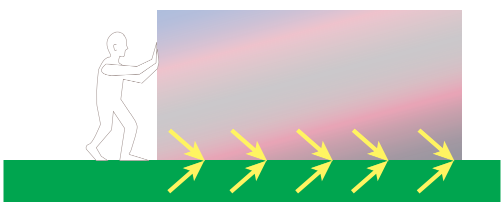
# An Introduction to Ball Bearings

## Introduction

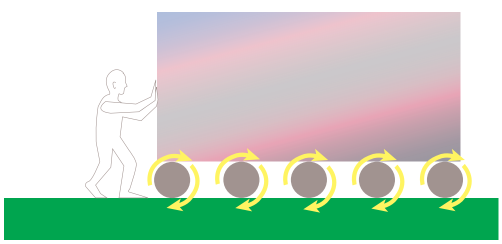
Whether you've worked with bearings for many years or are new to your position, you most likely already know that bearings have been in use for centuries. Because they work so well and seem to be such a relatively simple component within an application, bearings are taken for granted. They're also often blamed incorrectly as the cause for equipment and product failure.

Our objective with this guide is to provide you with a basic understanding of the principles of bearing design and function. We will not attempt to discuss everything there is to learn about bearings—more advanced concepts will be covered in other guides. Whatever your level of familiarity, we hope you'll find at least one piece of new information and, for those who have more experience with the subject, we hope that it will serve as a refresher course for you or assist you in training others.

Let's begin by addressing some of the basic elements and principles common to all bearings.



Sliding friction



Rolling friction

## Principles of Friction

You've been asked to move a one ton, smoothly polished block of granite to another location. During your initial attempt to move the block, the two surfaces in contact (the base of the granite block and the ground) resist movement. This is called *static friction*. Trying harder, you exert greater force, enough so that the surfaces begin to slide against one another. Once in motion, the resisting force is from *kinetic*, or *sliding friction*, rather than static friction.

If that same block is now placed on five equally spaced rollers the force required to move the block is significantly decreased. Why? The rollers, in contact with both the surfaces of the roadway and block, still encounter friction; however, the rotating action of the rollers carries the block forward with less effort. The rollers eliminate the need to slide the block and have eliminated the resisting force of kinetic friction: the friction encountered is now classified as *rolling friction*. Rolling element bearings are designed to take advantage of this principle. They eliminate sliding friction and utilize the efficiencies of rolling friction to carry a load.

## Rolling Element Bearings

Rolling element bearings consist of two circular steel rings and a set of rolling elements. One of the rings is much larger than the other—in fact, it is large enough for the other to fit well within its perimeter. This larger ring is referred to as the *outer ring*. The smaller of the two is the *inner ring*. A predetermined number of solid balls or rollers are formed into geometric shapes and placed at equal intervals in the open space between the two rings. These components are usually made of steel and are referred to as *rolling elements*. A *cage*, or *retainer*, is then used to maintain the intervals between the elements. This basic terminology will be used and expanded upon in the pages to come to describe the simple design and construction of a bearing.

## Rolling Element Bearing Classifications

The rolling elements are formed as standard geometric shapes which include:

- Balls
- Cylindrical Rollers
- Needle Rollers
- Tapered Rollers
- Spherical Rollers

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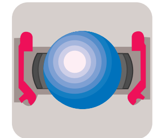
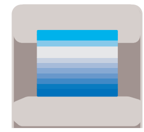
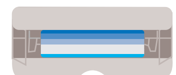
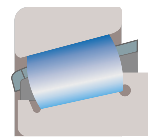
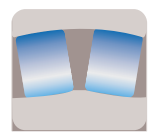
The geometric shape of these rolling elements are used to define the classification, or name, of each rolling element bearing type. Ball bearings use perfectly round balls as their rolling elements, cylindrical roller bearings use cylindrical rollers, etc.


Ball


Cylindrical


Needle


Tapered


Spherical

## Rolling Element Bearings and Tolerances

The precise operation of a rolling element bearing increases incrementally as each of the individual components approach "perfection" in its manufacture. The *American Bearing Manufacturing Association (ABMA)* has established two sets of tolerance classes that define the acceptable minimum and maximum manufacturing ranges for rolling element bearings. These are the *ABEC (Annular Bearing Engineering Committee)* tolerance classes for ball bearing and *RBEC (Roller Bearing Engineering Committee)* tolerance classes for roller bearings.

The international bearing community also has an association to regulate international standards, the *ISO*, or *International Standards Organization*. ISO and ABMA standards are identical with respect to these tolerances, although they use different class designations. Some manufacturers refer to ABMA designations while NTN and others use ISO designations. Either way, the tolerances are identical.

Bearings manufactured within tighter tolerance ranges provide greater accuracy of shaft rotation and contribute to higher speed capability.

## Bearing Loads

The rolling element bearing is subject to forces from gears, pulleys, or other components. These forces simultaneously act on the bearing from many different directions. The direction in which force is exerted on the bearing helps identify the type of *load* on the bearing:

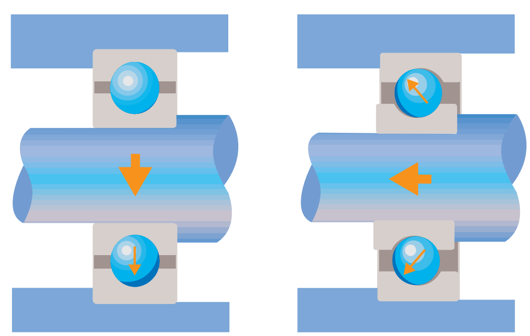
*Radial loads* are exerted on the bearing on a plane perpendicular *(90°)* to the shaft.

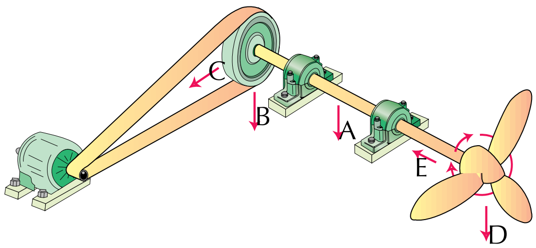
*Axial loads*, or *thrust loads*, are exerted on the bearing on a plane parallel to the center of the shaft.

*Combination loads* exert both a radial and axial load on the bearing.

The illustration on the following page shows a shaft mounted fan driven by a belt and powered by a motor. Two bearings support the shaft and are subjected to loads as follows:

Pure radial load    Pure thrust load






Radial, axial and combination loads

Radial loads originate from the: (A) weight of the shaft; (B) weight of the pulley; (C) tension of the belt; and, (D) weight of the propeller. Note: Radial loads exerted on the ends of the shaft, outside of the two bearings supporting the load (i.e. the belt tension, pulley weight and propeller weight), are compounded by a lever affect and are referred to as *overhung loads.*

Axial loads originate from the wind (E) induced by the propeller rotation.

Combination loads are the result of both radial load(s) and axial load(s) being combined and exerted on a single bearing.

## Bearing Life

*Bearing life* refers to the amount of time any bearing will perform in a specified operation before failure. Bearing life is commonly defined in terms of *L-10* life, which is sometimes referred to as *B-10*. This is the life which 90% of identical bearings subjected to identical usage applications and environments will attain (or surpass) before bearing material fails from fatigue. The bearing's calculated L-10 life is primarily a function of the load supported by (and/or applied to) the bearing and its operating speed.

Many factors have a profound affect on the actual life of the bearing. Some of these factors are:

- Temperature
- Lubrication
- Improper care in mounting resulting in:
  - Contamination
  - Misalignment
  - Deformation

As a result of these factors, an estimated *95%* of all failures are classified as premature bearing failures.

## Applications

Rolling element bearings are used in an extremely wide variety of tools, machinery and equipment. Just some of these applications include: construction, agricultural, automotive and industrial equipment. They may be used in fans, gear boxes, transmissions, axles, compressors, electric motors, engines, final drives, jet engine main shafts, blenders, saws, mixers, etc. Most rotating shafts use a rolling element bearing.

Having addressed concepts common to bearings, we'll now turn our attention to the specific principles and functions of ball bearings.

## Standard Ball Bearing Components

Bearings have a lot in common with cars. A car's basic design begins with a number of essential components for normal operation and can include additional components which may enhance performance. The same is true for bearings. The essential components of a ball bearing are defined as follows.

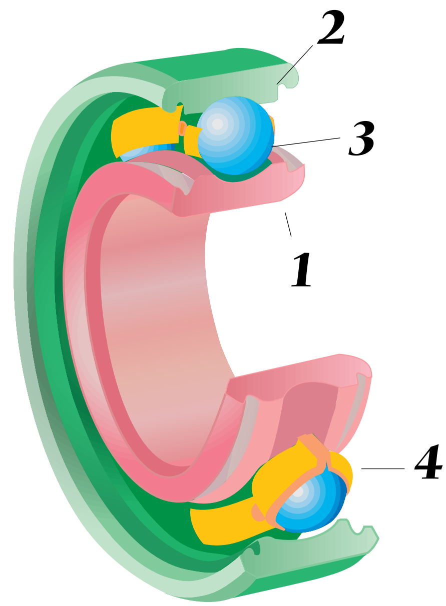
### The Inner Ring (1)
This is the smaller of the two bearing rings and gets its name from the position it holds. It has a groove on its *outside* diameter to form a path for the balls. The surface of this path is precision finished to extremely tight tolerances and is honed to a very smooth, mirror-like surface finish. The inner ring is mounted on the shaft and is usually the rotating element.

### The Outer Ring (2)
This is the larger of the two rings and, like its counterpart the inner ring, its name is derived from the position it holds. Conversely, there is a groove on its *inside* diameter to form a pathway for the balls. This surface also has the same high precision finish of the inner ring. The outer ring is normally placed into a housing and is usually held stationery.

### The Balls (3)
These are the rolling elements that separate the inner and outer ring and permit the bearing to rotate with minimal friction. The ball radius is slightly smaller than the grooved ball track on the inner and outer rings. This allows the balls to contact the rings at a single point, appropriately called *point contact.* Ball dimensions are controlled to very tight tolerances. Ball roundness, size variations, and surface finish are very important attributes and are controlled to a micro inch level (1 micro inch = 1/1,000,000th, or one-millionth of an inch).

### The Cage (Retainer) (4)
The main purpose of the cage is to separate the balls, maintaining an even and consistent spacing, to accurately guide the balls in the paths, or *raceways*, during rotation, and to prevent the balls from falling out.

### Lubrication
The lubricant is an integral part of a bearing's standard components. However, the complexity of the subject merits more detailed examination and will be addressed in other training modules.



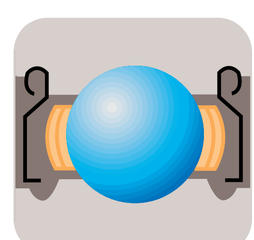
Standard bearing components

## Optional Bearing Components
The following ball bearing components enhance the performance and life of the bearing. These components are not added to the bearing unless specifically ordered. Each component is assigned an alphabetical or alpha/numeric code for clarity when ordering.

### Shields and Seals
*Shields* and *seals* are most commonly used on grease lubricated bearings in applications where the bearing can be exposed to external elements. The main function of the shields and seals is to keep possible contamination away from the most critical internal working components while keeping the lubricant clean and contained within the bearing.

### Shields
The shield is a stamped, profiled sheet metal disc. It is pressed into a very small groove on the inside edge diameter of the outer ring. A small space or gap remains open between the outside diameter of the inner ring and shield. Because the shield does not contact the inner ring of the bearing, there is no added friction between the shield and bearing. This results in a bearing that has a very low *torque* (the amount of twisting force required to

Shield (ZZ)



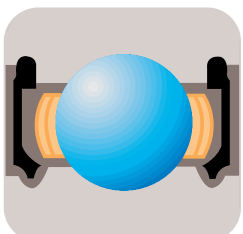
 

rotate the inner ring of the bearing relative to the outer ring). Shields keep larger particles of contamination from entering the bearing and are effective for many general bearing applications. NTN's designation for a shield applied to only one side of the bearing is the suffix *Z*; if shields are needed on both sides the suffix designation is *ZZ*.

### Seals

Seals are available in a variety of types and composition, the most common being synthetic rubber molded to a steel plate. The seal is also inserted into the very small groove on the inside, edge diameter of the outer ring. The inner edge of the seal is molded into a specifically designed lip configuration. NTN's generic suffix designation for any type of seal applied to one side of the bearing is *L*; for seals required on both sides it is *LL*.

NTN's standard seals are provided in two different configurations, *contact* and *non-contact*.



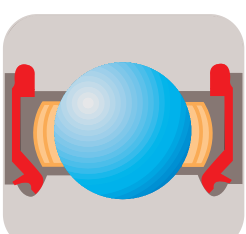
Non-contact seal (LLB)

### The Non-Contact Seal

The *non-contact seal* is NTN's unique single lip seal design. When assembled into the bearing, the seal's moulded, single lip fits into a specially designed seal groove machined on the outside edge diameter of the inner ring. The lip of the seal does not come into contact with the inner ring of the bearing, hence the name *non-contact seal*. The circular concave lip of the seal combines with the V-shaped trough of the inner ring to create an open area where grease is allowed to collect. These factors combine to form a very effective *labyrinth seal*—so called because the combination of the seal's design, the groove in which it fits and the grease combine to create a difficult maze through which the contaminants must pass to penetrate the seal.

There are many unique benefits associated with the non-contact seal: it requires very little torque to rotate, it is highly resistant to dust buildup, and operating temperatures are comparable to that of a shielded bearing. The non-contact seal offers the benefits that are usually provided by a shield with the additional advantages offered by seals. This type of seal was specially designed to meet the demanding requirements of modern day electric motors.

NTN's suffix designation for a non-contact seal placed on one side only is *LB*; when applied to both sides it is *LLB*. NTN generally molds the synthetic rubber non-contact seal in the color black, visually simplifying the identification process in comparison with other types of seals.



Contact seal (LLU)

### The Contact Seal

The *contact seal* is another option. Other manufacturers offer contact seals but the NTN design is unique in that it utilizes a molded, double lip seal to insure optimum protection from dust penetration. When assembled in the bearing, the inner lip of the seal contacts the inside edge of the seal groove on the inner ring. This is why the seal is called a *contact seal*.

A slight gap remains between the outer lip of the seal and the inner ring of the bearing, forming an area for grease to accumulate (hence a secondary labyrinth seal). Should friction cause the inner lip of the seal to wear, the outer lip will compensate for the wear by constricting around the outer landing of the bearing's inner ring. This preserves the perfect protection afforded by the NTN contact seal.

NTN's contact seal, as well as those manufactured by other companies, encounters sliding friction as the seal rubs the inner ring of the bearing:

- requiring a higher torque to rotate the bearing; and,
- generating heat (thus causing the bearing to operate at a slightly higher temperature), the effect of this is to reduce the speed limits of the bearing.

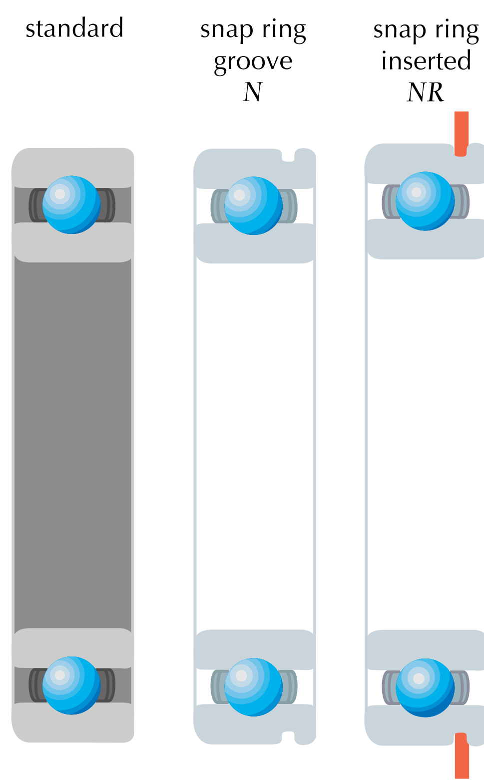
NTN's suffix designation for a contact seal on only one side *is LU* ; for contact seals applied to both sides it is *LLU*. Also, NTN generally molds the synthetic rubber contact seals in the color red to aid in recognition.

## Outer Ring Modifications

Most applications require the outside surface of the bearing's outer ring to be straight (without channels or lips, etc.). This is to be considered "normal" and needs no designation as a specifier. Some application designs call for the bearing to be held in place by using a ***snap ring***, a narrow, thin steel external ring applied (or snapped) to the bearing for positioning purposes. This requires a groove to be machined into the outer ring of the bearing that will accept the snap ring. This modification is referred to as the ***snap ring groove*** and is designated with the suffix *N* by NTN. If the bearing is supplied with a snap ring installed in the bearing's snap ring groove, the NTN suffix designation is ***NR.***

Other application designs specify the bearing to be supplied with a ***flange*** or ***flanged outer ring***. (The ring is formed with a flat extension to the outside edge of the outer ring which is used for positioning purposes.) NTN's designation for this design is the prefix ***FL.***

The primary purpose of both the snap ring and flanged outer ring is to position and hold the bearing's outer ring in its proper position in the housing.




## Inner Ring Modifications

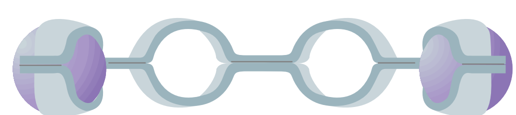
Most applications require the inside surface of the bearing's inner ring (bore) to be straight. This is considered "normal" and needs no designation as a specifier. Some applications call for the bearing to be held in place by a lock nut and washer to make field service and replacement much easier. In these cases, the shaft is normally made with a slight taper of 1/12" (for every 12" of distance, the shaft's diameter would be reduced by 1 inch). Therefore, the bore of the bearing must also be tapered to match the taper of the shaft. NTN's suffix designation for this is *K*.

### Cage (Retainer) Composition

The cage is an essential bearing component. It may be constructed using a variety of different materials (steel, brass, nylon) and manufacturing techniques (pressed, machined, molded).

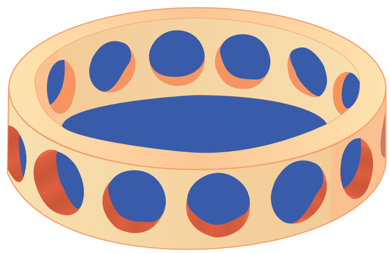
### Pressed Steel Cages

Pressed steel cages are the most common type of cage produced by NTN. In this process, steel is formed (pressed) into the proper shape and size to fit the rolling elements, their spacing, etc. Some steel cages are pressed as a one-piece retainer while others are pressed as two separate halves and assembled to form a two-piece retainer. The assembly methods used for

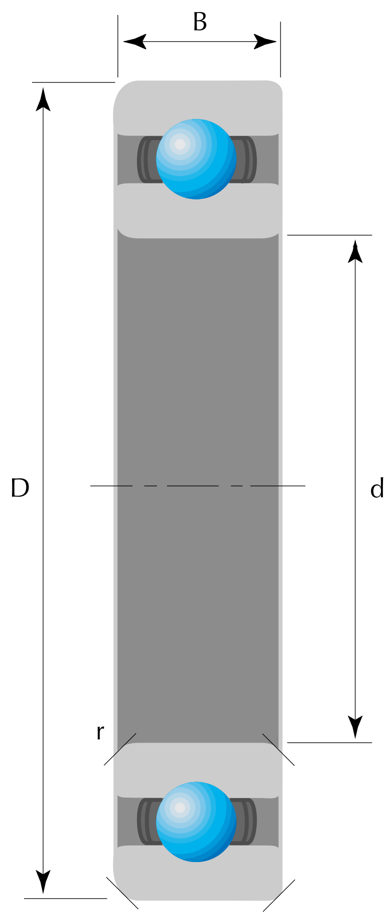


Pressed steel cage

Nylon cage



Machined cage




Basic boundary dimensions

two-piece steel retainers are spot welds, rivets, or *bent finger* joints. (The bent finger joints are designed into the stamped cage halves and are created when they are folded, or bent, over each other to hold the cage together). Although NTN's suffix for a pressed steel cage is *J*, it is seldom used because it is considered to be "standard" unless otherwise specified.

### Nylon Cages

Nylon cages are designed as a one-piece cage and created by an injection molding process. NTN typically uses glass-reinforced Nylon 66 for these cages; they are identified with the suffix designation *T2*.

### Machined Cages

Machined cages may be specified for larger, heavier, more precise bearing applications and are made of either brass, steel or *phenolic* (a polymer capable of withstanding high temperatures). Since they are machined, they have much tighter dimensional specifications and controls. The NTN suffix designations are listed below.

**NTN Designations for Machined Cages**

| | | |
|---|---|---|
| Brass | G1 | Cylindrical Roller Bearings |
| Brass | L1 | All Other Bearings |
| Leaded Steel | F3 | All Bearings |
| Molybdenum (Cr-Mo) Steel | F5 | All Bearings |
| Phenolic | T1 | All Bearings |

## Basic Boundary Dimensions

The ABMA and ISO assign bearing dimensional specifications for basic boundary dimensions, sometimes referred to as the bearing's *envelope dimensions*. These dimensions are established for all types and sizes of bearings and are normally listed in every bearing manufacturer's catalog as the *outside diameter, inside diameter* and *width*.

Note: Most basic boundary dimensions are measured in millimeters (mm), or a fraction thereof. One millimeter = 1/1,000 (.001) of a meter, or 25.4 mm = one (1) inch.

### The Outside Diameter (D)

The *outside diameter, (O.D.)*, is the straight line measurement from the outside edge of the outer ring across the entire distance of the bearing to the opposite, outside edge of the outer ring. This dimension is noted as *D* in NTN catalogs. The outside diameter normally fits into a housing.

### The Inside Diameter (d)

The *inside diameter, (I.D.)*, sometimes referred to as the bearing's *bore*, is the straight line measurement from the inside edge of the inner ring across the hole in the center of the bearing to the opposite inside edge of the inner ring. This dimension is noted as a *d* in NTN catalogs. The shaft normally fits into the bore of the bearing.

### The Width (B)

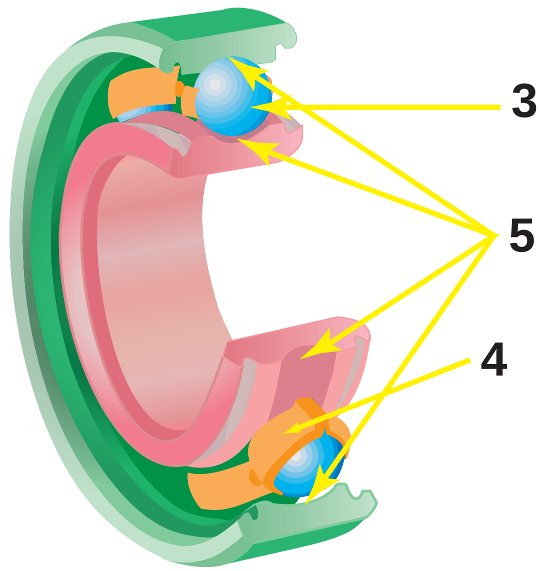
The *width* is the straight line measurement from one side of the outer ring across the outside surface to the opposite side of the outer ring. This measurement may also be taken from one side of the inner ring, across its surface, to the opposite side. In most cases, the width of the inner and outer rings will be identical; however, it does not have to be the same. This NTN catalog designation is *B*.

### The Chamfer (r)

The *chamfer* refers to the corner (edge) formed when the outside surface of the outer ring intersects the edge surface (or face) of the outer ring. It also refers to the corner (edge) formed, when the inside surface of the inner ring intersects the edge surface (or face) of the inner ring. This measurement is noted in NTN's catalog with an *r*.

## Load Carrying Surfaces

As noted earlier, a bearing is designed to carry a load and reduce friction. The critical surfaces involved in supporting or carrying the load are:



Load carrying surfaces

### The Balls (3)

Balls have been defined previously as one of the essential bearing components. They are subjected to the full brunt of the load carried by the bearing.

### Cages (4)

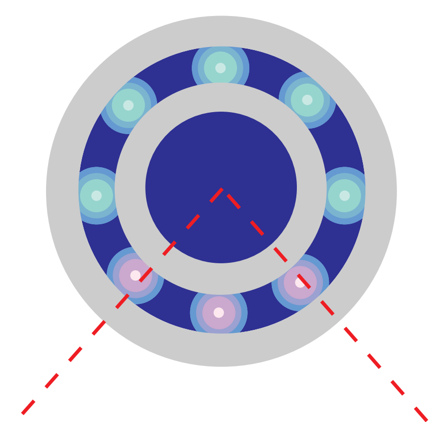
Under normal conditions, cages carry very little load. However, when a bearing is not installed properly, is subjected to loads and speeds higher than recommended by the manufacturer, does not maintain proper lubrication, etc., the cage then may be subjected to loads far beyond what it is able to carry. These conditions can lead to premature cage failure.

### The Raceways (5)

*Raceways* are the large, honed (highly polished), track surfaces on the inside of the outer ring (referred to as the outer raceway) and the outside of the inner ring (the inner raceway), that form a closed circle around the circumference of the ring. As the bearing rotates the rolling elements run on these surfaces.

## The Load Zone and Contact Points

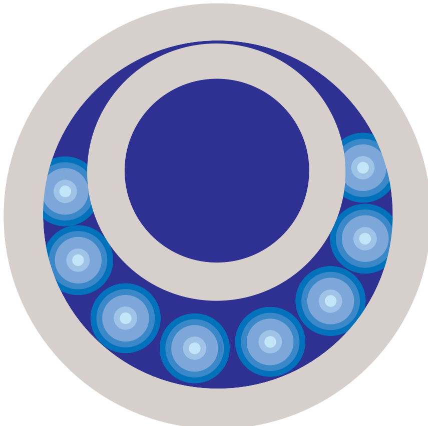
When a bearing is supporting a radial load, the load is distributed through only a portion of the bearing—approximately one-third (1/3)—at any given time. This area supporting the load is called the bearing *load zone*.


Load zone

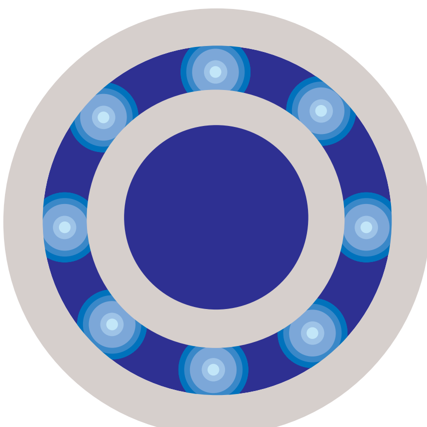
Every point or surface where loads are supported by the bearing are load carrying *contact points* or surfaces. These include the outer Ring O.D., inner Ring I.D., the adjacent surfaces that form right angles to each other, raceways and rolling elements.

## Ball Bearings Types

There are two basic types of ball bearings, radial and thrust. Although both are designed to carry one type of primary load, depending on the specific bearing design, they may also carry a variety or combination of loads.



Conrad bearing



## Radial Ball Bearings

Radial ball bearings are probably the most widely used and most recognized ball bearing. These bearings have one row of balls (referred to as a *single row*), that revolves around the ball path. This feature provides another name for the bearings, they are commonly called *deep groove ball bearings*. Although designed to primarily carry radial loads, a radial ball bearing's raceways are deep enough that it can also carry reasonable thrust loads. (However, if thrust loads are excessive, an alternative type of bearing should be considered.)

Most ball bearings, including single row, deep groove ball bearings (SRDG), are assembled using the *Conrad* method of construction. As an historical note, the inventor of this bearing assembly procedure, Robert Conrad, was given British patent no. 12,206 back in 1903, and U.S. patent no. 822,723 in 1906. This method of construction first takes an inner ring and outer ring and places the inner ring inside of the outer. With the rings oriented in the same direction, the inner is positioned so that it touches the outer ring at one point. This creates a crescent-shaped open area between the rings where the proper number of balls of the appropriate size are placed. The inner ring is then snapped into its proper position in relationship to the outer ring. The balls are evenly distributed around the raceway and the retainer is assembled or inserted into place.

Radial ball bearings are designed to carry primarily a radial load. When a pure radial load is applied to the bearing, the balls settle to the deepest point of the raceways and the load is transferred through the rings and balls where they contact one another. These points of contact created within the bearing will be perpendicular to the shaft.

The SRDG ball bearings are most commonly used in motors, hand tools, fans, etc., and are widely used for their versatility and durability. NTN's designation for these types of bearings is a *6* in the first position of a three (3), or four (4) digit base bearing number.

**Examples of the NTN SRDG Ball Bearing Series**

- *6*00
- *6*000
- *6*200
- *6*300
- *6*400
- *6*700
- *6*800
- *6*900

## SRDG Cartridge Bearings

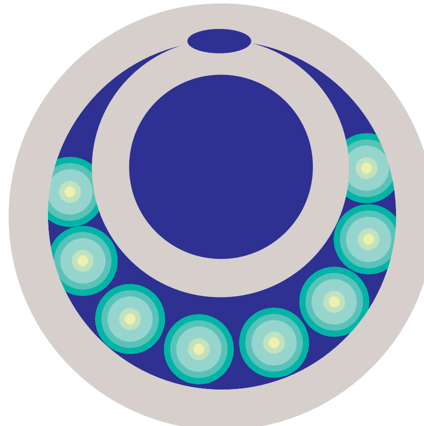
These bearings are identical to the SRDG described above with one exception: they are wider so as to accommodate more grease. They are, in fact, the same width as the double row angular contact bearings to be covered later in this section. NTN's designation for this type of bearing is *63* in the first two positions of a five (5) digit base bearing number.

**Examples of the NTN SRDG Cartridge Bearing Series**

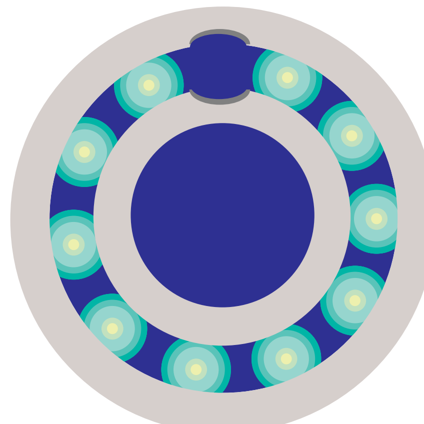
- *63*200
- *63*300

## Maximum Capacity SRDG Ball Bearings

These bearings are designed to the same envelope dimensions as the original SRDG bearings described above but carry a 20% to 35% higher dynamic *load rating*. (The load at which a bearing will achieve an L10 life of one million revolutions), it also carries a substantially higher static load rating. (The static load rating is identified as the maximum load that can be applied to the bearing without resulting in permanent deformation of the bearing components.) These increased load ratings are the result of adding more balls to the "normal" SRDG ball bearing; therefore the load is carried by more balls at any one time.



Maximum capacity bearings



Because the Conrad construction method does not allow more balls to be added to the bearing, the rings are slightly modified by cutting a small notch, or *filling slot*, on one side of the raceway (in both inner and outer rings). The bearings are constructed using standard Conrad procedures, up to and including the inner ring being snapped into position. The rings are then rotated until the filling slots are in line with each other and additional ball(s) are inserted into the bearing through the filling slot. The balls are evenly distributed around the raceways and the retainer installed.

The increased load carrying capabilities of the maximum capacity, or max. type SRDG ball bearing, *are intended to support primarily radial loads*. Thrust loads, from either direction, will cause the balls to ride up onto the sides of the raceways and into the edge of the filling slots. This will very quickly cause permanent damage and premature bearing failure.

NTN's designation for the SRDG maximum capacity bearing is a *BL* prefix in front of a three (3) digit base bearing number.

**Examples of the NTN Maximum Capacity, SRDG Ball Bearing Series**
- *BL*200
- *BL*300

Note: This design is becoming less popular due to improvements in Conrad type bearings, such as NTN's TMB bearings, which permit the replacement of max. type bearings with no performance penalty.

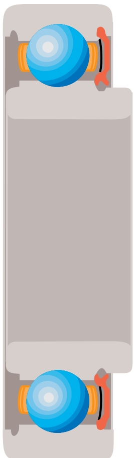
## TMB SRDG Ball Bearings

A recent development in bearing technology has yielded a greatly improved version of the standard SRDG conrad ball bearing, the TMB ball bearing. This specially heat-treated bearing transforms a standard 6200 or 6300 series SRDG ball bearing into a bearing that offers substantially longer life than standard or maximum capacity SRDG bearings. TMB bearings offer the following advantages:

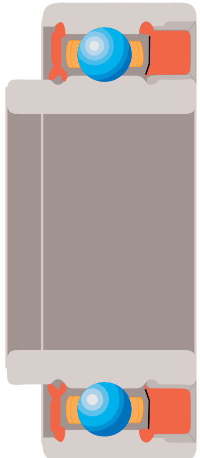
- TMB bearings run quieter than the standard maximum capacity SRDG ball bearing;
- They are capable of taking thrust loads where maximum capacity SRDG ball bearings cannot because they do not require a filling slot;
- TMB bearings have a rated L-10 life over 2 times the standard 6200 and 6300 series SRDG ball bearings; and,
- They offer greatly increased bearing life in heavily contaminated applications.

NTN's designation for this type of bearing is the prefix *TMB*, before the three (3) digit base bearing number.

**Examples of the NTN TMB Bearing Series**
- *TMB*200
- *TMB*300



8000



WC88000

## The 8000 Series Ball Bearing

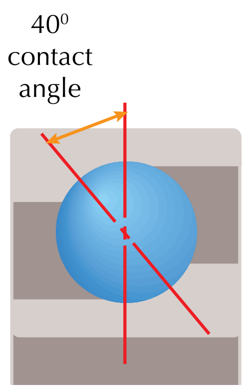
These SRDG radial ball bearings combine some interesting elements of an older, functional design with benefits provided by modern technology and components to create a bearing with an unusual appearance.

This series of bearing was originally designed utilizing the most “modern” technology of its day—a seal made from a very thick felt material. The seal’s thick felt material enhanced its sealing capacity and the bearing’s inner ring(s) were extended to ensure the seal was in complete contact with the inner ring across the seal’s entire surface. If a seal was used only on one side of the bearing, the inner ring was extended on one side only. If a seal was installed on both sides of the bearing, the inner ring was also extended on both sides. The most common designation for a *felt seal* installed in the bearing was *8*. In applications where a more dimensionally proportioned bearing was needed, the outer ring was extended to match; thus the designation *WC* to indicate *wide cup*.

Today, the most sophisticated seal designs and materials have been incorporated into this bearing and are used instead of the original felt seal designs, but the legacy of the single or double-sided extended inner ring, wide cup, as well as nomenclature using the 8 and WC, remain.

**Examples of the NTN Felt Seal Ball Bearing Series**

- *8000*
- *8500*
- *8600*
- *87000*
- *87500*
- *87600*
- *88000*
- *88500*
- *88600*
- *WC8000*
- *WC8500*
- *WC87000*
- *WC87500*
- *WC88000*




Angular contact bearings

## Angular Contact Ball Bearings

Angular contact ball bearings are classified as *single row, radial ball bearings.* However, many refer to them incorrectly as *thrust bearings* because they are designed to carry a heavier axial load. Unlike other radial ball bearings, the contact points through the angular contact bearing are measured in terms of how far they deviate from the normal pure radial load (at a *90°* angle to the shaft). Angular contact bearings are designed to operate with an internal contact angle of either *15°*, *30°* or *40°* from the standard *90°* angle to the shaft. NTN’s designations for the various contact angles are as follows:

**NTN Designation for Angular Contact Bearings**

| | |
|---|---|
| *15°* angle of contact | C |
| *40°* angle of contact | B |
| *30°* angle of contact | No Designation |

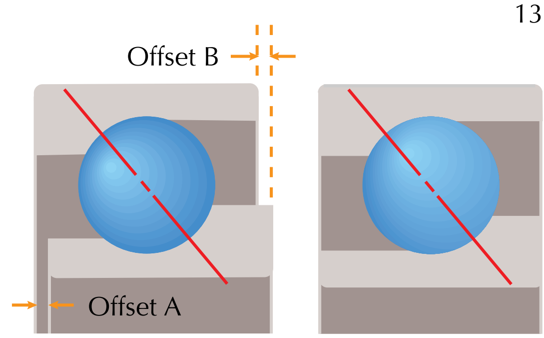
These bearings are designed for the balls to ride high on the edge of one of the raceways: the raceway on the opposite side of the outer ring is much shorter to accommodate assembly. If the angular contact bearing is installed facing the wrong direction, it will separate and result in a catastrophic premature bearing failure.

NTN’s designation for this type of bearing is a 7 in the first position of a four (4) digit base bearing number.

**Examples of the NTN Angular Contact Bearing Series**

- 7000
- 7200
- 7300

After an angular contact bearing is installed, excessive *end play*, or the axial movement of one ring in relationship to the other before subjected to any external load, may lead to premature bearing failure. The illustration to the left (labeled "Before") shows the shift that occurs (Offset A and B), which is referred to as *stickout*. To control end play, the faces of the bearings are *flush ground* as pictured in the illustration also to the left (labeled "After"). They may now be duplexed (see below). Maintaining this controlled end play promotes good load sharing support by each bearing, eliminating heat generation and power loss. NTN designates that a bearing is flush ground with the suffix *G*.




Before (A=B) After

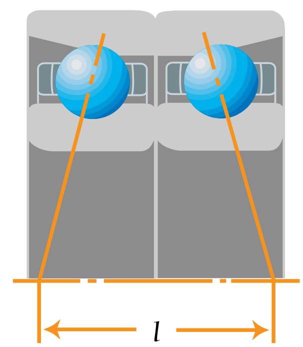
Flush ground

## Duplexing of Angular Contact Bearings

Angular contact ball bearings may be installed in sets of 2, 3 or more, either all in the same direction to carry heavier loads or in opposing directions to offset opposing loads. Some applications that do not require precision angular contact sets (i.e. irrigation well pumps, etc.) may use standard, individual flush ground angular contact bearings.

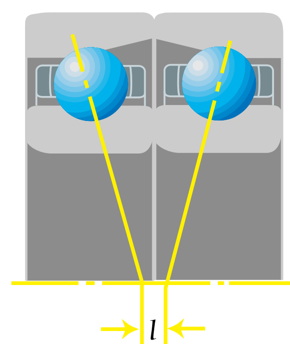
Note: Although many applications require individual angular contact bearings that do not need to be flush ground, it is a common practice for U.S. distributors to primarily stock flush ground angular contact bearings. This is done because the distributor may not always know when bearings are installed in sets where uncontrolled end play may cause equipment failure.

Axial loads may be present from either direction; thus angular contact bearings may be mounted in either a back-to-back or face-to-face configuration. In a back-to-back configuration, the set is installed with the large outer ring faces touching; the smaller outer ring faces are turned to the outside of the set; and it is used for added rigidity. This is identified by NTN with the suffix *DB*.



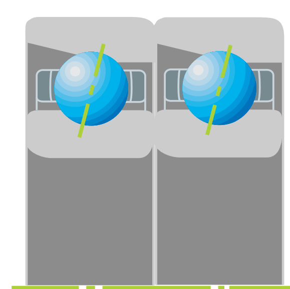

DB
back-to-back

A face-to-face configuration (the set is installed with the smaller outer ring faces touching and larger outer ring faces turned to the outside of the set) has a larger allowable misalignment angle and is identified by NTN with the suffix *DF*.




DF
face-to-face

When a very heavy axial load is exerted from one direction only, the bearings are stacked in tandem. Each bearing added increases the load carrying capability of the tandem set. NTN designates with the suffix *DT*.



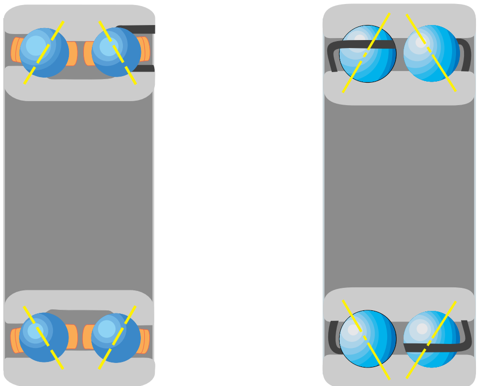
DT
tandem

## Duplexing of Precision Angular Contact Bearings

Many angular contact bearings are installed in precision sets that normally specify a predetermined amount of preload. This requires additional manufacturing processes where the inner and outer ring faces on each side of the bearing are ground such that when the bearings are assembled as a set, there is a small measured gap remaining between either the inner or outer ring faces.

In the case of a back-to-back arrangement, the gap would be between the inner ring faces when the outer rings are pressed together. In the case of a face-to-face arrangement there would be a small gap between the outer ring faces when the inner rings are pressed together. This small gap is the amount of axial clearance manufactured into the bearing set. As the rings are pressed together during assembly, the gap is eliminated and the bearings are preloaded to provide rigidity and greater running accuracy.

NTN's suffix designation for preloaded precision sets are *N* for ***normal*** preload, *L* for ***light*** preload, *M* for ***medium*** preload and *H* for ***heavy*** pre-load.



Double row angular contact

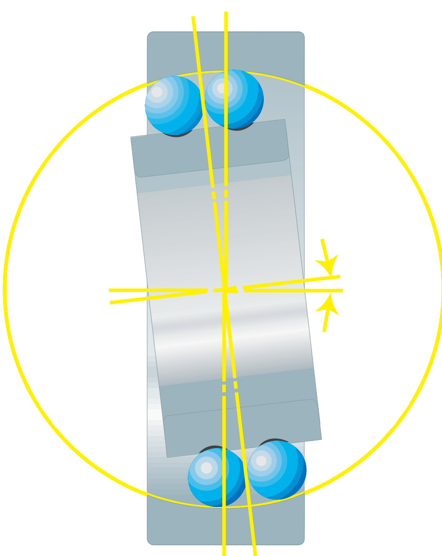
## Double Row Angular Contact Ball Bearings

The design of these bearings incorporates two (2) rows of balls into a single inner and outer ring and accommodates a thrust load from either direction. Obviously, they are much wider than a single row bearing and perform as if two bearings had been installed. NTN's double row angular contact ball bearings are made using diverging angles of contact. The illustration shows how the opposing *30*° contact angles do not converge (come together) within the bearing's inner ring; therefore they are described as "diverging" or "divergent." Double row angular contact bearings also come in either a maximum capacity version (with filling slots) or standard (non-filling slot) types.

NTN's designation for double row maximum capacity (filling slot) bearings is a *3* in the first position of a four (4) digit base bearing number and a *5* in the first position of a four (4) digit base bearing number to indicate a double row, non-filling slot type ball bearing.

**Examples of the NTN Double Row Angular Contact Bearing Series**

| | |
|---|---|
| • *3200* | • *5200* |
| • *3300* | • *5300* |


Double row self aligning ball bearing

## Double Row Self Aligning Ball Bearings

Like the double row angular contact ball bearing, this bearing is also designed with two rows of balls that rotate within one set of inner and outer rings. The ***self aligning*** ball bearing has a normal-looking inner ring with two (2) separate pathways around its perimeter. However, the outer ring is very unconventional in its design in that there is no noticeable ball path in the outer ring. Instead, the inside of the outer ring is a smooth, contoured spherical surface, with a center common to the bearing's center. This is what gives the bearing its special features. The design allows the bearing to properly operate, even though the bore of the housing (into which the outer ring fits) and the shaft may not be parallel. NTN's designation for this type of bearing is a *1* or *2* in the first position of a four (4) digit base bearing number.

**Examples of the NTN Double Row Self Aligning Bearing Series**

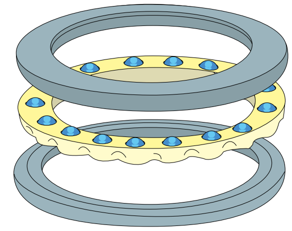
| | |
|---|---|
| • *1200* | • *2200* |
| • *1300* | • *2300* |

## Thrust Ball Bearings

Thrust Ball Bearings are designed to carry a pure form of thrust (axial) loads. When a load is properly applied to this bearing, the internal contact points are aligned on a plane parallel to the shaft. Radial loads will dislodge the balls from their track and cause the bearing to separate. Thrust ball bearings are made in two configurations, single direction and double direction designs.

## Single Direction Thrust Ball Bearings

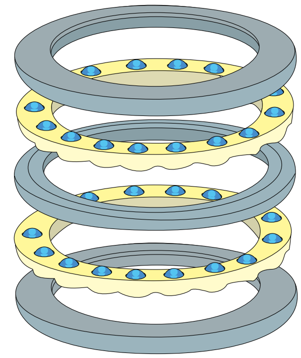
These bearings consist of one row of balls which rotate between a housing washer and a shaft washer. The housing washer is the thrust bearing's equivalent of a radial bearing's outer ring and is seating in the housing. It has a ball pathway machined on one of its sides (faces). The shaft washer is the equivalent of a radial bearing's inner ring and is seated against the shaft. It also has a ball pathway machined on only one of its sides. As the name implies, this bearing should be used to accommodate a thrust load from one direction. NTN's designation for this type of bearing is *51* in the first two positions of a five (5) digit base bearing number.



Single direction thrust bearing

**Examples of the NTN Single Direction Thrust Ball Bearing Series**
- *51*100
- *51*200
- *51*300
- *51*400

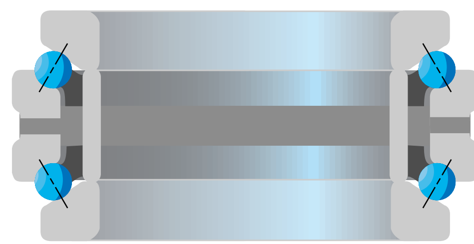
### Double Direction Thrust Ball Bearings
These bearings consist of two separate rows of balls which rotate between a center shaft washer (having raceways machined on both faces) and two housing washers (described above). This bearing should be used when a thrust load is applied from two directions. NTN's designation for this type of bearing is *52* in the first two positions of a five (5) digit base bearing number.



Double direction thrust bearing

**Examples of the NTN Double Direction Thrust Ball Bearing Series**
- *52*200
- *52*300
- *52*400

### Double Direction Angular Contact Thrust Ball Bearings
This bearing is constructed using two separate rows of balls and uniquely designed inner and outer rings. The bearing will accommodate a thrust load from either direction. It differs from the other angular contact bearings in that it has an internally designed contact angle of *60˚*. They are used in equipment where extremely high accuracy is required, such as machine tools, etc. NTN's designation for this type of bearing is *562* in the first three positions of a six (6) digit base bearing number.

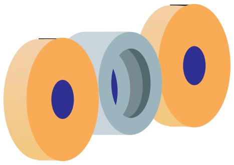


Double direction angular contact thrust ball bearing

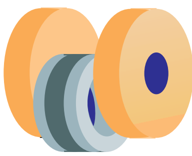
**Examples of the NTN Double Direction Angular Contact Thrust Ball Bearing**
- *562*000
- *562*900

## Ball Bearing Materials
Ball bearings are generally made of high carbon steels, such as *AISI 52100 (fifty-two, one hundred)*. One of the factors that determines the life of the bearing steel (thus the bearing itself) is the purity or cleanliness of the steel. The 52100 steel is subjected to a rigorous purification process with stringent controls in order to meet the ever increasing standards for cleanliness—eliminating nonmetallic inclusions or impurities. These impurities are removed through various processes such as *vacuum degassing* and *consumable-electrode vacuum melting (CEVM)*, to name just two of the processes referred to when discussing the merits and cleanliness of bearing steel.

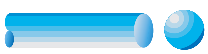
The hardening of the steel is achieved by a *heat treating* process in which the steel microstructure is manipulated by cycles of heating and quick cooling to obtain the optimum hardness range for the steel—usually on the order of 60 to 64 on the *Rockwell C Hardness* scale. Penetration hardness tests (such as Rockwell or Brinell) provide the means to estimate the actual hardness of metals.



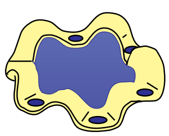
Grinding the outer diameter



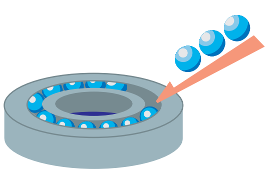
Finish grinding of the ring faces



Bearing steel wire cold stamped



Retainers finish formed



Bearing assembled & treated with rust preventative

# The Manufacture of Ball Bearings

Ball bearings are at the heart of almost every product with a rotating shaft. We've come to rely heavily on these products—and in turn on the bearings too—for the benefits they provide. We expect these products (and the bearings within) to give us uninterrupted, dependable "lifetime" service. This expectation has been built, in part, due to the increasingly reliable performance of precision components such as bearings. The highly precise surface finish, material properties, cleanliness, dimensions and tolerances of today's bearings contribute significantly to product performance.

Although most bearing specifications and manufacturing tolerances are quantified in one-ten thousandths of an inch (1/10,000) by ABMA, NTN actually measures the production process in micron and submicron ranges. It is this precise measuring capability that gives NTN the ability to produce a product with less variation from piece to piece, lot to lot, and day to day. NTN's efforts have led to recognition as a world leader in *Statistical Process Control (SPC).* Every manufacturing process is 100% checked and feedback provided to ensure the integrity of the process and product.

Note: A *micron* (an abbreviation for *micrometers*) is one-millionth of a meter, or, 25,400 microns equals one (1) inch.

**Inner/Outer Ring Manufacturing Process**

- The bearing steel is machined (turned) or forged into rough cut, basic ring configurations;
- Rings are machined to within rough tolerance specifications;
- Rings are heat treated to increase the steel's strength;
- Ring faces receive the final grinding, removing any rough spots;
- The ring O.D. and I.D. are finish ground to a smooth surface;
- Raceways are also finish ground to an even surface;
- The raceways are honed to a polished finish; and,
- The rings are then cleaned and readied for assembly.

**Ball Manufacturing Process**

- The bearing steel wire is cold stamped (headed) into roughly shaped balls;
- Balls are rough ground to remove the flashing (orbit) created during heading;
- The balls are heat treated for strength;
- Balls are rough ground again to remove coarser imperfections;
- The balls are next finish ground;
- The balls are lapped (a fine-polishing process); and,
- Finally, the balls are cleaned and readied for assembly.

**The Stamped Steel Cage Manufacturing Process**

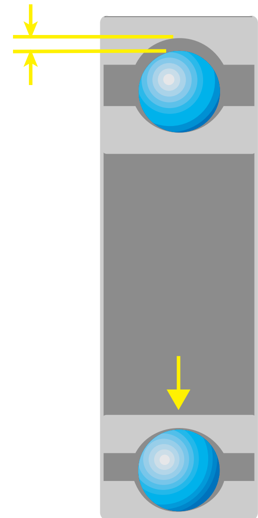
- Blanks, or donut shaped discs, are stamped out of strip steel;
- The retainers are partially (rough) formed;
- The retainers are next finish formed;
- Retainers are then punched (if rivets are to be used);
- Retainers go through a deburring process; and,
- The finished retainers are cleaned and readied for assembly.

**Ball Bearing Assembly**

The bearing components will next go through the final assemby process. The assembled bearing is then cleaned, lubricated, noise tested, etc.; it's ready to meet your expectations!

# Repeatability in the Manufacturing Process

Predictable uniformity, or repeatability, in the manufacturing process is crucial to ensuring consistent bearing performance. If variations occur in the manufacturing process from part to part, the production line may make bearings that fall within the complete spectrum of the allowable tolerance standards. That inconsistency—producing parts that go from one end of the range to the other—can lead in turn to variations in the performance of each bearing, either individually or from lot to lot. The narrower the variation in each step of the manufacturing process, the greater the consistency of each bearing's performance. Not only does NTN manufacture close to the midpoint of tolerance limits, but our own internal standards require NTN parts to fall in an increasingly narrow range. NTN's actual in-house standards are, in fact, more strict than ABEC and ISO standards.

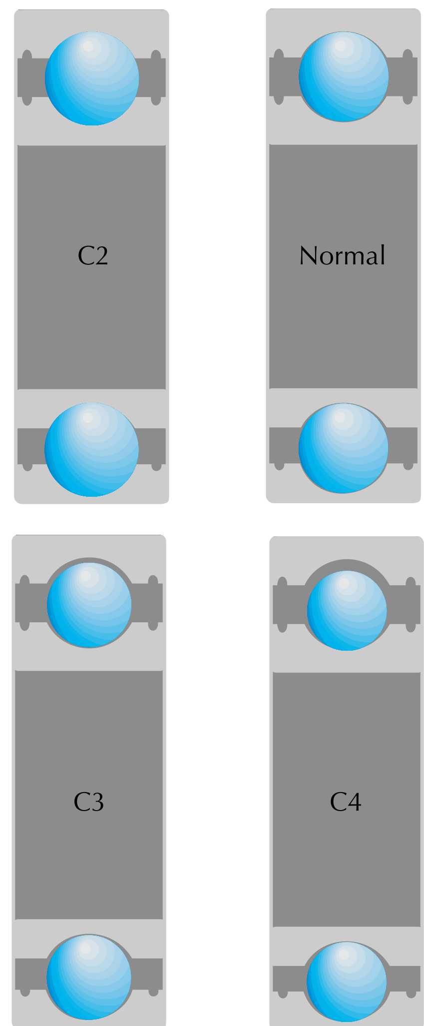


Measuring radial clearance

# The Internal Clearance of the Bearing

In order to freely rotate, a ball bearing must have a certain amount of internal freedom of movement (*internal clearance*, or the space between the raceway and ball). Without this internal clearance, the bearing can be difficult to rotate or may even freeze-up and be impossible to rotate. On the other hand, too much internal clearance will result in an unstable bearing that may generate excessive noise or allow the shaft to wobble. It is therefore imperative that the bearing be manufactured with the proper amount of measured internal clearance to meet the needs of the application.

Loads are applied to the bearing both from the axial and radial directions; likewise, the internal clearance is measured in terms of the direction of the load (*radial internal clearance* and *axial internal clearance*). When manufactured and not yet shaft mounted, the bearing is measured in terms of its *unmounted internal clearance.*

Clearance standards



## Measuring Radial Internal Clearance

The ABMA and ISO have established standards for five (5) defined classifications of radial internal clearance. The nomenclature for these classifications (in ascending order of size from the smallest clearance to the largest) are *C2*, *normal (no designation)*, *C3*, *C4*, and *C5*. Typically, bearings stocked by distributors are C3 clearance. Clearance must be specified when ordering to obtain the proper bearing for the application.

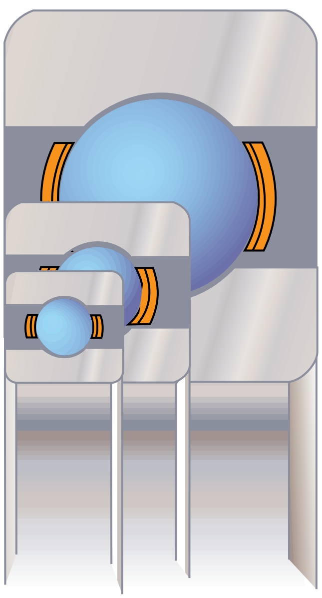
The illustration at the top of this page demonstrates how internal clearance is measured. The example shows a radial ball bearing, so the radial internal clearance is measured. The bearing is grasped at one point on the inner ring and at another point on the outer ring, directly opposite (see large arrows). The bearing is held together to assure radial contact between the inner raceway, balls, and outer raceway. This allows measurement of the bearing's internal clearance at a point on the opposite side of the bearing—*180°*—from where the points of contact are being made. The small gap between the top ball and the raceway represents the bearing's radial internal clearance.

The C2 through C5 classifications are further defined within strict minimum and maximum ranges, according to the bore size of the bearing. An actual example of this range as it applies to each internal clearance classification for a SRDG ball bearing with a bore size of over 10mm through 18mm follows on the next page.

| Bore Diameter | Over (mm) | Incl (mm) |
|---|---|---|
| | 10 | 18 |
| **Clearance** | **Min** (μ) | **Max** (μ) |
| C2 | 0 | 9 |
| Normal | 3 | 18 |
| C3 | 11 | 25 |
| C4 | 18 | 33 |
| C5 | 25 | 45 |

Note: All NTN internal clearance specifications to ISO standards are stated in microns, an abbreviation for "micrometers." (One micron is one-millionth of a meter, or, 25,400 microns equal one (1) inch.)

Normally, a bearing is pressed onto a shaft with a tight fit *(press fit)*. This slightly stretches the inner ring and effectively removes some of the unmounted internal radial clearance. The resulting remaining radial internal clearance is the *mounted internal clearance*. The mounted internal clearance may also be reduced in the bearing as it is pressed into a housing. As a general rule, you will not see an application where both the shaft and housing will call for a pressed fit. This could squeeze the bearing and cause a very quick failure. Under normal operating conditions heat is usually generated, causing the shaft to expand and eliminating additional internal clearance.



Bore dimensions

## The Basic Bearing Number System

Usually, with all the bearings discussed so far, the last two digits of the base bearing number indicate the diameter (size) of the bearing's bore in millimeters. The first four (4) must be memorized.

- 00 = 10mm
- 01 = 12mm
- 02 = 15mm
- 03 = 17mm

When the last two digits of the base bearing number are 04 or larger, simply multiply the double digit number by five (5) and you have the bore size in millimeters, i.e., 04 = 20mm, 10 = 50mm, and 24 = 120mm.

The third digit of the base bearing number from the right usually denotes the series (cross section size or duty) of the bearing. For any given bore size, the larger the series number is, the larger the bearing O.D. and width will be. For example, let's consider 50mm bore SRDG ball bearings.

| Bearing | Bore (mm) | O.D. (mm) | Width (mm) |
|---|---|---|---|
| 6010 | 50 | 80 | 16 |
| 6210 | 50 | 90 | 20 |
| 6310 | 50 | 110 | 27 |
| 6410 | 50 | 130 | 31 |

You are now ready to study and understand the basics of NTN's ball bearing numbering system.

# The NTN Bearing Numbering System

The diagrams to follow cover the basics of the NTN numbering system for bearings. Additional information is available in the NTN A1000-V catalog.

## Radial Ball Bearings

**6203 ■ LLB N C3 /5C**

| | | |
|---|---|---|
| Basic Number | Series | 6 |
| | Size | 2 |
| | Bore Diameter | 03 |
| Supple-mentary Suffix Code | Cage | ■ |
| | Seal or Shield | LLB |
| | Ring Modification | N |
| | Clearance | C3 |
| | Grease | /5C |

For additional information, see page 16 in the NTN A1000 catalog.

## Angular Contact Bearings

**7305 B ■ L1 G**

| | | |
|---|---|---|
| Basic Number | Series | 7 |
| | Size | 3 |
| | Bore Diameter | 05 |
| Suffix Code | Contact Angle | B |
| | Duplex | ■ |
| | Cage | L1 |
| | Duplex Arrangement | G |

For additional information, see page 41 in the NTN A1000 catalog.

## Self Aligning Bearings

**1205 ■ K C**

| | | |
|---|---|---|
| Basic Number | Series | 1 |
| | Size | 2 |
| | Bore Diameter | 05 |
| Suffix Code | Cage | ■ |
| | Ring Modification | K |
| | Clearance | C |

For additional information, see page 55 in the NTN A1000 catalog.

## Thrust Bearings

**51316 ■**

| | | |
|---|---|---|
| Basic Number | Series | 51 |
| | Size | 3 |
| | Internal Diameter | 16 |
| Suffix Code | Cage | ■ |

For additional information, see page 123 in the NTN A1000 catalog.

## Notes

# Glossary

**ABEC** (The Annular Bearing Engineering Committee) : one of two sets of tolerance standards set by the ABMA to define acceptable minimum and maximum manufacturing ranges for rolling element bearings, now combined with RBEC into the *Bearing Technical Committee*.

**ABMA** (The American Bearing Manufacturing Association) : a U.S. based organization concerned with bearing manufacturing standards.

**axial internal clearance** : amount of internal freedom designed into a bearing to permit proper axial looseness, allowing proper rotational movement; see also *internal, mounted, radial* and *unmounted internal clearance.*

**axial load(s)** 1. forces exerted on the bearing which originate on a plane parallel to the shaft axis; 2. also referred to as *thrust load(s)*.

**B** : NTN catalog designation for width.

**B-10 life** (archaic) : calculation to designate rated bearing life; see also *L-10 life*.

**ball** : a rolling element used in ball bearings.

**bearing life** : the amount of time any bearing will perform in a specified operation before failure; see also *B-10* or *L-10* life.

**bearing torque** : amount of twisting resistance encountered when rotating one ring relative to the other.

**bent-finger joints** 1. an assembly method used to join pressed steel cages; 2. extension joints designed into stamped cage halves; joints created when retainer extensions are folded over each other to hold the cage together.

**BL x x x** : NTN designation for maximum capacity bearing.

**C** : NTN designation for 15° angle of contact in angular contact bearing.

**C2, normal, C3, C4 and C5** 1. five classifications of internal clearance defined by the ABMA and ISO; 2. from smallest (C2) to greatest (C5) each classification has predetermined minimum and maximum ranges; see also *internal clearance.*

**cage** 1. a pressed, stamped or machined element designed to separate the bearing's rolling elements, allowing them to maintain even and consistent spacing, and to prevent the elements from falling out; 2. also referred to as the *retainer.*

**cartridge bearing** : Single row, deep groove ball bearing (SRDG), wider than a standard SRDG ball bearing.

**chamfer** : the corner, or edge, formed when the outside surface of the bearing outer ring intersects the edge surface of the outer ring; also located on the inner ring.

**combination load(s)** : forces which originate and are exerted on the bearing on a plane perpendicular as well as parallel to the shaft axis; see also *axial* and *radial load(s)*.

**Conrad, Robert** : inventor of the Conrad method of construction for single row, deep groove ball bearings, also known as *conrad bearings*.

**conrad** : method of construction for SRDG ball bearings.

**consumable-electrode vacuum melted (CEVM)** : steel manufacturing process used to remove impurities.

**contact point(s)** : the place on the bearing surface where loads either enter or leave the bearing; see also *load(s).*

**contact seal** 1. a unique double lip seal design from NTN; a molded seal provides protection from dust penetration; 2. the inner lip of the NTN seal contacts the inside edge of the trough on the inner ring; see also *seal(s).*

**cylindrical roller** 1. a solid rolling element bounded by two parallel planes; 2. a rolling element used in bearings similar to tapered and spherical rollers.

**D** : NTN catalog designation for outside diameter; see also *O.D.*

**d** : NTN catalog designation for inside diameter; see also *I.D.*

**deep groove** : radial ball bearings designed to primarily carry radial loads.

**deflection** : internal axial movement within an angular contact bearing that results in inner and outer ring movement in relationship to one another.
**diverging angles of contact** : angles of contact, created within a double row ball bearing, that do not meet within the bearing's inner ring.
**double row bearing** : a single bearing having two rows of rolling elements.
**dynamic load rating** : the constant (axial or thrust) load under which a bearing will achieve an L10 life of one million revolutions.
**envelope dimensions** : basic boundary dimensions defining the I.D., O.D. and width of bearing; see also *inside diameter* and *outside diameter.*
**F3** : NTN designation for machined leaded steel cage.
**F5** : NTN designation for machined molybdenum (CR-MO) steel cage.
**FL** : NTN designation for flanged outer ring or flange.
**felt seal bearing** 1. SRDG bearing with an extended inner ring, originally designed to ensure contact across the entire felt seal surface; 2. historically, a bearing seal made of a thick felt material; see also *seal(s).*
**filling slot** : a small notch cut into one side of the bearing raceway (both inner and outer rings) permitting the insertion of additional balls over the standard number.
**flange** : flat extensions on the outside edge of a bearing's outer ring, used for positioning purposes.
**flashing** : orbit formed around the circumference of a ball when it is initially stamped from wire.
**flush ground** : an angular contact bearing having parallel ring faces after allowances for normal deflection.
**friction** : a force that acts to resist or retard the relative motion of two objects that are in contact; see also *rolling, sliding* and *static friction.*
**G** : NTN designation for flush ground angular contact bearing.
**G1** : NTN designation for machined brass cage in cylindrical roller bearing.
**headed** : stamping process in which balls are formed from wire.
**I. D**. : see *inside diameter*.
**inner ring** : the innermost ring of the two circular steel rings that house the bearing's rolling elements.
**inside diameter (I.D.)** : the straight line measurement from inside edge of the inner ring across the diameter of the bearing center to the opposite inside edge of the inner ring.
**internal clearance** 1. amount of internal freedom designed into a bearing to permit proper rotational movement; see also *axial, internal, mounted* and *unmounted internal clearance*.
**ISO (International Standards Organization)** : an international organization focusing its concerns on developing and maintaining manufacturing standards.
**J** : NTN designation for pressed steel cage.
**K** : NTN designation for tapered bore.
**kinetic friction** : see *sliding friction*.
**L (or LL)** : NTN general designation for any type of seal.
**L1** : NTN designation for machined brass retainer used on most bearings.
**L-10 life** : calculations to designate rated bearing life; the life which 90% of identical bearings operating under identical conditions will attain or surpass before material failure by fatigue; see also *B-10 life.*
**LB (or LLB)** : NTN designation for single (LB) or double (LLB) non-contact seal(s).
**LU (or LLU)** : NTN designation for single (LU) or double (LLU) contact seal(s).
**labyrinth seal** : combination of seal design, groove placement and grease interacting to create a difficult maze through which contaminants must pass if they are to penetrate the seal.
**load(s)** : the overall force to which a bearing or its elements are subjected; see also *axial, combination* and *radial load(s).*

**load zone** : portion of bearing that carries the load at any given time (normally one-third of a radial ball bearing).

**machined cage** 1. cages cut from solid material, normally used for larger, heavier precision bearing applications; 2. composition may be ferrous or nonferrous materials.

**maximum capacity bearing** : ball bearings holding more balls than normal conrad construction bearings, incorporating a filling slot to facilitate inclusion of the additional balls.

**micrometer** (abbr. micron) : one-millionth of a meter; one inch equals 25,400 micrometers.

**micron** : abbreviation, see *micrometer.*

**millimeter** (abbr. mm) : one-thousandth of a meter; one inch equals 25.4 millimeters.

**mounted internal clearance** : resultant internal clearance after bearing is press fitted onto shaft, see also *internal clearance; axial, radial* and *unmounted internal clearance.*

**N** : NTN designation for snap ring groove in the outer ring.

**NR** : NTN designation for bearing supplied with snap ring assembled in the snap ring groove.

**needle rollers** : a narrow, proportionately longer, cylindrically shaped rolling element.

**non-contact seal** : a unique single lip seal design from NTN; the lip of the seal does not come into contact with the inner ring of the bearing; see also *seal(s)*.

**nylon cage** : one-piece injection molded cage composed of Nylon 66.

**O.D.** : see *outside diameter*.

**outer ring** : the outermost ring of the two circular steel rings that house the bearings rolling elements.

**outside diameter (O.D.)** : the straight line measurement from the outside edge of the bearing outer ring across the circumference of the bearing to the opposite outside edge of the outer ring.

**overhung load(s)** : radial loads exerted on the ends of the shaft beyond the support of the bearing that is compounded by the lever effect; see also *radial load(s).*

**point contact** : area where the ball(s) come in contact with the raceway when the ball radius is smaller than the grooved raceway.

**premature bearing failure** : bearing failure occurring before the predicted life for that bearing and its relative application; see also *L-10 life*.

**pressed steel cage** : steel shaped and sized to form retainer to hold rolling elements within inner and outer rings; see also *cage* and *retainer.*

**r** : NTN catalog designation for chamfer.

**raceway(s)** 1. the large honed track surfaces on the inside of the bearing outer ring, referred to as the outer raceway, forming a closed circle around the circumference of the ring; 2. also, the track surfaces on the outside of the bearing inner ring, referred to as the inner raceway; 3. during bearing rotation, rolling elements run on these surfaces.

**radial internal clearance** : amount of internal freedom designed into bearing to permit appropriate radial looseness, allowing proper rotational movement; see also *internal clearance; axial, mounted* and *unmounted internal clearance.*

**radial load(s)** 1. Forces exerted on the bearing which originate on a plane perpendicular, 90˚, to the shaft.

**RBEC** (The Roller Bearing Engineering Committee) : one of two committees established by the ABMA to define acceptable minimum and maximum manufacturing ranges for roller bearings now combined with ABEC into the *Bearing Technical Committee*.

**repeatability** : the ability in the manufacturing process to achieve predictable consistency.

**retainer** : see *cage*.

**Rockwell C Hardness** : scale used in determining the penetration hardness of bearing steel and other metals.
**rolling elements** : solid balls or other geometrical shapes enclosed within a cage and placed between the inner and outer rings of a bearing.
**rolling friction** : a force opposing the motion of any body which is rolling over the surface of another.
**SPC** : see *Statistical Process Control.*
**SRDG** : see *single row* and *deep groove*.
**seal(s)** 1. generally constructed of synthetic rubber molded to a stamped, sheet metal plate; 2. used to keep larger particles of contamination from entering the bearing.
**self-aligning bearing** : bearing designed to operate correctly when shaft and housing may not be parallel.
**shield(s)** 1. a stamped, profiled sheet metal plate which is pressed into a small groove on the inside edge diameter of the outer ring; 2. used to keep larger particles of contamination from entering the bearing.
**single row bearing** : bearing containing only one row of rolling elements.
**sliding friction** : the resultant force that acts to resist or retard relative motion of two contacting surfaces when sliding against each other.
**snap ring** : a narrow, thin steel external ring applied (or snapped) to the outer ring of the bearing for positioning purposes; see also snap ring groove.
**snap ring groove** : a special groove machined in the outer ring of the bearing; see *snap ring*.
**spherical roller(s)** : a solid rolling element having a barrel shape used in spherical roller bearings.
**static friction** : the force resisting the initiation of sliding motion of one body over another with which it is in contact; see also *rolling* and *sliding friction*.
**static load rating** : maximum load that can be applied to the bearing without permanently damaging the bearing.
**Statistical Process Control (SPC)** ; a closed loop method of manufacturing that utilizes measurement, feedback and corrective action.
**T1** : NTN designation for a machined phenolic cage.
**T2** : NTN designation for a nylon cage.
**tapered bore** : bore made with a slight taper to fit a tapered shaft.
**tapered roller(s)** : a long, solid rolling element which has a gradual decrease in thickness from base to top.
**tapered shaft** : a shaft made with a slight taper, or gradual decrease in the diameter of the shaft from top to base, to facilitate field servicing and replacement.
**thrust bearing(s)** 1. bearings designed to carry primarily thrust loads; 2. angular contact bearings; see also *axial load(s)*.
**thrust load(s)** : see *axial load(s)*.
**unmounted internal clearance** : amount of internal freedom designed into a bearing during manufacture process (prior to mounting) to allow for proper rotational movement.
**vacuum degassing** : a steel manufacturing method used to remove impurities.
**wide cup** : designation in felt seal bearing indicating that the outer ring is extended; see also *felt seal.*
**width** 1. the straight line measurement from one side of the bearing's outer ring across the outside surface to the opposite side of the bearing; 2. or, from one side of the inner ring across the surface to the opposite side.
**Z (or ZZ)** : NTN designation for single (Z) or double (ZZ) shield(s).

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