CYLINDRICAL AND TAPERED ROLLER BEARINGS
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Cylindrical Roller Bearings

**THE M SERIES** designated by the letter M satisfies most commercial applications and is available in a broad range of sizes and types up to 20" (508 mm) outside diameter.

**THE MAX-PAK OR W-60000 SERIES** is designed for applications with very heavy radial loads and where space for the bearing may be limited. The envelope dimensions are the same as the M series.

**THE MOJ SERIES** offers economical journal roller assemblies without inner or outer rings for operation in very limited space.

**SPECIAL BEARINGS** are available for the chain and mast guide, steel mill, rear wheel and pinion applications. Other bearings can be engineered for special requirements.
SINGLE ROW TAPERED ROLLER BEARINGS are available in many different series with straight and flanged cups up to 24" (610 mm) diameter.

TWO ROW TAPERED ROLLER BEARINGS are available in many different series and configurations up to 20" (508 mm) outside diameter.
### Glossary of Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Cylindrical bearing inner ring raceway diameter</td>
</tr>
<tr>
<td>a₁</td>
<td>Life adjustment factor for reliability</td>
</tr>
<tr>
<td>a₂</td>
<td>Life adjustment factor for material</td>
</tr>
<tr>
<td>a₃</td>
<td>Life adjustment factor for lubrication</td>
</tr>
<tr>
<td>a₄</td>
<td>Life adjustment factor for misalignment</td>
</tr>
<tr>
<td>a₅</td>
<td>Life adjustment factor for load zone size</td>
</tr>
<tr>
<td>B</td>
<td>Bearing inner ring bore</td>
</tr>
<tr>
<td>C</td>
<td>Cylindrical bearing outer ring raceway diameter</td>
</tr>
<tr>
<td>Cr</td>
<td>Bearing dynamic load rating (ISO)</td>
</tr>
<tr>
<td>Cor</td>
<td>Bearing static load rating (ISO)</td>
</tr>
<tr>
<td>CCW</td>
<td>Counterclockwise</td>
</tr>
<tr>
<td>CF</td>
<td>Centrifugal force</td>
</tr>
<tr>
<td>CW</td>
<td>Clockwise</td>
</tr>
<tr>
<td>D</td>
<td>Bearing outside diameter</td>
</tr>
<tr>
<td>E</td>
<td>Modulus of elasticity</td>
</tr>
<tr>
<td>e</td>
<td>Equivalent load factor</td>
</tr>
<tr>
<td>F</td>
<td>Force</td>
</tr>
<tr>
<td>Fₐ</td>
<td>Thrust (Axial) component of Fₙ or axial force</td>
</tr>
<tr>
<td>Fₙ</td>
<td>Normal force</td>
</tr>
<tr>
<td>Fₚ</td>
<td>Radial force</td>
</tr>
<tr>
<td>Fₛ</td>
<td>Separating component of Fₙ</td>
</tr>
<tr>
<td>Fₜ</td>
<td>Tangentail component of Fₙ</td>
</tr>
<tr>
<td>fₚₙ</td>
<td>Preload factor</td>
</tr>
<tr>
<td>G</td>
<td>Subscript for ring gear</td>
</tr>
<tr>
<td>H</td>
<td>Housing O.D.</td>
</tr>
<tr>
<td>HP</td>
<td>Horsepower</td>
</tr>
<tr>
<td>IF</td>
<td>Interference fit</td>
</tr>
<tr>
<td>J</td>
<td>Hollow shaft I.D.</td>
</tr>
<tr>
<td>K</td>
<td>Ratio of radial to thrust rating for tapered roller bearings</td>
</tr>
<tr>
<td>L₁₀</td>
<td>Bearing life @ 90% reliability level</td>
</tr>
<tr>
<td>Lₙ</td>
<td>Bearing life @ n reliability level</td>
</tr>
<tr>
<td>L'₁₀</td>
<td>Adjusted bearing life @ 90% reliability level</td>
</tr>
<tr>
<td>L'ₙ</td>
<td>Adjusted bearing life @ n reliability level</td>
</tr>
<tr>
<td>LH</td>
<td>Left hand</td>
</tr>
<tr>
<td>MPD</td>
<td>Mean pitch diameter</td>
</tr>
<tr>
<td>Nₙ</td>
<td>Number of teeth in gear “n”</td>
</tr>
<tr>
<td>n</td>
<td>Subscript index</td>
</tr>
<tr>
<td>P</td>
<td>Equivalent radial load for tapered roller bearings</td>
</tr>
<tr>
<td>Pₚ</td>
<td>Subscript for pinion</td>
</tr>
<tr>
<td>PD</td>
<td>Pitch diameter</td>
</tr>
<tr>
<td>p</td>
<td>Radial contact pressure</td>
</tr>
<tr>
<td>Q</td>
<td>Torque</td>
</tr>
<tr>
<td>Rₙ</td>
<td>Bearing “n” radial reaction</td>
</tr>
<tr>
<td>RH</td>
<td>Right hand</td>
</tr>
<tr>
<td>r</td>
<td>Radius</td>
</tr>
<tr>
<td>S</td>
<td>Rotational speed (rpm)</td>
</tr>
<tr>
<td>T₁</td>
<td>Belt tension-tight side</td>
</tr>
<tr>
<td>T₂</td>
<td>Belt tension-loose side</td>
</tr>
<tr>
<td>TRₙ</td>
<td>Thrust reaction of tapered bearing “n”</td>
</tr>
<tr>
<td>W</td>
<td>Gear face width</td>
</tr>
<tr>
<td>Wt</td>
<td>Weight</td>
</tr>
<tr>
<td>Y₁</td>
<td>Axial load factor</td>
</tr>
<tr>
<td>Y₂</td>
<td>Axial load factor</td>
</tr>
<tr>
<td>α (alpha)</td>
<td>1/2 included cup angle</td>
</tr>
<tr>
<td>β (beta)</td>
<td>Pitch angle for straight, zerol, and spiral bevel gears</td>
</tr>
<tr>
<td>β (beta)</td>
<td>Face angle of hypoid pinion and root angle of hypoid gear</td>
</tr>
<tr>
<td>δ₁ (delta)</td>
<td>Change in inner ring raceway diameter</td>
</tr>
<tr>
<td>δ₀ (delta)</td>
<td>Change in outer ring raceway diameter</td>
</tr>
<tr>
<td>ν (nu)</td>
<td>Poisson’s ratio</td>
</tr>
<tr>
<td>Σ (sigma)</td>
<td>Summation</td>
</tr>
<tr>
<td>ϕ (phi)</td>
<td>Normal pressure angle</td>
</tr>
<tr>
<td>ϕ₀ (phi)</td>
<td>Pressure angle in plane of rotation</td>
</tr>
<tr>
<td>ψ (psi)</td>
<td>Helix or spiral angle</td>
</tr>
</tbody>
</table>
INTRODUCTION

The selection of the proper bearings for all mechanical systems is essential to the functional and commercial success of that system. The bearings must not only be of the right type, but also the correct size to assure reliability and cost effectiveness. The bearings must be installed properly, supplied with the correct lubricant, and provided with a compatible environment for the system to be successful. This catalog is designed to provide guidelines for the engineer to follow in making proper bearing selection and in establishing an operating environment that will lead to reliable system performance. Because it is impossible to cover all aspects of bearing selection within any text due to the vast number of variables encountered, NTN maintains a staff of Bearing Application Engineers to assist customers in making bearing selections for applications of all kinds. We urge our customers to take advantage of this service. Application engineering assistance may be obtained by calling NTN Sales, or by contacting:

NTN Bearing Corporation of America
Application Engineering Department
1600 E. Bishop Court
Mt. Prospect, IL 60056
847-298-7500 (Fax: 847-294-1208)

BEARING LIFE DEFINITION

All roller bearings have finite lives. Therefore, it is necessary to develop techniques to estimate their lives. Theoretical bearing life is defined as the time (measured in revolutions) to the initial occurrence of rolling contact fatigue on either raceway or any rolling element. Rolling contact fatigue is subsurface initiated damage that occurs after many revolutions of the bearing. When a bearing is rotated under load, the raceways and rolling elements are subjected to cyclic Hertzian stresses as they pass through the load zone. After millions of cycles, microscopic cracks form beneath the bearing surfaces. As the bearing continues to operate, the cracks eventually propagate to the surface causing small particles of steel to break away from the surface. This type of damage is called spalling. See Figure 1.

The laboratory criterion used to define the fatigue life of a bearing is the time period until either raceway or any rolling element develops a spall with an area of 0.01 in² (6 mm²). This definition is necessary for a meaningful comparison of bearing lives under controlled conditions. However, in many applications, a spall of this size may have no immediate or short term adverse effect on total system performance. The size of a spall before a bearing becomes unsuitable for further use is dependent on the nature of the application and how much noise, vibration, or both can be tolerated. The time when a bearing becomes unsuitable for further service is sometimes referred to as its useful life in contrast to its fatigue life. The length of the period between the fatigue life and the useful life is a function of the stress level, the steel alloy and its heat-treatment, and the lubrication. Further information on this subject may be obtained from the NTN Application Engineering Department.

It is impossible to predict the exact fatigue life of an individual bearing. A group of apparently identical bearings subjected to the same conditions of load, speed, lubrication, and temperature will produce a considerable scatter of fatigue lives. Therefore, statistical methods are required to predict the life of the group. The Weibull distribution is generally used to evaluate these types of data. It is common practice to specify the life of the group at the L₁₀ level which is the life that 90% of the group will achieve or exceed. Stating this another way, 10% of the group will have experienced fatigue of one or more components at the L₁₀ level.

Many other factors besides fatigue may effect bearing performance. These include lubrication, misalignment, contamination, internal operating clearance, etc. Evaluation of these parameters is addressed in the life adjustment factor portion of the Bearing Life Calculations section, page 14.

FIGURE 1
BEARING LOAD RATINGS

As previously defined, the fatigue life of a rolling bearing is determined by the number of revolutions under load that a bearing experiences prior to the initiation of rolling contact fatigue. Because of the natural scatter of lives in a group of bearings operating under identical conditions, the life of the group is specified at some reliability level, usually 90%. In order to evaluate the life of a bearing in a specific application, a radial load rating has been established for each bearing size. This load rating is based on a 90% survival expectation of a group of bearings operating under a constant radial load for a specific number of revolutions. It is common industry practice to specify the load rating for roller bearings at 1 million revolutions (500 hrs @ 33 1/3 rpm). This rating is designated by the symbol “C_r”. These load ratings are tabulated in the appropriate product line sections of this catalog. The use of the load rating to estimate bearing life for a specific application is covered in the Bearing Life Calculations section, page 14.

BEARING SELECTION

Introduction

The prime factors in bearing selection are a total system reliability for its design life and the cost effectiveness. To achieve such reliability, the bearings must be of the proper type and size. The selection process must consider all factors which will affect bearing performance and cost. These factors include:

- Magnitude and direction of loads
- Speed of rotation
- Required life
- Available Space
- Lubrication
- Shaft and housing designs
- Alignment
- Adjustment
- Temperature
- Environment

It is impossible to select any one of these factors as being the most critical. All must be considered in every bearing application. Each application will dictate their relative importance which will in turn guide the engineer toward proper bearing selection. It is recommended that the NTN Application Engineering Department be consulted on all bearing applications.

Life Calculation Methods

Standard methods for estimating bearing lives have been developed for most applications. Such methods include:

- Maximum horsepower
- Skid torque
- Tractive effort
- Design load
- Work schedule

Whenever possible, the bearing selection for new applications should be based on a comparison of the calculated lives of bearings in similar successful applications using the same method. For example, in truck applications, the wheel bearing life calculations may be based on the design GVW (Gross Vehicle Weight) at 40 mph and the power train on tractive effort methods or specific route schedules. Design bogies are established for each method to assure commercial success of the vehicle. This procedure has proven to be successful in selecting bearings for many different applications. Ongoing programs update calculation methods to make them more realistically correlate with actual field conditions. An engineer must be careful when comparing new and old application calculations that the methods and the bearing ratings are identical. NTN-Bower has established life goals (measured in hours or vehicle roll miles) based on the calculated loads and speeds from the standard evaluation methods. This information is available from the NTN Application Engineering Department.
Load Analysis

In many applications, the load and speed considerations are critical to the bearing selection. Methods of analyzing load sources and the resolution of these loads into bearing reactions are presented below. Frequently, the methods to evaluate the magnitude of the load and the speed are based on a history of performance of similar equipment. Such standard approaches are essential when the bearings are exposed to a full spectrum of loads and speeds and/or a wide variety of work schedules.

The first step in the process is to determine the magnitude and direction of the loads which the bearings are required to support. Loads may originate from a variety of sources including dead weight, belts, chains, sprockets, gears, imbalance, etc. Each load source is discussed below:

**Dead weight** may be either concentrated or distributed over a given area. For most bearing applications, distributed loads may be resolved into a single concentrated load acting vertically through the center of gravity. For example, the location of the center of gravity in an automobile will determine load distribution between the four wheels. The load at each wheel is distributed over the area of contact between the tire and the road. This load may be considered concentrated at the geometric center of the contact area acting normal to the road surface.

**Belts** are encountered in a wide variety of industrial applications. They are used for both power transmission and conveyor systems. Power transmission belts may be flat, “V” sectioned, or caged for timing applications. Conveyor belts are normally flat for moving palletized loads or contoured to a trough shape for bulk materials. Friction between the drive pulley and the belt transmits the motive power in all applications except for caged timing belts. To assure that sufficient frictional forces exist, the belts must be installed with the proper amount of preload tension. Belt manufacturers provide guidelines to establish the correct value for the preload.

The resultant force created on the drive and idler pulleys in any belt system must include the preload tension, the forces caused by the driving horsepower, and the weight of the material being transported in the case of conveyor systems. When the belt wrap is around 180°, formula (1) approximates the force which must be supported by the pulley bearings.

\[
F = T_1 + T_2 = \frac{126050 \times HP \times f_{pl}}{S \times PD}
\]

Where:
- \( T_1 \) = Tension on the tight side lb.
- \( T_2 \) = Tension on the slack side lb.
- \( HP \) = Horsepower
- \( S \) = Speed in rpm
- \( PD \) = Pulley pitch diameter in.
- \( f_{pl} \) = Preload factor
  - 1.1 to 1.2 caged belts
  - 1.5 to 2.0 V-belts
  - 2.0 to 4.0 flat belts

The relatively wide ranges for the \( f_{pl} \) factor are due to the variations in field practices for setting the preload on the belt. Experience with similar installations is necessary for a closer approximation for \( f_{pl} \). Note that in static conditions \( T_1 = T_2 = \) preload tension. When the belt wrap varies significantly from 180°, the vector sum of \( T_1 \) and \( T_2 \) should be used to calculate \( F \).

**Chain and sprocket** drives do not rely on friction to transmit the motive power to the chain and therefore may have zero or only a small preload. Formula (1) given above for belts is still valid for many chain and sprocket drives using \( f_{pl} \) in the range of 1.0 to 1.2. Some sprocket drives, such as used in crawler tractors, may have a heavy preload from hydraulic and/or mechanical systems to keep the track taut. The \( f_{pl} \) factor must be significantly increased to account for this preload. For further information, consult with the NTN Application Engineering Department.

**Spur gears** are the most common type used for positive power transmission between parallel shafts. The faces of the teeth are nearly always of involute form with a pressure angle of 14.5°, 20°, or 25°. The tooth surfaces are parallel to the axis of rotation.
The tangential component is sometimes referred to as the working component since it is directly proportional to the torque transmitted by the shaft. Spur gears may also be operated at a spread center distance in which case the operating pressure angle will increase above the theoretical value. In some bearing load calculations, an engineer may find it convenient to use the normal force.

**Helical gears** are similar to spur gears except that the teeth form a helix at the pitch diameter of the gear. Helical gears are formed by either hobbing or shaping. The tooth profile and the pressure angle are defined normal to the tooth surface for hobbed gears and in the plane of rotation for shaped gears. The two types will not mesh with each other.

**Straight Bevel, Zerol Bevel, Spiral Bevel and Hypoid Gears** are used to transmit power between non-parallel shafts; the most common angle between the shafts being 90°. The axes of rotation of the straight, zerol, and spiral bevel gears are coplanar while the axes of the hypoid gears are offset. The pitch diameter is defined at the heel (large end) of the ring gear. Because the load is distributed across the face of the tooth, the mean pitch diameter (defined in equation 11) is used in calculating the gear forces. The mean pitch diameter of the pinion is calculated by equation 12. The tangential components of the gear force are determined for the pinion and the gear by equations 13 and 14. Table I provides the formulas for the separating and thrust components of the ring gear and pinion forces.
TABLE I

<table>
<thead>
<tr>
<th>Driving Member Hand &amp; Rotation</th>
<th>Axial Component (Thrust)</th>
<th>Separating Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH/CW or LH/CCW</td>
<td>Driving Member</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$F_a = \frac{F_t}{\cos \psi}$ (tan $\phi \sin \beta - \sin \psi \cos \beta$)</td>
<td>$F_s = \frac{F_t}{\cos \psi}$ (tan $\phi \cos \beta + \sin \psi \sin \beta$)</td>
</tr>
<tr>
<td></td>
<td>Driven Member</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$F_a = \frac{F_t}{\cos \psi}$ (tan $\phi \sin \beta + \sin \psi \cos \beta$)</td>
<td>$F_s = \frac{F_t}{\cos \psi}$ (tan $\phi \cos \beta - \sin \psi \sin \beta$)</td>
</tr>
<tr>
<td>RH/CCW or LH/CCW</td>
<td>Driving Member</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$F_a = \frac{F_t}{\cos \psi}$ (tan $\phi \sin \beta - \sin \psi \cos \beta$)</td>
<td>$F_s = \frac{F_t}{\cos \psi}$ (tan $\phi \cos \beta - \sin \psi \sin \beta$)</td>
</tr>
<tr>
<td></td>
<td>Driven Member</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$F_a = \frac{F_t}{\cos \psi}$ (tan $\phi \sin \beta + \sin \psi \cos \beta$)</td>
<td>$F_s = \frac{F_t}{\cos \psi}$ (tan $\phi \cos \beta + \sin \psi \sin \beta$)</td>
</tr>
</tbody>
</table>

1. The appropriate values of $\phi$, $\psi$, and $\beta$ for the driving and driven member must be used, respectively.
2. A positive (+) value indicates the gears are separating.
3. A negative (−) value indicates the gears are being drawn together.
4. The load point on a hypoid pinion is determined from the offset and the MPD$_G$ as shown in Figure 6.

$$x = \left[ \frac{(\text{MPD}_G)}{2} - \text{offset}^2 \right]^{1/2} \quad (15)$$
5. For straight and zero bevel gears, $\psi = 0$, therefore simplifying the equations in Table I.
6. For hypoid gears, $\beta$ equals the face angle of the pinion and the root angle of the gear.
An Imbalance Force is generated when a mass rotates on an axis offset from its center of gravity. This imbalance, called a centrifugal force, will put an additional load on the support bearings. This load direction will remain stationary in regard to the rotating ring. The magnitude of the centrifugal force may be determined from equation 16.

\[
C.F. = \frac{W \times r \times S^2}{3.52 \times 10^4} \text{ lb.}
\]  

The evaluation of a combination of rotating loads and stationary loads is a complex calculation and should be referred to the NTN Application Engineering Department.

THE CALCULATION OF BEARING LOADS

Before the actual bearing loads can be calculated, the bearing spread must be defined. For a shaft supported on two bearings, the bearing spread is defined as the distance between the two points which are considered to be the center of support for the load on the bearing. For cylindrical roller bearings, the point is defined as the intersection of the axis of rotation of the bearings and a plane normal to the axis through the midpoint of the roller length. See Figure 7.

For tapered roller bearings, the load on the bearing is considered to be normal to the shaft at a point which is the intersection of the axis of rotation and a line which is projected normal to the cup surface from the midpoint of the roller contact. This point is called the effective load center for a single row tapered roller bearing and is located at dimension “a” from the back face of the cone. This dimension “a” is tabulated for each cone in the dimensional data of the series listing of tapered roller bearings. For double row tapered roller bearings, the geometric center of the pair is used as the load center unless the external thrust load is sufficient to unseat one row in which case the effective center of the loaded row is used.

Single row tapered roller bearings may be mounted in either a direct mounting (Figure 8) or an indirect mounting (Figure 9). The direct mounting is frequently found in countershafts of transmissions in order to provide and end play adjustment through the stationary cups. The indirect mounting is common in wheel assemblies in order to provide greater stability to the assembly and, also, to allow for end play adjustment through the stationary cones. Certain thermal considerations may also influence the design and/or the end play recommendation. For further information, please contact the NTN Application Engineering Department.
A SIMPLIFIED METHOD FOR FIGURING BEARING LOADS

The simplified method for solving bearing loads described below is merely a condensed or consolidated version of standard methods of basic mechanics. It makes full use of the basic laws of equilibrium, namely, for any system of forces:

\[
\begin{align*}
\Sigma F &= \text{Summation of forces} = 0 \\
\Sigma M &= \text{Summation of moments about an arbitrary point} = 0
\end{align*}
\]

Combining these laws with the Pythagorean theorem, the required bearing loads are easily determined. It must be remembered that the applied loads and moments in conjunction with the bearing reactions create equilibrium for the system. The following rules provide an orderly procedure which will minimize the chance of error.

1. Break all forces into components that may be projected onto one of two convenient planes passing through the shaft centerline and at right angles to each other. These convenient planes will normally be horizontal and vertical and will, hereafter, be referred to as such.

2. The sign of the moment of a force about a point in its plane will be regarded as positive if the sense of rotation is counterclockwise and negative if the sense of rotation is clockwise.

3. Always use the right hand bearing as the moment-center.

4. Solve for the left bearing load components by taking moments of all the forces about the right hand bearing and DIVIDING THEIR ALGEBRAIC SUM BY THE BEARING SPREAD. Combine the equations for the horizontal and vertical components by the Pythagorean theorem and solve for the bearing load.

Example 1:

\[
R_A = \left( \frac{-F_1 \times a + F_2 \times c}{l} \right)^2 + \left( \frac{F_2 \times b - F_4 \times d}{l} \right)^2 \right)^{\frac{1}{2}}  \tag{17}
\]

In any pair of bearings, the second bearing load \(R_B\) may be found by the summation of forces. This summation will include the components of \(R_A\), remembering that the reaction of \(R_A\) must be used as the load on the shaft, hence, the load components of \(R_A\) must be multiplied by minus one.

\[
R_B = \left( (-F_1 + F_3 \mp V_A)^2 + (F_2 - F_4 \mp H_A)^2 \right)^{\frac{1}{2}}  \tag{18}
\]

By locating equation 18 near equation 17, the equation for \(R_B\) may be set up by taking the load figures directly from the equation for \(R_A\) without further reference to the diagram.

\[
R_B = \left( \frac{-F_1 \times a + F_2 \times c}{l} \right)^2 + \left( \frac{F_2 \times b - F_4 \times d}{l} \right)^2 \right)^{\frac{1}{2}}  \tag{17}
\]

\[
R_B = \left( (-F_1 + F_3 \mp V_A)^2 + (F_2 - F_4 \mp H_A)^2 \right)^{\frac{1}{2}}  \tag{18}
\]

Note that the sign of the individual forces is the same for \(R_B\) as it was in \(R_A\) while the signs for the components \(V_A\) and \(H_A\) have been reversed as previously explained.
1. **Thrust Forces.** Thrust forces are reduced to components in the two specified planes and moments are taken about the right hand bearing to solve $R_A$. When solving for the second bearing load, it must be remembered that the thrust components are parallel to the axis of the shaft and, therefore, do not enter into the summation of the horizontal or vertical forces.

![Example 2 diagram](image)

$$R_A = \left[ \left( \frac{-V_A}{l} \right)^2 + \left( \frac{-H_A}{l} \right)^2 \right]^{\frac{1}{2}} \quad (19)$$

$$R_B = [(+V_A)^2 + (+H_A)^2]^{\frac{1}{2}} \quad (20)$$

Combine examples 1 and 2.

2. **Overhanging Forces.** Definition: An overhanging force is any force so located (1) as to not be between the two support points, and (2) as to not have one of the supports between it and the moment-center. Thus, when the right hand support is used as the moment-center, all forces to the right of the right hand support (moment-center) are overhanging forces.

**Rule:** When carrying the value of the overhanging force down to solve for $R_B$, the sign must be reversed. This is obvious from the fact that a shaft loading consisting of only an overhanging force, the two support reactions are of the opposite sense. It may be necessary to refer to a diagram here to avoid missing an overhanging force with reference to $R_B$.

![Example 3 diagram](image)

$$R_A = \left[ \left( \frac{F_5 \times h - F_7 \times m}{l} \right) + \left( \frac{\pm V_A}{l} \right)^2 \right]^{\frac{1}{2}} \quad (23)$$

$$R_B = [(F_5 + F_7 + V_A)^2 + (-F_6 + H_A)^2]^{\frac{1}{2}} \quad (24)$$

Note: By definition, $F_6$ and $F_7$ are overhanging forces and therefore require a change in sign in solving for $R_B$ by summation of forces. Also, by definition, $F_5$ is not considered an overhanging force.
Cylindrical Roller Bearings

Cylindrical roller bearings with opposed solid ribs on the inner and outer rings will support light to moderate thrust loads. The maximum thrust load that a cylindrical roller bearing will support is defined later in this section. Field experience and laboratory tests have proven that as long as the applied thrust load is less than the applied radial load and less than the limiting thrust rating, the fatigue life of the bearing will not be adversely affected. Therefore, the fatigue life of a cylindrical roller bearing under such combined loading conditions will be equivalent to the life under the applied radial load. The Equivalent Radial Load concept is not applicable to cylindrical roller bearings.

Tapered Roller Bearings

Tapered roller bearings, due to their basic design, generate a thrust reaction when subjected to a radial load. The magnitude of this thrust reaction is a function of the load, the included cup angle, and the size of the load zone within the bearing. For convenience in load and life calculations, a Y₂ factor has been assigned to each tapered bearing series. This factor is defined for single row bearings as:

\[ Y_2 = 0.4 \cot \alpha \]  

Where \( \alpha = 1/2 \) included cup angle

When the load on bearing (A) is pure radial (\( R_A \)) and the load zone within the bearing is 180° or less, the approximate thrust reaction (\( TR_A \)) is:

\[ TR_A = \frac{0.50 R_A}{Y_2 A} \]  

(28)

When the load on bearing (B) approaches 360° due to a combined radial load (\( R_B \)) and an external thrust load, its approximate thrust reaction is:

\[ TR_B = \frac{0.60 R_B}{Y_2 B} \]  

(29)

These thrust reactions are a critical part of the Equivalent Radial Load equations for tapered roller bearings.

The general ABMA equation for the equivalent radial load is:

\[ P = X F_r + Y F_a \]  

(30)

Where:  
\( P = \) Equivalent radial load  
\( F_r = \) Applied radial load  
\( F_a = \) Applied thrust load  
\( X = \) Radial load factor  
\( Y = \) Thrust load factor

Suggestions:

1. If the overhanging forces are always located at the end of each component in the equation, the possibility of overlooking them and the accompanying sign change will be reduced.

2. It will be much easier to learn one set of rules and always use the right hand support as the moment-center; however, the left hand support may be used if it is necessary. When using the left hand support as the moment-center, the signs for clockwise and counterclockwise rotation must be reversed. All other rules remain the same. Be sure to follow the strict definition of an overhanging force.

**COMBINED LOADING EQUATIONS**

Bearings are frequently required to support a combination of radial and thrust loads. In order to calculate the bearing life under such conditions, it is necessary to calculate an Equivalent Radial Load. The theoretical bearing life under combined radial and thrust loading conditions will be the same as that which would be expected under a pure radial load equal to the Equivalent Radial Load.
The values of X and Y are determined using Table 2:

**TABLE 2**

<table>
<thead>
<tr>
<th>Bearing Config.</th>
<th>( \frac{F_a}{F_r} \leq e )</th>
<th>( \frac{F_a}{F_r} &gt; e )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>X</td>
<td>Y</td>
</tr>
<tr>
<td>Double</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>0.40</td>
<td>( Y_2 )</td>
</tr>
</tbody>
</table>

Values for e, \( Y_1 \), and \( Y_2 \) are listed in the tapered roller bearing dimension tables.

In the calculation of the equivalent radial load for a tapered roller bearing, the algebraic sum of all external thrust loads and the thrust reactions of the bearings must be considered. All factors are automatically included in the Equivalent Radial Load formulas shown in Table 3 through 5. Note, when the calculated Equivalent Radial Load is less than the applied radial load, the radial load alone is used to estimate the bearing life.

**Equivalent Radial Load Formulas**

**Single Row Mounting**

**TABLE 3**

<table>
<thead>
<tr>
<th>Thrust Condition</th>
<th>Equivalent Radial Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{0.5R_A}{Y_A} \leq \frac{0.5R_A}{Y_B} + \frac{(F_a)_A}{Y_A} )</td>
<td>( P_A = 0.4R_A + Y_A \left( \frac{0.5R_A}{Y_B} + \frac{(F_a)_A}{Y_A} \right) )</td>
</tr>
<tr>
<td>( \frac{0.5R_A}{Y_A} &gt; \frac{0.5R_A}{Y_B} + \frac{(F_a)_A}{Y_A} )</td>
<td>( P_A = R_A )</td>
</tr>
</tbody>
</table>

**Two Row Mounting - Identical Series**

**TABLE 4**

<table>
<thead>
<tr>
<th>Thrust Condition</th>
<th>Equivalent Radial Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>( (F_a)_A &lt; \frac{0.6R}{Y_A} )</td>
<td>( P_A = \frac{R}{2} + 0.83 \frac{Y_B}{Y_A} (F_a)_A ) ( P_B = 0 )</td>
</tr>
<tr>
<td>( (F_a)_A &gt; \frac{0.6R}{Y_A} )</td>
<td>( P_A = 0.4R + Y_A (F_a)_A )</td>
</tr>
</tbody>
</table>

**Two Row Mounting - Dissimilar Series**

**TABLE 5**

<table>
<thead>
<tr>
<th>Thrust Condition</th>
<th>Equivalent Radial Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>( (F_a)_A &lt; \frac{0.6R}{Y_A} )</td>
<td>( P_A = \frac{Y_A}{Y_A + Y_B} (R + 1.67 Y_B (F_a)_A) ) ( P_B = 0 )</td>
</tr>
<tr>
<td>( (F_a)_A &gt; \frac{0.6R}{Y_A} )</td>
<td>( P_A = 0.4R + Y_A (F_a)_A )</td>
</tr>
</tbody>
</table>

Where:
- \( R \) = Total radial load—lbs.
- \( R_A \) = Radial load, brg. A—lbs.
- \( R_B \) = Radial load, brg. B—lbs.
- \( (F_a)_A \) = External thrust on brg. A*—lbs.
- \( Y_A \) = Axial load factor brg. A
- \( Y_B \) = Axial load factor brg. B
- \( P_A \) = Equivalent radial load, brg. A—lbs.
- \( P_B \) = Equivalent radial load, brg. B—lbs.

* When there are no external thrust loads \( F_a = 0 \) in equations above.
LOAD RATINGS AND FATIGUE LIFE

Bearing Life

Even in bearings operating under normal conditions, the surfaces of the raceway and rolling elements are constantly subjected to stresses which cause flaking of these surfaces to occur. This flaking is due to material fatigue, and will eventually cause the bearings to fail. The effective life of a bearing is usually defined in terms of the total number of revolutions a bearing can undergo before flaking of either the raceway surface or the rolling element surfaces occurs.

Other causes of bearing failure are attributed to problems such as seizing, abrasions, cracking, chipping, rust, etc. However, the “causes” of bearing failure are usually themselves caused by improper installation, insufficient or improper lubrication, faulty sealing or inaccurate bearing selection. Since these “causes” of bearing failure can be avoided by taking the proper precautions, and are not simply caused by material fatigue, they are considered separately from the flaking aspect.

Basic Rated Life & Basic Dynamic Load Rating

Basic rated bearing life is based on a 90% statistical model which is expressed as the total number of revolutions 90% of the bearings in an identical group, subjected to identical operating conditions, will attain or surpass before flaking due to material fatigue occurs. For bearings operating at fixed constant speeds, the basic rated life (90% reliability) is expressed in the total number of hours of operation.

The basic dynamic load rating is an expression of the load capacity of a bearing based on a constant load which the bearing can sustain for one million revolutions (the basic life rating). The basic dynamic load ratings given in the bearing tables of this catalog are for bearings constructed of NTN standard bearing materials, using standard manufacturing techniques. Please consult NTN for basic load ratings of bearings constructed of special materials or using special manufacturing techniques.

The relationship between the basic rated life, the basic dynamic load rating and the bearing load is given in the formula

$$L_{10} = \left( \frac{C_r}{P} \right)^{10/3}$$  \hspace{1cm} (31)

Where:

- $L_{10}$: Basic rated life in $10^6$ revolutions
- $C_r$: Basic dynamic radial rated load
- $P$: Equivalent radial load

The basic rated life can also be expressed in terms of hours of operation, and is calculated by modifying the equation above as follows:

$$L_{10h} = \frac{10^6}{60 \times n} \left( \frac{C_r}{P} \right)^{10/3}$$  \hspace{1cm} (32)

Where:

- $L_{10h}$: Basic rated life in hours
- $n$: Rotational speed; (rpm)

Adjusted Life Rating Factor

The basic bearing life rating (90% reliability factor) can be calculated through the formulas mentioned above. However, in some applications a bearing life factor of over 90% reliability may be required. To meet this requirement, bearing life can be lengthened by the use of special bearing materials or special construction techniques. In addition, the elastohydrodynamic
lubrication theory shows that bearing operating conditions (lubrication, temperature, speed, etc.) exert an effect on bearing life as well. All these factors are taken into consideration when calculating bearing life, and using the life adjustment factor as prescribed in ISO 281, the adjusted bearing life can be arrived at:

\[
L_{na} = a_1 \times a_2 \times a_3 \times a_4 \times a_5 \times 10^6 \left( \frac{C_i}{P_r} \right)^{10/3} \tag{33}
\]

Where:

- \(L_{na}\): Adjusted life rating in hours; adjusted for reliability, material and operating conditions
- \(a_1\): Reliability factor
- \(a_2\): Material/construction factor
- \(a_3\): Lubrication factor
- \(a_4\): Misalignment factor
- \(a_5\): Load distribution factor

\(a_1\)—Reliability Factor

As previously defined, normal industry practice and the radial load ratings in this catalog are based on the 90% reliability level. In some applications, a more stringent reliability level may be required. As defined by ABMA, the reliability factor is:

\[
a_1 = 4.48 \times \left[ \ln \left( \frac{100}{R} \right) \right]^{2/3} \tag{34}
\]

For convenience, specific values are shown in Table 6.

<table>
<thead>
<tr>
<th>Reliability Level</th>
<th>Life Adjustment Factor</th>
<th>(L_{na})</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>1.00</td>
<td>(L_{10})</td>
</tr>
<tr>
<td>95</td>
<td>0.62</td>
<td>(L_{5})</td>
</tr>
<tr>
<td>96</td>
<td>0.53</td>
<td>(L_{4})</td>
</tr>
<tr>
<td>97</td>
<td>0.44</td>
<td>(L_{3})</td>
</tr>
<tr>
<td>98</td>
<td>0.33</td>
<td>(L_{2})</td>
</tr>
<tr>
<td>99</td>
<td>0.21</td>
<td>(L_{1})</td>
</tr>
</tbody>
</table>

\(a_2\)—Material/Construction Factor

Most NTN-Bower bearings are manufactured from carburizing grades of alloy steels processed to meet exacting bearing quality standards. A few special products utilize alternate materials specifically selected for their intended applications.

\(a_3\)—Lubrication Factor

The lubricant selected for the application, the operating temperature, and the bearing load and speed combine to affect bearing life. When any of these deviate substantially from the base conditions, the expected bearing life can be adjusted by the lubrication life factor \(a_3\). In general, higher viscosity lubricants, higher speeds, and lower temperatures yield an adjustment factor greater than 1.0\((a_3 > 1.0)\). Figures 10 through 13 are used to approximate the lubrication factor - \(a_3\). This procedure is intended only to provide a ballpark figure for \(a_3\).

NTN has developed the long life HL (High Lubrication) bearing, to help increase the film thickness between the contact elements and thus alleviate the problem of surface flaking under poor lubrication conditions.

All load ratings published in this catalog reflect the use of case carburized bearing quality alloy steel. Therefore, the material factor \(a_5\) is equal to 1.4.

In some applications, it may not be possible to find a standard bearing with adequate fatigue life within the boundary restraints. To avoid the necessity of a redesign of the entire system, bearings manufactured from premium materials have longer fatigue life due to fewer and more widely separated non-metallic inclusions in the steel matrix, which reduces the number and severity of possible fatigue initiation sites. NTN has established material life adjustment factors for these premium steels as shown on Table 7.

NTN-Bower also offers advanced heat treatment options that improve the fatigue life of the bearing. Austenite strengthening (‘AS’) treatment can increase the fatigue life of a bearing by 50%.

In order to offer optimum bearing performance for special applications, NTN-Bower has developed the Extended Life (XL100) tapered roller bearing line. XL100 construction uses optimal material and heat treatment to increase fatigue life as well as other internal modifications to enhance performance.

The values for the material/construction factor \(a_2\) can be found in Table 7.

<table>
<thead>
<tr>
<th>Material/Construction</th>
<th>Life Adjustment Factor (a_2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard (case carburized steel)</td>
<td>1.4</td>
</tr>
<tr>
<td>XL100 Construction</td>
<td>1.9</td>
</tr>
<tr>
<td>‘AS’ Treatment (case carburized steel)</td>
<td>2.1</td>
</tr>
<tr>
<td>‘AS’ + XL100 Construction</td>
<td>2.8</td>
</tr>
</tbody>
</table>

NTN-Bower bear...
For a more exact determination of \( a_4 \) and for more information on NTN’s HL bearing, contact the NTN Application Engineering Department.

**\( a_4 \)—Misalignment Factor**

Although bearings should be perfectly aligned, some degree of misalignment is virtually always present in an application. A small degree of misalignment is allowed for in the bearing ratios. However, the factor, \( a_4 \), should be considered when misalignment exceeds a value of 0.001 radian. Misalignment is a measurement of the angle between the axis of rotation of the outer ring. Figure 14 is used to estimate the misalignment factor—\( a_4 \) for cylindrical and tapered roller bearings. For a more exact evaluation, contact the NTN Application Engineering Department.

**\( a_5 \)—Load Distribution Factor**

The distribution of load within a bearing is a function of mounted clearance, support stiffness and the magnitude of the load. For a given application there exists an optimum mounted internal clearance to maximize a bearing’s fatigue life. The proper selection of the fitting practice for cylindrical roller bearings with preset radial clearance is critical to bearing performance. For adjustable tapered roller bearings, the opportunity exists to optimize bearing performance through adjustment methods.

The technique used to estimate the influence of internal clearance on fatigue life involves the computer analysis of many variables. The bearing user should consult the NTN Application Engineering Department for evaluation of the load distribution factor.

**Weighted Life Equation**

Bearing selection is sometimes based on life expectancy at maximum load and speed requirements. However, in some applications, the load and/or speed may vary at different time intervals. Therefore, a more economical bearing selection can be considered if these variations are evaluated to determine a weighted life for the bearing.

To determine a weighted bearing \( L_{10} \) life in hours where the life at various conditions has been determined and a work schedule is known, use equation (35).

\[
L_{WT} = \frac{1}{T_1 \cdot L_{10_1} + T_2 \cdot L_{10_2} + \ldots + T_n \cdot L_{10_n}}
\]  

(35)

Where:

- \( L_{10} \) = Life in Hours
- \( T_1, T_2, \ldots, T_n \) = Time in % of Total Time occurring during a loading cycle
- \( L_{WT} \) = Weighted \( L_{10} \) Life

**Example:**

Given: Selected bearing has \( Cr = 27,800 \) lbs for rear countershaft position on five speed truck transmission. Operating schedule tabulated above.

**Truck Operating Schedule**

<table>
<thead>
<tr>
<th>Gear</th>
<th>Load (P) lbs</th>
<th>Speed (S) rpm</th>
<th>Time (T) %</th>
<th>Life (( L_{10} )) hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>16190</td>
<td>100</td>
<td>3</td>
<td>1010</td>
</tr>
<tr>
<td>2nd</td>
<td>8550</td>
<td>400</td>
<td>5</td>
<td>2122</td>
</tr>
<tr>
<td>3rd</td>
<td>5850</td>
<td>900</td>
<td>30</td>
<td>3341</td>
</tr>
<tr>
<td>4th</td>
<td>3840</td>
<td>1200</td>
<td>42</td>
<td>10195</td>
</tr>
<tr>
<td>5th</td>
<td>2880</td>
<td>1500</td>
<td>20</td>
<td>21278</td>
</tr>
</tbody>
</table>

Problem: Determine weighted \( L_{10} \) life of selected bearing

\[
L_{WT} = \frac{1}{0.03 \cdot 1010 + 0.05 \cdot 2122 + 0.30 \cdot 3341 + 0.42 \cdot 10195 + 0.20 \cdot 21278} = 5164 \text{ hrs.}
\]
INSTRUCTIONS

1. Determine Lubricant Parameter according to temperature and type of Lubricant from Figure 10.

2. Multiply Lubricant Parameter by Bearing Pitch Diameter*.

3. Determine Specific Film Thickness “L” from Figure 11 or 12.

4. Determine Lubrication Factor “a3” from Figure 13.

*Pitch Diameter (in.) = \( \frac{\text{Bore Diameter} + \text{Outside Diameter}}{2} \)
Roller Bearings

Figure 14

Roller Bearing Misalignment Life Adjustment Factor

<table>
<thead>
<tr>
<th>Misalignment Factor (a₄)</th>
<th>(Inches/Inch)</th>
<th>(Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>.0010</td>
<td>3.4</td>
</tr>
<tr>
<td>.9</td>
<td>.0016</td>
<td>5.5</td>
</tr>
<tr>
<td>.8</td>
<td>.0022</td>
<td>7.6</td>
</tr>
<tr>
<td>.7</td>
<td>.0028</td>
<td>9.6</td>
</tr>
<tr>
<td>.6</td>
<td>.0034</td>
<td>11.7</td>
</tr>
<tr>
<td>.5</td>
<td>.0040</td>
<td>13.8</td>
</tr>
<tr>
<td>.4</td>
<td>.0046</td>
<td>15.8</td>
</tr>
<tr>
<td>.3</td>
<td>.0052</td>
<td>17.9</td>
</tr>
<tr>
<td>.2</td>
<td>.0058</td>
<td>19.9</td>
</tr>
</tbody>
</table>

Basic Static Load Rating

When stationary roller bearings are subjected to static loads of moderate magnitude, they suffer from partial permanent deformation of the contact surfaces at the contact point between the rolling elements and the raceway. The amount of deformity increases as the load increases, and if this increase in load exceeds certain limits, the subsequent smooth operation of the bearings is impaired.

It has been found that a permanent deformity of 0.0001 times the diameter of the rolling element, occurring at the most heavily stressed contact point between the raceway and rolling elements, can be tolerated with negligible impairment in running efficiency.

The basic static load rating refers to a fixed static load limit at which a specified amount of permanent deformation occurs. The maximum applied load values for contact stress occurring at the rolling element and raceway contact points for roller bearings is 4,000 MPa.

Allowable Misalignment

Optimized design for roller and raceway contact, not only prevents the occurrence of roller edge loading at the contact surface, but also tolerates some misalignment between the inner and outer rings for mounting error. The allowable misalignment for cylindrical roller bearings is approximately 0.001 radian (0°, 3.5’) for width series 1 bearings and 0.0005 radian (0°, 1.5’) for width series 5 and 7 bearings.

THRUST RATING OF CYLINDRICAL ROLLER BEARINGS

Cylindrical roller bearings with opposed integral ribs on the inner and outer rings can support light to moderate thrust loads. The mechanism for supporting the thrust load in a cylindrical roller bearing is different from that in any other type of rolling bearing. In a ball bearing, the thrust load, as well as the radial load, is carried through the rolling contact between the balls and the raceways. In a tapered roller bearing, the major portion of the thrust load is carried on the rolling contact between the O.D. of the rollers and the raceways and the balance of sliding contact of the spherical head against the large cone flange. The cylindrical roller bearing can only support thrust loads on the ends of the rollers in a sliding contact with the raceway ribs, thus limiting thrust load carrying capabilities.

Several important factors must be considered when using cylindrical roller bearings in thrust applications. The thrust reactions at the diametrically opposed raceway ribs create a radial overturning moment on the roller and the sliding action creates a circumferential skewing moment. To overcome the radial moment and stabilize the roller, the applied radial load must be greater than the thrust load. The longer rollers in wide series cylindrical roller bearings are more adversely affected by the skewing moment and, therefore, are more restricted in thrust capabilities. The shaft alignment must be within 0.0001 radian of the true position to obtain equal load sharing between the rollers. Because of the sliding action, the lubricant must provide an adequate film between the roller ends and the raceway ribs; high viscosity oil is preferred.
LIMITING SPEEDS

Because of the many factors involved in determining the speed capabilities of a rolling bearing, it is impossible to develop a simple formula to establish an exact value for the limiting speed. Besides the precision of the bearing itself, the magnitude and direction of the load, the type of cage, the type of lubricant and lubrication system, the rate of heat dissipation, the alignment, the mounting practice, and the balance of the rotating components all play a significant role.

Since each application must be evaluated on its own merits, it is recommended the NTN Application Engineering Department be consulted when the speed approaches the limiting value.

EFFECTS OF FITTING PRACTICE

Cylindrical roller bearings are manufactured with a preset amount of radial clearance. They are available in two styles, the standard series and the “A” series. The standard series is designed to be installed with a press fit on one ring and a tap fit on the other as defined in the cylindrical roller bearing fitting practice section of this catalog, pages 89-105. The “A” series is designed for a press fit on the inner ring and a heavy press fit on the outer ring which are required for heavy duty applications.

The press fit of either the inner ring or the outer ring reduces the radial clearance within the bearing. This reduction in clearance has been compensated for at the time of bearing manufacture. Therefore, it is essential that the recommended fitting practices be adhered to in order to assure that the bearing will operate with the proper installed clearance.

The inner ring will expand according to equation (36) for the general case.

\[
\delta_i = \frac{pa}{E_1} \left[\frac{2 \times B^2}{A^2 - B^2}\right]
\]  

(36)

Where:
- \(\delta_i\) = Expansion of inner ring raceway diameter (in)
- \(p_i\) = Radial contact pressure between inner ring and shaft (psi)
- \(A\) = Inner ring raceway diameter (in)
- \(B\) = Inner ring bore (in)
- \(E_1\) = Inner ring modulus of elasticity = 30 x 10^6 psi

For a solid steel shaft equation (36) reduces to:

\[
\delta_i = \frac{B}{A} (IF)_i
\]  

(37)

The outer ring will contract according to equation (38) for the general case.

\[
\delta_o = -\frac{p_o C}{E_1} \left[\frac{2 \times D^2}{D^2 - C^2}\right]
\]  

(38)

Where:
- \(\delta_o\) = Contraction of outer ring raceway (in)
- \(p_o\) = Radial contact pressure between outer ring and housing (psi)
- \(C\) = Outer ring raceway diameter (in)
- \(D\) = Outer ring O.D. (in)
- \(E_1\) = Outer ring modulus of elasticity = 30 x 10^6 psi

For massive steel housing equation (38) reduces to

\[
\delta_o = -\frac{C}{D} (IF)_o
\]  

(39)
For the general case, \( p_I \) and \( p_O \) may be solved for from the following equations, respectively:

\[
(\text{IF})_I = \frac{p_B}{E_1} \left[ \frac{A^2 + B^2}{A^2 - B^2} + \nu_1 \right] + \frac{p_B}{E_2} \left[ \frac{B^2 + J^2}{B^2 - J^2} - \nu_2 \right] \tag{40}
\]

\[
(\text{IF})_O = \frac{p_O}{E_1} \left[ \frac{D^2 + C^2}{D^2 - C^2} - \nu_1 \right] + \frac{p_O}{E_3} \left[ \frac{H^2 + D^2}{H^2 - D^2} + \nu_3 \right] \tag{41}
\]

Where:
- \( (\text{IF})_I \) = Interference fit of inner ring on shaft (in)
- \( (\text{IF})_O \) = Interference fit of outer ring in housing (in)
- \( \nu_1 \) = Poisson’s ratio for bearing rings = 0.27
- \( E_2 \) = Modulus of elasticity for shaft (psi)
- \( \nu_2 \) = Poisson’s ratio for shaft
- \( E_3 \) = Modulus of elasticity for housing (psi)
- \( \nu_3 \) = Poisson’s ratio for housing
- \( A \) = Inner ring raceway
- \( B \) = Inner ring bore
- \( C \) = Outer ring raceway diameter
- \( D \) = Outer ring O.D.
- \( J \) = Hollow shaft bore
- \( H \) = Housing O.D.

Tapered roller bearings have a more complex reaction to interference fits. Not only do the bearing raceways change in a radial direction, but, due to the tapered relationship of the raceways, there is also an expansion of bearing width which may effect the bearing setting. Please consult NTN Application Engineering Department for further information.
LUBRICATION

The following information on lubrication is intended only as a general guide. Due to the complexity of the subject, contact NTN Application Engineering Department for recommendations on specific applications.

To obtain the full, calculated life of a bearing in an application, it is essential to select an adequate lubricant viscosity and method of lubrication.

The necessary data and formula to adjust bearing life for oil film thickness, based on the Elastohydrodynamic Theory (EHD), is provided in the “Bearing Selection” section under “Life Adjustment Factors” on page 15. Bearing life adjustment evaluation for grease lubrication is not given since other factors must be considered, including bearing load, humidity conditions, service life required and frequency of re-lubrication.

Bearing lubricants basically are used to:

- Provide a minimum lubricant film thickness that will separate the contacting surfaces at bearing operating temperature and speed
- Reduce friction and thus prevent wear
- Dissipate heat generated within the bearing
- Protect the contacting surfaces from corrosion within the bearing
- Remove or seal out foreign material from the bearing

To select an adequate bearing lubricant, it is necessary to be familiar with the environment in which the bearing will operate. Lubricant selection is influenced by:

- Bearing operating temperatures
- Bearing operating speeds
- Lubrication requirements of related components
- Compatibility with sealing devices
- Method and amount of lubrication required for the bearing

Oil Vs. Grease

Lubricants for roller bearings in commercial applications are of two basic types, oil or grease. While oil is the preferred lubricant because it has the desirable characteristics of a fluid, both have their advantages and limitations:

Oil

- Suitable for all speeds—but must be used for extremely high speeds
- For elevated temperatures—where the oil is circulated to cool the bearing
- For extremely low temperatures
- To provide a clean, filtered environment
- For a closed lubrication system—where related components require lubrication in addition to the bearings
- For critical applications—where the quantity of the lubricant must be controlled
- For more positive feeding of lubricant to heavily loaded contact surfaces
- For low running torque condition use an oil mist lubrication system

Grease

- For extremely low to moderate speeds
- For low to moderate loads
- For moderate temperatures
- As an aid in excluding severe contamination because of its consistency
- For less complicated lubrication systems
- For simple, positive lubrication as in a self-contained, sealed, pre-lubricated unit
- For a simplified housing design
- For ease of sealing
Oil

Oil, the preferred lubricant for roller bearings, consists of either petroleum fluids refined from crude oil or synthetic fluids produced by chemical synthesis. Most commercial lubricating oils are available with an additive or combination of additives to meet various environmental or operating conditions. Common types of additives and their primary functions are:

- **Oxidation inhibitor:**
  Retards oil deterioration and formation of sludge, carbon and varnish
- **Rust inhibitor:**
  Protects lubricated surfaces from rust and corrosion
- **Detergent—dispersant:**
  Reduces and controls degradation products and helps maintain cleanliness of lubricated surfaces
- **Defoaming agent:**
  Prevents formation of air bubbles
- **Extreme Pressure (EP) additive:**
  Prevents high friction, wear or scoring under various conditions of sliding or marginal lubrication
- **Viscosity Index (VI) improver:**
  Reduces the affect of temperature changes on oil viscosity
- **Pour—Point Depressant:**
  Lowers the solidification point of oil

The above list is not meant to imply that all or any of these specific additives mentioned are always required. Proper use of additives is fundamental to obtaining long and satisfactory roller bearing service. It is recommended that a reputable oil company be consulted for the specific operating conditions under consideration. Special attention should be given to stability over the operating temperature range of the oil and to possible chemical changes in the oil from storage or service conditions.

The oil lubrication systems most commonly used in commercial applications are:

- **Splash Feed System.** In many transmission and gear box systems, sufficient splash is generated by the gears to lubricate the bearings. However, if excessive contaminants are generated by the gears or if the system cannot be cleaned frequently, contaminants may cause serious damage to the bearings. It is recommended that magnetic drain plugs be used in these systems.
- **Oil Circulating System.** This system is used for the same speed ranges as the Oil Drop Feed System. However, it is designed for use when excessive heat or contamination must be removed from the bearing. To meet the contamination problem, a suitable filter should be incorporated into the system.
- **Oil Mist System.** This system is recommended for use when the speeds are extremely high, provided the air which atomizes the oil is clean and dry.
- **Constant Oil Level.** In low and medium speed applications, a constant oil level system is used. The oil level should immerse approximately fifty percent of the lowest roller when the bearing is stationary.
- **Drop Feed System.** When the speed is too high for the oil level system, the drop feed system is often used. In this case, the oil is fed into the bearing in droplet form. It moves through the bearing and out the drain, which is located on the side opposite the oil supply. It is not recommended where contamination is a problem or where good cooling is required.
Grease

Greases in general use for roller bearings are composed of oil thickened with a metallic soap base, in various proportions, to form a desired consistency. The oil is of a specified viscosity no lower than 70 SUS (Saybolt Universal Seconds) at 100°F. The soap base type may be sodium (soda), calcium (lime), lithium, calcium complex, aluminum complex or various synthetic and non-soap base types. Properties of some of the soap base types are:

- **Sodium**—good stability at the higher permissible speed and temperature ranges; not water resistant
- **Calcium**—inexpensive; good water resistance; limited to temperatures under 150°F.
- **Lithium**—generally stable at higher temperatures, good water resistance, good internal cohesion, “multi-purpose”.

Sodium and mixed sodium-calcium soap greases are considered good “general purpose” lubricants. Calcium, lithium and non-soap greases are used where water resistance is required.

Synthetic oil greases are more expensive than petroleum oil greases and are used where it is desirable to broaden the temperature range beyond that of petroleum base greases.

- Silicone oil greases are used for both high and low temperature operation (-100°F to +450°F), but have a limited load carrying capacity
- Ester oil greases cover a wide temperature range (-100°F to +350°F)
- Di-ester oil greases cover the low temperature range to -65°F

The grease consistency at bearing operating temperature is an important factor in selecting a suitable grease. Its melting point should be considerably higher than the operating temperature. Roller bearing greases in general use are a NLGI #1 or #2 grade, multipurpose, with an ASTM worked penetration number between 265-340.

The following guide applies to general applications under normal loading at operating speeds of 100—1000 rpm. For heavy loads and low speeds, the advice of a lubrication engineer should be obtained.

**TABLE 8**

<table>
<thead>
<tr>
<th>GREASE TEMPERATURE GUIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grease Grade</td>
</tr>
<tr>
<td>#0</td>
</tr>
<tr>
<td>#1</td>
</tr>
<tr>
<td>#2</td>
</tr>
</tbody>
</table>

**TABLE 9**

<table>
<thead>
<tr>
<th>GREASE CONSISTENCY CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grease Grade</td>
</tr>
<tr>
<td>#0</td>
</tr>
<tr>
<td>#1</td>
</tr>
<tr>
<td>#2</td>
</tr>
</tbody>
</table>

Grease churns when used in excessive quantities, resulting in excessive temperatures, separation of the grease components and breakdown in the lubricant. Generally, the cavity in which the bearing is mounted should be kept ½—⅓ full for normal speeds.

A suitable grease should remain mechanically and chemically stable at operating temperature. It should not thicken, harden, separate, or become acid or alkaline to any marked degree.

Re-lubrication intervals should be established based on the experience of similar applications. The recommended grease type should be used.
HANDLING AND INSTALLATION

Improper handling practices prior to and during installation can easily damage the quality and precision built into NTN-Bower roller bearings. Although a general set of rules cannot adequately cover all the ways that a roller bearing should be handled to prevent it from becoming unserviceable, certain essential precautions and care will minimize such damage.

Prior to shipment, NTN-Bower roller bearings are thoroughly cleaned, coated with a rust preventative, and carefully packaged for protection against contamination and oxidation. A positive effort should be made to keep the bearings in this condition prior to final assembly. The bearing package should be kept closed until ready for immediate installation. If it is necessary to unwrap the bearings before that time, they should be placed on a clean surface and covered with a lint free cloth. Prior to bearing installation, housings, shafts, and other adjacent parts should be wiped clean or washed. In addition, foundry sand should be completely removed from castings.

Roller bearings should be installed in an area where a clean atmosphere exists. In addition, it is imperative that assembly benches and tools be kept clean to prevent contaminants such as dust, grit and steel chips from entering the bearing. Contamination not only causes rough and noisy operation, but usually results in premature bearing fatigue. It is much easier to keep a bearing clean than it is to wash it clean enough for service.

New bearings must be cleaned prior to installation only if they become contaminated after being removed from their original package. Light spindle oils (less than SAE 10 Viscosity) or Stoddard solvents are recommended for washing purposes. It is recommended that chlorinated solvents not be used because of rust hazards associated with certain types. Compressed air may be used to blow out foreign matter. However, care must be taken not to free spin the bearing because permanent damage may result from dirt particles scoring the rolling surfaces. The compressed air must be filtered so that it is free from moisture, otherwise it could corrode the bearing surfaces.

The bearings must be carefully inspected after cleaning to make certain they are clean enough for use. They should then be coated with a rust preventative and installed immediately or wrapped in a grease proof paper and properly labeled for future identification.

The bearing mounting must be properly designed from a functional standpoint and must have correct shaft and housing fits and shoulder heights. In addition, the design should be such that the bearings and other components can be installed as easily as possible.

Proper assembly tools such as arbor presses, pullers, and sleeves will not only facilitate assembly, but will also avoid damage to the bearings. When a roller bearing is pressed on a shaft, the inner ring must be started squarely. A “cocked” ring may score the shaft and damage the bearing. The pressure must be applied directly on the ring being pressed, avoiding all pressure through the rollers. The bearing must not be tapped in place with direct blows on the bearing ring. The preferred practice is to place a sleeve between the bearing ring and the hammer and to tap the sleeve lightly all around. Hammers that shed chips should not be used as the chips may get into the bearing recesses.

Sometimes a bearing must be heated so that it can be more easily assembled on a shaft. A convenient method of doing this is to insert a heat source such as an electric light bulb in the bore of the bearing, keeping it there until the inner ring has expanded sufficiently. Another method is to heat the bearing in a bath of hot oil. The oil must be clean and the temperature should not exceed 250° F. Higher temperatures may cause the oil to decompose and the bearing to lose its proper hardness.

Further information regarding the care and installation of roller bearings may be obtained from the NTN Application Engineering Department.
Cylindrical roller bearings are manufactured by NTN-Bower in several series that differ in proportion, width, and load rating. Bore size for each series increases in multiples of five or more millimeters and for each bore size a selection of different narrow and wide series is available to meet the needs of most applications. External dimensions and tolerances conform to RBEC #1 metric bearing standards as defined in the American Bearing Manufacturers Association (ABMA) and American National Standards Institute (ANSI).

NTN-Bower standard product lines include two basic series: the “M” series for light and medium radial loads and the “W” series for heavy to extra heavy radial loads. Only complete bearing assemblies interchange between the Max-Pak and the “M” series bearings; separable rings and roller assemblies do not.

The “W” (Max-Pak) series provides an average radial load rating increase of 20 percent and a life increase of 80 percent. These increases are possible by reducing the wall thickness of the bearing rings. This reduction provides additional space for larger rollers resulting in higher calculated ratings.

While cylindrical roller bearings are designed primarily for high radial loads, certain types are capable of handling light and intermittent thrust loads, which also permits them to be used for axial shaft location.

The cylindrical roller bearing is a nonadjustable design. The correct radial internal clearance is built in at time of manufacture; when properly installed, the bearing has the correct running clearance. By using an “A” style outer ring, a press fit for the outer ring is obtained when installed in a housing previously designed to produce a tap fit.

NTN-Bower also manufactures a limited number of specialty bearings that include the “MOJ” and “MOX” style, custom “R” series, mast and chain guide bearings. A part number listing, dimensional data and load ratings can be found in the special bearing section of this catalog on page 72.
"M" SERIES BEARINGS
The “M” series designated by the prefix letter “M” satisfies most commercial applications and is available in a broad range of sizes and types up to 20” (508 mm) outside diameter. This series is available with several types of cages including composite steel, “X” bar, stamped steel, and “Fibron. This series is also available with a full complement of rollers (i.e., no cage).

"W" (MAX-PAK) SERIES BEARINGS
The Max-Pak series with the prefix letter “W” interchanges with the “M” series and is designed for applications with very heavy radial loads. This series can be produced in most of the same types and sizes as the “M” series and is available with an “X” bar steel or stamped steel cage.

“A” style (oversize outer ring for heavy press fit in a standard size housing bore) is the standard Outside Diameter for the Max-Pak series.

For individual part number availability, contact NTN Sales.

**“Fibron” is the NTN—Bower trade name for nonmetallic cages**
**Bearing Design**

**CAGES**

“M” series bearings are supplied with one of four basic cage styles; composite steel, one piece steel, “X” bar, and Fibron. Bearing load ratings for various cage styles are included in the “Dimensions and Load Ratings” section of this catalog. Load ratings for bearings using Fibron cages are the same as the column for inner ring assemblies with one-piece steel cages.

The composite steel cage provides more rollers for a given bearing size than is possible with other designs to offer greater radial load carrying capacity. Guidance for this cage is located on the ground ribs of the ring containing the rollers.

The one piece steel cage provides a maximum number of equally spaced rollers for a given bearing size. This cage is simple, light weight and exceptionally strong. Its open construction permits free flow of lubricant through the bearing, which is especially important for relatively high temperature and high speed applications.

The “X” bar steel cage offers line contact at four locations to each roller resulting in superior roller guidance. This can allow for higher rotational speeds and greater running accuracy.

**MATERIAL**

Both rings and rollers of NTN-Bower cylindrical roller bearings are made from case hardened alloy steel of “Bearing Quality” to provide maximum fatigue life and reliability. Precise control of heat treatment, dimensions, and surface finish of the components further contribute to reliable bearing performance.

**CROWNED ROLLERS**

NTN-Bower’s pioneering efforts in developing crowned rollers for cylindrical roller bearings have resulted in greater load carrying capacity and substantially longer bearing life. Crowned rollers, under load, distribute stress equally along their full length of contact with the raceways, thereby eliminating stress concentration at the roller ends. This design concept also compensates for minor misalignment between shaft and housing bores and deflections under load by reducing stress concentratons.

Crowned rollers are manufactured in two basic profiles. A full crown roller is used in small size bearings or in applications where high misalignment is expected and a modified “dubbed” crown in the large size bearings.
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### Numbering System

**PREFIX LETTERS**

<table>
<thead>
<tr>
<th>1</th>
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<tbody>
<tr>
<td>A</td>
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<td>E</td>
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<td>G</td>
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<tr>
<td>N</td>
<td>R</td>
<td>S</td>
<td>U</td>
</tr>
<tr>
<td>W</td>
<td>X</td>
<td></td>
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</tr>
</tbody>
</table>

- **A**: Plain Inner Ring
- **B**: Special Features
- **C**: Mast and Chain Guide Bearings
- **D**: Inner Ring Bore 5mm Undersize (Max-Pak Series Only)
- **E**: Inner Ring Bore 10mm Undersize (Max-Pak Series Only)
- **F**: Unground Rib O.D.
- **G**: Inner Ring Bore 15mm Undersize (Max-Pak Series Only)
- **M**: Standard Metric Series
- **N**: Inner Ring Plate
- **R**: One Ribbed Inner Ring
- **S**: Short, One Ribbed Inner Ring
- **T**: Two Ribbed Inner Ring
- **U**: Max-Pak 60000 Series
- **W**: Unground Rib O.D.

**SUFFIX LETTERS**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
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<tr>
<td>V</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **A**: Oversized O.D. for Heavy Press Fit in Standard Housing Bore
- **B**: Special Features
- **C**: Plain Outer Ring
- **D**: One Ribbed Outer Ring
- **E**: Two Ribbed Outer Ring
- **F**: Unground Rib I.D.
- **G**: Snap Ring Groove in Outer Ring O.D.
- **H**: Blind Dowel Hole in Outer Ring O.D.
- **J**: Brass or Bronze Cage
- **L**: Composite Steel Cage
- **M**: Full Complement Bearing (No Cage)
- **N**: Outer Ring Plate
- **R**: Snap Ring Assembled in Outer Ring O.D.
- **S**: Short, One Ribbed Outer Ring
- **T**: Two Retaining Rings in Outer Ring I.D.
- **U**: One Rib, One Retaining Ring in Outer Ring I.D.
- **V**: One Piece Steel Cage
- **X**: Unground Rib I.D.
- **X**: “X” Bar Composite Steel Cage

### INNER RING TYPES

- **A**: Standard Metric Series
- **R**: Inner Ring Plate
- **N**: Custom Series
- **S**: One Ribbed Inner Ring
- **T**: Short, One Ribbed Inner Ring
- **U**: Two Ribbed Inner Ring
- **W**: Max-Pak 60000 Series
- **X**: Unground Rib O.D.

### OUTER RING TYPES

- **C**: Oversized O.D. for Heavy Press Fit
- **D**: Special Features
- **E**: Plain Outer Ring
- **S**: One Ribbed Outer Ring
- **N**: Two Ribbed Outer Ring
- **R**: Unground Rib I.D.
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- **X**: One Piece Steel Cage
- **X**: Unground Rib I.D.
- **X**: “X” Bar Composite Steel Cage
Nomenclature

RELATIVE BEARING SIZES

Seven M series bearings having the same bore size.

<table>
<thead>
<tr>
<th>Size</th>
<th>1900</th>
<th>1000</th>
<th>1200</th>
<th>5200</th>
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<th>7300</th>
<th>5300</th>
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</tbody>
</table>
### Bearing Types

#### SEPARABLE INNER RINGS

<table>
<thead>
<tr>
<th>Design Features</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Two ribbed outer ring.</td>
<td>• Permits axial float of shaft.</td>
</tr>
<tr>
<td>• Straight, separable inner ring.</td>
<td>• Accomodates contraction or expansion at one end of a shaft. Bearing at opposite end locates shaft.</td>
</tr>
<tr>
<td>• Rollers retained with outer ring.</td>
<td></td>
</tr>
<tr>
<td>• Composite steel cage.</td>
<td></td>
</tr>
<tr>
<td><strong>MA----EL</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design Features</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Two split retaining rings in outer ring.</td>
<td>• Permits axial float of shaft.</td>
</tr>
<tr>
<td>• Straight, separable inner ring.</td>
<td>• Low cost bearing type.</td>
</tr>
<tr>
<td>• Rollers retained with outer ring.</td>
<td>• Accomodates contraction or expansion at one end of a shaft. Bearing at opposite end locates shaft.</td>
</tr>
<tr>
<td>• One-piece steel cage.</td>
<td></td>
</tr>
<tr>
<td><strong>MA----TV</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design Features</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Two ribbed outer ring.</td>
<td>• Takes moderate thrust loads or locates shaft in one direction only.</td>
</tr>
<tr>
<td>• One ribbed, separable inner ring.</td>
<td>• When used in pairs on a common shaft, thrust loads can be taken or shaft located in either direction.</td>
</tr>
<tr>
<td>• Rollers retained with outer ring.</td>
<td></td>
</tr>
<tr>
<td>• Composite steel cage.</td>
<td></td>
</tr>
<tr>
<td><strong>MR----EL</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design Features</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Two split retaining rings in outer ring.</td>
<td>• Outer ring is located, axially, in one direction by inner ring rib. Location in opposite direction must be provided for.</td>
</tr>
<tr>
<td>• One ribbed, separable inner ring.</td>
<td>• Rib on inner ring can be used to facilitate its removal from shaft.</td>
</tr>
<tr>
<td>• Rollers retained with outer ring.</td>
<td>• Will not accomodate thrust loads or locate shaft.</td>
</tr>
<tr>
<td>• One-piece steel cage.</td>
<td></td>
</tr>
<tr>
<td><strong>MR----TV</strong></td>
<td></td>
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</tbody>
</table>
## Bearing Types

### SEPARABLE INNER RINGS (continued)

<table>
<thead>
<tr>
<th>Bearing Type</th>
<th>Design Features</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR----UV</td>
<td>Design Features</td>
<td>Application</td>
</tr>
<tr>
<td></td>
<td>• One split retaining ring and one rib in outer race.</td>
<td>• Takes moderate thrust loads or locates rotating member in one direction.</td>
</tr>
<tr>
<td></td>
<td>• One ribbed, separable inner ring.</td>
<td>• When used in pairs on a common shaft, thrust loads can be taken or shaft located in either direction.</td>
</tr>
<tr>
<td></td>
<td>• Rollers retained with outer ring.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• One-piece steel cage.</td>
<td></td>
</tr>
<tr>
<td>MSN----EL</td>
<td>Design Features</td>
<td>Application</td>
</tr>
<tr>
<td></td>
<td>• Two ribbed outer ring.</td>
<td>• Takes moderate thrust loads or locates rotating member, axially, in both directions.</td>
</tr>
<tr>
<td></td>
<td>• Removable, short, one ribbed inner ring and loose side plate.</td>
<td>• Bearing can be installed separately or as a unit.</td>
</tr>
<tr>
<td></td>
<td>• Rollers retained with outer ring.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Composite steel cage</td>
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### SEPARABLE OUTER RINGS

<table>
<thead>
<tr>
<th>Bearing Type</th>
<th>Design Features</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>MU----CL</td>
<td>Design Features</td>
<td>Application</td>
</tr>
<tr>
<td></td>
<td>• Straight, separable outer ring.</td>
<td>• Permits axial float of shaft like MA—EL but rollers are retained with inner ring; desirable for some applications.</td>
</tr>
<tr>
<td></td>
<td>• Two ribbed inner ring.</td>
<td>• Straight outer ring design is ideal for oil flow and purging contaminants.</td>
</tr>
<tr>
<td></td>
<td>• Rollers retained with inner ring.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Composite steel cage</td>
<td></td>
</tr>
<tr>
<td>MU----CV</td>
<td>Same design features and application as described above for MU—CL, except uses one-piece steel cage.</td>
<td></td>
</tr>
</tbody>
</table>
### Bearing Types

#### SEPARABLE OUTER RINGS (continued)

<table>
<thead>
<tr>
<th>Model</th>
<th>Design Features</th>
<th>Application</th>
</tr>
</thead>
</table>
| MU---DL | • One ribbed, separable outer ring.  
• Two ribbed inner ring.  
• Rollers retained with inner ring.  
• Composite steel cage. | • Takes moderate thrust loads or locates shaft in one direction only.  
• When used in pairs on common shaft, thrust loads can be taken or shaft located in either direction. |
| MU---DV | Same design features and applications as MU—DL above, except uses one-piece steel cage. |                                                                                  |
| MU---SNL | • Removable, short, one ribbed outer ring and loose side plate.  
• Two ribbed inner ring.  
• Rollers retained with inner ring.  
• Composite steel cage | • Takes moderate thrust loads or locates rotating members axially in both directions.  
• Bearing can be installed separately or as a unit. |
| MU---SNV | Same design features and application as MU—SNL above except uses one-piece steel cage. |                                                                                  |
### Bearing Types

#### INNER OR OUTER RING OMITTED

<table>
<thead>
<tr>
<th>Type</th>
<th>Design Features</th>
<th>Application</th>
</tr>
</thead>
</table>
| M----EL | • Two ribbed outer ring.  
• Inner ring omitted.  
• Composite steel cage. | • Where mounting space is limited, rollers run directly on a hardened and ground shaft.*  
• Shaft diameter can be increased to replace omitted outer ring for added stiffness.  
• Savings are possible by using a smaller bearing and eliminating inner ring. |
| M----TV | • Two split retaining rings in outer ring.  
• Inner ring omitted.  
• One-piece steel cage. | • Use is similar to M—EL above. |
| MU----L | • Outer ring is omitted.  
• Two ribbed inner ring.  
• Composite steel cage. | • Where space is limited, housing bore can be reduced—permitting rollers to run directly on hardened and ground housing bore.*  
• Shaft diameter can be increased for added stiffness by eliminating outer ring and using next larger size bearing bore.  
• Housing bore is modified to suit diameter over the rollers.  
• Savings are possible through eliminating outer ring. |
| MU----V | | Same design features and application as MU—L above except bearing uses one-piece steel cage. |

*Note: Shaft or housing bore surfaces functioning as bearing raceways must have a hardness of Rockwell C58 to C64 and a maximum surface finish of 18 AA. Deviation from this surface finish or hardness will require a reduction in the catalog rating of the bearing. Consult NTN Engineering for a recommendation.*
### Bearing Types

#### NON-SEPARABLE BEARINGS

<table>
<thead>
<tr>
<th>Design Features</th>
<th>Application</th>
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</table>
| - Two split retaining rings in outer ring.  
- Two ribbed inner ring.  
- One-piece steel cage. | - Used where bearing must be assembled as a unit and where design has no provision to retain outer ring axially.  
- Will not accommodate thrust loads or locate shaft. |

#### MU----TV

Same design features and applications as MU—TV above, except outer ring contains one split retaining ring and one solid rib which will take moderate thrust loads or locate shaft in one direction.

<table>
<thead>
<tr>
<th>Design Features</th>
<th>Application</th>
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</table>
| - Two split retaining rings in outer ring.  
- Two ribbed inner ring.  
- No cage (full complement of rollers). | - Use is similar to MU—TV above.  
- Cage is omitted and rollers are added for increased radial load capacity. Permissible bearing speed, however, is less than the caged type bearing. |

#### MU----UV

Same design features and application as MU—TM above except outer ring contains one split retaining ring and one solid rib that will take a moderate thrust load or locate shaft in one direction.
# Interchange Charts for Basic Series

## Cylindrical Roller Bearings

### Separable Inner Ring Type Bearings

<table>
<thead>
<tr>
<th>BOWER</th>
<th>MA----TV</th>
<th>MA----EL</th>
<th>MR----TV</th>
<th>MR----EL</th>
<th>MR----UV</th>
<th>MSN----EL</th>
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<td>--RU--</td>
<td>--RR--</td>
<td>--RJ--</td>
<td>--RS--</td>
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<td>E----U</td>
<td>L----B</td>
<td>L----U</td>
<td>L----J</td>
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### Separable Outer Ring Type Bearings

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</table>

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*Charted bearings interchange for boundary dimensions (I.D., O.D., width) and bearing types. They may not interchange due to differences in load ratings or cage styles.*
The basic boundary dimensions (bore, outside diameter, width) in the following tables conform to the standards established by ABMA/ANSI.

A description of dimensions represented by various letters is given below:

B Maximum bearing bore diameter. The minus tolerance is given on page 79 and the range in “Fitting Practice” section

D Maximum bearing O.D. The minus tolerance is given on page 79 and the range in “Fitting Practice” section

W Maximum bearing width. The minus tolerance is given on page 79.

A Maximum O.D. of the inner ring raceway

C Minimum I.D. of the outer ring raceway

F Maximum rib O.D. of the inner ring

H Minimum rib I.D. of the outer ring

R Maximum fillet on the shaft that the bearing corner will clear

r Maximum fillet in the housing that the bearing corner will clear

X Recommended maximum housing shoulder diameter for plain outer rings

V Recommended minimum shaft shoulder diameter for ribbed inner rings

Z Recommended maximum housing shoulder diameter for ribbed outer rings

U Recommended minimum shaft shoulder diameter for plain inner rings

Dimensions shown in tables are given in both inch and metric units and are based on:

1 inch = 25.4 mm exactly
1 micrometer = 1µm = 10⁻⁶ m
1 micrometer = .001 mm

LOAD RATINGS

The radial load ratings in this catalog are based on 500 hrs L₁₀ life at 33 1/3 rpm or 1 million cycles for either inner or outer ring rotation. To convert this rating to 3000 hrs L₁₀ life at 500 rpm or 90 million cycles basis, divide by 3.857.

The load ratings, dynamic and static, are shown in both pounds and newtons, i.e.,

1 pound = 4.448 newtons
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<th>W: Width</th>
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<th>X Bar Steel Cage</th>
<th>Full Complement (No Cage)</th>
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* Oversize outer ring for heavy press fit in standard housing bore.
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<th>C (Inch/mm)</th>
<th>F (Inch/mm)</th>
<th>H (Inch/mm)</th>
<th>R (Inch/mm)</th>
<th>r (Inch/mm)</th>
<th>U (Inch/mm)</th>
<th>V (Inch/mm)</th>
<th>X (Inch/mm)</th>
<th>Z (Inch/mm)</th>
<th>Maximum * Fillet Radius</th>
<th>Minimum Shaft Shoulder Diameter</th>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
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* Oversize outer ring for heavy press fit in standard housing bore.
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
Cylindrical Roller Bearings

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* Oversize outer ring for heavy press fit in standard housing bore.
### Dimensions and Ratings

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*The maximum fillet on the shaft or in the housing that the bearing corner will clear.*
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* Oversize outer ring for heavy press fit in standard housing bore.
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
# Cylindrical Roller Bearings

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* Oversize outer ring for heavy press fit in standard housing bore.
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
## Cylindrical Roller Bearings

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* Oversize outer ring for heavy press fit in standard housing bore.
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
### Cylindrical Roller Bearings

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* * Oversize outer ring for heavy press fit in standard housing bore.
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
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* Oversize outer ring for heavy press fit in standard housing bore.
## Dimensions and Ratings

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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.

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5234 8.090 10.934 8.625 10.423 0.250 0.125 7.76 8.09 11.32 10.93 5234
205.49 277.72 219.08 264.74 6.35 3.18 197.1 205.5 287.5 227.6

1334 8.532 12.338 9.290 11.654 0.375 0.125 8.12 8.53 12.93 12.33 1334
216.71 313.39 235.97 296.01 9.52 3.18 206.2 216.7 328.4 313.2

7334 8.532 12.338 9.290 11.654 0.375 0.125 8.12 8.53 12.93 12.33 7334
216.71 313.39 235.97 296.01 9.52 3.18 206.2 216.7 328.4 313.2

5334 8.532 12.338 9.290 11.654 0.375 0.125 8.12 8.53 12.93 12.33 5334
216.71 313.39 235.97 296.01 9.52 3.18 206.2 216.7 328.4 313.2

1936 7.780 9.159 8.055 8.885 0.156 0.080 7.60 7.78 9.38 9.15 1936
197.61 232.64 204.60 225.68 4.75 2.03 193.0 197.6 238.3 232.4

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205.59 254.56 215.34 244.61 4.75 2.03 199.6 205.5 262.9 254.5

1236 8.515 11.360 9.050 10.849 0.250 0.125 8.17 8.53 13.60 12.93 1236
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207.72 242.77 214.71 235.79 3.96 2.03 202.9 207.5 248.4 242.6

1038 8.488 10.416 8.872 10.032 0.187 0.080 8.25 8.48 10.74 10.41 1038
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242.16 347.85 263.27 328.96 9.52 3.96 229.6 242.1 357.4 347.7
## Cylindrical Roller Bearings

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* Oversize outer ring for heavy press fit in standard housing bore.
### Dimensions and Ratings

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* * The maximum fillet on the shaft or in the housing that the bearing corner will clear.
## Cylindrical Roller Bearings

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* Oversize outer ring for heavy press fit in standard housing bore.
### Dimensions and Ratings

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**Notes:**
- Inner Ring O.D.
- Outer Ring I.D.
- Inner Ring Rib O.D.
- Outer Ring Rib I.D.
- Maximum Fillet Radius
- Minimum Shaft Shoulder Diameter
- Maximum Housing Shoulder Diameter

*The maximum fillet on the shaft or in the housing that the bearing corner will clear.*
### Max-Pak Cylindrical Roller Bearings

#### MAX-PAK (Maximum Capacity) W60000 Series

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* Oversize outer ring for heavy press fit in standard housing bore.
## Dimensions and Ratings

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* Oversize outer ring for heavy press fit in standard housing bore.
Max-Pak Cylindrical Roller Bearings

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(Maximum Capacity)
W60000 Series

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* Oversize outer ring for heavy press fit in standard housing bore.
# Dimensions and Ratings

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* Oversize outer ring for heavy press fit in standard housing bore.
# Max-Pak Cylindrical Roller Bearings

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* Oversize outer ring for heavy press fit in standard housing bore.
### Max-Pak Cylindrical Roller Bearings

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(Maximum Capacity)
W60000 Series

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* Oversize outer ring for heavy press fit in standard housing bore.
## MAX-PAK (Maximum Capacity) W60000 Series

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* Oversize outer ring for heavy press fit in standard housing bore.
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* Oversize outer ring for heavy press fit in standard housing bore.
## Dimensions and Ratings

### MAX-PAK (Maximum Capacity) W60000 Series

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* Oversize outer ring for heavy press fit in standard housing bore.
MOJ & MOX Style Cylindrical Roller Bearings

Economical MOJ and MOX roller bearings operate in a very limited space and are easily assembled and disassembled for servicing. The rollers run directly on the hardened and ground surfaces of the shaft and housing, which must have a hardness of Rockwell C58-64 and surface finish no greater than 18 AA to perform at their maximum capacity. Any deviation will result in a reduced load rating which should be discussed with the NTN Application Engineering Department.

MOJ and MOX bearings consist of the same roller complement and composite steel cage components used in the “M” or “W” series bearings.

A part number listing, load ratings, and dimensions are shown on the following pages. For availability and additional information contact NTN sales.

The final drive planetary in this rubber tired earth mover wheel is an ideal application for MOJ or MOX bearings, which must resist shock and carry very heavy radial loads at low speed.
### MOJ & MOX Style Bearings
#### Dimensions and Load Ratings

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* Special crown roller
## Cylindrical Roller Bearings

### MOJ & MOX Style Bearings

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* Special crown roller
Custom “R” Series

In addition to the standard and special cylindrical roller bearings described in previous pages of this catalog, NTN-Bower also manufactures a customized line of precision non-standard cylindrical roller bearings. This line of bearings was custom designed and manufactured to a customer requirement, or was recommended by NTN-Bower to improve the performance of an existing application.

Typical applications for this product line include:

- Automotive Rear Wheels
- Automotive and Truck Pinion Pilot
- Industrial Clutch Pilot Support
- Steel Mill Ingot Car Wheels
- Steel Mill Conveyor Wheels

Listed below and on the following pages is a part number listing and contains the basic bearing dimensions, and radial and static load ratings.

Since this product line is of a customized nature and contains many different bearing configurations, cage styles, etc., contact NTN Sales for additional information and part number availability.

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<th>Basic Bearing Dimensions</th>
<th>Roller Assembly Number</th>
<th>Basic Bearing Dimensions</th>
<th>Radial Load Ratings</th>
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## “R” Series
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Mast and Chain Guide Bearings

Fork lift trucks are employed in almost every manufacturing and shipping facility where lifting or movement of materials is required. An essential part of a fork lift truck is the channeled lift structure which is commonly called the mast. Roller bearings are a basic part of the mast as they guide and retain the forks in the vertical channels. Chain sheave roller bearings which guide the chain and facilitate the lifting and lowering of the mast are an important part of the entire upright system.

Fork lift trucks handle loads ranging from light, bulky material to heavy loads in excess of 4,000 pounds. Mast guide bearings are specifically designed to withstand the heavy impact and radial loads required in this type of application. Mast or chain guide bearings have heavy section outer rings which serve as rollers, or guides for the carriage in the mast channels. The configuration of the outer ring is designed to fit the contour of the mast channel or chain.

In conjunction with the heavy radial loads experienced, thrust loading is also present, which tends to cause misalignment. The internal construction of NTN-Bower cylindrical roller bearings resists misalignment of the outer ring. All mast guide and chain sheave roller bearings are sealed and factory lubricated with a water resistant grease to prevent contamination of the rolling elements and raceways.

NTN-Bower cylindrical roller bearings for mast and chain guide applications are manufactured for leading fork lift truck manufacturers. They are basic full roller complement (no cage) 1200 and 1300 series bearings of single row construction.
## Mast and Chain Guide Bearings Dimensions and Load Ratings

<table>
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<tr>
<th>Bearing Number</th>
<th>Style</th>
<th>Inside Diameter (Inch/mm)</th>
<th>Outside Diameter (Inch/mm)</th>
<th>Race Width (Inch/mm)</th>
<th>Break (Inch/mm)</th>
<th>Sheave (Inch/mm)</th>
<th>Dynamic Load (lbs/N)</th>
<th>Static Load (lbs/N)</th>
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<td>C 1.5748 3.755 0.905</td>
<td>1.307 0.070 R 1.095 4.250</td>
<td>CGM-1209-PPB</td>
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<td>C 1.5748 3.740 1.140</td>
<td>1.025 0.070 R 1.073 4.252</td>
</tr>
</tbody>
</table>

### Notes:
- **Two 1/8 inch diameter holes in inner ring, 180° apart.**
- **Inner ring not central to outer ring.**
- **Spherical O.D.**
- **Dynamic radial load ratings are based on 500 hrs. L10 Life @ 33 1/3 rpm.**
Cylindrical Roller Bearings

ABMA/ANSI Dimensional Tolerances

### Inner Ring

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<th>Basic Bore Diameter</th>
<th>Bore Diameter Tolerances*</th>
<th>Out of Roundness</th>
<th>Radial Runout</th>
<th>Width Limits</th>
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<td>000</td>
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* B Mean represents the Mean Bore Diameter Tolerance. 
Out of Roundness represents the Maximum Bore Diameter Variation in a single radial plane.

### Outer Ring

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<th>Bearing With Internal Snap Rings</th>
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** D Mean represents the Mean Outside Diameter Tolerance. 
Out of Roundness represents the Maximum Outside Diameter Variation in a single radial plane.
Rotational or lateral movement of an outer ring can be prevented by doweling the ring in the housing. This method of mounting is used with either loosely fitted or heavily fitted rings as a precautionary measure. It is important that the blind dowel hole in the ring be located outside the load zone of the bearing.

The dowel holes are located centrally in the width of the outer ring and are identified by a letter “H” in the suffix of the bearing part number. Example: MR1310EHL. The dowel hole dimensions for each bearing size are charted below.

### Basic Bearing Number

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<th>'W' Series</th>
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<th>B</th>
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<td>1300 7300</td>
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Outer Ring Groove & Snap Ring Dimensions

Outer rings can be retained axially in the housing bore by use of snap rings.

The groove without the snap ring is sometimes used as a puller groove to facilitate servicing.

The groove and snap ring are identified by the letters G & R in the suffix of the bearing part number.

Example: MU1310GCLR (Groove with snap ring)
MU1310GCL (Groove only)

### Table: Outer Ring Groove & Snap Ring Dimensions

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### Notes:

- **A** (Groove Location)
- **B**
- **C**
- **D**
- **T**
- **W**
- **X**

**Dimensions:**

- **Inch/mm**: Nominal/Minimum
- **Tolerance**: Maximum - Nominal

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**Example:**

- **MU1310GCLR** (Groove with snap ring)
- **MU1310GCL** (Groove only)
## Outer Ring Groove & Snap Ring Dimensions

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The internal diametral clearance for cylindrical roller bearings listed in this catalog are given on the following tables. Unlike ISO cylindrical and ball bearings whose diametral clearance follows ABMA/ANSI guidelines, Bower cylindricals are manufactured to a set clearance range. This range is designed to result in the optimal mounted clearance condition when using recommended Bower fitting practices as outlined in this catalog.

Special clearance ranges that fall outside those listed on the following tables can be manufactured on request. The part number for the bearing will reflect this special clearance range with a “CB” suffix followed the mean clearance condition in .0001 inches.

For example, MU1208UMCB40 would have a mean clearance value of .0040 inches, whereas the standard clearance condition is .00215 inches.
### Internal Diametral Clearance For Standard “M” Series Cylindrical Roller Bearings

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### Notes:
- Basic “M” Series Radial Clearance — .0001 Inches/Micrometers
- Standard and “A” Style
- Min = Minimum
- Max = Maximum

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**Cylindrical Roller Bearings**

[Source: NTN Bower Catalog](http://www.ntnbower.com/catalog)

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## Dimensions and Ratings

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**Note:** The values in the table represent the minimum and maximum diametral clearances in thousandths of an inch.
General Fitting Practice

Separable Bearings

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* "A" Style Fitting Practice

Over Size O.D.

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Inner or Outer Ring Omitted

Inner Ring Omitted

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* Over size outer ring for heavy press fit in standard (tap fit) size housing bore.

NOTE: The NTN Engineering Department should be consulted for any modification of the above fitting practice.
Fitting Practice

The fitting practice given in the following tables conforms to industry and ABMA/ANSI standards, where applicable. The tables provide maximum and minimum sizes for bearing bore and O.D., shaft and housing bore, and the resultant effects of each type of fit.

Dimensions are given in both inch and metric units with deviations in .0001 inch and micrometers.

The looseness or tightness of a ring mounted on a shaft or in a housing bore depends on the conditions under which the bearing will operate and how it will be installed. The three most generally used fits are: PRESS, TAP AND PUSH.

PRESS fit is used to fit a ring tightly to a rotating member (shaft or housing) to prevent creep or slippage that could result in damage to the shaft or housing bore.

TAP fit usually accompanies PRESS fit, for fitting the opposite ring to the stationary member, if the bearing rings are separable.

PUSH fit is used instead of TAP, for a stationary outer ring, if the bearing is non-separable.

HEAVY PRESS fit (“A” style) is an NTN-Bower innovation for cylindrical roller bearings. It is used to prevent the outer ring from turning in the housing bore, where the bearing is operating under very heavy loads. The outer ring O.D. is made oversize to provide a heavy press fit in a standard (tap fit) size housing bore. The accompanying inner ring uses a PRESS fit on the shaft.

The catalog fitting practice does not apply to bearings mounted on hollow shafts or in housings of materials softer than steel, such as aluminum. Since these conditions usually require heavier press fits, the NTN Engineering Department should be consulted for recommendation.

The chart on the opposite page summarizes the recommended fitting practice for various installations and bearing types, including bearings with inner or outer rings omitted.
## Inner Ring PRESS Fit for Rotating Shaft

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## Outer Ring PRESS Fit for Stationary Shaft

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## Cylindrical Roller Bearings

### Outer Ring PRESS Fit for Stationary Shaft

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| 928 | 026 | 221 | 318 | 7.4803 | 7.4791 | 7.4787 | 7.4779 | 6L | 24T |
| 930 | 028 | 222 | 319 | 7.8740 | 7.8728 | 7.8734 | 7.8716 | 6L | 24T |
| 932 | 030 | 224 | 320 | 8.2677 | 8.2665 | 8.2671 | 8.2653 | 6L | 24T |
| 934 | 032 | 230 | 321 | 8.6514 | 8.6602 | 8.6608 | 8.6590 | 6L | 24T |
| 940 | 036 | 328 | 324 | 10.2362 | 10.2348 | 10.2356 | 10.2336 | 8L | 26T |
| 944 | 038 | 330 | 332 | 11.0236 | 11.0222 | 11.0230 | 11.0210 | 8L | 26T |
| 948 | 040 | 336 | 334 | 11.8110 | 11.8096 | 11.8104 | 11.8084 | 8L | 26T |
|      | 256 | 360 | 350 | 15.7480 | 15.7464 | 15.7474 | 15.7451 | 10L | 29T |
|      |     | 252 | 356 | 17.3228 | 17.3210 | 17.3221 | 17.3197 | 11L | 31T |
|      |     | 254 | 358 | 18.1876 | 18.1858 | 18.1896 | 18.1895 | 11L | 31T |
|      |     | 256 | 360 | 18.9876 | 18.9858 | 18.9896 | 18.9895 | 11L | 31T |

**Note:** ABMA Fit Class N7 indicates a non-standard fit.
## Outer Ring HEAVY PRESS Fit

“A” Style Bearing with Oversize O.D. For Heavy Press Fit — Use with Press Fit Inner Ring

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### Outer Ring HEAVY PRESS Fit (Cont.)

“A” Style Bearing with Oversize O.D. For Heavy Press Fit — Use with Press Fit Inner Ring

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- **NONE**
Mounting and Fitting Practice

Shaft Diameter — Inner Ring Omitted
With Outer Ring TAP and HEAVY PRESS Fits for Rotating Shaft

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NOTE: Shaft surface functioning as a bearing raceway must have a hardness of Rockwell C-58-64 and a maximum finish of 18 AA Deviation from this hardness or surface finish will require a reduction in the catalog load rating of the bearing. Consult NTN Engineering Department for a recommendation.
### Cylindrical Roller Bearings

**Shaft Diameter — Inner Ring Omitted**

*With Outer Ring PRESS Fit for Stationary Shaft*

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**NOTE:** Shaft surface functioning as a bearing raceway must have a hardness of Rockwell C-58-64 and a maximum finish of 18 AA Deviation from this hardness or surface finish will require a reduction in the catalog load rating of the bearing. Consult NTN Engineering Department for a recommendation.
### Housing Bore — Outer Ring Omitted

**With Inner Ring TAP Fit for Stationary Shaft**

**NOTE:** Shaft surface functioning as a bearing raceway must have a hardness of Rockwell C-58-64 and a maximum finish of 18 AA Deviation from this hardness or surface finish will require a reduction in the catalog load rating of the bearing. Consult NTN Engineering Department for a recommendation.

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### Cylindrical Roller Bearings

**Housing Bore — Outer Ring Omitted**

*With Inner Ring PRESS Fit for Rotating Shaft*

![Image of cylindrical roller bearings](image)

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**NOTE:** Shaft surface functioning as a bearing raceway must have a hardness of Rockwell C-58-64 and a maximum finish of 18 AA Deviation from this hardness or surface finish will require a reduction in the catalog load rating of the bearing. Consult NTN Engineering Department for a recommendation.
Tapered Roller Bearings

Tapered roller bearings, due to tapered raceways and rollers, have the capability to support various combinations of thrust and radial loads. The thrust load capability varies with the cup angle; the greater the cup angle the greater is the ratio of thrust to radial rating.

Tapered roller bearings are manufactured by NTN-Bower in many different series to meet various application requirements. All the bearings in a series have the same internal construction and load carrying capability. Each series also include a number of cones which differ only in bore size and/or corner radius. Any cone within a given series may be combined with any cup in the same series and each combination will have the same load rating as discussed later in this catalog.

NTN-Bower makes various types of single row, two row and four row tapered roller bearings consisting of a variety of cone and cup configurations as described below:

**Single Row Bearings (TS Type)**

The TS type bearing is the most commonly used tapered roller bearing. It consists of a single cone and a single cup. The TS type is available in various bores, widths, outside diameters, and cup angles to provide a range of envelope dimensions and radial and thrust load ratings to meet various application requirements. The TS type bearing with a steeper cup angle can support a greater thrust load than a radial load.

**Flanged Cup Single Row Bearings (TSF Type)**

The TSF type bearing consists of a single cone and a single cup flanged on its outside diameter. The cup flange is mounted against the side face of the housing eliminating the need for a shoulder inside the housing to support thrust loads. This feature permits through-boring of the housing to achieve a more accurate alignment for the cup seats. In other respects, the flanged cup bearings are similar to the TS type bearing described previously.

**Double Cup Two Row Bearings (TDO Type)**

Double cup two row bearings are manufactured in many of the same series as single row tapered roller bearings. The TDO type bearing consists of a double cup having one piece construction with two raceways, and two single cones. The TDO type bearing cup provides a groove with oil holes for lubrication. These bearings are available with or without cone spacers.
The TDO type bearing with the cone spacer is sold as a matched assembly to provide preset clearance for achieving optimum bearing life. It saves installation time by eliminating the need to adjust clearance during bearing installation in the system. The components for the TDO type bearing without cone spacer can be bought individually by the bearing user. In either case, the NTN Application Engineering Department should be consulted to determine the optimum clearance needed for the application. These bearings can support thrust loads in either direction and have radial load capabilities greater than the single row bearings.

The TDO type bearing is also available in a configuration designated as TDOCD type. This type of bearing is similar in every respect to the type TDO bearing except it has one of the lubrication holes counter-bored in the cup. By inserting a pin in this hole the cup can be locked in place against circumferential and axial movement in the housing.

The TDODC type version is also the same as the TDO type bearing except that the TDODC cup has no groove in the O.D. and only one hole counter-bored for pinning plus a lubrication passage.

Non-Adjustable Double Cup Two Row Bearings (TNA Type)

The TNA, TNACD, TNADC and TNASWE types for similar to TDO, TDOCD and TDODC types except the former types have the internal clearance controlled by flush-mounting the extended front faces of the cones against each other. Slots in the cone front face of the TNASWE type allow for the flow of lubricant. For most applications, the pre-set internal clearance is satisfactory, provided the recommended fitting practices are used.

Double Cone Two Row Bearings (TDI Type)

The TDI type bearing consists of a double cone having one piece construction with two raceways, and two single cups. The bearing is available with or without a cup spacer. The TDI type bearing with a cup spacer is sold as a matched assembly to provide preset clearance for optimum bearing life. These bearings can support thrust loads in either direction, and have radial load capabilities greater than single row bearings.

Double Cone Four Row Bearings (TQO Type)

The TQO type bearing consists of two double cones, one double cup, two single cups, one cone spacer and two cup spacers. The TQO type bearing has lubrication holes provided in the cup spacers, the cone spacer, and the double cup. The TQO type bearing is a matched assembly to provide the required end play for the application. This bearing can support thrust loads in either direction and has thrust and radial load capabilities greater than the TDI type and TDO type bearings. These bearings are normally used as work roll bearings in steel mills.
Bearing Design

True Rolling Contact
Tapered roller bearings have true rolling motion between rollers and raceways. The bearing is designed so that straight lines extended from the tapered surface of each roller and raceway contact meet at a common point called the apex located on the centerline of the bearing axis. This produces true rolling motion at each roller and raceway contact.

Crowned Rollers
NTN-Bower’s pioneering efforts in developing crowned rollers have resulted in greater load carrying capability and longer bearing life. Crowned rollers under load distribute stress equally along their full length of contact with the raceways, thereby eliminating stress concentration at the roller ends. This design concept also compensates for minor misalignment between shaft and housing bore and deflection under load thereby reducing stress concentration.

Material
Cups, cones and rollers of NTN-Bower tapered roller bearing are made from case hardened alloy steel of “Bearing Quality” to provide superior fatigue life and reliability. Precise control of heat treatment, dimensions and surface finish of the components further contribute to reliable bearing performance. Premium steels and heat treatments are available for applications requiring extended life and high reliability.

Roller End-Rib Face Contact Geometry
Because the cup and cone raceway angles are different, the resultant forces between roller-cup contact and roller-cone contact are not equal. The difference between two resultant forces on each roller produces a seating force between the large end of the roller and the cone large rib. This seating force produces positive roller guidance. NTN-Bower tapered roller bearings have a spherical surface precision ground on the large end of the rollers. The large roller end and large rib face contact geometry is optimized to promote hydrodynamic lubrication to achieve lower operating temperature and bearing torque.

Nomenclature
### Bearing Selection by Bore Size

The Bearing Selection Chart by bore size is an aid to the design engineer in selecting the best single row bearing for the application. This chart identifies the minimum bearing outside diameter and minimum bearing width available in each series. This will aid in selecting a bearing where space is limited.

The bearing bore is normally selected for an application according to the required shaft size. After the design engineer has established the bearing bore size, this chart will identify all bearing series which include the required bore size plus information on the axial load factor and dynamic radial rating to assist in making the final bearing selection. This chart also refers to the page number where the detailed information about bearings in each series can be found. NTN Sales is available to assist in making the most economical bearing selection.

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<th>Bearing Boundary Dimensions</th>
<th>Bore Diameter Range</th>
<th>Outside Diameter</th>
<th>Bearing Width</th>
<th>Dynamic Radial Rating (^*) (C_e)</th>
<th>Axial Load Factors (Y_2)</th>
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\(*\) Radial load ratings are based on 500 hrs. \(L_{10}\) Life @ 33 1/3 rpm

---

**Tapered Roller Bearings**

- A bearing where space is limited.
- Design engineer in selecting the best single row bearing.
- Economical bearing selection.
- Available to assist in making the most economical selection.
- Bearing bore is normally selected for application.
- Bearing selection chart.

**Bearing Boundary Dimensions**

- **Bore Diameter Range:** 1.7812 to 2.1250
- **Outside Diameter:** Min to Max
- **Bearing Width:** Min to Max
- **Dynamic Radial Rating \(C_e\):** Min to Max
- **Axial Load Factors \(Y_2\):** Min to Max
- **Series Number:** Min to Max
- **Page No.:** 164

**Dynamic Radial Rating \(C_e\):**

- 0.43 to 1.40

**Axial Load Factors \(Y_2\):**

- 1.41 to 1.40

**Series Number:**

- LM60300

**Page No.:**

- 164

---

**Radial Load Ratings:**

- Based on 500 hrs. \(L_{10}\) Life @ 33 1/3 rpm.

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**Bore Diameter Range:**

- 1.7812 to 2.1250

**Outside Diameter:**

- Min to Max

**Bearing Width:**

- Min to Max

**Dynamic Radial Rating \(C_e\):**

- Min to Max

**Axial Load Factors \(Y_2\):**

- Min to Max

**Series Number:**

- Min to Max

**Page No.:**

- 164
### Bearing Boundary Dimensions

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* Radial load ratings are based on 500 hrs. L₁₀ Life @ 33 1/3 rpm
## Tapered Roller Bearings

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* Radial load ratings are based on 500 hrs. Life @ 33 1/3 rpm
### Bearing Selection by Bore Size

#### Bearing Boundary Dimensions

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* Radial load ratings are based on 500 hrs. L10 Life @ 33 1/2 rpm

### Dynamic Radial Load Rating

- C0: 37500 lbs/N
- C3: 57000 lbs/N
- C4: 184000 lbs/N
- Y2: 82000 lbs/N

### Load Factors

- Series Number: M229300, M231600, HH234500, M235150, HM534100, M236800, HM237000

### Page Numbers

- Series Number Page No.: 138, 155, 172, 156, 181, 156, 156
### Tapered Roller Bearings

#### Bearing Boundary Dimensions

<table>
<thead>
<tr>
<th>Bore Diameter Range</th>
<th>Outside Diameter</th>
<th>Bearing Width</th>
<th>Dynamic Radial Rating C* lbf/N</th>
<th>Axial Load Factors e y*</th>
<th>Series Number</th>
<th>Page No.</th>
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#### Bearing Boundary Dimensions

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<tr>
<th>Bore Diameter Range</th>
<th>Outside Diameter</th>
<th>Bearing Width</th>
<th>Dynamic Radial Rating C* lbf/N</th>
<th>Axial Load Factors e y*</th>
<th>Series Number</th>
<th>Page No.</th>
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<td><strong>Minimum</strong></td>
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* Radial load ratings are based on 500 hrs. L₁₀ Life @ 33 3/4 rpm
**Dimensions**

The basic boundary dimensions (bore, outside diameter, width) in the following tables conform to the standards established by ABMA/ANSI.

A description of dimensions represented by various letters is given below:

- **B** Nominal cone bore diameter. The tolerance is given on pages 198–199 and the range is in the “Fitting Practice” section

- **Wi** Nominal cone width. The tolerance is given on pages 198–199

- **R** Maximum fillet on the shaft that the bearing corner will clear

- **a** The distance from the cone backface to the effective load center

- **U** Recommended minimum shaft shoulder diameter

- **V** Recommended minimum shaft shoulder diameter

- **D** Nominal cup outside diameter. The tolerance is given on pages 198–199 and the range is in the “Fitting Practice” section

- **Wo** Nominal cup width. The tolerance is given on pages 198–199

- **r** Maximum fillet in the housing that the bearing corner will clear

- **X** Recommended maximum housing shoulder diameter for TSF Type

- **Z** Recommended maximum housing shoulder diameter for TS Type

- **W** Nominal bearing width. The tolerance is given on pages 198–199

Dimensions shown in the tables are given in both inch and metric units and are based on:

- 1 inch = 25.4 mm exactly
- 1 micrometer = 1\( \mu \text{m} = 10^{-6} \text{ m} \)
- 1 micrometer = .001 mm

**Load Ratings**

The radial load ratings in this catalog are based on 500 hrs \( L_{10} \) life at 33 ½ rpm or 1 million cycles for either cone or cup rotation. To convert this rating to 3000 hrs \( L_{10} \) life at 500 rpm or 90 million cycles basis, divide by 3.857.

The load ratings, dynamic and static, are shown in both pounds and newtons.

- 1 pound = 4.448 newtons
### Tapered Roller Bearings

**Radial Rating**

- **Load Rating:** 3000 hrs L10 Life @ 500 rpm
- **K Factor**
- **Cone Number**
- **Bore Diameter**
- **Cone Width**
- **Maximum Shaft Fillet Radius**
- **Effective Load Center**
- **Minimum Shaft Diameter**
- **Minimum Shaft Shoulder Diameter**
- **Bearing Width**
- **Outside Diameter**
- **Cup Width**
- **Maximum Housing Fillet Radius**
- **Maximum Housing Shoulder Diameter**
- **Maximum Housing Shoulder Diameter**
- **Bearing Width**

### Basic Load Ratings Axial Load Factor

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<th>Static C, lbs/N</th>
<th>Factor Y2</th>
<th>365 Series</th>
<th>Inch/mm</th>
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</table>

* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
† Positive value indicates the effective load center is outside the backface of the cone.
▲ For additional “B” cup dimensions, see pages 173 to 174.
■ For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
* Designate bearings with hollow rollers and pinned-type retainers.
♦ Bearing is equipped with seals (and in some instances side rings).
## Dimensions and Ratings

<table>
<thead>
<tr>
<th>Bore Diameter</th>
<th>Cone Width</th>
<th>Minimum Shaft Shoulder Diameter</th>
<th>Minimum Shaft Shoulder Diameter</th>
<th>Cup Number</th>
<th>Outside Diameter</th>
<th>Cup Width</th>
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</table>

* The maximum fillet on the shaft or in the housing that the bearing corner will clear.

† Positive value indicates the effective load center is outside the backface of the cone.

▲ For additional "B" cup dimensions, see pages 173 to 174.

★ For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.

* Designate bearings with hollow rollers and pinned-type retainers.

† Bearing is equipped with seals (and in some instances side rings).
### Basic Load Ratings

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<tr>
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<th>Static Load Rating C₀</th>
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<th>R</th>
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<th>V</th>
<th>Cup Number</th>
<th>D</th>
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</table>

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† Positive value indicates the effective load center is outside the backface of the cone.
‡ For additional “B” cup dimensions, see pages 173 to 174.
§ For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
¶ Designate bearings with hollow rollers and pinned-type retainers.
∥ Bearing is equipped with seals (and in some instances side rings).
<table>
<thead>
<tr>
<th>Basic Load Ratings</th>
<th>Axial Load Factor C_y</th>
<th>Dimensions and Ratings</th>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
† Positive value indicates the effective load center is outside the backface of the cone.
▲ For additional "B" cup dimensions, see pages 173 to 174.
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★ Designate bearings with hollow rollers and pinned-type retainers.
◆ Bearing is equipped with seals (and in some instances side rings).
### Tapered Roller Bearings

#### Load Ratings

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**Bearing Type**: TS Type  
**Bearing Type**: TSF Type

---

* The maximum fillet on the shaft or in the housing that the bearing corner will clear.  
† Positive value indicates the effective load center is outside the backface of the cone.  
▲ For additional “B” cup dimensions, see pages 173 to 174.  
■ For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.  
★ Designate bearings with hollow rollers and pinned-type retainers.  
♦ Bearing is equipped with seals (and in some instances side rings).
### Basic Load Ratings

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### Axial Load Factor

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<th>Cone Width</th>
<th>Maximum Shaft Fillet Radius</th>
<th>Effective Load Center†</th>
<th>Minimum Shaft Shoulder Diameter</th>
<th>Minimum Housing Shoulder Diameter</th>
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### Additional Notes

- * The maximum fillet on the shaft or in the housing that the bearing corner will clear.
- † Positive value indicates the effective load center is outside the backface of the cone.
- ▲ For additional "B" cup dimensions, see pages 173 to 174.
- ★ For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
- ◆ Designate bearings with hollow rollers and pinned-type retainers.
- ♦ Bearing is equipped with seals (and in some instances side rings).
### Tapered Roller Bearings

**Basic Load Ratings**

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<th>Maximum Shaft Fillet Radius</th>
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**Axial Load Factor**

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**Cone Number**

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<th>Cone Width</th>
<th>Maximum Shaft Fillet Radius</th>
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</table>

**Notes**

- The maximum fillet on the shaft or in the housing that the bearing corner will clear.
- Positive value indicates the effective load center is outside the backface of the cone.
- For additional “B” cup dimensions, see pages 173 to 174.
- For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
- Designate bearings with hollow rollers and pinned-type retainers.
- Bearing is equipped with seals (and in some instances side rings).
### Dimensions and Ratings

<table>
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<th>Dynamic $C_r$</th>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.

† Positive value indicates the effective load center is outside the backface of the cone.

▲ For additional "B" cup dimensions, see pages 173 to 174.

■ For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.

* Designate bearings with hollow rollers and pinned-type retainers.

♦ Bearing is equipped with seals (and in some instances side rings).

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* Designate bearings with hollow rollers and pinned-type retainers.

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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
† Positive value indicates the effective load center is outside the backface of the cone.
▲ For additional "B" cup dimensions, see pages 173 to 174.
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### Dimensions and Ratings

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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
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▲ For additional "B" cup dimensions, see pages 173 to 174.
♦ For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
☆ Designate bearings with hollow rollers and pinned-type retainers.
♦ Bearing is equipped with seals (and in some instances side rings).
## Tapered Roller Bearings

### Basic Load Ratings

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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
† Positive value indicates the effective load center is outside the backface of the cone.
▲ For additional “B” cup dimensions, see pages 173 to 174.
★ For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
◆ Designate bearings with hollow rollers and pinned-type retainers.
◆ Bearing is equipped with seals (and in some instances side rings).
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
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▲ For additional "B" cup dimensions, see pages 173 to 174.
■ For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
* Designate bearings with hollow rollers and pinned-type retainers.
* Bearing is equipped with seals (and in some instances side rings).
### Tapered Roller Bearings

**TS Type**

| Basic Load Ratings | Axial Load Factor $C_r$ | Static Load Factor $C_m$ | Cone Number | Bore Diameter (mm) | Cone Width (mm) | Maximum Shaft Fillet Radius (mm) | Effective Load Center† | Minimum Shaft Shoulder Diameter (mm) | Minimum Shaft Diameter (mm) | Cup Number | Outside Diameter (mm) | Cup Width (mm) | Maximum Housing Fillet Radius (mm) | Maximum Housing Shoulder Diameter (mm) | Bearing Width (mm) |
|--------------------|-------------------------|--------------------------|-------------|--------------------|-----------------|----------------------------------|------------------------|-------------------------------|--------------------------|------------|----------------------|----------------|---------------------------|---------------------------|----------------|----------------|
| 85500              | 380000                  | 300000                   | 855         | 5.000              | 2.2650          | 0.31                             | -0.60                  | 4.65                          | 4.06                     | 854        | 7.500                | 1.7500         | 0.13                       | 6.85                      | 6.69           | 2.2500         |
| 85500              | 380000                  | 300000                   | 857         | 5.250              | 2.2650          | 0.31                             | -0.60                  | 4.76                          | 4.17                     | 854B       | 7.500                | 1.7500         | 0.13                       | 6.85                      | 6.69           | 2.2500         |
| 85500              | 380000                  | 300000                   | 860         | 4.0000             | 2.2650          | 0.38                             | -0.60                  | 5.63                          | 4.29                     | 854        | 101.600              | 57.351         | 8.0                                                     | 114.0                      |                |
| 85500              | 380000                  | 300000                   | 861         | 4.0000             | 2.2650          | 0.31                             | -0.60                  | 5.08                          | 4.49                     | 854        | 101.600              | 57.351         | 8.0                                                     | 114.0                      |                |
| 85500              | 380000                  | 300000                   | 864         | 3.750              | 2.2650          | 0.31                             | -0.60                  | 4.84                          | 4.25                     | 854        | 95.250               | 57.351         | 8.0                                                     | 114.0                      |                |
| 85500              | 380000                  | 300000                   | 866         | 3.8750             | 2.2650          | 0.14                             | -0.60                  | 4.65                          | 4.37                     | 854        | 96.450               | 57.351         | 8.0                                                     | 114.0                      |                |
| 85500              | 380000                  | 300000                   | 869         | 3.4875             | 2.2650          | 0.31                             | -0.60                  | 4.80                          | 3.74                     | 854        | 87.312               | 57.351         | 8.0                                                     | 95.0                       |                |

**TSF Type**

| Basic Load Ratings | Axial Load Factor $C_r$ | Static Load Factor $C_m$ | Cone Number | Bore Diameter (mm) | Cone Width (mm) | Maximum Shaft Fillet Radius (mm) | Effective Load Center† | Minimum Shaft Shoulder Diameter (mm) | Minimum Shaft Diameter (mm) | Cup Number | Outside Diameter (mm) | Cup Width (mm) | Maximum Housing Fillet Radius (mm) | Maximum Housing Shoulder Diameter (mm) | Bearing Width (mm) |
|--------------------|-------------------------|--------------------------|-------------|--------------------|-----------------|----------------------------------|------------------------|-------------------------------|--------------------------|------------|----------------------|----------------|---------------------------|---------------------------|----------------|----------------|
| 98000              | 435000                  | 162000                   | 896         | 5.3750             | 2.2500          | 0.14                             | -0.24                  | 6.14                          | 5.91                     | 892        | 9.000                | 1.7500         | 0.13                       | 8.50                      | 8.07           | 2.2500         |
| 98000              | 435000                  | 162000                   | 898         | 5.5000             | 2.2500          | 0.14                             | -0.24                  | 6.30                          | 6.02                     | 892B       | 9.000                | 1.7500         | 0.13                       | 8.50                      | 8.07           | 2.2500         |
| 98000              | 435000                  | 162000                   | 896A        | 5.5000             | 2.2500          | 0.25                             | -0.24                  | 6.50                          | 6.02                     | 892B       | 9.000                | 1.7500         | 0.13                       | 8.50                      | 8.07           | 2.2500         |

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 Designate bearings with hollow rollers and pinned-type retainers.
 Bearing is equipped with seals (and in some instances side rings).

For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.

For additional "B" cup dimensions, see pages 173 to 174.

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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
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For additional “B” cup dimensions, see pages 173 to 174.
* For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
+ Designate bearings with hollow rollers and pinned-type retainers.
△ Bearing is equipped with seals (and in some instances side rings).

For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
### Tapered Roller Bearings

**TS Type**

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▲ For additional “B” cup dimensions, see pages 173 to 174.
■ For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
★ Designate bearings with hollow rollers and pinned-type retainers.
♦ Bearing is equipped with seals (and in some instances side rings).
### Dimensions and Ratings

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**The maximum fillet on the shaft or in the housing that the bearing corner will clear.**

**Positive value indicates the effective load center is outside the backface of the cone.**

**For additional “B” cup dimensions, see pages 173 to 174.**

**For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.**

**Designate bearings with hollow rollers and pinned-type retainers.**

**Bearing is equipped with seals (and in some instances side rings).**
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♦ Bearing is equipped with seals (and in some instances side rings).
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## Tapered Roller Bearings

**TS Type**

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<th>Axial Load Factor</th>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.

For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.

Designate bearings with hollow rollers and pinned-type retainers.

Bearing is equipped with seals (and in some instances side rings).
### Dimensions and Ratings

#### Basic Load Ratings

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<th>Effective Load Center</th>
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#### Ratings

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### Notes

- The maximum fillet on the shaft or in the housing that the bearing corner will clear.
- Positive value indicates the effective load center is outside the backface of the cone.
- For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
- For additional "B" cup dimensions, see pages 173 to 174.
- Designate bearings with hollow rollers and pinned-type retainers.
- Bearing is equipped with seals (and in some instances side rings).
### Tapered Roller Bearings

#### TS Type

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<th>Basic Load Ratings</th>
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¶ Designate bearings with hollow rollers and pinned-type retainers.
♦ Bearing is equipped with seals (and in some instances side rings).
### Tapered Roller Bearings

**TS Type**

- **Bore Diameter**: W
- **Cone Width**: Wo
- **Maximum Shaft Fillet Radius**: a
- **Effective Load Center**: R
- **Minimum Shaft Diameter**: V
- **Minimum Shaft Shoulder Diameter**: W

**TSF Type**

- **Bore Diameter**: W
- **Cone Width**: Wo
- **Maximum Shaft Fillet Radius**: a
- **Effective Load Center**: R
- **Minimum Shaft Diameter**: V
- **Minimum Shaft Shoulder Diameter**: W

#### Basic Load Ratings

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<th>Dynamic</th>
<th>Static</th>
<th>Axial Load Factor</th>
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<th>Bore Diameter</th>
<th>Cone Width</th>
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- ♦: Bearing is equipped with seals (and in some instances side rings).
<table>
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<th>Basic Load Ratings</th>
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<th>W (Cup Width)</th>
<th>Maximum Housing Fillet Radius</th>
<th>Maximum Housing Shoulder Diameter</th>
<th>Bearing Width</th>
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<td>107.0</td>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
† Positive value indicates the effective load center is outside the backface of the cone.
▲ For additional “B” cup dimensions, see pages 173 to 174.
§ For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
★ Designate bearings with hollow rollers and pinned-type retainers.
◆ Bearing is equipped with seals (and in some instances side rings).
<table>
<thead>
<tr>
<th>Basic Load Ratings</th>
<th>Axial Load Factor</th>
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<th>B</th>
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<th>R</th>
<th>a</th>
<th>U</th>
<th>V</th>
<th>Cup Number</th>
<th>D</th>
<th>W_o</th>
<th>r</th>
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<td>7.60</td>
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</table>

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▲ For additional “B” cup dimensions, see pages 173 to 174.
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★ Designate bearings with hollow rollers and pinned-type retainers.
♦ Bearing is equipped with seals (and in some instances side rings).
<table>
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<tr>
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<td>55215C</td>
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* Designate bearings with hollow rollers and pinned-type retainers.
♦ Bearing is equipped with seals (and in some instances side rings).
### Tapered Roller Bearings

#### Basic Load Ratings

<table>
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<th>Type</th>
<th>Load Category</th>
<th>Number</th>
<th>Width</th>
<th>Outside Diameter</th>
<th>Cup Width</th>
<th>Maximum Housing Shoulder Diameter</th>
<th>Minimum Housing Shoulder Diameter</th>
<th>Bearing Width</th>
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#### axial load factor

- Cone Number
- Bore Diameter
- Cone Width
- Maximum Shaft Fillet Radius
- Effective Load Center
- Minimum Shaft Shoulder Diameter
- Minimum Shaft Shoulder Diameter

- Cup Number
- Outside Diameter
- Cup Width
- Maximum Housing Fillet Radius
- Maximum Housing Shoulder Diameter
- Maximum Housing Shoulder Diameter
- Bearing Width

#### Notes:

- * The maximum fillet on the shaft or in the housing that the bearing corner will clear.
- † Positive value indicates the effective load center is outside the backface of the cone.
- ▲ For additional "B" cup dimensions, see pages 173 to 174.
- ▲ For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
- ▲ Designate bearings with hollow rollers and pinned-type retainers.
- ▲ Bearing is equipped with seals (and in some instances side rings).
<table>
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<tr>
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<th>Minimum Shoulder Diameter</th>
<th>Minimum Shaft Shoulder Diameter</th>
<th>Minimum Shaft Fillet Radius</th>
<th>Effective Load Center</th>
<th>Cup Number</th>
<th>Outside Diameter</th>
<th>Cup Width</th>
<th>Maximum Housing Shoulder Diameter</th>
<th>Maximum Housing Shoulder Diameter</th>
<th>Bearing Width</th>
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### Basic Load Ratings

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<th>Dynamic C &lt;sub&gt;r&lt;/sub&gt;</th>
<th>Static C &lt;sub&gt;er&lt;/sub&gt;</th>
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<th>R</th>
<th>a</th>
<th>U</th>
<th>V</th>
<th>Cup Number</th>
<th>D</th>
<th>W&lt;sub&gt;0&lt;/sub&gt;</th>
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### Dimensions and Ratings

#### Basic Load Ratings

<table>
<thead>
<tr>
<th>Dynamic $C_r$</th>
<th>Static $C_0$</th>
<th>Cone Number</th>
<th>Bore Diameter (Inch/mm)</th>
<th>Cone Width (Inch/mm)</th>
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<th>Effective Load Center (Inch/mm)</th>
<th>Minimum Shaft Shoulder Diameter (Inch/mm)</th>
<th>Minimum Housing Shoulder Diameter (Inch/mm)</th>
<th>Cup Number</th>
<th>Outside Diameter (Inch/mm)</th>
<th>Cup Width (Inch/mm)</th>
<th>Maximum Housing Filet Radius (Inch/mm)</th>
<th>Maximum Housing Shoulder Diameter (Inch/mm)</th>
<th>Bearing Width (Inch/mm)</th>
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#### Thrust Ratings

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* Positive value indicates the effective load center is outside the backface of the cone.
* ▲ For additional "B" cup dimensions, see pages 173 to 174.
* ▲ For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
* Designate bearings with hollow rollers and pinned-type retainers.
* Bearing is equipped with seals (and in some instances side rings).
### Basic Load Ratings

<table>
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<th>Dynamic Load</th>
<th>Static Load Factor</th>
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<th>V</th>
<th>Cup Number</th>
<th>D</th>
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**Inch/mm**

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<p>| * The maximum fillet on the shaft or in the housing that the bearing corner will clear. |
| † Positive value indicates the effective load center is outside the backface of the cone. |
| ▲ For additional &quot;B&quot; cup dimensions, see pages 173 to 174. |
| ■ For parts with a &quot;U&quot; prefix, use metric tolerances given on page 199 and fitting practice given on page 201. |
| â Designate bearings with hollow rollers and pinned-type retainers. |
| ‡ Bearing is equipped with seals (and in some instances side rings). |</p>
<table>
<thead>
<tr>
<th>Basic Load Ratings</th>
<th>Axial Load Factor f_x</th>
<th>Cone Number</th>
<th>Bore Diameter (Inch/mm)</th>
<th>Cone Width (Inch/mm)</th>
<th>Maximum Shaft Fillet Radius (Inch/mm)</th>
<th>Effective Load (Lb/Inch)</th>
<th>Minimum Shaft Diameter (Inch/mm)</th>
<th>Minimum Housing Diameter (Inch/mm)</th>
<th>Cup Diameter (Inch/mm)</th>
<th>Cup Width (Inch/mm)</th>
<th>Outside Diameter (Inch/mm)</th>
<th>Cup Width (Inch/mm)</th>
<th>Maximum Housing Diameter (Inch/mm)</th>
<th>Maximum Housing Diameter (Inch/mm)</th>
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### Tapered Roller Bearings

**Basic Load Ratings**

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**Axial Load Factor**

- Static Load Rating $C_{as}$
- Dynamic Load Rating $C_{d}$

**Cone Number**

- 87737
- 87750
- 87762
- 88900
- 88925
- 88931
- 90334
- 90354
- 90381

**Bore Diameter**

- 7.3750
- 7.5000
- 7.6250
- 9.0000
- 9.2500
- 9.3125
- 3.3465
- 3.5433
- 3.8125

**Cone Width**

- 1.8750
- 1.8750
- 1.8750
- 1.9375
- 1.9375
- 1.7500
- 2.0772
- 1.8125
- 1.8125

**Maximum Shaft Fillet Radius**

- 3.5
- 3.5
- 3.5
- 6.4
- 6.4
- 3.5
- 3.5
- 3.5
- 3.5

**Effective Load Center**

- 8.15
- 8.23
- 8.31
- 9.96
- 10.16
- 10.16
- 4.57
- 4.72
- 4.92

**Minimum Shaft Shoulder Diameter**

- 7.91
- 7.99
- 8.11
- 9.53
- 9.69
- 9.69
- 4.41
- 4.40
- 4.44

**Minimum Shaft Shoulder Diameter**

- 8.15
- 9.96
- 8.11
- 9.53
- 9.69
- 9.69
- 4.41
- 4.40
- 4.44

**Outside Diameter**

- 11.1250
- 11.1250
- 11.1250
- 12.6250
- 12.8750
- 12.8750
- 7.4375
- 7.4375
- 7.4375

**Cup Width**

- 4.41
- 4.40
- 4.44
- 12.00
- 12.00
- 12.00
- 11.20
- 11.20
- 11.20

**Maximum Housing Fillet Radius**

- 3.3
- 3.3
- 3.3
- 3.3
- 3.3
- 3.3
- 3.3
- 3.3
- 3.3

**Maximum Housing Shoulder Diameter**

- 10.50
- 10.71
- —
- 12.17
- 12.17
- 12.17
- 12.17
- 12.17
- 12.17

**Maximum Housing Shoulder Diameter**

- 10.28
- —
- —
- 11.77
- 11.77
- 11.77
- 11.77
- 11.77
- 11.77

**Bearing Width**

- 2.0000
- 2.0000
- 2.0000
- 1.2500
- 1.2500
- 1.2500
- 1.2500
- 1.2500
- 1.2500

---

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▲ For additional “B” cup dimensions, see pages 173 to 174.

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★ Designate bearings with hollow rollers and pinned-type retainers.

◆ Bearing is equipped with seals (and in some instances side rings).
<table>
<thead>
<tr>
<th>Basic Load Ratings</th>
<th>Axial Load Factor</th>
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<th>( R )</th>
<th>( a )</th>
<th>( U )</th>
<th>( V )</th>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
† Positive value indicates the effective load center is outside the backface of the cone.
▲ For additional “B” cup dimensions, see pages 173 to 174.
■ For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
◆ Designate bearings with hollow rollers and pinned-type retainers.
♦ Bearing is equipped with seals (and in some instances side rings).
### Tapered Roller Bearings

#### Basic Load Ratings

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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
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\[ \text{For additional "B" cup dimensions, see pages 173 to 174.} \]
\[ \text{For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.} \]
\[ \text{Designate bearings with hollow rollers and pinned-type retainers.} \]
\[ \text{Bearing is equipped with seals (and in some instances side rings).} \]
### Tapered Roller Bearings

#### TS Type

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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.

† Positive value indicates the effective load center is outside the backface of the cone.

▲ For additional "B" cup dimensions, see pages 173 to 174.

■ For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.

* Designate bearings with hollow rollers and pinned-type retainers.

◆ Bearing is equipped with seals (and in some instances side rings).
### Dimensions and Ratings

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### Basic Load Ratings

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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.

† Positive value indicates the effective load center is outside the backface of the cone.

▲ For additional “B” cup dimensions, see pages 173 to 174.

■ For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.

★ Designate bearings with hollow rollers and pinned-type retainers.

♦ Bearing is equipped with seals (and in some instances side rings).
### Dimensions and Ratings

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<td>Designate bearings with hollow rollers and pinned-type retainers.</td>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.

† Positive value indicates the effective load center is outside the backface of the cone.

▲ For additional “B” cup dimensions, see pages 173 to 174.

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**Tapered Roller Bearings**

**Designate bearings with hollow rollers and pinned-type retainers.**

**For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.**

**For additional “B” cup dimensions, see pages 173 to 174.**

**The maximum fillet on the shaft or in the housing that the bearing corner will clear.**

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† Positive value indicates the effective load center is outside the backface of the cone.

▲ For additional “B” cup dimensions, see pages 173 to 174.

■ For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.

* Designate bearings with hollow rollers and pinned-type retainers.

◆ Bearing is equipped with seals (and in some instances side rings).
| Basic Load Ratings | Axial Load Factor C_a | Cone Number | B | Bore Diameter | W_l | Cone Width | R | Maximum Shaft Fillet Radius | a | Minimum Shaft Shoulder Diameter | U | Minimum Shaft Shoulder Diameter | V | Cup Number | D | Outside Diameter | W_o | Cup Width | r | X | Z | W |
|-------------------|----------------------|-------------|---|----------------|-----|-------------|---|-----------------------------|---|---------------------------|---|---------------------------|---|----------------|---|----------------|---|---|---|---|
| 103000 | 460000 | 0.33 | M238800 Series | 7.0000 | 2.1875 | 0.14 | -0.24 | 7.80 | 7.64 | M238810 | 10.6250 | 1.6875 | 0.13 | 10.08 | 9.84 | 2.1875 |
| 815000 | 365000 | 0.32 | LM241100 Series | 8.0000 | 1.6875 | 0.14 | 0.07 | 8.62 | 8.43 | LM241110 | 10.8750 | 1.3438 | 0.13 | 10.51 | 10.24 | 1.6875 |
| 118000 | 525000 | 0.33 | M241500 Series | 7.8750 | 2.2813 | 0.14 | -0.19 | 8.62 | 8.46 | M241510 | 11.5000 | 1.8125 | 0.13 | 10.98 | 10.71 | 2.2813 |
| 251000 | 1120000 | 0.40 | EE244180 Series | 18.0000 | 2.8750 | 0.38 | +1.07 | 19.65 | 18.35 | EE244190 | 23.5000 | 5.3575 | 0.13 | 22.87 | 23.27 | 3.0000 |
| 135000 | 600000 | 0.33 | M244200 Series | 8.6875 | 2.4375 | 0.25 | -0.18 | 9.65 | 9.25 | M244210 | 12.3750 | 1.9375 | 0.13 | 11.81 | 11.54 | 2.4375 |
| 292000 | 130000 | 0.33 | LL244500 Series | 9.1250 | 0.8465 | 0.08 | 0.62 | 9.49 | 9.33 | LL244510 | 10.5625 | 0.7283 | 0.08 | 10.35 | 10.28 | 0.8858 |
| 160000 | 710000 | 0.33 | M246900 Series | 9.1250 | 2.5625 | 0.25 | -0.19 | 10.16 | 9.80 | M246910 | 13.2500 | 2.0000 | 0.13 | 12.68 | 12.32 | 2.5625 |
| 320000 | 1430000 | 0.33 | H247500 Series | 7.8750 | 4.4375 | 0.25 | -1.10 | 9.49 | 9.09 | H247510 | 15.1250 | 3.5625 | 0.25 | 14.26 | 13.62 | 4.4375 |
| 105000 | 465000 | 0.33 | LM249700 Series | 10.0000 | 1.6875 | 0.14 | -2.31 | 10.67 | 10.63 | LM249710 | 13.6875 | 1.2500 | 0.13 | 13.46 | 13.07 | 1.7500 |

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For additional "B" cup dimensions, see pages 173 to 174.
For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
Designate bearings with hollow rollers and pinned-type retainers.
Bearing is equipped with seals (and in some instances side rings).
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
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### Tapered Roller Bearings

**TS Type**

**TSF Type**

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<th>Axial Load Factor ( K_e )</th>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
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♦ Bearing is equipped with seals (and in some instances side rings).
### Tapered Roller Bearings

#### Basic Load Ratings

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### Tapered Roller Bearings

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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
† Positive value indicates the effective load center is outside the backface of the cone.
▲ For additional “B” cup dimensions, see pages 173 to 174.
■ For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
◆ Designate bearings with hollow rollers and pinned-type retainers.
◊ Bearing is equipped with seals (and in some instances side rings).
### Tapered Roller Bearings

#### LM714100 Series

<table>
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<th>Minimum Shoulder Diameter</th>
<th>Maximum Housing Shoulder Diameter</th>
<th>Maximum Housing Fillet Radius</th>
<th>Maximum Cup Width</th>
<th>Outside Diameter</th>
<th>Cup Width</th>
<th>Minimum Cup Width</th>
<th>Cone Width</th>
<th>Minimum Shaft Shoulder Diameter</th>
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<th>Cone Width</th>
<th>Minimum Shaft Shoulder Diameter</th>
<th>Minimum Shaft Fillet Radius</th>
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#### TS Type

#### TSF Type

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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
* Positive value indicates the effective load center is outside the backface of the cone.

For additional "B" cup dimensions, see pages 173 to 174.

For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.

Designate bearings with hollow rollers and pinned-type retainers.

Bearings are equipped with seals (and in some instances side rings).
### Dimensions and Ratings

<table>
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<th>Basic Load Ratings</th>
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<th>Static Load Factor (C_s)</th>
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<th>Cone Width (mm)</th>
<th>Maximum Shaft Fillet Radius (mm)</th>
<th>Effective Load Center (mm)</th>
<th>Minimum Shoulder Diameter (mm)</th>
<th>Minimum Shoulder Diameter (mm)</th>
<th>Cup Number</th>
<th>Outside Diameter (mm)</th>
<th>Cup Width (mm)</th>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.

† Positive value indicates the effective load center is outside the backface of the cone.

▲ For additional "B" cup dimensions, see pages 173 to 174.

‡ For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.

* Designate bearings with hollow rollers and pinned-type retainers.

♦ Bearing is equipped with seals (and in some instances side rings).
Tapered Roller Bearings

<table>
<thead>
<tr>
<th>Basic Load Ratings</th>
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<th>V</th>
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<th>D</th>
<th>W₀</th>
<th>r</th>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
† Positive value indicates the effective load center is outside the backface of the cone.
▲ For additional “B” cup dimensions, see pages 173 to 174.
■ For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
♦ Designate bearings with hollow rollers and pinned-type retainers.
♣ Bearing is equipped with seals (and in some instances side rings).

Note: The table includes dimensions and load ratings for various series of Tapered Roller Bearings, with columns for bore diameter, cone width, maximum shaft diameter, effective load center, minimum shaft shoulder diameter, cup diameter, cup width, maximum housing shoulder diameter, and bearing width. Each row corresponds to a specific bearing model, with additional notes and prefixes for variations and specifications.
<table>
<thead>
<tr>
<th>Basic Load Ratings</th>
<th>Dynamic Factor $C_d$</th>
<th>Static Factor $C_{01}$</th>
<th>Cone Number</th>
<th>Bore Diameter</th>
<th>Cone Width</th>
<th>Maximum Shaft Fillet Radius</th>
<th>Effective Load Center</th>
<th>Minimum Shaft Shoulder Diameter</th>
<th>Minimum Shaft Shoulder Diameter</th>
<th>Cup Number</th>
<th>Outside Diameter</th>
<th>Cup Width</th>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
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For additional “B” cup dimensions, see pages 173 to 174.

For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.

Designate bearings with hollow rollers and pinned-type retainers.

Bearing is equipped with seals (and in some instances side rings).
### Basic Load Ratings

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### Basic Load Ratings (inches mm)

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<th>a</th>
<th>U</th>
<th>V</th>
<th>Cup Number</th>
<th>D</th>
<th>W&lt;sub&gt;o&lt;/sub&gt;</th>
<th>r</th>
<th>X</th>
<th>Z</th>
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</table>

* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
† Positive value indicates the effective load center is outside the backface of the cone.
△ For additional “B” cup dimensions, see pages 173 to 174.
□ For parts with a “J” prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
◆ Designate bearings with hollow rollers and pinned-type retainers.
☆ Bearing is equipped with seals (and in some instances side rings).
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<th>R</th>
<th>a</th>
<th>U</th>
<th>V</th>
<th>Cup Number</th>
<th>D</th>
<th>( W_0 )</th>
<th>r</th>
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<td>0.73</td>
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</table>

† Positive value indicates the effective load center is outside the backface of the cone.

For additional "B" cup dimensions, see pages 173 to 174.

For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.

Designate bearings with hollow rollers and pinned-type retainers.

Bearing is equipped with seals (and in some instances side rings).

The maximum fillet on the shaft or in the housing that the bearing corner will clear.

Dimensions and Ratings

<table>
<thead>
<tr>
<th>Series</th>
<th>Bore Diameter</th>
<th>Cone Width</th>
<th>Maximum Shaft Fillet Radius</th>
<th>Effective Load Center</th>
<th>Minimum Shaft Shoulder Diameter</th>
<th>Minimum Shaft Shoulder Diameter</th>
<th>Cup Number</th>
<th>Outside Diameter</th>
<th>Cup Width</th>
<th>Maximum Housing Fillet Radius</th>
<th>Maximum Housing Shoulder Diameter</th>
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### Tapered Roller Bearings

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<th>Effective Load Center</th>
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<th>Outside Diameter</th>
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#### LM961500 Series

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<th>Cup Number</th>
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<th>Cup Width</th>
<th>Maximum Housing Fillet Radius</th>
<th>Maximum Housing Shoulder Diameter</th>
<th>Bearing Width</th>
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</thead>
<tbody>
<tr>
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#### Radial Rating

- Load Rating: 3000 hrs L 10 Life @ 500 rpm

#### Thrust Rating

- Factor Cone Number
- Cup Number
- Bore Diameter
- Cone Width
- Maximum Shaft Fillet Radius
- Effective Load Center
- Minimum Shaft Shoulder Diameter
- Minimum Shaft Shoulder Diameter
- Cup Number
- Outside Diameter
- Cup Width
- Maximum Housing Fillet Radius
- Maximum Housing Shoulder Diameter
- Maximum Housing Shoulder Diameter
- Bearing Width

* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
† Positive value indicates the effective load center is outside the backface of the cone.
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☆ Designate bearings with hollow rollers and pinned-type retainers.
♦ Bearing is equipped with seals (and in some instances side rings).
### Dimensions and Ratings

<table>
<thead>
<tr>
<th>Cone Number</th>
<th>Cup Number</th>
<th>Df</th>
<th>Wf</th>
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For parts with a "J" prefix, use metric tolerances given on page 199 and fitting practice given on page 201.
## Dimensions and Ratings

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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
## Tapered Roller Bearings

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### Notes

* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
<table>
<thead>
<tr>
<th>Series</th>
<th>Two Row</th>
<th>Four Row</th>
<th>Bore Diameter</th>
<th>Cone Width</th>
<th>Maximum Shaft Fillet Radius</th>
<th>Minimum Shaft Diameter</th>
<th>Outside Diameter</th>
<th>Maximum Housing Fillet Radius</th>
<th>Maximum Housing Shoulder Diameter</th>
<th>Bearing Width Through Cones</th>
<th>Bearing Width Over Cups</th>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
★ Designate bearings with hollow rollers and pinned-type retainers.
◆ Bearing is equipped with seals (and in some instances side rings).
### Basic Load Ratings

<table>
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### Designation

- **TDI Type**
- **TQO Type**

*The maximum fillet on the shaft or in the housing that the bearing corner will clear.
★ Designate bearings with hollow rollers and pinned-type retainers.
## Load Rating:

3000 hrs L10 Life @ 500 rpm

### Dimensions and Ratings

<table>
<thead>
<tr>
<th>Basic Load Ratings</th>
<th>Axial Load Rating</th>
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<th>Cone Width</th>
<th>Maximum Shaft Fillet Radius</th>
<th>Minimum Shaft Shoulder Diameter</th>
<th>Cup Number</th>
<th>Outside Diameter</th>
<th>Maximum Housing Fillet Radius</th>
<th>Maximum Housing Shoulder Diameter</th>
<th>Bearing Width Through Cones</th>
<th>Bearing Width Over Cups</th>
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</table>

* The maximum fillet on the shaft or in the housing that the bearing corner will clear.

** Designate bearings with hollow rollers and pinned-type retainers.
### Tapered Roller Bearings

![Diagram of Tapered Roller Bearings](image)

<table>
<thead>
<tr>
<th>Series</th>
<th>Bore Diameter</th>
<th>Maximum Shaft Fillet Radius</th>
<th>Minimum Shaft Shoulder Diameter</th>
<th>Cup Number</th>
<th>Outside Diameter</th>
<th>Cup Width</th>
<th>Maximum Housing Fillet Radius</th>
<th>Maximum Housing Shoulder Diameter</th>
<th>Bearing Width Through Cones</th>
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</thead>
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<td>95.250</td>
</tr>
</tbody>
</table>

* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
† Any cone within a series may be used with a double cup of the same series.
Contact the NTN Application Engineering Department for possible changes in dimension Wn.
### Basic Load Ratings

#### Dynamic Load Factors

<table>
<thead>
<tr>
<th>Dynamic Load Factors</th>
<th>Static Load Factors</th>
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<td>$C_s$</td>
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<td>lbs/N</td>
<td>lbs/N</td>
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#### Cone Number

<table>
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<th>Cone Number †</th>
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#### Bore Diameter

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#### Maximum Shaft Fillet Radius *

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#### Minimum Shaft Shoulder Diameter

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#### Cup Width

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#### Maximum Housing Fillet Radius *

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#### Bearing Width Through Cones

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#### Load Ratings

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<th>Rating Two Row</th>
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#### K Factor

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#### Dimensions and Ratings

- The maximum fillet on the shaft or in the housing that the bearing corner will clear.
- Any cone within a series may be used with a double cup of the same series.
- Contact the NTN Application Engineering Department for possible changes in dimension $W_n$. 

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*Contact the NTN Application Engineering Department for possible changes in dimension $W_n$.**
### Basic Load Ratings

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† Any cone within a series may be used with a double cup of the same series.
Contact the NTN Application Engineering Department for possible changes in dimension Wₑ.
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## Basic Load Ratings

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### Basic Load Ratings

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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
† Any cone within a series may be used with a double cup of the same series.

Contact the NTN Application Engineering Department for possible changes in dimension Wᵣ.
### Basic Load Ratings

<table>
<thead>
<tr>
<th>Type</th>
<th>Dynamic Load Factors</th>
<th>Static Load Factors</th>
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<tbody>
<tr>
<td>Cone Number</td>
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<td>Inch/mm</td>
<td></td>
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<tr>
<td>lbs/N</td>
<td>lbs/N</td>
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<td>Dynamic</td>
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<tr>
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- **395 Series**
  - NA397: 2.3622, 60,000, 0.14, 2.87
  - 394D: 4.3307, 110,000, 0.03, 4.11
  - Series: 2.0625

- **455 Series**
  - NA455: 2.0000, 50,000, 0.14, 2.56
  - 452D: 4.2500, 107,950, 0.03, 3.94
  - Series: 2.5626

- **475 Series**
  - NA462: 2.7500, 69,850, 0.14, 3.27
  - 472D: 4.7244, 120,000, 0.03, 4.49
  - Series: 2.5626

- **495 Series**
  - NA495A: 3.0000, 76,200, 0.14, 3.62
  - 493D: 5.3750, 136,525, 0.03, 5.12
  - Series: 2.7500

- **555 Series**
  - NA558: 2.3750, 60,325, 0.14, 2.99
  - 552D: 4.8750, 123,825, 0.06, 4.53
  - Series: 3.1250

- **565 Series**
  - NA569: 2.6250, 66,675, 0.14, 3.23
  - 563D: 5.0000, 127,000, 0.06, 4.89
  - Series: 3.1875

- **575 Series**
  - NA580: 3.2500, 82,550, 0.14, 3.86
  - 572D: 5.5115, 139,992, 0.03, 5.24
  - Series: 3.2500

* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
### Dimensions and Ratings

<table>
<thead>
<tr>
<th>Bore Diameter</th>
<th>Tolerance (Class 2)</th>
<th>Outside Diameter</th>
<th>Tolerance (Class 2)</th>
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<td>.0001 Inch/micrometers</td>
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<td>Inclusive</td>
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<td>Low</td>
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<tr>
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<td>0.0000</td>
<td>+ 5</td>
<td>0</td>
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<th>Cup Number</th>
<th>D</th>
<th>Rotating Cone</th>
<th>Stationary Cup</th>
<th>Stationary Cone</th>
<th>Rotating Cup</th>
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<td>Inch/mm</td>
<td>.0001 Inch/micrometers</td>
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<td>NA580</td>
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<td>572D</td>
<td>5.5115</td>
<td>3.2525</td>
<td>25T</td>
<td>5.5135</td>
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</tbody>
</table>

* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
### Basic Load Ratings

<table>
<thead>
<tr>
<th>Dynamic $C_r$</th>
<th>Static $C_{r0}$</th>
<th>Axial Load Factors $e$, $Y_1$, $Y_2$</th>
<th>Cone Number</th>
<th>Bore Diameter</th>
<th>Maximum Shaft Fillet Radius *</th>
<th>Minimum Shaft Shoulder Diameter</th>
<th>Cup Number</th>
<th>D</th>
<th>W_D</th>
<th>r</th>
<th>X</th>
<th>W_n</th>
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</thead>
<tbody>
<tr>
<td>68500</td>
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<td>162000</td>
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<td>5.91</td>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
### Dimensions and Ratings

<table>
<thead>
<tr>
<th>Bore Diameter</th>
<th>Tolerance (Class 2)</th>
<th>Outside Diameter</th>
<th>Stationary Cup</th>
<th>Stationary Cone</th>
<th>Rotating Cup</th>
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<tbody>
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<td>.0001 Inch/micrometers</td>
<td>Inch/mm</td>
<td>.0001 Inch/micrometers</td>
<td>Inch/mm</td>
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<td>Low</td>
<td>Over</td>
<td>Inclusive</td>
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<tr>
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<td>3.0000</td>
<td>+ 5</td>
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<td>0</td>
<td>12.0000</td>
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<tr>
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</table>

* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
### Tapered Roller Bearings

#### Basic Load Ratings

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<thead>
<tr>
<th>Dynamic $C_d$</th>
<th>Static $C_{0r}$</th>
<th>Cone</th>
<th>Bore Diameter (mm)</th>
<th>Maximum Shaft Fillet Radius *</th>
<th>Minimum Shaft Shoulder Diameter (mm)</th>
<th>Cup</th>
<th>Outside Diameter (mm)</th>
<th>Cup Width (mm)</th>
<th>Maximum Housing Fillet Radius *</th>
<th>Maximum Housing Shoulder Diameter (mm)</th>
<th>Bearing Width Through Cones (mm)</th>
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<tbody>
<tr>
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<td>1.47</td>
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<td>4.2500</td>
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<td>5.8250</td>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
### Dimensions and Ratings

#### Bore Diameter

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<th>Inch/mm</th>
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#### Outside Diameter

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#### Tolerance (Class 2)

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#### Cone Number

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#### B Rotating Cone

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#### Stationary Cup

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#### Stationary Cone

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#### Rotating Cup

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</tbody>
</table>

*The maximum fillet on the shaft or in the housing that the bearing corner will clear.*
Tapered Roller Bearings

The maximum fillet on the shaft or in the housing that the bearing corner will clear.

<table>
<thead>
<tr>
<th>Basic Load Ratings</th>
<th>Axial Load Factors</th>
<th>Cone Number</th>
<th>B</th>
<th>R</th>
<th>U</th>
<th>Cup Number</th>
<th>D</th>
<th>W_D</th>
<th>r</th>
<th>X</th>
<th>W_N</th>
</tr>
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<tbody>
<tr>
<td>Dynamic C_e</td>
<td>Static C_{er}</td>
<td>Dynamic Load Factors</td>
<td>Static Load Factors</td>
<td>Cone Number</td>
<td>Bore Diameter</td>
<td>Minimum Shaft Fillet Radius *</td>
<td>Minimum Shaft Shoulder Diameter</td>
<td>Cup Number</td>
<td>Outside Diameter</td>
<td>Cup Width</td>
<td>Maximum Housing Fillet Radius *</td>
</tr>
<tr>
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<td>inches</td>
<td>mm</td>
<td>lbs/N</td>
<td>inches</td>
<td>mm</td>
<td>lbs/N</td>
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
### Tapered Roller Bearings

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* The maximum fillet on the shaft or in the housing that the bearing corner will clear.
### Tapered Roller Bearings

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<td>82.550</td>
</tr>
<tr>
<td>200000</td>
<td>515000</td>
<td>0.36</td>
<td>1.88</td>
<td>2.80</td>
<td>LM357000 Series LM357049NW</td>
<td>12.0000</td>
<td>0.25</td>
<td>12.95</td>
<td>13.797</td>
<td>LM357010D</td>
<td>15.5000</td>
<td>393.700</td>
<td>82.550</td>
</tr>
</tbody>
</table>

* The maximum fillet on the shaft or in the housing that the bearing corner will clear.

**Cone large flange diameter** ($D_1$) is ground for sealing purposes.
<table>
<thead>
<tr>
<th>Bore Diameter</th>
<th>Tolerance (Class 2)</th>
<th>Outside Diameter</th>
<th>Tolerance (Class 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inch/mm</td>
<td>.0001 Inch/micrometers</td>
<td>Inch/mm</td>
<td>.0001 Inch/micrometers</td>
</tr>
<tr>
<td></td>
<td>Over</td>
<td>Inclusive</td>
<td>High</td>
</tr>
<tr>
<td>3.0000</td>
<td>0</td>
<td>3.0000</td>
<td>+ 5</td>
</tr>
<tr>
<td>76.200</td>
<td>0</td>
<td>76.200</td>
<td>+ 13</td>
</tr>
<tr>
<td>10.5000</td>
<td>0</td>
<td>10.5000</td>
<td>+ 10</td>
</tr>
<tr>
<td>266.700</td>
<td>0</td>
<td>266.700</td>
<td>+ 25</td>
</tr>
<tr>
<td>9.2500</td>
<td>0</td>
<td>9.2500</td>
<td>+ 5</td>
</tr>
<tr>
<td>12.8725</td>
<td>0</td>
<td>12.8725</td>
<td>+ 25</td>
</tr>
<tr>
<td>50T</td>
<td>0</td>
<td>50T</td>
<td>30T</td>
</tr>
<tr>
<td>60T</td>
<td>0</td>
<td>60T</td>
<td>40T</td>
</tr>
<tr>
<td>25L</td>
<td>0</td>
<td>25L</td>
<td>15L</td>
</tr>
<tr>
<td>20T</td>
<td>0</td>
<td>20T</td>
<td>10T</td>
</tr>
<tr>
<td>234.950</td>
<td>0</td>
<td>234.950</td>
<td>127T</td>
</tr>
<tr>
<td>326.949</td>
<td>0</td>
<td>326.949</td>
<td>152T</td>
</tr>
<tr>
<td>234.925</td>
<td>0</td>
<td>234.925</td>
<td>63L</td>
</tr>
<tr>
<td>327.000</td>
<td>0</td>
<td>327.000</td>
<td>25T</td>
</tr>
<tr>
<td>234.900</td>
<td>0</td>
<td>234.900</td>
<td>10T</td>
</tr>
<tr>
<td>326.974</td>
<td>0</td>
<td>326.974</td>
<td>51T</td>
</tr>
</tbody>
</table>

*The maximum fillet on the shaft or in the housing that the bearing corner will clear.*
### Tapered Roller Bearing Tolerance Tables

#### Tapered Roller Bearing Tolerance Tables

<table>
<thead>
<tr>
<th>Bearing Types</th>
<th>Bore Diameter Tolerance</th>
<th>Cone Width Tolerance</th>
<th>Cone Stand Tolerance</th>
<th>Cup Stand Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TS</td>
<td>TNA</td>
<td>TDI</td>
<td>TS</td>
</tr>
</tbody>
</table>

### Tapered Roller Bearing Tolerance Tables

<table>
<thead>
<tr>
<th>Bore Diameter/mm</th>
<th>Class 4</th>
<th>Class 2</th>
<th>Class 4</th>
<th>Class 2</th>
<th>Class 4</th>
<th>Class 2</th>
<th>Class 4</th>
<th>Class 2</th>
</tr>
</thead>
</table>
| Tapered Roller Bearing Tolerance Tables

<table>
<thead>
<tr>
<th>Bearing Types</th>
<th>Outside Diameter Tol</th>
<th>Cup Width Tolerance</th>
<th>Cup Flange Diameter Tol</th>
<th>Assembled Radial Runout</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TS</td>
<td>TNA</td>
<td>TDI</td>
<td>TS</td>
</tr>
</tbody>
</table>

### Tapered Roller Bearing Tolerance Tables

<table>
<thead>
<tr>
<th>Outside Diameter/mm</th>
<th>Class 4</th>
<th>Class 2</th>
<th>Class 4</th>
<th>Class 2</th>
<th>Class 4</th>
<th>Class 2</th>
<th>Class 4</th>
<th>Class 2</th>
</tr>
</thead>
</table>
| Tapered Roller Bearing Tolerance Tables

<table>
<thead>
<tr>
<th>Bearing Types</th>
<th>Overall Bearing Width Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TS</td>
</tr>
</tbody>
</table>

### Tapered Roller Bearing Tolerance Tables

<table>
<thead>
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<th>Bore Diameter/mm</th>
<th>Class 4</th>
<th>Class 2</th>
<th>Class 4</th>
<th>Class 2</th>
<th>Class 4</th>
<th>Class 2</th>
<th>Class 4</th>
<th>Class 2</th>
</tr>
</thead>
</table>

* For TNASW type bearings, see tolerance tables located on page 197.

▲ For TSF type bearings, the cup stand is measured from the backface of the flange.

---

For TSF type bearings, the tolerance is applied to the dimension from the backface of the flange to the backface of the cone.
### Tolerances for Metric System Bearings Class K and Class N
(For “J” Prefix Bearings)

<table>
<thead>
<tr>
<th>Bearing Types</th>
<th>Outside Diameter Tolerance</th>
<th>Cup Width Tolerance</th>
<th>Cup Flange Diameter Tolerance</th>
<th>Assembled Bearing Radial Runout</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TS</td>
<td>TSF</td>
<td>TS</td>
<td>TSF</td>
</tr>
<tr>
<td>Bore Diameter</td>
<td>Class K</td>
<td>Class N</td>
<td>Class K</td>
<td>Class N</td>
</tr>
<tr>
<td>Inch/mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over Inclusive</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>0.7087</td>
<td>1.9685</td>
<td>-5</td>
<td>-5</td>
<td>-39</td>
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<tr>
<td>1.9685</td>
<td>3.1496</td>
<td>-6</td>
<td>-6</td>
<td>-59</td>
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<td>5.9055</td>
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<td>-10</td>
<td>-79</td>
</tr>
<tr>
<td>7.0866</td>
<td>9.8425</td>
<td>-12</td>
<td>-12</td>
<td>-79</td>
</tr>
<tr>
<td>9.8425</td>
<td>12.4016</td>
<td>-14</td>
<td>-14</td>
<td>-98</td>
</tr>
</tbody>
</table>

For TSF type bearings, the tolerance is applied to the dimension from the backface of the flange to the backface of the cone.

### Tolerances for Metric System Bearings Class K and Class N
(For “J” Prefix Bearings)

<table>
<thead>
<tr>
<th>Bearing Types</th>
<th>Outside Diameter Tolerance</th>
<th>Cup Width Tolerance</th>
<th>Cup Flange Diameter Tolerance</th>
<th>Assembled Bearing Radial Runout</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TS</td>
<td>TSF</td>
<td>TS</td>
<td>TSF</td>
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<tr>
<td>Overall Brg Width</td>
<td>Class K</td>
<td>Class N</td>
<td>Class K</td>
<td>Class N</td>
</tr>
<tr>
<td>Inch/mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over Inclusive</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>80.000</td>
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<td>-20</td>
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<tr>
<td>150.000</td>
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<td>-25</td>
<td>-25</td>
<td>-250</td>
</tr>
<tr>
<td>180.000</td>
<td>250.000</td>
<td>-30</td>
<td>-30</td>
<td>-250</td>
</tr>
<tr>
<td>9.8425</td>
<td>12.4016</td>
<td>-35</td>
<td>-35</td>
<td>-250</td>
</tr>
</tbody>
</table>

For TSF type bearings, the tolerance is applied to the dimension from the backface of the flange to the backface of the cone.
The fitting practice data given in the following tables conforms to industry and ABMA/ANSI standards. These tables apply to solid or heavy-sectioned steel shafts, heavy-sectioned ferrous housings and normal operating conditions. Certain fitting practice data given in these tables may not be adequate for applications involving very heavy loads, very high speeds, unusual thermal conditions, light shafts and housing sections. In certain cases the method of assembly and the means and ease of obtaining the bearing setting may require fits different from those given in the tables.

Fitting practice for nonadjustable TNA and TNASW two row bearings are shown on pages 184 to 195. Shaft and housing material, geometry, hardness and surface finish must be carefully controlled. Ground shafts should be finished to 50 micro-inches AA or better, for turned shafts a finish of 100 micro-inches AA or better, and housing bores should be finished to 160 micro-inches AA or better.

**Cone Fitting Practice for Inch System Bearings Class 4 and Class 2**

<table>
<thead>
<tr>
<th>Bore Diameter</th>
<th>Rotating Cone</th>
<th>Rotating or Stationary Cone</th>
<th>Stationary Cone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inch/mm</td>
<td>Ground Shaft</td>
<td>Ground Shaft or Unground Shaft</td>
<td>Unground Shaft</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Over</th>
<th>Inc1</th>
<th>Tolerance</th>
<th>Shaft Diameter</th>
<th>Resultant Fit</th>
<th>Shaft Diameter</th>
<th>Resultant Fit</th>
<th>Shaft Diameter</th>
<th>Resultant Fit</th>
<th>Shaft Diameter</th>
<th>Resultant Fit</th>
<th>Shaft Diameter</th>
<th>Resultant Fit</th>
<th>Shaft Diameter</th>
<th>Resultant Fit</th>
<th>Shaft Diameter</th>
<th>Resultant Fit</th>
<th>Shaft Diameter</th>
<th>Resultant Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>3.0000 + 5</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>+ 10</td>
<td>10T</td>
<td>0</td>
<td>0</td>
<td>5T</td>
<td>0</td>
<td>5L</td>
<td>0</td>
<td>5T</td>
<td>0</td>
<td>5L</td>
<td>0</td>
<td>5T</td>
<td>0</td>
</tr>
<tr>
<td>0.0</td>
<td>76.200 + 15</td>
<td>0</td>
<td>0</td>
<td>76</td>
<td>+ 10</td>
<td>10T</td>
<td>0</td>
<td>0</td>
<td>10L</td>
<td>0</td>
<td>10T</td>
<td>0</td>
<td>10L</td>
<td>0</td>
<td>10T</td>
<td>0</td>
<td>10L</td>
<td>0</td>
</tr>
<tr>
<td>3.0000</td>
<td>12.0000 + 25</td>
<td>0</td>
<td>0</td>
<td>3.0000</td>
<td>10T</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>10L</td>
<td>0</td>
<td>10T</td>
<td>0</td>
<td>10L</td>
<td>0</td>
<td>10T</td>
<td>0</td>
<td>10L</td>
<td>0</td>
</tr>
<tr>
<td>76.200</td>
<td>304.800 + 38</td>
<td>0</td>
<td>0</td>
<td>76.200</td>
<td>10T</td>
<td>0</td>
<td>0</td>
<td>76</td>
<td>10L</td>
<td>0</td>
<td>10T</td>
<td>0</td>
<td>10L</td>
<td>0</td>
<td>10T</td>
<td>0</td>
<td>10L</td>
<td>0</td>
</tr>
<tr>
<td>12.0000</td>
<td>304.800 + 51</td>
<td>0</td>
<td>0</td>
<td>12.0000</td>
<td>10T</td>
<td>0</td>
<td>0</td>
<td>127</td>
<td>10L</td>
<td>0</td>
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<td>10L</td>
<td>0</td>
<td>10T</td>
<td>0</td>
<td>10L</td>
<td>0</td>
</tr>
<tr>
<td>12.0000</td>
<td>304.800 + 76</td>
<td>0</td>
<td>0</td>
<td>12.0000</td>
<td>10T</td>
<td>0</td>
<td>0</td>
<td>304.800</td>
<td>10L</td>
<td>0</td>
<td>10T</td>
<td>0</td>
<td>10L</td>
<td>0</td>
<td>10T</td>
<td>0</td>
<td>10L</td>
<td>0</td>
</tr>
</tbody>
</table>

**NOTE:** It is recommended that all shafts be ground. In those cases where this is not possible, a minimum shaft diameter should be provided equal to the Bore Diameter plus .0005 In/mm (0.012 mm/mm) of Bore Diameter. Add this value to the Bore Diameter tolerance.

**Cup Fitting Practice for Inch System Bearings Class 4 and Class 2**

<table>
<thead>
<tr>
<th>Outside Diameter</th>
<th>Stationary Cup</th>
<th>Stationary or Rotating Cup</th>
<th>Rotating Cup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inch/mm</td>
<td>Clamped or Floating</td>
<td>Adjustable</td>
<td>Nonadjustable or Sheaves—Clamped</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Over</th>
<th>Inc1</th>
<th>Tolerance</th>
<th>Housing Diameter</th>
<th>Resultant Fit</th>
<th>Housing Diameter</th>
<th>Resultant Fit</th>
<th>Housing Diameter</th>
<th>Resultant Fit</th>
<th>Housing Diameter</th>
<th>Resultant Fit</th>
<th>Housing Diameter</th>
<th>Resultant Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>3.0000 + 10</td>
<td>0</td>
<td>0</td>
<td>10L</td>
<td>0</td>
<td>10T</td>
<td>- 15</td>
<td>25T</td>
<td>- 30</td>
<td>20T</td>
<td>- 30</td>
<td>20T</td>
</tr>
<tr>
<td>0.0</td>
<td>76.200 + 25</td>
<td>0</td>
<td>0</td>
<td>76.200</td>
<td>10L</td>
<td>0</td>
<td>10T</td>
<td>- 10</td>
<td>25T</td>
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<td>20T</td>
<td>- 25</td>
</tr>
<tr>
<td>3.0000</td>
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<td>0</td>
<td>3.0000</td>
<td>10L</td>
<td>0</td>
<td>10T</td>
<td>- 10</td>
<td>25T</td>
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<td>20T</td>
<td>- 25</td>
</tr>
<tr>
<td>76.200</td>
<td>127.000 + 51</td>
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<td>0</td>
<td>76.200</td>
<td>10L</td>
<td>0</td>
<td>10T</td>
<td>- 10</td>
<td>25T</td>
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<td>- 25</td>
</tr>
<tr>
<td>5.0000</td>
<td>12.0000 + 76</td>
<td>0</td>
<td>0</td>
<td>5.0000</td>
<td>10L</td>
<td>0</td>
<td>10T</td>
<td>- 10</td>
<td>25T</td>
<td>- 25</td>
<td>20T</td>
<td>- 25</td>
</tr>
<tr>
<td>12.0000</td>
<td>24.0000 + 102</td>
<td>0</td>
<td>0</td>
<td>12.0000</td>
<td>10L</td>
<td>0</td>
<td>10T</td>
<td>- 10</td>
<td>25T</td>
<td>- 25</td>
<td>20T</td>
<td>- 25</td>
</tr>
<tr>
<td>12.0000</td>
<td>304.800 + 152</td>
<td>0</td>
<td>0</td>
<td>12.0000</td>
<td>10L</td>
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<td>10T</td>
<td>- 10</td>
<td>25T</td>
<td>- 25</td>
<td>20T</td>
<td>- 25</td>
</tr>
</tbody>
</table>

These tables apply to solid or heavy-sectioned steel shafts, heavy-sectioned ferrous housings and normal operating conditions. Certain fitting practice data given in these tables may not be adequate for applications involving very heavy loads, very high speeds, unusual thermal conditions, light shafts and housing sections. In certain cases the method of assembly and the means and ease of obtaining the bearing setting may require fits different from those given in the tables.
### Cone Fitting Practice for Metric System Bearings Class K and Class N (For “J” Prefix Bearings)

<table>
<thead>
<tr>
<th>Bore Diameter</th>
<th>Resultant Fit Symbol Shaft Diameter</th>
<th>Resultant Fit Symbol Shaft Diameter</th>
<th>Resultant Fit Symbol Shaft Diameter</th>
<th>Resultant Fit Symbol Shaft Diameter</th>
<th>Resultant Fit Symbol Shaft Diameter</th>
<th>Resultant Fit Symbol Shaft Diameter</th>
<th>Resultant Fit Symbol Shaft Diameter</th>
<th>Resultant Fit Symbol Shaft Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inch/mm</td>
<td>.0001 Inch/Micrometers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Over</td>
<td>Tolerance</td>
<td>Outside Diameter</td>
<td>Stationary Cone</td>
<td>Nonadjustable</td>
<td>Nonadjustable</td>
<td>Sheaves—Unclamped</td>
<td>Rotating Cone</td>
<td>Rotating or Stationary Cone</td>
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<td>3.1496</td>
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<td></td>
</tr>
<tr>
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<td></td>
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<td></td>
</tr>
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<tr>
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<td>120.000</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
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<td>150.000</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>12.0000</td>
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<td>180.000</td>
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<td></td>
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</tr>
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<td>250.000</td>
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</tr>
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<td>315.000</td>
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</tr>
</tbody>
</table>

### Cup Fitting Practice for Metric System Bearings Class K and Class N (For “J” Prefix Bearings)

<table>
<thead>
<tr>
<th>Outside Diameter</th>
<th>.0001 Inch/Micrometers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inch/mm</td>
<td></td>
</tr>
<tr>
<td>Over</td>
<td>Tolerance</td>
</tr>
<tr>
<td>3.1496</td>
<td>-7</td>
</tr>
<tr>
<td>4.7244</td>
<td>-8</td>
</tr>
<tr>
<td>7.0866</td>
<td>-10</td>
</tr>
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