Engineering Information

The information in this section will assist the design engineer in the selection of the ball bearing products that best suit critical application requirements for performance, life and cost. Early involvement by NMB Sales and Application Engineers is recommended. Engineering support services available from the company's engineering laboratories are described together with special testing capabilities.

Size, materials, component parts and lubrication alternatives are discussed in this section. These are followed by a detailed analysis of the important considerations which should be evaluated simultaneously when choosing the proper bearing for a particular design. Emphasis is also placed on the operations and aftermarket services available to the designer for installation and use of the bearings after delivery.

Engineering Services

Designing To Lower Total Cost

The majority of applications can be effectively handled using a “standard bearing.” A “standard bearing,” in this case, refers to a bearing that is in such worldwide demand that large volumes are produced. This virtually guarantees continuity of supply while assuring pricing benefits for the O.E.M. Selection of a “standard bearing” at the design stage cannot be over emphasized. The considerations necessary to design for lower cost include:

- Dimensional size
- Material type
- Lubrication
- Enclosures
- Cage style (retainer)
- Manufacturability
- Assembly and fits
- Packaging
- Quality requirements

Although different designers may vary in their approach to bearing selection, the following is one method that works well.

- Establish operating, environmental and performance requirements such as load, speed, noise, etc.
- Select a bearing configuration to meet the above requirements.

  Some examples of configuration types are:

  1. Flanged or unflanged
  2. With or without a snap ring
  3. Ball complement/size

- Determine bearing envelope to accommodate shaft and housing requirements. This step is critical to cost. It is quite often more cost-effective to design the housing and shaft around a popular bearing size than vice versa.
- Specify enclosures as necessary. Be careful not to specify a more expensive enclosure than necessary to perform properly in the application.
- Specify required cage type. For the majority of cases, the standard cage for a particular chassis size will be adequate.
- Determine the bearing noise rating that is required for the application. For most cases, our standard “No Code” noise rating will provide quieter operation than most other components in the system. For extremely noise sensitive applications, a quieter noise rating can be specified.
- Determine degree of precision needed to achieve the performance requirements (ABEC Level). Do not over estimate what is truly necessary to achieve the desired performance.
- Determine the radial play specification. The standard radial play specification for a chassis size will be adequate to-handle normal press fits, moderate temperature differentials and normal speeds.
- Determine lubrication requirements. This should include lubrication characteristics and the amount of lubricant needed. This is a critical step in the performance and reliability of the bearing in the application.

Care should be taken throughout this process with respect to both cost and performance. The key in designing for the lowest total cost is to involve the Sales and Application Engineering staff early in the selection process. Costs will be impacted greatly if the envelope dimensions are not given consideration at the time of bearing selection. NMB offers an experienced Sales and Engineering staff to help in the design and selection process insuring your success.

Engineering Services

Functional Tests For Ball Bearings

We have devised a series of rigidly monitored tests to insure that every bearing we manufacture will meet our commitment to quality and reliability. Our testing procedures measure dimensional characteristics, radial play and noise performance.

A bearing envelope and internal tolerance will not always reveal how the bearing will perform under dynamic conditions. NMB has developed “noise ratings” to assure exact bearing performance.

Every motor quality bearing produced is evaluated. During the assembly process, anderonmeters test for bearing noise and vibration. The bearings are tested under a controlled load and speed to meet their particular noise specification. This procedure allows the user to know how the bearings will perform under dynamic conditions.

Starting torque defines the effort required to initiate bearing rotation. This is a prime concern to ball bearing users. It can be a critical factor in applications requiring multiple low speed, start/stop movements.

Running torque is a measure of effort required to maintain rotation, under a certain load, after rotation has been initiated. NMB has the capabilty to perform running torque tests under a variety of conditions, ranging from 1-7,000 rpm with various applied thrust loads. NMB can customize tests based on specific application requirements. Tests may be fully monitored and analyzed for various ball bearing characteristics.

Accurate testing of ball bearings requires the tester to closely simulate the actual operating conditions of the intended application. Please consult an NMB Sales Engineer or a member of the Applications Engineering staff for their recommendations on the many specialized tests we can perform.

Engineering Test Laboratory

NMB maintains a fully equipped Engineering Test Laboratory where we can confirm the performance characteristics of our ball bearing designs. NMB has a full complement of commercially available equipment such as Talysurfs, Talyronds and Anderonmeters, running and starting torque testers, and real time analyzers. In addition, we have developed our own specialized state-of-the-art equipment, precisely tailored to our own requirements.

Typical of this equipment is a specially designed anechoic chamber, that includes a spindle for rotating ball bearings under loaded conditions. This can be used with a sonic analyzer to measure and record airborne noise, vibration and structureborne vibration.

Materials Laboratory

Our Materials Laboratory has been specifically designed and equipped to perform complex chemical, metallurgical, and visual analysis of the many component parts in ball bearings. Besides internal projects, this laboratory can also perform wear and failure studies on a customer’s bearings.

Modern chemical analysis of organic compounds is usually carried out on a dual-beam infrared spectrophotometer. Likewise, alloy composition is determined with x-ray defraction spectrography and non-destructive test methods.

Metallurgical studies can be done with metallograph and microhardness testers. The metallograph will perform microstructure photography at magnification from 25 to 2000 times. Micro-hardness testers investigate surface effects and alloy homogeneity using diamond indentation under loads from 1 to 10,000 grams.

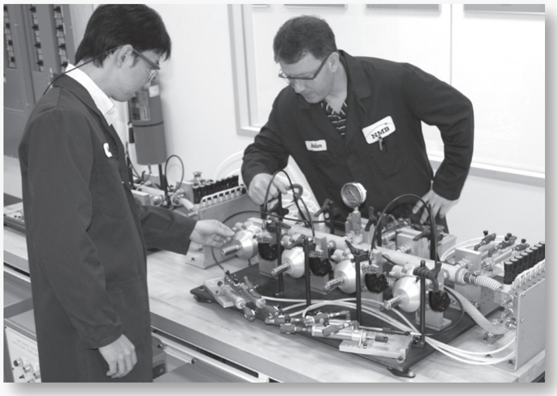
During bearing inspection and failure analysis, ball bearings are disassembled and examined under a laminar flow hood. Many findings can be recorded permanently with a photo-microscope for analysis and future reference.

Engineering Services

NMB Technical Center

The NMB Technical Center, a cutting edge testing facility located in Wixom, MI is designed to advance the function and performance of NMB products with customer applications. This facility supplies customers with application specific validation, as well as market leading technical information and services. The NMB Technical Center provides testing and analysis capabilities in the following areas:

- Equipment simulates a customer specific application to determine the expected performance of the component in real world conditions. Provides optimized component design and selection to maximize the performance and benefit under different conditions.
- Environmental testing analyzes product and application performance under varying environmental conditions such as temperature, humidity, altitude, contamination, corrosion and vibration. Provides baseline comparative tests of bearing and motor components such as lubricants, fits and sealing mechanisms to provide a database of performance characteristics. This capability can shorten the design time to reach an optimal bearing or motor selection.
- Chemistry testing analyzes the chemical makeup and condition of components and the interactions of various materials. Provides detailed analysis of lubricants and non-metallic parts to improve product performance.
- Metrology equipment measures NMB products and related components to determine their effect on system performance, including physical dimension, form, surface finish and roundness.
- Noise and vibration test equipment determines the audible noise and vibration of components and systems to improve noise characteristics of the application.
- Metallurgy tests determine the hardness, microhardness and microstructure of NMB and customer components.



Internal Bearing Geometry

When designing ball bearings for optimum performance, internal bearing geometry is a critical factor. For any given bearing load, internal stresses can be either high or low, depending on the geometric relationship between the balls and raceways inside the ball bearing structure.

When a ball bearing is running under a load, force is transmitted from one bearing ring to the other through the ball set. Since the contact area between each ball and the rings is relatively small, even moderate loads can produce stresses of tens or even hundreds of thousands of pounds per square inch. Because internal stress levels have such an important effect on bearing life and performance, internal geometry must be carefully chosen for each application so bearing loads can be distributed properly.

Definitions

Raceway, Track Diameter, and Track Radius

The raceway in a ball bearing is the circular groove formed in the outside surface of the inner ring and in the inside surface of the outer ring. When the rings are aligned, these grooves form a circular track that contains the ball set.

The track diameter and track radius are two dimensions that define the configuration of each raceway. Track diameter is the measurement of the diameter of the imaginary circle running around the deepest portion of the raceway, whether it be an inner or outer ring. This measurement is made along a line perpendicular to, and intersecting, the axis of rotation. Track radius describes the cross section of the arc formed by the raceway groove. It is measured when viewed in a direction perpendicular to the axis of the ring. In the context of ball bearing terminology, track radius has no mathematical relationship to track diameter. The distinction between the two is shown in Figure 1.

Radial and Axial Play

Most ball bearings are assembled in such a way that a slight amount of looseness exists between balls and raceways. This looseness is referred to as radial play and axial play. Specifically, radial play is the maximum distance that one bearing ring can be displaced with respect to the other, in a direction perpendicular to the bearing axis, when the bearing is in an unmounted state. Axial play, or end play, is the maximum relative displacement between the two rings of an unmounted ball bearing in the direction parallel to the bearing axis. Figure 2 illustrates these concepts.

Since radial play and axial play are both consequences of the same degree of looseness between the components in a ball bearing, they bear a mutual dependence. While this is true, both values are usually quite different in magnitude.

In most ball bearing applications, radial play is functionally more critical than axial play. If axial play is determined to be an essential requirement, control can be obtained through manipulation of the radial play specification. Please consult with Application Engineering if axial play ranges for a particular chassis size are required.

Some general statements about Radial Play:

1. The initial contact angle of the bearing is directly related to radial play- the higher the radial play, the higher the contact angle. The chart on the following page gives nominal values under no load.
2. For support of pure radial loads, a low level of radial play is desirable; where thrust loading is predominant, higher radial play levels are recommended.
3. Radial play is affected by any interference fit between the shaft and bearing I.D. or between the housing and bearing O.D.

If the system spring rate is critical, or if extremes of temperature or thermal gradient will be encountered, consult with our Engineering Department prior to design finalization.

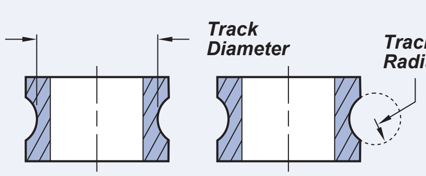


Figure 1. The distinction between track radius and track diameter (inner ring).

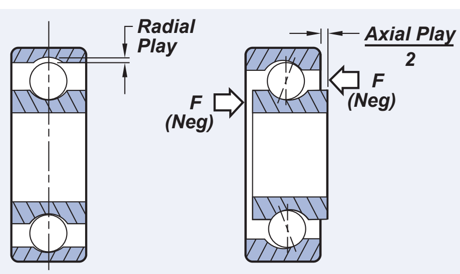


Figure 2. The distinction between radial play and axial play.

Internal Bearing Geometry

Table Of Contact Angles α_o

Ball Size D_w	RADIAL PLAY CODE P25	RADIAL PLAY CODE P58
.025	18°	24½°
1/32 & 0.8 mm	16½°	22°
1mm	14½°	20°
3/64	14°	18°
1/16	12°	16°
3/32	9½°	13°
1/8	12½°	17°
9/64	12°	16°
5/32	11°	15°
3/16	10°	14°

The contact angle is given for the mean radial play of the range shown i.e., for P25 (.0002" to .0005") contact angle is given for .00035". Contact angle is affected by race curvature. For your specific application, contact NMB Engineering.

Typical radial play ranges are:

Description	Radial Play Range	NMB Code
Tight	.0001" to .0003"	P13
Normal	.0002" to .0005"	P25
Loose	.0005" to .0008"	P58

Raceway Curvature

Raceway curvature is an expression that defines the relationship between the arc of the raceway's track radius and the arc formed by the slightly smaller ball that runs in the raceway. It is simply the track radius of the bearing raceway expressed as a percentage of the ball diameter. This number is a convenient index of “fit” between the raceway and ball. Figure 3 illustrates this relationship.

Track curvature values typically range from approximately 52 to 58 percent. The lower percentage, tight fitting curvatures are useful in applications where heavy loads are encountered. The higher percentage, loose curvatures are more suitable for torque sensitive applications. Curvatures less than 52 percent are generally avoided because of excessive rolling friction that is caused by the tight conformity between the ball and raceway. Values above 58 percent are also avoided because of the high stress levels that can result from the small ball-to-raceway conformity at the contact area.

Contact Angle

The contact angle is the angle between a plane perpendicular to the ball bearing axis and a line joining the two points where the ball makes contact with the inner and outer raceways. The contact angle of a ball bearing is determined by its free radial play value, as well as its inner and outer track curvatures.

The contact angle of thrust-loaded bearings provides an indication of ball position inside the raceways. When a thrust load is applied to a ball bearing, the balls will move away from the median planes of the raceways and assume positions somewhere between the deepest portions of the raceways and their edges. Figure 4 illustrates the concept of contact angle by showing a cross sectional view of a ball bearing that is loaded in pure thrust.

Free Angle and Angle of Misalignment

As a result of the previously described looseness, or play, which is purposely permitted to exist between the components of most ball bearings, the inner ring can be cocked or tilted a small amount with respect to the outer ring. This displacement is called the free angle of the bearing, and corresponds to the case of an unmounted bearing. The size of the free angle in a given ball bearing is determined by its radial play and track curvature values. Figure 5 illustrates this concept.

For the bearing mounted in an application, any misalignment present between the inner and outer rings (housing and shaft) is called the angle of misalignment. The misalignment capability of a bearing can have positive practical significance because it enables a ball bearing to accommodate small dimensional variations which may exist in associated shafts and housings. A maximum angle of misalignment of 1/4° is recommended before bearing life is reduced. Slightly larger angles can be accommodated, but bearing life will not be optimized.

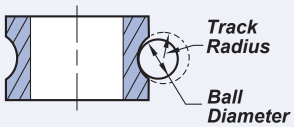


Figure 3. The relationship of track radius to ball diameter.

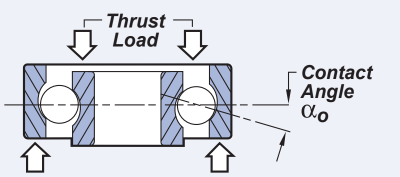


Figure 4. Contact angle for bearing loaded in pure thrust.

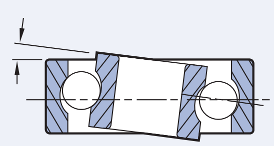


Figure 5. Free angle of the bearing.

Material/Cages/Retainers

Bearing Materials

Chrome Steel

Bearing steel used for standard ball bearing applications in uses and in environments where corrosion resistance is not a critical factor.

52100 or Equivalent

The most commonly used ball bearing steel in such applications as SAE 52100 or its equivalent. Due to its structure, this is the material chosen for extreme noise sensitive applications.

MKJ3* Chrome Steel

Developed by NMB's parent company, MKJ3 is a high carbon chromium bearing steel combined with a heat treating process. This steel has a higher hardness and a more stable structure than standard chrome bearing steel. This alows the steel to retain its shape under adverse conditions. For bearings designated with the KJ part number, the bearing race material is MKJ3, while the balls are made of standard 52100 or equivalent. KJ bearings were developed for use in hard disk drive and other specialty applications where the running accuracy performance is critical. The combination of materials used with the KJ designation results in a bearing that will have high shock load resistance, high load carrying capacity, and will resist increased sound levels with extended use.

Stainless Steel

DD400™ 0.7% C; 13% Cr

A 400 series Martensitic stainless steel combined with a heat treating process was exclusively developed by NMB's parent company. Miniature and instrument bearings manufactured from "DD™" Martensitic stainless steel, or "DD Bearings™", 0meet the performance specifications of such bearings using AISI 440C Martensitic stainless steel, and it is equal to or superior in hardness, superior in low noise characteristics, and is at least equivalent in corrosion resistance. These material characteristic advantages make for lower torque, smoother running, and longer life bearings.

The retainer, also referred to as the cage or separator, is the component part of a ball bearing that separates and positions the balls at approximately equal intervals around the bearing's raceway. There are two basic types that we supply: the crown or open end design and the ribbon or closed ball pocket design. The most common retainer is the two-piece closed pocket metal ribbon retainer.

The Open End design, or crown retainer, as shown in Figure 1 is of metal material. The metal retainer, constructed of hardened stainless steel, is very light-weight and has coined ball pockets which present a hard, smooth, low-friction contact surface to the balls. A feature of this assembly is its smooth running characteristic. Crown retainers manufactured from molded plastics are available for some sizes. Plastic molded nylon retainers are advantageous when application speeds are high relative to the particular bearing used. For special retainer requirements, please consult a member of our Sales-Engineering or Applications Engineering Department.

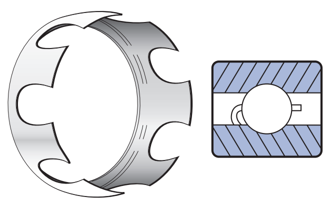


Figure 1. Standard one-piece crown retainer.

Closed Pocket Design (two-piece construction). The two-piece closed pocket design, as outlined in Figure 2 with clinching tabs, is our standard design for most miniature and instrument size ball bearings. The use of loosely clinched tabs is favorable for starting torque, and the closed pocket design provides good durability required for various applications.

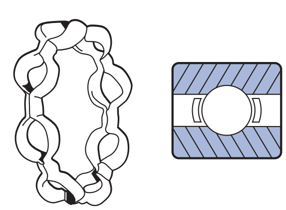


Figure 2. Two-piece closed pocket metal ribbon retainer.

For special retainer requirements, please consult a member of our Sales Engineering or Applications Engineering Department.

*U.S. Reg. Pat. No. 6491768

Shield and Seal Types

Shields and seals are necessary to provide optimum ball bearing life by retaining lubricants and preventing contaminants from reaching central work surfaces. NMB can manufacture ball bearings with several types of protective closures that have been designed to satisfy the requirements of most applications. Different types of closures can be supplied on the same bearing and nearly all are removable and replaceable. They are manufactured with the same care and precision that goes into our ball bearings. The following are descriptions of the most common types of shields and seals we can supply. Please consult a member of the company's Sales Engineering or Applications Engineering staff for information on the availability of special designs that may be suited to your specific applications.

K, Z & H Type Shields

"K", "Z" and "H" type shields designate non-contact metal shields. "Z" type shields are the simplest form of closure and, for most bearings, are removable. "K" and "H" type shields are similar to "Z" types but are not removable.

It is advantageous to use shields rather than seals in some applications because there are no interacting surfaces to create drag. This results in no appreciable increase in torque or speed limitations and operation can be compared to that of open ball bearings.

Contact Seals

"D" type seals consist of a molded Buna-N lip seal with an integral steel insert. While this closure type provides excellent sealing characteristics, several factors must be considered for its application. The material normally used on this seal has a maximum continuous operating temperature limit of 250°F. Although it is impervious to many oils and greases, consideration must be given to lubrication selection. It is also capable of providing a better seal than most other types by increasing the seal lip pressure against the inner ring O.D. This can result in a higher bearing torque than with other type seals and may cause undesirable seal lip heat build-up in high speed applications.

The DSD64 and the DSD21 type seals have the same operating characteristics as the "D" type seal, resulting in the same considerations of temperature limitations and lubricant selection. The DSD64 seal is comprised of a double-lip contact rubber seal with a stepped inner ring similar to the "D" type seal. The double-lip contact design configuration offers additional protection from extreme environments such as liquid contamination or high-pressure drops accross the bearing. The DSD21 type seal is comprised of a contact rubber seal combined with a labyrinth designed inner ring. The labyrinth design configuration creates an extended path to the raceway, combined with a contact seal, minimizes the tendency for contaminates to enter the bearing.

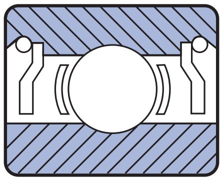


Figure 1. Two "Z" Shields (removable)

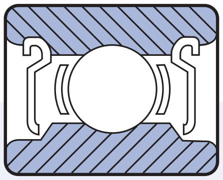


Figure 2. Two "H" Shields (non-removable)

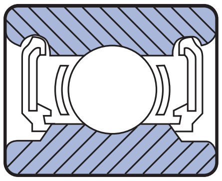


Figure 3. Two "D" Seals (contact rubber)

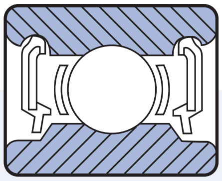


Figure 4. Two "S" Seals (non-contact rubber)

Shield and Seal Types

Non-Contact Seals

“S” type seals are constructed in the same fashion as the “D” type seals. This closure type has the same temperature limitation of 250°F. It also is impervious to many oils and greases, but the same considerations should be noted on lubrication selection. The “S” type seal is uniquely designed to avoid contact on the inner ring land, significantly reducing torque over the “D” type configuration.

“L” type seals are fabricated from glass re-inforced teflon. When assembled, a very small gap exists between the seal lip and the inner ring O.D. It is common for some contact to occur between these components, resulting in an operating torque increase. The nature of the seal material serves to keep this torque increase to a minimum. In addition, the use of this material allows high operating temperatures with this configuration.

The SSD21 type seals have the same operating characteristics as the “D” and “S” type seals, resulting in the same considerations of temperature limitation and lubricant selection. The SSD21 type seal is comprised of a non-contact rubber seal combined with a labyrinth designed inner ring, while the DSD21 type seal is the contact seal version with the labyrinth inner ring. The labyrinth design configuration creates an extended path to the raceway minimizing the tendency for contaminants to creep into the ball bearing.

If you have any questions concerning the performance of NMB Technologies Corporation seals in special environments or high speed applications, please contact a member of our Sales Engineering or Applications Engineering staff.

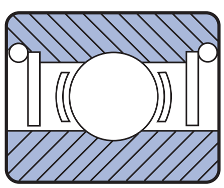


Figure 5. Two “L” Seals (non-flexed teflon)

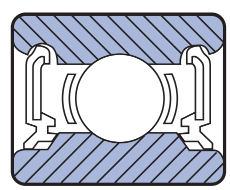


Figure 7. Two “DSD64” Double-lip Seals

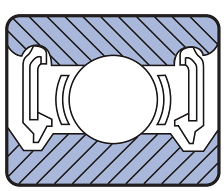


Figure 6. Two “SSD21” Seals (labyrinth design seal)

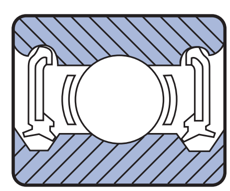


Figure 8. Two “DSD21” Labyrinth Seals (light contact)

Lubrication

Lubricant Types

Oil

Oil is the basic lubricant for ball bearings. Previously most lubricating oil was refined from petroleum. Today, however, synthetic oils such as diesters, silicone polymers, and fluorinated compounds have found acceptance because of improvements in properties. Compared to petroleum base oils, diesters in general have better low temperature properties, lower volatility, and better temperature/viscosity characteristics. Silicones and fluorinated compounds possess even lower volatility and wider temperature/viscosity properties.

Virtually all petroleum and diester oils contain additives that limit chemical changes, protect the metal from corrosion, and improve physical properties.

Grease

Grease is an oil to which a thickener has been added to prevent oil migration from the lubrication site. It is used in situations where frequent replenishment of the lubricant is undesirable or impossible. All of the oil types mentioned in the next section can be used as grease bases to which are added metallic soaps, synthetic fillers and thickeners. The operative properties of grease depend almost wholly on the base oil. Other factors being equal, the use of grease rather than oil results in higher starting and running torque and can limit the bearing to lower speeds.

Oils and Base Fluids

Petroleum Mineral Lubricants

Petroleum lubricants have excellent load carrying abilities and are naturally good against corrosion, but are useable only at moderate temperature ranges (-25° to 250°F). Greases of this type would be recommended for use at moderate temperatures, light to heavy loads and moderate to high speeds.

Super-Refined Petroleum Lubricants

While these lubricants are usable at higher temperatures than petroleum oils (-65° to 350°F), they still exhibit the same excellent load carrying capacity. This further refinement eliminates unwanted properties, leaving only the desired chemical chains. Additives are introduced to increase the oxidation resistance, etc.

Synthetic Lubricants

The esters, diesters and poly-α-olefins are probably the most common synthetic lubricants. They do not have the film strength capacity of a petroleum product, but do have a wide temperature range (-65° to 350°F) and are oxidation resistant.

Synthetic hydrocarbons are finding a greater use in the miniature and instrument ball bearing industry because they have proved to be a superior general purpose lubricant for a variety of speeds, temperatures and environments.

Silicone Lubricants

Silicone products are useful over a much wider temperature range (-100° to 400°F), but do not have the load carrying ability of petroleum types and other synthetics. It has become customary in the instrument and miniature bearing industry, in recent years, to derate the dynamic load rating (C_r) of a bearing to 1/3 of the value shown in this catalog if a silicone product is used.

Perfluorinated Polyether (PFPE)

Oils and greases of this type have found wide use where stability at extremely high temperatures and/or chemical inertness are required. This specialty lubricant has excellent load carrying capabilities but its inertness makes it less compatible to additives, and less corrosion resistant.

Lubrication

Lubrication Methods

Grease packing to approximately one quarter to one third of a ball bearing's free volume is one of the most common methods of lubrication. Volumes can be controlled to a fraction of a percent for precision applications by special lubricators. In some instances, customers have requested that bearings be lubricated 100% full of grease. Excessive grease, however, is as detrimental to a bearing as insufficient grease. It causes shearing, heat buildup, unnecessarily high torque, and deterioration through constant churning which can ultimately result in bearing failure.

Centrifuging an oil lubricated bearing removes excess oil and leaves only a very thin film on all surfaces. This method is used on very low torque bearings and can be specified by the customer for critical applications.

There are many lubricants available for ball bearings. The chart below lists a variety of types, one of which should work well for most operating conditions.

Table of Commonly Used Lubricant Types

Code	Basic Type Oil	*Operating Temp. °F	Uses
L01	Ester oil	-60° to +250°	Low speed instrument oil Rust preventative. Low torque.
LY48	Synthetic oil + clay thickener	-65° to +350°	Developed for aircraft bearings and mechanisms. OK for low-speed oscillation. Low torque. Considered noisy in bearings.
LY121	Ester oil + lithium soap thickener	-40° to +300°	Very quiet, widely-used motor grease. HDD spindle motor applications. OK for low speed oscillation.
LY694	Synthetic hydrocarbon and refined mineral oil + diurea soap thickener	-50° to +300°	Encoders, HDD actuators applications. OK for high speed oscillation.
LY532	Ester oil + urea soap thickener	-40° to +350°	Suitable for automotive radiator cooling fan applications and other high temperature motor bearings.
LY551	Poly-alpha-olefin oil + urea soap thickener	-40° to +300°	Vacuum cleaner and power tool applications. Low noise and high speed.

* Based on manufacturer's published operating temperatures

Dynamic Load Ratings and Fatigue Life

Dynamic Radial Load Rating

The dynamic radial load rating (C_r) for a radial ball bearing is a calculated, constant radial load which a group of identical bearings can theoretically endure for a rating life of one million revolutions. The dynamic radial load rating is a reference value only. The base value of one million revolutions Rating Life has been chosen for ease of calculation. Since applied loading equal to the basic load rating tends to cause permanent deformation of the rolling surfaces, such excessive loading is not normally applied. Typically, a radial load that corresponds to 15 percent, or more, of the dynamic radial load rating is considered heavy loading for a ball bearing. In cases where loading of this degree is required, please consult an NMB Application Engineer for information regarding bearing life and lubricant recommendations.

Rating Life

The "rating life" (L_{10}) of a group of apparently identical ball bearings is the life in millions of revolutions, or number of hours, that 90 percent of the group will complete or exceed. For a single bearing, L_{10} also refers to the life associated with 90 percent reliability. The life which 50 percent of the group of ball bearings will complete or exceed ("median life" L_{50}) is usually not greater than five times the rating life.

Calculation of Rating Life:
The magnitude of the rating life, L_{10}, in millions of revolutions for a ball bearing application is

$$L_{10} = \left(\frac{C_r}{P_r}\right)^3$$

Where

L_{10} = Rating life as described above
C_r = Dynamic radial load rating (Kgf)
P_r = Dynamic equivalent radial load (Kgf)

The dynamic radial load rating (C_r) can be found on the product listing pages. The dynamic equivalent load must be calculated according to the following procedure:

$$P_r = XF_r + YF_a$$

Where
P_r = Dynamic equivalent radial load (Kgf)
X, Y = Obtained from the following X and Y table
F_r = Radial load on the bearing during operation (Kgf)
F_a = Axial load on the bearing during operation (Kgf)

The L_{10} life can be converted from millions of revolutions to hours using the rotation speed. This can be done as follows:

$$L_{10}\text{ (millions of revolutions)} \times \frac{1{,}000{,}000}{\text{RPM} * 60} = L_{10}\text{ (hours)}$$

Relative Axial Load		$F_a/F_r \le e$		$F_a/F_r \ge e$	
$\frac{F_a}{Z*D_w^2}$	e	X	Y	X	Y
0.0175	0.19	1	0	0.56	2.30
0.0352	0.22				1.99
0.0703	0.26				1.71
0.105	0.28				1.55
0.143	0.30				1.45
0.211	0.34				1.31
0.352	0.38				1.15
0.527	0.42				1.04
0.703	0.44				1.00

Z = Number of balls D_w = Ball size (mm)

Step 1:
Calculate F_a/ZD_w^2 and cross reference value "e".
Step 2:
Determine F_a/F_r relationship to find X and Y values.

NOTE: Pounds to Kilograms Force Conversion:
Multiply pounds by .45359 to get Kgf (Lbs*.45359 = Kgf)

Dynamic Load Ratings and Fatigue Life

Life Modifiers

For most cases, the L_{10} life obtained from the equation discussed previously will be satisfactory as a bearing performance criterion. However, for particular applications, it might be desirable to consider life calculations for different reliabilities and/or special bearing properties and operating conditions. Reliability adjustment factors, bearing material adjustment, and special operating conditions are discussed below. For assistance with questions regarding bearing life, please consult an NMB Applications Engineer.

Reliability Modifier

Where a more conservative approach than conventional rating life (L_{10}) is desired, the ABMA offers a means for such estimates. The table below provides selected modifiers (a_2) for calculating failure rates down to 1% (L_1).

Bearing Material

NMB recommends that radial load ratings published for chrome steel be reduced by 20% for stainless steel. This is a conservative approach to insure that bearing capacity is not exceeded under the most adverse conditions. This is incorporated in the a_2 modifier as shown in the table to the right.

Table of Reliability/Material Life Modifier a_2

Required Relability –%	L_n	Value of a_2 Chrome	DD
90	L_{10}	1.00	0.50
95	L_5	0.62	0.31
96	L_4	0.53	0.27
97	L_3	0.44	0.22
98	L_2	0.33	0.17
99	L_1	0.21	0.11

Static Capacity

Other Life Adjustments

The conventional rating life often has to be modified as a consequence of application abnormalities, whether they be intentional or unknown. Seldom are loads ideally applied. The following conditions all have the practical effect of modifying the ideal, theoretical rating life (L_{10}).

a. Vibration and/or shock-impact loads
b. Angular misalignment
c. High-speed effects
d. Operation at elevated temperatures
e. Fits
f. Internal design

NMB can assist in gauging the impact of these conditions when they are of a major concern to the application. Please consult an NMB Sales Engineer or a member of the Applications Engineering staff.

Oscillatory Service Life

Frequently, ball bearings do not operate with one ring rotating unidirectionally. Instead, they execute a partial revolution, reverse motion, and then repeat this cycle, most often in a uniform manner. Efforts to forecast a reliable fatigue life by simply relating oscillation rate to an "equivalent" rotational speed are invalid. The actual fatigue life of bearings operating in the oscillatory mode is governed by four factors; these factors are: applied load, angle of oscillation, rate of oscillation, and lubricant. NMB can provide guidance on practical life of ball bearings in oscillatory applications.

Lubricant Life

In many instances a bearing's effective life is governed by the lubricant's life. This is usually the case where applications involve very light loads and/or very slow speeds.

With light loads and/or slow speeds the conventional fatigue life forecast will be unrealistically high. The lubricant's ability to provide sufficient film strength is sustained only for a limited time. This is governed by:

a. Quality and quantity of the lubricant in the bearing
b. Environmental conditions
   (i.e., ambient temperature, area cleanliness)
c. The load-speed cycle

Specialized oils and greases are available that exhibit favorable properties over an extended period. Please consult an NMB Sales Engineer or a member of the Applications Engineering staff for guidance on practical lubricant life.

Static Radial Load Rating

The static radial load rating (C_{or}) given on the product listing pages is the radial load which a non-rotating ball bearing will support without damage, and will continue to provide satisfactory performance and life.

The static radial load rating is dependent on the maximum contact stress between the balls and either of the two raceways. The load ratings shown were calculated in accordance with the ABMA standard. The ABMA has established the maximum acceptable stress level resulting from a pure radial load, in a static condition, to be 4.2 GPa (609,000 psi).

Static Axial Load Capacity

The static axial load capacity is axial load which a non-rotating ball bearing will support without damage. The axial static load capacity varies with bearing size, bearing material, and radial play. Due to the multiple combinations possible for each bearing, the axial static load capacities are not listed in this catalog. For information regarding axial load capacities, please consult an NMB Sales Engineer or Applications Engineer.

High Static Loads

Radial static load ratings and thrust static load ratings in excess of the C_{or} value shown in this text have practical applications where smoothness of operation and/or low noise are **not** of concern. Properly manufactured ball bearings, when used under controlled shaft and housing fitting practice, can sustain significantly greater permanent deformation (i.e., brinells) than the deformations associated with the static load ratings listed in this catalog.

NMB can provide specific recommendations for extraordinary high static load applications. Please consult a member of our Sales Engineering or Applications Engineering staff.

Preloading

Ball bearing systems are preloaded:

1. To eliminate radial and axial looseness.
2. To reduce operating noise by stabilizing the rotating mass.
3. To control the axial and radial location of the rotating mass and to control movement of this mass due to external force influences.
4. To reduce the repetitive and non-repetitive runout of the rotational axis.
5. To reduce the possibility of damage due to vibratory loading.
6. To increase stiffness.

Spindle motors and tape guides are examples of applications where preloaded bearings are used to accurately control shaft position when external loads are applied. As the name implies, a preloaded assembly is one in which a bearing load (normally a thrust load) is applied to the system so the bearings are already carrying a load before any external load is applied.

There are essentially two ways to preload a ball bearing system - by using a spring and by a solid stack of parts.

Spring Preloading

For many applications, one of the simplest and most effective methods of applying a preload is by means of a spring. This can consist of a coil spring or perhaps a wavy washer which applies a force against the inner or outer ring of one of the bearings in an assembly.

When a spring is used, it is normally located on the non-rotating component; i.e., with shaft rotation, the spring should be located in the housing against the outer rings. Springs can be very effective where differential thermal expansion is a problem. In the spindle assembly (Figure 1), when the shaft becomes very hot and expands in length, the spring will move the outer ring of the left bearing and thus maintain system preload. Care must be taken to allow for enough spring movement to accommodate the potential shaft expansion.

Since, in a spring, the load is fairly consistent over a wide range of compressed length, the use of a spring for preloading negates the necessity for holding tight location tolerances on machined parts. For example, retaining rings can be used in the spindle assembly, thus saving the cost of locating shoulders, shims, or threaded members.

Normally, a spring preload would **not** be used where the assembly is required to withstand reversing thrust loads.

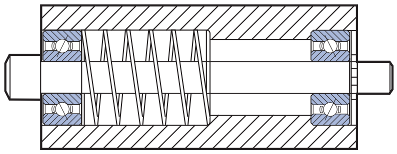


Figure 1. Spindle Assembly using compression coil spring — shaft rotation

Preloading

Solid Stack Preloading

Where precise location control is required, as in a precision motor (Figure 2) or a flanged tape guide (Figure 3), a solid preload system is indicated.

A solid stack, "hard" or "rigid" preload, can be achieved in a variety of ways. Theoretically, it is possible to preload an assembly by tightening a screw as shown (Figure 3) or inserting shims (Figure 4) to obtain the desired rigidity. It should be noted that care must be taken when using a solid stack preloading system with miniature and instrument bearings. Overload of the bearings must be avoided so that the bearings are not damaged during this process.

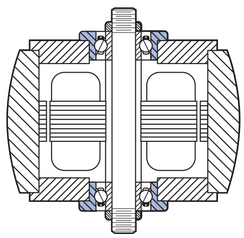


Figure 2. Typical Motor design using rotor as outer ring spacer and stator mount as inner ring spacer – outer ring rotation – Solid preload

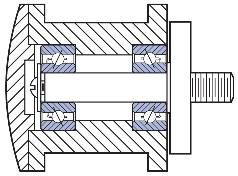


Figure 3. Typical Tape Guide design using screw and washer to solidly preload by clamping inner rings – Outer Ring Rotation

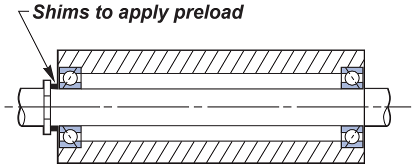


Figure 4.

Preload Levels

Preloading is an effective means of positioning and controlling stiffness because of the nature of the ball/raceway contact. Under light loads, the ball/raceway contact area is very small and so the amount of "yield" or "definition" is substantial with respect to the amount of load. As the load is increased, the ball/raceway contact area increases in size (the contact is in the shape of an ellipse) and so provides increased stiffness or reduced "yield" per unit of applied load.

When two bearings are preloaded together and subjected to an external thrust load, the axial yield rate for the pair is drastically reduced because of the preload and the interaction of the forces exerted by the external load and the reactions of the two bearings. As can be seen by the lower curve in Figure 5, the yield rate for the preloaded pair is essentially linear.

Application Engineers at NMB can provide assistance in selecting appropriate preload specifications and in providing specific information on bearing yield rates where that is required.

Packaging/Post Service Analysis

Our bearings are normally packaged in plastic vials, a quantity of 10 or more per vial. For chrome bearings, if prelubrication or protective coating is not specified by the applicable drawing or order, a preservative oil will be used to prevent corrosion.

Other special types of packaging to suit specific needs will be considered. Check with our Engineering Department when questions or special requirements arise.

Our Engineering staff stands ready to perform post service analysis on any bearings that have been in actual use. If bearings have failed in service, it is frequently possible to determine the cause of failure by examining parts and debris, even though the failure was catastrophic. All of the bearing components and as much as possible of the assembly in which they ran, should be made available for examination by our engineers. For example, if a small motor fails on life test, send the complete motor, assembled just as it came off the test bench, to us. A complete detailed examination will be made and a written report submitted. The report will contain details of the condition of bearings and mating parts, including actual measurements where applicable, and specific recommendations for overall improvement of the bearing performance in this particular application. Even if no failure occurs and particularly when units have been in actual field service for a long period of time, a wealth of valuable information and data can frequently be accumulated from post service analysis. This information can be very useful in product improvement and cost reduction programs.

The keys to gaining useful information from post service analysis are:

- Availability of the undisturbed assembled device, or as many components as possible, and
- Availability of as much historical information as possible describing the conditions under which the device operated. Speeds, loads, temperature, atmospheric conditions, any unusual shock, vibration or handling situations, etc., should be noted for consideration when the parts are examined.

When a failure occurs, or better yet, when a significantly successful test or field unit is obtained, contact us prior to tear-down to make arrangements for a post service analysis that may help you in your product improvement efforts.

Quality Assurance/Dimensional Control

NMB Quality Control Systems meet ISO 9001 Standards.

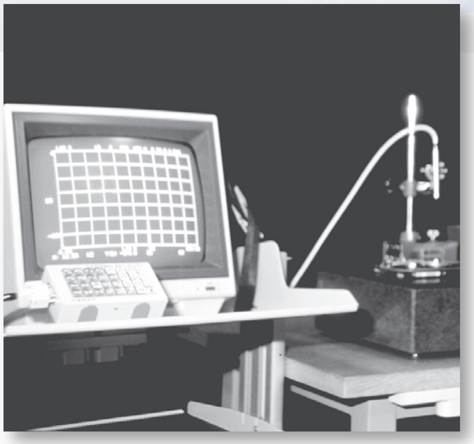
In addition to the normal incoming material, first article, lot and in-process component inspections, the QC Department maintains process surveillance on all production operations particularly heat treat, deburring, grinding, and race finishing. This is to ensure that these operations, which generate the characteristics of the finished product, remain in control at all times.

The company has equipped the Quality Assurance Department with the latest and finest test and measurement equipment available. Roundness, and concentricity are measured.

Every bearing is guaranteed to be free of defects in workmanship and materials for twelve (12) months from invoice date. Any bearing found defective within the warranty period may be repaired, replaced or the purchase price repaid, provided that it is returned to the company and, upon inspection, is found to have been properly mounted, lubricated, protected and not subjected to any mishandling.

NMB follows the specifications of the American Bearing Manufacturers Association (ABMA) and its associated ball bearing technical committee, the Annular Bearing Engineers' Committee (ABEC).

The ABEC tolerances on the next page are current at this catalog's printing. These tolerances are reviewed regularly and updated as required. The ABMA Standards may be obtained by contacting: ABMA, 2025 M Street, NW, Suite 800, Washington, DC 20036. All dimensions are in inches.



Dimensional Control

Tolerances: Miniature and Instrument Ball Bearings Inner Ring

Characteristic	ABEC 1	ABEC 3	ABEC 5	ABEC 7
Mean Bore Tolerance Limits	+.0000 -.0003	+.0000 -.0002	+.0000 -.0002	+.0000 -.0002
Radial Runout Width Variation	.0003 (1) —	.0002 (1) —	.00015 .00020	.0001 .0001
Bore Runout with Face	—	—	.00030	.0001
Race Runout with Face	—	—	.00030	.0001

(1) Add .0001 to the tolerance if bore size is over 10mm (.3937 inch).

Outer Ring

Characteristic	Configuration	Size Range	ABEC 1	ABEC 3	ABEC 5	ABEC 7
Mean O.D. Tolerance Limits	All	0-18mm (0-.709)	+.0000 -.0003	+.0000 -.0003	+.0000 -.0002	+.0000 -.0002
	All	over 18-30mm (.709-1.1811)	+.00000 -.00035	+.0000 -.0003	+.0000 -.0002	+.0000 -.0002
Radial Runout	All	0-18mm	.0006	.0004	.0002	.00015
	All	over 18-30mm	.0006	.0004	.0002	.00015
Width Variation	All	0-30mm	—	—	.0002	.00010
O.D. Runout with Face	All	0-30mm	—	—	.0003	.00015
Race Runout with Face	Plain	0-18mm	—	—	.0003	.00020
	Plain	over 18-30mm	—	—	.0003	.00020
	Flanged	0-30mm	—	—	.0003	.00030
Flange Width Tolerance Limits	— —	— —	— —	+.0000 -.0020	+.0000 -.0020	+.0000 -.0020
Flange Diameter Tolerance Limits	— —	— —	— —	+.0050 -.0020	+.0000 -.0010	+.0000 -.0010

Ring Width

Characteristic	ABEC 1	ABEC 3	ABEC 5	ABEC 7
Width Tolerance	+.000 -.005	+.000 -.005	+.000 -.001	+.000 -.001

Temperature Conversion Table

The numbers in the center column refer to the temperatures either in Celsius or Fahrenheit which need conversion to the other scale. When converting from Fahrenheit to Celsius, the equivalent temperature will be found to the left of the center column. If converting from Celsius to Fahrenheit the answer will be found to the right.

°C	°C/°F	°F	°C	°C/°F	°F	°C	°C/°F	°F	°C	°C/°F	°F
-79	-110	-166	37.7	100	212	204	400	752	371	700	1292
-73	-100	-148	43	110	230	210	410	770	376	710	1310
-68	-90	-130	49	120	248	215	420	788	382	720	1328
-62	-80	-112	54	130	266	221	430	806	387	730	1346
-57	-70	-94	60	140	284	226	440	824	393	740	1364
-51	-60	-76	65	150	302	232	450	842	565	1050	1922
-46	-50	-58	71	160	320	238	460	860	571	1060	1940
-40	-40	-40	76	170	338	243	470	878	576	1070	1958
-34	-30	-22	83	180	356	249	480	896	582	1080	1976
-29	-20	-4	88	190	374	254	490	914	587	1090	1994
-23	-10	14	93	200	392	260	500	932	593	1100	2012
-17.7	0	32	99	210	410	265	510	950	598	1110	2030
-17.2	1	33.8	104	220	428	271	520	968	604	1120	2048
-16.6	2	35.6	110	230	446	276	530	986	609	1130	2066
-16.1	3	37.4	115	240	464	282	540	1004	615	1140	2084
-15.5	4	39.2	121	250	482	288	550	1022	620	1150	2102
-15.0	5	41.0	127	260	500	293	560	1040	626	1160	2120
-14.4	6	42.8	132	270	518	299	570	1058	631	1170	2138
-13.9	7	44.6	138	280	536	304	580	1076	637	1180	2156
-13.3	8	46.4	143	290	554	310	590	1094	642	1190	2174
-12.7	9	48.2	149	300	572	315	600	1112	648	1200	2192
-12.2	10	50.0	154	310	590	321	610	1130	653	1210	2210
-6.6	20	68.0	160	320	608	326	620	1148	659	1220	2228
-1.1	30	86.0	165	330	626	332	630	1166	664	1230	2246
4.4	40	104.0	171	340	644	338	640	1184	670	1240	2264
9.9	50	122.0	177	350	662	343	650	1202	675	1250	2282
15.6	60	140.0	182	360	680	349	660	1220	681	1260	2300
21.0	70	158.0	188	370	698	354	670	1238	686	1270	2318
26.8	80	176.0	193	380	716	360	680	1256	692	1280	2336
32.1	90	194.0	199	390	734	365	690	1274	697	1290	2354

Metric Conversion Tables

Fraction	Inch	mm	Fraction	Inch	mm	Fraction	Inch	mm
1/64	0.0156	0.3969		0.2883	7.3228	11/16	0.6875	17.4625
	0.0250	0.6350	19/64	0.2969	7.5406	45/64	0.7031	17.8594
1/32	0.0312	0.7937	5/16	0.3125	7.9375		0.7087	**18.0000**
	0.0394	**1.0000**		0.3150	**8.0000**	23/32	0.7187	18.2562
	0.0400	1.0160	21/64	0.3281	8.3344	47/64	0.7344	18.6532
3/64	0.0469	1.1906	11/32	0.3437	8.7312		0.7435	18.8849
	0.0472	1.2000		0.3543	**9.0000**		0.7480	**19.0000**
	0.0550	1.3970	23/64	0.3594	9.1281	**3/4**	0.7500	19.0500
	0.0591	**1.5000**	**3/8**	0.3750	9.5250	49/64	0.7656	19.4469
1/16	0.0625	1.5875	25/64	0.3906	9.9213		0.7717	19.6012
	0.0709	1.8000		0.3937	**10.0000**	25/32	0.7812	19.8433
5/64	0.0781	1.9844	13/32	0.4062	10.3187		0.7874	**20.0000**
	0.0787	**2.0000**		0.4100	10.4140	51/64	0.7969	20.2402
	0.0906	2.3012	27/64	0.4219	10.7156	13/16	0.8125	20.6375
3/32	0.0937	2.3812		0.4250	10.7950		0.8268	**21.0000**
	0.0984	**2.5000**		0.4331	**11.0000**	53/64	0.8281	21.0344
	0.1000	2.5400	7/16	0.4375	11.1125	27/32	0.8437	21.4312
	0.1024	2.6000	29/64	0.4531	11.5094	55/64	0.8594	21.8281
7/64	0.1094	2.7781		0.4600	11.6840		0.8661	**22.0000**
	0.1100	2.7940	15/32	0.4687	11.9062	**7/8**	0.8750	22.2250
	0.1102	2.8000		0.4724	**12.0000**	57/64	0.8906	22.6219
	0.1181	**3.0000**	31/64	0.4844	12.3031		0.9055	**23.0000**
1/8	0.1250	3.1750	**1/2**	0.5000	12.7000	29/32	0.9062	23.0187
	0.1256	3.1902		0.5118	**13.0000**	59/64	0.9219	23.4156
	0.1378	**3.5000**	33/64	0.5156	13.0968	15/16	0.9375	23.8125
9/64	0.1406	3.5719	17/32	0.5312	13.4937		0.9449	**24.0000**
5/32	0.1562	3.9687	35/64	0.5469	13.8906	61/64	0.9531	24.2094
	0.1575	**4.0000**		0.5512	**14.0000**	31/32	0.9687	24.6062
11/64	0.1719	4.3656	9/16	0.5625	14.2875		0.9843	**25.0000**
3/16	0.1875	4.7625	37/64	0.5781	14.6844	63/64	0.9844	25.0031
	0.1892	4.8057		0.5906	**15.0000**		**1.0000**	25.4000
	0.1969	**5.0000**	19/32	0.5937	15.0812		1.0236	**26.0000**
13/64	0.2031	5.1594	39/64	0.6094	15.4781		1.0415	26.4541
	0.2165	5.4991	**5/8**	0.6250	15.8750		1.0480	26.6192
7/32	0.2187	5.5562		0.6299	**16.0000**	1-1/16	1.0625	26.9875
15/64	0.2344	5.9531	41/64	0.6406	16.2719		1.0630	**27.0000**
	0.2362	**6.0000**		0.6500	16.5100		1.1025	**28.0000**
1/4	0.2500	6.3500	21/32	0.6562	16.6687	**1-1/8**	1.1250	28.5750
17/64	0.2656	6.7469		0.6620	16.8148		1.1417	**29.0000**
	0.2756	**7.0000**		0.6693	**17.0000**		1.1812	**30.0000**
9/32	0.2812	7.1437	43/64	0.6719	17.0656	1-3/16	1.1875	30.1625
						1-1/4	1.2500	31.7500
						1-1/2	1.5000	38.1000

The Care and Handling of Precision Ball Bearings

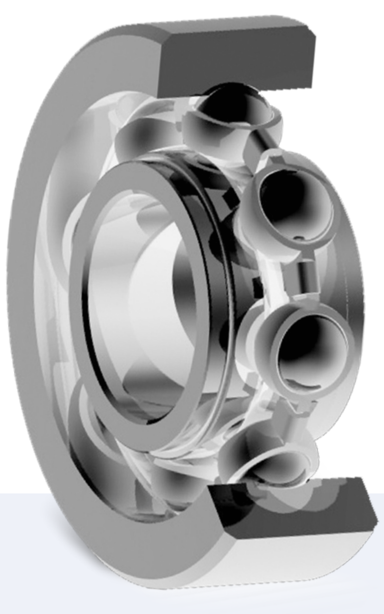
NMB miniature ball bearings are high precision devices compared to many mechanical parts. Good performance will therefore require treatment that takes into account their characteristics and operating environment.

A high percentage of bearing problems, including failures, are the result of improper handling procedures. The following pages represent the results of our most common case studies. We hope you will find the information useful in the care and handling of precision ball bearings.

Particle Contamination

The performance of miniature precision ball bearings is critically affected by minute particle contamination. Particles as small as 0.005mm, once inside a bearing, can cause raceway scratches, abrasion and can decrease performance, shortened life and generate acoustic noise and vibration. Avoiding exposing the bearings to any environment where particles may be present is highly recommended.

Shields and seals are used to prevent contaminants from reaching the inside of the bearing. However, after assembly, there is still a small gap between the shield and the inner ring. This gap may permit particle entry. Please observe the following procedures carefully:



- Keep your bearings handling room as clean as possible.
- Do not remove the bearings from their packaging until just before use. If you move the bearings to a container, be sure the container is clean. The lid should be kept close, and it should be cleaned every day to prevent particle accumulation
- Never use a bearing that has been dropped. It may be brinelled (race track dented). In use, a brinelled bearing will generate a high level of acoustic noise.
- Before applying adhesive to a bearing, use a clean cloth dampened with an alcohol agent to clean oily materials such as anti-corrosion oil from the inner ad outer rings. Do not saturate the cloth excessively with the cleaning agent. The liquid agent itself could leak into the bearing, carrying particles with it.
- When applying a lubricant to the outer circumference of a bearing, take care to make sure the lubricant is not contaminated. You might inadvertently transfer the contamination into the bearing.
- Never use an applicator that will leave contaminants on or near the bearings. A cotton swab, for instance, may leave small fibrous particles behind. We recommend a mechanical dispenser, many are available, or a clean room type of applicator.
- Do not handle bearings in a place where they could be directly exposed to outside air. Airborne contaminants include dust, dirt, and humidity.

Rust Contamination

Since bearings are metallic products, they rust easily. Their treatment requires certain precautions:

- When handling bearings, use finger caps, tweezers or gloves that do not generate cotton fibers.
- When using unprotected fingers to handle a bearing, first make sure they are clean and free from perspiration and dust. Apply a quality mineral oil to the fingertips before touching the bearing. Do not use hand cream, as it may induce rust.
- If a shaft is dirty on the surface, rust may gather between the shaft and the bearing after they are fitted. It is important to make sure that the shaft is free from finger prints, perspiration, dust and dirt.
- When handling bearings, chose a place that is dry and clean. Always place the bearing boxes on a shelf or a pallet. Avoid placing the boxes directly on the floor or other locations where moisture and dirt may be present.
- Avoid storing bearings near air conditioners and direct sunlight. Bearings may rust when placed near an air conditioner outlet, or any place where wind or sunlight can enter directly
- A great temperature difference may cause condensation to form on the bearings. In colder climates, allow the bearings to reach room temperature before unpacking them.
- Store bearings in centrally heated and properly ventilated environments.

Varnish applied to a motor winding may also cause bearings to rust when the acid generated by varnish gas is absorbed into the grease of the bearing. Be sure to test for this condition, and be aware that changes in procedures, such as drying time changes, may affect this condition.

Mounting Bearings

When bearings are mounted incorrectly, the balls will cause brinelling on the raceway and undermine bearing performance and life. Brinelling (dents and abrasions to the raceway) as small as 0.1 micron in depth will have an adverse effect on acoustic noise levels as well as causing increased torque levels.

Several general rules apply to mounting bearings. When assembling a bearing with its shaft or housing, it is critical that no force be applied to the balls. When mounting a bearing to a shaft, always press the inner ring. When mounting it into a housing, press the outer ring. Never apply force to the outer ring when mounting to a shaft, or to the inner ring when mounting into a housing. And never apply a shock load in either case.

- When manually fitting a shaft into a bearing through its bore, do not force the shaft because it may cause brinelling to the bearing.
- After gluing a bearing to a housing using a guide through the bearing bore, take the guide out very carefully or it may cause brinelling to the bearing.
- When motors are being assembled, be aware that bearings may be attracted by the magnet and could slip from your fingers. To avoid this, hold the motor shaft in your palm, and cautiously insert the rotor. For automated assembly, use an air cylinder, and steadily operate the assembly.

Basic Technical Information

Shock Forces

Bearings are easily affected by shock forces. Depending on the size of the bearing, a shock force from a 100 gram weight at 4mm away could cause brinelling.

Brinelling could also occur when bearings are automatically pres-fitted to a rotor shaft, if the shaft and bearing bore are not kept accurately in line.

A typical example of shock causing brinelling is when motors are placed on a conveyor belt. As the motors moved through the conveyor, the movement causes the motors to hit the iron plate underneath the conveyor, resulting in shock which causes brinelling to the bearing. Holes made on the iron plate prevent this type of shock force to be generated.

Application Environment

The environment in which bearings are used will largely determine their life. Chlorine gas, ozone and other chemicals will shorten bearing life, as the grease will become contaminated relatively quickly.

Generally, grease life will fall by half with every 10ºC to 15ºC the ambient temperature increases. Therefore, it is critical to select the correct lubricant for the anticipated operating temperature.

If you have any questions concerning the care and handling of NMB's miniature precision ball bearings, please contact a member of our Applications Engineering staff.