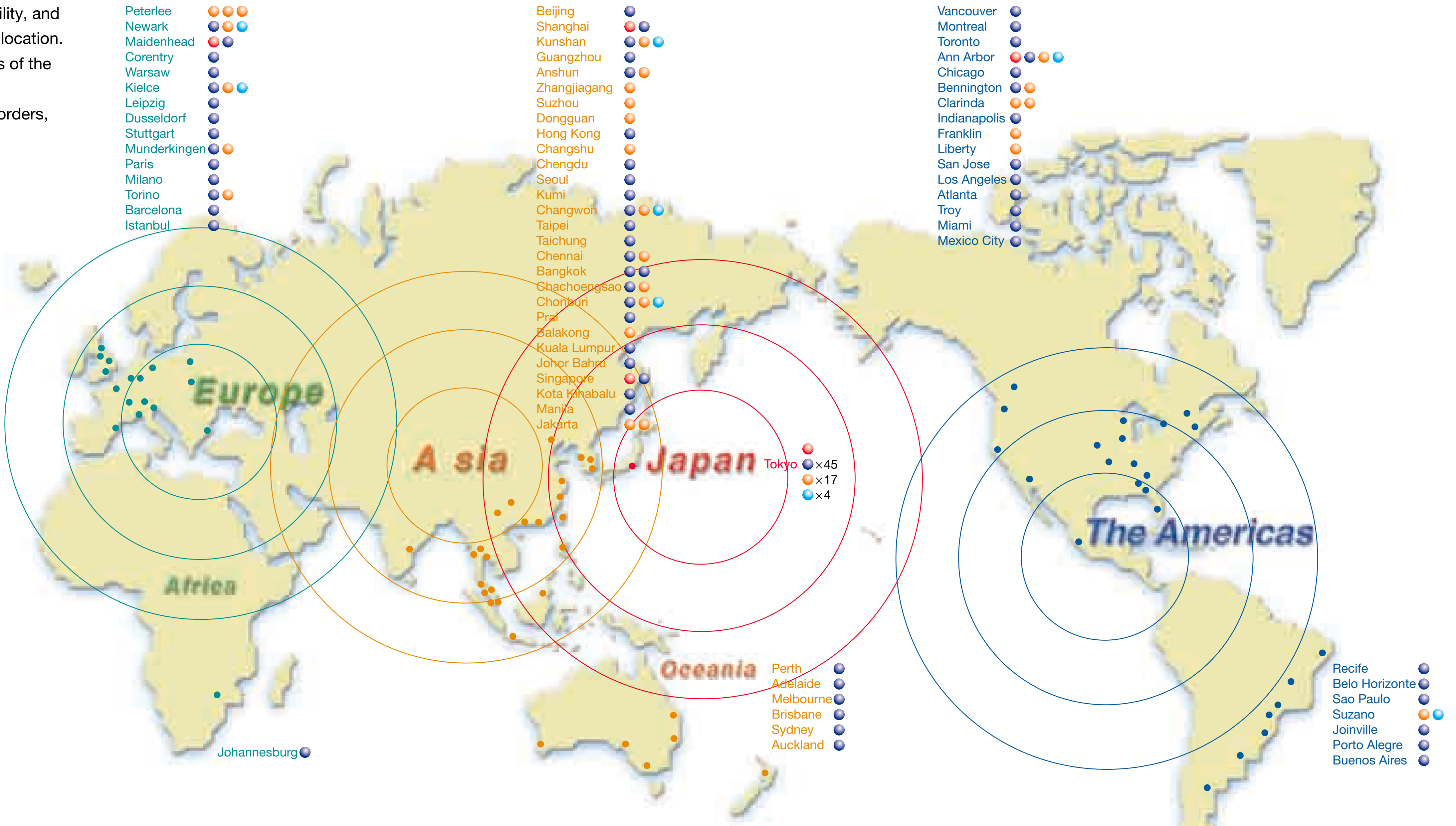
NSK's global network means excellent products and superior customer service.

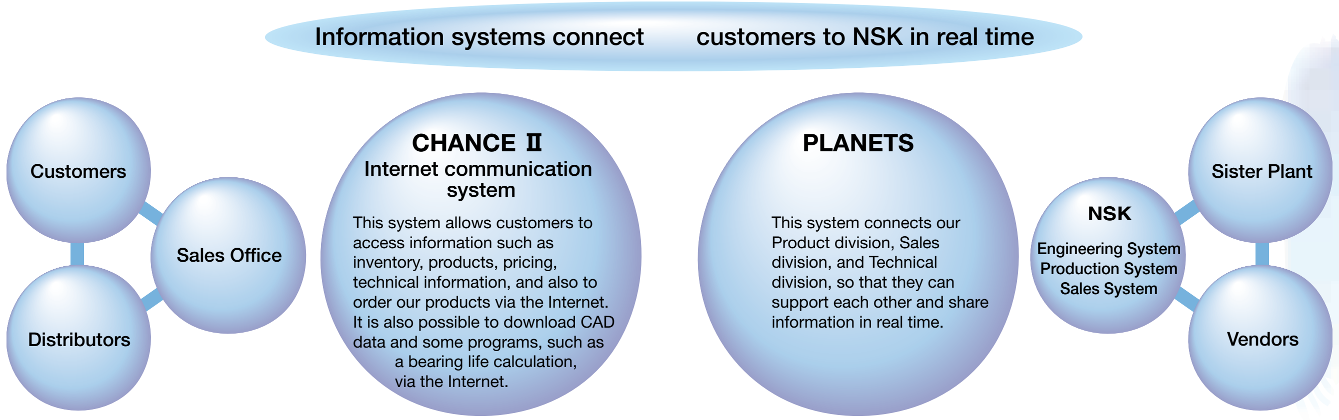
NSK has established a communication system that links the major markets of the world in Europe, Asia, Japan, and the Americas. We use this highly developed system to share information, in real time, related to changes and the trends of each market. As a result, we can react quickly to meet changing customer needs to supply the best, high quality products. Our global network makes NSK a truly global company. We are able to transcend borders and other restrictions to meet the needs of our global customers.

Wherever our customers are in the world, our global support network is there.

Our extensive global network is able to receive orders and supply products anywhere in the world. NSK's distributors cover the world, and keep inventory of all critical products in all the major markets and locations, making it possible to supply the products to customers without delay. NSK also provides technical support globally to help customers determine the best bearing for each application and to respond quickly to any questions and deal immediately with any problems our customers may have.

http://www.nsk.com





This system allows customers to access information such as inventory, products, pricing, technical information, and also to order our products via the Internet. It is also possible to download CAD data and some programs, such as a bearing life calculation, via the Internet.

This system connects our Product division, Sales division, and Technical division, so that they can support each other and share information in real time.

CHANCE Ⅱ
Convenient Helpful Access environment for NSK Communication Exchange Ⅱ

PLANETS
Practical Link by Advanced NSK E-business Technology System

Research & Development

Communicating through our global network, the Technology Centers in Europe, The Americas and Japan engage in a continual exchange of ideas, reflecting NSK's extensive commitment to research and development.

NSK's key technology is Tribology (the study of the friction and wear).
By decreasing friction and wear, it is possible to save energy and conserve resources, thus preventing machine failures and increasing reliability. NSK operates three Technology Centers located in Europe, the USA and Japan. They concentrate on Tribology as a means to develop innovative new technologies. Each Technology Center supports the customers in its region and all three communicate continually via our global network to share new information and findings.
The Technology Center in Japan acts as a direct support to Asian customers. It is also the center that systematically gathers information on market needs in Europe, Asia and the Americas to identify emerging needs and market trends so that NSK can aggressively develop the next generation of products.

Proposing a new approach to value

New technology development

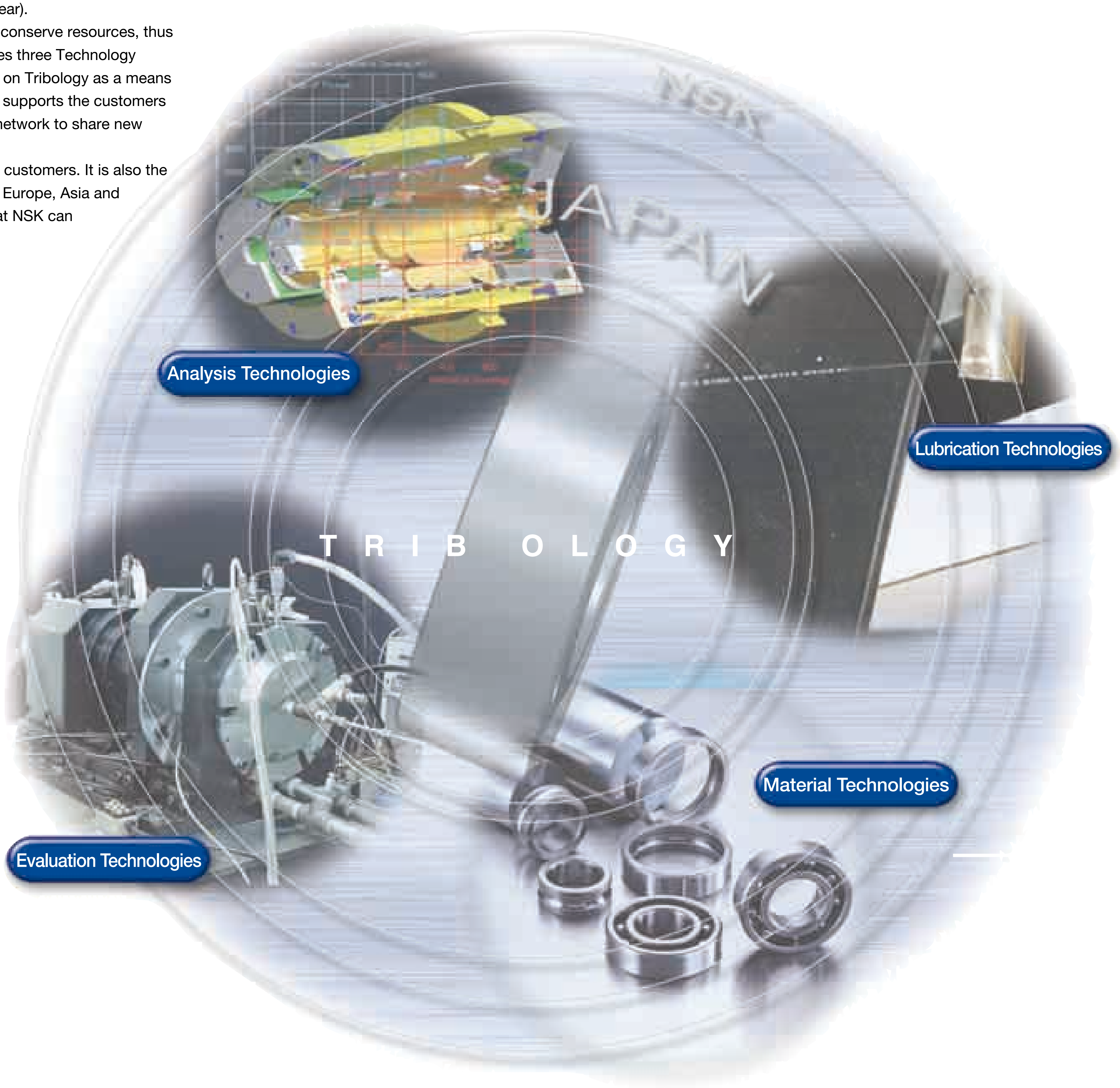
NSK is developing four basic technologies, Analysis, Materials, Lubrication, and Evaluation. Using these technologies, NSK produces new products that satisfy the unique requirements in each application. This approach provides real value to our customers.

Custom products for unique customer applications

Each Technology Center works closely with our customers to determine their precise application needs. In doing so we can help them identify the right NSK product for each application so they receive maximum efficiency and cost effectiveness. Upon request, we can also supply completely customized products to satisfy highly specialized customer needs.

Technology Center customer support

In addition to basic research, each Technology Center provides technical support to the customers in its region. As a result of this support, our customers are able to use NSK's products in their best condition and achieve their best performance.



Bearing Technology Center
(Japan)

European Technology Center
(England)

American Technology Center
(USA)

Quality & Production

We employ the latest manufacturing technologies and quality control procedures to produce products that are recognized as having the highest degree of accuracy in the world.

NSK precision bearings deliver the highest level of quality because of our production capability, state of the art equipment, extensive manufacturing expertise, and our commitment to applying the same rigorous quality control procedures at every stage of the production process in every NSK facility.

Manufacturing technologies to produce high accuracy products

To maintain our reputation for manufacturing precision bearings with the highest degree of accuracy in the world, all precision bearings are checked nanometer accuracy.

Global production in England and Japan

NSK's precision bearings are made in both England and Japan. The combined expertise of these manufacturing facilities, and their global locations allow us to meet every customer need.

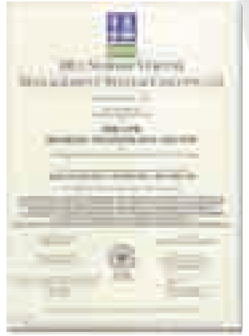
NSK Newark Plant

NSK Fujisawa Plant

Complete quality control and environmental responsibility

As an ISO 9001 certified company, every NSK manufacturing facility adheres to the same strict standards for quality control. Frequent quality checks are one part of the production process to ensure that all our products maintain the same high level of quality.
Our company has also received ISO 14001 Certification and all our facilities operate to the highest level of environmental responsibility.

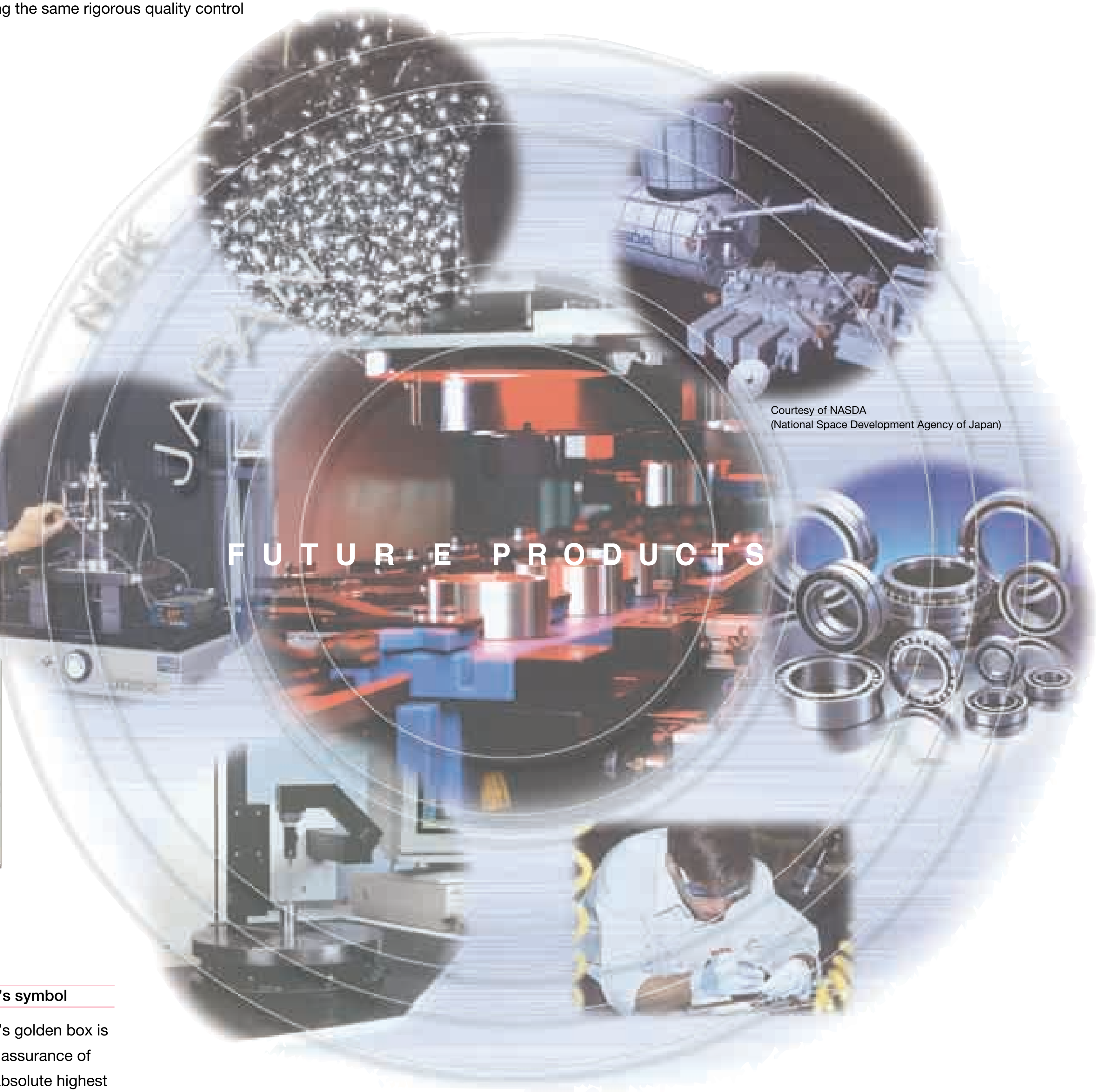
ISO 14001 Certification



ISO 9001 Certification

NSK's symbol

NSK's golden box is your assurance of the absolute highest level of quality.



Courtesy of NASDA
(National Space Development Agency of Japan)

Newark Plant

Bearing Production (Newark Plant)

Inspection Process (Fujisawa Plant)

Machining Process (Fujisawa Plant)

High Performance in the Next Generation:

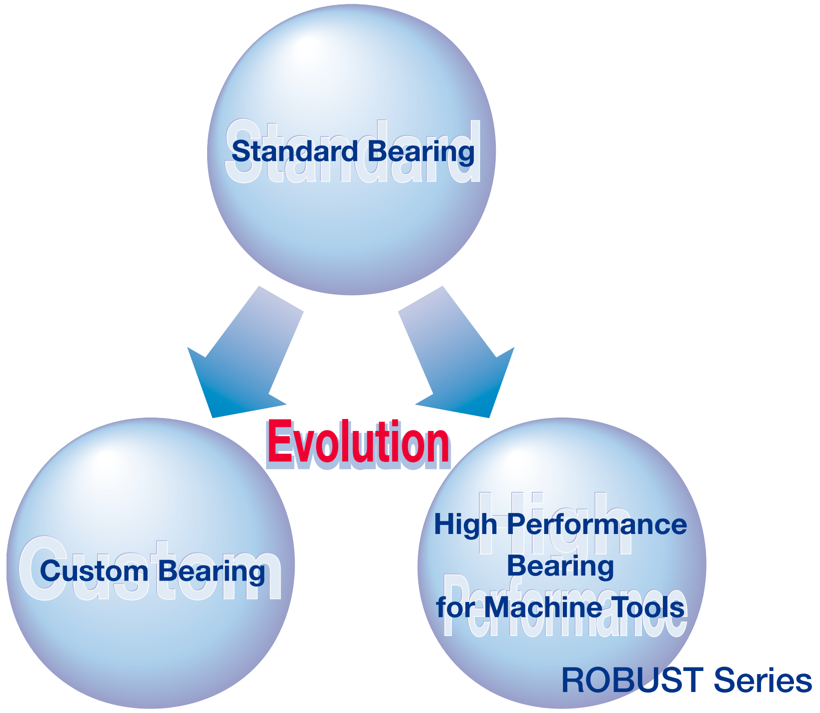
NSK continually challenges the status quo to explore new possibilities. As our design philosophy does not allow us to compromise quality in manufacturing, we are driven to develop total solution technologies.

By using the latest material and analysis technologies we are able to design and manufacture exceptional, high performance precision bearings.

NSK will always strive to achieve the quality and performance that will be required in next generation bearings.

CONCEPT

NSK's precision bearings, for Long Life and High Performance.



Depending on each application and its operating conditions, there are the following choices:

Standard Bearings

The NSK standard precision bearing series covers a wide range of sizes and conforms to ISO standards. The bearing rings are made of Z Steel, (a high cleanliness SUJ2 bearing steel) which extends bearing life.

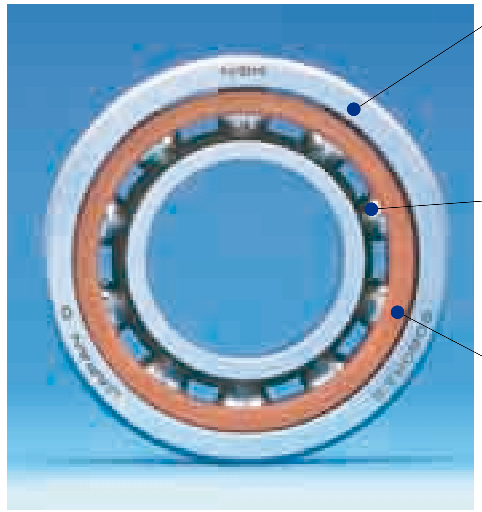
High Performance Bearings for Machine Tools

Using new material and analysis technologies to optimize the design for high speed operation, NSK has developed a ROBUST series of high performance bearings for machine tool main spindles.

Custom Bearings

NSK provides custom bearings by using advanced materials and an optimal design suited to each application and operating condition.

Quality controlled NSK bearing components



Raceway Material

NSK uses only selected materials, such as Z Steel or EP Steel, to achieve longer life. SHX Steel provides seizure-resistant performance at ultra high speeds.

Rolling Element Material

NSK bearings deliver high performance at high operating speeds by using steel balls with ultra high accuracy or high performance, lightweight ceramic rolling elements.

Cage

NSK cages, made of standard materials such as phenolic resin, polyamide, and new engineered polymer, offer benefits of high temperature resistance, light weight and high rigidity. NSK cages provide reliable operation in a variety of applications.

Metallurgical Technologies to Extend Bearing Life

MATERIAL TECHNOLOGY

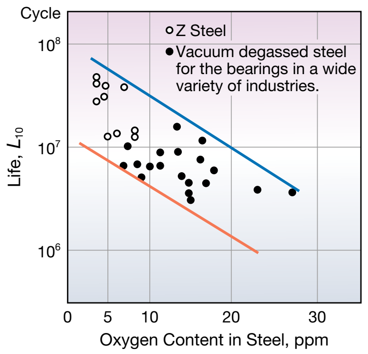
Advanced materials combined with strict quality controls allow NSK bearings to provide both long life and high performance.

It is well known that the rolling fatigue life of high carbon chrome bearing steel (SAE52100, SUJ2) used for rolling bearings is greatly affected by non-metallic inclusions. Life tests show that oxide non-metallic inclusions exert a particularly adverse affect on the rolling fatigue life. In cooperation with a steel supplier, NSK improved the steel making process and operating conditions to reduce impurities substantially, thereby achieving a decrease in oxide non-metallic inclusions. The resulting long-life steel is Z Steel and EP Steel.

Long Life Material Z Steel

Features of Z Steel

Z Steel is produced by reducing the amount of non-metallic inclusions, oxide and other inclusions such as Ti, or S, inside of the steel. Bearings made of this steel have a significantly extended service life when compared to conventional vacuum degassed steel. (up to 1.8 times longer)



Products made of Z Steel

NSK uses this Z Steel as a standard material

ACBB

CRB

Extra Long Life and High Reliability Steel EP Steel

Features of EP Steel

Bearings made from EP Steel have increased reliability due to minimal variations in life resulting from the new evaluation technique and significant reductions in impurities.

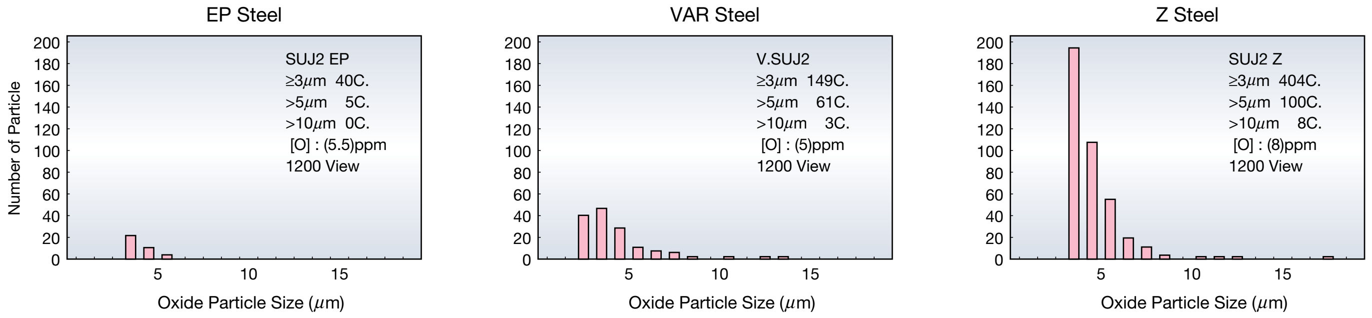
- The establishment of new a evaluation technique

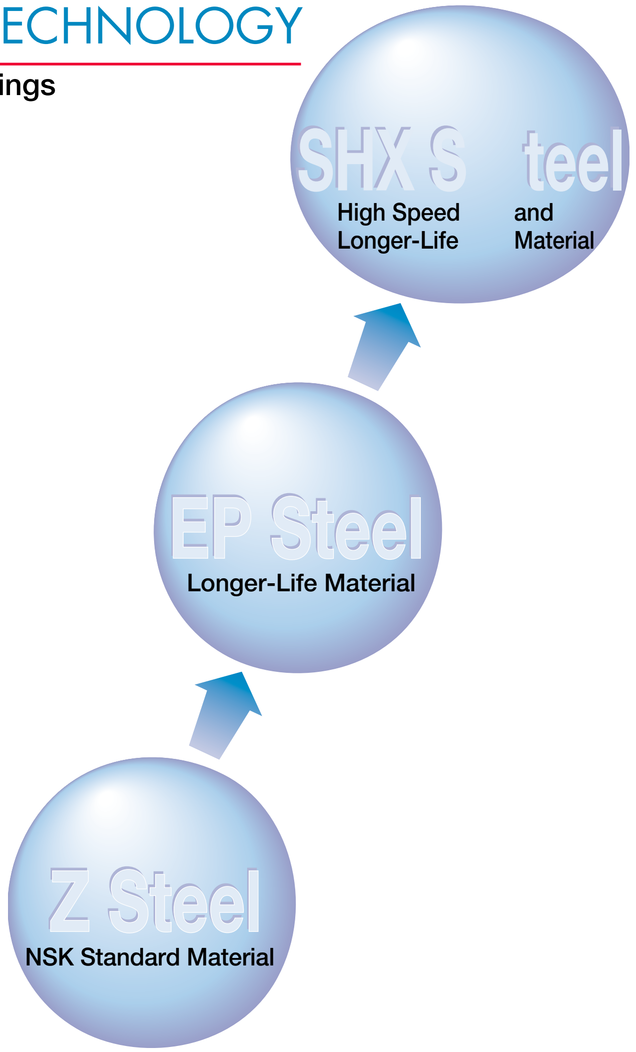
In order to improve the evaluation of oxide non-metallic inclusions, NSK has established the NSK-ISD^2 Method (an image analysis system and a special steel making procedure.)

- Improvement of steel making procedures

The introduction of this technique into steel manufacturing technology resulted in a significant improvement in purity and reduction of non-metallic inclusions relative to Z Steel. EP Steel has fewer large sized particles than Vacuum Arc Remelted (VAR) or conventionally refined Z Steel.

Purity comparison through image analysis





Products made of EP Steel

Ball Screw Support Bearings for Machine Tool Applications

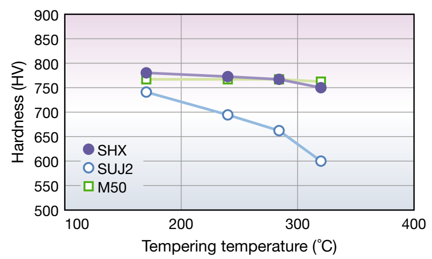
Heat Resistant Steel, Extends the Life of Bearings used in Ultra High Speed Applications SHX Steel

The Feature of SHX Steel

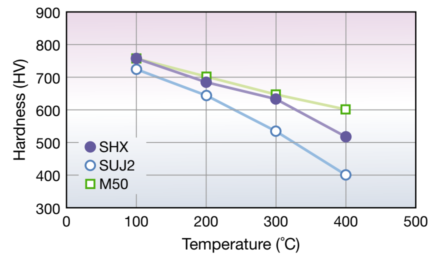
SHX is a heat resistant steel resulting from NSK's special heat treatment technology. SHX Steel has similar heat resistant performance to M50 steel which is used for bearings on the main shaft of jet engine applications where temperatures reach 300°C. This heat resistance, combined with lower friction performance and indentation resistance are ideally suited steel characteristics for ultra high speed machine tool bearings. Patent Number: 2961768JP

Heat Resistance

Tempering temperature and hardness of each material

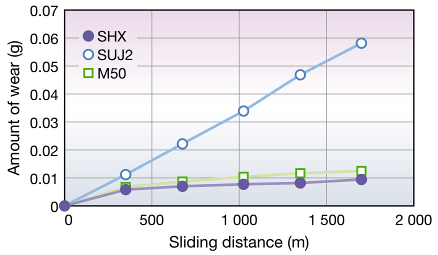


High temperature hardness of each material

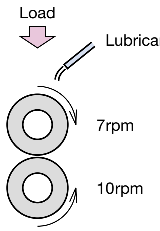


Wear Resistance

Wear resistance of each material (2 cylindrical rollers wear test)



2 cylindrical rollers wear test

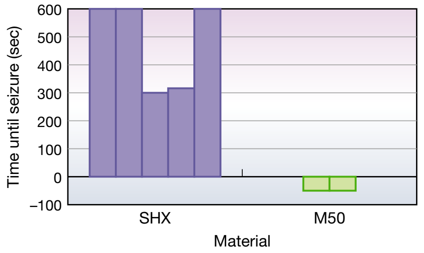


Test conditions
Surface pressure : 880MPa
Sliding ratio : 30%
Lubrication : Spindle oil (2cc/min)
Temperature : Room temperature

Seizure Resistance

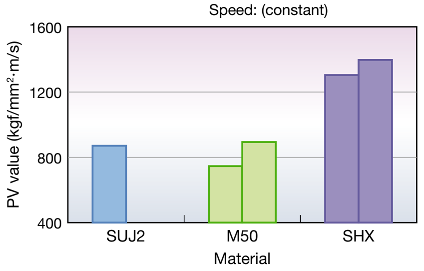
Dry seizure limit test (4 balls test)

Test conditions Lubrication: None
Sliding condition: PV=380kgf·mm^2·m/s

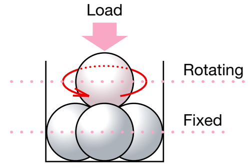


Oil bath seizure limit test (4 balls test)

Test conditions Lubrication: Oil bath
Speed: (constant)

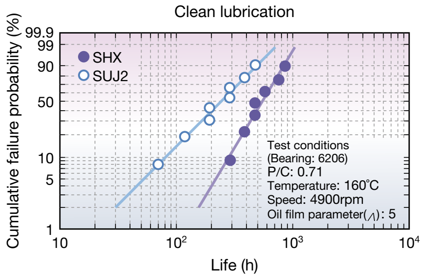


4 balls test

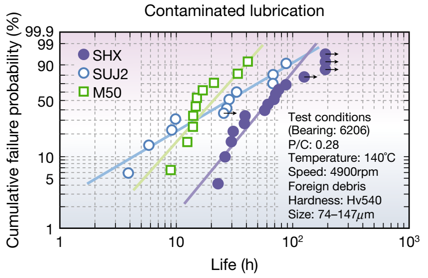


Fatigue Life

Subsurface originated flaking test



Surface originated flaking test



Bearings made of SHX Steel have a significantly extended service life when compared to SUJ2 Steel. (4 times longer)

Products made of SHX Steel

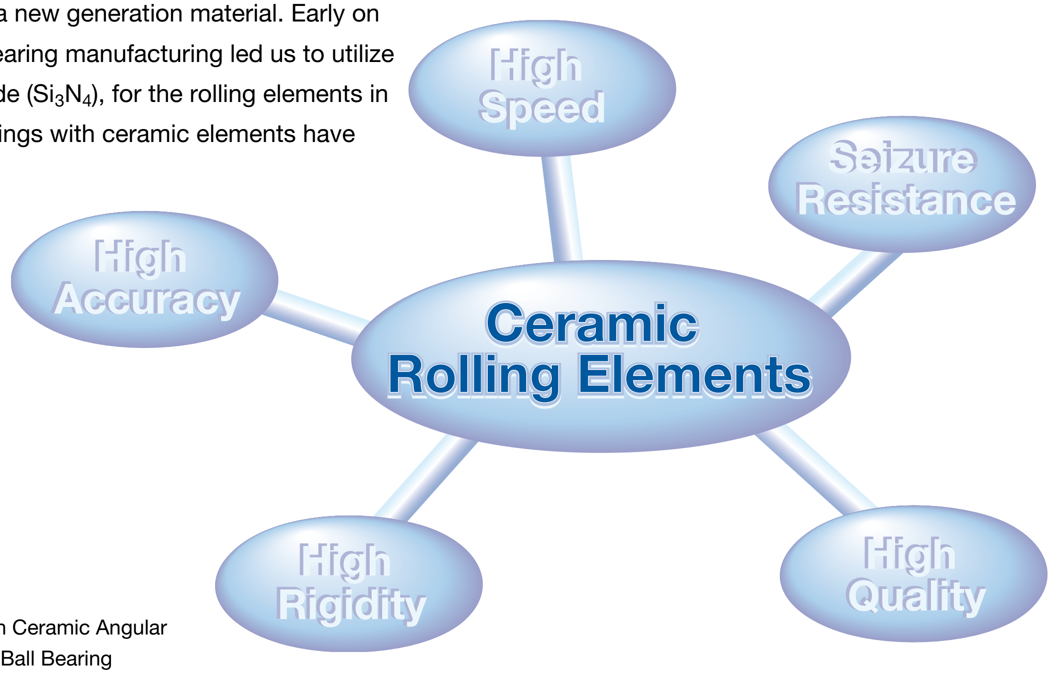
Ultra High-Speed ACBB
ROBUST Series X, XE type

Ultra High-Speed Single Row CRB
ROBUST Series RX, RXH type

Ceramic Rolling Elements MATERIAL TECHNOLOGY

High speed, high rigidity, and high reliability are all achieved using ceramic rolling elements.

Ceramic hybrid bearings have many excellent performance characteristics such as heat resistance, extended life, light weight, lower thermal expansion, electrically non-conductive, and thus can be used in an infinite number of applications as a new generation material. Early on NSK's knowledge of materials and bearing manufacturing led us to utilize one ceramic in particular, silicon nitride (Si_3N_4), for the rolling elements in ceramic hybrid bearings. Hybrid bearings with ceramic elements have earned a good reputation in the field for ultra high speed combined with ultra high accuracy, a performance combination that is not achievable in bearings with steel rolling elements.



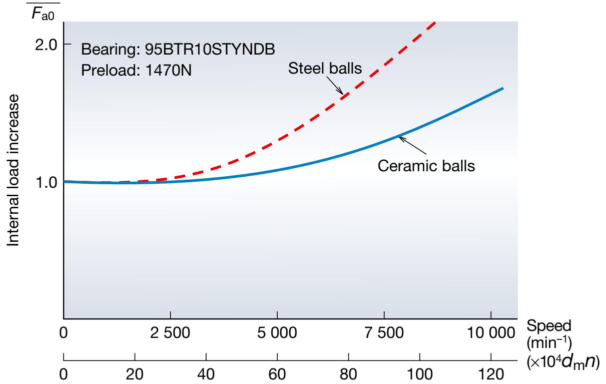
Precision Ceramic Angular Contact Ball Bearing

Superior High Speed Performance

- **Lightweight**

  As the density is 40% lower than that of steel, the centrifugal force applied to the rolling elements is smaller, thus extending bearing life.

Preload Increase Due To Centrifugal Force



Note $(\frac{F_{ain}}{F_{a0}})$: Ratio of operating preload to initial preload

- **Low coefficient of linear expansion**

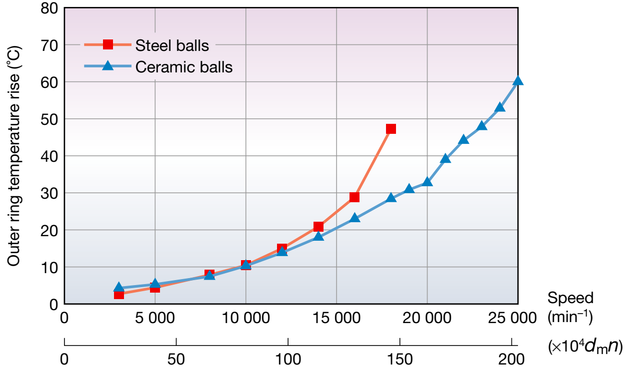
  In applications involving high speed operation, although the temperature of the bearing is high, this low coefficient results in lower preload and lower heat generation.

- **Low friction**

  The slip of the rolling element during operation is reduced, and this means less heat is generated.

Bearing: 65BNR10XTDB+KL144
Grease lubrication (Isoflex NBU15)
Position preload (No Jacket Cooling)
Preload after mounted: 300 (N)

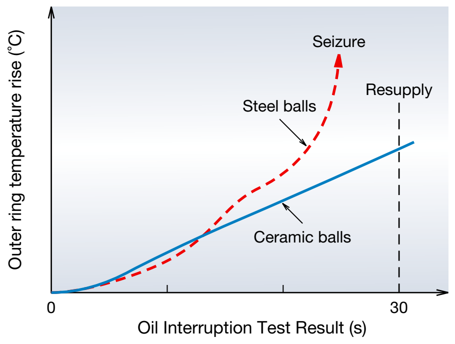
The Outer Ring Temperature Rise in High Speed Operation.



Seizure Resistance

Relative to steel rolling elements, ceramics have a higher seizure resistance.

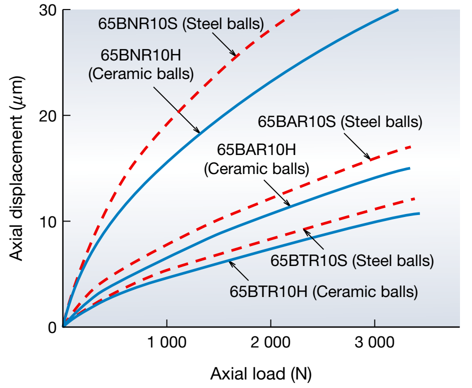
Oil Interruption Test Result



High Rigidity

Ceramic balls have a Youngs Modulus that is 50% higher than that of steel, making it an ideal material for use in machine tool spindles requiring rigid cutting performance.

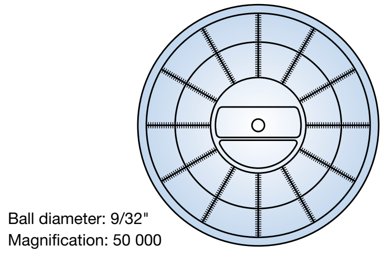
Axial rigidity of ceramic angular contact ball bearings



High Accuracy through Manufacturing Technology

NSK's expertise in the manufacturing of balls and rollers, and improvements in the sintering process and the grade of materials used, enables NSK to produce higher accuracy balls and rollers.

Roundness of Ceramic Ball



High Quality by Selecting the Best Materials

By including the purchase of materials in the QA system, NSK's bearings with ceramic rolling elements are well accepted in the field as being of the highest quality.

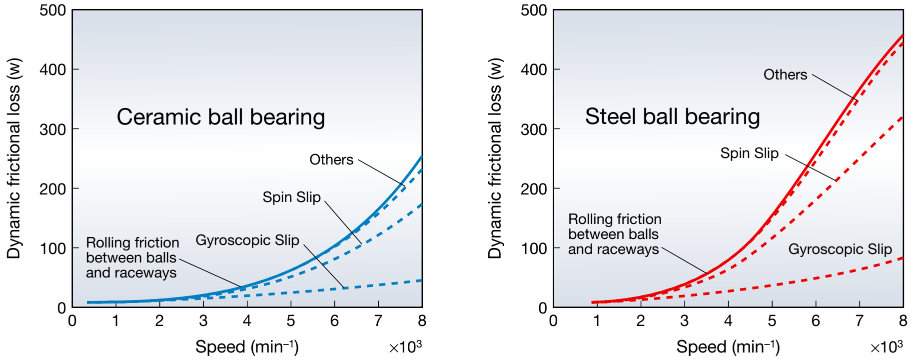
High Speed Performance Characteristics of Balls and Rollers

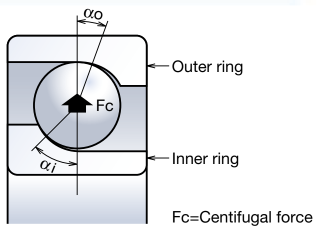
When using ceramic rolling elements in

ACBB: low centrifugal forces decrease the gyroscopic and spin slip in high speed operation

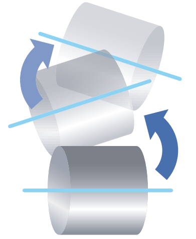
CRB: low material density reduces the heat generation caused by the skew of the rollers

Calculated result of heat generation





ACBB: Difference in Contact Angles in High Speed Operation



CRB: Roller Skewing in High Speed Operation

Cages MATERIAL TECHNOLOGY

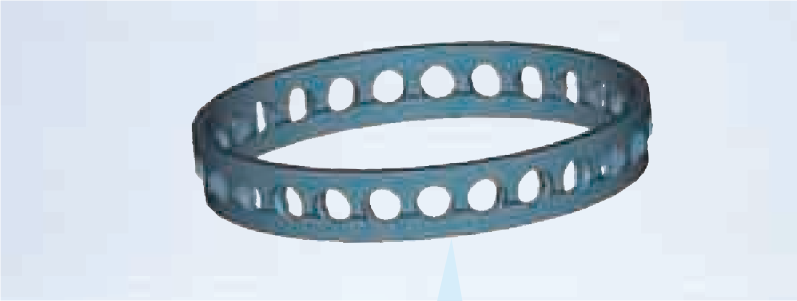
Engineered Polymer Cages Suited for High Speed Operation

Because of lightweight (polymer density is 1/6 that of brass), easy formability, and high corrosion resistance, polymer materials are used widely in bearing cages. Polymers can be engineered to have lower friction and thus lower heat generation and higher speed capability. Polymers can be engineered for low wear, thus extending grease life. The engineered polymer cage is well suited for bearings used in machine tool main spindles.

Cage for Angular Contact Ball Bearing

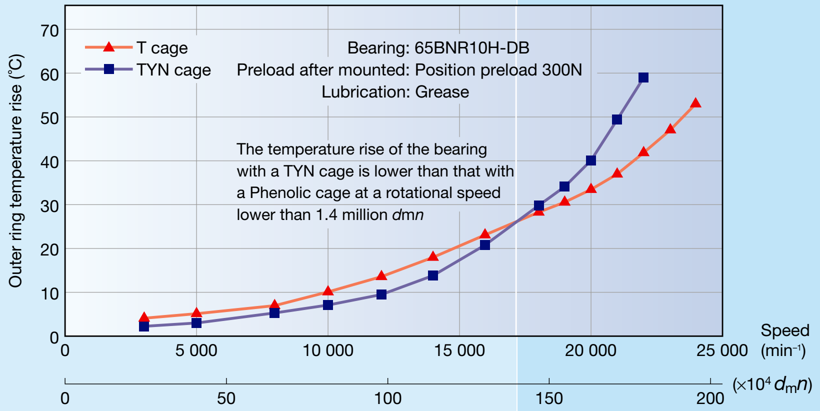
Ball Guided Polyamide Cage (TYN) Engineered Polymer

- This special design allows the bearing to have lower friction and lower noise.
- This cage is effective with grease lubrication. The internal free space of the bearing in this cage is larger than that with outer ring guided cage so, it is possible to keep more grease inside of the bearing.
- The period of the grease running in procedure for a bearing with this cage is shorter than that of a bearing, with a phenolic cage.



Application Example
Ultra High-Speed ACBB ROBUST Series

Cage Performance Test Result



Outer Ring Guided Phenolic Cage (T, TR) Phenolic Resin

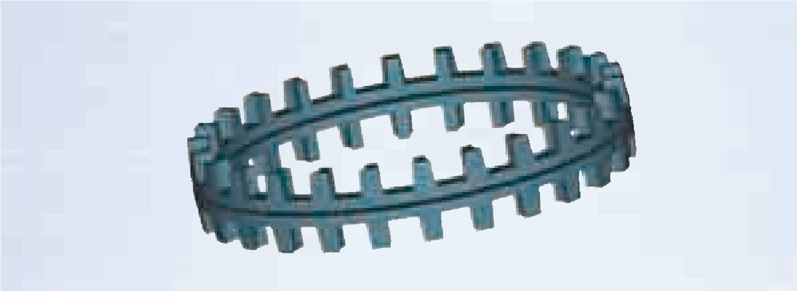
- The rotational movement of the outer ring guided cage is more stable in high speed operation.

Application Example
Standard Series ACBB standard Series
Ultra High-Speed ACBB ROBUST Series

Cage for Cylindrical Roller Bearing

High Strength Roller Guided PPS Cage (TB) Engineered Polymer

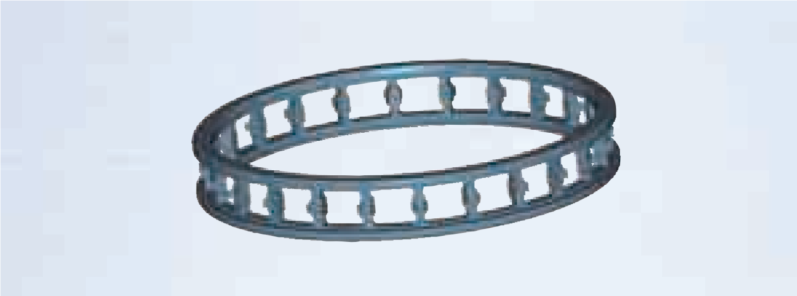
- High temperature resistance to a maximum of 220˚C.
- Complete chemical resistance against most acid, alkaline or organic solutions.
- Physical properties include high strength, toughness, wear and fatigue resistance relative to current Polyamide cage material.



Application Example
Double row CRB High Rigidity Series

Outer Ring Guided PEEK Cage with Ultra High Temperature Resistance (TP) Engineered Polymer

- High temperature resistance to a maximum of 240˚C.
- Excellent wear-resistant performance and suited to minimal oil lubrication.
- Physical properties include high strength, toughness, wear and fatigue resistance.
- Dimensional stability results in minimal deformation during high speed operation.

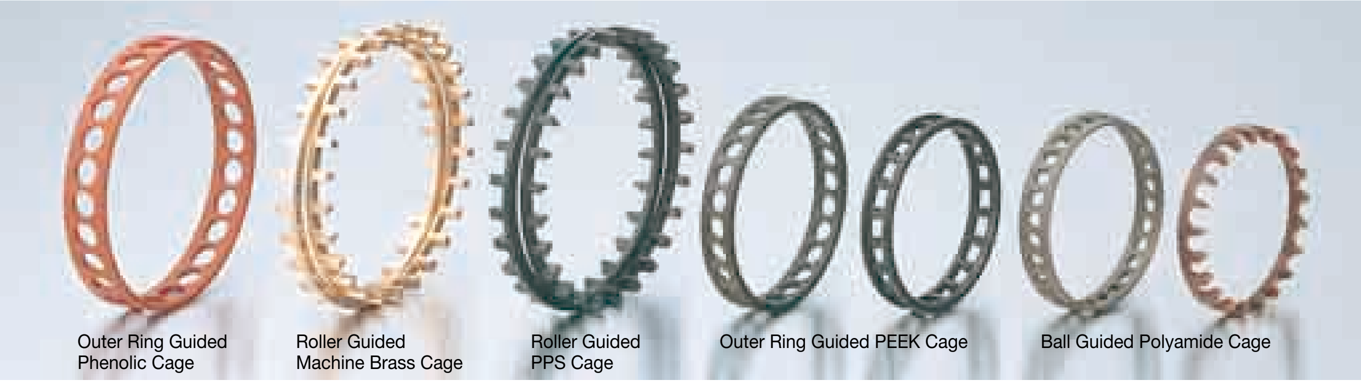


Application Example
Ultra High-Speed Single Row CRB
Robust Series

Roller Guided Machined Brass Cage (MB, MR)

- This cage demonstrates high temperature resistance, high strength, and high rigidity.

Cage Variations



Super Precision Bearings – Product Range

Several types of super precision bearings are available from NSK, including the ROBUST™ series of high performance bearings, the special series of bearings for unique and specialized applications, and the standard series bearings.

High Precision Angular Contact Ball Bearings Standard Series

Basic NSK super precision bearings manufactured to conform to ISO standard.

- 70xx, 72xx, 79xx series
- Three types of contact angle: 15˚ (C), 25˚ (A5), 30˚ (A)
- Two types of cage design: Select either phenolic (TR) or polyamide (TYN), depending on application requirements

Ultra High-Speed Angular Contact Ball Bearings BNR, BER Series

High performance bearings developed for high speed operation with low temperature rise. Suitable for ultra high precision machining applications, and ultra high speed applications.

- Two types of contact angle: 18˚ (BNR), 25˚ (BER)
- Two types of ball material: steel (S type) and ceramic (H and X type)
- Two types of cage design: Select either phenolic (T) or polyamide (TYN), depending on application requirements
- ROBUST series also can be used for ultra high speed applications of over 3 million d_mn.

High-Speed Angular Contact Thrust Ball Bearings BAR, BTR Series

High rigidity thrust bearings for lathe applications.

- Two types of contact angle: 30˚ (BAR), 40˚ (BTR)
- Two types of ball material: steel (S type) and ceramic (H type)

Ultra High Precision Angular Contact Ball Bearings BGR Series

High Performance bearings developed specifically for internal grinding or high speed motor applications under spring preload.

- Bore size range: ϕ6–25 mm, contact angle: 15˚
- Two types of ball material: steel (S type) and ceramic (H and X type)
- Non separable type
- Universal combinations (DU and SU)

Sealed Angular Contact Ball Bearings Special Series

Pre greased and sealed to reduce handling problems. Suitable for maintenance of machine tool spindles.

- Standard series super precision angular contact ball bearings
- ROBUST series high speed angular contact ball bearings

Bore size range: ϕ30–100 mm in ISO series 10 and 19 (70xx and 79xx)

ROBUST series is the high performance series of NSK super precision bearings.

Ultra High-Speed Single Row Cylindrical Roller Bearings ROBUST Series Standard Series

High performance cylindrical bearings designed for ultra high speed applications, such as machining center spindles.

- Two types of cage material: Brass (MR)(1) and PEEK resin (TP)
- Three types of roller material: Steel, SHX and Ceramic
- Ultra high speed ROBUST RXH design can be used up to 3 million d_mn

(1) MR cage is used in the standard series

Double Row Cylindrical Roller Bearings High Rigidity Series

Designed to deliver high rigidity in high speed applications such as lathe spindles.

- Two types of cage material: Brass (MB), PPS resin (TB)
- Standard specification E44: Outer ring oil holes and groove

Angular Contact Thrust Ball Bearings for Ball Screw Support for Machine Tool Applications

High rigidity thrust bearings designed specifically for ball screw support applications in machine tools.

- Contact angle: 60˚
- Can be universally matched to any required rigidity specification or life cycle
- A pre-greased line using special grease is also available
- A new series is available, supplied with contact seals and waterproof grease

Angular Contact Thrust Ball Bearings for Ball Screw Support for Injection Molding Machines

The high load capacity design delivers five times the life expectancy compared to ball screw support bearings for machine tool applications of a similar size. The number of rows can also be reduced.

- Easier handling than tapered roller bearings or thrust spherical roller bearings as a result of non-separable configuration
- Optimum ball bearing design results in lower rotational torque
- Can be universally matched to any required rigidity specification or life cycle

High Precision Deep Groove Ball Bearings Special Series

Suitable for high speed and high precision motors.

- Three types of cage : Ball guided polyamide cage (T1X,TYA) and inner ring guided phenolic cage (T), selection depends on the application
- Suitable for silent or low vibration operation

Ultra High-Speed Angular Contact Ball Bearings

Designed to achieve high speed operation combined with low heat generation —ROBUST Series

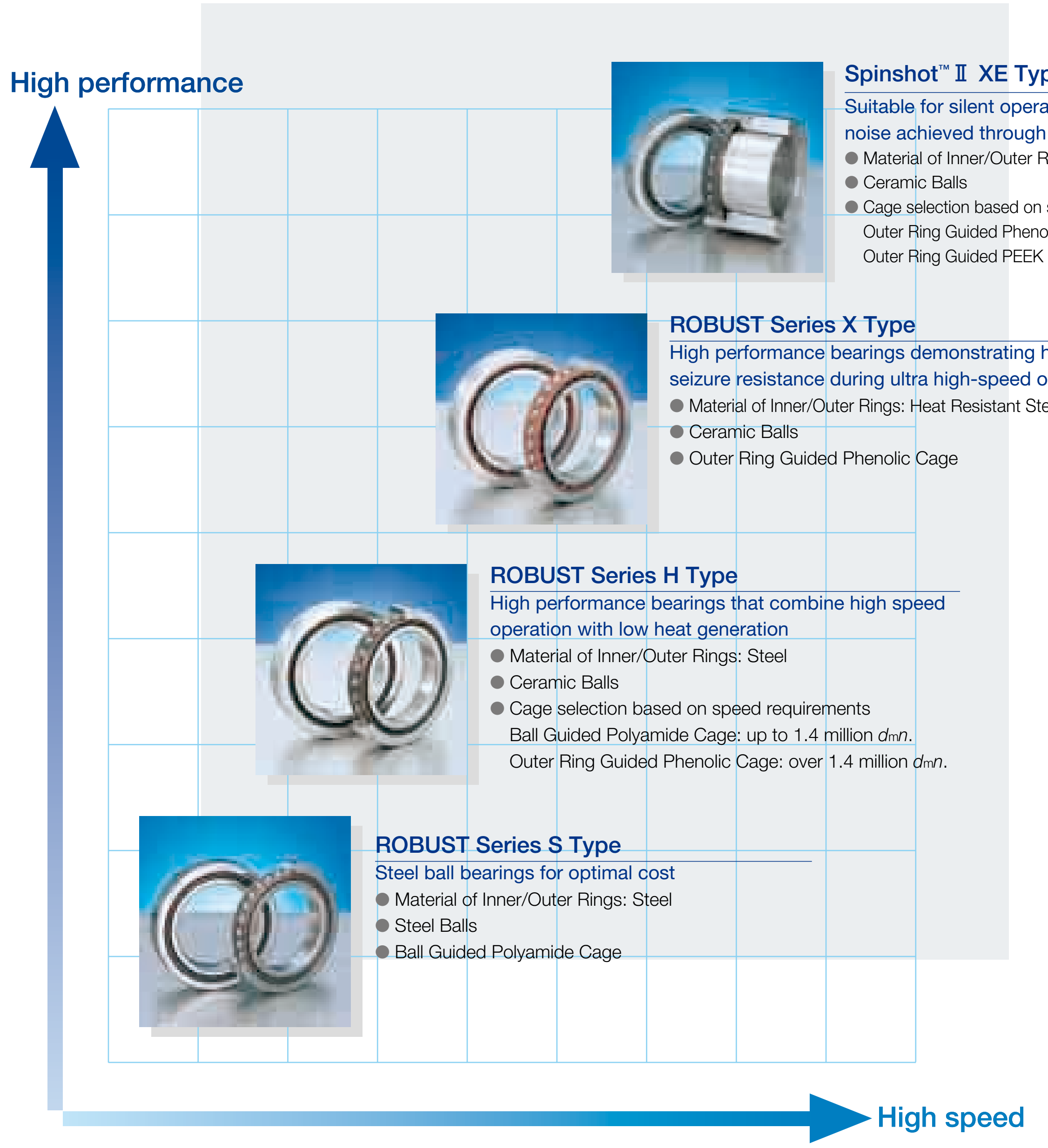
Benefits

1
Low Heat Generation

2
High Seizure Resistance

3
Better Temperature Stability “Robustness”

4
Stable during High Speed Operation



Spinshot™ Ⅱ XE Type

Suitable for silent operation due to reduced air-noise achieved through oil-air lubrication design

- Material of Inner/Outer Rings: Heat Resistant Steel “SHX”
- Ceramic Balls
- Cage selection based on speed requirements
  Outer Ring Guided Phenolic Cage: up to 2.5 million d_mn.
  Outer Ring Guided PEEK Cage: over 2.5 million d_mn

ROBUST Series X Type

High performance bearings demonstrating high wear and seizure resistance during ultra high-speed operation

- Material of Inner/Outer Rings: Heat Resistant Steel “SHX”
- Ceramic Balls
- Outer Ring Guided Phenolic Cage

ROBUST Series H Type

High performance bearings that combine high speed operation with low heat generation

- Material of Inner/Outer Rings: Steel
- Ceramic Balls
- Cage selection based on speed requirements
  Ball Guided Polyamide Cage: up to 1.4 million d_mn.
  Outer Ring Guided Phenolic Cage: over 1.4 million d_mn.

ROBUST Series S Type

Steel ball bearings for optimal cost

- Material of Inner/Outer Rings: Steel
- Steel Balls
- Ball Guided Polyamide Cage

Features of “XE” series

High Speed Performance (in Position Preload)

High speed performance in position preload to a maximum of 2.5 million d_mn with jacket cooling (Max. 2.7 million d_mn without jacket cooling)

Silent Operation

Silent operation 3-5 dB quieter than conventional oil-air lubrication.

Orientation

Remains stable in either vertical or horizontal spindle orientation.

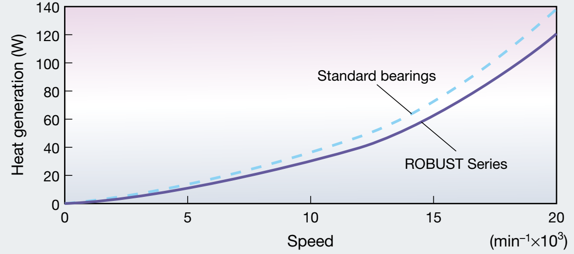
Reduced Air Consumption

Air consumption can be 1/3 relative to conventional oil-air lubrication.

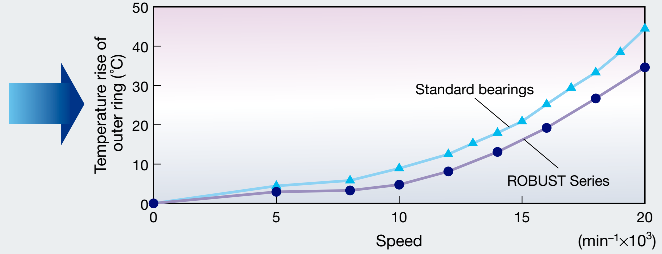
Analysis Data

Sophisticated analysis software takes into account the slip inside the bearing and simulates temperature rise to establish optimum design specifications. By reducing the heat generated, ROBUST series bearings remain much more stable during high speed operation than current series bearings.

Heat Generation with Grease Lubrication
Analytical Value (ø65 mm)

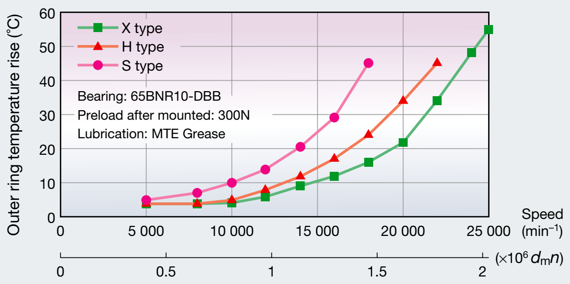


Outer Ring Temperature Rise with Grease Lubrication
Test Result (ø65 mm)

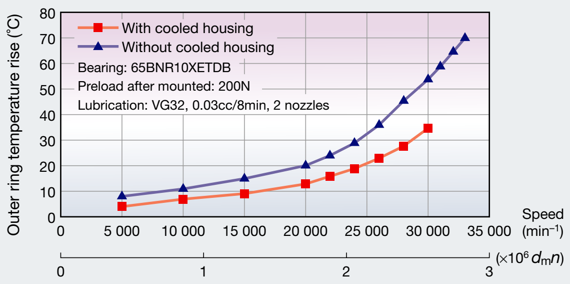


Test Data

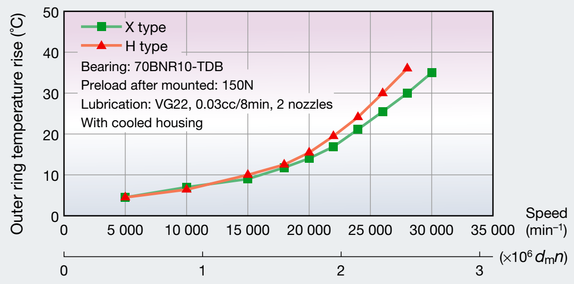
Temperature Data with Grease Lubrication



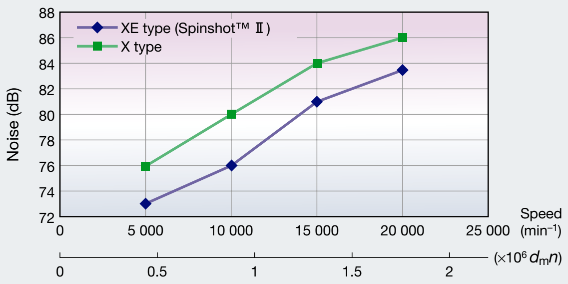
Temperature Data of Spinshot™ Ⅱ



Temperature Data with Oil-Air Lubrication



Noise Comparison



ROBUST Series Standard Series

High Performance Cylindrical Roller Bearings

Designed to achieve high speed performance combined with high rigidity

Benefits

1
Low Heat Generation

2
Improved Seizure Resistance

3
Stable Operation in Ultra High Speed

High performance

ROBUST Series RXH Type

Ultra High-Speed Single Row Cylindrical Roller Bearings

Highest performance for optimum seizure resistance during ultra high-speed operation

- Material of Inner/Outer Rings: Heat Resistant Steel "SHX"
- Ceramic Rollers
- Outer Ring Guided PEEK Cage

ROBUST Series RX Type

Ultra High-Speed Single Row Cylindrical Roller Bearings

High performance with wear and seizure resistance during ultra high speed operation

- Material of Inner/Outer Rings: Heat Resistant Steel "SHX"
- SHX Rollers
- Outer Ring Guided PEEK Cage

High Rigidity Series

Double Row Cylindrical Roller Bearings

High performance series with a newly developed polymer cage

- Material of Inner/Outer Rings: Steel
- Roller Guided PPS Cage or Roller Guided Brass Cage. Selection based on application requirements

ROBUST Series RS Type

Ultra High-Speed Single Row Cylindrical Roller Bearings

Designed to deliver cost effective high-speed performance

- Material of Inner/Outer Rings: Steel
- Steel Rollers
- Outer Ring Guided PEEK Cage

Standard Series

Single Row Cylindrical Roller Bearings

Standard type bearing with brass cage

- Material of Inner/Outer Rings: Steel
- Roller Guided Brass Cage

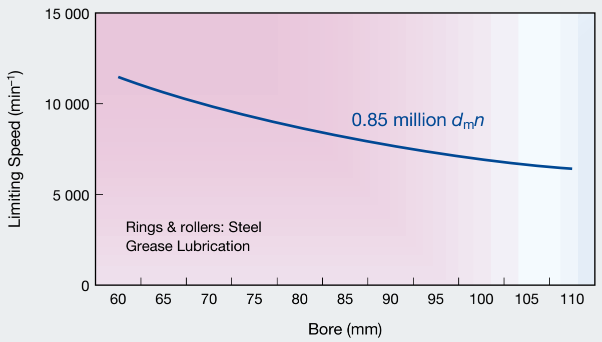
High speed

Features of High Rigidity Double Row Cylindrical Roller Bearings

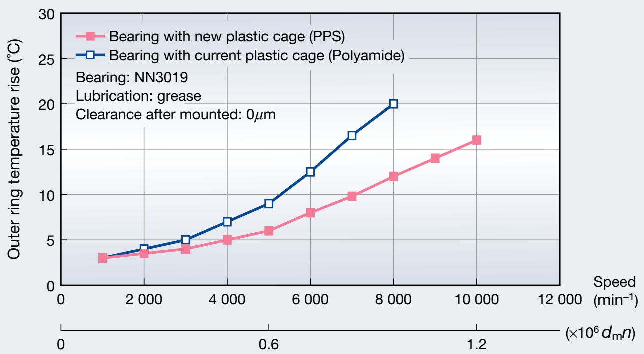
● Longer Bearing Life

The PPS (engineered polymer) cage is heat resistant and provides high rigidity. As compared to a brass cage, this cage eliminates any wear particles, allowing an extended grease life.

Limiting Speed



Temperature Rise with Grease Lubrication



Features of the ROBUST series Ultra High-Speed Single Row Cylindrical Roller Bearings

● Low Heat Generation

Internal design and advanced cage material result in low heat generation.

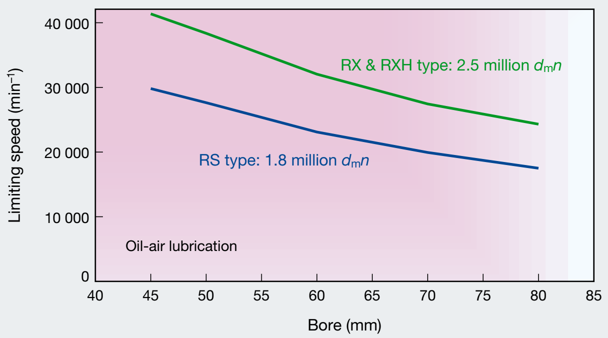
● Seizure Resistance

RX and RXH types are made with SHX steel resulting in improved seizure resistance.

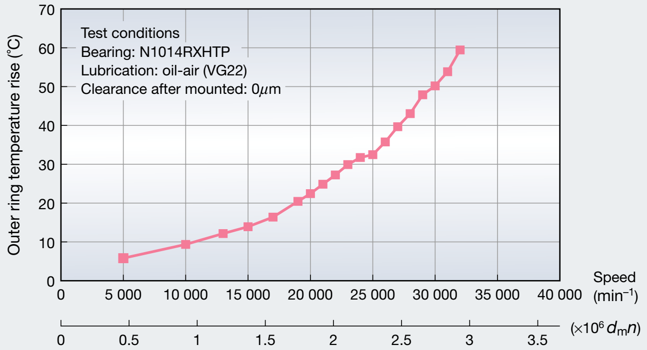
● High Speed Capability

RS, RX and RXH types have cages made of heat resistant PEEK material for ultra high speed operation (over 2.5 million $d_m n$)

Limiting Speed



Temperature Rise with Oil-Air Lubrication

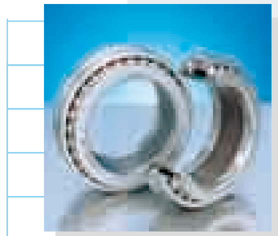


High-Speed Angular Contact Thrust Ball Bearings

High performance bearings that combine high speed capability with high rigidity—ROBUST Series

Benefits

1
High Speed Capability
2
Low Heat Generation
3
High Accuracy



Double Row Angular Contact Thrust Ball Bearings

TAC Series

60˚ contact angle with the highest axial rigidity.

High-Speed Angular Contact Thrust Ball Bearings

BTR10 Series

40˚ contact angle and high axial rigidity and low heat generation. Interchangeable with TAC series.

High-Speed Angular Contact Thrust Ball Bearings

BAR10 Series

30˚ contact angle delivers higher speed capability. Interchangeable with BTR and TAC series.

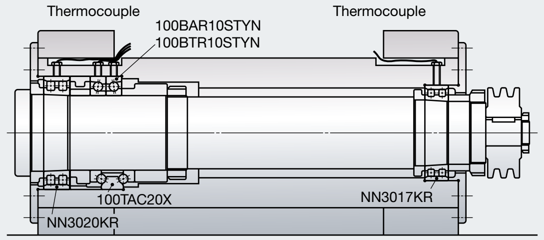
Features of Angular Contact Thrust Ball Bearings

- **High Accuracy**

  Due to the high degree of accuracy, they are particularly suited for lathe spindle applications.

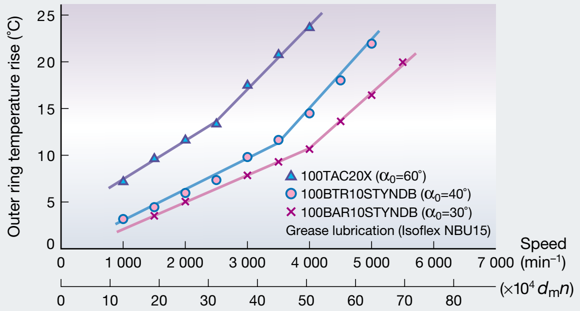
- **Interchangeable**

  To adjust spindle stiffness characteristics, BTR and BAR series can be interchanged with TAC series, with minimal modification of the spindle. (See right figure).

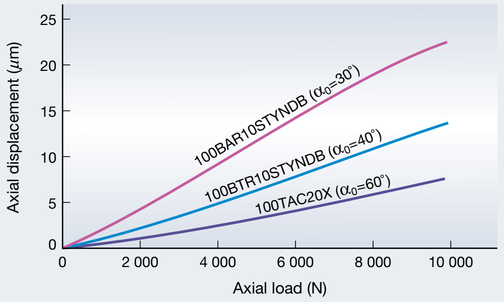


Test machine structure

Data with Grease Lubrication



Axial Load and Axial Displacement



Ultra High Precision Angular Contact Ball Bearings

Ultra high speed internal grinding spindle bearings for high accuracy and longer life—BGR Series

Benefits

1
Optimum Internal Design
2
Easy Handling Due to Non Separable Feature
3
Free Choice of Arrangement with Universal Combination

Features of the BGR Series

- **Optimum Design**

  Optimum outer ring guided cage design for better lubrication. Inner ring shoulder relieved to enable a stable supply of oil into the bearing.

- **Longer Life**

  Heat resistant SHX steel for longer life.

- **Easy Handling**

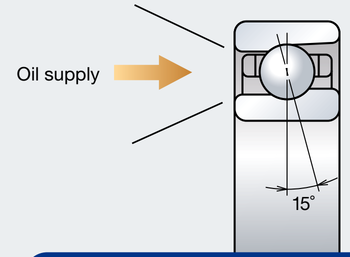
  Non separable structure makes handling easy.

- **Ultra High Accuracy**

  ISO class 2 (ABMA ABEC9) is the standard.

- **Universal Combination**

  Bearings can be configured in the usual arrangements of DB/DF/DT, as well as a variety of other arrangements.



Optimal design with non separable structure

Special Series

Ball Screw Support Angular Contact Thrust Ball Bearings
(for Machine Tool Applications)

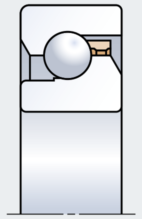
High performance special bearings with high rigidity—TAC B Series

Benefits

1
Longer Life
2
Lower Torque
3
Easy Handling
4
High Accuracy

Features of Ball Screw Support Bearings for Machine Tools

- **Longer Life**
  Components made from longer life EP extremely purified steel.
- **High Rigidity**
  Special internal design (60˚ contact angle and more balls) for higher axial rigidity.
- **Lower Torque**
  Lower starting torque than either tapered or cylindrical roller bearings means high rotation accuracy even at low driven power.
- **Universal Combination**
  Bearings can be configured in the usual arrangements of DB/DF/DT, as well as a variety of other arrangements.
  A pre greased option is also available (with Alvania No.2 grease).
- **Easy Handling and Increased Reliability**
  New series with contact seals and waterproof grease has higher reliability and easier handling.
  Single universal combination (SU) is the standard for this series.
- **High Running Accuracy**
  New polyamide cage for high running accuracy.



Cross Section of TAC B

Special Series

Ball Screw Support Angular Contact Thrust Ball Bearings
(for Injection Molding Machines)

These special high performance bearings can simplify machine design and reduce costs—TAC 02, 03 Series

Benefits

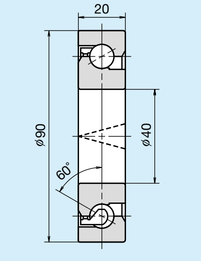
1
Space Saving, High Load Capacity
2
High Reliability
3
Easy Handling
4
Reduced Torque from Optimized Design

Features of Ball Screw Support Bearings for Injection Molding Machines

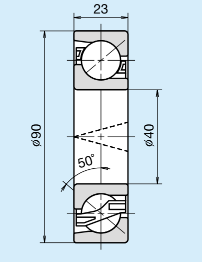
- **High Reliability**
  High load capacity design delivers five times the life value compared to the similarly sized TAC B series.
- **Easy Handling**
  Easier to handle and use than tapered roller bearings or thrust spherical roller bearings due to the non separable design.
- **Simplified Design Leads to Reduced Costs**
  Preload is preset so assembly is fast and without any preload adjustment. Design of special parts for preload adjustment is unnecessary, which saves time and cost.
- **Lower Rotational Torque**
  Optimal internal design for lower torque (i.e., in cases where roller bearings are currently being used because of large load, these bearings can be used to reduce the bearing torque generated by roller bearings).

Cross Section of the Bearing for Machine Tools and Injection Molding Machines

For Machine Tools
40TAC90B



For Injection Molding Machines
40TAC03AT85



Special Series

Sealed Angular Contact Ball Bearings

Suitable for spindle maintenance — ROBUST series and Standard series

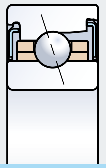
Features of Sealed Angular Contact Ball Bearings

- **Easy handling**

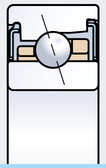
  No need to grease the bearing during spindle assembly.

- **Environmentally Friendly**

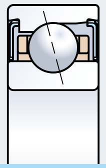
  Sealed design avoids grease loss.



ROBUST Series with T cage



ROBUST Series with TYN cage



Standard Series with TR cage

Other Products

Sealed Precision Spacers

Sealed spacers eliminate the possibility of contamination
Precision spacers available for machine tool spindles

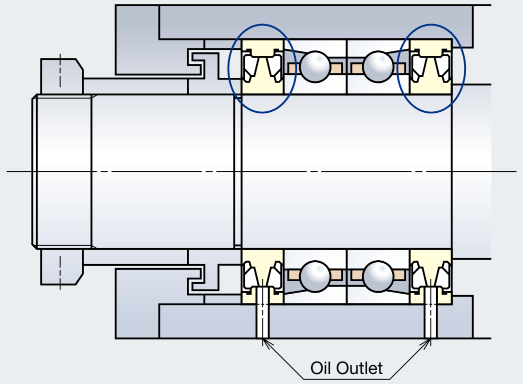
Features of Sealed Precision Spacers

- **Environmentally Friendly**

  Sealed design prevents grease loss.

- **High Reliability**

  Reduced contamination from dust or coolant in grease lubricated spindles.



Other Products

High Performance Greases for Machine Tool Spindles

MTS, MTE, ENS

Features of Greases for Machine Tool Spindles

MTS	Contains urea thickener and delivers higher heat resistance. Recommended for use with ultra high speed machine tool spindles.
MTE	Formulated to handle higher load capacities. Recommended for use in high speed machine tool spindles.
ENS	Environmentally friendly thanks to biodegradability.

MTE and MTS are available in 100g tubes as well as 1kg cans, and ENS is available in 2.5kg cans.

Characteristics of each grease

Items	Condition	MTS	MTE	ENS	Test Method
Thickener	—	Urea	Barium Complex	Urea	—
Base Oil	—	Mixed Synthetic Oil	Ester Oil	Ester Oil	—
Kinematic Viscosity of Base Oil (mm^2/S)	40˚C	22	20	32	JIS K 2220 5.19
Worked Penetration	25˚C, 60W	2–3	2	2	JIS K 2220 5.3
Dropping Point (˚C)	—	> 220	> 200	> 260	JIS K 2220 5.4
Evaporation (mass%)	99˚C×22H	0.3	0.4	0.4	JIS K 2220 5.6B
Oil Separation (mass%)	100˚C×24H	0.4	1.0	1.1	JIS K 2220 5.7

Selecting the Right Bearing is Critical

Precision bearings are designed to deliver the high accuracy, high rotational speed, and high rigidity needed for demanding machine tool applications. As each application has its own unique requirements, and each type of bearing has different characteristics, it is essential to select the type of bearing based on the specific demands of a given application.

Take Advantage of NSK Technical Support when Selecting Bearings

NSK is committed to helping customers select the proper bearings that will deliver the best performance based on the application involved.

When designing a new spindle, including ultra high speed, specialized or custom applications, or making your bearing selection, please don't hesitate to ask us for technical assistance. We have the experience and expertise in state of the art, high speed, main shaft spindle technology to assure that you get the very best bearings for your application.

For more information on the latest NSK technology, please visit our Web site or call today.

NSK Web Site
http://www.nsk.com

Part 3

Bearing Selection P32

Typical High Speed Main Shaft Spindle Structures P34

Other Spindle Structures P36

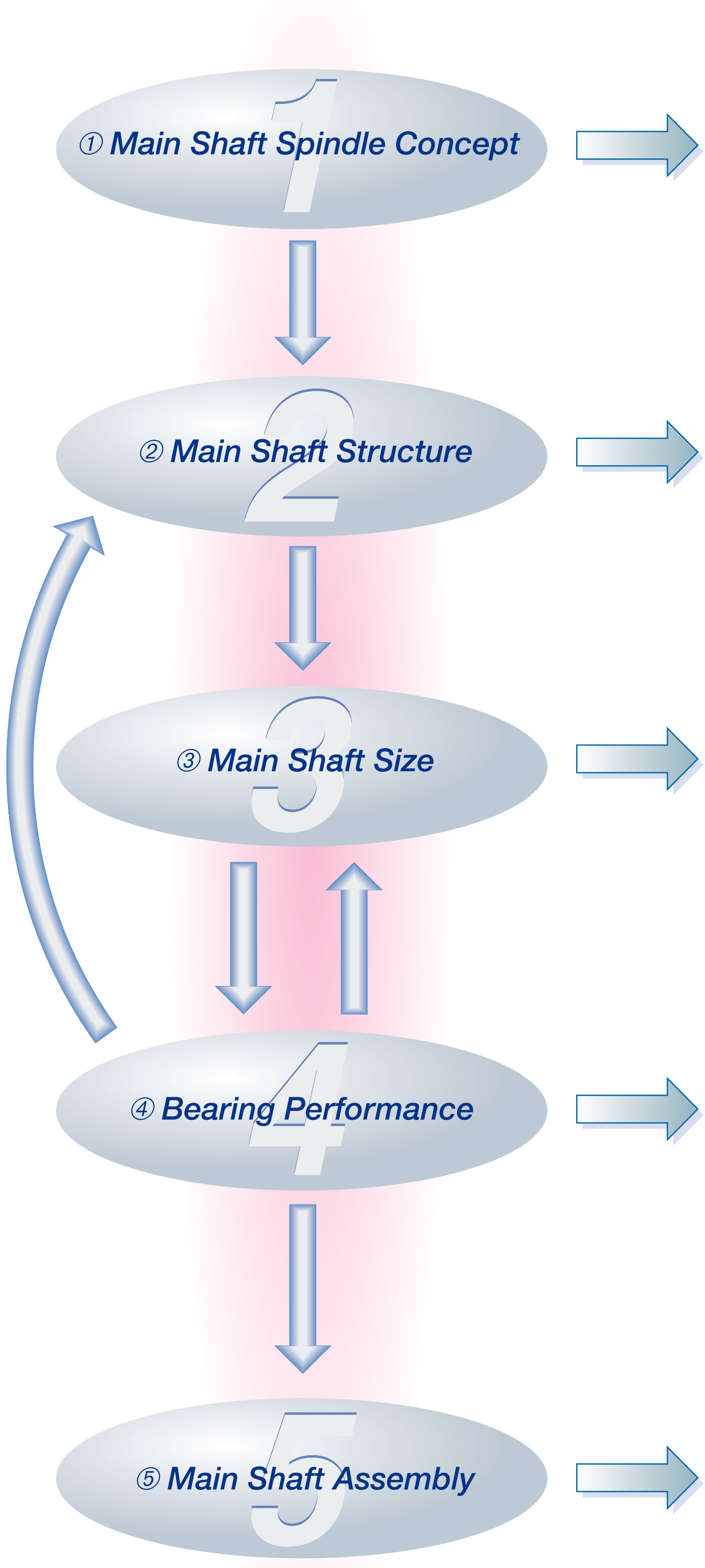
Features of Angular Contact Ball Bearings P38

Features of Cylindrical Roller Bearings P40

BEARING SELECTION

The chart below outlines the correct five step procedure to follow when selecting the proper bearing for a typical high-speed spindle application, including the factors to be considered in each stage of the selection process.

Remember, NSK technical support is always at your disposal when designing a new spindle, an ultra high speed spindle or a spindle for a unique specialized application. We offer customers our experience and our expertise in advanced technology.



① Main Shaft Spindle Concept

- Speed
- Running Accuracy
- Rigidity
- Life
- Spindle Heat Generation
- Reliability

When designing a new main shaft spindle, we recommend a thorough analysis of the desired spindle performance before selecting the bearing. In designing the spindle, it is necessary to determine which performance factor is most important. For example, deciding if the rotational speed is more important than the rigidity, or vice versa. Once the performance factors are prioritized proceed to the next step.

② Main Shaft Structure

- Bearing Type
- Drive Type
- Bearing Arrangement
- Lubrication
- Preload Method
- Jacket Cooling

After the performance analysis of the main shaft has been completed, the next step is to determine the structure of the main shaft. To determine the optimum structure, consideration must be given to each individual component: the bearing design (ball bearing or roller bearing); combination (the number of rows); type of drive (belt, gear, coupling or integral motor); and lubrication system (grease, oil-air, oil mist, or jet). Care must be taken to ensure that the structure is compatible with the criteria and priority established in your analysis of spindle performance. Please refer to the chart on Page 34–35, which shows the relationship between the main shaft structure and its rigidity and speed.

See Part 3

③ Main Shaft Size

- Shaft Diameter and Length
- Main Shaft Rigidity
- Distance between Bearings
- Natural Frequency of the Shaft
- Limiting Speed
- Bearing Series

After the structure has been determined, the dimensions of the shaft must be determined, including diameter, length, and distance between the bearings. The size of the main shaft will determine the limiting speed of the bearing, the rigidity of the main shaft, and the natural frequency of the main shaft. As the size, type, combination of bearing used, and the method of lubrication all affect the limiting speed, please refer to Part 4 and Part 5 before making a final determination.

See Part 4 and Part 5

④ Bearing Performance

- Fatigue Life
- Preload
- Rigidity
- Clearance
- Bearing Heat Generation
- Running Accuracy
- Lubrication Life
- Static Load Capacity

Once the size and type of the bearing are selected, the specification of the bearing should be determined. In order to select the appropriate clearance, or preload, of the bearing it is necessary to consider such factors as fatigue life, axial and radial rigidity, and heat generation. Clearance or preload must be selected carefully, as these factors have the largest impact on overall spindle performance, especially during high speed operation. If the preload is wrong it may cause problems such as early failure or seizure. Sometimes it is necessary to repeat step ③, or even steps ② and ③, before the most accurate spindle design is achieved.

See Part 5

⑤ Main Shaft Assembly

- Shaft Run out
- Nut Tightening Force
- Housing Accuracy
- Checking Preload
- Fit and Clearance
- Checking Clearance
- Compression Amount of Retaining Cover
- Quantity of Oil Supply

After the specification of the main shaft is complete, the final stage is the specification of the assembly method. Accuracy of the shaft and housing at the bearing seats is important. Specify the fit and clearance of the bearings to the shaft and housing. Use the correct nut tightening force to fix the bearings. And double check that the preload, or clearance, after the bearing has been mounted is correct.

See Part 6

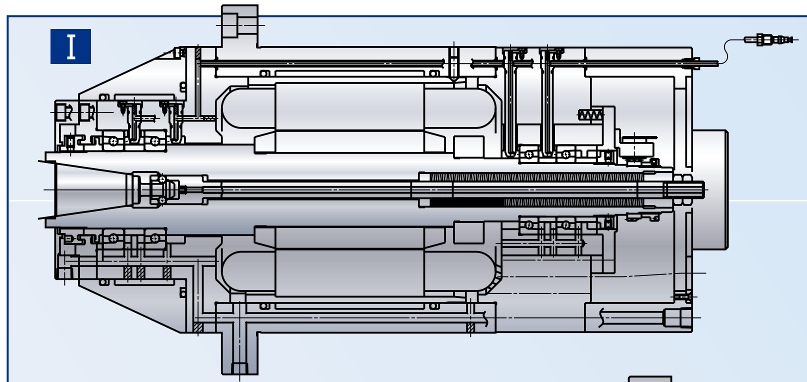
TYPICAL HIGH SPEED MAIN SHAFT SPINDLE STRUCTURES

(Speeds Higher than 0.7 million d_mn)

Rotational Speed (d_mn)

Rigidity of The Main Shaft

Ⅰ



Bearing Arrangement Ⅰ

Front side: Ultra high-speed angular contact ball bearing duplex sets (DT)

Rear side: Ultra high-speed angular contact ball bearing duplex sets (DT)

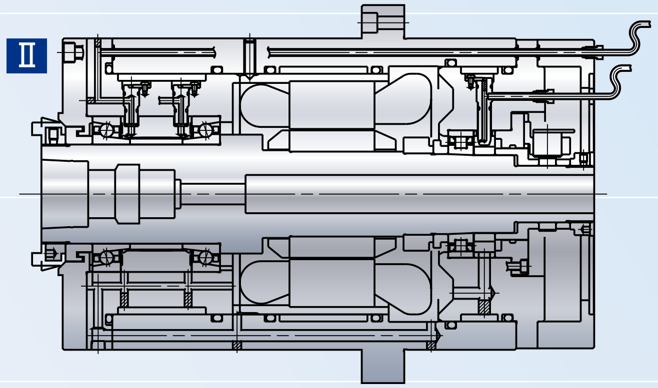
Spindles with this arrangement are suited for ultra high speed operation and use constant pressure preload. Although this spindle has lower rigidity it delivers higher speed capability with a lower temperature rise performance relative to a spindle with position preload.

Applications: Machining Center, Grinding Machine, High Frequency Spindle, etc.

Oil-air lubrication d_mn 3.5M

Grease lubrication d_mn 2.0M

Ⅱ



Bearing Arrangement Ⅱ

Front side: Ultra high-speed angular contact ball bearing duplex sets (DB)

Rear side: Ultra high-speed single row cylindrical roller bearing (In case of angular contact ball bearings, either position or constant pressure preload is applicable)

Spindles with this arrangement are suited for ultra high speed operation and use position preload. They achieve higher radial and axial rigidity than spindles with Bearing Arrangement Ⅰ. It is possible to use a cylindrical roller bearing on the rear side, for better slide performance.

Applications: Machining Center, Grinding Machine, High Frequency Spindle, etc.

Oil-air lubrication d_mn 2.5M

Grease lubrication d_mn 1.5M

Bearing Arrangement Ⅲ

Front side: Ultra high-speed angular contact ball bearing quad sets (DBB)

Rear side: Ultra high-speed single row cylindrical roller bearing (In case of angular contact ball bearings, either position or constant pressure preload is applicable)

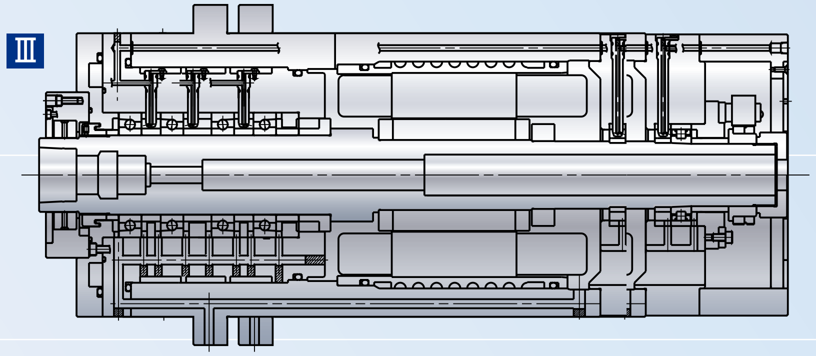
Spindles with this arrangement will have lower speed capability, and higher radial and axial rigidity relative to Bearing Arrangement Ⅱ.

Applications: NC Lathe, NC Milling Machine, Machining Center, etc.

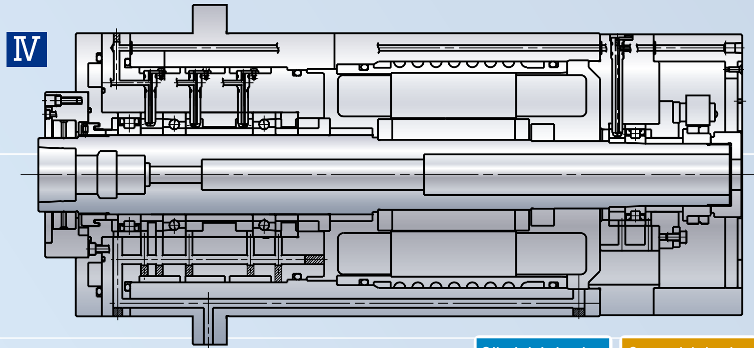
Oil-air lubrication d_mn 2.2M

Grease lubrication d_mn 1.3M

Ⅲ



Ⅳ



Bearing Arrangement Ⅳ

Front side: Ultra high-speed single row cylindrical roller bearing, Angular contact ball bearing duplex sets (DB)

Rear side: Ultra high-speed single row cylindrical roller bearing (In case of angular contact ball bearing, either position or constant pressure preload is applicable)

Spindles with this arrangement have high-speed capability similar to spindles with Bearing Arrangement Ⅲ. As there is a cylindrical roller bearing in the front side, the radial rigidity is high, so it is possible to have both high speed and heavy cuts.

Applications: NC Lathe, NC Milling Machine, Machining Center, etc.

Oil-air lubrication d_mn 2.2M

Grease lubrication d_mn 1.3M

Bearing Arrangement Ⅴ

Front side: Ultra high-speed angular contact ball bearing triplex sets (DBD)

Rear side: Ultra high-speed single row cylindrical roller bearing (In case of angular contact ball bearing, either position or constant pressure preload is applicable)

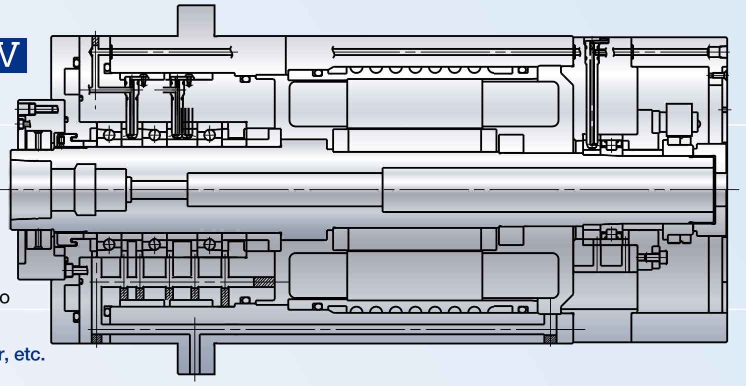
Spindles with this arrangement will have lower speed capability, and higher radial and axial rigidity relative to Bearing Arrangement Ⅱ, and lower speed capability and rigidity relative to Bearing Arrangements Ⅲ and Ⅳ.

Applications: NC Lathe, NC Milling Machine, Machining Center, etc.

Oil-air lubrication d_mn 1.8M

Grease lubrication d_mn 1.2M

Ⅴ



Bearing Arrangement Ⅵ

Front side: High rigidity double row cylindrical roller bearing, angular contact ball bearing duplex sets (DB)

Rear side: High rigidity double row cylindrical roller bearing

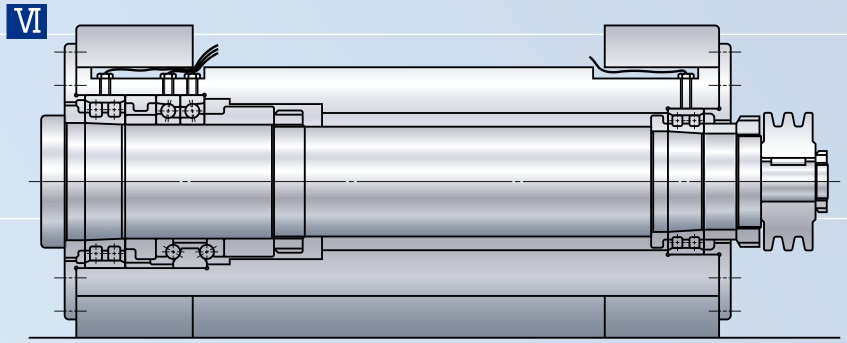
Although spindles with this arrangement have lower speed capability, the radial and axial rigidity of these spindles are highest.

Applications: NC Lathe, NC Milling Machine, Machining Center, etc.

Oil-air lubrication d_mn 1.0M

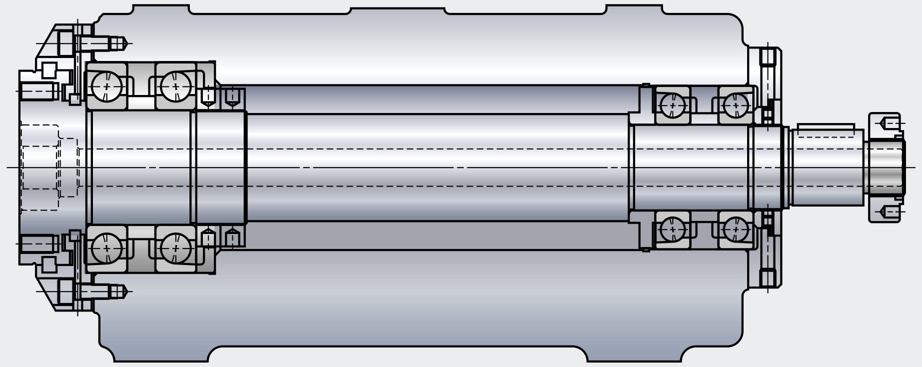
Grease lubrication d_mn 0.8M

Ⅵ

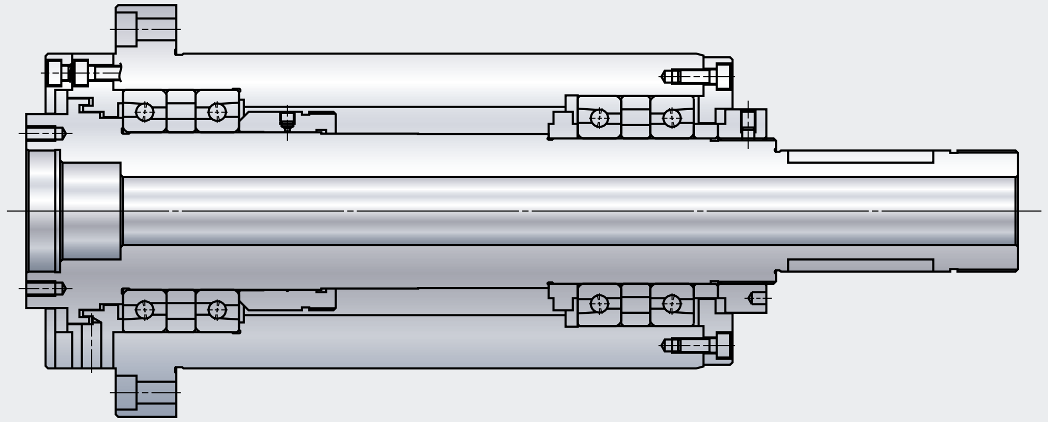


OTHER SPINDLE STRUCTURES

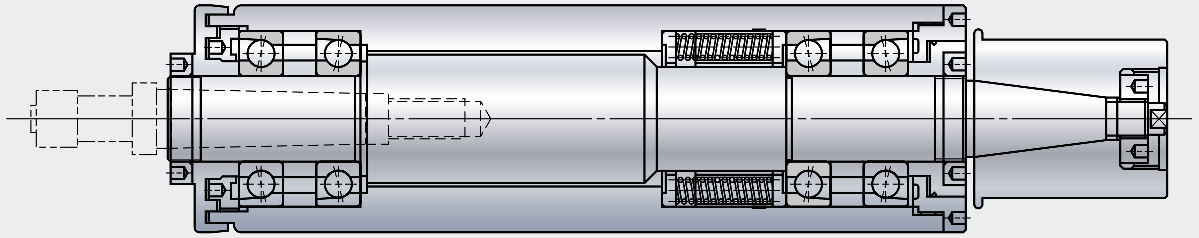
Boring Head



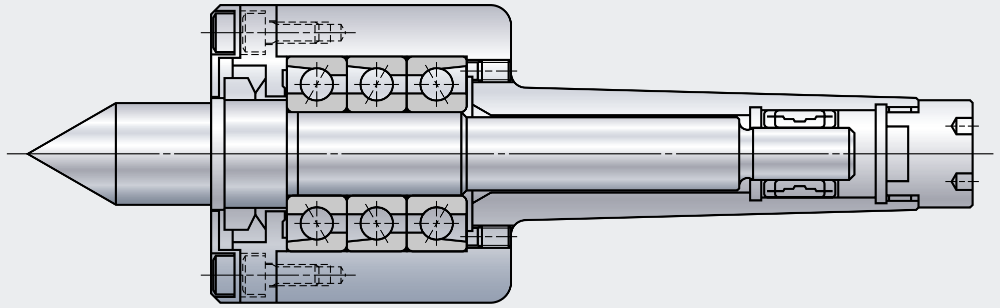
High Precision Spindle for Lathe



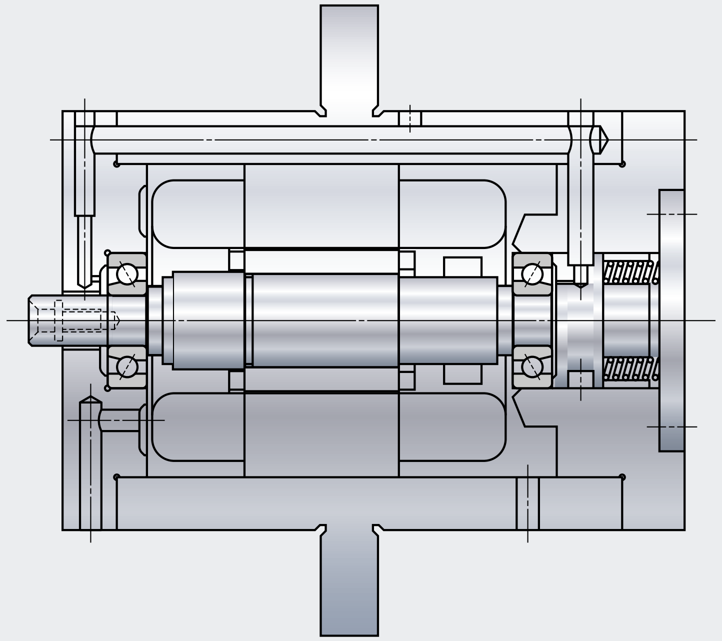
Grinding Spindle



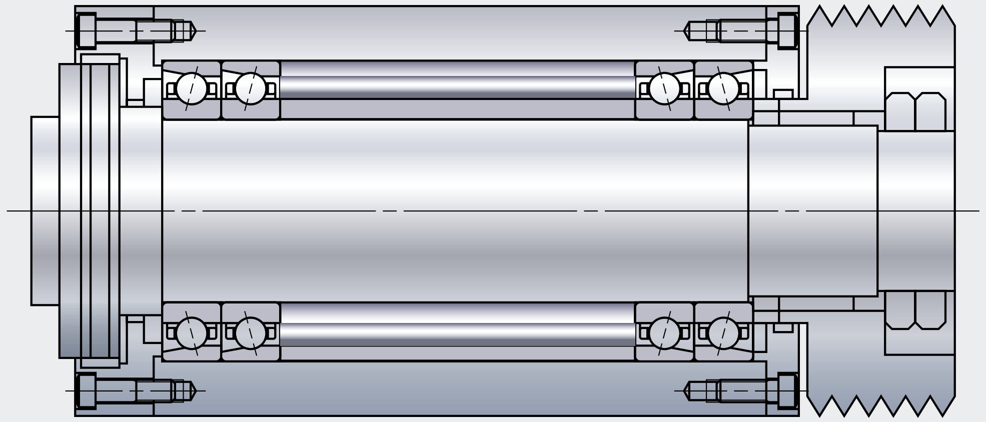
Live Center



High Frequency Spindle



Work Head Spindle



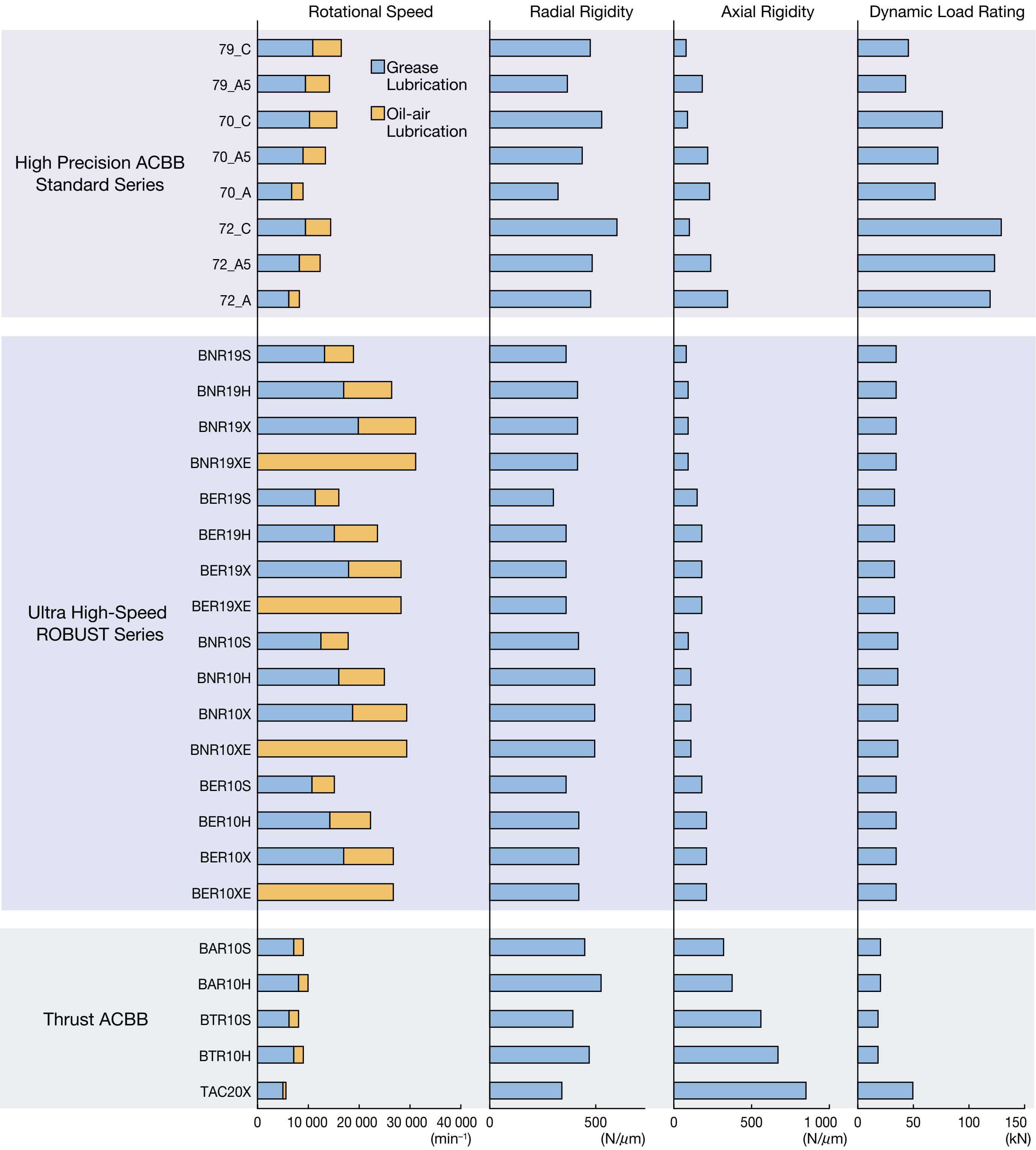
FEATURES OF ANGULAR CONTACT BALL BEARING

The main features of the ACBB are (1) a predefined contact angle, and (2) they are used in matched combinations with preload.

When selecting Angular Contact Ball Bearings, it is important to take these features into account, as each ACBB has different performance. It is important to understand the affect of changes in contact angle and preload on performance so that you select the ACBB that is best suited to the application.

The following graphs represent the relative performance of each type of ACBB, depending on the contact angle, under the same size, preload, and combination.

Performance Comparison of Each type of Bearing (Bore size–70mm, DB combination, L preload)

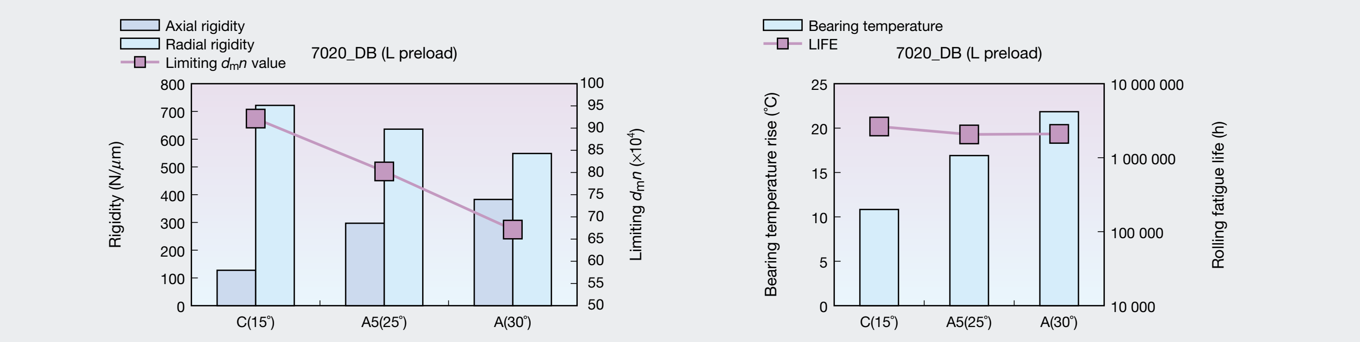


The Effect of Contact Angle

As the contact angle increases, Angular Contact Ball Bearings have a higher axial load capacity, but a lower speed capability. Thus, the ACBB with a smaller contact angle is better suited for high speed and high radial load applications.

The figure below compares the rigidity, limiting speed and temperature rise of a 7020 Angular Contact Ball Bearing with different contact angles: C angle (15˚), A5 angle (25˚) and A angle (30˚)

Under the same light preload level (L), the bearing with C angle has higher radial rigidity with lower temperature rise relative to the bearing with A angle. The bearing with A angle has the highest axial rigidity, three times higher than that of the bearing with C angle, but the limiting speed is lower than the others.

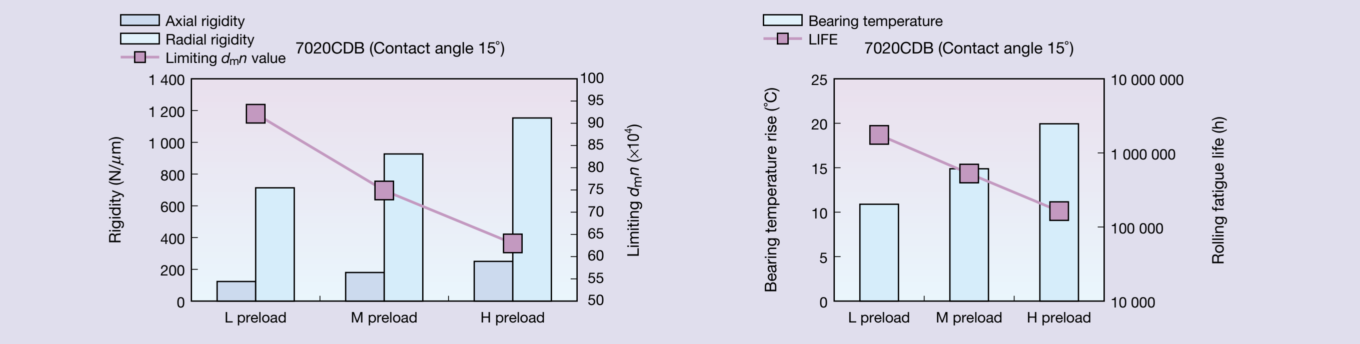


The Effect of Preload

Preload affects performance of ACBBs in much the same way that the contact angle does. As preload increases, the rigidity increases but the speed capability decreases. NSK has defined standard preload levels as extra light (EL), light (L), medium (M) and heavy (H).

The figure below compares the performance of a 7020CDB with each preload level. Even if the contact angle is held constant, when the preload is larger, both axial and radial rigidity are increased. However the temperature also rises, so the limiting speed and calculated life become lower.

In order to maintain high rigidity, it is necessary to sacrifice higher speed. Similarly to accomplish higher speed, it is necessary to sacrifice high rigidity. Caution must be exercised. If too high a preload is combined with high operation speed, there is a possibility of seizure.

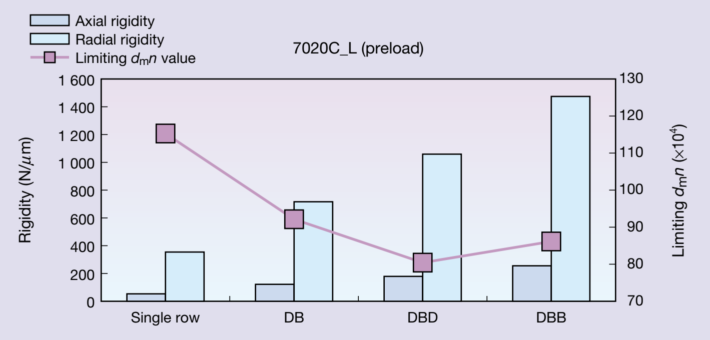


The Effect of Combination

ACBBs are usually used as multiple bearing sets.

There are three types of combinations —Back to Back (DB), Face to Face (DF) and Tandem (DT).

Two row, three row, and four row are the most popular multiple bearing sets. When the combination is held constant, and the number of rows is increased, the rigidity and the load capacity become larger, but the limiting speed becomes lower.

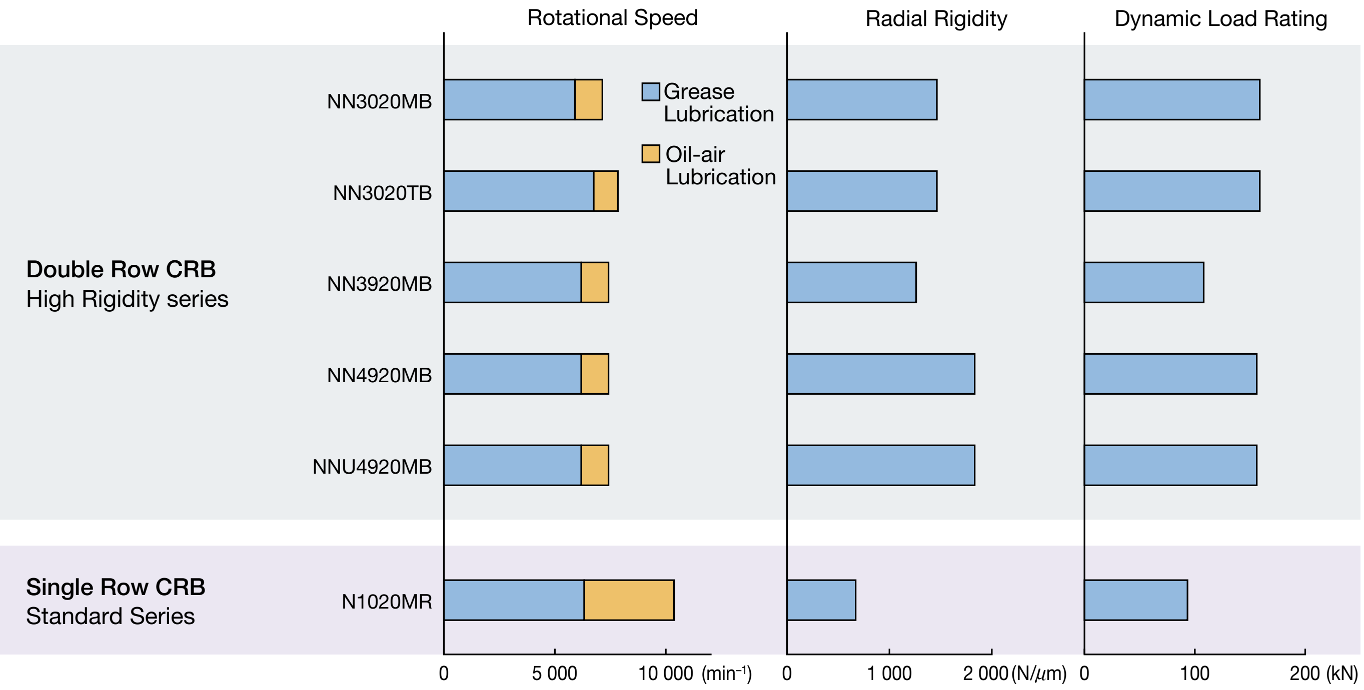


FEATURES OF CYLINDRICAL ROLLER BEARINGS

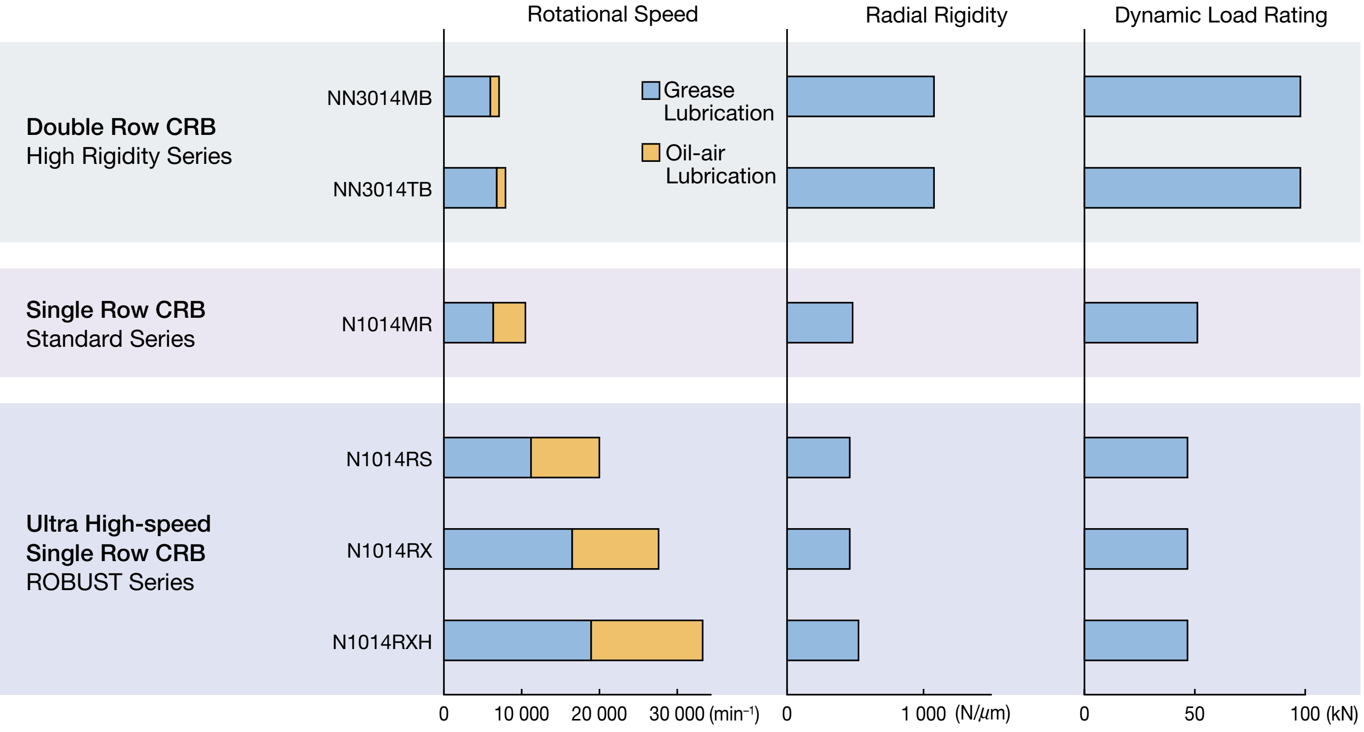
Unlike ACBB's which support both axial and radial loads, cylindrical roller bearings support only radial loads. However the radial load capacity rating is larger than that of ACBBs. Depending on the application either double row CRBs (NN type and NNU type) or single row CRBs (N type) are used.

Generally, double row cylindrical roller bearings are used in high rigidity applications such as a lathes, while single row cylindrical roller bearings are used in high speed applications such as a machining centers. The following graphs represent cylindrical roller bearing performance depending on the type of bearing (single or double row) and the radial clearance involved.

Performance Comparison Relative to CRB Type (bore size 100 mm)



Performance Comparison Relative to CRB Type: (bore size 70 mm)

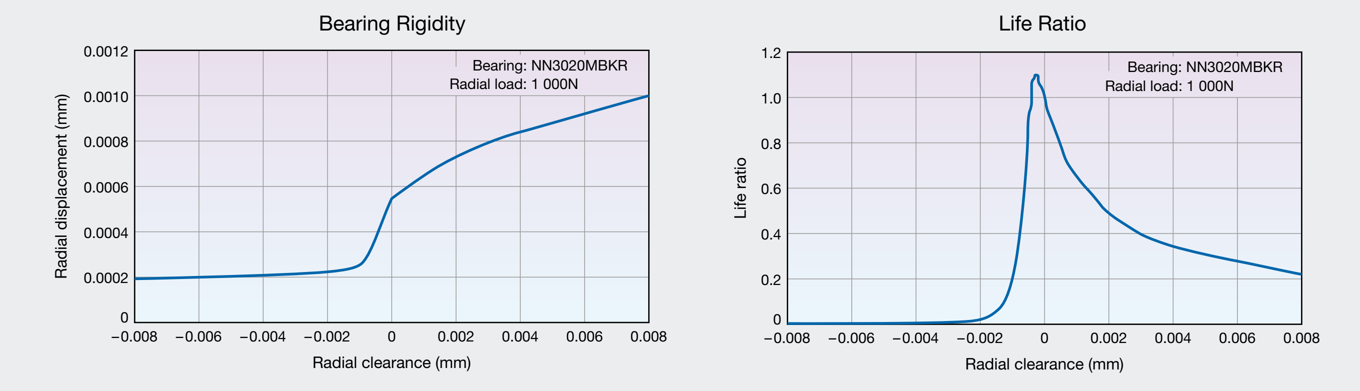


The Effect of the Radial Clearance

When using cylindrical roller bearings, it is important to control the radial clearance since it will have the greatest impact on bearing performance.

As the radial clearance increases, both rigidity and calculated fatigue life decrease. With higher radial clearances heat generation during operation also decreases. Conversely, as the figure below illustrates, rigidity is not increased if the radial clearance drops below –0.003 mm, while the calculated fatigue life continues to decrease. Therefore, the optimum clearance target to achieve high rigidity and long life is 0 or just slightly negative clearance.

For applications involving high speed, it is necessary to control the clearance during operation. Properly adjusting the radial clearance when the bearing is installed to compensate for the effects of high speed operation does this.



The Relationship Between Radial Clearance and Temperature Rise

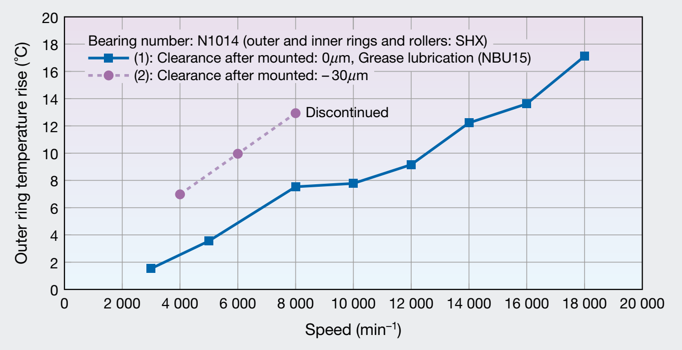
The figure at the right shows test result of the temperature rise of CRB.

After-mounted Radial Clearance

Bearing (1): 0 μm

Bearing (2): –30 μm

The temperature rise of bearing (2) is larger and the limiting speed is lower than bearing (1), clearly demonstrating the importance of properly controlling the clearance.



A CRB with a tapered bore is used to control radial clearance during spindle assembly because it is easy to adjust the radial clearance to any value. For a CRB with a tapered bore, the popular unmounted noninterchangeable radial clearance classes are CC9, CC0, and CC1. The specific features of each are outlined below.

CC0 clearance (NSK's recommended clearance)

Matched clearance range less than CC1. This range overlaps with the upper values of CC9 and lower values of CC1. As this clearance is easy for customers to target this range, it is the recommended clearance offered for CRB with taper bore.

● CC1 clearance

Matched clearance range is greater than CC0. While not the standard, this clearance is most popular in the field. When clearance is at its maximum, special care is required to accomodate expansion of the inner ring. If care is not used, and the spindle's cross-section is thin, deformation of the bearing or shaft may occur.

● CC9 clearance

Matched clearance range is less than CC0. This clearance will help avoid potential deformation of the inner ring or the shaft when there is little tolerance for inner ring expansion. Since the radial clearance is reduced to the minimum, the interference between the inner ring and the shaft becomes small. In high speed applications, this may cause loosening of the inner ring from the shaft and result in some creep damage.

High Precision Angular Contact Ball Bearings

Standard Series

Ultra High-Speed Angular Contact Ball Bearings

ROBUST Series

Ultra High-Speed Angular Contact Ball Bearings

Spinshot™ Ⅱ

Ultra High Precision Angular Contact Ball Bearings

BGR Series

Angular Contact Ball Bearings

High Precision Angular Contact Ball Bearings (Standard Series) ···P44-56
  - Features
  - Numbering System
  - Bearing Tables
    - Miniature Series
    - 79 Series
    - 70 Series
    - 72 Series

Ultra High-Speed Angular Contact Ball Bearings (ROBUST Series) ···P58-69
  - Features
  - Numbering System
  - Bearing Tables
    - BNR19, BER19 Series
    - BNR10, BER10 Series
    - BNR19XE, BER19XE Series (Spinshot™ Ⅱ)
    - BNR10XE, BER10XE Series (Spinshot™ Ⅱ)

Ultra High Precision Angular Contact Ball Bearings (BGR Series) ···P70-74
  - Features
  - Numbering System
  - Bearing Tables
    - BGR19 Series
    - BGR10 Series
    - BGR02 Series

Angular Contac t Ball Bearings

1. ANGULAR CONTACT BALL BEARINGS

High Precision Angular Contact Ball Bearing (Standard Series)

Features

Single row angular contact ball bearings have a line connecting the contact points drawn in the radial direction, which is called the contact angle. The contact angle makes this bearing suitable for accommodating radial loads, single direction axial loads, and a combination of both. Furthermore, since an axial component is generated when a radial load is applied, these bearings are generally used in pairs, triplex sets, quadruplex sets, or multiplex sets.

Contact Angle

Fig. 1.2

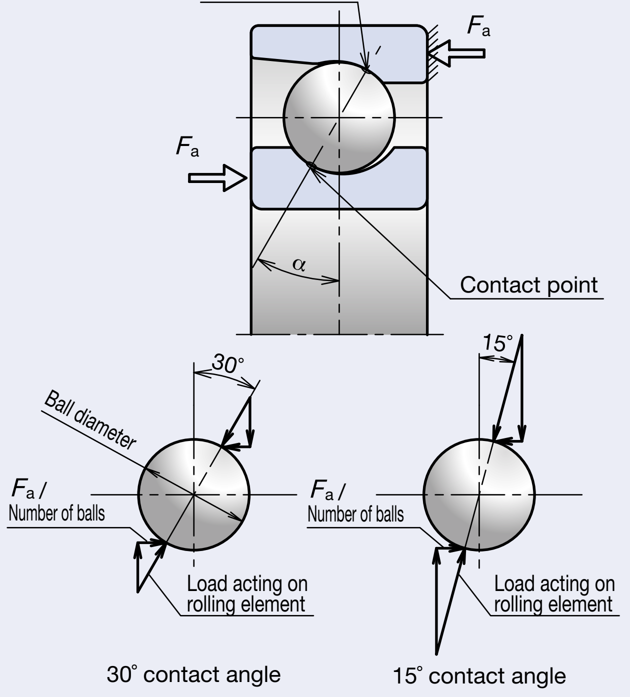
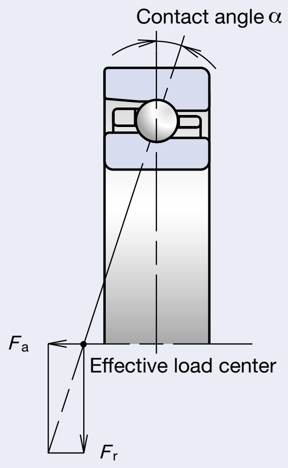


Fig. 1.1



When a load is applied to an angular contact ball bearing, elastic deformation and the amount of stress at the contact point changes as a result of the varying load conditions of the balls, inner ring, and outer ring according to the contact angle of the bearing.

Figure 1.2 illustrates loads acting on two rolling elements for a 30° contact angle, and a 15° contact angle. The relation between an axial load being applied to the bearing and resulting load acting on the rolling element can be formulated as:

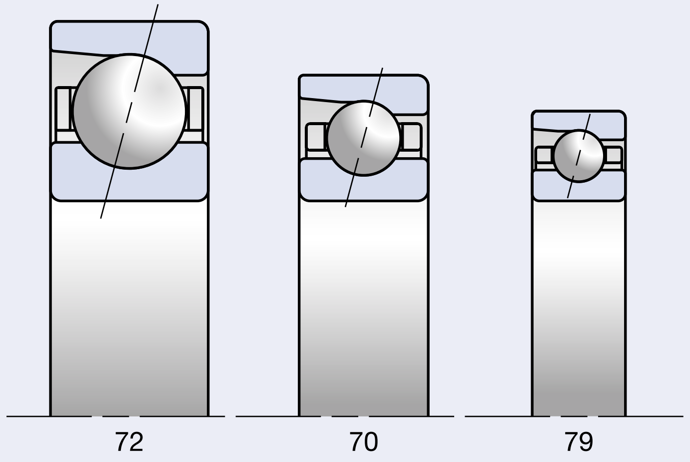
Fa/(Number of balls $\times$ sinα).

Therefore, the larger the contact angle, the smaller the load acting on the rolling element. Load at the contact point, and its consequential deformation, is reduced thus resulting in longer life. When a radial load is applied, the smaller the contact angle, the smaller the load acting on the rolling element, thus resulting in reduced load at the contact point.

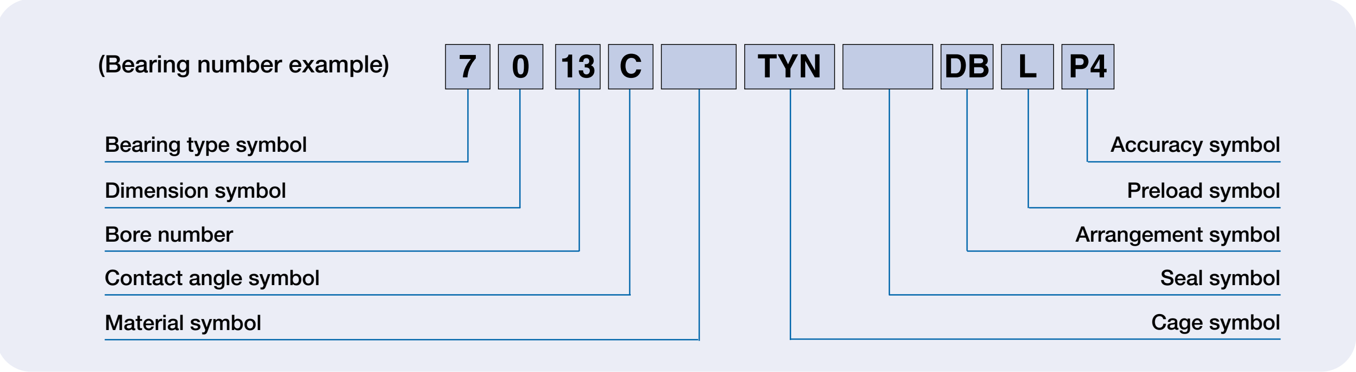
(See Pages 38 and 39 for contact angle specifics.)

Dimension Series

Fig. 1.3



Numbering System of High Precision Angular Contact Ball Bearings (Standard Series)



			Reference pages
7	**Bearing type**	7: single row angular contact ball bearing	38-39, 44
0	**Dimension**	9: 19 series, 0: 10 series, 2: 02 series	38-39, 44
13	**Bore number**	Less than 03, Bearing bore 00: 10mm, 01: 12mm 02: 15mm, 03: 17mm Over 04, Bearing bore Bore number×5 (mm)	46-56
C	**Contact angle**	C: 15°, A5: 25°, A: 30°	38-39, 44
	Material	No symbol: bearing steel (SUJ2) SN24: ceramic ball (Si_3N_4) (²)	12-15
TYN	**Cage**	TYN: ball guided polyamide resin cage; limiting speed d_mn = 1 400 000; operational temperature limit = 120°C TR: outer ring guided phenolic resin cage; operational temperature limit = 120°C	16-17
	Seal	No symbol: open type V1V: non-contact rubber seal (¹)	28
DB	**Arrangement**	SU: universal arrangement (single row) DU: universal arrangement (double row) DB: back-to-back arrangement DF: face-to-face arrangement DT: tandem arrangement DBD, DFD, DTD, DUD: triplex set arrangement • DBB, DFF, DBT, DFT, DTT, QU: quadruplex set arrangement	38-39 130-133
L	**Preload**	EL: extra light preload, L: light preload, M: medium preload, H: heavy preload CP: special preload, CA: special axial clearance	38-39 134-142
P4	**Accuracy**	P2: ISO Class 2, P4: ISO Class 4, P5: ISO Class 5 P3: special class (dimensional accuracy: ISO Class 4; rotating accuracy: ISO Class 2) P4Y: special accuracy (Bore diameter and outside diameter are exclusive to NSK. All others are ISO Class 4.)	133 158-161

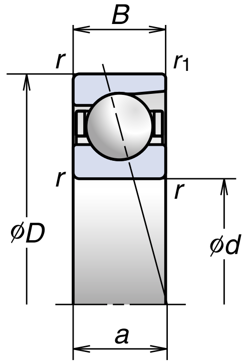
(¹) Sealed angular contact ball bearings are standardized for SU arrangement and ISO Class 3.
Sealed angular contact ball bearing correspondence numbers 79, 70: Bore diameter= ϕ30-100mm.

(²) Angular contact ceramic ball bearing correspondence numbers 79, 70: Bore diameter= ϕ10-100mm.

High Precision Angular Contact Ball Bearings (Miniature Series)

70 Series
72 Series

Bore Diameter 5-8 mm



Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (¹) (kN)	Effective Load Center (mm) *a*	Mass (g) (approx)	Limiting Speeds (²) (min⁻¹)	
	d	*D*	*B*	*r* (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)				Grease	Oil
725C	**5**	**16**	**5**	0.3	0.15	1.700	0.660	0.545	3.91	4.5	110 000	167 000
725A	**5**	**16**	**5**	0.3	0.15	1.610	0.620	0.665	5.53	4.5	72 000	96 000
706C	**6**	**17**	**6**	0.3	0.15	2.150	0.845	0.765	4.54	5.5	100 000	153 000
706A	**6**	**17**	**6**	0.3	0.15	2.030	0.795	0.725	6.32	5.5	66 000	87 000
726C	**6**	**19**	**6**	0.3	0.15	2.390	1.000	0.835	4.67	7.8	92 000	140 000
726A	**6**	**19**	**6**	0.3	0.15	2.240	0.940	0.395	6.61	7.8	60 000	80 000
707C	**7**	**19**	**6**	0.3	0.15	2.390	1.000	0.835	4.67	7.4	89 000	135 000
707A	**7**	**19**	**6**	0.3	0.15	2.240	0.940	0.375	6.61	7.4	58 000	77 000
708C	**8**	**22**	**7**	0.3	0.15	3.550	1.540	1.300	5.51	12.0	77 000	117 000
708A	**8**	**22**	**7**	0.3	0.15	3.350	1.450	1.020	7.84	12.0	50 000	67 000
728C	**8**	**24**	**8**	0.3	0.15	3.600	1.580	1.330	6.14	16.0	72 000	110 000
728A	**8**	**24**	**8**	0.3	0.15	3.350	1.480	0.610	8.62	16.0	47 000	63 000

(¹) For permissible axial load, please refer to Page 129.

(²) For application of limiting speeds, please refer to Page 152.

Note: Bearing numbers with a "C" suffix: nominal contact angle 15°
Bearing numbers with an "A" suffix: nominal contact angle 30°

High Precision Angular Contact Ball Bearings (Standard Series)

For additional information: Page No.

- Dynamic equivalent load ························121
- Static equivalent load ···························128
- Preload and rigidity ······························134
- Abutment and fillet dimensions ···············168
- Nozzle position ····································174
- Quantity of packed grease·······················157

79 Series

Bore Diameter 10-55 mm

Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (¹) (kN)	Factor f_o	Effective Load Center (mm) *a*	Mass (kg) (approx)	Sealed Design	Limiting Speeds (²) (min⁻¹)	
	d	*D*	*B*	*r* (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)						Grease	Oil
7900C	**10**	**22**	**6**	0.3	0.15	3.00	1.52	1.23	14.1	5.1	0.010	–	71 900	109 400
7900A5	**10**	**22**	**6**	0.3	0.15	2.88	1.45	1.44	–	6.7	0.009	–	62 500	93 800
7901C	**12**	**24**	**6**	0.3	0.15	3.35	1.86	1.45	14.7	5.4	0.011	–	63 900	97 300
7901A5	**12**	**24**	**6**	0.3	0.15	3.20	1.77	1.71	–	7.2	0.011	–	55 600	83 400
7902C	**15**	**28**	**7**	0.3	0.15	4.75	2.64	1.93	14.5	6.4	0.016	–	53 500	81 400
7902A5	**15**	**28**	**7**	0.3	0.15	4.55	2.53	2.22	–	8.5	0.016	–	46 600	69 800
7903C	**17**	**30**	**7**	0.3	0.15	5.00	2.94	2.09	14.8	6.6	0.017	–	49 000	74 500
7903A5	**17**	**30**	**7**	0.3	0.15	4.75	2.80	2.21	–	9.0	0.017	–	42 600	63 900
7904C	**20**	**37**	**9**	0.3	0.15	6.95	4.25	3.20	14.9	8.3	0.036	–	40 400	61 500
7904A5	**20**	**37**	**9**	0.3	0.15	6.60	4.05	3.55	–	11.1	0.037	–	35 100	52 700
7905C	**25**	**42**	**9**	0.3	0.15	7.85	5.40	3.90	15.5	9.0	0.043	–	34 400	52 300
7905A5	**25**	**42**	**9**	0.3	0.15	7.45	5.15	4.40	–	12.3	0.043	–	29 900	44 800
7906C	**30**	**47**	**9**	0.3	0.15	8.30	6.25	4.40	15.9	9.7	0.049	○	29 900	45 500
7906A5	**30**	**47**	**9**	0.3	0.15	7.85	5.95	4.95	–	13.5	0.050	○	26 000	39 000
7907C	**35**	**55**	**10**	0.6	0.3	12.1	9.15	6.60	15.7	11.0	0.074	○	25 600	38 900
7907A5	**35**	**55**	**10**	0.6	0.3	11.4	8.70	7.20	–	15.5	0.075	○	22 300	33 400
7908C	**40**	**62**	**12**	0.6	0.3	15.1	11.7	8.40	15.7	12.8	0.109	○	22 600	34 400
7908A5	**40**	**62**	**12**	0.6	0.3	14.3	11.2	8.90	–	17.9	0.110	○	19 700	29 500
7909C	**45**	**68**	**12**	0.6	0.3	16.0	13.4	8.55	16.0	13.6	0.129	○	20 400	31 000
7909A5	**45**	**68**	**12**	0.6	0.3	15.1	12.7	9.95	–	19.2	0.130	○	17 700	26 600
7910C	**50**	**72**	**12**	0.6	0.3	16.9	15.0	9.45	16.2	14.2	0.130	○	18 900	28 700
7910A5	**50**	**72**	**12**	0.6	0.3	15.9	14.2	11.0	–	20.2	0.132	○	16 400	24 600
7911C	**55**	**80**	**13**	1.0	0.6	19.1	17.7	11.0	16.3	15.5	0.182	○	17 100	26 000
7911A5	**55**	**80**	**13**	1.0	0.6	18.1	16.8	12.5	–	22.2	0.184	○	14 900	22 300

(¹) For permissible axial load, please refer to Page 129.

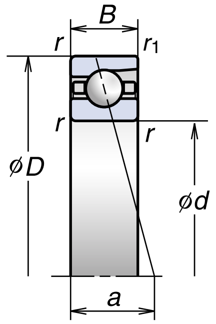
(²) For application of limiting speeds, please refer to Page 152.
When a ceramic ball is used, limiting speed value will be 1.25 times the value of steel ball.

Note: Bearing numbers with a "C" suffix: nominal contact angle 15°
Bearing numbers with an "A5" suffix: nominal contact angle 25°

High Precision Angular Contact Ball Bearings (Standard Series)

79 Series

Bore Diameter 60-280 mm



Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Factor f_0	Effective Load Center (mm) a	Mass (kg) (approx)	Sealed Design	Limiting Speeds (2) (min^{-1})	
	d	D	B	r (min)	r_1 (min)	C_r (Dynamic)	C_{0r} (Static)						Grease	Oil
7912C	**60**	**85**	**13**	1.0	0.6	19.4	18.7	11.5	16.5	16.2	0.195	○	15 900	24 200
7912A5	**60**	**85**	**13**	1.0	0.6	18.3	17.7	13.0	–	23.4	0.198	○	13 800	20 700
7913C	**65**	**90**	**13**	1.0	0.6	20.2	20.5	12.5	16.7	16.9	0.208	○	14 900	22 600
7913A5	**65**	**90**	**13**	1.0	0.6	19.1	19.4	14.2	–	24.6	0.211	○	13 000	19 400
7914C	**70**	**100**	**16**	1.0	0.6	28.1	27.8	17.3	16.4	19.4	0.338	○	13 600	20 600
7914A5	**70**	**100**	**16**	1.0	0.6	26.5	26.3	20.3	–	27.8	0.341	○	11 800	17 700
7915C	**75**	**105**	**16**	1.0	0.6	28.6	29.3	18.0	16.6	20.1	0.358	○	12 800	19 500
7915A5	**75**	**105**	**16**	1.0	0.6	26.9	27.7	21.2	–	29.0	0.355	○	11 200	16 700
7916C	**80**	**110**	**16**	1.0	0.6	29.0	30.5	18.7	16.7	20.7	0.377	○	12 200	18 500
7916A5	**80**	**110**	**16**	1.0	0.6	27.3	29.0	22.1	–	30.2	0.381	○	10 600	15 800
7917C	**85**	**120**	**18**	1.1	0.6	39.0	40.5	25.9	16.5	22.7	0.534	○	11 300	17 100
7917A5	**85**	**120**	**18**	1.1	0.6	36.5	38.5	30.0	–	32.9	0.541	○	9 800	14 700
7918C	**90**	**125**	**18**	1.1	0.6	41.5	46.0	29.1	16.6	23.4	0.568	○	10 700	16 300
7918A5	**90**	**125**	**18**	1.1	0.6	39.5	43.5	33.5	–	34.1	0.560	○	9 400	14 000
7919C	**95**	**130**	**18**	1.1	0.6	42.5	48.0	30.0	16.7	24.1	0.597	○	10 300	15 600
7919A5	**95**	**130**	**18**	1.1	0.6	40.0	45.5	35.0	–	35.2	0.603	○	8 900	13 400
7920C	**100**	**140**	**20**	1.1	0.6	50.0	54.0	33.0	16.5	26.1	0.800	○	9 600	14 600
7920A5	**100**	**140**	**20**	1.1	0.6	47.5	51.5	39.5	–	38.0	0.808	○	8 400	12 500
7921C	**105**	**145**	**20**	1.1	0.6	51.0	57.0	34.5	16.6	26.7	0.831	–	9 200	14 000
7921A5	**105**	**145**	**20**	1.1	0.6	48.0	54.0	41.0	–	39.2	0.820	–	8 000	12 000
7922C	**110**	**150**	**20**	1.1	0.6	52.0	59.5	35.5	16.7	27.4	0.867	–	8 900	13 500
7922A5	**110**	**150**	**20**	1.1	0.6	49.0	56.0	43.0	–	40.3	0.877	–	7 700	11 600
7924C	**120**	**165**	**22**	1.1	0.6	72.0	81.0	50.5	16.5	30.1	1.160	–	8 100	12 300
7924A5	**120**	**165**	**22**	1.1	0.6	67.5	77.0	59.5	–	44.2	1.150	–	7 100	10 600

(1) For permissible axial load, please refer to Page 129.

(2) For application of limiting speeds, please refer to Page 152.
When a ceramic ball is used, limiting speed value will be 1.25 times the value of steel ball.

Note: Bearing numbers with a "C" suffix: nominal contact angle 15°
Bearing numbers with an "A5" suffix: nominal contact angle 25°

For additional information:	Page No.
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79 Series (continued)

Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Factor f_0	Effective Load Center (mm) a	Mass (kg) (approx)	Sealed Design	Limiting Speeds (2) (min^{-1})	
	d	D	B	r (min)	r_1 (min)	C_r (Dynamic)	C_{0r} (Static)						Grease	Oil
7926C	**130**	**180**	**24**	1.5	1.0	78.5	91.0	55.0	16.5	32.8	1.500	–	7 500	11 300
7926A5	**130**	**180**	**24**	1.5	1.0	74.0	86.0	63.5	–	48.1	1.540	–	6 500	9 700
7928C	**140**	**190**	**24**	1.5	1.0	79.5	95.5	58.0	16.7	34.1	1.630	–	7 000	10 700
7928A5	**140**	**190**	**24**	1.5	1.0	75.0	90.0	68.0	–	50.5	1.630	–	6 100	9 100
7930C	**150**	**210**	**28**	2.0	1.0	102	122	74.0	16.6	38.1	2.960	–	6 400	9 800
7930A5	**150**	**210**	**28**	2.0	1.0	96.5	115	84.5	–	56.0	2.970	–	5 600	8 400
7932C	**160**	**220**	**28**	2.0	1.0	106	133	80.0	16.7	39.4	3.100	–	6 100	9 300
7932A5	**160**	**220**	**28**	2.0	1.0	100	125	93.5	–	58.3	3.120	–	5 300	7 900
7934C	**170**	**230**	**28**	2.0	1.0	113	148	88.5	16.8	40.8	3.360	–	5 800	8 800
7934A5	**170**	**230**	**28**	2.0	1.0	106	140	103	–	60.6	3.360	–	5 000	7 500
7936C	**180**	**250**	**33**	2.0	1.0	145	184	111	16.6	45.3	4.900	–	5 400	8 200
7936A5	**180**	**250**	**33**	2.0	1.0	137	174	127	–	66.6	4.940	–	4 700	7 000
7938C	**190**	**260**	**33**	2.0	1.0	147	192	115	16.7	46.6	4.980	–	5 200	7 800
7938A5	**190**	**260**	**33**	2.0	1.0	139	182	131	–	69.0	5.120	–	4 500	6 700
7940C	**200**	**280**	**38**	2.1	1.1	189	244	144	16.5	51.2	6.850	–	4 800	7 300
7940A5	**200**	**280**	**38**	2.1	1.1	178	231	169	–	75.0	6.920	–	4 200	6 300
7944C	**220**	**300**	**38**	2.1	1.1	190	256	235	16.7	53.8	6.665	–	4 500	6 800
7944A5	**220**	**300**	**38**	2.1	1.1	179	242	174	–	79.6	6.665	–	3 900	5 800
7948C	**240**	**320**	**38**	2.1	1.1	200	286	260	16.8	56.5	7.224	–	4 200	6 300
7948A5	**240**	**320**	**38**	2.1	1.1	189	270	193	–	84.3	7.224	–	3 600	5 400
7952C	**260**	**360**	**46**	2.1	1.1	256	365	340	16.6	64.5	11.936	–	3 800	5 700
7952A5	**260**	**360**	**46**	2.1	1.1	241	345	252	–	95.3	11.936	–	3 300	4 900
7956C	**280**	**380**	**46**	2.1	1.1	272	410	380	16.7	67.2	12.853	–	3 500	5 400
7956A5	**280**	**380**	**46**	2.1	1.1	256	390	283	–	99.9	12.853	–	3 100	4 600

(1) For permissible axial load, please refer to Page 129.

(2) For application of limiting speeds, please refer to Page 152.

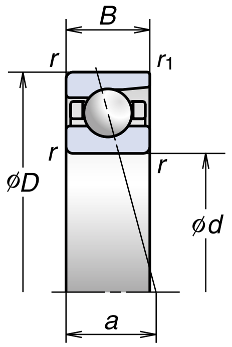
Note: Bearing numbers with a "C" suffix: nominal contact angle 15°
Bearing numbers with an "A5" suffix: nominal contact angle 25°

1. ANGULAR CONTACT BALL BEARINGS

High Precision Angular Contact Ball Bearings (Standard Series)

70 Series

Bore Diameter 10-75 mm



Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (¹) (kN)	Factor f_o	Effective Load Center (mm) a	Mass (kg) (approx)	Sealed Design	Limiting Speeds (²) (min⁻¹)	
	d	D	B	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)						Grease	Oil
7000C	**10**	**26**	**8**	0.3	0.15	5.30	2.49	2.16	12.6	6.4	0.019	–	63 900	97 300
7000A5	**10**	**26**	**8**	0.3	0.15	5.15	2.41	2.48	–	8.2	0.019	–	55 600	83 400
7000A	**10**	**26**	**8**	0.3	0.15	5.00	2.34	1.91	–	9.2	0.019	–	41 700	55 600
7001C	**12**	**28**	**8**	0.3	0.15	5.80	2.90	2.40	13.2	6.7	0.021	–	57 500	87 500
7001A5	**12**	**28**	**8**	0.3	0.15	5.60	2.79	2.82	–	8.7	0.021	–	50 000	75 000
7001A	**12**	**28**	**8**	0.3	0.15	5.40	2.71	2.13	–	9.8	0.021	–	37 500	50 000
7002C	**15**	**32**	**9**	0.3	0.15	6.25	3.40	2.63	14.1	7.6	0.030	–	49 000	74 500
7002A5	**15**	**32**	**9**	0.3	0.15	5.95	3.25	3.05	–	10.0	0.030	–	42 600	63 900
7002A	**15**	**32**	**9**	0.3	0.15	5.80	3.15	2.36	–	11.3	0.030	–	32 000	42 600
7003C	**17**	**35**	**10**	0.3	0.15	6.60	3.80	2.85	14.5	8.5	0.039	–	44 300	67 400
7003A5	**17**	**35**	**10**	0.3	0.15	6.30	3.65	3.35	–	11.1	0.040	–	38 500	57 700
7003A	**17**	**35**	**10**	0.3	0.15	6.10	3.50	2.59	–	12.5	0.040	–	28 900	38 500
7004C	**20**	**42**	**12**	0.6	0.3	11.1	6.55	4.80	14.0	10.1	0.067	–	37 100	56 500
7004A5	**20**	**42**	**12**	0.6	0.3	10.6	6.25	5.45	–	13.2	0.067	–	32 300	48 400
7004A	**20**	**42**	**12**	0.6	0.3	10.3	6.10	4.20	–	14.9	0.068	–	24 200	32 300
7005C	**25**	**47**	**12**	0.6	0.3	11.7	7.40	5.20	14.7	10.8	0.078	–	32 000	48 700
7005A5	**25**	**47**	**12**	0.6	0.3	11.1	7.10	5.95	–	14.4	0.077	–	27 800	41 700
7005A	**25**	**47**	**12**	0.6	0.3	10.7	6.85	4.55	–	16.4	0.079	–	20 900	27 800
7006C	**30**	**55**	**13**	1.0	0.6	15.1	10.3	6.85	14.9	12.2	0.114	○	27 100	41 200
7006A5	**30**	**55**	**13**	1.0	0.6	14.4	9.80	8.05	–	16.4	0.114	○	23 600	35 300
7006A	**30**	**55**	**13**	1.0	0.6	13.9	9.45	6.20	–	18.8	0.116	○	17 700	23 600
7007C	**35**	**62**	**14**	1.0	0.6	19.1	13.7	9.35	15.0	13.5	0.151	○	23 800	36 100
7007A5	**35**	**62**	**14**	1.0	0.6	18.2	13.0	11.4	–	18.3	0.151	○	20 700	31 000
7007A	**35**	**62**	**14**	1.0	0.6	17.5	12.6	8.75	–	21.0	0.153	○	15 500	20 700

(¹) For permissible axial load, please refer to Page 129.

(²) For application of limiting speeds, please refer to Page 152.
When a ceramic ball is used, limiting speed value will be 1.25 times the value of steel ball.

Note: Bearing numbers with a “C” suffix: nominal contact angle 15˚
Bearing numbers with an “A5” suffix: nominal contact angle 25˚
Bearing numbers with an “A” suffix: nominal contact angle 30˚

For additional information:	Page No.
● Dynamic equivalent load	121
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● Quantity of packed grease	157

70 Series (continued)

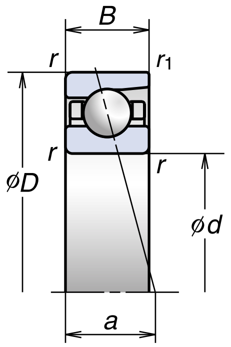
Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (¹) (kN)	Factor f_o	Effective Load Center (mm) a	Mass (kg) (approx)	Sealed Design	Limiting Speeds (²) (min⁻¹)	
	d	D	B	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)						Grease	Oil
7008C	**40**	**68**	**15**	1.0	0.6	20.6	15.9	10.6	15.4	14.7	0.189	○	21 300	32 500
7008A5	**40**	**68**	**15**	1.0	0.6	19.5	15.1	12.0	–	20.1	0.188	○	18 600	27 800
7008A	**40**	**68**	**15**	1.0	0.6	18.8	14.6	9.15	–	23.1	0.191	○	13 900	18 600
7009C	**45**	**75**	**16**	1.0	0.6	24.4	19.3	12.4	15.4	16.0	0.238	○	19 200	29 200
7009A5	**45**	**75**	**16**	1.0	0.6	23.1	18.3	14.5	–	22.0	0.250	○	16 700	25 000
7009A	**45**	**75**	**16**	1.0	0.6	22.3	17.7	11.1	–	25.3	0.241	○	12 500	16 700
7010C	**50**	**80**	**16**	1.0	0.6	26.0	21.9	13.9	15.7	16.7	0.259	○	17 700	27 000
7010A5	**50**	**80**	**16**	1.0	0.6	24.6	20.8	16.2	–	23.2	0.270	○	15 400	23 100
7010A	**50**	**80**	**16**	1.0	0.6	23.7	20.1	12.5	–	26.8	0.262	○	11 600	15 400
7011C	**55**	**90**	**18**	1.1	0.6	34.0	28.6	18.9	15.5	18.7	0.380	○	15 900	24 200
7011A5	**55**	**90**	**18**	1.1	0.6	32.5	27.2	21.8	–	25.9	0.383	○	13 800	20 700
7011A	**55**	**90**	**18**	1.1	0.6	31.0	26.3	16.6	–	29.9	0.385	○	10 400	13 800
7012C	**60**	**95**	**18**	1.1	0.6	35.0	30.5	19.9	15.7	19.4	0.405	○	14 900	22 600
7012A5	**60**	**95**	**18**	1.1	0.6	33.0	29.1	23.0	–	27.1	0.408	○	13 000	19 400
7012A	**60**	**95**	**18**	1.1	0.6	32.0	28.1	17.6	–	31.4	0.410	○	9 700	13 000
7013C	**65**	**100**	**18**	1.1	0.6	37.0	34.5	22.0	15.9	20.0	0.435	○	14 000	21 300
7013A5	**65**	**100**	**18**	1.1	0.6	35.0	32.5	25.4	–	28.2	0.455	○	12 200	18 200
7013A	**65**	**100**	**18**	1.1	0.6	33.5	31.5	19.5	–	32.8	0.441	○	9 100	12 200
7014C	**70**	**110**	**20**	1.1	0.6	47.0	43.0	26.8	15.7	22.1	0.606	○	12 800	19 500
7014A5	**70**	**110**	**20**	1.1	0.6	44.5	41.0	32.0	–	31.0	0.625	○	11 200	16 700
7014A	**70**	**110**	**20**	1.1	0.6	42.5	39.5	24.6	–	36.0	0.613	○	8 400	11 200
7015C	**75**	**115**	**20**	1.1	0.6	48.0	45.5	28.1	15.9	22.7	0.643	○	12 200	18 500
7015A5	**75**	**115**	**20**	1.1	0.6	45.5	43.5	33.5	–	32.1	0.652	○	10 600	15 800
7015A	**75**	**115**	**20**	1.1	0.6	43.5	41.5	25.9	–	37.4	0.650	○	7 900	10 600

(¹) For permissible axial load, please refer to Page 129.

(²) For application of limiting speeds, please refer to Page 152.
When a ceramic ball is used, limiting speed value will be 1.25 times the value of steel ball.

Note: Bearing numbers with a “C” suffix: nominal contact angle 15˚
Bearing numbers with an “A5” suffix: nominal contact angle 25˚
Bearing numbers with an “A” suffix: nominal contact angle 30˚

High Precision Angular Contact Ball Bearings (Standard Series)



70 Series

Bore Diameter 80-200 mm

Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Factor f_o	Effective Load Center (mm) a	Mass (kg) (approx)	Sealed Design	Limiting Speeds (2) (min⁻¹)	
	d	D	B	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)						Grease	Oil
7016C	**80**	**125**	**22**	1.1	0.6	58.5	55.5	34.5	15.7	24.7	0.855	○	11 300	17 100
7016A5	**80**	**125**	**22**	1.1	0.6	55.5	52.5	41.0	–	34.9	0.880	○	9 800	14 700
7016A	**80**	**125**	**22**	1.1	0.6	53.5	50.5	31.5	–	40.6	0.864	○	7 400	9 800
7017C	**85**	**130**	**22**	1.1	0.6	60.0	58.5	38.0	15.9	25.4	0.898	○	10 700	16 300
7017A5	**85**	**130**	**22**	1.1	0.6	57.0	55.5	43.0	–	36.1	0.904	○	9 400	14 000
7017A	**85**	**130**	**22**	1.1	0.6	54.5	53.5	33.0	–	42.0	0.907	○	7 000	9 400
7018C	**90**	**140**	**24**	1.5	1.0	71.5	69.0	44.5	15.7	27.4	1.160	○	10 000	15 300
7018A5	**90**	**140**	**24**	1.5	1.0	68.0	65.5	52.0	–	38.8	1.170	○	8 700	13 100
7018A	**90**	**140**	**24**	1.5	1.0	65.0	63.5	40.5	–	45.2	1.180	○	6 600	8 700
7019C	**95**	**145**	**24**	1.5	1.0	73.5	73.0	47.0	15.9	28.1	1.210	○	9 600	14 600
7019A5	**95**	**145**	**24**	1.5	1.0	69.5	69.5	52.5	–	40.0	1.410	○	8 400	12 500
7019A	**95**	**145**	**24**	1.5	1.0	67.0	67.0	40.5	–	46.6	1.230	○	6 300	8 400
7020C	**100**	**150**	**24**	1.5	1.0	75.5	77.0	49.0	16.0	28.7	1.270	○	9 200	14 000
7020A5	**100**	**150**	**24**	1.5	1.0	71.0	73.5	57.5	–	41.1	1.450	○	8 000	12 000
7020A	**100**	**150**	**24**	1.5	1.0	68.5	70.5	44.5	–	48.1	1.280	○	6 000	8 000
7021C	**105**	**160**	**26**	2.0	1.0	88.0	89.5	57.0	15.9	30.7	1.580	–	8 700	13 300
7021A5	**105**	**160**	**26**	2.0	1.0	83.5	85.0	66.5	–	43.9	1.820	–	7 600	11 400
7021A	**105**	**160**	**26**	2.0	1.0	80.0	81.5	51.0	–	51.2	1.600	–	5 700	7 600
7022C	**110**	**170**	**28**	2.0	1.0	106	104	68.5	15.6	32.7	1.940	–	8 300	12 500
7022A5	**110**	**170**	**28**	2.0	1.0	100	99.0	79.5	–	46.6	2.260	–	7 200	10 800
7022A	**110**	**170**	**28**	2.0	1.0	96.5	95.5	61.0	–	54.4	1.960	–	5 400	7 200
7024C	**120**	**180**	**28**	2.0	1.0	112	117	75.5	15.8	34.1	2.090	–	7 700	11 700
7024A5	**120**	**180**	**28**	2.0	1.0	106	111	87.5	–	49.0	2.430	–	6 700	10 000
7024A	**120**	**180**	**28**	2.0	1.0	102	107	67.5	–	57.3	2.120	–	5 000	6 700

(1) For permissible axial load, please refer to Page 129.

(2) For application of limiting speeds, please refer to Page 152.
When a ceramic ball is used, limiting speed value will be 1.25 times the value of steel ball.

Note: Bearing numbers with a "C" suffix: nominal contact angle 15˚
Bearing numbers with an "A5" suffix: nominal contact angle 25˚
Bearing numbers with an "A" suffix: nominal contact angle 30˚

For additional information:	Page No.
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● Static equivalent load	128
● Preload and rigidity	134
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● Quantity of packed grease	157

70 Series (continued)

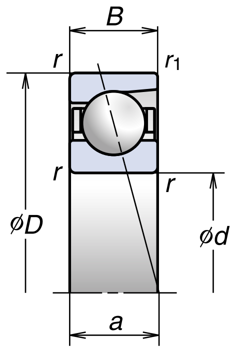
Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Factor f_o	Effective Load Center (mm) a	Mass (kg) (approx)	Sealed Design	Limiting Speeds (2) (min⁻¹)	
	d	D	B	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)						Grease	Oil
7026C	**130**	**200**	**33**	2.0	1.0	129	137	86.0	15.9	38.6	3.220	–	7 000	10 700
7026A5	**130**	**200**	**33**	2.0	1.0	122	130	99.5	–	55.0	3.660	–	6 100	9 100
7026A	**130**	**200**	**33**	2.0	1.0	117	125	76.5	–	64.1	3.260	–	4 600	6 100
7028C	**140**	**210**	**33**	2.0	1.0	132	145	90.0	16.0	39.9	3.410	–	6 600	10 000
7028A5	**140**	**210**	**33**	2.0	1.0	125	138	104	–	57.3	3.870	–	5 800	8 600
7028A	**140**	**210**	**33**	2.0	1.0	120	133	80.5	–	67.0	3.440	–	4 300	5 800
7030C	**150**	**225**	**35**	2.1	1.1	151	168	105	16.0	42.6	4.150	–	6 200	9 400
7030A5	**150**	**225**	**35**	2.1	1.1	143	160	123	–	61.2	4.690	–	5 400	8 000
7030A	**150**	**225**	**35**	2.1	1.1	137	154	95.0	–	71.6	4.190	–	4 000	5 400
7032C	**160**	**240**	**38**	2.1	1.1	171	193	118	16.0	45.8	5.110	–	5 800	8 800
7032A5	**160**	**240**	**38**	2.1	1.1	162	183	138	–	65.6	5.710	–	5 000	7 500
7032A	**160**	**240**	**38**	2.1	1.1	155	176	106	–	76.7	5.160	–	3 800	5 000
7034C	**170**	**260**	**42**	2.1	1.1	205	234	149	15.9	49.8	6.880	–	5 400	8 200
7034A5	**170**	**260**	**42**	2.1	1.1	193	223	168	–	71.1	7.830	–	4 700	7 000
7034A	**170**	**260**	**42**	2.1	1.1	186	214	129	–	83.1	6.940	–	3 500	4 700
7036C	**180**	**280**	**46**	2.1	1.1	228	276	175	15.8	53.8	10.40	–	5 000	7 700
7036A5	**180**	**280**	**46**	2.1	1.1	216	262	195	–	76.6	10.40	–	4 400	6 600
7036A	**180**	**280**	**46**	2.1	1.1	207	252	151	–	89.4	9.270	–	3 300	4 400
7038C	**190**	**290**	**46**	2.1	1.1	247	305	192	15.9	55.2	11.20	–	4 800	7 300
7038A5	**190**	**290**	**46**	2.1	1.1	233	291	222	–	79.0	11.20	–	4 200	6 300
7038A	**190**	**290**	**46**	2.1	1.1	224	280	172	–	92.3	11.30	–	3 200	4 200
7040C	**200**	**310**	**51**	2.1	1.1	265	340	213	15.9	59.7	13.60	–	4 600	6 900
7040A5	**200**	**310**	**51**	2.1	1.1	250	325	245	–	85.0	13.70	–	4 000	5 900
7040A	**200**	**310**	**51**	2.1	1.1	240	310	190	–	99.1	13.70	–	3 000	4 000

(1) For permissible axial load, please refer to Page 129.

(2) For application of limiting speeds, please refer to Page 152.

Note: Bearing numbers with a "C" suffix: nominal contact angle 15˚
Bearing numbers with an "A5" suffix: nominal contact angle 25˚
Bearing numbers with an "A" suffix: nominal contact angle 30˚

High Precision Angular Contact Ball Bearings (Standard Series)



72 Series

Bore Diameter 10-105 mm

Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Factor f_0	Effective Load Center (mm) a	Mass (kg) (approx)	Limiting Speeds (2) (min^{-1})	
	d	D	B	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)					Grease	Oil
7200C	**10**	**30**	**9**	0.6	0.3	5.40	2.61	2.16	13.2	7.2	0.032	57 500	87 500
7200A5	**10**	**30**	**9**	0.6	0.3	5.20	2.51	2.49	–	9.2	0.031	50 000	75 000
7200A	**10**	**30**	**9**	0.6	0.3	5.05	2.44	1.92	–	10.3	0.032	37 500	50 000
7201C	**12**	**32**	**10**	0.6	0.3	7.90	3.85	3.45	12.5	7.9	0.036	52 300	79 600
7201A5	**12**	**32**	**10**	0.6	0.3	7.65	3.70	3.55	–	10.1	0.036	45 500	68 200
7201A	**12**	**32**	**10**	0.6	0.3	7.45	3.65	2.72	–	11.4	0.030	34 100	45 500
7202C	**15**	**35**	**11**	0.6	0.3	8.65	4.55	3.85	13.2	8.8	0.045	46 000	70 000
7202A5	**15**	**35**	**11**	0.6	0.3	8.35	4.35	3.95	–	11.3	0.044	40 000	60 000
7202A	**15**	**35**	**11**	0.6	0.3	8.10	4.25	3.00	–	12.7	0.045	30 000	40 000
7203C	**17**	**40**	**12**	0.6	0.3	10.9	5.85	4.85	13.3	9.8	0.065	40 400	61 500
7203A5	**17**	**40**	**12**	0.6	0.3	10.4	5.60	5.30	–	12.6	0.064	35 100	52 700
7203A	**17**	**40**	**12**	0.6	0.3	10.1	5.45	4.05	–	14.2	0.065	26 400	35 100
7204C	**20**	**47**	**14**	1.0	0.6	14.6	8.05	6.30	13.3	11.5	0.103	34 400	52 300
7204A5	**20**	**47**	**14**	1.0	0.6	14.0	7.75	7.40	–	14.8	0.102	29 900	44 800
7204A	**20**	**47**	**14**	1.0	0.6	13.6	7.55	5.75	–	16.7	0.104	22 400	29 900
7205C	**25**	**52**	**15**	1.0	0.6	16.6	10.2	7.50	14.0	12.7	0.127	29 900	45 500
7205A5	**25**	**52**	**15**	1.0	0.6	15.9	9.80	9.05	–	16.5	0.130	26 000	39 000
7205A	**25**	**52**	**15**	1.0	0.6	15.4	9.45	6.95	–	18.6	0.129	19 500	26 000
7206C	**30**	**62**	**16**	1.0	0.6	23.0	14.7	10.3	13.9	14.2	0.194	25 000	38 100
7206A5	**30**	**62**	**16**	1.0	0.6	22.1	14.1	12.0	–	18.7	0.194	21 800	32 700
7206A	**30**	**62**	**16**	1.0	0.6	21.3	13.6	9.20	–	21.3	0.197	16 400	21 800
7207C	**35**	**72**	**17**	1.1	0.6	30.5	19.9	14.4	13.9	15.7	0.280	21 500	32 800
7207A5	**35**	**72**	**17**	1.1	0.6	29.1	19.1	16.6	–	21.0	0.277	18 700	28 100
7207A	**35**	**72**	**17**	1.1	0.6	28.2	18.5	12.7	–	23.9	0.284	14 100	18 700
7208C	**40**	**80**	**18**	1.1	0.6	36.5	25.2	17.6	14.1	17.0	0.366	19 200	29 200
7208A5	**40**	**80**	**18**	1.1	0.6	34.5	24.1	20.6	–	23.0	0.362	16 700	25 000
7208A	**40**	**80**	**18**	1.1	0.6	33.5	23.3	15.8	–	26.3	0.370	12 500	16 700
7209C	**45**	**85**	**19**	1.1	0.6	41.0	28.8	19.6	14.2	18.2	0.406	17 700	27 000
7209A5	**45**	**85**	**19**	1.1	0.6	39.0	27.6	23.3	–	24.7	0.402	15 400	23 100
7209A	**45**	**85**	**19**	1.1	0.6	37.5	26.7	18.0	–	28.3	0.410	11 600	15 400
7210C	**50**	**90**	**20**	1.1	0.6	43.0	31.5	21.1	14.5	19.4	0.457	16 500	25 000
7210A5	**50**	**90**	**20**	1.1	0.6	41.0	30.5	25.2	–	26.3	0.453	14 300	21 500
7210A	**50**	**90**	**20**	1.1	0.6	39.5	29.3	19.4	–	30.2	0.462	10 800	14 300

(1) For permissible axial load, please refer to Page 129.

(2) For application of limiting speeds, please refer to Page 152.

Note: Bearing numbers with a “C” suffix: nominal contact angle 15°
Bearing numbers with an “A5” suffix: nominal contact angle 25°
Bearing numbers with an “A” suffix: nominal contact angle 30°

For additional information:	Page No.
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● Static equivalent load	128
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● Nozzle position	174
● Quantity of packed grease	157

72 Series (continued)

Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Factor f_0	Effective Load Center (mm) a	Mass (kg) (approx)	Limiting Speeds (2) (min^{-1})	
	d	D	B	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)					Grease	Oil
7211C	**55**	**100**	**21**	1.5	1.0	53.0	40.0	27.6	14.5	20.9	0.601	14 900	22 600
7211A5	**55**	**100**	**21**	1.5	1.0	50.5	38.0	32.5	–	28.6	0.596	13 000	19 400
7211A	**55**	**100**	**21**	1.5	1.0	49.0	37.0	25.0	–	32.9	0.609	9 700	13 000
7212C	**60**	**110**	**22**	1.5	1.0	64.0	49.0	34.0	14.4	22.4	0.780	13 600	20 600
7212A5	**60**	**110**	**22**	1.5	1.0	61.0	47.0	40.0	–	30.8	0.773	11 800	17 700
7212A	**60**	**110**	**22**	1.5	1.0	59.0	45.5	30.5	–	35.5	0.789	8 900	11 800
7213C	**65**	**120**	**23**	1.5	1.0	73.0	58.5	40.0	14.6	23.9	1.010	12 500	19 000
7213A5	**65**	**120**	**23**	1.5	1.0	69.5	56.0	46.5	–	33.1	1.000	10 900	16 300
7213A	**65**	**120**	**23**	1.5	1.0	67.5	54.0	36.0	–	38.2	1.020	8 200	10 900
7214C	**70**	**125**	**24**	1.5	1.0	79.5	64.5	43.0	14.6	25.1	1.090	11 800	18 000
7214A5	**70**	**125**	**24**	1.5	1.0	76.0	61.5	49.5	–	34.7	1.080	10 300	15 400
7214A	**70**	**125**	**24**	1.5	1.0	73.0	59.5	38.0	–	40.1	1.100	7 700	10 300
7215C	**75**	**130**	**25**	1.5	1.0	83.0	70.0	46.0	14.8	26.2	1.190	11 300	17 100
7215A5	**75**	**130**	**25**	1.5	1.0	79.0	66.5	53.0	–	36.4	1.180	9 800	14 700
7215A	**75**	**130**	**25**	1.5	1.0	76.0	64.5	40.5	–	42.1	1.200	7 400	9 800
7216C	**80**	**140**	**26**	2.0	1.0	93.0	77.5	54.5	14.7	27.7	1.430	10 500	16 000
7216A5	**80**	**140**	**26**	2.0	1.0	88.5	74.0	62.0	–	38.6	1.420	9 100	13 700
7216A	**80**	**140**	**26**	2.0	1.0	85.5	71.5	47.5	–	44.8	1.450	6 900	9 100
7217C	**85**	**150**	**28**	2.0	1.0	107	90.5	60.5	14.7	29.7	1.790	9 800	14 900
7217A5	**85**	**150**	**28**	2.0	1.0	102	86.5	70.0	–	41.4	1.790	8 600	12 800
7217A	**85**	**150**	**28**	2.0	1.0	98.5	83.5	53.5	–	47.9	1.800	6 400	8 600
7218C	**90**	**160**	**30**	2.0	1.0	123	105	72.0	14.6	31.7	2.200	9 200	14 000
7218A5	**90**	**160**	**30**	2.0	1.0	117	100	83.5	–	44.1	2.310	8 000	12 000
7218A	**90**	**160**	**30**	2.0	1.0	113	96.5	64.5	–	51.1	2.230	6 000	8 000
7219C	**95**	**170**	**32**	2.1	1.1	133	112	76.0	14.6	33.7	2.640	8 700	13 300
7219A5	**95**	**170**	**32**	2.1	1.1	127	107	87.0	–	46.9	2.630	7 600	11 400
7219A	**95**	**170**	**32**	2.1	1.1	122	103	67.0	–	54.2	2.670	5 700	7 600
7220C	**100**	**180**	**34**	2.1	1.1	149	127	88.5	14.5	35.7	3.180	8 300	12 500
7220A5	**100**	**180**	**34**	2.1	1.1	142	121	103	–	49.6	3.160	7 200	10 800
7220A	**100**	**180**	**34**	2.1	1.1	137	117	79.5	–	57.4	3.210	5 400	7 200
7221C	**105**	**190**	**36**	2.1	1.1	162	143	97.5	14.5	37.7	3.780	7 800	11 900
7221A5	**105**	**190**	**36**	2.1	1.1	155	137	111	–	52.4	3.770	6 800	10 200
7221A	**105**	**190**	**36**	2.1	1.1	150	132	85.0	–	60.6	3.820	5 100	6 800

(1) For permissible axial load, please refer to Page 129.

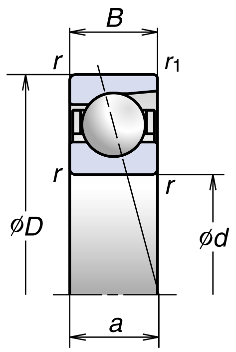
(2) For application of limiting speeds, please refer to Page 152.

Note: Bearing numbers with a “C” suffix: nominal contact angle 15°
Bearing numbers with an “A5” suffix: nominal contact angle 25°
Bearing numbers with an “A” suffix: nominal contact angle 30°

High Precision Angular Contact Ball Bearings (Standard Series)

72 Series

Bore Diameter 110-150 mm



Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Factor f_0	Effective Load Center (mm) a	Mass (kg) (approx)	Limiting Speeds (2) (min⁻¹)	
	d	**D**	**B**	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)					Grease	Oil
7222C	**110**	**200**	**38**	2.1	1.1	176	160	108	14.5	39.8	4.450	7 500	11 300
7222A5	**110**	**200**	**38**	2.1	1.1	168	153	126	–	55.1	4.450	6 500	9 700
7222A	**110**	**200**	**38**	2.1	1.1	162	148	97.0	–	63.7	4.490	4 900	6 500
7224C	**120**	**215**	**40**	2.1	1.1	199	192	132	14.6	42.4	5.420	6 900	10 500
7224A5	**120**	**215**	**40**	2.1	1.1	189	184	150	–	59.1	5.420	6 000	9 000
7224A	**120**	**215**	**40**	2.1	1.1	183	177	116	–	68.3	5.450	4 500	6 000
7226C	**130**	**230**	**40**	3.0	1.1	206	209	144	14.9	44.1	6.230	6 400	9 800
7226A5	**130**	**230**	**40**	3.0	1.1	196	199	163	–	62.0	6.220	5 600	8 400
7226A	**130**	**230**	**40**	3.0	1.1	189	193	127	–	72.0	6.280	4 200	5 600
7228C	**140**	**250**	**42**	3.0	1.1	238	254	172	14.8	47.1	7.910	5 900	9 000
7228A5	**140**	**250**	**42**	3.0	1.1	226	242	194	–	66.5	7.910	5 200	7 700
7228A	**140**	**250**	**42**	3.0	1.1	218	234	150	–	77.3	7.970	3 900	5 200
7230C	**150**	**270**	**45**	3.0	1.1	270	305	205	14.7	50.6	11.100	5 500	8 400
7230A5	**150**	**270**	**45**	3.0	1.1	258	290	231	–	71.5	11.100	4 800	7 200
7230A	**150**	**270**	**45**	3.0	1.1	248	280	179	–	83.1	11.200	3 600	4 800

(1) For permissible axial load, please refer to Page 129.

(2) For application of limiting speeds, please refer to Page 152.

Note: Bearing numbers with a "C" suffix: nominal contact angle 15°
Bearing numbers with an "A5" suffix: nominal contact angle 25°
Bearing numbers with an "A" suffix: nominal contact angle 30°

1. ANGULAR CONTACT BALL BEARINGS

Ultra High-Speed Angular Contact Ball Bearings (ROBUST Series)

Features

Optimum Design

Robust design achieved with NSK's proprietary analytical technology.
Optimum design achieved by computer simulation of temperature rise resulting from ball skid.

Long Life

New SHX steel material provides superior heat and wear resistance.
Enhanced service life measures include raising the seizure limit under low lubrication and high-speed operating conditions.

High Accuracy

Rolling element material can be tailored to match the application.
Ceramic balls are used for ROBUST series angular contact ball bearings.
Highly accurate P2 series is available.
NSK's experience and know-how ensure bearing specifications with a high degree of accuracy.

High Speed

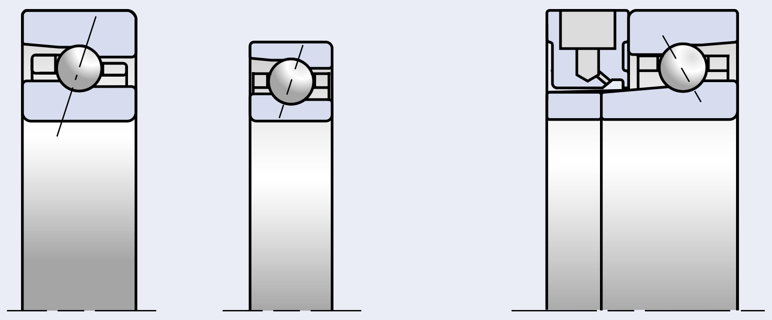
Cage engineered for high-speed operations.
Benefits of the lightweight, high strength engineered resin cage include heat resistance and high rigidity, making this cage indispensable for high-speed applications.

Low Noise

Quieter running high-speed spindle featuring Spinshot ™ Ⅱ lubrication system.
Eliminates noise caused by compressed air of the oil-air lubrication system.

Dimension Series

Fig. 1.4

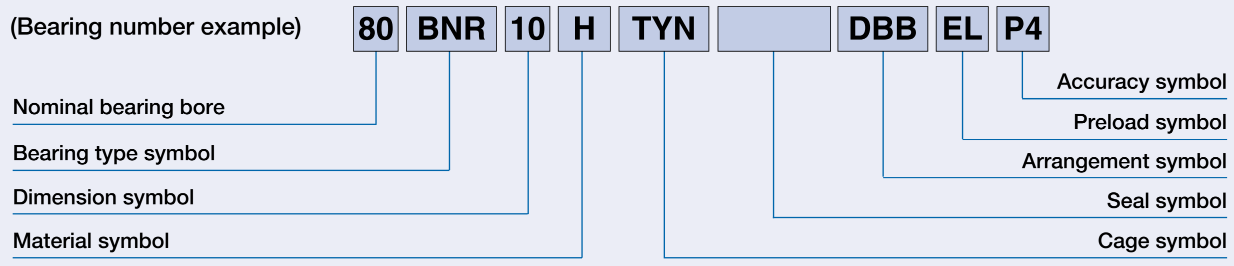


BNR10
BER10

BNR19
BER19

Spinshot™ Ⅱ
(XE type)

Numbering System of Ultra High-Speed Angular Contact Ball Bearings (ROBUST Series)



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DBD, DFD, DTD, DUD: triplex set arrangement DBB, DFF, DBT, DFT, DTT, QU: quadruplex set arrangement</td><td>38-39
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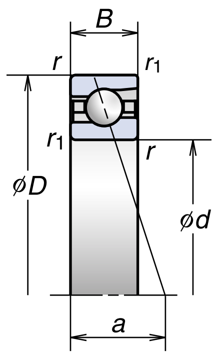
<tr><td>EL</td><td>Preload</td><td>EL: extra light preload, L: light preload, M: medium preload, H: heavy preload
CP: special preload, CA: special axial clearance</td><td>38-39
134-142
143-146</td></tr>
<tr><td>P4</td><td>Accuracy</td><td>P2: ISO Class 2, P4: ISO Class 4, P5: ISO Class 5
P3: special class (dimensional accuracy: ISO Class 4; rotating accuracy: ISO Class 2)
P4Y: special accuracy (Bore diameter and outside diameter are exclusive to NSK. All others are ISO Class 4.)</td><td>133
158-161</td></tr>
</table>

(1) Sealed angular contact ball bearings are standardized for SU arrangement and ISO Class 3.
Sealed angular contact ball bearing correspondence numbers BNR19, BER19, BNR10, BER10: Bore diameter=ϕ30-100mm

Ultra High-Speed Angular Contact Ball Bearings (ROBUST Series)

BNR 19 Series
BER 19 Series

Bore Diameter 25-80 mm



Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm) a	Mass (kg) (approx)	Sealed Design	Limiting Speeds (2) (min^{-1})	
	d	D	B	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)					Grease	Oil
25BNR19S	**25**	**42**	**9**	0.3	0.15	5.95	3.50	4.95	9.9	0.042	–	41 800	59 800
25BNR19H	**25**	**42**	**9**	0.3	0.15			3.25		0.038	–	53 800	83 600
25BNR19X	**25**	**42**	**9**	0.3	0.15					0.038	–	62 700	98 600
25BER19S	**25**	**42**	**9**	0.3	0.15	5.70	3.40	5.90	12.3	0.042	–	35 900	50 800
25BER19H	**25**	**42**	**9**	0.3	0.15			3.95		0.038	–	47 800	74 700
25BER19X	**25**	**42**	**9**	0.3	0.15					0.038	–	56 800	89 600
30BNR19S	**30**	**47**	**9**	0.3	0.15	6.30	4.05	5.75	10.8	0.048	○	36 400	52 000
30BNR19H	**30**	**47**	**9**	0.3	0.15			3.80		0.043	○	46 800	72 800
30BNR19X	**30**	**47**	**9**	0.3	0.15					0.043	○	54 600	85 800
30BER19S	**30**	**47**	**9**	0.3	0.15	6.00	3.90	6.80	13.5	0.048	○	31 200	44 200
30BER19H	**30**	**47**	**9**	0.3	0.15			4.60		0.043	○	41 600	65 000
30BER19X	**30**	**47**	**9**	0.3	0.15					0.043	○	49 400	78 000
35BNR19S	**35**	**55**	**10**	0.6	0.3	9.20	6.00	8.55	12.3	0.072	○	31 200	44 500
35BNR19H	**35**	**55**	**10**	0.6	0.3			5.60		0.063	○	40 000	62 300
35BNR19X	**35**	**55**	**10**	0.6	0.3					0.063	○	46 700	73 400
35BER19S	**35**	**55**	**10**	0.6	0.3	8.80	5.75	10.0	15.5	0.072	○	26 700	37 800
35BER19H	**35**	**55**	**10**	0.6	0.3			6.80		0.063	○	35 600	55 600
35BER19X	**35**	**55**	**10**	0.6	0.3					0.063	○	42 300	66 700
40BNR19S	**40**	**62**	**12**	0.6	0.3	11.5	7.65	10.8	14.3	0.105	○	27 500	39 300
40BNR19H	**40**	**62**	**12**	0.6	0.3			7.10		0.092	○	35 300	55 000
40BNR19X	**40**	**62**	**12**	0.6	0.3					0.092	○	41 200	64 800
40BER19S	**40**	**62**	**12**	0.6	0.3	11.0	7.35	12.8	17.9	0.105	○	23 600	33 400
40BER19H	**40**	**62**	**12**	0.6	0.3			8.65		0.092	○	31 400	49 100
40BER19X	**40**	**62**	**12**	0.6	0.3					0.092	○	37 300	58 900
45BNR19S	**45**	**68**	**12**	0.6	0.3	12.1	8.70	12.4	15.2	0.125	○	24 800	35 400
45BNR19H	**45**	**68**	**12**	0.6	0.3			8.10		0.111	○	31 900	49 600
45BNR19X	**45**	**68**	**12**	0.6	0.3					0.111	○	37 200	58 500
45BER19S	**45**	**68**	**12**	0.6	0.3	11.6	8.35	14.6	19.2	0.125	○	21 300	30 100
45BER19H	**45**	**68**	**12**	0.6	0.3			9.85		0.111	○	28 400	44 300
45BER19X	**45**	**68**	**12**	0.6	0.3					0.111	○	33 700	53 100
50BNR19S	**50**	**72**	**12**	0.6	0.3	12.8	9.75	13.9	15.9	0.127	○	23 000	32 800
50BNR19H	**50**	**72**	**12**	0.6	0.3			9.10		0.111	○	29 600	46 000
50BNR19X	**50**	**72**	**12**	0.6	0.3					0.111	○	34 500	54 100
50BER19S	**50**	**72**	**12**	0.6	0.3	12.3	9.35	16.3	20.2	0.127	○	19 700	27 900
50BER19H	**50**	**72**	**12**	0.6	0.3			11.0		0.111	○	26 300	41 000
50BER19X	**50**	**72**	**12**	0.6	0.3					0.111	○	31 200	49 200

(1) For permissible axial load, please refer to Page 129.

(2) For application of limiting speeds, please refer to Page 152.

Note: Bearing type BNR: nominal contact angle 18˚
Bearing type BER: nominal contact angle 25˚

For additional information:	Page No.
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● Static equivalent load	128
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● Nozzle position	174
● Quantity of packed grease	157

BNR 19
BER 19 Series (continued)

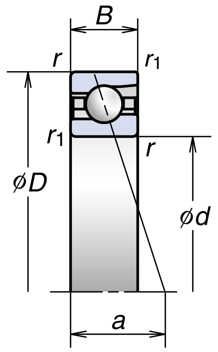
Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm) a	Mass (kg) (approx)	Sealed Design	Limiting Speeds (2) (min^{-1})	
	d	D	B	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)					Grease	Oil
55BNR19S	**55**	**80**	**13**	1.0	0.6	14.4	11.4	16.2	17.5	0.178	○	20 800	29 700
55BNR19H	**55**	**80**	**13**	1.0	0.6			10.6		0.158	○	26 700	41 500
55BNR19X	**55**	**80**	**13**	1.0	0.6					0.158	○	31 200	48 900
55BER19S	**55**	**80**	**13**	1.0	0.6	13.8	10.9	16.1	22.2	0.178	○	17 800	25 200
55BER19H	**55**	**80**	**13**	1.0	0.6			12.9		0.158	○	23 800	37 100
55BER19X	**55**	**80**	**13**	1.0	0.6					0.158	○	28 200	44 500
60BNR19S	**60**	**85**	**13**	1.0	0.6	14.6	12.0	17.1	18.3	0.190	○	19 400	27 600
60BNR19H	**60**	**85**	**13**	1.0	0.6			11.2		0.170	○	24 900	38 700
60BNR19X	**60**	**85**	**13**	1.0	0.6					0.170	○	29 000	45 600
60BER19S	**60**	**85**	**13**	1.0	0.6	14.0	11.5	20.1	23.4	0.190	○	16 600	23 500
60BER19H	**60**	**85**	**13**	1.0	0.6			13.6		0.170	○	22 100	34 500
60BER19X	**60**	**85**	**13**	1.0	0.6					0.170	○	26 300	41 400
65BNR19S	**65**	**90**	**13**	1.0	0.6	15.2	13.2	18.7	19.1	0.204	○	18 100	25 900
65BNR19H	**65**	**90**	**13**	1.0	0.6			12.3		0.181	○	23 300	36 200
65BNR19X	**65**	**90**	**13**	1.0	0.6					0.181	○	27 100	42 600
65BER19S	**65**	**90**	**13**	1.0	0.6	14.5	12.6	22.1	24.6	0.204	○	15 500	22 000
65BER19H	**65**	**90**	**13**	1.0	0.6			14.9		0.181	○	20 700	32 300
65BER19X	**65**	**90**	**13**	1.0	0.6					0.181	○	24 600	38 800
70BNR19S	**70**	**100**	**16**	1.0	0.6	21.3	18.1	26.1	21.8	0.328	○	16 500	23 600
70BNR19H	**70**	**100**	**16**	1.0	0.6			17.1		0.292	○	21 200	33 000
70BNR19X	**70**	**100**	**16**	1.0	0.6					0.292	○	24 800	38 900
70BER19S	**70**	**100**	**16**	1.0	0.6	20.4	17.3	30.5	27.8	0.328	○	14 200	20 000
70BER19H	**70**	**100**	**16**	1.0	0.6			20.7		0.292	○	18 900	29 500
70BER19X	**70**	**100**	**16**	1.0	0.6					0.292	○	22 400	35 300
75BNR19S	**75**	**105**	**16**	1.0	0.6	21.6	19.0	27.5	22.6	0.348	○	15 600	22 300
75BNR19H	**75**	**105**	**16**	1.0	0.6			18.0		0.310	○	20 000	31 200
75BNR19X	**75**	**105**	**16**	1.0	0.6					0.310	○	23 400	36 700
75BER19S	**75**	**105**	**16**	1.0	0.6	20.7	18.2	32.5	29.0	0.348	○	13 400	18 900
75BER19H	**75**	**105**	**16**	1.0	0.6			21.7		0.310	○	17 800	27 800
75BER19X	**75**	**105**	**16**	1.0	0.6					0.310	○	21 200	33 400
80BNR19S	**80**	**110**	**16**	1.0	0.6	22.0	19.9	28.9	23.4	0.366	○	14 800	21 100
80BNR19H	**80**	**110**	**16**	1.0	0.6			18.9		0.326	○	19 000	29 500
80BNR19X	**80**	**110**	**16**	1.0	0.6					0.326	○	22 200	34 800
80BER19S	**80**	**110**	**16**	1.0	0.6	21.0	19.1	34.0	30.1	0.366	○	12 700	17 900
80BER19H	**80**	**110**	**16**	1.0	0.6			22.8		0.326	○	16 900	26 400
80BER19X	**80**	**110**	**16**	1.0	0.6					0.326	○	20 000	31 600

(1) For permissible axial load, please refer to Page 129.
(2) For application of limiting speeds, please refer to Page 152.
Note: Bearing type BNR: nominal contact angle 18˚
Bearing type BER: nominal contact angle 25˚

Ultra High-Speed Angular Contact Ball Bearings (ROBUST Series)

BNR 19 Series
BER 19 Series

Bore Diameter 85-150 mm



Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm) a	Mass (kg) (approx)	Sealed Design	Limiting Speeds (2) (min^{-1})	
	d	D	B	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)					Grease	Oil
85BNR19S	85	120	18	1.1	0.6	29.4	26.3	38.0	25.7	0.527	○	13 700	19 600
85BNR19H	85	120	18	1.1	0.6			24.8		0.456	○	17 600	27 400
85BNR19X	85	120	18	1.1	0.6					0.456	○	20 500	32 200
85BER19S	85	120	18	1.1	0.6	28.1	25.2	35.5	32.9	0.527	○	11 800	16 600
85BER19H	85	120	18	1.1	0.6			30.0		0.456	○	15 700	24 400
85BER19X	85	120	18	1.1	0.6					0.456	○	18 600	29 300
90BNR19S	90	125	18	1.1	0.6	31.5	29.7	43.0	26.5	0.552	○	13 100	18 700
90BNR19H	90	125	18	1.1	0.6			28.1		0.480	○	16 800	26 100
90BNR19X	90	125	18	1.1	0.6					0.480	○	19 600	30 700
90BER19S	90	125	18	1.1	0.6	30.0	28.5	50.5	34.1	0.552	○	11 200	15 900
90BER19H	90	125	18	1.1	0.6			34.0		0.480	○	14 900	23 300
90BER19X	90	125	18	1.1	0.6					0.480	○	17 700	28 000
95BNR19S	95	130	18	1.1	0.6	32.0	31.0	50.0	28.3	0.571	○	12 500	17 800
95BNR19H	95	130	18	1.1	0.6			32.5		0.497	○	16 000	24 900
95BNR19X	95	130	18	1.1	0.6					0.497	○	18 700	29 400
95BER19S	95	130	18	1.1	0.6	30.5	29.7	58.5	36.7	0.571	○	10 700	15 200
95BER19H	95	130	18	1.1	0.6			39.5		0.497	○	14 300	22 300
95BER19X	95	130	18	1.1	0.6					0.497	○	16 900	26 700
100BNR19S	100	140	20	1.1	0.6	38.0	35.0	50.5	29.5	0.571	○	11 700	16 700
100BNR19H	100	140	20	1.1	0.6			33.0		0.497	○	15 000	23 400
100BNR19X	100	140	20	1.1	0.6					0.497	○	17 500	27 500
100BER19S	100	140	20	1.1	0.6	36.0	33.5	59.5	38.0	0.770	○	10 000	14 200
100BER19H	100	140	20	1.1	0.6			40.0		0.673	○	13 400	20 900
100BER19X	100	140	20	1.1	0.6					0.673	○	15 900	25 000
105BNR19S	105	145	20	1.1	0.6	38.5	36.5	53.0	31.5	0.795	–	11 200	16 000
105BNR19H	105	145	20	1.1	0.6			39.0		0.693	–	14 400	22 400
105BNR19X	105	145	20	1.1	0.6					0.693	–	16 800	26 400
105BER19S	105	145	20	1.1	0.6	37.0	35.0	62.0	40.9	0.795	–	9 600	13 600
105BER19H	105	145	20	1.1	0.6			42.0		0.693	–	12 800	20 000
105BER19X	105	145	20	1.1	0.6					0.693	–	15 200	24 000

(1) For permissible axial load, please refer to Page 129.

(2) For application of limiting speeds, please refer to Page 152.

Note: Bearing type BNR: nominal contact angle 18°
Bearing type BER: nominal contact angle 25°

For additional information:	Page No.
● Dynamic equivalent load	121
● Static equivalent load	128
● Preload and rigidity	134
● Abutment and fillet dimensions	168
● Nozzle position	174
● Quantity of packed grease	157

BNR 19 BER 19 Series (continued)

Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm) a	Mass (kg) (approx)	Sealed Design	Limiting Speeds (2) (min^{-1})	
	d	D	B	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)					Grease	Oil
110BNR19S	110	150	20	1.1	0.6	39.0	38.0	55.5	31.1	0.838	–	10 800	15 400
110BNR19H	110	150	20	1.1	0.6			42.0		0.733	–	13 900	21 600
110BNR19X	110	150	20	1.1	0.6					0.733	–	16 200	25 400
110BER19S	110	150	20	1.1	0.6	37.5	36.5	65.0	40.3	0.838	–	9 300	13 100
110BER19H	110	150	20	1.1	0.6			44.0		0.733	–	12 400	19 300
110BER19X	110	150	20	1.1	0.6					0.733	–	14 700	23 100
120BNR19S	120	165	22	1.1	0.6	54.0	52.0	75.0	34.2	1.124	–	9 900	14 100
120BNR19H	120	165	22	1.1	0.6			49.0		0.949	–	12 700	19 700
120BNR19X	120	165	22	1.1	0.6					0.949	–	14 800	23 200
120BER19S	120	165	22	1.1	0.6	51.5	50.0	88.0	44.2	1.124	–	8 500	12 000
120BER19H	120	165	22	1.1	0.6			59.5		0.949	–	11 300	17 600
120BER19X	120	165	22	1.1	0.6					0.949	–	13 400	21 100
130BNR19S	130	180	24	1.5	1.0	59.5	58.5	85.0	37.2	1.477	–	9 100	13 000
130BNR19H	130	180	24	1.5	1.0			56.0		1.265	–	11 700	18 100
130BER19S	130	180	24	1.5	1.0	57.0	56.5	100	48.1	1.477	–	7 800	11 000
130BER19H	130	180	24	1.5	1.0			67.5		1.265	–	10 400	16 200
140BNR19S	140	190	24	1.5	1.0	60.0	61.5	89.5	38.8	1.567	–	8 500	12 200
140BNR19H	140	190	24	1.5	1.0			58.5		1.353	–	11 000	17 000
140BER19S	140	190	24	1.5	1.0	57.5	59.0	105	50.5	1.567	–	7 300	10 400
140BER19H	140	190	24	1.5	1.0			70.5		1.353	–	9 700	15 200
150BNR19S	150	210	28	2.0	1.0	77.0	78.5	114	43.2	2.459	–	7 800	11 200
150BNR19H	150	210	28	2.0	1.0			75.0		2.139	–	10 000	15 600
150BER19S	150	210	28	2.0	1.0	73.5	75.5	134	55.9	2.459	–	6 700	9 500
150BER19H	150	210	28	2.0	1.0			90.5		2.139	–	8 900	13 900

(1) For permissible axial load, please refer to Page 129.

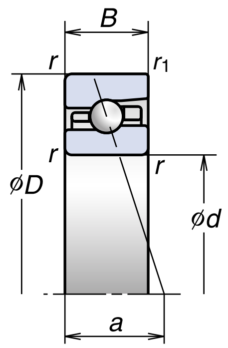
(2) For application of limiting speeds, please refer to Page 152.

Note: Bearing type BNR: nominal contact angle 18°
Bearing type BER: nominal contact angle 25°

Ultra High-Speed Angular Contact Ball Bearings (ROBUST Series)

BNR 10 Series
BER 10 Series

Bore Diameter 30-80 mm



Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm)	Mass (kg)	Sealed Design	Limiting Speeds (2) (min^{-1})	
	d	D	B	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)		a	(approx)		Grease	Oil
30BNR10S	**30**	**55**	**13**	1.0	0.6	8.65	5.75	8.20	13.3	0.124	○	33 000	47 100
30BNR10H	**30**	**55**	**13**	1.0	0.6			5.35		0.116	○	42 400	65 900
30BNR10X	**30**	**55**	**13**	1.0	0.6					0.116	○	49 500	77 700
30BER10S	**30**	**55**	**13**	1.0	0.6	8.30	5.50	9.65	16.3	0.124	○	28 300	40 000
30BER10H	**30**	**55**	**13**	1.0	0.6			6.50		0.116	○	37 700	58 900
30BER10X	**30**	**55**	**13**	1.0	0.6					0.116	○	44 800	70 600
35BNR10S	**35**	**62**	**14**	1.0	0.6	10.1	7.10	10.2	14.8	0.164	○	28 900	41 300
35BNR10H	**35**	**62**	**14**	1.0	0.6			6.70		0.154	○	37 200	57 800
35BNR10X	**35**	**62**	**14**	1.0	0.6					0.154	○	43 300	68 100
35BER10S	**35**	**62**	**14**	1.0	0.6	9.70	6.85	12.0	18.2	0.164	○	24 800	35 100
35BER10H	**35**	**62**	**14**	1.0	0.6			8.10		0.154	○	33 000	51 600
35BER10X	**35**	**62**	**14**	1.0	0.6					0.154	○	39 200	61 900
40BNR10S	**40**	**68**	**15**	1.0	0.6	10.6	7.95	11.5	16.2	0.204	○	26 000	37 100
40BNR10H	**40**	**68**	**15**	1.0	0.6			7.50		0.193	○	33 400	51 900
40BNR10X	**40**	**68**	**15**	1.0	0.6					0.193	○	38 900	61 200
40BER10S	**40**	**68**	**15**	1.0	0.6	10.1	7.65	13.5	19.9	0.204	○	22 300	31 500
40BER10H	**40**	**68**	**15**	1.0	0.6			9.10		0.193	○	29 700	46 300
40BER10X	**40**	**68**	**15**	1.0	0.6					0.193	○	35 200	55 600
45BNR10S	**45**	**75**	**16**	1.0	0.6	11.7	9.00	12.7	17.6	0.259	○	23 400	33 400
45BNR10H	**45**	**75**	**16**	1.0	0.6			8.35		0.246	○	30 000	46 700
45BNR10X	**45**	**75**	**16**	1.0	0.6					0.246	○	35 000	55 000
45BER10S	**45**	**75**	**16**	1.0	0.6	11.2	8.60	15.0	21.8	0.259	○	20 000	28 400
45BER10H	**45**	**75**	**16**	1.0	0.6			10.1		0.246	○	26 700	41 700
45BER10X	**45**	**75**	**16**	1.0	0.6					0.246	○	31 700	50 000
50BNR10S	**50**	**80**	**16**	1.0	0.6	12.2	9.90	14.0	18.4	0.281	○	21 600	30 800
50BNR10H	**50**	**80**	**16**	1.0	0.6			9.20		0.266	○	27 700	43 100
50BNR10X	**50**	**80**	**16**	1.0	0.6					0.266	○	32 400	50 800
50BER10S	**50**	**80**	**16**	1.0	0.6	11.6	9.50	16.5	23.0	0.281	○	18 500	26 200
50BER10H	**50**	**80**	**16**	1.0	0.6			11.1		0.266	○	24 700	38 500
50BER10X	**50**	**80**	**16**	1.0	0.6					0.266	○	29 300	46 200

(1) For permissible axial load, please refer to Page 129.

(2) For application of limiting speeds, please refer to Page 152.

Note: Bearing type BNR: nominal contact angle 18°
Bearing type BER: nominal contact angle 25°

For additional information: Page No.

● Dynamic equivalent load	121
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● Quantity of packed grease	157

BNR 10 BER 10 Series (continued)

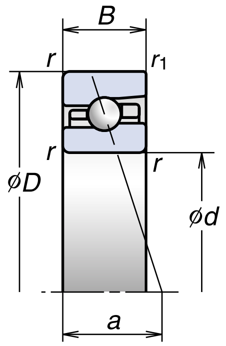
Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm)	Mass (kg)	Sealed Design	Limiting Speeds (2) (min^{-1})	
	d	D	B	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)		a	(approx)		Grease	Oil
55BNR10S	**55**	**90**	**18**	1.1	0.6	15.1	12.5	17.8	20.6	0.414	○	19400	27600
55BNR10H	**55**	**90**	**18**	1.1	0.6			11.7		0.393	○	24 900	38 700
55BNR10X	**55**	**90**	**18**	1.1	0.6					0.393	○	29 000	45 600
55BER10S	**55**	**90**	**18**	1.1	0.6	14.4	12.0	21.0	25.7	0.414	○	16 600	23 500
55BER10H	**55**	**90**	**18**	1.1	0.6			14.1		0.393	○	22 100	34 500
55BER10X	**55**	**90**	**18**	1.1	0.6					0.393	○	26 300	41 400
60BNR10S	**60**	**95**	**18**	1.1	0.6	15.6	13.7	19.5	21.5	0.443	○	18 100	25 900
60BNR10H	**60**	**95**	**18**	1.1	0.6			12.8		0.419	○	23 300	36 200
60BNR10X	**60**	**95**	**18**	1.1	0.6					0.419	○	27 100	42 600
60BER10S	**60**	**95**	**18**	1.1	0.6	15.0	13.1	22.9	26.9	0.443	○	15 500	22 000
60BER10H	**60**	**95**	**18**	1.1	0.6			15.5		0.419	○	20 700	32 300
60BER10X	**60**	**95**	**18**	1.1	0.6					0.419	○	24 600	38 800
65BNR10S	**65**	**100**	**18**	1.1	0.6	16.2	14.8	21.1	22.3	0.472	○	17 000	24 300
65BNR10H	**65**	**100**	**18**	1.1	0.6			13.9		0.447	○	21 900	34 000
65BNR10X	**65**	**100**	**18**	1.1	0.6					0.447	○	25 500	40 000
65BER10S	**65**	**100**	**18**	1.1	0.6	15.5	14.2	24.9	28.0	0.472	○	14 600	20 700
65BER10H	**65**	**100**	**18**	1.1	0.6			16.8		0.447	○	19 400	30 400
65BER10X	**65**	**100**	**18**	1.1	0.6					0.447	○	23 100	36 400
70BNR10S	**70**	**110**	**20**	1.1	0.6	22.3	19.8	28.6	24.5	0.645	○	15 600	22 300
70BNR10H	**70**	**110**	**20**	1.1	0.6			18.8		0.605	○	20 000	31 200
70BNR10X	**70**	**110**	**20**	1.1	0.6					0.605	○	23 400	36 700
70BER10S	**70**	**110**	**20**	1.1	0.6	21.3	18.9	33.5	30.8	0.645	○	13 400	18 900
70BER10H	**70**	**110**	**20**	1.1	0.6			22.6		0.605	○	17 800	27 800
70BER10X	**70**	**110**	**20**	1.1	0.6					0.605	○	21 200	33 400
75BNR10S	**75**	**115**	**20**	1.1	0.6	22.6	20.7	30.0	25.3	0.679	○	14 800	21 100
75BNR10H	**75**	**115**	**20**	1.1	0.6			19.7		0.638	○	19 000	29 500
75BNR10X	**75**	**115**	**20**	1.1	0.6					0.638	○	22 200	34 800
75BER10S	**75**	**115**	**20**	1.1	0.6	21.6	19.8	35.0	31.9	0.679	○	12 700	17 900
75BER10H	**75**	**115**	**20**	1.1	0.6			23.7		0.638	○	16 900	26 400
75BER10X	**75**	**115**	**20**	1.1	0.6					0.638	○	20 000	31 600
80BNR10S	**80**	**125**	**22**	1.1	0.6	26.5	24.5	35.5	27.5	0.921	○	13 700	19 600
80BNR10H	**80**	**125**	**22**	1.1	0.6			23.4		0.867	○	17 600	27 400
80BNR10X	**80**	**125**	**22**	1.1	0.6					0.867	○	20 500	32 200
80BER10S	**80**	**125**	**22**	1.1	0.6	25.3	23.5	42.0	34.6	0.921	○	11 800	16 600
80BER10H	**80**	**125**	**22**	1.1	0.6			28.2		0.867	○	15 700	24 400
80BER10X	**80**	**125**	**22**	1.1	0.6					0.867	○	18 600	29 300

(1) For permissible axial load, please refer to Page 129.
(2) For application of limiting speeds, please refer to Page 152.
Note: Bearing type BNR: nominal contact angle α=18°
Bearing type BER: nominal contact angle α=25°

Ultra High-Speed Angular Contact Ball Bearings (ROBUST Series)

BNR 10 Series
BER 10 Series

Bore Diameter 85-150 mm



Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm) *a*	Mass (kg) (approx)	Sealed Design	Limiting Speeds (2) (min^{-1})	
	d	***D***	***B***	*r* (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)					Grease	Oil
85BNR10S	**85**	**130**	**22**	1.1	0.6	26.8	25.7	37.5	28.4	0.962	○	13 100	18 700
85BNR10H	**85**	**130**	**22**	1.1	0.6			24.5		0.906	○	16 800	26 100
85BNR10X	**85**	**130**	**22**	1.1	0.6					0.906	○	19 600	30 700
85BER10S	**85**	**130**	**22**	1.1	0.6	25.6	24.6	43.5	36.1	0.962	○	11 200	15 900
85BER10H	**85**	**130**	**22**	1.1	0.6			29.5		0.906	○	14 900	23 300
85BER10X	**85**	**130**	**22**	1.1	0.6					0.906	○	17 700	28 000
90BNR10S	**90**	**140**	**24**	1.5	1.0	35.0	33.0	48.0	30.7	1.241	○	12 200	17 400
90BNR10H	**90**	**140**	**24**	1.5	1.0			31.5		1.155	○	15 700	24 400
90BNR10X	**90**	**140**	**24**	1.5	1.0					1.155	○	18 300	28 700
90BER10S	**90**	**140**	**24**	1.5	1.0	33.5	31.5	56.0	38.8	1.241	○	10 500	14 800
90BER10H	**90**	**140**	**24**	1.5	1.0			38.0		1.155	○	14 000	21 800
90BER10X	**90**	**140**	**24**	1.5	1.0					1.155	○	16 600	26 100
95BNR10S	**95**	**145**	**24**	1.5	1.0	35.5	34.5	50.0	31.3	1.298	○	11 700	16 700
95BNR10H	**95**	**145**	**24**	1.5	1.0			32.5		1.209	○	15 000	23 400
95BNR10X	**95**	**145**	**24**	1.5	1.0					1.209	○	17 500	27 500
95BER10S	**95**	**145**	**24**	1.5	1.0	34.0	33.0	58.5	39.7	1.298	○	10 000	14 200
95BER10H	**95**	**145**	**24**	1.5	1.0			39.5		1.209	○	13 400	20 900
95BER10X	**95**	**145**	**24**	1.5	1.0					1.209	○	15 900	25 000
100BNR10S	**100**	**150**	**24**	1.5	1.0	36.0	36.0	52.0	32.3	1.245	○	11 200	16 000
100BNR10H	**100**	**150**	**24**	1.5	1.0			34.0		1.253	○	14 400	22 400
100BNR10X	**100**	**150**	**24**	1.5	1.0					1.253	○	16 800	26 400
100BER10S	**100**	**150**	**24**	1.5	1.0	34.5	34.5	61.0	41.2	1.245	○	9 600	13 600
100BER10H	**100**	**150**	**24**	1.5	1.0			41.0		1.253	○	12 800	20 000
100BER10X	**100**	**150**	**24**	1.5	1.0					1.253	○	15 200	24 000
105BNR10S	**105**	**160**	**26**	2.0	1.0	41.0	41.0	59.5	34.5	1.698	–	10 600	15 100
105BNR10H	**105**	**160**	**26**	2.0	1.0			39.0		1.585	–	13 600	21 200
105BNR10X	**105**	**160**	**26**	2.0	1.0					1.585	–	15 900	25 000
105BER10S	**105**	**160**	**26**	2.0	1.0	39.0	39.5	70.0	43.9	1.698	–	9 100	12 900
105BER10H	**105**	**160**	**26**	2.0	1.0			47.5		1.585	–	12 100	18 900
105BER10X	**105**	**160**	**26**	2.0	1.0					1.585	–	14 400	22 700

(1) For permissible axial load, please refer to Page 129.

(2) For application of limiting speeds, please refer to Page 152.

Note: Bearing type BNR: nominal contact angle 18°
Bearing type BER: nominal contact angle 25°

For additional information:	Page No.
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● Static equivalent load	128
● Preload and rigidity	134
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● Quantity of packed grease	157

BNR 10
BER 10 Series (continued)

Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm) *a*	Mass (kg) (approx)	Sealed Design	Limiting Speeds (2) (min^{-1})	
	d	***D***	***B***	*r* (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)					Grease	Oil
110BNR10S	**110**	**170**	**28**	2.0	1.0	46.0	47.0	68.0	36.7	2.133	–	10 000	14 300
110BNR10H	**110**	**170**	**28**	2.0	1.0			44.5		1.996	–	12 900	20 000
110BNR10X	**110**	**170**	**28**	2.0	1.0					1.996	–	15 000	23 600
110BER10S	**110**	**170**	**28**	2.0	1.0	44.0	45.0	79.5	46.7	2.133	–	8 600	12 200
110BER10H	**110**	**170**	**28**	2.0	1.0			54.0		1.996	–	11 500	17 900
110BER10X	**110**	**170**	**28**	2.0	1.0					1.996	–	13 600	21 500
120BNR10S	**120**	**180**	**28**	2.0	1.0	47.5	50.5	73.5	38.4	2.286	–	9 400	13 400
120BNR10H	**120**	**180**	**28**	2.0	1.0			48.0		2.139	–	12 000	18 700
120BNR10X	**120**	**180**	**28**	2.0	1.0					2.139	–	14 000	22 000
120BER10S	**120**	**180**	**28**	2.0	1.0	45.5	48.5	86.0	49.0	2.286	–	8 000	11 400
120BER10H	**120**	**180**	**28**	2.0	1.0			58.0		2.139	–	10 700	16 700
120BER10X	**120**	**180**	**28**	2.0	1.0					2.139	–	12 700	20 000
130BNR10S	**130**	**200**	**33**	2.0	1.0	60.0	61.5	89.5	43.0	3.408	–	8 500	12 200
130BNR10H	**130**	**200**	**33**	2.0	1.0			58.5		3.194	–	11 000	17 000
130BER10S	**130**	**200**	**33**	2.0	1.0	57.5	59.0	105	54.6	3.408	–	7 300	10 400
130BER10H	**130**	**200**	**33**	2.0	1.0			70.5		3.194	–	9 700	15 200
140BNR10S	**140**	**210**	**33**	2.0	1.0	62.5	66.5	97.0	44.6	3.647	–	8 000	11 500
140BNR10H	**140**	**210**	**33**	2.0	1.0			63.5		3.419	–	10 300	16 000
140BER10S	**140**	**210**	**33**	2.0	1.0	59.5	64.0	113	56.9	3.647	–	6 900	9 800
140BER10H	**140**	**210**	**33**	2.0	1.0			76.5		3.419	–	9 200	14 300
150BNR10S	**150**	**225**	**35**	2.1	1.0	73.5	78.0	114	47.6	4.405	–	7 500	10 700
150BNR10H	**150**	**225**	**35**	2.1	1.0			74.5		4.129	–	9 600	15 000
150BER10S	**150**	**225**	**35**	2.1	1.0	70.0	75.0	99.5	60.8	4.405	–	6 400	9 100
150BER10H	**150**	**225**	**35**	2.1	1.0			90.0		4.129	–	8 600	13 400

(1) For permissible axial load, please refer to Page 129.

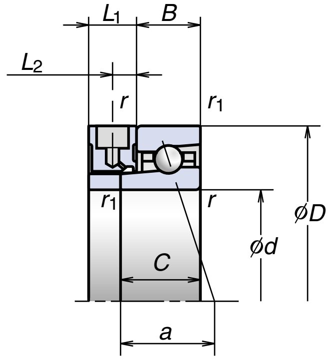
(2) For application of limiting speeds, please refer to Page 152.

Note: Bearing type BNR: nominal contact angle 18°
Bearing type BER: nominal contact angle 25°

Ultra High-Speed Angular Contact Ball Bearings (Spinshot™ II Series)

BNR 19XE Series
BER 19XE Series

Bore Diameter 40-110 mm



Bearing Numbers	Boundary Dimensions (mm)						Spinshot™ Spacer Dimension (mm)		Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm) a	Mass (kg) (approx)	Limiting Speeds (2) (min⁻¹)
	d	D	B	C	r (min)	r_1 (min)	L_1 (approx)	L_2 (approx)	C_r (Dynamic)	C_{or} (Static)				Oil
40BNR19XE	**40**	**62**	**12**	**17**	0.6	0.3	15	7.5	11.5	7.65	7.10	19.3	0.106	64 800
40BER19XE	**40**	**62**	**12**	**17**	0.6	0.3	15	7.5	11.0	7.35	8.65	22.9	0.106	58 900
45BNR19XE	**45**	**68**	**12**	**17**	0.6	0.3	15	7.5	12.1	8.70	8.10	20.2	0.128	58 500
45BER19XE	**45**	**68**	**12**	**17**	0.6	0.3	15	7.5	11.6	8.35	9.85	24.2	0.128	53 100
50BNR19XE	**50**	**72**	**12**	**17**	0.6	0.3	15	7.5	12.8	9.75	9.10	20.9	0.129	54 100
50BER19XE	**50**	**72**	**12**	**17**	0.6	0.3	15	7.5	12.3	9.35	11.0	25.2	0.129	49 200
55BNR19XE	**55**	**80**	**13**	**18**	1.0	0.6	15	7.5	14.4	11.4	10.6	22.5	0.182	48 900
55BER19XE	**55**	**80**	**13**	**18**	1.0	0.6	15	7.5	13.8	10.9	12.9	27.2	0.182	44 500
60BNR19XE	**60**	**85**	**13**	**18**	1.0	0.6	15	7.5	14.6	12.0	11.2	23.3	0.196	45 600
60BER19XE	**60**	**85**	**13**	**18**	1.0	0.6	15	7.5	14.0	11.5	13.6	28.4	0.196	41 400
65BNR19XE	**65**	**90**	**13**	**18**	1.0	0.6	15	7.5	15.2	13.2	12.3	24.1	0.209	42 600
65BER19XE	**65**	**90**	**13**	**18**	1.0	0.6	15	7.5	14.5	12.6	14.9	29.6	0.209	38 800
70BNR19XE	**70**	**100**	**16**	**21**	1.0	0.6	15	7.5	21.3	18.1	17.1	26.8	0.328	38 900
70BER19XE	**70**	**100**	**16**	**21**	1.0	0.6	15	7.5	20.4	17.3	20.7	32.8	0.328	35 300
75BNR19XE	**75**	**105**	**16**	**21**	1.0	0.6	15	7.5	21.6	19.0	18.0	27.6	0.348	36 700
75BER19XE	**75**	**105**	**16**	**21**	1.0	0.6	15	7.5	20.7	18.2	21.7	34.0	0.348	33 400
80BNR19XE	**80**	**110**	**16**	**21**	1.0	0.6	15	7.5	22.0	19.9	18.9	28.4	0.366	34 800
80BER19XE	**80**	**110**	**16**	**21**	1.0	0.6	15	7.5	21.0	19.1	22.8	35.1	0.366	31 600
85BNR19XE	**85**	**120**	**18**	**23**	1.1	0.6	15	7.5	29.4	26.3	24.8	30.7	0.506	32 200
85BER19XE	**85**	**120**	**18**	**23**	1.1	0.6	15	7.5	28.1	25.2	30.0	37.9	0.506	29 300
90BNR19XE	**90**	**125**	**18**	**23**	1.1	0.6	15	7.5	31.5	29.7	28.1	31.5	0.532	30 700
90BER19XE	**90**	**125**	**18**	**23**	1.1	0.6	15	7.5	30.0	28.5	34.0	39.1	0.532	28 000
95BNR19XE	**95**	**130**	**18**	**23**	1.1	0.6	15	7.5	35.5	34.5	32.5	33.3	0.589	29 400
95BER19XE	**95**	**130**	**18**	**23**	1.1	0.6	15	7.5	34.0	33.0	39.5	41.7	0.589	26 700
100BNR19XE	**100**	**140**	**20**	**25**	1.1	0.6	15	7.5	38.0	35.0	33.0	34.5	0.739	27 500
100BER19XE	**100**	**140**	**20**	**25**	1.1	0.6	15	7.5	36.0	33.5	40.0	43.0	0.739	25 000
105BNR19XE	**105**	**145**	**20**	**25**	1.1	0.6	15	7.5	41.0	41.0	39.0	36.5	0.758	26 400
105BER19XE	**105**	**145**	**20**	**25**	1.1	0.6	15	7.5	39.0	39.5	47.5	45.9	0.758	24 000
110BNR19XE	**110**	**150**	**20**	**25**	1.1	0.6	15	7.5	39.0	38.0	36.5	36.1	0.804	25 400
110BER19XE	**110**	**150**	**20**	**25**	1.1	0.6	15	7.5	37.5	36.5	44.0	45.3	0.804	23 100

(1) For permissible axial load, please refer to Page 129.

(2) For application of limiting speeds, please refer to Page 152.

Note: Bearing type BNR: nominal contact angle 18˚
Bearing type BER: nominal contact angle 25˚

BNR 10XE Series
BER 10XE Series

Bore Diameter 40-110 mm

For additional information:	Page No.
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● Preload and rigidity	134
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Bearing Numbers	Boundary Dimensions (mm)						Spinshot™ Spacer Dimension (mm)		Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm) a	Mass (kg) (approx)	Limiting Speeds (2) (min⁻¹)
	d	D	B	C	r (min)	r_1 (min)	L_1 (approx)	L_2 (approx)	C_r (Dynamic)	C_{or} (Static)				Oil
40BNR10XE	**40**	**68**	**15**	**20**	1.0	0.6	15	7.5	10.6	7.95	7.50	21.2	0.217	61 200
40BER10XE	**40**	**68**	**15**	**20**	1.0	0.6	15	7.5	10.1	7.65	9.10	24.9	0.217	55 600
45BNR10XE	**45**	**75**	**16**	**21**	1.0	0.6	15	7.5	11.7	9.00	8.35	22.6	0.273	55 000
45BER10XE	**45**	**75**	**16**	**21**	1.0	0.6	15	7.5	11.2	8.60	10.1	26.8	0.273	50 000
50BNR10XE	**50**	**80**	**16**	**21**	1.0	0.6	15	7.5	12.2	9.90	9.20	23.4	0.296	50 800
50BER10XE	**50**	**80**	**16**	**21**	1.0	0.6	15	7.5	11.6	9.50	11.1	28.0	0.296	46 200
55BNR10XE	**55**	**90**	**18**	**23**	1.1	0.6	15	7.5	15.1	12.5	11.7	25.6	0.433	45 600
55BER10XE	**55**	**90**	**18**	**23**	1.1	0.6	15	7.5	14.4	12.0	14.1	30.7	0.433	41 400
60BNR10XE	**60**	**95**	**18**	**23**	1.1	0.6	15	7.5	15.6	13.7	12.8	26.5	0.463	42 600
60BER10XE	**60**	**95**	**18**	**23**	1.1	0.6	15	7.5	15.0	13.1	15.5	31.9	0.463	38 800
65BNR10XE	**65**	**100**	**18**	**23**	1.1	0.6	15	7.5	16.2	14.8	13.9	27.3	0.493	40 000
65BER10XE	**65**	**100**	**18**	**23**	1.1	0.6	15	7.5	15.5	14.2	16.8	33.0	0.493	36 400
70BNR10XE	**70**	**110**	**20**	**25**	1.1	0.6	15	7.5	22.3	19.8	18.8	29.5	0.660	36 700
70BER10XE	**70**	**110**	**20**	**25**	1.1	0.6	15	7.5	21.3	18.9	22.6	35.8	0.660	33 400
75BNR10XE	**75**	**115**	**22**	**27**	1.1	0.6	15	7.5	22.6	20.7	19.7	30.3	0.697	34 800
75BER10XE	**75**	**115**	**22**	**27**	1.1	0.6	15	7.5	21.6	19.8	23.7	36.9	0.697	31 600
80BNR10XE	**80**	**125**	**22**	**27**	1.1	0.6	15	7.5	26.5	24.5	23.4	32.5	0.939	32 200
80BER10XE	**80**	**125**	**22**	**27**	1.1	0.6	15	7.5	25.3	23.5	28.2	39.6	0.939	29 300
85BNR10XE	**85**	**130**	**22**	**27**	1.1	0.6	15	7.5	26.8	25.7	24.5	33.4	0.988	30 700
85BER10XE	**85**	**130**	**22**	**27**	1.1	0.6	15	7.5	25.6	24.6	29.5	41.1	0.988	28 000
90BNR10XE	**90**	**140**	**24**	**29**	1.5	1.0	15	7.5	35.0	33.0	31.5	35.7	1.250	28 700
90BER10XE	**90**	**140**	**24**	**29**	1.5	1.0	15	7.5	33.5	31.5	38.0	43.8	1.250	26 100
95BNR10XE	**95**	**145**	**24**	**29**	1.5	1.0	15	7.5	35.5	34.5	32.5	36.3	1.300	27 500
95BER10XE	**95**	**145**	**24**	**29**	1.5	1.0	15	7.5	34.0	33.0	39.5	44.7	1.300	25 000
100BNR10XE	**100**	**150**	**24**	**29**	1.5	1.0	15	7.5	36.0	36.0	34.0	37.3	1.359	26 400
100BER10XE	**100**	**150**	**24**	**29**	1.5	1.0	15	7.5	34.5	34.5	41.0	46.2	1.359	24 000
105BNR10XE	**105**	**160**	**26**	**31**	2.0	1.0	15	7.5	41.0	41.0	39.0	39.5	1.707	25 000
105BER10XE	**105**	**160**	**26**	**31**	2.0	1.0	15	7.5	39.0	39.5	47.5	48.9	1.707	22 700
110BNR10XE	**110**	**170**	**28**	**33**	2.0	1.0	15	7.5	46.0	47.0	44.5	41.7	2.139	23 600
110BER10XE	**110**	**170**	**28**	**33**	2.0	1.0	15	7.5	44.0	45.0	54.0	51.7	2.139	21 500

(1) For permissible axial load, please refer to Page 129.

(2) For application of limiting speeds, please refer to Page 152.

Note: Bearing type BNR: nominal contact angle 18˚
Bearing type BER: nominal contact angle 25˚

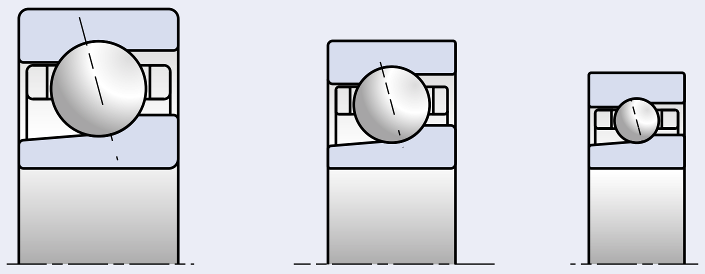
Ultra High Precision Angular Contact Ball Bearings (BGR Series)

Features

Optimum Design	An outer ring guided cage is used to improve lubrication performance. The counter-bore inner ring improves oil-mist flow to ensure a stable oil supply.
Long Life	Special heat resistant SHX steel and ceramic balls significantly improve service life (X-type bearings).
Easy Mounting	Non-separable inner ring design greatly simplifies mounting and dismounting procedures. Interchangeable assembly for any desired arrangement to meet customer needs.
High Accuracy	BGR Series are standardized for ISO Class 2 (ABMA ABEC 9).

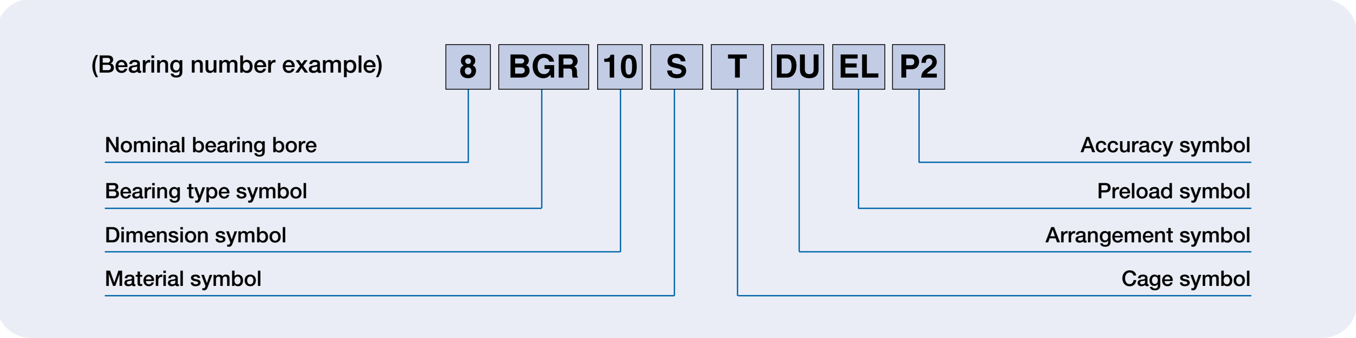
Dimension Series

Fig. 1.5



BGR02 BGR10 BGR19

Numbering System of Ultra High Precision Angular Contact Ball Bearings (BGR Series)



(Bearing number example) 8 BGR 10 S T DU EL P2

- 8 — Nominal bearing bore
- BGR — Bearing type symbol
- 10 — Dimension symbol
- S — Material symbol
- T — Cage symbol
- DU — Arrangement symbol
- EL — Preload symbol
- P2 — Accuracy symbol

<table>
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<tr><td>BGR</td><td>Bearing type</td><td>BGR: 15˚ contact angle</td><td>38-39, 44</td></tr>
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<tr><th>Rings</th><th>Rolling elements</th></tr>
<tr><td>S</td><td>Bearing steel (SUJ2)</td><td>Bearing steel (SUJ2)</td></tr>
<tr><td>H</td><td>Bearing steel (SUJ2)</td><td>Ceramics (Si_3N_4)</td></tr>
<tr><td>X</td><td>Heat resistant steel (SHX)</td><td>Ceramics (Si_3N_4)</td></tr>
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25</td></tr>
<tr><td>T</td><td>Cage</td><td>T: phenolic resin cage with outer ring guide; operational temperature limit = 120˚C</td><td>16-17</td></tr>
<tr><td>DU</td><td>Arrangement</td><td>SU: universal arrangement (single row) DU: universal arrangement (double row)</td><td>38-39
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<tr><td>EL</td><td>Preload</td><td>EL: extra light preload</td><td>38-39
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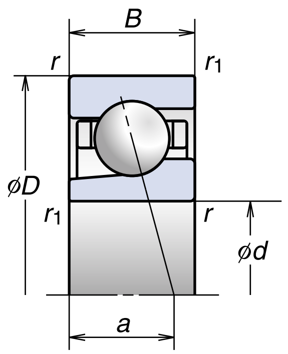
<tr><td>P2</td><td>Accuracy</td><td>P2: ISO Class 2</td><td>158-161</td></tr>
</table>

Ultra High Precision Angular Contact Ball Bearings (BGR Series)



BGR 19 Series

Bore Diameter 10-25 mm

Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm) *a*	Mass (kg) (approx)	Limiting Speeds (2) (min^{-1})	
	d	*D*	*B*	*r* (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)				Grease	Oil
10BGR19S	**10**	**22**	**6**	0.3	0.15	2.03	0.78	0.93	5.1	0.010	100 000	138 000
10BGR19H	**10**	**22**	**6**	0.3	0.15			0.61		0.009	119 000	175 000
10BGR19X	**10**	**22**	**6**	0.3	0.15					0.009	138 000	188 000
12BGR19S	**12**	**24**	**6**	0.3	0.15	2.28	0.95	1.14	5.4	0.011	88 900	123 000
12BGR19H	**12**	**24**	**6**	0.3	0.15			0.74		0.010	106 000	156 000
12BGR19X	**12**	**24**	**6**	0.3	0.15					0.010	123 000	167 000
15BGR19S	**15**	**28**	**7**	0.3	0.15	3.25	1.35	1.67	6.4	0.016	74 500	103 000
15BGR19H	**15**	**28**	**7**	0.3	0.15			1.09		0.014	88 400	131 000
15BGR19X	**15**	**28**	**7**	0.3	0.15					0.014	103 000	140 000
17BGR19S	**17**	**30**	**7**	0.3	0.15	3.40	1.50	1.86	6.6	0.017	68 100	93 700
17BGR19H	**17**	**30**	**7**	0.3	0.15			1.21		0.015	80 900	120 000
17BGR19X	**17**	**30**	**7**	0.3	0.15					0.015	93 700	128 000
20BGR19S	**20**	**37**	**9**	0.3	0.15	4.75	2.16	2.66	8.3	0.036	56 200	77 200
20BGR19H	**20**	**37**	**9**	0.3	0.15			1.73		0.033	66 700	98 300
20BGR19X	**20**	**37**	**9**	0.3	0.15					0.033	77 200	106 000
25BGR19S	**25**	**42**	**9**	0.3	0.15	5.40	2.76	3.40	9.0	0.043	47 800	65 700
25BGR19H	**25**	**42**	**9**	0.3	0.15			2.22		0.039	56 800	83 600
25BGR19X	**25**	**42**	**9**	0.3	0.15					0.039	65 700	89 600

(1) For permissible axial load, please refer to Page 129.

(2) For application of limiting speeds, please refer to Page 152.

Note: Bearing type BGR: nominal contact angle 15°

BGR 10 Series

Bore Diameter 6-25 mm

For additional information:	Page No.
● Dynamic equivalent load	121
● Static equivalent load	128
● Preload and rigidity	134
● Abutment and fillet dimensions	168
● Nozzle position	174
● Quantity of packed grease	157

Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm) *a*	Mass (kg) (approx)	Limiting Speeds (2) (min^{-1})	
	d	*D*	*B*	*r* (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)				Grease	Oil
6BGR10S	**6**	**17**	**6**	0.3	0.15	1.42	0.43	0.51	4.5	0.006	140 000	192 000
6BGR10H	**6**	**17**	**6**	0.3	0.15			0.34		0.005	166 000	244 000
6BGR10X	**6**	**17**	**6**	0.3	0.15					0.005	192 000	261 000
7BGR10S	**7**	**19**	**6**	0.3	0.15	1.60	0.52	0.62	4.7	0.008	124 000	170 000
7BGR10H	**7**	**19**	**6**	0.3	0.15			0.40		0.007	147 000	216 000
7BGR10X	**7**	**19**	**6**	0.3	0.15					0.007	170 000	231 000
8BGR10S	**8**	**22**	**7**	0.3	0.15	2.37	0.80	0.97	5.5	0.012	107 000	147 000
8BGR10H	**8**	**22**	**7**	0.3	0.15			0.63		0.011	127 000	187 000
8BGR10X	**8**	**22**	**7**	0.3	0.15					0.011	147 000	200 000
10BGR10S	**10**	**26**	**8**	0.3	0.15	3.50	1.27	1.55	6.4	0.019	88 900	123 000
10BGR10H	**10**	**26**	**8**	0.3	0.15			1.00		0.016	106 000	156 000
10BGR10X	**10**	**26**	**8**	0.3	0.15					0.016	123 000	167 000
12BGR10S	**12**	**28**	**8**	0.3	0.15	3.85	1.48	1.80	6.7	0.021	80 000	110 000
12BGR10H	**12**	**28**	**8**	0.3	0.15			1.17		0.018	95 000	140 000
12BGR10X	**12**	**28**	**8**	0.3	0.15					0.018	110 000	150 000
15BGR10S	**15**	**32**	**9**	0.3	0.15	4.20	1.72	2.12	7.6	0.029	68 100	93 700
15BGR10H	**15**	**32**	**9**	0.3	0.15			1.37		0.026	80 900	120 000
15BGR10X	**15**	**32**	**9**	0.3	0.15					0.026	93 700	128 000
17BGR10S	**17**	**35**	**10**	0.3	0.15	4.45	1.93	2.39	8.5	0.038	61 600	84 700
17BGR10H	**17**	**35**	**10**	0.3	0.15			1.55		0.035	73 100	108 000
17BGR10X	**17**	**35**	**10**	0.3	0.15					0.035	84 700	116 000
20BGR10S	**20**	**42**	**12**	0.6	0.3	7.45	3.35	4.10	10.2	0.066	51 700	71 000
20BGR10H	**20**	**42**	**12**	0.6	0.3			2.67		0.059	61 300	90 400
20BGR10X	**20**	**42**	**12**	0.6	0.3					0.059	71 000	96 800
25BGR10S	**25**	**47**	**12**	0.6	0.3	7.90	3.75	4.65	10.8	0.076	44 500	61 200
25BGR10H	**25**	**47**	**12**	0.6	0.3			3.05		0.068	52 800	77 800
25BGR10X	**25**	**47**	**12**	0.6	0.3					0.068	61 200	83 400

(1) For permissible axial load, please refer to Page 129.

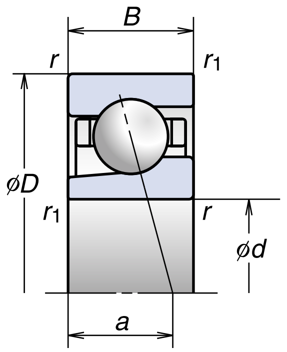
(2) For application of limiting speeds, please refer to Page 152.

Note: Bearing type BGR: nominal contact angle 15°

Ultra High Precision Angular Contact Ball Bearings (BGR Series)

BGR 02 Series

Bore Diameter 10-25 mm



Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (¹) (kN)	Effective Load Center (mm) *a*	Mass (kg) (approx)	Limiting Speeds (²) (min⁻¹)	
	d	*D*	*B*	*r* (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)				Grease	Oil
10BGR02S	**10**	**30**	**9**	0.6	0.3	3.60	1.33	1.62	7.2	0.032	80 000	110 000
10BGR02H	**10**	**30**	**9**	0.6	0.3			1.06		0.029	95 000	140 000
10BGR02X	**10**	**30**	**9**	0.6	0.3					0.029	110 000	150 000
12BGR02S	**12**	**32**	**10**	0.6	0.3	5.30	1.99	2.46	7.9	0.036	72 800	100 000
12BGR02H	**12**	**32**	**10**	0.6	0.3			1.60		0.032	86 400	128 000
12BGR02X	**12**	**32**	**10**	0.6	0.3					0.032	100 000	137 000
15BGR02S	**15**	**35**	**11**	0.6	0.3	5.80	2.34	2.90	8.8	0.045	64 000	88 000
15BGR02H	**15**	**35**	**11**	0.6	0.3			1.89		0.040	76 000	112 000
15BGR02X	**15**	**35**	**11**	0.6	0.3					0.040	88 000	120 000
17BGR02S	**17**	**40**	**12**	0.6	0.3	7.25	2.98	3.65	9.8	0.065	56 200	77 200
17BGR02H	**17**	**40**	**12**	0.6	0.3			2.39		0.057	66 700	98 300
17BGR02X	**17**	**40**	**12**	0.6	0.3					0.057	77 200	106 000
20BGR02S	**20**	**47**	**14**	1.0	0.6	9.70	4.10	5.10	11.5	0.103	47 800	65 700
20BGR02H	**20**	**47**	**14**	1.0	0.6			3.30		0.091	56 800	83 600
20BGR02X	**20**	**47**	**14**	1.0	0.6					0.091	65 700	89 600
25BGR02S	**25**	**52**	**15**	1.0	0.6	11.1	5.20	6.45	12.7	0.127	41 600	57 200
25BGR02H	**25**	**52**	**15**	1.0	0.6			4.20		0.112	49 400	72 800
25BGR02X	**25**	**52**	**15**	1.0	0.6					0.112	57 200	78 000

(¹) For permissible axial load, please refer to Page 129.

(²) For application of limiting speeds, please refer to Page 152.

Note: Bearing type BGR: nominal contact angle 15°

Double Row Cylindrical Roller Bearings

High Rigidity Series

Single Row Cylindrical Roller Bearings

Standard Series

Ultra High-Speed Single Row Cylindrical Roller Bearings

ROBUST Series

Cylindrical Roller Bearings

Cylindrical Roller Bearings ······································P78-85
Features
    Numbering System
    Bearing Tables
        Double Row Cylindrical Roller Bearings (High Rigidity Series)
            30 Series
            39 Series
            49 Series
        Single Row Cylindrical Roller Bearings (Standard Series)
            10 Series
        Ultra High-Speed Single Row Cylindrical Roller Bearings (ROBUST Series)
            10 Series

Cylindrical Roller Bearings

Features

The high rigidity of NSK's double row cylindrical roller bearings makes them a perfect match for use in machine tool spindles. Typically, single row and double row cylindrical roller bearings have either a cylindrical bore or a tapered bore. Double row cylindrical roller bearings with a tapered bore are often mounted to the main shaft as a fixed-end bearing. Simplicity in design and the ability to adjust radial internal clearance after mounting continue to make these bearings popular among machine tool users.

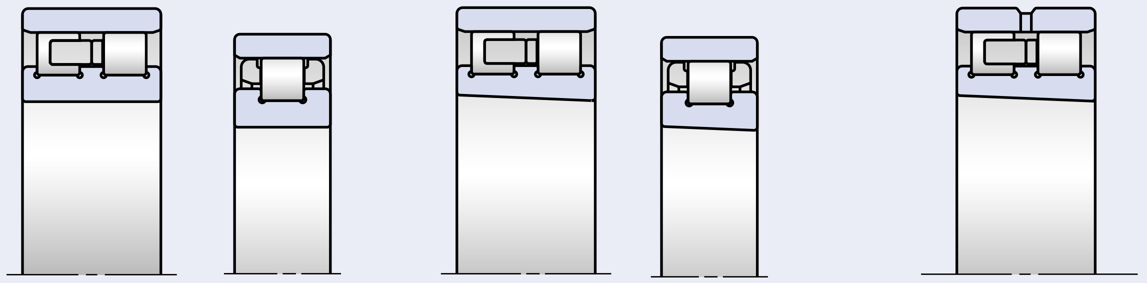
NSK offers several types of cylindrical roller bearings. Users can request an E44 configuration, which includes both lubrication holes and a machined lubrication groove on the outside surface of the outer ring. Types of bearings include the NNU type, which features double ribbed outer rings, and the NN type, which features excellently grease discharge during the initial running-in period, and helps promote steady oil flow throughout the bearing.

For thin section type bearings, the narrower NN39 series is more suitable than the wider NN49 series due to less heat generation and greater roller stability. Machined brass cages are most common with cylindrical roller bearings. NSK offers a roller-guided PPS (polyphenylene sulfide) resin cage for the NN30 series, and a PEEK (polyether ether ketone) resin cage, which is guided by the outer ring, for N10 series of ultra high-speed single row cylindrical roller bearings.

Bearing type	Cage symbol	Specification	Available size
NN	MB	Roller-guided machined brass cage	NN3005-NN3040 NN3920-NN3956 NN4920-NN4940
	TB	Roller-guided PPS resin cage	NN3006-NN3026
NNU	MB	Roller-guided machined brass cage	NNU4920-NNU4940
N	MR	Roller-guided machined brass cage	N1006-N1028
	TP	Outer ring-guided PEEK resin cage	N1009-N1017

Specification of Bore and Lubrication Holes

Fig. 2.1



Cylindrical bore type

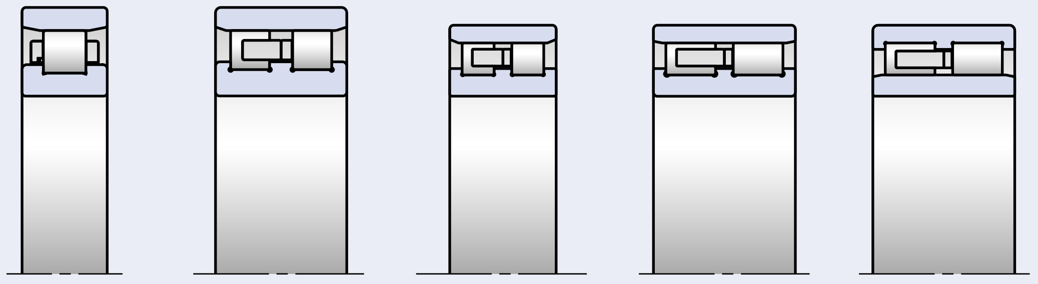
Tapered bore type

Machined lubrication groove on outside surface and lubrication holes on the outer ring (E44)

Double row and single row bearings available with cylindrical bore or tapered bore.
Double row cylindrical roller bearings available with a machined lubrication groove and lubrication holes (the best solution for oil lubrication).

Bearing Type and Dimension Series

Fig. 2.2



N10 NN30 NN39 NN49 NNU49

Numbering System of Double Row Cylindrical Roller Bearings (High Rigidity Series)

(Bearing number example) **NN 30 17 TB KR E44 CC0 P4**

Bearing type symbol
Dimension symbol
Bore number
Cage symbol
Tapered bore symbol
Lubrication holes symbol
Radial clearance symbol
Accuracy symbol

			Reference pages
NN	Bearing type	NN: double row cylindrical roller bearing with triple-ribbed inner ring NNU: double row cylindrical roller bearing with triple-ribbed outer ring	40-41, 78
30	Dimension	30: 30 series, 39: 39 series, 49: 49 series	40-41, 78
17	Bore number	Bearing bore=bore number×5 (mm)	80-83
MB	Cage	TB: roller guided PPS resin cage; operational temperature limit=220˚C MB: roller-guided machined brass cage; operational temperature limit=300˚C	16-17 22-23
KR	Tapered bore	KR: 1/12 tapered bore (Leave this symbol blank for cylindrical bore)	162-163
E44	Lubrication holes	E44: outer ring with machined lubrication groove and lubrication holes (Leave this symbol blank for no lubrication holes)	80-83
CC0	Radial clearance	CC1: standard clearance for cylindrical bore CC0: standard clearance for tapered bore CCG: special radial clearance	40-41 151
P4	Accuracy	P2: ISO Class 2, P4: ISO Class 4, P4Y: special accuracy (Bore diameter and outside diameter are exclusive to NSK. All others are ISO Class 4.)	133 158-163

Numbering System of Single Row Cylindrical Roller Bearings (Standard Series and ROBUST Series)

(Bearing number example) **N 10 12 RX TP KR CC0 P4**

Bearing type symbol
Dimension symbol
Bore number
Material symbol
Cage symbol
Tapered bore symbol
Radial clearance symbol
Accuracy symbol

<table>
<tr><th></th><th></th><th></th><th>Reference pages</th></tr>
<tr><td>N</td><td>Bearing type</td><td>N: single row cylindrical roller bearing with double-ribbed inner ring</td><td>40-41, 78</td></tr>
<tr><td>10</td><td>Dimension</td><td>10: 10 series</td><td>40-41, 78</td></tr>
<tr><td>12</td><td>Bore number</td><td>Bearing bore=bore number×5 (mm)</td><td>84-85</td></tr>
<tr><td>RX</td><td>Material</td><td>No symbol indicates our standard cylindrical roller bearing material (rings and rolling elements are SUJ2 bearing steel).
RS·RX·RXH: ultra high-speed single row cylindrical roller bearing (ROBUST series)
<table>
<tr><th rowspan="2">Type</th><th colspan="2">Material</th></tr>
<tr><th>Rings</th><th>Rolling elements</th></tr>
<tr><td>RS</td><td>Bearing steel (SUJ2)</td><td>Bearing steel (SUJ2)</td></tr>
<tr><td>RX</td><td>Heat resistant steel (SHX)</td><td>Heat resistant steel (SHX)</td></tr>
<tr><td>RXH</td><td>Heat resistant steel (SHX)</td><td>Ceramics (Si_3N_4)</td></tr>
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22-23</td></tr>
<tr><td>TP</td><td>Cage</td><td>TP: outer ring guided PEEK resin cage; operational temperature limit=240˚C
MR: roller guided machined brass cage; operational temperature limit=300˚C</td><td>16-17</td></tr>
<tr><td>KR</td><td>Tapered bore</td><td>KR: 1/12 tapered bore
(Leave this symbol blank for cylindrical bore)</td><td>162-163</td></tr>
<tr><td>CC0</td><td>Radial clearance</td><td>CC1: standard clearance for cylindrical bore
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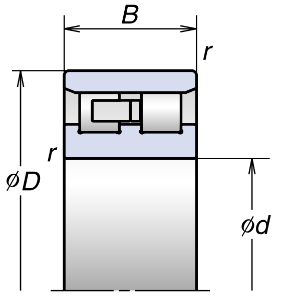
<tr><td>P4</td><td>Accuracy</td><td>P2: ISO Class 2, P4: ISO Class 4,
P4Y: special accuracy (Bore diameter and outside diameter are exclusive to NSK. All others are ISO Class 4.)</td><td>133
158-163</td></tr>
</table>

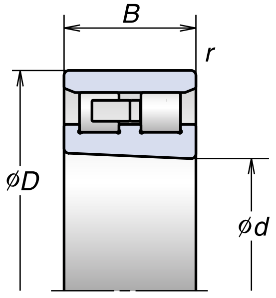
Double Row Cylindrical Roller Bearings (High Rigidity Series)

30 Series

Bore Diameter 25-200 mm



*Cylindrical Bore



Tapered Bore

Bearing Numbers	Boundary Dimensions (mm)				Basic Load Ratings (kN)		Mass (kg)	Limiting Speeds (1) (min^{-1})	
	d	*D*	*B*	*r*	C_r (Dynamic)	C_{0r} (Static)	(approx)	Grease	Oil
NN3005MBKR	**25**	**47**	**16**	0.6	25.8	30.0	0.127	20 900	25 000
NN3006MBKR	**30**	**55**	**19**	1.0	31.0	37.0	0.198	17 700	21 200
NN3006TBKR	**30**	**55**	**19**	1.0	31.0	37.0	0.172	20 000	23 600
NN3007MBKR	**35**	**62**	**20**	1.0	39.5	50.0	0.258	15 500	18 600
NN3007TBKR	**35**	**62**	**20**	1.0	39.5	50.0	0.224	17 600	20 700
NN3008MBKR	**40**	**68**	**21**	1.0	43.5	55.5	0.309	13 900	16 700
NN3008TBKR	**40**	**68**	**21**	1.0	43.5	55.5	0.283	15 800	18 600
NN3009MBKR	**45**	**75**	**23**	1.0	52.0	68.5	0.407	12 500	15 000
NN3009TBKR	**45**	**75**	**23**	1.0	52.0	68.5	0.373	14 200	16 700
NN3010MBKR	**50**	**80**	**23**	1.0	53.0	72.5	0.436	11 600	13 900
NN3010TBKR	**50**	**80**	**23**	1.0	53.0	72.5	0.402	13 100	15 400
NN3011MBKR	**55**	**90**	**26**	1.1	69.5	96.5	0.647	10 400	12 500
NN3011TBKR	**55**	**90**	**26**	1.1	69.5	96.5	0.592	11 800	13 800
NN3012MBKR	**60**	**95**	**26**	1.1	73.5	106	0.693	9 700	11 700
NN3012TBKR	**60**	**95**	**26**	1.1	73.5	106	0.635	11 000	13 000
NN3013MBKR	**65**	**100**	**26**	1.1	77.0	116	0.741	9 100	11 000
NN3013TBKR	**65**	**100**	**26**	1.1	77.0	116	0.681	10 400	12 200
NN3014MBKR	**70**	**110**	**30**	1.1	94.5	143	1.060	8 400	10 000
NN3014TBKR	**70**	**110**	**30**	1.1	94.5	143	0.988	9 500	11 200
NN3015MBKR	**75**	**115**	**30**	1.1	96.5	149	1.110	7 900	9 500
NN3015TBKR	**75**	**115**	**30**	1.1	96.5	149	1.030	9 000	10 600
NN3016MBKR	**80**	**125**	**34**	1.1	119	186	1.540	7 400	8 800
NN3016TBKR	**80**	**125**	**34**	1.1	119	186	1.440	8 300	9 800
NN3017MBKR	**85**	**130**	**34**	1.1	122	194	1.630	7 000	8 400
NN3017TBKR	**85**	**130**	**34**	1.1	122	194	1.520	8 000	9 400

(1) For application of limiting speeds, please refer to Page 152.
*For the cylindrical bore type, eliminate the "KR" symbol and leave this symbol blank.

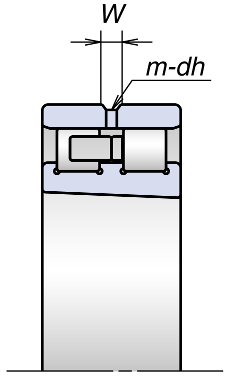
30 Series (continued)

Bearing Numbers	Boundary Dimensions (mm)				Basic Load Ratings (kN)		Mass (kg)	Limiting Speeds (1) (min^{-1})	
	d	*D*	*B*	*r*	C_r (Dynamic)	C_{0r} (Static)	(approx)	Grease	Oil
NN3018MBKR	**90**	**140**	**37**	1.5	143	228	2.090	6 600	7 900
NN3018TBKR	**90**	**140**	**37**	1.5	143	228	1.930	7 400	8 700
NN3019MBKR	**95**	**145**	**37**	1.5	146	238	2.190	6 300	7 500
NN3019TBKR	**95**	**145**	**37**	1.5	146	238	2.030	7 100	8 400
NN3020MBKR	**100**	**150**	**37**	1.5	149	247	2.280	6 000	7 200
NN3020TBKR	**100**	**150**	**37**	1.5	149	247	2.120	6 800	8 000
NN3021MBKR	**105**	**160**	**41**	2.0	192	310	2.880	5 700	6 800
NN3021TBKR	**105**	**160**	**41**	2.0	192	310	2.690	6 500	7 600
NN3022MBKR	**110**	**170**	**45**	2.0	222	360	3.710	5 400	6 500
NN3022TBKR	**110**	**170**	**45**	2.0	222	360	3.440	6 100	7 200
NN3024MBKR	**120**	**180**	**46**	2.0	233	390	4.040	5 000	6 000
NN3024TBKR	**120**	**180**	**46**	2.0	233	390	3.750	5 700	6 700
NN3026MBKR	**130**	**200**	**52**	2.0	284	475	5.880	4 600	5 500
NN3026TBKR	**130**	**200**	**52**	2.0	284	475	5.470	5 200	6 100
NN3028MBKR	**140**	**210**	**53**	2.0	298	515	6.340	4 300	5 200
NN3030MBKR	**150**	**225**	**56**	2.1	335	585	7.760	4 000	4 800
NN3032MBKR	**160**	**240**	**60**	2.1	375	660	9.410	3 800	4 500
NN3034MBKR	**170**	**260**	**67**	2.1	450	805	12.80	3 500	4 200
NN3036MBKR	**180**	**280**	**74**	2.1	565	995	16.80	3 300	4 000
NN3038MBKR	**190**	**290**	**75**	2.1	595	1 080	17.80	3 200	3 800
NN3040MBKR	**200**	**310**	**82**	2.1	655	1 170	22.70	3 000	3 600

(1) For application of limiting speeds, please refer to Page 152.

Lubrication Holes Dimensions (E44 Specification) Unit: mm

Outer Ring Width		Lubrication Hole	Machined Lubrication Groove	Number of Holes
Over	incl.	*dh*	*W*	*m*
–	30	2	3.5	4
30	40	2.5	5	
40	50	3	6	
50	60	4	8	
60	80	5	9	
80	120	6	12	
120	160	8	15	
160	200	10	18	
200	–	12	20	



For additional information:	Page No.
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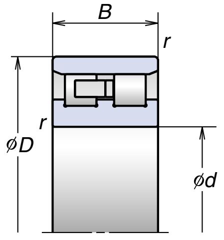
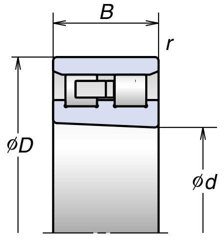
● Quantity of packed grease	157

Double Row Cylindrical Roller Bearings (High Rigidity Series)



*NN39 Cylindrical Bore



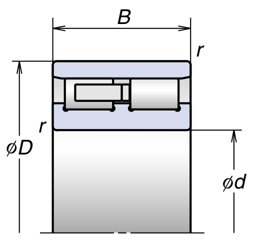
NN39 Tapered Bore

39 Series

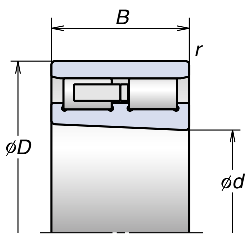
Bore Diameter 100-280 mm

Bearing Numbers	Boundary Dimensions (mm)				Basic Load Ratings (kN)		Mass (kg)	Limiting Speeds (1) (min^{-1})	
	d	***D***	***B***	*r*	C_r (Dynamic)	C_{or} (Static)	(approx)	Grease	Oil
NN3920MBKR	**100**	**140**	**30**	1.1	106	182	1.32	6 300	7 500
NN3921MBKR	**105**	**145**	**30**	1.1	110	194	1.50	6 000	7 200
NN3922MBKR	**110**	**150**	**30**	1.1	114	207	1.41	5 800	7 000
NN3924MBKR	**120**	**165**	**34**	1.1	138	251	1.99	5 300	6 400
NN3926MBKR	**130**	**180**	**37**	1.5	173	325	2.64	4 900	5 900
NN3928MBKR	**140**	**190**	**37**	1.5	201	375	2.97	4 600	5 500
NN3930MBKR	**150**	**210**	**45**	2.0	262	490	4.47	4 200	5 000
NN3932MBKR	**160**	**220**	**45**	2.0	271	520	4.75	4 000	4 800
NN3934MBKR	**170**	**230**	**45**	2.0	280	550	5.01	3 800	4 500
NN3936MBKR	**180**	**250**	**52**	2.0	340	655	7.76	3 500	4 200
NN3938MBKR	**190**	**260**	**52**	2.0	345	680	7.46	3 400	4 000
NN3940MBKR	**200**	**280**	**60**	2.1	420	815	10.60	3 200	3 800
NN3944MBKR	**220**	**300**	**60**	2.1	440	895	11.40	2 900	3 500
NN3948MBKR	**240**	**320**	**60**	2.1	460	975	12.10	2 700	3 300
NN3952MBKR	**260**	**360**	**75**	2.1	670	1 380	21.40	2 500	3 000
NN3956MBKR	**280**	**380**	**75**	2.1	695	1 460	22.70	2 300	2 800

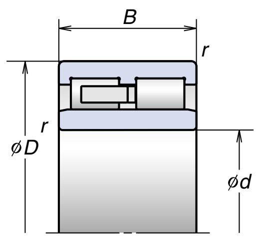
(1) For application of limiting speeds, please refer to Page 152.
*For the cylindrical bore type, eliminate the “KR” symbol and leave this symbol blank.



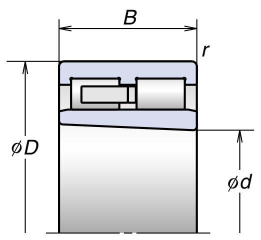
*NN49 Cylindrical Bore



NN49 Tapered Bore



*NNU49 Cylindrical Bore



NNU49 Tapered Bore

49 Series

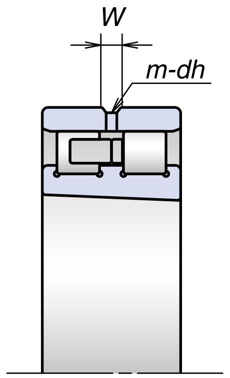
Bore Diameter 100-200mm

Bearing Numbers	Boundary Dimensions (mm)				Basic Load Ratings (kN)		Mass (kg)	Limiting Speed (1) (min^{-1})	
	d	***D***	***B***	*r*	C_r (Dynamic)	C_{or} (Static)	(approx)	Grease	Oil
NN4920MBKR	**100**	**140**	**40**	1.1	155	295	1.76	6 300	7 500
NNU4920MBKR	**100**	**140**	**40**	1.1	155	295	1.90	6 300	7 500
NN4921MBKR	**105**	**145**	**40**	1.1	161	315	2.00	6 000	7 200
NNU4921MBKR	**105**	**145**	**40**	1.1	161	315	1.99	6 000	7 200
NN4922MBKR	**110**	**150**	**40**	1.1	167	335	2.10	5 800	7 000
NNU4922MBKR	**110**	**150**	**40**	1.1	167	335	2.07	5 800	7 000
NN4924MBKR	**120**	**165**	**45**	1.1	183	360	2.87	5 300	6 400
NNU4924MBKR	**120**	**165**	**45**	1.1	183	360	2.85	5 300	6 400
NN4926MBKR	**130**	**180**	**50**	1.5	274	545	3.84	4 900	5 900
NNU4926MBKR	**130**	**180**	**50**	1.5	274	545	3.85	4 900	5 900
NN4928MBKR	**140**	**190**	**50**	1.5	283	585	4.07	4 600	5 500
NNU4928MBKR	**140**	**190**	**50**	1.5	283	585	4.08	4 600	5 500
NN4930MBKR	**150**	**210**	**60**	2.0	350	715	6.36	4 200	5 000
NNU4930MBKR	**150**	**210**	**60**	2.0	350	715	6.39	4 200	5 000
NN4932MBKR	**160**	**220**	**60**	2.0	365	760	6.77	4 000	4 800
NNU4932MBKR	**160**	**220**	**60**	2.0	365	760	6.76	4 000	4 800
NN4934MBKR	**170**	**230**	**60**	2.0	375	805	7.13	3 800	4 500
NNU4934MBKR	**170**	**230**	**60**	2.0	375	805	7.12	3 800	4 500
NN4936MBKR	**180**	**250**	**69**	2.0	480	1 020	10.4	3 500	4 200
NNU4936MBKR	**180**	**250**	**69**	2.0	480	1 020	10.4	3 500	4 200
NN4938MBKR	**190**	**260**	**69**	2.0	485	1 060	10.9	3 400	4 000
NNU4938MBKR	**190**	**260**	**69**	2.0	485	1 060	10.9	3 400	4 000
NN4940MBKR	**200**	**280**	**80**	2.1	570	1 220	15.3	3 200	3 800
NNU4940MBKR	**200**	**280**	**80**	2.1	570	1 220	15.3	3 200	3 800

(1) For application of limiting speeds, please refer to Page 152.
*For the cylindrical bore type, eliminate the “KR” symbol and leave this symbol blank.

Lubrication Holes Dimensions (E44 Specification) Unit: mm

Outer Ring Width		Lubrication Hole	Machined Lubrication Groove	Number of Holes
Over	incl.	*dh*	*W*	*m*
–	30	2	3.5	4
30	40	2.5	5	
40	50	3	6	
50	60	4	8	
60	80	5	9	
80	120	6	12	
120	160	8	15	
160	200	10	18	
200	–	12	20	



For additional information:	Page No.
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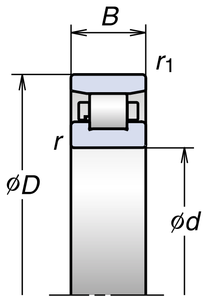
● Nozzle position	174
● Quantity of packed grease	157

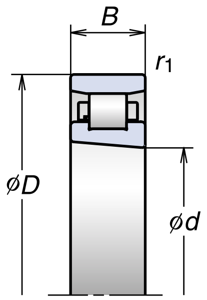
Single Row Cylindrical Roller Bearings (Standard Series)

10 Series

Bore Diameter 30-140 mm



*Cylindrical Bore



Tapered Bore

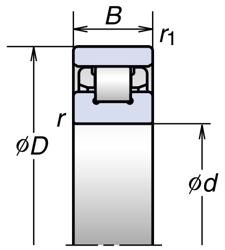
Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Mass (kg)	Limiting Speeds (1) (min^{-1})	
	d	***D***	***B***	*r*	r_1	C_r (Dynamic)	C_{or} (Static)	(approx)	Grease	Oil
N1006MR1KR	**30**	**55**	**13**	1.0	0.6	19.7	19.6	0.133	19 000	31 000
N1007MRKR	**35**	**62**	**14**	1.0	0.6	22.6	23.2	0.153	17 000	27 000
N1008MRKR	**40**	**68**	**15**	1.0	0.6	27.3	29.0	0.192	15 000	25 000
N1009MRKR	**45**	**75**	**16**	1.0	0.6	32.5	35.5	0.318	14 000	22 000
N1010MRKR	**50**	**80**	**16**	1.0	0.6	32.0	36.0	0.339	13 000	20 000
N1011BMR1KR	**55**	**90**	**18**	1.1	1.0	37.5	44.0	0.487	12 000	18 000
N1012BMR1KR	**60**	**95**	**18**	1.1	1.0	40.0	48.5	0.519	11 000	17 000
N1013BMR1KR	**65**	**100**	**18**	1.1	1.0	41.0	51.0	0.541	10 000	16 000
N1014BMR1KR	**70**	**110**	**20**	1.1	1.0	50.0	63.0	0.752	9 000	15 000
N1015MRKR	**75**	**115**	**20**	1.1	1.0	60.0	74.5	0.935	8 500	13 700
N1016BMR1KR	**80**	**125**	**22**	1.1	1.0	63.5	82.0	1.038	7 900	12 700
N1017BMR1KR	**85**	**130**	**22**	1.1	1.0	65.0	86.0	1.067	7 500	12 100
N1018MRKR	**90**	**140**	**24**	1.5	1.1	88.0	114	1.200	7 000	11 400
N1019BMR1KR	**95**	**145**	**24**	1.5	1.1	83.0	114	1.260	6 700	10 900
N1020MRKR	**100**	**150**	**24**	1.5	1.1	93.0	126	1.320	6 400	10 400
N1021MRKR	**105**	**160**	**26**	2.0	1.1	109	149	1.670	6 100	9 900
N1022BMR1KR	**110**	**170**	**28**	2.0	1.1	126	173	2.070	5 800	9 300
N1024MRKR	**120**	**180**	**28**	2.0	1.1	139	191	2.190	5 400	8 700
N1026MRKR	**130**	**200**	**33**	2.0	1.1	172	238	3.320	4 900	7 900
N1028BMR1KR	**140**	**210**	**33**	2.0	1.1	164	240	3.810	4 600	7 500

(1) For application of limiting speeds, please refer to Page 152.
*For the cylindrical bore type, eliminate the "KR" symbol and leave this symbol blank.

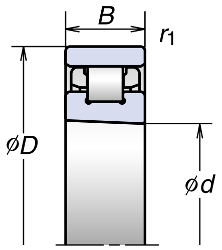
Ultra High-Speed Cylindrical Roller Bearings (ROBUST Series)

10 Series

Bore Diameter 45-85 mm



*Cylindrical Bore



Tapered Bore

For additional information: Page No.

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- ● Static equivalent load ···············128
- ● Radial clearance ······················151
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- ● Quantity of packed grease·········157

Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Mass (kg)	Limiting Speeds (1) (min^{-1})	
	d	***D***	***B***	*r*	r_1	C_r (Dynamic)	C_{or} (Static)	(approx)	Grease	Oil
N1009RSTPKR	**45**	**75**	**16**	1.0	0.6	24.6	26.1	0.262	22 000	30 000
N1009RXTPKR	**45**	**75**	**16**	1.0	0.6	24.6	26.1	0.262	25 000	42 000
N1009RXHTPKR	**45**	**75**	**16**	1.0	0.6	24.6	26.1	0.228	29 000	50 000
N1010RSTPKR	**50**	**80**	**16**	1.0	0.6	26.6	29.7	0.283	20 000	28 000
N1010RXTPKR	**50**	**80**	**16**	1.0	0.6	26.6	29.7	0.283	24 000	39 000
N1010RXHTPKR	**50**	**80**	**16**	1.0	0.6	26.6	29.7	0.246	27 000	47 000
N1011RSTPKR	**55**	**90**	**18**	1.1	1.0	35.0	39.5	0.372	18 000	25 000
N1011RXTPKR	**55**	**90**	**18**	1.1	1.0	35.0	39.5	0.372	21 000	35 000
N1011RXHTPKR	**55**	**90**	**18**	1.1	1.0	35.0	39.5	0.324	24 000	42 000
N1012RSTPKR	**60**	**95**	**18**	1.1	1.0	37.5	44.0	0.442	17 000	24 000
N1012RXTPKR	**60**	**95**	**18**	1.1	1.0	37.5	44.0	0.442	20 000	33 000
N1012RXHTPKR	**60**	**95**	**18**	1.1	1.0	37.5	44.0	0.385	22 000	39 000
N1013RSTPKR	**65**	**100**	**18**	1.1	1.0	39.5	49.0	0.518	16 000	22 000
N1013RXTPKR	**65**	**100**	**18**	1.1	1.0	39.5	49.0	0.518	19 000	31 000
N1013RXHTPKR	**65**	**100**	**18**	1.1	1.0	39.5	49.0	0.451	21 000	37 000
N1014RSTPKR	**70**	**110**	**20**	1.1	1.0	46.5	57.0	0.648	15 000	20 000
N1014RXTPKR	**70**	**110**	**20**	1.1	1.0	46.5	57.0	0.648	17 000	28 000
N1014RXHTPKR	**70**	**110**	**20**	1.1	1.0	46.5	57.0	0.564	19 000	34 000
N1015RSTPKR	**75**	**115**	**20**	1.1	1.0	49.5	63.0	0.672	14 000	19 000
N1015RXTPKR	**75**	**115**	**20**	1.1	1.0	49.5	63.0	0.585	16 000	27 000
N1015RXHTPKR	**75**	**115**	**20**	1.1	1.0	49.5	63.0	0.585	18 000	32 000
N1016RSTPKR	**80**	**125**	**22**	1.1	1.0	61.5	81.5	0.926	13 000	18 000
N1016RXTPKR	**80**	**125**	**22**	1.1	1.0	61.5	81.5	0.926	15 000	25 000
N1016RXHTPKR	**80**	**125**	**22**	1.1	1.0	61.5	81.5	0.812	17 000	30 000
N1017RSTPKR	**85**	**130**	**22**	1.1	1.0	65.0	86.0	0.943	13 000	17 000
N1017RXTPKR	**85**	**130**	**22**	1.1	1.0	65.0	86.0	0.943	14 000	24 000
N1017RXHTPKR	**85**	**130**	**22**	1.1	1.0	65.0	86.0	0.826	16 000	28 000

(1) For application of limiting speeds, please refer to Page 152.
*For the cylindrical bore type, eliminate the "KR" symbol and leave this symbol blank.

High-Speed Angular Contact Thrust Ball Bearings

(ROBUST Series)

Double-Direction Angular Contact Thrust Ball Bearings

(TAC Series)

Angular Contact Thrust Ball Bearings

Angular Contact Thrust Ball Bearings ···························88-95
  Features
  Numbering System
  Bearing Tables
    High-Speed Angular Contact Thrust Ball Bearings (ROBUST Series)
      BAR10 Series
      BTR10 Series
    Double-Direction Angular Contact Thrust Ball Bearings (TAC Series)
      TAC29X Series
      TAC20X Series

Angular Contact Thrust Ball Bearings

3. ANGULAR CONTACT THRUST BALL BEARINGS

Features

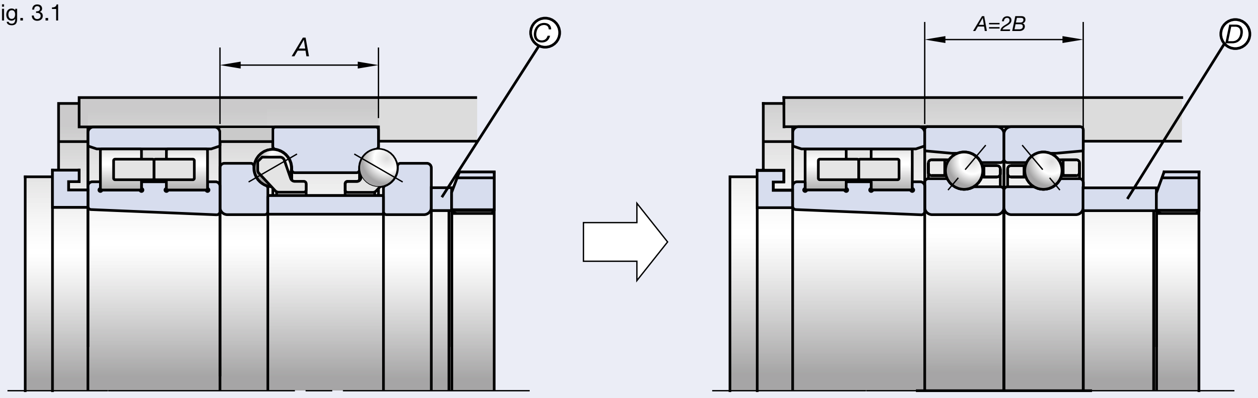
For the main spindles of machine tools, good high speed performance and high rigidity are required for the ball bearings used in combination with double-row cylindrical roller bearings. For these applications, to allow selection appropriate for the characteristics of the machine, NSK provides three types of bearings.

All these bearings have special outer ring outside diameter tolerances (P4A Class and P2A Class) to provide clearance between the outer ring periphery and housing bore in order to avoid any load. NSK's ROBUST series high-speed angular contact thrust ball bearings are capable of high-speed operations while maintaining high rigidity. Ball diameter and number of balls are the same as TAC type bearings. BTR type bearings have a 40˚ contact angle, and BAR type bearings have a 30˚ contact angle. The result is superior high-speed performance that minimizes heat generation.

Interchangeability

Customers can easily replace their TAC20X series bearings with NSK's BAR type or BTR type bearings without having to change the shaft or housing of the machine tool spindle. Both types of bearings have unique width dimensions that accommodate a new spacer (D), which replaces the older one (C) (see Fig. 3.1).

Fig. 3.1



Contact Angle

For the differing contact angles, TAC type bearings rank highest in levels of rigidity, closely followed by BTR type bearings, with BAR type bearings coming in last. For temperature rise of the outer ring, however, this ranking is reversed with BAR type bearings having the highest tolerance, followed by BTR type bearings, and finally TAC type bearings with the least tolerance.
Be sure to select the product that will best meet the needs of your specific operating conditions.

Fig. 3.2

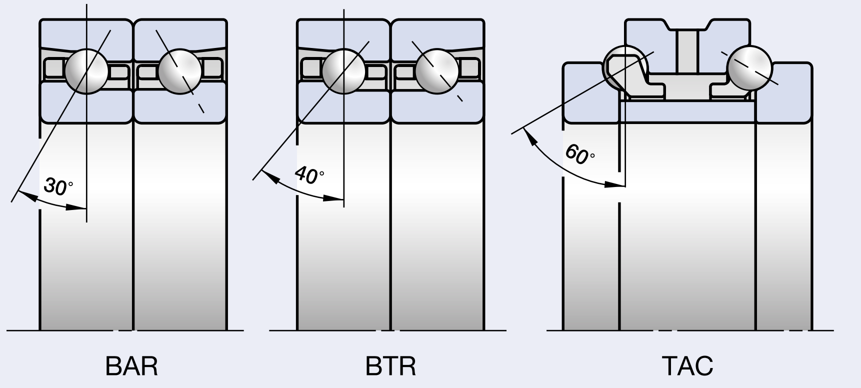
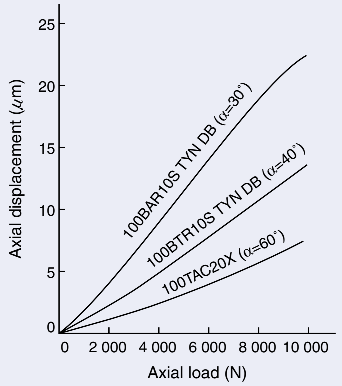
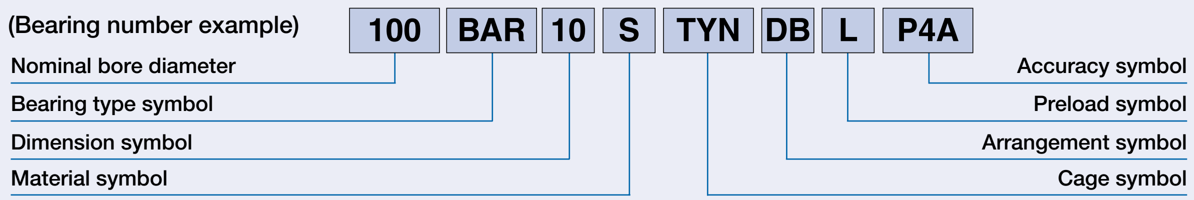


Fig. 3.3 Axial Load and Axial Displacement

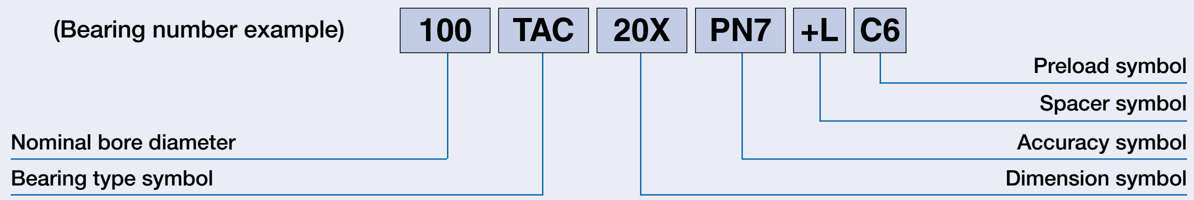


Numbering System of High-Speed Angular Contact Thrust Ball Bearings (ROBUST Series)



			Reference pages
100	Nominal bore diameter	Bore diameter (mm)	90-93
BAR	Bearing type	BAR: 30˚ contact angle BTR: 40˚ contact angle	24, 38-39, 88
10	Dimension	10: 10 series (bore, outer diameter, and NSK-specific dimensions are available)	38-39, 88
S	Material	S: bearing steel (SUJ2) H: ceramic ball (Si_3N_4)	12-15, 24
TYN	Cage	TYN: ball guided polyamide resin cage; limiting speed d_mn=1 400 000; operational temperature limit=120˚C Bearing with TYN cage (10 series with a maximum bore diameter of 150 mm) (Leave this symbol blank for machined brass cages)	16-17
DB	Arrangement	DB: back-to-back arrangement	38-39, 130-133
L	Preload	EL: extra light preload, L: light preload CP: special preload, CA: special axial clearance	38-39, 134-137, 148
P4A	Accuracy	P2A: ISO Class 2 except outer diameter P4A: ISO Class 4 except outer diameter	164

Numbering System of Double-Direction Angular Contact Thrust Ball Bearings (TAC Series)

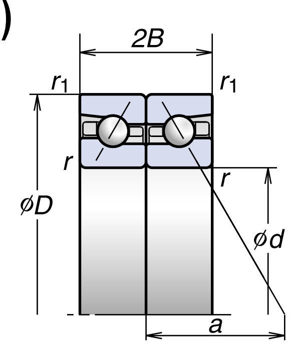


			Reference pages
100	Nominal bore diameter	Bore diameter (mm)	94-95
TAC	Bearing type	Angular contact thrust ball bearing; 60˚ contact angle	24, 38-39, 88
20X	Dimension	20X: combined with NN30 series 29X: combined with NN39 and NN49 series	38-39, 88
PN7	Accuracy	PN7: special precision accuracy	164
+L	Spacer	Inner ring spacer	–
C6	Preload	C6: standard preload for grease lubrication C7: standard preload for oil lubrication	38-39 134-137 149

High-Speed Angular Contact Thrust Ball Bearings (ROBUST Series)

BAR 10 Series
BTR 10 Series

Bore Diameter 50-105 mm



Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm) a	Mass (kg) (approx)	Limiting Speeds (2) (min⁻¹)	
	d	D	$2B$	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)				Grease	Oil
50BAR10S	**50**	**80**	**28.5**	1.0	0.6	14.7	27.7	18.4	25.7	0.272	11 600	14 700
50BAR10H	**50**	**80**	**28.5**	1.0	0.6			12.6		0.257	13 100	16 200
50BTR10S	**50**	**80**	**28.5**	1.0	0.6	17.4	31.5	21.5	34.1	0.272	10 000	13 100
50BTR10H	**50**	**80**	**28.5**	1.0	0.6			15.5		0.257	11 600	14 700
55BAR10S	**55**	**90**	**33.0**	1.1	0.6	18.2	35.0	23.4	28.9	0.412	10 400	13 200
55BAR10H	**55**	**90**	**33.0**	1.1	0.6			16.0		0.391	11 800	14 500
55BTR10S	**55**	**90**	**33.0**	1.1	0.6	21.6	40.0	26.4	38.3	0.412	9 000	11 800
55BTR10H	**55**	**90**	**33.0**	1.1	0.6			19.7		0.391	10 400	13 200
60BAR10S	**60**	**95**	**33.0**	1.1	0.6	18.9	38.0	25.5	30.4	0.420	9 700	12 300
60BAR10H	**60**	**95**	**33.0**	1.1	0.6			17.5		0.397	11 000	13 600
60BTR10S	**60**	**95**	**33.0**	1.1	0.6	22.4	43.5	25.8	40.4	0.420	8 400	11 000
60BTR10H	**60**	**95**	**33.0**	1.1	0.6			21.5		0.397	9 700	12 300
65BAR10S	**65**	**100**	**33.0**	1.1	0.6	19.5	41.5	27.7	31.8	0.447	9 100	11 600
65BAR10H	**65**	**100**	**33.0**	1.1	0.6			19.0		0.406	10 400	12 800
65BTR10S	**65**	**100**	**33.0**	1.1	0.6	23.1	47.0	27.3	42.5	0.447	7 900	10 400
65BTR10H	**65**	**100**	**33.0**	1.1	0.6			23.3		0.406	9 100	11 600
70BAR10S	**70**	**110**	**36.0**	1.1	0.6	26.9	55.0	37.5	34.7	0.601	8 400	10 600
70BAR10H	**70**	**110**	**36.0**	1.1	0.6			25.5		0.561	9 500	11 700
70BTR10S	**70**	**110**	**36.0**	1.1	0.6	32.0	63.0	35.0	46.3	0.601	7 300	9 500
70BTR10H	**70**	**110**	**36.0**	1.1	0.6			31.5		0.561	8 400	10 600
75BAR10S	**75**	**115**	**36.0**	1.1	0.6	27.3	58.0	39.0	36.1	0.634	7 900	10 000
75BAR10H	**75**	**115**	**36.0**	1.1	0.6			26.7		0.592	9 000	11 100
75BTR10S	**75**	**115**	**36.0**	1.1	0.6	32.5	65.5	36.5	48.4	0.634	6 900	9 000
75BTR10H	**75**	**115**	**36.0**	1.1	0.6			33.0		0.592	7 900	10 000

(1) For permissible axial load, please refer to Page 129.

(2) For application of limiting speeds, please refer to Page 152.
Limiting speeds listed on this page are based on a back-to-back arrangement (DB) with extra light preload (EL).
Adjust the limiting speed to 85% of the figure shown when a light preload (L) has been selected.

Note: Bearing type BAR10: nominal contact angle 30°
Bearing type BTR10: nominal contact angle 40°

For additional information: Page No.

● Dynamic equivalent load	121
● Static equivalent load	128
● Preload and rigidity	134
● Abutment and fillet dimensions	168
● Nozzle position	174
● Quantity of packed grease	157

BAR10 BTR10 Series (continued)

Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm) a	Mass (kg) (approx)	Limiting Speeds (2) (min⁻¹)	
	d	D	$2B$	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)				Grease	Oil
80BAR10S	**80**	**125**	**40.5**	1.1	0.6	32.0	68.5	46.5	39.4	0.875	7 400	9 300
80BAR10H	**80**	**125**	**40.5**	1.1	0.6			32.0		0.821	8 300	10 300
80BTR10S	**80**	**125**	**40.5**	1.1	0.6	38.0	78.0	43.0	52.7	0.875	6 400	8 300
80BTR10H	**80**	**125**	**40.5**	1.1	0.6			39.0		0.821	7 400	9 300
85BAR10S	**85**	**130**	**40.5**	1.1	0.6	32.5	71.5	48.5	41.1	0.971	7 000	8 900
85BAR10H	**85**	**130**	**40.5**	1.1	0.6			33.0		0.915	8 000	9 800
85BTR10S	**85**	**130**	**40.5**	1.1	0.6	38.5	81.5	50.5	55.2	0.971	6 100	8 000
85BTR10H	**85**	**130**	**40.5**	1.1	0.6			41.0		0.915	7 000	8 900
90BAR10S	**90**	**140**	**45**	1.5	1.0	42.5	92.5	62.5	44.4	1.198	6 600	8 300
90BAR10H	**90**	**140**	**45**	1.5	1.0			43.0		1.124	7 400	9 200
90BTR10S	**90**	**140**	**45**	1.5	1.0	50.0	105	58.0	59.5	1.198	5 700	7 400
90BTR10H	**90**	**140**	**45**	1.5	1.0			52.5		1.124	6 600	8 300
95BAR10S	**95**	**145**	**45**	1.5	1.0	43.0	96.5	65.0	45.5	1.320	6 300	8 000
95BAR10H	**95**	**145**	**45**	1.5	1.0			44.5		1.231	7 100	8 800
95BTR10S	**95**	**145**	**45**	1.5	1.0	51.0	110	69.0	61.0	1.320	5 500	7 100
95BTR10H	**95**	**145**	**45**	1.5	1.0			55.0		1.231	6 300	8 000
100BAR10S	**100**	**150**	**45**	1.5	1.0	43.5	100	68.0	47.3	1.399	6 000	7 600
100BAR10H	**100**	**150**	**45**	1.5	1.0			46.5		1.307	6 800	8 400
100BTR10S	**100**	**150**	**45**	1.5	1.0	51.5	114	66.5	63.7	1.399	5 200	6 800
100BTR10H	**100**	**150**	**45**	1.5	1.0			57.0		1.307	6 000	7 600
105BAR10S	**105**	**160**	**49.5**	2.0	1.0	49.5	115	78.0	50.6	1.740	5 700	7 200
105BAR10H	**105**	**160**	**49.5**	2.0	1.0			53.5		1.624	6 500	8 000
105BTR10S	**105**	**160**	**49.5**	2.0	1.0	58.5	131	84.0	68.0	1.740	5 000	6 500
105BTR10H	**105**	**160**	**49.5**	2.0	1.0			65.5		1.624	5 700	7 200

(1) For permissible axial load, please refer to Page 129.

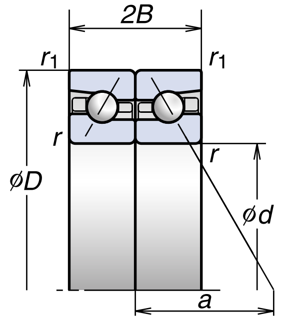
(2) For application of limiting speeds, please refer to Page 152.
Limiting speeds listed on this page are based on a back-to-back arrangement (DB) with extra light preload (EL).
Adjust the limiting speed to 85% of the figure shown when a light preload (L) has been selected.

Note: Bearing type BAR10: nominal contact angle 30°
Bearing type BTR10: nominal contact angle 40°

High-Speed Angular Contact Thrust Ball Bearings (ROBUST Series)

BAR 10 Series
BTR 10 Series

Bore Diameter 110-200 mm



Bearing Numbers	Boundary Dimensions (mm)					Basic Load Ratings (kN)		Permissible Axial Load (1) (kN)	Effective Load Center (mm) a	Mass (kg) (approx)	Limiting Speeds (2) (min^{-1})	
	d	D	$2B$	r (min)	r_1 (min)	C_r (Dynamic)	C_{or} (Static)				Grease	Oil
110BAR10S	**110**	**170**	**54.0**	2.0	1.0	55.5	131	89.0	53.9	2.11	5 400	6 800
110BAR10H	**110**	**170**	**54.0**	2.0	1.0			60.5		1.972	6 100	7 500
110BTR10S	**110**	**170**	**54.0**	2.0	1.0	66.0	148	82.5	72.2	2.11	4 700	6 100
110BTR10H	**110**	**170**	**54.0**	2.0	1.0			74.5		1.972	5 400	6 800
120BAR10S	**120**	**180**	**54.0**	2.0	1.0	57.0	141	96.0	56.8	2.262	5 000	6 400
120BAR10H	**120**	**180**	**54.0**	2.0	1.0			65.5		2.114	5 700	7 000
120BTR10S	**120**	**180**	**54.0**	2.0	1.0	68.0	160	88.5	76.4	2.262	4 400	5 700
120BTR10H	**120**	**180**	**54.0**	2.0	1.0			80.5		2.114	5 000	6 400
130BAR10S	**130**	**200**	**63.0**	2.0	1.0	72.5	172	117	63.4	3.362	4 600	5 800
130BAR10H	**130**	**200**	**63.0**	2.0	1.0			79.5		3.148	5 200	6 400
130BTR10S	**130**	**200**	**63.0**	2.0	1.0	86.0	195	106	85.0	3.362	4 000	5 200
130BTR10H	**130**	**200**	**63.0**	2.0	1.0			98.0		3.148	4 600	5 800
140BAR10S	**140**	**210**	**63.0**	2.0	1.0	78.5	200	135	66.2	3.558	4 300	5 500
140BTR10S	**140**	**210**	**63.0**	2.0	1.0	93.0	227	84.0	89.1	3.558	3 800	4 900
150BAR10S	**150**	**225**	**67.5**	2.1	1.1	92.5	234	160	71	4.354	4 000	5 100
150BTR10S	**150**	**225**	**67.5**	2.1	1.1	110	267	104	95.5	4.354	3 500	4 600
160BAR10S	**160**	**240**	**72.0**	2.1	1.1	98.5	250	175	75.7	5.64	3 800	4 800
160BTR10S	**160**	**240**	**72.0**	2.1	1.1	117	284	184	101.9	5.64	3 300	4 300
170BAR10S	**170**	**260**	**81.0**	2.1	1.1	115	295	207	82.3	7.90	3 500	4 500
170BTR10S	**170**	**260**	**81.0**	2.1	1.1	136	335	220	110.5	7.90	3 100	4 000
180BAR10S	**180**	**280**	**90.0**	2.1	1.1	151	385	262	88.8	10.2	3 300	4 200
180BTR10S	**180**	**280**	**90.0**	2.1	1.1	179	440	255	118.9	10.2	2 900	3 700
190BAR10S	**190**	**290**	**90.0**	2.1	1.1	151	390	273	91.8	10.7	3 200	4 000
190BTR10S	**190**	**290**	**90.0**	2.1	1.1	179	445	281	123.2	10.7	2 800	3 600
200BAR10S	**200**	**310**	**99.0**	2.1	1.1	169	444	300	98.3	13.8	3 000	3 800
200BTR10S	**200**	**310**	**99.0**	2.1	1.1	201	505	310	131.7	13.8	2 600	3 400

(1) For permissible axial load, please refer to Page 129.

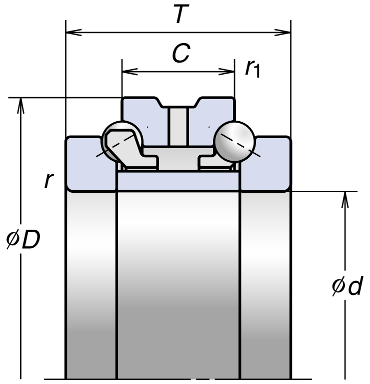
(2) For application of limiting speeds, please refer to Page 152.
Limiting speeds listed on this page are based on a back-to-back arrangement (DB) with extra light preload (EL).
Adjust the limiting speed to 85% of the figure shown when a light preload (L) has been selected.

Note: Bearing type BAR10: nominal contact angle 30°
Bearing type BTR10: nominal contact angle 40°

Double Direction Angular Contact Thrust Ball Bearings (TAC Series)

TAC 29X Series
TAC 20X Series

Bore Diameter 35-280 mm



Bearing Numbers	Boundary Dimensions (mm)						Basic Load Ratings (kN)		Mass (kg)	Limiting Speeds(1) (min^{-1})	
	d	*D*	*T*	*C*	*r* (min)	r_1 (min)	C_a (Dynamic)	C_{oa} (Static)	(approx)	Grease	Oil
35TAC20X+L	**35**	**62**	**34**	**17**	1.0	0.6	22.8	53.5	0.375	10 000	11 000
40TAC20X+L	**40**	**68**	**36**	**18**	1.0	0.6	23.6	59.0	0.460	9 000	10 000
45TAC20X+L	**45**	**75**	**38**	**19**	1.0	0.6	26.3	67.5	0.580	8 000	9 000
50TAC20X+L	**50**	**80**	**38**	**19**	1.0	0.6	27.2	74.0	0.625	7 000	8 000
55TAC20X+L	**55**	**90**	**44**	**22**	1.1	0.6	33.5	94.0	0.945	6 300	6 900
60TAC20X+L	**60**	**95**	**44**	**22**	1.1	0.6	35.0	102	1.000	5 900	6 500
65TAC20X+L	**65**	**100**	**44**	**22**	1.1	0.6	36.0	110	1.080	5 500	6 100
70TAC20X+L	**70**	**110**	**48**	**24**	1.1	0.6	49.5	146	1.460	5 000	5 600
75TAC20X+L	**75**	**115**	**48**	**24**	1.1	0.6	50.0	152	1.550	4 800	5 300
80TAC20X+L	**80**	**125**	**54**	**27**	1.1	0.6	59.0	181	2.110	4 400	4 900
85TAC20X+L	**85**	**130**	**54**	**27**	1.1	0.6	59.5	189	2.210	4 200	4 700
90TAC20X+L	**90**	**140**	**60**	**30**	1.5	1.0	78.5	246	2.930	4 000	4 400
95TAC20X+L	**95**	**145**	**60**	**30**	1.5	1.0	79.5	256	3.050	3 800	4 200
100TAC29X+L	**100**	**140**	**48**	**24**	1.1	0.6	55.0	196	1.950	3 800	4 200
100TAC20X+L	**100**	**150**	**60**	**30**	1.5	1.0	80.5	267	3.200	3 600	4 000
105TAC29X+L	**105**	**145**	**48**	**24**	1.1	0.6	56.5	208	2.040	3 600	4 000
105TAC20X+L	**105**	**160**	**66**	**33**	2.0	1.0	91.5	305	4.100	3 400	3 800
110TAC29X+L	**110**	**150**	**48**	**24**	1.1	0.6	57.0	215	2.120	3 500	3 900
110TAC20X+L	**110**	**170**	**72**	**36**	2.0	1.0	103	350	5.150	3 300	3 600
120TAC29X+L	**120**	**165**	**54**	**27**	1.1	0.6	66.5	256	2.940	3 200	3 600
120TAC20X+L	**120**	**180**	**72**	**36**	2.0	1.0	106	375	5.500	3 000	3 400
130TAC29X+L	**130**	**180**	**60**	**30**	1.5	1.0	79.5	315	3.950	3 000	3 300
130TAC20X+L	**130**	**200**	**84**	**42**	2.0	1.0	134	455	8.200	2 800	3 100

(1) Limiting speeds listed on this page are based on recommended standard preload (C6 & C7)

Note: Bearing type TAC29X: nominal contact angle 60˚
Bearing type TAC20X: nominal contact angle 60˚

For additional information:	Page No.
● Dynamic equivalent load	121
● Static equivalent load	128
● Preload and rigidity	134
● Abutment and fillet dimensions	168
● Quantity of packed grease	157

TAC 29X TAC 20X Series (continued)

Bearing Numbers	Boundary Dimensions (mm)						Basic Load Ratings (kN)		Mass (kg)	Limiting Speeds(1) (min^{-1})	
	d	*D*	*T*	*C*	*r* (min)	r_1 (min)	C_a (Dynamic)	C_{oa} (Static)	(approx)	Grease	Oil
140TAC29D+L	**140**	**190**	**60**	**30**	1.5	1.0	91.5	365	4.200	2 800	3 100
140TAC20D+L	**140**	**210**	**84**	**42**	2.0	1.0	145	525	8.750	2 600	2 900
150TAC29D+L	**150**	**210**	**72**	**36**	2.0	1.0	116	465	6.600	2 500	2 800
150TAC20D+L	**150**	**225**	**90**	**45**	2.1	1.1	172	620	10.700	2 400	2 700
160TAC29D+L	**160**	**220**	**72**	**36**	2.0	1.0	118	490	7.000	2 400	2 700
160TAC20D+L	**160**	**240**	**96**	**48**	2.1	1.1	185	680	13.000	2 300	2 500
170TAC29D+L	**170**	**230**	**72**	**36**	2.0	1.0	120	520	7.350	2 300	2 500
170TAC20D+L	**170**	**260**	**108**	**54**	2.1	1.1	218	810	17.700	2 100	2 400
180TAC29D+L	**180**	**250**	**84**	**42**	2.0	1.0	158	655	10.700	2 100	2 400
180TAC20D+L	**180**	**280**	**120**	**60**	2.1	1.1	281	1 020	23.400	2 000	2 200
190TAC29D+L	**190**	**260**	**84**	**42**	2.0	1.0	161	695	11.200	2 000	2 300
190TAC20D+L	**190**	**290**	**120**	**60**	2.1	1.1	285	1 060	24.400	1 900	2 100
200TAC29D+L	**200**	**280**	**96**	**48**	2.1	1.1	204	855	15.700	1 900	2 100
200TAC20D+L	**200**	**310**	**132**	**66**	2.1	1.1	315	1 180	31.500	1 800	2 000
220TAC29D+L	**220**	**300**	**96**	**48**	2.1	1.1	210	930	17.000	1 800	2 000
240TAC29D+L	**240**	**320**	**96**	**48**	2.1	1.1	213	980	18.300	1 700	1 800
260TAC29D+L	**260**	**360**	**120**	**60**	2.1	1.1	315	1 390	31.500	1 500	1 700
280TAC29D+L	**280**	**380**	**120**	**60**	2.1	1.1	320	1 470	33.500	1 400	1 600

(1) Limiting speeds listed on this page are based on recommended standard preload (C6 & C7)

Note: Bearing type TAC29X: nominal contact angle 60˚
Bearing type TAC20X: nominal contact angle 60˚

Machine Tool Applications

TAC B Series

Electric Injection Molding Machines

TAC 02 and 03 Series

Angular Contact Thrust Ball Bearings for Ball Screw Support

Angular Contact Thrust Ball Bearings for Ball Screw Support ······P98-103
  Features
  Numbering System
  Bearing Tables
    Machine Tool Applications
      TAC B Series
    Electric Injection Molding Machines
      TAC02 and 03 Series

Angular Contact Thrust Ball Bearings for Ball Screw Support

Features

High precision angular contact thrust ball bearings to support precision ball screws, have better performance than earlier combinations of angular contact ball bearings or combinations using thrust bearings. They are especially suitable for high precision machine-tool feeding mechanisms and similar applications.

TAC B Series

The axial rigidity is high because of a large number of balls and a contact angle of 60˚. Compared with tapered roller bearings of cylindrical roller bearings, this type has lower starting torque; so smoother rotation is possible with less driving force.

TAC B series bearings incorporate NSK's recently developed molded polyamide resin cage. In addition, using extra-pure (EP) steel for the inner and outer rings has further enhanced service life. Our EP steel is manufactured by controlling the amount of harmful oxide-based non-metallic inclusions, which eliminates large size inclusions and enjoys higher purity than vacuum arc remelted (VAR) steel.

This series with “DG” seal, low torque contact seal, with “WPH” grease, an waterproof grease, increase the reliability and provide for easy handling.

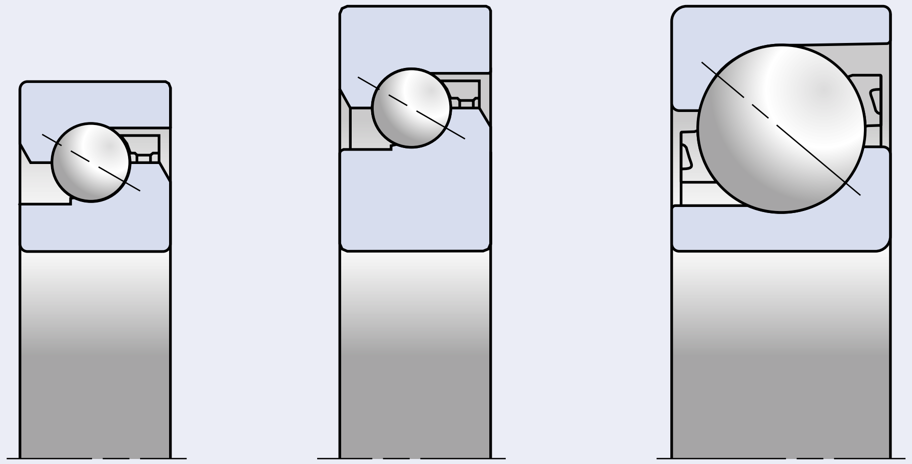
TAC 02 & 03 Series

TAC 02 & 03 series are angular contact ball bearings that provide support for large size ball screws operating under a heavy load from the driving mechanism of electric injection molding machines. Low torque is achieved by optimum design of the ball bearings. Users can significantly reduce bearing torque by replacing their roller bearings with these series.

TAC B and TAC 02, 03 Differences

Electric injection molding machines produce a heavier load on ball screw support bearings than that of machine tools. TAC 02 and 03 bearings are designed to operate under such heavy load conditions. Conversely, TAC B bearings are designed for increased permissible load by increasing the number of balls and bearing width.

Fig. 4.1

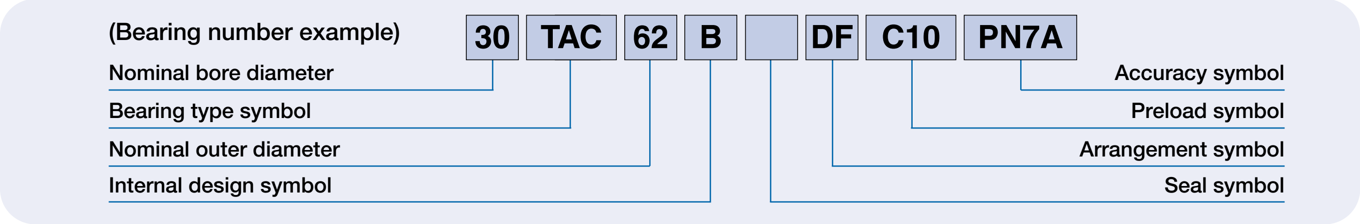


55TAC100B
(TAC B series)

55TAC120B
(TAC B series)

55TAC03A
(TAC02, 03 series)

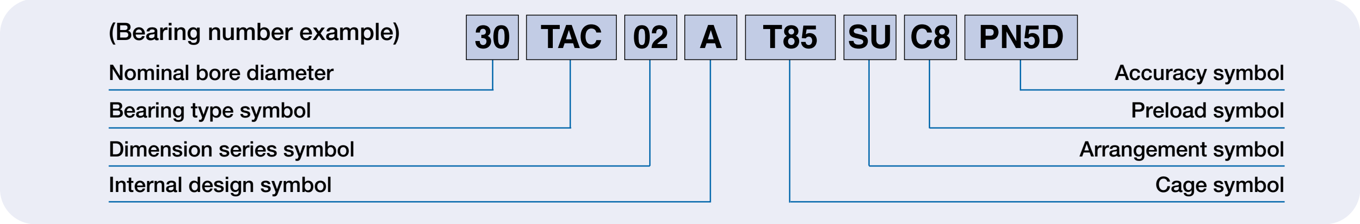
Numbering System of Angular Contact Thrust Ball Bearings for Ball Screw Support (Machine Tool Applications)



			Reference pages
30	Nominal bore diameter	Bore diameter (mm)	100-101
TAC	Bearing type	Angular contact thrust ball bearing; 60˚contact angle	26, 98
62	Nominal outer diameter	Outer diameter (mm)	100-101
B	Internal design		–
	Seal	No symbol: open type DDG: contact rubber seal (¹)	26
DF	Arrangement	SU: universal arrangement (single row) DU: universal arrangement (double row) DB: back-to-back arrangement DF: face-to-face arrangement DT: tandem arrangement DBD, DFD, DTD: triplex set arrangement DBB, DFF, DBT, DFT, DTT: quadruplex set arrangement	130-133
C10	Preload	C10: standard preload C9: light preload (low torque specification)	134-137, 150
PN7A	Accuracy	PN7A: standard accuracy (Equivalent to ISO Class 4) PN7B: special accuracy (Bore diameter and outside diameter are exclusive to NSK. Equivalent to ISO Class 4. For SU arrangement only.)	165

(¹) Sealed angular contact ball bearings for ball screw support are standardized for SU arrangement and PN7B accuracy.

Numbering System of Angular Contact Thrust Ball Bearings for Ball Screw Support (Electric Injection Molding Machines)



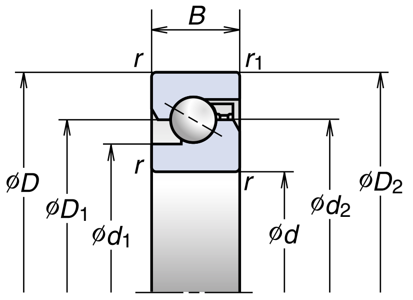
			Reference pages
30	Nominal bore diameter	Bore diameter (mm)	102-103
TAC	Bearing type	Angular contact thrust ball bearing; 60˚contact angle	27, 98
02	Dimension series	02: 02 series 03: 03 series	98
A	Internal design		–
T85	Cage	T85: polyamide resin cage M: machined brass cage	–
SU	Arrangement	SU: universal arrangement (single row)	130-133
C8	Preload	C8: standard preload	134-137, 150
PN5D	Accuracy	PN5D: standard accuracy (Equivalent to ISO Class 5)	165

4. ANGULAR CONTACT THRUST BALL BEARINGS for BALL SCREW SUPPORT

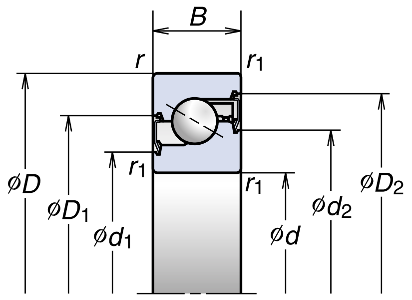
For Machine Tool Applications

TAC B Series

Bore Diameter 15-60 mm



Open type



Sealed type DDG

(Open type)

Bearing Numbers	Boundary Dimensions (mm)					Reference Dimensions (mm)				Recommended Grease Quantities (cc)	Limiting Speeds (1) (min^{-1})		Basic Dynamic Load Rating C_a			Limiting Axial Load			Mass (kg) (approx)
	d	D	B	r (min)	r_1 (min)	d_1	d_2	D_1	D_2		Grease	Oil	Single Row Load DF, DB (kN)	Double Row Load DT, DFD, DBD, DFF, DBB (kN)	Triple Row Load DTD, DFT, DBT (kN)	Single Row Load DF, DB (kN)	Double Row Load DT, DFD,DBD, DFF, DBB (kN)	Triple Row Load DTD, DFT, DBT (kN)	
15 TAC 47B	**15**	**47**	**15**	1.0	0.6	27.2	34	34	39.6	2.2	6 000	8 000	21.9	35.5	47.5	26.6	53.0	79.5	0.144
17 TAC 47B	**17**	**47**	**15**	1.0	0.6	27.2	34	34	39.6	2.2	6 000	8 000	21.9	35.5	47.5	26.6	53.0	79.5	0.144
20 TAC 47B	**20**	**47**	**15**	1.0	0.6	27.2	34	34	39.6	2.2	6 000	8 000	21.9	35.5	47.5	26.6	53.0	79.5	0.135
25 TAC 62B	**25**	**62**	**15**	1.0	0.6	37	45	45	50.7	3.0	4 500	6 000	28.5	46.5	61.5	40.5	81.5	122	0.252
30 TAC 62B	**30**	**62**	**15**	1.0	0.6	39.5	47	47	53.2	3.2	4 300	5 600	29.2	47.5	63.0	43.0	86.0	129	0.224
35 TAC 72B	**35**	**72**	**15**	1.0	0.6	47	55	55	60.7	3.8	3 600	5 000	31.0	50.5	67.0	50.0	100	150	0.310
40 TAC 72B	**40**	**72**	**15**	1.0	0.6	49	57	57	62.7	3.9	3 600	4 800	31.5	51.5	68.5	52.0	104	157	0.275
40 TAC 90B	**40**	**90**	**20**	1.0	0.6	57	68	68	77.2	8.8	3 000	4 000	59.0	95.5	127	89.5	179	269	0.674
45 TAC 75B	**45**	**75**	**15**	1.0	0.6	54	62	62	67.7	4.2	3 200	4 300	33.0	53.5	71.0	57.0	114	170	0.270
45 TAC 100B	**45**	**100**	**20**	1.0	0.6	64	75	75	84.2	9.7	2 600	3 600	61.5	100	133	99.0	198	298	0.842
50 TAC 100B	**50**	**100**	**20**	1.0	0.6	67.5	79	79	87.7	10.2	2 600	3 400	63.0	102	136	104	208	310	0.778
55 TAC 100B	**55**	**100**	**20**	1.0	0.6	67.5	79	79	87.7	10.2	2 600	3 400	63.0	102	136	104	208	310	0.714
55 TAC 120B	**55**	**120**	**20**	1.0	0.6	82	93	93	102.2	12	2 200	3 000	67.5	109	145	123	246	370	1.230
60 TAC 120B	**60**	**120**	**20**	1.0	0.6	82	93	93	102.2	12	2 200	3 000	67.5	109	145	123	246	370	1.160

(Sealed type)

Bearing Numbers	Boundary Dimensions (mm)					Reference Dimensions (mm)				Limiting Speeds (1) (min^{-1})	Basic Dynamic Load Rating C_a			Limiting Axial Load			Mass (kg) (approx)
	d	D	B	r (min)	r_1 (min)	d_1	d_2	D_1	D_2	Grease	Single Row Load DF, DB (kN)	Double Row Load DT, DFD, DBD, DFF, DBB (kN)	Triple Row Load DTD, DFT, DBT (kN)	Single Row Load DF, DB (kN)	Double Row Load DT, DFD,DBD, DFF, DBB (kN)	Triple Row Load DTD, DFT, DBT (kN)	
15 TAC 47B DDG	**15**	**47**	**15**	1.0	0.6	25.1	30.8	36	41.8	6 000	21.9	35.5	47.5	26.6	53.0	79.5	0.144
17 TAC 47B DDG	**17**	**47**	**15**	1.0	0.6	25.1	30.8	36	41.8	6 000	21.9	35.5	47.5	26.6	53.0	79.5	0.144
20 TAC 47B DDG	**20**	**47**	**15**	1.0	0.6	25.1	30.8	36	41.8	6 000	21.9	35.5	47.5	26.6	53.0	79.5	0.135
25 TAC 62B DDG	**25**	**62**	**15**	1.0	0.6	34.3	40.5	46.5	52.9	4 500	28.5	46.5	61.5	40.5	81.5	122	0.252
30 TAC 62B DDG	**30**	**62**	**15**	1.0	0.6	36.8	43	49	55.4	4 300	29.2	47.5	63.0	43.0	86.0	129	0.224
35 TAC 72B DDG	**35**	**72**	**15**	1.0	0.6	44.3	50.5	56.5	62.9	3 600	31.0	50.5	67.0	50.0	100	150	0.310
40 TAC 72B DDG	**40**	**72**	**15**	1.0	0.6	46.3	52.5	58.5	64.9	3 600	31.5	51.5	68.5	52.0	104	157	0.275
40 TAC 90B DDG	**40**	**90**	**20**	1.0	0.6	54	64	70	79.4	3 000	59.0	95.5	127	89.5	179	269	0.674
45 TAC 100B DDG	**45**	**100**	**20**	1.0	0.6	61	71	77	86.4	2 600	61.5	100	133	99.0	198	298	0.842

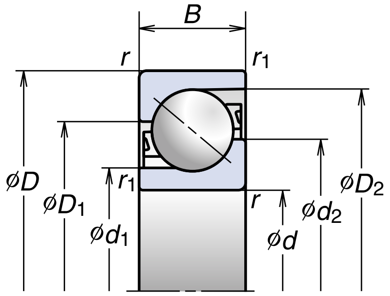
(1) Limiting speeds are based on C10 preload. In case of C9 preload, the figures become 1.3 times of the figures listed above.

Note: Bearing type TAC B: nominal contact angle 60°

For Electric Injection Molding Machines

TAC 02 and 03 Series

Bore Diameter 15-120 mm



Bearing Numbers	Boundary Dimensions (mm)					Reference Dimensions (mm)				Contact angle (Degree)	Limiting Speeds (1) (min^{-1})		Dynamic Axial Load Rating C_a			Limiting Axial Load		
	d	D	B	r (min)	r_1 (min)	d_1	d_2	D_1	D_2		Grease	Oil	Single Row Load DF, DB (kN)	Double Row Load DT, DFD, DBD, DFF, DBB (kN)	Triple Row Load DTD, DFT, DBT (kN)	Single Row Load DF, DB (kN)	Double Row Load DT, DFD, DBD, DFF, DBB (kN)	Triple Row Load DTD, DFT, DBT (kN)
15TAC02AT85	**15**	**35**	**11**	0.6	0.3	19.5	23.5	26.5	31.9	50	8 000	10 000	18.8	30.5	40.5	11.5	22.9	34.5
25TAC02AT85	**25**	**52**	**15**	1.0	0.6	30.5	36.6	40.4	47.4	50	5 100	7 000	33.5	54.5	72.0	22.7	45.5	68.0
TAC35-2T85	**35**	**90**	**23**	1.5	1.0	49.7	61.4	68.6	81.9	50	3 000	4 100	102	166	220	75.5	151	226
40TAC03AT85	**40**	**90**	**23**	1.5	1.0	49.7	61.4	68.6	81.9	50	3 000	4 100	102	166	220	75.5	151	226
45TAC03AT85	**45**	**100**	**25**	1.5	1.0	55.8	68.6	76.4	91.0	50	2 700	3 700	120	195	259	91.5	183	274
TAC45-2T85	**45**	**110**	**27**	2.0	1.0	60.3	75.6	84.5	100.9	50	2 500	3 300	150	243	325	116	232	350
50TAC03AT85	**50**	**110**	**27**	2.0	1.0	60.3	75.6	84.5	100.9	50	2 500	3 300	150	243	325	116	232	350
55TAC03AT85	**55**	**120**	**29**	2.0	1.0	67.1	82.7	92.3	110.1	50	2 200	3 000	171	278	370	133	266	400
60TAC03AT85	**60**	**130**	**31**	2.1	1.1	72.1	89.8	100.2	119.4	50	2 100	2 800	196	320	425	152	305	455
80TAC03AM	**80**	**170**	**39**	2.1	1.1	94.0	118.5	131.5	152.5	50	1 500	2 100	274	445	590	238	475	715
100TAC03CMC	**100**	**215**	**47**	3.0	1.1	122.5	156.9	158.1	188.1	55	1 200	1 600	365	595	795	231	460	690
120TAC03CMC	**120**	**260**	**55**	3.0	1.1	153.0	189.3	190.7	223.5	55	1 000	1 300	430	700	930	295	590	885

(1) Limiting speeds listed on this page are based on a standard preload (C8)

Precision Deep Groove Ball Bearings

General Purpose Motors, High Speed Spindle Motors

Woodworking Machinery Spindle Motors

Precision Deep Groove Ball Bearings

Precision Deep Groove Ball Bearings ······················P106-109
Features
Numbering System
Bearing Table
60, 62 and 63 Series (T1X and TYA Types)
60 and 62 Series

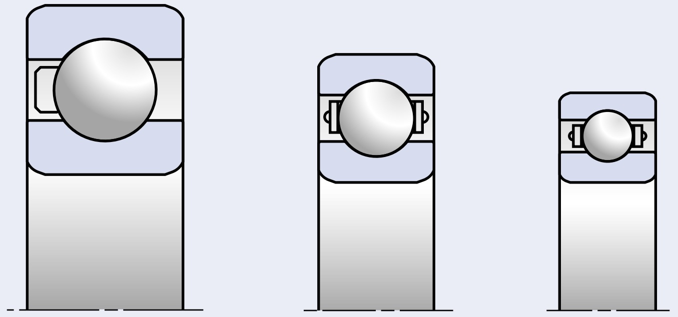
Deep Groove Ball Bearings

5. PRECISION DEEP GROOVE BALL BEARINGS

Features

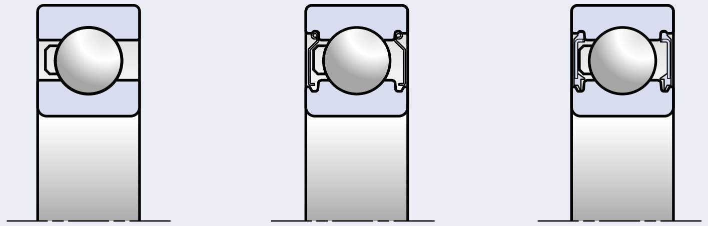
- Capable of bearing not only radial loads but also axial loads in both directions.
- Frictional torque is small, thus suitable for operations requiring high speed, low noise, and low vibrations.
- Three types are available: open type; shielded type (steel shield); and sealed type (rubber seal).

Dimension series



63 62 60

Structure

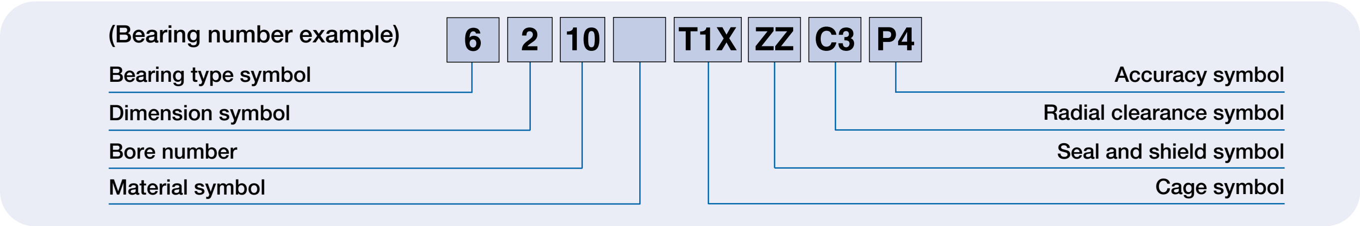


Open type Shielded type (ZZ) Non-contact rubber seal type (VV)

Cages

T1X	Ball guided polyamide resin cage: provides superior wear resistance for general purpose motors.
TYA	Ball guided polyamide resin cage: incorporates the same design concepts of angular contact ball bearings for high speed motors.
T	Inner ring guided phenolic resin cage: well balanced symmetry, offering superior heat resistance for high speed operations of woodworking machinery spindles.

Numbering System of Precision Deep Groove Ball Bearings



(Bearing number example) 6 2 10 T1X ZZ C3 P4

Bearing type symbol

Dimension symbol

Bore number

Material symbol

Accuracy symbol

Radial clearance symbol

Seal and shield symbol

Cage symbol

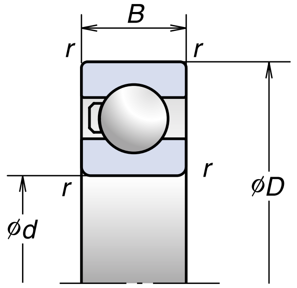
			Reference pages
6	Bearing type	6: single row deep groove ball bearing	106
2	Dimension	0: 10 series, 2:02 series, 3: 03 series	106
10	Bore number	Less than 03 bearing bore 00: 10mm, 01: 12mm, 02: 15mm, 03: 17mm More than 04 bearing bore: Bore number x 5 (mm)	108-109
	Material	No symbol: bearing steel (SUJ2) SN24: ceramic ball (Si_3N_4)	12-15, 25
T1X	Cage	T1X: ball guided polyamide resin cage TYA: high speed, ball guided polyamide resin cage T: inner ring guided phenolic resin cage	106
ZZ	Seal and shield	No symbol: open type ZZ: steel shield VV: non-contact rubber seal	106
C3	Radial clearance	No symbol: normal clearance C3: larger than normal clearance CM: special clearance for electric motor CG: special radial clearance	–
P4	Accuracy	P2: ISO Class 2 P4: ISO Class 4 P5: ISO Class 5	158-161

T1X Type (Polyamide Resin Cage)

60, 62, and 63 Series

Bore Diameter 10-85 mm

Open type	Shield type	Seal type
6000	ZZ	VV



Bearing Numbers (1)	Shield type	Seal type	Boundary Dimensions (mm)				Basic Load Ratings (kN)		Limiting Speeds (2) (min^{-1})
			d	D	B	r	C_r (Dynamic)	C_{or} (Static)	
6000T1X	**ZZ**	**VV**	**10**	**26**	**8**	0.3	4.55	1.87	38 900
6200T1X	**ZZ**	**VV**	**10**	**30**	**9**	0.6	5.10	2.39	35 000
6001T1X	**ZZ**	**VV**	**12**	**28**	**8**	0.3	5.10	2.37	35 000
6201T1X	**ZZ**	**VV**	**12**	**32**	**10**	0.6	6.80	3.05	31 900
6301T1X	**ZZ**	**VV**	**12**	**37**	**12**	1.0	9.70	4.20	28 600
6002T1X	**ZZ**	**VV**	**15**	**32**	**9**	0.3	5.60	2.83	29 800
6202T1X	**ZZ**	**VV**	**15**	**35**	**11**	0.6	7.65	3.75	28 000
6302T1X	**ZZ**	**VV**	**15**	**42**	**13**	1.0	11.4	5.45	24 600
6003T1X	**ZZ**	**VV**	**17**	**35**	**10**	0.3	6.00	3.25	27 000
6203T1X	**ZZ**	**VV**	**17**	**40**	**12**	0.6	9.55	4.80	24 600
6303T1X	**ZZ**	**VV**	**17**	**47**	**14**	1.0	13.6	6.65	21 900
6004T1X	**ZZ**	**VV**	**20**	**42**	**12**	0.6	9.40	5.00	22 600
6204T1X	**ZZ**	**VV**	**20**	**47**	**14**	1.0	12.8	6.60	20 900
6005T1X	**ZZ**	**VV**	**25**	**47**	**12**	0.6	10.1	5.85	19 500
6205T1X	**ZZ**	**VV**	**25**	**52**	**15**	1.0	14.0	7.85	18 200
6305T1X	**ZZ**	**VV**	**25**	**62**	**17**	1.5	20.6	11.2	16 100
6006T1X	**ZZ**	**VV**	**30**	**55**	**13**	1.0	13.2	8.30	16 500
6206T1X	**ZZ**	**VV**	**30**	**62**	**16**	1.0	19.5	11.3	15 300
6306T1X	**ZZ**	**VV**	**30**	**72**	**19**	2.0	26.7	14.1	13 800
6007T1X	**ZZ**	**VV**	**35**	**62**	**14**	1.0	16.0	10.3	14 500
6207T1X	**ZZ**	**VV**	**35**	**72**	**17**	1.0	25.7	15.3	13 100
6307T1X	**ZZ**	**VV**	**35**	**80**	**21**	2.5	33.5	18.0	12 200
6008T1X	**ZZ**	**VV**	**40**	**68**	**15**	1.0	16.8	11.5	13 000
6208T1X	**ZZ**	**VV**	**40**	**80**	**18**	1.0	29.1	17.9	11 700
6308T1X	**ZZ**	**VV**	**40**	**90**	**23**	2.5	40.5	22.6	10 800
6009T1X	**ZZ**	**VV**	**45**	**75**	**16**	1.0	20.9	15.2	11 700
6209T1X	**ZZ**	**VV**	**45**	**85**	**19**	1.0	31.5	20.4	10 800
6010T1X	**ZZ**	**VV**	**50**	**80**	**16**	1.0	21.8	16.6	10 800
6210GT1X	**ZZ**	**VV**	**50**	**90**	**20**	1.0	35.0	23.2	10 000

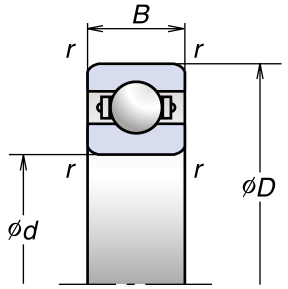
(1) TYA cage available for high speed motor application. Contact NSK for details.

(2) Limiting speed figures are based on T1X.
Adjust the limiting speeds by 115% for TYA cages.

T Type (Phenolic Resin Cage)

60 and 62 Series

Bore Diameter 20-120 mm



Bearing Numbers	Boundary Dimensions (mm)				Basic Load Ratings (kN)		Limiting Speeds (1) (min^{-1})	
	d	D	B	r	C_r (Dynamic)	C_{or} (Static)	Grease	Oil
6004T	**20**	**42**	**12**	0.6	9.38	5.03	32 000	48 000
6204T	**20**	**47**	**14**	1.0	12.8	6.58	35 000	44 000
6005T	**25**	**47**	**12**	0.6	10.1	5.85	27 000	45 200
6205T	**25**	**52**	**15**	1.0	14	7.83	26 000	42 800
6006T	**30**	**55**	**13**	1.0	13.2	8.27	23 000	40 000
6206T	**30**	**62**	**16**	1.0	19.5	11.3	21 000	37 300
6007T	**35**	**62**	**14**	1.0	16	10.3	22 000	35 800
6207T	**35**	**72**	**17**	1.0	25.7	15.3	18 500	32 700
6008T	**40**	**68**	**15**	1.0	16.8	11.5	21 000	32 400
6208T	**40**	**80**	**18**	1.0	29.1	17.9	16 600	26 700
6009T	**45**	**75**	**16**	1.0	19.9	14	18 800	29 000
6209T	**45**	**85**	**19**	1.0	32.7	20.4	15 300	26 000
6010T	**50**	**80**	**16**	1.0	20.8	15.4	17 300	26 700
6210T	**50**	**90**	**20**	1.0	35.1	23.2	14 300	24 200
6011T	**55**	**90**	**18**	1.0	28.3	21.2	16 700	23 800
6211T	**55**	**100**	**21**	1.5	43.4	29.2	12 000	21 900
6012T	**60**	**95**	**18**	1.0	29.4	23.2	15 700	21 900
6212T	**60**	**110**	**22**	1.5	52.5	36	11 700	19 700
6013T	**65**	**100**	**18**	1.0	29.2	23.5	13 300	20 600
6213T	**65**	**120**	**23**	1.5	57.5	40	10 800	17 800
6014T	**70**	**110**	**20**	1.0	38.1	30.9	11 900	18 400
6214T	**70**	**125**	**24**	1.5	62	44	10 200	16 700
6015T	**75**	**115**	**20**	1.0	37.8	31.2	11 100	17 200
6215T	**75**	**130**	**25**	1.5	66	49	10 100	15 600
6016T	**80**	**125**	**22**	1.0	47.6	39.7	10 200	15 700
6216T	**80**	**140**	**26**	2.0	72.5	53	9 200	14 300
6017T	**85**	**130**	**22**	1.0	47.5	40	9 500	14 700
6217T	**85**	**150**	**28**	2.0	84	62	8 500	13 100
6018T	**90**	**140**	**24**	1.5	58.2	49.6	8 700	13 500
6019T	**95**	**145**	**24**	1.5	58	50	8 100	12 600
6020T	**100**	**150**	**24**	1.5	60	54	7 800	12 000
6022T	**110**	**170**	**28**	2.0	85	73	6 500	10 100
6024T	**120**	**180**	**28**	2.0	85	80	6 100	9 400

(1) For application of limiting speed, please refer to Page 152.

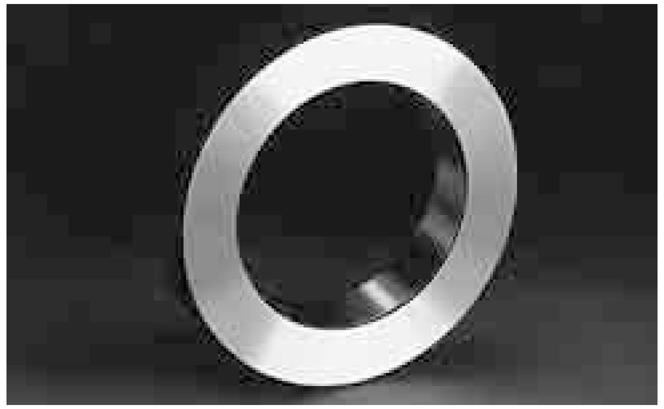
Gauges And Oil-Air Lubricator

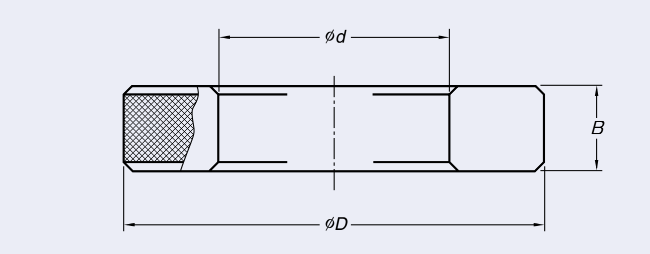
Gauges ··············· P112-115
  GR Gauges
    Features
    Numbering System
  GTR Gauges
    Features
    Numbering System
  GN Gauges
    Features
    Numbering System
Oil-Air Lubricator ··············· P116-117

Gauges and Oil -Air Lubricator

Ring Gauges GR Series

Housing bore diameter precision measuring gauges





To obtain satisfactory performance of precision rolling bearings for machine tool spindles, it is important to have an accurate fitting with the shaft and housing.
To achieve an accurate fitting, it is necessary to measure the shaft outside diameter and housing bore exactly.

NSK Ring Gauges GR series are master gauges for measuring the bore diameters of housings with in an accuracy of 0.001mm.

Features

- Ring design enables reliable cylinder gauge settings.
- Ring thickness eliminates any deformation caused by measuring pressure.
- Heat treatment during manufacturing of the ring negates any effects of aging on ring dimensions.
- Exact gauging is possible due to precisely measured dimensions that are marked on the gauges in 0.001 mm units in both the X and Y directions.

Applicable Bearings					Gauge Numbers	Boundary Dimensions (mm)			Mass (kg) (approx)
79 69 NN39 NN49	BNR19 BER19	70 60 N10 NN30	BNR10 BER10	72 62 N2		*d*	*D*	*B*	
–	–	00	–	–	GR 26	26	75	20	0.6
02	–	01	–	–	GR 28	28	75	20	0.6
03	–	–	–	00	GR 30	30	80	20	0.7
–	–	02	–	01	GR 32	32	80	20	0.7
–	–	03	–	02	GR 35	35	85	20	0.7
04	–	–	–	–	GR 37	37	85	20	0.7
–	–	–	–	03	GR 40	40	90	20	0.8
05	–	04	–	–	GR 42	42	95	20	0.9
06	–	05	–	04	GR 47	47	95	20	0.8
07	–	–	–	05	GR 52	52	100	20	0.9
–	–	06	30	–	GR 55	55	100	20	0.9
08	–	07	35	06	GR 62	62	100	20	0.8
09	–	08	40	–	GR 68	68	110	20	0.9
10	50	–	–	07	GR 72	72	115	20	1.0
–	–	09	45	–	GR 75	75	115	20	0.9
11	55	10	50	08	GR 80	80	120	25	1.2
12	60	–	–	09	GR 85	85	130	25	1.5
13	65	11	55	10	GR 90	90	135	25	1.5
–	–	12	60	–	GR 95	95	140	25	1.6
14	70	13	65	11	GR 100	100	145	25	1.7
15	75	–	–	–	GR 105	105	150	25	1.8
16	80	14	70	12	GR 110	110	160	25	2.1
–	–	15	75	–	GR 115	115	165	25	2.1
17	85	–	–	13	GR 120	120	170	25	2.2
18	90	16	80	14	GR 125	125	175	25	2.3
19	95	17	85	15	GR 130	130	180	25	2.4
20	100	18	90	16	GR 140	140	190	25	2.5
21	105	19	95	–	GR 145	145	200	30	3.5
22	110	20	100	17	GR 150	150	205	30	3.6
–	–	21	105	18	GR 160	160	215	30	3.8
24	120	–	–	–	GR 165	165	220	30	3.9
–	–	22	110	19	GR 170	170	225	30	4.0
26	130	24	120	20	GR 180	180	230	30	3.8
28	140	–	–	21	GR 190	190	240	30	4.0
–	–	26	130	22	GR 200	200	250	30	4.1

Taper Gauges GTR30 Series

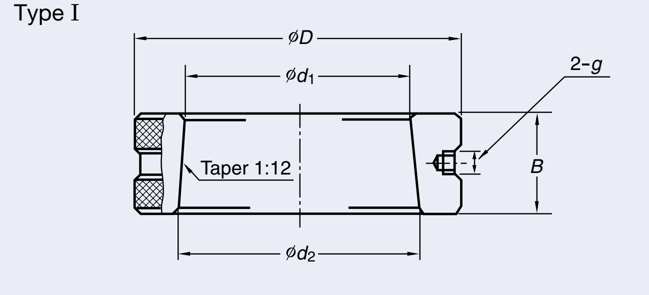
Shaft taper measuring gauges

NN30XXKR are tapered bore, double row cylindrical roller bearings that have high rigidity and are suitable for high speeds, so they are often used in machine tool spindles.
To use these bearings, it is important to exactly match the taper of the bearing bore with that of the spindle. The bearing taper (taper 1:12) is precisely controlled and manufactured for a specific accuracy. A Tapered Gauge
GTR30 is one whose bore is precision finished with a taper identical with that of a bearing.
By machining the taper of a spindle to match this taper gauge, its exact contact with bearing is assured.

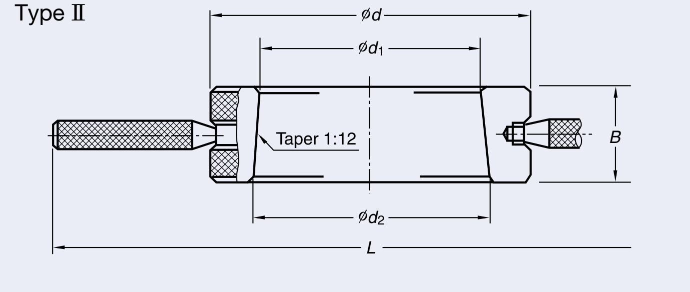
Features

- Ring thickness eliminate any deformation caused by measuring pressure.
- Heat treatment during manufacturing of the ring negates any effects of aging on ring dimensions.

Type I



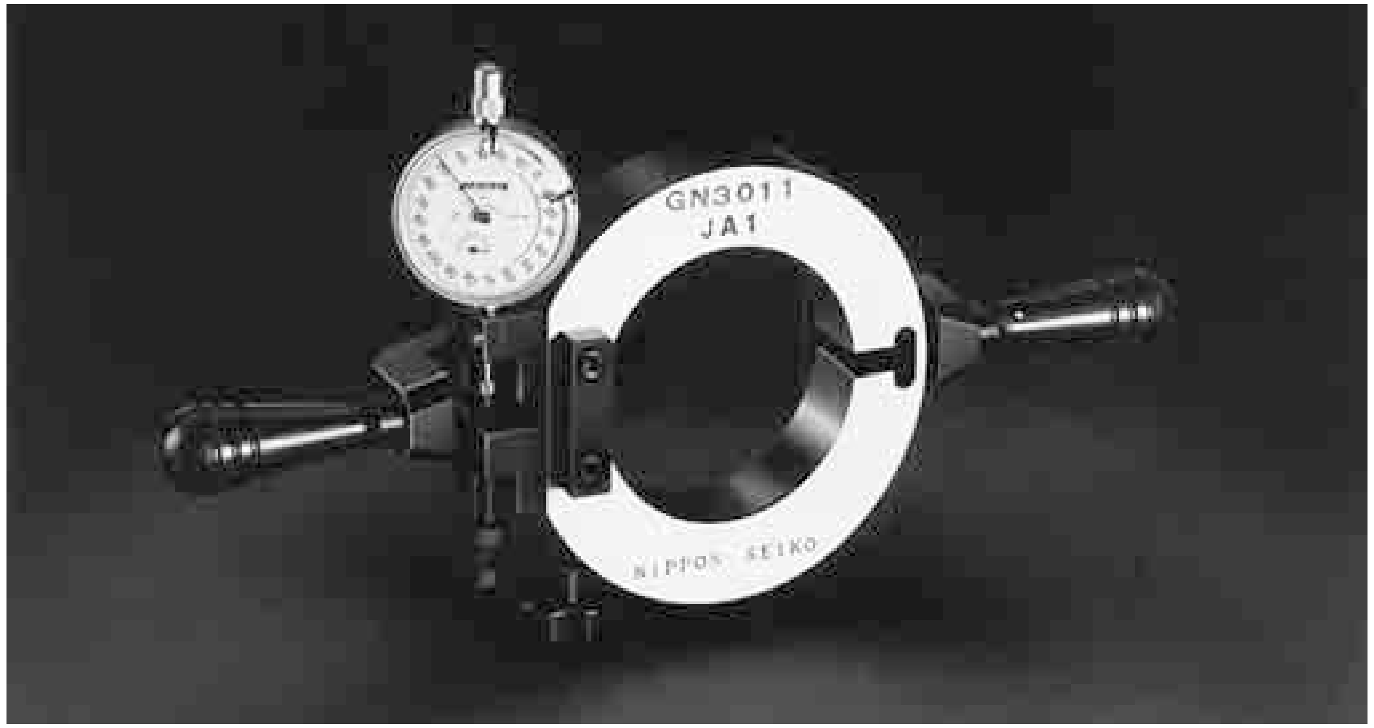
Type II



Applicable Bearings	Gauge Numbers	Types	Boundary dimensions (mm)						Mass (kg) (approx)
			d_1	d_2	*D*	*B*	*L*	*g*	
NN3006KR	GTR3006	I	30	31.583	70	19	–	M3×0.5	0.5
NN3007KR	GTR3007	I	35	36.667	75	20	–	M3×0.5	0.5
NN3008KR	GTR3008	I	40	41.750	80	21	–	M3×0.5	0.6
NN3009KR	GTR3009	I	45	46.917	85	23	–	M5×0.8	0.7
NN3010KR	GTR3010	I	50	51.917	90	23	–	M5×0.8	0.8
NN3011KR	GTR3011	I	55	57.167	95	26	–	M5×0.8	0.9
NN3012KR	GTR3012	I	60	62.167	100	26	–	M5×0.8	1.0
NN3013KR	GTR3013	I	65	67.167	105	26	–	M5×0.8	1.0
NN3014KR	GTR3014	I	70	72.500	110	30	–	M5×0.8	1.3
NN3015KR	GTR3015	I	75	77.500	115	30	–	M5×0.8	1.3
NN3016KR	GTR3016	I	80	82.833	125	34	–	M5×0.8	1.8
NN3017KR	GTR3017	I	85	87.833	130	34	–	M5×0.8	1.9
NN3018KR	GTR3018	II	90	93.083	140	37	358	–	2.5
NN3019KR	GTR3019	II	95	98.083	145	37	363	–	2.6
NN3020KR	GTR3020	II	100	103.083	150	37	368	–	2.7
NN3021KR	GTR3021	II	105	108.417	160	41	376	–	3.5
NN3022KR	GTR3022	II	110	113.750	165	45	381	–	4.0
NN3024KR	GTR3024	II	120	123.833	170	46	386	–	3.9
NN3026KR	GTR3026	II	130	134.333	180	52	396	–	4.6
NN3028KR	GTR3028	II	140	144.417	190	53	406	–	5.0
NN3030KR	GTR3030	II	150	154.667	210	56	426	–	7.0
NN3032KR	GTR3032	II	160	165.000	220	60	436	–	7.8

GN gauges GN30 Series

Precision measuring gauges for residual radial clearance of double row cylindrical roller bearings (NN30XX)



When mounting a double row cylindrical roller bearing with a tapered bore onto a shaft, it is important to accurately match the spindle taper with that of the bearing, and to ensure that the desired radial internal clearance is attained after mounting.

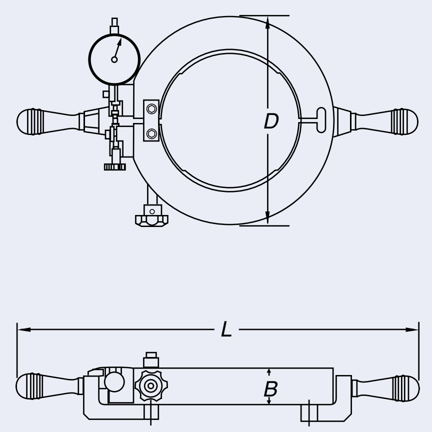
If there is excessive residual radial internal clearance, the main shaft will have some play and machining accuracy will be adversely affected. If clearance is too small, despite little or no change in rigidity, heat generation will become excessive and rolling fatigue life will be extremely shortened. (See page 137)

With the recent trends toward higher speed and higher precision, it is necessary to control residual radial internal clearance more carefully. In the past, radial clearance measuring methods were very difficult and required much skill. GN gauges developed by NSK for residual radial internal clearance measurements of double row cylindrical roller bearing simplify bearing mounting and improve mounting accuracy. (Use of GN gauges also require a bore measuring cylinder gauge.)

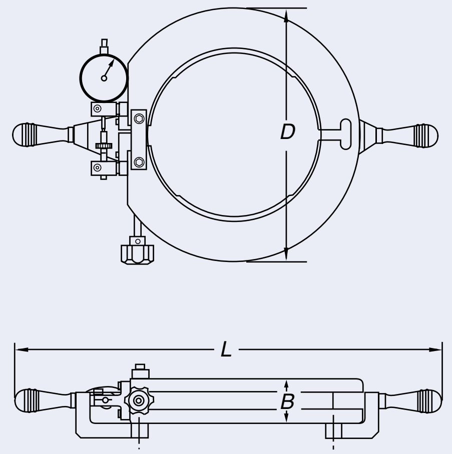
Features

- ● Simple, reliable, and accurate measurements can be made.
- ● No more complicated calculations for corrections based on interference of an outer ring with housing.
- ● Both positive and negative clearance (preload) can be measured.
- ● Accurate measurements are obtained since all GN gauges are calibrated fo measuring pressure.

Type Ⅰ



Type Ⅱ



Applicable Bearings	Gauge Numbers	Types	Boundary dimensions (mm)			Mass (kg)
			D	***B***	***L***	(approx)
NN3007	**GN3007**	Ⅰ	102	23	292	1.3
NN3008	**GN3008**	Ⅰ	108	23	297	1.4
NN3009	**GN3009**	Ⅰ	115	23	305	1.5
NN3010	**GN3010**	Ⅰ	120	23	310	1.6
NN3011	**GN3011**	Ⅰ	131	26	324	2.1
NN3012	**GN3012**	Ⅰ	138	26	329	2.2
NN3013	**GN3013**	Ⅰ	145	26	335	2.4
NN3014	**GN3014**	Ⅰ	156	30	347	3.0
NN3015	**GN3015**	Ⅰ	162	30	353	3.1
NN3016	**GN3016**	Ⅰ	175	33	374	4.2
NN3017	**GN3017**	Ⅰ	185	33	381	4.3
NN3018	**GN3018**	Ⅰ	195	35	393	5.2
NN3019	**GN3019**	Ⅰ	204	35	399	5.6
NN3020	**GN3020**	Ⅰ	210	35	411	6.1
NN3021	**GN3021**	Ⅰ	224	39	419	7.1
NN3022	**GN3022**	Ⅰ	233	44	433	8.5
NN3024	**GN3024**	Ⅱ	254	44	470	7.5
NN3026	**GN3026**	Ⅱ	280	50	492	9.5
NN3028	**GN3028**	Ⅱ	289	50	500	9.5
NN3030	**GN3030**	Ⅱ	314	54	520	12
NN3032	**GN3032**	Ⅱ	329	54	540	13

6. GAUGES AND OIL-AIR LUBRICATOR

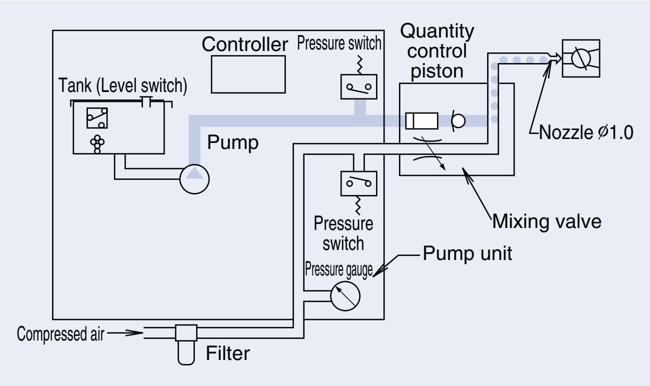
FINE-LUBE Oil-Air Lubricator

[Features]

Remarkable technological innovations continue in the field of machine tools. Particularly, spindle motors are operating faster than before. New developments for improving bearing and lubrication methods to facilitate the higher speeds are therefore vital.

NSK has made many developments in oil-air lubrication systems and oil supply equipment. In 1984, NSK introduced the FINE-LUBE oil-air lubricator to the market, and continues to enjoy success with this product. The FINE-LUBE has evolved with the times, and has been adopted for use in many machine tools, while earning a reputation for excellent performance and high reliability.

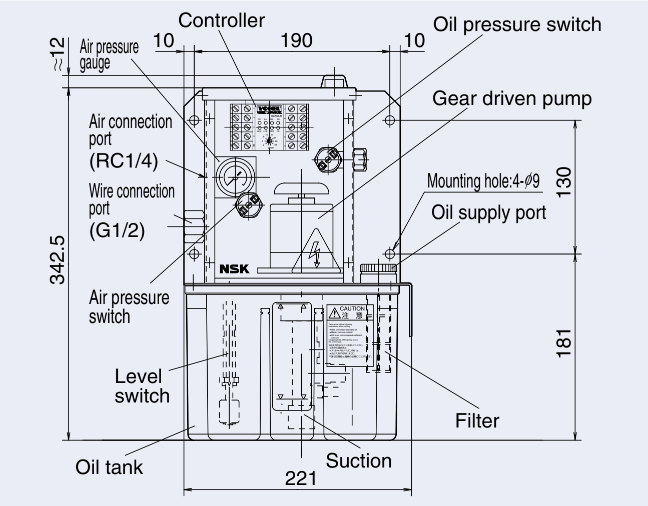
The FINE-LUBE oil-air lubricator enjoys a leading position in the oil-air lubrication market. This unit provides oil-air lubrication by a system, which consists of a pump, mixing valves, and a control unit. Reliability has been further improved by incorporating safety devices.



[Precautions]

- ● Use clean, dry compressed air at a pressure of 0.2–0.4MPa.
- ● Use fresh, clean lubricating oil with a viscosity of ISO VG 10 or higher. Please take extra care to avoid oil contamination, which can shorten the life of equipment.
- ● Take extra care in selecting quality oil lines for use between the pump and mixing valves. Oil lines exceeding 5m in length require you contact NSK prior to use.
- ● Oil lines from the mixing valve to the spindle should be limited to 1.5–5m.

OAEG Pump Unit



Model number:
OAEG (Incl. controller)
OAEG-N (No controller)

- · Lubrication: high speed spindle oil, or turbine oil
- · Power supply: 100V
- · Tank capacity: 2.7L
- · Effective oil level: 1.7L

[Features]

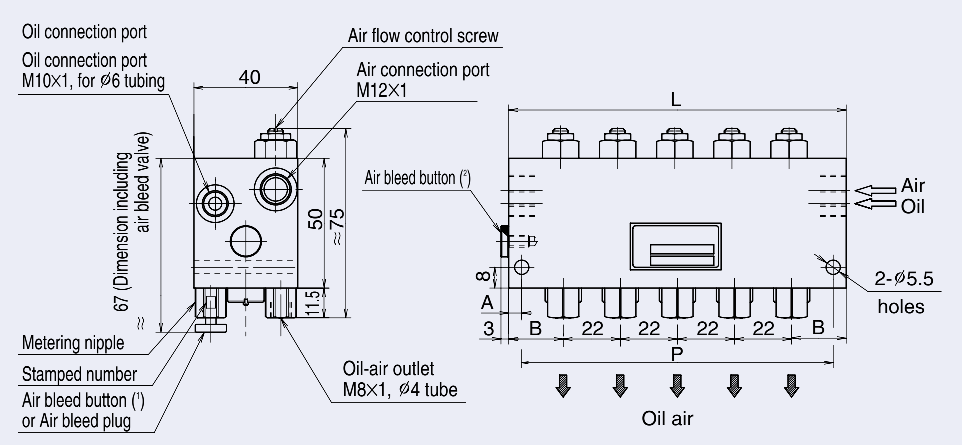
- · The OAEG unit is a newly developed low viscosity gear driven pump.
  (Operating oil viscosity range: 10–68 cst/˚C)
- · A special controller is used to set lubricating intervals at 1, 2, 4, 8, 16, 24, 32, 48, 64, or 128 minutes.
- · Standard safety devices include:

①Oil level switch
②Power failure warning
③Air pressure switch
④Oil pressure switch

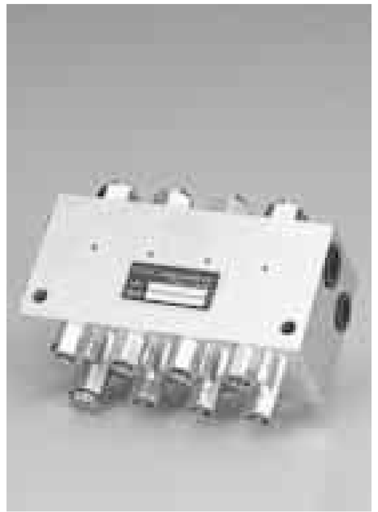
- · Components of pump unit: Controller, air pressure switch, Oil pressure switch and Float switch.

NSK also offers a more economical pump unit that is CE Mark approved.
This pump can be controlled exclusively by our controller, or by a machine equipment sequencer.

Mixing Valve MVF



(Drawing is for MVX5)



[Features]

- · Adopts a piston-type control for discharging small, fixed quantities of oil.
- · Discharged quantities of 0.01, 0.03, and 0.06 cm³ per stroke can be selected.
- · Number of outlets and discharge quantities can be selected depending on each condition.

Type number	Number of valves	L	A	P	B
MVF1	1	42	10	22	21
MVF2	2	64	9.5	45	21
MVF3	3	86	8	70	21
MVF4	4	108	6.5	95	21
MVF5	5	130	5	120	21
MVF6	6	155	5	145	22.5

Notes (¹) In case the discharged quantity is 0.01cm³, use Air bleed plug for Air bleed procedure.
In case the discharged quantity is 0.03cm³, or 0.06cm³, attach Air bleed button instead of Air bleed plug, for Air bleed procedure.
(²) In case the discharged quantity is 0.03cm³, or 0.06cm³, attach the Air bleed button to this position, during the operation.

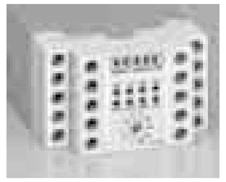
Discharge quantity (cm³/stroke)	Stamping number	Code number
0.01	1	P1
0.03	3	P2
0.06	6	P3

Optional Parts.

[Controller]

(Equipped on OAEG)

- · The controller monitors pump operations. At first indication of a lubricating abnormality, an alarm is signaled and the machine tool spindle can be stopped.
- · An LED display helps the user pinpoint any of seven different failure modes.



[Pressure Switch]

OAG

- · Monitors for increases in air and oil pressure and any drop in oil pressure.

(Equipped on OAEG)

[Oil Filter]

OAV-02/03

- · Filters remove minute foreign particles from the oil.
- · Two types are available: 3μm and 20μm

[Air Bleed Valve]

OAV-01

- · Bleed valves facilitate bleeding air after disconnecting oil lines for maintenance of the lubricator.

Technical Guide

Technical Guide

1. Life ………………………………………………P120-127
    - ·Rolling Fatigue Life and Basic Load Rating
    - ·New Life Theory
2. Static Load Rating and Static Equivalent Loads ……P128-129
3. Angular Contact Ball Bearing Combinations …………P130-133
    - ·Features of Each Combination
    - ·Universal Combination
4. Preload and Rigidity ………………………………P134-151
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1. LIFE

Rolling Fatigue Life and Basic Load Rating

Bearing Life

The various functions required of rolling bearings vary according to the bearing application. These functions must be performed for a prolonged period. Even if bearings are properly mounted and correctly operated, they will eventually fail to perform satisfactorily due to an increase in noise and vibration, loss of running accuracy, deterioration of grease, or fatigue flaking of the rolling surfaces.

Bearing life, in the broad sense of the term, is the period during which bearings continue to operate and to satisfy their required functions. This bearing life may be defined as noise life, abrasion life, grease life, or rolling fatigue life, depending on which one causes loss of bearing service.

Aside from the failure of bearings to function due to natural deterioration, bearings may fail when conditions such as heat-seizure, fracture, scoring of the rings, wear of the seals, or other damage occurs. Conditions such as these should not be interpreted as normal bearing failure since they often occur as a result of errors in bearing selection, improper design or manufacture of the bearing surroundings, incorrect mounting, or insufficient maintenance.

Rolling Fatigue Life and Basic Rating Life

When rolling bearings are operated under load, the raceways of their inner and outer rings and rolling elements are subjected to repeated cyclic stress. Because of metal fatigue of the rolling contact surfaces of the raceways and rolling elements, scaly particles may separate from the bearing material

This phenomenon is called “flaking” Rolling fatigue life is represented by the total number of revolutions at which time the bearing surface will start flaking due to stress. This is called fatigue life. Even for seemingly identical bearings, which are of the same type, size, and material and receive the same heat treatment and other processing, the rolling fatigue life varies greatly, even under identical operating conditions. This is because the flaking of materials due to fatigue is subject to many other variables. Consequently, “basic rating life”, in which rolling fatigue life is treated as a statistical phenomenon, is used in preference to actual rolling fatigue life.

Suppose a number of bearings of the same type are operated individually under the same conditions. After a certain period of time, 10% of them fail as a result of flaking caused by rolling fatigue. The total number of revolutions at this point is defined as the basic rating life or, if the speed is constant, the basic rating life is often expressed by the total number of operating hours completed when 10% of the bearings become inoperable due to flaking.

In determining bearing life, basic rating life is often the only factor considered. However, other factors must also be taken into account. For example, the grease life of grease-prelubricated bearings can be estimated. Since noise life and abrasion life are determined according to individual standards for different applications, specific values for noise or abrasion life must be determined empirically.

Basic Dynamic Load Rating

The basic dynamic load rating is defined as the constant load applied on bearings with stationary outer rings that the inner rings can endure for a rating life of one million revolutions (10^6 rev). The basic load rating of radial bearings is defined as a central radial load of constant direction and magnitude, while the basic load rating of thrust bearings is defined as an axial load of constant magnitude in the same deflection as the central axis. The load ratings are listed under C_r for radial bearings and C_a for thrust bearings in the dimension tables.

Basic Rating Life

The following relation exists between bearing load and basic rating life:

For ball bearings
$$L_{10}=\left(\frac{C}{P}\right)^3$$
$$L_{10}=\frac{10^6}{60n}\left(\frac{C}{P}\right)^3 \quad \text{(h)}$$

For roller bearings
$$L_{10}=\left(\frac{C}{P}\right)^{10/3}$$
$$L_{10}=\frac{10^6}{60n}\left(\frac{C}{P}\right)^{10/3} \quad \text{(h)}$$

where L_{10} : Basic rating life (10^6 rev, or h)

P : Bearing load (equivalent load) (N)
(Refer to Page 121)

C : Bearing dynamic load rating (N)
For radial bearings, C is written C_r
For thrust bearings, C is written C_a

n : Rotational Speed (min^{-1})

In the case of bearings that run at a constant speed, it is convenient to express the fatigue life in terms of hours.

Dynamic Equivalent Load

In some cases, the loads applied on bearings are purely radial or axial loads; however, in most cases, the loads are a combination of both. In addition, such loads usually fluctuate in both magnitude and direction.

In such cases, the loads actually applied on bearings cannot be used for bearings life calculations; therefore, a hypothetical load should be estimated that has a constant magnitude and passes through the center of the bearing, and will give the same bearing life that the bearing would attain under actual conditions of load and rotation. Such a hypothetical load is called the dynamic equivalent load.

Assuming the equivalent radial load as P_r, the radial load as F_r, the axial load as F_a, and the contact angle as α, the relationship between the equivalent radial load and bearing load can be approximated as follows:

$$P_r = XF_r + YF_a$$

where X : Radial load factor
Y : Axial load factor
} See Table 1.1

The axial load factor varies depending on the contact angle. In the case of roller bearings, the contact angle remains the same regardless of the magnitude of the axial load. In the case of single row deep groove ball bearings and angular contact ball bearings, the contact angle increases when the axial load is increased. Such change in the contact angle can be expressed by the ratio of the basic static load rating C_{0r} and axial load F_a. Table 1.1 shows the axial load factor at the contact angle corresponding to this ratio. Regarding angular contact ball bearings, the effect of change in the contact angle on the load factor may be ignored under normal conditions even if the contact angle is as large as 25°, 30° or 40°.

For the thrust bearing with the contact angle of $\alpha \neq 90°$ receiving both radial and axial loads simultaneously, the equivalent axial load P_a becomes as follows:

$$P_a = XF_r + YF_a$$

Table 1.1 Value of Factors X and Y

Normal Contact Angle	$\frac{if_0F_a}{C_{0r}}$*	e	Single, DT				DB or DF			
			$F_a/F_r\leqq e$		$F_a/F_r>e$		$F_a/F_r\leqq e$		$F_a/F_r>e$	
			X	Y	X	Y	X	Y	X	Y
15	0.178	0.38	1	0	0.44	1.47	1	1.65	0.72	2.39
	0.357	0.40				1.40		1.57		2.28
	0.714	0.43				1.30		1.46		2.11
	1.070	0.46				1.23		1.38		2.00
	1.430	0.47				1.19		1.34		1.93
	2.140	0.50				1.12		1.26		1.82
	3.570	0.55				1.02		1.14		1.66
	5.350	0.56				1.00		1.12		1.63
18	–	0.57	1	0	0.43	1.00	1	1.09	0.70	1.63
25	–	0.68	1	0	0.41	0.87	1	0.92	0.67	1.41
30	–	0.80	1	0	0.39	0.76	1	0.78	0.63	1.24
40	–	1.14	1	0	0.35	0.57	1	0.55	0.57	0.93
50	–	1.49	–	–	0.73	1	1.37	0.57	0.73	1
55	–	1.79	–	–	0.81	1	1.60	0.56	0.81	1
60	–	2.17	–	–	0.92	1	1.90	0.55	0.92	1

*For *i*, use 2 for DB, DF and 1 for DT

Table 1.2 Basic Load Rating of ACBB as Multiple Sets

Double Row		Triple Row		Quadruple Row	
C_r	C_{or}	C_r	C_{or}	C_r	C_{or}
1.62times relative to Single row	2times relative to Single row	2.15times relative to Single row	3times relative to Single row	2.64times relative to Single row	4times relative to Single row

Life Calculation of Multiple Bearings as a Group

When multiple rolling bearings are used in one machine, the fatigue life of individual bearings can be determined if the load acting on individual bearings is known. Generally, however, the machine becomes inoperative if a bearing in any part fails. It may therefore be necessary in certain cases to know the fatigue life of a group of bearings used in one machine.

The fatigue life of the bearings varies greatly and our fatigue life calculation equation $L_{10} = \left(\frac{C}{P}\right)^3$ applies to the 90% life (also called the rating fatigue life, which is either the gross number of revolution or hours to which 90% of multiple similar bearings operated under similar conditions can reach).

In other words, the calculated fatigue life for one bearing has a probability of 90%. Since the endurance probability of a group of multiple bearings for a certain period is a product of the endurance probability of individual bearings for the same period, the rating fatigue life of a group of multiple bearings is not determined solely from the shortest rating fatigue life among the individual bearings. In fact, the group life is much shorter than the life of the bearing with the shortest fatigue life.

Assuming the rating fatigue life of individual bearings as L_1, L_2, L_3 ...Ln and the rating fatigue life of the entire group of bearings as L, the below equation is obtained :

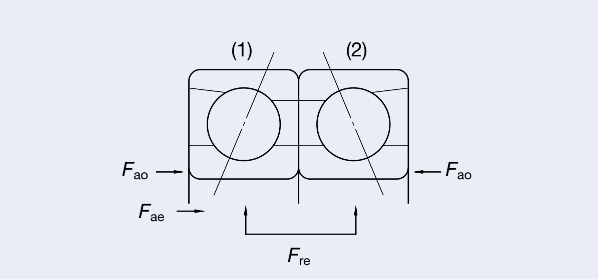
$$\frac{1}{L^e} = \frac{1}{L_1{}^e} + \frac{1}{L_2{}^e} + \frac{1}{L_3{}^e} + \cdots\cdots + \frac{1}{L_n{}^e}$$

where, e = 1.1 (both for ball and roller bearings)

Life Calculations of Preloaded Angular Contact Ball Bearings

To establish the total radial (F_r) and axial (F_a) load components on each bearing in a multiple arrangement of preloaded angular contact ball bearings, the externally applied radial load (F_{re}) and axial load (F_{ae}), the axial preload (F_{ao}) and the load distribution must be taken into account. The latter is a function of the rolling element to raceway deflection which is proportional to (load)$^{2/3}$. The calculation procedure for popular mounting variations of identical bearings is detailed below.

Back-to-back, Pair of Bearings



Under external radial load (F_{re}), total Preload (F_{ap}) is the following,

$$F_{ap} = \frac{F_{re} \times 1.2 \times tan\alpha + F_{ao}}{2}$$

when $F_{ap} < F_{ao}$, use $F_{ap} = F_{ao}$

Total axial component of (F_{a1}, F_{a2}) with applied axial load on each bearing (1 and 2) :

$$F_{a1} = 2/3F_{ae} + F_{ap}$$

$$F_{a2} = F_{ap} - 1/3F_{ae}$$

when $F_{a2} < 0$ the preload is relieved so that $F_{a1} = F_{ao}$, and Fa2 = 0

Total radial component of load (F_r) on each bearing is proportioned by the ratio of the axial load on each bearing to the total axial load, each component raised to the power of 2/3:

$$F_{r1} = \frac{F_{a1}^{2/3}}{F_{a1}^{2/3} + F_{a2}^{2/3}} \times F_{re}$$

$$F_{r2} = \frac{F_{a2}^{2/3}}{F_{a1}^{2/3} + F_{a2}^{2/3}} \times F_{re}$$

The dynamic equivalent radial load (P_{r1}) and (P_{r2}) for each bearing is calculated from :

$$P_{r1} = XF_{r1} + YF_{a1}$$

$$P_{r2} = XF_{r2} + YF_{a2}$$

The values of X and Y are obtained from Table 1.1 (Page 121)

The basic rating life (L_{10}) of each bearing is :

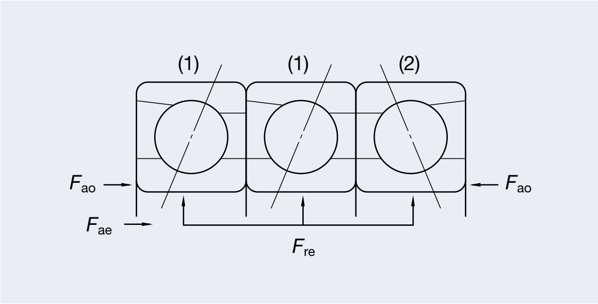
$$L_{10\,(1)} = \frac{16\,667}{n}\left(\frac{C_r}{P_{r1}}\right)^3 \quad \text{(h)}$$

$$L_{10\,(2)} = \frac{16\,667}{n}\left(\frac{C_r}{P_{r2}}\right)^3 \quad \text{(h)}$$

The two bearings may be considered as a unit and according to the theory of probability, the life of the unit, or pair of bearings, will be shorter than the shortest rating life of the individual bearings. Thus :

$$L_{10} = \frac{1}{\left(\frac{1}{L_{10(1)}^{1.1}} + \frac{1}{L_{10(2)}^{1.1}}\right)^{\frac{1}{1.1}}} \quad \text{(h)}$$

DBD Set of Bearings



Under external radial load (F_{re}), total Preload (F_{ap}) is the following

$$F_{ap1} = \frac{F_{re} \times 1.2 \times tan\alpha + F_{ao}}{4}$$

$$F_{ap2} = \frac{F_{re} \times 1.2 \times tan\alpha + F_{ao}}{2}$$

when $F_{ap1} < F_{ao}/2$, use $F_{ap1} = F_{ao}/2$

and $F_{ap2} < F_{ao}$, use $F_{ap2} = F_{ao}$

Total axial component of load (F_{a1}, F_{a2}) on each bearing with applied axial load :

$$F_{a1} = 0.4F_{ae} + F_{ap1}$$

$$F_{a2} = F_{ap2} - 0.2F_{ae}$$

When $F_{a2} < 0$ the preload is relieved so that

$$F_{a1} = \frac{F_{ae}}{2} \text{ and } F_{a2} = 0$$

Total radial component of load (F_r) on each bearing :

$$F_{r1} = \frac{F_{a1}^{2/3}}{2F_{a1}^{2/3} + F_{a2}^{2/3}} \times F_{re}$$

$$F_{r2} = \frac{F_{a2}^{2/3}}{2F_{a1}^{2/3} + F_{a2}^{2/3}} \times F_{re}$$

The dynamic equivalent radial load (P_{r1}) and (P_{r2}) for each bearing :

$$P_{r1} = XF_{r1} + YF_{a1}$$

$$P_{r2} = XF_{r2} + YF_{a2}$$

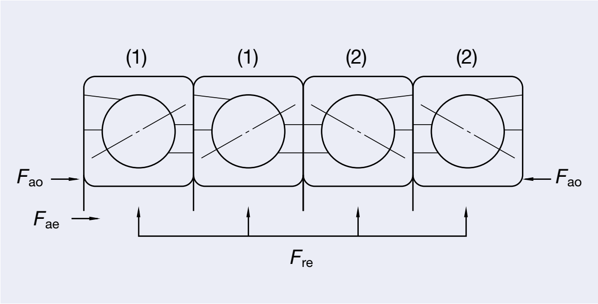
The values of X and Y are obtained from Table 1.1, page 121. The basic rating life (L_{10}) of each bearing :

$$L_{10(1)} = \frac{16\,667}{n}\left(\frac{C_r}{P_{r1}}\right)^3 \quad \text{(h)}$$

$$L_{10(2)} = \frac{16\,667}{n}\left(\frac{C_r}{P_{r2}}\right)^3 \quad \text{(h)}$$

$$L_{10} \text{ for the unit} = \frac{1}{\left(\frac{1}{L_{10(1)}^{1.1}} + \frac{1}{L_{10(2)}^{1.1}}\right)^{\frac{1}{1.1}}} \quad \text{(h)}$$

DBB Set of Bearings



Under external radial load (F_{re}), total Preload (F_{ap}) is the following

$$F_{ap} = \frac{F_{re} \times 1.2 \times tan\alpha + F_{ao}}{4}$$

When $F_{ap} < F_{ao}/2$, use $F_{ap} = F_{ao}/2$

Total axial component of load (F_{a1}, F_{a2}) on each bearing with applied axial load

$$F_{a1} = 1/3F_{ae} + F_{ap}$$

$$F_{a2} = Fap - 1/6F_{ae}$$

When $Fa2 < 0$ the preload is relieved so that

$$F_{a1} = \frac{F_{ae}}{2} \text{ and } F_{a2} = 0$$

Total radial component of load (F_r) on each bearing :

$$F_{r1} = \frac{F_{a1}^{2/3}}{F_{a1}^{2/3} + F_{a2}^{2/3}} \times \frac{F_{re}}{2}$$

$$F_{r2} = \frac{F_{a2}^{2/3}}{F_{a1}^{2/3} + F_{a2}^{2/3}} \times \frac{F_{re}}{2}$$

The dynamic equivalent radial load (P_{r1}) and (P_{r2}) for each bearing :

$$P_{r1} = XF_{r1} + YF_{a1}$$

$$P_{r2} = XF_{r2} + YF_{a2}$$

The values of X and Y are obtained from Table 1.1, page 121. The basic rating life (L_{10}) of each bearing :

$$L_{10(1)} = \frac{16\,667}{n}\left(\frac{C_r}{P_{r1}}\right)^3 \quad \text{(h)}$$

$$L_{10(2)} = \frac{16\,667}{n}\left(\frac{C_r}{P_{r2}}\right)^3 \quad \text{(h)}$$

$$L_{10} \text{ for the unit} = \frac{1}{\left(\frac{1}{L_{10(1)}^{1.1}} + \frac{1}{L_{10(2)}^{1.1}}\right)^{\frac{1}{1.1}}} \quad \text{(h)}$$

New Life Theory

Introduction

Bearing technology has advanced rapidly in recent years, particularly in the areas of dimensional accuracy and material cleanliness. As a result, bearings can now have a longer rolling fatigue life in a cleaner environment, than the life obtained by the traditional ISO life calculation formula. This extended life is partly due to the important advancements in bearing related technology such as lubrication cleanliness and filtration.

The conventional life calculation formula, based on the theories of G. Lundberg and A. Palmgren (L-P theory, hereafter) addresses only sub-surface originated flaking. This is the phenomenon in which cracks initially occur due to dynamic shear stress immediately below the rolling surface then progressively reach the surface in the form of flaking.

$$1n\frac{1}{S}\propto\frac{\tau_o^c\cdot N^e\cdot V}{Z_o^h}$$

NSK's new life calculation formula theorizes that rolling fatigue life is the sum total of the combined effects of both sub-surface originated flaking and surface originated flaking occurring simultaneously.

NSK New Life Calculation Formula

(1) Sub-surface originated flaking

A pre-condition of sub-surface originated flaking of rolling bearings is contact of the rolling elements with the raceway via a sufficient and continuous oil film under clean lubrication conditions.

Fig. 1.1 plots the L_{10} life for each test condition with maximum surface contact pressure (P_{max}) and the number of repeated stresses applied on the ordinate and the abscissa, respectively.

In the figure, line L_{10} theoretical is the theoretical line obtained using the conventional life calculation formula. As maximum surface contact pressure decreases, the actual life line separates from the line created by using conventional theoretical calculation and moves towards longer life. This separation suggests the presence of fatigue load limit P_u below which no rolling fatigue occurs. This is better illustrated in Fig. 1.2.

Fig. 1.1 Life Test Result under Clean Lubrication Condition

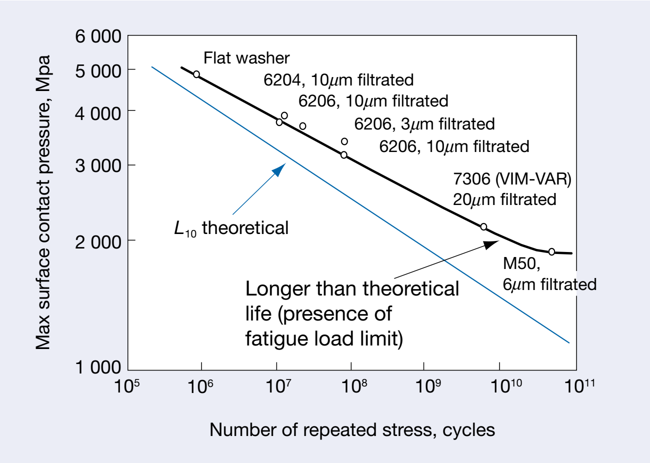
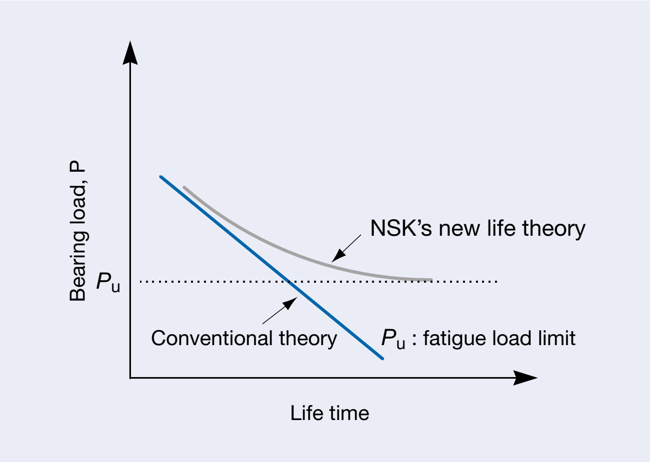


Fig. 1.2 NSK's New Life Theory That Considers Fatigue Limit



(2) Surface originated flaking

Under actual bearing operation, the lubricant is often contaminated with foreign objects such as metal chips, burrs, cast sand, etc.

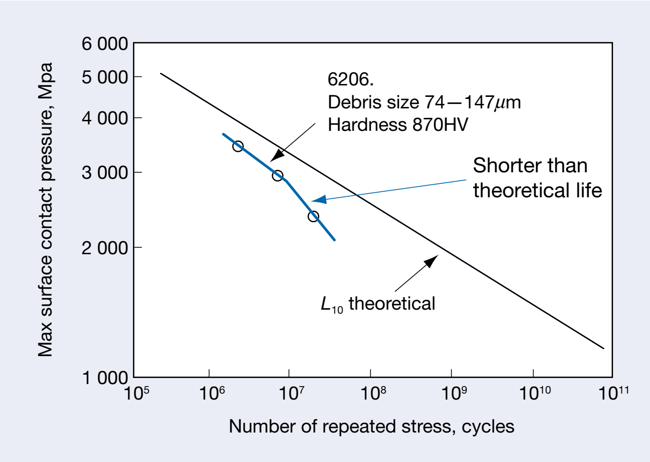
When the foreign particles are mixed in the lubricant, the particles are pressed onto the raceways by the rolling elements and dents occur on the surfaces of the raceways and rolling elements. Stress concentration occurs at the edges of the dents, generating fine cracks, which over time, propagate into flaking of the raceways and rolling elements..

As shown in Fig. 1.3, the actual life is shorter than conventional calculated life, under conditions of contaminated lubrication at low max surface pressure. The actual life line separates from the line created by theoretical life calculations and moves towards a shorter life. This result shows that the actual life under contaminated lubrication is further shortened compared to the theoretical life because of the decrease in maximum surface contact pressure.

Table 1.3 Value of Contamination Coefficient a_c

	Very clean	Clean	Normal	Contaminated	Heavily contaminated
a_c factor	1	0.8	0.5	0.4–0.1	0.05
Application guide	10μm filtration	10–30μm filtration	30–100μm filtration	Greater than 100μm filtration or no filtration (oil bath, circulating lubrication, etc.)	No filtration, presence of many fine particles
Application examples	Sealed grease lubricated bearing for electrical appliances and information technology equipment, etc.	Sealed grease lubricated bearing for electric motors Sealed grease bearing for railway axle boxes and machine tools, etc.	Normal usage Automotive hub unit bearing. etc.	Bearing for automotive transmission; Bearing for industrial gearbox; Bearing for construction machine, etc.	—

Fig. 1.3 Life Test Result under Contaminated Lubrication Condition



Therefore, the NSK new life calculation formula considers the trend in the results of the life test under conditions of clean environment and at low load zone. Based on these results, the new life equation is a function of $(P-P_u)/C$, which is affected by specific lubrication conditions identified by the lubrication parameter. Also, it is assumed that effects of different types and shapes of foreign particles are strongly influenced by the bearing load and lubrication conditions present, and that such a relationship can be expressed as a function of the load parameter. This relationship of the new life calculation formula is defined by $(P-P_u)/C \cdot 1/a_c$.

Calculation formula for surface originated flaking, based on the above concept, is as follows:

$$1n\frac{1}{S}\propto N^e\int_V\frac{(\tau-\tau_u)^c}{Z_o^h}dV\times\left\{\frac{1}{f\,(a_c,a_L)}-1\right\}$$

V = stress volume

The contamination coefficient in terms of lubrication cleanliness is shown in Table 1.3. Test results on ball and roller bearings with grease lubrication and clean filtration show the life as being a number of times longer than that of the contaminated calculation. Yet when the foreign object is harder than Hv350, hardness becomes a factor and a dent appears on the raceway. Fatigue damage from these dents, can progress to flaking in a short time. Test results on ball and roller bearings under conditions of foreign object contamination show from 1/3 to 1/10 the life when compared with conventionally calculated life.

Based on these test results, the contamination coefficient a_c is classified into five steps for NSK's new life theory.

(3) New life calculation formula.

The following formula, which combines sub-surface originated flaking and surface originated flaking, is proposed as the new life calculation formula.

$$1n\frac{1}{S}\propto N^e\int_V\frac{(\tau-\tau_u)^c}{Z_o^h}dV\times\left\{\frac{1}{f\,(a_c,a_L)}\right\}$$

$$L_{able}=a_1\cdot a_{NSK}\cdot L_{10}$$

Life Correction Factor a_{NSK}

The life correction factor a_{nsk} is the function of lubrication parameter $(P\text{-}P_u)/C \cdot 1/a_c$ as shown below.

$$a_{NSK} \propto F \left\{ a_L, , \left(\frac{P\text{-}P_u}{C \cdot a_c} \right) \right\}$$

NSK's new life theory considers the life extending affect of improved material and heat treatment by correcting the contamination factor a_c. The theory also utilizes viscosity ratio k ($k = v/v_1$ where v is the operational viscosity and v_1 the required viscosity) because the lubrication parameter a_L changes with the degree of oil film formation, based on the lubricant and operating temperature. The theory indicates that the better the lubrication conditions (higher k) the longer the life.

Figures 1.4 and 1.5 show the diagrams of the correction factor a_{nsk} as a function of the new life calculation formula. Also in this new life calculation formula, point contact and line contact are considered separately for ball and roller bearings respectively.

New Life Calculation Formula L_{able}

The concept of new life calculation formula is simplified into one factor as shown by the formula below in which conventional life calculation formula (L_{10}) is multiplied with correction factor (a_{NSK}) and reliability factor (a_1; Table 1.4)

$$L_{able} = a_1 \cdot a_{NSK} \cdot L_{10}$$

Table 1.4 Reliability Factor

Reliability (%)	90	95	96	97	98	99
Reliability Factor	1.00	0.62	0.53	0.44	0.33	0.21

New Life Theory Applied to Precision Bearings for Machine Tools

When the new life calculation formula is applied to precision bearings, a_{NSK} is determined to be:

$$a_{NSK} \fallingdotseq 14$$

This is based on NSK Precision bearings made with standard Z steel, used with grease lubrication or with lubricant of VG22 - VG68 viscosity, in a clean environment.

Fig. 1.4 New Life Calculation Diagram for Ball Bearings

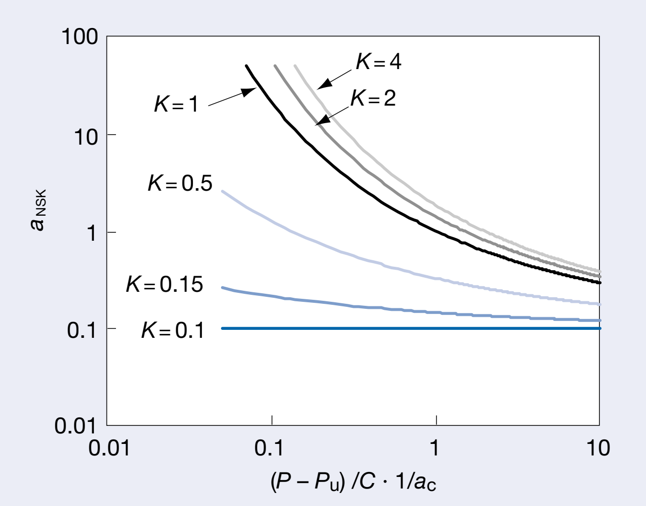
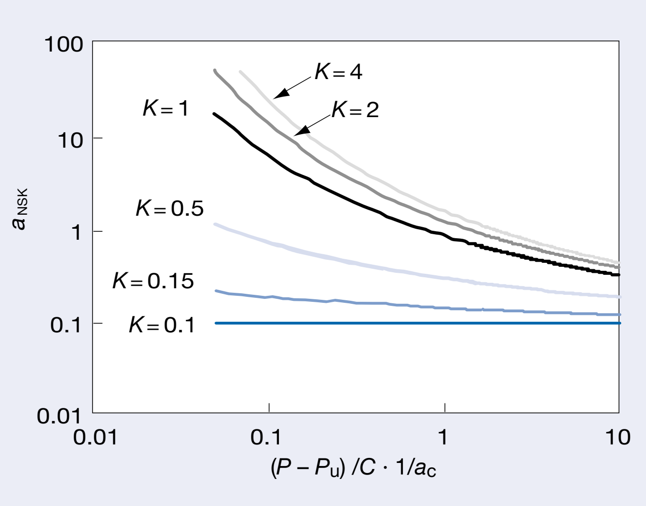


Fig. 1.5 New Life Calculation Diagram for Roller Bearings



To Access the NSK Calculation Tools

Visit our website at http://home2.nsk.com/index2.html

Life of High Speed Bearings

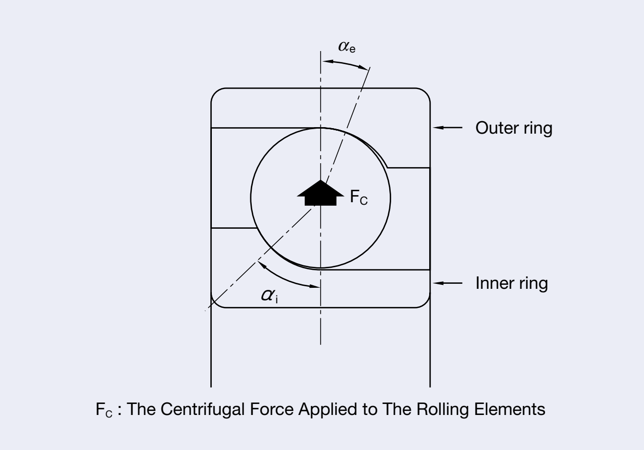
When bearings operate at high speed, in addition to the external load, the internal load generated by the centrifugal force acting on the rolling element must be taken into account.
A computer should be used for the calculation of the load conditions on bearings operation at high speeds. (in excess of 800,000 d_mn)
Balance among the forces acting on the rolling elements and inner/outer rings as well as changes in contact angle are obtained by using convergence calculations(1), based on the load condition of the bearing (radial load, axial load, centrifugal force on rolling elements, etc.).

Life is initially calculated for each individual rolling elements under load between inner and outer ring and then the life of the entire single row of bearing is obtained.

(1) Convergence calculations allow NSK to calculate with great accuracy the centrifugal force exerted on balls and to actually perform load calculations for each rolling element.

For life calculations on bearings used in high speed applications, please contact NSK.

Fig. 1.6 Change in Contact Angle Due to Centrifugal Force.



F_C : The Centrifugal Force Applied to The Rolling Elements

Life of Ceramic Hybrid Bearings

C_r, C_{or} valves and L_{10} standards do not exist in ISO281 for ceramic bearings.
However, ceramic bearing life tends to be longer than that of conventional steel ball bearings, under the same appropriate operating conditions.
This may be especially true in the situations where the centrifugal force on the balls are significant.

2. STATIC LOAD RATINGS AND STATIC EQUIVALENT LOADS

Static Load Ratings

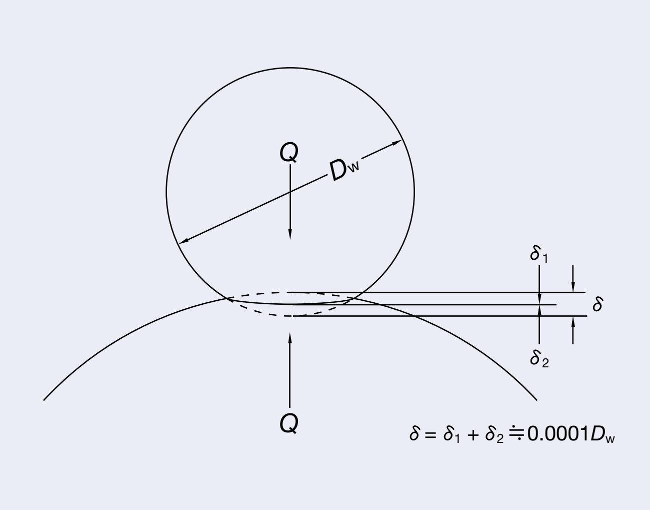
When subjected to an excessive load or a strong shock load, rolling bearings may incur a local permanent deformation of the rolling elements and raceway surface if the elastic limit is exceeded. The nonelastic deformation increases in area and depth as the load increases, and when the load exceeds a certain limit, the smooth running of the bearing is impeded.

The basic static load rating is defined as that static load which produces the following calculated contact stress at the center of the contact area between the rolling element subjected to the maximum stress and the raceway surface.

For ball bearings : 4 200MPa
For roller bearings : 4 000MPa

In this most heavily contact area, the sum of the permanent deformation of the rolling element and that of the raceway is nearly 0.0001 times the rolling element's diameter. The basic static load rating C_0 is written C_{0r} for radial bearings and C_{oa} for thrust bearings in the bearing tables.

Fig. 2.1 The Relation between Indentations and Basic Static Load Rating



Static Equivalent Loads

The static equivalent load is a hypothetical load that produces a contact stress equal the above maximum stress under actual conditions, while the bearing is stationary (including very slow rotation or oscillation), in the area of contact between the most heavily stressed rolling element and bearing raceway.

The static radial load passing through the bearing center is taken as the static equivalent load for radial bearings, while the static axial load in the direction coinciding with the central axis is taken as the static equivalent load for thrust bearings.

Static equivalent load on radial bearings.

The greater of the two values calculated from the following equations should be adopted as the static equivalent load on radial bearings.

$$P_0 = X_0F_r + Y_0F_a$$
$$P_0 = F_r$$

Static equivalent load on thrust bearings

$$P_0 = X_0F_r + F_a \quad \alpha \neq 90^\circ$$

Table 2.1 Static Equivalent Load $P_0 = X_0F_r + Y_0F_a$

Contact Angle	Single. DT		DB or DF	
	X_0	Y_0	X_0	Y_0
15	0.5	0.46	1	0.92
18	0.5	0.42	1	0.84
25	0.5	0.38	1	0.76
30	0.5	0.33	1	0.66
40	0.5	0.26	1	0.52

where

P_0 : Static equivalent load (N)
F_r : Radial load (N)
F_a : Axial load (N)
X_0 : Static radial load factor
Y_0 : Static axial load factor

When single or DT mounting and $F_r > 0.5F_r + Y_0F_a$, use $P_0 = Fr$

Permissible Static Load Factor

The permissible static equivalent load on bearings varies depending on the basic static load rating and also their application and operating conditions.

The permissible static load factor is a safety factor that is applied to the basic static load rating, and it is defined by the ratio in equation bellow.

$$f_S = (C_0/P_0)$$

where

C_0 : Basic static load rating (N)
P_0 : Static equivalent load (N)

Table 2.2 Values of Permissible Static Load Factor f_s

Operating conditions	Lower limit of f_s	
	Ball bearings	Roller bearings
Low-noise applications	2.0	3.0
Bearings subjected to vibration and shock loads	1.5	2.0
Standard operating conditions	1.0	1.5

Permissible Axial Loads

In order to optimize bearing performance, NSK has defined the permissible axial loads statistically, based on the following 2 situations:

1 --The limiting load at which a contact ellipse is generated between the ball and raceway due to a change in the contact angle when a radial bearing, which is under an axial load, rides over the shoulder of the raceway groove.

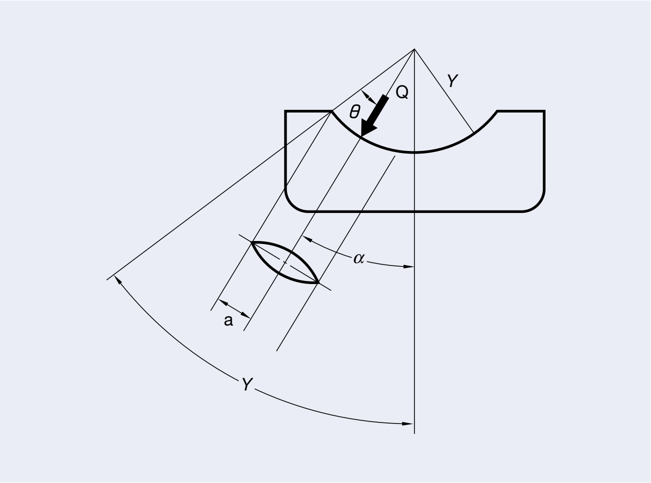
2 --The value of a static equivalent load P_0 which is determined from the basic static load rating C_0 using static axial load factor Y_0.

The permissible axial loads is determined by the lower of the two values defined above.

This value has been proven through experience, and includes a safety factor .

(Refer to the bearing tables for permissible axial loads)

Fig. 2.2 Contact Ellipse and the Limiting Axial Loads



3. ANGULAR CONTACT BALL BEARING COMBINATIONS

Angular Contact Ball Bearings Combinations Available

Normally, NSK supplies matched super precision angular contact ball bearings as 2, 3, and 4 row combinations. The combinations available for the fixed end of spindles are usually 2 rows (DB), 3 rows (DBD), and 4 rows (DBB) sets. However, in the case of 3 row combinations, since the preload distribution to each bearing is not equal, the optimum preload setting range is very limited making them unsuitable for high speed applications.

Matched bearings are manufactured as sets, so when they are mounted adjacent to each other, a given preload is automatically obtained. The variation per pair of matched bearings for bore and outer diameters is adjusted to less than 1/3 of the permissible tolerance.

Table 3.1 Features of Each Combination

	DB	DF	DT	DBD	DBB
Load direction	⇔	⇔	→	⇔	⇔
Moment stiffness	◎	○	△	◎	⦾
Speed capability	◎	◎	⦾	△	○
Heat generation	◎	◎	⦾	△	○
Stiffness	○	○	△	◎	⦾

⦾Excellent ◎Very good ○Good △Fair →One direction only ⇔Two directions

Features of Each Combination

- Back-to-back Arrangement, DB

Axial loads in both directions and radial loads can be sustained. Since the distance between the effective load centers is large, this type is suitable if moments are applied. However, if accuracy of housing is not enough and there is a misalignment in the spindle, internal loads of bearings could be large enough to possibly cause premature failure due to greater moment stiffness.

- Face-to-face Arrangement, DF

Compared with the DB type, the distance between the effective load centers is small, so the capacity to sustain moments is inferior to the DB type.
On the other hand, this type is suitable for using with housings that have less accuracy or larger shaft deflections due to low bending stiffness of shaft.

- Tandem Arrangement, DT

Axial loads in one direction and radial loads can be sustained. Since axial stiffness of this type is twice the value of a single row type, this arrangement is used when the axial load in one direction is heavy.

- 3 rows Arrangement, DBD

Axial loads in both directions and radial loads can be sustained.
However, the preload distribution to each bearing is not equal, and preload on the counter side (single side) is twice that of other side.
Consequently, this type is unsuitable for high speed operation because of the large increase of internal load of the single side which could lead to bearing failure.

- 4 rows Arrangement, DBB

Axial loads in both directions and radial loads can be sustained.
In situations that have the same axial clearance as DB arrangement, preload and stiffness are twice that of the DB arrangement. Also, the permissible axial load of a 4 row arrangement is larger than that of a DB arrangement.

Fig. 3.1 The Distance between the Effective Load Centers of Back-to-back and Face-to-face Arrangements

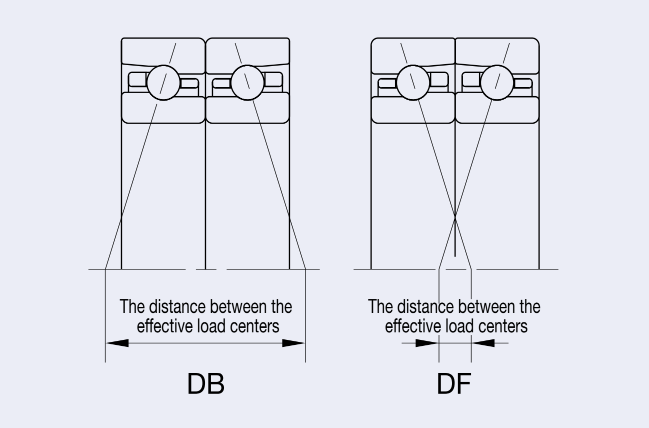


Fig. 3.2 Load Direction in Back-to-Back and Tandem Arrangements

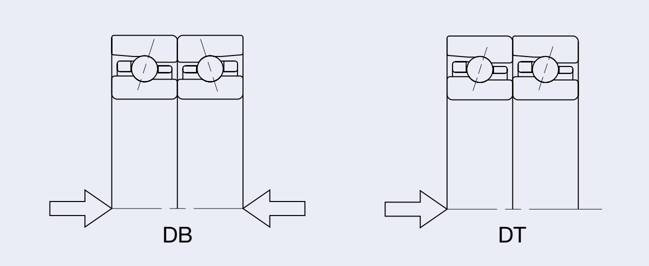
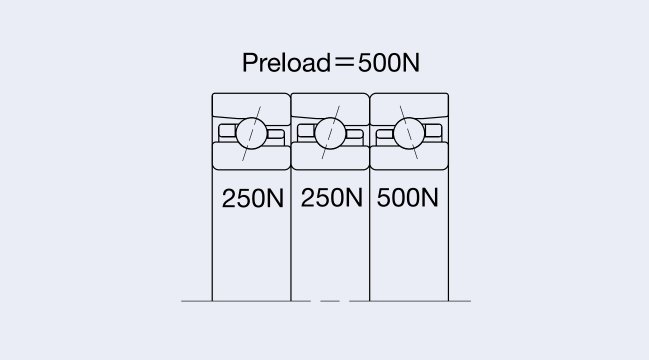


Fig. 3.3 Internal Preload in DBD Arrangement



Shaft Bending Comparison between Back-to-back and Face-to-face Arrangements

Moment stiffness is different between Back-to-back and Face-to-face arrangements as shown in the shaft bending comparison calculation example below. In this example, angular contact ball bearings (75BNR10XET) are used in the front side and the typically shaft deflections are shown for both DB and DF configurations. When 1 000N of radial load is applied on the spindle nose, radial displacements on the spindle nose are calculated as follows.

$$\sigma_{DB}=2.4079\times10^{-2}$$

$$\sigma_{DF}=2.9853\times10^{-2}$$

This demonstrates the effect of the distance between effective load centers on spindle bending.

Mounting Instructions for Angular Contact Ball Bearings — Matching Method

Direction of Matching

For matched bearings, the mounting order and load application direction are very important.

A "V" is marked on the bearings outer diameter surfaces as shown in the figure on the right. When the bearings are mounted so their marks correctly form a "V", they are properly matched and aligned.

On the side surface or chamfered part of the inner rings, the symbol "○" is marked to indicate the position of maximum radial runout. Optimum accuracy is achieved when the bearing is mounted so the "○" symbol is placed just opposite the position of shaft maximum eccentricity.

Fig. 3.5 The Symbol for the Position of Maximum Radial Runout of Inner Ring

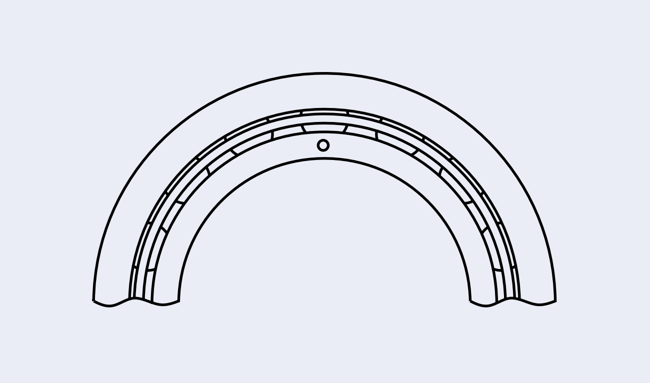


Fig. 3.4 Spindle Displacement Curve

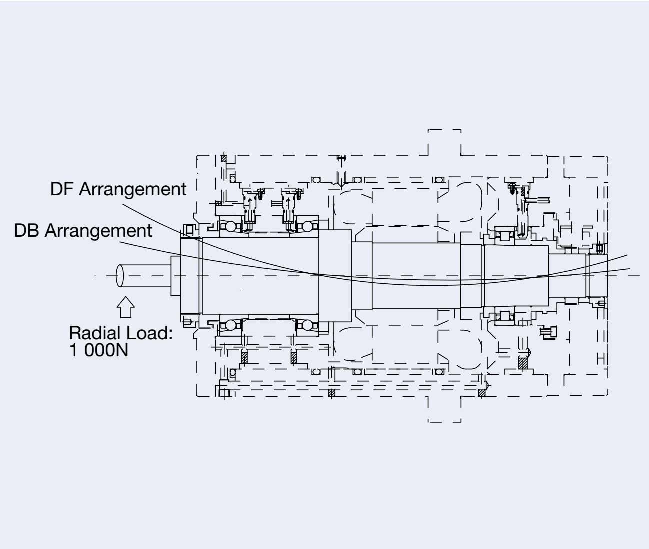
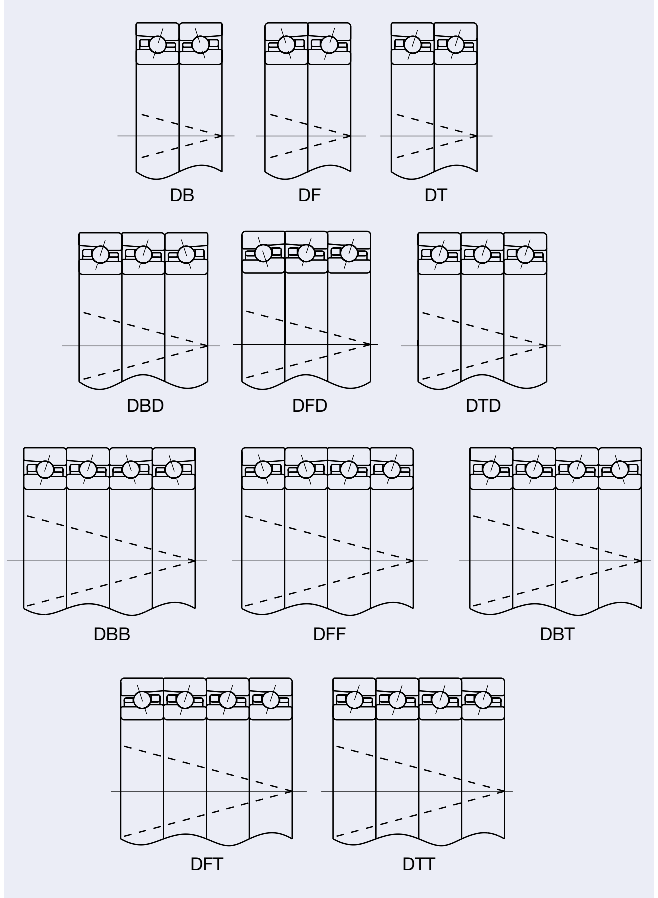


Fig. 3.6 Combinations of Angular Contact Ball Bearings

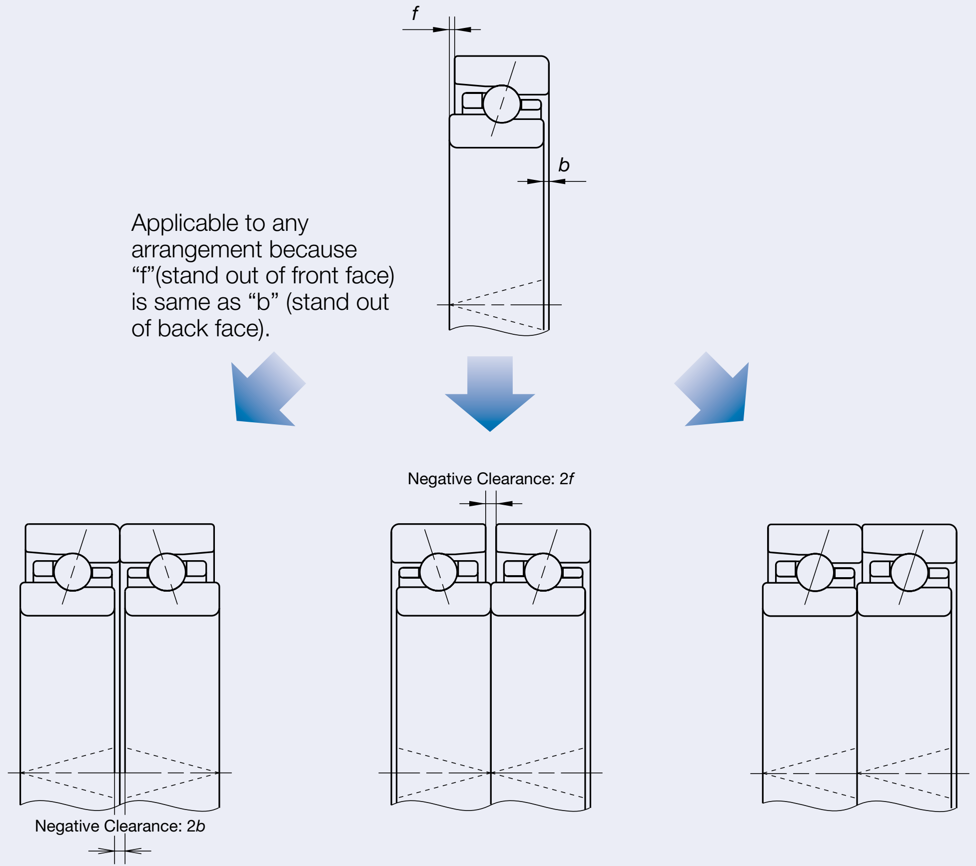


Universal Combination

NSK supplies universal combination angular contact ball bearings that have the same amount of stand out on both the front and back face. This means that when bearings that have the same reference number are combined, they have the specified amount for each standard preload.

For universal combination bearings, the “V” combination marks on the outer diameter surface of outer ring prevent “direction” mistakes, ensure correct matching when they are mounted, and indicate the direction of the contact angle.

Fig. 3.7 Universal Combination



Applicable to any arrangement because “f”(stand out of front face) is same as “b” (stand out of back face).

DB arrangement
Preload is “stand out of back face x 2 = 2b (=2f)” and it is the specified amount for each standard preload

DF arrangement
Preload is “stand out of front face x 2 = 2f (=2b)” and it is the specified amount for each standard preload

DT arrangement
There is no clearance on DT surface because stand out of front face “f” is same as stand out of back face “b”. This situation is the same as bearings combined as DT.

Difference between SU and DU Bearings

There are 2 types of NSK universal combination bearings as shown in the table below.

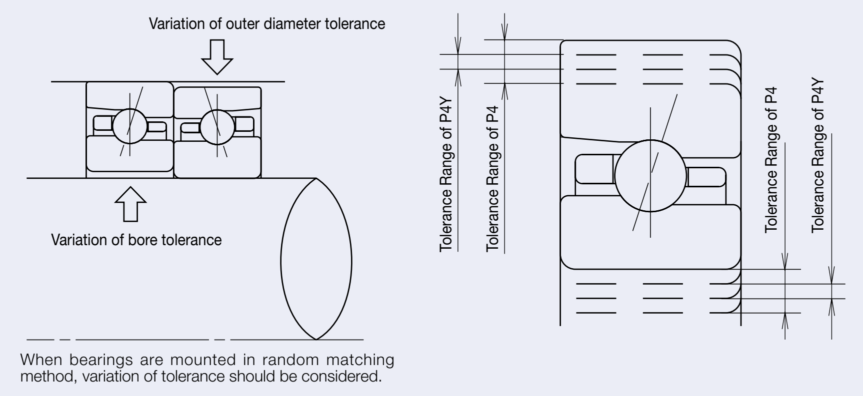
Table 3.2 Features of SU and DU Bearings

	SU	DU
Row of bearings	1	2
Variation of bore and outer diameter tolerance	–	Controlled in 1/3 of tolerance

Notice for Use of Single Universal (SU) Bearings

- When these bearings are used as part of multiple combined bearings, it is recommended that the variation of bore and outer diameter tolerance is within 1/3 of tolerance range.
- There are also special bearings with special accuracy “P4Y” that can accommodate small variations of bore and outer diameter tolerance. “P4Y” tolerance has the same running accuracy as P4 but has a narrower tolerance range of bore and outer diameter than P4. It is suitable for “random matching method” universal combination bearings.
- ”P4Y” is suitable for use “random matching method” universal combination bearings. However, when these bearings are operated over 1 500 000 d_mn, there is a possibility that this very small variation of fits with either the shaft or the housing can cause bearing failure because of imbalance of internal load in each row. If these bearings are considered for such high speed applications, this issue should be taken into account.

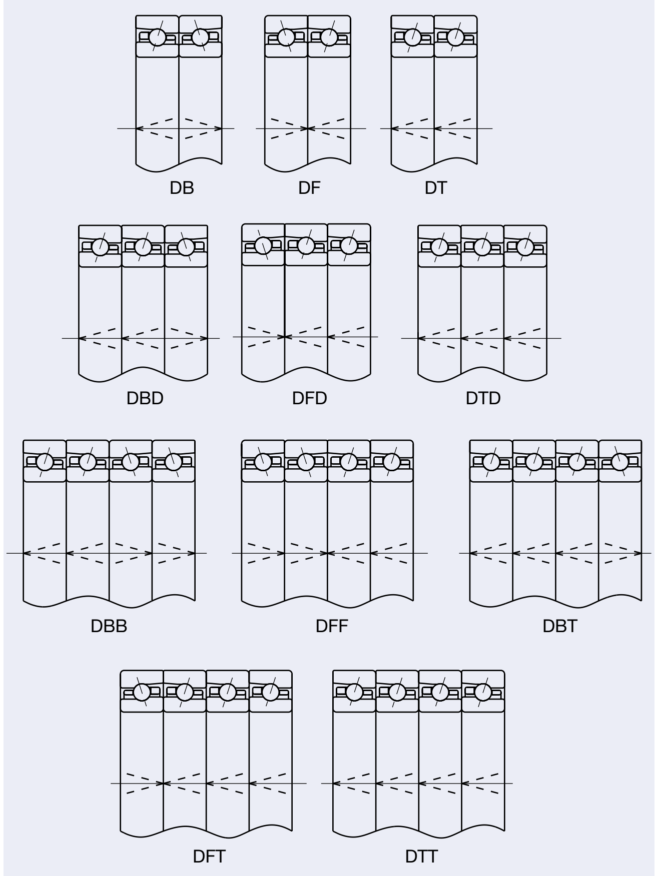
Fig. 3.8 Tolerance of P4 and P4Y Accuracy



When bearings are mounted in random matching method, variation of tolerance should be considered.

Combination Mark and Matching Method for Universal Combination Bearings

Fig. 3.9 Universal Bearings Combinations



Bore and Outer Diameter Tolerance (P4Y Accuracy)

Table 3.3 Tolerance of Bore Diameter of Inner Ring Unit: μm

Bore diameter		P4		P4Y (Controlled to medium value)	
Over	Incl	High	Low	High	Low
30	50	0	– 6	–1	–3
50	80	0	– 7	–2	–5
80	120	0	– 8	–3	–6
120	150	0	–10	–3	–7

✻Tolerances for bearings under 30mm bore are the same as values quoted between 30–50 mm bore.

Table 3.4 Tolerance of Outer Diameter of Outer Ring Unit: μm

Outer diameter		P4		P4Y (Controlled to medium value)	
Over	Incl	High	Low	High	Low
50	80	0	– 7	–2	–6
80	120	0	– 8	–2	–6
120	150	0	– 9	–3	–7
150	180	0	–10	–3	–7
180	200	0	–11	–4	–9
200	Under 215	0	–11	–2	–9

✻Tolerances for bearings under 50mm outer diameter are the same as values quoted between 50–80 mm outer diameter.

4. PRELOAD AND RIGIDITY

Regarding the rigidity of machine tool spindles, it is possible to think of the bearings as being springs. Axial displacement, when an axial load is applied to the spindle, is determined by the axial rigidity of the fixed end bearings.

When high radial rigidity is required, cylindrical roller bearings are generally used. Axial loads are usually sustained by angular contact ball bearings. The bigger the contact angle of the angular contact ball bearings, the higher the axial rigidity. Bearings of the same bore size, which have more rolling elements (diameter series 0 or 9; or BNR10 or BNR19 series), have higher rigidity, even though the diameter or the rolling elements is smaller.

Normally, preload is applied to bearings in order to increase rigidity of machine tool spindles. But if the preload is excessively high, flaking and possible seizure will result. Many users increase rigidity by using a combination of two or more angular contact ball bearings. This is especially true for ball screw support bearings, where high rigidity is required, the contact angle is big, and preload is higher than that for a spindle. Axial loads are widely sustained with two or three bearings.

Purpose

The main purposes of preloaded bearings in a machine tool spindle are as follows;

- · To improve and maintain the running accuracy of the shaft.
- · To increase bearing rigidity
- · To minimize noise due to axial vibration and resonance.
- · To prevent false brinelling.
- · To prevent sliding between the rolling elements and raceways due to gyroscopic moments.
- · To maintain the rolling elements in their proper position.

Usually a preload is applied to bearings by using two or more bearings in combination with each other, such as angular contact ball bearings or tapered roller bearings.

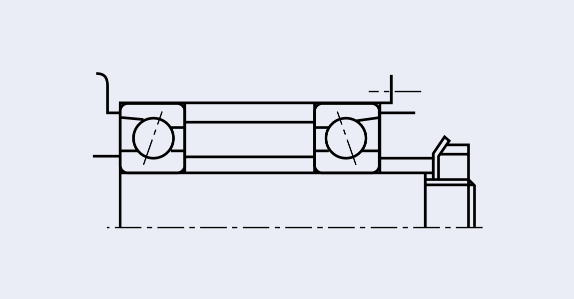
Cylindrical roller bearings can be preloaded by making the radial internal clearance negative.

(1) Position Preload

A position preload is achieved by fixing two axially opposed bearings in a position that remains unchanged while in operation. In practice, the following three methods are generally used to obtain a position preload.

1. By installing a duplex bearing set with previously adjusted stand-out dimensions and axial clearance
2. By using a spacer or shim of proper size to obtain the required spacing and preload (see Fig. 4.1).
3. By utilizing bolts or nuts to allow adjustment of the axial preload (In this case, the starting torque should be measured to verify the proper preload. However, this method cannot be recommended for high precision machine tool spindles due to difficulty in verifying the proper preload, thus risking vertical displacement (tilting) of the bearing.)

Fig. 4.1 Position Preload

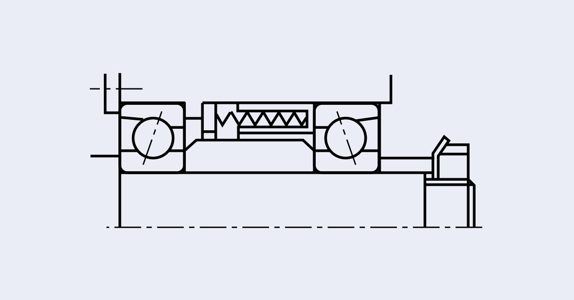


(2) Constant Pressure Preload

A constant pressure preload is achieved using a coil or leaf spring.

Even if the relative position of the bearings change during operation, the magnitude of the preload remains relatively constant. An angular contact ball bearing arrangement for high speed rotation is shown in Fig. 4.2.

Fig. 4.2 Constant Pressure Preload



Change of Rigidity by Preload

Position Preload and Axial Rigidity

When the inner rings of the duplex bearings shown in Fig. 4.3 are fixed axially, bearing A and B are displaced δ_{aoA} and δ_{aoB} and axial space δ_{ao} between the inner rings is eliminated. With this condition, a preload F_{ao} is imposed on each bearing. The relation between axial load, F_a and displacement in a duplex set is shown in Fig. 4.4. Figures.4.5 and 4.6 illustrate the same concepts for a DBD arrangement.

Back-to-Back Arrangement (DB)

Fig. 4.3 Preloaded DB Arrangement

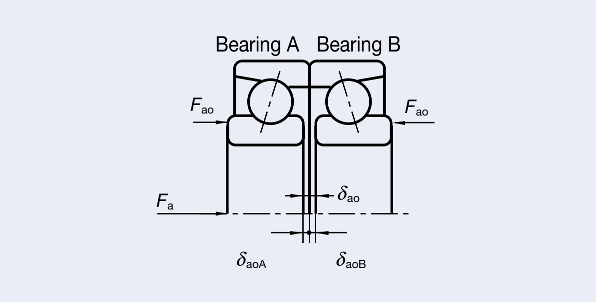
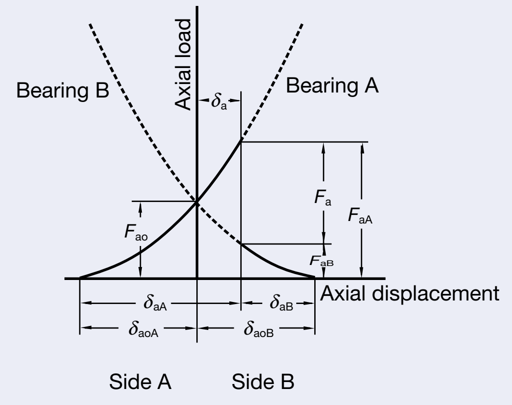


Fig. 4.4 Preloaded Axial Displacement of DB Arrangement



F_a : Axial load applied from outside
F_{aA} : Axial load imposed on bearing A
F_{aB} : Axial load imposed on bearing B
δ_a : Displacement of duplex set
δ_{aA} : Displacement of bearing A
δ_{aB} : Displacement of bearing B

DBD Arrangement

Fig. 4.5 Preloaded DBD Arrangement

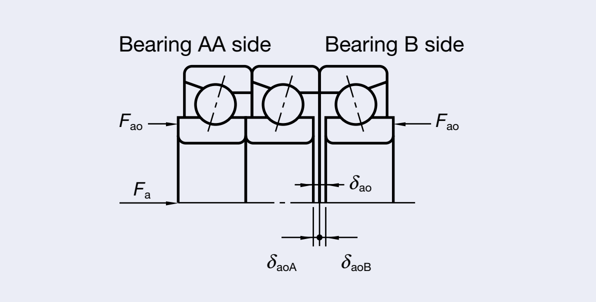
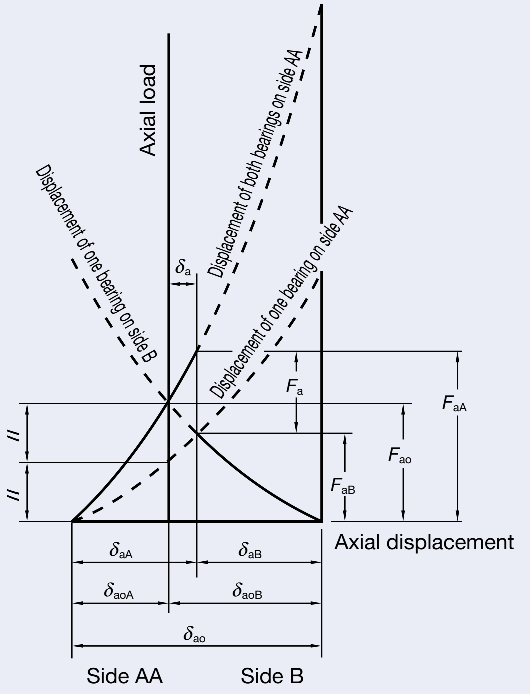


Fig. 4.6 Preloaded Axial Displacement of DBD Arrangement



F_a : Axial load applied from outside
F_{aA} : Axial load imposed on bearing AA
F_{aB} : Axial load imposed on bearing B
δ_a : Displacement of triplex set
δ_{aA} : Displacement of bearing AA
δ_{aB} : Displacement of bearing B

Constant Pressure Preload and Axial Rigidity

Fig. 4.7 illustrates duplex bearing under constant pressure preload. The deflection curve of the spring is nearly parellel to the horizontal axis due to the rigidity of the springs being smaller than that of the bearing. As a result, rigidity under constant pressure preload is approximately equal to that for a single bearing with a preload of F_{ao} being applied to it.

Fig. 4.8 compares the rigidity of a bearing with position preloading and one with constant pressure preloading.

Fig. 4.7 Axial Displacement with Constant Pressure Preload

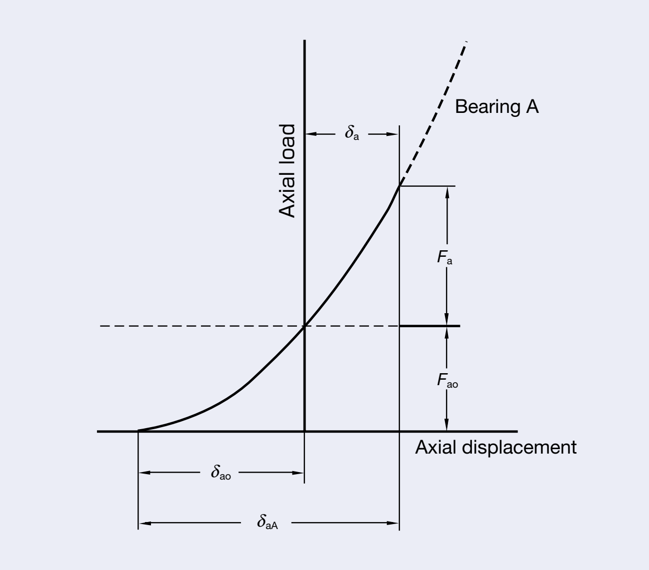
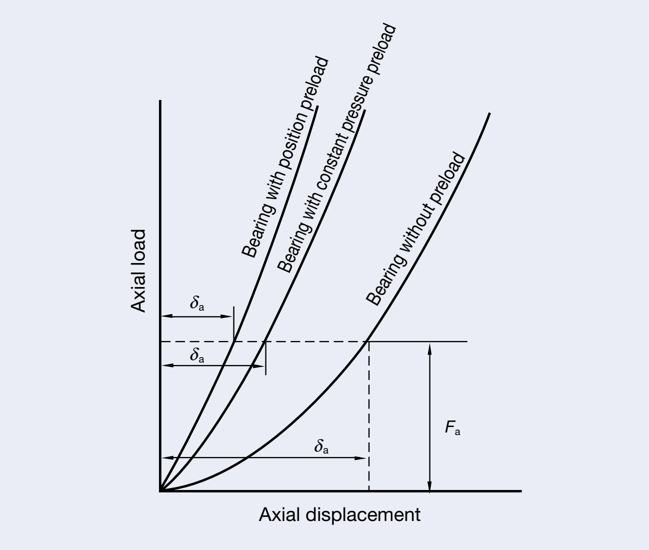


Fig. 4.8 Comparison of Stiffness and Preloading



Comparison of Preloading Methods

Position preload and constant pressure preload can be compared as follows:

(1) When both of the preloads are equal, the position preload provides greater bearing rigidity. In other words, the deflection due to external loads is less for bearings with a position preload.

(2) Under position preload, the preload varies depending on such factors as a difference in axial expansion due to a temperature difference between the shaft and housing, a difference in radial expansion due to a temperature difference between the inner and outer rings, and deflection due to load. Under constant pressure preload, it is possible to minimize any change in preload because the variation of the spring load with shaft expansion and contraction is negligible.

From the foregoing explanation, it is seen that position preloads are generally preferred for increasing rigidity while constant pressure preloads are more suitable for high speed applications.

Preload Amount

A larger preload results in higher rigidity. However, if preload is larger than necessary, abnormal heat is generated, which reduces fatigue life. In extreme cases, it may result in excessive wear or even seizure. Therefore, the amount of preload should be carefully studied and selected to avoid excessive preload while taking into consideration the type of application and the operating conditions.

High Speed Spindles and Preload

When bearings operate at high speed, the contact surface pressure between the balls and the inner and outer ring raceways increases due to expansion of the internal axial load caused by centrifugal force, generation of internal axial load caused by centrifugal force on the balls, and temperature difference between inner and outer rings. For bearings having a contact angle, such as angular contact ball bearings, pure rolling motion with sliding due to spin moments and gyroscopic moments on the balls may occur.

Sliding increases as bearing speed increases. As a result, the intensity of heat generated in the contact areas increases and the viscosity of the lubricating oil decreases. In some cases, a breakdown of the oil film occurs, resulting in complete seizure of the bearing. In other words, if the contact surface pressure at low speed operation is equal to that of high speed operation, then heat generation, which is due to sliding at high speeds, becomes more intense. This concept can be expressed quantitatively as a PV value, where P is the contact surface pressure, and V is the slip rate. The PV value can be applied to the rolling contact area of the bearing. If the PV value is constant, sliding is greater at high speed operation than at low speed operation. Whereas velocity is increased, it becomes necessary to reduce the contact surface pressure. NSK can calculate contact surface pressure and slip rate generated during high speed operations by computer. Taking advantage of abundant empirical test data and actual market results, we can determine the preload according to limiting factors, which are based on the lubricating method and rotating speed. For operations exceeding a $d_m n$ value of 800,000, please contact NSK.

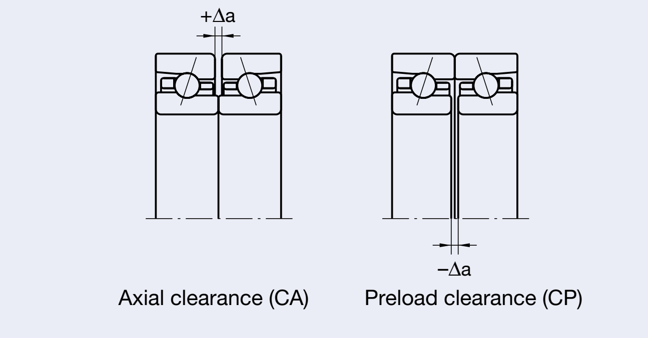
Special Clearance

For special clearance of combined angular contact ball bearings, NSK offers both CA and CP clearances.

CA: axial clearance (Clearance exists in the axial direction.)

CP: preload clearance (Preload is generated)

Fig. 4.9 Special Clearance



Preload Adjustment

When you change preload (for example "EL→L"), please adjust the difference of the measured axial clearance, by a spacer. (When increasing preload, inner spacer should be shorter, and outer spacer should be shorter when decreasing preload)

Please refer Page 138–146 of the measured axial clearances.

Please refer the measuring load of axial clearance to Table 4.1.

Table 4.1 Measuring load of axial clearance

Nominal Outside Diameter (mm)		Measuring load (N)
Over	Incl	
*10	50	24.5
50	120	49
120	200	98
200	–	196

* Applied to the bearing with the O. D. less htan 10mm.

Fig. 4.10 Radial Clearance in Double Row Cylindrical Roller Bearing and Variation of Rolling Fatique Life

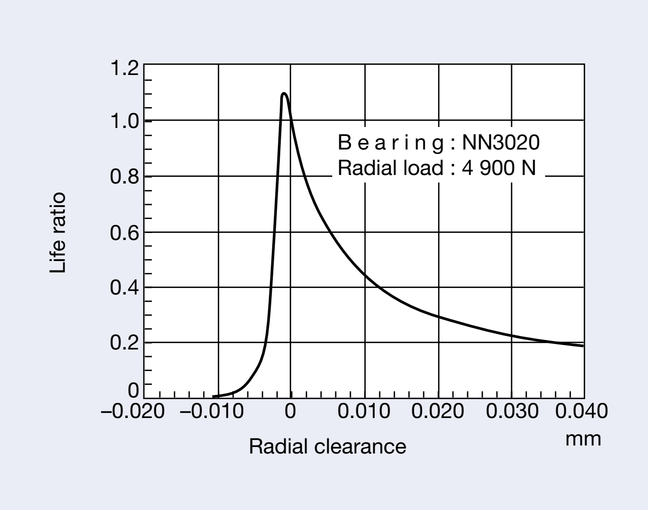
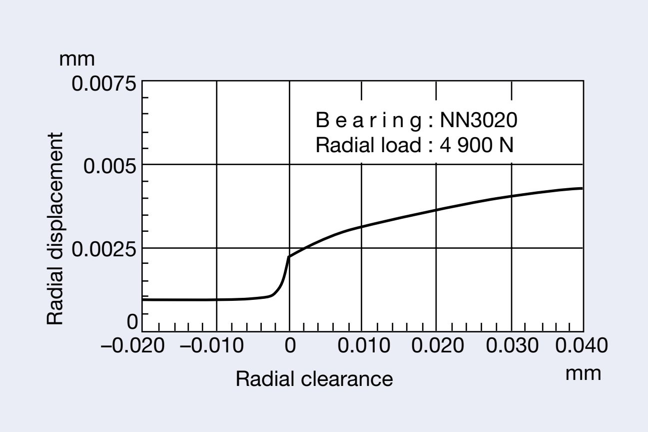


Fig. 4.11 Radial Clearance in Double Row Cylindrical Roller Bearing and Variation of Rigidity



Internal Clearance in Cylindrical Roller Bearings

In order for machine tool spindles to have high running accuracy and rigidity, bearings are used with minimum internal clearance or preload after mounted. Cylindrical roller bearings with tapered bores are usually used to allow easier adjustment of internal clearance. In general, cylindrical roller bearings for the front end (fixed end) of the spindle are adjusted to apply a preload during operating. Bearing for the rear end (free end) are adjusted when mounted to produce a slight clearance during operating. The amount of radial internal clearance after mounted is based on several factors such speed, load, lubricating method, bearing size, required rigidity, life, etc.

Fig. 4.10 illustrates the relation between radial internal clearance in a bearing and life. Fig. 4.11 shows the relation between radial internal clearance and radial elastic displacement of an NN3020 (Bore diameter 100mm, outside diameter 150mm, width 37mm).

Preload and Rigidity (DB and DF Arrangement)

High Precision Angular Contact Ball Bearing

(Standard series)

Calculation of radial rigidity
Multiply axial rigidity by factors in table A.

Table A

	EL	L	M	H
15˚	6.5	6.0	5.0	4.5
18˚	4.5			
25˚	2.0			
30˚	1.4			
40˚	0.7			

79 series, C angle
Nominal contact angle 15˚ Steel ball and Ceramic ball*

Bore Number	Nominal Bearing Bore (mm)	EL			L			M			H		
		Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
00	10	7	(5)	10	15	(2)	14	29	(–1)	19	59	(–6)	27
01	12	8.6	(4)	12	15	(2)	16	39	(–3)	24	78	(–8)	34
02	15	12	(3)	14	25	(0)	20	49	(–4)	26	100	(–11)	38
03	17	12	(3)	15	25	(0)	20	59	(–5)	30	120	(–12)	43
04	20	19	(1)	19	39	(–3)	26	78	(–8)	35	150	(–15)	48
05	25	19	(1)	21	39	(–2)	28	100	(–9)	43	200	(–17)	61
06	30	24	(0)	25	49	(–3)	33	100	(–9)	45	200	(–16)	65
07	35	34	(2)	29	69	(–2)	39	150	(–9)	55	290	(–18)	78
08	40	39	(1)	32	78	(–3)	42	200	(–12)	63	390	(–22)	88
09	45	50	(0)	37	100	(–5)	50	200	(–12)	66	390	(–21)	94
10	50	50	(0)	39	100	(–4)	51	250	(–14)	78	490	(–24)	111
11	55	60	(–1)	45	120	(–6)	58	290	(–15)	90	590	(–26)	127
12	60	60	(–1)	46	120	(–5)	60	290	(–14)	93	590	(–25)	128
13	65	75	(–2)	53	150	(–7)	71	340	(–16)	104	690	(–27)	146
14	70	100	(–4)	59	200	(–10)	79	490	(–22)	119	980	(–35)	168
15	75	100	(–4)	61	200	(–10)	88	490	(–21)	120	980	(–35)	171
16	80	100	(–4)	62	200	(–9)	80	490	(–21)	124	980	(–34)	173
17	85	145	(–6)	73	290	(–13)	97	640	(–25)	138	1 270	(–41)	191
18	90	145	(–3)	79	290	(–9)	102	740	(–23)	156	1 470	(–39)	219
19	95	145	(–3)	81	290	(–9)	105	780	(–24)	165	1 570	(–40)	231
20	100	195	(–5)	83	390	(–13)	112	880	(–27)	164	1 770	(–46)	231
21	105	195	(–5)	86	390	(–13)	116	880	(–27)	167	1 770	(–45)	235
22	110	195	(–5)	89	390	(–13)	120	930	(–27)	173	1 860	(–45)	244
24	120	270	(–8)	102	540	(–17)	135	1 270	(–35)	200	2 550	(–56)	278
26	130	320	(–10)	108	640	(–20)	148	1 470	(–38)	214	2 940	(–61)	302
28	140	320	(–10)	111	640	(–19)	150	1 470	(–37)	218	2 940	(–60)	309
30	150	395	(–7)	124	790	(–18)	166	1 790	(–38)	239	3 560	(–63)	334
32	160	425	(–8)	134	855	(–19)	179	1 930	(–39)	258	3 840	(–64)	361
34	170	485	(–9)	151	970	(–20)	200	2 180	(–40)	288	4 310	(–65)	403
36	180	595	(–12)	158	1 190	(–25)	211	2 650	(–48)	302	5 340	(–78)	425
38	190	605	(–12)	162	1 210	(–25)	217	2 790	(–49)	315	5 600	(–79)	443
40	200	785	(–16)	183	1 570	(–31)	244	3 570	(–58)	352	7 110	(–92)	493

79 series, A5 angle
Nominal contact angle 25˚ Steel ball and Ceramic ball*

Bore Number	Nominal Bearing Bore (mm)	EL			L			M			H		
		Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
00	10	9.8	(2)	24	20	(1)	31	49	(–3)	44	100	(–6)	59
01	12	16	(1)	32	29	(–1)	40	59	(–3)	52	120	(–7)	70
02	15	16	(1)	33	39	(–1)	46	78	(–4)	60	150	(–9)	78
03	17	19	(1)	34	39	(–1)	46	78	(–4)	62	150	(–8)	81
04	20	29	(0)	43	59	(–3)	60	120	(–6)	75	250	(–12)	103
05	25	34	(–1)	56	69	(–3)	70	150	(–7)	95	290	(–12)	123
06	30	39	(–1)	61	78	(–3)	77	150	(–6)	99	290	(–11)	131
07	35	50	(0)	70	100	(–3)	94	250	(–8)	127	490	(–15)	170
08	40	60	(–1)	72	120	(–3)	97	290	(–9)	139	590	(–16)	182
09	45	75	(–1)	87	150	(–4)	114	340	(–10)	160	690	(–17)	207
10	50	75	(–1)	94	150	(–4)	124	390	(–10)	175	780	(–18)	235
11	55	100	(–2)	112	200	(–5)	144	440	(–11)	198	880	(–18)	263
12	60	100	(–2)	117	200	(–5)	150	440	(–10)	198	880	(–18)	267
13	65	100	(–2)	125	200	(–5)	161	490	(–11)	223	980	(–18)	289
14	70	145	(–3)	138	290	(–7)	183	690	(–14)	249	1 370	(–24)	334
15	75	145	(–3)	142	290	(–7)	188	740	(–15)	267	1 470	(–24)	347
16	80	170	(–4)	156	340	(–8)	203	780	(–15)	274	1 570	(–25)	367
17	85	220	(–5)	172	440	(–9)	229	980	(–17)	306	1 960	(–29)	402
18	90	245	(–4)	188	490	(–8)	253	1 080	(–16)	340	2 160	(–27)	449
19	95	245	(–3)	195	490	(–8)	262	1 180	(–17)	363	2 350	(–28)	475
20	100	295	(–5)	197	590	(–10)	266	1 270	(–19)	346	2 550	(–31)	463
21	105	295	(–4)	203	590	(–9)	264	1 370	(–19)	368	2 750	(–32)	490
22	110	320	(–5)	222	640	(–10)	284	1 470	(–20)	391	2 940	(–33)	517
24	120	440	(–7)	244	880	(–13)	328	1 960	(–24)	441	3 920	(–39)	580
26	130	490	(–7)	262	980	(–14)	346	2 160	(–25)	460	4 310	(–41)	611
28	140	490	(–7)	273	980	(–13)	348	2 260	(–26)	479	4 510	(–42)	635
30	150	625	(–7)	308	1 250	(–14)	393	2 880	(–28)	540	5 860	(–47)	719
32	160	665	(–7)	330	1 330	(–14)	422	3 230	(–29)	592	6 290	(–47)	775
34	170	775	(–8)	376	1 550	(–15)	478	3 520	(–29)	653	7 110	(–48)	867
36	180	1 010	(–10)	397	2 020	(–19)	514	4 420	(–35)	693	8 830	(–57)	917
38	190	1 035	(–10)	409	2 070	(–19)	531	4 550	(–35)	717	9 110	(–57)	949
40	200	1 280	(–12)	453	2 560	(–22)	585	5 840	(–41)	801	11 620	(–66)	1 057

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* When a ceramic ball is used, Preload and axial rigidity value will be 1.2 times the value of steel ball.
The value in ( ) shows a measured axial clearance.

Calculation of preload and axial rigidity for combination bearings
Multiply by factors in table B.
For radial rigidity, multiply the value obtained in table A with factors in table B.

Table B

	DBD	DBB
Precoad factor	1.36	2
Axial rigidity	1.48	2
Radial rigidity	1.54	2

70 series, C angle
Nominal contact angle 15˚ Steel ball and Ceramic ball*

Bore Number	Nominal Bearing Bore (mm)	EL			L			M			H		
		Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
00	10	12	(3)	12	25	(0)	17	49	(–5)	23	100	(–12)	32
01	12	12	(3)	14	25	(0)	18	59	(–6)	26	120	(–14)	37
02	15	14	(3)	16	29	(–1)	20	69	(–7)	29	150	(–16)	43
03	17	14	(2)	16	29	(–1)	21	69	(–7)	31	150	(–16)	45
04	20	24	(0)	21	49	(–4)	28	120	(–12)	42	250	(–22)	59
05	25	29	(–1)	24	59	(–5)	32	150	(–14)	48	290	(–24)	68
06	30	39	(1)	29	78	(–3)	39	200	(–13)	59	390	(–24)	83
07	35	60	(–1)	36	120	(–7)	49	250	(–16)	68	490	(–28)	94
08	40	60	(–1)	39	120	(–6)	51	290	(–17)	77	590	(–30)	110
09	45	75	(–3)	43	150	(–8)	58	340	(–19)	85	690	(–33)	121
10	50	75	(–2)	46	150	(–8)	63	390	(–20)	96	780	(–34)	136
11	55	100	(–4)	51	200	(–11)	69	490	(–24)	102	980	(–40)	145
12	60	100	(–4)	53	200	(–11)	70	540	(–26)	110	1 080	(–42)	158
13	65	125	(–6)	61	250	(–13)	82	540	(–24)	117	1 080	(–39)	164
14	70	145	(–7)	68	290	(–14)	88	740	(–30)	135	1 470	(–48)	190
15	75	145	(–7)	70	290	(–14)	92	780	(–31)	144	1 570	(–49)	202
16	80	195	(–6)	76	390	(–14)	103	930	(–31)	152	1 860	(–52)	216
17	85	195	(–6)	78	390	(–14)	106	980	(–32)	161	1 960	(–52)	225
18	90	245	(–8)	87	490	(–18)	117	1 180	(–37)	172	2 350	(–60)	242
19	95	270	(–9)	93	540	(–19)	124	1 180	(–36)	176	2 350	(–58)	246
20	100	270	(–9)	97	540	(–18)	127	1 270	(–37)	187	2 550	(–60)	264
21	105	320	(–11)	103	640	(–21)	134	1 470	(–42)	198	2 940	(–67)	277
22	110	370	(–13)	104	740	(–25)	137	1 770	(–49)	203	3 530	(–78)	286
24	120	415	(–14)	116	830	(–26)	153	1 960	(–50)	225	3 920	(–79)	317
26	130	490	(–16)	126	980	(–29)	167	2 260	(–54)	244	4 510	(–85)	344
28	140	500	(–11)	132	1 000	(–24)	174	2 210	(–47)	248	4 420	(–77)	349
30	150	575	(–13)	141	1 150	(–27)	187	2 560	(–52)	267	5 100	(–84)	374
32	160	625	(–14)	147	1 250	(–29)	197	2 930	(–57)	288	5 840	(–90)	403
34	170	780	(–18)	160	1 560	(–35)	213	3 560	(–66)	309	7 150	(–104)	435
36	180	930	(–21)	179	1 860	(–39)	238	4 160	(–71)	342	8 320	(–111)	479
38	190	1 030	(–23)	188	2 060	(–42)	251	4 640	(–76)	360	9 340	(–119)	507
40	200	1 150	(–25)	198	2 300	(–45)	264	5 170	(–81)	379	10 350	(–126)	533

70 series, A5 angle
Nominal contact angle 25˚ Steel ball and Ceramic ball*

Bore Number	Nominal Bearing Bore (mm)	EL			L			M			H		
		Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
00	10	19	(1)	29	39	(–2)	41	78	(–5)	51	150	(–10)	67
01	12	19	(1)	31	39	(–2)	45	100	(–6)	60	200	(–12)	81
02	15	19	(1)	33	39	(–1)	43	100	(–6)	65	200	(–11)	84
03	17	24	(0)	41	49	(–2)	52	120	(–7)	75	250	(–13)	99
04	20	39	(–1)	51	78	(–4)	68	200	(–10)	97	390	(–17)	128
05	25	50	(–2)	61	100	(–5)	79	200	(–9)	99	390	(–16)	133
06	30	60	(–1)	68	120	(–4)	89	290	(–10)	129	590	(–18)	171
07	35	75	(–1)	78	150	(–5)	107	390	(–12)	149	780	(–21)	198
08	40	100	(–2)	95	200	(–6)	127	440	(–12)	168	880	(–21)	223
09	45	100	(–2)	99	200	(–6)	132	490	(–13)	181	980	(–22)	238
10	50	120	(–3)	118	250	(–7)	154	590	(–14)	208	1 180	(–24)	278
11	55	170	(–4)	127	340	(–9)	170	780	(–18)	235	1 570	(–29)	307
12	60	170	(–4)	134	340	(–9)	179	780	(–17)	241	1 570	(–28)	317
13	65	195	(–5)	157	390	(–9)	196	880	(–18)	272	1 770	(–29)	356
14	70	245	(–6)	170	490	(–11)	218	1 080	(–20)	293	2 160	(–33)	390
15	75	245	(–6)	179	490	(–11)	229	1 180	(–21)	316	2 350	(–34)	418
16	80	320	(–6)	187	640	(–11)	245	1 470	(–23)	343	2 940	(–37)	448
17	85	320	(–5)	196	640	(–11)	257	1 470	(–22)	352	2 940	(–36)	462
18	90	390	(–7)	218	780	(–13)	275	1 770	(–25)	374	3 530	(–41)	494
19	95	415	(–7)	227	830	(–13)	287	1 860	(–25)	392	3 730	(–42)	525
20	100	415	(–7)	235	830	(–13)	299	1 960	(–26)	417	3 920	(–42)	548
21	105	490	(–8)	246	980	(–15)	317	2 260	(–28)	430	4 510	(–46)	571
22	110	590	(–10)	258	1 180	(–18)	330	2 650	(–33)	447	5 300	(–53)	588
24	120	635	(–10)	281	1 270	(–18)	361	2 940	(–33)	491	5 880	(–54)	654
26	130	785	(–12)	305	1 570	(–20)	396	3 430	(–36)	536	6 860	(–58)	710
28	140	785	(–9)	317	1 570	(–18)	413	3 660	(–35)	569	7 270	(–56)	750
30	150	930	(–11)	351	1 850	(–20)	446	4 070	(–37)	601	8 250	(–61)	800
32	160	1 080	(–12)	376	2 160	(–22)	482	4 700	(–40)	649	9 380	(–65)	858
34	170	1 270	(–14)	401	2 550	(–25)	514	5 900	(–47)	707	11 600	(–75)	929
36	180	1 550	(–16)	450	3 100	(–28)	577	6 820	(–50)	779	13 560	(–80)	1 028
38	190	1 660	(–17)	460	3 320	(–29)	599	7 560	(–53)	819	15 130	(–85)	1 084
40	200	1 850	(–18)	493	3 700	(–31)	631	8 360	(–56)	860	16 820	(–90)	1 141

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* When a ceramic ball is used, Preload and axial rigidity value will be 1.2 times the value of steel ball.
The value in ( ) shows a measured axial clearance.

4. PRELOAD AND RIGIDITY

Preload and Rigidity (DB and DF Arrangement)

High Precision Angular Contact Ball Bearing

(Standard series)

Calculation of radial rigidity
Multiply axial rigidity by factors in table A.

Table A

	EL	L	M	H
15˚	6.5	6.0	5.0	4.5
18˚	4.5			
25˚	2.0			
30˚	1.4			
40˚	0.7			

70 series, A angle
Nominal contact angle 30˚ Steel ball

Bore Number	Nominal Bearing Bore (mm)	EL			L			M			H		
		Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
00	10	25	(0)	44	100	(-5)	71	210	(–10)	94	–		–
01	12	25	(0)	48	110	(-5)	78	220	(–10)	104	–		–
02	15	25	(0)	50	110	(-5)	85	240	(–10)	113	–		–
03	17	25	(0)	52	120	(-5)	91	250	(–10)	122	–		–
04	20	25	(0)	58	130	(-5)	103	280	(–10)	139	470	(–15)	170
05	25	25	(0)	61	140	(-5)	111	290	(–10)	149	510	(–15)	183
06	30	50	(0)	85	190	(-5)	138	390	(–10)	180	640	(–15)	217
07	35	50	(0)	92	210	(–5)	150	420	(–10)	196	700	(–15)	237
08	40	50	(0)	100	220	(–5)	168	460	(–10)	220	760	(–15)	267
09	45	50	(0)	103	230	(–5)	175	480	(–10)	230	1 180	(–20)	324
10	50	50	(0)	110	250	(–5)	194	530	(–10)	255	1 270	(–20)	360
11	55	50	(0)	112	250	(–5)	196	880	(–15)	311	1 270	(–20)	360
12	60	50	(0)	116	250	(–5)	205	930	(–15)	327	1 370	(–20)	380
13	65	50	(0)	124	270	(–5)	224	980	(–15)	360	1 470	(–20)	417
14	70	50	(0)	127	270	(–5)	230	1 080	(–16)	370	2 060	(–25)	482
15	75	50	(0)	131	280	(–5)	241	1 080	(–15)	387	2 160	(–25)	505
16	80	100	(0)	168	760	(–10)	340	1 770	(–20)	464	3 040	(–30)	572
17	85	100	(0)	173	780	(–10)	355	1 860	(–20)	486	3 240	(–30)	600
18	90	100	(0)	174	780	(–10)	358	2 450	(–25)	542	3 920	(–35)	650
19	95	100	(0)	180	810	(–10)	372	2 550	(–25)	568	4 120	(–35)	680
20	100	100	(0)	185	840	(–10)	368	2 750	(–25)	595	4 310	(–35)	713
21	105	100	(0)	185	840	(–10)	388	2 750	(–25)	591	4 310	(–35)	707
22	110	100	(0)	180	1 320	(–15)	443	3 330	(–30)	620	5 980	(–45)	774
24	120	100	(0)	193	1 470	(–15)	486	3 630	(–30)	683	6 570	(–45)	853
26	130	100	(0)	200	1 470	(–15)	507	4 710	(–35)	772	7 940	(–50)	942
28	140	200	(0)	206	1 770	(–15)	557	5 300	(–35)	828	8 730	(–50)	1 005
30	150	200	(0)	256	1 830	(–15)	573	5 850	(–37)	876	11 700	(–60)	1 146
32	160	200	(0)	260	1 880	(–15)	591	5 545	(–35)	870	12 070	(–60)	1 143
34	170	200	(0)	262	2 669	(–20)	669	6 024	(–37)	899	12 048	(–60)	1 178
36	180	200	(0)	273	3 580	(–24)	778	7 157	(–40)	1 001	14 314	(–64)	1 311
38	190	200	(0)	276	3 851	(–25)	809	8 081	(–43)	1 060	16 162	(–69)	1 389
40	200	200	(0)	279	5 012	(–30)	902	13 314	(–60)	1 294	26 628	(–95)	1 708

The value in ( ) shows a measured axial clearance.

Calculation of preload and axial rigidity for combination bearings
Multiply by factors in table B.
For radial rigidity, multiply the value obtained in table A with factors in table B.

Table B

	DBD	DBB
Preload factor	1.36	2
Axial rigidity	1.48	2
Radial rigidity	1.54	2

72 series, C angle
Nominal contact angle 15˚ Steel ball

Bore Number	Nominal Bearing Bore (mm)	EL			L			M			H		
		Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
00	10	14	(3)	13	29	(–1)	18	69	(–8)	27	150	(–18)	38
01	12	19	(1)	16	39	(–3)	21	100	(–12)	33	200	(–22)	46
02	15	19	(1)	17	39	(–3)	23	100	(–11)	34	200	(–21)	48
03	17	24	(0)	19	49	(–4)	25	150	(–16)	42	290	(–28)	59
04	20	34	(–2)	23	69	(–7)	30	200	(–20)	49	390	(–33)	70
05	25	39	(1)	26	78	(–4)	36	200	(–15)	53	390	(–26)	76
06	30	60	(–1)	32	120	(–8)	43	290	(–20)	66	590	(–35)	94
07	35	75	(–3)	37	150	(–10)	50	390	(–25)	75	780	(–43)	108
08	40	100	(–5)	44	200	(–13)	60	490	(–29)	90	980	(–47)	126
09	45	125	(–7)	49	250	(–16)	67	540	(–30)	94	1 080	(–49)	132
10	50	125	(–7)	52	250	(–15)	69	590	(–31)	102	1 180	(–50)	143
11	55	145	(–8)	56	290	(–17)	74	780	(–38)	117	1 570	(–60)	163
12	60	195	(–11)	64	390	(–22)	86	930	(–42)	126	1 860	(–67)	179
13	65	220	(–12)	71	440	(–23)	95	1 080	(–44)	141	2 160	(–70)	200
14	70	245	(–9)	75	490	(–20)	100	1 180	(–43)	148	2 350	(–69)	210
15	75	270	(–10)	81	540	(–21)	108	1 230	(–42)	157	2 450	(–68)	220
16	80	295	(–12)	83	590	(–24)	109	1 370	(–47)	159	2 750	(–76)	224
17	85	345	(–14)	88	690	(–27)	120	1 670	(–53)	177	3 330	(–85)	251
18	90	390	(–15)	97	780	(–29)	126	1 860	(–57)	187	3 730	(–90)	263
19	95	440	(–18)	98	880	(–33)	130	2 060	(–63)	192	4 120	(–99)	271
20	100	490	(–20)	101	980	(–36)	137	2 350	(–68)	202	4 710	(–107)	285
21	105	540	(–21)	108	1 080	(–38)	144	2 650	(–73)	216	5 300	(–114)	305
22	110	635	(–24)	117	1 270	(–43)	156	2 940	(–78)	228	5 880	(–121)	321
24	120	700	(–19)	128	1 400	(–38)	170	3 210	(–73)	247	6 350	(–116)	345
26	130	760	(–20)	138	1 520	(–39)	183	3 400	(–73)	262	6 740	(–116)	367
28	140	925	(–24)	152	1 850	(–45)	202	4 110	(–82)	288	8 300	(–131)	406
30	150	1 110	(–28)	167	2 220	(–51)	222	4 960	(–92)	318	9 970	(–145)	447

72 series, A5 angle
Nominal contact angle 25˚ Steel ball

Bore Number	Nominal Bearing Bore (mm)	EL			L			M			H		
		Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
00	10	19	(1)	29	39	(–2)	41	100	(–7)	58	200	(–13)	73
01	12	29	(–1)	36	59	(–3)	49	150	(–9)	70	290	(–16)	92
02	15	34	(–1)	43	69	(–4)	57	200	(–11)	83	390	(–19)	111
03	17	39	(–1)	46	78	(–4)	60	200	(–11)	87	390	(–18)	116
04	20	60	(–3)	59	120	(–6)	73	290	(–14)	104	590	(–24)	140
05	25	75	(–2)	68	150	(–5)	90	340	(–12)	124	690	(–22)	167
06	30	100	(–3)	85	200	(–7)	107	440	(–15)	147	880	(–25)	192
07	35	125	(–4)	95	250	(–8)	118	590	(–18)	167	1 180	(–30)	218
08	40	145	(–4)	104	290	(–9)	136	740	(–20)	195	1 470	(–33)	258
09	45	170	(–5)	115	340	(–10)	147	880	(–22)	212	1 770	(–37)	280
10	50	195	(–6)	129	390	(–11)	163	980	(–23)	233	1 960	(–37)	306
11	55	245	(–7)	141	490	(–13)	181	1 180	(–26)	255	2 350	(–42)	337
12	60	295	(–8)	155	590	(–15)	202	1 470	(–29)	281	2 940	(–47)	374
13	65	345	(–9)	177	690	(–15)	221	1 670	(–30)	314	3 330	(–48)	414
14	70	390	(–8)	188	780	(–15)	238	1 860	(–30)	331	3 730	(–49)	438
15	75	415	(–8)	199	830	(–15)	253	1 960	(–30)	352	3 920	(–49)	466
16	80	465	(–9)	200	930	(–17)	258	2 160	(–33)	356	4 310	(–54)	472
17	85	540	(–10)	217	1 080	(–19)	283	2 450	(–35)	383	4 900	(–57)	507
18	90	635	(–12)	239	1 270	(–21)	304	2 940	(–39)	416	5 880	(–64)	556
19	95	685	(–13)	240	1 370	(–23)	308	3 140	(–42)	419	6 280	(–68)	557
20	100	785	(–14)	251	1 570	(–25)	325	3 530	(–45)	441	7 060	(–73)	587
21	105	885	(–15)	267	1 770	(–27)	348	3 920	(–48)	471	7 850	(–77)	624
22	110	980	(–16)	280	1 960	(–29)	368	4 410	(–51)	496	8 830	(–82)	660
24	120	1 140	(–15)	315	2 280	(–28)	409	5 180	(–52)	559	10 350	(–85)	739
26	130	1 200	(–15)	334	2 410	(–28)	435	5 500	(–52)	595	11 000	(–83)	788
28	140	1 480	(–18)	373	2 970	(–32)	481	6 650	(–58)	654	13 480	(–93)	870
30	150	1 810	(–21)	416	3 620	(–36)	532	7 990	(–64)	719	16 350	(–104)	960

The value in ( ) shows a measured axial clearance.

Preload and Rigidity (DB and DF Arrangement)

High Precision Angular Contact Ball Bearing

(Standard series)

Calculation of radial rigidity
Multiply axial rigidity by factors in table A.

Table A

	EL	L	M	H
15˚	6.5	6.0	5.0	4.5
18˚	4.5			
25˚	2.0			
30˚	1.4			
40˚	0.7			

72 series, A angle
Nominal contact angle 30˚ Steel ball

Bore Number	Nominal Bearing Bore (mm)	EL			L			M			H		
		Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
00	10	25	(0)	44	100	(–5)	71	210	(–10)	94	–		–
01	12	25	(0)	47	110	(–5)	78	220	(–10)	103	360	(–15)	125
02	15	25	(0)	50	110	(–5)	85	240	(–10)	114	390	(–15)	139
03	17	25	(0)	52	190	(–5)	108	250	(–10)	120	410	(–15)	145
04	20	25	(0)	55	260	(–10)	128	440	(–15)	155	650	(–20)	180
05	25	50	(0)	79	350	(–10)	160	580	(–15)	193	840	(–20)	223
06	30	50	(0)	85	380	(–10)	175	630	(–15)	210	910	(–20)	423
07	35	50	(0)	88	400	(–10)	184	660	(–15)	220	1 270	(–25)	285
08	40	50	(0)	95	440	(–10)	205	730	(–15)	246	1 470	(–26)	318
09	45	50	(0)	98	450	(–10)	212	1 080	(–20)	292	1 860	(–30)	363
10	50	50	(0)	103	480	(–10)	227	1 180	(–20)	314	2 060	(–30)	390
11	55	50	(0)	106	490	(–10)	235	1 670	(–26)	364	2 650	(–35)	438
12	60	50	(0)	110	510	(–10)	246	1 670	(–25)	380	2 750	(–35)	455
13	65	50	(0)	117	550	(–10)	270	1 860	(–25)	416	3 040	(–35)	500
14	70	100	(0)	150	1 080	(–15)	345	2 650	(–30)	480	3 920	(–40)	562
15	75	100	(0)	157	1 080	(–15)	366	2 750	(–30)	512	4 220	(–40)	598
16	80	100	(0)	154	1 080	(–15)	355	2 650	(–30)	494	4 020	(–40)	575
17	85	100	(0)	160	1 180	(–16)	370	3 430	(–35)	560	5 790	(–50)	678
18	90	100	(0)	162	1 670	(–20)	434	4 310	(–40)	615	5 980	(–50)	697
19	95	360	(–5)	248	1 670	(–20)	421	4 220	(–40)	595	6 670	(–55)	710
20	100	370	(–5)	252	1 670	(–20)	430	5 100	(–45)	645	7 650	(–60)	758
21	105	380	(–5)	260	2 260	(–25)	493	5 200	(–45)	665	8 920	(–65)	818
22	110	380	(–5)	266	2 350	(–25)	504	6 180	(–50)	720	10 200	(–70)	871
24	120	550	(–5)	320	2 840	(–25)	570	8 140	(–55)	843	11 570	(–70)	964
26	130	560	(–5)	340	3 730	(–30)	660	9 810	(–60)	942	13 530	(–75)	1 068
28	140	580	(–5)	352	5 000	(–36)	750	11 470	(–65)	1 022	15 490	(–80)	1 150
30	150	600	(–5)	366	5 000	(–35)	772	12 100	(–66)	1 063	16 500	(–81)	1 194

Small size angular contact ball bearing

Bearing Number	EL			L			M			H		
	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
725C	1.3	(10)	4.0	5.5	(7)	7.3	12.1	(4)	10.3	24.2	(0)	14.4
725A	5.0	(3)	18.5	10.3	(2)	23.8	24.5	(0)	32.6	49.0	(–3)	42.5
706C	1.5	(10)	4.3	7.9	(6)	8.3	15.1	(3)	11.1	30.3	(–2)	15.4
706A	4.9	(3)	18.6	16.8	(1)	28.7	24.4	(0)	32.8	48.8	(–3)	42.4
726C	1.8	(9)	5.1	9.2	(5)	9.6	17.6	(2)	12.8	35.2	(–3)	27.8
726A	3.7	(3)	18.4	16.2	(1)	30.8	34.0	(–1)	40.3	68.0	(–4)	52.4
707C	1.8	(9)	5.1	9.2	(5)	9.6	17.6	(2)	12.8	35.2	(–3)	17.8
707A	3.7	(3)	18.4	16.2	(1)	30.8	34.0	(–1)	40.3	68.0	(–4)	52.4
708C	4.2	(7)	7.5	14.1	(3)	12.2	28.6	(–1)	16.7	57.1	(–7)	23.3
708A	8.1	(2)	26.3	24.5	(0)	38.8	46.4	(–2)	48.9	92.8	(–5)	63.4
728C	4.2	(7)	7.5	14.1	(3)	12.2	28.5	(–1)	16.7	57.0	(–7)	23.3
728A	8.1	(2)	26.3	24.5	(–1)	38.8	46.4	(–2)	48.9	92.9	(–5)	63.4

The value in ( ) shows a measured axial clearance.

Ultra High Speed Angular Contact Ball Bearing

(ROBUST series)

Calculation of preload and axial rigidity for combination bearings
Preload and axial rigidity can be obtained by multipling factors in table B.
For radial rigidity, multiply the value obtained in table A with factors in table B.

Table B

	DBD	DBB
Preload factor	1.36	2
Axial rigidity	1.48	2
Radial rigidity	1.54	2

BNR19S
Nominal contact angle 18˚ Steel ball

Nominal Bearing Bore (mm)	EL			L			M		
	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
25	25	(0)	26	94	(–8)	43	188	(–16)	57
30	50	(0)	36	100	(–8)	48	200	(–15)	63
35	50	(0)	37	140	(–8)	55	280	(–17)	73
40	50	(0)	38	140	(–8)	57	280	(–16)	74
45	50	(0)	41	150	(–8)	62	300	(–16)	82
50	50	(0)	44	160	(–8)	68	320	(–16)	89
55	50	(0)	46	170	(–8)	71	340	(–16)	94
60	50	(0)	47	170	(–8)	74	340	(–16)	97
65	50	(0)	50	180	(–8)	79	360	(–16)	104
70	50	(0)	50	180	(–8)	80	360	(–16)	104
75	50	(0)	52	180	(–8)	83	460	(–19)	117
80	50	(0)	53	190	(–8)	86	474	(–19)	121
85	50	(0)	54	190	(–8)	88	646	(–24)	138
90	100	(0)	75	280	(–8)	110	709	(–21)	154
95	100	(0)	76	290	(–8)	110	768	(–22)	163
100	100	(0)	72	330	(–10)	110	871	(–26)	161
105	100	(0)	74	330	(–10)	120	898	(–26)	166
110	100	(0)	76	400	(–12)	130	925	(–26)	172
120	100	(0)	78	410	(–12)	130	1 275	(–33)	198
130	100	(0)	80	712	(–20)	160	1 408	(–35)	209
140	100	(0)	82	732	(–20)	160	1 508	(–36)	220
150	200	(0)	110	930	(–20)	185	1 894	(–38)	242

BER19S
Nominal contact angle 25˚ Steel ball

Nominal Bearing Bore (mm)	EL			L			M		
	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
25	25	(0)	42	150	(–8)	80	300	(–14)	105
30	25	(0)	58	160	(–8)	90	320	(–14)	116
35	50	(0)	61	210	(–8)	100	420	(–15)	132
40	50	(0)	63	220	(–8)	110	440	(–15)	137
45	50	(0)	67	240	(–8)	120	480	(–15)	152
50	50	(0)	72	250	(–8)	130	500	(–15)	164
55	50	(0)	75	260	(–8)	140	520	(–15)	174
60	50	(0)	78	270	(–8)	140	540	(–15)	181
65	50	(0)	82	290	(–8)	150	580	(–15)	196
70	50	(0)	83	290	(–8)	150	598	(–15)	198
75	50	(0)	86	300	(–8)	160	619	(–15)	206
80	50	(0)	88	310	(–8)	170	639	(–15)	214
85	50	(0)	90	310	(–8)	170	889	(–19)	245
90	100	(0)	120	430	(–8)	210	968	(–17)	273
95	100	(0)	130	440	(–8)	210	996	(–17)	282
100	100	(0)	120	520	(–10)	210	1 131	(–20)	279
105	100	(0)	120	530	(–10)	220	1 169	(–20)	290
110	100	(0)	130	550	(–10)	230	1 206	(–20)	301
120	100	(0)	130	680	(–12)	250	1 743	(–26)	351
130	100	(0)	135	972	(–16)	289	1 880	(–27)	368
140	100	(0)	135	1 002	(–16)	300	1 944	(–27)	381
150	200	(0)	175	1 308	(–17)	336	2 555	(–30)	428

The value in ( ) shows a measured axial clearance.

Preload and Rigidity (DB and DF Arrangement)

Ultra High Speed Angular Contact Ball Bearing

(ROBUST series)

Calculation of radial rigidity
Multiply axial rigidity by factors in table A.

Table A

	EL	L	M	H
15˚	6.5	6.0	5.0	4.5
18˚	4.5			
25˚	2.0			
30˚	1.4			
40˚	0.7			

BNR19H, BNR19X, BNR19XE
Nominal contact angle 18˚ Ceramic ball

Nominal Bearing Bore (mm)	EL			L			M		
	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
25	25	(0)	29	105	(–8)	51	210	(–15)	67
30	50	(0)	40	110	(–8)	55	220	(–15)	72
35	50	(0)	41	150	(–8)	64	300	(–16)	83
40	50	(0)	42	160	(–8)	66	320	(–17)	87
45	50	(0)	45	170	(–8)	72	340	(–16)	95
50	50	(0)	49	180	(–8)	78	360	(–16)	103
55	50	(0)	51	180	(–8)	82	360	(–15)	106
60	50	(0)	52	190	(–8)	85	380	(–16)	112
65	50	(0)	55	200	(–8)	91	400	(–16)	120
70	50	(0)	56	200	(–8)	92	400	(–16)	120
75	50	(0)	58	200	(–8)	96	525	(–19)	137
80	50	(0)	59	210	(–8)	99	542	(–19)	142
85	50	(0)	61	210	(–8)	100	744	(–24)	162
90	100	(0)	83	310	(–8)	130	804	(–21)	180
95	100	(0)	85	310	(–8)	130	873	(–22)	190
100	100	(0)	81	360	(–10)	130	994	(–26)	188
105	100	(0)	83	370	(–10)	130	1 026	(–26)	194
110	100	(0)	85	450	(–12)	150	1 058	(–26)	201
120	100	(0)	87	460	(–12)	150	1 469	(–33)	233
130	100	(0)	90	809	(–20)	158	1 625	(–35)	245
140	100	(0)	92	833	(–20)	195	1 744	(–36)	259
150	200	(0)	120	1 040	(–20)	214	2 166	(–38)	284

BER19H, BER19X, BER19XE
Nominal contact angle 25˚ Ceramic ball

Nominal Bearing Bore (mm)	EL			L			M		
	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
25	25	(0)	47	172	(–8)	96	342	(–14)	124
30	50	(0)	65	180	(–8)	100	360	(–14)	134
35	50	(0)	68	240	(–8)	120	480	(–15)	153
40	50	(0)	70	250	(–8)	120	500	(–15)	160
45	50	(0)	75	260	(–8)	140	520	(–15)	174
50	50	(0)	80	280	(–8)	150	560	(–15)	190
55	50	(0)	84	300	(–8)	160	600	(–15)	203
60	50	(0)	87	300	(–8)	160	600	(–14)	209
65	50	(0)	92	320	(–8)	180	640	(–14)	225
70	50	(0)	93	330	(–8)	180	689	(–15)	233
75	50	(0)	96	340	(–8)	190	713	(–15)	243
80	50	(0)	98	350	(–8)	190	738	(–15)	252
85	50	(0)	100	360	(–8)	200	1 032	(–19)	290
90	100	(0)	140	480	(–8)	240	1 110	(–17)	321
95	100	(0)	140	490	(–8)	250	1 143	(–17)	332
100	100	(0)	130	580	(–10)	250	1 302	(–20)	328
105	100	(0)	140	600	(–10)	260	1 346	(–20)	341
110	100	(0)	140	620	(–10)	260	1 390	(–20)	354
120	100	(0)	150	780	(–12)	300	2 023	(–26)	414
130	100	(0)	150	1 115	(–16)	340	2 185	(–27)	434
140	100	(0)	150	1 151	(–16)	353	2 261	(–27)	450
150	200	(0)	198	1 484	(–17)	393	2 948	(–30)	504

The value in ( ) shows a measured axial clearance.

Calculation of preload and axial rigidity for combination bearings
Preload and axial rigidity can be obtained by multipling factors in table B.
For radial rigidity, multiply the value obtained in table A with factors in table B.

Table B

	DBD	DBB
Preload factor	1.36	2
Axial rigidity	1.48	2
Radial rigidity	1.54	2

BNR10S
Nominal contact angle 18˚ Steel ball

Nominal Bearing Bore (mm)	EL			L			M		
	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
30	50	(0)	39	110	(–5)	52	220	(–13)	69
35	50	(0)	41	110	(–5)	55	220	(–12)	73
40	50	(0)	44	110	(–5)	60	220	(–11)	77
45	50	(0)	44	110	(–5)	60	220	(–11)	77
50	50	(0)	47	120	(–5)	64	249	(–12)	85
55	50	(0)	48	120	(–5)	67	302	(–14)	95
60	50	(0)	51	130	(–5)	71	345	(–15)	104
65	50	(0)	53	130	(–5)	75	364	(–15)	111
70	50	(0)	53	230	(–10)	93	505	(–20)	125
75	50	(0)	54	240	(–10)	96	520	(–20)	129
80	100	(0)	71	330	(–10)	110	606	(–19)	141
85	100	(0)	73	330	(–10)	110	622	(–19)	145
90	100	(0)	74	340	(–10)	120	823	(–24)	163
95	100	(0)	76	350	(–10)	120	846	(–24)	168
100	100	(0)	78	350	(–10)	120	870	(–24)	174
105	100	(0)	80	420	(–12)	130	1 054	(–27)	195
110	100	(0)	81	540	(–15)	150	1 144	(–29)	200
120	100	(0)	85	560	(–15)	160	1 208	(–29)	213
130	100	(0)	85	732	(–20)	166	1 508	(–36)	220
140	200	(0)	105	775	(–15)	178	1 606	(–30)	236
150	200	(0)	110	916	(–18)	190	1 917	(–35)	253

BER10S
Nominal contact angle 25˚ Steel ball

Nominal Bearing Bore (mm)	EL			L			M		
	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
30	50	(0)	63	220	(–8)	110	440	(–15)	140
35	50	(0)	67	240	(–8)	120	480	(–15)	153
40	50	(0)	72	250	(–8)	130	500	(–15)	165
45	50	(0)	73	250	(–8)	130	500	(–15)	166
50	50	(0)	77	270	(–8)	140	540	(–15)	180
55	50	(0)	80	350	(–10)	160	700	(–18)	205
60	50	(0)	84	380	(–10)	170	760	(–18)	222
65	50	(0)	88	400	(–10)	180	800	(–18)	235
70	50	(0)	88	400	(–10)	180	800	(–18)	235
75	50	(0)	90	510	(–12)	200	1 020	(–21)	263
80	100	(0)	120	620	(–12)	220	1 240	(–22)	290
85	100	(0)	120	640	(–12)	230	1 280	(–22)	300
90	100	(0)	120	650	(–12)	240	1 300	(–22)	305
95	100	(0)	130	670	(–12)	240	1 340	(–22)	316
100	100	(0)	130	690	(–12)	250	1 380	(–22)	327
105	100	(0)	130	910	(–15)	290	1 820	(–26)	369
110	100	(0)	130	930	(–15)	290	1 860	(–26)	379
120	100	(0)	140	980	(–15)	310	1 960	(–26)	403
130	100	(0)	140	1 002	(–16)	310	2 004	(–27)	389
140	200	(0)	180	1 098	(–13)	325	2 196	(–23)	421
150	200	(0)	180	1 274	(–15)	345	2 562	(–28)	444

The value in ( ) shows a measured axial clearance.

Preload and Rigidity (DB and DF Arrangement)

Ultra High Speed Angular Contact Ball Bearing

(ROBUST series)

Calculation of radial rigidity
Multiply axial rigidity by factors in table A.

Table A

	EL	L	M	H
15˚	6.5	6.0	5.0	4.5
18˚	4.5			
25˚	2.0			
30˚	1.4			
40˚	0.7			

BNR10H, BNR10X, BNR10XE
Nominal contact angle 18˚ Ceramic ball

Nominal Bearing Bore (mm)	EL			L			M		
	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
30	50	(0)	43	110	(–5)	59	220	(–11)	79
35	50	(0)	46	120	(–5)	63	240	(–12)	83
40	50	(0)	49	120	(–5)	68	240	(–11)	88
45	50	(0)	49	120	(–5)	69	240	(–11)	88
50	50	(0)	52	130	(–5)	73	279	(–12)	99
55	50	(0)	54	130	(–5)	76	341	(–14)	110
60	50	(0)	57	140	(–5)	82	391	(–15)	121
65	50	(0)	60	140	(–5)	87	413	(–15)	130
70	50	(0)	59	260	(–10)	110	578	(–20)	147
75	50	(0)	61	270	(–10)	110	597	(–20)	151
80	100	(0)	80	360	(–10)	130	684	(–19)	164
85	100	(0)	82	370	(–10)	130	703	(–19)	169
90	100	(0)	83	370	(–10)	130	938	(–24)	191
95	100	(0)	85	380	(–10)	140	965	(–24)	197
100	100	(0)	87	390	(–10)	140	993	(–24)	204
105	100	(0)	89	470	(–12)	160	1 209	(–28)	229
110	100	(0)	91	600	(–15)	170	1 315	(–29)	235
120	100	(0)	95	630	(–15)	180	1 391	(–29)	250
130	100	(0)	95	833	(–20)	195	1 745	(–36)	260
140	200	(0)	125	860	(–15)	206	1 829	(–30)	276
150	200	(0)	125	1 025	(–18)	221	2 194	(–35)	297

BER10H, BER10X, BER10XE
Nominal contact angle 25˚ Ceramic ball

Nominal Bearing Bore (mm)	EL			L			M		
	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)	Preload (N)		Axial Rigidity (N/μm)
30	50	(0)	71	250	(–8)	130	500	(–15)	163
35	50	(0)	75	260	(–8)	140	520	(–15)	175
40	50	(0)	80	280	(–8)	150	560	(–15)	191
45	50	(0)	81	280	(–8)	150	560	(–14)	192
50	50	(0)	86	300	(–8)	160	600	(–14)	208
55	50	(0)	89	400	(–10)	190	800	(–18)	240
60	50	(0)	94	430	(–10)	200	860	(–18)	260
65	50	(0)	99	450	(–10)	210	900	(–17)	275
70	50	(0)	98	450	(–10)	210	900	(–17)	275
75	50	(0)	100	580	(–12)	240	1 160	(–21)	306
80	100	(0)	130	700	(–12)	260	1 400	(–21)	336
85	100	(0)	130	720	(–12)	270	1 440	(–21)	347
90	100	(0)	140	740	(–12)	280	1 480	(–21)	355
95	100	(0)	140	760	(–12)	290	1 520	(–21)	367
100	100	(0)	150	780	(–12)	300	1 560	(–21)	381
105	100	(0)	150	1 040	(–15)	330	2 080	(–26)	430
110	100	(0)	150	1 060	(–15)	340	2 120	(–26)	440
120	100	(0)	160	1 120	(–15)	370	2 240	(–26)	469
130	100	(0)	160	1 150	(–16)	370	2 302	(–27)	469
140	200	(0)	200	1 240	(–13)	380	2 476	(–23)	489
150	200	(0)	200	1 444	(–15)	403	2 957	(–28)	552

The value in ( ) shows a measured axial clearance.

Ultra High Precision Angular Contact Ball Bearing

(BGR series)

Calculation of preload and axial rigidity for combination bearings
Preload and axial rigidity can be obtained by multipling factors in table B.
For radial rigidity, multiply the value obtained in table A with factors in table B.

Table B

	DBD	DBB
Preload factor	1.36	2
Axial rigidity	1.48	2
Radial rigidity	1.54	2

BGR19S
Nominal contact angle 15˚ Steel ball

Nominal Bearing Bore (mm)	EL	
	Preload (N)	Axial Rigidity (N/μm)
10	25	15.2
12	25	16.8
15	25	16.6
17	25	17.5
20	25	18.1
25	25	20.6

BGR10S
Nominal contact angle 15˚ Steel ball

Nominal Bearing Bore (mm)	EL	
	Preload (N)	Axial Rigidity (N/μm)
6	25	11.0
7	25	12.0
8	25	13.0
10	25	14.0
12	25	15.0
15	25	16.0
17	25	17.0
20	25	18.0
25	25	19.0

BGR02S
Nominal contact angle 15˚ Steel ball

Nominal Bearing Bore (mm)	EL	
	Preload (N)	Axial Rigidity (N/μm)
10	25	14.5
12	25	15.2
15	25	16.2
17	25	16.7
20	25	17.4
25	50	25.3

BGR19H, BGR19X
Nominal contact angle 15˚ Ceramic ball

Nominal Bearing Bore (mm)	EL	
	Preload (N)	Axial Rigidity (N/μm)
10	25	16.8
12	25	18.5
15	25	18.4
17	25	19.3
20	25	20.1
25	25	22.9

BGR10H, BGR10X
Nominal contact angle 15˚ Ceramic ball

Nominal Bearing Bore (mm)	EL	
	Preload (N)	Axial Rigidity (N/μm)
6	25	12.6
7	25	13.7
8	25	14.4
10	25	15.9
12	25	16.9
15	25	18.0
17	25	19.0
20	25	20.0
25	25	21.6

BGR02H, BGR02X
Nominal contact angle 15˚ Ceramic ball

Nominal Bearing Bore (mm)	EL	
	Preload (N)	Axial Rigidity (N/μm)
10	25	16.0
12	25	17.0
15	25	18.0
17	25	18.6
20	25	19.4
25	50	28.1

Preload and Rigidity (DB and DF Arrangement)

High Speed Angular Contact Thrust Ball Bearing

(ROBUST series)

BAR10S

Nominal contact angle 30˚ Steel ball

Nominal Bearing Bore (mm)	EL		L	
	Preload (N)	Axial Rigidity (N/μm)	Preload (N)	Axial Rigidity (N/μm)
40	210	150	430	200
45	210	150	430	200
50	220	170	460	220
55	230	180	600	250
60	240	190	650	270
65	250	200	690	290
70	250	200	910	320
75	260	210	940	330
80	340	240	1 100	360
85	350	240	1 130	370
90	360	250	1 660	430
95	360	260	1 720	450
100	370	270	1 770	460
105	380	280	1 820	470
110	390	280	1 870	490
120	390	300	1 980	520
130	390	300	2 530	550
140	580	360	3 190	655
150	580	360	3 690	690
160	590	370	4 080	720
170	600	380	4 210	750
180	605	385	5 200	800
190	610	390	5 370	830
200	610	390	5 990	860

BAR10H

Nominal contact angle 30˚ Ceramic ball

Nominal Bearing Bore (mm)	EL		L	
	Preload (N)	Axial Rigidity (N/μm)	Preload (N)	Axial Rigidity (N/μm)
40	230	175	485	230
45	230	180	490	235
50	245	195	525	255
55	255	200	690	290
60	270	220	750	320
65	285	240	800	340
70	285	240	1 060	375
75	290	245	1 090	390
80	380	275	1 260	420
85	390	280	1 280	430
90	400	290	1 930	510
95	405	300	1 970	520
100	420	310	2 060	550
105	420	315	2 090	555
110	440	330	2 180	580
120	455	350	2 310	620
130	455	350	2 960	650

BTR10S

Nominal contact angle 40˚ Steel ball

Nominal Bearing Bore (mm)	EL		L	
	Preload (N)	Axial Rigidity (N/μm)	Preload (N)	Axial Rigidity (N/μm)
40	310	260	700	350
45	310	260	700	350
50	330	290	760	390
55	350	310	800	410
60	370	330	860	440
65	390	350	910	470
70	390	350	1 560	560
75	400	360	1 610	590
80	510	400	1 820	630
85	520	420	1 880	650
90	530	430	2 830	770
95	550	450	2 930	790
100	560	460	3 030	820
105	570	470	3 120	850
110	580	490	3 210	870
120	610	520	3 420	930
130	610	520	4 410	980
140	810	600	5 310	1 140
150	820	605	5 370	1 160
160	830	615	5 480	1 180
170	850	635	7 280	1 330
180	855	640	9 080	1 450
190	875	660	9 390	1 500
200	875	660	11 290	1 600

BAR10S

Nominal contact angle 30˚ Ceramic ball

Nominal Bearing Bore (mm)	EL		L	
	Preload (N)	Axial Rigidity (N/μm)	Preload (N)	Axial Rigidity (N/μm)
40	350	300	800	410
45	355	310	810	415
50	375	335	875	450
55	395	350	915	475
60	425	390	1 000	520
65	450	415	1 060	560
70	450	415	1 830	670
75	460	430	1 890	700
80	570	475	2 120	745
85	580	475	2 160	780
90	600	505	3 320	910
95	605	505	3 390	940
100	630	540	3 560	980
105	640	540	3 610	1 010
110	665	575	3 770	1 040
120	700	615	4 020	1 115
130	700	615	5 200	1 170

Preload and Rigidity

Double-Direction Angular Contact Thrust Ball Bearing

(TAC series)

TAC20 series

Nominal contact angle 60˚ Steel ball

Nominal Bearing Bore (mm)	C6		C7		C8	
	Preload (N)	Axial Rigidity (N/μm)	Preload (N)	Axial Rigidity (N/μm)	Preload (N)	Axial Rigidity (N/μm)
35	–	–	343	470	588	570
40	–	–	343	510	588	620
45	–	–	343	530	784	700
50	–	–	392	570	882	760
55	–	–	588	680	1 176	865
60	–	–	588	730	1 274	935
65	–	–	588	790	1 274	1 005
70	–	–	882	850	1 568	1 050
75	–	–	882	880	1 568	1 090
80	–	–	980	965	2 156	1 240
85	–	–	980	1 000	2 156	1 285
90	–	–	1 372	1 110	2 646	1 380
95	10	200	1 372	1 150	2 646	1 435
100	10	200	1 470	1 190	2 744	1 485
105	98	500	1 764	1 320	3 234	1 610
110	245	700	1 862	1 365	3 822	1 740
120	490	900	1 960	1 460	4 018	1 860
130	686	980	2 548	1 530	5 194	1 940
140	980	1 200	3 626	1 900	9 310	2 600
150	980	1 210	4 704	2 060	9 408	2 640
160	1 274	1 370	4 802	2 140	10 780	2 830
170	2 058	1 650	6 762	2 450	13 720	3 120
180	2 940	1 875	6 762	2 475	15 680	3 265
190	3 038	1 940	7 056	2 560	18 620	3 560
200	3 038	1 950	7 056	2 570	18 620	3 570

TAC29 series

Nominal contact angle 60˚ Steel ball

Nominal Bearing Bore (mm)	C6		C7		C8	
	Preload (N)	Axial Rigidity (N/μm)	Preload (N)	Axial Rigidity (N/μm)	Preload (N)	Axial Rigidity (N/μm)
100	–	–	1 176	1 150	2 156	1 410
105	–	–	1 274	1 215	2 254	1 490
110	–	–	1 274	1 250	2 254	1 530
120	98	550	1 274	1 310	2 842	1 700
130	98	580	1 764	1 415	3 528	1 915
140	98	750	2 254	1 700	5 194	2 260
150	196	775	4 116	2 150	7 056	2 590
160	196	800	4 410	2 260	7 448	2 720
170	196	800	4 410	2 370	7 742	2 860
180	1 078	1 470	4 410	2 320	9 800	3 040
190	1 078	1 440	4 606	2 440	10 290	3 200
200	1 078	1 500	4 606	2 430	11 760	3 340
220	1 176	1 615	4 900	2 620	12 740	3 615
240	1 176	1 690	5 096	2 750	13 230	3 800
260	1 176	1 670	5 096	2 720	13 230	3 750
280	1 274	1 755	5 390	2 865	13 720	3 950

Preload and Rigidity

Angular Contact Thrust Ball Bearing for Ball Screw Support

TAC B series (for machine tool)
Nominal contact angle 60˚ Steel ball

C9 Preload

Bearing Number	Duplex Set Arrangement (DB or DF)			Triplex Set Arrangement (DBD or DFD)			Quadruplex Set Arrangement (DBB or DFF)		
	Preload (N)	Axial Rigidity (N/μm)	Starting Torque (N·m)	Preload (N)	Axial Rigidity (N/μm)	Starting Torque (N·m)	Preload (N)	Axial Rigidity (N/μm)	Starting Torque (N·m)
15TAC47B	1 000	555	0.05	1 370	795	0.07	2 010	1 110	0.11
17TAC47B	1 000	555	0.05	1 370	795	0.07	2 010	1 110	0.11
20TAC47B	1 000	555	0.05	1 370	795	0.07	2 010	1 110	0.11
25TAC62B	1 490	733	0.09	2 030	1 050	0.12	2 980	1 465	0.17
30TAC62B	1 563	772	0.09	2 130	1 105	0.12	3 130	1 545	0.18
35TAC72B	1 785	890	0.10	2 430	1 275	0.14	3 570	1 780	0.21
40TAC72B	1 860	930	0.11	2 530	1 330	0.14	3 720	1 860	0.21
40ATC90B	2 365	1015	0.18	3 220	1 465	0.24	4 730	2 030	0.36
45TAC75B	2 005	1005	0.12	2 730	1 445	0.16	4 015	2 015	0.23
45TAC100B	2 880	1160	0.23	3 920	1 670	0.31	5 760	2 320	0.46
50TAC100B	3 010	1210	0.24	4 095	1 745	0.32	6 020	2 425	0.48
55TAC100B	3 010	1210	0.24	4 095	1 745	0.32	6 020	2 425	0.48
55TAC120B	3 520	1430	0.28	4 790	2 055	0.37	7 040	2 855	0.56
60TAC120B	3 520	1430	0.28	4 790	2 055	0.37	7 040	2 855	0.56

C10 Preload

Bearing Number	Duplex Set Arrangement (DB or DF)			Triplex Set Arrangement (DBD or DFD)			Quadruplex Set Arrangement (DBB or DFF)		
	Preload (N)	Axial Rigidity (N/μm)	Starting Torque (N·m)	Preload (N)	Axial Rigidity (N/μm)	Starting Torque (N·m)	Preload (N)	Axial Rigidity (N/μm)	Starting Torque (N·m)
15TAC47B	2 150	750	0.14	2 950	1 080	0.20	4 300	1 470	0.29
17TAC47B	2 150	750	0.14	2 950	1 080	0.20	4 300	1 470	0.29
20TAC47B	2 150	750	0.14	2 950	1 080	0.20	4 300	1 470	0.29
25TAC62B	3 150	1 000	0.23	4 300	1 470	0.31	6 250	1 960	0.46
30TAC62B	3 350	1 030	0.24	4 500	1 520	0.33	6 650	2 010	0.49
35TAC72B	3 800	1 180	0.28	5 200	1 710	0.37	7 650	2 350	0.55
40TAC72B	3 900	1 230	0.28	5 300	1 810	0.38	7 850	2 400	0.57
40ATC90B	5 000	1 320	0.48	6 750	1 960	0.65	10 300	2 650	0.96
45TAC75B	4 100	1 270	0.29	5 600	1 910	0.40	8 250	2 550	0.59
45TAC100B	5 900	1 520	0.58	8 050	2 210	0.78	11 800	3 000	1.16
50TAC100B	6 100	1 570	0.60	8 250	2 300	0.80	12 300	3 100	1.18
55TAC100B	6 100	1 570	0.60	8 250	2 300	0.80	12 300	3 100	1.18
55TAC120B	6 650	1 810	0.64	9 100	2 650	0.86	13 200	3 550	1.27
60TAC120B	6 650	1 810	0.64	9 100	2 650	0.86	13 200	3 550	1.27

TAC 02, 03 series (for electric injection machine)
Nominal contact angle 60˚ Steel ball

C8 Preload

Bearing Number	Duplex Set Arrangement (DB or DF)			Triplex Set Arrangement (DBD or DFD)			Quadruplex Set Arrangement (DBT or DFT)		
	Preload (N)	Axial Rigidity (N/μm)	Starting Torque (N·m)	Preload (N)	Axial Rigidity (N/μm)	Starting Torque (N·m)	Preload (N)	Axial Rigidity (N/μm)	Starting Torque (N·m)
15TAC02AT85	365	262	0.017	495	385	0.024	575	490	0.027
25TAC02AT85(1)	1 440	520	0.113	1 960	755	0.153	2 260	950	0.175
TAC35-2T85	2 270	705	0.266	3 100	1 020	0.360	3 550	1 280	0.415
40TAC03AT85	2 270	705	0.266	3 100	1 020	0.360	3 550	1 280	0.415
45TAC03AT85	2 740	775	0.355	3 750	1 120	0.480	4 300	1 410	0.550
TAC45-2T85	3 550	880	0.520	4 850	1 270	0.705	5 600	1 600	0.810
50TAC03AT85	3 550	880	0.520	4 850	1 270	0.705	5 600	1 600	0.810
55TAC03AT85	4 100	945	0.650	5 600	1 370	0.880	6 500	1 720	1.000
60TAC03AT85	4 750	1 020	0.810	6 450	1 480	1.100	7 450	1 850	1.250
80TAC03AM	7 350	1 270	1.550	10 000	1 840	2.100	11 500	2 330	2.450
100TAC03CMC(2)	1 000	830	0.105	1 400	1 240	0.147	1 600	1 575	0.166
120TAC03CMC(2)	1 100	930	0.120	1 500	1 378	0.163	1 800	1 775	0.196

(1) Value of 25TAC02AT85 is based on C9 preload.
(2) Values of 100TAC03CMC and 120TAC03CMC are based on C2 preload.

Radial Internal Clearance of Cylindrical Roller Bearings

Clearance in matched bearings with tapered bore

Unit: μm

Nominal Bearing Bore (mm)		Clearance in Matched Bearings with Tapered Bore															
		CC9(1)		CC0		CC1		CC2		CC(2)		CC3		CC4		CC5	
over	incl	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max
24	**30**	5	10	8	15	10	25	25	35	40	50	50	60	60	70	80	95
30	**40**	5	12	8	15	12	25	25	40	45	55	55	70	70	80	95	110
40	**50**	5	15	10	20	15	30	30	45	50	65	65	80	80	95	110	125
50	**65**	5	15	10	20	15	35	35	50	55	75	75	90	90	110	130	150
65	**80**	10	20	15	30	20	40	40	60	70	90	90	110	110	130	150	170
80	**100**	10	25	20	35	25	45	45	70	80	105	105	125	125	150	180	205
100	**120**	10	25	20	35	25	50	50	80	95	120	120	145	145	170	205	230
120	**140**	15	30	25	40	30	60	60	90	105	135	135	160	160	190	230	260
140	**160**	15	35	30	50	35	65	65	100	115	150	150	180	180	215	260	295
160	**180**	15	35	30	50	35	75	75	110	125	165	165	200	200	240	285	320
180	**200**	20	40	30	50	40	80	80	120	140	180	180	220	220	260	315	355
200	**225**	20	45	35	60	45	90	90	135	155	200	200	240	240	285	350	395
225	**250**	25	50	40	65	50	100	100	150	170	215	215	265	265	315	380	430
250	**280**	25	55	40	70	55	110	110	165	185	240	240	295	295	350	420	475

(1) Applicable to cylindrical roller bearings of ISO accuracy Class 4 and 5 with tapered bores.
(2) Denotes normal clearance for matched cylindrical roller bearings.

Clearance in matched bearings with cylindrical bore

Unit: μm

Nominal Bearing Bore (mm)		Clearance in Matched Bearings with Cylindrical Bore											
		CC1		CC2		CC(3)		CC3		CC4		CC5	
over	incl	min	max	min	max	min	max	min	max	min	max	min	max
24	**30**	5	15	10	25	25	35	40	50	50	60	70	80
30	**40**	5	15	12	25	25	40	45	55	55	70	80	95
40	**50**	5	18	15	30	30	45	50	65	65	80	95	110
50	**65**	5	20	15	35	35	50	55	75	75	90	110	130
65	**80**	10	25	20	40	40	60	70	90	90	110	130	150
80	**100**	10	30	25	45	45	70	80	105	105	125	155	180
100	**120**	10	30	25	50	50	80	95	120	120	145	180	205
120	**140**	10	35	30	60	60	90	105	135	135	160	200	230
140	**160**	10	35	35	65	65	100	115	150	150	180	225	260
160	**180**	10	40	35	75	75	110	125	165	165	200	250	285
180	**200**	15	45	40	80	80	120	140	180	180	220	275	315
200	**225**	15	50	45	90	90	135	155	200	200	240	305	350
225	**250**	15	50	50	100	100	150	170	215	215	265	330	380
250	**280**	20	55	55	110	110	165	185	240	240	295	370	420

(3) Denotes normal clearance for matched cylindrical roller bearings.

5. LIMITING SPEEDS

Limiting Speeds

The limiting speeds listed in the Bearing Dimensional Tables are guideline values. They are based on a single bearing that is lightly preloaded by means of a spring and subjected to relatively light loads with good heat dissipation.

The limiting speeds with grease lubrication are determined using high quality grease in appropriate amounts. Those listed for oil lubrication are based on the use of oil-air (or oil mist) lubrication. In situations where the lubricating oil is used as a means to remove heat, higher speed can be achieved, however a large amount of oil must be pressure fed through the bearing, so there is a significant loss of power.

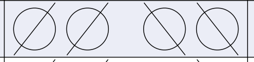
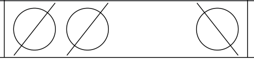
When single bearings are used in two, three or four row combinations, or the preload is increased to improve spindle rigidity, limiting speeds will be lower than those listed.

Speed Factors

The limiting speed of a matched bearing set operating under position preload conditions is calculated by multiplying the limiting speed of a single bearing in the set by the appropriate adjustment factor listed in Table 5.1.

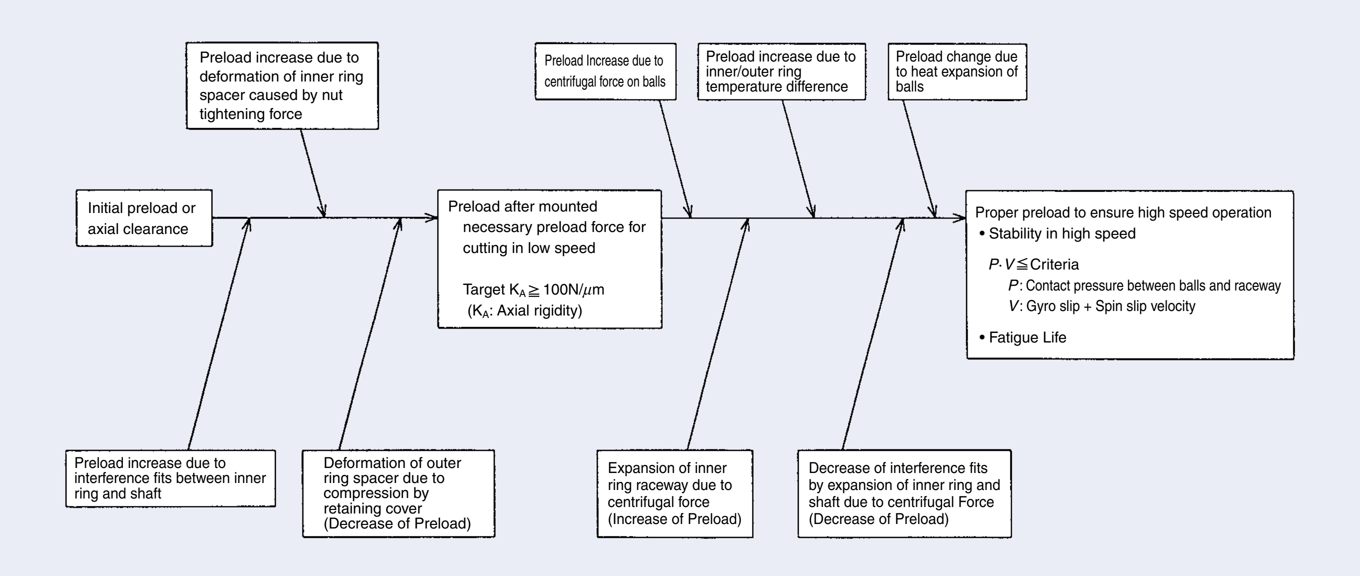
In this table, preloads mean the preload values after the bearing has been attached to the spindle. Preload values after the bearing has been mounted on the spindle will change as a result of the shaft fit requirements of high speed operation and spacer deformation due to tightening force. In such case, particular in high speed applications, it is necessary to adjust the spacer lengths relative to each other in order to compensate for the changes in preload after bearing mounting.

Table 5.1 Speed Factors

	Arrangement	EL	L	M	H
DB		0.85	0.80	0.65	0.55
DBB		0.80	0.75	0.60	0.45
DBD		0.75	0.70	0.55	0.40

Factors that Change Preload

Fig. 5.1 Preload Setting Study Flow



Factors Influencing Limiting Speeds

The limiting speed of the bearing, inside of the spindle, is affected by the following operating conditions.

1. Lubrication Method

The thickness of the lubricating film created by the oil-air or oil mist lubrication replenishment method is larger compared to the thickness created by the grease lubrication method. Therefore the limiting speed is higher when the oil-air or oil mist lubrication method is used.

In the case of jet lubrication, the large volume of oil supplied into the bearing for lubrication also removes heat efficiently so that much higher operating speeds are possible.

2. Combination

If bearings are used as multiple bearing sets, the number of bearings in the set affects the limiting speed. As the number is increased, the limiting speed becomes lower because the ability to dissipate that heat becomes lower.

3. Preload

If the preload after mounted is high, the contact surface pressure between the rolling elements and raceways increases, which causes extra heat. As a result of this heat, the preload during operation increases further and the risk of bearing failure will be higher. To avoid this type of bearing failure, the limiting speed is reduced. Also in case of cylindrical roller bearings, when the radial clearance is reduced and the preload increases during operation, the limiting speed is reduced.

4. Drive Method

The limiting speed of a bearing will also change depending on the spindle drive system.

In the case of motor built-in spindles the heat inside of the spindles is higher. If there is also a jacket-cooling system, the temperature difference between the inner ring and the outer ring becomes higher, so the preload is increased and the limiting speed becomes lower. (see Fig. 5.2) Jacket cooling also affects the clearance between the bearing and the housing. (see Fig. 5.3) Therefore, the clearance between the bearing and the housing could become negative, in which case the preload would be increased.

Fig. 5.2 The Influence of The Jacket Cooling on Limiting Speed

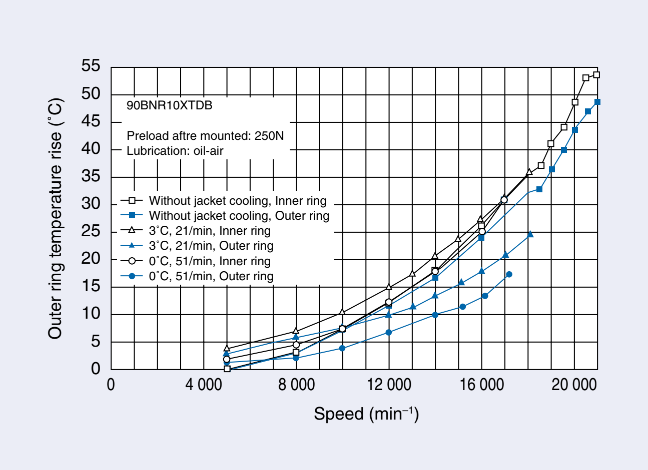
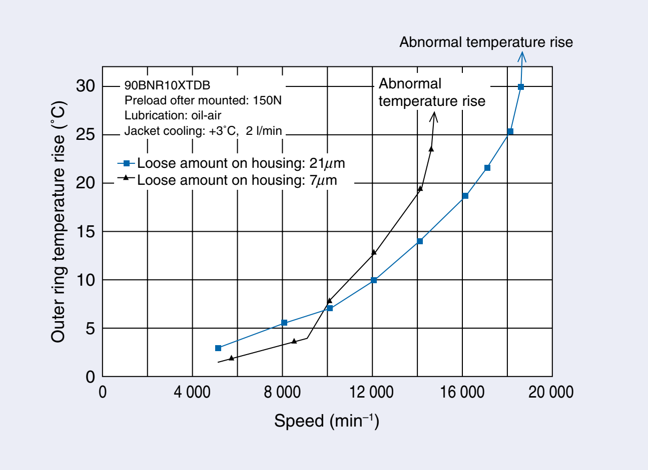


Fig. 5.3 The Influence of The Clearance between The Bearing & The Housing on Limiting Speed



Purposes of Lubrication

The main purposes of lubrication are to reduce friction and wear inside the bearing thet may cause premature failure. The effects of lubrication may be briefly explained as follows:

(1) Reduction of Friction and Wear

Direct metallic contact between the bearing rings, rolling elements, and cage, which are the basic parts of a bearing, is prevented by an oil film which reduces the friction and wear in the contact areas.

(2) Extension of Fatigue Life

The rolling fatigue life of bearings depends greatly upon the viscosity and film thickness between the rolling contact surfaces. A heavy film thickness prolongs the fatigue life, but it is shortened if the viscosity of the oil is too low so the film thickness is insufficient.

(3) Dissipation of Heat

Circulating lubrication may be used to carry away frictional heat or heat transferred from the outside to prevent the bearing from overheating and oil from deteriorating.

(4) Others

Adequate lubrication also helps to prevent foreign material from entering the bearings and guards against corrosion or rusting.

Lubricating Methods

For machine tool spindles in which high accuracy is important, it is necessary to prevent excessive temperature rise of the spindle to reduce thermal deformation.

Bearing heat generation is divided into a load term determined by the bearing type and load, and a speed term determined by the lubricating method and speed.

Generally, the speed term is greater, but if a lubricating method resulting in a small speed term is selected, the influence of the load term cannot be disregarded. Therefore, it is important to select a low heat generating bearing (load term) and lubricating method (speed term).

Regarding heat generation, both the lubrication method and quantity of lubricant have important effects. Lubrication using a small amount of grease is common since this method is economical, maintenance free, and there is little heat generation. At high speeds, to maintain a constant low temperature, the oil-air lubrication method, which requires a minimum quantity of oil, was developed.

The relation between oil quantity and heat generation (frictional loss) and temperature rise is already known as shown in Fig. 6.1 Therefore, for machine tool spindles, to avoid excessive temperature rise, adoption of a lubricating method aiming at either zone A or B is necessary.

The lubricating methods in zones A and B are summarized in Table 6.1

Dynamic torque of bearing (heat generation)

$M=Ml+Mv$

Load term (Determined by bearing type and load)

$Ml=f_1Fd_m$

where f_1 : Coefficient determined by bearing type and load

F : Load

d_m : Pitch circle diameter of rolling element

Speed term (Determined by oil viscosity, amount, speed)

$Mv=f_0(\nu_0 n)^{2/3}dm^3$

where f_0 : Coefficient determined by bearing and lubricating method

ν_0 : Kinematic viscosity of oil

n : Speed

Fig. 6.1 Oil Quantity and Temperature Rise

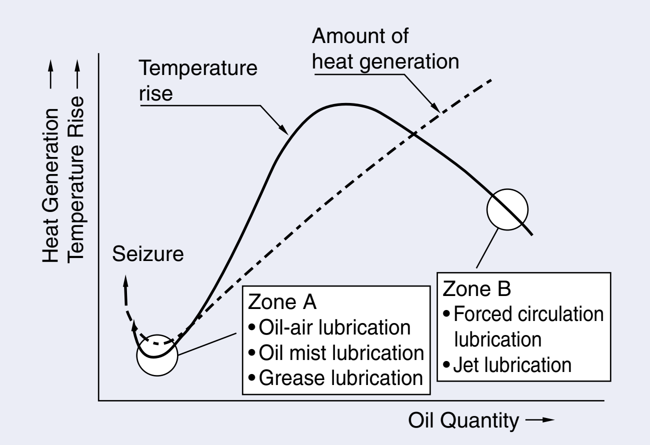


Table 6.1 Comparison of Lubricating Methods

Lubricating Methods	Advantages	Disadvantages
Grease Lubrication	○Low cost ○Limitation of temperature rise is possible. ○Maintenance free	○If packed grease deteriorates, seizure may occur. ○May allow penetration of dust or cutting fluid.
Oil Mist Lubrication	○Since new oil is always fed, no fear of oil deterioration. ○Dust and cutting fluid cannot easily enter.	○Pollution of environment. ○Oil supply quantity varies depending on the oil viscosity and temperature, so control of a small flow rate is difficult. ○It is difficult to confirm that oil is actually fed.
Jet Lubrication	○Since the oil flow rate is high, dust and cutting fluid cannot enter and seizure hardly ever occurs. ○Because of cooling by oil, the bearing temperature can be controlled to some degree.	○Frictional loss is high. ○Since oil leaks, it is difficult to use for vertical spindles. ○Cost is high.
Oil-Air Lubrication	○Since oil quantity control is possible, the optimum quantity of oil is fed and heat generation is low. ○Besides little heat-generation, there is a cooling effect of the air, so the temperature is low. ○Since new oil is always fed, no fear of oil deterioration. ○Dust, cutting fluid cannot easily enter. ○Environmental pollution mist is slight.	○Cost is rather high. ○Confirmation of whether oil is actually fed to bearing is difficult.

Grease Lubrication

(1) Recommended Greases

Lithium base greases with mineral oil as the base oil have good sticking properties and excellent characteristics for rolling bearings. These are usually usable over a temperature range of –10˚C to +110˚C.

As grease for high speed machine tool spindles that require low temperature rise and long life, a consistency No.2 grease with a synthetic base oil (diester, diester +mineral oil, etc.) is recommended.

Table 6.2 lists the brand names and properties of greases widely used in machine tools main spindles and ball screw support bearings.

(2) Grease Life

Grease life depends greatly upon operating temperature; therefore, it is necessary to keep the temperature of the bearing (including atmospheric temperature) cooler, in order to extend the grease life.

High performance wide range grease is often used for high speed spindle bearings, or spindle motor bearings.

The following equation shows the mean life of wide range grease.

$$\log t=6.12-1.4n/N_{max}-(0.018-0.006n/N_{max})\,T$$

where t : Mean Grease life (h)

N_{max} : Limiting speed (min^{-1})

n : Operating speed (min^{-1})

T : Bearing running temperature (˚C)

(3) Quantity of Grease for High Speed Spindle Bearings

To operate bearings at high speed with grease lubrication, the recommended quantity to be packed is 10 to 20% of internal space. If too much grease is packed, during running in, abnormal heat generation occurs and this may cause the grease to deteriorate. To avoid such a risk, it is necessary to run in spindles for a sufficient time. Based on their experience, NSK determines the packing quantity which allows easy running in and will provide sufficient lubrication. For the amount, please refer to the tables on Page 157.

Table 6.2 Grease Brand Names and Properties

Brand names	Manufacturers	Thickeners	Base oils	Base oils viscosity mm²⁄s(40˚C)	Dropping point (˚C)	Working temperature range, (˚C)	Main application
MTE	NSK	Barium complex	Ester oil	20	200	–30 – +120	Bearings for high speed spindles, high speed cylindrical roller bearings
MTS	NSK	Urea	Ester+Synthetic hydro carbon oil	22	220	–40 – +130	Bearings for high speed spindles
Isoflex NBU15	Klüber	Barium complex	Diester oil +Mineral oil	20	250	–30 – +120	Bearings for main spindles
Isoflex NCA15	Klüber	Special Ca	Ester oil	23	180	–40 – +130	Bearings for main spindles
Mobilux 2	Mobil	Lithium	Mineral oil	26	190	–10 – +110	Bearings for boring heads, live centers
Multemp LRL3	Kyodo Yushi	Lithium	Tetraester oil	37	208	–30 – +130	Bearings for main spindles
Stabragus NBU8EP	Klüber	Barium complex	Mineral oil	105	220	–30 – +130	Heavy load cylindrical roller bearings
Alvania 2	Shell	Lithium	Mineral oil	130	182	–10 – +110	Ball screw support bearings
ENS	NSK	Diurea	Tetraester oil	32	260	–40 – +160	Bearings for motors

6. LUBRICATION

Oil Lubrication

(1) Oil Mist Lubrication and Oil-Air Lubrication (Minimal Oil Quantity Lubrication)

Spray oiling is a method of spraying oil by turning it into a mist using compressed air. It is also called oil mist lubrication.

Oil-air lubrication is a method of feeding oil continuously by injecting oil into a compressed air stream by means of a mixing valve that intermittently discharges the minimum quantity of oil using a constant-quantity piston.

Fig. 6.2 shows the recommended oil quantity for the lubrication methods described above, each quantity is for one bearing.

In case of oil mist lubrication, it's necessary to adjust the oil quantity to accommodate for the effects of the branches in path tubing, and leakage from the gaps around the spacers.

Please ask NSK, as the oil quantity should be increased, in cases where the $d_m n$ value is higher than 1 800 000.

For the position of the spray nozzle, please refer to Page 174.

(2) Jet Lubrication

Jet lubrication is mainly used for high speed bearings with a $d_m n$ value over one million. Through one to several nozzles, jets of lubricating oil under a constant pressure pass through the bearings. At high speed, the air surrounding the bearing rotates together with the bearing and forms an air wall. The speed of the jet from each nozzle must be faster by 20% than the circumferential speed of the inner ring outside surface. Since the jet lubrication uses a large quantity of oil, there is much agitation resistance, so it is necessary to dissipate the heat effectively using a large oil discharge outlet and forced discharge.

For machine tool spindle bearings, this method is used in some applications as a means for stable operation at ultra high speeds (see Fig. 6.3)

For the position of the spray nozzle, please refer to page 174.

Fig. 6.2 Recommended Oil Quantity for Each Bore Size of Bearing (Minimal Oil Quantity Lubrication)

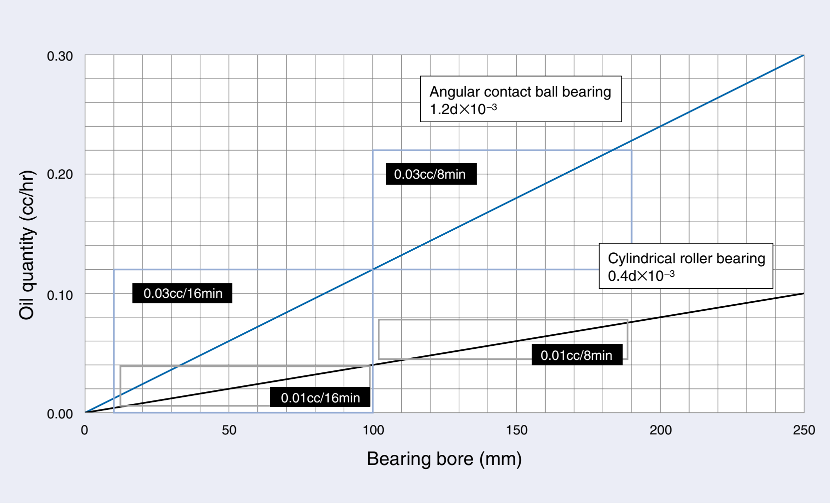
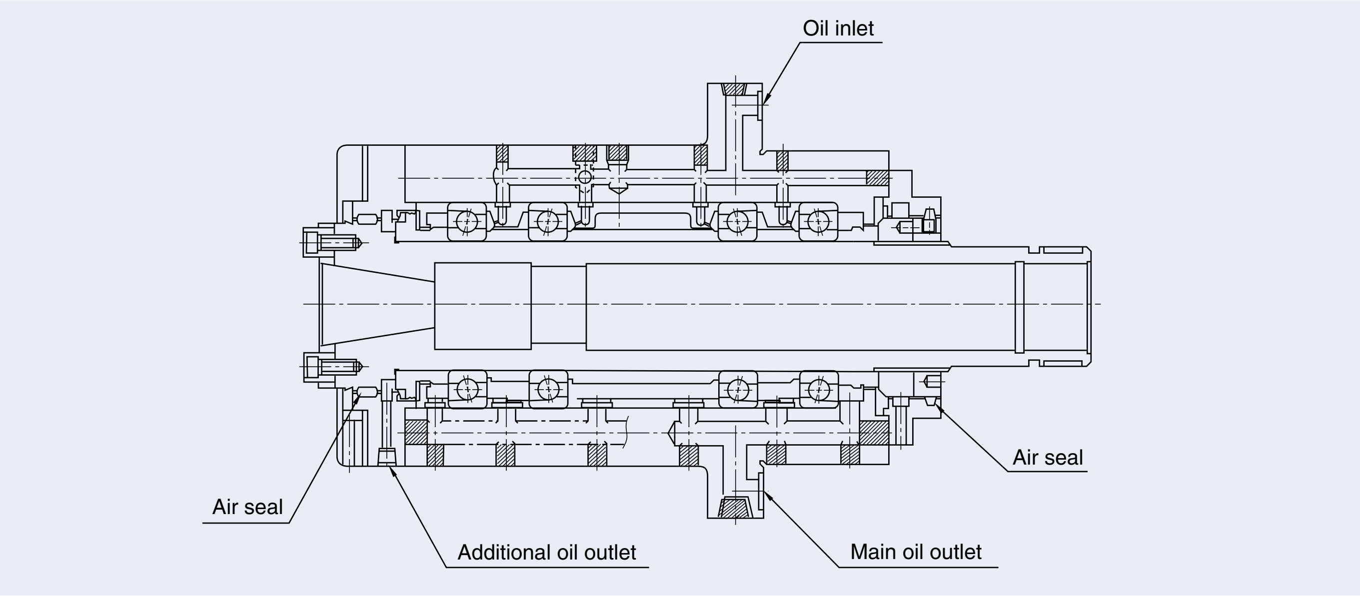


Fig. 6.3 Spindle Structure with Jet Lubrication.



The Recommended Grease Quantities for High-speed Spindle Bearings

Unit: cc/bearing

Bore number	Bore diameter. (mm)	ACBB : 15% of internal space				CRB : 10% of internal space			
		BNR19 BGR19 79xx	BGR10 70xx	BGR02 72xx	BNR10 BAR10 BTR10	NN49	NN39	NN30	N10
		X-quantity	X-quantity	X-quantity	X-quantity	X-quantity	X-quantity	X-quantity	X-quantity
5	5	–	–	0.03	–	–	–	–	–
6	6	–	0.04	0.07	–	–	–	–	–
7	7	–	0.07	–	–	–	–	–	–
8	8	–	0.12	0.10	–	–	–	–	–
00	10	0.06	0.13	0.16	–	–	–	–	–
01	12	0.06	0.14	0.23	–	–	–	–	–
02	15	0.11	0.18	0.29	–	–	–	–	–
03	17	0.13	0.24	0.41	–	–	–	–	–
04	20	0.23	0.44	0.68	–	–	–	–	–
05	25	0.27	0.52	0.85	–	–	–	0.4	–
06	30	0.31	0.69	1.2	0.58	–	–	0.6	0.4
07	35	0.48	0.98	1.7	0.78	–	–	0.8	0.6
08	40	0.75	1.2	2.1	0.92	–	–	1.0	0.7
09	45	0.83	1.5	2.6	1.2	–	–	1.3	1.0
10	50	0.91	1.6	3.0	1.2	–	–	1.4	1.1
11	55	1.1	2.4	3.9	1.7	–	–	2.0	1.5
12	60	1.2	2.6	4.8	1.8	–	–	2.1	1.6
13	65	1.3	2.6	5.7	1.9	–	–	2.2	1.6
14	70	2.1	3.6	6.5	2.8	–	–	3.2	2.4
15	75	2.3	3.6	7.0	2.9	–	–	3.5	2.5
16	80	2.4	5.1	8.7	3.8	–	–	4.7	3.5
17	85	3.5	5.3	11	4.0	–	–	4.9	3.7
18	90	3.6	6.6	13	5.5	–	–	6.5	4.5
19	95	3.6	6.8	16	5.7	–	–	6.6	4.7
20	100	4.9	7.2	19	6.1	5.4	4.5	6.8	4.9
21	105	5.1	9.0	23	7.6	5.6	4.6	9.3	5.9
22	110	5.2	12	27	9.1	5.7	4.8	11	7.5
24	120	7.9	12	31	9.8	8.4	6.5	12.5	8.1
26	130	9.0	18	34	15	11	8.5	18	12.4
28	140	9.9	20	42	17	12	9.3	20	12.9
30	150	14	25	53	22	24	14	23	–
32	160	16	34	–	26	20	15	29	–
34	170	14	42	–	33	21	15	38	–
36	180	22	51	–	46	28	23	51	–
38	190	27	47	–	50	30	24	54	–
40	200	39	76	–	61	44	35	69	–
44	220	42	–	–	–	–	37	–	–
48	240	41	–	–	–	–	40	–	–
52	260	77	–	–	–	–	70	–	–
56	280	80	–	–	–	–	75	–	–

The grease quantity of “xxTAC20(29)X(D)” should be same as the double row cylindrical roller bearing's, which is assembled with this bearing together.
Multiply 0.98 (density) to the quantity above, for the weight of the grease.
For the reccomended grease quantity for angular contact thrust ball bearing for ball screw support, please refer to Page 100.

7. BEARING TOLERANCES

The tolerance for the boundary dimensions and running accuracy of NSK radial bearings are specified by the Accuracies of Rolling Bearings in ISO 492/199/582/1132-1, and Rolling Bearing Tolerances in JIS B 1514. In addition to the above tolerances, NSK manufactures angular contact ball bearings with precision classes ABEC5, 7, and 9 as specified by American Bearing Manufacturers Association (ABMA) Standard 20.

Rough definitions of the items listed for running accuracy and their measuring methods are described in Fig. 7.1 and Table 7.1. Further details are available in ISO 5593, Rolling Bearings Vocabulary in JIS B 0104, and Measuring Methods for Rolling Bearings in JIS B 1515.

Table 7.1

Running Accuracy	Inner Ring	Outer Ring	Dial Gauge
Radial runout of assembled bearing inner ring K_{ia}	Rotating	Stationary	A
Radial runout of assembled bearing outer ring K_{ea}	Stationary	Rotating	A
Assembled bearing inner ring face (backface) runout with raceway S_{ia}	Rotating	Stationary	B_1
Assembled bearing outer ring face (backface) runout with raceway S_{ea}	Stationary	Rotating	B_2
Inner ring reference face (backface, where applicable) runout with raceway S_d	Rotating	Stationary	C
Variation of bearing outside surface generatrix inclination with outer ring reference face (backface) S_D	N/A	Rotating	D

Tolerance for Radial Bearings

Inner Ring

Table 7.2 Inner Ring (Class 5)

Unit: μm

Nominal Bore Diameter d (mm)		Single Plane Mean Bore Dia. Deviation Δ_{dmp}(2)		Bore Dia. Variation in a Single Radial Plane V_{dp}(2)		Mean Bore Dia. Variation V_{dmp}(2)	Radial Runout of Inner Ring K_{ia}	Inner Ring Run out with Bore S_d	Inner Ring Face Run out with Raceway S_{ia}(4)	Deviation of Single Inner Ring Width Δ_{Bs}			Inner Ring Width Variation V_{Bs}
				Diameter Series 9	Diameter Series 0, 2, 3					Single Bearing Combined Bearing	Single Bearing	(1) Combined Bearing	
over	incl	high	low	max		max	max	max	max	high	low		max
2.5	**10**	0	− 5	5	4	3	4	7	7	0	− 40	−250	5
10	**18**	0	− 5	5	4	3	4	7	7	0	− 80	−250	5
18	**30**	0	− 6	6	5	3	4	8	8	0	−120	−250	5
30	**50**	0	− 8	8	6	4	5	8	8	0	−120	−250	5
50	**80**	0	− 9	9	7	5	5	8	8	0	−150	−250	6
80	**120**	0	−10	10	8	5	6	9	9	0	−200	−380	7
120	**180**	0	−13	13	10	7	8	10	10	0	−250	−380	8
180	**250**	0	−15	15	12	8	10	11	13	0	−300	−500	10
250	**315**	0	−18	18	14	9	13	13	15	0	−350	−500	13

Table 7.3 Inner Ring (Class 4)

Unit: μm

Nominal Bore Diameter d (mm)		Single plane mean bore dia. deviation Δ_{dmp}(2)		Deviation of a Single Bore Dia. Δ_{ds}(2)		Bore dia. Variation in a Single Radial Plane V_{dp}(2)		Mean Bore Dia. Variation V_{dmp}(2)	Radial Runout of Inner Ring K_{ia}	Inner Ring Runout with bore S_d	Inner Ring Face Runout with Raceway S_{ia}(4)	Deviation of Single inner Ring Width Δ_{Bs}			Inner Ring Width Variation V_{Bs}
						Diameter Series 9	Diameter Series 0, 2, 3					Single Bearing Combined Bearing	Single Bearing	(1) Combined Bearing	
over	incl	high	low	high	low	max		max	max	max	max	high	low		max
2.5	**10**	0	− 4	0	−4	4	3	2	2.5	3	3	0	− 40	−250	2.5
10	**18**	0	− 4	0	−4	4	3	2	2.5	3	3	0	− 80	−250	2.5
18	**30**	0	− 5	0	−5	5	4	2.5	3	4	4	0	−120	−250	2.5
30	**50**	0	− 6	0	−6	6	5	3	4	4	4	0	−120	−250	3
50	**80**	0	− 7	0	−7	7	5	3.5	4	5	5	0	−150	−250	4
80	**120**	0	− 8	0	−8	8	6	4	5	5	5	0	−200	−380	4
120	**180**	0	−10	0	−10	10	8	5	6	6	7	0	−250	−380	5
180	**250**	0	−12	0	−12	12	9	6	8	7	8	0	−300	−500	6

(1) Applicable to individual rings manufactured for combined bearings.

(2) Applicable to bearings with cylindrical bores.

(3) Class 3 is NSK's original accuracy. Tolerance of bearing bore diameter and outer ring diameter are Class 4. Other tolerances are Class 2.

(4) Applicable to ball bearings.

Remarks: 1. The cylindrical bore diameter tolerance limit (high), as per the no-go side of a plug gage as specified in this table, is not necessarily applicable within a distance of 1.2 times the chamfer dimension r (max) from the ring face.

2. ABMA Standards ABEC5, ABEC7, and ABEC9 are equivalent to ISO (JIS) Classes 5, 4, and 2 respectively.
ABMA Standards are applicable to angular contact ball bearings.

Fig. 7.1 Measuring Methods for Running Accuracy

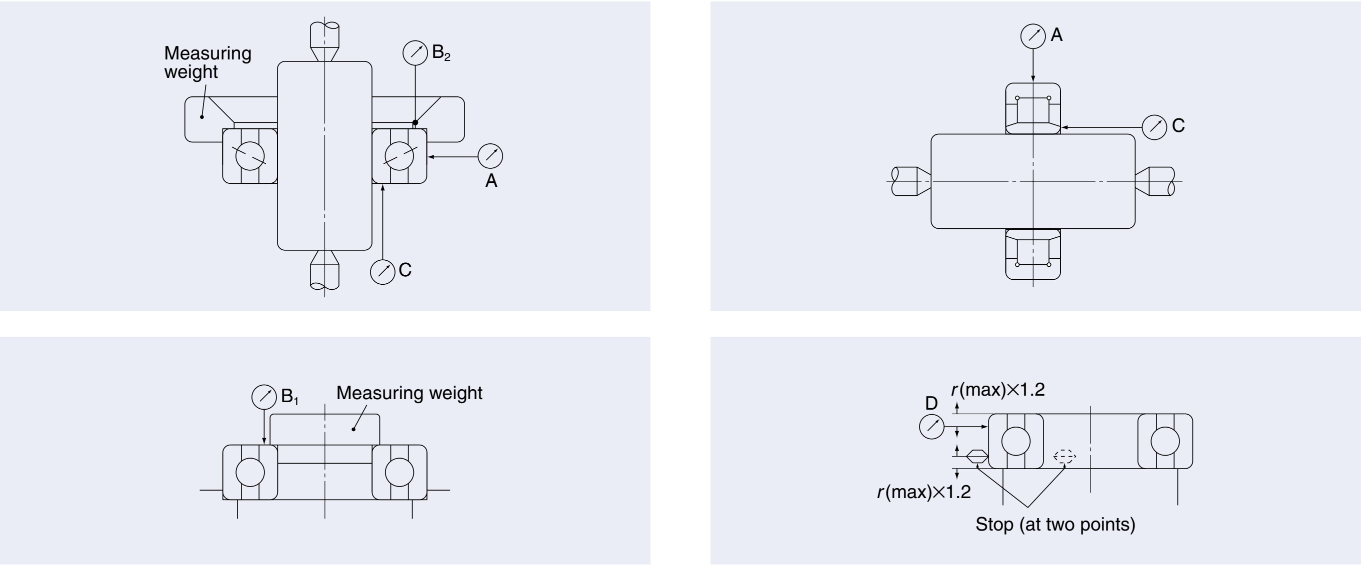


Table 7.4 Inner Ring (Class 3) (3)

Unit: μm

Nominal Bore Diameter d (mm)		Single Plane Mean Bore Dia. Deviation Δ_{dmp}(2)		Deviation of a Single Bore Dia. Δ_{ds}(2)		Bore Dia. Variation in a Single Radial Plane V_{dp}(2)	Mean Bore Dia. Variation V_{dmp}(2)	Radial Runout of Inner Ring K_{ia}	Inner Ring Runout with Bore S_d	Inner Ring Face Runout with Raceway S_{ia}(4)	Deviation of Single Inner Ring Width Δ_{Bs}			Inner Ring Width Variation V_{Bs}
											Single Bearing Combined Bearing	Single Bearing	(1) Combined Bearing	
over	incl	high	low	high	low	max	max	max	max	max	high	low		max
2.5	**10**	0	− 4	0	− 4	2.5	1.5	1.5	1.5	1.5	0	− 40	−250	1.5
10	**18**	0	− 4	0	− 4	2.5	1.5	1.5	1.5	1.5	0	− 80	−250	1.5
18	**30**	0	− 5	0	− 5	2.5	1.5	2.5	1.5	2.5	0	−120	−250	1.5
30	**50**	0	− 6	0	− 6	2.5	1.5	2.5	1.5	2.5	0	−120	−250	1.5
50	**80**	0	− 7	0	− 7	4	2	2.5	1.5	2.5	0	−150	−250	1.5
80	**120**	0	− 8	0	− 8	5	2.5	2.5	2.5	2.5	0	−200	−380	2.5
120	**150**	0	−10	0	−10	7	3.5	2.5	2.5	2.5	0	−250	−380	2.5
150	**180**	0	−10	0	−10	7	3.5	5	4	5	0	−250	−380	4
180	**250**	0	−12	0	−12	8	4	5	5	5	0	−300	−500	5

Table 7.5 Inner Ring (Class 2)

Unit: μm

Nominal Bore Diameter d (mm)		Single Plane Mean Bore Dia. Deviation Δ_{dmp}(2)		Deviation of a Single Bore Dia. Δ_{ds}(2)		Bore Dia. Variation in a Single Radial Plane V_{dp}(2)	Mean Bore Dia. Variation V_{dmp}(2)	Radial Runout of Inner Ring K_{ia}	Inner Ring Runout with Bore S_d	Inner Ring Face Runout with Raceway S_{ia}(4)	Deviation of Single Inner Ring Width Δ_{Bs}			Inner Ring Width Variation V_{Bs}
											Single Bearing Combined Bearing	Single Bearing	(1) Combined Bearing	
over	incl	high	low	high	low	max	max	max	max	max	high	low		max
2.5	**10**	0	−2.5	0	−2.5	2.5	1.5	1.5	1.5	1.5	0	− 40	−250	1.5
10	**18**	0	−2.5	0	−2.5	2.5	1.5	1.5	1.5	1.5	0	− 80	−250	1.5
18	**30**	0	−2.5	0	−2.5	2.5	1.5	2.5	1.5	2.5	0	−120	−250	1.5
30	**50**	0	−2.5	0	−2.5	2.5	1.5	2.5	1.5	2.5	0	−120	−250	1.5
50	**80**	0	−4	0	−4	4	2	2.5	1.5	2.5	0	−150	−250	1.5
80	**120**	0	−5	0	−5	5	2.5	2.5	2.5	2.5	0	−200	−380	2.5
120	**150**	0	−7	0	−7	7	3.5	2.5	2.5	2.5	0	−250	−380	2.5
150	**180**	0	−7	0	−7	7	3.5	5	4	5	0	−250	−380	4
180	**250**	0	−8	0	−8	8	4	5	5	5	0	−300	−500	5

Tolerance for Radial Bearing

Outer Ring

Table 7.6 Outer Ring (Class 5)

Unit: μm

Nominal Outside Diameter D (mm)		Single Plane Mean Outside Dia. Deviation Δ_{Dmp}		Outside Dia. Variation in a Single Radial Plane V_{Dp}		Mean Outside Dia. Variation V_{Dmp}	Radial Runout of Outer Ring K_{ea}	Variation of Outside Surface Generatrix Inclination with Face S_D	Outer Ring Face Runout with Raceway S_{ea}(¹)	Deviation of Single Outer Ring Width Δ_{Cs}	Outer Ring Width Variation V_{Cs}
				Diameter Series 9	0, 2						
over	incl	high	low	max		max	max	max	max		max
6	**18**	0	– 5	5	4	3	5	8	8	Equal to the value of inner ring (Δ_{Bs}) of the same bearing number.	5
18	**30**	0	– 6	6	5	3	6	8	8		5
30	**50**	0	– 7	7	5	4	7	8	8		5
50	**80**	0	– 9	9	7	5	8	8	10		6
80	**120**	0	– 10	10	8	5	10	9	11		8
120	**150**	0	–11	11	8	6	11	10	13		8
150	**180**	0	–13	13	10	7	13	10	14		8
180	**250**	0	–15	15	11	8	15	11	15		10
250	**315**	0	–18	18	14	9	18	13	18		11
315	**400**	0	–20	20	15	10	20	13	20		13

Table 7.7 Outer Ring (Class 4)

Unit: μm

Nominal Outside Diameter D (mm)		Single Plane Mean Outside Dia. Deviation Δ_{Dmp}		Deviation of Single Outside Dia. Δ_{DS}		Outside Dia. Variation in a Single Radial Plane V_{Dp}		Mean Outside Dia. Variation V_{Dmp}	Radial Runout of Outer Ring K_{ea}	Variation of Outside Surface Generatrix Inclination with Face S_D	Outer Ring Face Runout with Raceway S_{ea}(¹)	Deviation of Single Outer Ring Width Δ_{Cs}	Outer Ring Width Variation V_{Cs}
						Diameter Series 9	0, 2						
over	incl	high	low	high	low	max		max	max	max	max		max
6	**18**	0	– 4	0	– 4	4	3	2	3	4	5	Equal to the value of inner ring (Δ_{Bs}) of the same bearing number.	2.5
18	**30**	0	– 5	0	– 5	5	4	2.5	4	4	5		2.5
30	**50**	0	– 6	0	– 6	6	5	3	5	4	5		2.5
50	**80**	0	– 7	0	– 7	7	5	3.5	5	4	5		3
80	**120**	0	– 8	0	– 8	8	6	4	6	5	6		4
120	**150**	0	– 9	0	– 9	9	7	5	7	5	7		5
150	**180**	0	–10	0	–10	10	8	5	8	5	8		5
180	**250**	0	–11	0	–11	11	8	6	10	7	10		7
250	**315**	0	–13	0	–13	13	10	7	11	8	10		7
315	**400**	0	–15	0	–15	15	11	8	13	10	13		8

Table 7.8 Outer Ring (Class 3)(²)

Unit: μm

Nominal Outside Diameter D (mm)		Single Plane Mean Outside Dia. Deviation Δ_{Dmp}		Deviation of Single Outside Dia. Δ_{Ds}		Outside Dia. Variation in a Single Radial Plane V_{Dp}	Mean Outside Dia. Variation V_{Dmp}	Radial Runout of Outer Ring K_{ea}	Variation of Outside Surface Generatrix Inclination with Face S_D	Outer Ring Face Runout with Raceway S_{ea}(¹)	Deviation of Single Outer Ring Width Δ_{Cs}	Outer Ring Width Variation V_{Cs}
over	incl	high	low	high	low	max	max	max	max	max		max
6	**18**	0	– 4	0	– 4	2.5	1.5	1.5	1.5	1.5	Equal to the value of inner ring (Δ_{Bs}) of the same bearing number.	1.5
18	**30**	0	– 5	0	– 5	4	2	2.5	1.5	2.5		1.5
30	**50**	0	– 6	0	– 6	4	2	2.5	1.5	2.5		1.5
50	**80**	0	– 7	0	– 7	4	2	4	1.5	4		1.5
80	**120**	0	– 8	0	– 8	5	2.5	5	2.5	5		2.5
120	**150**	0	– 9	0	– 9	5	2.5	5	2.5	5		2.5
150	**180**	0	–10	0	–10	7	3.5	5	2.5	5		2.5
180	**250**	0	–11	0	–11	8	4	7	4	7		4
250	**315**	0	–13	0	–13	8	4	7	5	7		5
315	**400**	0	–15	0	–15	10	5	8	7	8		7

Table 7.9 Outer Ring (Class 2)

Unit: μm

Nominal Outside Diameter D (mm)		Single Plane Mean Outside Dia. Deviation Δ_{Dmp}		Deviation of Single Outside Dia. Δ_{Ds}		Outside Dia. Variation in a Single Radial Plane V_{Dp}	Mean Outside Dia. Variation V_{Dmp}	Radial Runout of Outer Ring K_{ea}	Variation of Outside Surface Generatrix Inclination with Face S_D	Outer Ring Face Runout with Raceway S_{ea}(¹)	Deviation of Single Outer Ring Width Δ_{Cs}	Outer Ring Width Variation V_{Cs}
over	incl	high	low	high	low	max	max	max	max	max		max
6	**18**	0	– 2.5	0	– 2.5	2.5	1.5	1.5	1.5	1.5	Equal to the value of inner ring (Δ_{Bs}) of the same bearing number.	1.5
18	**30**	0	– 4	0	– 4	4	2	2.5	1.5	2.5		1.5
30	**50**	0	– 4	0	– 4	4	2	2.5	1.5	2.5		1.5
50	**80**	0	– 4	0	– 4	4	2	4	1.5	4		1.5
80	**120**	0	– 5	0	– 5	5	2.5	5	2.5	5		2.5
120	**150**	0	– 5	0	– 5	5	2.5	5	2.5	5		2.5
150	**180**	0	– 7	0	– 7	7	3.5	5	2.5	5		2.5
180	**250**	0	– 8	0	– 8	8	4	7	4	7		4
250	**315**	0	– 8	0	– 8	8	4	7	5	7		5
315	**400**	0	– 10	0	– 10	10	5	8	7	8		7

(¹) Applicable to ball bearings.

(²) Class 3 is NSK's original accuracy. Tolerance of bearing bore diameter and outer ring diameter are Class 4. Other tolerances are Class 2.

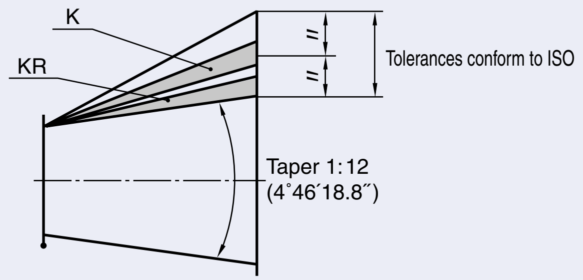
Remarks:
1. The cylindrical bore diameter tolerance limit (high), as per the no-go side of a plug gage as specified in this table, is not necessarily applicable within a distance of 1.2 times the chamfer dimension r (max) from the ring face.
2. ABMA Standards ABEC5, ABEC7, and ABEC9 are equivalent to ISO (JIS) Classes 5, 4, and 2 respectively. ABMA Standards are applicable to angular contact ball bearings.

Tolerances for Tapered Bores of Cylindrical Roller Bearing

Tolerances of tapered bores

The bore accuracy of tapered bore cylindrical roller bearings is specified by ISO. However, in this standard, the tolerances are rather wide. For precision-class cylindrical roller bearings, NSK established its own narrower tolerances. As is customary, however, two taper angles are available within the tolerance range specified by ISO (see Fig. 7.2).

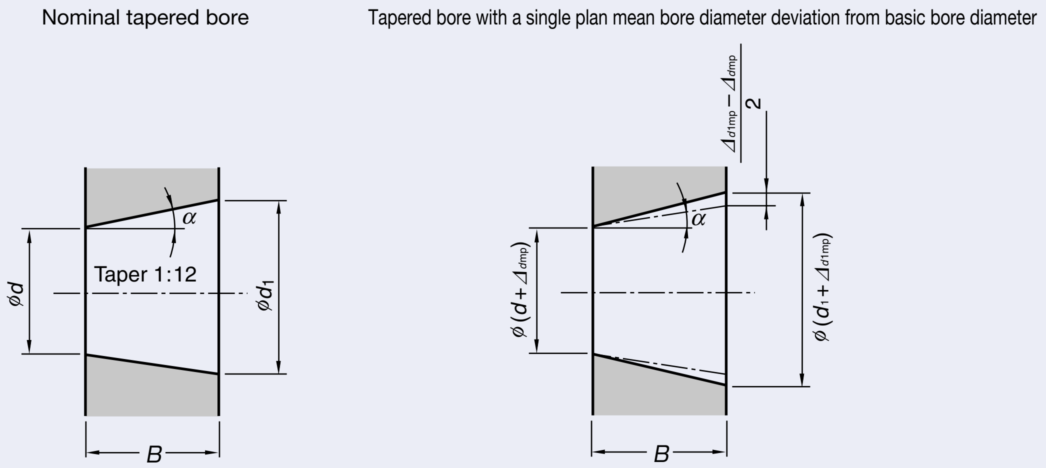
Fig. 7.2 Tolerances



K : NSK's original tolerance for tapered bore has a very narrow range that is positioned midrange of the ISO standard. Bore dimensional tolerances are identical to those of ISO.

KR : Newly created tolerance for tapered bores has a very narrow range that is positioned towards the lower limit of the standard ISO range. This NSK tolerance is narrower than that of ISO, which enhances easier mounting.

Fig. 7.3 Tapered Bore Tolerances



d : Nominal bore diameter

d_1 : Theoretical large bore end of tapered bore

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

Δ_{dmp} : Single plane mean bore diameter deviation in the theoretical small bore end of the bore

Δ_{d1mp} : Single plane mean bore diameter deviation in the theoretical large bore end of the bore

B : Nominal inner ring width

α : Half of taper angle of tapered bore

$\alpha=2°23'9.4''$

$=2.38594°$

$=0.041643\text{rad}$

Table 7.10 KR Tapered Bores

Unit: μm

d (mm)		Δ_{dmp}		(Reference) (²) $\Delta_{d1mp}-\Delta_{dmp}$		V_{dp}(¹)
over	incl	high	low	high	low	max
18	**30**	+13	0	+3	0	4
30	**50**	+16	0	+3	0	5
50	**80**	+19	0	+4	0	6
80	**120**	+22	0	+5	0	7
120	**180**	+25	0	+7	0	9
180	**250**	+29	0	+9	0	12

(¹) Bore diameter variation in an single radial plane, which is applicable to all radial planes of tapered bores.

(²) Taper angular tolerance, $4°46'18.8''\,^{+25''}_{0}$

Table 7.11 K Tapered Bores

Unit: μm

d (mm)		Δ_{dmp}		$\Delta_{d1mp}-\Delta_{dmp}$		V_{dp}(¹)
over	incl	high	low	high	low	max
18	**30**	+21	0	+21	0	4
30	**50**	+25	0	+25	0	5
50	**80**	+30	0	+30	0	6
80	**120**	+35	0	+35	0	7
120	**180**	+40	0	+40	0	9
180	**250**	+46	0	+46	0	12
250	**315**	+52	0	+52	0	14
315	**400**	+57	0	+57	0	16
400	**500**	+63	0	+63	0	18

(¹) Bore diameter variation in an single radial plane, which is applicable to all radial planes of tapered bores.

Tolerances for Angular Contact Thrust Ball Bearing

Tolerances for high speed angular contact thrust ball bearing (Class 4A(1) of BAR and BTR types)

Table 7.12 Inner ring

Unit: μm

Nominal Bore Diameter d (mm)		Single Plane Mean Bore Dia. Deviation Δ_{dmp}		Deviation of a Single Bore Dia. Δ_{ds}		Bore Dia. Variation in a Single Radial Plane V_{dp}		Mean Bore Dia. Variation V_{dmp}	Radial Runout of Inner Ring K_{ia}	Inner Ring Runout with Bore S_d	Inner Ring Face Runout with Raceway S_{ia}	Inner Ring Width Variation V_{Bs}	Deviation of Single Inner Ring Width $\Delta_{Bs}(\Delta_{Cs})$	
						Diameter Series								
						9	0							
over	incl	high	low	high	low	max	max	max	max	max	max	max	high	low
–	**50**	0	– 6	0	– 6	6	5	3	4	4	4	3	0	– 300
50	**80**	0	– 7	0	– 7	7	5	3.5	4	5	5	4	0	– 500
80	**120**	0	– 8	0	– 8	8	6	4	5	5	5	4	0	– 500
120	**150**	0	–10	0	–10	10	8	5	6	6	7	5	0	– 750
150	**180**	0	–10	0	–10	10	8	5	6	6	7	5	0	– 750
180	**250**	0	–12	0	–12	12	9	6	8	7	8	6	0	–1000

Table 7.13 Outer ring

Unit: μm

Nominal Outside Diameter D (mm)		Single Plane Mean Outside Dia. Deviation Δ_{Dmp}		Deviation of Single Outside Dia. Δ_{Ds}		Outside dia. Variation in a Single Radial Plane V_{Dp}		Mean Outside Dia. Variation V_{Dmp}	Radial Runout of Outer Ring K_{ea}	Variation of Outside Surface Generatrix Inclination with Face S_D	Outer Ring Face Runout with Raceway S_{ea}	Outer Ring Width Variation V_{Cs}
						Diameter Series						
						9	0					
over	incl	high	low	high	low	max	max	max	max	max	max	max
–	**80**	–30	–37	–30	–37	7	5	3.5	5	4	5	3
80	**120**	–40	–48	–40	–48	8	6	4	6	5	6	4
120	**150**	–50	–59	–50	–59	9	7	5	7	5	7	5
150	**180**	–50	–60	–50	–60	10	8	5	8	5	8	5
180	**250**	–50	–61	–50	–61	11	8	6	10	7	10	7
250	**315**	–60	–73	–60	–73	13	10	7	11	8	10	7

Tolerance of double direction angular contact thrust ball bearing (Class 7(2) of TAC type)

Table 7.14 Tolerances of inner ring, outer ring, and bearing height

Unit: μm

Nominal Bore Diameter d (mm)		Deviation of a Single Bore Diameter Δ_{ds}		Deviation of the Actual Bearing Height Δ_{Ts}		Radial Runout of Assembled Bearing Inner ring (Outer Ring) K_{ia} (K_{ea})	Inner Ring Runout with Bore S_d	Inner ring (Outer Ring) Face Runout with Raceway S_{ia} (S_{ea})
over	incl	high	low	high	low	max	max	max
–	**30**	0	– 5	0	– 300	5	4	3
30	**50**	0	– 5	0	– 400	5	4	3
50	**80**	0	– 8	0	– 500	6	5	5
80	**120**	0	– 8	0	– 600	6	5	5
120	**180**	0	–10	0	– 700	8	8	5
180	**250**	0	–13	0	– 800	8	8	6
250	**315**	0	–15	0	– 900	10	10	6
315	**400**	0	–18	0	–1200	10	12	7

Table 7.15 Tolerance of outer ring

Unit: μm

Nominal Outside Diameter D (mm)		Deviation of Single Outside Dia. Δ_{Ds}	
over	incl	high	low
30	**50**	–25	– 41
50	**80**	–30	– 49
80	**120**	–36	– 58
120	**180**	–43	– 68
180	**250**	–50	– 79
250	**315**	–56	– 88
315	**400**	–62	– 98
400	**500**	–68	–108
500	**630**	–76	–120

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(1) NSK specification. Equivalent to ISO Class 4 except for tolerance of outer ring outside diameter.

(2) NSK specification

Tolerances for Angular Contact Ball Bearing for Ball Screw Support

Machine Tool Applications

Table 7.16 TAC B series

Unit: μm

Nominal Bore or Outside Diameters (mm)		Deviation of Bore Diameter				Deviation of Outside Diameter				Deviation of Inner Ring Width		Inner or Outer Ring Runout with Raceway
		Tolerance Classes				Tolerance Classes				Tolerance Classes		Tolerance Classes
		PN7A		PN7B		PN7A		PN7B		PN7A PN7B		PN7A PN7B
over	incl	high	low	high	low	high	low	high	low	high	low	max
10	**18**	0	–4	0	–4	–	–	–	–	0	–120	2.5
18	**30**	0	–5	0	–4	–	–	–	–	0	–120	2.5
30	**50**	0	–6	0	–4	0	–6	0	–4	0	–120	2.5
50	**80**	0	–7	0	–5	0	–7	0	–5	0	–150	2.5
80	**120**	0	–8	0	–6	0	–8	0	–6	0	–200	2.5

Remark: Variation of outer ring width is the same as that for the inner ring of the same bearing.

Class PN7A is the standard tolerance for these bearings. This corresponds to ISO Class 4 for radial ball bearings, but for the runout of the inner and outer rings, more stringent values are applied.

The stricter Class PN7B applies to the dimensional tolerances of the bores and outside diameters of single-row universal arrangement bearings (SU).

Electrical Injection Molding Machine

Table 7.17 TAC 02 and 03 series

Unit: μm

Nominal Bore or Outside Diameter (mm)		Deviation of Bore Diameter		Deviation of Outside Diameter		Deviation of Inner Ring Width		Inner or outer Ring Runout with Raceway
		Tolerance Class						
		PN5D						
over	incl	high	low	high	low	high	low	max
10	**18**	0	– 5	–	–	0	– 80	5
18	**30**	0	– 6	–	–	0	–120	5
30	**50**	0	– 8	0	– 7	0	–120	8
50	**80**	0	– 9	0	– 9	0	–150	8
80	**120**	0	–10	0	–10	0	–200	8
120	**150**	–	–	0	–11	–	–	–
150	**180**	–	–	0	–13	–	–	–
180	**250**	–	–	0	–15	–	–	–
250	**315**	–	–	0	–18	–	–	–

Remark: Variation of outer ring width is the same as that for the inner ring of the same bearing.

Class PN5D is the standard tolerance for these bearings. This corresponds to ISO Class 5 for radial ball bearings, but for the runout of the inner and outer rings, more stringent values are applied.

Fitting of Shaft and Housing

It is of utmost importance that shafts and housings are accurately and precisely mated in order to take full advantage of the precision bearings' capabilities, which include rotational accuracy, high speed performance, and low heat generation.

When the inner ring or outer ring is mounted onto a shaft or into a housing with some interference, the shape of shaft or housing (out of roundness) is transferred to the bearing raceway surfaces and affects running accuracy. When multiple angular contact ball bearings are used, cylindricality affects the distribution of preload for each bearing. Therefore, the mating parts should be as accurate as possible.

Inaccurate mating of parts can cause the formation of peaks or ridges along the shaft of a precision lathe, which can affect the quality of finished work.

Table 8.1 Fits on Shafts (1)

Bearing Type	Shaft Outer Diameter (mm)		Tolerance of Shaft (2) Outer Diameter (mm)		Target Interference (2) (4) (mm)	
	over	incl	min	max	min	max
Machine tool spindle bearing (3)	**10**	**18**	–0.003	0	0	0.002 T
	18	**50**	–0.004	0	0	0.0025T
	50	**80**	–0.005	0	0	0.003 T
	80	**120**	–0.003	0.003	0	0.004 T
	120	**180**	–0.004	0.004	0	0.004 T
	180	**250**	–0.005	0.005	0	0.005 T
Angular contact thrust ball bearing for ball screw support	**10**	**18**	–0.008	0	–	–
	18	**30**	–0.009	0	–	–
	30	**50**	–0.011	0	–	–
	50	**80**	–0.013	0	–	–
	80	**120**	–0.015	0	–	–

Table 8.2 Fits on Housings (1)

Bearing Type	Housing Bore Diameter (mm)		Tolerance of Housing (2) Bore Diameter (mm)		Target Clearance (2) (4) (mm)	
	over	incl	min	max	min	max
Angular contact ball bearing (Fixed end)	**18**	**50**	–0.002	0.002	0.002L	0.006L
	50	**80**	–0.0025	0.0025	0.002L	0.006L
	80	**120**	–0.003	0.003	0.003L	0.008L
	120	**180**	–0.004	0.004	0.003L	0.008L
	180	**250**	–0.005	0.005	0.005L	0.010L
Angular contact ball bearing (Free end)	**18**	**50**	0	0.004	0.006L	0.011L
	50	**80**	0	0.005	0.006L	0.011L
	80	**120**	0	0.006	0.009L	0.015L
	120	**180**	0	0.008	0.009L	0.015L
	180	**250**	0	0.010	0.015L	0.022L
Cylindrical roller bearing	**18**	**50**	–0.006	0	0.002L	0.002T
	50	**80**	–0.007	0	0.002L	0.002T
	80	**120**	–0.008	0	0.002L	0.002T
	120	**180**	–0.009	0	0.002L	0.002T
	180	**250**	–0.011	0	0.002L	0.002T
Angular contact thrust ball bearing for ball screw support	**10**	**18**	–	–	–	–
	18	**30**	–	–	–	–
	30	**50**	0	0.016	–	–
	50	**80**	0	0.019	–	–
	80	**120**	0	0.022	–	–

(1) The fitting data above provides general recommendations for machine tool spindles operating under normal conditions and for $d_{\mathrm{m}}n$ values of less than 800,000. For high speeds, heavy loads, or outer ring rotation, please contact NSK for assistance.

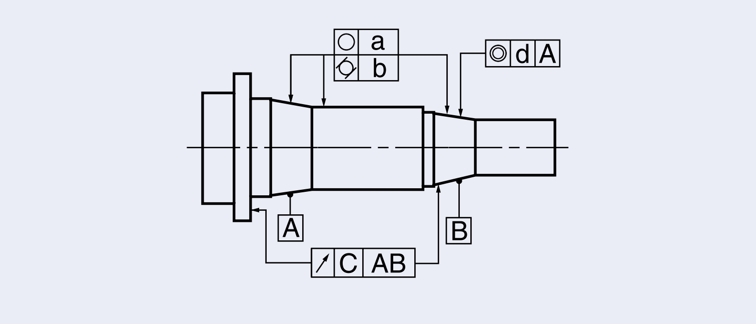
(2) Use the target interference when the bearing can be matched to the shaft or housing, Otherwise, use the shaft outer diameter and housing bore min and max for random matching.

(3) Applies to angular contact ball bearings: 70XX, 79XX, 72XX, BNR and BER
Angular contact thrust ball bearings: BAR, BTR and TAC
Cylindrical rollers bearings: N10XX, NN30XX, NN39XX, NN49XX and NNU49XX.

(4) T=Interference or tight fit
L=Clearance or loose fit

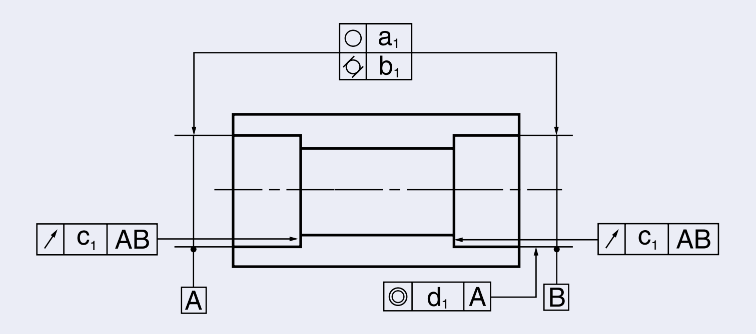
If the taper of the inner ring for a double row cylindrical roller bearing with a tapered bore does not match that of the shaft, the residual clearance will be different for two of the rows. Therefore, load will not be sustained normally, and will impair rigidity or cause irregular movement of the rollers due to taper of the inner ring groove. We recommend that you gauge the tapered parts to be mated with bearings. Contact should cover more than 80% of the total surface area that is dyed blue. The recommended accuracy and surface roughness of bearing mounting seats are shown in following tables:

Table 8.3 Tolerance for and Mean Roughness of Shafts



Shaft Diameter (mm)		Tolerance Grades and Mean Roughness (μm)									
		Out-of-roundness (○)		Cylindricity (⌭)		Runout (↗)		Coaxiality (◎)		Roughness	
		a		b		c		d		R_{a}	
		Bearing Accuracy		Bearing Accuracy		Bearing Accuracy		Bearing Accuracy		Bearing Accuracy	
over	incl	P5, P4	P3, P2	P5, P4	P3, P2	P5, P4	P3, P2	P5, P4	P3, P2	P5, P4	P3, P2
–	**10**	0.7	0.5	0.7	0.5	2	1.2	4	2.5	0.2	0.1
10	**18**	1	0.6	1	0.6	2.5	1.5	5	3	0.2	0.1
18	**30**	1.2	0.7	1.2	0.7	3	2	6	4	0.2	0.1
30	**50**	1.2	0.7	1.2	0.7	3.5	2	7	4	0.2	0.1
50	**80**	1.5	1	1.5	1	4	2.5	8	5	0.2	0.1
80	**120**	2	1.2	2	1.2	5	3	10	6	0.4	0.2
120	**180**	2.5	1.7	2.5	1.7	6	4	12	8	0.4	0.2
180	**250**	3.5	2.2	3.5	2.2	7	5	14	10	0.4	0.2
250	**315**	4	3	4	3	8	6	16	12	0.4	0.2

Table 8.4 Tolerance for and Mean Roughness of Housings



Housing Bore Diameter (mm)		Tolerance Grades and Mean Roughness (μm)									
		Out-of-roundness (○)		Cylindricity (⌭)		Runout (↗)		Coaxiality (◎)		Roughness	
		a_1		b_1		c_1		d_1		R_{a}	
		Bearing Accuracy		Bearing Accuracy		Bearing Accuracy		Bearing Accuracy		Bearing Accuracy	
over	incl	P5, P4	P3, P2	P5, P4	P3, P2	P5, P4	P3, P2	P5, P4	P3, P2	P5, P4	P3, P2
10	**18**	1	0.6	1	0.6	2.5	1.5	5	3	0.4	0.2
18	**30**	1.2	0.7	1.2	0.7	3	2	6	4	0.4	0.2
30	**50**	1.2	0.7	1.2	0.7	3.5	2	7	4	0.4	0.2
50	**80**	1.5	1	1.5	1	4	2.5	8	5	0.4	0.2
80	**120**	2	1.2	2	1.2	5	3	10	6	0.8	0.4
120	**180**	2.5	1.7	2.5	1.7	6	4	12	8	0.8	0.4
180	**250**	3.5	2.2	3.5	2.2	7	5	14	10	0.8	0.4
250	**315**	4	3	4	3	8	6	16	12	1.6	0.8
315	**400**	4.5	3.5	4.5	3.5	9	6.5	18	13	1.6	0.8

Shoulder and Fillet Dimensions

Table 8.5 Shoulder and Fillet Dimensions for Angular Contact Ball Bearings

Unit: mm

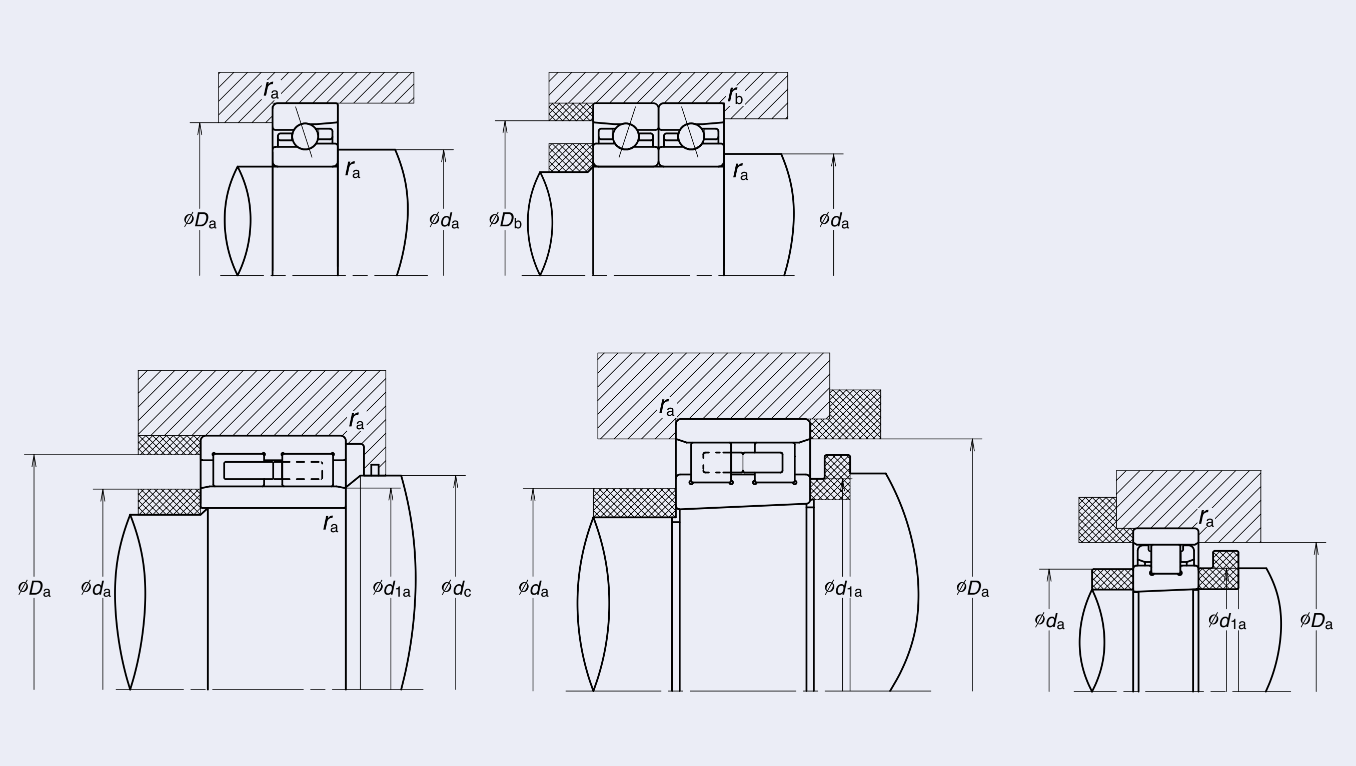
Nominal Bore Diameter	Dimension Series 19 79XX, BNR19, BER19, BAR19, BTR19, BGR19, TAC29X					Dimension Series 10 70XX, BNR10, BER10, BAR10, BTR10, BGR10, TAC20X					Dimension Series 02 72XX, BGR02				
	d_a (min)	D_a (max)	D_b (max)	r_a (max)	r_b (max)	d_a (min)	D_a (max)	D_b (max)	r_a (max)	r_b (max)	d_a (min)	D_a (max)	D_b (max)	r_a (max)	r_b (max)
5	–	–	–	–	–	–	–	–	–	–	7.5	13.5	–	0.3	–
6	–	–	–	–	–	8.5	14.5	–	0.3	–	8.5	16.5	–	0.3	–
7	–	–	–	–	–	9.5	16.5	–	0.3	–	–	–	–	–	–
8	–	–	–	–	–	10.5	19.5	–	0.3	–	10.5	21.5	–	0.3	–
10	12.5	19.5	20.8	0.3	0.15	12.5	23.5	24.8	0.3	0.15	15	25	27.5	0.6	0.3
12	14.5	21.5	22.8	0.3	0.15	14.5	25.5	26.8	0.3	0.15	17	27	29.5	0.6	0.3
15	17.5	25.5	26.8	0.3	0.15	17.5	29.5	30.8	0.3	0.15	20	30	32.5	0.6	0.3
17	19.5	27.5	28.8	0.3	0.15	19.5	32.5	33.8	0.3	0.15	22	35	37.5	0.6	0.3
20	22.5	34.5	35.8	0.3	0.15	25	37	39.5	0.6	0.3	26	41	42	1.0	0.5
25	27.5	39.5	40.8	0.3	0.15	30	42	44.5	0.6	0.3	31	46	47	1.0	0.5
30	32.5	44.5	45.8	0.3	0.15	36	49	50	1.0	0.5	36	56	57	1.0	0.5
35	40	50	52.5	0.6	0.3	41	56	57	1.0	0.5	42	65	67	1.0	0.6
40	45	57	59.5	0.6	0.3	46	62	63	1.0	0.5	47	73	75	1.0	0.6
45	50	63	65.5	0.6	0.3	51	69	70	1.0	0.5	52	78	80	1.0	0.6
50	55	67	69.5	0.6	0.3	56	74	75	1.0	0.5	57	83	85	1.0	0.6
55	61	74	75	1.0	0.5	62	83	85	1.0	0.6	64	91	94	1.5	0.8
60	66	79	80	1.0	0.5	67	88	90	1.0	0.6	69	101	104	1.5	0.8
65	71	84	85	1.0	0.5	72	93	95	1.0	0.6	74	111	114	1.5	0.8
70	76	94	95	1.0	0.5	77	103	105	1.0	0.6	79	116	119	1.5	0.8
75	81	99	100	1.0	0.5	82	108	110	1.0	0.6	84	121	124	1.5	0.8
80	86	104	105	1.0	0.5	87	118	120	1.0	0.6	90	130	134	2.0	1.0
85	92	113	115	1.0	0.6	92	123	125	1.0	0.6	95	140	144	2.0	1.0
90	97	118	120	1.0	0.6	99	131	134	1.5	0.8	100	150	154	2.0	1.0
95	102	123	125	1.0	0.6	104	136	139	1.5	0.8	107	158	163	2.0	1.0
100	107	133	135	1.0	0.6	109	141	144	1.5	0.8	112	168	173	2.0	1.0
105	112	138	140	1.0	0.6	115	150	154	2.0	1.0	117	178	183	2.0	1.0
110	117	143	145	1.0	0.6	120	160	164	2.0	1.0	122	188	193	2.0	1.0
120	127	158	160	1.0	0.6	130	170	174	2.0	1.0	132	203	208	2.0	1.0
130	139	171	174	1.5	0.8	140	190	194	2.0	1.0	144	216	223	2.5	1.0
140	149	181	184	1.5	0.8	150	200	204	2.0	1.0	154	236	243	2.5	1.0
150	160	200	204	2.0	1.0	162	213	218	2.0	1.0	164	256	263	2.5	1.0
160	170	210	214	2.0	1.0	172	228	233	2.0	1.0	174	276	283	2.5	1.0
170	180	220	224	2.0	1.0	182	248	253	2.0	1.0	188	292	301	3.0	1.5
180	190	240	244	2.0	1.0	192	268	273	2.0	1.0	198	302	311	3.0	1.5
190	200	250	254	2.0	1.0	202	278	283	2.0	1.0	208	322	331	3.0	1.5
200	212	268	273	2.0	1.0	212	298	303	2.0	1.0	218	342	351	3.0	1.5
220	242	282	287	2.0	1.0	–	–	–	–	–	–	–	–	–	–
240	263	301	306	2.0	1.0	–	–	–	–	–	–	–	–	–	–
260	283	341	345	2.0	1.0	–	–	–	–	–	–	–	–	–	–
280	304	360	365	2.0	1.0	–	–	–	–	–	–	–	–	–	–

Table 8.6 Shoulder and Fillet Dimension for Cylindrical Roller Bearings

Unit: mm

Nominal Bore Diameter	Dimension Series 19 NN39, NN49, NNU49						Dimension Series 10 (Double row) NN30XX					Dimension Series 10 (Single row) N10XX				
	d_a	d_{1a}	d_c	D_a		r_a	d_a	d_{1a}	D_a		r_a	d_a	d_{1a}	D_a		r_a
	(min)	(min)	(min)	(max)	(min)	(max)	(max)	(min)	(max)	(min)	(max)	(min)	(min)	(max)	(min)	(max)
25	–	–	–	–	–	–	29	29	43	42	0.6	–	–	–	–	–
30	–	–	–	–	–	–	35	36	50	50	1.0	35	36	51	49	0.5
35	–	–	–	–	–	–	40	41	57	56	1.0	40	41	57	56	0.5
40	–	–	–	–	–	–	45	46	63	62	1.0	45	46	63	62	0.6
45	–	–	–	–	–	–	50	51	70	69	1.0	50	51	70	69	0.6
50	–	–	–	–	–	–	55	56	75	74	1.0	55	56	75	74	0.6
55	–	–	–	–	–	–	61.5	62	83.5	83	1.0	61.5	61	83.5	83	1.0
60	–	–	–	–	–	–	66.5	67	88.5	88	1.0	66.5	66	88.5	88	1.0
65	–	–	–	–	–	–	71.5	72	93.5	93	1.0	71.5	71	93.5	93	1.0
70	–	–	–	–	–	–	76.5	77	103.5	102	1.0	76.5	76	103.5	102	1.0
75	–	–	–	–	–	–	81.5	82	108.5	107	1.0	81.5	81	108.5	107	1.0
80	–	–	–	–	–	–	86.5	87	118.5	115	1.0	86.5	86	118.5	115	1.0
85	–	–	–	–	–	–	91.5	92	123.5	120	1.0	91.5	91	123.5	120	1.0
90	–	–	–	–	–	–	98	99	132	129	1.5	98	97	132	129	1.0
95	–	–	–	–	–	–	103	104	137	134	1.5	103	102	137	134	1.0
100	106.5	108	115	133.5	131	1.0	108	109	142	139	1.5	108	107	142	139	1.0
105	111.5	113	120	138.5	136	1.0	114	115	151	148	2.0	114	114	151	148	1.0
110	116.5	118	125	143.5	141	1.0	119	121	161	157	2.0	119	119	161	157	1.0
120	126.5	128	137	158.5	154.5	1.0	129	131	171	167	2.0	129	129	171	167	1.0
130	138	140	148	172	169	1.5	139	141	191	185	2.0	139	140	191	185	1.0
140	148	150	158	182	180	1.5	149	151	201	195	2.0	149	150	203.5	194	1.0
150	159	162	171	201	197	2.0	161	162	214	209	2.0	–	–	–	–	–
160	169	172	182	211	207	2.0	171	172	229	222	2.0	–	–	–	–	–
170	179	182	192	221	217	2.0	181	183	249	239	2.0	–	–	–	–	–
180	189	193	205	241	234	2.0	191	193	269	258	2.0	–	–	–	–	–
190	199	203	217	251	245.5	2.0	201	203	279	268	2.0	–	–	–	–	–
200	211	214	228	269	261	2.0	211	214	299	285	2.0	–	–	–	–	–
220	231	234	–	289	281	2.0	–	–	–	–	–	–	–	–	–	–
240	251	254	–	309	302	2.0	–	–	–	–	–	–	–	–	–	–
260	271	275	–	349	338	2.0	–	–	–	–	–	–	–	–	–	–
280	291	295	–	369	358	2.0	–	–	–	–	–	–	–	–	–	–

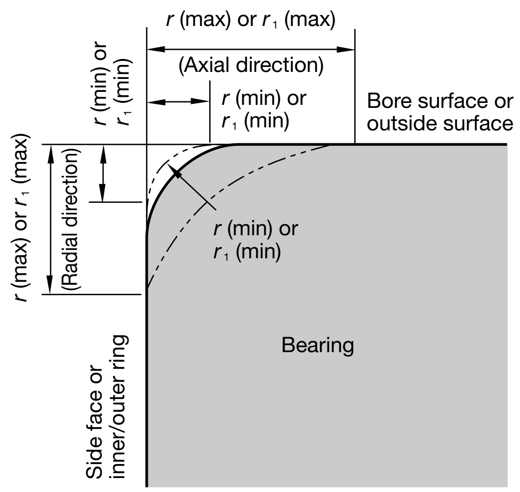
Fig. 8.1 Figure of Shoulder and Fillet Dimension



8. DESIGN OF SHAFTS AND HOUSINGS

Chamfer Dimension Limits and Corner Radius of Shaft or Housing

Fig. 8.2 Chamfer Dimension



r: chamfer dimension of inner/outer ring
r_1: chamfer dimension of inner/outer ring
(Front side)

Remarks: The precise shape of chamfer surfaces has not been specified but its profile in the axial plane shall not intersect an arc of radius r (min) or r_1 (min) touching the side face of an inner ring and bore surface, or the side face of an outer ring and outside surface.

Table 8.7 Chamfer Dimension Limits

Unit: mm

Permissible Chamfer Dimension for Inner/Outer Rings r (min) or r_1 (min)	Nominal Bore Diameter d		Permissible Chamfer Dimension for Inner/Outer Rings r (max) or r_1 (max)		Reference Corner Radius of Shaft or Housing r_a
	over	incl	Radial Direction	Axial Direction (1)	max
0.05	–	–	0.1	0.2	0.05
0.08	–	–	0.16	0.3	0.08
0.1	–	–	0.2	0.4	0.1
0.15	–	–	0.3	0.6	0.15
0.2	–	–	0.5	0.8	0.2
0.3	–	40	0.6	1	0.3
0.3	40	–	0.8	1	0.3
0.6	–	40	1	2	0.6
0.6	40	–	1.3	2	0.6
1	–	50	1.5	3	1
1	50	–	1.9	3	1
1.1	–	120	2	3.5	1
1.1	120	–	2.5	4	1
1.5	–	120	2.3	4	1.5
1.5	120	–	3	5	1.5
2	–	80	3	4.5	2
2	80	220	3.5	5	2
2	220	–	3.8	6	2
2.1	–	280	4	6.5	2
2.1	280	–	4.5	7	2
2.5	–	100	3.8	6	2
2.5	100	280	4.5	6	2
2.5	280	–	5	7	2
3	–	280	5	8	2.5
3	280	–	5.5	8	2.5
4	–	–	6.5	9	3
5	–	–	8	10	4
6	–	–	10	13	5
7.5	–	–	12.5	17	6
9.5	–	–	15	19	8
12	–	–	18	24	10
15	–	–	21	30	12
19	–	–	25	38	15

Note(1) For bearings with nominal widths less than 2 mm, the value of r (max) in the axial direction is the same as that in the radial direction.

9. SPACER

Spacer Dimension

The dimensions of standard spacers for angular contact ball bearings (19, 10, and 02 series) are listed below:

Additional information:

Material of spacer: Steel (SUJ2) or S##C steel

When using spacers, parallelism of spacer end surfaces should be less than 0.003 mm.

19 Series

Standard Spacers for Dimension Series 19 (79, BNR19, BER19, BGR19)

Unit: mm

Bore Numbers	Nominal Bore Diameter	Outer Diameter	Outer Ring Spacer		Inner Ring Spacer		Spacer Chamfer
			Outer Diameter (1)	Bore	Outer Diameter	Bore (2)	
00	10	22	21.5	17.5	14.5	10.5	0.2
01	12	24	23.5	19.5	16.5	12.5	0.2
02	15	28	27.5	23.5	19.5	15.5	0.2
03	17	30	29.5	25.5	21.5	17.5	0.2
04	20	37	36.5	31.5	26	20.5	0.2
05	25	42	41.5	36	31	25.5	0.2
06	30	47	46.5	41	36	30.5	0.2
07	35	55	54.5	48	42	35.5	0.3
08	40	62	61.5	54.5	47.5	40.5	0.3
09	45	68	67.5	60	53	45.5	0.3
10	50	72	71.5	66	56	50.5	0.3
11	55	80	79.5	72	64	55.5	0.5
12	60	85	84.5	77	68	60.5	0.5
13	65	90	89.5	82	73	65.5	0.5
14	70	100	99.5	91.5	79	70.5	0.5
15	75	105	104.5	96.5	84	75.5	0.5
16	80	110	109.5	101.5	89.5	80.5	0.5
17	85	120	119.5	110	95	85.5	0.5
18	90	125	124.2	116	100	90.5	0.5
19	95	130	129.2	120	106	95.5	0.5
20	100	140	139.2	129	112	100.5	0.5
21	105	145	144.2	133	117	105.5	0.5
22	110	150	149.2	138	122	110.5	0.5
24	120	165	164.2	152	133	120.5	0.5
26	130	180	179.2	166	144	130.8	0.8
28	140	190	189.2	176	154	140.8	0.8
30	150	210	209.2	193	167	150.8	1.0
32	160	220	219.2	213	175	160.8	1.0
34	170	230	229.2	214	188	170.8	1.0
36	180	250	249.2	231	200	180.8	1.0
38	190	260	259.2	242	206	190.8	1.0
40	200	280	279.2	255	225	200.8	1.0

(1) For outer ring spacers operating under oil mist lubrication or jet lubrication, the outer diameter of the outer ring spacer is the same as that of the bearing outside diameter. Recommend maintaining a tolerance of g5 or better.

(2) For high speed operations exceeding a $d_m n$ value of 700 thousands, the bore diameter of the inner ring spacer is the same as that of the bearing bore. Recommend maintaining a tolerance of F6 or better.

Additional information:

Material of spacer: Steel (SUJ2) or S##C steel

When using spacers, parallelism of spacer end surfaces should be less than 0.003 mm.

10 Series Standard spacers for dimension series 10 (70, BNR10, BER10, BGR10)

Unit: mm

Bore Numbers	Nominal Bore Diameter	Outer Diameter	Outer Ring Spacer		Inner Ring Spacer		Spacer Chamfer
			Outer Diameter (1)	Bore	Outer Diameter	Bore (2)	
00	10	26	25.5	21.5	14.5	10.5	0.2
01	12	28	27.5	23.5	17	12.5	0.2
02	15	32	31.5	27	20	15.5	0.2
03	17	35	34.5	29.5	23	17.5	0.2
04	20	42	41.5	35	27	20.5	0.3
05	25	47	46.5	40.5	32	25.5	0.3
06	30	55	54.5	47.5	38	30.5	0.5
07	35	62	61.5	54	43	35.5	0.5
08	40	68	67.5	60	48	40.5	0.5
09	45	75	74.5	66	55	45.5	0.5
10	50	80	79.5	71	60	50.5	0.5
11	55	90	89.5	81	66	55.5	0.5
12	60	95	94.5	86	69	60.5	0.5
13	65	100	99.5	91	74	65.5	0.5
14	70	110	109.5	98	83	70.5	0.5
15	75	115	114.5	105	85	75.5	0.5
16	80	125	124.2	112	93	80.5	0.5
17	85	130	129.2	117	99	85.5	0.5
18	90	140	139.2	126	104	90.5	0.8
19	95	145	144.2	131	109	95.5	0.8
20	100	150	149.2	136	114	100.5	0.8
21	105	160	159.2	144	121	105.5	1.0
22	110	170	169.2	153	128	110.5	1.0
24	120	180	179.2	166	136	120.5	1.0
26	130	200	199.2	177	150	130.8	1.0
28	140	210	209.2	190	160	140.8	1.0
30	150	225	224.2	203	172	150.8	1.2
32	160	240	239.2	217	183	160.8	1.2
34	170	260	259.2	230.5	199.5	170.8	1.2
36	180	280	279.2	250	210	180.8	1.2
38	190	290	289.2	261	221	190.8	1.2
40	200	310	309.2	278	232	200.8	1.2

(1) For outer ring spacers operating under oil mist lubrication or jet lubrication, the outer diameter of the outer ring spacer is the same as that of the bearing outside diameter. Recommend maintaining a tolerance of g5 or better.

(2) For high speed operations exceeding a $d_m n$ value of 700 thousands, the bore diameter of the inner ring spacer is the same as that of the bearing bore. Recommend maintaining a tolerance of F6 or better.

02 Series Standard spacers for dimension series 10 (70, BNR10, BER10, BGR10)

Unit: mm

Bore Numbers	Nominal Bore Diameter	Outer Diameter	Outer Ring Spacer		Inner Ring Spacer		Spacer Chamfer
			Outer Diameter (1)	Bore	Outer Diameter	Bore (2)	
00	10	30	29.5	25	17	10.5	0.3
01	12	32	31.5	27	18	12.5	0.3
02	15	35	34.5	29	21	15.5	0.3
03	17	40	39.5	33	24	17.5	0.3
04	20	47	46.5	39	28	20.5	0.5
05	25	52	51.5	44	33	25.5	0.5
06	30	62	61.5	53	40	30.5	0.5
07	35	72	71.5	62	46	35.5	0.5
08	40	80	79.5	68	52	40.5	0.5
09	45	85	84.5	75	56	45.5	0.5
10	50	90	89.5	80	60	50.5	0.5
11	55	100	99.5	90	65	55.5	0.8
12	60	110	109.5	95	75	60.5	0.8
13	65	120	119.5	105	80	65.5	0.8
14	70	125	124.2	110	85	70.5	0.8
15	75	130	129.2	115	90	75.5	0.8
16	80	140	139.2	125	95	80.5	1.0
17	85	150	149.2	135	105	85.5	1.0
18	90	160	159.2	140	110	90.5	1.0
19	95	170	169.2	150	115	95.5	1.0
20	100	180	179.2	160	125	100.5	1.0
21	105	190	189.2	170	132	105.5	1.0
22	110	200	199.2	175	135	110.5	1.0
24	120	215	214.2	190	145	120.5	1.0
26	130	230	229.2	203	157	130.8	1.2
28	140	250	249.2	220	170	140.8	1.2
30	150	270	269.2	233	189	150.8	1.2

(1) For outer ring spacers operating under oil mist lubrication or jet lubrication, the outer diameter of the outer ring spacer is the same as that of the bearing outside diameter. Recommend maintaining a tolerance of g5 or better.

(2) For high speed operations exceeding a $d_m n$ value of 700 thousands, the bore diameter of the inner ring spacer is the same as that of the bearing bore. Recommend maintaining a tolerance of F6 or better.

Position of The Spray Nozzle

The following table lists positions of a spray nozzle for oil-air, oil mist, and oil jet lubricating systems.

Unit: mm

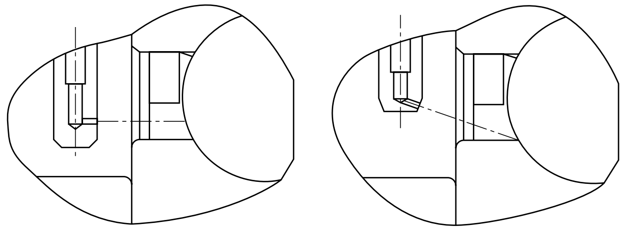
Bore Numbers	Nominal Bearing Bore	79 Series		70 Series		72 Series		N10XXMR (Standard series)		N10XXR (ROBUST series)	
		ϕA (1)	B	ϕA (1)	B	ϕA (1)	B	ϕA	B	ϕA	B
00	10	14.5	0.4	16.1	0.5	18.1	0.5	–	–	–	–
01	12	16.5	0.4	18.3	0.5	19.6	0.5	–	–	–	–
02	15	20.0	0.5	21.3	0.5	22.6	0.7	–	–	–	–
03	17	21.8	0.5	23.5	1.0	25.9	0.7	–	–	–	–
04	20	26.1	0.5	28.2	1.0	30.5	1.0	–	–	–	–
05	25	31.1	0.5	32.9	1.0	35.5	1.0	–	–	–	–
06	30	36.1	0.5	39.5	1.0	42.4	1.0	39.7	1.2	–	–
07	35	42.6	0.5	44.6	1.0	49.2	0.7	45.4	1.5	–	–
08	40	47.9	0.5	50.0	1.0	55.5	0.7	50.6	1.5	–	–
09	45	53.4	0.5	55.6	1.0	60.2	0.7	56.5	2.0	60.0	0.6
10	50	57.9	0.5	60.6	1.0	65.2	1.0	61.5	2.0	64.5	1.3
11	55	64.0	0.5	67.3	1.0	72.0	1.0	69.2	2.5	71.0	1.2
12	60	69.0	0.5	72.5	1.0	79.0	0.7	74.3	2.5	76.5	1.2
13	65	74.0	0.5	77.5	1.0	86.2	0.7	79.2	2.5	81.5	1.2
14	70	80.9	0.7	83.7	1.0	90.9	0.7	86.6	3.0	89.0	1.5
15	75	85.5	0.7	89.4	1.0	95.9	0.7	90.0	2.5	94.5	1.5
16	80	90.5	0.7	96.5	1.0	102.8	0.7	98.5	3.0	101.0	2.0
17	85	98.8	0.7	101.5	1.0	109.8	1.0	103.5	3.0	106.0	2.0
18	90	102.8	0.7	108.6	1.0	116.7	1.0	109.0	3.0	–	–
19	95	107.7	0.7	113.3	1.0	123.6	1.0	115.5	2.5	–	–
20	100	116.0	0.7	118.6	1.0	130.6	1.0	119.0	2.5	–	–
21	105	119.5	0.7	125.1	0.7	137.4	1.0	125.5	3.0	–	–
22	110	124.5	0.7	131.9	0.7	144.4	1.0	134.0	3.0	–	–
24	120	136.3	0.7	142.3	0.7	156.3	1.0	142.0	3.0	–	–
26	130	149.3	0.7	156.2	1.0	168.9	1.0	156.0	4.5	–	–
28	140	158.1	0.7	165.7	2.5	182.6	1.0	168.0	4.5	–	–
30	150	171.8	0.7	178.1	2.5	196.5	1.0	–	–	–	–
32	160	181.8	0.7	190.4	2.5	–	–	–	–	–	–
34	170	191.8	0.7	203.4	2.5	–	–	–	–	–	–
36	180	205.6	0.7	217.1	2.5	–	–	–	–	–	–
38	190	215.4	0.7	227.1	2.5	–	–	–	–	–	–
40	200	229.0	0.7	240.9	2.5	–	–	–	–	–	–

(1) In compliance with DIN Standard 628-6.

Attention

- For bearings operating under normal operating speed, proper lubrication can be achieved by positioning the nozzle bore along the side of the bearing and aiming directly into the bearing interior at the level of the inner ring. For constant high speed operations, it is advantageous to position the nozzle bore so that the lubricant is directed into the bearing interior at an angle of about 15°or 20°. Please contact NSK for further details.
- An appropriate means of draining oil sump is necessary to prevent severe oil shear friction, which can result in bearing damage at the sliding section.
- Recommend using a maximum 5 micron filter to provide filtration of oil entering the lubricating system.

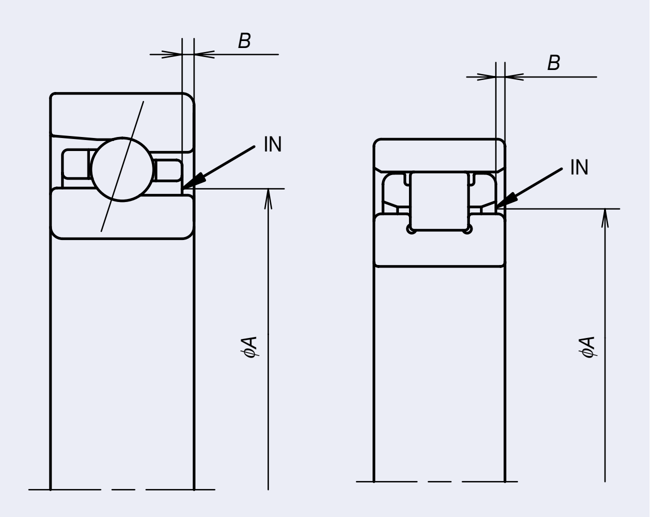
Fig. 9.1 Angle of nozzle



Unit: mm

Nominal Bearing Bore	BNR19 BER19		BNR10 BER10		BGR19		BGR10		BGR02		BAR10 BTR10	
	ϕA	B	ϕA	B	ϕA	B	ϕA	B	ϕA	B	ϕA	B
6	–	–	–	–	–	–	9.0	0.4	–	–	–	–
7	–	–	–	–	–	–	10.5	0.4	–	–	–	–
8	–	–	–	–	–	–	12.0	0.5	–	–	–	–
10	–	–	–	–	13.5	0.4	14.5	0.5	17.0	1.0	–	–
12	–	–	–	–	15.5	0.4	16.5	0.5	18.0	0.5	–	–
15	–	–	–	–	18.5	0.5	20.0	1.0	21.0	1.0	–	–
17	–	–	–	–	20.5	0.5	22.5	1.5	24.0	0.5	–	–
20	–	–	–	–	25.0	0.8	26.5	0.8	28.3	0.5	–	–
25	31.0	0.5	–	–	30.0	0.8	31.5	0.8	33.2	1.0	–	–
30	35.5	0.5	39.0	1.0	–	–	–	–	–	–	–	–
35	42.0	0.5	44.5	1.2	–	–	–	–	–	–	–	–
40	48.0	0.5	50.0	1.5	–	–	–	–	–	–	–	–
45	53.0	0.5	55.5	1.7	–	–	–	–	–	–	–	–
50	57.5	0.5	60.5	1.7	–	–	–	–	–	–	60.5	0.9
55	63.5	0.5	67.5	1.5	–	–	–	–	–	–	67.5	0.7
60	68.5	0.5	73.0	1.5	–	–	–	–	–	–	73.5	0.7
65	73.5	0.5	77.5	1.5	–	–	–	–	–	–	77.5	0.7
70	80.5	0.7	84.0	1.7	–	–	–	–	–	–	84.0	0.7
75	85.0	0.7	89.0	1.7	–	–	–	–	–	–	89.0	0.7
80	90.5	0.7	96.0	1.7	–	–	–	–	–	–	96.0	0.9
85	98.5	0.7	102.0	1.7	–	–	–	–	–	–	102.0	0.9
90	102.0	0.7	109.0	1.7	–	–	–	–	–	–	108.5	1.2
95	107.0	0.7	112.0	1.7	–	–	–	–	–	–	112.5	1.2
100	113.5	0.7	118.5	2.5	–	–	–	–	–	–	118.5	1.7
105	119.0	0.7	125.0	1.7	–	–	–	–	–	–	126.0	1.4
110	124.0	0.7	132.5	1.7	–	–	–	–	–	–	132.5	1.2
120	136.0	0.7	143.0	1.7	–	–	–	–	–	–	142.5	1.2
130	149.0	0.7	156.5	1.7	–	–	–	–	–	–	155.5	1.7
140	157.5	0.7	166.0	1.7	–	–	–	–	–	–	167	1.7
150	171.5	0.7	178.5	1.7	–	–	–	–	–	–	179.5	1.9
160	–	–	–	–	–	–	–	–	–	–	190	2.0
170	–	–	–	–	–	–	–	–	–	–	205	1.7
180	–	–	–	–	–	–	–	–	–	–	218	2.0
190	–	–	–	–	–	–	–	–	–	–	228	2.0
200	–	–	–	–	–	–	–	–	–	–	242	2.2

Fig. 9.2 Position and Direction of Spray Nozzle



Bearing Handling

1. Mounting ······································· P178-191
    1. Cleaning Bearings and Related Parts
    2. Checking Dimensions of Related Parts
    3. Mounting Procedures
    4. Inspection after Mounting
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3. Maintenance and Inspection ························· P194-197

Bearing Handling

Introduction

Mounting Procedure

The method of mounting rolling bearings strongly affects their accuracy, life, and performance.It is recommended that the handling procedures for bearings be fully analyzed by design and engineers and that standards be established with respect to following items:

1. Cleaning the bearings and related parts
2. Checking the dimensions of related parts
3. Mounting procedures
4. Inspection after mounting

Bearings should not be unpacked until immediately before mounting. However, bearings for instruments or for high speed operations must first be cleaned with clean filtered oil in order to remove the anti-corrosion agent.
After the bearings are cleaned with filtered oil, they should be protected to prevent corrosion. Prelubricated bearings must be used without cleaning.
Bearing mounting procedures vary according to the type of bearing and type of fit.
Since precision bearing are widely used for rotating shafts, their inner rings require a tight fit.
Bearings with cylindrical bores are usually mounted by fitting with a press (press fit), or by heating them to expand their inner ring (shrink fit). The outer ring is usually inserted into the housing with a loose fit. In case where the outer ring has an interference fit, a press may be used.

Precautions for Proper Handling of Bearings

Since rolling bearings are high precision machine parts, they must be handled accordingly.
Even if high quality bearings are used, their expected performance cannot be achieved if they are not handled properly. The main precautions to be observed are as follows:

■ Keep bearings and surrounding area clean

Foreign particles, even if invisible to the naked eye, have harmful effects on bearings. Take care to prevent the entry of dirt and debris into the bearing by maintaining a clean working environment.

■ Handle bearings carefully

Avoid any heavy shocks during handling. Shock loads can scratch or otherwise damage a bearing, possibly resulting in failure. An excessively strong impact may cause brinelling, breakage, or cracks.

■ Use proper tools

Always use the proper equipment when handling bearing. Do not use general purpose tools.

■ Prevent corrosion

Handling bearings with bare hands can corrode the bearing surfaces because of the acidic moisture or other contaminations on the hands.
Keep your hands clean when handling bearings, and wear dust free gloves whenever possible. Take measures to prevent rusting of bearing caused by moisture and corrosive gasses.

Storage method

■ Although bearings are coated with an anti-corrosion agent, and then wrapped and packed, it is impossible to completely avoid exposure to the air surrounding the bearings. Store the bearings in a dry location and avoid exposure to moisture and humidity.

■ Bearings should be stored in a clean, dry, and well-ventilated location that also provides protection from direct sunlight. Store the bearings in a locker or on shelves that are at least 30 cm from the floor.

■ When bearings are unpacked for acceptance inspection, take measure to prevent rusting and contamination. After inspection, follow the guidelines given above to ensure proper storage.

1. Cleaning the Bearings

Delivered bearings are coated with an anti-corrosion agent for dustproofing and prevention during transportation.
After opening the package, bearings need to be cleaned in order to remove the anti-corrosion agent.
Some bearings, such as sealed or pregreased bearings, can be used without cleaning.

■ Cleaning method ■

1. Use kerosene or light oil to clean the bearings.

2. Use separate tanks for rough cleaning and final cleaning. Each tank should be equipped with a wire rack to prevent direct contact of the bearing with any contamination that may have settled at the bottom.

3. In the rough cleaning tank, avoid rotating the bearings. After cleaning the outside surfaces with a brush, move the bearings to the final cleaning tank.

4. In the final cleaning tank rotate the bearing by hand. Make sure that the cleaning fluid in the final cleaning tank is kept clean.

5. Remove excess cleaning fluid from the bearings after cleaning.
   Bearings using ordinary grease lubrication need to be packed with grease. Oil lubricated bearings should be mounted on the machine tool spindle while take care not to rotate the bearing. Prior to mounting, slightly coat the bearing inner and outer surface areas with a thin film of lubrication oil.

2. Checking Dimension of Related Parts

Inspection of shaft and housing

■ Mating housing and shaft surfaces should be cleaned and checked for flows or burrs.

■ The dimensions of the shafts and housing bores should be checked to confirm a matching fit with the bearing bore and outer diameter. Recommended fits for shafts and housing bores are listed on Page 166.

■ Take measurements and mount the bearings in a thermostatic chamber. Parts should be left until they have reached a constant and stable temperature. Using a micrometer or cylinder gauge, take measurements at several different points to confirm there are no significant differences in measurement values. Recommended measurements for accuracy of the shafts and housing bores are listed on Page 167.

Inspection of spacers

For main spindle, a spacer parallelism of less than 0.003mm is recommended. Spacer parallelism exceeding this recommendation will tilt the bearings, thus causing inaccuracies and bearing noise.

3. Mounting of Procedures

Grease lubricated bearings and oil-air (oil mist) lubricated bearings which are cleaned are mounted on the shaft and housing bore. Procedures for mounting vary according to the fit requirements of the inner and outer rings. Primarily, it is the inner ring of a machine tool bearing that rotates, thus bearings with cylindrical bores are usually mounted by heating them to expand the inner ring (shrink fit).

Bearing with tapered bores can be mounted directly onto a tapered shaft. For high speed operations, GN gauges are recommended for attaining accurate radial clearance when mounting. Page 184 provides details on how to use GN gauges.

Outer rings are mounted with some clearance; so mounting tool are not usually required. The housing can be heated to make mounting much easier.

3.1. Mounting of Bearings with Cylindrical Bores

(1) Press fit

Fitting with a press is widely used for small bearings. First, apply a thin coat of oil to the mating shaft surface before mounting to help reduce the amount of force required for press fitting.

Next, place a mounting tool against the inner rings as shown in Fig. 1.1. Apply steady pressure from the mounting tool to drive the bearing firmly against the shoulder of the shaft.

Avoid press fitting onto a shaft by applying pressure to the outer rings as this may damege the bearing.

Also, avoid using a hammer when mounting precision bearings.

For separable bearings, such as cylindrical roller bearings, the inner and outer rings can be mounted onto the shaft and into the housing as separate units. When assembling the two units, When assembling the two units, take extra care to align the inner and outer rings correctly. Careless or forced assembly may cause scratches on the rolling contact surfaces.

(2) Shrink fit

Since press fitting large bearings requires a great deal of force, the shrink fitting method is widely used. The bearing are first heated to expand the inner ring before mounting onto the shaft. This method prevents excessive force from being imposed on the bearings and enables mounting them in a short time.

The expansion of the inner ring for various temperature differences and bearing size is shown in Fig. 1.2

The following precautions need to be taken when shrink fitting.

1. Do not heat bearings to more than 120°C.
2. Heat the bearings to a temperature 20°C to 30°C higher than the lowest temperature required for mounting without interference since the inner ring will cool a little during mounting.
3. After mounting, the bearings will shrink in the axial direction as well as the radial direction while cooling. Therefore, drive the bearing firmly up against the shaft shoulder using locating methods to eliminate any clearance between the bearing and shoulder.

Fig. 1.1 Press Fitting Inner Ring

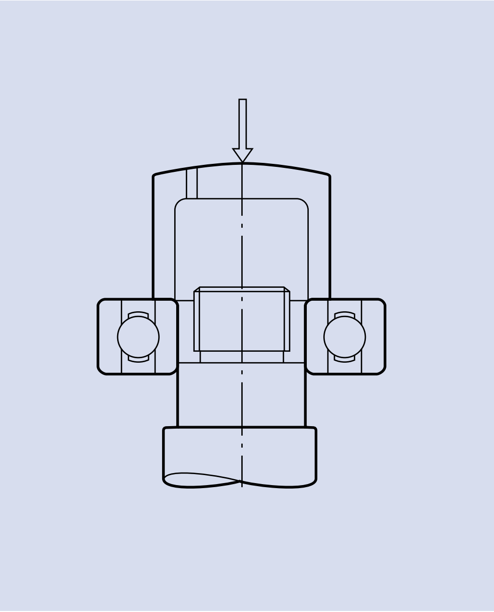
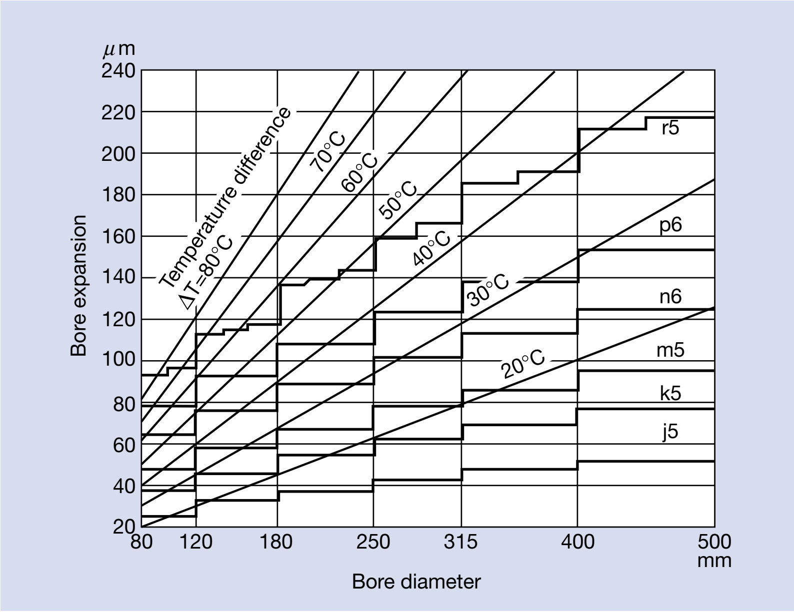


Fig. 1.2 Temperature and Thermal Expansion of Inner Ring

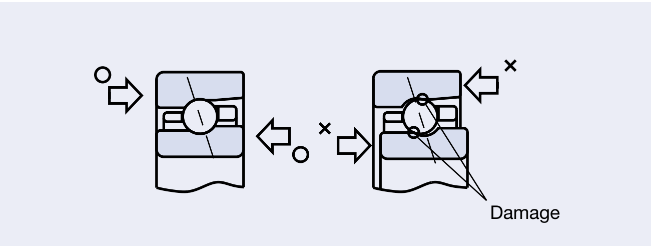


3.2. Precautions for Mounting Angular Contact Ball Bearings

Due to design restriction, an angular contact ball bearing can sustain loads in only one direction. Therefore, when mounting angular contact ball bearings onto the shaft or into the housing, it is imposing any loads in the wrong direction.

Pay special attention to the order of mounting for combination bearings. Mounting onto the shaft and into the housing is different for back-to-back and face-to-face arrangements.

Fig. 1.3 Direction of Load for Angular Contact Ball Bearings

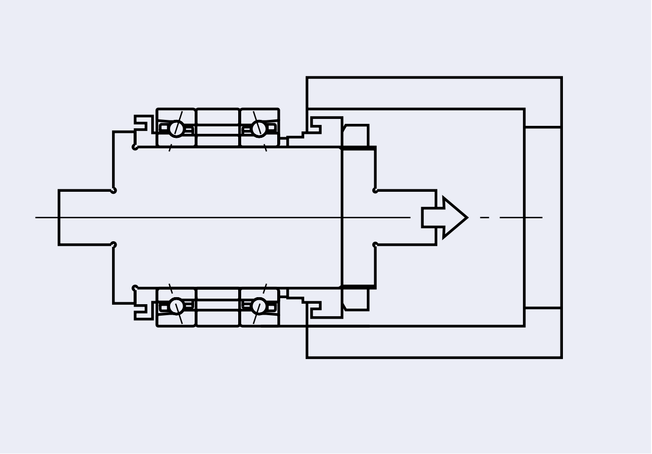


Load applied in direction "x" results in damage to the bearing.

Back-to-back arrangement:

① Press the bearing onto the shaft.
② Tighten the bearing locknut for preloading.
③ Insert the bearing and the shaft into the housing, and attach the retaining cover.

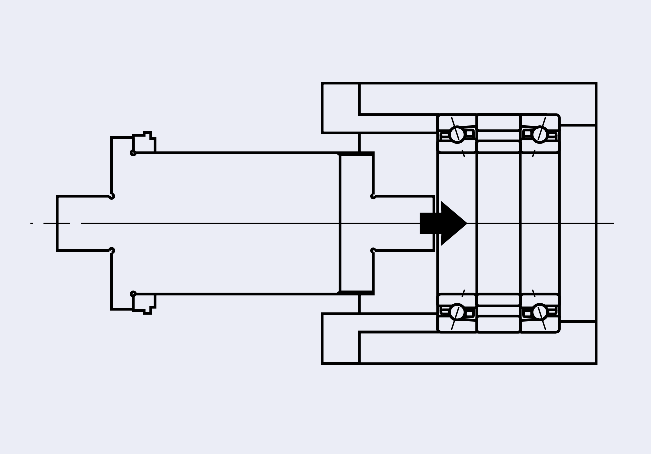
Fig. 1.4 Mounting of Back-to-back Arrangement



Face-to-face arrangement:

① Press the bearing into the housing.
② Secure the retaining cover for preloading.
③ Insert the shaft into the inner ring and tighten the bearing locknut.

Fig. 1.5 Mounting of Face-to-face Arrangement



Reverse the order of each step for dismounting.

3.3. Securing the bearing

(1) Securing the inner ring

The inner ring is usually secured onto the shaft by tightening the bearing locknut, which explains why perpendicularity of the threads and end face are very important. Even if accuracy as a single component is good, the gap between the shaft and locknut can result in runout of the locknut, causing the shaft and bearing to bend. (see Fig. 1.21, Page 189) Therefore, making adjustments are necessary to ensure constant running accuracy.

It is also important that the locknut be completely tightened so as to eliminate any possibility of it becoming loose. Seating torque information for bearing locknuts is shown in Table 1.1.

There is a risk of unbalance due to face and runout of the locknut or a minor inaccuracy of the mating parts. Here, sleeves are widely used in high speed, high precision machine tool spindles to secure the bearing to the shaft by a large interference fit between the shaft and sleeve bore. However, the sleeve tends to become loose after continuous operation, so it must be checked periodically.

When a wide spacer is used between combined angular contact ball bearings, and the seating torque of the locknut is excessive, the inner ring spacer may become deformed and alter the preload to a level higher than expected. It is necessary to consider this deformation when the preload is set.

(2) Securing the outer ring

A retaining cover held by bolts is generally used to secure the bearing outer ring axially. If a bolt is tightened excessively or a combination of bolts is tightened unevenly, the bearing outer ring may become deformed.

For example, Fig. 1.6 shows possible deformation of the outer diameter of the outer ring caused by uneven tightening of the retaining cover, when the outer ring end face is pressed as a pilot ring.

Fig. 1.7 shows an example of poor retaining cover tightening for a fixed end bearing resulting in outer ring deformation.

Fig. 1.8 shows deformation of an outer ring raceway surface caused by tightening of a double row cylindrical roller bearing.

The amount of deformation depends on the clearance of the mating parts. It is recommended that the clearance between the retaining cover and housing end face be adjusted to about 0.01 to 0.05 mm before the bolts are completely tightened.

Fig. 1.6 Raceway Surface Deformation Caused by Excessive Tightening

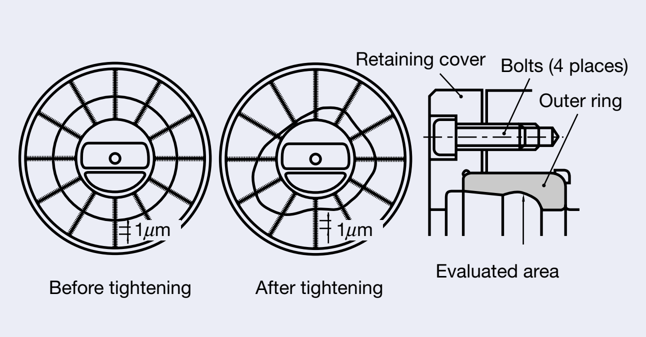


Fig. 1.7 Raceway Surface Deformation Caused by Excessive Tightening

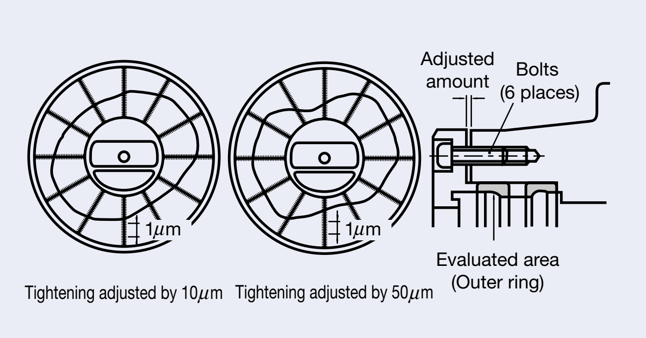


Fig. 1.8 Deformation of the Outer Ring of a Double Row Cylindrical Roller Bearing Caused Excessive Tightening

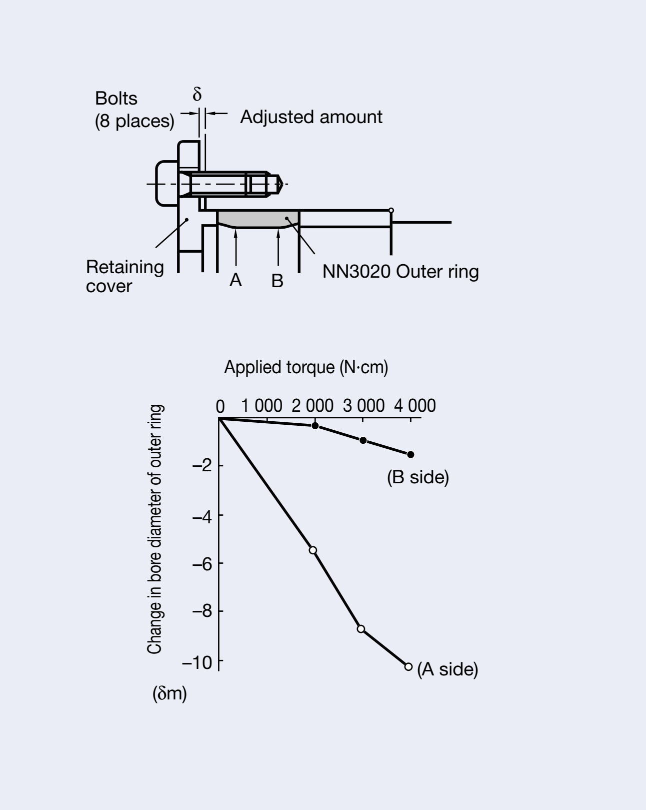


Table 1.1 Bearing Locknut Tightening Torque and Clearance between Retaining Cover and Housing

Nominal bearing bore (mm)	Locknut tightening force (N)	Locknut tightening torque Reference (N·m)	Clearance between retaining cover and housing (mm)
6	1 500	2	0.01 –0.03
8		2	
10		3	
12	3 000	7	
15		8	
17		9	
20	4 900	17	
25		21	
30		25	
35	9 800	57	
40		64	
45		72	
50		80	
55	14 700	132	
60		142	
65		153	
70		166	
75		176	
80	19 600	251	
85		267	
90		281	
95		296	
100		311	
105		327	
110		343	
120		371	
130		403	
140	29 400	649	0.03 –0.05
150		695	
160		745	
170		796	
180		841	
190		886	
200		932	
220	39 200	–	
240		–	
260		–	
280		–	
300		–	

When interference fit of the shaft increases under high speed operations, the amount of tightening torque applied to the locknut must also be increased.

The tightening force of Angular contact thrust ball bearing for ball screw support should be 2.5–3.0 times of the preload.

■ Conversion equation of locknut tightening torque

$$T=0.5F\left\{d_p\cdot \tan(p^{*}+\beta)+d_w\cdot\mu_w\right\} \quad [\text{N·mm}]$$

The values of locknut tightening torque in the table are calculated by friction coefficient of 0.15.

T :Locknut tightening torque [N·mm]
F :Locknut tightening force [N]
d_p :Effective diameter of locknut [mm]
p^{*} :Friction angle of locknut surface
$p^{*}=\tan^{-1}\mu_S$
μ_S :Friction coefficient of locknut surface
d_w :Frictional torque equivalent diameter at locknut surface [mm]
μ_w :Friction coefficient of locknut surface
β :Lead angle of nut
$\beta=\tan^{-1}(\text{pitch}/(3.142\cdot dp))$

■ Equation of push up force

$$\mathrm{K}=\mu\cdot p_m\cdot\pi\cdot d\cdot B \quad [\text{N}]$$

$$p_m=\frac{E}{2}\;\frac{\Delta d}{d}\;\frac{(1-k^2)(1-k_0^2)}{1-k^2\,k_0^2}$$

μ :Friction coefficient at fitting surface [=0.12]
p_m :Surface pressure [MPa]
d :Shaft diameter [mm]
B :Bearing width [mm]
Δd :Effective interference [mm]
E :Young’s modulus of steel [MPa]
k :Wall thickness ratio ($k=d/D_i$)
D_i :Raceway diameter of inner ring [mm]
k_0 :Wall thickness ratio of hollow shaft ($k_0=d_0/d$)
d_0 :Bore diameter of hollow shaft [mm]

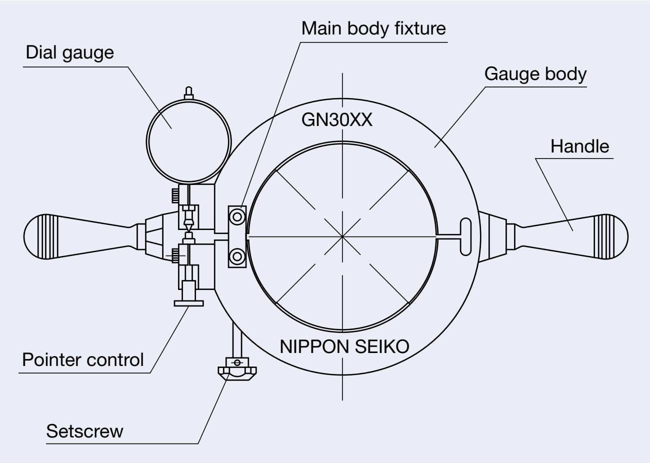
3.4. Mounting of Cylindrical Roller Bearings

(1) Measuring radial clearance of cylindrical roller bearings

A GN gauge is an instrument for matching the tapered section of a shaft to the tapered bore of a bearing when mounting a cylindrical roller bearing with a tapered bore onto a machine tool spindle. After mounting, the GN gauge is used for precise control of the bearing's radial internal clearance. This instrument is especially effective when a cylindrical roller bearing is used with radial preload.

Fig. 1.9 describes the GN gauge components.

Fig. 1.9 GN Gauge



How to use a GN gauge

① Insert outer ring into housing.

The recommended fit between outer ring and housing is:

Clearance 2μm - Interference 2μm

② Zero setting of cylinder gauge

Confirm that the temperatures are the same for the outer ring (inserted into the housing), the inner ring, and the shaft. Then, measure the bore diameter of the outer ring at about four different locations. Determine the average for the measurements and the cylinder gauge to zero (see Fig. 1.10).

Fig. 1.10 Zero Setting of Cylinder Gauge

③ Adjust the inscribed diameter of GN gauge

Loosen the bolt of the main body fixture on the GN gauge. Apply the cylinder gauge to the inscribed diameter surface of the GN gauge and adjust the setscrew to the setting of the dial on the cylinder gauge to zero (see step ②)

(Use the GN gauge in an upright position to avoid inaccuracies due to its own weight.)

④ Correction of GN gauge

Using the results from step ③, use the pointer control on the dial gauge to adjust the pointer on the GN gauge to the red mark for gauge correction. Confirm that the short needle is near 2 on the dial.

(Gauge correction corrects for elastic deformation of the roller due to measuring pressure on the gauge. The amount of correction for each gauge is determined upon shipment a gauge.)

Fig. 1.11 Adjust the Inscribed Diameter of the GN Gauge

⑤ Mounting of inner ring

Mount the inner ring onto the shaft and tighten the locknut lightly. Art this time, the bearings should be cleaned, but not yet coated with grease.

⑥ Setting of GN gauge

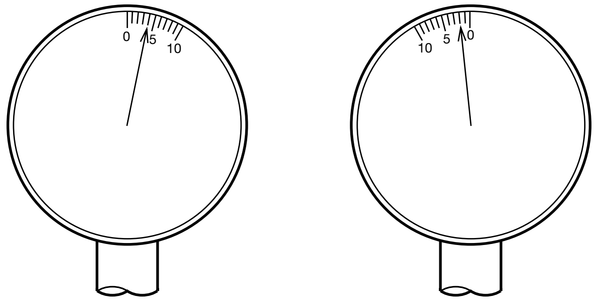
Adjust the setscrew on the GN gauge (0.2mm to 0.3mm on the dial face) to spread open the dial on the GN gauge. The GN gauge is placed in the center of inner ring and the setscrew is loosened.

⑦ Reading of the scale

Read the scale on the dial gauge of the GN gauge at this time.

Example 1: A half-shift of the dial from zero in the clockwise direction indicates positive clearance.

Example 2: A half-shift of the dial from zero in the counter-clockwise direction indicates negative clearance.



Example 1: Pointing to "4" in the clockwise direction indicates a radial crealance of +0.002mm

Example 2: Pointing to "2" in the counter-clockwise direction indicates a radial clearance of –0.001mm

⑧ Adjustment

In addition to procedures given in step ⑥, use the screw to spread the dial of the GN gauge. Remove the gauge from inner ring and tighten the locknut. Repeat steps ⑥ through ⑧ until the scale of the dial gauge reaches the target clearance value.

⑨ Adjustment of spacer

Measure the clearance between the shaft shoulder and the end face on the large diameter side of NN30XXKR by using block gauge. Measure more than three places on circumference to both an average and the finish width of spacer for that average.

Fig. 1.12 Insertion of Inner Ring

Fig. 1.13 Setting of GN Gauge

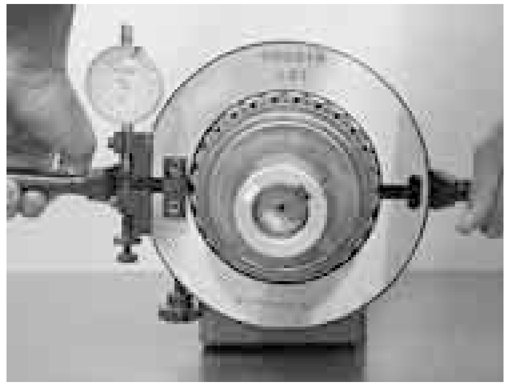


Fig. 1.14 Reading of the Scale

Fig. 1.15 Measurement of Spacer Width

(2) Measuring radial clearance of cylindrical roller bearings (GN gauge is not used)

When the GN gauge is not used, it is necessary to adjust the spacer width by considering the following two items:

- Shrinkage of outer ring raceway diameter due to fitting in housing (Δr_e)
- Expansion of the inner ring raceway diameter due to fitting, which includes a hollow shaft ratio. (Δr_i)

■ Calculation of Δr

The finish dimension (La) of the spacer, which is used for setting the post-mounting radial clearance of Δr, can be calculated as follows:

$$L_a = L - K\,(\Delta r_m - \Delta r + \Delta r_e)$$

Table 1.2 Hollow Shaft Ratio and Coefficient K

Hollow shaft Ratio k_0	Coefficient K
45–55%	14
55–65%	15
65–75%	16

L_a :Finish dimension of spacer for setting post mounting radial clearance

L :Width of block gauge (Measured result from step ⑤ on Page 187.)

Δr_m :Movement of the outer ring in radial direction (Measured result from step ④ on Page 187.)

Δr :Radial clearance after mounting

Δr_e :Shrinkage of outer ring raceway diameter due to fitting

K :Coefficient (Converted value which includes shrinkage of a hollow shaft with a 1/12 tapered hole)

k_0 :A/B×100

A: Shaft bore diameter B: Shaft outer diameter

■ Calculation of Δr_e

$$\Delta r_e = (D_h - D) \times h$$

when $\Delta r_e \geqq 0$ assume $\Delta r_e = 0$

D_h :Housing bore diameter

D :Outer diameter of outer ring (Refer to bearing inspection sheet)

h :Shrinkage rate of the outer ring raceway diameter

(0.62 for NN30 and N10 series)

(0.7 for NN39 and NN49 series)

Measuring of radial clearance of Δr_m

① Mount the inner ring onto the tapered section of the shaft. (At this point, degrease the tapered section of the shaft and internal surface of the inner ring with organic solvent.)

② Place the outer ring on circumscribing part of the rollers and apply the dial gauge to outer diameter of the outer ring.

③ Tighten the spacer and the locknut now to expand the inner ring. (see Fig. 1.16)

④ Push the outer ring in up and down and measure the radial movement of the outer ring with dial gauge (*1). Repeat steps ③ and ④ until play of the outer ring (Δr_m) becomes about 0.005mm. (*2) (Fig. 1.17)

⑤ When Δr_m is set at about 0.005mm, measure the distance from shaft shoulder to the inner ring end face (Dimension L) with block gauge and the thickness gauge. (*3) (see Fig. 1.18)

Remarks

(*1) If the measurement takes too long, the temperature of the outer ring may have risen to body temperature resulting in an erroneous measurement. Wearing gloves is recommended to for making a quick measurement.

(*2) If there is an excessive amount of play, the outer ring may have deformed into an ellipse when pressed by hand. This would result in an erroneous measurement. Therefore, 0.005mm of play is acceptable. (0.005mm is the target value, but 0.001mm to 0.002mm is also acceptable.)

(*3) For the measurement of dimension L, the value obtained is produced by inserting the block gauge in the left half of the zone shown in Fig. 1.18 (This is due to tilting that occurs between the shaft shoulder and inner ring end face.)

Fig. 1.16 Insertion of Outer Ring

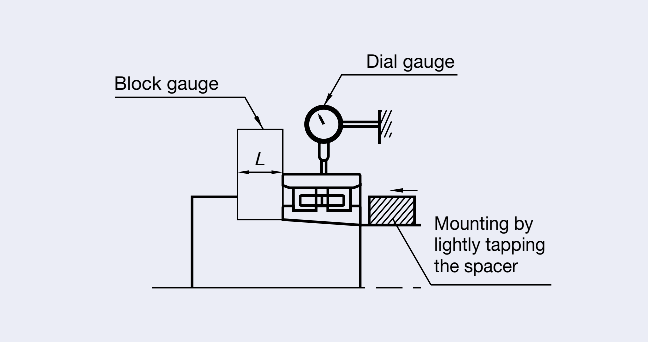


Fig. 1.17 Measuring Outer Ring Movement

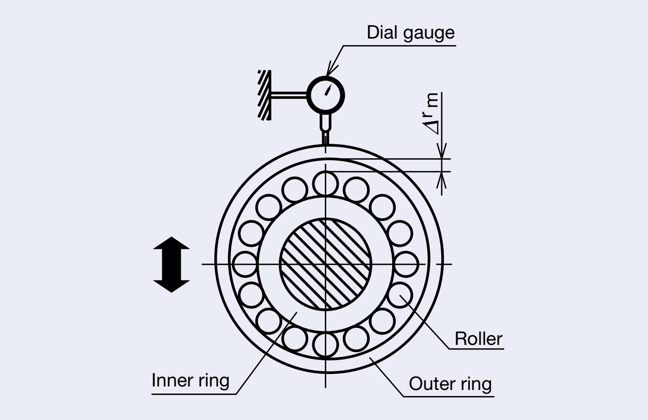
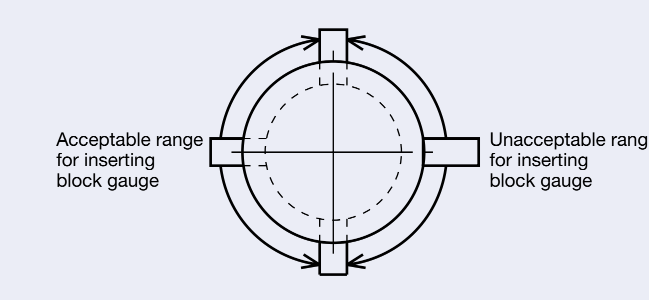


Fig. 1.18 Measuring Width Dimension with Block Gauge



(Example of calculation)

Setting radial clearance to Δr=–0.002mm for NN3020MBKR after mounting.

Shrinkage of outer ring raceway diameter due to fitting: Δr_e=–0.004 (Interference) (When $\Delta r_e \geqq 0$ assume Δr_e=0)

Movement of outer ring (Measured value in step ④) Δr_m=0.007mm

Block gauge width (Measured value in step ⑤) L=20.55mm

Finish spacer width dimension

$$L_a = 20.55 - 15 \times (0.007 - \underline{(-0.002)} - \underline{0.004})$$
$$= 20.55 - 0.075$$
$$= 20.475$$

Note the code!

3.5. Grease Packing

Procedure for packing grease after cleaning bearings

A rapid rise in temperature may occur during initial running in due to improper packing of grease. This can result in a long running in period, or lead to seizure and bearing failure. Following proper procedures for packing grease and using the correct amount of grease deserves careful attention. Recommended procedures are as follows:

(1) Pre-inspection

Check to ensure there is no foreign matter in the bearing interior. Bearings for high speed spindle shafts should be cleaned, degreased, and packed with grease. For other applications, remove any anti-corrosion agent adhering to interior surfaces of the bearings.

(2) Grease dispensers

Use a grease dispenser, such as a plastic syringe for precision grease dispensing. If possible, use a dispenser that comes with a gauge for packing accurate amounts of grease.

(3) Amount of grease

Recommended amounts of grease packing for precision bearings:

Angular contact ball bearings for high speed machine tool spindles: 15%±2% of internal space

Cylindrical roller bearings for high speed machine tool spindle: 10%±2% of internal space

Ball bearings for motors: 20% to 30% of internal space

Recommendation of grease amount for various bearing types and numbers is shown on Page 157.

■ Packing method for ball bearings

(1) Pack grease evenly between the balls. If an outer ring guided cage is used, such as a phenolic resin cage, apply a light coating of grease on the guided surface.

(2) Rotate the bearing by hand to spread grease evenly on the surfaces of the raceway, ball, and cage.

■ Packing method for cylindrical roller bearings

(1) Coat about 80% of the grease amount evenly on roller rolling surface. Avoid putting too much grease on the cage bore. Grease on the cage bore is difficult disperse during the running in period, which can result in a rapid rise in temperature or a long running in period.

(2) Coat roller surfaces with a thin film of grease, including the roller end faces, roller cage contact points, and along the face edges of each cage pocket.

(3) Using the remaining 20% of grease, apply a thin film of grease to the raceway surface of the outer ring.

Fig. 1.19 Grease Packed Angular Contact Ball Bearing

Fig. 1.20 Grease Packed Cylindrical Roller Bearing

4. Inspection after Mounting

4.1. Runout accuracy

Accurate mounting and related parts are indispensable to ensure precision and accuracy of the machine tool spindle.

1: Assembled bearing outer ring face runout with raceway for angular contact ball bearings

Adjust to 0.002mm or less by tapping on the outer ring end face.

2: Variation of bearing outside surface generatrix inclination with outer ring reference face for angular contact ball bearings

Adjust to 0.005mm or less tilting the locknut. (see Fig. 1.21)

3. Concentricity of rear side housing 0.010mm or less

If these accuracies cannot be met, disassembled the bearings and check the accuracy of parts again.

Fig. 1.21 Tilting the Shaft Locknut

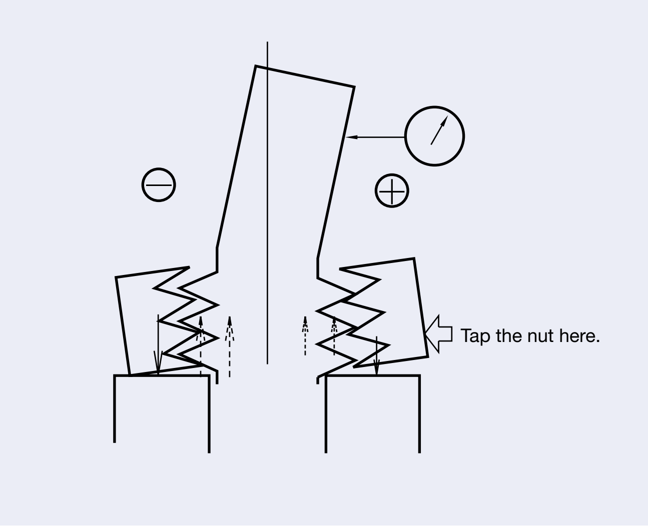
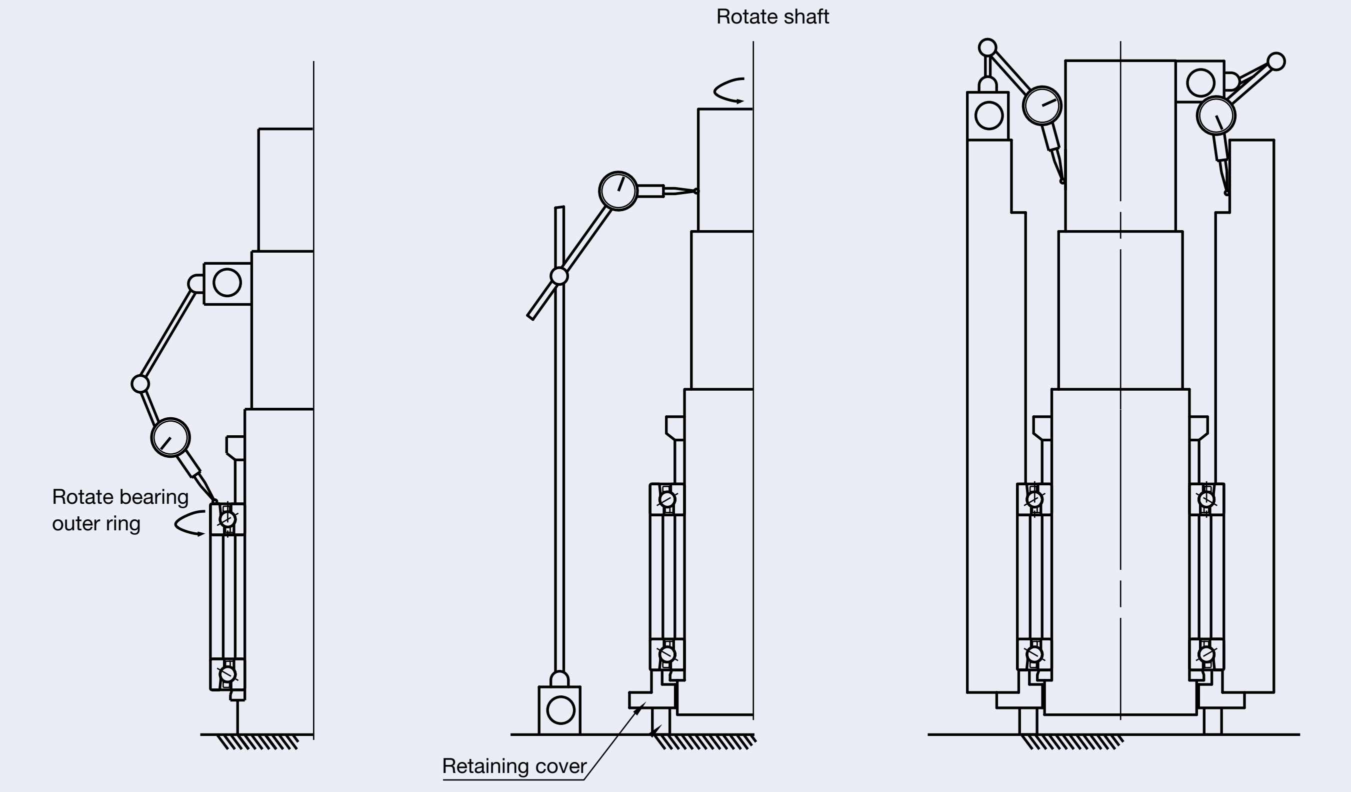


Fig. 1.22 Runout Accuracy of Machine Tool Spindle



Assembled bearing outer ring face runout with raceway for angular contact ball bearings

Variation of bearing outside surface generatrix inclination with outer ring reference face for angular contact ball bearings

Concentricity of rear side housing

4.2. Control of Preload after Mounting of Bearing

If the preload of rolling bearing is set larger, the rigidity of bearing is increased, but heat generation is also increased, and in extreme cases, seizure may occur. Therefore, it is necessary to control optimum preload carefully in response to operating condition. Measuring method of preload for angular contact ball bearing is introduced below. For the preload of cylindrical roller bearing, it is recommended to control by using GN gauge at mounting process. (see Page 184)

Measuring of preload for angular contact ball bearing

There are three methods for checking preload of bearings after mounting onto main shaft, such as starting torque method, thrust static rigidity method, and natural frequency method.

Features of these methods are summarized in Table 1.3.

Table 1.3

	Starting torque method	Thrust static rigidity method	Natural frequency method
Advantage	**Used for heavy preload,** If starting torque is high, measurement error is small.	**Used for light preload**	**Measurement accuracy is high.** **Good repeatability.**
Disadvantage	**Not good for light preload.** If starting torque is small, variation of measurement is large.	**Not good for heavy preload.** Loading equipment is too large scale. Affected easily by deformation of contact part other than bearing.	**Influence of spindle fixing condition should not be ignored.**

(1) Starting torque method

[Characteristic]

High speed main shaft spindle bearings are often used with light preload so that starting torque is low and measurement error is large.

[Method]

Starting torque is obtained mainly by measuring tangential force. (see Fig. 1.23)

Preload is obtained from the relationship between measured starting torque and preload. (see Fig. 1.24)

When oil film formation in rolling contact area is unstable during measurement, sticking occurs. (Rotation does not start even under tangential force and rotation starts suddenly when tangential force is increased gradually). The torque at such occasion tends to be higher than predicted calculated torque so that excessive measurement result needs to be excluded.

Fig. 1.23 Starting Torque Method

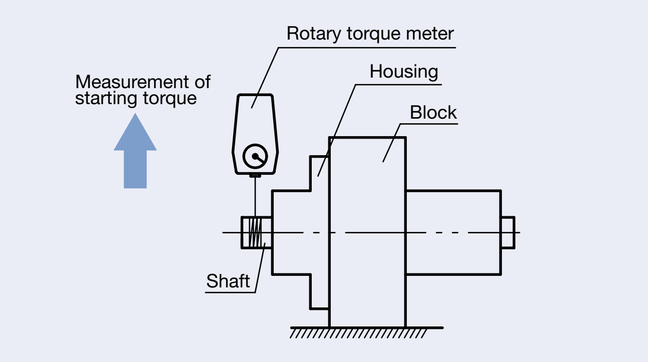
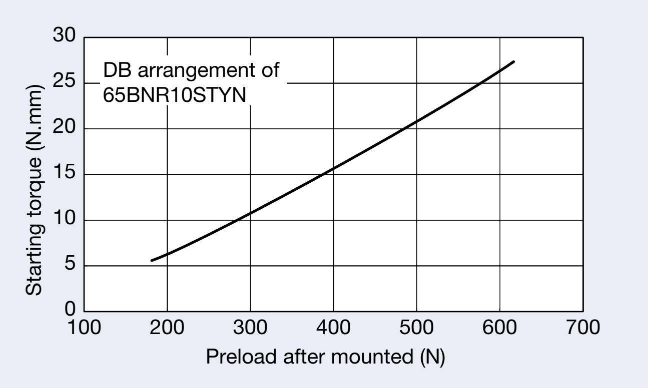


Fig. 1.24 Relation between Starting Torque and Preload



(2) Thrust static rigidity method

[Characteristic]

When axial rigidity of the bearing is high, axial force necessary for measurement becomes very high and loading equipment is necessary. (Example: If axial rigidity is 200N/μm, 2 000N load is needed to generate 10μm displacement.) When measurement load is large, besides elastic deformation of bearing interior, effect of surface deformation and elastic deformation of other related parts are added. Measured rigidity tends to be lower than theoretical value and error often occurs.

[Method]

Thrust load is applied to shaft and its axial displacement is measured for obtaining preload. (see Fig. 1.25 1.26)

(3) Natural frequency method

[Characteristic]

Measuring sensitivity is the highest and repeatability is good, but tend to be affected by spindle fixing condition.

[Method]

Shaft is vibrated in axial direction and resonance frequency of shaft is measured at the same time. Preload can be obtained by the resonance frequency. (see Figs. 1.27 and 1.28)

Measurement of resonance frequency (*Fz*) for main shaft in axial direction

↓ **Convert**

Axial spring constant of main shaft

↓ **Convert**

Preload after mounted

$$F_z=\frac{1}{2\pi}\sqrt{\frac{K_a}{m}}\times1\ 000$$

K_a : Axial spring constant of bearing (N/μm)
F_z : Resonance frequency (Hz)
m : Mass of rotating body (kg)

Fig. 1.25 Thrust Static Rigidity Method

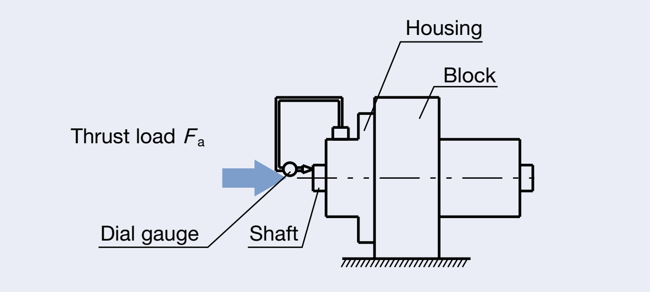


Fig. 1.26 Relation between Axial Displacement and Preload

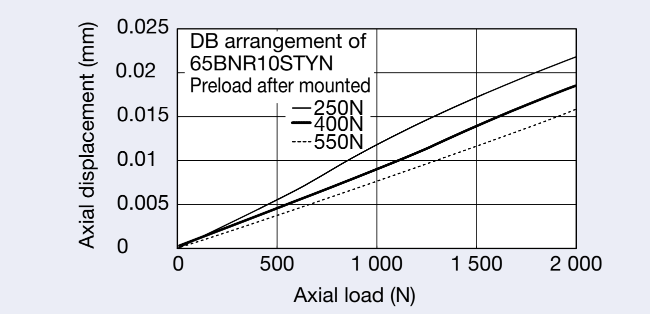


Fig. 1.27 Natural Frequency Method

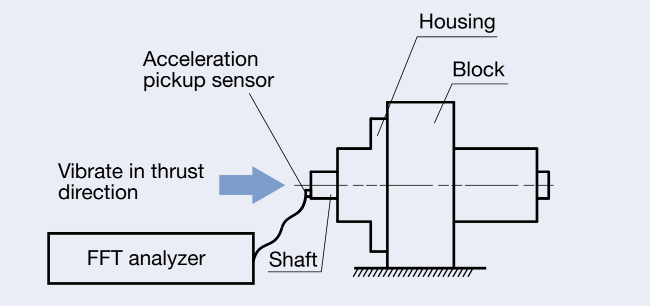
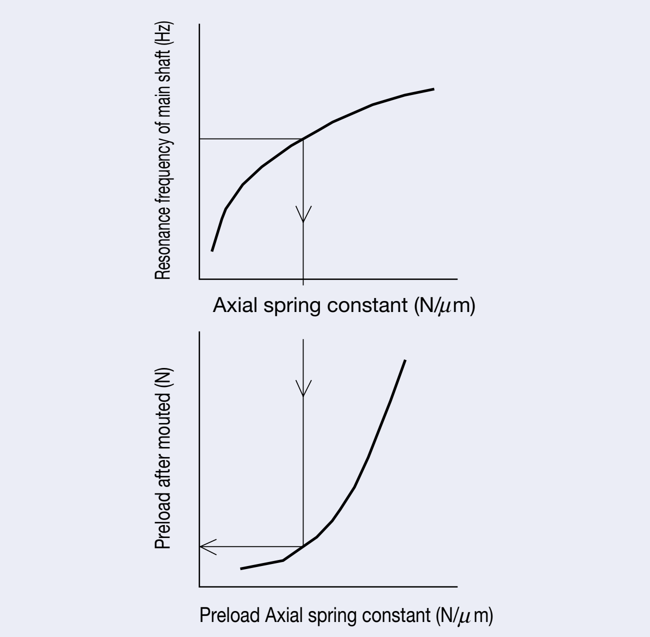


Fig. 1.28 Relation between Resonance Frequency of Main Shaft and Spring Constant



Preparations

The following running in procedures are necessary after properly mounting of bearing.

■ Balance of Shaft and Assmbly

Any unbalance of rotating components will cause repeated stress or excessive vibrations due to centrifugal force. This is especially true for spindles, which are operated at a $d_{\mathrm{m}}n$ value of 1 000 000 or higher. Therefore, it is imperative that both the shaft assembly are well balanced.

■ Spindle Assembly

Spindle assemblies with a V-belt drive should have misalignment of the spindle pulley center and motor pully center corrected to a target of 0.1mm or less. Coupling joints should have misalignment of the spindle shaft center and motor shaft center corrected to a target of 0.01mm or less.

Initial Running Procedure Method

If operating speed is suddenly increased after the bearing is mounted, the operating temperature will rise abruptly and bearing failure may occur. Grease lubricated bearings, especially, require that you follow proper running in procedures. Increase operating speed gradually to completely orient the initially filled grease on each contact surface raceway. Running should be conducted under ambient temperature conditions (15°C to 25°C) while monitoring bearing temperature.

Maximum operating temperature of the spindle housing exterior should be targeted at about 50°C. Do not to exceed 55°C. If a rapid temperature increase occurs, temporarily stop the running in process or decelerate to lower the temperature. Some spindle assemblies incorporate both cylindrical roller bearings and angular contact ball bearing. Since cylindrical roller bearings tend to experience a more rapid temperature increase in comparison with ball bearings, timing of speed increases must be set to correspond with the roller bearings.

[Caution]

Spindle assemblies operating under oil mist and oil air lubricating conditions risk a sudden temperature rise at initial operation, or after the spindle assembly has not been operated for a long time. Excess oil that has collected in the oil lines of the lubrication system may suddenly flood the bearing interior, causing a temperature spike. Performing running in procedures for bearings with these lubricating systems require much less time than grease-based systems, and is highly recommended.

(1) Continuous running procedure

[Feature]

Continuous running works by gradually increasing operating speed from the low speed zone. Although somewhat time consuming, this procedure helps machine operators to detect potential problems related to the main shaft, thus avoiding costly damege to the bearings.

[Method]

Maximum operating speed of the application is achieved by repeating several steps in a cycle.

Step 1. Begin at a reasonably low operating speed.

Step 2. Monitor for temperature rise.

Step 3. Stable temperature is reached.

Step 4. Continue incremental increases of operating speed.

Continue repeating the above cycle until an equilibrium temperature is reached at the maximum operating speed and divide it into ten stages to determine the target speed for each stage. Then, repeat above cycle for one or two hours until the target speed is reached for that stage. Move up to the next stage and repeat the above cycle until you reach the next target speed.

Fig. 2.1 Temperature Change of Constant Speed running Operation

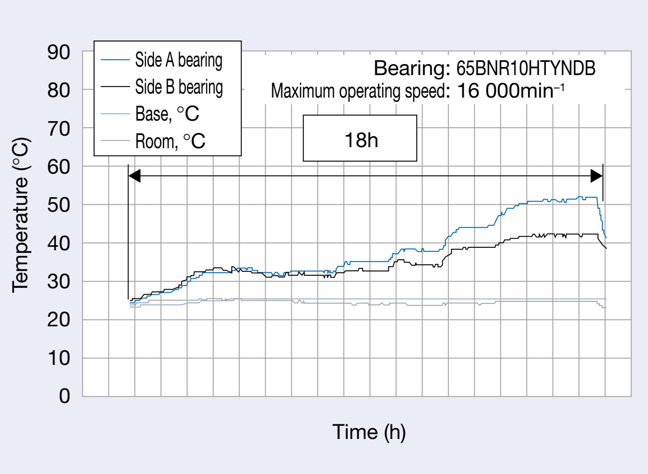
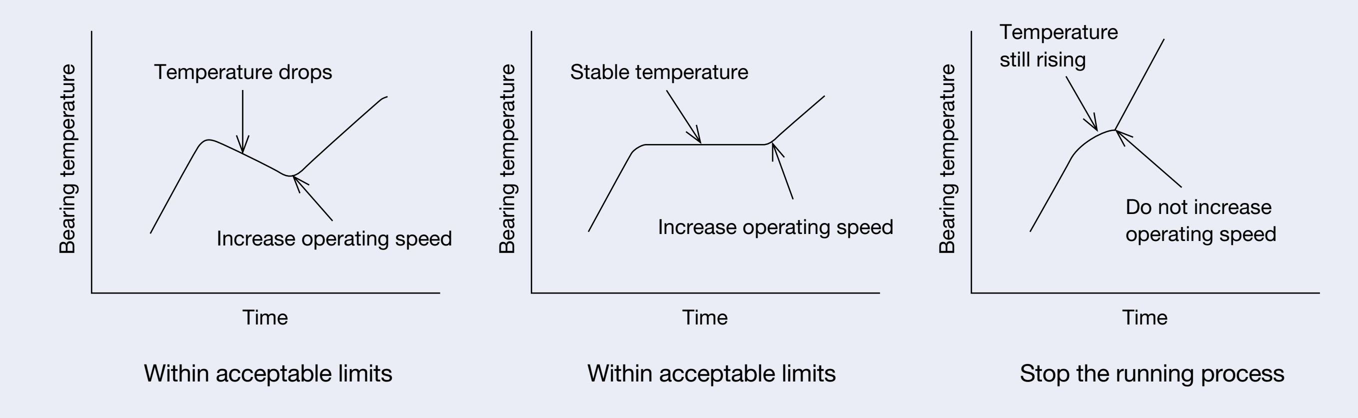


Fig. 2.2 Increase of Operating Speed Continuous Running



Increase operating speed when temperature rise characteristics are within limits.

(2) Intermittent Running procedure

[Feature]

Intermittent Running in works by stopping operation and stabilizing temperatures before there is a rapid temperature rise, which is caused by a sudden supply of grease to the bearing interior during initial operation. This procedure allows us to shorten the amount of time required for running in. Procedures for intermittent running in vary from machine to machine and bearing arrangements. Be sure to confirm the bearing arrangement for each spindle application.

[Method]

First, take the maximum operating speed and divide it into eight or ten stages to determine the maximum target speed for each stage. Each stage is divided into 10 cycles that are approximately one minute long.

During each cycle, rapidly accelerate the spindle assembly to the target speed for the current stage decelerate back to zero. Repeat this cycle about 10 times. Move up to the next stage and repeat the above cycle 10 times for the target speed of that stage.

Fig. 2.3 shows temperature rise data for a bearing with a maximum operating speed of 16 000min^{-1}. The maximum speed was divided into 8 stages with 10 cycles each of rapid acceleration and deceleration. Fig. 2.4 shows an example of 1 cycle. And it is desirable to make it rotate slowly by about 500min^{-1} for 15 minutes, and to familiarize grease and before operating start. As for after an operation end, it is desirable tp perform fixed operation about 1 hour at maximum speed.

Fig. 2.3 Temperature Change of Intermittent Running Operation

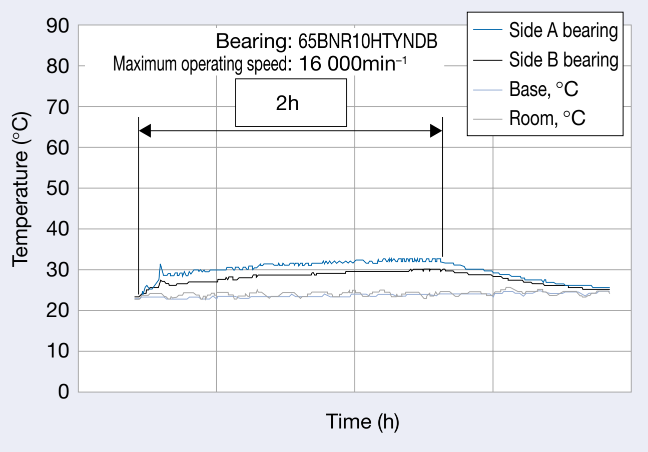
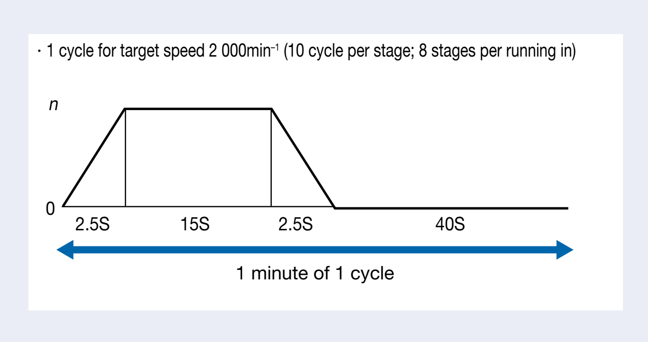


Fig. 2.4 One Cycle for Intermittent Running in Procedure



Operating Inspection

After mounting has been completed, a test run should be conducted to determine if the bearing has been mounted correctly. Small equipment may be manually operated to assure that they rotate smoothly. Items to be checked include sticking due to foreign matter, visible flaws, uneven torque caused by improper mounting, or an improper mounting surface. Other items include excessive torque caused by an inadequate clearance, mounting errors, or seal friction.

If there are no abnormalities, then a powered test run can be started. For high-speed equipment, perform running in procedures before a powered test run (Page 192-193). A powered test run should be started slowly without load. Make close observations to determine whether or not abnormalities exist. If everything seems satisfactory, then gradually increase the speed, load, etc., until normal operating conditions are reached.

During a test run operation, check for abnormal noise, excessive rise of bearing temperature, leakage and contamination of lubricants, etc. If any abnormality is found, stop the test run immediately and inspect the machinery. If necessary, the bearing should be dismounted for examination as well. Although the temperature of the outside surface of the housing can generally help determine bearing temperature, it is better to directly measure the temperature of the outer ring using oil holes for access. The bearing temperature should rise gradually to a steady level within one or two hours after operation starts. If the bearing experiences trouble, or if an error was made in mounting, the bearing temperature may increase rapidly and become abnormally high. The cause of this abnormal temperature may be an excessive amount of lubricant, insufficient bearing clearance, incorrect mounting, or excessive friction of the seals. In the case of high speed operations, an incorrect selection of bearing type or lubricating method may also cause an abnormal temperature rise.

Bearing noise can be checked with an acoustic or other instruments. Abnormal conditions are indicated by a loud metallic sound, or other irregular noise. Possible causes include incorrect lubrication, poor alignment of the shaft and housing, or the entry of foreign matter into the bearing. Possible causes and countermeasures for irregularities are listed in Table 3.1.

■NSK Bearing Monitor■

Bearing abnormality detector

It is important to detect signs of irregularities early on during operations before damege becomes severe. The NSK Bearing Monitor is an instrument that monitors the condition of bearing and issues a warning of possible abnormalities. It can prevent serious trouble. The NSK Bearing Monitor enhances proper maintenance and reduces costs.

Table 3.1 Cause and Countermeasures for Operating Irregularities

Irregularities		Possible cause	Countermeasures
Noise	Loud metallic sound (1)	Abnormal load	Improve the fit, internal clearance, preload,position of housing shoulder, etc.
		Incorrect mounting	Improve the machining accuracy and alignment of shaft and housing, accuracy of mounting method.
		Insufficient or improper lubricant	Replenish the lubricant or select another lubricant.
		Contact of rotating parts	Modify the labyrinth seal, etc.
	Loud regular sound	Dents generated by foreign matters, corrosion, flaws, or scratches on raceways	Replace or clean the bearing, improve the seals, and use clean lubricant.
		Brinelling	Replace the bearing, and use care when handling bearings.
		Flaking on raceway	Replace the bearing.
	Irregular sound	Excessive clearance	Improve the fit, clearance, and preload.
		Penetration of foreign particles	Replace or clean the bearing, improve the seals, and use clean lubricant.
		Flaws or flaking on balls	Replace the bearing.
Abnormal temperature rise		Excessive amount of lubricant	Reduce amount of lubricant, or select stiffer grease.
		Insufficient or improper lubricant	Replenish lubricant or select a better one.
		Abnormal load	Improve the fit, internal clearance, preload, or position of housing shoulder.
		Incorrect mounting	Improve the machining accuracy and alignment of the shaft and housing, accuracy of mounting, or mounting method.
		Creep on fitted surface, excessive seal friction	Correct the seals, replace the bearing, or correct the fitting or mounting.
Vibration (Radial runout of shaft)		Brinelling	Replace the bearing and use care when handling bearing.
		Flaking	Replace the bearing.
		Incorrect mounting	Correct the squareness between the shaft and housing shoulder or side of spacer.
		Penetration of foreign particles	Replace or clean the bearing, improve the seals.
Leakage or discoloration of lubricant		Too much lubricant. Penetration by foreign matter or abrasion chips	Reduce the amount of lubricant, select a stiffer grease. Replace the bearing or lubricant. Clean the housing and adjacent parts.

Note (1) Squeaking may arise from grease lubricated ball bearings or cylindrical roller bearings (medium to large sized). This is especially true during winter when temperatures are low. In general, even though squeaking may occur, the bearing temperature will not rise, leaving fatigue or grease life unaffected. Consequently, such a bearing can continue to be used. If you concerns regarding squeaking noise, please contact NSK.

Maintenance, Inspection and Correcting Irregularities

In order to maintain the original performance of a bearing for as long as possible, proper maintenance and inspection should be performed. If proper procedures are used, many bearing problems can be avoided and the reliability, productivity, and operating costs of the equipment containing the bearings are all improved. It is suggested that periodic maintenance be done following the procedure specified. This periodic maintenance encompasses the supervision of operating conditions, the supply or replacement of lubricants, and regular periodic inspection.

Items that should be regularly checked during operation include bearing noise, vibration, temperature, and lubrication. If an irregularity is found during operation, the cause should be determined and the proper corrective actions should be taken after referring to Table 3.1.

If necessary, the bearing should be dismounted and examined in detail.

Bearing Failure and Countermeasures

In general, if rolling bearings are used correctly they will survive to their predicted fatigue life.

However, they often fail prematurely due to avoidable mistakes. In contrast to fatigue life, this premature failure is caused by improper mounting, handling or lubrication, entry of foreign matter, or abnormal heat generation. For instance, the causes of rib scoring, as one example, use of improper lubricant, faulty lubricant system, entry of foreign matter, bearing mounting error, excessive deflection of the shaft, or any combination of these. Thus, it is difficult to determine the real cause of some premature failures. If all the conditions at that time of failure and previous to the time of failure are known, including the application, the operating conditions, and environment; then by studying the nature of the failure and its probable causes, the possibility of similar future failures can be reduced. The most frequent types of bearing failure, along with their causes and corrective actions, are listed in Table 3.2.

Table 3.2 Causes and Countermeasure for Bearing Failure

Type of failure	Probable causes	Countermeasures
Flaking		
Flaking of one-side of the raceway of radial bearing	Abnormal axial load.	A loose fit should be used when mounting the outer ring of free-end bearings to allow axial expansion of the shaft.
Flaking pattern inclined relative to the raceway in radial ball bearings Flaking near the edge of the raceway and rolling surface in roller bearing	Improper mounting, deflection of shaft, inadequate tolerances for shaft and housing.	Use care in mounting and centering, select a bearing with a large clearance, and correct the shaft and housing shoulder.
Flaking of raceway with same spacing as rolling element	Large shock load during mounting, rusting while bearing is out of operation for prolonged period.	Use care in mounting and apply a rust preventive when machine operation is suspended for a long time.
Premature flaking of raceway and rolling element	Insufficient clearance, excessive load, improper lubrication, rust, etc.	Select proper fit, bearing clearance, and lubricant.
Premature flaking of duplex bearings	Excessive preload.	Adjust the preload.
Scoring		
Scoring or smearing between raceway and rolling surface	Inadequate initial lubrication, excessively hard grease and high acceleration when starting.	Use a softer grease and avoid rapid acceleration.
Scoring or smearing between the end face of the end face of the rollers and guide rib	Inadequate lubrication, incorrect mounting and large axial load.	Select proper lubricant and modify the mounting.
Cracks		
Crack in outer or inner ring	Excessive shock load, excessive interference in fitting, poor surface cylindricity, improper sleeve taper, large fillet radius, development of thermal cracks and advancement of flaking.	Examine the loading conditions, modify the fit of bearing and sleeve. The fillet radius must be smaller than the bearing chamfer.
Crack in rolling element Broken rib	Advancement of flaking, shock applied to the rib during mounting or dropped during handling.	Be careful in handling and mounting.
Fracture cage	Abnormal loading of cage due to incorrect mounting and improper lubrication.	Reduce the mounting error and review the lubricating method and lubricant.
Indentations		
Indentations in raceway in same pattern as rolling elements	Shock load during mounting or excessive load when not rotating.	Use care in handling.
Indentations in raceway and rolling elements.	Foreign matter such as metallic chips or sand.	Clean the housing, improve the seals, and use a clean lubricant.
Abnormal wear		
False brinelling (phenomenon similar to brinelling)	Vibration of the bearing without rotation during shipment or rocking motion of small amplitude.	Secure the shaft and housing, use oil as a lubricant and reduce vibration by applying a preload.
Fretting Limited part wear with reddish-brown wear dust at fitting surface	Slight wear of the fitting surface.	Increase interference and apply oil.
Wearing of raceway, rolling elements, rib, and cage	Penetration by foreign matter, incorrect lubrication, and rust.	Improve the seals, clean the housing, and use a clean lubricant.
Creep Scoring wear at fitting surface	Insufficient interference, Insufficient tightened sleeve.	Increase interference, proper tightening of sleeve.
Seizure		
Discoloration and melting of raceway, rolling elements and ribs	Insufficient clearance, incorrect lubrication, or improper mounting.	Review the internal clearance and bearing fit, supply an adequate amount of the proper lubricant and improve the mounting method and related parts.
Corrosion & Rust		
Rust and corrosion of fitting surfaces and bearing interior	Condensation of water from the air, or fretting. Penetration by corrosive substance (especially vanish-gas, etc).	Use care in storing and avoid high temperature and high humidity, treatment for rust prevention is necessary when operation is stopped for long time. Selection of vanish and grease.

Appendices

Appendices

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Tolerances for Shaft Diameters

Unit: μm

Diameter classification (mm)		d6	e6	f6	g5	g6	h5	h6	h7	h8	h9	h10	js5	js6
over	incl													
3	**6**	–30 –38	–20 –28	–10 –18	–4 –9	–4 –12	0 –5	0 –8	0 –12	0 –18	0 –30	0 –48	±2.5	±4
6	**10**	–40 –49	–25 –34	–13 –22	–5 –11	–5 –14	0 –6	0 –9	0 –15	0 –22	0 –36	0 –58	±3	±4.5
10	**18**	–50 –61	–32 –43	–16 –27	–6 –14	–6 –17	0 –8	0 –11	0 –18	0 –27	0 –43	0 –70	±4	±5.5
18	**30**	–65 –78	–40 –53	–20 –33	–7 –16	–7 –20	0 –9	0 –13	0 –21	0 –33	0 –52	0 –84	±4.5	±6.5
30	**50**	–80 –96	–50 –66	–25 –41	–9 –20	–9 –25	0 –11	0 –16	0 –25	0 –39	0 –62	0 –100	±5.5	±8
50	**80**	–100 –119	–60 –79	–30 –49	–10 –23	–10 –29	0 –13	0 –19	0 –30	0 –46	0 –74	0 –120	±6.5	±9.5
80	**120**	–120 –142	–72 –94	–36 –58	–12 –27	–12 –34	0 –15	0 –22	0 –35	0 –54	0 –87	0 –140	±7.5	±11
120	**180**	–145 –170	–85 –110	–43 –68	–14 –32	–14 –39	0 –18	0 –25	0 –40	0 –63	0 –100	0 –160	±9	±12.5
180	**250**	–170 –199	–100 –129	–50 –79	–15 –35	–15 –44	0 –20	0 –29	0 –46	0 –72	0 –115	0 –185	±10	±14.5
250	**315**	–190 –222	–110 –142	–56 –88	–17 –40	–17 –49	0 –23	0 –32	0 –52	0 –81	0 –130	0 –210	±11.5	±16
315	**400**	–210 –246	–125 –161	–62 –98	–18 –43	–18 –54	0 –25	0 –36	0 –57	0 –89	0 –140	0 –230	±12.5	±18
400	**500**	–230 –270	–135 –175	–68 –108	–20 –47	–20 –60	0 –27	0 –40	0 –63	0 –97	0 –155	0 –250	±13.5	±20
500	**630**	–260 –304	–145 –189	–76 –120	–	–22 –66	–	0 –44	0 –70	0 –110	0 –175	0 –280	–	±22
630	**800**	–290 –340	–160 –210	–80 –130	–	–24 –74	–	0 –50	0 –80	0 –125	0 –200	0 –320	–	±25
800	**1 000**	–320 –376	–170 –226	–86 –142	–	–26 –82	–	0 –56	0 –90	0 –140	0 –230	0 –360	–	±28
1 000	**1 250**	–350 –416	–195 –261	–98 –164	–	–28 –94	–	0 –66	0 –105	0 –165	0 –260	0 –420	–	±33
1 250	**1 600**	–390 –468	–220 –298	–110 –188	–	–30 –108	–	0 –78	0 –125	0 –195	0 –310	0 –500	–	±39
1 600	**2 000**	–430 –522	–240 –332	–120 –212	–	–32 –124	–	0 –92	0 –150	0 –230	0 –370	0 –600	–	±46

j5	j6	j7	k5	k6	k7	m5	m6	n6	p6	r6	r7	Diameter classification (mm)	
												over	incl
+3 –2	+6 –2	+8 –4	+6 +1	+9 +1	+13 +1	+9 +4	+12 +4	+16 +8	+20 +12	+23 +15	+27 +15	**3**	**6**
+4 –2	+7 –2	+10 –5	+7 +1	+10 +1	+16 +1	+12 +6	+15 +6	+19 +10	+24 +15	+28 +19	+34 +19	**6**	**10**
+5 –3	+8 –3	+12 –6	+9 +1	+12 +1	+19 +1	+15 +7	+18 +7	+23 +12	+29 +18	+34 +23	+41 +23	**10**	**18**
+5 –4	+9 –4	+13 –8	+11 +2	+15 +2	+23 +2	+17 +8	+21 +8	+28 +15	+35 +22	+41 +28	+49 +28	**18**	**30**
+6 –5	+11 –5	+15 –10	+13 +2	+18 +2	+27 +2	+20 +9	+25 +9	+33 +17	+42 +26	+50 +34	+59 +34	**30**	**50**
+6 –7	+12 –7	+18 –12	+15 +2	+21 +2	+32 +2	+24 +11	+30 +11	+39 +20	+51 +32	+60 +41	+71 +41	**50**	**65**
+6 –7	+12 –7	+18 –12	+15 +2	+21 +2	+32 +2	+24 +11	+30 +11	+39 +20	+51 +32	+62 +43	+73 +43	**65**	**80**
+6 –9	+13 –9	+20 –15	+18 +3	+25 +3	+38 +3	+28 +13	+35 +13	+45 +23	+59 +37	+73 +51	+86 +51	**80**	**100**
+6 –9	+13 –9	+20 –15	+18 +3	+25 +3	+38 +3	+28 +13	+35 +13	+45 +23	+59 +37	+76 +54	+89 +54	**100**	**120**
+7 –11	+14 –11	+22 –18	+21 +3	+28 +3	+43 +3	+33 +15	+40 +15	+52 +27	+68 +43	+88 +63	+103 +63	**120**	**140**
+7 –11	+14 –11	+22 –18	+21 +3	+28 +3	+43 +3	+33 +15	+40 +15	+52 +27	+68 +43	+90 +65	+105 +65	**140**	**160**
+7 –11	+14 –11	+22 –18	+21 +3	+28 +3	+43 +3	+33 +15	+40 +15	+52 +27	+68 +43	+93 +68	+108 +68	**160**	**180**
+7 –13	+16 –13	+25 –21	+24 +4	+33 +4	+50 +4	+37 +17	+46 +17	+60 +31	+79 +50	+106 +77	+123 +77	**180**	**200**
+7 –13	+16 –13	+25 –21	+24 +4	+33 +4	+50 +4	+37 +17	+46 +17	+60 +31	+79 +50	+109 +80	+126 +80	**200**	**225**
+7 –13	+16 –13	+25 –21	+24 +4	+33 +4	+50 +4	+37 +17	+46 +17	+60 +31	+79 +50	+113 +84	+130 +84	**225**	**250**
+7 –16	±16 ±16	±26 ±26	+27 +4	+36 +4	+56 +4	+43 +20	+52 +20	+66 +34	+88 +56	+126 +94	+146 +94	**250**	**280**
+7 –16	±16 ±16	±26 ±26	+27 +4	+36 +4	+56 +4	+43 +20	+52 +20	+66 +34	+88 +56	+130 +98	+150 +98	**280**	**315**
+7 –18	±18 ±18	+29 –28	+29 +4	+40 +4	+61 +4	+46 +21	+57 +21	+73 +37	+98 +62	+144 +108	+165 +108	**315**	**355**
+7 –18	±18 ±18	+29 –28	+29 +4	+40 +4	+61 +4	+46 +21	+57 +21	+73 +37	+98 +62	+150 +114	+171 +114	**355**	**400**
+7 –20	±20 ±20	+31 –32	+32 +5	+45 +5	+68 +5	+50 +23	+63 +23	+80 +40	+108 +68	+166 +126	+189 +126	**400**	**450**
+7 –20	±20 ±20	+31 –32	+32 +5	+45 +5	+68 +5	+50 +23	+63 +23	+80 +40	+108 +68	+172 +132	+195 +132	**450**	**500**
– –	– –	– –	– –	+44 0	+70 0	– –	+70 +26	+88 +44	+122 +78	+194 +150	+220 +150	**500**	**560**
– –	– –	– –	– –	+44 0	+70 0	– –	+70 +26	+88 +44	+122 +78	+199 +155	+225 +155	**560**	**630**
– –	– –	– –	– –	+50 0	+80 0	– –	+80 +30	+100 +50	+138 +88	+225 +175	+255 +175	**630**	**710**
– –	– –	– –	– –	+50 0	+80 0	– –	+80 +30	+100 +50	+138 +88	+235 +185	+265 +185	**710**	**800**
– –	– –	– –	– –	+56 0	+90 0	– –	+90 +34	+112 +56	+156 +100	+266 +210	+300 +210	**800**	**900**
– –	– –	– –	– –	+56 0	+90 0	– –	+90 +34	+112 +56	+156 +100	+276 +220	+310 +220	**900**	**1 000**
– –	– –	– –	– –	+66 0	+105 0	– –	+106 +40	+132 +66	+186 +120	+316 +250	+355 +250	**1 000**	**1 120**
– –	– –	– –	– –	+66 0	+105 0	– –	+106 +40	+132 +66	+186 +120	+326 +260	+365 +260	**1 120**	**1 250**
– –	– –	– –	– –	+78 0	+125 0	– –	+126 +48	+156 +78	+218 +140	+378 +300	+425 +300	**1 250**	**1 400**
– –	– –	– –	– –	+78 0	+125 0	– –	+126 +48	+156 +78	+218 +140	+408 +330	+455 +330	**1 400**	**1 600**
– –	– –	– –	– –	+92 0	+150 0	– –	+150 +58	+184 +92	+262 +170	+462 +370	+520 +370	**1 600**	**1 800**
– –	– –	– –	– –	+92 0	+150 0	– –	+150 +58	+184 +92	+262 +170	+492 +400	+550 +400	**1 800**	**2 000**

Tolerances for Housing Bore Diameters

Unit: μm

Diameter classification (mm)		E6	F6	F7	G6	G7	H6	H7	H8	J6	J7	JS6	JS7
over	incl												
10	**18**	+43 +32	+27 +16	+34 +16	+17 +6	+24 +6	+11 0	+18 0	+27 0	+6 −5	+10 −8	±5.5	±9
18	**30**	+53 +40	+33 +20	+41 +20	+20 +7	+28 +7	+13 0	+21 0	+33 0	+8 −5	+12 −9	±6.5	±10.5
30	**50**	+66 +50	+41 +25	+50 +25	+25 +9	+34 +9	+16 0	+25 0	+39 0	+10 −6	+14 −11	±8	±12.5
50	**80**	+79 +60	+49 +30	+60 +30	+29 +10	+40 +10	+19 0	+30 0	+46 0	+13 −6	+18 −12	±9.5	±15
80	**120**	+94 +72	+58 +36	+71 +36	+34 +12	+47 +12	+22 0	+35 0	+54 0	+16 −6	+22 −13	±11	±17.5
120	**180**	+110 +85	+68 +43	+83 +43	+39 +14	+54 +14	+25 0	+40 0	+63 0	+18 −7	+26 −14	±12.5	±20
180	**250**	+129 +100	+79 +50	+96 +50	+44 +15	+61 +15	+29 0	+46 0	+72 0	+22 −7	+30 −16	±14.5	±23
250	**315**	+142 +110	+88 +56	+108 +56	+49 +17	+69 +17	+32 0	+52 0	+81 0	+25 −7	+36 −16	±16	±26
315	**400**	+161 +125	+98 +62	+119 +62	+54 +18	+75 +18	+36 0	+57 0	+89 0	+29 −7	+39 −18	±18	±28.5
400	**500**	+175 +135	+108 +68	+131 +68	+60 +20	+83 +20	+40 0	+63 0	+97 0	+33 −7	+43 −20	±20	±31.5
500	**630**	+189 +145	+120 +76	+146 +76	+66 +22	+92 +22	+44 0	+70 0	+110 0	–	–	±22	±35
630	**800**	+210 +160	+130 +80	+160 +80	+74 +24	+104 +24	+50 0	+80 0	+125 0	–	–	±25	±40
800	**1 000**	+226 +170	+142 +86	+176 +86	+82 +26	+116 +26	+56 0	+90 0	+140 0	–	–	±28	±45
1 000	**1 250**	+261 +195	+164 +98	+203 +98	+94 +28	+133 +28	+66 0	+105 0	+165 0	–	–	±33	±52.5
1 250	**1 600**	+298 +220	+188 +110	+235 +110	+108 +30	+155 +30	+78 0	+125 0	+195 0	–	–	±39	±62.5
1 600	**2 000**	+332 +240	+212 +120	+270 +120	+124 +32	+182 +32	+92 0	+150 0	+230 0	–	–	±46	±75
2 000	**2 500**	+370 +260	+240 +130	+305 +130	+144 +34	+209 +34	+110 0	+175 0	+280 0	–	–	±55	±87.5

K5	K6	K7	M5	M6	M7	N5	N6	N7	P6	P7	Diameter classification (mm)	
											over	incl
+2 −6	+2 −9	+6 −12	−4 −12	−4 −15	0 −18	−9 −17	−9 −20	−5 −23	−15 −26	−11 −29	**10**	**18**
+1 −8	+2 −11	+6 −15	−5 −14	−4 −17	0 −21	−12 −21	−11 −24	−7 −28	−18 −31	−14 −35	**18**	**30**
+2 −9	+3 −13	+7 −18	−5 −16	−4 −20	0 −25	−13 −24	−12 −28	−8 −33	−21 −37	−17 −42	**30**	**50**
+3 −10	+4 −15	+9 −21	−6 −19	−5 −24	0 −30	−15 −28	−14 −33	−9 −39	−26 −45	−21 −51	**50**	**80**
+2 −13	+4 −18	+10 −25	−8 −23	−6 −28	0 −35	−18 −33	−16 −38	−10 −45	−30 −52	−24 −59	**80**	**120**
+3 −15	+4 −21	+12 −28	−9 −27	−8 −33	0 −40	−21 −39	−20 −45	−12 −52	−36 −61	−28 −68	**120**	**180**
+2 −18	+5 −24	+13 −33	−11 −31	−8 −37	0 −46	−25 −45	−22 −51	−14 −60	−41 −70	−33 −79	**180**	**250**
+3 −20	+5 −27	+16 −36	−13 −36	−9 −41	0 −52	−27 −50	−25 −57	−14 −66	−47 −79	−36 −88	**250**	**315**
+3 −22	+7 −29	+17 −40	−14 −39	−10 −46	0 −57	−30 −55	−26 −62	−16 −73	−51 −87	−41 −98	**315**	**400**
+2 −25	+8 −32	+18 −45	−16 −43	−10 −50	0 −63	−33 −60	−27 −67	−17 −80	−55 −95	−45 −108	**400**	**500**
–	0 −44	0 −70	–	−26 −70	−26 −96	–	−44 −88	−44 −114	−78 −122	−78 −148	**500**	**630**
–	0 −50	0 −80	–	−30 −80	−30 −110	–	−50 −100	−50 −130	−88 −138	−88 −168	**630**	**800**
–	0 −56	0 −90	–	−34 −90	−34 −124	–	−56 −112	−56 −146	−100 −156	−100 −190	**800**	**1 000**
–	0 −66	0 −105	–	−40 −106	−40 −145	–	−66 −132	−66 −171	−120 −186	−120 −225	**1 000**	**1 250**
–	0 −78	0 −125	–	−48 −126	−48 −173	–	−78 −156	−78 −203	−140 −218	−140 −265	**1 250**	**1 600**
–	0 −92	0 −150	–	−58 −150	−58 −208	–	−92 −184	−92 −242	−170 −262	−170 −320	**1 600**	**2 000**
–	0 −110	0 −175	–	−68 −178	−68 −243	–	−110 −220	−110 −285	−195 −305	−195 −370	**2 000**	**2 500**

Values of Standard Tolerance for IT Grade

Basic size (mm)		Standard grade								
		IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9
over	incl	Tolerances (µm)								
–	**3**	0.8	1.2	2	3	4	6	10	14	25
3	**6**	1	1.5	2.5	4	5	8	12	18	30
6	**10**	1	1.5	2.5	4	6	9	15	22	36
10	**18**	1.2	2	3	5	8	11	18	27	43
18	**30**	1.5	2.5	4	6	9	13	21	33	52
30	**50**	1.5	2.5	4	7	11	16	25	39	62
50	**80**	2	3	5	8	13	19	30	46	74
80	**120**	2.5	4	6	10	15	22	35	54	87
120	**180**	3.5	5	8	12	18	25	40	63	100
180	**250**	4.5	7	10	14	20	29	46	72	115
250	**315**	6	8	12	16	23	32	52	81	130
315	**400**	7	9	13	18	25	36	57	89	140
400	**500**	8	10	15	20	27	40	63	97	155
500	**630**	9	11	16	22	30	44	70	110	175
630	**800**	10	13	18	25	35	50	80	125	200
800	**1 000**	11	15	21	29	40	56	90	140	230
1 000	**1 250**	13	18	24	34	46	66	105	165	260
1 250	**1 600**	15	21	29	40	54	78	125	195	310
1 600	**2 000**	18	25	35	48	65	92	150	230	370
2 000	**2 500**	22	30	41	57	77	110	175	280	440
2 500	**3 150**	26	36	50	69	93	135	210	330	540

Standard grade									Basic size (mm)	
IT10	IT11	IT12	IT13	IT14	IT15	IT16	IT17	IT18		
Tolerances (µm)									over	incl
40	60	0.10	0.14	0.26	0.40	0.60	1.00	1.40	–	**3**
48	75	0.12	0.18	0.30	0.48	0.75	1.20	1.80	**3**	**6**
58	90	0.15	0.22	0.36	0.58	0.90	1.50	2.20	**6**	**10**
70	110	0.18	0.27	0.43	0.70	1.10	1.80	2.70	**10**	**18**
84	130	0.21	0.33	0.52	0.84	1.30	2.10	3.30	**18**	**30**
100	160	0.25	0.39	0.62	1.00	1.60	2.50	3.90	**30**	**50**
120	190	0.30	0.46	0.74	1.20	1.90	3.00	4.60	**50**	**80**
140	220	0.35	0.54	0.87	1.40	2.20	3.50	5.40	**80**	**120**
160	250	0.40	0.63	1.00	1.60	2.50	4.00	6.30	**120**	**180**
185	290	0.46	0.72	1.15	1.85	2.90	4.60	7.20	**180**	**250**
210	320	0.52	0.81	1.30	2.10	3.20	5.20	8.10	**250**	**315**
230	360	0.57	0.89	1.40	2.30	3.60	5.70	8.90	**315**	**400**
250	400	0.63	0.97	1.55	2.50	4.00	6.30	9.70	**400**	**500**
280	440	0.70	1.10	1.75	2.80	4.40	7.00	11.00	**500**	**630**
320	500	0.80	1.25	2.00	3.20	5.00	8.00	12.50	**630**	**800**
360	560	0.90	1.40	2.30	3.60	5.60	9.00	14.00	**800**	**1 000**
420	660	1.05	1.65	2.60	4.20	6.60	10.50	16.50	**1 000**	**1 250**
500	780	1.25	1.95	3.10	5.00	7.80	12.50	19.50	**1 250**	**1 600**
600	920	1.50	2.30	3.70	6.00	9.20	15.00	23.00	**1 600**	**2 000**
700	1 100	1.75	2.80	4.40	7.00	11.00	17.50	28.00	**2 000**	**2 500**
860	1 350	2.10	3.30	5.40	8.60	13.50	21.00	33.00	**2 500**	**3 150**

Remarks 1. Standard tolerance grades IT14 to IT18 shall not be used for basic sizes less than or equal to 1mm.
2. Values for standard tolerance grades IT1 to IT5 for basic size over 500mm are included for experimental use.

Hardness Conversion Table (Reference)

Rockwell C scale hardness (1471N)	Vickers hardness	Brinell hardness		Rockwell hardness		Shore hardness
		Standard ball	Tungsten Carbide ball	A scale Load 588.4N Brale indenter	B scale Load 980.7N 1.588mm Ball	
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	–	87
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	484	451	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	28
(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

Physical and Mechanical Properties of Material

Application	Material code	Heat treatment	Density g/cm^3	Specific heat KJ/(kg·K)	Thermal conductivity W/(m·K)	Electric resistance $\mu\Omega$·cm	Coefficient of linear expansion (0°–100°C) ×10^{-6}/°C	Young's modulus MPa	Yield point MPa	Tensile strength MPa	Elongation %	Hardness HB	Remarks
Bearing	SUJ2	Hardening, tempering	7.83	0.47	46	22	12.5	208 000	1 370	1 570 –1 960	Max. 0.5	650 –740	High-carbon chromium bearing steel type 2
	SUJ2	Spheroidizing tempering	7.86				11.9		420	647	27	180	
	SCr420	Hardening, low temperature tempering	7.83		48	21	12.8		882	1 225	15	370	Chromium steel
	SAE4320 (SNCM420)	Hardening, low temperature tempering			44	20	11.7		902	1 009	16	**293 –375	Nickel-chromium-molybdenum steel
	SNCM815	Hardening, low temperature tempering	7.89		40	35	–		–	Min. *1 080	Min. *12	*311 –375	Nickel-chromium-molybdenum steel
	SUS440C	Hardening, low temperature tempering	7.68	0.46	24	60	10.1	200 000	1 860	1 960	–	**580	Martensitic stainless steel
	SPCC	Annealing	7.86	0.47	59	15	11.6	206 000	–	Min. *275	Min. *32	–	Cold-rolled steel
	S25C	Annealing		0.48	50	17	11.8		323	431	33	120	Carbon steel for machine structure use
	HB_SC1		8.5	0.38	123	6.2	19.1	103 000	–	Min. *431	Min. *20	–	High-strength brass casting

Notes *Standard value of JIS or reference value.

**The hardness is usually expressed using the Rockwell C scale, but for comparison, it is converted into Brinell hardness.

Reference Proportional limits of SUJ2 and Scr420 are 833MPa (85kgf/mm^2) and 440MPa (45kgf/mm^2) respectively.

Application	Material code	Heat treatment	Density g/cm³	Specific heat KJ/(kg·K)	Thermal conductivity W/(m·K)	Electric resistance μΩ·cm	Coefficient of linear expansion (0°–100°C) ×10⁻⁶/°C	Young's modulus MPa	Yield point MPa	Tensile strength MPa	Elongation %	Hardness HB	Remarks
Shaft	S45C	Hardening, 650 tempering	7.83	0.48	47	18	12.8	207 000	440	735	25	217	Carbon steel for machine structure use
	SCr430	Hardening, 520-62 quenching				22	12.5	208 000	Min. *637	Min. *784	Min. *18	*229 –293	Chromium steel
	SCr440	Hardening, 520-620 quenching			45	23			Min. *784	Min. *930	Min. *13	*269 –331	Chromium steel
	SCM420	Hardening, 150-200 quenching		0.47	48	21	12.8		–	Min. *930	Min. *14	*262 –352	Chromium-molybdenum steel
	SNCM439	Hardening, 650 tempering			38	30	11.3	207 000	920	1 030	18	320	Nickel-chromium-molybdenum steel
	SC46	Normalizing	–	–	–	–	–	206 000	294	520	27	143	Low carbon steel
	SUS420J2	1038 oil cooling, 400 air cooling	7.75	0.46	22	55	10.4	200 000	1 440	1 650	10	400	Martensitic stinless steel
Housing	FC200	N/A	7.3	0.50	43	–		98 000	–	Min. *200	–	Max. *217	Gray iron
	FCD400	N/A	7.0	0.48	20	–	11.7		Min. *250	Min. *400	Min. *12	Max. *201	Ductile iron
	A1100	Annealing	2.69	0.90	222	3.0	23.7	70 000	34	78	35	–	Engineering pure aluminum
	AC4C	N/A	2.68	0.88	151	4.2	21.5	72 000	88	167	7	–	Sand casting aluminum alloy
	ADC10	N/A	2.74	0.96	96	7.5	22.0	71 000	167	323	4	–	Die casting aluminum alloy
	SUS304	Annealing	8.03	0.50	15	72	15.7–16.8	193 000	245	588	60	150	Austenitic stainless steel

Notes *Standard value of JIS or reference value.

**Hardness is usually expressed using the Rockwell C Scale, but for comparison, it is converted into Brinell hardness.

Reference Proportional limits of SUJ2 and Scr420 are 833MPa (85kgf/mm²) and 440MPa (45kgf/mm²) respectively.

Request for Specification Investigation

To request specification investigation, please contact the nearest NSK office and provide us with the following information:

Request for a specification investigation regarding precision bearings

Name of company ____________________

● Operating conditions

Type of machine [Machining Center, Lathe, Internal Grinding Machine, Motor, Others (   )]

Model number ____________________

Position of bearing [Main shaft spindle, Ball screw support]   [Fixed-end, Free-end]

Main shaft position [Vertical, Horizontal, Other (   )]

Bearing type Please circle all that apply.

Angular contact ball bearing	[Standard series, ROBUST BNR series, ROBUST BER series, ROBUST BGR series]
Cylindrical roller bearing	[Single row cylindrical roller bearing, Ultra high speed ROBUST series Double row cylindrical roller bearing]
Angular contact thrust ball bearing	[Main shaft TAC, ROBUST BAR series ROBUST BTR series]
Deep groove ball bearing	[High precision deep groove ball bearing for spindle motor]
Ball screw support bearing	[For machine tool, For electric injection molding machine]

Arrangement [DB · DBD · DBB · DF · DFD · DFF · Other (   )]

NSK bearing number ____________________

Other maker number ____________________

Bore ________ mm　Outer diameter ________ mm　Overall wide ________ mm

Outer ring width ________ mm　Inner ring width ________ mm　Accuracy class ________ class

Clearance ________

● Load condition

Rotating speed ________ min⁻¹　Radial load ________ N　Axial load ________ N

Moment ________ N·mm　Unclamp force ________ N

● Shaft and housing

Tolerance of shaft ________　Tolerance of housing ________　Outer diameter of housing ________ mm

Material of shaft ________　Material of housing ________　Bore diameter of hollow shaft ________ mm

Driving method ________　Cooling method (External cylinder cooling: Yes, No) ________　Preload type (Position preload or constant pressure preload) ________

Spacer length ________ mm　Ambient temperature ________ °C

● Requirement value

Rigidity ________ N/μm　Preload ________ N　Life ________ h

● Comments

Please indicate any special requests, questions, or comments here:

Attachments: (Yes) (No)

Old and new number contrast table

Bearings	New name	Old name	Notes
High precision ACBB	79xxCTYNDBL	79xxCTYDBC7	TYN: Ball guided polyamide 46 resin cage TY: Ball guided polyamide 66 resin cage EL←C2, L←C7 M←C8, H←C9
	70xxCTYNDBL	70xxCTYDBC7	
	72xxCTYNDBL	72xxCTYDBC7	
	70xxATYNDBL	70xxATYDBC7	
	72xxATYNDBL	72xxATYDBC7	
	79xxA5TYN	79xxA5TY	TYN: Ball guided polyamide 46 resin cage TY: Ball guided polyamide 66 resin cage
	70xxA5TYN	70xxA5TY	
	72xxA5TYN	72xxA5TY	
Ultra high-speed ACBB	xxBNR19STYN	xxBNC19TY	TYN: Ball guided polyamide 46 resin cage TY: Ball guided polyamide 66 resin cage
	xxBNR10STYN	xxBNC10TY	
	xxBNR19HTYN	xxBNC19SN24TY	
	xxBNR10HTYN	xxBNC10SN24TY	
Ultra high precision ACBB	xxBGR10S	xxBNT10F	BGR: Non-separable type BNT: separable type
	xxBGR10H	xxBNT10FSN24	
Double row CRB	NN30xxTB	NN30xxT	TB: Roller guided PPS resin cage TP: Outer ring guided PEEK resin cage T: Roller guided polyamide66 resin cage
Ultra high-speed single row CRB	N10xxRSTP	N10xxBT	
High-speed thrust ACBB	xxBAR10STYN	xxBA10XTY	TYN: Ball guided polyamide 46 resin cage TY: Ball guided polyamide 66 resin cage
	xxBTR10STYN	xxBT10XTY	

Please contact NSK for assistance regarding any other number.

MEMO