

Bearing Basics

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Bearing Selection

Introduction

The following general information will serve the purpose of aiding the machine designer or bearing user when applying the bearings covered in this catalog. Additional data dealing solely with each type of bearing is found in each respective section. Cross references are made whenever necessary. Engineering data should be carefully considered in selecting the proper design and size bearing.

For those applications where unusual or abnormal operating conditions exist, it is advisable to consult Application Engineering for recommendations. Examples of such conditions requiring special consideration are those involving high or low temperatures, misalignment, shaft and housing fits that might cause the bearing to be too tightly fitted internally after mounting, vibration, moisture, contamination, etc.

Application Considerations

The proper selection and application of power transmission products and components, including the related area of product safety, is the responsibility of the customer. Operating and performance requirements and potential associated issues will vary appreciably depending upon the use and application of such products and components. The scope of the technical and application information included in this publication is necessarily limited. Unusual operating environments and conditions, lubrication requirements, loading supports, and other factors can materially affect the application and operating results of the products and components and the customer should carefully review its requirements. Any technical advice or review furnished by Regal Power Transmission Solutions and its divisions with respect to the use of products and components is given in good faith and without charge, and Regal assumes no obligation or liability for the advice given, or results obtained, all such advice and review being given and accepted at customer's risk.

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Bearing Selection Continued

Bearing Selection

Before beginning the bearing selection process for a particular application it is important to have a good idea of where the bearing will be installed, what its purpose will be, what operating conditions will the bearing be expected to function in, and a desired bearing life. Each bearing type has certain characteristics which make it suitable for a certain application(s). Having comprehensive knowledge of these requirements will aid in bearing selection. In most cases there are several factors to consider when choosing a bearing type. Therefore the following information is to be used only as a guide. In the selection process the following factors must be considered:

1. **Equipment constraints**
2. **Load – Magnitude and Direction**
 - Magnitude
 - Direction
 - ◇ Radial
 - ◇ Thrust
 - ◇ Combined
3. **Misalignment**
 - Static
 - Dynamic
4. **Expansion**
5. **Noise**
6. **Vibration and shock loading**
7. **Environment**
8. **Bearing Type**

Equipment Constraints

Sometimes, bearing bore diameter and housing type are predetermined by the equipment and shaft diameter with which the bearing will be used. Small diameter shafts typically are used when light loads are transferred and may lead to the choice of a ball bearing. Higher loads typically dictate larger shaft diameters and then taper or spherical roller bearings may be needed. For mounted bearings, equipment constraints can also dictate what type of housing style can be used (i.e. pillow block, 2-bolt flange, 4-bolt flange, etc.).

Load – Magnitude and Direction

Load magnitude typically dictates size of bearing required but it can also affect the type of bearing. Ball bearings work well in light to moderate loads, roller bearings work well for moderate to heavy loads. Bearings with a full complement of rollers are generally better for higher loads than a caged bearing of the same size and full complement bearings are also recommended for applications with oscillatory rotation.

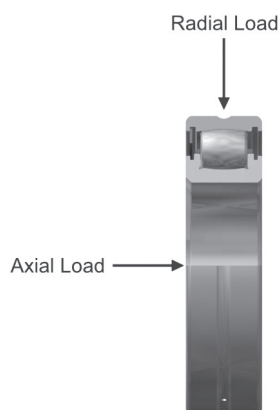
Load direction can be radial, axial, or a combination of these two directions. These directions along with load magnitude are deciding factors in selection of bearing type.

Bearing Selection Continued

Radial loading is the most common type of bearing load and is defined as a load perpendicular, or 90 degrees to the shaft centerline. Most ball and roller bearings are designed to accept primarily radial loads.

Thrust, or axial, loading is defined as loading in the direction through the shaft centerline. The ability of the bearing to carry a thrust load is dependent on the bearing contact angle geometry. The larger the contact angle the more thrust load that can be carried. Typically, tapered roller and double row spherical roller bearings are better suited for applications with a higher degree of thrust load.

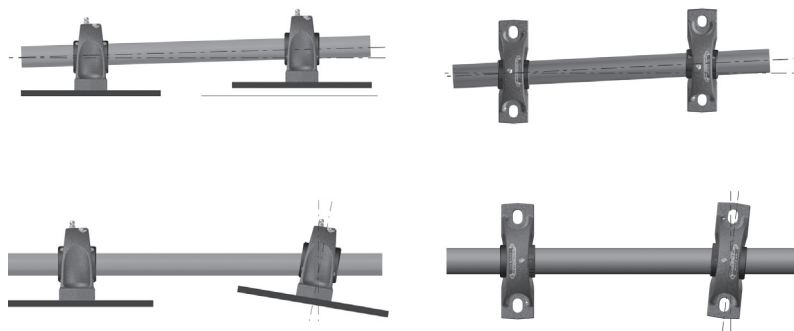
Combination loading consists of both a radial and a thrust load acting simultaneously on the bearing. When combination loads are acting on a bearing it is necessary to determine an equivalent radial load when calculating bearing life.



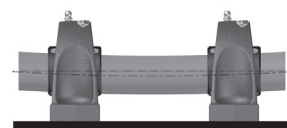
Misalignment

Bearing misalignment is a result of angular misalignment between the shaft and housing. This misalignment comes in two different forms, static and dynamic. Static misalignment is the outcome of bearings that are mounted on different planes causing an angular shaft displacement and resulting in the bearing operating under a fixed misalignment angle. Mounted ball bearings, certain series mounted roller bearings, and spherical roller bearings have a design feature that allows them to accommodate a limited degree of fixed misalignment. Dynamic misalignment is an eccentric shaft rotation caused by shafting imperfections and resulting in the bearing operating under a varying misalignment angle. Spherical roller bearings are typically best suited for applications involving dynamic misalignment.

Static System Misalignment

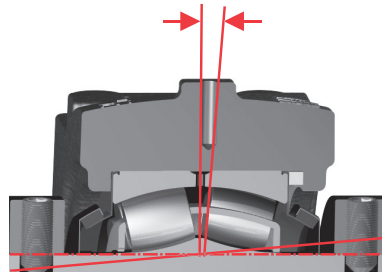


Dynamic System Misalignment



Bearing Selection Continued

Each bearing type is capable of accommodating a certain amount of either static, dynamic, or combination misalignment. When application misalignment exceeds the allowable limit for the particular bearing, increased contact stresses between bearing rolling elements and raceways occurs and bearing life is reduced. Individual product sections contain additional information regarding what types and degrees of misalignment each bearing type is capable of handling.



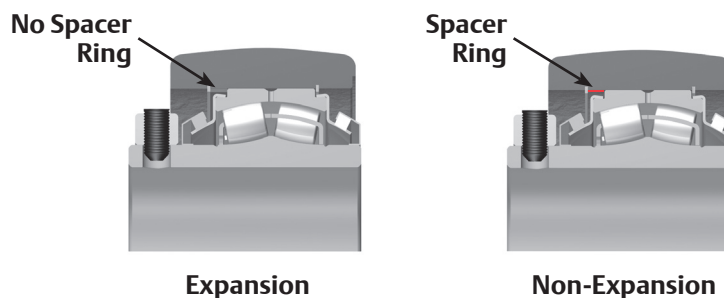
Example of Sealmaster Mounted Spherical Roller Bearing Misalignment

Expansion

For applications in which shaft linear growth must be accommodated, this expansion must be taken into account with either the bearing mounting method or bearing type selection. Typically this expansion is due to the difference in thermal changes in the shaft versus that in the support structure. Therefore change in length can be determined using standard thermal expansion equations. The maximum temperature difference between the shaft and the support structure should be used in the calculation of the shaft growth. Likewise, consideration must be given to the shaft and structure materials, as different materials can have different rates of expansion or contraction.

To allow for shaft expansion, some applications will require the bearing to be of an expansion type. An expansion type bearing is one that has an internal design feature which allows it to accommodate axial expansion. Before installation, make sure proper linear shaft expansion is accounted for. Expansion units should be placed in a location where relative movement between the bearing insert and the housing can be tolerated. For most applications using expansion type units, the fixed unit (non-expansion unit) is placed at the drive end of the shaft. Not providing expansion where necessary may result in undesirable thrust loads, thus reducing bearing operating life.

Example of Sealmaster Mounted Spherical Roller Bearing Expansion and Non-Expansion



Bearing Selection Continued

Noise

Noise sensitive applications such as fans require smooth running bearings. These are typically low duty environments which makes ball bearings a good choice. Concentric locking mechanisms are preferred to keep vibration at a minimum, but not required. Regal Power Transmission Solutions offers a special suffix that can be applied to many mounted ball bearing products for air handling applications. This option offers a loose fit between the bearing insert and housing for easy self-aligning, as well as noise testing of all units.

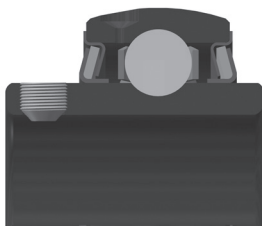
Vibration and Shock Loading

Vibration and shock loading present in vibratory conveyors, shakers, and other heavy industrial applications transfer large forces to bearings and accompanying raceways. These loads create large stresses at the interface between the rolling elements and raceways and can cause considerable damage and a reduction of bearing life. Roller bearings may be a good selection because of their larger supporting contact area with the bearing races. This allows loads to be carried over a larger area thus reducing stress. Special housing fits for mounted bearings can be added from the factory to aid in longer bearing life.

Environment

Environmental factors such as solids contamination (particle type, size, quantity), exposure to moisture (water, acid caustic), and thermal conditions are important variables in bearing selection. Bearing components (seals, grease, bearing material, etc.) can be modified in order to better suit a specialized application. Availability of special features may be affected by shaft size, bearing type, and housing type therefore this must be considered in the bearing selection process. Individual product sections contain additional information regarding these specialized features and availability.

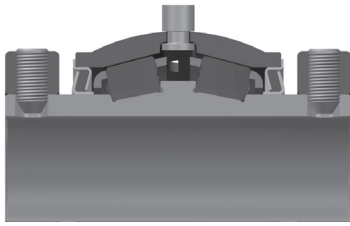
Bearing Type



Radial Ball Bearings

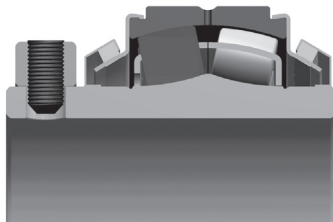
Radial ball bearings create a fairly small elliptical contact between the ball-path and rolling element thus distributing loads across a small area. Surface contact is minimized and less friction and heat is generated which allows ball bearings a higher speed range. This small contact area also limits ball bearings to accepting only light to moderate loads. Radial ball bearings have a zero degree free contact angle but can accept light thrust loads (in combination with a radial load) due to the shape geometry of their raceways. Mounted ball bearing units have some degree of external static self-aligning capability (the bearing insert can misalign with respect to the housing). Mounted ball bearings come in a variety of housing styles and features to suit a wide variety of applications.

Bearing Selection Continued



Tapered Radial Roller Bearings

Tapered radial roller bearings create a line contact between the raceway and rolling element distributing loads across a larger area. Also, a double row provides twice as many rolling elements available to carry bearing load which increases bearing load capacity. Because tapered roller bearings are set at an angle, they can accept heavy loads from both the radial (Y) and thrust (X) directions. This makes them ideal for tough applications such as mining, bulk material handling, and off-highway applications. Many mounted tapered roller bearing units are similar to mounted ball units in that they are externally self aligning to accommodate some static misalignment. There are a variety of housing styles and features available.



Spherical radial roller bearings

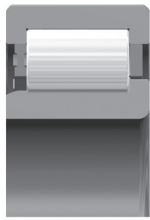
Spherical radial roller bearings have a barrel shaped profile. This combined with a curved raceway allows relative motion between the rolling elements and raceways (internally self-aligning). This attribute makes them ideal for application where both static and dynamic misalignment is present. Spherical roller bearings create an elliptical shaped contact area that is larger than a ball bearing. Single row design spherical roller bearings should not be used in combined loading applications when the thrust load exceeds 20% of the applied radial load. Mounted spherical roller bearings employ a double row design, which are set at an angle and can accept a limited degree of thrust load in combination with radial load. Due to some sliding that occurs at the bearing and raceway interface, spherical roller bearings are generally not suitable for higher speed applications.



Needle Radial Roller Bearing

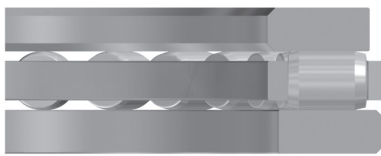
A needle radial roller bearing is a cylindrical roller where the length of the roller is significantly larger than the diameter. The rollers make a large line contact with the raceways, allowing them to accept fairly high radial load. Needle roller bearings also do not have a contact angle and are not recommended in applications where thrust loading is present. If high thrust loads are present, provisions should be put in place to allow bearings better suited to handle the thrust loads. Needle bearing assemblies typically consist of an inner race (or sometimes a precision shaft), a needle cage which orients and contains the needle rollers, the needle rollers themselves, and an outer race. The needle cage is sometimes omitted and a full complement of rollers is used instead for oscillatory and high load applications.

Bearing Selection Continued



Cylindrical Radial Roller Bearings

Cylindrical radial roller bearings are similar in design to needle roller bearing but the dimensions of diameter and roller length are closer in magnitude. The rolling elements create a line contact with the raceways and can handle relatively high radial loads. These bearings typically use cage separated rollers which allows for higher operating speeds. Cylindrical roller bearings can also accept incidental to light thrust loads. Rollway Cylindrical roller bearings are crowned to maximize load carrying potential, reduce edge loading, and tolerate some minor misalignment.



Thrust Cylindrical Roller

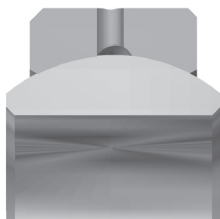
Thrust cylindrical roller and thrust spherical roller bearings use rolling elements as described above. However, instead of radial rings for raceways, thrust bearings use plate rings so that these designs can be applied to support pure thrust loads. These designs do not support radial loads. The cylindrical roller type provides a fairly rigid construction capable of supporting fairly heavy thrust loads. The spherical roller type can also support heavy thrust loads, and can also accommodate some misalignment.



Rod ends

Rod ends are designed to provide an efficient smooth transfer of motion in a wide variety of applications and equipment. This motion is usually associated with various types of linkage controls. Commonly referred to as plain or sliding bearings, they are designed primarily to assist and provide motion transfer, support a load, allow for angular motion and angular misalignment.

Rod ends can be joined together or connected with a threaded rod or tube to form linkage assemblies allowing design engineers flexibility in transferring motion between points with long center distances. There are two surface areas in contact rubbing against each other, therefore normal operation of rod ends results in wear of the raceways leading to fatigue or fracture of the outer member. Give consideration to this in the design of the equipment. In general, rod ends are designed to accept radial loads and not intended to carry thrust loads. Applications of rod ends with thrust loading should be reviewed with Application Engineering.













Spherical Plain Bearings

Spherical plain bearings provide a similar function as rod ends and must be supported in a housing. Spherical bearings are typically more capable of supporting higher loads versus an equivalent rod end bore size. This occurs because rod end load capacity is controlled by the head and shank geometry. Spherical bearings have a larger bearing area and generally are less restricted by the housing material or dimensions in which they are mounted. Static thrust rating of plain spherical bearings is 20% of the static radial rating of each unit but proper housing design is needed to support the bearing.

Bearing Selection Guide

The following chart can be used as a reference guide when working through the selection process. More detailed information on each bearing type as well as the available housing and seal options can be found in sections dealing with the individual bearing types.

	Bearing Type	Pure Radial Loading	Pure Axial Loading	Combination Loading	High Speeds	Static Self-Aligning Capability	Dynamic Self-Aligning Capability
	Mounted Ball Bearings	●	◐	◐	●	●	○
	Mounted Taper Roller Bearings	●	◐	●	◐	●	○
	Mounted Spherical Roller Bearings	●	◐	●	◐	●	●
	Cylindrical Roller Bearings	◐	varied based on design	○	●	○	○
	Unmounted Needle Bearings	●	○	◐	◐	○	○
	Rod Ends	●	◐	◐	◐	◐	◐
	Plain Spherical Bearings	●	◐	◐	◐	◐	◐
	Cylindrical Thrust Bearings	○	●	○	○	○	○
	Tapered Thrust Bearings	○	●	○	◐	○	○
	Journal Roller Bearings	●	○	○	◐	○	○

○ = Not Recommended
 ◐ ◑ ◒ ◓ ◔
 Poor ← → Best

Load Ratings and Life

Introduction

The following general information will serve the purpose of aiding the machine designer or bearing user when applying bearings covered by this catalog. Additional data dealing solely with each type of bearing is found in each respective section. Cross references are made whenever necessary. Engineering data should be carefully considered in selecting the proper design and size bearing.

For those applications where unusual or abnormal operating conditions exist, it is advisable to consult Application Engineering for recommendations. Examples of such conditions requiring special consideration are those involving high or low temperatures, misalignment, shaft and housing fits that might cause the bearing to be too tightly fitted internally after mounting, vibration, moisture, contamination, etc.

Load Ratings

The basic load rating or Basic Dynamic Rating as defined by the American Bearing Manufacturers Association (ABMA) is that calculated, constant radial load which 90% of a group of apparently identical bearings with stationary outer ring can theoretically endure for a Rating Life. For bearing types other than tapered roller, the basic rating life is one million revolutions (33 1/3 RPM for 500 hours). For tapered roller bearings, the basic rating life is ninety million revolutions. The basic load rating is a reference value only, the basic rating life value having been chosen for a means of life calculation.

It is not anticipated that bearing loading equal to the Basic Dynamic Rating would normally be applied while the bearing is rotating. Bearings in this catalog should not normally be subjected to dynamic loads greater than 50 percent of the Basic Dynamic Rating. Consult Application Engineering if such conditions exist.

Bearing Life – L10

Bearings which have been properly sized for the application, solidly mounted, lubricated, and protected will operate with minimal, if any, internal wear until fatigue of the rings or rolling elements takes place. Fatigue is the first evidence of spalling of the rolling contact surfaces of these parts, and occurs because of the repeated stressing of the contacts.

The “life” of an individual bearing is defined as the number of revolutions (or hours at a given constant speed) which the bearing runs before the first evidence of fatigue develops in the material of either ring or of any of the rolling elements. The L10 or “rating life” of a group of apparently identical roller bearings is defined as the number of revolutions (or hours at some given constant speed) that 90% of the group of bearings will complete or exceed before the first evidence of fatigue develops.

Load Ratings and Life

Life Calculations

The L10 (rating) life for any given application and bearing selection can be calculated in terms of millions of revolutions by using the bearing Basic Dynamic Rating (BDR) and applied radial load (or, equivalent radial load in the case of radial bearing applications having combined radial and thrust loads). The L10 life for any given application can be calculated in terms of hours, using the bearing Basic Dynamic Rating, applied load (or equivalent radial load) and suitable speed factors, by the following equation:

$$L_{10} = \left(\frac{C}{P}\right)^p \times \frac{1,000,000}{60 \times n} = \left(\frac{C}{P}\right)^p \times \frac{16667}{n}$$

Where: L_{10} = The # of hours that 90% of identical bearings under ideal conditions will operate at a specific speed and condition before fatigue is expected to occur.

C = Basic Dynamic Rating (lbs)
1,000,000 Revolutions

P = Constant Equivalent Radial Load (lbs)

p = Exponent for life
3 for ball bearings
10/3 for roller bearings

n = Speed (RPM)

For thrust cylindrical roller and thrust tapered roller bearings the above equations change to:

$$L_{10} = \left(\frac{C}{P}\right)^{10/3} \times \frac{1,000,000}{60 \times n} = \left(\frac{C}{P}\right)^{10/3} \times \frac{16667}{n}$$

Where: L_{10} = The # of hours that 90% of identical bearings under ideal conditions will operate at a specific speed and condition before fatigue is expected to occur.

C = Basic Dynamic Thrust Rating (lbs)
1,000,000 Revolutions

P = Constant Equivalent Thrust Load (lbs)

p = 10/3

n = Speed (RPM)

The BDR for tapered roller bearings is based on 90 million revolutions instead of one million for other types of bearings. Therefore there is a specific equation used to calculate their L10 life.

$$L_{10} = \left(\frac{C90}{P}\right)^{10/3} \times \frac{90,000,000}{60 \times n} = \left(\frac{C90}{P}\right)^{10/3} \times \frac{1,500,000}{n}$$

Where:

Where: L_{10} = The # of hours that 90% of identical bearings under ideal conditions will operate at a specific speed and condition before fatigue is expected to occur.

C90 = 2-Row Basic Dynamic Rating (lbs)
90,000,000 Revolutions

P = Constant Equivalent Radial Load (lbs)

n = Speed (RPM)

* For speeds less than 50 RPM, use 50 RPM when doing L10 calculations.

Note: L10 life does not apply to rod ends and plain spherical bearings due to the sliding motion between components versus a rolling motion. Normal operation of these types of bearings results in wear of the raceways or fatigue or fracture of the outer member. Give consideration to this in the design of the equipment.

Load Ratings and Life Continued

Additionally, the ABMA provides application factors for all types of bearings which need to be considered to determine an adjusted Rated Life (L_{na}). L10 life rating is based on laboratory conditions yet other factors are encountered in actual bearing application that will reduce bearing life. L_{na} life rating takes into account reliability factors, material type, and operating conditions.

$$L_{na} = a_1 \times a_2 \times a_3 \times L_{10}$$

Where:

L_{na} = Adjusted Rated Life.

a_1 = Reliability Factor. Adjustment factor applied where estimated fatigue life is based on reliability other than 90% (See Table No 1).

Table No. 1 Life Adjustment Factor for Reliability

Reliability %	L_{na}	a_1
90	L10	1
95	L5	0.62
96	L4	0.53
97	L3	0.44
98	L2	0.33
99	L1	0.21
50	L50	5

a_2 = Material Factor. Life adjustment for bearing race material. Regal Power Transmission Solutions bearing races are manufactured from bearing quality steel. Therefore the a_2 factor is 1.0.

a_3 = Life Adjustment Factor for Operating Conditions. This factor should take into account the adequacy of lubricant, presence of foreign matter, conditions causing changes in material properties, and unusual loading or mounting conditions. Assuming a properly selected and mounted bearing having adequate seals and lubricant operating below 250°F and tight fitted to the shaft, the a_3 factor should be 1.0.

Mounted bearings are typically “slip fitted” to the shaft and rely on design features such as the inner race length and locking device for support. ABMA recommends an a_3 factor of .456 for “slip fit” ball bearings.

Vibration and shock loading can act as an additional loading to the steady expected applied load. When shock or vibration is present, an a_3 Life Adjustment Factor can be applied. Shock loading has many variables which often are not easily determined. Typically, it is best to rely on one’s experience with the particular application. Consult Application Engineering for assistance with applications involving shock or vibration loading.

The a_3 factor takes into account a wide range of application and mounting conditions as well as bearing features and design. Accurate determination of this factor is normally achieved through testing and in-field experience. Regal Power Transmission Solutions offers a wide range of options which can maximize bearing performance. Consult Application Engineering for more information. Example calculations can be found in the individual engineering sections at the end of the various product sections.

Load Ratings and Life Continued

Variable Load Formula

Root mean load (RML) is to be used when a number of varying loads are applied to a bearing for varying time limits. Maximum loading still must be considered for bearing size selection.

$$RML^* = \sqrt[p]{\frac{(L_1^p N_1) + (L_2^p N_2) + (L_3^p N_3)}{100}}$$

Where:

p = Exponent for life

3 for ball bearings

10/3 for roller bearings

L₁, L₂, etc. = Load in pounds

N₁, N₂, etc. = Percent of total time operated at loads L₁, L₂, etc.

* Apply RML to rating at mean speed to determine resultant life.

Mean Speed Formula

The following formula is to be used when operating speed varies over time.

$$\text{Mean Speed} = \frac{S_1 N_1 + S_2 N_2 + S_3 N_3}{100}$$

S₁, S₂, etc = Speeds in RPM

N₁, N₂, etc = Percentage of total time operated at speeds S₁, S₂, etc

Bearing Life In Oscillating Applications

The equivalent rotative speed (ERS) is used in life calculations when the bearing does not make complete revolutions during operation. The ERS is then used as the bearing operating speed in the calculation of the L10 (Rating) Life. The formula is based on sufficient angular rotation to have roller paths overlap.

ERS = Equivalent Rotative Speed

N = Total number of degrees per minute through which the bearing will rotate.

$$ERS = \frac{N}{360}$$

In the above formula, allowance is made for the total number of stress applications on the weakest race per unit time, which, in turn, determines fatigue life and the speed factors. When the oscillation angle is very small, fretting corrosion can take place. The theory behind fretting corrosion is best explained by the fact that the rolling elements in small angles of oscillation retrace a path over an unchanging area of the inner or outer races where the lubricant is prevented by inertia from flowing in behind the roller as the bearing oscillates in one direction. Upon reversal, this small area of rolling contact is traversed by the same roller in the dry state. The friction of the two unlubricated surfaces causes fretting corrosion and produces failures which are unpredictable from a normal life standpoint. For applications with small angles of oscillation, it is recommended that it be reviewed with Application Engineering to select a bearing type that will help minimize potential fretting corrosion.

Load Ratings and Life Continued

With a given bearing selected for an oscillating application, the best lubrication means is a light mineral oil under positive flow conditions. With a light oil, there is a tendency for all areas in the bearing load zone to be immersed in lubricant at all times. The full flow lubrication dictates that any oxidized material which may form is immediately carried away by the lubricant, and since these oxides are abrasive, further wear tends to be avoided. If grease lubrication must be used, it is best to consult with either the bearing manufacturer or the lubricant manufacturer to determine the best possible type of lubricant. Greases have been compounded to resist the detrimental effect of fretting corrosion for such applications.

Static Load Rating

The “static load rating” for rolling element bearings is that uniformly distributed static radial load acting on a non-rotating bearing, which produces a contact stress of 580,000 psi for roller bearings and 609,000 psi for ball bearings, at the center of the most heavily loaded rolling element. At this stress level, plastic deformation begins to be significant. Experience has shown that the plastic deformation at this stress level can be tolerated in most bearing applications without impairment of subsequent bearing operation. In certain applications where subsequent rotation of the bearing is slow and where smoothness and friction requirements are not too exacting, a higher static load limit can be tolerated. Where extreme smoothness is required or friction requirements are critical, a lower static load limit may be necessary.

Minimum Bearing Load

Skidding, or sliding, of the rolling elements on the raceway instead of a true rolling motion can cause excessive wear. Applications with high speeds and light loading are particularly prone to skidding. As a general guideline, rolling element bearings should be radially loaded at least 2% of Basic Dynamic Rating for roller bearings and 1% of Basic Dynamic Rating for ball bearings. For applications where load is light relative to the bearings dynamic load rating, consult Application Engineering for assistance.

Load Ratings and Life Continued

Computing Bearing Loads

In the computation of bearing loads in any application of a Regal Power Transmission Solutions unit, the principal factor determining the selection of the unit is the equivalent radial load to which the bearing will be subjected. These radial loads result from any one or any combination of the following sources:

1. Weights of machine parts supported by bearings.
2. Tension due to belt or chain pull.
3. Centrifugal force from out of balance, eccentric or cam action.

The resulting load from any one, or any combination of the above sources is further determined by knowing:

1. The magnitude of the load.
2. Direction of the load.
3. The point of load application.
4. The distance between bearing centers.

Bearing loads are the result of force acting on the shaft. Direction, magnitude, and location with respect to the bearings must be considered when calculating bearing loads. The following cases are typical examples of loads encountered and methods of calculating bearing loads.

CASE #1
Drive Load Calculation

$$P = \frac{126,000 \times \text{HP}}{\text{RPM} \times d} \times K$$
 K = Apply P to Case 2, 3 or 4 if applicable
 HP = horsepower
 RPM = revolutions per minute
 d = pitch of pulley in inches
 K = constant for type of drive used
 K = 1.5 for V-belts
 K = 2 to 3 for flat transmission belts
 K = 1.1 for chain drives

CASE #2
Cantilever and Drive

Load on Bearing A = $\frac{P_1 \times (a + k) - (P_2 \times b)}{k}$
 $= \frac{200 \times (4 + 9) - (80 \times 2)}{9}$
 $= 271 \text{ lbs.}$
 Load on Bearing B = $\frac{P_2 \times (k + b) - (P_1 \times a)}{k}$
 $= \frac{80 \times (9 + 2) - (200 \times 4)}{9}$
 $= 9 \text{ lbs.}$

CASE #3
Straddle, Cantilever Drive

Load on Bearing A = $\frac{P_1 \times (k + a) + (P_2 \times c) - (P_3 \times d)}{k}$
 $= \frac{60 \times (12 + 2) + (180 \times 6) - (70 \times 4)}{12}$
 $= 137 \text{ lbs.}$
 Load on Bearing B = $\frac{-(P_1 \times a) + (P_2 \times b) + P_3 \times (k + d)}{k}$
 $= \frac{-(60 \times 2) + (180 \times 6) + 70 \times (12 + 4)}{12}$
 $= 173 \text{ lbs.}$

CASE #4
Straddle Mount, Cantilever Drive

Load on Bearing A = $\frac{(P_1 \times b) - (P_2 \times c)}{k}$
 $= \frac{(1000 \times 4) - (150 \times 3)}{11}$
 $= 323 \text{ lbs.}$
 Load on Bearing B = $\frac{(P_1 \times a) + (c + k) \times (P_2)}{k}$
 $= \frac{(1000 \times 7) + (3 + 11) \times (150)}{11}$
 $= 827 \text{ lbs.}$

CASE #5
Vibrating Drives

Load due to Centrifugal and Inertial Forces - In a shaker or gyrating screen bearing application, the load on the bearings is increased by sudden stopping, starting, and reversing of typically large loads. This can be expressed as a basic physical law:

Force = Mass x Accelerations

In order to use this law, we develop from it the following equation:

$$F = .000341 \times WR(\text{RPM})^2$$

Where: F = Load of force in lbs.
 W = Weight of rotating mass in lbs.
 R = Radius of rotation or throw in feet
 RPM = Shaft rotation in revolutions per minute

What is the centrifugal bearing load on a shaker screen which weighs 2,500 lbs., has a throw of 1/4 in. and whose shaft speed is 500 RPM?

$$F = .000341 \times 2,500 \times \frac{.250}{12} \times (500)^2 = 4,440 \text{ lbs.}$$

For more information on Bearing Basics, please contact Application Engineering (800) 626-2093.

Lubrication

Proper lubrication is essential to achieving desired bearing life. Each bearing application creates individually different requirements for adequate lubrication. To assist in selecting the lubricant and lubrication method, the following information is furnished as a general guide. Generally, the assistance of a qualified engineering representative from a lubricant company should be enlisted. If specific recommendations are required for a particular application, consult Application Engineering.

Lubricants are used to:

- a. Reduce friction and wear
- b. Reduce adhesion
- c. Provide a barrier to contamination
- d. Cool the moving elements
- e. Protect against corrosion

Adequate lubrication is necessary in the rolling-contact areas, on contacts between rolling element and retainer, on contacts between a roller end and flange and on other areas where sliding takes place. Lubrication is required to reduce galling, adhesion, wear, corrosion, scuffing, welding and pitting. Of primary importance is adequate lubrication of the rolling element (Hertzian) contacts to avoid reduction of bearing fatigue life. These heavily loaded areas between the rolling elements and raceways impose the most critical requirement on the lubricant and its properties.

Lubricants of too low an initial viscosity or those too sensitive to temperature changes may induce shallow spalls under conditions of high slip (as in misalignment) or may induce plastic flow of the contacting surfaces.

Lubricants are often limited by their ability to:

- a. Replenish themselves
- b. Dissipate frictional heat
- c. Resist high environmental temperatures
- d. Remain stable under operating conditions

One important purpose of a lubricant is to prevent corrosion of the bearing surfaces engaged in rolling (Hertzian) contact. Many applications involve environments which allow water to accumulate in the bearing cavity. Whether from direct intake or condensation, moisture is detrimental and a lubricant must be selected to disperse the water or to prevent its attack on the metal since corrosion drastically reduces bearing life. Applications involving heavy loads and high operating temperatures also require careful approaches. Here extreme pressure (EP) lubricants should be used. High shaft speeds generally dictate lubricant selection based on the need for cooling, the suppression of churning or aeration of conventional lubricant and, most important of all, the inherent speed limitations of certain bearing types.

Elastohydrodynamic (EHL) lubrication is the model that explains the lubrication of anti-friction bearings. EHL takes into account the deformation of the rolling elements and raceways as well as the increased viscosity of the lubricant in the load zone.

Lubrication Continued

In a rotating rolling element bearing there is one of three types of lubrication conditions present; 1) boundary, 2) thin film, 3) thick film. Bearing operating speed is an important element in determining the lubrication condition. Boundary lubrication occurs when there is metal on metal contact between rolling elements and races. This may be due to low speed and/or oil viscosity that is too low to separate the surfaces. Boundary lubrication is the most severe condition for antifriction bearings and distress of the rolling elements and races will occur. In the thin film condition, partial separation of the surfaces of the rolling elements and races occur with some asperities in contact. This condition may be due to low speed and/or oil viscosity too low to separate the surfaces completely. Some distress of the bearing surfaces will take place in thin film lubrication. Thick film lubrication is the preferred condition for optimum bearing performance. The speed of the bearing and/or the lubricant viscosity is sufficient to separate the rolling elements and raceways. Higher viscosity oils (or higher operating speeds) can help to attain the thick film lubrication condition, but excessively high oil viscosities may lead to higher operating temperatures from churning of the oil or skidding of the rolling elements. Lower viscosity oils sufficient to attain a thick film lubrication condition at the operating speed are selected in high speed applications as they have less tendency to churn or cause skidding.

Grease Lubrication

Greases are applied where fluid lubricants cannot be used because of the difficulty of retention, relubrication, or because of the danger of churning. Rolling contact bearings are often grease lubricated because grease is easier to retain in the housing over a longer period than oil and grease acts, to some extent, as a seal against the entry of dirt and other contaminants into the bearing. Greases are usually made by using soap or other inorganic compounds to thicken petroleum or synthetic oils. The thickener is used to immobilize the oil, acting as a reservoir to release the oil at a slow rate. Though the thickener may have lubrication properties itself, the oil bleeding from the bulk of the grease is felt to be the determining factor. When the oil has depleted to approximately 50% of the total weight of the grease, the lubricating ability of the grease becomes doubtful.

Greases are divided into grades by the NLGI (National Lubricating Grease Institute), ranging from 0, the softest, up through 6, the stiffest. The grade is determined by testing a penetrometer, measuring the depth of penetration of a specific weighted cone. Most greases have thixotropic properties (they soften with working) and, as such, must be considered for their worked properties rather than in the “as-received” condition. Conversely, many greases are found to stiffen when exposed to high shear rates in automatic grease dispensing equipment.

To limit shock loads and settling, grease-lubricated bearing housings should have dividers or seals to keep the bulk of the grease in place. Grease lubrication depends on a relatively small amount of mobile lubricant (the oil bled out of the bulk) to replenish that thrown out of the bearing during operation. If the space between the bulk of the grease and the bearing is too large, then a long delay (determined by the grease bleed rate and its temperature) will be encountered before lubricant in the bearing is resupplied. This delay may affect bearing life.

Grease is normally applied with the material in the cavity contacting the bearing in the lower quadrant for bearings mounted on horizontal shafts. The initial action of the bearing when rotated is to purge itself of excess grease and to clear a path for bleed oil to enter the bearing. Therefore, greases selected are often of an NLGI grade 2 or 3 consistency, referred to as the “channeling” variety.

Lubrication Continued

Grease usually consists of three primary components: oil, thickener, and additives.

Oil is the primary lubricating component in grease and consists of two types: petroleum and synthetic. Petroleum oils are the primary oils used today. Synthetic hydrocarbons can be thought of as synthetic petroleum oils. Other synthetics include esters, silicones, fluorinated hydrocarbons, etc.

Oil is a fluid and can be obtained in varying viscosities. Viscosity refers to the “thickness” of the oil and is usually directly related to an oil’s shear strength or its ability to resist loading. Selection of oil viscosity for rolling element bearing applications is normally dependent on bearing size, speed, load and operating temperature. Method of lubrication may also affect the selected oil viscosity. With these factors known, selection of proper oil viscosity can be made on the basis of elastohydrodynamic analysis, which can be provided by Application Engineering.

The thickeners primary purposes are to retain the oil so that it remains in the bearing, release the oil as needed, and reabsorb the oil as needed. The thickener can also provide additional sealing and protection from contamination and heat dissipation. There are many types of grease thickeners including lithium, calcium, sodium, aluminum, polyurea, etc.

Lithium Soap Grease

For grease lubrication, lithium soap base greases are most common. They are preferred for needle bearings in general because of their ability to stand up under churning action of rollers in a confined space. These greases are not channeling types, therefore provide constant lubrication for roller contact surfaces. They are also insoluble in water. Typical operating temperature range is approximately -30°F to +250°F (-35°C to +120°C).

Sodium Soap Grease

Sodium soap greases are suitable for many applications since they do have a relatively broad useful operating temperature range. However, they are generally restricted to the lower operating speeds because they are typically fibrous and more adhesive than other grease types. Because of this, they resist throw-off, but the fibrous texture causes higher operating temperatures than lithium or calcium soap greases. Very small amounts of water can be absorbed by sodium soap greases, which may be an advantage in some applications; however, this type grease will be washed away if excessive water is present. Typical operating temperature range is approximately -5°F to +200°F (-20°C to +93°C).

Calcium Soap Grease

Calcium soap greases are typically used because they are water resistant. They are smooth textured and have good mechanical stability, but are limited to lower operating temperatures than lithium or sodium soap greases. Typical operating temperature range is approximately -5°F to +150°F (-20°C to +65°C).

Lubrication Continued

Polyurea Thickened Grease

Polyurea thickened greases are smooth textured with good mechanical stability. They exhibit very good oxidation and water resistance properties. Oxidation resistance makes this grease type suitable for higher operating temperatures. Typical operating temperature range is approximately -30°F to +350°F (-35°C to +175°C).

Bentonite or Clay Thickened Grease

These smooth textured greases have very good heat resistance, as the thickener will not melt. They are limited by the base oil temperature properties. Operating temperatures up to +350°F (+175°C) are typical, with intermittent operation up to +450°F (+230°C) sometimes possible. Low temperature properties are satisfactory. However, this type is often formulated with a high oil viscosity for high temperature. Such formulations may not be suitable for low temperature applications.

Greases also can also contain additives. These additives may increase load capacity, resist corrosion, resist temperature extremes, resist oxidation, affect oil viscosity, thickener consistency characteristics, as well as many other characteristics.

Consult Application Engineering when using EP additives or other solid additives such as molybdenum disulfide, graphite, brass, nickel, etc.

Food Grade Grease

“Food Grade” grease may be desirable in applications that are within close proximity to food production. “Food Grade” grease is an option in most Regal Power Transmission Solutions bearing products. Please consult Application Engineering for current specifications.

Reduced Maintenance

Some bearings offered by Regal Power Transmission Solutions have features which can help extend bearing operating life and therefore are not provided with provisions for relubrication. This type of bearing may have an operating life limited by the life of the original grease fill and the ability of the seals to protect the bearing from contamination. Regal Power Transmission Solutions has many seal and grease options for reduced maintenance bearings. Further information for these offerings can be found in the respective bearing type Engineering sections.

High Temperature Grease

High temperature grease options are available for most Regal Power Transmission Solutions bearings. Consult Application Engineering for a suggested lubricant for your application. Higher operating temperatures can also affect required lubrication interval. Refer to the lubrication interval information in the respective bearing type Engineering section.

Lubrication Continued

Grease Compatibility

Combinations of greases with different thickeners can result in a mixture having poorer performance or physical properties than the individual components. Incompatibility can also result from other than different thickeners. Because grease is a combination of thickener, oil and additives, it is also possible that any of these components may be incompatible with those of the other grease. Therefore caution should be used when relubricating with or combining different greases. Contact Application Engineering for current grease specifications. Contact your grease manufacturer for grease compatibility.

Petroleum oils and synthetic hydrocarbons are, generally speaking, compatible. Other synthetic oils are, more often than not, incompatible with other oils.

Additives may cause compatibility problems in some cases. Caution should be used when relubricating with or combining different greases. Contact Application Engineering for current grease specifications and your grease manufacturer to verify grease compatibility.

Oil Lubrication

Oil lubrication is normally used when speeds and temperatures are high or when it is desired to have a central oil supply for the machine as a whole. Cooled oil is sometimes circulated through the bearing to carry off excess heat resulting from high speeds heavy loads. Oil for anti-friction bearing lubrication should be well refined with high film strength, good resistance to oxidation and good corrosion protection. Anti-oxidation additives are generally acceptable but are of significance only at higher operating temperatures (over 185 °F). Anti-corrosion additives are always desirable.

Since oils are considerably more uniform in their characteristics than greases, their selection is much easier. The primary requirement, following viscosity, is a high grade mineral oil — not animal or vegetable oils which have a tendency to deteriorate. The oil must be resistant to oxidation, gumming and evaporation so that viscosity assumes the important role. For extremely low starting temperatures, an oil must be selected which has a sufficiently low pour point so the bearing will not be locked by stiff oil. The oil level should normally be maintained at the center of the lower-most rolling element when the bearing is stationary. An over supply of lubricant causes excessive churning action and can lead to heat generation. Oils of varying viscosity may be selected, depending on application conditions. Selection of oil viscosity for rolling element bearing applications is normally dependent on bearing size, speed, load and operating temperature. Method of lubrication may also affect the selected oil viscosity. With these factors known, selection of proper oil viscosity can be made on the basis of elastohydrodynamic analysis, which can be provided by Application Engineering. A general rule is to maintain the following lubricating oil viscosities for the respective bearing types at the bearing operating temperature.

Product	Viscosity at Operating Temperature
Ball	70 SUS (13 cSt)
Needle and Spherical Roller	100-150 SUS (30 cSt)
Cylindrical Roller	110 SUS (23 cSt)
Cylindrical Thrust	125 SUS (26 cSt)
Tapered and Tandem Thrust	160 SUS (34 cSt)

Lubrication Continued

Oil Lubrication Systems

This method of lubrication is generally applicable to unmounted bearing products. The lubrication system must provide each roller bearing with a uniform, continuous supply of clean oil and must satisfy the cooling requirement of the bearing. Oil lubrication systems are also designed to meet the following needs:

- a. Adaptability to function over the range of variables encountered in the operating regime
- b. Reliability in a given operating environment and over the length of the normal maintenance periods
- c. Maintainability
- d. Overall ability to meet the requirements of the system application
- e. Relative cost when compared to the cost of machine or application

The table below provides a list of commonly used lubrication systems and shows some of the significant features that must be considered in their design and selection for roller bearing applications.

Lubrication System	Initial Cost	Required Maintenance	Oil Flow	Cooling	Reliability	Sensitivity to Environmental Changes	Sealing Requirements
Manual	Low	High	Variable and dependent on worker for continuity	Minimal and variable	Poor	Highly adaptable	Not Significant
Drip Feed	Low	Contingent upon type of service and location of lubrication points	May vary with time	Low	Average	May be affected by temperature variations	Not Significant
Splash	Dependent on Design	Negligible	Dependent upon maintenance of oil level in housing	Fair	High	Sensitive to low temperature. may accumulate moisture due to condensation	Generally critical
Wick Feed	Low to Medium	Medium	Uniform, filtered, continuous	Negligible	High, if wick is maintained	Sensitive to low temperature	Not Significant
Pressure Circulating System	High	Medium	Controlled and continuous. Adding filtration ensures clean oil supply	Excellent, can include heat exchanger	High	May accumulate moisture due to condensation	Important
Air-Oil Mist	High	Medium	Positive, automatic delivery of regulated oil quantity, free of contamination	Excellent	High	Sensitive to low temperature	Important

Lubrication Continued

Lubrication Frequency

Lubrication frequency is dependent on application speed, temperature, and level of contamination. Relubrication schedules are only general recommendations. Experience and testing may be required for specific applications. Check individual product sections for more information on specific Regal Power Transmission Solutions product lubrication guidelines.

Solid Lubricants

Oil saturated polymers (OSP) are generally a porous plastic that retains oil and are used in place of grease. This option may be used in inaccessible areas where relubrication is difficult. Oil is released during bearing operation and excess oil is reabsorbed when operation stops. Since the polymer material fills the bearing cavity, it also helps to keep out contaminant. This product is generally limited to slower operating speeds and generally to temperatures below +200°F (+93°C).

Graphite is another form of solid lubrication. A semi-solid graphite mixture is inserted into the bearing and then baked to cure the material. Lubrication comes in the form of a thin layer of solid graphite that is deposited on all friction surfaces. This type of lubrication works well in extreme temperature (high or low), high contamination, or even when the bearing is submerged (lubricant does not have anti-corrosion properties).

Dry Film

Dry film lubricants such as molybdenum disulfide or graphite are well suited for specialized applications such as: high temperature, oscillatory rotation, maintenance free operation, or locations where bearings cannot be reached for easy maintenance. The lubricant is applied as a thin film and is permanently bonded to the bearing surfaces. The interaction of the rolling elements with this solid lubricant works to compact the lubricant into the surface imperfections of the bearing elements and reduces metal-to-metal contact.

Mounting

Mounting the bearing has important effects on performance, durability and reliability. Proper tools, fixtures and techniques are a must for any bearing application, and it is the responsibility of the design engineer to provide for this in his design, advisory notes, mounting instructions and service manuals. Nicks, dents, scores, scratches, corrosion staining and dirt must be avoided if reliability, long life and smooth running are to be expected. This section is provided as a reference only, additional data dealing solely with each type of bearing is found in each respective section.

Fit selections given in the various sections will serve as a guide for the majority of applications where the bearings are subjected to normal or heavy loads and other normal operating conditions. When bearings are subjected to very heavy or vibratory loads it may be necessary to employ shaft and housing fits tighter than standard. The same applies if shafts or housings of soft metal or those not having smoothly ground bearing seats (i.e., the smoothness ordinarily associated with ground or reamed bores) are used. Furthermore, if speeds are abnormally high, it may be necessary to maintain shaft and housing fits other than those shown in tables. Consult Application Engineering for recommendations for these abnormal conditions.

Shaft Fit – Mounted Product

Most mounted bearings are used to provide rotational support by inserting a shaft through them, typically with a slip fit. The shafts tolerance and finish is of utmost importance for proper bearing function and useful life. Ground shaft finishes are normally suggested for most applications; however, in some cases, a ground finish is not practical. In these situations, a machined finish may be acceptable; consult Application Engineering for recommendations. Additional shaft requirements dealing solely with each type of bearing are found in each respective section.

High Load Applications – Mounted Product

Applications where the loading approaches the load listed in the respective mounted product's rating table at 5000 hours life and 150/250 rpm should be reviewed and given special consideration. Modifications to consider include:

- Shaft size should be closely controlled for a line to line to a light press fit.
- Skwezloc® Locking Collar or double lock is the preferred lock system.
- Lubricants with "EP" extreme pressure additives may be required.
- Care in housing selection, load direction, and mounting techniques should be exercised. Refer to respective mounted product's installation instructions.

High Speed Applications – Mounted Product

Applications where the speed is in the range of 80% to 100% of the maximum speed listed in the respective mounted product's rating table should be reviewed and given special consideration. Modifications to consider include:

- Shaft size should be controlled to specifications listed in the installation section.
- Skwezloc Locking Collar or double lock is the preferred lock system.
- High quality lubricants should be used.
- Grease should be added more frequently and in small amounts. Refer to respective mounted product's relubrication schedule.
- Care in mounting techniques should be exercised. Refer to respective mounted product's installation instructions.

Mounting Continued

Shaft Fit – Unmounted Product

The slipping or creeping of a bearing race on a rotating shaft, or in a rotating housing, occurs when the fit is loose. Such slipping or creeping action can result in rapid wear of both the shaft and bearing races when the surfaces are dry and heavily loaded. To help prevent this, the bearing is customarily mounted with a press fit on the rotating race and a push fit on the stationary race with the tightness or looseness dependent upon the service intended. Bearings should be mounted squarely when press fitted, either in housings or on shafts, and installation pressure should be applied to the press fitted member only, or should be evenly distributed over both members. Where shock or vibratory loads are to be encountered, fits should be made tighter than for ordinary service. When heavier shaft fits are encountered, the assembly of a bearing on a shaft is best done by expanding the inner race by heating. Heat should not be applied directly to the bearing, but should be conducted to the bearing by some fluid medium. It is recommended that such heating be accomplished in clean mineral oil or in a temperature-controlled furnace at a temperature of between 200°F and 250°F as overheating will reduce the hardness of the races. Sealed bearings should not be mounted by this method as the grease with which the bearings are prelubricated may be affected.

Housing Fit – Mounted Product

For mounted bearing product (pillow blocks, flange blocks...) proper housing fit is dependent on bearing application variables: amount of shock/vibration, high speed fan applications, and need for low torque self-aligning capabilities. Applications with high shock and vibration require tighter fits between the bearing insert and the housing. Shock and vibration work to loosen the fit over time so it is best to start with tight fits. Fan applications require a loose fit to allow for easy self-aligning capabilities to adjust for variations in mounting surfaces that are typically found in air handling mounting structures.

Housing Fit – Unmounted Product

These types of bearings will be mounted into the customer's housing and therefore is application dependent. In the case of unmounted roller bearings or ER style bearings, housing fit is dependent on whether the outer ring is stationary or rotating. In general, a rotating outer ring requires a tighter fit than if the outer ring is stationary. In applications where bearing housings are made of soft materials (aluminum, magnesium, light sheet metal, etc.) or those which lose their fit because of different thermal expansion, outer race mounting must be approached cautiously. First, determine the possible consequences of race loosening and turning. The type of loading must also be considered to determine its effect on race loosening. The force exerted by the rotating elements on the outer race can initiate a precession which will aggravate the race loosening problem through wear, pounding, and abrasion. Since the pressing force is usually greater than the friction forces in effect between the outer race and housing, no foolproof method can be recommended for securing outer races in housings which deform significantly under load or after appreciable service wear. The surest solution is to press the race into a housing of sufficient stiffness with the heaviest fit consistent with the bearing operating clearances. Often, inserts or liners of cast iron or steel are used to maintain the desired fit and increase useful life of both bearing and housing. When stationary outer rings are required to float (move axially in the housing bore to compensate for expansion), a housing bore surface finish of 65 micro inches Ra maximum is recommended.

Mounting Continued

Housing Fit – Cam Follower

Proper mounting of stud type cam follower and track roller bearings requires a close fit between the bearing stud and the housing hole. The endplate must be backed up by the housing member face. Likewise the face of the housing adjacent to the bearing endplate face should be square to the housing bore.

Endplate support is also critical when mounting yoke-type series cam followers and track rollers. If the endplates are not properly backed up, they can partially or completely work off the inner ring. The preferred mounting method is by use of a separate bushing at one side to permit complete axial clamping of the endplates. If the endplates can not be clamped end-wise, it is essential to have a close fit axially in the yoke in which the bearing is mounted to prevent the bearing endplates displacing axially. Refer to the Camrol engineering section for more detailed information regarding cam follower mounting.

Mounting for Precision and Quiet Running Applications - Radial Cylindrical Roller Bearings

In applications of roller bearings where smoothness of operation is important, special precautions must be taken to eliminate those conditions which serve to initiate radial and axial motions. Accompanying these motions are forces that can excite bearing system excursions in resonance with shaft or housing components over a range of frequencies from well below shaft speed to as much as 100 times above it. The more sensitive the configuration, the greater the need for precision in the bearing and mounting. Among the important elements to be controlled are shaft, race, and housing roundness, squareness of faces, diameters, and shoulders. Though not readily appreciated, grinding chatter, lobular out-of-roundness, waviness and any localized deviation from an average or mean diameter (even as a consequence of flat spots as small as .0005 in.) can cause significant operating roughness. To detect the aforementioned deficiencies and ensure the selection of good components, three-point electronic indicator inspection must be made. For ultra precise or quiet applications, components are often checked on a continuous recording instrument capable of measuring to within a few millionths of an inch. Though this may seem extreme, it has been found that shaft deformities will be reflected through the bearings' inner races. Similarly, tight-fit outer races pick up significant deviations in housings. Special attention is required both in housing design and in assembly of the bearing to shaft and housing. Housing response to axial excursions forced by bearing wobble resulting from out-of-square mounting has been found to be a major source of noise and howl in rotating equipment. Stiffer housings and careful alignment of bearing races make significant improvements in applications where noise or vibrations have been found to be objectionable.

Squareness and Alignment - Radial Cylindrical Roller Bearings

In addition to the limits for roundness, squareness of end faces and shoulders must be closely controlled. Tolerances of .0001 in. full indicator reading per inch of diameter are normally required for shoulders, in addition to appropriately selected limits for fillet eccentricities. The latter must also fall within specified limits for radii tolerances to prevent interference with bearing race fillets, which results in cocking of the race. Reference should be made to the individual bearing dimension tables, which list the corner radius for each bearing. Shoulders must also be of sufficient height to ensure proper support for the races.

Mounting Continued

Rollway Cylindrical Roller and McGill Spherical Roller Bearings – Shaft and Housing Seat Diameters

The tolerances, specified in the following charts for shaft and housing bearing seat fits, may be followed for specific application conditions that are encountered, as indicated. For special applications not covered by the following, Application Engineering should be consulted for additional assistance. The proper shaft and housing seat tolerances are designated by a letter and number. For shafts, a lower case letter is used, and for housings, a capital letter, both indicating the location of the tolerance range in relation to the nominal bearing dimension. The numbers indicate the grade of accuracy.

Housing Seat Fits

Housing Construction	Operating Conditions		Fit Symbol*
Housing not split radially	Housing rotating relative to load direction	Heavy loads on bearing in thin wall housing	P7
		Normal and heavy loads	N7
		Light loads	M7
	The direction of the load indeterminate	Heavy shock loads	
			Heavy and normal loads axial displacement of outer ring not required
Housing split or not split radially	Housing stationary relative to load direction	Normal and light loads axial displacement of outer ring desirable	J7
		Shock loads, temporary complete unloading	
		All loads	Housing not split radially
	Housing split radially		H8
		Heat supplied through the shaft	G7

* For cast iron or steel housing.

For housings of light metal, tolerances are generally selected that give slightly tighter fits than those shown.

Mounting Continued

Shaft Seat Fits

Operating Condition		Spherical Roller Bearings			Cylindrical Roller Bearings		
		Nominal Shaft Dia.		Fit Symbol	Nominal Shaft Dia.		Fit Symbol
		MM	Inch		MM	Inch	
Stationary inner ring relative to load direction, all loads	Inner ring easily displaced	All diameters	All diameters	g6	All diameters	All diameters	g6
	Inner ring not easily displaced	All diameters	All diameters	h6	All diameters	All diameters	h6
Inner ring rotating relative to load direction, or load direction indeterminate	Radial load $\leq .08$ BDR*	≤ 40 Over 40 to 100 Over 100 to 200	≤ 1.57 Over 1.57 to 3.94 Over 3.94 to 7.88	j6 k6 m6	≤ 40 Over 40 to 140 Over 140 to 320	≤ 1.57 Over 1.57 to 5.51 Over 5.51 to 12.6	j6 k6 m6
	Radial load $> .08$ BDR* $\leq .18$ BDR*	≤ 40 Over 40 to 65 Over 65 to 100 Over 100 to 140 Over 140 to 280	≤ 1.57 Over 1.57 to 2.56 Over 2.56 to 3.94 Over 3.94 to 5.52 Over 5.52 to 11.10	k5 m5 m6 n6 p6	≤ 40 Over 40 to 100 Over 100 to 140 Over 140 to 320 Over 320 to 500	≤ 1.57 Over 1.57 to 3.94 Over 3.94 to 5.51 Over 5.51 to 12.6 Over 12.6 to 19.7	k5 m5 m6 n6 p6
	Radial load $> .18$ BDR	≤ 40 Over 40 to 65 Over 65 to 100 Over 100 to 140 Over 140 to 200 Over 200 to 500	≤ 1.57 Over 1.57 to 2.56 Over 2.56 to 3.94 Over 3.94 to 5.52 Over 5.52 to 7.88 Over 7.88 to 19.69	m5 m6 n6 p6 r6 r7	≤ 40 Over 40 to 65 Over 65 to 140 Over 140 to 200 Over 200 to 500 Over 500	≤ 1.57 Over 1.57 to 2.56 Over 2.56 to 5.51 Over 5.51 to 7.87 Over 7.87 to 19.7 Over 19.7	m5 m6 n6 p6 r6 r7

* BDR - Bearing Basic Dynamic Rating

Mounting Continued

Standard Shaft Fits

Dimensions in 0.0001 inches

Bore mm		g6	h6	j5	j6	k5	k6	m5	m6	n6	p6	r6
3	6	-2	0	+1	+2	+2	-	+4	-	-	-	-
		-5	-3	-1	-1	0	-	+2	-	-	-	-
7	10	-2	0	+2	+3	+3	-	+5	-	-	-	-
		-6	-4	-1	-1	0	-	+2	-	-	-	-
11	18	-2	0	+2	+3	+4	-	+6	-	-	-	-
		-7	-4	-1	-1	0	-	+3	-	-	-	-
19	30	-3	0	+2	+4	+4	-	+7	-	-	-	-
		-8	-5	-2	-2	+1	-	+3	-	-	-	-
31	50	-4	0	+2	+4	+5	+7	+8	+10	-	-	-
		-10	-6	-2	-2	+1	+1	+4	+4	-	-	-
51	80	-4	0	+2	+5	+6	+8	+9	+12	+15	-	-
		-11	-7	-3	-3	+1	+1	+4	+4	+8	-	-
81	120	-5	0	+2	+5	+7	+10	+11	+14	+18	+23	-
		-13	-9	-4	-4	+1	+1	+5	+5	+9	+15	-
121	180	-6	0	+3	+6	+8	+11	+13	+16	+20	+27	+35
		-15	-10	-4	-4	+1	+1	+6	+6	+11	+17	+26
181	200	-6	0	+3	+6	+9	-	+15	+18	+24	+31	+42
		-17	-11	-5	-5	+2	-	+7	+7	+12	+20	+30
201	225	-6	0	+3	+6	+9	-	+15	+18	+24	+31	+43
		-17	-11	-5	-5	+2	-	+7	+7	+12	+20	+31
226	250	-6	0	+3	+6	+9	-	+15	+18	+24	+31	+44
		-17	-11	-5	-5	+2	-	+7	+7	+12	+20	+33
251	280	-7	0	+3	+6	+11	-	+17	+20	+26	+35	+50
		-19	-13	-6	-6	+2	-	+8	+8	+13	+22	+37
281	315	-7	0	+3	+6	+11	-	+17	+20	+26	+35	+51
		-19	-13	-6	-6	+2	-	+8	+8	+13	+22	+39
316	355	-7	0	+3	+7	+11	-	+18	+22	+29	+39	+57
		-21	-14	-7	-7	+2	-	+8	+8	+15	+24	+43
356	400	-7	0	+3	+7	+11	-	+18	-	+29	+39	+59
		-21	-14	-8	-7	+2	-	+8	-	+15	+24	+45
401	450	-8	0	+3	+8	+13	-	+20	-	+31	+43	+65
		-24	-16	-8	-8	+2	-	+9	-	+16	+27	+50
451	500	-8	0	+3	+8	+13	-	+20	-	+31	+43	+68
		-24	-16	-8	-8	+2	-	+9	-	+16	+27	+52
501	560	-9	0	+3	+9	+12	-	+22	-	-	+48	+76
		-26	-17	-9	-9	0	-	+10	-	-	+31	+59
561	630	-9	0	+3	+9	+12	-	+22	-	-	+48	+78
		-26	-17	-9	-9	0	-	+10	-	-	+31	+61
631	710	-9	0	+4	+10	+14	-	+26	-	-	+54	+89
		-29	-20	-10	-10	0	-	+12	-	-	+35	+69

Mounting Continued

Standard Shaft Fits

Dimensions in 0.0001 inches

Bore mm		g6	h6	j5	j6	k5	k6	m5	m6	n6	p6	r6
3	6	-2	0	+1	+2	+2	-	+4	-	-	-	-
		-5	-3	-1	-1	0	-	+2	-	-	-	-
7	10	-2	0	+2	+3	+3	-	+5	-	-	-	-
		-6	-4	-1	-1	0	-	+2	-	-	-	-
11	18	-2	0	+2	+3	+4	-	+6	-	-	-	-
		-7	-4	-1	-1	0	-	+3	-	-	-	-
19	30	-3	0	+2	+4	+4	-	+7	-	-	-	-
		-8	-5	-2	-2	+1	-	+3	-	-	-	-
31	50	-4	0	+2	+4	+5	+7	+8	+10	-	-	-
		-10	-6	-2	-2	+1	+1	+4	+4	-	-	-
51	80	-4	0	+2	+5	+6	+8	+9	+12	+15	-	-
		-11	-7	-3	-3	+1	+1	+4	+4	+8	-	-
81	120	-5	0	+2	+5	+7	+10	+11	+14	+18	+23	-
		-13	-9	-4	-4	+1	+1	+5	+5	+9	+15	-
121	180	-6	0	+3	+6	+8	+11	+13	+16	+20	+27	+35
		-15	-10	-4	-4	+1	+1	+6	+6	+11	+17	+26
181	200	-6	0	+3	+6	+9	-	+15	+18	+24	+31	+42
		-17	-11	-5	-5	+2	-	+7	+7	+12	+20	+30
201	225	-6	0	+3	+6	+9	-	+15	+18	+24	+31	+43
		-17	-11	-5	-5	+2	-	+7	+7	+12	+20	+31
226	250	-6	0	+3	+6	+9	-	+15	+18	+24	+31	+44
		-17	-11	-5	-5	+2	-	+7	+7	+12	+20	+33
251	280	-7	0	+3	+6	+11	-	+17	+20	+26	+35	+50
		-19	-13	-6	-6	+2	-	+8	+8	+13	+22	+37
281	315	-7	0	+3	+6	+11	-	+17	+20	+26	+35	+51
		-19	-13	-6	-6	+2	-	+8	+8	+13	+22	+39
316	355	-7	0	+3	+7	+11	-	+18	+22	+29	+39	+57
		-21	-14	-7	-7	+2	-	+8	+8	+15	+24	+43
356	400	-7	0	+3	+7	+11	-	+18	-	+29	+39	+59
		-21	-14	-8	-7	+2	-	+8	-	+15	+24	+45
401	450	-8	0	+3	+8	+13	-	+20	-	+31	+43	+65
		-24	-16	-8	-8	+2	-	+9	-	+16	+27	+50
451	500	-8	0	+3	+8	+13	-	+20	-	+31	+43	+68
		-24	-16	-8	-8	+2	-	+9	-	+16	+27	+52
501	560	-9	0	+3	+9	+12	-	+22	-	-	+48	+76
		-26	-17	-9	-9	0	-	+10	-	-	+31	+59
561	630	-9	0	+3	+9	+12	-	+22	-	-	+48	+78
		-26	-17	-9	-9	0	-	+10	-	-	+31	+61
631	710	-9	0	+4	+10	+14	-	+26	-	-	+54	+89
		-29	-20	-10	-10	0	-	+12	-	-	+35	+69

Mounting Continued

Standard Housing Fits

Dimensions in 0.0001 inches

OD mm		G7	H8	H7	H6	J6	J7	K6	K7	M6	M7	N6	N7	P6	P7
10	18	+2	0	0	0	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11
		+9	+11	+7	+4	+2	+4	+1	+2	-2	0	4	-2	-6	-4
19	30	+3	0	0	0	-2	-4	-4	-6	-7	-8	-9	-11	-12	-14
		+11	+13	+8	+5	+3	+5	+1	+2	-2	0	-4	-3	-7	-6
31	50	+4	0	0	0	-2	-4	-5	-7	-8	-10	-11	-13	-15	-17
		+13	+15	+10	+6	+4	+6	+1	+3	-2	0	-5	-3	-8	-7
51	80	+4	0	0	0	-2	-5	-6	-8	-9	-12	-13	-15	-18	-20
		+16	+18	+12	+7	+5	+7	+2	+4	-2	0	-6	-4	-10	-8
81	120	+5	0	0	0	-2	-5	-7	-10	-11	-14	-15	-18	-20	-23
		+19	+21	+14	+9	+6	+9	+2	+4	-2	0	-6	-4	-12	-9
121	150	+6	0	0	0	-3	-6	-8	-11	-13	-16	-18	-20	-24	-27
		+21	+25	+16	+10	+7	+10	+2	+5	-3	0	-8	-5	-14	-11
151	180	+6	0	0	0	-3	-6	-8	-11	-13	-16	-18	-20	-24	-27
		+21	+25	+16	+10	+7	+10	+2	+5	-3	0	-8	-5	-14	-11
181	250	+6	0	0	0	-3	-6	-9	-13	-15	-18	-20	-24	-28	-31
		+24	+28	+18	+11	+9	+12	+2	+5	-3	0	-9	-6	-16	-13
251	315	+7	0	0	0	-3	-6	-11	-14	-16	-20	-22	-26	-31	-35
		+27	+32	+20	+13	+10	+14	+2	+6	-4	0	-10	-6	-19	-14
316	400	+7	0	0	0	-3	-7	-11	-16	-18	-22	-24	-29	-34	-39
		+30	+35	+22	+14	+11	+15	+3	+7	-4	0	-10	-6	-20	-16
401	500	+8	0	0	0	-3	-8	-13	-18	-20	-25	-26	-31	-37	-43
		+33	+38	+25	+16	+13	+17	+3	+7	-4	0	-11	-7	-22	-18
501	630	+9	0	0	0	-3	-9	-17	-28	-28	-38	-35	-45	-48	-58
		+36	+43	+28	+17	+15	+19	0	0	-10	-10	-17	-17	-31	-31
631	800	+9	0	0	0	-4	-9	-20	-31	-31	-43	-39	-51	-54	-66
		+41	+49	+31	+20	+16	+22	0	0	-12	-12	-20	-20	-35	-35
801	1000	+10	0	0	0	-4	-10	-22	-35	-35	-49	-44	-57	-61	-75
		+46	+55	+35	+22	+18	+25	0	0	-13	-13	-22	-22	-39	-39

Internal Clearance

Radial and Axial Internal Clearance

Anti-friction bearings are manufactured with specific radial clearances between the raceways and rolling elements. The clearances are designed for normal operating temperatures and application conditions. Certain bearing products, such as spherical roller bearings, are available with industry standard radial clearance ranges. Other bearing products will incorporate radial clearance as determined by the manufacturer. For high temperature and high speed applications, increased radial clearance options may be available to allow for thermal expansion. For mounted bearings exposed to high shock load and vibration, reduced internal clearance may be an option to distribute load over more rolling elements and reduce the stress per rolling element. Oscillatory applications may also benefit from reduced internal clearance. Load is carried over more rolling elements thus putting less stress on bearing raceways and potentially reducing wear.

Axial clearance between rolling elements and raceways also allows an inherent axial movement within the bearing, this is known as end play. End play, is the maximum relative displacement of the bearing rings relative to one another, in a direction parallel to the axis of rotation. The amount of endplay in a given bearing product is based on the design experience of the manufacturer and partly controlled by manufacturing tolerances.

Bearing Stiffness

Bearing stiffness is the relationship between bearing load and bearing deflection due to that load. Bearing stiffness is dependent on several variables: rolling element type, contact angle, applied load, and bearing preload.

Rolling element type comes into play due to the different contact patterns that the rolling elements make with the raceways. Therefore roller bearings, with their large line contact, will be stiffer than the point type contact produced by ball bearings. Additionally, the greater the number of rolling elements within the bearing the stiffer it will be.

Contact angle affects whether a bearing has better radial or axial stiffness. A small contact angle will produce a bearing with higher radial stiffness while a large contact angle will create higher axial stiffness.

Preload increases stiffness by removing internal clearance which in turn puts more rolling elements in contact with the raceway. As a negative affect, preload can increase operational temperatures and internal friction which can lead to reduced bearing life.

For specific information concerning stiffness data related to Regal Power Transmission Solutions bearings, please contact Application Engineering.

Bearing Materials

A portion of bearing life and reliability of a rolling element bearing is based upon the material that the bearing components are made from. L10 bearing life equations are based upon the fatigue limit of the metal surfaces, both raceways and rolling elements. Therefore the proper and highest quality materials must be used.

Through-hardened Steels

52100 is the most common type of through-hardened steel used for bearing components as it is widely recognized as a superior bearing steel. It is resistant to shock loading and carries high metal fatigue life ratings. In addition, Regal Power Transmission Solutions specifies all steel to be vacuum degassed (VDG). This is an extra manufacturing operation to filter impurities and remove inclusions that often appear during steelmaking. The result is a cleaner and more pure material that is better able to withstand subsurface cracking and subsequent premature metal fatigue failures.

Some bearing product produced using 52100 utilizes a zone hardening process in which only the raceway and immediate area is hardened. This creates a hardened surface for rolling elements but ductile in other areas for improved durability and shock load resistance.

Case-hardened Steels

Case hardening is used for certain applications when a through hardened part is undesirable. The surface can be hardened to an acceptable level yet the core of the part remains soft to resistant vibration and impact loads.

8620, 4118 and 9310 are examples of case hardening steel used by Regal Power Transmission Solutions for bearing components. These low carbon alloy steels have good hardenability characteristics and toughness when properly carburized and hardened.

Corrosion Resistant Steels

A variety of corrosion resistant steels are used across the Regal Power Transmission Solutions bearing line. The type of steel used depends on the component, cost effectiveness, and level of corrosion resistance needed.

The most common steel used for corrosion resistant bearing products is 400 series stainless steel. Its corrosion resistance is less than austenitic grades but it can be heat treated to obtain acceptable hardness value needed for anti-friction bearings.

300 series stainless steel is the most common type of stainless steel used for consumer products. It has excellent corrosion resistance when compared to 440C or coatings. However it cannot be hardened to acceptable levels for use in bearings. Therefore it can only be used in certain areas of bearing design that do not see a direct load from rolling elements. This includes components such as housings, seal stampings, setscrews, grease fittings, etc.

Standard bearing steels can also be coated or plated with various substances to provide good corrosion resistance as well as good harness values.

Bearing Materials

High Temperature Steels

As temperature rises, bearing rating is reduced, depending upon the bearing material and the operating temperature. Various types of tool steel, stainless steel and some of the more exotic materials are being used in order to meet the need for bearings to operate at elevated temperatures.

Bearing applications involving elevated temperatures preclude the use of standard bearing materials if full capacity is to be realized. In general, the temperature range is divided as follows:

- 250°F to 400° F
- 400°F to 800°F
- Over 800°F

Applications in range (a) can be generally handled by standard alloy steels , such as SAE 52100 or carburized SAE 8620 , suitably hardened and stabilized for the range of operating temperature . Little or no reduction in basic capacity should be expected. For range (b), high alloy tool steels (M-50) may be used. For range (c), materials such as ceramics are generally required. Design options in this range are generally limited.

Composites – Bushings

Replacing rollers, a non-metallic bushing provides load support and a sliding motion that eliminates or reduces need for bearing lubrication. Recommended for use where relubrication is not convenient or where the possibility of grease contamination of the product being processed is not acceptable. Application limitations are lighter loads and lower speeds when compared to a rolling element bearing.

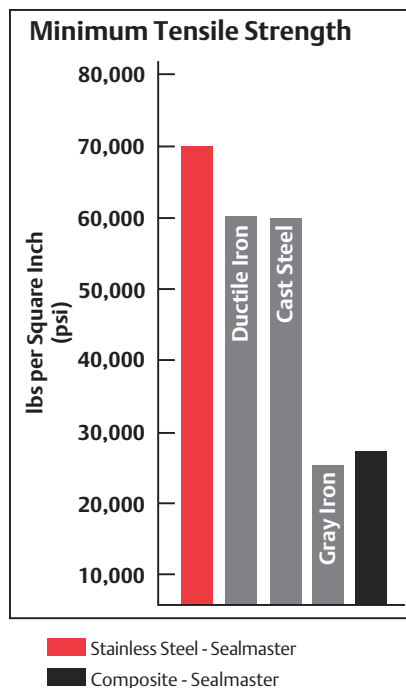
McGill bushing type CAMROL® bearings have a maximum allowable continuous operating temperature of 200°F (120°). The bushings are intended to be used in the self-lubricated mode. However, continuous feed oil lubrication can be used to provide reduced wear rates. Grease lubrication should not be used.

Housing Material

A variety of housing materials are offered within the Regal Power Transmission Solutions mounted bearing product line. Selection of proper materials is application dependent and based upon variables such as type of loading, cost, and environmental conditions.

Gray iron, or cast iron, is the most common housing material type and has adequate strength for most applications. However, certain application conditions must be considered. Cast iron can be a brittle material when higher tensile (pulling) forces are applied; therefore it is not recommended in applications where shock loads are present.

Ductile iron or cast steel is preferred in applications with heavy loads, shock, and vibration since these materials have higher tensile strength and ductility. The chart below shows a comparison of housing materials and their tensile strengths. There is a slightly higher cost associated with ductile iron and cast steel housings and availability may be limited depending on product line.

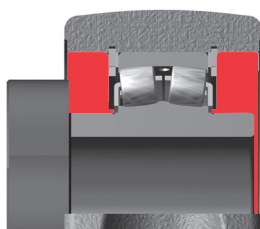


In applications where there is significant humidity, moisture or chemicals present there is a likelihood that corrosion may occur over time. A coating or alternative material maybe required to meet material performance or customer aesthetic requirements. For each product line, Regal Power Transmission Solutions can offer an alternate coating or material to improve corrosion resistance. Refer to each product section or the Corrosion Resistant Engineered Solutions (CRES) section K for more details on available options.

Seal Selection

The purpose of seals on a bearing is to help keep contamination from entering the bearing and to help retain lubricant inside the bearing cavity. Proper seal selection is dependent on a number of application variables: operational speed, level of contamination, type of contamination, operational temperature, and type of lubricant used.

Seal Type



Non-contacting/ Labyrinth Seals

Recommended for use in dry, low contamination environments. Constructed from multiple metal stampings, typically with one element that rotates with the shaft, creating a centrifugal force to help keep out contamination. Excess grease purges from the seal to help remove contaminants caught in the lubricant and prevent seal damage from over lubrication. These types of non-contact seals save energy by reducing drag and normally cannot be blown by over greasing.

Contacting Seals

Contacting seals can be used in a variety of applications depending on type of seal and material used. These factors affect the type and severity of contamination that the seal can withstand.



Felt Seal

The design incorporates a series of passageways with a highly effective filtering media that together block the ingress of contaminants and allow for the purging of oxidized grease during re-lubrication. Protective metal flingers are primary factors in seal performance. The inner flinger is pressed into the outer race and is a stationary foundation for the sealing system. The outer flinger, the first barrier to contaminant entry, is attached to the inner race and therefore rotates with the shaft. The rotation of the outer flinger offers two significant benefits. The first is the creation of a centrifugal force that repels debris by “slinging” it away from the seal area. The second is an extension of the flinger internally into the bearing chamber that initiates a vortex that churns the lubricant back toward the ball path. The design operates with less drag and less heat generation than rubber contact seals.

Recommend for use in dry applications with light to moderate contamination. Standard felt seals can operate in temperatures up to 200°F (93°C). Nomex felt can be used for temperatures 200°F to 400°F (93°C to 204°C).



Rubber Lip

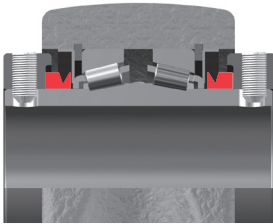
Positive contact molded rubber lip seal with or without an auxiliary flinger. This type of seal functions well in wet and dirty environments up to 250°F (120°C). High temperature versions are available for conditions up to 450°F (232°C). Multiple lip seals are also available for severe applications. Rubber lip seals come in a variety of materials: Buna N Nitrile, FKM, and silicone.

Seal Selection Continued



Spring Loaded

This V-shaped rubber seal is molded into a metal stamping. A spring is retained in the body of the “V” to maintain constant pressure against the inner race over the life of the seal. Seal lip can be oriented inward for increased lubricant retention. For better exclusion of contaminants the lip is oriented outward. High temperature versions available.



V-Ring

The rubber contact face seal is designed to retain lubricant and help exclude contaminants. The seal is designed with a long flexible face that seals axially against the counterface. The contact seal is self purging. It retains low torque characteristics and rotates with the shaft to help reduce contaminate build-up on the seal. Its low friction reduces heat generation and wear.

Bearing Retainers

The function of a bearing retainer (cage) is to separate the rolling elements at evenly spaced intervals and reduce internal friction which allows for increased speeds. In roller bearing product the retainer also provides stability to the rolling elements, keeping them from skewing as they rotate. Retainers are sometimes omitted and a full complement of rolling elements is used instead. Additional rolling elements help to add rigidity and increase static capacity.

In some cases use of retainers can also help in aiding longer bearing life. A retained bearing has a larger grease reservoir than a similar bearing that is a full complement.

Mounted Ball



Land Riding

A land riding is a design used in Sealmaster mounted ball product. This design minimizes friction and provides maximum grease circulation. The retainer is designed to “float” on the ground extension (or lands) of the outer ring while spacing the balls precisely for more even load distribution. This minimizes wear on both balls and retainer, while maximizing stability, especially important in applications involving vibration, shock loading or high operating speeds. For applications involving high temperatures, +220°F, land riding brass retainers are available.



Ball Riding

Ball riding retainers are designed to retain the balls within the cage pockets, which improves manufacturability, but can wipe oil away from the rolling elements removing it from these critical components. Sealmaster Material Handling Bearings and Browning Mounted Ball Bearing utilize a one piece ball riding nylon retainer molded from nylon 6/6. Nylon retainers are a low cost alternative to brass retainers that have many good characteristics: low friction, natural lubricity, and resistant to many chemicals. Nylon retainers are capable of continuous use up to 250°F, but many other components in the bearing may prevent. Some manufacturers utilize a steel riveted ball riding retainer.

Mounted Roller



Stamped Steel

A one-piece, low carbon steel stamping. This type of retainer provides roller guidance as well as retaining rolling elements with the inner ring.

Bearing Retainers Continued

Unmounted Roller – McGill



Stamped Steel Retainer – SPHERE-ROL

One-piece, low carbon steel stamping. Land riding design only provides roller spacing and helps provide greater speed capability.



Stamped Steel Retainer – CAGEROL

One-piece, low carbon steel stamping. Retains and spaces the rollers. Provides roller guidance to prevent skewing. Allows for an increased lubricant reservoir. Minimizes radial play of rollers to ease assembly. Helps provide higher speed capability.

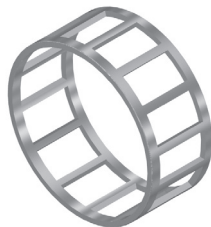


Stamped Steel Retainer – Metric CAMROL

One-piece, low carbon steel stamping. Retainers are heat treated to allow for roller guidance. The retainers are designed with two rollers per pocket (except 13, 16, and 19mm OD's) to help maximize static and dynamic load ratings, yet still offer the advantages of a caged construction.

Note: Inch CAMROL is a full complement bearing design that does not utilize a retainer.

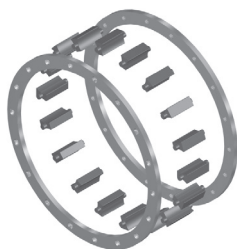
Unmounted Roller - Rollway



Stamped Steel Retainer

A one-piece, low carbon steel stamping. Supplied on some bearings with snap ring retention. (TRU-ROL numbering suffix of "B") Recommended for low speed operations.

Bearing Retainers Continued



Segmented Steel Retainer

A built-up type of retainer utilizing low carbon steel segments rigidly held between stamped, low carbon steel end plates. This is the standard retainer supplied with commercial bearings identified with the TRU-ROL numbering system. Recommended for moderate speed applications.



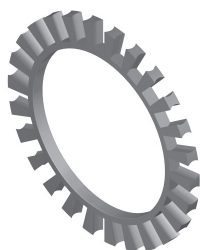
Two-Piece Retainer

This type of retainer is fabricated from brass. This is the standard retainer supplied with Rollway bearings identified with the MAX numbering system, ISO numbering system, TRU-ROL numbering system when the "MR" suffix is used, and any bearing with bore size over 180mm. Recommended for moderate to high speed applications.



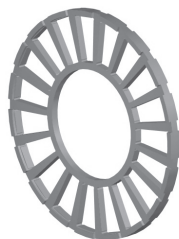
One-Piece Retainer

This land piloting retainer is fabricated from brass or steel with radial retention of the rollers provided by closing the roller "pocket" with small projections formed by mechanically upsetting the retainer material. This retainer design is typically made to order for high speed applications, though it is applicable for other applications.



Cylindrical Thrust - Machined Brass

Thrust bearing retainers are machined from centrifugally cast brass. The retainers for all cylindrical roller thrust bearings are designed to be roller riding. The contoured roller pockets are accurately machined at right angles to the thrust force, which will be applied to the bearing. The rollers are retained in the assembly by a steel ring pinned to the outside diameter of the retainer.



Tapered Thrust – Machined Brass

Taper thrust bearing retainers are machined from a single piece of centrifugally cast brass. The retainer is designed to pilot on the thrust plates' flanges. The roller pockets are accurately machined at right angles to the thrust force which will be applied to the bearing. The T-Flat retainers are "pin through" style (pins extend through the center of the roller). The retainer consists of two steel rings through which the hardened steel pins are secured. An alternate design is a retainer machined from a single piece of centrifugally cast brass with the rollers retained by two pins.

Bearing Storage

Cleanliness and accuracy are stressed in all phases of bearing manufacture to help provide a clean and precise mechanical instrument. It is therefore essential the same care be taken in subsequent shipping, storage, and handling, as well as in mounting to make sure of the ultimate in bearing performance.

After completion, each bearing is thoroughly cleaned, preserved and packaged in a shipping carton with proper identification.

Lint-free commercial packing such as polystyrene foam packaging materials, crumpled newspaper or batting material may be used to cushion cartons of bearings in shipping containers. Materials having fine particulate, such as saw dust, are not recommended as such material may contaminate the bearings. The wrappings should never be removed from bearings until they are ready to be mounted. For those bearings preserved with a protective neutral compound, it is generally unnecessary to remove this coating as it will normally mix with any type lubricant.

When necessary to keep bearings in storage, they should be placed in a dry, cool location, and provision should be made to utilize the old stock before using new stock. Avoid dropping or other large impacts to the bearing as these forces will create damage to the bearing components and result in less than ideal bearing life.

ABMA and ISO

ABMA

These letters refer to American Bearing Manufacturers' Association - an organization comprised of the leading bearing and bearing-related manufacturers in the United States. The main purpose of the ABMA is to bring about standardization within the industry and to pass these benefits on to the bearing users.

ISO

ISO is the name for the International Organization for Standards. ISO is a worldwide federation of national standards bodies. The mission of ISO is to promote the development of standardization and related activities in the world. ISO's work results in international agreements which are published as International Standards.