TIMKEN



TIMKEN ENGINEERING MANUAL



Patented June 28, 1898.

Inventors

ENGINEERING MANUAL INDEX

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GROW STRONGER WITH TIMKEN

Every day, people around the world count on the strength of Timken. Our expertise in metallurgy, friction management and mechanical power transmission helps them accelerate improvements in productivity and uptime.

We supply products and services that can help keep your operations moving forward, whether you need drive train kits for commercial vehicles, durable housings for bearings in dirty environments, couplings that avoid metal-to-metal contact between motors and gearboxes, repair services for bearings and gearboxes, roller chain for dry, abrasive and high-moisture applications or other products and services for your applications.

When you choose Timken, you receive more than high-quality products and services: You gain a worldwide team of highly trained and experienced Timken people committed to working collaboratively with you to improve your business.

Globally, our 17,000 people provide reliable answers for a wide range of operations in manufacturing, mining, medical equipment, aerospace, transportation, oil and gas – and other diverse industries.



INCREASE YOUR EQUIPMENT UPTIME

In addition to high-quality bearings and mechanical power transmission components, we provide valuable integrated products and services. For example, we offer repair services and equipment monitoring equipment that can alert you to problems before they impact your uptime.

Additionally, we offer a broad selection of seals, premium lubricants, lubricators, couplings and chain to keep your operations moving smoothly.

Our 12 technology and engineering centers in the United States, Europe and Asia help pioneer tomorrow's innovations with extensive basic and applied scientific research programs. Through internal development and strategic acquisition of innovative companies, we continue to expand our portfolio of highly engineered bearings, power transmission products and advanced services.





INTRODUCTION

Timken is a leader in the advancement of bearing technology. Expert craftsmanship, well-equipped production facilities, and a continuing investment in technology programs ensure that our products are synonymous with quality and reliability. Today, our plants manufacture several bearing types over a broad range of sizes.

Anti-friction bearings inherently manage broad ranges of speed and many combinations of radial and thrust loads. Other important environmental conditions, such as low and high temperature, dust and dirt, moisture, and unusual mounting conditions, affect bearing operation.

This engineering section is not intended to be comprehensive, but does serve as a useful guide in bearing selection.

Where more complex bearing applications are involved, your Timken engineer should be consulted. The following topics are covered within this manual:

- Bearing design types.
- Cage design types.
- Life analysis procedure.
- Bearing tolerances.
- Fitting practice and mounting recommendations.
- Operating temperatures.
- Speed ratings.
- Lubrication recommendations.
- Seal design options.

HOW TO USE THIS CATALOG

We designed this catalog to help you find the Timken® spherical roller bearing solid-block housed units best suited to your specifications.

Timken offers an extensive range of bearings and accessories in both imperial and metric sizes. For your convenience, size ranges are indicated in millimeters and inches. Contact your Timken engineer to learn more about our complete line for the special needs of your application.

This publication contains dimensions, tolerances and load ratings, as well as engineering sections describing fitting practices for shafts and housings, internal clearances, materials and other bearing features. It provides valuable assistance in the initial consideration of the type and characteristics of the bearings that may best suit your particular needs.

ISO and ANSI/ABMA, as used in this publication, refer to the International Organization for Standardization and the American National Standards Institute/American Bearing Manufacturers Association.



SHELF LIFE AND STORAGE OF GREASE-LUBRICATED BEARINGS AND COMPONENTS

To help you get the most value from our products, Timken provides guidelines for the shelf life of grease-lubricated ball and roller bearings, components and assemblies. Shelf life information is based on Timken and industry test data and experience.

SHELF LIFE

Shelf life should be distinguished from lubricated bearing/component design life as follows:

- Shelf life of the grease-lubricated bearing/component represents the period of time prior to use or installation.
- The shelf life is a portion of the anticipated aggregate design life. It is impossible to accurately predict design life due to variations in lubricant bleed rates, oil migration, operating conditions, installation conditions, temperature, humidity and extended storage.
- Shelf life values, available from Timken, represent a maximum limit and assume adherence to the storage and handling guidelines suggested in this catalog or by a Timken associate. Deviations from the Timken storage and handling guidelines may reduce shelf life. Any specification or operating practice that defines a shorter shelf life should be used.

Timken cannot anticipate the performance of the grease lubricant after the bearing or component is installed or placed in service.

TIMKEN IS NOT RESPONSIBLE FOR THE SHELF LIFE OF ANY BEARING/COMPONENT LUBRICATED BY ANOTHER PARTY.

European REACH Compliance

Timken lubricants, greases and similar products sold in standalone containers or delivery systems are subject to the European REACH (**R**egistration, **E**valuation, **A**uthorization and Restriction of **CH**emicals) directive. For import into the European Union, Timken can sell and provide only those lubricants and greases that are registered with ECHA (**E**uropean **CH**emical **A**gency). For further information, please contact your Timken engineer.



STORAGE

Timken suggests the following storage guidelines for our finished products (bearings, components and assemblies, referred to as "products"):

- Unless directed otherwise by Timken, products should be kept in their original packaging until they are ready to be placed into service.
- Do not remove or alter any labels or stencil markings on the packaging.
- Products should be stored in such a way that the packaging is not pierced, crushed or otherwise damaged.
- After a product is removed from its packaging, it should be placed into service as soon as possible.
- When removing a product that is not individually packaged from a bulk pack container, the container should be resealed immediately after the product is removed.
- Do not use product that has exceeded its shelf life. Contact your local Timken engineer for further information on shelf life limits.
- The storage area temperature should be maintained between 0° C (32° F) and 40° C (104° F); temperature fluctuations should be minimized.
- The relative humidity should be maintained below 60 percent and the surfaces should be dry.
- The storage area should be kept free from airborne contaminants such as, but not limited to, dust, dirt, harmful vapors, etc.
- The storage area should be isolated from undue vibration.
- Extreme conditions of any kind should be avoided.

Due to the fact that Timken is not familiar with your particular storage conditions, we strongly suggest following these guidelines. However, you may be required by circumstances or applicable government requirements to adhere to stricter storage requirements.

Most bearing components typically ship protected with a corrosion-preventive compound that is not a lubricant. These components may be used in oil-lubricated applications without removal of the corrosion-preventive compound. When using some specialized grease lubrications, we advise you to remove the corrosion-preventive compound before packing the bearing components with suitable grease.

We pre-pack most housed unit types in this catalog with general-purpose grease suitable for their normal applications. It may be necessary for you to frequently replenish the grease for optimum performance.

Be careful in selecting lubrication, however, since different lubricants are often incompatible. You may order housed units pre-lubricated with a specified lubrication.

When you receive a bearing or housed unit shipment, do not remove products from their packaging until they are ready for mounting so they do not become corroded or contaminated.

Store bearings and housed units in an appropriate atmosphere so they remain protected for the intended period.

⚠WARNING
Failure to observe the following warnings could create a risk of death or serious injury.

Proper maintenance and handling practices are critical. Always follow installation instructions and maintain proper lubrication.

Never spin a bearing with compressed air. The rollers may be forcefully expelled.

Warnings for this product line are found in this catalog and posted on www.timken.com/warnings

⚠ CAUTION
Failure to observe the following warnings could create a risk of death or serious injury.

Remove oil or rust inhibitor from parts before heating, to avoid fire and fumes.

NOTE

Mixing greases can result in improper bearing lubrication. Always follow the specific lubrication instructions of your equipment supplier.

NOTE

Product performance is affected by many factors beyond the control of Timken. Therefore, the suitability and feasibility of all designs and product selection should be validated by you. This catalog is provided solely to give you, a customer of Timken or its parent or affiliates, analysis tools and data to assist you in your design. No warranty, expressed or implied, including any warranty of fitness for a particular purpose, is made by Timken. Timken products and services are sold subject to a Limited Warranty.

You can see your Timken engineer for more information.

NOTE

Never attempt a press fit on a shaft by applying pressure to the outer ring or a press fit in a housing by applying pressure to the inner ring.

DISCLAIMER

This catalog is provided solely to give you analysis tools and data to assist you in your product selection. Product performance is affected by many factors beyond the control of Timken.

Therefore, the suitability and feasibility of all product selection must be validated by you.

Timken products are sold subject to Timken's terms and conditions of sale, which include its limited warranty and remedy, which terms may be found at www.timken.com/ termsandconditionsofsale. Please consult with your Timken sales engineer for more information and assistance.

Every reasonable effort has been made to ensure the accuracy of the information in this writing, but no liability is accepted for errors, omissions or for any other reason.

COMPLIANCE

To view the complete engineering catalog, please visit www.timken.com. To order the catalog, please contact your Timken sales engineer and request a copy of the Timken Engineering Manual (order number 10424).

***European REACH compliance** Timken-branded lubricants, greases and similar products sold in stand-alone containers or delivery systems are subject to the European REACH (**R**egistration, **E**valuation, **A**uthorization and Restriction of **CH**emicals) directive. For import into the European Union, Timken can sell and provide only those lubricants and greases that are registered with ECHA (**E**uropean **CH**emical **A**gency). For further information, please contact your Timken sales engineer.*

The Timken Company products shown in this catalog may be directly, or indirectly subject to a number of regulatory standards and directives originating from authorities in the USA, European Union, and around the world, including: REACH (EC 1907/2006, RoHS (2011/65/EU), ATEX (94/9/EC), 'CE' MARKING (93/68/EEC), CONFLICT MINERALS (Section 1502 of the Dodd-Frank Wall Street Reform and Consumer Protection Act).

For any questions or concerns regarding the compliancy or applicability of Timken products to these, or other unspecified standards, please contact your Timken sales engineer or customer services representative.

Updates are made periodically to this catalog. Visit www.timken.com for the most recent version of the Timken Spherical Roller Bearing Solid-Block Housed Units Catalog.

BEARING SELECTION PROCESS

The first step in bearing selection is to identify the best bearing type for the application. Each bearing type has advantages and disadvantages based on its internal design. Table 1, on page 10, ranks the different bearing types on various performance characteristics.

The next step is to assess the bearing size constraints including the bore, outside diameter (O.D.) and width. This is done by defining the minimum shaft diameter, maximum housing diameter and available width for the bearing in the application. At this point, bearings may be selected from the manual that fit within the defined size constraints. Several bearings with different load-carrying capacities may be available that fit within the envelope.

The third step is to evaluate the known environmental conditions and application requirements. Environmental conditions include factors such as ambient temperature, applied load, bearing speed and cleanliness of the environment immediately surrounding the bearing. Application requirements such as bearing fits, bearing setting, lubricant type, cage type and flange arrangements are determined based on the speed, temperature, mounting conditions and loading conditions within the application.

Lastly, bearing life calculations are performed that take into account all of the environmental and application conditions. If more than one bearing has been evaluated up to this point, selection is based on the bearing that provides the best overall performance for the application. A detailed explanation of this analysis procedure is included in the following sections. For assistance, contact your Timken engineer for a comprehensive computer analysis of your bearing application.



To view more Timken catalogs, go to www.timken.com/catalogs for interactive versions, or to download a catalog app for your smart phone or mobile device scan the QR code or go to timkencatalogs.com.

BEARING TYPES



Tapered roller bearing



Thrust tapered roller bearing



Cylindrical roller bearing



Thrust cylindrical roller bearing



Spherical roller bearing



Thrust spherical roller bearing



Radial ball bearing



Thrust ball bearing



Angular contact ball bearing

TABLE 1. RELATIVE OPERATING CHARACTERISTICS OF VARIOUS BEARING TYPES

Characteristic	Tapered Roller Bearing	Thrust Tapered Roller Bearing	Cylindrical Roller Bearing	Thrust Cylindrical Roller Bearing	Spherical Roller Bearing	Thrust Spherical Roller Bearing	Radial Ball Bearing	Thrust Ball Bearing	Angular Contact Ball Bearing
Pure radial load	Good	Unsuitable	Excellent	Unsuitable	Good	Unsuitable	Good	Poor	Fair
Pure axial load	Good	Excellent	Unsuitable	Good	Fair	Excellent	Fair	Excellent	Good
Combined load	Excellent	Poor	Fair	Unsuitable	Good	Fair	Good	Poor	Excellent
Moment load	Excellent	Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Fair	Poor	Good
High stiffness	Excellent	Excellent	Good	Excellent	Good	Good	Fair	Good	Good
Low friction	Good	Good	Excellent	Poor	Fair	Fair	Excellent	Good	Good
Misalignment	Poor	Poor	Poor	Unsuitable	Excellent	Excellent	Good	Poor	Poor
Locating position (fixed)	Excellent	Good	Fair	Fair	Good	Good	Good	Excellent	Good
Non-locating position (floating)	Good	Unsuitable	Excellent	Unsuitable	Good	Unsuitable	Good	Unsuitable	Good
Speed	Good	Good	Excellent	Poor	Fair	Fair	Excellent	Excellent	Excellent

RADIAL BALL BEARINGS

Although radial ball bearings are designed primarily to support a radial load, they perform relatively well under thrust or combined radial and thrust load conditions.

Deep-groove ball bearings, commonly called Conrad or non-filling-slot bearings, are assembled by displacing the inner ring relative to the outer ring and inserting balls into the space between the rings. By this method, only slightly more than half the annular space between the inner and outer rings can be filled with balls. Thus, capacity is limited.

To increase capacity, a filling slot or notch can be cut into the inner ring, permitting the insertion of balls. Once the balls have been inserted, the slot is filled by an insert. The increased number of balls increases radial load capacity, but thrust load capacity is sacrificed because of the filling slot.

The non-filling-slot or Conrad bearing is designated by the suffix K and the filling slot bearing is designated by the suffix W.

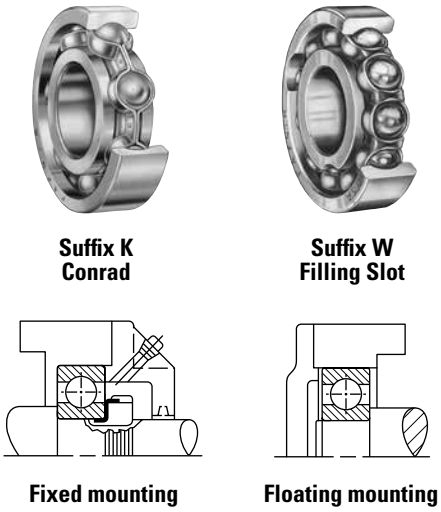


Fig. 1. Typical mountings for radial ball bearings.

BALL BEARINGS WITH SNAP RINGS (WIRELOC)

Single-row radial ball bearings, including those with seals or shields and open and shielded double-row types, are available with snap rings. The snap ring protrudes from a groove in the outer ring and acts as a shoulder to maintain bearing position. It is designed for mounting in through-bored housings. This feature is designated by adding the suffix G to the standard bearing number. Single-shielded or sealed bearings with snap rings can be supplied with the snap ring on the same side or opposite the shield or seal position.

These bearings are advantageous in automobile transmission design and in all applications where compactness is essential, or where it is difficult and costly to machine housing shoulders. The snap ring provides an adequate shoulder for the bearings without a sacrifice in bearing capacity. The thrust capacity of the snap ring in shear exceeds the thrust capacity of the bearing.

Typical designs illustrating how mounting simplification can be accomplished through the use of snap ring bearings are shown below.

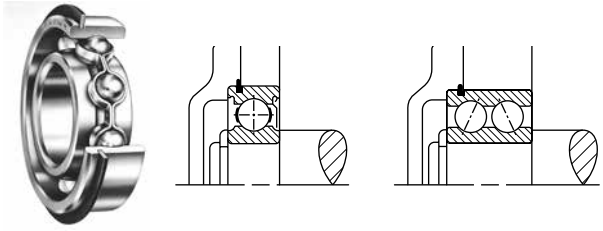


Fig. 2. Typical mountings for snap ring bearings.

ANGULAR CONTACT BALL BEARINGS

SINGLE-ROW

Single-row, angular contact ball bearings are designed for combination loading with high thrust capacity in one direction, and are suggested for applications where the magnitude of the thrust component is high enough to preclude the use of radial-type ball bearings. They are dimensionally interchangeable with single-row radial bearings of corresponding sizes.

The angular contact ball bearing has a relatively large contact angle, high ring depths, and a maximum complement of balls assembled through a counterbore in the outer ring. These features provide bearings with significantly more thrust capacity than radial bearings of the same size.

Angular contact bearings are used in such applications as gear reducers, pumps, worm drives, vertical shafts and machine tool spindles, where they are frequently mounted in various single-row arrangements.

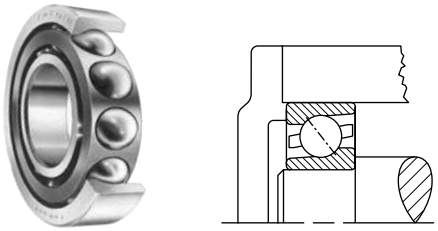


Fig. 3. Typical mounting for single-row, angular contact ball bearings.

DOUBLE-ROW

Double-row, angular contact ball bearings are used effectively where heavy radial, thrust or combined loads demand axial rigidity of the shaft. This type is similar to a duplex pair of single-row bearings by virtue of its two rows of balls and angular-contact construction, which provide greater axial and radial rigidity than can be obtained by using a single-row radial bearing.

With the exception of small sizes, double-row ball bearings are made in the filling slot construction, and therefore, do not have as much thrust capacity as equivalent size single-row, angular contact bearings mounted in duplex pairs. Fixed and floating mountings of double-row bearings are shown. Smaller sizes are supplied with polymer retainers.

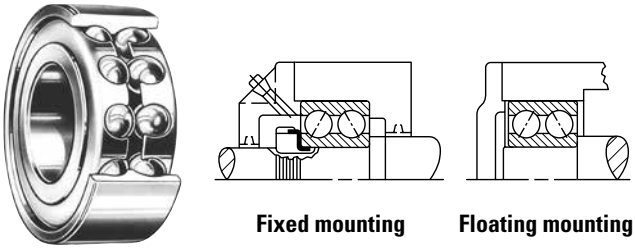


Fig. 4. Typical mountings for double-row, angular contact ball bearings.

PRECISION BEARINGS[1]

MINIATURE AND THIN-SECTION BALL BEARINGS

Timken produces precision ball bearings and assemblies in miniature, instrument and thin-section series. All are manufactured with quality steel, tolerances and features that meet demanding application challenges. These precision bearings and assemblies are found in surgical and diagnostic imaging devices, precision pumps, measurement and material handling equipment, as well as guidance, weapons and space applications. Standard sizes range from 1 mm to 279.40 mm bore (0.0250 in. to 11.000 in. bore).

Radial ball bearings



Fig. 5. Radial ball bearing.

These Conrad bearings are available in ISO P5/ABEC 5 to ISO P4/ABEC 7 precision levels as a standard catalog offering. The deep-groove construction allows for handling of radial, thrust or combination loads. These are offered primarily with 440C stainless-steel rings and balls with one-piece fully machined snap-in phenolic cages. In addition to 52100, other material and cage options are available, as well as shields and seals, and ceramic or titanium carbide-coated balls. Flanges are offered on miniature product. Typical applications include guidance systems, medical (surgical instruments and devices) and robotic joints.

Angular contact ball bearings



Fig. 6. Angular contact ball bearing.

Angular contact ball bearings offer maximum ball complement with a one-piece precision-machined retainer. The increased ball complement, combined with a relatively high contact angle, maximizes axial stiffness. Angular contact ball bearings are manufactured to the same tolerances and standards as the radial ball bearings. Rings and balls are normally 440C stainless steel, but other material options are offered. Steel and ceramic balls are available as standard. Typical applications use preloaded pairs for maximum stiffness, high speeds and precise positioning. These include surgical handpieces, control moment gyros and other high-speed or high-stiffness applications.

[1]For additional information, refer to the Timken Super Precision Bearings for Machine Tool Applications Catalog (order no. 5918) on www.timken.com.

Fractured ring ball bearings



Fig. 7. Fractured ring ball bearing.

These bearings have outer rings that are radially fractured in one location. This permits the ring to be opened for complete flexibility in the choice of ball complement and cage in a deep-groove radial bearing. High-strength stainless-steel holding bands are pressed on the ground shoulders to retain tight abutment and alignment of the fractured surface during handling and normal operation. Full complement and retainer configurations are available.

Typical applications have a limited radial cross section and a limited axial width. These applications require a bearing with maximum radial capacity, as well as axial capacity in both directions.

Pivot ball bearings

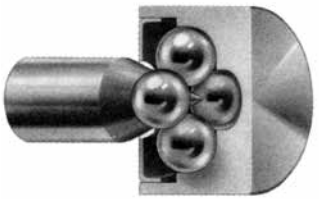


Fig. 8. Pivot ball bearing.

Designed for space constrained environments where low torque is required, pivot bearings use the mating shaft for the inner raceway. These bearings achieve maximum power density with a full complement of larger balls, no cage or inner ring. Shields are available for the standard line. Typical applications are in guidance systems, such as commercial gyroscopes.

Thrust ball bearings



Fig. 9. Thrust ball bearing.

These bearings are designed for applications where high axial load, low speed and relatively high torque are allowable. The standard offering has all stainless steel components for use where inert materials are required. Stainless steel allows operation as a fuel control governor.

PRECISION BEARINGS – *continued*

TAPERED ROLLER BEARINGS

Timken's high-precision tapered roller bearings consist of carefully matched components that offer an added degree of fine-tuning in the bearing setting and adjustment procedure to maximize customer machine productivity. Timken manufactures high-speed designs with a variable preload capability for optimum performance. Timken also manufacturers Precision Plus bearings – having an overall radial runout less than a single micron.

TS and TSF single-row bearings

These bearings are similar in design to the types described on page 16. They are only produced in high-precision quality, to be used in machine tool spindles, printing press cylinders and other applications where accuracy of rotation is required.

TSHR - Hydra-Rib™ bearing with preload adjustment device

For many applications, notably in the machine tool industry, bearings are required to run at high speeds with a controlled preload setting. The Hydra-Rib™ bearing has a floating outer ring rib controlled by hydraulic or pneumatic pressure, which ensures that the required bearing preload is maintained irrespective of the differential expansions or changes in loading taking place within the system.



Fig. 10. Hydra-Rib™ bearing.

TXR - crossed roller bearing

A crossed roller bearing is two sets of bearing rings and rollers brought together at right angles with alternate rollers facing opposite directions. TXR bearings have a section height not much greater than that of a TS bearing. The steep angle, tapered geometry of the bearing causes the load-carrying center of each of the rings to be projected along the axis, resulting in a total effective bearing spread many times greater than the width of the bearing itself. This type of bearing offers a high resistance to overturning moments.

The normal design of the bearing is type TXRDO, which has a double outer ring and two inner rings, with rollers spaced by polymer cages. Crossed roller bearings are manufactured in precision classes.



TXR

Fig. 11. TXR crossed roller bearing.

SUPER PRECISION BALL BEARINGS

The Timken line of super precision machine tool ball bearings is designed to meet ISO and ABEC tolerance levels. However, Timken manufactures all super precision ball bearings to surpass ISO/ABMA criteria to ensure that the end users receive only the highest quality product to maximize machine performance. Spindle bearings are the most popular type of super precision ball bearing used within the machine tool industry. These angular contact bearings are used primarily in precision, high-speed machine tool spindles. Timken manufactures super precision machine tool bearings in four metric ISO dimensional series. In addition, because of specialized variations of bearing design and geometry, Timken offers a total of seven angular contact bearing types within these four basic series:



Fig. 12. Super precision ball bearing.

- ISO 19 (9300WI, 9300HX series).
- ISO 10 (9100WI, 9100HX, 99100WN series).
- ISO 02 (200WI series).
- ISO 03 (300WI series).

Multiple internal geometries are available to optimize either load-carrying capacity or speed capability with part number suffixes designated as: WI, WN, HX or K. WI-type bearings are designed to maximize capacity of the various bearing cross sections and are used in low to moderate speeds. The HX is Timken's proven high-speed design. It has a significant advantage at higher speeds, generating less heat and less centrifugal loading forces. The WN-type is generally a compromise between the WI and HX as it offers higher speed capability than the WI, but lower capacity, higher stiffness and lower speed capability than the HX design.

Most of the bearing types are available in either 15 degree (2MM) or 25 degree (3MM) contact angles. In addition, Timken now stocks more ceramic ball sizes than ever for the highest speed requirements. The K-type deep-groove (Conrad) super precision radial ball bearing is generally used in applications where capacity and stiffness do not require sets containing multiple bearings. By virtue of the single-row, radial deep-groove construction, and super precision level tolerances, these are capable of carrying thrust loads in either direction. Also, they

have a relatively high-speed capability – especially if a light axial preload is applied. Timken offers deep-groove super precision ball bearings in the following ISO dimensional series:

- ISO 10 (9100K series).
- ISO 02 (200K series).
- ISO 03 (300K series).

For additional information, refer to the Timken Super Precision Bearings for Machine Tool Applications Catalog (order number 5918) on www.timken.com. Or, contact your Timken engineer.

BALL BEARINGS WITH LOCKING DEVICES

By virtue of their independent locking devices, these bearings are suitable for mounting on straight shafting (no shoulders, etc.). They are often supplied with spherical outer rings for self-alignment at mounting. Mounted alignment is usually required because these bearings are generally assembled into pillow blocks or flanged cartridges, or other housings bolted to pedestals or frames independent of each other.

SELF-LOCKING (ECCENTRIC) COLLAR

Timken invented the eccentric self-locking collar to facilitate mounting of wide inner ring bearings. The self-locking collar eliminates the need for locknuts, lock washers, shoulders, sleeves and adapters.

The locking collar has a counterbored recess eccentric with the collar bore. This eccentric recess engages or mates with an eccentric cam end of the bearing inner ring when the bearing is assembled on the shaft.

The collar is engaged on the inner ring cam of the bearing. This assembly grips the shaft tightly with a positive binding action that increases with use. No adjustments are necessary. The collar setscrew provides supplementary locking.



RA-RR series extended inner ring with locking collar

Shroud-seal KRRB series wide inner ring with locking collar

Fig. 13. Self-locking (eccentric) collar.

Easiest of all to install, wide inner ring ball bearings with self-locking collars are available in various sizes. These bearings, shown with various seal and inner ring width variations, serve many purposes in farm and industrial applications.

SETSCREW SERIES BEARINGS

The GYA-RRB and the GY-KRRB series are extended inner ring and wide inner ring type bearings with specially designed setscrews to lock on the shaft. These bearings can be purchased so that they can be relubricated. Positive contact land-riding R-Seals provide protection against harmful contaminants and retain lubricant. Extended inner ring bearings are used when space is at a premium and overturning loads are not a problem. The wide inner ring setscrew series is available when additional surface contact on the shaft is a requirement for added stability.

Fig. 14. YA-RR series.



CONCENTRIC COLLAR

Using the concentric collar, the bearing is locked to the shaft by two setscrews, 120 degrees apart, tightened in the collar and passing through drilled holes in the inner ring. These units are suited for applications where space is limited and reversing shaft rotation is encountered.

Fig. 15. GC-KRRB series.



TAPERED ROLLER BEARINGS

SINGLE-ROW BEARINGS

TS - Single-row

This is the basic and the most widely used type of tapered roller bearing. It consists of the inner ring assembly and the outer ring. It is usually fitted as one of an opposing pair. During equipment assembly, single-row bearings can be "set" to the required clearance (endplay) or preload condition to optimize performance.



Fig. 16. Single-row TS bearing.

TSF - Single-row, with flanged outer ring

The TSF type is a variation on the basic single-row bearing. TSF bearings have a flanged outer ring to facilitate axial location and accurately aligned seats in a through-bored housing.



Fig. 17. Single-row TSF bearing with flanged outer ring.

DOUBLE-ROW BEARINGS

TDO - Double outer ring

This has a one-piece (double) outer ring and two single inner-rings. It is usually supplied complete with a inner-ring spacer as a pre-set assembly. This configuration gives a wide effective bearing spread and is frequently chosen for applications where overturning moments are a significant load component. TDO bearings can be used in fixed (locating) positions or allowed to float in the housing bore, for example, to compensate for shaft expansion. TDOCD outer rings also are available in most sizes. These outer rings have holes in the O.D. that permit the use of pins to prevent outer ring rotation in the housing.



Fig. 18. Double-row TDO bearing.

TDI - Double inner ring
TDIT - Double inner ring with tapered bore

Both comprise a one-piece (double) inner ring and two single outer rings. They are usually supplied complete with an outer-ring spacer as a pre-set assembly. TDI and TDIT bearings can be used at fixed (locating) positions on rotating shaft applications. For rotating housing applications, the double inner ring of type TDI can be used to float on the stationary shaft. Type TDIT has a tapered bore to facilitate removal when an interference fit is essential, yet regular removal is required.



TDI **TDIT**

Fig. 19. Double-row, double-inner-ring bearings.

TNA - Non-adjustable
TNASW - Non-adjustable with lubricant slots
TNASWE - Non-adjustable with lubricant slots and extended back face rib

These three bearing types are similar to the TDO with a one-piece (double) outer ring and two single inner rings. The inner ring front faces are extended so they abut, eliminating the need for a separate inner-ring spacer. Supplied with a built-in clearance to give a standard setting range, these bearings provide a solution for many fixed or floating bearing applications where optimum simplicity of assembly is required.

Types TNASW and TNASWE are variations having chamfers and slots on the front face of the inner ring to provide lubrication through the shaft. Type TNASWE have extended back face ribs on the inner rings which are ground on the O.D. to allow for the use of a seal or stamped closure. These designs are typically used on stationary shaft applications.



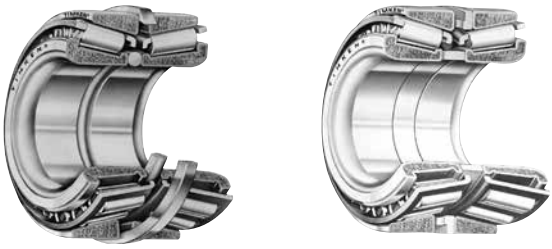
TNA TNASW TNASWE

Fig. 20. Double-row, non-adjustable bearings.

SPACER ASSEMBLIES

Any two single-row bearings (type TS) can be supplied as a double-row, pre-set, ready-to-fit assembly by the addition of spacers, machined to pre-determined dimensions and tolerances.

Spacer assemblies are provided in two types: "2S" and "SR". This concept can be applied to produce custom-made double-row bearings to suit specific applications. In addition to providing a bearing that automatically gives a pre-determined setting at assembly without the need for a manual setting, it is possible to modify the assembly width to suit an application, simply by varying the spacer widths.



2S SR

Fig. 21. Spacer assemblies.

2S - Two single-row assembly

Often referred to as snap-ring assemblies, type 2S consist of two basic single-row bearings (type TS). They are supplied complete with inner-ring and outer-ring spacers to give a pre-determined bearing setting when assembled. Type 2S have a specified setting range to suit the duty of the application. They have an inner-ring spacer and a snap-ring, which also serves as the outer-ring spacer, to give axial location in a through-bored housing.

SR - SET-RIGHT™ assembly

Type SR are made to a standard setting range, based on Timken's SET-RIGHT™ automated setting technique suitable for most industrial applications. They have two spacers and an optional snap-ring that may be used for axial location. Because both types are made up of popular sizes of single-row bearings, they provide a low-cost option for many applications.

TAPERED ROLLER BEARINGS – *continued*

There are three basic mounting arrangements for spacer assemblies.

- **Type 2TS-IM (indirect mounting)**
  These consist of two single-row bearings with an inner-ring and outer-ring spacer. In some applications, the outer-ring spacer is replaced by a shoulder in the bearing housing.
- **Type 2TS-DM (direct mounting)**
  These consist of two single-row bearings, with inner rings abutting and an outer-ring spacer. They are generally used at fixed (locating) positions on rotating shaft applications.
- **Type 2TS-TM (tandem mounting)**
  Where combined radial and thrust load capacity is required, but the thrust component is beyond the capacity of a single bearing (within a given maximum O.D.), two single-row bearings can be mounted in tandem. Appropriate inner-ring and outer-ring spacers are supplied. Consult your Timken engineer for the most effective and economical solution.

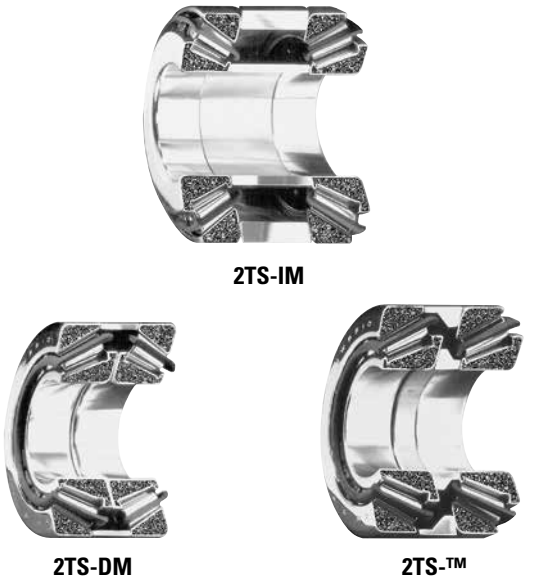


Fig. 22. Basic spacer assemblies.

PACKAGED BEARINGS



PINION PAC™ UNIPAC™ UNIPAC-PLUS™ AP™ SP™

Fig. 23. Packaged bearings.

Pinion Pac™ bearing

The Pinion Pac™ bearing is a ready-to-install, pre-set and sealed package consisting of two rows of tapered roller bearings mounted in a carrier. It is custom designed for the final drive pinions of heavy commercial vehicles. The package gives the differential pinion builder considerable improvements in reliability, ease of assembly and supply logistics.

UNIPAC™ bearing

The UNIPAC-PLUS™ bearing is a ready-to-install, pre-set, pre-lubricated and sealed double-row assembly with a flanged outer ring. Originally designed for the high-volume needs of passenger car wheels, the UNIPAC bearing now has wider application in wheel hubs of heavy vehicles as well as in industrial equipment.

The UNIPAC bearing provides improvements in reliability, ease of assembly and supply logistics.

UNIPAC-PLUS™ bearing

The UNIPAC-PLUS™ bearing is a ready-to-install, pre-set, sealed double-row assembly with a flanged outer ring. It also is lubricated for the reasonable life of the bearing. It is designed for wheel applications subjected to moderate to heavy loading. The UNIPAC-PLUS bearing provides advantages of improved reliability, reduced weight and easier assembly.

AP™ bearing

The AP™ bearing is a self-contained assembly, made in a wide range of sizes. It consists of two single inner rings, a counterbored double outer ring, a backing ring, two radial seals, an end cap and cap screws. The AP bearing is supplied as a pre-set, pre-lubricated and sealed package. It was originally designed for railroad journals, but also is used in many industrial applications.

SP™ bearing

Similar in concept to AP bearings, the SP™ bearing is designed for rail journal bearing applications. The SP bearing type differs from the AP bearing in that SP bearings are more compact in size and are manufactured to metric boundary dimensions.

HIGH-SPEED BEARINGS

TSMA - Single-row with axial oil
TSMR - Single-row with radial oil

Some applications require extreme high-speed capability where special lubrication methods must be provided.

The TSMA and TSMR are single-row bearings with provisions for lubrication of critical roller-rib contact area to ensure adequate lubrication at high speeds. The TSMA concept works by capturing oil in a manifold (attached to the inner ring), which is then directed to the rib-roller contact through holes drilled axially through the large inner ring rib. The TSMR functions in a similar manner with the difference being that holes are drilled radially from the inner ring bore to the large rib face. Oil is captured in a circumferential groove in the inner ring bore. It is directed to the rib-roller contact area through radial holes.



Fig. 24. TSMA bearing.

OTHER DOUBLE-ROW BEARINGS

Type TDIE - Extended double inner ring
Type TDIA - Extended single inner ring

These double-row bearings are designed for applications where it is required to lock the loose-fitted inner ring to a shaft, with provision also for effective closure or sealing. Typical applications include pillow blocks, disc-harrow and similar agricultural machinery shafts and line shafts.

Type TDIE is available in two forms – cylindrical bore with the inner ring extended at both ends and provisions for setscrews and locking collars at each end, or with an inherently self-locking square bore – ideal for farm machinery applications.

Type TDIA is similar to type TDIE with a cylindrical bore. There is a provision for a locking collar at one end only. The compact configuration is suited to pillow blocks and similar applications.

On all types, the hardened and ground O.D. of the inner ring extension provides an excellent surface for effective closure or sealing.

Type TNASWH - Non-adjustable, heavy-duty, double outer ring
Type TNASWHF - Non-adjustable, heavy-duty, with flanged double outer ring

These are double-row bearing assemblies with two inner rings and a one-piece outer ring, similar to type TNASWE listed in this manual on page 17.

The outer rings have a heavy wall section (type TNASWH), allowing the bearings to be used directly as steady rest rollers, in sheet and strip levellers or, with a flange (type TNASWHF), as a complete wheel assembly for use on rails.

The outer ring is extended at both ends and counterbored to accept stamped closures. Contacting seals are available for certain sizes. These bearings are typically supplied as a unit assembly and are pre-lubricated.



TDIE **TDIE (square bore)** **TDIA** **TNASWH** **TNASWHF**

Fig. 25. Other double-row bearings.

FOUR-ROW BEARINGS

Four-row bearings combine the inherent high-load, radial/thrust capacity and direct/indirect mounting variations of tapered roller bearings into assemblies of maximum load rating in a minimum space. Their main application is on the roll necks of rolling mill equipment.

All four-row bearings are supplied as pre-set matched assemblies, with all components numbered to ensure correct installation sequence.

Type TQO - Quad taper
Type TQOW - Quad taper with lubrication slots

These pairs of directly mounted bearings consist of two double inner rings, two single and one double outer ring, with an inner-ring spacer and two outer-ring spacers. These types are used on roll necks of low- and medium-speed rolling mills, applied to the necks with a loose fit. When the fillet and/or filler rings do not have lubrication slots, they are provided in the faces of the bearing inner rings (type TQOW). Slots in the inner-ring spacer permit lubricant to flow from the bearing chamber to the roll neck. The inner-ring spacers also are hardened to minimize face wear.



Fig. 26. Four-row bearing assemblies.

TQO/ TQOW

Sealed roll neck

The sealed roll neck bearing is similar to the TQO. A specially designed sealing arrangement is incorporated in the bearing to endure highly contaminated environments. The special seal design is built into the bearing to prevent ingress of contamination from outside the bearing envelope and extend the useful bearing life.



Fig. 27. Sealed roll neck bearing.

Type TQITS
Type TQITSE

The main feature of these bearings is a tapered bore – the taper being matched and continuous through the inner rings. This permits an interference fit on the backup rolls of high-speed mills, where a loose inner ring fit of a straight bore type TQO bearing could result in excessive neck wear.

These four-row bearings consist of two pairs of indirectly mounted bearings: two single and one double inner ring, four single outer rings and three outer-ring spacers. The adjacent faces of the inner-rings are extended so that they abut, eliminating the need for inner-ring spacers. The indirect mounting of the bearing pairs increase the overall effective spread of the bearing, to give optimum stability and roll rigidity.

Type TQITSE is the same as TQITS, but has an extension to the large bore inner ring adjacent to the roll body. This not only provides a hardened, concentric and smooth surface for radial lip seals, but also improves roll neck rigidity by eliminating a fillet ring. This allows the centerline of the bearing to move closer to the roll body. It also permits shorter and less costly rolls.



TQITS **TQITSE**

Fig. 28. Four-row bearings with tapered bore.

SEALED BEARINGS

TSL

Timken offers a wide range of sealed bearings such as the DUO-FACE® PLUS seal shown in fig 29. The TSL incorporates a DUO-FACE PLUS seal, making it an economical choice for grease-lubricated applications at moderate speeds. See the SEALS section in the back of this manual for additional seal designs.



Fig. 29. TSL sealed bearing.

THRUST BEARINGS

Standard types of thrust bearings manufactured by Timken are included in this section. Each type is designed to take thrust loads, but four types (TVL, DTVL, TTHD and TSR) accommodate radial loads as well. All types reflect advanced design concepts, with large rolling elements for maximum capacity. In roller thrust bearings, controlled-contour rollers are used to ensure uniform, full-length contact between rollers and raceways with resultant high capacity. Thrust bearings should operate under continuous load for satisfactory performance.

Type TVB – Grooved-ring thrust ball bearing

Type TVL – Angular contact thrust ball bearing

Type DTVL – Two direction angular contact thrust ball bearing

Type TP – Thrust cylindrical roller bearing

Type TPS – Self-aligning thrust cylindrical roller bearing

Type TTHD – Thrust tapered roller bearing

Type TSR – Thrust spherical roller bearing

Type TTHDFL – V-flat thrust tapered roller bearing

Type TTVS – Self-aligning V-flat thrust tapered roller bearing

Type TTSP – Steering pivot thrust cylindrical roller bearing

THRUST BALL BEARINGS

Thrust ball bearings are used for lighter loads and higher speeds than thrust roller bearings. Types TVB, TVL and DTVL are shown in fig. 30.

Type TVB thrust ball bearing is separable and consists of two hardened and ground steel rings with grooved raceways, and a cage that separates and retains precision-ground and lapped balls. The standard cage material is brass, but this may be varied according to the requirements of the application. Timken standard tolerances for type TVB bearings are equivalent to ABEC 1 where applicable, but higher grades of precision are available.

Type TVB bearings provide axial rigidity in one direction and their use to support radial loads is not suggested. Usually the rotating ring is shaft-mounted. The stationary ring should be housed with sufficient O.D. clearance to allow the bearing to assume its proper operating position. In most sizes, both rings have the same bore and O.D. The housing must be designed to clear the O.D. of the rotating ring, and it is necessary to step the shaft to clear the bore of the stationary ring.

Type TVL is a separable angular contact ball bearing primarily designed for unidirectional thrust loads. The angular contact design, however, will accommodate combined radial and thrust loads since the loads are transmitted angularly through the balls.

The bearing has two hardened and ground steel rings with ball grooves and a one-piece brass cage that spaces the ball complement. Although not strictly an angular ball bearing, the larger ring is still called the outer ring, and the smaller the inner ring. Timken standard tolerances for type TVL bearings are equivalent to ABEC 1 where applicable, but higher grades of precision are available.

Usually the inner ring is the rotating member and is shaft mounted. The outer ring is normally stationary and should be mounted with O.D. clearance to allow the bearing to assume its proper operating position. If combined loads exist, the outer ring must be radially located in the housing.

Type TVL bearings should always be operated under thrust load. Normally, this presents no problem as the bearing is usually applied on vertical shafts in oil field rotary tables and machine tool indexing tables. If constant thrust load is not present, it should be imposed by springs or other built-in devices.

Low friction, cool running and quiet operation are advantages of TVL bearings, which may be operated at relatively high speeds. TVL bearings also are less sensitive to misalignment than other types of rigid thrust bearings.

DTVL is similar in design to TVL except the DTVL has an additional ring and ball complement permitting it to carry moderate thrust in one direction and light thrust in the other direction.

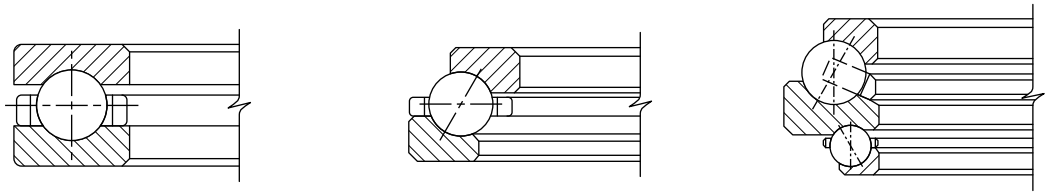


Fig. 30. Thrust ball bearing types.

THRUST CYLINDRICAL ROLLER BEARINGS

Thrust cylindrical roller bearings withstand heavy loads at relatively moderate speeds. Standard thrust bearings can be operated at bearing O.D. peripheral speeds of 3000 fpm (15 m/s). Special design features can be incorporated into the bearing and mounting to attain higher operating speeds.

Because loads are usually high, extreme-pressure (EP) lubricants should be used with cylindrical roller thrust bearings. Preferably, the lubricant should be introduced at the bearing bore and distributed by centrifugal force.

All types of thrust roller bearings are made to Timken Standard Tolerances. Higher precision may be obtained when required.

Type TP thrust cylindrical roller bearings have two hardened and ground steel rings, with a cage retaining one or more controlled-contour rollers in each pocket. When two or more rollers are used in a pocket, they are of different lengths and are placed in staggered position in adjacent cage pockets to create overlapping roller paths. This prevents wearing grooves in the raceways and helps prolong bearing life.

Because of the simplicity of their design, type TP bearings are economical. Shaft and housing seats must be square to the axis of rotation to prevent initial misalignment problems.

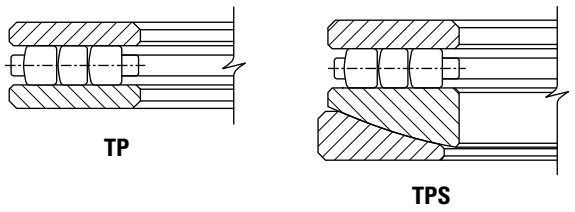


Fig. 31. Thrust cylindrical roller bearings.

Type TPS bearings are the same as type TP bearings except one ring is spherically ground to seat against an aligning ring, thus making the bearing adaptable to initial misalignment. Its use is not suggested for operating conditions where alignment is continuously changing (dynamic misalignment).

THRUST SPHERICAL ROLLER BEARINGS

Type TSR

The TSR thrust spherical roller bearing design achieves a high thrust capacity with low friction and continuous roller alignment. The bearings can accommodate pure thrust loads as well as combined radial and thrust loads. Typical applications are air regenerators, centrifugal pumps and deep well pumps. Maximum axial misalignment between inner and outer ring is ±2.5 degrees.

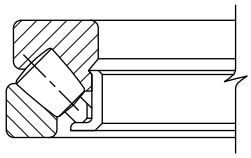


Fig. 32. Thrust spherical roller bearing, type TSR.

THRUST TAPERED ROLLER BEARINGS

Type TTHD

Type TTHD thrust tapered roller bearings have an identical pair of hardened and ground steel rings with conical raceways and a complement of controlled-contour tapered rollers equally spaced by a cage. The raceways of both rings and the tapered rollers have a common vertex at the bearing center. This assures true rolling motion.

TTHD bearings are well-suited for applications such as crane hooks, where extremely high thrust loads and heavy shock must be resisted and some measure of radial location obtained.

For very low-speed, heavily loaded applications, these bearings are supplied with a full complement of rollers for maximum capacity. For application review of the full complement type TTHD bearing, consult your Timken engineer.

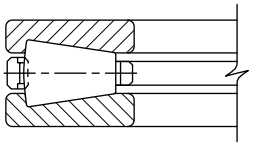


Fig. 33. Thrust tapered roller bearing, type TTHD.

THRUST BEARINGS – *continued*

TTC cageless
TTSP steering pivot

There are two basic types of Timken® tapered roller thrust bearings designed for applications where the only load component is thrust, TTC and TTSP. The TTC bearing uses a full complement of tapered rollers without a cage and is used when the speeds are slow. The TTSP bearing uses a cage and is well-suited for the oscillating motion of steering pivot positions.

Type TTHDFL
Type TTHDSX
Type TTVS
Type TTHDSV

V-flat tapered roller bearings (TTHDFL and TTVS) combine the best features of thrust tapered and cylindrical roller bearings, offering the highest possible capacity of any thrust bearing of its size. V-flat design includes one flat ring and the second with a tapered raceway matching the rollers. The design was originally developed to be screwed down in metal rolling mill applications where the thrust loads commonly exceed one million pounds. These bearings have exceptional dynamic capacity within a given envelope and provide superior static capacity. They are used inheavily loaded extruders, cone crushers and other applications where a wide range of operating conditions are found.

Most sizes utilize cages with hardened pins through the center of the rollers, allowing closer spacing of the rollers to maximize capacity. Smaller sizes have cast-brass cages, carefully machined to permit full flow of lubricant.

Self-aligning V-flat bearings (TTVS) employ the same basic roller and raceway design, except the lower ring is in two pieces, with the contacting faces spherically ground permitting self-alignment under conditions of initial misalignment. TTVS bearings should not be used if dynamic misalignment (changing under load) is expected.

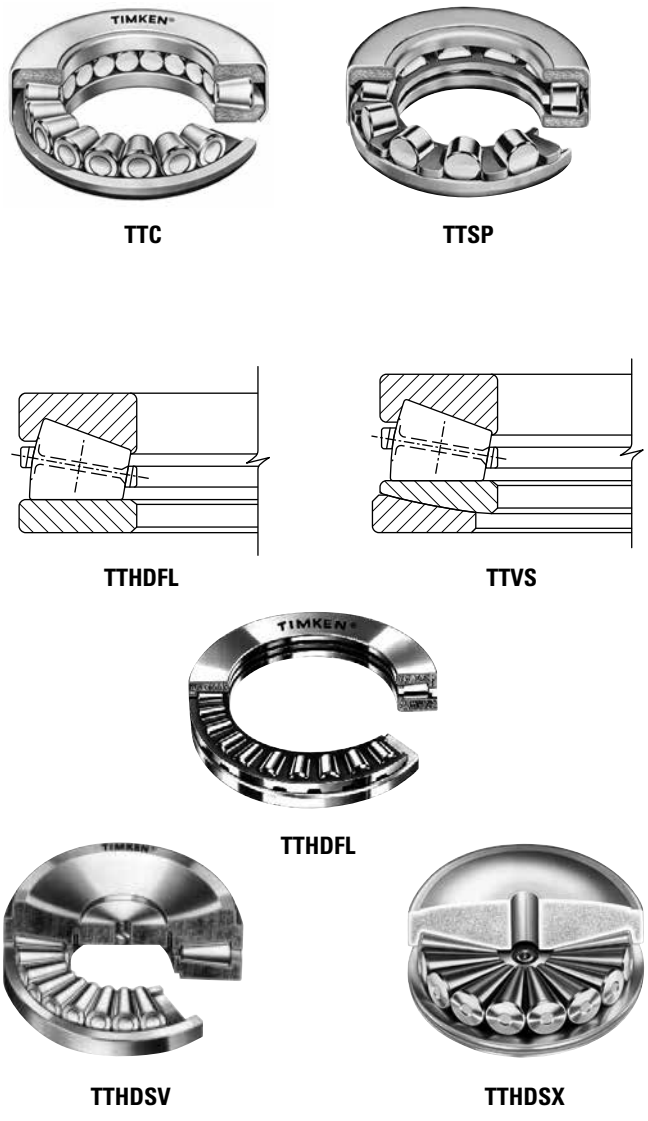


Fig. 34. Thrust tapered roller bearings.

RADIAL SPHERICAL ROLLER BEARINGS

The principle styles of radial spherical roller bearings that Timken offers are:

- ≤400 mm outer diameter: EJ, EM and EMB.
- >400 mm outer diameter: YM, YMB, YMD and YP.

The newly redesigned Timken® EJ, EM and EMB bearings offer higher load ratings, increased thermal speed ratings and reduced operating temperatures compared to the previous offering.

In addition to these improvements, cage designs vary between the different styles as noted below. See the cage section for more details.

Style	Cage Design
EJ	Land-riding steel cage; one per row
EM / YM	Roller-riding one-piece brass cage
EMB/YMB	Land-riding one-piece brass cage
YMD	Land-riding two-piece brass cage
YP	Steel pin-type cage



Fig. 35. Radial spherical roller bearings.

Most Timken spherical roller bearings are available with a cylindrical bore as well as a tapered bore. Tapered bore bearing part numbers are designated with a K suffix.

A taper of 1:12 is standard except for 240, 241 and 242 series, which have a taper of 1:30.

OPTIONAL FEATURES AVAILABLE WITH TIMKEN SPHERICAL ROLLER BEARINGS

W33 lubrication groove and oil holes

A lubrication groove and three oil holes are provided in the bearing outer ring as standard. This is designated by the W33 suffix. It eliminates the expense of machining a channel in the housing bore for introducing lubricant to the bearing. This design feature allows the lubricant to flow between the roller paths, through a single lubrication fitting. The lubricant moves laterally outward from the center of the bearing, reaching all contact surfaces and flushing the bearing. To order, add the suffix W33 to the bearing number (e.g. 22216EMW33).

Bearings for vibratory applications

Timken offers specific spherical roller bearing designs for vibratory applications. They are designated by the W800 modification code and made to a C4 clearance. Specify W800 when ordering. This design provides:

- A lubrication groove on the outer ring with three lubrication holes to facilitate bearing lubrication.
- Extra-close running accuracy (P5) with high and low points marked on the bearing.
- Reduced bore and outside diameter tolerances.
- Radial internal clearance is made in upper two-thirds of C4 clearance range.

These bearings are available with either a cylindrical or tapered bore.

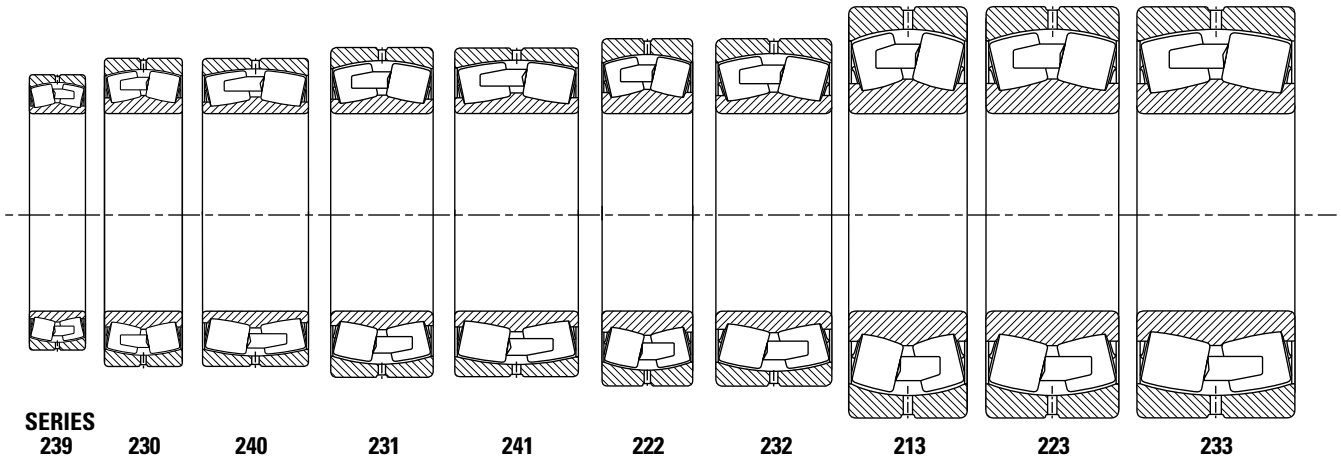


Fig. 36. Radial spherical roller bearing series.

RADIAL CYLINDRICAL ROLLER BEARINGS

STANDARD STYLES

Timken® cylindrical roller bearings consist of an inner and outer ring, a roller-retaining cage, and a complement of controlled-contour cylindrical rollers. Depending on the type of bearing, either the inner or the outer ring has two roller-guiding ribs. The other ring is separable from the assembly and has one rib or none. The ring with two ribs axially locates the position of the roller assembly. The ground diameters of these ribs may be used to support the roller cage. One of the ribs may be used to carry light thrust loads when an opposing rib is provided.

The decision as to which ring should be double ribbed is normally determined by considering assembly and mounting procedures in the application.

Type NU has double-ribbed outer and straight inner rings. Type N has double-ribbed inner and straight outer rings. The use of either type at one position on a shaft is ideal for accommodating shaft expansion or contraction. The relative axial displacement of one ring to the other occurs with minimum friction while the bearing is rotating. These bearings may be used in two positions for shaft support if other means of axial location are provided.

Type NJ has double-ribbed outer and single-ribbed inner rings. Type NF has double-ribbed inner and single-ribbed outer rings. Both types can support heavy radial loads, as well as light unidirectional thrust loads. The thrust load is transmitted between the diagonally opposed rib faces in a sliding action. When limiting thrust conditions are approached, lubrication can become critical. Your Timken engineer should be consulted for assistance in such applications. When thrust loads are very light, these bearings may be used in an opposed mounting to locate the shaft. In such cases, shaft endplay should be adjusted at time of assembly.

Type NUP has double-ribbed outer and single-ribbed inner ring with a loose rib that allows the bearing to provide axial location in both directions. Type NP has a double-ribbed inner ring and a single-ribbed outer ring with a loose rib. Both types can carry heavy radial loads and light thrust loads in both directions. Factors governing the thrust capacity are the same as for types NJ and NF bearings.

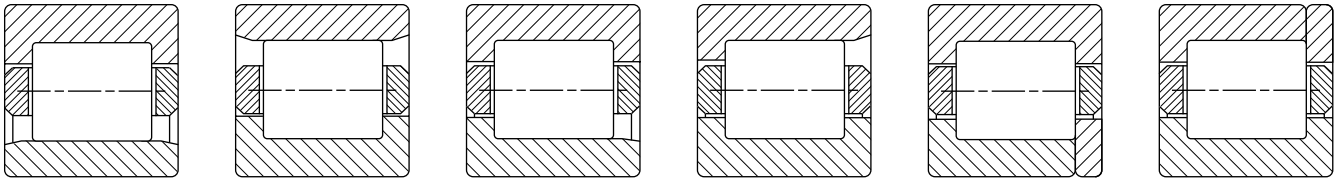
A type NUP or NP bearing may be used in conjunction with type N or NU bearings for applications where axial shaft expansion is anticipated. In such cases, the N or NU bearing accommodates the shaft expansion. The NUP or NP bearing is considered the fixed bearing because the ribs restrict the axial movement of the rolling element. The fixed bearing is usually placed nearest the drive end of the shaft to minimize alignment variations in the drive. Shaft endplay, or float, is determined by the axial clearance in the fixed bearing.

Types NU, N, NJ, NF, NUP and NP conform to ISO and DIN standards for loose rib rings (thrust collars) and typical industry diameters over or under roller.

The cylindrical roller bearing part numbers are in accordance with ISO 15. They are composed of four digits, the first two digits identify the dimensional series and the last two digits of the part number are the bore size divided by 5. In the dimensional series, the first digit is the width series and the second is the diameter (outer) series. The width series increase width in the sequence 8 0 1 2 3 4 5 6 7. The diameter series increase radial section in the sequence 7 8 9 0 1 2 3 4.

Types having an R prefix are similar in construction to their N counterparts. However, they were designed to conform to ABMA standards.

Inch-size bearings are identified by the letter I in the part number. RIU, for example, indicates an inch bearing while RU indicates the equivalent style in metric dimensions.



NU, RIU, RU | N, RIN, RN | NJ, RIJ, RJ | NF, RIF, RF | NUP, RIT, RT | NP, RIP, RP

Fig. 37. Radial cylindrical roller bearings.

EMA SERIES

The Timken® single-row EMA series cylindrical roller bearings incorporate a unique cage design, proprietary internal geometry and special surface textures. These features help to improve bearing performance and can help to improve uptime and reduce maintenance costs.

The cage is a one-piece brass design with full-milled pockets. It is a land-riding cage which, unlike traditional roller-riding cages, minimizes drag on the roller elements. This reduces heat generation and improves bearing life. The high cage rigidity allows for more rollers than possible with other brass cage configurations.

Proprietary profiles on the rings and/or rollers increase the ability to handle heavier loads than competing designs.

Engineered processes for rings and rollers provide enhanced surface textures, resulting in lower friction, lower operating temperatures and longer bearing life.

EMA series bearings are available in types N, NU, NJ and NUP.

FULL-COMPLEMENT (NCF)

The full-complement (NCF) single-row bearings include integral flanges on the inner and outer rings. These bearings also can manage axial loads in one direction and permit small axial displacements.

5200 METRIC SERIES

This series features enhanced radial load ratings due to its internal design proportions. In this series, the outer ring is double-ribbed and the inner ring is full-width with a cylindrical O.D. The bearing also can be furnished without an inner ring for applications where radial space is limited. When so used, the shaft journal must be hardened to HRC 58 minimum, and the surface finished to 15 RMS maximum. The W designation in the suffix indicates the outer ring is provided. The inner ring also can be furnished separately. The A prefix indicates that the inner ring is furnished either separately or as part of the assembly.

The bearing is usually provided with a rugged stamped-steel cage (S designation) and is land-riding on the outer ring ribs. The cage features depressed bars, which not only space rollers evenly, but retain them as a complete assembly with the outer ring. Cages of machined brass (M designation) are available for applications where reversing loads or high speeds might indicate their need. Outer rings are made from bearing quality alloy steel. The inner rings are deep-case hardened to accommodate the hoop stresses resulting from heavy press fits.

The standard bearing is produced with radial internal clearances designated as R6. Other internal clearances can be supplied upon request. Proper roller guidance is assured by integral ribs and roller end clearance control.

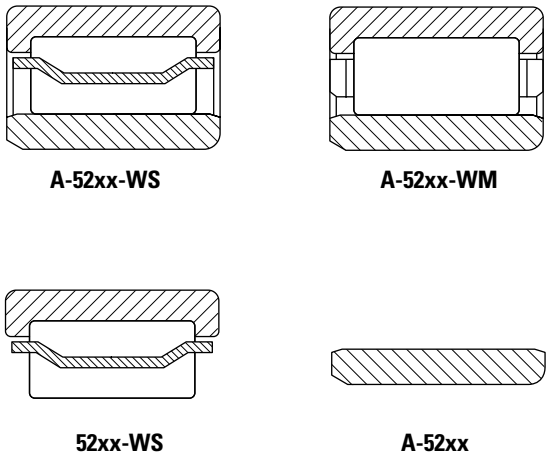


Fig. 38. 5200 metric series bearings.

CAGES

Cages (also referred to as rolling element retainers) serve several purposes in the proper operation of a rolling element bearing. Cages separate the rolling elements and prevent rolling element on rolling element contact and wear. Cages align the rolling elements on the inner ring to prevent rolling element sliding, skidding, and skewing to facilitate true rolling motion. For handling purposes, cages retain the rolling elements on the inner ring assembly to allow for bearing installation. In some instances, cages also improve flow of the lubricant to the bearing raceway or rib contacting surfaces.

The following sections discuss the common types of cages used for each major bearing design type (tapered, cylindrical, spherical, and ball bearing). The basic design geometry, material, and manufacture are discussed for each cage type.

TAPERED ROLLER BEARING CAGES

STAMPED-STEEL CAGES

The most common type of cage used for tapered roller bearings is the stamped-steel cage. These cages are mass produced from low-carbon sheet steel using a series of cutting, forming and punching operations. These cages can be used in high temperature and harsh lubricant environments.



Fig. 39. Stamped-steel cage.

POLYMER CAGES

Cages for tapered roller bearings made of polymer material are used primarily for pre-greased and sealed package designs. The most common polymer materials used are Nylon thermoplastics with glass reinforcement. Polymer cages can be mass produced in large quantities and offer more design flexibility than stamped-steel types. Polymer cages are lightweight and easy to assemble. In some instances, increased bearing rating can be achieved by allowing one or two extra rollers in the bearing complement. Care should be exercised when using aggressive lubricants with EP (extreme-pressure) additives in combination with elevated temperatures greater than 107° C (225° F).

MACHINED CAGES

Machined cages for tapered roller bearings are robust in design and are suited for high-speed and high-load applications. Machined cages use alloy steels and are produced through milling and broaching operations. Assembly does not require a close-in operation and rollers can be retained using nibs or staking. Oil holes also can be easily added for extra lubrication for demanding applications. Some designs are silver plated for special applications.

PIN-TYPE CAGES

Tapered roller bearing pin-type cages retain the rolling elements by the use of a pin located through an axial hole in the center of the roller. Pin-type cages for tapered roller bearings consist of two rings with roller pins attached by screw threads at one end and welding at the other end. These types of cages are primarily used for larger tapered roller bearing designs (greater than 400 mm [15.7480 in.] O.D.). Pin-type cages are machined out of steel and typically allow for an increased number of rolling elements. Pin-type cages are restricted to low-speed applications (less than 20 m/sec [4000 ft/min] rib speed).

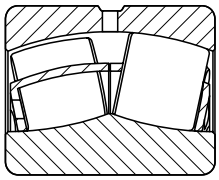
SPHERICAL ROLLER BEARING CAGES

STAMPED-STEEL CAGES

The redesigned Timken® EJ bearings incorporate a unique stamped-steel cage design.

The EJ design includes two independent cages, one for each row of rollers, which are assembled into an individual bearing. This feature serves to prevent cage bending when the operating environment is favorable for this to occur.

This cage is guided on the inner ring and runs above pitch. Each cage is surface hardened (nitrided) to provide improved wear resistance as well as additional strength to allow the bearing to operate in even the most severe environment. Face slots have been designed for improved lubrication flow. This can result in a lower operating temperature and longer bearing life.



EJ

Fig. 40. EJ bearing.



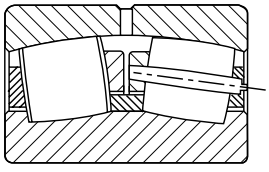
EJ

Fig. 41. EJ cage.

PIN-TYPE CAGES

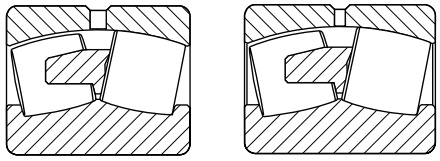
Large diameter spherical roller bearings can be supplied with these cages. Pin-type cages, one for each row of rollers, consist of two rings and a series of pins running through the center of the rolling element. The design of pin-type cages permits an increased roller complement, giving the bearing enhanced load-carrying ability. Consult your Timken engineer for suggestions on the application of this cage.

Fig. 42. Pin-type cage.



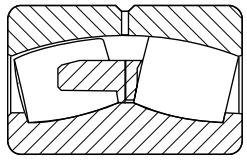
MACHINED-BRASS CAGE

EM, EMB, YM, YMB and YMD bearing cages are precision-machined from brass as shown in figs. 44-46. Their rugged construction provides an advantage in more severe applications. The open-end, finger-type design permits lubricant to reach all surfaces easily, ensuring ample lubrication and a cooler running bearing.



EM/YM YMD

Fig. 43. Machined cages.



EMB/YMB

EM, EMB, YM and YMB are all one-piece designs that are differentiated by their means of guidance within the bearing. With EM and YM designs, the cage mass is low and the rollers are used for guidance, while EMB and YMB cage designs typically have more mass and guide on the inner ring.

YMD cages are similar to YMB, except they have a two-piece design. Two independent cages, one for each row of rollers, are assembled into an individual bearing. This allows each row of rollers to rotate independently when required by the application, and prevents bending of the cage fingers.



Fig. 44. One-piece, machined-brass, roller-riding, finger-type cage.



Fig. 45. One-piece, machined-brass, land-riding, finger-type cage.



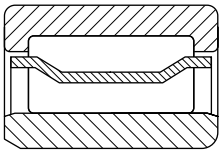
Fig. 46. Split, machined-brass, land-riding, finger-type cage.

CYLINDRICAL ROLLER BEARING CAGES

STAMPED-STEEL CAGES

Stamped-steel cages for cylindrical roller bearings consist of low-carbon steel and are manufactured using a series of cutting, forming, and punching operations. These cages are made in a variety of different designs and are suitable for most general purpose cylindrical roller bearing applications. One specific type is the S-type design for the 5200 series cylindrical roller bearing, which is a land-riding cage piloted on the outer ring ribs. This design has depressed cage bridges which evenly space the rolling elements and retain them on the outer ring. Stamped-steel cages are easily mass produced and can be used in high-temperature and harsh-lubricant environments.

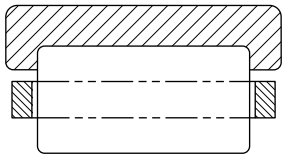
Fig. 47. S-type cage.



PIN-TYPE CAGES

Pin-type cages for cylindrical roller bearings consist of two rings and a series of pins running through the center of the rolling elements. These cages are used for large diameter cylindrical roller bearings where machined brass cages are not available. With this design, additional rollers can typically be added, resulting in increased load capacity.

Fig. 48. Pin-type cage.



MACHINED CAGES

Machined cages are an option for smaller cylindrical bearing sizes, and are typically made from brass. Machined cage designs for cylindrical roller bearings offer increased strength for more demanding applications.

Designs can be one-piece or two-piece cages. One-piece designs can be either a finger-type as shown in fig. 49 or a standard cage configuration having fully milled pockets. The one-piece finger-type and the two-piece design with cage ring (fig. 50) are more common in standard cylindrical roller bearings. They also are roller-guided designs.

The one-piece version with fully milled roller pockets (fig. 51) is our premium cage. This cage is used with our EMA series bearings. Unlike traditional roller-riding cages, it is a land-riding cage which minimizes drag on the roller elements. This reduces heat generation, resulting in improved bearing life. Compared to a two-piece design, this one-piece cage also reduces heat and wear by enhancing lubrication flow.



Fig. 49. One-piece finger-type cage.



Fig. 50. Two-piece brass cage.



Fig. 51. One-piece premium cage.

BALL BEARING CAGES

PRESSED-STEEL WELDED CAGES

This cage type consists of two formed cage halves welded together. This type of cage is standard for most radial non-filling-slot ball bearings and provides high strength and rigidity as well as good uniformity of ball to pocket clearance. It is suitable for very high-temperature applications, but does not accommodate application misalignment.



Fig. 52. Pressed-steel welded cage.

MOLDED-NYLON FINGER-TYPE CAGES



Fig. 53. Molded-nylon cage.

These types of cages consist of a one-piece molded design. Rolling elements simply snap into place. These cages are molded of Nylon 66 which is heat stabilized and moisture conditioned. This cage type is used in the majority of wide inner ring (WIR) ball bearings. The polymer can withstand continuous operating temperatures up to 120° C (250° F) with spikes up to 150° C (300° F) and provides a non-corrosive, self-lubricating material with good resistance to abrasion, wear, most solvents, oils, and greases. This cage type can accommodate application misalignment.

Care also needs to be exercised when using aggressive lubrications with extreme-pressure (EP) additives in combination with elevated temperatures greater than 107° C (225° F).

MOLDED REINFORCED NYLON-TYPE CAGES

These types of cages are one-piece outer-ring-piloted or ball guided. Cages of this type are molded out of Nylon 66 with 30 percent glass fiber added for moisture dimensional stability. The polymer can withstand continuous operating temperatures up to 120° C (250° F) with spikes up to 150° C (300° F) and provides a non-corrosive, self-lubricating material with good resistance to abrasion, wear, most solvents, oils, and greases.



Fig. 54. Reinforced nylon cage.

Care also needs to be exercised when using aggressive lubrications with extreme-pressure (EP) additives in combination with elevated temperatures greater than 107° C (225° F).

MACHINED PHENOLIC-TYPE CAGES

Cages of this type are a one-piece design and are usually ring piloted. The cage is light weight, has oil-absorbing capability, and is suitable for high-speed applications. Cages of this type can be precisely machined, which reduces inertial ball and cage impact forces at high speeds. It does not provide for retention of the balls for handling purposes.

BRASS- AND STEEL-TYPE CAGES

Ball bearing cages made of brass or steel are designed for heavily loaded applications. Cage design variations include one-piece machined-steel or machined-brass and two-piece riveted cast brass. Most designs are ring piloted. Cages of this type also can be silver plated for applications requiring high reliability. The silver plating provides lubrication at the ball-cage interface during start-up to prevent skidding of the balls.



Fig. 55. Cast-brass cage.



Fig. 56. Machined-brass cage.

DETERMINATION OF APPLIED LOADS AND BEARING ANALYSIS

SUMMARY OF SYMBOLS USED TO DETERMINE APPLIED LOADS AND BEARING ANALYSIS

Symbol	Description	Units (Metric/Inch System)
a	Axial Distance from Inner Ring Backface to Effective Load Center	mm, in.
a_1	Reliability Life Factor	unitless
a_2	Material Life Factor	unitless
a_3	Operating Condition Life Factor	unitless
a_{3d}	Debris Life Factor	unitless
a_{3k}	Load Zone Life Factor	unitless
a_{3l}	Lubrication Life Factor	unitless
a_{3p}	Low-Load Life Factor	unitless
a_e	Effective Bearing Spread	mm, in.
A, B, …	Bearing Position (used as subscripts)	unitless
B	Outer Ring Width	mm, in.
B_1	Inner Ring Width	mm, in.
b	Tooth Length	mm, in.
c_1, c_2	Linear Distance (positive or negative).	mm, in.
C	Basic Dynamic Radial Load Rating of a Double-Row Bearing for an L_{10} of One Million Revolutions	N, lbf
C_{a90}	Basic Dynamic Thrust Load Rating of a Single-Row Bearing for an L_{10} of 90 Million Revolutions or 3000 Hours at 500 RPM	N, lbf
C_o	Basic Static Radial Load Rating	N, lbf
C_{oa}	Basic Static Axial Load Rating	N, lbf
C_{90}	Basic Dynamic Radial Load Rating of a Single-Row Bearing for an L_{10} of 90 Million Revolutions	N, lbf
$C_{90(2)}$	Basic Dynamic Radial Load Rating of a Double-Row Bearing for an L_{10} of 90 Million Revolutions	N, lbf
C_a	Basic Dynamic Axial Load Rating	N, lbf
C_g	Geometry Factor (used in a_{3l} equation)	unitless
C_l	Load Factor (used in a_{3l} equation)	unitless
C_j	Load Zone Factor (used in a_{3l} equation)	unitless
C_s	Speed Factor (used in a_{3l} equation)	unitless
C_v	Viscosity Factor (used in a_{3l} equation)	unitless
C_{gr}	Grease Lubrication Factor (used in a_{3l} equation)	unitless
Cp	Specific Heat of Lubricant	J/(Kg - °C), BTU/(lbf - °F)
C_t	Basic Thrust Dynamic Load Rating	N, lbf
d	Bearing Bore Diameter	mm, in.
d	Ball Diameter	mm, in.
d_1	Spherical Diameter	mm, in.
d_a	Shaft Shoulder Diameter	mm, in.
d_0	Mean Inner Ring Diameter	mm, in.
dc	Distance Between Gear Centers	mm, in.
dm	Mean Bearing Diameter	mm, in.
d_{si}	Shaft Inside Diameter	mm, in.
D	Bearing Outside Diameter	mm, in.
D_0	Tapered Roller Bearing Outer Ring Mean Raceway Diameter	mm, in.
Dh	Housing Outside Diameter	mm, in.
Dm	Mean Diameter or Effective Working Diameter of a Sprocket, Pulley, Wheel or Tire	mm, in.
Dm	Tapered Roller Mean Large Rib Diameter	mm, in.

Symbol	Description	Units (Metric/Inch System)
Dm_G	Mean or Effective Working Diameter of the Gear	mm, in.
Dm_P	Effective Working Diameter of the Pinion	mm, in.
Dm_W	Effective Working Diameter of the Worm	mm, in.
Dp_G	Pitch Diameter of the Gear	mm, in.
Dp_P	Pitch Diameter of the Pinion	mm, in.
Dp_W	Pitch Diameter of the Worm	mm, in.
e	Life Exponent	unitless
e	Limiting Value of F_a/F_r for the Applicability of Different Values of Factors X and Y	unitless
E	Free Endplay	mm, in.
f	Lubricant Flow Rate	L/min, U.S. pt/min
f_0	Viscous Dependent Torque Coefficient	unitless
f_1	Load Dependent Torque Coefficient	unitless
f_b	Belt or Chain Pull	N, lbf
f_n	Speed Factor	unitless
f_2	Combined Load Factor	unitless
f_3	Combined Load Factor	unitless
F	General Term for Force	N, lbf
F_1, F_2, …, F_n	Magnitudes of Applied Force During a Loading Cycle	N, lbf
F_a	Applied Thrust (Axial) Load	N, lbf
F_{ai}	Induced Thrust (Axial) Load Due to Radial Loading	N, lbf
F_{ac}	Induced Thrust (Axial) Load Due to Centrifugal Loading	N, lbf
F_{aG}	Thrust Force on Gear	N, lbf
F_{aP}	Thrust Force on Pinion	N, lbf
F_{aW}	Thrust Force on Worm	N, lbf
F_{az}	Allowable Axial Load	N, lbf
F_b	Belt or Chain Pull	N, lbf
F_β	Load Term for Torque Equation	N, lbf
Fc	Centrifugal Force	N, lbf
F_r	Applied Radial Load	N, lbf
F_{rh}	Resultant Horizontal Force	N, lbf
F_{RS}	Resultant Separating Force	N, lbf
F_{RV}	Resultant Vertical Force	N, lbf
F_S	Separating Force on Gear	N, lbf
Fs_G	Separating Force on Gear	N, lbf
Fs_P	Separating Force on Pinion	N, lbf
Fs_W	Separating Force on Worm	N, lbf
F_t	Tangential Force	N, lbf
F_{te}	Tractive Effort on Vehicle Wheels	N, lbf
F_{tG}	Tangential Force on Gear	N, lbf
F_{tP}	Tangential Force on Pinion	N, lbf
F_{tW}	Tangential Force on Worm	N, lbf
F_W	Force of Unbalance	N, lbf
F_{WB}	Weighted Average Load	N, lbf
G	Gear (used as subscript)	unitless
G_1	Geometry Factor from Bearing Data Tables	unitless
G_2	Geometry Factor from Bearing Data Tables	unitless
H	Power	kW, hp
H_s	Housing Shoulder Inner Diameter	mm, in.

Symbol	Description	Units (Metric/Inch System)
HFs	Static Load Rating Adjustment Factor for Raceway Hardness	unitless
i	Number of Rows of Rollers in a Bearing	unitless
i_B	Number of Bearing Rows Taking Load	unitless
k	Centrifugal Force Constant	lbf/RPM^2
k_1	Bearing Torque Constant	unitless
k_4, k_5, k_6	Dimensional Factor to Calculate Heat Generation	unitless
K	Tapered Roller Bearing K-factor; ratio of basic dynamic radial load rating to basic dynamic thrust rating in a single-row bearing	unitless
K	Ball Bearing Constant Based on Geometry	
K_1, K_2	Super Precision K-Factors	unitless
K_{ea}	Radial Runout of Outer Ring Assembly	mm, in.
K_o	Outer Ring Contour Radius Expressed as a Decimal Fraction of the Ball Diameter	decimal fraction
K_i	Inner Ring Contour Radius Expressed as a Decimal Fraction of the Ball Diameter	decimal fraction
Kia	Radial Runout of Inner Ring Assembly	mm, in.
K_N	K-factor for Bearing #n	unitless
K_T	Relative Thrust Load Factor – Ball Bearings	unitless
L_H	Lead – Axial Advance of a Helix for One Complete Revolution	mm, in.
L	Distance Between Bearing Geometric Center Lines	mm, in.
L_{10}	Bearing Life	revolutions or hours
L_f	Life Factor	unitless
m	Gearing Ratio	unitless
M	Bearing Operating Torque	N-m, N-mm, lb.-in.
M_0	Moment	N-m, N-mm, lb.-in.
n	Bearing Operating Speed or General Term for Speed	rot/min, RPM
n_1, n_2,…, n_n	Rotation Speeds During a Loading Cycle	rot/min, RPM
N_A	Reference Speed	rot/min, RPM
n_G	Gear Operating Speed	rot/min, RPM
n_P	Pinion Operating Speed	rot/min, RPM
n_W	Worm Operating Speed	rot/min, RPM
N_c	Number of Rotations of the Ball and Cage Assembly	unitless
N_i	Number of Rotations of the Inner Ring	unitless
N_G	Number of Teeth in the Gear	unitless
N_P	Number of Teeth in the Pinion	unitless
N_S	Number of Teeth in the Sprocket	unitless
N_f	Speed Factor	unitless
P	Pinion (used as subscript)	unitless
P_o	Static Equivalent Load	N, lbf
P_{oa}	Static Equivalent Thrust (Axial)	N, lbf
P_{or}	Static Equivalent Radial Load	N, lbf
P_a	Dynamic Equivalent Axial Load	N, lbf
P_r	Dynamic Equivalent Radial Load	N, lbf
P_{eq}	Equivalent Dynamic Load	N, lbf
Q	Generated Heat or Heat Dissipation Rate	W, BTU/min
Q_{gen}	Generated Heat	W, BTU/min
Q_{oil}	Heat Dissipated by a Circulating Oil System	W, BTU/min
r	Radius to Center of Mass	mm, in.
R	Percent Reliability, Used in the Calculation of the a_1 Factor	unitless

Symbol	Description	Units (Metric/Inch System)
RIC	Radial Internal Clearance	mm, in.
S	Shaft Diameter	mm, in.
s	Shaft (used as subscript)	unitless
S_d	Inner Ring Reference Face Runout	mm, in.
S_D	Outside Cylindrical Surface Runout	mm, in.
S_{ea}	Axial Runout of Outer Ring Assembly	mm, in.
S_{ia}	Axial Runout of Inner Ring Assembly	mm, in.
t_1, t_2, …, t_N	Fractions of Time During a Loading Cycle	unitless
T	Applied Thrust (Axial) Load	N, lbf
T_E	Equivalent Thrust Load	N, lbf
v	Vertical (used as subscript)	unitless
V	Linear Velocity or Speed	km/h, mph
V_{BS}	Inner Ring Width Variation	mm, in.
V_{CS}	Outer Ring Width Variation	mm, in.
Vr	Rubbing, Surface or Tapered Roller Bearing Rib Velocity	m/s, fpm
W	Worm (used as subscript)	unitless
X	Dynamic Radial Load Factor	unitless
X_0	Static Radial Load Factor	unitless
Y, Y_1, Y_2, …	Dynamic Thrust (Axial) Load Factor	unitless
Y_0	Static Thrust (Axial) Load Factor	unitless
Z	Number of Rolling Elements	unitless
α_T	Coefficient of Linear Expansion	mm/mm/°C, in./in./°F
α_o	Tapered Roller Bearing Half Included Outer Ring Raceway Angle	deg.
α	Ball Bearing Nominal Contact Angle	deg.
ΔT	Temperature Difference Between Shaft/Inner Ring/ Rollers and Housing/Outer Ring	°C, °F
Δ_{Bs}	Inner Ring Width Deviation	mm, in.
Δ_{Cs}	Outer Ring Width Deviation	mm, in.
Δ_{dmp}	Deviation of Mean Bore Diameter in a Single Plane	mm, in.
Δ_{Dmp}	Deviation of Mean Outside Diameter in a Single Plane	mm, in.
δs	Interference Fit of Inner Ring on Shaft	mm, in.
δh	Interference Fit of Outer Ring in Housing	mm, in.
η	Efficiency, Decimal Fraction	
θ_1, θ_2, θ_3	Gear Mesh Angles Relative to the Reference Plane	deg., rad
θi, θo	Oil Inlet or Outlet Temperature	°C, °F
λ	Worm Gear Lead Angle	deg.
μ	Coefficient of Friction	unitless
μ	Lubricant Dynamic Viscosity	cP
v	Lubricant Kinematic Viscosity	cSt
σ_o	Approximate Maximum Contact Stress	MPa, psi
Φ_G	Normal Tooth Pressure Angle for the Gear	deg.
Φ_P	Normal Tooth Pressure Angle for the Pinion	deg.
Ψ_G	Helix (Helical) or Spiral Angle for the Gear	deg.
Ψ_P	Helix (Helical) or Spiral Angle for the Pinion	deg.
ρ	Lubricant Density	kg/m^3, lb./ft^3
Υ_G	Bevel Gearing – Gear Pitch Angle	deg.
	Hypoid Gearing – Gear Root Angle	deg.
Υ_P	Bevel Gearing – Pinion Pitch Angle	deg.
	Hypoid Gearing – Pinion Face Angle	deg.

GEARING

The following equations are used to determine the forces developed by machine elements commonly encountered in bearing applications.

SPUR GEARING

Tangential force

$$F_{tG} = \frac{(1.91 \times 10^7)\, H}{Dp_G\, n_G} \quad \text{(metric system)}$$

$$= \frac{(1.26 \times 10^5)\, H}{Dp_G\, n_G} \quad \text{(inch system)}$$

Separating force

$$Fs_G = F_{tG} \tan \Phi_G$$

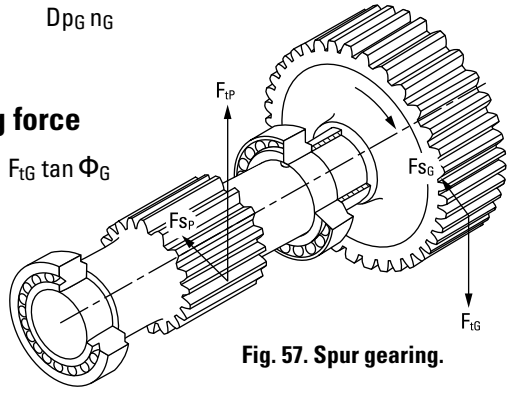


Fig. 57. Spur gearing.

SINGLE HELICAL GEARING

Tangential force

$$F_{tG} = \frac{(1.91 \times 10^7)\, H}{Dp_G\, n_G} \quad \text{(metric system)}$$

$$= \frac{(1.26 \times 10^5)\, H}{Dp_G\, n_G} \quad \text{(inch system)}$$

Thrust force

$$F_{aG} = F_{tG} \tan \Psi_G$$

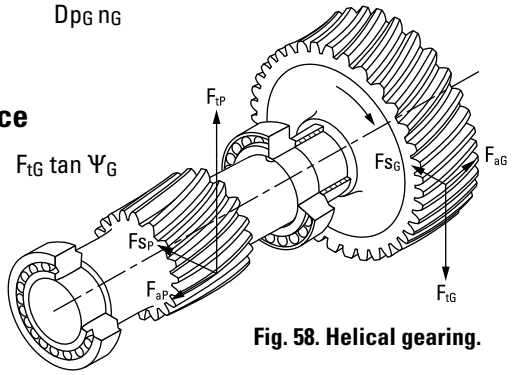


Fig. 58. Helical gearing.

Separating force

$$Fs_G = \frac{F_{tG} \tan \Phi_G}{\cos \Psi_G}$$

STRAIGHT BEVEL AND ZEROL GEARING WITH ZERO DEGREES SPIRAL

In straight bevel and zerol gearing, the gear forces tend to push the pinion and gear out of mesh, such that the directions of the thrust and separating forces are always the same regardless of direction of rotation (fig. 59). In calculating the tangential force (F_{tP} or F_{tG}) for bevel gearing, the pinion or gear mean diameter (Dm_P or Dm_G) is used instead of the pitch diameter (Dp_P or Dp_G). The mean diameter is calculated as follows:

$$Dm_G = Dp_G - b \sin \Upsilon_G \quad \text{or} \quad Dm_P = Dp_P - b \sin \Upsilon_P$$

In straight bevel and zerol gearing:

$$F_{tP} = F_{tG}$$

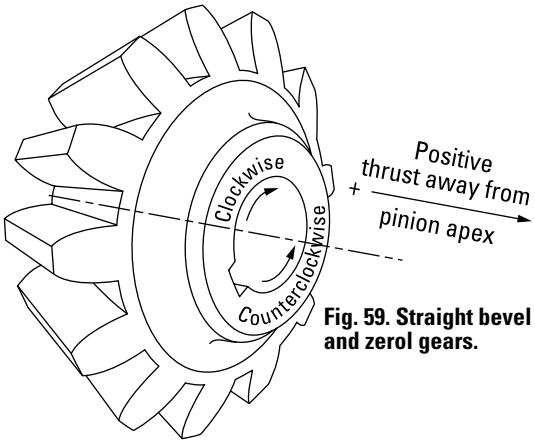


Fig. 59. Straight bevel and zerol gears.

PINION

Tangential force

$$F_{tP} = \frac{(1.91 \times 10^7)\, H}{Dm_P\, n_P} \quad \text{(metric system)}$$

$$= \frac{(1.26 \times 10^5)\, H}{Dm_P\, n_P} \quad \text{(inch system)}$$

Thrust force

$$F_{aP} = F_{tP} \tan \Phi_P \sin \Upsilon_P$$

Separating force

$$Fs_P = F_{tP} \tan \Phi_P \cos \Upsilon_P$$

STRAIGHT BEVEL GEAR

Tangential force

$$F_{tG} = \frac{(1.91 \times 10^7)\, H}{Dm_G\, n_G} \quad \text{(metric system)}$$

$$= \frac{(1.26 \times 10^5)\, H}{Dm_G\, n_G} \quad \text{(inch system)}$$

Thrust force

$$F_{aG} = F_{tG} \tan \Phi_G \sin \Upsilon_G$$

Separating force

$$Fs_G = F_{tG} \tan \Phi_G \cos \Upsilon_G$$

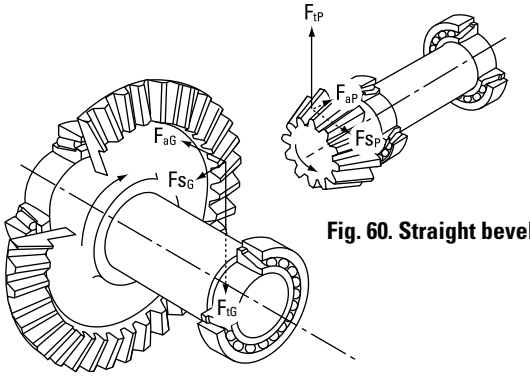


Fig. 60. Straight bevel gearing.

SPIRAL BEVEL AND HYPOID GEARING

In spiral bevel and hypoid gearing, the directions of the thrust and separating forces depend upon spiral angle, hand of spiral, direction of rotation, and whether the gear is driving or driven (see fig. 61). The hand of the spiral is determined by noting whether the tooth curvature on the near face of the gear (fig. 62) inclines to the left or right from the shaft axis. Direction of rotation is determined by viewing toward the gear or pinion apex.

In spiral bevel gearing:

$$F_{tP} = F_{tG}$$

In hypoid gearing:

$$F_{tP} = \frac{F_{tG} \cos \Psi_P}{\cos \Psi_G}$$

Hypoid pinion effective working diameter:

$$Dm_P = Dm_G \left(\frac{N_p}{N_G} \right) \left(\frac{\cos \Psi_G}{\cos \Psi_P} \right)$$

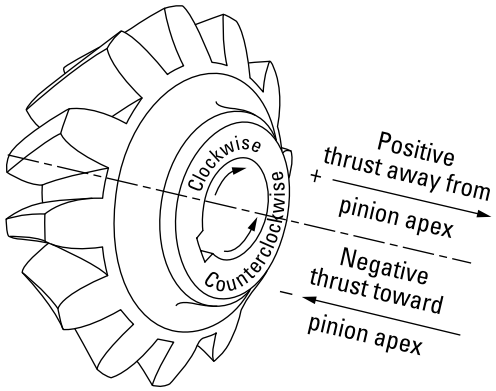


Fig. 61. Spiral bevel and hypoid gears.

Tangential force

$$F_{tG} = \frac{(1.91 \times 10^7)\, H}{Dm_G\, n_G} \quad \text{(metric system)}$$

$$= \frac{(1.26 \times 10^5)\, H}{Dm_G\, n_G} \quad \text{(inch system)}$$

Hypoid gear effective working diameter:

$$Dm_G = Dp_G - b \sin \Upsilon_G$$

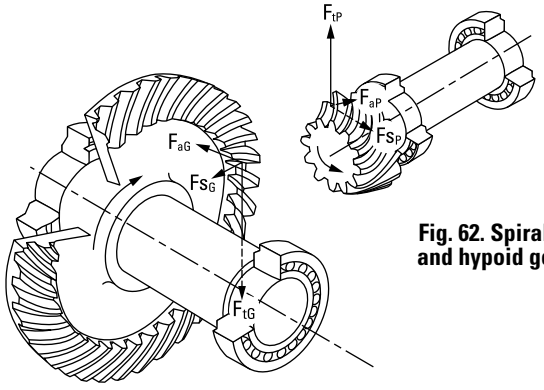


Fig. 62. Spiral bevel and hypoid gearing.

TABLE 2. SPIRAL BEVEL AND HYPOID BEARING EQUATIONS

Driving Member Rotation	Thrust Force	Separating Force
Right-hand spiral clockwise or Left-hand spiral counterclockwise	Driving member	Driving member
	$F_{aP} = \frac{F_{tP}}{\cos \Psi_P} (\tan \Phi_P \sin \Upsilon_P - \sin \Psi_P \cos \Upsilon_P)$	$F_{sP} = \frac{F_{tP}}{\cos \Psi_P} (\tan \Phi_P \cos \Upsilon_P + \sin \Psi_P \sin \Upsilon_P)$
	Driven member	Driven member
	$F_{aG} = \frac{F_{tG}}{\cos \Psi_G} (\tan \Phi_G \sin \Upsilon_G + \sin \Psi_G \cos \Upsilon_G)$	$F_{sG} = \frac{F_{tG}}{\cos \Psi_G} (\tan \Phi_G \cos \Upsilon_G - \sin \Psi_G \sin \Upsilon_G)$
Right-hand spiral counterclockwise or Left-hand spiral clockwise	Driving member	Driving member
	$F_{aP} = \frac{F_{tP}}{\cos \Psi_P} (\tan \Phi_P \sin \Upsilon_P + \sin \Psi_P \cos \Upsilon_P)$	$F_{sP} = \frac{F_{tP}}{\cos \Psi_P} (\tan \Phi_P \cos \Upsilon_P - \sin \Psi_P \sin \Upsilon_P)$
	Driven member	Driven member
	$F_{aG} = \frac{F_{tG}}{\cos \Psi_G} (\tan \Phi_G \sin \Upsilon_G - \sin \Psi_G \cos \Upsilon_G)$	$F_{sG} = \frac{F_{tG}}{\cos \Psi_G} (\tan \Phi_G \cos \Upsilon_G + \sin \Psi_G \sin \Upsilon_G)$

STRAIGHT WORM GEARING

Worm

Tangential force

$$F_{tW} = \frac{(1.91 \times 10^7)\, H}{D_{PW}\, n_W} \quad \text{(metric system)}$$

$$= \frac{(1.26 \times 10^5)\, H}{D_{pW}\, n_W} \quad \text{(inch system)}$$

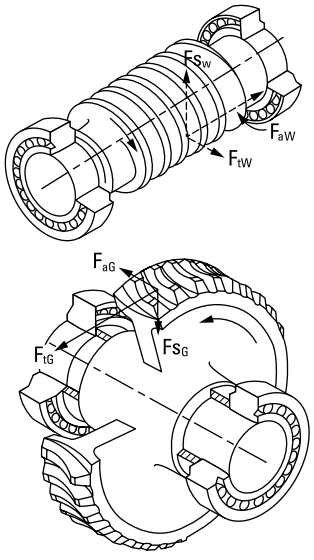


Fig. 63. Straight worm gearing.

Thrust force

$$F_{aW} = \frac{(1.91 \times 10^7)\, H\, \eta}{D_{pG}\, n_G} \quad \text{(metric system)}$$

$$= \frac{(1.26 \times 10^5)\, H\, \eta}{D_{pG}\, n_G} \quad \text{(inch system)}$$

or

$$F_{aW} = \frac{F_{tW}\, \eta}{\tan \lambda}$$

Separating force

$$F_{sW} = \frac{F_{tW} \sin \Phi}{\cos \Phi \sin \lambda + \mu \cos \lambda}$$

Worm Gear

Tangential force

$$F_{tG} = \frac{(1.91 \times 10^7)\, H\, \eta}{Dp_G\, n_G} \quad \text{(metric system)}$$

$$= \frac{(1.26 \times 10^5)\, H\, \eta}{Dp_G\, n_G} \quad \text{(inch system)}$$

or

$$F_{tG} = \frac{F_{tW}\, \eta}{\tan \lambda}$$

Thrust force

$$F_{aG} = \frac{(1.91 \times 10^7)\, H}{Dp_W\, n_W} \quad \text{(metric system)}$$

$$= \frac{(1.26 \times 10^5)\, H}{Dp_W\, n_W} \quad \text{(inch system)}$$

Separating force

$$Fs_G = \frac{F_{tW} \sin \Phi}{\cos \Phi \sin \lambda + \mu \cos \lambda}$$

Where:

$$\lambda = \tan^{-1} \left(\frac{Dp_G}{m\, Dp_W} \right)$$

or

$$\lambda = \tan^{-1} \left(\frac{L_H}{\pi\, Dp_W} \right)$$

and

$$\eta = \frac{\cos \Phi - \mu \tan \lambda}{\cos \Phi + \mu \cot \lambda}$$

Metric system

$$\mu^{(1)} = (5.34 \times 10^{-7})\, V_r^3 + \frac{0.146}{V_r^{0.09}} - 0.103$$

$$V_r = \frac{Dp_W\, n_W}{(1.91 \times 10^4) \cos \lambda} \quad \text{(meters per second)}$$

Inch system

$$\mu^{(1)} = (7 \times 10^{-14})\, V_r^3 + \frac{0.235}{V_r^{0.09}} - 0.103$$

$$V_r = \frac{Dp_W\, n_W}{3.82 \cos \lambda} \quad \text{(feet per minute)}$$

(1) Approximate coefficient of friction for the 0.015 to 15 m/s (3 to 3000 ft/min) rubbing velocity range.

DOUBLE ENVELOPING WORM GEARING

Worm

Tangential force

$$F_{tW} = \frac{(1.91 \times 10^7)\, H}{Dm_W\, n_W} \quad \text{(metric system)}$$

$$= \frac{(1.26 \times 10^5)\, H}{Dm_W\, n_W} \quad \text{(inch system)}$$

Thrust force

$$F_{aW} = 0.98\, F_{tG}$$

Use this value for F_{tG} for bearing loading calculations on worm gear shaft. For torque calculations, use the following F_{tG} equations.

Separating force

$$Fs_W = \frac{0.98\, F_{tG} \tan \Phi}{\cos \lambda}$$

Worm Gear

Tangential force

$$F_{tG} = \frac{(1.91 \times 10^7)\, H\, m\, \eta}{Dp_G\, n_W} \quad \text{(metric system)}$$

$$= \frac{(1.26 \times 10^5)\, H\, m\, \eta}{Dp_G\, n_W} \quad \text{(inch system)}$$

or

$$F_{tG} = \frac{(1.91 \times 10^7)\, H\, \eta}{Dp_G\, n_G} \quad \text{(metric system)}$$

$$= \frac{(1.26 \times 10^5)\, H\, \eta}{Dp_G\, n_G} \quad \text{(inch system)}$$

Use this value for calculating torque in subsequent gears and shafts. For bearing loading calculations, use the equation for F_{aW}.

Thrust force

$$F_{aG} = \frac{(1.91 \times 10^7)\, H}{Dm_W\, n_W} \quad \text{(metric system)}$$

$$= \frac{(1.26 \times 10^5)\, H}{Dm_W\, n_W} \quad \text{(inch system)}$$

Separating force

$$Fs_G = \frac{0.98\, F_{tG} \tan \Phi}{\cos \lambda}$$

Where:

η = efficiency (refer to manufacturer's catalog)

$Dm_W = 2d_c - 0.98\, Dp_G$

Lead angle at center of worm:

$$\lambda = \tan^{-1} \left(\frac{Dp_G}{m\, Dp_W} \right) = \tan^{-1} \left(\frac{L_H}{\pi\, Dp_W} \right)$$

Belt and chain drive factors

Due to the variations of belt tightness as set by various operators, an exact equation relating total belt pull to tension F_1 on the tight side and tension F_2 on the slack side (fig. 64) is difficult to establish. The following equation and table 3 may be used to estimate the total pull from various types of belt and pulley, and chain and sprocket designs:

$$F_b = \frac{(1.91 \times 10^7)\, H\, f_B}{D_m\, n} \quad \text{(metric system)}$$

$$= \frac{(1.26 \times 10^5)\, H\, f_B}{D_m\, n} \quad \text{(inch system)}$$

Standard roller chain sprocket mean diameter.

$$D_m = \frac{P}{\sin\left(\frac{180}{N_s}\right)}$$

Where:

P = chain pitch

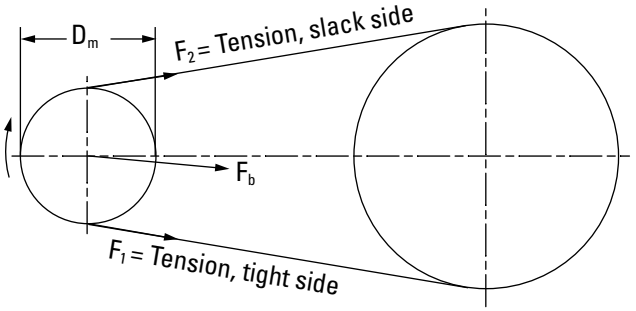


Fig. 64. Belt or chain drive.

TABLE 3. BELT OR CHAIN PULL FACTOR BASED ON 180 DEGREES ANGLE OF WRAP

Type	f_B
Chains, single	1.00
Chains, double	1.25
"V" belts.....	1.50

SHOCK LOADS

It is difficult to determine the exact effect that shock loading has on bearing life. The magnitude of the shock load depends on the masses of the colliding bodies, their velocities and deformations at impact.

The effect on the bearing depends on how much of the shock is absorbed between the point of impact and the bearing, as well as whether the shock load is great enough to cause bearing damage. It also is dependent on frequency and duration of shock loads.

As a minimum, a suddenly applied load is equivalent to twice its static value. It may be considerably more than this, depending on the velocity of impact.

Shock involves a number of variables that generally are not known or easily determined. Therefore, it is good practice to rely on experience. Timken has years of experience with many types of equipment under the most severe loading conditions. Your Timken engineer should be consulted on any application involving unusual loading or service requirements.

CENTRIFUGAL FORCE

Centrifugal force resulting from imbalance in a rotating member:

$$F_c = \frac{F_w\, r\, n^2}{8.94 \times 10^5} \quad \text{(metric system)}$$

$$= \frac{F_w\, r\, n^2}{3.52 \times 10^4} \quad \text{(inch system)}$$

TRACTIVE EFFORT AND WHEEL SPEED

Tractive effort is the tangential force between the driving wheels and the road necessary to propel a vehicle at a given speed against the combined grade, air and rolling resistance. The relationships of tractive effort, power, wheel speed and vehicle speed are:

$$H = \frac{F_{te}\, V}{3600}$$

$$H = \frac{F_{te}\, V}{375}$$

and

$$n = \frac{5300V}{D_m}$$

$$n = \frac{336V}{D_m}$$

BEARING REACTIONS

For a shaft on two supports, bearing radial loads are determined by:

- Defining the bearing effective spread.
- Resolving forces applied to the shaft into horizontal and vertical components, relative to a convenient reference plane.
- Summing moments about the effective center of each of the bearing supports, and solving for the radial and axial reactions at each support.

EFFECTIVE SPREAD

TAPERED ROLLER OR ANGULAR CONTACT BALL BEARINGS

When a load is applied to a tapered roller or angular contact ball bearing, the internal forces at each rolling element-to-outer raceway contact act normal to the raceway. These forces have radial and axial components. With the exception of the special case of pure axial loads, the inner ring and the shaft will experience moments imposed by the asymmetrical axial components of the forces on the rolling elements. The effective center for tapered roller bearings is defined as the point at which the lines of force normal to the outer ring raceway intersect the bearing axis. As an approximation, it also applies to angular contact ball bearings. The effective spread is then defined as the distance between the bearing effective centers for a two-bearing system. It can be demonstrated mathematically that, if the shaft is modeled as being supported at its effective bearing center rather than at its geometric bearing center, the bearing moment may be ignored when calculating radial loads on the bearing.

Only externally applied loads need to be considered, and moments are taken about the effective centers of the bearings to determine loads or reactions.

Fig. 65 shows single-row bearings in a direct and indirect mounting configuration. The choice of whether to use direct or indirect mounting depends upon the application.

SPHERICAL ROLLER BEARINGS

The effective center for each row of spherical rollers intersects the shaft axis at the bearing geometric center as shown in fig. 66. As the distance between effective centers for each row of a bearing is zero (i.e. zero moment arm), a pure couple cannot be generated internal to the bearing. Therefore, when a shaft and housing are misaligned, the inner and outer rings of the bearing rotate up to a few degrees relative to each other, without creating internal forces. This self-aligning capability in turn prevents an external moment load from being supported by the bearing. Therefore, spherical roller bearings can only accommodate external shaft and housing loads through radial and axial reaction forces.

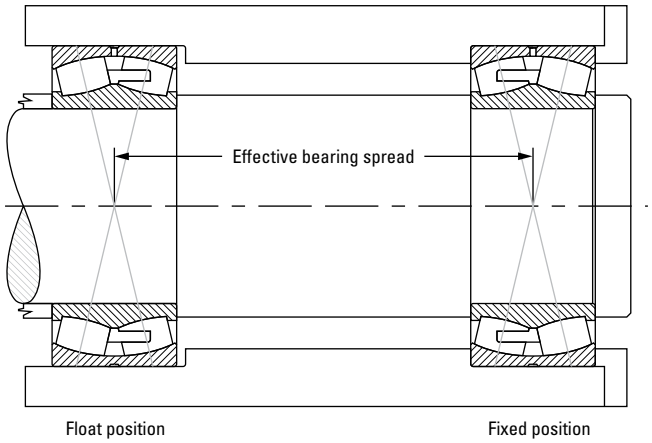
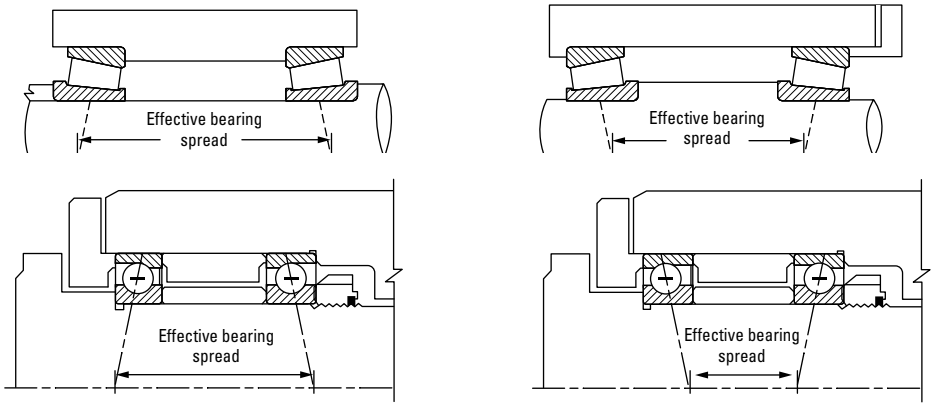


Fig. 66. Spherical roller bearing.



Indirect Mounting – Tapered Roller Bearings Back-to-Back/DB – Angular Contact Ball Bearings

Direct Mounting – Tapered Roller Bearings Face-to-Face/DF – Angular Contact Ball Bearings

Fig. 65. Choice of mounting configuration for single-row bearings, showing position of effective load-carrying centers.

FORCE RESOLUTION

SHAFTS ON TWO SUPPORTS

Simple beam equations are used to translate the externally applied forces on a shaft into bearing reactions acting at the bearing effective centers.

The following equations are for the case of a shaft on two supports with gear forces F_t (tangential), F_s (separating), and F_a (thrust), an external radial load F, and an external moment M_o. The loads are applied at arbitrary angles (θ_1, θ_2, and θ_3) relative to the reference plane indicated in fig. 67. Using the principle of superposition, the equations for vertical and horizontal reactions (F_{rv} and F_{rh}) can be expanded to include any number of gears, external forces or moments. For the bearing reaction calculations, the gear forces should include the sign (+/-) generated from the respective gear force equation.

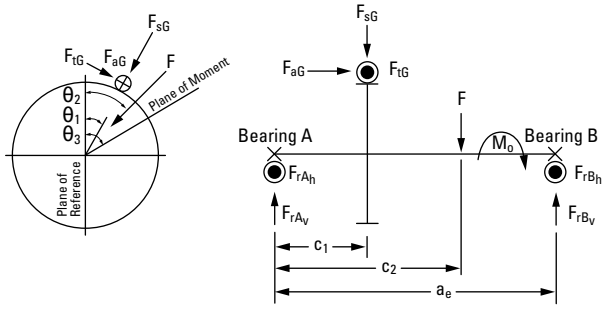


Fig. 67. Bearing radial reactions.

Care should be used when doing this to ensure proper supporting degrees of freedom are used. That is, tapered roller bearings and ball bearings support radial loads, moment loads and thrust loads in both directions. Spherical roller bearings will not support a moment load, but will support radial and thrust loads in both directions. Cylindrical roller bearings support radial and moment loading, but can only support slight thrust loads depending upon thrust flange configuration.

SHAFT ON THREE OR MORE SUPPORTS

The equations of static equilibrium are insufficient to solve bearing reactions on a shaft having more than two supports. Such cases can be solved using computer programs if adequate information is available. In such problems, the deflections of the shaft, bearings and housings affect the distribution of loads. Any variance in these parameters can significantly affect bearing reactions.

Vertical reaction component at bearing position B:

$$F_{rBv} = \frac{1}{a_e}\left(c_1 (F_{sG} \cos \theta_1 + F_{tG} \sin \theta_1) + \frac{1}{2} (D_{pG} - b \sin \gamma_G) F_{aG} \cos \theta_1 + c_2 F \cos \theta_2 + M \cos \theta_3 \right)$$

Horizontal reaction component at bearing position B:

$$F_{rBh} = \frac{1}{a_e}\left(c_1 (F_{sG} \sin \theta_1 - F_{tG} \cos \theta_1) + \frac{1}{2} (D_{pG} - b \sin \gamma_G) F_{aG} \sin \theta_1 + c_2 F \sin \theta_2 + M \sin \theta_3 \right)$$

Vertical reaction component at bearing position A:

$$F_{rAv} = F_{sG} \cos \theta_1 + F_{tG} \sin \theta_1 + F \cos \theta_2 - F_{rBv}$$

Horizontal reaction component at bearing position A:

$$F_{rAh} = F_{sG} \sin \theta_1 - F_{tG} \cos \theta_1 + F \sin \theta_2 - F_{rBh}$$

Resultant radial reaction: $F_{rA} = \left[(F_{rAv})^2 + (F_{rAh})^2 \right]^{1/2}$ $F_{rB} = \left[(F_{rBv})^2 + (F_{rBh})^2 \right]^{1/2}$

Resultant axial reaction: $F_{aA} = F_{aG}$ (fixed position) $F_{aB} = 0$ (float position)

DYNAMIC EQUIVALENT RADIAL BEARING LOADS (P_r)

To calculate the L_{10} life, it is necessary to calculate a dynamic equivalent radial load, designated by P_r. The dynamic equivalent radial load is defined as a single radial load that, if applied to the bearing, will result in the same life as the combined loading under which the bearing operates. For all bearing types, the equation takes the following form:

$$P_r = XF_r + YF_a$$

SPHERICAL ROLLER BEARINGS

For spherical roller bearings, the values for P_r can be determined using the equations below. Calculate the ratio of the axial load to the radial load. Compare this ratio to the e value for the bearing.

In equation form,

$P_r = F_r + Y_1F_a$ for $F_a/F_r \leq e$, and

$P_r = 0.67F_r + Y_2F_a$ for $F_a/F_r > e$.

Values for e and Y are available in the Spherical Roller Bearing Catalog available on www.timken.com.

CYLINDRICAL ROLLER BEARINGS

For cylindrical roller bearings with purely radial applied load:

$$P_r = F_r$$

The maximum dynamic radial load that may be applied to a cylindrical roller bearing should be $\leq C/3$.

If, in addition to the radial load, an axial load F_a acts on the bearing, this axial load is taken into consideration when calculating the life of a bearing (with $F_a \leq F_{az}$; F_{az} is the allowable axial load).

TABLE 4. CYLINDRICAL ROLLER BEARING DYNAMIC EQUIVALENT RADIAL VALUES

Dimension Series	Load Ratio	Dynamic Equivalent Load
10.. 2..E, 3..E	$F_a/F_r \leq 0.11$	$P = F_r$
	$F_a/F_r > 0.11$	$P = 0.93\ F_r + 0.69\ F_a$
22..E, 23..E	$F_a/F_r \leq 0.17$	$P = F_r$
	$F_a/F_r > 0.17$	$P = 0.93\ F_r + 0.45\ F_a$

RADIAL AND ANGULAR CONTACT BALL BEARINGS

For ball bearings, the dynamic equivalent radial load equations can be found in table 5. The required Y factors are found in table 6 on page 42.

TABLE 5. DYNAMIC EQUIVALENT RADIAL LOAD EQUATIONS FOR BALL BEARINGS

RADIAL AND ANGULAR CONTACT BEARINGS			
Bearing Description (ref.)	Contact Angle	Single-Row and Tandem Mountings	Double-Row and Preload Pair Mountings
Bearing Type and or Series		$K_T = \frac{F_a}{i_B C_o}$	$K_T = \frac{F_a}{C_o}$
RADIAL TYPE BALL BEARINGS		**Use Larger Of Resulting P_r Value[1]**	
M9300K,MM9300K M9100K,MM9100K M200K,MM200K M300K,MM300K	0°	$P_r = F_r$ or $P_r = 0.56F_r + Y_1F_a$	$P_r = F_r + 1.20Y_1F_a$ or $P_r = 0.78F_r + 1.625Y_1F_a$
Small inch and metric 9300,9100,200,300 and derivatives XLS large inch W and GW Tri-Ply	0°	$P_r = F_r$ or $P_r = 0.56F_r + Y_1F_a$	
Wide inner ring ball bearing housed units	0°	$P_r = F_r$ or $P_r = 0.56F_r + Y_1F_a$	
ANGULAR CONTACT BALL BEARINGS		**Use Larger Of Resulting P_r Value**	
7200K, 7200W 7300W, 7400W 5200K-5300W 5311W-5318W 5218W, 5220W, 5407W 5221W, 5214W	20°	$P_r = F_r$ or $P_r = 0.43F_r + F_a$	$P_r = F_r + 1.09F_a$ or $P_r = 0.70F_r + 1.63F_a$
5200, 5200W (see 20° exceptions) 5300, 5300W (see 20° exceptions) 5400, 5400W (see 20° exceptions)	30°	$P_r = F_r$ or $P_r = 0.39F_r + 0.76F_a$	$P_r = F_r + 0.78F_a$ or $P_r = 0.63F_r + 1.24F_a$
7200WN 7300WN 7400WN	40°	$P_r = F_r$ or $P_r = 0.35F_r + 0.57F_a$	$P_r = F_r + 0.55F_a$ or $P_r = 0.57F_r + 0.93F_a$
2M9300WI 2MM9100WI 2M200WI, 2MM200WI 2MM300WI	15°	$P_r = F_r$ or $P_r = 0.44F_r + Y_2F_a$	$P_r = F_r + 1.124Y_2F_a$ or $P_r = 0.72F_r + 1.625Y_2F_a$
2MM9100WO		$P_r = F_r$ or $P_r = 0.44F_r + Y_3F_a$	$P_r = F_r + 1.124Y_3F_a$ or $P_r = 0.72F_r + 1.625Y_3F_a$
3M9300WI 3M9100WI, 3MM9100WI 3M200WI, 3MM200WI 3MM300WI	25°	$P_r = F_r$ or $P_r = 0.41F_r + 0.87F_a$	$P_r = F_r + 0.92F_a$ or $P_r = 0.67F_r + 1.41F_a$

[1]If $P_r > C_o$ or $P_r > 1/2\ C_E$ consult with your Timken engineer on life calculations.

TABLE 6. REQUIRED Y FACTORS FOR BALL BEARING DYNAMIC EQUIVALENT RADIAL LOADS

K_T	Y_1	Y_2	Y_3
0.015	2.30	1.47	1.60
0.020	2.22	1.44	1.59
0.025	2.10	1.41	1.57
0.030	2.00	1.39	1.56
0.040	1.86	1.35	1.55
0.050	1.76	1.32	1.53
0.060	1.68	1.29	1.51
0.080	1.57	1.25	1.49
0.100	1.48	1.21	1.47
0.120	1.42	1.19	1.45
0.150	1.34	1.14	1.42
0.200	1.25	1.09	1.39
0.250	1.18	1.05	1.35
0.300	1.13	1.02	1.33
0.400	1.05	1.00	1.29
0.500	1.00	1.00	1.25
0.600	—	—	1.22
0.800	—	—	1.17
1.000	—	—	1.13
1.200	—	—	1.10

TAPERED ROLLER BEARINGS

Tapered roller bearings are designed to carry radial loads, thrust loads or any combination of the two. Because of the tapered design of the raceways, a radial load will induce a thrust reaction within the bearing, which must be opposed by an equal or greater thrust load to keep the inner ring and outer ring from separating. The induced thrust adds to or subtracts from any externally applied thrust loads, depending upon the direction of the applied thrust load. As a result, the seated bearing sees the induced thrust of the opposing bearing plus the external thrust. The unseated bearing sees only its own induced thrust.

The ratio of the radial to the thrust load and the bearing included outer ring angle determine the load zone in a given bearing. The number of rollers in contact as a result of this ratio defines the load zone. If all the rollers are in contact, the load zone is referred to as being 360 degrees.

When only radial load is applied to a tapered roller bearing, for convenience it is assumed in using the traditional calculation method that half the rollers support the load – the load zone is 180 degrees. In this case, induced bearing thrust is:

$$F_{a(180)} = \frac{0.47\ F_r}{K}$$

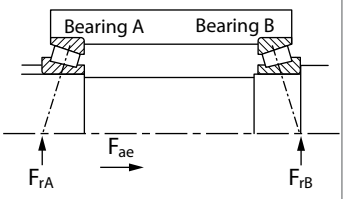
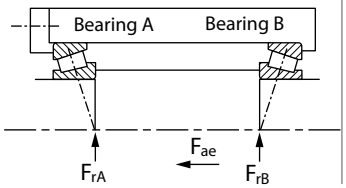
The basic dynamic radial load rating, C_{90}, is assumed to be the radial load-carrying capacity with a 180-degree load zone in the bearing. When the thrust load on a bearing exceeds the induced thrust, $F_{a(180)}$, a dynamic equivalent radial load must be used to calculate bearing life.

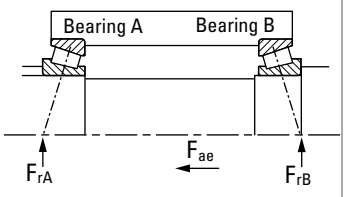
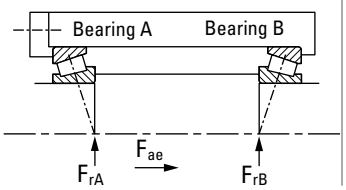
The equations in tables 7 and 8 provide approximations of the dynamic equivalent radial load assuming a 180-degree load zone in one bearing and 180 degrees or more in the opposite bearing.

Single-row mounting

To use this table for a single-row mounting, determine if bearings are direct or indirect mounted and to which bearing, A or B, thrust F_{ae} is applied. Once the appropriate design is established, follow across the page opposite that design, and check to determine which thrust load and dynamic equivalent radial load equations apply.

TABLE 7. DYNAMIC EQUIVALENT RADIAL LOAD EQUATIONS, SINGLE-ROW TAPERED ROLLER BEARING MOUNTING

Design	Thrust Condition	Axial Load	Dynamic Equivalent Radial Load
	$\frac{0.47\ F_{rA}}{K_A} \le \frac{0.47\ F_{rB}}{K_B} + F_{ae}$	$F_{aA} = \frac{0.47\ F_{rB}}{K_B} + F_{ae}$ $F_{aB} = \frac{0.47\ F_{rB}}{K_B}$	$P_A = 0.4\ F_{rA} + K_A\ F_{aA}$ [1] $P_B = F_{rB}$
	$\frac{0.47\ F_{rA}}{K_A} > \frac{0.47\ F_{rB}}{K_B} + F_{ae}$	$F_{aA} = \frac{0.47\ F_{rA}}{K_A}$ $F_{aB} = \frac{0.47\ F_{rA}}{K_A} - F_{ae}$	$P_A = F_{rA}$ $P_B = 0.4\ F_{rB} + K_B\ F_{aB}$ [1]

Design	Thrust Condition	Axial Load	Dynamic Equivalent Radial Load
	$\frac{0.47\ F_{rB}}{K_B} \le \frac{0.47\ F_{rA}}{K_A} + F_{ae}$	$F_{aA} = \frac{0.47\ F_{rA}}{K_A}$ $F_{aB} = \frac{0.47\ F_{rA}}{K_A} + F_{ae}$	$P_A = F_{rA}$ $P_B = 0.4\ F_{rB} + K_B\ F_{aB}$ [1]
	$\frac{0.47\ F_{rB}}{K_B} > \frac{0.47\ F_{rA}}{K_A} + F_{ae}$	$F_{aA} = \frac{0.47\ F_{rB}}{K_B} - F_{ae}$ $F_{aB} = \frac{0.47\ F_{rB}}{K_B}$	$P_A = 0.4\ F_{rA} + K_A\ F_{aA}$ [1] $P_B = F_{rB}$

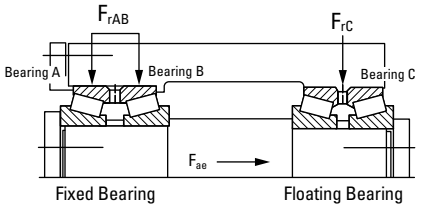
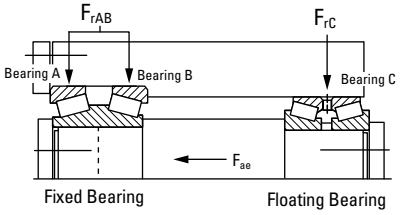
[1] If $P_A < F_{rA}$, use $P_A = F_{rA}$ or if $P_B < F_{rB}$, use $P_B = F_{rB}$.

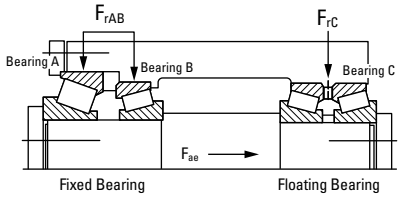
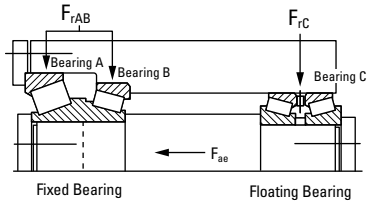
Double-row mounting, fixed or floating, similar bearing series

For double-row tapered roller bearings, the following table can be used. In this table, only bearing A has an applied thrust load. If bearing B has the applied thrust load, the A's in the equations should be replaced by B's and vice versa.

For double-row similar bearing series with no external thrust, F_{ae}=0, the dynamic equivalent radial load, P_r, equals F_{rAB} or F_{rC}. Since F_{rAB} or F_{rC} is the radial load on the double-row assembly, the double-row basic dynamic radial load rating, $C_{90(2)}$, is to be used to calculate bearing life.

TABLE 8. DYNAMIC EQUIVALENT RADIAL LOAD EQUATIONS, DOUBLE-ROW TAPERED ROLLER BEARING MOUNTING

Design – Similar Bearing Series	Thrust Condition	Dynamic Equivalent Radial Load
	$F_{ae} \leq \frac{0.6\ F_{rAB}}{K}$	$P_A = 0.5\ F_{rAB} + 0.83\ K_A\ F_{ae}$ $P_B = 0.5\ F_{rAB} - 0.83\ K_A\ F_{ae}$
	$F_{ae} > \frac{0.6\ F_{rAB}}{K}$	$P_A = 0.4\ F_{rAB} + K_A\ F_{ae}$ $P_B = 0$

Design – Dissimilar Bearing Series	Thrust Condition	Dynamic Equivalent Radial Load
	$F_{ae} \leq \frac{0.6\ F_{rAB}}{K_A}$	$P_A = \frac{K_A}{K_A + K_B}\ (F_{rAB} + 1.67\ K_B\ F_{ae})$ $P_B = \frac{K_B}{K_A + K_B}\ (F_{rAB} - 1.67\ K_A\ F_{ae})$
	$F_{ae} > \frac{0.6\ F_{rAB}}{K_A}$	$P_A = 0.4\ F_{rAB} + K_A\ F_{ae}$ $P_B = 0$

NOTE: F_{rAB} is the radial load on the double-row assembly. The single-row basic dynamic radial load rating, C_{90}, is to be applied when calculating life based on the above equations.

DYNAMIC EQUIVALENT THRUST BEARING LOADS (P_a)

For thrust ball, thrust spherical and thrust tapered roller bearings, the existence of radial loads introduces complex load calculations that must be carefully considered. If the radial load is zero, the equivalent dynamic thrust load (P_a) will be equal to the applied thrust load (F_a). If any radial load is expected in the application, consult your Timken engineer for advice on bearing selection.

THRUST ANGULAR CONTACT BALL BEARINGS

For thrust angular contact ball bearings, the dynamic equivalent thrust load is determined by:

$$P_a = X_r F + YF_a$$

The minimum permissible thrust load to radial load ratios (F_a/F_r), X factors and Y factors are listed in the bearing dimension tables in the Thrust Bearing Catalog available on www.timken.com.

THRUST SPHERICAL ROLLER BEARINGS

Thrust spherical roller bearing dynamic loads are determined by:

$$P_a = 1.2F_r + F_a$$

Radial load (F_r) of a thrust spherical roller bearing is proportional to the applied axial load (F_a) such that $F_r \leq 0.55\ F_a$. The steep roller angle induces a thrust load ($F_{ai} = 1.2F_r$) when a radial load is applied. This thrust load must be resisted by another thrust bearing on the shaft or by an axial load greater than F_{ai}.

STATIC RADIAL AND AXIAL EQUIVALENT LOADS

To compare the load on a non-rotating bearing with the basic static capacity, it is necessary to determine the static equivalent load. The static equivalent load is defined as the pure radial or thrust load, whichever is appropriate, that produces the same contact pressure in the center of the most heavily stressed rolling element as the actual combined load. The static equivalent radial and/or axial loading is dependent on the bearing type selected. For bearings designed to accommodate only radial or thrust loading, the static equivalent load is equivalent to the applied load.

For all bearings, the maximum contact stress can be approximated using the static equivalent load and the static rating.

For roller bearings:

$$\sigma_0 = 4000 \left(\frac{P_o}{C_o}\right)^{1/2} \text{MPa}$$

$$\sigma_0 = 580 \left(\frac{P_o}{C_o}\right)^{1/2} \text{ksi}$$

For ball bearings:

$$\sigma_0 = 4200 \left(\frac{P_o}{C_o}\right)^{1/3} \text{MPa}$$

$$\sigma_0 = 607 \left(\frac{P_o}{C_o}\right)^{1/3} \text{ksi}$$

SPHERICAL ROLLER, RADIAL BALL AND ANGULAR CONTACT BALL BEARINGS

The load factors X_o and Y_o, listed in table 9, are used with the following equation to estimate the static radial equivalent load.

$$P_{or} = X_o F_r + Y_o F_a$$

THRUST BALL BEARINGS

Similar to radial ball bearings, thrust ball bearings use the same equation for equivalent static and dynamic loading.

$$P_{oa} = X_o F_r + Y_o F_a$$

The X and Y factors are listed in the Thrust Bearing Catalog available on www.timken.com along with the minimum required thrust load-to-radial load ratio for maintaining proper operation.

THRUST SPHERICAL ROLLER BEARINGS

The following equation is used for thrust spherical roller bearings:

$$P_{oa} = F_a + 2.7\ F_r$$

Thrust spherical roller bearings require a minimum thrust load for proper operation. P_{oa} should not be greater than $0.5\ C_{oa}$. If conditions exceed this, consult your Timken engineer.

TABLE 9. VALUES OF X_0 AND Y_0 FOR STATICALLY STRESSED RADIAL BEARINGS

Bearing Type	Contact Angle (α)	Single-Row		Double-Row	
		X_o	Y_o	X_o	Y_o
Radial Ball		0.6	0.5	0.6	0.5
Angular Contact Ball	15	0.5	0.47	1	0.94
	20	0.5	0.42	1	0.84
	25	0.5	0.38	1	0.76
	30	0.5	0.33	1	0.66
	35	0.5	0.29	1	0.58
	40	0.5	0.26	1	
Spherical Roller		0.5	0.22 cotα	1	0.44 cotα

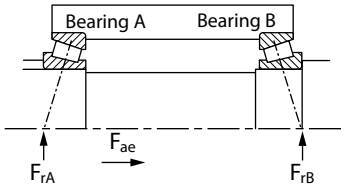
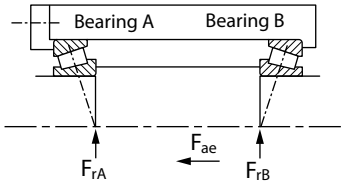
TAPERED ROLLER BEARINGS

To determine the static equivalent radial load for a single-row mounting, first determine the thrust load, (F_a), then use the equations in this section, depending on the appropriate thrust load condition.

The bearing data tables do not include static ratings for double-row bearings. The double-row static radial rating can be estimated as:

$$C_{o(2)} = 2C_o$$

TABLE 10. STATIC EQUIVALENT LOAD EQUATIONS, SINGLE-ROW TAPERED ROLLER BEARING

Design	Thrust Condition	Axial Load	Static Equivalent Radial Load
	$\frac{0.47\ F_{rA}}{K_A} \leq \frac{0.47\ F_{rB}}{K_B} + F_{ae}$	$F_{aA} = \frac{0.47\ F_{rB}}{K_B} + F_{ae}$ $F_{aB} = \frac{0.47\ F_{rB}}{K_B}$	$P_{0B} = F_{rB}$ for $F_{aA} < 0.6\ F_{rA} / K_A$ $P_{0A} = 1.6\ F_{rA} - 1.269\ K_A\ F_{aA}$ for $F_{aA} > 0.6\ F_{rA} / K_A$ $P_{0A} = 0.5\ F_{rA} + 0.564\ K_A\ F_{aA}$
 Design (external axial load, F_{ae}, onto bearing A)	$\frac{0.47\ F_{rA}}{K_A} > \frac{0.47\ F_{rB}}{K_B} + F_{ae}$	$F_{aA} = \frac{0.47\ F_{rA}}{K_A}$ $F_{aB} = \frac{0.47\ F_{rA}}{K_A} - F_{ae}$	for $F_{aB} > 0.6\ F_{rB} / K_B$ $P_{0B} = 0.5\ F_{rB} + 0.564\ K_B\ F_{aB}$ for $F_{aB} < 0.6\ F_{rB} / K_B$ $P_{0B} = 1.6\ F_{rB} - 1.269\ K_B\ F_{aB}$ $P_{0A} = F_{rA}$

Use the values of P_0 calculated for comparison with the static rating (C_0), even if P_0 is less than the radial applied F_r.

MINIMUM BEARING LOAD

Slippage can occur if loads are too light and, if accompanied by inadequate lubrication, may cause damage to the bearings. The minimum load for radial cylindrical and spherical roller bearings is $P_r = 0.04\ C$.

Centrifugal force in thrust spherical roller bearings tends to propel the rollers outward. The bearing geometry converts this force to another induced thrust component, which must be overcome by an axial load. This induced thrust (F_{ac}) is given by:

$$F_{ac} = k\ n^2 \times 10^{-5} \quad \text{(pounds force per RPM)}$$

The minimum required working thrust load on a thrust spherical roller bearing ($F_{a\ min}$) is then computed by:

$$F_{a\ min} = 1.2\ F_r + F_{ac} \geq \frac{C_{0a}}{1000} \quad \text{(lbf)}$$

In addition to meeting the above calculated value, the minimum required working thrust load ($F_{a\ min}$) should be equal to or greater than 0.1 percent of the static thrust load rating (C_{0a}).

BEARING RATINGS

There are two fundamental load ratings for bearings, a dynamic load rating and a static load rating. The dynamic load rating is used to estimate the life of a rotating bearing. Static load ratings are used to determine the maximum permissible load that can be applied to a non-rotating bearing.

DYNAMIC LOAD RATING

Published dynamic load ratings for Timken bearings are typically based on a rated life of one million revolutions. This rating, designated as C, is defined as the radial load under which a population of bearings will achieve an L_{10} life of one million revolutions. For Timken tapered roller bearings, the dynamic load rating is more commonly based on a rated life of 90 million revolutions, with the designation of C_{90}. This rating is the radial load under which a population of bearings will achieve an L_{10} life of 90 million revolutions. For tapered roller bearings, the dynamic thrust rating also is published and is designated as C_{a90}. The C_{a90} rating is the thrust load under which a population of bearings will achieve an L_{10} life of 90 million revolutions.

The dynamic load rating of a bearing is a function of the internal bearing geometry, which includes raceway angles, contact length between rolling elements and raceways, and the number and size of rolling elements. It also is a function of material cleanliness.

STATIC LOAD RATING

The basic static radial load rating and thrust load rating for Timken bearings are based on a maximum contact stress within a non-rotating bearing of 4000 MPa (580 ksi) for roller bearings and 4200 MPa (609 ksi) for ball bearings, at the center of contact on the most heavily loaded rolling element.

The 4000 MPa (580 ksi) or 4200 MPa (609 ksi) stress levels may cause visible light Brinell marks on the bearing raceways. This degree of marking will not have a measurable effect on fatigue life when the bearing is subsequently rotating under a lower application load. If sound, vibration or torque are critical, or if a pronounced shock load is present, a lower load limit should be applied. For more information on selecting a bearing for static load conditions, consult your Timken engineer.

BEARING LIFE

Many different performance criteria exist that dictate how a bearing should be selected. These include bearing fatigue life, rotational precision, power requirements, temperature limits, speed capabilities, sound, etc. This section deals primarily with bearing life as related to material-associated fatigue. Bearing life is defined as the length of time, or number of revolutions, until a fatigue spall of 6 mm^2 (0.01 $in.^2$) develops. Since fatigue is a statistical phenomenon, the life of an individual bearing is impossible to predetermine precisely. Bearings that may appear to be identical can exhibit considerable life scatter when tested under identical conditions. Thus it is necessary to base life predictions on a statistical evaluation of a large number of bearings operating under similar conditions. The Weibull distribution function is the accepted standard for predicting the life of a population of bearings at any given reliability level.

RATING LIFE

Rating life, (L_{10}), is the life that 90 percent of a group of apparently identical bearings will complete or exceed before a fatigue spall develops. The L_{10} life also is associated with 90 percent reliability for a single bearing under a certain load.

BEARING LIFE EQUATIONS

Traditionally, the L_{10} life has been calculated as follows for bearings under radial or combined loading, where the dynamic equivalent radial load, P_r, has been determined and the dynamic load rating is based on one million cycles:

$$L_{10} = \left(\frac{C}{P_r}\right)^e (1x10^6) \quad \text{revolutions}$$

or

$$L_{10} = \left(\frac{C}{P_r}\right)^e \left(\frac{1x10^6}{60n}\right) \quad \text{hours}$$

For thrust bearings, the above equations change to the following.

$$L_{10} = \left(\frac{C_a}{P_a}\right)^e (1x10^6) \quad \text{revolutions}$$

or

$$L_{10} = \left(\frac{C_a}{P_a}\right)^e \left(\frac{1x10^6}{60n}\right) \quad \text{hours}$$

e = 3 for ball bearings
= $^{10}/_3$ for tapered, cylindrical and spherical roller bearings

Tapered roller bearings often use a dynamic load rating based on 90 million cycles, as opposed to one million cycles, changing the equations as follows:

$$L_{10} = \left(\frac{C_{90}}{P_r}\right)^{10/3} (90x10^6) \quad \text{revolutions}$$

or

$$L_{10} = \left(\frac{C_{90}}{P_r}\right)^{10/3} \left(\frac{90x10^6}{60n}\right) \quad \text{hours}$$

and

$$L_{10} = \left(\frac{C_{a90}}{P_a}\right)^{10/3} (90x10^6) \quad \text{revolutions}$$

or

$$L_{10} = \left(\frac{C_{a90}}{P_a}\right)^{10/3} \frac{90x10^6}{60n} \quad \text{hours}$$

The traditional form of the equations based on dynamic load ratings of one million cycles is most common and will, therefore, be used throughout the rest of this section. The dynamic equivalent load equations and the life adjustment factors defined in subsequent sections are applicable to all forms of the life equation.

With increased emphasis on the relationship between the reference conditions and the actual environment in which the bearing operates in the machine, the traditional life equations have been expanded to include certain additional variables that affect bearing performance. The approach whereby these factors are considered in the bearing analysis and selection has been termed Bearing Systems Analysis (BSA).

The ABMA expanded bearing life equation is:

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

The Timken expanded bearing life equation is:

$$L_{na} = a_1 a_2 a_{3d} a_{3k} a_{3l} a_{3m} a_{3p} \left(\frac{C}{P_r}\right)^e (1x10^6) \quad \text{revolutions}$$

Where:

e = 3 for ball bearings
= $^{10}/_3$ for tapered, cylindrical and spherical roller bearings

RELIABILITY LIFE FACTOR (a_1)

Reliability, in the context of bearing life for a group of apparently identical bearings operating under the same conditions, is the percentage of the group that is expected to attain or exceed a specified life. The reliability of an individual bearing is the probability that the bearing will attain or exceed a specified life.

The reliability life adjustment factor is:

$$a_1 = 4.26\left(\ln \frac{100}{R}\right)^{2/3} + 0.05$$

ln = natural logarithm (base e)

To adjust the calculated L_{10} life for reliability, multiply by the a_1 factor. If 90 (90 percent reliability) is substituted for R in the above equation, $a_1 = 1$. For R = 99 (99 percent reliability), $a_1 = 0.25$. The following table lists the reliability factor for commonly used reliability values.

TABLE 11. RELIABILITY FACTORS

R (percent)	L_n	a_1
90	*L_{10}*	*1.00*
95	L_5	0.64
96	L_4	0.55
97	L_3	0.47
98	L_2	0.37
99	L_1	0.25
99.5	$L_{0.5}$	0.175
99.9	$L_{0.1}$	0.093

Note that the equation for reliability adjustment assumes there is a short minimum life below which the probability of bearing damage is minimal (e.g., zero probability of bearing damage producing a short life). Extensive bearing fatigue life testing has shown the minimum life, below which the probability of bearing damage is negligible, to be larger than predicted using the above adjustment factor. For a more accurate prediction of bearing lives at high levels of reliability, consult your Timken engineer.

MATERIAL LIFE FACTOR (a_2)

The life adjustment factor for bearing material, a_2, for standard Timken bearings manufactured from bearing quality steel is 1.0. Bearings also are manufactured from premium steels, containing fewer and smaller inclusion impurities than standard steels and providing the benefit of extending bearing fatigue life (e.g., DuraSpexx® bearing). Application of the material life factor requires that fatigue life is limited by nonmetallic inclusions, that contact stresses are approximately less than 2400 MPa (350 ksi), and adequate lubrication is provided. It is important to note that improvements in material cannot offset poor lubrication in an operating bearing system. Consult your Timken engineer for applicability of the material factor.

DEBRIS LIFE FACTOR (a_{3d})

Debris within a lubrication system reduces the life of a roller bearing by creating indentations on the contacting surfaces, leading to stress risers. The Timken life rating equations were developed based on test data obtained with 40 µm oil filtration, and measured ISO cleanliness levels of approximately 15/12, which is typical of cleanliness levels found in normal industrial machinery. When more or less debris is present within the system, the fatigue life predictions can be adjusted according to the measured or expected ISO lubricant cleanliness level to more accurately reflect the expected bearing performance.

A more accurate option for predicting bearing life in a debris environment is to perform a Debris Signature Analysis™. The Debris Signature Analysis is a process for determining the effects of the actual debris present in your system on the bearing performance. The typical way in which this occurs is through measurements of dented/bruised surfaces on actual bearings run in a given application. This type of analysis can be beneficial because different types of debris cause differing levels of performance degradation. Soft, ductile particles can cause differing levels of performance degradation than hard, brittle particles. Hard, ductile particles are typically most detrimental to bearing life. Brittle particles can break down, thus not affecting performance to as large of a degree as hard ductile particles. For more information on Debris Signature Analysis or the availability of debris-resistant bearings for your application, consult your Timken engineer.

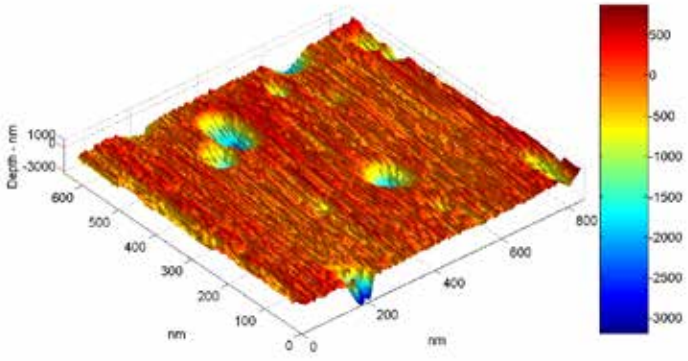


Fig. 68. Surface map of a bearing raceway with debris denting.

LOAD ZONE LIFE FACTOR (a_{3k})

Bearing fatigue life is a function of the stresses between rolling elements and raceways as well as the number of stress cycles the bearing surfaces experience per revolution. Stresses are influenced by the magnitude of the applied load, the internal bearing geometry and the number of rolling elements supporting the load. The number of stress cycles is a function of the number of rollers supporting the load, which, in turn, is influenced by the number of rollers per row, the bearing geometry, applied load and bearing setting.

The arc defined by the rollers supporting the load is called the bearing load zone. The load zone is significantly influenced by bearing setting or internal clearance, either radial or axial depending on the bearing type. Neglecting preload, less clearance in a bearing results in a larger load zone and subsequently longer bearing life.

The dynamic equivalent load (P_r) is used instead of the applied load (F_r) to approximate the combined load zone effect on L_{10a}. If a more accurate assessment of the load zone adjusted life is necessary (e.g., including the effects of internal clearance or fitting practice), consult your Timken engineer.

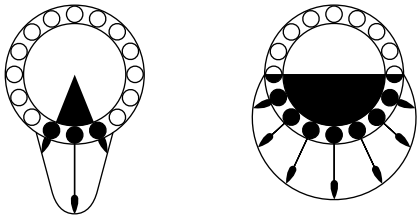


Fig. 69. Bearing load zones and roller-raceway contact loading.

LUBRICATION LIFE FACTOR (a_{3l})

The influence of lubrication film on bearing performance is related to the reduction or prevention of asperity (metal-metal) contact between the bearing surfaces. Extensive testing has been done at The Timken Technology Center to quantify the effects of the lubrication-related parameters on bearing life. It has been found that the roller and raceway surface finish, relative to lubricant film thickness, has the most notable effect on improving bearing performance. Factors such as bearing geometry, material, loads and load zones also play an important role in bearing performance.

The following equation provides a method to calculate the lubrication factor for a more accurate prediction of the influence of lubrication on bearing life (L_{10a}):

$$a_{3l} = C_g\, C_l\, C_j\, C_s\, C_v\, C_{gr}$$

The a_{3l} maximum is 2.88 for all bearings. The a_{3l} minimum is 0.200 for case-carburized bearings and 0.126 for through-hardened bearings.

A lubricant contamination factor is not included in the lubrication factor because Timken endurance tests are typically run with a 40 µm filter to provide a realistic level of lubricant cleanness for most applications.

Geometry factor (C_g)

C_g is given for most part numbers that are available in the bearing catalogs on www.timken.com. The geometry factor also includes the material effects and load zone considerations for non-tapered roller bearings, as these also are inherent to the bearing design. However, it should be noted that the primary effect of the load zone is on roller load distributions and contact stresses within the bearing, which are not quantified within the lubrication factor. Refer to the previous section Load Zone Life Factor (a_{3k}) for more information.

The geometry factor (C_g) is not applicable to our DuraSpexx™ product. For more information on our DuraSpexx product, consult your Timken engineer.

Load factor (C_l)

The C_l factor can be obtained from fig. 70. Note that the factor is different based on the type of bearing utilized. P_r is the equivalent load applied to the bearing in Newtons and is determined in the Dynamic Equivalent Bearing Loads (P_r) section.

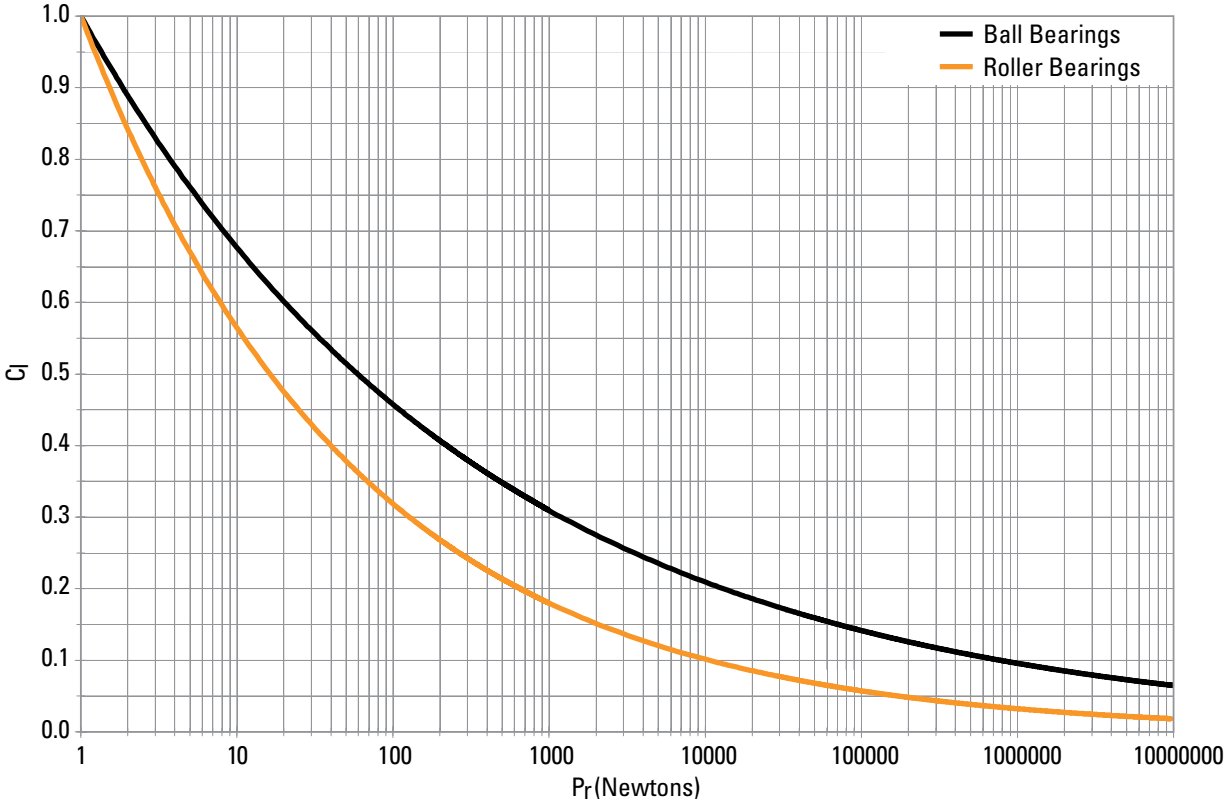


Fig. 70. Load factor (C_l) vs. dynamic equivalent bearing load (P_r).

Load zone factor (C_j)

For all non-tapered roller bearings, the load zone factor is one (1). For tapered roller bearings, the load zone factor can be taken from fig. 71.

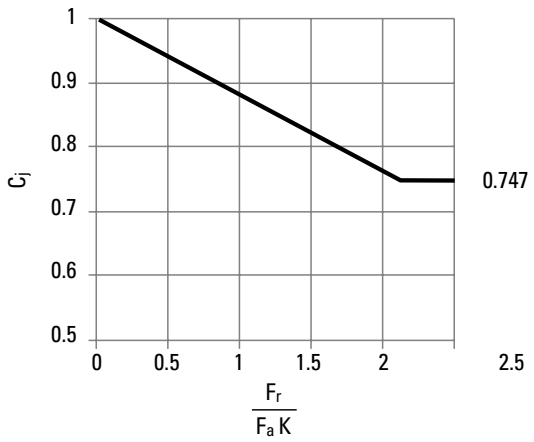


Fig. 71. Load zone factor (C_j) for tapered roller bearings.

Speed factor (C_s)

C_s can be determined from fig. 72, where rev/min (RPM) is the rotational speed of the inner ring relative to the outer ring.

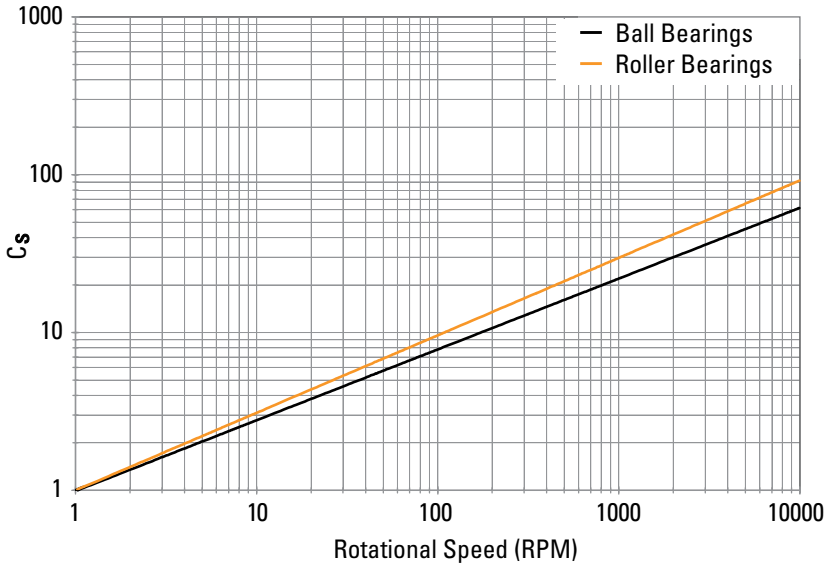


Fig. 72. Speed factor (C_s) vs. rotational speed.

Viscosity factor (C_v)

The lubricant kinematic viscosity (centistokes [cSt]) is taken at the operating temperature of the bearing. The operating viscosity can be estimated by fig. 73. The viscosity factor (C_v) can then be determined from figs. 73 and 74 shown here.

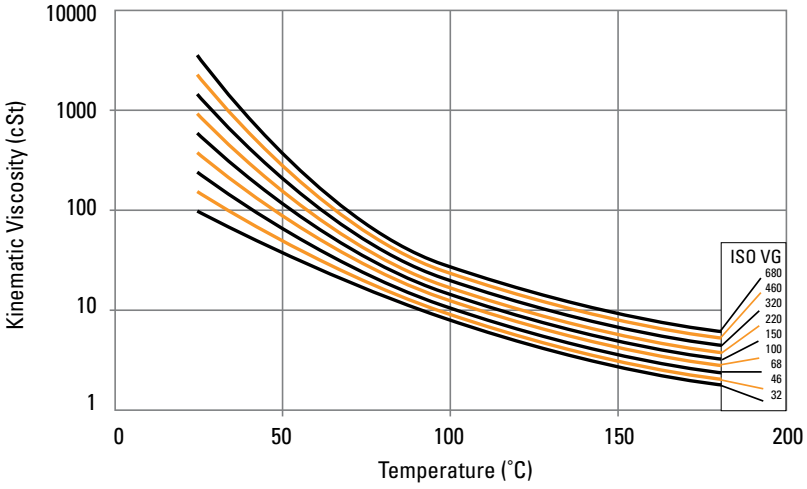


Fig. 73. Temperature vs. kinematic viscosity.

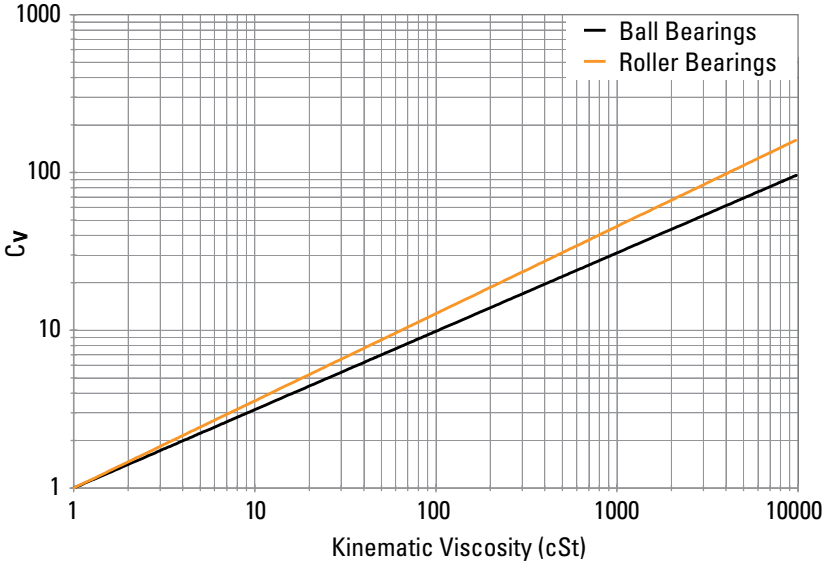


Fig. 74. Viscosity factor (C_v) vs. kinematic viscosity.

GREASE LUBRICATION FACTOR (C_{gr})

Over time, grease degradation causes a reduction in lubricant film thickness. Consequently, a reduction factor (C_{gr}) should be used to adjust for this effect.

$$C_{gr} = 0.79$$

LOW-LOAD LIFE FACTOR (a_{3p})

Bearing life tests show greatly extended bearing fatigue life performance is achievable when the bearing contact stresses are low and the lubricant film is sufficient to fully separate the micro-scale textures of the contacting surfaces. Mating the test data with sophisticated computer programs for predicting bearing performance, Timken engineers developed a low-load factor to predict the life increase expected when operating under low-bearing loads. Fig. 75 shows the low-load factor (a_{3p}) as a function of the lubricant life factor (a_{3l}) and the ratio of bearing dynamic rating to the bearing equivalent load.

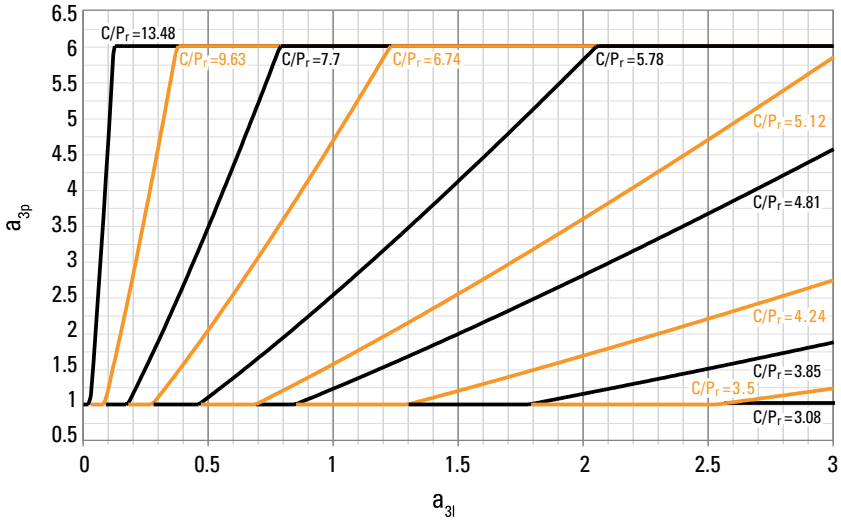


Fig. 75. Low-load life adjustment factor.

MISALIGNMENT LIFE FACTOR (a_{3m})

Accurate alignment of the shaft relative to the housing is critical for bearing performance. As misalignment increases under moderate to heavy loads, high contact stresses can be generated at the edges of contact between the raceway and rolling element. Special profiling of the raceway or rolling element can in most cases offset the effects of misalignment as shown in fig. 76. This figure shows the roller-to-inner ring contact stress of a tapered roller bearing under a misaligned condition with and without special profiling. The profiling significantly reduces the edge stress, resulting in improved bearing performance. The misalignment factor takes into account the effects of profiling on bearing life.

For tapered roller bearings, the base or reference condition upon which the bearing rating is generated includes a misalignment of 0.0005 radians. Above this misalignment value, reduction in life can be expected and will be reflected in the misalignment factor.

For cylindrical roller bearings, the misalignment factor is also a measure of the effect of bearing axial load on life. Axial loading of the bearing causes a moment to be generated about the roller center, thus shifting the roller-raceway contact stresses toward the end of the roller, similar to bearing misalignment.

Maximum recommended misalignment values for cylindrical roller bearings having profiled rollers are listed in the following table.

TABLE 12. CYLINDRICAL ROLLER BEARING MAXIMUM MISALIGNMENT RECOMMENDATIONS

Load as %C	Maximum Recommended Misalignment	
	mrad	Degrees
<20	1.2	0.07
20-35	0.5	0.03
>35	Check with your Timken engineer.	

The misalignment factor for spherical roller bearings is 1.0 due to the self-aligning capabilities of a spherical roller bearing. The allowable misalignment of a spherical roller bearing is between 0.5 and 1.25 degrees, depending on the bearing series as noted in table 13. Life will be reduced if these limits are exceeded.

Performance of all Timken bearings under various levels of misalignment and radial and axial load can be predicted using sophisticated computer programs. Using these programs, Timken engineers can design special bearing-contact profiles to accommodate the conditions of radial load, axial load and/or bearing misalignment in your application. Consult your Timken engineer for more information.

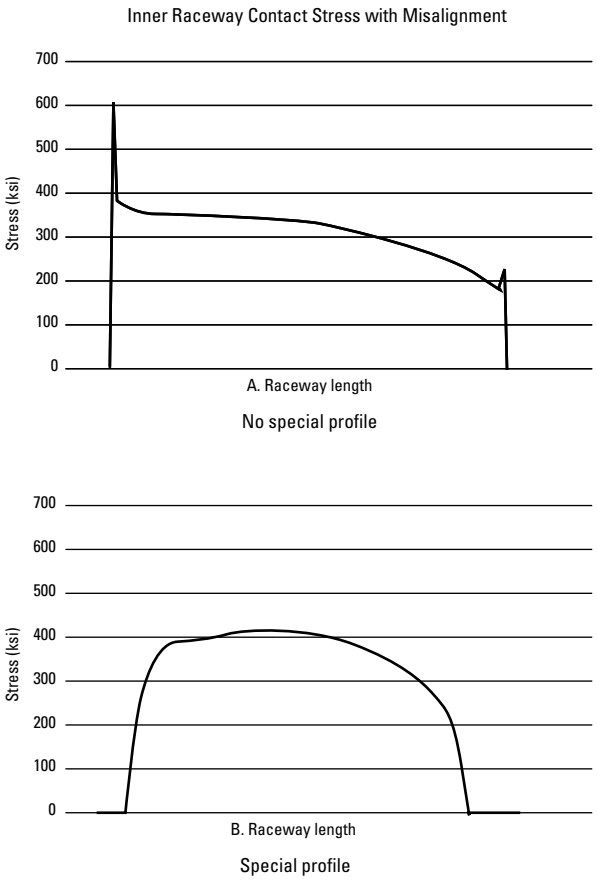


Fig. 76. Tapered roller bearing contact stress under misaligned condition.

TABLE 13. SPHERICAL ROLLER BEARING MAXIMUM MISALIGNMENT RECOMMENDATIONS

Bearing Series	Maximum Misalignment (Degrees)
238	±0.5
222, 230, 231, 239, 249	±0.75
223, 240	±1
232, 241	±1.25

SYSTEM LIFE AND WEIGHTED AVERAGE LOAD AND LIFE

SYSTEM LIFE

System reliability is the probability that all of the given bearings in a system will attain or exceed some required life. System reliability is the product of the individual bearing reliabilities in the system:

$$R_{(system)} = R_A R_B R_C \ldots R_n$$

In the application, the L_{10} system life for a number of bearings each having different L_{10} life is:

$$L_{10(system)} = [(1/L_{10A})^{3/2} + (1/L_{10B})^{3/2} + \ldots.(1/L_{10n})^{3/2}]^{-2/3}$$

WEIGHTED AVERAGE LOAD AND LIFE EQUATIONS

In many applications, bearings are subjected to various conditions of loading, and bearing selection is often made on the basis of maximum load and speed. However, under these conditions, a more meaningful analysis may be made by examining the loading cycle to determine the weighted average load.

Bearing selection based on weighted average loading will take into account variations in speed, load, and proportion of time during which the variable loads and speeds occur. However, it is still necessary to consider extreme loading conditions to evaluate bearing contact stresses and alignment.

WEIGHTED AVERAGE LOAD

Variable speed, load and proportion time:

$$F_{wt} = [(n_1 t_1 F_1^{10/3} + \ldots.n_n t_n F_n^{10/3}) / n_a]^{0.3}$$

Uniformly increasing load, constant speed:

$$F_{wt} = [(3/13) (F_{max}^{13/3} - F_{min}^{13/3}) / (F_{max} - F_{min})]^{0.3}$$

Use of the weighted average load in the bearing life equation does not take into account the effects of different speeds on the lubrication factor a_{3l}. For load cycles with varying speeds, it is recommended that life calculations be made for each condition and that the life for each condition be plugged into the weighted average life equation.

WEIGHTED AVERAGE LIFE

$$L_{nwt} = 1/\left\{[t_1 / (L_n)_1] + [t_2 / (L_n)_2] + \ldots [t_n / (L_n)_n]\right\}$$

BEARING TOLERANCES, METRIC AND INCH SYSTEMS

BEARING TOLERANCES, METRIC AND INCH SYSTEMS

Ball and roller bearings are manufactured to a number of specifications, with each having classes that define tolerances on dimensions such as bore, O.D., width and runout. In addition, bearings are produced in both inch and metric systems with the boundary dimension tolerances being different for these two systems. The major difference between the two systems is that inch bearings have historically been manufactured to positive bore and O.D. tolerances, whereas metric bearings have been manufactured to corresponding standard negative tolerances.

The following table summarizes the different specifications and classes for ball, tapered roller, cylindrical roller and spherical roller bearings. For the purposes of this manual, ISO specifications are shown for ball, cylindrical roller and spherical roller bearings. Timken specifications are shown for tapered roller bearings.

Boundary dimension tolerances for ball and roller bearing usage are listed in the following tables. These tolerances are provided for use in selecting bearings for general applications in conjunction with the bearing mounting and fitting practices offered in later sections.

TABLE 14. BEARING SPECIFICATIONS AND CLASSES

System	Specification	Bearing Type	Standard Bearing Class		Precision Bearing Class			
Metric	Timken	Tapered Roller Bearings	K	N	C	B	A	AA
	ISO/DIN	All Bearing Types	P0	P6	P5	P4	P2	-
	ABMA	Cylindrical, Spherical Roller Bearings	RBEC 1	RBEC 3	RBEC 5	RBEC 7	RBEC 9	-
		Ball Bearings	ABEC 1	ABEC 3	ABEC 5	ABEC 7	ABEC 9	-
		Tapered Roller Bearings	K	N	C	B	A	-
Inch	Timken	Tapered Roller Bearings	4	2	3	0	00	000
	ABMA	Tapered Roller Bearings	4	2	3	0	00	-

METRIC SYSTEM

RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARINGS

Standard Timken® radial ball, radial spherical roller and radial cylindrical roller bearings maintain normal tolerances according to the current ISO 492 standard. Tables 15 and 16 list the critical tolerances for these bearing types. For applications where running tolerance is critical, P6 or P5 tolerances are recommended.

The term deviation is defined as the difference between a single ring dimension and the nominal dimension. For metric tolerances, the nominal dimension is at a +0 mm (0 in.) tolerance. The deviation is the tolerance range for the listed parameter. Variation is defined as the difference between the largest and smallest measurements of a given parameter for an individual ring.

TABLE 15. RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARING TOLERANCES – INNER RING (Metric)

Bearing Bore		Bore Deviation[1] Δ_{dmp}			Width Variation V_{BS}			Radial Runout K_{ia}			Face Runout with Bore S_d	Axial Runout S_{ia}	Width Deviation Inner & Outer Rings[1] Δ_{Bs} and Δ_{Cs}	
Over	Incl.	P0	P6	P5	P0	P6	P5	P0	P6	P5	P5	P5	P0, P6	P5
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
2.5000 0.0984	**10.000** 0.3937	**-0.008** -0.0003	**-0.007** -0.0003	**-0.005** -0.0002	**0.015** 0.0006	**0.015** 0.0006	**0.005** 0.0002	**0.010** 0.0004	**0.006** 0.0002	**0.004** 0.0002	**0.007** 0.0003	**0.007** 0.0003	**-0.120** -0.0047	**-0.040** -0.0157
10.000 0.3937	**18.000** 0.7087	**-0.008** -0.0003	**-0.007** -0.0003	**-0.005** -0.0002	**0.020** 0.0008	**0.020** 0.0008	**0.005** 0.0002	**0.010** 0.0004	**0.007** 0.0003	**0.004** 0.0002	**0.007** 0.0003	**0.007** 0.0003	**-0.120** -0.0047	**-0.080** -0.0031
18.000 0.7087	**30.000** 1.1811	**-0.010** -0.0004	**-0.008** -0.0003	**-0.006** -0.0002	**0.020** 0.0008	**0.020** 0.0008	**0.005** 0.0002	**0.013** 0.0005	**0.008** 0.0003	**0.004** 0.0002	**0.008** 0.0003	**0.008** 0.0003	**-0.120** -0.0047	**-0.120** -0.0047
30.000 1.1811	**50.000** 1.9685	**-0.012** -0.0005	**-0.010** -0.0004	**-0.008** -0.0003	**0.020** 0.0008	**0.020** 0.0008	**0.005** 0.0002	**0.015** 0.0006	**0.010** 0.0004	**0.005** 0.0002	**0.008** 0.0003	**0.008** 0.0003	**-0.120** -0.0047	**-0.120** -0.0047
50.000 1.9685	**80.000** 3.1496	**-0.015** -0.0006	**-0.012** -0.0005	**-0.009** -0.0004	**0.025** 0.0010	**0.025** 0.0010	**0.006** 0.0002	**0.020** 0.0008	**0.010** 0.0004	**0.005** 0.0002	**0.008** 0.0003	**0.008** 0.0003	**-0.150** -0.0059	**-0.150** -0.0059
80.000 3.1496	**120.000** 4.7244	**-0.020** -0.0008	**-0.015** -0.0006	**-0.010** -0.0004	**0.025** 0.0010	**0.025** 0.0010	**0.007** 0.0003	**0.025** 0.0010	**0.013** 0.0005	**0.006** 0.0002	**0.009** 0.0004	**0.009** 0.0004	**-0.200** -0.0079	**-0.200** -0.0079
120.000 4.7244	**150.000** 5.9055	**-0.025** -0.0010	**-0.018** -0.0007	**-0.013** -0.0005	**0.030** 0.0012	**0.030** 0.0012	**0.008** 0.0003	**0.030** 0.0012	**0.018** 0.0007	**0.008** 0.0003	**0.010** 0.0004	**0.010** 0.0004	**-0.250** -0.0098	**-0.250** -0.0098
150.000 5.9055	**180.000** 7.0866	**-0.025** -0.0010	**-0.018** -0.0007	**-0.013** -0.0005	**0.030** 0.0012	**0.030** 0.0012	**0.008** 0.0003	**0.030** 0.0012	**0.018** 0.0007	**0.008** 0.0003	**0.010** 0.0004	**0.010** 0.0004	**-0.250** -0.0098	**-0.250** -0.0098
180.000 7.0866	**250.000** 9.8425	**-0.030** -0.0012	**-0.022** -0.0009	**-0.015** -0.0006	**0.030** 0.0012	**0.030** 0.0012	**0.010** 0.0004	**0.040** 0.0016	**0.020** 0.0008	**0.010** 0.0004	**0.011** 0.0004	**0.013** 0.0005	**-0.300** -0.0018	**-0.300** -0.0018
250.000 9.8425	**315.000** 12.4016	**-0.035** -0.0014	**-0.025** -0.0010	**-0.018** -0.0007	**0.035** 0.0014	**0.035** 0.0014	**0.013** 0.0005	**0.050** 0.0020	**0.025** 0.0010	**0.013** 0.0005	**0.013** 0.0005	**0.015** 0.0006	**-0.350** -0.0138	**-0.350** -0.0138
315.000 12.4016	**400.000** 15.7480	**-0.040** -0.0016	**-0.030** -0.0012	**-0.023** -0.0009	**0.040** 0.0016	**0.040** 0.0016	**0.015** 0.0006	**0.060** 0.0024	**0.030** 0.0012	**0.015** 0.0006	**0.015** 0.0006	**0.020** 0.0008	**-0.400** -0.0157	**-0.400** -0.0157
400.000 15.7480	**500.000** 19.6850	**-0.045** -0.0018	**-0.035** -0.0014	– –	**0.050** 0.0020	**0.045** 0.0018	– –	**0.065** 0.0026	**0.035** 0.0014	– –	– –	– –	**-0.450** -0.0177	– –
500.000 19.6850	**630.000** 24.8031	**-0.050** -0.0020	**-0.040** -0.0016	– –	**0.060** 0.0024	**0.050** 0.0020	– –	**0.070** 0.0028	**0.040** 0.0016	– –	– –	– –	**-0.500** -0.0197	– –
630.000 24.8031	**800.000** 31.4961	**-0.075** -0.0030	– –	– –	**0.070** 0.0028	– –	– –	**0.080** 0.0031	– –	– –	– –	– –	**-0.750** -0.0295	– –

[1]Tolerance range is from +0 to value listed.

TABLE 16. RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARING TOLERANCES – OUTER RING (Metric)

Bearing O.D.		Outside Deviation[1] Δ_{Dmp}			Width Variation V_{CS}		Radial Runout K_{ea}			Axial Runout S_{ea}	Outside Diameter Runout With Face S_D
Over	Incl.	P0	P6	P5	P0	P6	P0	P6	P5	P5	P5
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0.000 0.0000	**18.000** 0.7087	**-0.008** -0.0003	**-0.007** -0.0003	**-0.005** -0.0002	**0.015** 0.0006	**0.005** 0.0002	**0.015** 0.0006	**0.008** 0.0003	**0.005** 0.0002	**0.008** 0.0003	**0.008** 0.0003
18.000 0.7087	**30.000** 1.1811	**-0.009** -0.0004	**-0.008** -0.0003	**-0.006** -0.00024	**0.020** 0.0008	**0.005** 0.0002	**0.015** 0.0006	**0.009** 0.0004	**0.006** 0.00024	**0.008** 0.0003	**0.008** 0.0003
30.000 1.1811	**50.000** 1.9685	**-0.011** -0.0004	**-0.009** -0.0004	**-0.007** -0.0003	**0.020** 0.0008	**0.005** 0.0002	**0.020** 0.0008	**0.010** 0.0004	**0.007** 0.0003	**0.008** 0.0003	**0.008** 0.0003
50.000 1.9685	**80.000** 3.1496	**-0.013** -0.0005	**-0.011** -0.0004	**-0.009** -0.0004	**0.025** 0.0010	**0.006** 0.00024	**0.025** 0.0010	**0.013** 0.0005	**0.008** 0.0003	**0.010** 0.0004	**0.008** 0.0003
80.000 3.1496	**120.000** 4.7244	**-0.015** -0.0006	**-0.013** -0.0005	**-0.010** -0.0004	**0.025** 0.0010	**0.008** 0.0003	**0.035** 0.0014	**0.018** 0.0007	**0.010** 0.0004	**0.011** 0.0004	**0.009** 0.0004
120.000 4.7244	**150.000** 5.9055	**-0.018** -0.0007	**-0.015** -0.0006	**-0.011** -0.0004	**0.030** 0.0012	**0.008** 0.0003	**0.040** 0.0016	**0.020** 0.0008	**0.011** 0.0004	**0.013** 0.0005	**0.010** 0.0004
150.000 5.9055	**180.000** 7.0866	**-0.025** -0.0010	**-0.018** -0.0007	**-0.013** -0.0005	**0.030** 0.0012	**0.008** 0.0003	**0.045** 0.0018	**0.023** 0.0009	**0.013** 0.0005	**0.014** 0.0006	**0.010** 0.0004
180.000 7.0866	**250.000** 9.8425	**-0.030** -0.0012	**-0.020** -0.0008	**-0.015** -0.0006	**0.030** 0.0012	**0.010** 0.0004	**0.050** 0.0020	**0.025** 0.0010	**0.015** 0.0006	**0.015** 0.0006	**0.011** 0.0004
250.000 9.8425	**315.000** 12.4016	**-0.035** -0.0014	**-0.025** -0.0010	**-0.018** -0.0007	**0.035** 0.0014	**0.011** 0.0004	**0.060** 0.0024	**0.030** 0.0012	**0.018** 0.0007	**0.018** 0.0007	**0.013** 0.0005
315.000 12.4016	**400.000** 15.7480	**-0.040** -0.0016	**-0.028** -0.0011	**-0.020** -0.0008	**0.040** 0.0016	**0.013** 0.0005	**0.070** 0.0028	**0.035** 0.0014	**0.020** 0.0008	**0.020** 0.0008	**0.013** 0.0005
400.000 15.7480	**500.000** 19.6850	**-0.045** -0.0018	**-0.033** -0.0013	**-0.023** -0.0009	**0.045** 0.0018	**0.015** 0.0006	**0.080** 0.0031	**0.040** 0.0016	**0.023** 0.0009	**0.023** 0.0009	**0.015** 0.0006
500.000 19.6850	**630.000** 24.8031	**-0.050** -0.0020	**-0.038** -0.0015	**-0.028** -0.0011	**0.050** 0.0020	**0.018** 0.0007	**0.100** 0.0039	**0.050** 0.0020	**0.025** 0.0010	**0.025** 0.0010	**0.018** 0.0007
630.000 24.8031	**800.000** 31.4961	**-0.075** -0.0030	**-0.045** -0.0018	**-0.035** -0.0014	**–** –	**0.020** 0.0008	**0.120** 0.0047	**0.060** 0.0024	**0.030** 0.0012	**0.030** 0.0012	**0.020** 0.0008
800.000 31.4961	**1000.000** 39.3701	**-0.100** -0.0040	**-0.060** -0.0024	– –	– –	– –	**0.140** 0.0055	**0.075** 0.0030	– –	– –	– –
1000.000 39.3701	**1250.000** 49.2126	**-0.125** -0.0050	– –	– –	– –	– –	**0.160** 0.0063	– –	– –	– –	– –

[1]Tolerance range is from +0 to value listed.

TABLE 17. THRUST BALL BEARING TOLERANCES – TYPE TVB

Bore			O.D.			Height			
Bearing Bore		Tolerance[1]	Bearing O.D.		Tolerance[1]	Bearing Bore		Tolerance	
Over	Incl.		Over	Incl.		Over	Incl.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0.000 0 .0000	**171.450** 6.7500	**+0.127** +0.0050	**0.000** 0.0000	**134.938** 5.3125	**-0.051** -0.0020	**0.000** 0.0000	**46.038** 1.8125	**+0.127** +0.0050	**-0.127** -0.0050
171.450 6.7500	**508.000** 20.0000	**+0.178** +0.0070	**134.938** 5.3125	**441.325** 17.3750	**-0.076** -0.0030	**46.038** 1.8125	**304.800** 12.0000	**+0.254** +0.0100	**-0.254** -0.0100
– –	– –	– –	**441.325** 17.3750	**1000.000** 39.3701	**-0.102** -0.0040	**304.800** 12.0000	**508.000** 20.0000	**+0.381** +0.0150	**-0.381** -0.0150

[1]The tolerances in this table conform to ABMA Standard 21.2.

TABLE 18. THRUST BALL BEARING TOLERANCES – TYPES TVL & DTVL

Bore			O.D.			Height		
Bearing Bore		Tolerance[1]	Bearing O.D.		Tolerance[1]	Bearing Bore		Tolerance
Over	Incl.		Over	Incl.		Over	Incl.	Max.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0.000 0.0000	**504.825** 19.8750	**-0.076** -0.0030	**0.000** 0.0000	**584.000** 23.0000	**-0.076** -0.0030	All Sizes		**±0.381** ±0.0150
504.825 19.8750	**1524.000** 60.0000	**-0.127** -0.0050	**584.000** 23.0000	**1778.000** 70.0000	**-0.127** -0.0050			– –

[1]The tolerances in this table conform to ABMA Standard 21.2.

TABLE 19. THRUST SPHERICAL ROLLER BEARING TOLERANCES

Inner Ring				Outer Ring							
Bore		Tolerance		O.D.		Tolerance		Bore Diameter		Tolerance	
										Height	
Over	Incl.	Bore[1]	Radial Runout	Over	Incl.	O.D.[1]	Radial Runout	Over	Incl.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
80.000 3.1496	**120.000** 4.7244	**-0.020** -0.0008	**0.025** 0.0010	**120.000** 4.7244	**150.000** 5.9055	**-0.020** -0.0080	**0.041** 0.0016	**80.000** 3.1496	**120.000** 4.7244	**+0.094** +0.0037	**-0.254** -0.0100
120.000 4.7244	**180.000** 7.0866	**-0.025** -0.0010	**0.030** 0.0012	**150.000** 5.9055	**180.000** 7.0866	**-0.025** -0.0010	**0.046** 0.0018	**120.000** 4.7244	**180.000** 7.0866	**+0.109** +0.0043	**-0.300** -0.0118
180.000 7.0866	**250.000** 9.8425	**-0.030** -0.0012	**0.041** 0.0016	**180.000** 7.0866	**250.000** 9.8425	**-0.030** -0.0012	**0.051** 0.0020	**180.000** 7.0866	**250.000** 9.8425	**+0.130** +0.0051	**-0.366** -0.0144
250.000 9.8425	**315.000** 12.4016	**-0.036** -0.0014	**0.051** 0.0020	**250.000** 9.8425	**315.000** 12.4016	**-0.036** -0.0014	**0.061** 0.0024	**250.000** 9.8425	**315.000** 12.4016	**+0.155** +0.0061	**-0.434** -0.0171
315.000 12.4016	**400.000** 15.7480	**-0.041** -0.0016	**0.061** 0.0024	**315.000** 12.4016	**400.000** 15.7480	**-0.041** -0.0016	**0.071** 0.0028	**315.000** 12.4016	**400.000** 15.7480	**+0.170** +0.0067	**-0.480** -0.0189
400.000 15.7480	**500.000** 19.6850	**-0.046** -0.0018	**0.066** 0.0026	**400.000** 15.7480	**500.000** 19.6850	**-0.046** -0.0018	**0.081** 0.0032	**400.000** 15.7480	**500.000** 19.6850	**+0.185** +0.0073	**-0.526** -0.0207
500.000 19.6850	**630.000** 24.8031	**-0.051** -0.0020	**0.071** 0.0028	**500.000** 19.6850	**630.000** 24.8031	**-0.051** -0.0020	**0.102** 0.0040	**500.000** 19.6850	**and up**	**+0.203** +0.0080	**-0.584** -0.0230
630.000 24.8031	**800.000** 31.4961	**-0.076** -0.0030	**0.081** 0.0032	**630.000** 24.8031	**800.000** 31.4961	**-0.076** -0.0030	**0.119** 0.0047	– –	– –	– –	– –
800.000 31.4961	**1000.000** 39.3701	**-0.102** -0.0040	**0.089** 0.0035	**800.000** 31.4961	**1000.000** 39.3701	**-0.102** -0.0040	**0.140** 0.0055	– –	– –	– –	– –
1000.000 39.3701	**1250.000** 49.2126	**-0.127** -0.0050	**0.102** 0.0040	**1000.000** 39.3701	**1250.000** 49.2126	**-0.127** -0.0050	**0.163** 0.0064	– –	– –	– –	– –
– –	– –	– –	**1250.000** 49.2126	**1600.000** 62.9921	**-0.165** -0.0065	**0.193** 0.0076	– –	– –	– –	– –	– –
– –	– –	– –	**1600.000** 62.9921	**2000.000** 78.7402	**-0.203** -0.0080	**0.229** 0.009	– –	– –	– –	– –	– –

[1]Tolerance range is from +0 to value listed.

TAPERED ROLLER BEARING

Metric system bearings (ISO and J Prefix Parts)

Timken manufactures metric system bearings to six tolerance classes. Classes K and N are often referred to as standard classes. Class N has more closely controlled width tolerances than K. Classes C, B, A and AA are precision classes. These tolerances lie within those currently specified in ISO 492 with the exception of a small number of dimensions indicated in the tables. The differences normally have an insignificant effect on the mounting and performance of tapered roller bearings. For bearings that exceed the size ranges listed in the tables, consult your Timken engineer.

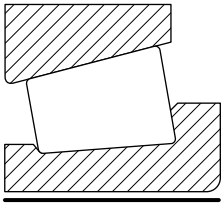
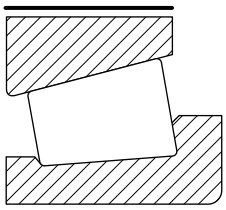


TABLE 20. TAPERED ROLLER BEARING TOLERANCES – INNER RING BORE (Metric)

Bearing Types	Bore		Standard Bearing Class				Precision Bearing Class							
			K		N		C		B		A		AA	
	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF SR[1]	**10.000** 0.3937	**18.000** 0.7087	**0** 0	**-0.012** -0.0005	**0** 0	**-0.012** -0.0005	**0** 0	**-0.007** -0.00028	**0** 0	**-0.005** -0.00020	**0** 0	**-0.004** -0.00016	**0** 0	**-0.004** -0.00016
	18.000 0.7087	**30.000** 1.1811	**0** 0	**-0.012** -0.0005	**0** 0	**-0.012** -0.0005	**0** 0	**-0.008** -0.00031	**0** 0	**-0.006** -0.00024	**0** 0	**-0.004** -0.00016	**0** 0	**-0.004** -0.00016
	30.000 1.1811	**50.000** 1.9685	**0** 0	**-0.012** -0.0005	**0** 0	**-0.012** -0.0005	**0** 0	**-0.010** -0.0004	**0** 0	**-0.008** -0.00031	**0** 0	**-0.005** -0.00020	**0** 0	**-0.005** -0.00020
	50.000 1.9685	**80.000** 3.1496	**0** 0	**-0.015** -0.0006	**0** 0	**-0.015** -0.0006	**0** 0	**-0.012** -0.0005	**0** 0	**-0.009** -0.00035	**0** 0	**-0.005** -0.00020	**0** 0	**-0.005** -0.00020
	80.000 3.1496	**120.000** 4.7244	**0** 0	**-0.020** -0.0008	**0** 0	**-0.020** -0.0008	**0** 0	**-0.015** -0.0006	**0** 0	**-0.010** -0.0004	**0** 0	**-0.006** -0.00024	**0** 0	**-0.006** -0.00024
	120.000 4.7244	**180.000** 7.0886	**0** 0	**-0.025** -0.0010	**0** 0	**-0.025** -0.0010	**0** 0	**-0.018** -0.0007	**0** 0	**-0.013** -0.0005	**0** 0	**-0.007** -0.00028	**0** 0	**-0.007** -0.00028
	180.000 7.0866	**250.000** 9.8425	**0** 0	**-0.030** -0.0012	**0** 0	**-0.030** -0.0012	**0** 0	**-0.022** -0.0009	**0** 0	**-0.015** -0.0006	**0** 0	**-0.008** -0.00031	**0** 0	**-0.008** -0.00031
	250.000 9.8425	**315.000** 12.4016	**0** 0	**-0.035** -0.0014	**0** 0	**-0.035** -0.0014	**0** 0	**-0.022** -0.0009	**0** 0	**-0.015** -0.0006	**0** 0	**-0.008** -0.00031	**0** 0	**-0.008** -0.00031
	315.000 12.4016	**400.000** 15.7480	**0** 0	**-0.040** -0.0016	**0** 0	**-0.040** -0.0016	**0** 0	**-0.025** -0.0010	– –	– –	– –	– –	– –	– –
	400.000 15.7480	**500.000** 19.6850	**0** 0	**-0.045** -0.0018	**0** 0	**-0.045** -0.0018	**0** 0	**-0.025** -0.0010	– –	– –	– –	– –	– –	– –
	500.000 19.6850	**630.000** 24.8031	**0** 0	**-0.050** -0.0020	– –	– –	**0** 0	**-0.030** -0.0012	– –	– –	– –	– –	– –	– –
	630.000 24.8031	**800.000** 31.4961	**0** 0	**-0.075** -0.0030	– –	– –	**0** 0	**-0.040** -0.0016	– –	– –	– –	– –	– –	– –
	800.000 31.4961	**1000.000** 39.3701	**0** 0	**-0.100** -0.0039	– –	– –	**0** 0	**-0.050** -0.0020	– –	– –	– –	– –	– –	– –
	1000.000 39.3701	**1250.000** 49.2126	**0** 0	**-0.125** -0.0049	– –	– –	**0** 0	**-0.060** -0.0024	– –	– –	– –	– –	– –	– –
	1250.000 49.2126	**1600.000** 62.9921	**0** 0	**-0.160** -0.0063	– –	– –	**0** 0	**-0.080** -0.0031	– –	– –	– –	– –	– –	– –
	1600.000 **62.9921**	**2000.000** **78.7402**	**0** **0**	**-0.200** **-0.0079**	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
	2000.000 78.7402	**2500.000** 98.4252	**0** 0	**-0.250** -0.0098	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –

[1]SR assemblies are manufactured to tolerance class N only.

TABLE 21. TAPERED ROLLER BEARING TOLERANCES – OUTER RING OUTSIDE DIAMETER (Metric)



Bearing Type	O.D.		Standard Bearing Class				Precision Bearing Class							
			K		N		C		B		A		AA	
	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF SR[1]	**10.000** 0.3937	**18.000** 0.7087	**0** 0	**-0.012** -0.0005	**0** 0	**-0.012** -0.0005	**0** 0	**-0.008** -0.00031	**0** 0	**-0.006** -0.00024	**0** 0	**-0.005** -0.00020	**0** 0	**-0.005** -0.00020
	18.000 0.7087	**30.000** 1.1811	**0** 0	**-0.012** -0.0005	**0** 0	**-0.012** -0.0005	**0** 0	**-0.008** -0.00031	**0** 0	**-0.006** -0.00024	**0** 0	**-0.005** -0.00020	**0** 0	**-0.005** -0.00020
	30.000 1.1811	**50.000** 1.9685	**0** 0	**-0.014** -0.0006	**0** 0	**-0.014** -0.0006	**0** 0	**-0.009** -0.00035	**0** 0	**-0.007** -0.00028	**0** 0	**-0.005** -0.00020	**0** 0	**-0.005** -0.00020
	50.000 1.9685	**80.000** 3.1496	**0** 0	**-0.016** -0.0006	**0** 0	**-0.016** -0.0006	**0** 0	**-0.011** -0.0004	**0** 0	**-0.009** -0.00035	**0** 0	**-0.006** -0.00024	**0** 0	**-0.006** -0.00024
	80.000 3.1496	**120.000** 4.7244	**0** 0	**-0.018** -0.0007	**0** 0	**-0.018** -0.0007	**0** 0	**-0.013** -0.0005	**0** 0	**-0.010** -0.0004	**0** 0	**-0.006** -0.00024	**0** 0	**-0.006** -0.00024
	120.000 4.7244	**150.000** 5.9055	**0** 0	**-0.020** -0.0008	**0** 0	**-0.020** -0.0008	**0** 0	**-0.015** -0.0006	**0** 0	**-0.011** -0.0004	**0** 0	**-0.007** -0.00028	**0** 0	**-0.007** -0.00028
	150.000 5.9055	**180.000** 7.0866	**0** 0	**-0.025** -0.0010	**0** 0	**-0.025** -0.0010	**0** 0	**-0.018** -0.0007	**0** 0	**-0.013** -0.0005	**0** 0	**-0.007** -0.00028	**0** 0	**-0.007** -0.00028
	180.000 7.0866	**250.000** 9.8425	**0** 0	**-0.030** -0.0012	**0** 0	**-0.030** -0.0012	**0** 0	**-0.020** -0.0008	**0** 0	**-0.015** -0.0006	**0** 0	**-0.008** -0.00031	**0** 0	**-0.008** -0.00031
	250.000 9.8425	**315.000** 12.4016	**0** 0	**-0.035** -0.0014	**0** 0	**-0.035** -0.0014	**0** 0	**-0.025** -0.0010	**0** 0	**-0.018** -0.0007	**0** 0	**-0.009** -0.00035	**0** 0	**-0.009** -0.00035
	315.000 12.4016	**400.000** 15.7480	**0** 0	**-0.040** -0.0016	**0** 0	**-0.040** -0.0016	**0** 0	**-0.028** -0.0011	**0** 0	**-0.020** -0.0008	**0** 0	**-0.010** -0.0004	**0** 0	**-0.010** -0.0004
	400.000 15.7480	**500.000** 19.6850	**0** 0	**-0.045** -0.0018	**0** 0	**-0.045** -0.0018	**0** 0	**-0.030** -0.0012	– –	– –	– –	– –	– –	– –
	500.000 19.6850	**630.000** 24.8031	**0** 0	**-0.050** -0.0020	**0** 0	**-0.050** -0.0020	**0** 0	**-0.035** -0.0014	– –	– –	– –	– –	– –	– –
	630.000 24.8031	**800.000** 31.4961	**0** 0	**-0.075** -0.0030	– –	– –	**0** 0	**-0.040** -0.0016	– –	– –	– –	– –	– –	– –
	800.000 31.4961	**1000.000** 39.3701	**0** 0	**-0.100** -0.0039	– –	– –	**0** 0	**-0.050** -0.0020	– –	– –	– –	– –	– –	– –
	1000.000 39.3701	**1250.000** 49.2126	**0** 0	**-0.125** -0.0049	– –	– –	**0** 0	**-0.060** -0.0024	– –	– –	– –	– –	– –	– –
	1250.000 **49.2126**	**1600.000** **62.9921**	**0** **0**	**-0.160** **-0.0063**	– –	– –	**0** 0	**-0.080** -0.0031	– –	– –	– –	– –	– –	– –
	1600.000 62.9921	**2000.000** 78.7402	**0** 0	**-0.200** -0.0079	– –	– –	**0** 0	**-0.125** -0.0049	– –	– –	– –	– –	– –	– –
	2000.000 78.7402	**2500.000** 98.4252	**0** 0	**-0.250** -0.0098	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –

[1]SR assemblies are manufactured to tolerance class N only.

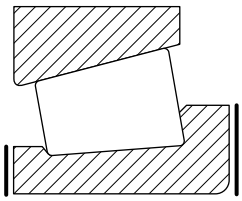


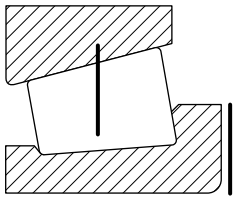
TABLE 22. TAPERED ROLLER BEARING TOLERANCES – INNER RING WIDTH (Metric)

Bearing Types	Bore		Standard Bearing Class				Precision Bearing Class							
			K		N		C		B		A		AA	
	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF	**10.000** 0.3937	**50.000** 1.9685	**0** 0	**-0.100** -0.0040	**0** 0	**-0.050** -0.0020	**0** 0	**-0.200** -0.0079	**0** 0	**-0.200** -0.0079	**0** 0	**-0.200** -0.0079	**0** 0	**-0.200** -0.0079
	50.000 1.9685	**120.000** 4.7244	**0** 0	**-0.150** -0.0059	**0** 0	**-0.050** -0.0020	**0** 0	**-0.300** -0.0118	**0** 0	**-0.300** -0.0118	**0** 0	**-0.300** -0.0118	**0** 0	**-0.300** -0.0118
	120.000 4.7244	**180.000** 7.0866	**0** 0	**-0.200** -0.0079	**0** 0	**-0.050** -0.0020	**0** 0	**-0.300** -0.0118	**0** 0	**-0.300** -0.0118	**0** 0	**-0.300** -0.0118	**0** 0	**-0.300** -0.0118
	180.000 7.0866	**250.000** 9.8425	**0** 0	**-0.200** -0.0079	**0** 0	**-0.050** -0.0020	**0** 0	**-0.350** -0.0138	**0** 0	**-0.350** -0.0138	**0** 0	**-0.350** -0.0138	**0** 0	**-0.350** -0.0138
	250.000 9.8425	**315.000** 12.4016	**0** 0	**-0.200** -0.0079	**0** 0	**-0.050** -0.0020	**0** 0	**-0.350** -0.0138	**0** 0	**-0.350** -0.0138	**0** 0	**-0.350** -0.0138	**0** 0	**-0.350** -0.0138
	315.000 12.4016	**400.000** 15.7480	**0** 0	**-0.250** -0.0098	**0** 0	**-0.050** -0.0020	**0** 0	**-0.350** -0.0138	– –	– –	– –	– –	– –	– –
	400.000 15.7480	**500.000** 19.6850	**0** 0	**-0.250** -0.0098	**0** 0	**-0.050** -0.0020	**0** 0	**-0.350** -0.0138	– –	– –	– –	– –	– –	– –
	500.000 19.6850	**630.000** 24.8031	**0** 0	**-0.250** -0.0098	– –	– –	**0** 0	**-0.350** -0.0138	– –	– –	– –	– –	– –	– –
	630.000 24.8031	**1250.000** 49.2126	**0** 0	**-0.300** -0.0118	– –	– –	**0** 0	**-0.350** -0.0138	– –	– –	– –	– –	– –	– –
	1250.000 49.2126	**1600.000** 62.9921	**0** 0	**-1.600** -0.0630	– –	– –	**0** 0	**-0.350** -0.0138	– –	– –	– –	– –	– –	– –
	1600.000 62.9921	**2000.000** 78.7402	**0** 0	**-2.000** -0.0787	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
	2000.000 78.7402	**2500.000** 98.4252	**0** 0	**-2.500** -0.0984	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –

TABLE 23. TAPERED ROLLER BEARING TOLERANCES – INNER RING STAND (Metric)

Bearing Types	Bore		Standard Bearing Class				Precision Bearing Class							
			K		N		C		B		A		AA	
	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF	**10.000** 0.3937	**80.000** 3.1496	**+0.100** +0.0039	**0** 0	**+0.050** +0.0020	**0** 0	**+0.100** +0.0039	**-0.100** -0.0039						
	80.000 3.1496	**120.000** 4.7244	**+0.100** +0.0039	**-0.100** -0.0039	**+0.050** +0.0020	**0** 0	**+0.100** +0.0039	**-0.100** -0.0039						
	120.000 4.7244	**180.000** 7.0866	**+0.150** +0.0059	**-0.150** -0.0059	**+0.050** +0.0020	**0** 0	**+0.100** +0.0039	**-0.100** -0.0039	(1)	(1)	(1)	(1)	(1)	(1)
	180.000 7.0866	**250.000** 9.8425	**+0.150** +0.0059	**-0.150** -0.0059	**+0.050** +0.0020	**0** 0	**+0.100** +0.0039	**-0.150** -0.0059						
	250.000 9.8425	**315.000** 12.4016	**+0.150** +0.0059	**-0.150** -0.0059	**+0.100** +0.0039	**0** 0	**+0.100** +0.0039	**-0.150** -0.0059						
	315.000 12.4016	**400.000** 15.7480	**+0.200** +0.0079	**-0.200** -0.0079	**+0.100** +0.0039	**0** 0	**+0.150** +0.0059	**-0.150** -0.0059	– –	– –	– –	– –	– –	– –
	400.000 15.7480	– –	(1)	(1)	(1)	(1)	(1)	(1)	– –	– –	– –	– –	– –	– –

(1)These sizes manufactured as matched assemblies only.



Inner Ring Stand. Inner ring stand is a measure of the variation in inner ring raceway size, taper and roller diameter. This is checked by measuring the axial location of the reference surface of a master outer ring or other type gauge with respect to the reference inner ring face.

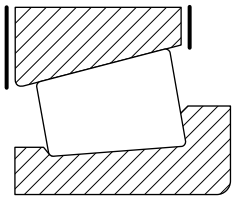


TABLE 24. TAPERED ROLLER BEARING TOLERANCES – OUTER RING WIDTH (Metric)

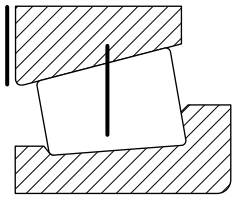
Bearing Types	O.D.		Standard Bearing Class				Precision Bearing Class							
			K		N		C		B		A		AA	
	Over	Incl.	Max.	Min.[1]	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF	**10.000** 0.3937	**80.000** 3.1496	**0** 0	**-0.150** -0.0059	**0** 0	**-0.100** -0.0039	**0** 0	**-0.150** -0.0059	**0** 0	**-0.150** -0.0059	**0** 0	**-0.150** -0.0059	**0** 0	**-0.150** -0.0059
	80.000 3.1496	**150.000** 5.9055	**0** 0	**-0.200** -0.0079	**0** 0	**-0.100** -0.0039	**0** 0	**-0.200** -0.0079	**0** 0	**-0.200** -0.0079	**0** 0	**-0.200** -0.0079	**0** 0	**-0.200** -0.0079
	150.000 5.9055	**180.000** 7.0866	**0** 0	**-0.200** -0.0079	**0** 0	**-0.100** -0.0039	**0** 0	**-0.250** -0.0098	**0** 0	**-0.250** -0.0098	**0** 0	**-0.250** -0.0098	**0** 0	**-0.250** -0.0098
	180.000 7.0866	**250.000** 9.8425	**0** 0	**-0.250** -0.0098	**0** 0	**-0.100** -0.0039	**0** 0	**-0.250** -0.0098	**0** 0	**-0.250** -0.0098	**0** 0	**-0.250** -0.0098	**0** 0	**-0.250** -0.0098
	250.000 9.8425	**315.000** 12.4016	**0** 0	**-0.250** -0.0098	**0** 0	**-0.100** -0.0039	**0** 0	**-0.300** -0.0118	**0** 0	**-0.300** -0.0118	**0** 0	**-0.300** -0.0118	**0** 0	**-0.300** -0.0118
	315.000 12.4016	**400.000** 15.7480	**0** 0	**-0.250** -0.0098	**0** 0	**-0.100** -0.0039	**0** 0	**-0.300** -0.0118	**0** 0	**-0.300** -0.0118	**0** 0	**-0.300** -0.0118	**0** 0	**-0.300** -0.0118
	400.000 15.7480	**500.000** 19.6850	**0** 0	**-0.300** -0.0118	**0** 0	**-0.100** -0.0039	**0** 0	**-0.350** -0.0138	– –	– –	– –	– –	– –	– –
	500.000 19.6850	**800.000** 31.4961	**0** 0	**-0.300** -0.0118	**0** 0	**-0.100** -0.0039	**0** 0	**-0.350** -0.0138	– –	– –	– –	– –	– –	– –
	800.000 31.4961	**1250.000** 49.2126	**0** 0	**-0.350** -0.0138	– –	– –	**0** 0	**-0.400** -0.0157	– –	– –	– –	– –	– –	– –

[1]These differ slightly from tolerances in ISO 492. These differences normally have an insignificant effect on the mounting and performance of tapered roller bearings. The 30000 series ISO bearings also are available with the above parameter according to ISO 492.

TABLE 25. TAPERED ROLLER BEARING TOLERANCES – OUTER RING STAND (Metric)

Bearing Types	Bore		Standard Bearing Class				Precision Bearing Class							
			K		N		C		B		A		AA	
	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF(1)	**10.000** 0.3937	**18.000** 0.7087	**+0.100** +0.0039	**0** 0	**+0.050** +0.0020	**0** 0	**+0.100** +0.0039	**-0.100** -0.0039	(2)		(2)		(2)	
	18.000 0.7087	**80.000** 3.1496	**+0.100** +0.0039	**0** 0	**+0.050** +0.0020	**0** 0	**+0.100** +0.0039	**-0.100** -0.0039						
	80.000 3.1496	**120.000** 4.7244	**+0.100** +0.0039	**-0.100** -0.0039	**+0.050** +0.0020	**0** 0	**+0.100** +0.0039	**-0.100** -0.0039						
	120.000 4.7244	**315.000** 12.4016	**+0.200** +0.0079	**-0.100** -0.0039	**+0.100** +0.0039	**0** 0	**+0.100** +0.0039	**-0.100** -0.0039						
	315.000 12.4016	**400.000** 15.7480	**+0.200** +0.0079	**-0.200** -0.0079	**+0.100** +0.0039	**0** 0	**+0.100** +0.0039	**-0.150** -0.0059	– –	– –	– –	– –	– –	– –
	400.000 15.7480	– –	(2)	(2)	(2)	(2)	(2)	(2)	– –	– –	– –	– –	– –	– –

(1)Stand for flanged outer ring is measured from flange backface (seating face).
(2)These sizes manufactured as matched assemblies only.



Outer Ring Stand. Outer ring stand is a measure of the variation in outer ring I.D. size and taper. This is checked by measuring the axial location of the reference surface of a master plug or other type gauge with respect to the reference face of the outer ring.

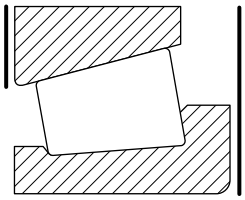


TABLE 26. TAPERED ROLLER BEARING TOLERANCES – OVERALL BEARING WIDTH (Metric)

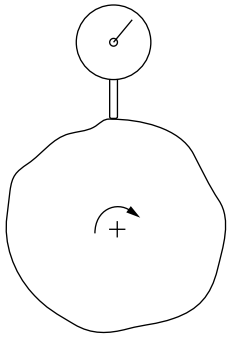
Bearing Types	Bore		Standard Bearing Class				Precision Bearing Class							
			K		N		C		B		A		AA	
	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF[1]	**10.000** 0.3937	**80.000** 3.1496	**+0.200** +0.0079	**0** 0	**+0.100** +0.0039	**0** 0	**+0.200** +0.0079	**-0.200** -0.0079	**+0.200** +0.0079	**-0.200** -0.0079	**+0.200** +0.0079	**-0.200** -0.0079	**+0.200** +0.0079	**-0.200** -0.0079
	80.000 3.1496	**120.000** 4.7244	**+0.200** +0.0079	**-0.200** -0.0079	**+0.100** +0.0039	**0** 0	**+0.200** +0.0079	**-0.200** -0.0079	**+0.200** +0.0079	**-0.200** -0.0079	**+0.200** +0.0079	**-0.200** -0.0079	**+0.200** +0.0079	**-0.200** -0.0079
	120.000 4.7244	**180.000** 7.0866	**+0.350** +0.0138	**-0.250** -0.0098	**+0.150** +0.0059	**0** 0	**+0.350** +0.0138	**-0.250** -0.0098	**+0.200** +0.0079	**-0.250** -0.0098	**+0.200** +0.0079	**-0.250** -0.0098	**+0.200** +0.0079	**-0.250** -0.0098
	180.000 7.0866	**250.000** 9.8425	**+0.350** +0.0138	**-0.250** -0.0098	**+0.150** +0.0059	**0** 0	**+0.350** +0.0138	**-0.250** -0.0098	**+0.200** +0.0079	**-0.250** -0.0098	**+0.200** +0.0079	**-0.300** -0.0118	**+0.200** +0.0079	**-0.300** -0.0118
	250.000 9.8425	**315.000** 12.4016	**+0.350** +0.0138	**-0.250** -0.0098	**+0.200** +0.0079	**0** 0	**+0.350** +0.0138	**-0.250** -0.0098	**+0.200** +0.0079	**-0.250** -0.0098	**+0.200** +0.0079	**-0.300** -0.0118	**+0.200** +0.0079	**-0.300** -0.0118
	315.000 12.4016	**400.000** 15.7480	**+0.400** +0.0157	**-0.400** -0.0157	**+0.200** +0.0079	**0** 0	**+0.350** +0.0138	**-0.300** -0.0118	– –	– –	– –	– –	– –	– –
	400.000 15.7480	**500.000** 19.6850	**+0.400** +0.0157	**-0.400** -0.0157	**+0.200** +0.0079	**0** 0	**+0.350** +0.0138	**-0.300** -0.0118	– –	– –	– –	– –	– –	– –
	500.000 19.6850	**630.000** 24.8031	**+0.400** +0.0157	**-0.400** -0.0157	– –	– –	**+0.350** +0.0138	**-0.400** -0.0157	– –	– –	– –	– –	– –	– –
	630.000 24.8031	**800.000** 31.4961	**+0.400** +0.0157	**-0.400** -0.0157	– –	– –	**+0.350** +0.0138	**-0.400** -0.0157	– –	– –	– –	– –	– –	– –
	800.000 31.4961	**1000.000** 39.3701	**+0.450** +0.0177	**-0.450** -0.0177	– –	– –	**+0.350** +0.0138	**-0.400** -0.0157	– –	– –	– –	– –	– –	– –
	1000.000 39.3701	**1250.000** 49.2126	**+0.450** +0.0177	**-0.450** -0.0177	– –	– –	**+0.350** +0.0138	**-0.450** -0.0177	– –	– –	– –	– –	– –	– –
	1250.000 49.2126	**1600.000** 62.9921	**+1.050** +0.0413	**-1.050** -0.0413	– –	– –	**+0.350** +0.0138	**-0.500** -0.0197	– –	– –	– –	– –	– –	– –
	1600.000 62.9921	**2000.000** 78.7402	**+1.200** +0.0472	**-1.200** -0.0472	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
	2000.000 78.7402	**2500.000** 98.4252	**+1.600** +0.0630	**-1.600** -0.0630	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –
SR[2]	**10.000** 0.3937	**500.000** 19.6850	– –	– –	**0** 0	**-0.150** -0.0059	– –	– –	– –	– –	– –	– –	– –	– –

[1]For bearing type TSF, the tolerance applies to the dimension T_1. Refer to the Tapered Roller Bearing Catalog available on www.timken.com.
[2]SR assemblies are manufactured to tolerance class N only.

TABLE 27. TAPERED ROLLER BEARING TOLERANCES – RADIAL RUNOUT (Metric)

Bearing Types	O.D. Over	O.D. Incl.	Standard Bearing Class K	Standard Bearing Class N	Precision Bearing Class C	Precision Bearing Class B	Precision Bearing Class A	Precision Bearing Class AA
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF SR[1]	**10.000** 0.3937	**18.000** 0.7087	**0.018** 0.0007	**0.018** 0.0007	**0.005** 0.00020	**0.003** 0.00012	**0.002** 0.00008	**0.001** 0.00004
	18.000 0.7087	**30.000** 1.1811	**0.018** 0.0007	**0.018** 0.0007	**0.005** 0.00020	**0.003** 0.00012	**0.002** 0.00008	**0.001** 0.00004
	30.000 1.1811	**50.000** 1.9685	**0.020** 0.0008	**0.020** 0.0008	**0.006** 0.00024	**0.003** 0.00012	**0.002** 0.00008	**0.001** 0.00004
	50.000 1.9685	**80.000** 3.1496	**0.025** 0.0010	**0.025** 0.0010	**0.006** 0.00024	**0.004** 0.00016	**0.002** 0.00008	**0.001** 0.00004
	80.000 3.1496	**120.000** 4.7244	**0.035** 0.0014	**0.035** 0.0014	**0.006** 0.00024	**0.004** 0.00016	**0.002** 0.00008	**0.001** 0.00004
	120.000 4.7244	**150.000** 5.9055	**0.040** 0.0016	**0.040** 0.0016	**0.007** 0.00028	**0.004** 0.00016	**0.002** 0.00008	**0.001** 0.00004
	150.000 5.9055	**180.000** 7.0866	**0.045** 0.0018	**0.045** 0.0018	**0.008** 0.00031	**0.004** 0.00016	**0.002** 0.00008	**0.001** 0.00004
	180.000 7.0866	**250.000** 9.8425	**0.050** 0.0020	**0.050** 0.0020	**0.010** 0.0004	**0.005** 0.00020	**0.002** 0.00008	**0.001** 0.00004
	250.000 9.8425	**315.000** 12.4016	**0.060** 0.0024	**0.060** 0.0024	**0.011** 0.0004	**0.005** 0.00020	**0.002** 0.00008	**0.001** 0.00004
	315.000 12.4016	**400.000** 15.7480	**0.070** 0.0028	**0.070** 0.0028	**0.013** 0.0005	**0.005** 0.00020	**0.002** 0.00008	**0.001** 0.00004
	400.000 15.7480	**500.000** 19.6850	**0.080** 0.0031	**0.080** 0.0031	**0.018** 0.0007	**–** –	**–** –	**–** –
	500.000 19.6850	**630.000** 24.8031	**0.100** 0.0039	**0.100** 0.0039	**0.025** 0.0010	**–** –	**–** –	**–** –
	630.000 24.8031	**800.000** 31.4961	**0.120** 0.0047	**–** –	**0.035** 0.0014	**–** –	**–** –	**–** –
	800.000 31.4961	**1000.000** 39.3701	**0.140** 0.0055	**–** –	**0.043** 0.0017	**–** –	**–** –	**–** –
	1000.000 39.3701	**1250.000** 49.2126	**0.160** 0.0063	**–** –	**0.052** 0.0020	**–** –	**–** –	**–** –
	1250.000 49.2126	**1600.000** 62.9921	**0.180** 0.0071	**–** –	**0.062** 0.0024	**–** –	**–** –	**–** –
	1600.000 62.9921	**2000.000** 78.7402	**0.200** 0.0079	**–** –	**0.073** 0.0029	**–** –	**–** –	**–** –
	2000.000 78.7402	**2500.000** 98.4252	**0.220** 0.0087	**–** –	**–** –	**–** –	**–** –	**–** –

[1]SR assemblies are manufactured to tolerance class N only.



Runout. Runout is a measure of rotational accuracy expressed by Total Indicator Reading (T.I.R.). Total displacement is measured by an instrument sensing against a moving surface, or moved with respect to a fixed surface. A radial runout measurement includes both roundness errors and the centering error of the surface that the instrument head senses against.

INCH SYSTEM

TAPERED ROLLER BEARINGS

Inch system bearings are manufactured to a number of tolerance classes. Classes 4 and 2 are often referred to as standard classes. Classes 3, 0, 00 and 000 are precision classes. Inch system bearings conform to ABMA standard 19.2.

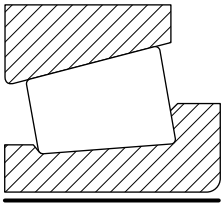


TABLE 28. TAPERED ROLLER BEARING TOLERANCES – INNER RING BORE (Inch)

Bearing Types	Bore		Standard Bearing Class				Precision Bearing Class							
			4		2		3		0		00		000	
	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF TSL[1] TDI TDIT TDO TNA	**0** 0	**76.200** 3.0000	**+0.013** +0.0005	**0** 0	**+0.013** +0.0005	**0** 0	**+0.013** +0.0005	**0** 0	**+0.013** +0.0005	**0** 0	**+0.008** +0.0003	**0** 0	**+0.008** +0.0003	**0** 0
	76.200 3.0000	**304.800** 12.0000	**+0.025** +0.0010	**0** 0	**+0.025** +0.0010	**0** 0	**+0.013** +0.0005	**0** 0	**+0.013** +0.0005	**0** 0	**+0.008** +0.0003	**0** 0	**+0.008** +0.0003	**0** 0
	304.800 12.0000	**609.600** 24.0000	– –	– –	**+0.051** +0.0020	**0** 0	**+0.025** +0.0010	**0** 0	– –	– –	– –	– –	– –	– –
	609.600 24.0000	**914.400** 36.0000	**+0.076** +0.0030	**0** 0	– –	– –	**+0.038** +0.0015	**0** 0	– –	– –	– –	– –	– –	– –
	914.400 36.0000	**1219.200** 48.0000	**+0.102** +0.0040	**0** 0	– –	– –	**+0.051** +0.0020	**0** 0	– –	– –	– –	– –	– –	– –
	1219.200 48.0000	– –	**+0.127** +0.0050	**0** 0	– –	– –	**+0.076** +0.0030	**0** 0	– –	– –	– –	– –	– –	– –

[1]For TSL bearings these are the normal tolerances of the inner ring bore. However, bore size can be slightly reduced at large end due to tight fit assembly of the seal on the rib. This should not have any effect on the performance of the bearing.

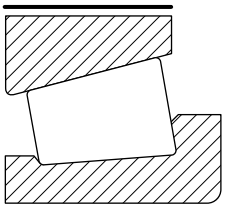
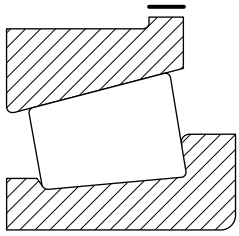


TABLE 29. TAPERED ROLLER BEARING TOLERANCES – OUTER RING OUTSIDE DIAMETER (Inch)

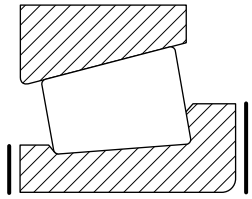
Bearing Types	O.D.		Standard Bearing Class				Precision Bearing Class							
			4		2		3		0		00		000	
	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF TSL TDI TDIT TDO TNA TNASW TNASWE	**0** 0	**304.800** 12.0000	**+0.025** +0.0010	**0** 0	**+0.025** +0.0010	**0** 0	**+0.013** +0.0005	**0** 0	**+0.013** +0.0005	**0** 0	**+0.008** +0.0003	**0** 0	**+0.008** +0.0003	**0** 0
	304.800 12.0000	**609.600** 24.0000	**+0.051** +0.0020	**0** 0	**+0.051** +0.0020	**0** 0	**+0.025** +0.0010	**0** 0	– –	– –	– –	– –	– –	– –
	609.600 24.0000	**914.400** 36.0000	**+0.076** +0.0030	**0** 0	**+0.076** +0.0030	**0** 0	**+0.038** +0.0015	**0** 0	– –	– –	– –	– –	– –	– –
	914.400 36.0000	**1219.200** 48.0000	**+0.102** +0.0040	**0** 0	– –	– –	**+0.051** +0.0020	**0** 0	– –	– –	– –	– –	– –	– –
	1219.200 48.0000	– –	**+0.127** +0.0050	**0** 0	– –	– –	**+0.076** +0.0030	**0** 0	– –	– –	– –	– –	– –	– –

TABLE 30. TAPERED ROLLER BEARING TOLERANCES – OUTER RING FLANGE (Inch)



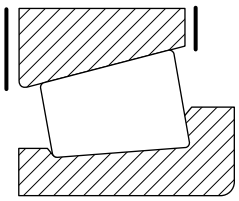
Bearing Types	O.D.		Standard Bearing Class				Precision Bearing Class							
			4		2		3		0		00		000	
	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TSF	**0** 0	**304.800** 12.0000	**+0.051** +0.0020	**0** 0	**+0.051** +0.0020	**0** 0	**+0.051** +0.0020	**0** 0	**+0.051** +0.0020	**0** 0	**+0.051** +0.0020	**0** 0	**+0.051** +0.0020	**0** 0
	304.800 12.0000	**609.600** 24.0000	**+0.076** +0.0030	**0** 0	**+0.076** +0.0030	**0** 0	**+0.076** +0.0030	**0** 0	**+0.051** +0.0020	**0** 0	**+0.051** +0.0020	**0** 0	**+0.051** +0.0020	**0** 0
	609.600 24.0000	**914.400** 36.0000	**+0.102** +0.0040	**0** 0	**+0.102** +0.0040	**0** 0	**+0.102** +0.0040	**0** 0	– –	– –	– –	– –	– –	– –
	914.400 36.0000	– –	**+0.127** +0.0050	**0** 0	– –	– –	**+0.127** +0.0050	**0** 0	– –	– –	– –	– –	– –	– –

TABLE 31. TAPERED ROLLER BEARING TOLERANCES – INNER RING WIDTH (Inch)

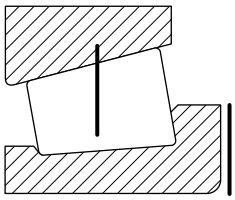


Bearing Types	Bore		Standard Bearing Class				Precision Bearing Class							
			4		2		3		0		00		000	
	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF TSL 2S TDI TDIT TDO	All Sizes		**+0.076** +0.0030	**-0.254** -0.0100	**+0.076** +0.0030	**-0.254** -0.0100	**+0.076** +0.0030	**-0.254** -0.0100	**+0.076** +0.0030	**-0.254** -0.0100	**+0.076** +0.0030	**-0.254** -0.0100	**+0.076** +0.0030	**-0.254** -0.0100

TABLE 32. TAPERED ROLLER BEARING TOLERANCES – OUTER RING WIDTH (Inch)



Bearing Types	O.D.		Standard Bearing Class				Precision Bearing Class							
			4		2		3		0		00		000	
	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
All Types	All Sizes		**+0.051** +0.0020	**-0.254** -0.0100	**+0.051** +0.0020	**-0.254** -0.0100	**+0.051** +0.0020	**-0.254** -0.0100	**+0.051** +0.0020	**-0.254** -0.0100	**+0.051** +0.0020	**-0.254** -0.0100	**+0.051** +0.0020	**-0.254** -0.0100

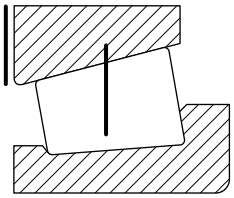


Inner Ring Stand. Inner ring stand is a measure of the variation in inner ring raceway size, taper and roller diameter. This is checked by measuring the axial location of the reference surface of a master outer ring or other type gauge with respect to the reference inner ring face.

TABLE 33. TAPERED ROLLER BEARING TOLERANCES – INNER RING STAND (Inch)

Bearing Types	Bore		Cup O.D.		Standard Bearing Class				Precision Bearing Class							
					4		2		3		0		00		000	
	Over	Incl.	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF TSL 2S TDI[1] TDIT[1] TDO	**0** 0	**101.600** 4.0000	**0** 0	– –	**+0.102** +0.0040	**0** 0	**+0.102** +0.0040	**0** 0	**+0.102** +0.0040	**-0.102** -0.0040	(2)	(2)	(2)	(2)	(2)	(2)
	101.600 4.0000	**304.800** 12.0000	**0** 0	– –	**+0.152** +0.0060	**-0.152** -0.0060	**+0.102** +0.0040	**0** 0	**+0.102** +0.0040	**-0.102** -0.0040						
	304.800 12.0000	**406.400** 16.0000	**0** 0	**508.000** 20.0000	– –	– –	**+0.178** +0.0070	**-0.178** -0.0070	**+0.102** +0.0040	**-0.102** -0.0040	– –	– –	– –	– –	– –	– –
	304.800 12.0000	**406.400** 16.0000	**508.000** 20.0000	– –	– –	– –	**+0.178** +0.0070	**-0.178** -0.0070	**+0.178** +0.0070	**-0.178** -0.0070	– –	– –	– –	– –	– –	– –
	406.400 16.0000	– –	**0** 0	– –	(2)		(2)		(2)		– –	– –	– –	– –	– –	– –

[1]For class 2, TDI and TDIT bearings with an inner ring bore of 101.600 to 304.800 mm (4.0000 to 12.0000 in.), the inner ring stand is ±0.102 mm (±0.0040 in.).
[2]These sizes manufactured as matched assemblies only.



Outer Ring Stand. Outer ring stand is a measure of the variation in outer ring I.D. size and taper. This is checked by measuring the axial location of the reference surface of a master plug or other type gauge with respect to the reference face of the outer ring.

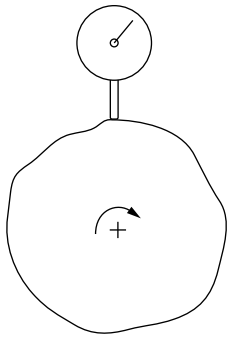
TABLE 34. TAPERED ROLLER BEARING TOLERANCES – OUTER RING STAND (Inch)

Bearing Types	Bore		Cup O.D.		Standard Bearing Class				Precision Bearing Class							
					4		2		3		0		00		000	
	Over	Incl.	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF[1] TSL TDI TDIT	**0** 0	**101.600** 4.0000	**0** 0	– –	**+0.102** +0.0040	**0** 0	**+0.102** +0.0040	**0** 0	**+0.102** +0.0040	**-0.102** -0.0040	(2)	(2)	(2)	(2)	(2)	(2)
	101.600 4.0000	**304.800** 12.0000	**0** 0	– –	**+0.203** +0.0080	**-0.102** -0.0040	**+0.102** +0.0040	**0** 0	**+0.102** +0.0040	**-0.102** -0.0040						
	304.800 12.0000	**406.400** 16.0000	**0** 0	**508.000** 20.0000	– –	– –	**+0.203** +0.0080	**-0.203** -0.0080	**+0.102** +0.0040	**-0.102** -0.0040	– –	– –	– –	– –	– –	– –
	304.800 12.0000	**406.400** 16.0000	**508.000** 20.0000	– –	**+0.203** +0.0080	**-0.203** -0.0080	**+0.203** +0.0080	**-0.203** -0.0080	**+0.203** +0.0080	**-0.203** -0.0080	– –	– –	– –	– –	– –	– –
	406.400 16.0000	– –	**0** 0	– –	(2)	(2)	(2)	(2)	(2)	(2)	– –	– –	– –	– –	– –	– –

[1]Stand for flanged outer ring is measured from flange backface (seating face).
[2]These sizes manufactured as matched assemblies only.

TABLE 35. TAPERED ROLLER BEARING TOLERANCES – RADIAL RUNOUT (Inch)

Bearing Types	O.D. Over	O.D. Incl.	Standard Bearing Class 4	Standard Bearing Class 2	Precision Bearing Class 3	Precision Bearing Class 0	Precision Bearing Class 00	Precision Bearing Class 000
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF TSL 2S TDI TDIT TDO TNA TNASW TNASWE	**0** 0	**304.800** 12.0000	**0.051** 0.0020	**0.038** 0.0015	**0.008** 0.0003	**0.004** 0.00015	**0.002** 0.000075	**0.001** 0.00004
	304.800 12.0000	**609.600** 24.0000	**0.051** 0.0020	**0.038** 0.0015	**0.018** 0.0007	**0.004** 0.00015	**0.002** 0.000075	**0.001** 0.00004
	609.600 24.0000	**914.400** 36.0000	**0.076** 0.0030	**0.051** 0.0020	**0.051** 0.0020	– –	– –	– –
	914.400 36.0000	– –	**0.076** 0.0030	– –	**0.076** 0.0030	– –	– –	– –



Runout. Runout is a measure of rotational accuracy expressed by Total Indicator Reading (T.I.R.). Total displacement is measured by an instrument sensing against a moving surface, or moved with respect to a fixed surface. A radial runout measurement includes both roundness errors and the centering error of the surface that the instrument head senses against.

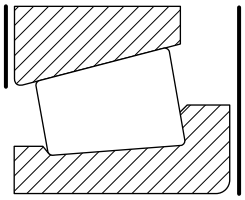
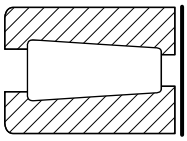


TABLE 36. TAPERED ROLLER BEARING TOLERANCES – OVERALL BEARING WIDTH (Inch)

Bearing Types	Bore		O.D.		Standard Bearing Class				Precision Bearing Class							
					4		2		3		0		00		000	
	Over	Incl.	Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
TS TSF[1] TSL	**0** 0	**101.600** 4.0000	– –	– –	**+0.203** +0.0080	**0** 0	**+0.203** +0.0080	**0** 0	**+0.203** +0.0080	**-0.203** -0.0080	**+0.203** +0.0080	**-0.203** -0.0080	**+0.203** +0.0080	**-0.203** -0.0080	**+0.203** +0.0080	**-0.203** -0.0080
	101.600 4.0000	**304.800** 12.0000	– –	– –	**+0.356** +0.0140	**-0.254** -0.0100	**+0.203** +0.0080	**0** 0	**+0.203** +0.0080	**-0.203** -0.0080	**+0.203** +0.0080	**-0.203** -0.0080	**+0.203** +0.0080	**-0.203** -0.0080	**+0.203** +0.0080	**-0.203** -0.0080
	304.800 12.0000	**609.600** 24.0000	**0** 0	**508.000** 20.0000	– –	– –	**+0.381** +0.0150	**-0.381** -0.0150	**+0.203** +0.0080	**-0.203** -0.0080	– –	– –	– –	– –	– –	– –
	304.800 12.0000	**609.600** 24.0000	**508.000** 20.0000	– –	– –	– –	**+0.381** +0.0150	**-0.381** -0.0150	**+0.381** +0.0150	**-0.381** -0.0150	– –	– –	– –	– –	– –	– –
	609.600 24.0000	– –	– –	– –	**+0.381** +0.0150	**-0.381** -0.0150	– –	– –	**+0.381** +0.0150	**-0.381** -0.0150	– –	– –	– –	– –	– –	– –
TNA TNASW TNASWE	**0** 0	**127.000** 5.0000	– –	– –	– –	– –	**+0.254** +0.0100	**0** 0	**+0.254** +0.0100	**0** 0	– –	– –	– –	– –	– –	– –
	127.000 5.0000	– –	– –	– –	– –	– –	**+0.762** +0.0300	**0** 0	**+0.762** +0.0300	**0** 0	– –	– –	– –	– –	– –	– –
TDI TDIT TDO	**0** 0	**101.600** 4.0000	– –	– –	**+0.406** +0.0160	**0** 0	**+0.406** +0.0160	**0** 0	**+0.406** +0.0160	**-0.406** -0.0160	**+0.406** +0.0160	**-0.406** -0.0160	**+0.406** +0.0160	**-0.406** -0.0160	**+0.406** +0.0160	**-0.406** -0.0160
	101.600 4.0000	**304.800** 12.0000	– –	– –	**+0.711** +0.0280	**-0.508** -0.0200	**+0.406** +0.0160	**-0.203** -0.0080	**+0.406** +0.0160	**-0.406** -0.0160	**+0.406** +0.0160	**-0.406** -0.0160	**+0.406** +0.0160	**-0.406** -0.0160	**+0.406** +0.0160	**-0.406** -0.0160
	304.800 12.0000	**609.600** 24.0000	**0** 0	**508.000** 20.0000	– –	– –	**+0.762** +0.0300	**-0.762** -0.0300	**+0.406** +0.0160	**-0.406** -0.0160	– –	– –	– –	– –	– –	– –
	304.800 12.0000	**609.600** 24.0000	**508.000** 20.0000	– –	– –	– –	**+0.762** +0.0300	**-0.762** -0.0300	**+0.762** +0.0300	**-0.762** -0.0300	– –	– –	– –	– –	– –	– –
	609.600 24.0000	– –	– –	– –	**+0.762** +0.0300	**-0.762** -0.0300	– –	– –	**+0.762** +0.0300	**-0.762** -0.0300	– –	– –	– –	– –	– –	– –
2S	**0** 0	**101.600** 4.0000	– –	– –	**+0.457** +0.0180	**-0.051** -0.0020	**+0.457** +0.0180	**-0.051** -0.0020	– –	– –	– –	– –	– –	– –	– –	– –

[1]For bearing type TSF, the tolerance applies to the dimension T_1. Refer to the Tapered Roller Bearing Catalog available on www.timken.com.

TABLE 37. THRUST TAPERED ROLLER BEARING TOLERANCES – BORE (Inch)



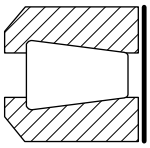
TTHD, TTHDFL, TTVS

TTHD, TTHDFL, TTVS

Bore		Bearing Class			
Range		Precision 2		Precision 3	
Over	Incl.	Over	Incl.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0 0	**304.800** 12.0000	**+0.025** +0.0010	**0** 0	**+0.013** +0.0005	**0** 0
304.800 12.0000	**609.600** 24.0000	**+0.051** +0.0020	**0** 0	**+0.025** +0.0010	**0** 0
609.600 24.0000	**914.400** 36.0000	**+0.076** +0.0030	**0** 0	**+0.038** +0.0015	**0** 0
914.400 36.0000	**1219.200** 48.0000	**+0.102** +0.0040	**0** 0	**+0.051** +0.0020	**0** 0
1219.200 48.0000	– –	**+0.127** +0.0050	**0** 0	**+0.076** +0.030	**0** 0

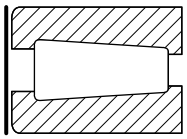
TTC, TTSP – CLASS 4

Bore		Deviation	
Range		Precision 4	
Over	Incl.	Over	Incl.
mm in.	**mm** in.	**mm** in.	**mm** in.
0 0	**25.400** 1.0000	**+0.076** +0.0030	**-0.076** -0.0030
25.400 1.0000	**76.200** 3.0000	**+0.102** +0.0040	**-0.102** -0.0040
76.200 3.0000	– –	**+0.127** +0.0050	**-0.127** -0.0050



TTC, TTSP

TABLE 38. THRUST TAPERED ROLLER BEARING TOLERANCES – OUTSIDE DIAMETER (Inch)



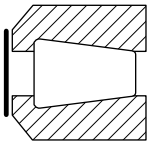
TTHD, TTHDFL, TTVS

TTHD, TTHDFL, TTVS

Outside Diameter		Bearing Class			
Range		Precision 2		Precision 3	
Over	Incl.	Over	Incl.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0 0	**304.800** 12.0000	**+0.025** +0.0010	**0** 0	**+0.013** +0.0005	**0** 0
304.800 12.0000	**609.600** 24.0000	**+0.051** +0.0020	**0** 0	**+0.025** +0.0010	**0** 0
609.600 24.0000	**914.400** 36.0000	**+0.076** +0.0030	**0** 0	**+0.038** +0.0015	**0** 0

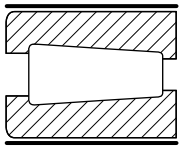
TTC, TTSP – CLASS 4

Outside Diameter		Deviation	
Range		Precision 4	
Over	Incl.	Over	Incl.
mm in.	**mm** in.	**mm** in.	**mm** in.
0 0	**127.000** 5.0000	**+0.254** +0.0100	**0** 0
127.000 5.0000	**203.200** 8.0000	**+0.381** +0.0150	**0** 0
203.200 8.0000	– –	**+0508** +0.200	**0** 0



TTC, TTSP

TABLE 39. THRUST TAPERED ROLLER BEARING TOLERANCES – WIDTH (Inch)



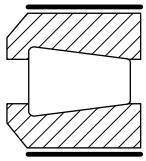
TTHD, TTHDFL, TTVS

TTHD, TTHDFL, TTVS

Width		Bearing Class			
Range		Precision 2		Precision 3	
Over	Incl.	Over	Incl.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
All Sizes		**+0.381** +0.0150	**-0.381** -0.0150	**+0.203** +0.0080	**-0.203** -0.0080

TTC, TTSP – CLASS 4

Width		Deviation	
Range		Precision 4	
Over	Incl.	Over	Incl.
mm in.	**mm** in.	**mm** in.	**mm** in.
0 0	**76.200** 3.0000	**+0.254** +0.0100	**-0.254** -0.0100
76.200 3.0000	**127.000** 5.0000	**+0.381** +0.0150	**-0.381** -0.0150
127.000 5.0000	– –	**+0508** +0.200	**-0.508** -0.0200



TTC, TTSP

MOUNTING DESIGN, FITTING PRACTICE, SETTING AND INSTALLATION

To achieve expected bearing performance, it is critical that proper mounting design, fitting practices, settings and installation procedures are followed. While there are differences between tapered roller, cylindrical roller, spherical roller, radial ball and angular contact ball bearings relative to these practices, there are many similarities that apply to all. These similarities are summarized in the sections below, followed by a summary of practices specific to each bearing type.

MOUNTING

All bearing types are typically mounted onto a shaft and into a housing wherein the shaft and housing have shoulders to back the rings. The purpose of the shoulder is to positively establish the axial location and alignment of the bearing under all operating conditions. Various types of backing shoulder designs can be used as shown in fig. 77. The conventional method uses a shoulder machined on a shaft or in the housing. In some applications, snap rings are used as the shoulder. For either solid shoulder or snap ring designs, spacers can be used between the bearing raceway and shoulder if necessary. It is essential that a shoulder be square with the bearing ring and of sufficient diameter to provide adequate backing of the bearing raceway. It also must be of sufficient section to resist axial movement under loading, and must be wear resistant at the interface with the bearing.

It is highly recommended that roller bearing shaft seats be ground to a surface finish of 1.6 µm (65 µin) Ra maximum. Ball bearing seats should be 0.8 µm (32 µin) for shafts under 2 inches and 1.6 µm (65 µin) for all other sizes.

When shaft seats are turned, a tighter heavy-duty fit should be used. The shaft diameter should be turned to a finish of 3.2 µm (125 µin) Ra maximum.

Housing bores should be finished to 3.2 µm (125 µin) Ra maximum.

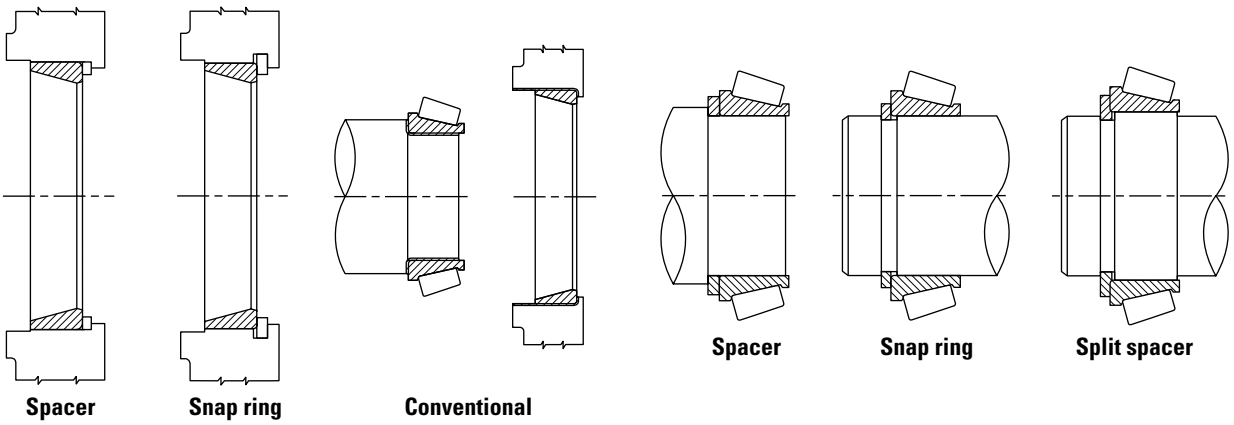


Fig. 77. Backing designs.

⚠WARNING
Failure to observe the following warnings could create a risk of death or serious injury.

Proper maintenance and handling practices are critical. Always follow installation instructions and maintain proper lubrication.

Never spin a bearing with compressed air. The rollers may be forcefully expelled.

FITTING PRACTICE

As a general guideline, bearing rings mounted on a rotating member should have an interference fit. Loose fits may permit the ring to creep or turn and wear the mating surface and backing shoulder. This wear can result in excessive bearing looseness and damage to the bearing, shaft or housing.

The choice of fitting practices will mainly depend upon the following parameters:

- Precision class of the bearing.
- Rotating or stationary ring.
- Type of layout (single- or double-row bearings).
- Type and direction of load (continuous/alternate rotating).
- Particular running conditions like shocks, vibrations, overloading or high speed.
- Capability for machining the seats (grinding, turning or boring).
- Shaft and housing section and material.
- Mounting and setting conditions.

Fig. 78 is a graphical representation of roller bearing shaft and housing fit selection that conforms to accepted industry standards and practices. The bars designated g6, h6, etc., represent shaft/housing diameter and tolerance ranges to achieve various loose and interference fits required for various load and ring rotation conditions.

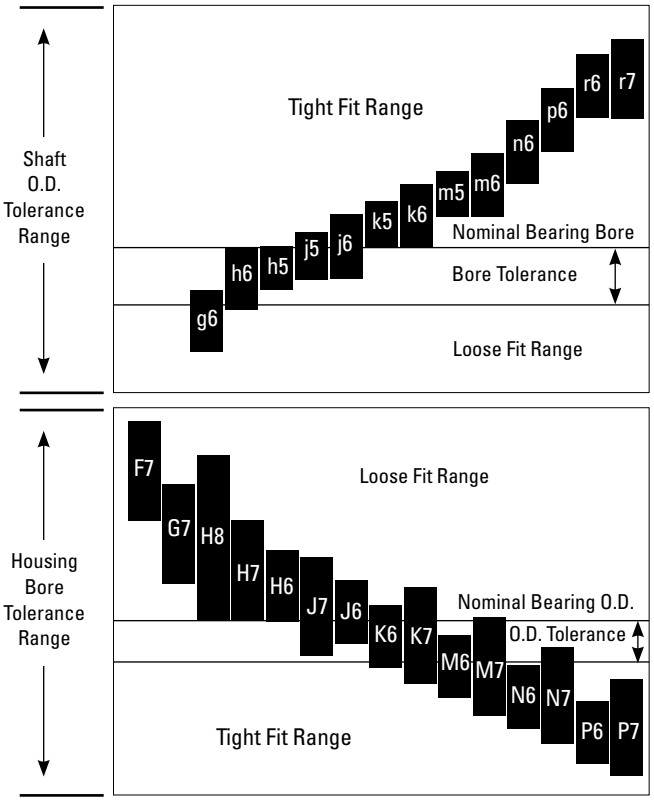


Fig. 78. Shaft and housing fit selection.

SETTING

In the manufacture of rolling element bearings, it is standard practice to assemble rings and rolling elements with a specified internal clearance.

Internal clearance is often utilized to compensate for the effects of interference fits and thermal expansion of bearings, shafts and housings. For some bearing types, it also can provide a desired contact angle in the bearing after mounting.

Internal clearance can be measured by either gauging radially or axially. Radial clearance is accepted as the typical setting characteristic to measure for most bearing types because it is more directly related to bearing fits. This is commonly referred to as radial internal clearance (RIC). Tapered roller bearings and angular contact bearings are the exception as setting in these bearings is usually measured in the axial direction.

Correct bearing mounting and fitting practices are key components of proper bearing setting.

INSTALLATION

Proper bearing installation, including cleanliness of the components, as well as use of proper tools, is critical to bearing performance.

Cleanliness of the bearing and mating components is essential for a bearing to achieve maximum service life. Burrs, foreign material and any raised portions of the components mating with the bearing can cause misalignment. Care should be taken to avoid these conditions. Shafts and housings, including lubrication holes, should be thoroughly cleaned before bearing installation. If blind holes are present, insert a magnetic rod to remove metal chips that might have accumulated during manufacture. An air hose may be used on shafts and housings, but should not be used on bearings. Bearings in their shipping containers are typically coated with a rust-inhibitive oil. This oil is compatible with most lubricants and does not need to be removed prior to installation.

Adequate tools must be used to properly fit the inner rings onto the shaft and outer rings into the housing to avoid damage. Direct shock on the rings must be avoided.

Most applications require a tight interference fit of one or both rings. It is acceptable to heat or cool rings to ease assembly. Standard bearings should not be heated above 120° C (250° F) or cooled below -55° C (-65° F). Precision bearings should not be heated above 65° C (150° F) or cooled below -30° C (-20° F).

An alternate method of mounting, generally used on smaller sizes, is to press the bearing onto the shaft or into the housing using an arbor press.

For more information on these installation procedures, please contact your Timken engineer.

Specific mounting design, fitting practice, setting and installation recommendations are summarized in the following pages for tapered roller, cylindrical roller, spherical roller, radial ball and angular contact ball bearings.

TAPERED ROLLER BEARINGS

MOUNTING

Tapered roller bearings are designed to take both radial and thrust loading. Under radial loads, a force is generated in the axial direction that must be counteracted. As a result, tapered roller bearings are normally adjusted against a second bearing. They can be mounted in either a direct or indirect mounting arrangement shown in fig. 79. For applications where a direct mounting arrangement is used and the outer ring is used to adjust the bearing setting, the outer ring is usually set in position by an outer-ring follower or mounted in an outer-ring carrier. See fig. 80.

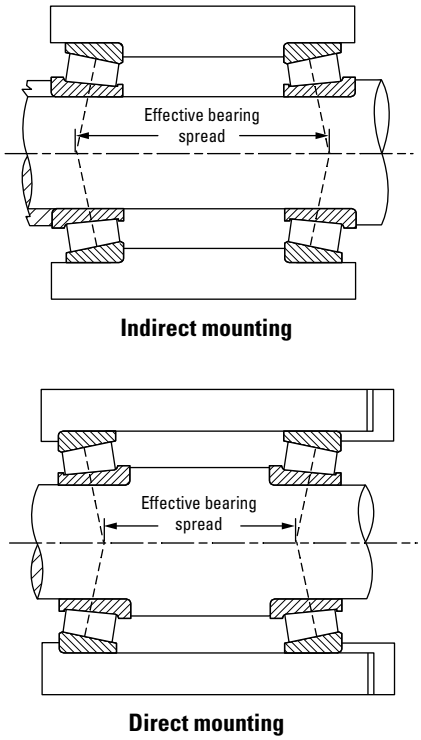


Fig. 79. Comparison of mounting stability between indirect and direct mountings.

For indirect mountings, bearing setting is typically achieved by clamping against one of the inner rings. Various designs, including locknuts, stakenuts and end plates as shown in fig. 81 can be used. For applications requiring precision-class bearings, a special precision nut can be used.

Backing shoulder diameters are listed for tapered roller bearings in the Tapered Roller Bearing Catalog on www.timken.com.

FITTING PRACTICE

General industrial application fitting practice standards for inner rings and outer rings are shown in the tables starting on page 154. These tables apply to solid or heavy-sectioned steel shafts, heavy-sectioned ferrous housings and normal operating conditions. To use the tables, it is necessary to determine if the member is rotating or stationary, the magnitude, direction and type of loading, and the shaft finish.

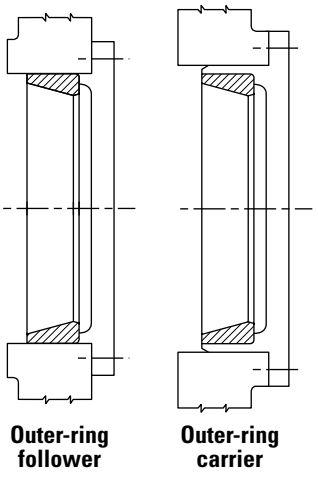


Fig. 80. Bearing setting devices - direct mounting.

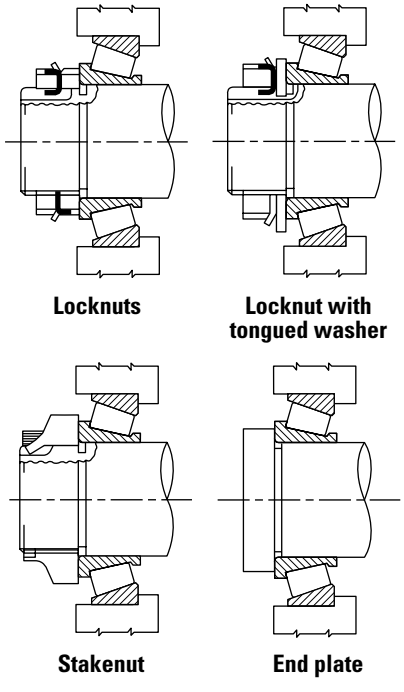


Fig. 81. Bearing setting devices – indirect mounting.

Certain table fits may not be adequate for light shaft and housing sections, shafts other than steel, nonferrous housings, critical operation conditions such as high speed, unusual thermal or loading conditions or a combination thereof. Also, assembly procedures and the means and ease of obtaining the bearing setting may require special fits. In these cases, experience should be used as a guideline or your Timken engineer should be consulted for review and suggestions.

Rotating inner rings generally should be applied with an interference fit. In special cases, loose fits may be considered if it has been determined by test or experience they will perform satisfactorily. The term "rotating inner ring" describes a condition in which the inner ring rotates relative to the load. This may occur with a rotating inner ring under a stationary load or a stationary inner ring with a rotating load. Loose fits will permit the inner rings to creep and wear the shaft and the backing shoulder. This may result in excessive bearing looseness and possible bearing and shaft damage.

Stationary inner ring fitting practice depends on the application. Under conditions of high speed, heavy loads or shock, interference fits using heavy-duty fitting practices should be used. With inner rings mounted on unground shafts subjected to moderate loads (no shock) and moderate speeds, a metal-to-metal or near zero average fit is used. In sheave and wheel applications using unground shafts, or in cases using ground shafts with moderate loads (no shock), a minimum fit near zero to a maximum looseness that varies with the inner ring bore size is suggested. In stationary inner ring applications requiring hardened and ground spindles, a slightly looser fit may be satisfactory. Special fits also may be necessary on installations such as multiple sheave crane blocks.

Rotating outer ring applications where the outer ring rotates relative to the load should always use an interference fit.

Stationary, non-adjustable and fixed single-row outer ring applications should be applied with a tight fit wherever practical. Generally, adjustable fits may be used where the bearing setup is obtained by sliding the outer ring axially in the housing bore. However, in certain heavy-duty, high-load applications, tight fits are necessary to prevent pounding and plastic deformation of the housing. Tightly fitted outer rings mounted in carriers can be used. Tight fits should always be used when the load rotates relative to the outer ring.

To permit through-boring when the outside diameters of single-row bearings mounted at each end of a shaft are equal, and one is adjustable and the other fixed, it is suggested that the same adjustable fit be used at both ends. However, tight fits should be used if outer rings are backed against snap rings to prevent excessive dishing of snap rings, groove wear and possible loss of ring retention. Only outer rings with a maximum housing fillet radius requirement of 1.3 mm (0.05 in.) or less should be considered for a snap ring backing.

Double-row stationary double outer rings are generally mounted with loose fits to permit assembly and disassembly. The loose fit also permits float when a floating bearing is mounted in conjunction with an axially fixed bearing on the other end of the shaft.

Fitting practice tables 70-81 on pages 138-163, have been prepared for both metric and inch dimensions.

For the inch system bearings, classes 4 and 2 (standard) and classes 3, 0, and 00 (precision) have been included.

The metric system bearings that have been included are: classes K and N (metric system standard bearings) and classes C, B, and A (metric system precision bearings).

Precision-class bearings should be mounted on shafts and in housings which are similarly finished to at least the same

precision limits as the bearing bore and O.D. High-quality surface finishes also should be provided. Recommended surface finishes are shown on page 119 for tapered roller bearings and pages 121-122 for ball bearings.

Effects of tight fits on bearing setting/width

Interference fits of the inner ring cause inner ring expansion and interference fits of the outer ring cause outer ring contraction. As the inner ring diameters increase and the outer ring diameters decrease, internal clearance within the bearing is reduced and bearing width is increased. The change in clearance or setting is approximately equal to the change in width.

For matched assemblies where the setting is pre-set from the factory and SET-RIGHT assemblies, the effects of fit must be taken into account to provide the desired mounted setting.

Double-row and four-row bearings that are provided with spacers are examples of matched assemblies. These bearings are pre-set to a specific bench endplay or axial clearance prior to installation into the application. Mounting the bearing with a tight fit will reduce this bench endplay. In order to meet the desired mounted setting, the bench endplay must be compensated for the fit effect.

SET-RIGHT assemblies rely on the control of bearing, shaft and housing tolerances to known distributions, resulting in a statistical mounted bearing setting range. This mounted setting takes into account any reductions in setting due to tight fits.

Bearing width increase can affect setting in applications such as outer-ring-adjusted, direct-mounting designs. In this case, a shim is inserted between the outer ring and a backing plate. Tight fits will affect calculation of the shim thickness. In other applications where axial tolerance summation calculations are made, tight fit effects must be taken into consideration.

For solid steel shafts and heavy-section steel housings, the change in setting is calculated as follows:

Inner ring setting reduction/width increase:

$$= 0.5 \left(\frac{K}{0.39}\right)\left(\frac{d}{d_o}\right)\delta_S$$

Outer ring setting reduction/width increase:

$$= 0.5 \left(\frac{K}{0.39}\right)\left(\frac{D_o}{D}\right)\delta_H$$

Interference fits on thin-walled shafts and light-section steel housings have a tendency to collapse the inner ring seat and stretch the outer ring seat, resulting in less change in bearing setting and overall width. The effects can be calculated according to the following formulas.

Inner ring setting reduction/width increase:

$$= 0.5 \left(\frac{K}{0.39}\right) \left\{ \frac{\left(\frac{d}{d_o}\right)\left[1 - \left(\frac{d_{si}}{d}\right)^2\right]}{1 - \left(\frac{d_{si}}{d_o}\right)^2} \delta_S \right\}$$

Outer ring setting reduction/width increase:

$$= 0.5 \left(\frac{K}{0.39}\right) \left\{ \frac{\left(\frac{D_o}{D}\right)\left[1 - \left(\frac{D}{D_H}\right)^2\right]}{1 - \left(\frac{D_o}{D_H}\right)^2} \delta_H \right\}$$

For shaft or housing material other than steel, consult your Timken engineer.

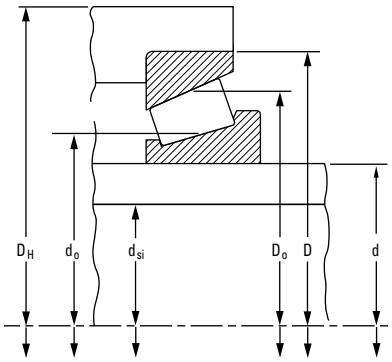


Fig. 82. Parameters for calculation of fit effect on setting.

SETTING

Setting is defined as the axial clearance between roller and raceway. Establishing the setting at the time of assembly is an inherent advantage of tapered roller bearings. They can be set to provide optimum performance in almost any application. Fig. 83 gives an example of the relationship between fatigue life and bearing setting. Unlike some types of anti-friction bearings, tapered roller bearings do not rely strictly on housing or shaft fits to obtain a certain bearing setting. One ring can be moved axially relative to the other to obtain the desired bearing setting.

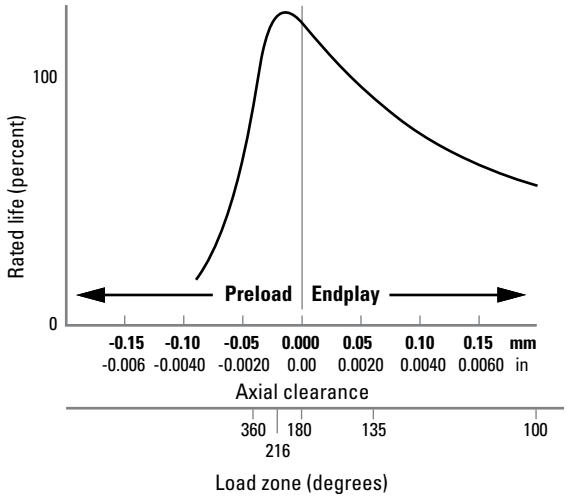


Fig. 83. Typical life vs. setting curve.

At assembly, the conditions of bearing setting are defined as:

- **Endplay (EP)** – An axial clearance between rollers and raceways producing a measurable axial shaft movement when a small axial force is applied – first in one direction then in the other, while oscillating or rotating the shaft. See fig. 84.
- **Preload (PL)** – An axial interference between rollers and raceways such that there is no measurable axial shaft movement when a small axial force is applied – in both directions – while oscillating or rotating the shaft.
- **Line-to-line** – A zero setting condition: the transitional point between endplay and preload.

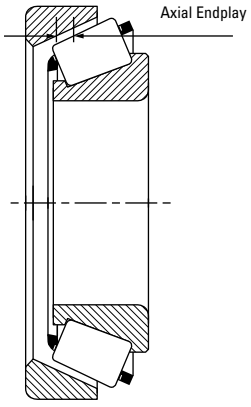


Fig. 84. Internal clearance – endplay.

Bearing setting obtained during initial assembly and adjustment is the cold or ambient bearing setting, and is established before the equipment is subjected to service.

Bearing setting during operation is known as the operating bearing setting, and is a result of changes in the ambient bearing setting due to thermal expansion and deflections encountered during service.

The ambient bearing setting necessary to produce the optimum operating bearing setting varies with the application. Application experience or testing generally determines optimum settings. Frequently, however, the exact relationship of ambient to operating bearing setting is unknown and an educated estimate has to be made. To determine a suggested ambient bearing setting for a specific application, contact your Timken engineer.

Generally, the ideal operating bearing setting is near zero to maximize bearing life (fig. 83). Most bearings are set with endplay at assembly to reach the desired near-zero setting at operating temperature.

There is an ideal bearing setting value for every application. To achieve this condition, the bearing setting must take into account deflection under load (radial + axial) as well as thermal expansions and material used.

1. Standard mounting

Operating setting = mounted setting ± temperature effect + deflection

2. Pre-set assemblies

Mounted EP or PL = bench EP or bench PL – effect of fits

Operating setting = mounted EP or PL (MEP or MPL) + deflection ± temperature effect

The temperature and fit effects will depend upon the type of mounting, bearing geometry and size, shaft and housing sizes, and material as defined in the following sections. Dimensional parameters affecting bearing setting are noted in fig. 85.

Fit effect[1]

Solid shaft/heavy section housing

Setting Reduction/Width Increase for Single Inner Ring

$$= 0.5 \left(\frac{K}{0.39}\right)\left(\frac{d}{d_o}\right) \delta_S$$

Setting Reduction/Width Increase for Single Outer Ring

$$= 0.5 \left(\frac{K}{0.39}\right)\left(\frac{D_o}{D}\right) \delta_H$$

Hollow shaft/thin-wall section

Shaft Reduction/Width Increase for Single Inner Ring

$$= 0.5 \left(\frac{K}{0.39}\right)\left(\frac{d}{d_o}\right) \left[\frac{1 - \left(\frac{d_{si}}{d}\right)^2}{1 - \left(\frac{d_{si}}{d_o}\right)^2}\right] \delta_S$$

Shaft Reduction/Width Increase for Single Outer Ring

$$= 0.5 \left(\frac{K}{0.39}\right)\left(\frac{D_o}{D}\right) \left[\frac{1 - \left(\frac{D}{D_H}\right)^2}{1 - \left(\frac{D_o}{D_H}\right)^2}\right] \delta_H$$

[1]These equations apply only to ferrous shaft and housing.

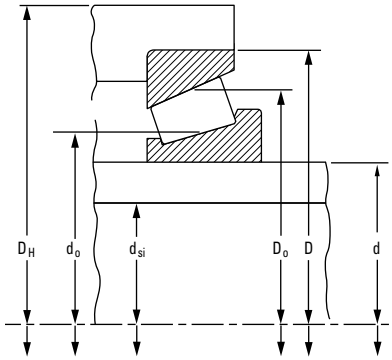


Fig. 85. Dimensional parameters affecting fit and temperature effects on setting.

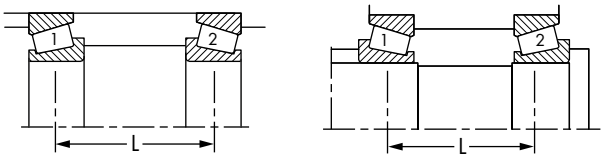
Temperature effect

Direct mounting - setting change due to temperature

$$= \alpha_T \Delta T \left[\left(\frac{K_1}{0.39}\right)\left(\frac{D_{o1}}{2}\right) + \left(\frac{K_2}{0.39}\right)\left(\frac{D_{o2}}{2}\right) + L\right]$$

Indirect mounting - setting change due to temperature

$$= \alpha_T \Delta T \left[\left(\frac{K_1}{0.39}\right)\left(\frac{D_{o1}}{2}\right) + \left(\frac{K_2}{0.39}\right)\left(\frac{D_{o2}}{2}\right) - L\right]$$



Direct mounting **Indirect mounting**

Fig. 86. Direct and indirect mounting.

Setting methods

Upper and lower limits of bearing setting values are determined by consideration of the following factors:

- Application type.
- Duty cycle/loading.
- Operational features of adjacent mechanical drive elements.
- Changes in bearing setting due to temperature differentials and deflections.
- Size of bearing and method of obtaining bearing setting.
- Lubrication method.
- Housing and shaft material.

The setting value to be applied during assembly will depend on any changes that may occur during operation. In the absence of experience with bearings of similar size and operating conditions, a bearing setting range suggestion should be obtained from your Timken engineer.

SPHERICAL AND CYLINDRICAL ROLLER BEARINGS

MOUNTING

Spherical roller bearings can be mounted individually, but most often are mounted in combination with another spherical roller bearing or a cylindrical roller bearing.

With spherical roller bearings, typically one bearing is fixed axially and the other is mounted with loose fits and axial space. This allows movement or float for environmental conditions such as uneven thermal growth between shaft and housing.

Cylindrical roller bearings can be mounted individually, but most often are mounted in combination with another cylindrical roller, a spherical roller or a tapered roller bearing.

Fig. 87 shows a typical gearbox application using two spherical roller bearings where one bearing is free to float and the other bearing is fixed axially.

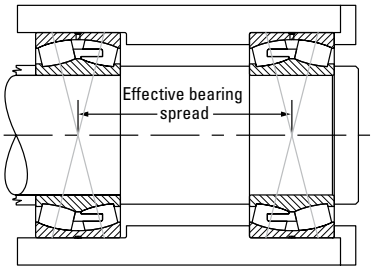


Fig. 87. Spherical roller bearing direct mounting.

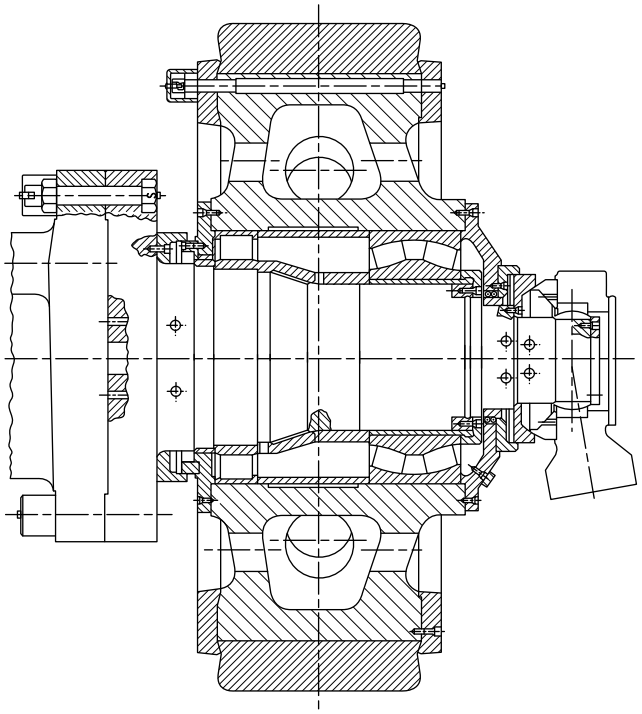


Fig. 88. Pulverizer wheel assembly.

Fig. 88 shows a pulverizer wheel assembly where a double-row spherical roller bearing is mounted in combination with a cylindrical roller bearing. In this application, the cylindrical roller bearing allows the shaft to float relative to the housing.

Fig. 89 shows a single-reduction gear reducer with herringbone gears. A tapered roller bearing is mounted in combination with a cylindrical roller bearing on the upper shaft, and two cylindrical roller bearings are mounted on the lower shaft.

FITTING PRACTICE

Tables 55-67 on pages 120-131 list the recommended fitting practices for spherical roller and cylindrical roller bearings. The tables assume:

- The bearing is of normal precision.
- The housing is thick and made from steel or cast iron.
- The shaft is solid and made from steel.
- The bearing seats are ground or accurately turned to less than approximately 1.6 µm Ra finish.

The suggested fit symbols are in accordance with ISO 286. For help with recommended fitting practices, contact your Timken engineer.

As a general guideline, rotating inner rings should be applied with an interference fit. Loose fits may permit the inner rings to creep or turn and wear the shaft and the backing shoulder. This wear may result in excessive bearing looseness and possible bearing and shaft damage. Additionally, abrasive metal particles resulting from creep or turning may enter into the bearing and cause damage and vibration.

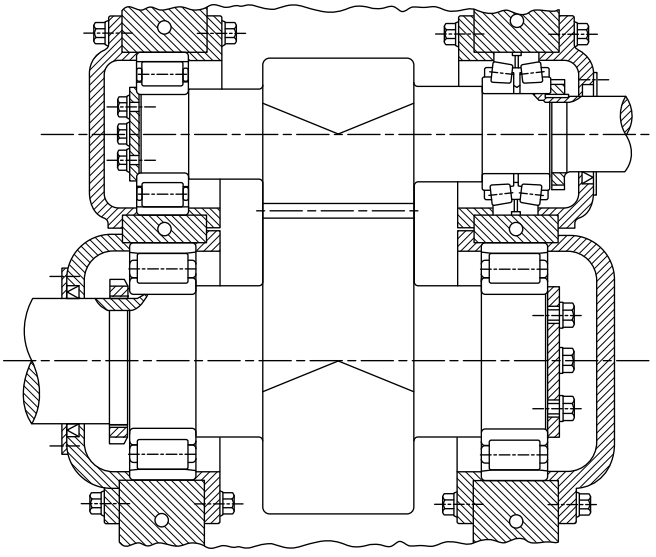


Fig. 89. Single-reduction gear reducer.

Stationary inner-ring fitting practice depends on the loading of the application. The load conditions and bearing envelope dimensions should be used to select the suggested shaft fit from the tables.

Similarly, rotating outer-ring applications should use an interference fit between the outer ring and housing.

Stationary outer rings are generally mounted with loose fits to permit assembly and disassembly. The loose fit also permits axial movement when a spherical bearing is mounted in the float position.

Thin-walled housings, light-alloy housings or hollow shafts must use press fits tighter than those required for thick-walled housings, steel, or cast iron housings or solid shafts. Tighter fits also are required when mounting the bearing on relatively rough or unground surfaces.

Tapered bore designs

Typically, the tapered bore bearings are selected to simplify shaft mounting and dismounting. Since the spherical roller bearing is not separable, mounting can be simplified by use of an adapter sleeve with a cylindrical bore and tapered O.D. A tapered bore roller bearing also can be mounted directly onto a tapered shaft.

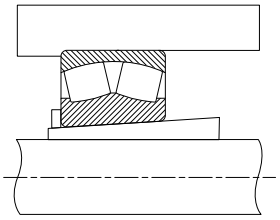


Fig. 90. Spherical roller bearing mounted with an adapter sleeve.

Bearings with a tapered bore typically require a tighter fit on the shaft than bearings with a cylindrical bore. A locknut is typically used to drive the inner ring up a tapered shaft sleeve. The locknut position is then secured by use of a lockwasher or lockplate. Timken offers a wide range of accessories to ease the assembly of spherical roller bearings with a tapered bore (see page 89). For approximating the clearance loss for axial drive-up, an 85 percent radial loss approximation can be used. That is, the radial clearance loss per axial drive-up can roughly be approximated as 71 µm/mm for a 1:12 tapered bore and 28 µm/mm for a 1:30 tapered bore. Table 41 on page 85 shows the relationship between axial displacement of the inner ring and the reduction in RIC (radial internal clearance) for tapered bore applications.

SETTING

To achieve appropriate operation clearance, attention must be paid to the effects fitting practice and thermal gradients have within the bearing.

Fitting practice

- An interference fit between the inner ring and a solid steel shaft will reduce the radial clearance within the bearing by approximately 80 percent of the fit.
- Interference fits between the outer ring and steel or cast iron housing will reduce radial clearance by approximately 60 percent.
- Spherical roller bearings with a tapered bore require a slightly greater interference fit on the shaft than a cylindrical bore bearing.

NOTE

It is critical to select the RIC that allows for this reduction.

Thermal gradients

- Thermal gradients within the bearing are primarily a function of the bearing rotational speed. As speed increases, thermal gradients increase, thermal growth occurs and the radial clearance is reduced.
- As a rule of thumb, radial clearance should be increased for speeds in excess of 70 percent of the speed rating.

For help selecting the correct radial internal clearance for your application, consult with your Timken engineer.

Radial internal clearance tolerances are listed in tables 40 and 41 for spherical and cylindrical roller bearings, respectively.

Spherical and cylindrical roller bearings are ordered with a specified standard or non-standard radial internal clearance value. The standard radial internal clearances are designated as C2, C0 (normal), C3, C4 or C5 and are in accordance with ISO 5753. C2 represents the minimum clearance and C5 represents the maximum clearance. Non-standardized values also are available by special request.

The clearance required for a given application depends on the desired operating precision, the rotational speed of the bearing, and the fitting practice used. Most applications use a normal or C3 clearance. Typically, larger clearance reduces the operating load zone of the bearing, increases the maximum roller load, and reduces the bearing's expected life. However, a spherical or cylindrical roller bearing that has been put into a preload condition can experience premature bearing damage caused by excessive heat generation and/or material fatigue. As a general guideline, spherical and cylindrical roller bearings should not operate in a preloaded condition.

TABLE 40. RADIAL INTERNAL CLEARANCE LIMITS – SPHERICAL ROLLER BEARINGS – CYLINDRICAL BORE

Bore (Nominal)		Radial Internal Clearance Prior To Mounting						Suggested Reduction of RIC Due to Installation		Suggested RIC After Installation
			Normal CO		C4					
			Min.	Max.	Min.	Max.				
		C2		C3		C5				
Over	Incl.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
20 0.9449	**30** 1.1811	**0.015** 0.0006	**0.025** 0.0010	**0.040** 0.0016	**0.055** 0.0022	**0.075** 0.0030	**0.095** 0.0037	**0.015** 0.0006	**0.020** 0.0008	**0.015** 0.0006
30 1.1811	**40** 1.5748	**0.015** 0.0006	**0.030** 0.0012	**0.045** 0.0018	**0.060** 0.0024	**0.080** 0.0031	**0.100** 0.0039	**0.020** 0.0008	**0.025** 0.0010	**0.015** 0.0006
40 1.5748	**50** 1.9685	**0.020** 0.0008	**0.035** 0.0014	**0.055** 0.0022	**0.075** 0.0030	**0.100** 0.0039	**0.125** 0.0049	**0.025** 0.0010	**0.030** 0.0012	**0.020** 0.0008
50 1.9685	**65** 2.5591	**0.020** 0.0008	**0.040** 0.0016	**0.065** 0.0026	**0.090** 0.0035	**0.120** 0.0047	**0.150** 0.0059	**0.030** 0.0012	**0.038** 0.0015	**0.025** 0.0010
65 2.5591	**80** 3.1496	**0.030** 0.0012	**0.050** 0.0020	**0.080** 0.0031	**0.110** 0.0043	**0.145** 0.0057	**0.180** 0.0071	**0.038** 0.0015	**0.051** 0.0020	**0.025** 0.0010
80 3.1496	**100** 3.9370	**0.035** 0.0014	**0.060** 0.0024	**0.100** 0.0039	**0.135** 0.0053	**0.180** 0.0071	**0.225** 0.0089	**0.046** 0.0018	**0.064** 0.0025	**0.036** 0.0014
100 3.9370	**120** 4.7244	**0.040** 0.0016	**0.075** 0.0030	**0.120** 0.0047	**0.160** 0.0063	**0.210** 0.0083	**0.260** 0.0102	**0.051** 0.0020	**0.071** 0.0028	**0.051** 0.0020
120 4.7244	**140** 5.5118	**0.050** 0.0020	**0.095** 0.0037	**0.145** 0.0057	**0.190** 0.0075	**0.240** 0.0094	**0.300** 0.0118	**0.064** 0.0025	**0.089** 0.0035	**0.056** 0.0022
140 5.5118	**160** 6.2992	**0.060** 0.0024	**0.110** 0.0043	**0.170** 0.0067	**0.220** 0.0087	**0.280** 0.0110	**0.350** 0.0138	**0.076** 0.0030	**0.102** 0.0040	**0.056** 0.0022
160 6.2992	**180** 7.0866	**0.065** 0.0026	**0.120** 0.0047	**0.180** 0.0071	**0.240** 0.0094	**0.310** 0.0122	**0.390** 0.0154	**0.076** 0.0030	**0.114** 0.0045	**0.061** 0.0024
180 7.0866	**200** 7.8740	**0.070** 0.0028	**0.130** 0.0051	**0.200** 0.0079	**0.260** 0.0102	**0.340** 0.0134	**0.430** 0.0169	**0.089** 0.0035	**0.127** 0.0050	**0.071** 0.0028
200 7.8740	**225** 8.8582	**0.080** 0.0031	**0.140** 0.0055	**0.220** 0.0087	**0.290** 0.0114	**0.380** 0.0150	**0.470** 0.0185	**0.102** 0.0040	**0.140** 0.0055	**0.076** 0.0030
225 8.8582	**250** 9.8425	**0.090** 0.0035	**0.150** 0.0059	**0.240** 0.0094	**0.320** 0.0126	**0.420** 0.0165	**0.520** 0.0205	**0.114** 0.0045	**0.152** 0.0060	**0.089** 0.0035
250 9.8425	**280** 11.0236	**0.100** 0.0039	**0.170** 0.0067	**0.260** 0.0102	**0.350** 0.0138	**0.460** 0.0181	**0.570** 0.0224	**0.114** 0.0045	**0.165** 0.0065	**0.102** 0.0040
280 11.0236	**315** 12.4016	**0.110** 0.0043	**0.190** 0.0075	**0.280** 0.0110	**0.370** 0.0146	**0.500** 0.0197	**0.630** 0.0248	**0.127** 0.0050	**0.178** 0.0070	**0.102** 0.0040
315 12.4016	**355** 13.9764	**0.120** 0.0047	**0.200** 0.0079	**0.310** 0.0122	**0.410** 0.0161	**0.550** 0.0217	**0.690** 0.0272	**0.140** 0.0055	**0.190** 0.0075	**0.114** 0.0045
355 13.9764	**400** 15.7480	**0.130** 0.0051	**0.220** 0.0087	**0.340** 0.0134	**0.450** 0.0177	**0.600** 0.0236	**0.750** 0.0295	**0.152** 0.0060	**0.203** 0.0080	**0.127** 0.0050
400 15.7480	**450** 17.7165	**0.140** 0.0055	**0.240** 0.0094	**0.370** 0.0146	**0.500** 0.0197	**0.660** 0.026	**0.820** 0.0323	**0.165** 0.0065	**0.216** 0.0085	**0.152** 0.0060
450 17.7165	**500** 19.6850	**0.140** 0.0055	**0.260** 0.0102	**0.410** 0.0161	**0.550** 0.0217	**0.720** 0.0283	**0.900** 0.0354	**0.178** 0.0070	**0.229** 0.0090	**0.165** 0.0065
500 19.6850	**560** 22.0472	**0.150** 0.0059	**0.280** 0.0110	**0.440** 0.0173	**0.600** 0.0236	**0.780** 0.0307	**1.000** 0.0394	**0.203** 0.0080	**0.254** 0.0100	**0.178** 0.0070
560 22.0472	**630** 24.8031	**0.170** 0.0067	**0.310** 0.0122	**0.480** 0.0189	**0.650** 0.0256	**0.850** 0.0335	**1.100** 0.0433	**0.229** 0.0090	**0.279** 0.0110	**0.203** 0.0080

Continued from previous page.

Bore (Nominal)		Radial Internal Clearance Prior To Mounting						Suggested Reduction of RIC Due to Installation		Suggested RIC After Installation
			Normal CO		C4					
			Min.	Max.	Min.	Max.				
		C2		C3		C5				
Over	Incl.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
630 24.8031	**710** 27.9528	**0.190** 0.0075	**0.350** 0.0138	**0.530** 0.0209	**0.700** 0.0276	**0.920** 0.0362	**1.190** 0.0469	**0.254** 0.0100	**0.305** 0.0120	**0.203** 0.080
710 27.9528	**800** 31.4961	**0.210** 0.0083	**0.390** 0.0154	**0.580** 0.0228	**0.770** 0.0303	**1.010** 0.0398	**1.300** 0.0512	**0279** 0.0110	**0.356** 0.0140	**0.229** 0.0900
800 31.4961	**900** 35.4331	**0.230** 0.0091	**0.430** 0.0169	**0.650** 0.0256	**0.860** 0.0339	**1.120** 0.0441	**1.440** 0.0567	**0305** 0.0120	**0.381** 0.0150	**0.252** 0.0100
900 35.4331	**1000** 39.3701	**0.260** 0.0102	**0.480** 0.0189	**0.710** 0.0280	**0.930** 0.0366	**1.220** 0.0480	**1.570** 0.0618	**0356** 0.0140	**0.432** 0.0170	**0.279** 0.0110
1000 39.3701	**1120** 44.0950	**0.290** 0.0114	**0.530** 0.0209	**0.780** 0.0307	**1.020** 0.0402	**1.330** 0.0524	**1.720** 0.0677	**0.4000** 0.0160	**0.480** 0.0190	**0.280** 0.0110
1120 44.0950	**1250** 49.2130	**0.320** 0.0126	**0.580** 0.0228	**0.860** 0.0339	**1.120** 0.0441	**1.460** 0.0575	**1.870** 0.0736	**0.430** 0.0170	**0.500** 0.0200	**0.330** 0.0130

TABLE 41. SPHERICAL ROLLER BEARING ENDPLAY

	Series	E.P / RIC
Spherical roller bearings	39	8.7
	30	7.0
	22	5.5
	31	5.0
	40	4.8
	32	4.4
	23	4.3
	41	4.2
	33	3.9

TABLE 42. RADIAL INTERNAL CLEARANCE LIMITS – SPHERICAL ROLLER BEARINGS – TAPERED BORE

Bore (Nominal)		Radial Internal Clearance Prior To Mounting						Suggested Reduction of RIC Due to Installation		Axial Displacement of Inner Ring for RIC Reduction – Tapered Shaft[1][2]				Minimum Permissible RIC After Installation[1]		
			Normal CO		C4					1:12 Taper		1:30 Taper				
		C2		C3		C5										
Over	Incl.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	CO	C3	C4
mm	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
20	**30**	**0.020**	**0.030**	**0.040**	**0.055**	**0.075**	**0.095**	**0.015**	**0.020**	**0.230**	**0.300**	**–**	**–**	**0.015**	**0.025**	**0.040**
0.9449	1.1811	0.0008	0.0012	0.0016	0.0022	0.0030	0.0037	0.0006	0.0008	0.0091	0.0118	–	–	0.0006	0.0010	0.0016
30	**40**	**0.025**	**0.035**	**0.050**	**0.065**	**0.085**	**0.105**	**0.020**	**0.025**	**0.300**	**0.380**	**–**	**–**	**0.015**	**0.025**	**0.040**
1.1811	1.5748	0.0010	0.0014	0.0020	0.0026	0.0033	0.0041	0.0008	0.0010	0.0118	0.0150	–	–	0.0006	0.0010	0.0016
40	**50**	**0.030**	**0.045**	**0.060**	**0.080**	**0.100**	**0.130**	**0.025**	**0.030**	**0.380**	**0.460**	**–**	**–**	**0.02**	**0.030**	**0.050**
1.5748	1.9685	0.0012	0.0018	0.0024	0.0031	0.0039	0.0051	0.0010	0.0012	0.0150	0.0181	–	–	0.0008	0.0012	0.0020
50	**65**	**0.040**	**0.055**	**0.075**	**0.095**	**0.120**	**0.160**	**0.030**	**0.038**	**0.460**	**0.560**	**–**	**–**	**0.025**	**0.040**	**0.060**
1.9685	2.5591	0.0016	0.0022	0.0030	0.0037	0.0047	0.0063	0.0012	0.0015	0.0181	0.0220	–	–	0.0010	0.0015	0.0025
65	**80**	**0.050**	**0.070**	**0.0950**	**0.120**	**0.150**	**0.200**	**0.038**	**0.051**	**0.560**	**0.760**	**–**	**–**	**0.025**	**0.045**	**0.075**
2.5591	3.1496	0.0020	0.0028	0.0037	0.0047	0.0059	0.0079	0.0015	0.0020	0.0220	0.0299	–	–	0.0010	0.0017	0.0030
80	**100**	**0.055**	**0.080**	**0.110**	**0.140**	**0.180**	**0.230**	**0.046**	**0.064**	**0.680**	**0.970**	**–**	**–**	**0.036**	**0.050**	**0.075**
3.1496	3.9370	0.0022	0.0030	0.0043	0.0055	0.0071	0.0091	0.0018	0.0025	0.0268	0.0382	–	–	0.0014	0.0020	0.0030
100	**120**	**0.065**	**0.100**	**0.135**	**0.170**	**0.220**	**0.280**	**0.051**	**0.071**	**0.760**	**1.070**	**1.900**	**2.540**	**0.051**	**0.060**	**0.100**
3.9370	4.7244	0.0026	0.0039	0.0053	0.0067	0.0087	0.0110	0.0020	0.0028	0.0299	0.0421	0.0748	0.1000	0.0020	0.0025	0.0040
120	**140**	**0.080**	**0.120**	**0.160**	**0.200**	**0.260**	**0.330**	**0.064**	**0.089**	**0.890**	**1.270**	**2.290**	**3.050**	**0.056**	**0.075**	**0.115**
4.7244	5.5118	0.0031	0.0047	0.0063	0.0079	0.0102	0.0130	0.0025	0.0035	0.0350	0.0500	0.0902	0.1201	0.0022	0.0030	0.0045
140	**160**	**0.090**	**0.130**	**0.180**	**0.230**	**0.300**	**0.380**	**0.076**	**0.102**	**1.140**	**1.520**	**2.670**	**3.430**	**0.056**	**0.075**	**0.125**
5.5118	6.2992	0.0035	0.0051	0.0071	0.0091	0.0118	0.0150	0.0030	0.0040	0.0449	0.0598	0.1051	0.1350	0.0022	0.0030	0.0050
160	**180**	**0.100**	**0.140**	**0.200**	**0.260**	**0.340**	**0.430**	**0.076**	**0.114**	**1.140**	**1.650**	**2.670**	**4.060**	**0.061**	**0.090**	**0.150**
6.2992	7.0866	0.0039	0.0055	0.0079	0.0102	0.0134	0.0169	0.0030	0.0045	0.0449	0.0650	0.1051	0.1598	0.0024	0.0035	0.0060
180	**200**	**0.110**	**0.160**	**0.220**	**0.290**	**0.370**	**0.470**	**0.089**	**0.127**	**1.400**	**1.900**	**3.050**	**4.450**	**0.071**	**0.100**	**0.165**
7.0866	7.8740	0.0043	0.0063	0.0087	0.0114	0.0146	0.0185	0.0035	0.0050	0.0551	0.0748	0.1201	0.1752	0.0028	0.0040	0.0065
200	**225**	**0.120**	**0.180**	**0.250**	**0.320**	**0.410**	**0.520**	**0.102**	**0.140**	**1.520**	**2.030**	**3.560**	**4.830**	**0.076**	**0.115**	**0.180**
7.8740	8.8582	0.0047	0.0071	0.0098	0.0126	0.0161	0.0205	0.0040	0.0055	0.0598	0.0799	0.1402	0.1902	0.0030	0.0045	0.0070
225	**250**	**0.140**	**0.200**	**0.270**	**0.350**	**0.450**	**0.570**	**0.114**	**0.152**	**1.780**	**2.290**	**4.060**	**5.330**	**0.089**	**0.115**	**0.200**
8.8582	9.8425	0.0055	0.0079	0.0106	0.0138	0.0177	0.0224	0.0045	0.0060	0.0701	0.0902	0.1598	0.2098	0.0035	0.0045	0.0080
250	**280**	**0.150**	**0.220**	**0.300**	**0.390**	**0.490**	**0.620**	**0.114**	**0.165**	**1.780**	**2.540**	**4.060**	**5.840**	**0.102**	**0.140**	**0.230**
9.8425	11.0236	0.0059	0.0087	0.0118	0.0154	0.0193	0.0244	0.0045	0.0065	0.0701	0.1000	0.1598	0.2299	0.0040	0.0055	0.0090
280	**315**	**0.170**	**0.240**	**0.330**	**0.430**	**0.540**	**0.680**	**0.127**	**0.178**	**1.900**	**2.670**	**4.450**	**6.220**	**0.102**	**0.150**	**0.250**
11.0236	12.4016	0.0067	0.0094	0.0130	0.0169	0.0213	0.0268	0.0050	0.0070	0.0748	0.1051	0.1752	0.2449	0.0040	0.0060	0.0100
315	**355**	**0.190**	**0.270**	**0.360**	**0.470**	**0.590**	**0.740**	**0.140**	**0.190**	**2.030**	**2.790**	**4.830**	**6.600**	**0.114**	**0.165**	**0.280**
12.4016	13.9764	0.0075	0.0106	0.0142	0.0185	0.0232	0.0291	0.0055	0.0075	0.0799	0.1098	0.1902	0.2598	0.0045	0.0065	0.0110
355	**400**	**0.210**	**0.300**	**0.400**	**0.520**	**0.650**	**0.820**	**0.152**	**0.203**	**2.290**	**3.050**	**5.330**	**7.110**	**0.127**	**0.190**	**0.330**
13.9764	15.7480	0.0083	0.0118	0.0157	0.0205	0.0256	0.0323	0.0060	0.0080	0.0902	0.1201	0.2098	0.2799	0.0050	0.0075	0.0130

Continued from previous page.

Bore (Nominal)		Radial Internal Clearance Prior To Mounting						Suggested Reduction of RIC Due to Installation		Axial Displacement of Inner Ring for RIC Reduction – Tapered Shaft[1][2]				Minimum Permissible RIC After Installation[1]		
				Normal CO		C4				1:12 Taper		1:30 Taper				
		C2		C3		C5										
Over	Incl.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	CO	C3	C4
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
400	**450**	**0.230**	**0.330**	**0.440**	**0.570**	**0.720**	**0.910**	**0.165**	**0.216**	**2.540**	**3.300**	**5.840**	**7.620**	**0.152**	**0.230**	**0.360**
15.7480	17.7165	0.0091	0.0130	0.0173	0.0224	0.0283	0.0358	0.0065	0.0085	0.1000	0.1299	0.2299	0.3000	0.0060	0.0090	0.0140
450	**500**	**0.260**	**0.370**	**0.490**	**0.630**	**0.790**	**1.000**	**0.178**	**0.229**	**2.670**	**3.430**	**6.220**	**8.000**	**0.165**	**0.270**	**0.410**
17.7165	19.6850	0.0102	0.0146	0.0193	0.0248	0.0311	0.0394	0.0070	0.0090	0.1051	0.1350	0.2449	0.3150	0.0065	0.0105	0.0160
500	**560**	**0.290**	**0.410**	**0.540**	**0.680**	**0.870**	**1.100**	**0.203**	**0.254**	**3.050**	**3.810**	**7.110**	**8.890**	**0.178**	**0.290**	**0.440**
19.6850	22.0472	0.0114	0.0161	0.0213	0.0268	0.0343	0.0433	0.0080	0.0100	0.1201	0.1500	0.2799	0.3500	0.0070	0.0115	0.0175
560	**630**	**0.320**	**0.460**	**0.600**	**0.760**	**0.980**	**1.230**	**0.229**	**0.279**	**3.430**	**4.190**	**8.000**	**9.780**	**0.203**	**0.320**	**0.510**
22.0472	24.8031	0.0126	0.0181	0.0236	0.0299	0.0386	0.0484	0.0090	0.0110	0.1350	0.1650	0.3150	0.3850	0.0080	0.0125	0.0200
630	**710**	**0.350**	**0.510**	**0.670**	**0.850**	**1.090**	**1.360**	**0.254**	**0.305**	**3.810**	**4.570**	**8.890**	**10.670**	**0.203**	**0.370**	**0.550**
24.8031	27.9528	0.0138	0.0201	0.0264	0.0335	0.0429	0.0535	0.0100	0.0120	0.1500	0.1799	0.3500	0.4201	0.0080	0.0145	0.0215
710	**800**	**0.390**	**0.570**	**0.750**	**0.960**	**1.220**	**1.500**	**0.279**	**0.356**	**4.190**	**5.330**	**9.780**	**12.450**	**0.229**	**0.390**	**0.610**
27.9528	31.4961	0.0154	0.0224	0.0295	0.0378	0.0480	0.0591	0.0110	0.0140	0.1650	0.2098	0.3850	0.4902	0.0090	0.0155	0.0240
800	**900**	**0.440**	**0.640**	**0.840**	**1.070**	**1.370**	**1.690**	**0.305**	**0.381**	**4.570**	**5.720**	**10.670**	**13.330**	**0.252**	**0.460**	**0.690**
31.4961	35.4331	0.0173	0.0252	0.0331	0.0421	0.0539	0.0665	0.0120	0.0150	0.1799	0.2252	0.4201	0.5248	0.0100	0.0180	0.0270
900	**1000**	**0.490**	**0.710**	**0.930**	**1.190**	**1.520**	**1.860**	**0.356**	**0.432**	**5.330**	**6.480**	**12.450**	**15.110**	**0.279**	**0.490**	**0.750**
35.4331	39.3701	0.0193	0.0280	0.0366	0.0469	0.0598	0.0732	0.0140	0.0170	0.2100	0.2551	0.4902	0.5949	0.0110	0.0195	0.0300
1000	**1120**	**0.530**	**0.770**	**1.030**	**1.300**	**1.670**	**2.050**	**0.400**	**0.480**	**6.100**	**7.240**	**14.220**	**16.890**	**0.280**	**0.550**	**0.810**
39.3701	44.0950	0.0209	0.0303	0.0406	0.0512	0.0657	0.0807	0.0160	0.0190	0.2400	0.2850	0.5600	0.6650	0.0110	0.0215	0.0320
1120	**1250**	**0.570**	**0.830**	**1.120**	**1.420**	**1.830**	**2.250**	**0.430**	**0.500**	**6.480**	**7.620**	**15.110**	**17.780**	**0.330**	**0.610**	**0.910**
44.0950	49.2130	0.0224	0.0327	0.0441	0.0559	0.0720	0.0886	0.0170	0.0200	0.2550	0.3000	0.5950	0.7000	0.0130	0.0240	0.0360

Note: Axial displacement values apply to solid steel shafts or hollow shafts with bore diameter less than half the shaft diameter. For shaft materials other than steel, or for thin-walled shafts, please consult your Timken sales engineer.

[1]This displacement is valid for assembly of tapered bore bearings and is measured starting from a line-to-line fit of the bearing bore to the tapered shaft.

[2]1:12 Taper used for 213, 222, 223, 230, 231, 232, 233, 238, 239 series. 1:30 Taper used for 240, 241, 242 series. For sleeve mounting, multiply axial displacement values by 1.1 for 1:12 Taper or by 1.05 for 1:30 Taper. For questions on tapered shaft data, consult your Timken sales engineer.

TABLE 43. RADIAL INTERNAL CLEARANCE LIMITS – CYLINDRICAL ROLLER BEARINGS – CYLINDRICAL BORE

Bore – RIC											
Bore (Nominal)		C2		C0		C3		C4		C5	
Over	Incl.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
– –	**10** 0.3937	**0.000** 0.0000	**0.025** 0.0010	**0.020** 0.0008	**0.045** 0.0018	**0.035** 0.0014	**0.060** 0.0024	**0.050** 0.0020	**0.075** 0.0030	– –	– –
10 0.3937	**24** 0.9449	**0.000** 0.0000	**0.025** 0.0010	**0.020** 0.0008	**0.045** 0.0018	**0.035** 0.0014	**0.060** 0.0024	**0.050** 0.0020	**0.075** 0.0030	**0.065** 0.0026	**0.090** 0.0035
24 0.9449	**30** 1.1811	**0.000** 0.0000	**0.025** 0.0010	**0.020** 0.0008	**0.045** 0.0018	**0.035** 0.0014	**0.060** 0.0024	**0.050** 0.0020	**0.075** 0.0030	**0.070** 0.0028	**0.095** 0.0037
30 1.1811	**40** 1.5748	**0.005** 0.0002	**0.030** 0.0012	**0.025** 0.0010	**0.050** 0.0020	**0.045** 0.0018	**0.070** 0.0028	**0.060** 0.0024	**0.085** 0.0033	**0.080** 0.0031	**0.105** 0.0041
40 1.5748	**50** 1.9685	**0.005** 0.0002	**0.035** 0.0014	**0.030** 0.0012	**0.060** 0.0024	**0.050** 0.0020	**0.080** 0.0031	**0.070** 0.0028	**0.100** 0.0039	**0.095** 0.0037	**0.125** 0.0049
50 1.9685	**65** 2.5591	**0.010** 0.0004	**0.040** 0.0016	**0.040** 0.0016	**0.070** 0.0028	**0.060** 0.0024	**0.090** 0.0035	**0.080** 0.0031	**0.110** 0.0043	**0.110** 0.0043	**0.140** 0.0055
65 2.5591	**80** 3.1496	**0.010** 0.0004	**0.045** 0.0018	**0.040** 0.0016	**0.075** 0.0030	**0.065** 0.0026	**0.100** 0.0039	**0.090** 0.0035	**0.125** 0.0049	**0.130** 0.0051	**0.165** 0.0065
80 3.1496	**100** 3.9370	**0.015** 0.0006	**0.050** 0.0020	**0.050** 0.0020	**0.085** 0.0033	**0.075** 0.0030	**0.110** 0.0043	**0.105** 0.0041	**0.140** 0.0055	**0.155** 0.0061	**0.190** 0.0075
100 3.9370	**120** 4.7244	**0.015** 0.0006	**0.055** 0.0022	**0.050** 0.0020	**0.090** 0.0035	**0.085** 0.0033	**0.125** 0.0049	**0.125** 0.0049	**0.165** 0.0065	**0.180** 0.0071	**0.220** 0.0087
120 4.7244	**140** 5.5118	**0.015** 0.0006	**0.060** 0.0024	**0.060** 0.0024	**0.105** 0.0041	**0.100** 0.0039	**0.145** 0.0057	**0.145** 0.0057	**0.190** 0.0075	**0.200** 0.0079	**0.245** 0.0096
140 5.5118	**160** 6.2992	**0.020** 0.0008	**0.070** 0.0028	**0.070** 0.0028	**0.120** 0.0047	**0.115** 0.0045	**0.165** 0.0065	**0.165** 0.0065	**0.215** 0.0085	**0.225** 0.0089	**0.275** 0.0108
160 6.2992	**180** 7.0866	**0.025** 0.0010	**0.075** 0.0030	**0.075** 0.0030	**0.125** 0.0049	**0.120** 0.0047	**0.170** 0.0067	**0.170** 0.0067	**0.220** 0.0087	**0.250** 0.0098	**0.300** 0.0118
180 7.0866	**200** 7.8740	**0.035** 0.0014	**0.090** 0.0035	**0.090** 0.0035	**0.145** 0.0057	**0.140** 0.0055	**0.195** 0.0077	**0.195** 0.0077	**0.250** 0.0098	**0.275** 0.0108	**0.330** 0.0130
200 7.8740	**225** 8.8583	**0.045** 0.0018	**0.105** 0.0041	**0.105** 0.0041	**0.165** 0.0065	**0.160** 0.0063	**0.220** 0.0087	**0.220** 0.0087	**0.280** 0.0110	**0.305** 0.0120	**0.365** 0.0144
225 8.8583	**250** 9.8425	**0.045** 0.0018	**0.110** 0.0043	**0.110** 0.0043	**0.175** 0.0069	**0.170** 0.0067	**0.235** 0.0093	**0.235** 0.0093	**0.300** 0.0118	**0.330** 0.0130	**0.395** 0.0156
250 9.8425	**280** 11.0236	**0.055** 0.0022	**0.125** 0.0049	**0.125** 0.0049	**0.195** 0.0077	**0.190** 0.0075	**0.260** 0.0102	**0.260** 0.0102	**0.330** 0.0130	**0.370** 0.0146	**0.440** 0.0173
280 11.0236	**315** 12.4016	**0.055** 0.0022	**0.130** 0.0051	**0.130** 0.0051	**0.205** 0.0081	**0.200** 0.0079	**0.275** 0.0108	**0.275** 0.0108	**0.350** 0.0138	**0.410** 0.0161	**0.485** 0.0191
315 12.4016	**355** 13.9764	**0.065** 0.0026	**0.145** 0.0057	**0.145** 0.0057	**0.225** 0.0089	**0.225** 0.0089	**0.305** 0.0120	**0.305** 0.0120	**0.385** 0.0152	**0.455** 0.0179	**0.535** 0.0211
355 13.9764	**400** 15.7480	**0.100** 0.0039	**0.190** 0.0075	**0.190** 0.0075	**0.280** 0.0110	**0.280** 0.0110	**0.370** 0.0146	**0.370** 0.0146	**0.460** 0.0181	**0.510** 0.0201	**0.600** 0.0236
400 15.7480	**450** 17.7165	**0.110** 0.0043	**0.210** 0.0083	**0.210** 0.0083	**0.310** 0.0122	**0.310** 0.0122	**0.410** 0.0161	**0.410** 0.0161	**0.510** 0.0201	**0.565** 0.0222	**0.665** 0.0262
450 17.7165	**500** 19.6850	**0.110** 0.0043	**0.220** 0.0087	**0.220** 0.0087	**0.330** 0.0130	**0.330** 0.0130	**0.440** 0.0173	**0.440** 0.0173	**0.550** 0.0217	**0.625** 0.0246	**0.735** 0.0289
500 19.6850	**560** 22.0472	**0.120** 0.0047	**0.240** 0.0095	**0.240** 0.0095	**0.360** 0.0142	**0.360** 0.0142	**0.480** 0.0189	**0.480** 0.0189	**0.600** 0.0236	**0.690** 0.0272	**0.810** 0.0319
560 22.0472	**630** 24.8031	**0.140** 0.0055	**0.260** 0.0102	**0.260** 0.0102	**0.380** 0.0150	**0.380** 0.0150	**0.500** 0.0197	**0.500** 0.0197	**0.620** 0.0244	**0.780** 0.0307	**0.900** 0.0354
630 24.8031	**710** 27.9528	**0.145** 0.0057	**0.285** 0.0112	**0.285** 0.0112	**0.425** 0.0167	**0.425** 0.0167	**0.565** 0.0222	**0.565** 0.0222	**0.705** 0.0278	**0.865** 0.0341	**1.005** 0.0396
710 27.9528	**800** 31.4961	**0.150** 0.0059	**0.310** 0.0122	**0.310** 0.0122	**0.470** 0.0185	**0.470** 0.0185	**0.630** 0.0248	**0.630** 0.0248	**0.790** 0.0311	**0.975** 0.0384	**1.135** 0.0447
800 31.4961	**900** 35.4331	**0.180** 0.0071	**0.350** 0.0138	**0.350** 0.0138	**0.520** 0.0205	**0.520** 0.0205	**0.690** 0.0272	**0.690** 0.0272	**0.860** 0.0339	**1.095** 0.0431	**1.265** 0.0498
900 35.4331	**1000** 39.3701	**0.200** 0.0079	**0.390** 0.0154	**0.390** 0.0154	**0.580** 0.0228	**0.580** 0.0228	**0.770** 0.0303	**0.770** 0.0303	**0.960** 0.0378	**1.215** 0.0478	**1.405** 0.0553

EXAMPLE #1 –
Calculating RIC Reduction Using a Spherical Roller Bearing with Tapered Bore

Step 1:
Place bearing in upright position and center the inner ring and rollers. Apply pressure to the inner ring and oscillate several times to properly seat the rollers.

Step 2:
Use a feeler gauge to measure the unmounted radial internal clearance (RIC) for both bearing rows.

- RIC must be checked at the unloaded roller.
- Feeler gauge must cover the length of the roller.
- Unmounted RIC is the thickest gauge that will slide through the gap between the roller and outer ring.
- Unmounted RIC is then the average reading for the two rows.



Fig. 91. Measure RIC before installation.

Example: 22328KEJW33C3 140 mm bore (5.5118 in.)
RIC measurement is 0.178 mm (0.0070 in.)

Step 3:
Use table 42 (page 86) to confirm that the measured unmounted RIC value is within specification.

Example: 22328KEJW33C3 140 mm bore (5.5118 in.)
RIC range is 0.160 mm – 0.200 mm (0.0063 in. – 0.0079 in.), the example's measured RIC is 0.178 mm (0.007 in.) so it is within specified range.

Step 4:
Use table 42 (page 86) to determine the Suggested Reduction of RIC Due to Installation.

Example: 22328KEJW33C3 140 mm bore (5.5118 in.)
Suggested Reduction of RIC Due to installation is 0.064 mm – 0.089 mm (0.0025 in. – 0.0035 in.).

Step 5:
Determine the maximum and minimum RIC after mounting.

MAX RIC = actual unmounted RIC – maximum suggested reduction in RIC

MIN RIC = actual unmounted RIC – maximum suggested reduction in RIC

Example: 22328KEJW33C3 140 mm bore (5.5118 in.)

Max Mounted RIC: 0.178 mm – 0.064 mm = 0.114 mm (0.0070 in. – 0.0025 in. = 0.0045 in.)

Min Mounted RIC: 0.178 mm – 0.089 mm = 0.089 mm (0.0070 in. – 0.0035 in. = 0.0035 in.)

Step 6:
Use table 42 (page 86) to determine Axial Displacement of Inner Ring for RIC Reduction.

Example: 22328KEJW33C3 140 mm bore (5.5118 in.)

22328KEJW33C3 is a 223 series which has a 1:12 tapered bore.

Axial Displacement of Inner Ring for RIC Reduction is 0.890 mm – 1.270 mm (0.035 in. – 0.050 in.).

Step 7:
Place bearing on tapered shaft (or tapered sleeve) until line-to-line contact exists with the bearing bore.



Fig. 92. During mounting, the RIC should be checked at the unloaded roller.

Step 8:
Use a locknut (or hydraulic nut) to apply installation force and move the bearing up the shaft or tapered sleeve until the mounted RIC reaches the desired range established in Step 5. During mounting, RIC should be measured at unloaded roller.

Example: 22328KEJW33C3 140 mm bore (5.5118 in.)
Mounted RIC range is 0.089 mm – 0.114 mm (0.0035 in. – 0.0045 in.).

Step 9:
Use table 42 (page 86) to evaluate mounted RIC against Minimum Permissible RIC After Installation.

Example: 22328KEJW33C3 140 mm bore (5.5118 in.)
The minimum permissible RIC after mounting would be 0.075 mm (0.0030 in.).

Step 7 (Alternative Procedure):
Use a locknut (or hydraulic nut) to apply installation force and move the bearing up the shaft or tapered sleeve until the axial displacement of the inner ring reaches the desired range. During mounting, the axial displacement of the inner ring should be measured.

Example: 22328KEJW33C3 140 mm bore (5.5118 in.)
Axial Displacement of Inner Ring for RIC Reduction is 0.890 mm – 1.270 mm (0.035 in. – 0.050 in.).

EXAMPLE #2 –
Calculating RIC Reduction Using a Spherical Roller Bearing with Cylindrical Bore

Step 1:
Gather general information required for fitting practice review.

- Bearing Bore and OD Dimensions/Tolerances
- Bearing operating conditions (Load/Speed)

Calculate bearing loading to bearing rating ratio by dividing the expected radial load by the basic dynamic radial load rating (BDLR) of the bearing.

Example: 22230EMW33

- Bore: 149.975 mm -150.00 mm (5.9045 in. – 5.9055 in.)
- OD: 269.965 mm – 270.00 mm (10.6285 in. – 10.6299 in.)
- BDLR: 1000 KN (225,000 lbf)
- Speed: 1,200 RPM; rotating shaft
- Radial Loading: 90 KN (20,250 lbf)
- Lubrication: grease
- Load/Bearing Rating Ratio:
  90 KN/1000 KN (20,250 lbf/225,000 lbf) = 0.09
  P= 0.09

Step 2:
Determine which shaft and housing fits should be used.

- Using table 56 (page 126) determine the suggested fits for the inner ring on the shaft.
- Using table 57 (page 127) determine the suggested fits for the outer ring in the housing.

Example: 22230EMW33

Inner Ring/Shaft: 150 mm (5.9055 in.)

- Rotating inner ring
- *Normal/light loads applied*
- *ISO fit – p6 suggested*

Outer Ring: 270 mm OD (10.6299 in.)

- Solid, one piece housing
- Normal/light loads applied
- ISO fit – H8 suggested

Step 3:
Determine the shaft OD and housing bore dimensions/tolerances.

- Using tables 68 and 69 (pages 132-137) determine the suggested shaft diameter dimensions
- Using table 70 and 71 (pages 138-145) determine the suggested housing bore dimension

Example: 22230EMW33

Shaft dimensions: p6 fit selected

Shaft tolerance: +0.043 mm/+0.068 mm
(+0.0017 in./+0.0027 in.)

Shaft diameter: 150.043 mm – 150.068 mm
(5.9072 in. – 5.9082 in.)

Housing Dimensions: H8 fit selected

Housing tolerance: +0.000 mm/+0.081 mm
(+0.0000 in./+0.0032 in.)

Housing diameter: 270.000 mm – 270.081 mm
(10.6299 in. – 10.6331 in.)

Step 4:
Calculate the resultant fits on the shaft and in the housing.

- Calculate the maximum and minimum interference fit on the shaft.
- Calculate the maximum and minimum interference fit in the housing.
- Note: Negative resultant fits are tight fit interference.
- Note: Positive resultant fits are loose fit interferences.

Example: 22230EMW33

Shaft Fit:

Max interference = min bore – max shaft OD 149.975 mm – 150.068 mm = -0.093 mm (tight fit) **OR**
5.9045 in. – 5.9082 in. = -0.0037 in. (tight fit)

Min interference = max bore – min shaft OD 150.000 mm – 150.043 mm = -0.043 mm (tight fit) **OR**
5.9055 in. – 5.9072 in. = -0.0017 in. (tight fit)

Housing Fit:

Max interference = min housing bore – max bearing OD
270.000 mm – 270.000 mm = 0.000 mm (loose) **OR**
10.6299 in. – 10.6299 in. = 0.0000 in. (loose)

Min interference = max housing bore – min bearing OD
270.081 mm – 269.965 mm = +0.116 mm (loose) **OR**
10.6331 in. – 10.6285 in. = +0.0046 in. (loose)

Step 5:
Calculate the RIC reduction due to fits.

- RIC reduction due to tight fit on the shaft = approx. 80% of the fit
- RIC reduction due to tight fit on the housing = approx. 60% of the fit

Example: 22230EMW33
RIC reduction due to tight fit on shaft:

Max RIC reduction: 0.80 x 0.093 mm = 0.074 mm (0.80 x 0.0037 in. = 0.0030 in.)

Min RIC reduction: 0.080 x 0.043 mm = 0.034 mm (0.80 x 0.0017 in. = 0.0014 in.)

RIC reduction is due to loose fit in the housing.
No reduction in RIC is due to loose fit.

Step 6:
Use table 40 (page 84) to determine the unmounted RIC.

Example: 22230EMW33
RIC designation is C0 (normal)
Unmounted RIC: 0.110 mm – 0.170 mm (0.0043 in. – 0.0067 in.)

Step 7:
Calculate the mounted RIC.

- Calculate the max mounted RIC Max unmounted RIC – min RIC fit reduction
- Calculate the min mounted RIC Min unmounted RIC – max RIC fit reduction

Example: 22230EMW33

Max mounted RIC: 0.170 mm – 0.034 mm = 0.136 mm (0.0067 in. – 0.0014 in. = 0.0053 in.)

Min mounted: RIC 0.110 mm – 0.074 mm = 0.036 mm (0.0043 in. – 0.0030 in. = 0.0013 in.)

Step 8:
Use table 40 (page 84) to evaluate the mounted RIC.

Example: 22230EMW33 (which has a C0 RIC)
Min permissible RIC is 0.056 mm (0.0022 in.)

Since min mounted RIC is below min permissible level, C0 fit selection needs to be reevaluated.

Step 9:
Review fitting repeating steps 6-8 using C3 clearance levels.

Example: 22230EMW33C3

Unmounted RIC: 0.170 mm – 0.220 mm (0.0067 in. – 0.0087 in.)

Mounted RIC: 0.096 mm – 0.186 mm (0.0037 in. – 0.0073 in.)

Mounted RIC is greater than min permissible, so C3 fit appears to be acceptable.

Step 10:
Confirm RIC designation selection against operating speeds.

As a general rule of thumb, the RIC level is increased for bearings operating at speeds that exceed 70% of thermal speed rating (page 56).

Example: 22230EMW33C3

From page 74 of the Spherical Roller Bearing Catalog (Order No. 10446), thermal reference speed: 2,000 rpm

2,000 rpm x 0.7 = 1,400 rpm

Current operating speed of application is 1,200 rpm.

Current C3 clearance designation appears to be acceptable.

INSTALLATION

When using a tight fit inner ring, the method of assembly will depend on whether the bearing has a cylindrical or tapered bore.

CLEANLINESS

- Choose a clean environment, free from dust and moisture.
- The installer should make every effort to ensure cleanliness by use of protective screens and clean cloths.

PLAN THE WORK

- Know your plans in advance and have the necessary tools at hand. This reduces the amount of time for the job and decreases the chance for dirt to get into the bearing.

INSPECTION AND PREPARATION

- All component parts of the machine should be on hand and thoroughly cleaned before proceeding.
- Housings should be cleaned, including blowing out the oil holes.
- Do not use air hose on bearings.
- If blind holes are used, insert a magnetic rod to remove metal chips that might be lodged there during fabrication.
- Shaft shoulders and spacer rings contacting the bearing should be square with the shaft axis.
- The shaft fillet must be small enough to clear the radius of the bearing.
- On original installations, all component parts should be checked against the detail specification prints for dimensional accuracy. Shaft and housing should be carefully checked for size and form (roundness, etc.).

SHAFT AND HOUSING FINISH

- Shaft surfaces on which the bearing will be mounted must be clean and free from nicks and burrs.
- For applications with stationary housing and rotating shaft, it is suggested that the bearing seat on the shaft be ground to 1.6 µm (65 µin.) Ra maximum.
- If it is impractical to use a ground finish, a machined finish of 3.2 µm (125 µin.) Ra is acceptable in many cases, but the amount of interference fit should be slightly increased.
- Housing bores should be finished to 3.2 µm (125 µin) Ra maximum.

Note: *Do not remove the bearing from its wrapping until you are ready to mount it.*



Fig. 93. Induction heater.

INSTALLING CYLINDRICAL BORE BEARINGS

Heat expansion method

- Most applications require a tight interference fit on the shaft.
- Mounting is simplified by heating the bearing to expand it sufficiently to slide easily onto the shaft.
- Two methods of heating are commonly used:
  - Induction heating.
  - Tank of heated oil.
- Induction heating:
  - The induction heating process can be used for mounting bearings.
  - Care must be taken to prevent bearing temperature from exceeding 121° C (250° F).
  - Trial runs with the unit and bearing are usually necessary to obtain proper timing.
  - Thermal crayons melted at predetermined temperatures can be used to check the bearing temperature.
  - While the bearing is hot, it should be positioned squarely against the shoulder.
  - Lockwashers and locknuts or clamping plates are then installed to hold the bearing against the shoulder of the shaft.
  - As the bearing cools, the locknut or clamping plate should be tightened.
  - In cases of outer ring rotation, where the outer ring is a tight fit in the housing, the housing member can be expanded by heating.
  - Fig. 93 shows a Timken induction heater.
- Oil bath:
  - This is accomplished by heating the bearing in a tank of oil that has a high flash point.
  - The oil temperature should not be allowed to exceed 121° C (250° F). The bearing should be heated for 20 or 30 minutes, or until it is expanded sufficiently to slide onto the shaft easily.
  - The bearing should not be in direct contact with the heat source.
  - The usual arrangement is to have a screen several inches from the bottom of the tank. Small support blocks separate the bearing from the screen.
  - It is important to keep the bearing away from any localized high-heat source that may raise its temperature excessively, resulting in ring hardness reduction.
  - Flame-type burners are commonly used. An automatic device for temperature control is desirable.
  - If safety regulations prevent the use of an open heated oil bath, a mixture of 15 percent soluble-oil water may be used. This mixture may be heated to a maximum of 121° C (250° F) without being flammable.

Arbor press method

- An alternate method of mounting, generally used only on smaller size bearings, is to press the bearing onto the shaft or into the housing. This can be done by using an arbor press and a mounting tube as shown in fig. 94.
- The tube should be made from soft steel with an inside diameter slightly larger than the shaft.
- The O.D. of the tube should not exceed the shaft backing diameter.
- The tube should be faced square at both ends. It should be thoroughly clean inside and out, and long enough to clear the end of the shaft after the bearing is mounted.
- If the outer ring is being pressed into the housing, the O.D. of the mounting tube should be slightly smaller than the housing bore. The I.D. should not be less than the suggested housing backing diameter in the table of dimensions.
- Coat the shaft with a light machine oil to reduce the force needed for a press fit.
- Carefully place the bearing on the shaft, making sure it is square with the shaft axis.
- Apply steady pressure from the arbor ram to drive the bearing firmly against the shoulder.

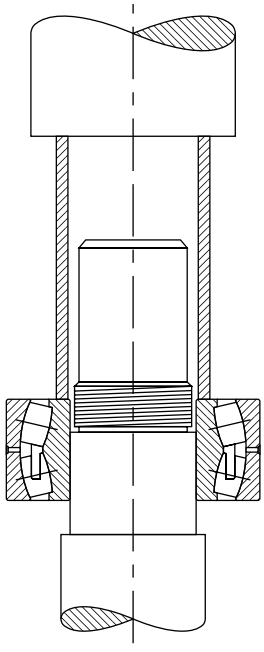


Fig. 94. Arbor press method.

NOTE

Never attempt a press fit on a shaft by applying pressure to the outer ring or a press fit in a housing by applying pressure to the inner ring.

NOTE

Never use steam or hot water when cleaning the bearings because these methods can create rust or corrosion.

NOTE

Never expose any surface of a bearing to the flame of a torch.

NOTE

Do not heat bearing beyond 121° C (250° F).

Mounting tapered bore spherical roller bearings

- Use a feeler gage with the thinnest blade of 0.038 mm (0.0015 inch).
- Place the bearing in an upright position with the inner and outer ring faces parallel.
- Place thumbs on the inner ring bore and oscillate the inner ring the distance of two or three roller spacings.
- Position the individual roller assemblies so that a roller is at the top of the inner ring on both sides of the bearing.
- With the roller in the correct position, insert a thin blade of the feeler gage between the roller and the outer ring.
- Move the feeler gage carefully along the top roller between the roller and outer ring raceway. Repeat this procedure using thicker feeler gage blades until one is found that will not go through.
- The blade thickness that preceded the "no-go" blade is a measure of RIC before installation.
- Start the mounting procedure by lubricating the tapered shaft with a light coat of machine oil.
- Slide the bearing onto the shaft as far as it will go by hand.
- As the locknut is tightened, the interference fit builds up, resulting in expansion of the inner ring.
- Periodically measure to keep track of the reduction in RIC.
- Continue the procedure until the proper amount of reduction is obtained. Do not exceed suggested amount of reduction.
- As a final check, make sure the remaining RIC equals or exceeds the minimum mounted clearance shown in table 42.
- During mounting, the RIC should be checked at the unloaded roller. If this is at the bottom, make sure that the roller is raised to seat firmly at the inboard position of the inner ring.
- When the suggested amount of RIC reduction has been accomplished, the bearing is properly fitted.
- Complete the procedure by peening the lockwasher tang into the locknut slot or securing the lockplate.



Fig. 95. Measure RIC before installation.

Mounting Cylindrical Bore Bearings - *continued*

Arbor press method

- An alternate method of mounting, generally used only on smaller size bearings, is to press the bearing onto the shaft or into the housing. This can be done by using an arbor press and a mounting tube as shown in fig. 96.
- The tube should be made from soft steel with an inside diameter slightly larger than the shaft.
- The O.D. of the tube should not exceed the shaft backing diameter given in the Timken Spherical Roller Bearing Catalog (order no. 10446), found on www.timken.com.
- The tube should be faced square at both ends. It should be thoroughly clean inside and out, and long enough to clear the end of the shaft after the bearing is mounted.

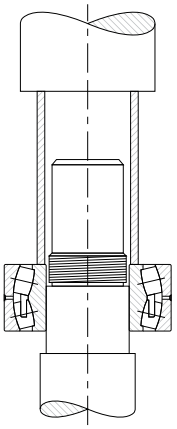


Fig. 96. Arbor press method.

- If the outer ring is being pressed into the housing, the O.D. of the mounting tube should be slightly smaller than the housing bore. The I.D. should not be less than the suggested housing backing diameter in the table of dimensions available in the Timken Spherical Roller Bearing Catalog (order no. 10446), found on www.timken.com.
- Coat the shaft with a light machine oil to reduce the force needed for a press fit.
- Carefully place the bearing on the shaft, making sure it is square with the shaft axis.
- Apply steady pressure from the arbor ram to drive the bearing firmly against the shoulder.

NOTE

Never attempt a press fit on a shaft by applying pressure to the outer ring or a press fit in a housing by applying pressure to the inner ring.

Mounting tapered bore spherical roller bearings

- Use a feeler gage with the thinnest blade of 0.038 mm (0.0015 in.).
- Place the bearing in an upright position with the inner and outer ring faces parallel.
- Place thumbs on the inner ring bore and oscillate the inner ring the distance of two or three roller spacings.
- Position the individual roller assemblies so that a roller is at the top of the inner ring on both sides of the bearing.
- With the roller in the correct position, insert a thin blade of the feeler gage between the roller and the outer ring.
- Move the feeler gage carefully along the top roller between the roller and outer ring raceway. Repeat this procedure using thicker feeler gage blades until one is found that will not go through.
- The blade thickness that preceded the “no-go” blade is a measure of RIC before installation.
- Start the mounting procedure by lubricating the tapered shaft with a light coat of machine oil.
- Slide the bearing onto the shaft as far as it will go by hand.
- As the locknut is tightened, the interference fit builds up, resulting in expansion of the inner ring.
- Periodically measure to keep track of the reduction in RIC.
- Continue the procedure until the proper amount of reduction is obtained. Do not exceed suggested amount of reduction.
- As a final check, make sure the remaining RIC equals or exceeds the minimum mounted clearance shown in table 42.
- During mounting, the RIC should be checked at the unloaded roller. If this is at the bottom, make sure that the roller is raised to seat firmly at the inboard position of the inner ring.
- When the suggested amount of RIC reduction has been accomplished, the bearing is properly fitted.
- Complete the procedure by peening the lockwasher tang into the locknut slot or securing the lockplate.



Fig. 97. Measure of RIC before installation.

ANGULAR CONTACT BALL BEARINGS

MOUNTING

Like tapered roller bearings, angular contact ball bearings are designed to take both radial and thrust loading. Forces are transmitted from the inner raceway to the outer raceway along a given contact angle, which is defined as the angle between the line of action of forces and a radial plane; see fig. 98. Forces along this contact angle can be resolved into radial and axial components. The axial force must be counteracted. As a result, most angular contact bearings are mounted in pairs and preloaded against each other to counteract the induced axial load from the opposing bearing and to stiffen the assembly in the axial direction.

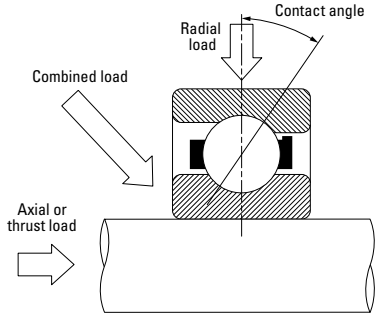


Fig. 98. Example of ball bearing loading.

In the case where an angular contact ball bearing is mounted alone, it requires adjustments and must be installed with care. As the bearing is relatively loose axially before mounting, it is important that the design incorporates some means to move the outer ring axially into its correct position relative to the inner ring. This adjustment should be made when the bearing is mounted. A common method is to place a preloaded spring or shims between either the inner raceway and shaft shoulder or outer raceway and housing such that the outer raceway is seated against the inner raceway.

A duplex bearing is comprised of two single-row bearings that are manufactured specifically for use as a unit. It is analogous to a double-row bearing having the same bore and outside diameter but twice the single-row width. Duplex bearings may be mounted back-to-back, face-to-face or in tandem as shown in figs. 100-102. The tandem mounting arrangement is used to achieve greater thrust-carrying capacity.

Typical applications for duplex angular contact ball bearings include deep well pumps, marine propeller shafts, machine tool spindles, speed reducers and elevator worm drives.

Duplex bearings may be used with spacers to increase bearing spread, which in turn increases the resistance to moment loading and decreases shaft deflection. Shaft and housing spacers must be accurately ground to the desired widths to ensure that proper preload is maintained. In addition, attention should be given to shaft and housing fits, squareness of shaft and housing shoulders and alignment of mating parts.

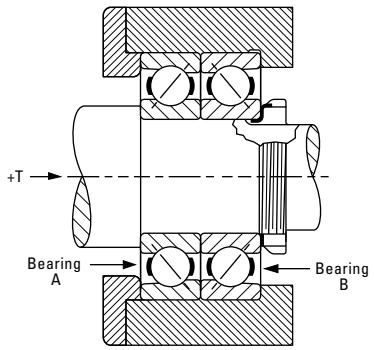


Fig. 99. Typical preload mountings.

Typical mountings of duplex bearings

Back-to-back mounting, DB or (O)
(Contact angles diverging toward shaft centerline)

Before mounting, there is clearance between the two adjacent inner-ring faces. After mounting, these faces are clamped together to provide an internal preload on each bearing. This arrangement is well-suited for pulleys, sheaves and in other applications where there are overturning loads. It also is suited in all floating positions where thermal expansion of the shaft occurs. It provides axial and radial rigidity and equal thrust capacity in either direction when used in a fixed location. Back-to-back is the most commonly used of all duplex arrangements.

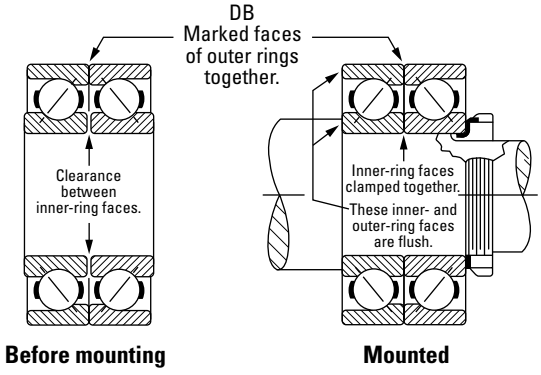


Fig. 100. Back-to-back bearing assemblies before and after mounting.

Face-to-face mounting, DF or (X)
(Contact angles converging toward shaft centerline)

Before mounting, there is clearance between the two adjacent outer-ring faces. After mounting, these faces are clamped together between the housing shoulder and cover-plate shoulder. This provides an internal preload on each bearing. This arrangement provides equal thrust capacity in either direction, as well as radial and axial rigidity.

Since the face-to-face mounting has inherent disadvantages of low resistance to moment loading and thermal instability, it should not be considered unless a significantly more convenient method of assembly or disassembly occurs from its use.

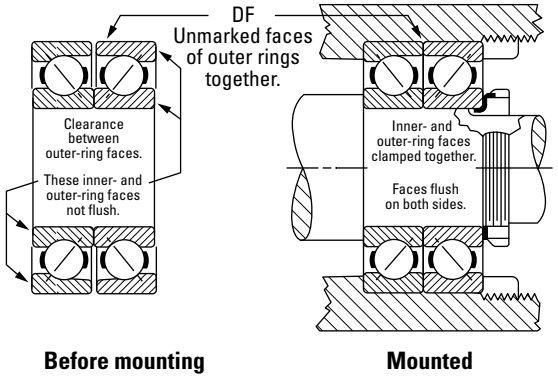


Fig. 101. Face-to-face bearing assemblies before and after mounting.

Tandem mounting, DT

Before mounting, the inner-ring faces of each bearing are offset from the outer-ring faces. After mounting, when a thrust load is applied equal to that of twice the normal preload, the inner- and outer-ring faces are brought into alignment on both sides. This arrangement provides double thrust capacity in one direction only. More than two bearings can be used in tandem if additional thrust capacity is required.

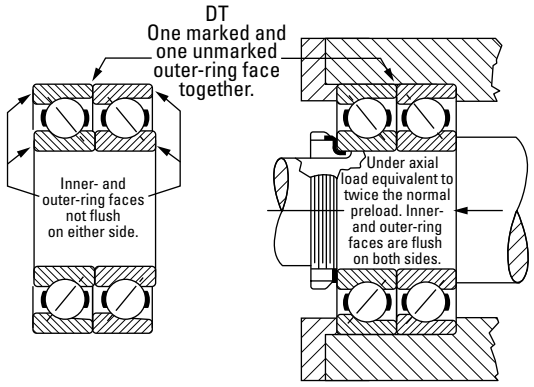


Fig. 102. Tandem bearing assemblies before and after mounting.

Other mountings

Flush-ground (DU) pairs may be mounted in combination with a single flush-ground bearing as a triplex (TU) set shown below (fig. 103). Also shown below is a quadruplex (QU) set where three bearings in tandem are mounted back-to-back with a single bearing. These arrangements provide high capacity in one direction and also a positively rigid mounting capable of carrying a moderate amount of reverse thrust.

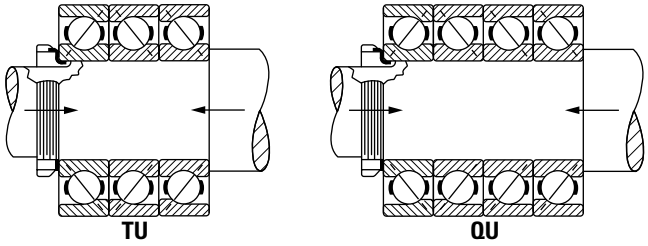


Fig. 103. Typical triplex and quadruplex bearing mountings.

FITTING PRACTICE

Recommended shaft fits are listed in table 72 on page 146 for 7000WN, 7200WU, 7300WN and 7400WN series. This table is to be used for applications where only one ring (either inner or outer) has an interference fit. In cases where interference fits are used for both rings, bearings with a special internal clearance may be required. Shaft diameter dimensions are for solid steel shafts. Consult your Timken engineer when special fits are required or when using hollow shafts.

SETTING

Timken has established standard preload levels that are considered proper for most duplex bearing applications. Special preloads also can be provided to satisfy extreme requirements. For example, a heavily loaded, slow-speed rotating shaft may require heavier-than-normal preload in order to minimize deflection. Although heavy preload provides slightly greater rigidity, it reduces bearing life and increases power consumption; therefore, preload levels should be chosen with care.

The axial deflection of a bearing subject to thrust loading is based on Hertz's theories for elastic bodies in contact. The general expression is:

$$\delta = K \left(\frac{F_a^2}{Zd^2} \right)^{1/3}$$

A typical axial deflection curve for an unpreloaded single-row angular contact bearing is shown as curve A in fig. 104. This curve represents the deflection characteristics of bearing A being subjected to thrust load F_a. The amount of deflection due to load F_{a1} is much greater than the increase in deflection caused by doubling the thrust load to F_{a2}. This illustrates the non-linear deflection of a ball bearing.

Curves C_1 and C_2 show the deflection of a double-row preloaded bearing as shown in fig. 104. Curve C_1 represents the bearing having a preload of F_{a1} and curve C_2 represents the bearing having a preload of F_{a2}. Comparing curves C_1 and C_2 with curve A shows the deflection of the preloaded pair is much lower than that of the unpreloaded bearing.

Curves B_1 and B_2 show the axial deflection of bearing B as mounted in fig. 105, from the preloaded conditions F_{a1} or F_{a2} to a non-preload condition.

Preloading can be accomplished by using springs or spacer width adjustment, but consult your Timken engineer for design review.

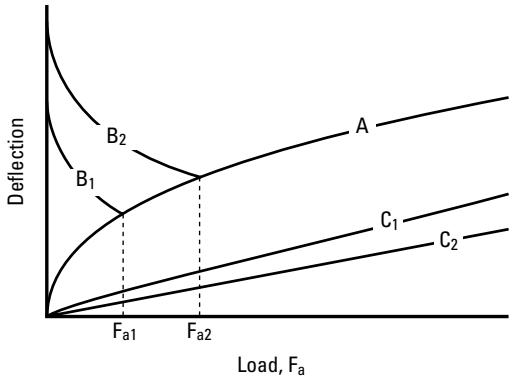


Fig. 104. Axial load-deflection curve of back-to-back mounted angular contact bearings. Curve A is for bearing A; B is for bearing B; and C_1 and C_2 are preload curves.

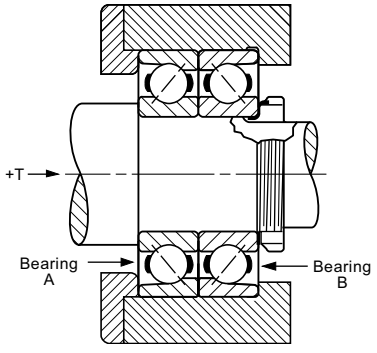


Fig. 105. Typical preload mountings.

RADIAL BALL BEARINGS

Radial ball bearings have historically been manufactured to standards established by ABEC and ABMA. These standards are being phased out and replaced by ISO standards. Table 44 lists ABEC standards and the corresponding ISO standard.

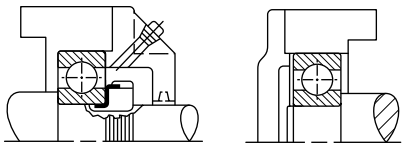
TABLE 44. BALL BEARING TOLERANCE STANDARDS

Specification	Standard Class	Precision Class			
ISO	P0	P6	P5	P4	P2
ABMA	ABEC 1	ABEC 3	ABEC 5	ABEC 7	ABEC 9

Among the tolerance classes, ISO P0/ABEC 1 applies to ball bearings made for standard usage. ISO P6, P5, P4, P2 and ABEC 3, 5, 7 and 9 classes apply to ball bearings of increased precision. For purposes of this manual, ISO P0/ABEC1 and ISO P6/ABEC 3 bearings are covered in this section. The remaining classes are covered in the PRECISION BEARINGS section starting on page 109.

MOUNTING

Although radial ball bearings are designed to carry a radial load, they perform well under combined radial and thrust loading. Radial ball bearings also are suitable for high speeds. As a result, they are used in a wide range of applications. Both the Conrad and filling-slot types can be mounted with or without locknuts. They also can be fixed or floating designs, as shown in fig. 106.



Fixed mounting **Floating mounting**

Fig. 106. Typical mounting designs.

Shaft and housing shoulders

Shaft and housing shoulder backing diameter recommendations are listed in tables 45-49 for individual bearing part numbers.

Fig. 107.

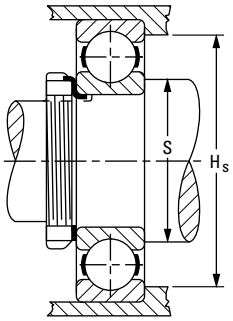


TABLE 45. RADIAL BALL BEARINGS – SHAFT AND HOUSING SHOULDERS

EXTRA-LIGHT • 9300 SERIES		
Basic Bearing Number	S Shaft Shoulder **± 0.25 mm** ±.010 in.	H_s Housing Shoulder **± 0.25 mm** ±.010 in.
	mm in.	**mm** in.
9301K	**14.7** 0.58	**21.6** 0.85
9302K	**17.8** 0.70	**25.4** 1.00
9303K	**19.8** 0.78	**27.4** 1.08
9304K	**23.9** 0.94	**33.5** 1.32
9305K	**29.0** 1.14	**38.6** 1.52
9306K	**33.5** 1.32	**43.4** 1.71
9307K	**39.6** 1.56	**50.8** 2.00
9308K	**45.0** 1.77	**57.4** 2.26
9309K	**50.3** 1.98	**63.2** 2.49
9310K	**54.9** 2.16	**67.6** 2.66
9311K	**61.0** 2.40	**74.7** 2.94
9312K	**65.8** 2.59	**79.8** 3.14

The preferred method of locating bearings on shafts and in housings is to provide accurate shoulders perpendicular to the shaft axis. Shoulders should be large enough to exceed the theoretical point of tangency between the corner radius and the face of the bearing. They also should be small enough to permit bearing removal with proper pullers.

Tables 45-49 list the suggested maximum and minimum shaft and housing shoulder diameters for the majority of applications. Where design limitations do not permit conformance to these suggested diameters, consult your Timken engineer.

Suggested shaft and housing fillet radii are listed in the dimensional tables of each product catalog. These must be used to assure proper seating against shaft and housing shoulders.

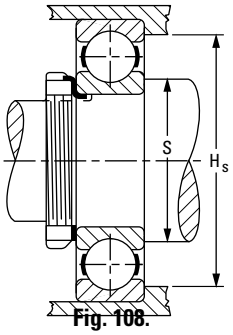


Fig. 108.

TABLE 46. RADIAL BALL BEARINGS – SHAFT AND HOUSING SHOULDERS

EXTRA-SMALL SERIES				
Basic Bearing Number	Shoulder Diameters			
	S Shaft		H_s Housing	
	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.
33K3	**5.1** 0.20	**4.8** 0.19	**8.1** 0.32	**7.9** 0.31
33K4	**6.1** 0.24	**5.8** 0.23	**11.2** 0.44	**10.9** 0.43
33K5	**6.6** 0.26	**6.4** 0.25	**11.2** 0.44	**10.9** 0.43
34K	**6.6** 0.26	**6.4** 0.25	**14.2** 0.56	**14.0** 0.55
35K	**9.4** 0.37	**9.1** 0.36	**17.0** 0.67	**16.8** 0.66
36K	**9.4** 0.37	**9.1** 0.36	**17.0** 0.67	**16.8** 0.66
37K	**11.2** 0.44	**10.7** 0.42	**20.1** 0.79	**19.6** 0.77
38K	**11.4** 0.45	**10.9** 0.43	**20.1** 0.79	**19.6** 0.77
38KV	**11.4** 0.45	**10.9** 0.43	**20.1** 0.79	**19.6** 0.77
39K	**13.0** 0.51	**12.5** 0.49	**23.1** 0.91	**22.6** 0.89
S1K7	**8.6** 0.34	**8.1** 0.32	**14.2** 0.56	**13.7** 0.54
S1K	**9.4** 0.37	**8.9** 0.35	**17.5** 0.69	**17.0** 0.67
S3K	**12.7** 0.50	**12.2** 0.48	**20.3** 0.80	**19.8** 0.78
S5K	**16.0** 0.63	**15.5** 0.61	**25.1** 0.99	**24.6** 0.97
S7K	**21.3** 0.84	**20.3** 0.80	**31.5** 1.24	**30.5** 1.20
S8K	**24.6** 0.97	**23.6** 0.93	**37.1** 1.46	**35.6** 1.40
S9K	**28.9** 1.14	**27.9** 1.10	**41.9** 1.65	**40.9** 1.61
S10K	**31.5** 1.24	**30.5** 1.20	**46.7** 1.84	**45.7** 1.80
S11K	**34.0** 1.34	**33.0** 1.30	**49.5** 1.95	**48.5** 1.91
S12K	**39.4** 1.55	**38.4** 1.51	**55.9** 2.20	**50.8** 2.00

TABLE 47. RADIAL BALL BEARINGS – SHAFT AND HOUSING SHOULDERS

EXTRA-LIGHT • 9100 SERIES					LIGHT • 200, 5200, 7200WN SERIES					MEDIUM • 300, 5300, 7300WN SERIES				
Basic Bearing Number	Shoulder Diameters				Basic Bearing Number	Shoulder Diameters				Basic Bearing Number	Shoulder Diameters			
	S Shaft		H_s Housing			S Shaft		H_s Housing			S Shaft		H_s Housing	
	Max.	Min.	Max.	Min.		Max.	Min.	Max.	Min.		Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.	**mm** in.	**mm** in.
9100	**13.2** 0.52	**11.9** 0.47	**24.1** 0.95	**23.1** 0.91	200	**14.2** 0.56	**12.7** 0.50	**24.9** 0.98	**24.6** 0.97	300	**15.0** 0.59	**12.7** 0.50	**30.0** 1.18	**29.2** 1.15
9101	**18.0** 0.71	**14.0** 0.55	**25.9** 1.02	**24.6** 0.97	201	**16.3** 0.64	**14.7** 0.58	**26.9** 1.06	**26.7** 1.05	301	**17.5** 0.69	**16.0** 0.63	**31.0** 1.22	**30.7** 1.21
9102	**19.0** 0.75	**17.0** 0.67	**30.0** 1.18	**28.7** 1.13	202	**19.0** 0.75	**17.5** 0.69	**30.0** 1.18	**29.2** 1.15	302	**20.6** 0.81	**19.0** 0.75	**36.1** 1.42	**35.6** 1.40
9103	**20.6** 0.81	**19.0** 0.75	**33.0** 1.30	**31.8** 1.25	203	**21.3** 0.84	**19.6** 0.77	**34.0** 1.34	**33.3** 1.31	303	**23.1** 0.91	**21.1** 0.83	**40.9** 1.61	**40.6** 1.60
9104	**24.9** 0.98	**22.6** 0.89	**37.1** 1.46	**35.8** 1.41	204	**25.4** 1.00	**23.9** 0.94	**40.9** 1.61	**40.1** 1.58	304	**26.9** 1.06	**23.9** 0.94	**45.0** 1.77	**44.4** 1.75
9105	**30.0** 1.18	**27.4** 1.08	**41.9** 1.65	**40.6** 1.60	205	**31.0** 1.22	**29.0** 1.14	**46.0** 1.81	**45.2** 1.78	305	**33.3** 1.31	**29.0** 1.14	**55.1** 2.17	**53.1** 2.09
9106	**35.1** 1.38	**34.0** 1.34	**49.0** 1.93	**47.8** 1.88	206	**37.3** 1.47	**34.0** 1.34	**56.1** 2.21	**54.9** 2.16	306	**39.6** 1.56	**34.0** 1.34	**65.0** 2.56	**62.0** 2.44
9107	**41.4** 1.63	**38.9** 1.53	**56.1** 2.21	**54.6** 2.15	207	**43.7** 1.72	**38.9** 1.53	**65.0** 2.56	**62.7** 2.47	307	**45.2** 1.78	**42.9** 1.69	**71.1** 2.80	**69.1** 2.72
9108	**46.0** 1.81	**43.9** 1.73	**62.0** 2.44	**60.7** 2.39	208	**49.3** 1.94	**43.9** 1.73	**72.9** 2.87	**70.6** 2.78	308	**50.8** 2.00	**49.0** 1.93	**81.0** 3.19	**77.7** 3.06
9109	**51.6** 2.03	**49.3** 1.94	**69.1** 2.72	**67.8** 2.67	209	**54.1** 2.13	**49.3** 1.94	**78.0** 3.07	**75.4** 2.97	309	**57.9** 2.28	**54.1** 2.13	**90.9** 3.58	**86.6** 3.41
9110	**56.4** 2.22	**54.1** 2.13	**73.9** 2.91	**72.6** 2.86	210	**59.4** 2.34	**54.1** 2.13	**83.1** 3.27	**80.5** 3.17	310	**63.5** 2.50	**59.9** 2.36	**100.1** 3.94	**95.2** 3.75
9111	**63.0** 2.48	**59.2** 2.33	**83.1** 3.27	**81.8** 3.22	211	**64.5** 2.54	**61.2** 2.41	**93.5** 3.68	**90.4** 3.56	311	**69.8** 2.75	**65.0** 2.56	**110.0** 4.33	**104.9** 4.13
9112	**67.8** 2.67	**64.3** 2.53	**88.1** 3.47	**86.9** 3.42	212	**71.4** 2.81	**67.8** 2.67	**101.1** 3.98	**98.3** 3.87	312	**74.7** 2.94	**72.1** 2.84	**118.1** 4.65	**112.8** 4.44
9113	**72.1** 2.84	**69.1** 2.72	**93.0** 3.66	**81.7** 3.61	213	**77.0** 3.03	**72.6** 2.86	**111.0** 4.37	**106.4** 4.19	313	**81.0** 3.19	**77.0** 3.03	**128.0** 5.04	**122.2** 4.81
9114	**79.0** 3.11	**73.9** 2.91	**103.1** 4.06	**100.8** 3.97	214	**81.8** 3.22	**77.7** 3.06	**116.1** 4.57	**112.0** 4.41	314	**87.4** 3.44	**82.0** 3.23	**137.9** 5.43	**130.3** 5.13
9115	**84.1** 3.31	**79.0** 3.11	**108.0** 4.25	**105.7** 4.16	215	**87.4** 3.44	**82.6** 3.25	**120.9** 4.76	**116.6** 4.59	315	**98.6** 3.88	**87.1** 3.43	**148.1** 5.83	**139.7** 5.50
9116	**90.4** 3.56	**84.1** 3.31	**118.1** 4.65	**114.3** 4.50	216	**93.7** 3.69	**90.2** 3.55	**130.0** 5.12	**125.2** 4.93	316	**100.1** 3.94	**91.9** 3.62	**158** 6.22	**149.4** 5.88
9117	**95.2** 3.75	**88.9** 3.50	**122.9** 4.84	**119.6** 4.71	217	**98.6** 3.88	**95.2** 3.75	**140.0** 5.51	**134.9** 5.31	317	**104.9** 4.13	**99.1** 3.90	**166.1** 6.54	**157.2** 6.19
9118	**102.4** 4.03	**97.5** 3.84	**131.1** 5.16	**130.3** 5.13	218	**105.7** 4.16	**100.1** 3.94	**150.1** 5.91	**142.7** 5.62	318	**111.3** 4.38	**103.9** 4.09	**176.0** 6.93	**165.1** 6.50
9120	**111.3** 4.38	**107.4** 4.23	**141.0** 5.55	**138.2** 5.44	219	**111.3** 4.38	**106.9** 4.21	**158.0** 6.22	**153.9** 6.06	319	**117.6** 4.63	**109.0** 4.29	**185.9** 7.32	**174.8** 6.88
9121	**118.4** 4.66	**115.1** 4.53	**150.1** 5.91	**146.0** 5.75	220	**117.6** 4.63	**112.0** 4.41	**167.9** 6.61	**160.3** 6.31	320	**124.0** 4.88	**114.0** 4.49	**200.9** 7.91	**187.4** 7.38
9122	**124.7** 4.91	**119.9** 4.72	**160.0** 6.30	**157.0** 6.18	221	**124.0** 4.88	**117.1** 4.61	**178.1** 7.01	**174.8** 6.88	321	**130.3** 5.13	**119.1** 4.69	**211.1** 8.31	**196.8** 7.75

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EXTRA-LIGHT • 9100 SERIES					LIGHT • 200, 5200, 7200WN SERIES					MEDIUM • 300, 5300, 7300WN SERIES				
Basic Bearing Number	Shoulder Diameters				Basic Bearing Number	Shoulder Diameters				Basic Bearing Number	Shoulder Diameters			
	S Shaft		H_s Housing			S Shaft		H_s Housing			S Shaft		H_s Housing	
	Max.	Min.	Max.	Min.		Max.	Min.	Max.	Min.		Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.	**mm** in.	**mm** in.
9124	**134.1** 5.28	**130.0** 5.12	**169.9** 6.69	**165.1** 6.50	222	**130.3** 5.13	**121.9** 4.80	**188.0** 7.40	**179.3** 7.06	322	**139.7** 5.50	**124.0** 4.88	**226.1** 8.90	**209.6** 8.25
9126	**147.6** 5.81	**140.0** 5.51	**190.0** 7.48	**184.1** 7.25	224	**143.0** 5.63	**132.1** 5.20	**202.9** 7.99	**192.0** 7.56	324	**152.4** 6.00	**134.1** 5.28	**246.1** 9.69	**226.8** 8.93
9128	**153.9** 6.06	**147.6** 5.81	**200.2** 7.88	**195.1** 7.68	226	**152.4** 6.00	**144.0** 5.67	**215.9** 8.50	**206.5** 8.13	326	**163.6** 6.44	**148.1** 5.83	**262.1** 10.32	**246.1** 9.69
9130	**167.4** 6.59	**162.1** 6.38	**213.1** 8.39	**206.5** 8.13	228	**165.1** 6.50	**153.9** 6.06	**236.0** 9.29	**223.8** 8.81	328	**176.0** 6.93	**158.0** 6.22	**281.9** 11.10	**263.7** 10.38
9132	**176.8** 6.96	**166.6** 6.56	**228.6** 9.00	**222.2** 8.75	230	**177.0** 6.97	**164.1** 6.46	**256.0** 10.08	**241.3** 9.50	330	**189.0** 7.44	**167.9** 6.61	**302.0** 11.89	**280.9** 11.06
9134	**192.0** 7.56	**182.1** 7.17	**247.9** 9.76	**239.8** 9.44	232	**186.9** 7.36	**174.0** 6.85	**276.1** 10.87	**260.4** 10.25	332	**188.0** 7.84	**178.0** 7.01	**322.1** 12.68	**294.1** 11.58
9138	**212.9** 8.38	**201.9** 7.95	**278.1** 10.95	**266.7** 10.5	234	**202.7** 7.98	**188.0** 7.40	**292.1** 11.50	**276.4** 10.88	334	**213.4** 8.40	**188.0** 7.40	**342.1** 13.47	**311.7** 12.27
9140	**224.5** 8.84	**212.1** 8.35	**297.9** 11.73	**285.0** 11.22	236	**212.9** 8.38	**198.1** 7.80	**302.0** 11.89	**281.7** 11.09	336	**223.5** 8.80	**198.1** 7.80	**362.0** 14.25	**331.5** 13.05
9144	**246.4** 9.70	**233.9** 9.21	**326.1** 12.84	**310.9** 12.24	238	**222.8** 8.77	**208.0** 8.19	**322.1** 12.68	**301.8** 11.88	338	**237.5** 9.35	**212.1** 8.35	**378.2** 14.89	**345.2** 13.59
9148	**266.7** 10.50	**254.0** 10.00	**345.9** 13.62	**330.7** 13.02	240	**239.3** 9.42	**217.9** 8.58	**342.1** 13.47	**319.3** 12.57	340	**249.9** 9.84	**222.0** 8.74	**398.0** 15.67	**365.0** 14.37
9152	**291.8** 1 1.49	**278.1** 10.95	**382.0** 15.04	**366.8** 14.44	242	**246.1** 9.69	**225.3** 8.87	**362.2** 14.26	**336.8** 13.26	342	**260.1** 10.24	**232.2** 9.14	**418.3** 16.47	**385.3** 15.17
9156	**313.2** 12.33	**297.9** 11.73	**402.1** 15.83	**386.8** 15.23	244	**257.6** 10.14	**238.0** 9.37	**382.0** 15.04	**356.6** 14.04	344	**272.5** 10.73	**242.1** 9.53	**437.9** 17.24	**405.4** 15.96
9160	**339.3** 1 3.36	**318.0** 12.52	**442.0** 17.40	**421.6** 16.60	246	**268.7** 10.58	**247.9** 9.76	**402.1** 15.83	**370.8** 14.60	348	**292.6** 11.52	**262.1** 10.32	**478.0** 18.82	**439.9** 17.32
9164	**360.4** 14.19	**338.1** 13.31	**462.0** 18.19	**441.7** 17.39	248	**283.5** 11.16	**258.1** 10.16	**421.9** 16.61	**385.6** 15.18	352	**318.5** 12.54	**288.0** 11.34	**512.1** 20.16	**474.0** 18.66
9180	**457.2** 18.00	**431.8** 17.00	**561.8** 22.12	**549.1** 21.62	250	**293.4** 11.55	**268.0** 10.55	**442.0** 17.40	**398.8** 15.70	356	**341.1** 13.43	**308.1** 12.13	**551.9** 21.73	**511.3** 20.13

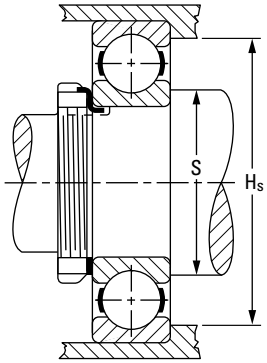


Fig. 109. Non-standard, extra-large.

TABLE 48. RADIAL BALL BEARINGS – SHAFT AND HOUSING SHOULDERS

HEAVY – 400, 7400 SERIES					NON-STANDARD EXTRA-LARGE				
Basic Bearing Number	Shoulder Diameters				Basic Bearing Number	Shoulder Diameters			
	S Shaft		H_s Housing			S Shaft		H_s Housing	
	Max.	Min.	Max.	Min.		Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.	**mm** in.	**mm** in.
7405	**37.3** 1.47	**34.0** 1.34	**71.1** 2.80	**66.8** 2.63	120W2	**117.6** 4.63	**111.8** 4.40	**150.1** 5.91	**146** 5.75
7406	**43.7** 1.72	**39.1** 1.54	**81.0** 3.19	**76.2** 3.00	122W	**124.7** 4.91	**120.1** 4.73	**162.8** 6.41	**158.8** 6.25
7407	**49.0** 1.93	**43.9** 1.73	**90.9** 3.58	**85.9** 3.38	124W	**134.1** 5.28	**130.0** 5.12	**178.1** 7.01	**174.5** 6.87
7408	**55.6** 2.19	**50.0** 1.97	**100.1** 3.94	**93.7** 3.69	126W	**147.8** 5.82	**139.7** 5.50	**193.0** 7.60	**185.7** 7.31
7409	**62.0** 2.44	**55.1** 2.17	**110.0** 4.33	**101.6** 4.00	128W	**157.2** 6.19	**150.1** 5.91	**207.8** 8.18	**202.2** 7.96
7410	**68.3** 2.69	**62.0** 2.44	**118.1** 4.65	**111.3** 4.38	130W	**167.4** 6.59	**162.1** 6.38	**223.0** 8.78	**216.2** 8.51
7411	**74.4** 2.93	**67.1** 2.64	**128.0** 5.04	**120.7** 4.75	132W	**189.0** 7.44	**174.0** 6.85	**234.7** 9.24	**223.8** 8.81
7412	**81.0** 3.19	**72.1** 2.84	**137.9** 5.43	**130.3** 5.13	134W	**191.0** 7.52	**185.2** 7.29	**249.7** 9.83	**244.1** 9.61
7413	**88.9** 3.50	**77.0** 3.03	**148.1** 5.83	**139.7** 5.50	136W	**203.2** 8.00	**195.3** 7.69	**264.7** 10.42	**257.8** 10.15
7414	**93.7** 3.69	**84.1** 3.31	**166.1** 6.54	**155.7** 6.13	138W	**214.4** 8.44	**205.2** 8.08	**284.7** 11.21	**276.1** 10.87
7415	**99.8** 3.93	**88.9** 3.50	**176.0** 6.93	**163.6** 6.44	224W	**143.0** 5.63	**132.1** 5.20	**203.2** 8.00	**192** 7.56
7416	**104.9** 4.13	**94.0** 3.70	**185.9** 7.32	**173.0** 6.81	226	**152.4** 6.00	**144.0** 5.67	**215.9** 8.50	**206.5** 8.13
7418	**119.1** 4.69	**108.0** 4.25	**207.0** 8.15	**196.9** 7.75	228	**165.1** 6.50	**153.9** 6.06	**236.0** 9.29	**223.8** 8.81
7420	**131.3** 5.17	**119.9** 4.72	**233.9** 9.21	**223.3** 8.79	276-2	**401.8** 15.82	**400.1** 15.75	**463.6** 18.25	**461.5** 18.17

Housing shoulder diameters of bearings with Mechani-Seals differ slightly from those of other types to allow for clearance between the external rotating member of the seal and the housing shoulder.

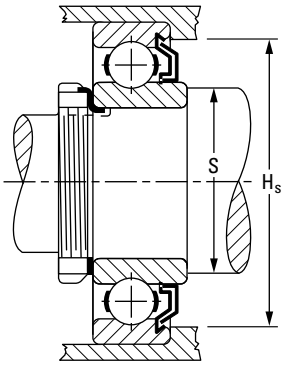


Fig. 110. Mechani-Seal KL, KLD, KLL types.

TABLE 49. RADIAL BALL BEARINGS – SHAFT AND HOUSING SHOULDERS

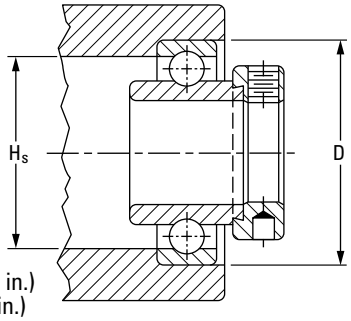
MECHANI-SEAL KL, KLD, KLL TYPES		
Basic Bearing Number	Housing Shoulder H_s Diameter	
	Max.	Min.
	mm in.	**mm** in.
36	**17.0** 0.67	**16.8** 0.66
36V	**17.0** 0.67	**16.8** 0.66
37	**20.1** 0.79	**19.6** 0.77
37V	**20.1** 0.79	**19.6** 0.77
34	**20.1** 0.79	**19.6** 0.77
38V	**20.1** 0.79	**19.6** 0.77
39	**23.1** 0.91	**22.6** 0.89
39V	**23.1** 0.91	**22.6** 0.89
200	**27.7** 1.09	**26.2** 1.03
201	**29.5** 1.16	**27.7** 1.09
20-2	**29.5** 1.16	**27.7** 1.09
201-3	**29.5** 1.16	**27.7** 1.09
202	**32.5** 1.28	**31.0** 1.22
202-2	**32.5** 1.28	**31.0** 1.22

MECHANI-SEAL KL, KLD, KLL TYPES		
Basic Bearing Number	Housing Shoulder H_s Diameter	
	Max.	Min.
	mm in.	**mm** in.
202-3	**32.5** 1.28	**31.0** 1.22
202-4	**32.5** 1.28	**31.0** 1.22
203	**36.6** 1.44	**35.8** 1.41
204	**43.7** 1.72	**41.1** 1.62
204-2	**43.7** 1.72	**41.1** 1.62
205	**48.5** 1.91	**46.7** 1.84
205-2	**48.5** 1.91	**46.7** 1.84
206	**57.9** 2.28	**56.4** 2.22
207	**67.6** 2.66	**64.3** 2.53
208	**75.4** 2.97	**71.4** 2.81
209	**80.3** 3.16	**77.0** 3.03
209-2	**80.3** 3.16	**77.0** 3.03
211	**93.7** 3.69	**90.4** 3.56

Continued in next column.

Wide inner ring ball bearings

With wide inner ring ball bearings, a locking collar is used to lock the bearing to the shaft. Since movement of the bearing relative to the shaft is not an issue, a slip fit of the bearing on the shaft is recommended. Suggested inner ring bore and shaft tolerances are listed below. It may be permissible to use increased shaft tolerances in some cases. Such cases should be reviewed by your Timken engineer.



Bearing bore tolerance:
½ in. - 2 3⁄16 in. = nominal to **+0.013 mm** (+0.0005 in.)
2 ¼ in. - 3 3⁄16 in. = nominal to **+0.015 mm** (+0.0006 in.)
3 7⁄16 in. - 3 15⁄16 in. = nominal to **+0.018 mm** (+0.0007 in.)

Shaft tolerances:
½ in. - 1 15⁄16 in. = nominal to **-0.013 mm** (-0.0005 in.)
2 in. - 3 15⁄16 in. = nominal to **-0.025 mm** (-0.0010 in.)

TABLE 50. WIDE INNER RING BALL BEARINGS – HOUSING, SHOULDERS AND SHAFT DIAMETERS

Bearing Number					Shaft Size	Basic Outer Ring Size	Stationary Housing			Shoulder Diameter	
							D Housing Bore		Mean Fit	H_s	
KRR TYPE	G-KRR TYPE	RA-RR TYPE	GRA-RR TYPE	GYA-RR(1) TYPE			Min.	Max.	Loose	Max.	Min.
					mm in.		mm in.	mm in.	mm in.	mm in.	mm in.
E17KRR	GE17KRR	RAE17RR	GRAE17RR	GYAE17RR	**17**						
1008KRR	–	RA008RR	GRA008RR	GYA0008RR	1/2	203	**40.000**	**40.015**	**0.013**	**34.8**	**34.0**
–	–	RA009RR	GRA009RR	GYA009RR	9/16		1.5748	1.5754	0.0005	1.37	1.34
1010KRR(KR)	G1010KRR	RA010RR	GRA010RR	GYA010RR	5/8						
1011KRR	G1011KRR	–	–	–	11/16						
E20KRR	GE20KRR	RAE20RR	GRAE20RR	GYAE20RR	**20**	204	**47.000**	**47.015**	**0.013**	**40.9**	**40.6**
1012KRR(KR)	G1012KRR	RA012RR	GRA012RR	GYA012RR	3/4		1.8504	1.8510	0.0005	1.61	1.60
E25KRR	GE25KRR	RAE25RR	GRAE25RR	GYAE25RR	**25**						
1013KRR	–	RA013RR	GRA013RR	GYA013RR	13/16	205	**51.999**	**52.017**	**0.015**	**46.0**	**45.7**
1014KRR	G1014KRR	RA014RR	GRA014RR	GYA014RR	7/8		2.0472	2.0479	0.0006	1.81	1.80
1015KRR(KR)	G1015KRR	RA015RR	GRA015RR	GYA015RR	15/16						
1100KRR(KR)	G1100KRR	RA100RR	GRA100RR	GYA100RR	1						
E30KRR	GE30KRR	RAE30RR	GRAE30RR	GYAE30RR	**30**						
–	G1101KRR	RA101RR	GRA101RR	GYA101RR	1 1/16	206	**61.999**	**62.017**	**0.015**	**56.1**	**54.9**
1102KRR(KR)	G1102KRR	RA102RR	GRA102RR	GYA102RR	1 1/8		2.4409	2.4416	0.0006	2.21	2.16
1103KRR(KR)	G1103KRR	RA103RR	GRA103RR	GYA103RR	1 3/16						
–	–	–	–	GYA103RR2	1 1/4						
E35KRR	GE35KRR	RAE35RR	GRAE35RR	GYAE35RR	**35**						
1104KRR(KR)	G1104KRR	RA104RR	GRA104RR	GYA104RR	1 1/4	207	**71.999**	**72.017**	**0.015**	**56.1**	**54.9**
1105KRR	–	RA105RR	GRA105RR	GYA105RR	1 5/16		2.8346	2.8353	0.0006	2.56	2.47
1106KRR	G1106KRR	RA106RR	GRA106RR	GYA106RR	1 3/8						
1107KRR(KR)	G1107KR	RRA107RR	GRA107RR	GYA107RR	1 7/16						
–	–	–	GRAE40RR	GYAE40RR	**40**	208	**80.000**	**80.018**	**0.020**	**78.0**	**75.4**
1108KRR(KR)	G1108KRR	RA108RR	GRA108RR	GYA108RR	1 1/2		3.1496	3.1503	0.0006	2.87	2.78
–	–	RA106RR	GRA109RR	GYA109RR	1 9/16						
E45KRR	–	–	GRAE45RR	GYAE45RR	**45**						
1110KRR	G1110KRR	RA110RR	GRA110RR	GYA110RR	1 5/8	209	**85.001**	**85.024**	**0.020**	**78.0**	**75.4**
1111KRR(KR)	G1111KRR	RA111RR	GRA111RR	GYA111RR	1 11/16		3.3465	3.3474	0.0008	3.07	2.97
1112KRR(KR)	G1112KRR	RA112RR	GRA112RR	GYA112RR	1 3/4						
E50KRR	GE50KRR	RAE50RR	GRAE50RR	GYAE50RR	**50**						
–	–	RA113RR	GRA113RR	GYA113RR	1 13/16	210	**90.000**	**90.023**	**0.020**	**83.1**	**81.0**
1114KRR	–	RA114RR	GRA114RR	GYA114RR	1 7/8		3.5433	3.5442	0.0008	3.27	3.19
1115KRR(KR)	G1115KRR	RA115RR	GRA115RR	GYA115RR	1 15/16						
–	–	–	GRA115RR2	–	2						
E55KRR	GE55KRR	RAE55RR	GRAE55RR	GYAE55RR	**55**						
1200KRR(KR)	G1200KRR	RA200RR	GRA200RR	GYA200RR	2	211	**100.000**	**100.023**	**0.020**	**90.9**	**90.4**
–	–	RA201RR	GRA201RR	GYA201RR	2 1/16		3.9370	3.9379	0.0008	3.58	3.56
1202KRR	–	RA202RR	GRA202RR	GYA202RR	2 1/8						
1203KRR(KR)	G1203KRR	RA203RR	GRA203RR	GYA203RR	2 3/16						
E60KRR	GE60KRR	–	–	–	**60**	212	**110.000**	**110.02**	**0.020**	**101.1**	**98.3**
1204KRR	–	–	–	–	2 1/4		4.3307	4.3316	0.0008	3.98	3.87
1207KRR(KR)	G1207KRR	–	–	–	2 7/16						
E75KRR	–	–	–	–	**75**	215	**130.000**	**130.025**	**0.023**	**120.9**	**116.6**
1215KRR	–	–	–	–	2 15/16		5.1181	5.1191	0.0009	4.76	4.59

(1)Available in applications that cannot be relubricated (omit prefix g).

FITTING PRACTICE

Table 73 on page 147 provide guidelines for shaft and housing fits related to particular operating conditions for ISO P0 (ABEC 1) and ISO P6 (ABEC 3) radial ball bearings. Shaft and housing tolerance guidelines are shown on pages 132-135.

SETTING

Correct bearing mounting and fitting practices are key components of proper bearing setting. Setting is the amount of clearance or interference within a mounted bearing. Bearing internal clearance is affected by the tightness of the fit to the inner and outer rings. Proper bearing setting is crucial to bearing life and performance. Application-dependant factors such as load, speed, bearing position, installation method, materials of construction, runout accuracy, thermal considerations, hoop stress, shaft design and housing design can affect internal clearance and should be taken into account when determining the bench setting. This section provides tables and discussion to aid in selection of the proper bearing mounting and fitting procedures to optimize performance in general applications. For special applications, please consult your Timken engineer for review.

In the manufacture of ball bearings, it is standard practice to assemble rings and rolling elements with a specified internal clearance. This characteristic is necessary to absorb the effect of press fitting the bearing rings at mounting.

Internal clearance also can be added to compensate for thermal expansion of bearings, shafts and housings or to provide a contact angle in the bearing after mounting.

Internal clearance can be measured either by gauging radially or axially.

For radial ball bearings, internal clearance is typically measured in the radial direction because it is more directly related to shaft and housing fits. It also is the method prescribed by the industry.

The radial internal clearance (RIC) of a radial contact ball bearing can be defined as the average outer ring raceway diameter minus the average inner-ring raceway diameter minus twice the ball diameter.

RIC can be measured mechanically by moving the outer ring horizontally, as pictured in fig. 111. The total movement of the outer ring when the balls are properly seated in the raceways determines the RIC. Several readings should be taken using different circumferential orientations of the rings to get a comprehensive average reading.

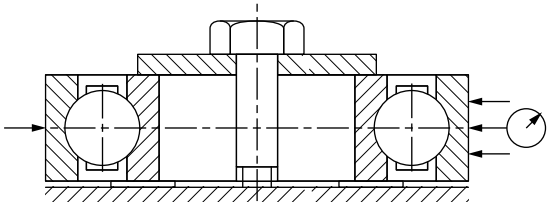


Fig. 111. Radial internal clearance.

The Timken Company radial clearance designations correlate with industry symbols as follows:

TABLE 51. RADIAL CLEARANCE DESIGNATION

Bearing Number Prefix	Industry Designation	Description
H	2	**Snug;** slight internal clearance; sometimes used to achieve a minimum of radial or axial play in an assembly. Example: H204K.
R	0	**Medium;** internal clearance generally satisfactory with suggested shaft and housing fits. Example: RMM204K.
P	3	**Loose;** considerable internal clearance required for applications involving press fits on both inner and outer rings, extra interference fits or temperature differentials. Example: P204K.
J	4	**Extra loose;** large amount of internal clearance for applications involving large interference fits or temperature differentials. Example: J204K.
JJ	5	**Extra-extra loose;** extra large amount of internal clearance for applications with large temperature differential and interference fits on both rings.

Endplay (axial clearance)

Endplay is an alternate method of measuring internal clearance and is rarely used except for certain special applications. Endplay is determined by mounting the bearing, as shown in fig. 112, with one of its rings clamped to prevent axial movement. A reversing measuring load is applied to the unclamped ring so that the resultant movement of that ring is parallel to the bearing axis. Endplay is the total movement of the unclamped ring when the load is applied first in one direction and then in the other.

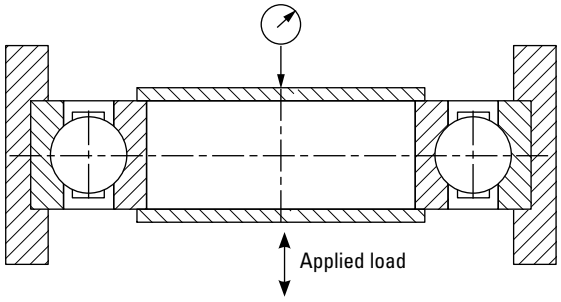


Fig. 112. Example of endplay.

When the inner and outer ring raceway curvatures are accurately known, the free endplay can readily be calculated from the values of no load radial clearance by the following formula:

$$E = \sqrt{4d[RIC](K_O + K_i - 1) - RIC^2} \text{ or } \cong \sqrt{4d[RIC](K_O + K_i - 1)}$$

(Where: RIC^2 is generally a very small value and can be omitted for most calculations without introducing undue inaccuracy.)

The contact angle (α) is related to internal clearance as follows:

$$\alpha = \sin^{-1} \frac{E}{2\,(K_o + K_i - 1)\,d}$$

Where: d is ball diameter.

TABLE 52. RADIAL BALL BEARINGS – RADIAL INTERNAL CLEARANCE ACCEPTANCE LIMITS[1]

Basic Bore Diameter		Timken® Prefix (Industry Designation)									
		H(C2)		R(C0)		P(C3)		J(C4)		JJ(C5)	
Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
mm in.		mm in.		mm in.		mm in.		mm in.		mm in.	
2.5000 0.0984	**10.000** 0.3937	**0.007** 0.0003	**0.000** 0.0000	**0.013** 0.0005	**0.002** 0.0001	**0.023** 0.0009	**0.008** 0.0003	**0.029** 0.0011	**0.014** 0.0006	**0.037** 0.0015	**0.020** 0.0008
10.000 0.3937	**18.000** 0.7087	**0.009** 0.00035	**0.000** 0.0000	**0.018** 0.0007	**0.003** 0.0001	**0.025** 0.001	**0.011** 0.0004	**0.033** 0.0013	**0.018** 0.0007	**0.045** 0.0018	**0.025** 0.0010
18.000 0.7087	**24.000** 0.9449	**0.010** 0.0004	**0.000** 0.0000	**0.020** 0.0008	**0.005** 0.0002	**0.028** 0.0011	**0.013** 0.0005	**0.036** 0.0014	**0.020** 0.0008	**0.048** 0.0019	**0.028** 0.0011
24.000 0.9449	**30.000** 1.811	**0.011** 0.00045	**0.001** 0.0001	**0.020** 0.0008	**0.005** 0.0002	**0.028** 0.0011	**0.013** 0.0005	**0.041** 0.0016	**0.023** 0.0009	**0.053** 0.0021	**0.030** 0.0012
30.000 1.811	**40.000** 1.5748	**0.011** 0.00045	**0.001** 0.0001	**0.020** 0.0008	**0.006** 0.0002	**0.033** 0.0013	**0.015** 0.0006	**0.046** 0.0018	**0.028** 0.0011	**0.064** 0.0025	**0.040** 0.0016
40.000 1.5748	**50.000** 1.9685	**0.011** 0.00045	**0.001** 0.0001	**0.023** 0.0009	**0.006** 0.00025	**0.036** 0.0014	**0.018** 0.0007	**0.051** 0.0020	**0.030** 0.0012	**0.073** 0.0029	**0.045** 0.0018
50.000 1.9685	**65.000** 2.5591	**0.015** 0.0006	**0.001** 0.0001	**0.028** 0.0011	**0.008** 0.00035	**0.043** 0.0017	**0.023** 0.0009	**0.061** 0.0024	**0.038** 0.0015	**0.090** 0.0035	**0.055** 0.0022
65.000 2.5591	**80.000** 3.1496	**0.015** 0.0006	**0.001** 0.0001	**0.030** 0.0012	**0.010** 0.0004	**0.051** 0.0020	**0.025** 0.0010	**0.071** 0.0028	**0.046** 0.0018	**0.105** 0.0041	**0.065** 0.0026
80.000 3.1496	**100.000** 3.9370	**0.018** 0.0007	**0.001** 0.0001	**0.036** 0.0014	**0.012** 0.00045	**0.058** 0.0023	**0.030** 0.0012	**0.084** 0.0033	**0.053** 0.0021	**0.120** 0.0047	**0.075** 0.0030
100.000 3.9370	**120.000** 4.7244	**0.020** 0.0008	**0.002** 0.0001	**0.041** 0.0016	**0.015** 0.0006	**0.066** 0.0026	**0.036** 0.0014	**0.097** 0.0038	**0.061** 0.0024	**0.140** 0.0055	**0.090** 0.0035
120.000 4.7244	**140.000** 5.5118	**0.023** 0.0009	**0.002** 0.0001	**0.048** 0.0019	**0.018** 0.0007	**0.081** 0.0032	**0.041** 0.0016	**0.114** 0.0045	**0.071** 0.0028	**0.160** 0.0063	**0.105** 0.0041
140.000 5.5118	**160.000** 6.2992	**0.023** 0.0009	**0.002** 0.0001	**0.053** 0.0021	**0.018** 0.0007	**0.091** 0.0036	**0.046** 0.0018	**0.130** 0.0051	**0.081** 0.0032	**0.180** 0.0071	**0.120** 0.0047
160.000 6.2992	**180.000** 7.0886	**0.025** 0.0010	**0.002** 0.0001	**0.061** 0.0024	**0.020** 0.0008	**0.102** 0.0040	**0.053** 0.0021	**0.147** 0.0058	**0.091** 0.0036	**0.200** 0.0079	**0.135** 0.0053
180.000 7.0886	**200.000** 7.8740	**0.030** 0.0012	**0.002** 0.0001	**0.071** 0.0028	**0.025** 0.0010	**0.117** 0.0046	**0.063** 0.0025	**0.163** 0.0064	**0.107** 0.0042	**0.230** 0.0091	**0.150** 0.0059
200.000 7.8740	**240.000** 9.4488	**0.036** 0.0014	**0.003** 0.0001	**0.081** 0.0032	**0.030** 0.0012	**0.137** 0.0054	**0.074** 0.0029	**0.193** 0.0076	**0.127** 0.0050	**0.267** 0.0105	**0.183** 0.0072
240.000 9.4488	**280.000** 11.0236	**0.041** 0.0016	**0.003** 0.0001	**0.097** 0.0038	**0.033** 0.0013	**0.157** 0.0062	**0.086** 0.0034	**0.224** 0.0088	**0.147** 0.0058	**0.310** 0.0122	**0.213** 0.0084
280.000 11.0236	**320.000** 12.5984	**0.048** 0.0019	**0.005** 0.0002	**0.114** 0.0045	**0.041** 0.0016	**0.180** 0.0071	**0.104** 0.0041	**0.257** 0.0101	**0.170** 0.0067	**0.353** 0.0139	**0.246** 0.0097
320.000 12.5984	**370.000** 14.5669	**0.053** 0.0021	**0.005** 0.0002	**0.127** 0.0050	**0.046** 0.0018	**0.208** 0.0082	**0.117** 0.0046	**0.295** 0.0116	**0.198** 0.0078	**0.409** 0.0161	**0.284** 0.0112
370.000 14.5669	**430.000** 26.9291	**0.064** 0.0025	**0.008** 0.0003	**0.147** 0.0058	**0.056** 0.0022	**0.241** 0.0095	**0.137** 0.0054	**0.340** 0.0134	**0.231** 0.0091	**0.475** 0.0187	**0.330** 0.013
430.000 26.9291	**500.000** 19.6850	**0.074** 0.0029	**0.010** 0.0004	**0.170** 0.0067	**0.066** 0.0026	**0.279** 0.0110	**0.160** 0.0063	**0.396** 0.0156	**0.269** 0.0106	**0.551** 0.0217	**0.386** 0.0152
500.000 19.6850	**570.000** 22.4409	**0.081** 0.0032	**0.010** 0.0004	**0.193** 0.0076	**0.074** 0.0029	**0.318** 0.0125	**0.183** 0.0072	**0.450** 0.0177	**0.307** 0.0121	**0.630** 0.0248	**0.439** 0.0173
570.000 22.4409	**640.000** 25.1969	**0.091** 0.0036	**0.013** 0.0005	**0.216** 0.0085	**0.085** 0.0033	**0.356** 0.0140	**0.206** 0.0081	**0.505** 0.0199	**0.345** 0.0136	**0.706** 0.0278	**0.495** 0.0195
640.000 25.1969	**710.000** 27.9528	**0.114** 0.0045	**0.020** 0.0008	**0.239** 0.0094	**0.107** 0.0042	**0.394** 0.0155	**0.229** 0.0090	**0.564** 0.0222	**0.384** 0.0151	**0.780** 0.0307	**0.554** 0.0218
710.000 27.9528	**800.000** 31.4961	**0.211** 0.0083	**0.028** 0.0011	**0.353** 0.0139	**0.201** 0.0079	**0.587** 0.0231	**0.345** 0.0136	**0.833** 0.0328	**0.577** 0.0227	**1.148** 0.0452	**0.823** 0.0324
800.000 31.4961	**1060.000** 41.7323	**0.211** 0.0083	**0.028** 0.0011	**0.353** 0.0139	**0.201** 0.0079	**0.587** 0.0231	**0.345** 0.0136	**0.833** 0.0328	**0.577** 0.0227	**1.148** 0.0452	**0.823** 0.0324

[1]Standard RIC values for Timken radial ball bearings are R(C0) and P(C3). For bearing O.D. greater than 52 mm (2.0472 in.), P(C3) is recommended.

PRECISION BEARINGS

MOUNTING

Machine tools are a common application for precision bearings and are provided as typical examples in the following discussions. Common terminology within the machine tool industry is to refer to the shaft as the spindle. In keeping with this industry preference, the term spindle is used in the PRECISION BEARINGS section of this manual.

Obtaining good spindle accuracy depends not only on selecting the proper precision bearings but also on the following factors:

- Good design and machining of the components that support the bearing (roundness and alignment of the seats, squareness of backing shoulders of both the spindle and the housing, and surface finish).
- Correct use of information provided with bearings.
- Correct fitting practices.
- Appropriate bearing setting.

Selection of the most appropriate mounting design is largely dictated by requirements for stiffness, speed capability and ease of assembly.

Design and accuracy of mounting surfaces

The total runout of a spindle bearing housing system is a combination of the runout of each component. A precision bearing ring will assume the shape of the spindle or housing to which it is mounted and will transmit any runout to the system. In machine tool applications, runout from the housing, spindle and bearing is transmitted to the workpiece. Therefore, particular attention needs to be paid to the design and accuracy of the mounting surfaces.

The primary function of the inner- or outer-ring seat and abutment is to positively establish the location and alignment of the bearing under all loading and operating conditions. To achieve optimum bearing performance, it is essential to design housing seats and abutments that are round and that are square in alignment with the spindle axis. Shoulders must be of sufficient section and design to resist axial deflection under load.

Housing design

Housings are usually made of cast iron or steel and are generally heat-treated to lessen possible distortion. For smaller, high-speed applications, steel housings are preferred.

The bore of the housing should be ground or bored and checked at a number of points throughout its length and diameter to ensure that it is round and does not taper.

It is preferable to mount the bearings in one casting; this permits machining the two housing bores in one setting, as well as accurate alignment of the bearings.

In many cases, it is advantageous to employ a steel sleeve between the outer ring of the bearing and the housing, thus allowing assembly of the bearings on the shaft and insertion of the entire unit into the sleeve. This method also provides a surface of proper hardness when housings are made of a material that has a low Brinell value, such as aluminum and other soft metals.

Shaft shoulders and housing shoulders should be square and true, and should be of such diameters as to meet the suggestions shown with the part numbers given. The choice between fillets and undercut reliefs rests with the individual shaft design and conditions surrounding its normal use.

Where screws are used to fasten end caps into the main housing, adequate section should be left between the screw hole and the housing bore. This is required to prevent distortion of the housing bore when the screws are tightened and the covers or other parts are pulled tightly into place.

Prior to assembly, shafts and housings, as well as all lubricant holes and channels, should be cleaned thoroughly to remove all debris that may be carried by the lubricant into the bearings and cause bearing damage.

Housing seals

A labyrinth combination of flinger and end cover provides a highly effective seal against the intrusion of foreign matter. This seal is suggested for use over a wide range of speeds. For slower-speed applications, a combination of flinger and a commercial contact-type seal is usually employed.

Flingers should be machined all over to assure true running. Their diameters should be concentric with the bore. The outside diameter of the flinger is often tapered to throw off cutting compounds, coolants, etc., from the point at which such liquids may enter the spindle. A drip or run-off groove adjacent to the open lip of the end cover is desirable and practical.

The axial clearances of the internal faces between flinger and end cover should be about 1.600 mm (0.0629 in.). The first radial clearance opening on any design through which liquid may pass should be made very close, about 0.089 mm (0.0035 in.) per side. The inner radial clearances should be between 0.380 mm (0.0149 in.) and 0.190 mm (0.0075 in.).

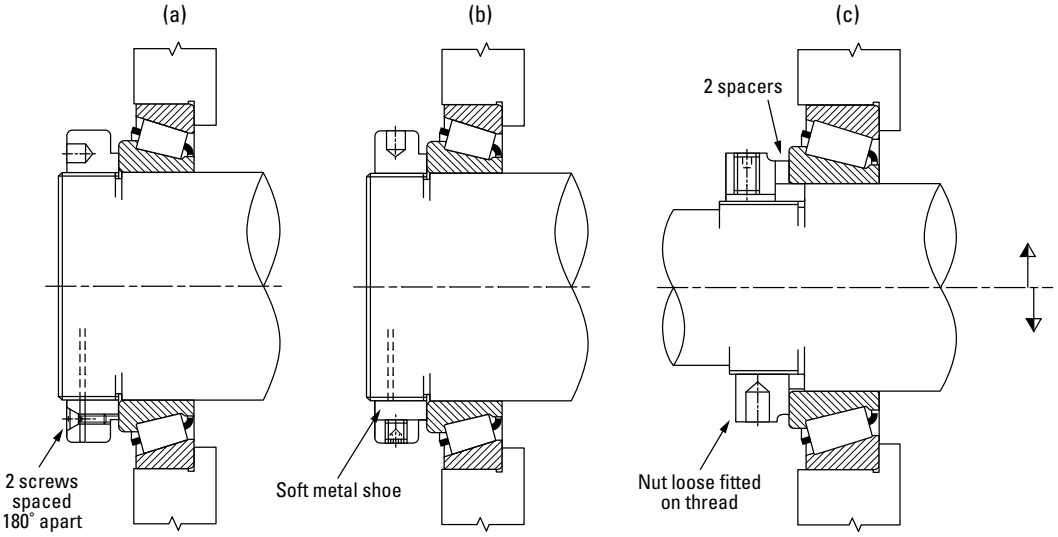


Fig. 113. Locking devices.

Shafts

Shafts are preferably made from hardened and ground steel; and, where suitable, a hardness of 45-50 HRC is recommended. If possible, bearing backing shoulders and seats should be ground in one operation. This promotes true balance and running accuracy, which are critical in high-speed applications. Suggested shaft geometry can be found on page 121.

Locking devices

In most cases, simple 2TS(F) spindle layouts are adjusted by correct positioning of the rear bearing inner ring. A commonly used device is a precision adjusting nut. A locking device must be provided to properly maintain the nut after setting: either axially by means of two screws 180 degrees opposite pinching the threads (fig. 113a), or radially by pressure of a screw on a soft metal shoe (fig. 113b).

For improved accuracy, a ground spacer in conjunction with a square-ground spindle shoulder and a locking precision nut also can be used (fig. 114). Good parallelism of the ground-spacer faces as well as the squareness of the spindle shoulder will ensure final position of the nut abutment face is tightly controlled resulting in proper position of the inner ring backface. This mounting configuration also offers assurance that the initially defined setting cannot be modified by the final user. Fig. 113c shows two different solutions with ground spacers. Note the practicality of the above centerline solution, which allows the spacer to both increase or decrease the initial setting.

A well-known method of providing good spindle alignment, roundness and backing squareness is to grind the inner ring seats and the backing shoulders during the same operation (fig. 115). In this method, the grinding of the adjusting nut (if any) abutment face also can be achieved by locking the nut on its thread. This eliminates possible misalignment of the nut due to internal thread clearance.

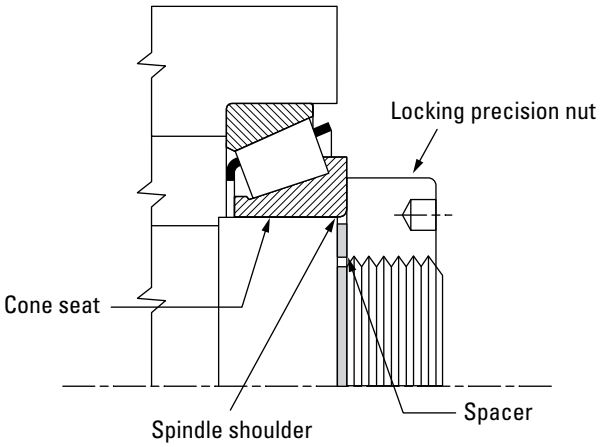


Fig. 114. Using ground spacer and spindle shoulder together with a precision nut for improved accuracy.

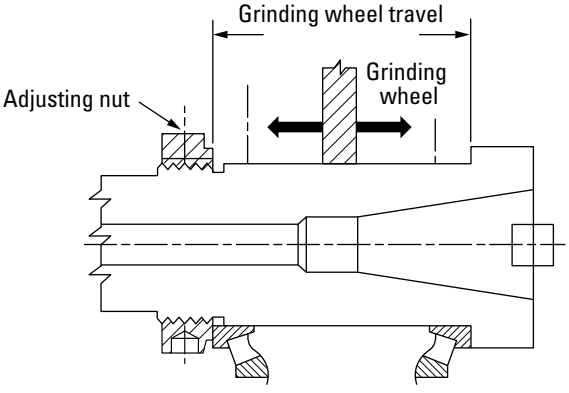


Fig. 115. Grinding of inner ring shaft and backing shoulders.

Precision tapered roller bearing mounting

Tapered roller bearings are generally used in two fundamental spindle design configurations:

- Three-support mountings for heavily loaded or long spindles.
- Simple mounting of two single-row bearings.

Three-support mounting

Fig. 116 shows the box-type mounting using three bearings. The two nose bearings are located axially (fixed position) and accept axial forces in both directions, while the rear bearing is fitted in a floating position to accommodate the thermal expansion of the spindle. The floating position can be supported either by a tapered roller bearing or a cylindrical roller bearing.

This kind of arrangement is mainly used for special heavy machines running at low or medium speeds, or for long spindle designs.

Simple mounting

The evolution of two single-row bearing arrangements for spindles, discussed on page 112, is directly related to the speed requirements and, consequently, the lubrication modes.

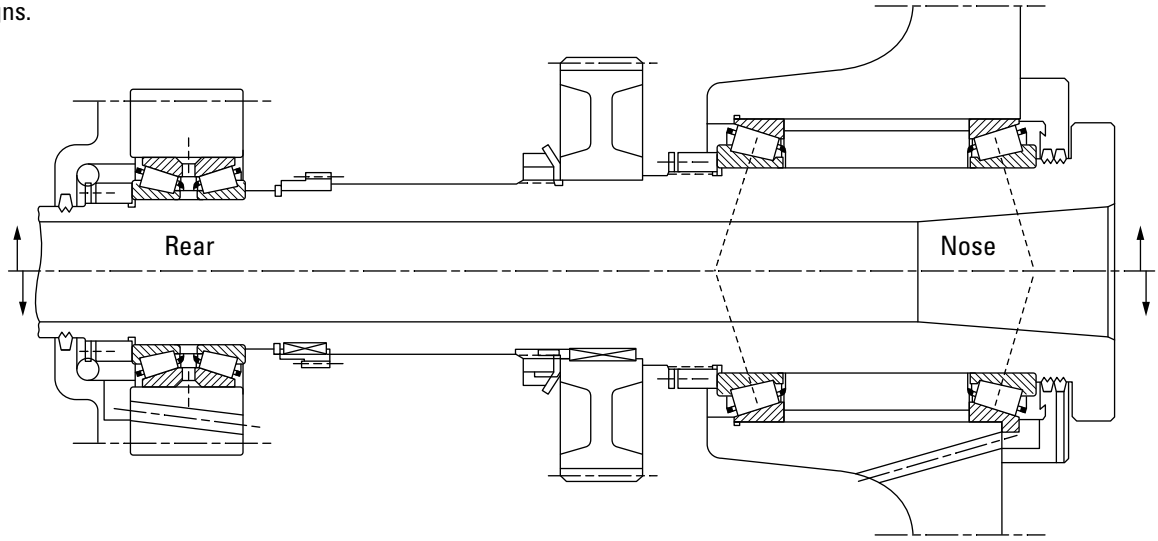


Fig. 116. Box-type mounting with a TDO at the floating position.

TS and TSF arrangement

The spindle is supported by one bearing at the nose position and a second one at the rear position. This layout offers the advantage of being a simple design that allows easy machining of adjacent parts. Mounting and setting can be easily achieved with standard tooling.

Stiffness calculations of the spindle-bearing system allow the optimum bearing spread to be determined precisely for each mounting, as a function of the overhung value of the spindle nose. A good approximation, however, is to consider that the distance between bearing centers should be two and a half to three times the spindle nose diameter. This represents an optimum value not only for stiffness, but for thermal expansion.

Fig. 117 represents the simplest layout of a two single-row bearing design. The view above the centerline shows flanged outer rings (Type TSF) allowing for through-bore machining of the housing, which offers increased accuracy with no need for outer ring backing shoulders. The arrangement shown below the centerline uses two single-row bearings (Type TS).

The bearings are adjusted by means of a ground spacer locked by a precision nut. Lubrication is often achieved by oil circulation, which enters through radial oil inlets, or special high-speed grease.

As shown in figs. 118 and 119, the next evolution of this arrangement consists of improving the lubrication system by using appropriate jets for oil inlets and cooling.

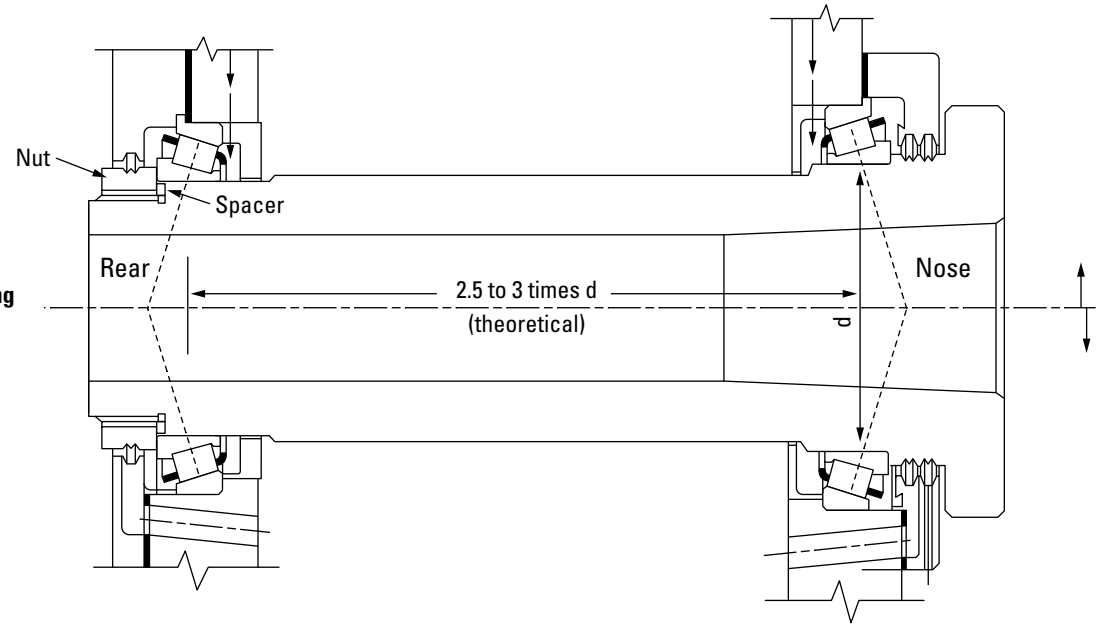


Fig. 117. Simple mounting with a pair of TS or TSF bearings.

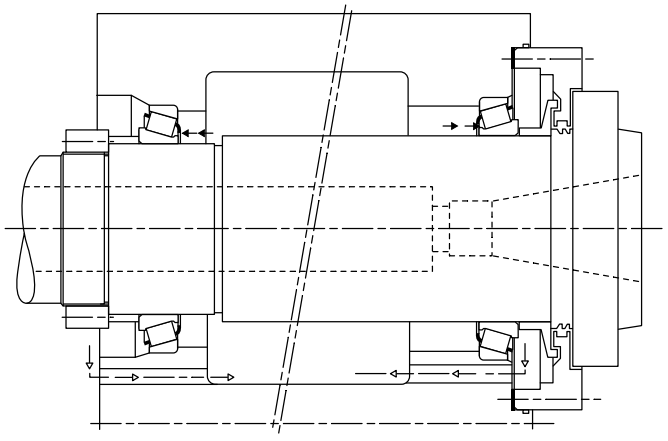


Fig. 118. Simple paired TS mounting with oil inlet at the small end of the rollers.

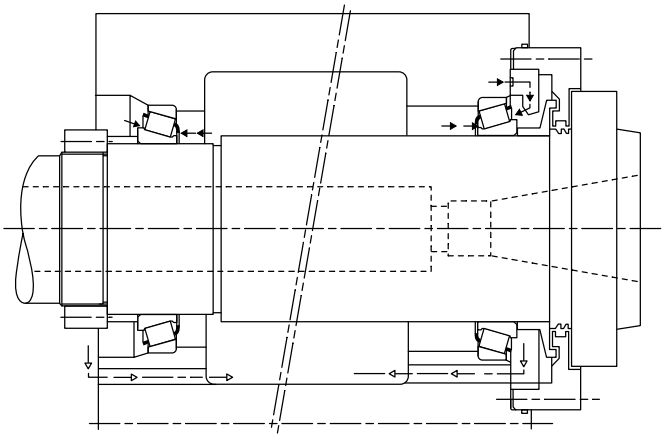


Fig. 119. Simple paired TS mounting with oil jets at both ends of the rollers for inlet and cooling.

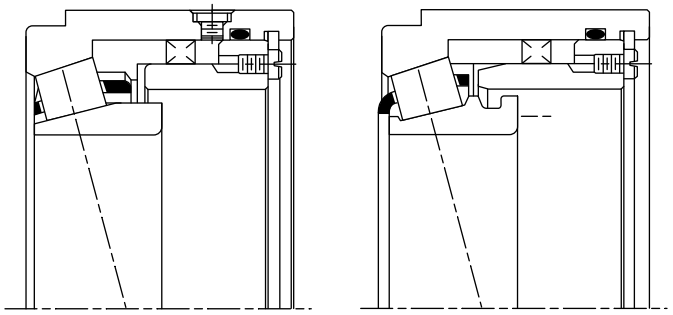


Fig. 120. Two designs of the Hydra-Rib bearing.

TS (F) and Hydra-Rib

A typical spindle arrangement is the combination of a Hydra-Rib bearing with a single-row TS bearing (fig. 121). The Hydra-Rib bearing is fitted at the rear position and the TS bearing at the nose position of the spindle. The outer-ring rib simplifies the lubrication at high speed since the natural flow of the oil under centrifugal effect feeds the oil to the rib. A simple axial oil inlet above the cage on the small roller end is therefore sufficient for lubricating the Hydra-Rib bearing.

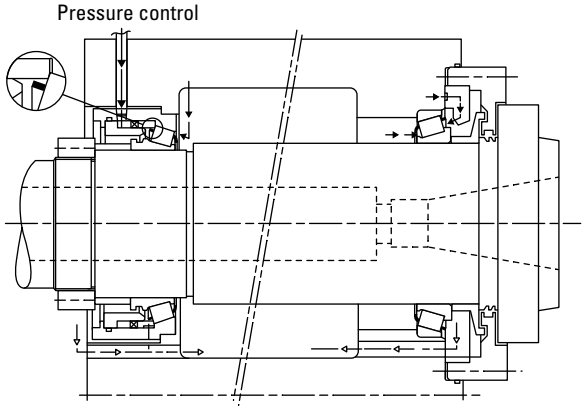


Fig. 121. Simple mounting with a Hydra-Rib cooled by an axial oil inlet and a TS bearing with oil jets at both ends of the rollers for inlet and cooling.

TSMA and Hydra-Rib

Fig. 122 shows the same arrangement with a TSMA bearing. This arrangement allows the widest range of operating speeds, under optimum preload.

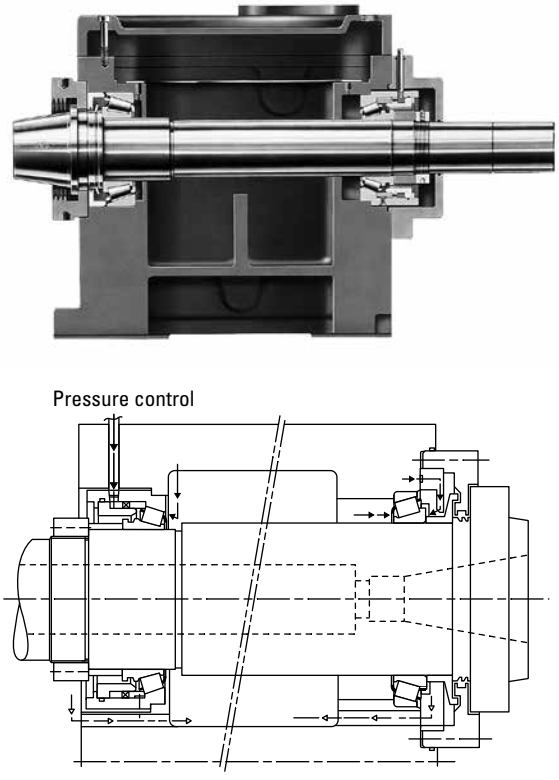


Fig. 122. Simple mounting with a Hydra-Rib bearing cooled by an axial oil inlet and a TSMA bearing with oil jets at both ends of the rollers for inlet and cooling.

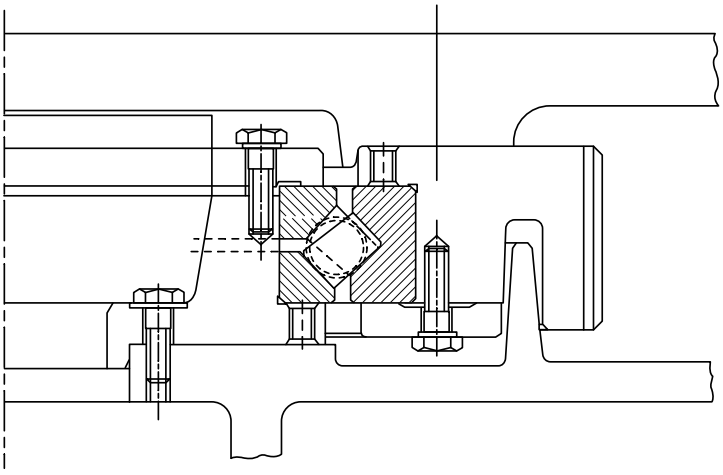


Fig. 123. Typical mounting arrangement of a TXRDO bearing.

Crossed roller bearing

TXR (DO)

A typical mounting arrangement for the type TXRDO crossed roller bearing is shown in fig. 123.

The arrangement shown is for lubrication by oil circulation in conjunction with an oil level maintained within the bearing. It can, however, be designed for grease lubrication with appropriate sealing arrangements.

The bore of the housing (DH) and the diameter of the spigot (DS) (fig. 124) should be machined to give a mean of the suggested interference fits (pages 178-179).

The bearing is adjusted externally by segments beneath the top inner-ring clamping plate (fig. 124) to get the required preload.

Your Timken engineer should be consulted for more details about the use of crossed roller bearings.

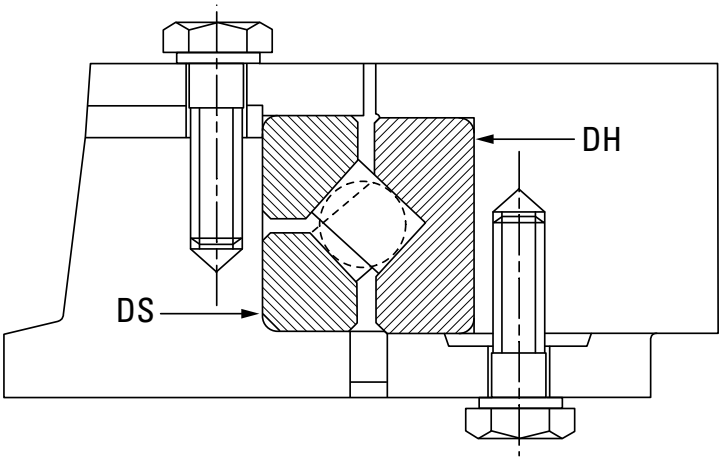


Fig. 124. Fitting and setting of TXR bearings.

Precision duplex ball bearing

Back-to-back mounting, DB or (O)
(Contact angles diverging toward shaft centerline)

Before mounting, there is clearance between the two adjacent inner-ring faces. After mounting, these faces are clamped together to provide an internal preload on each bearing. This arrangement is well-suited for pulleys, sheaves and other applications where there are overturning loads and also all floating positions where thermal expansion of the shaft occurs. It also provides axial and radial rigidity and equal axial capacity in either direction when used in a fixed location. Back-to-back is the most commonly used of all duplex arrangements.

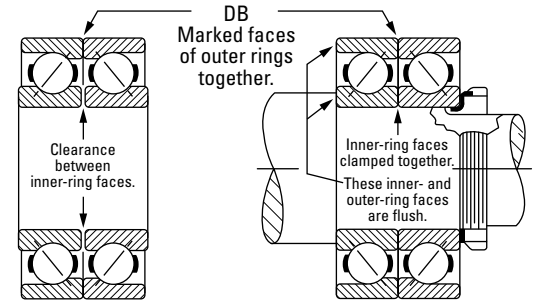


Fig. 125. Back-to-back bearing assemblies before and after mounting.

Face-to-face mounting, DF or (X)
(Contact angles converging toward shaft centerline)

Before mounting, there is clearance between the two adjacent outer-ring faces. After mounting, these faces are clamped together between the housing shoulder and cover plate shoulder, providing an internal preload on each bearing. This arrangement provides equal axial capacity in either direction as well as radial and axial rigidity. Since the face-to-face mounting has inherent disadvantages of low resistance to moment loading and thermal instability, it should not be considered unless a significantly more convenient method of assembly or disassembly occurs from its use.

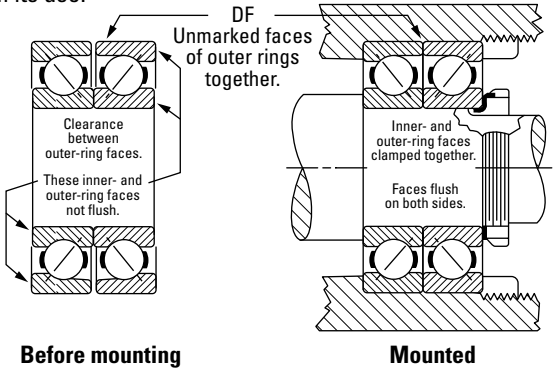


Fig. 126. Face-to-face bearing assemblies before and after mounting.

Tandem mounting, DT

Before mounting, the inner-ring faces of each bearing are offset from the outer ring faces. After mounting, when an axial load is applied equal to that of twice the normal preload, the inner and outer-ring faces are brought into alignment on both sides. This arrangement provides double axial capacity in one direction only. More than two bearings can be used in tandem if additional axial capacity is required.

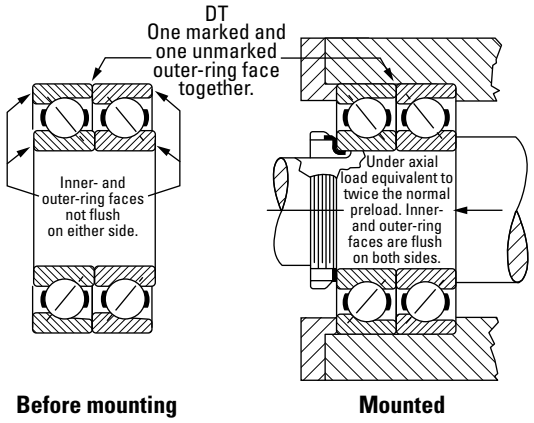


Fig. 127. Tandem bearing assemblies before and after mounting.

Other mountings

Flush-ground (DU) pairs may be mounted in combination with a single flush-ground bearing as a triplex (TU) set shown below. Also shown below is a quadruplex (QU) set where three bearings in tandem are mounted back-to-back with a single bearing. These arrangements provide high capacity in one direction and also a positively rigid mounting capable of carrying a moderate amount of reverse thrust.

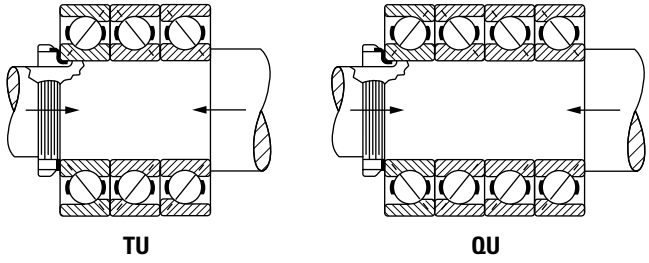


Fig. 128. Typical triplex and quadruplex bearing mountings.

Back-to-back versus face-to-face mountings

Mountings having bearings applied in any of the face-to-face (DF) arrangements are objectionable because they provide the least rigidity. Furthermore, when the operating speeds are comparatively high, such mountings may build up bearing preload excessively because of the temperature gradient between the housings, bearings and shafts. As this gradient increases, the bearing preload builds up, starting a detrimental cycle that may lead to premature spindle damage.

In machined mountings, the spindle temperature usually changes at a faster rate than the housing temperature, creating temperature differentials between the two members. This is due to the exposed housing having the ability to expel more heat. Thus, the spindle and the inner-ring spacer expand at a faster rate than the housing and the outer-ring spacer. As the spindle expands longitudinally and the inner-ring spacer lengthens, an axial load builds up on each bearing and continues to increase until the equilibrium temperature is reached. This occurs when the mean housing temperature levels off and the heat transferred from the bearings balances the heat generated within the system. Therefore, if the housing attains an excessively high temperature, the initial bearing temperature is built up considerably.

In a face-to-face mounting, fig. 129, the shaft expands radially and longitudinally and the inner-ring spacer lengthens, but at a faster rate than the outer-ring spacer. This thermal expansion causes an additional axial load to be imposed on both inner rings, increasing the preload of the bearings. Conversely, in back-to-back mounting, fig. 130, the longitudinal expansion of the inner-ring spacer tends to relieve, rather than build up, the bearing preload.

The two back-to-back pairs, shown in fig. 131, are mounted so that the two middle bearings are face-to-face. As previously observed, temperature gradients cause the preload of these inner bearings to increase during operation. This mounting operation is not suggested. In bearing mountings of the system seen in fig. 132, undue axial loads are put on the two outer bearings as the temperature along the shaft becomes higher than at the housing. The two inner bearings unload, starting a vicious cycle of increasing temperature, preload buildup and lubricant breakdown. This also is an unfavorable mounting arrangement and is not suggested. The same bearings are shown correctly mounted in tandem and arranged back-to-back in fig. 133. Lateral expansion of the shaft and inner-ring spacer of such mountings increases neither axial loading nor bearing preload.

Therefore, to prevent increases in preload due to the thermal expansion, back-to-back mountings are preferred for bearings on machine tool spindles. When two pairs are used, each pair should be mounted in tandem, but the combination should be arranged back-to-back as in fig. 133.

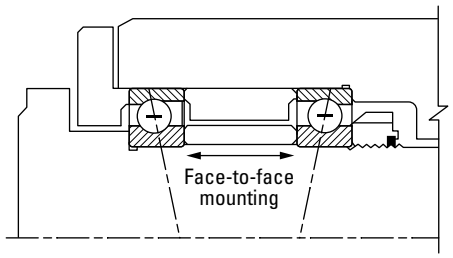


Fig. 129. DF Mounting, fixed (not suggested).

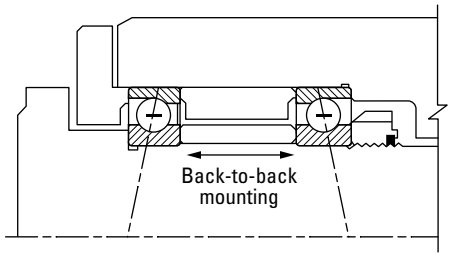


Fig. 130. DB Mounting, fixed (suggested).

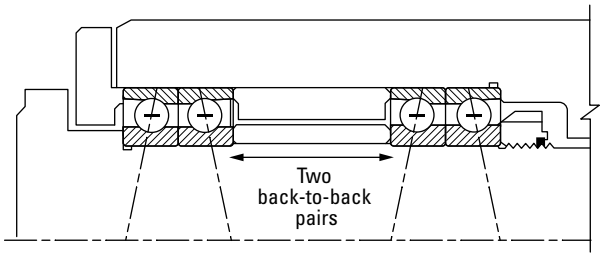


Fig. 131. DB-DB Mounting, fixed (not suggested).

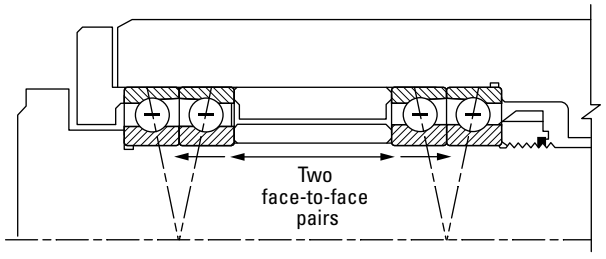


Fig. 132. DF-DF Mounting, fixed (not suggested).

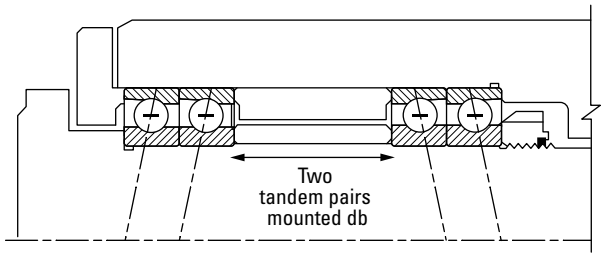


Fig. 133. DT-DB Mounting, fixed (suggested).

Spring-loaded mountings

For high-speed applications such as machine tools, radial and axial rigidity and smooth spindle performance may be obtained by spring loading the ball bearings with a predetermined axial load. Spring loading allows the spindle to float laterally during temperature changes without appreciably increasing or decreasing the original spring axial load.

As the inner ring heats up during operation, it expands radially. This radial expansion applies an increasing load through the rolling elements and outer ring and finally to the preload springs. The preload springs deflect slightly to compensate for the loads due to thermal expansion and maintain a consistent load on the spindle system.

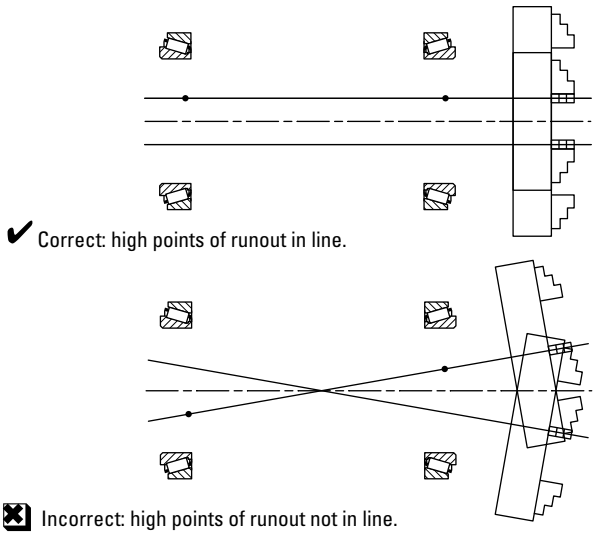
In some applications, single spring-loaded bearings are employed at the front and rear locations, mounted in back-to-back arrangement. Other mountings, similarly spring-loaded, have a pair of bearings installed in tandem at each end of the spindle in back-to-back arrangement (DT-DB). In either case, the spring pressure is applied to the pulley-end or rear bearing position, placing the shaft in tension between the two bearing locations.

High points of runout

Most precision ball and tapered roller bearings have the high point of radial runout marked on the inner and outer rings. These high points can be aligned to optimize accuracy of the spindle / housing system. The components should be mounted in the housing and on the spindle so that the high points are aligned with each other. In other words, the inner rings are fitted on the spindle so the high point of the rear ring is aligned with the high point of the nose ring. Similarly, the high points of the outer rings are aligned in the housing.

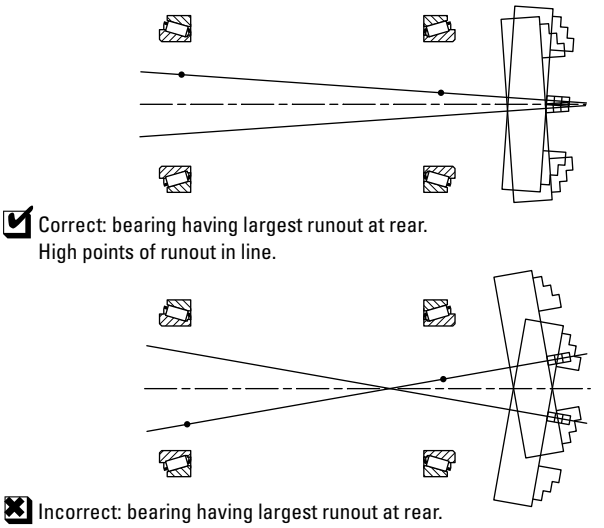
To obtain maximum precision, and when the high points of runout of both the spindle and the housing are known, the respective high points of the bearing components should be 180 degrees opposite to those of the spindle and the housing. This will tend to neutralize the eccentricity and minimize the effect of the high spots of all components. The figures to the right show typical examples of the correct and incorrect use of the high point of runout of bearings.

Greater accuracy can be achieved by grinding the spindle nose after the bearings are installed. This procedure will produce spindle runout considerably lower than the bearing runout.



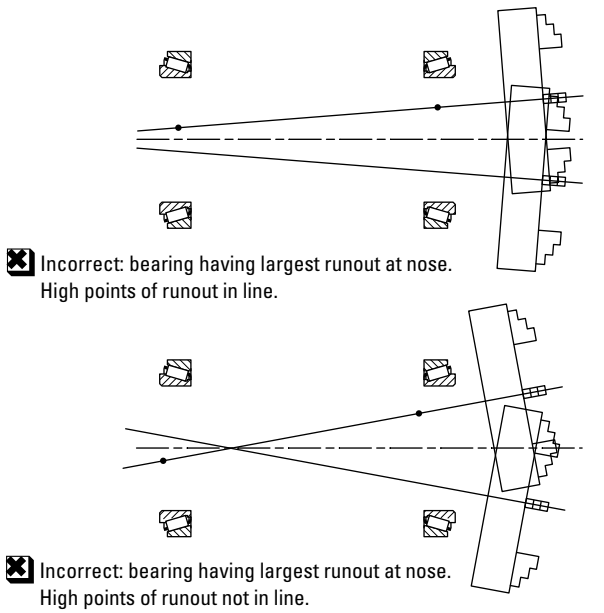
✔ Correct: high points of runout in line.

☒ Incorrect: high points of runout not in line.



☑ Correct: bearing having largest runout at rear.
High points of runout in line.

☒ Incorrect: bearing having largest runout at rear.
High points of runout not in line.



☒ Incorrect: bearing having largest runout at nose.
High points of runout in line.

☒ Incorrect: bearing having largest runout at nose.
High points of runout not in line.

Fig. 134. The effect of bearing runout high point locations on spindle accuracy.

FITTING PRACTICES

General guidelines for tapered roller bearings

The tapered roller bearing design permits the setting to be achieved during installation (or during running when using a Hydra-Rib), irrespective of the inner- and outer-ring fits on shaft and housing. This allows the use of the widest possible machining tolerances for shaft and housing and the use of the best possible fits for the inner rings and outer rings to match the duty of the bearing.

The fitting practice will depend upon the following parameters:

- Precision class of the bearing.
- Type of layout.
- Type and direction of loads.
- Running conditions (vibration, speed, temperature differential).
- Shaft and housing sections and materials.
- Mounting and setting conditions.

Certain table fits may not be adequate for light shaft and housing sections, shafts other than steel, nonferrous housings, critical operation conditions such as high speed, unusual thermal or loading conditions or a combination thereof. Also, assembly procedures and the means and ease of obtaining the bearing setting may require special fits. In these cases, experience should be used as a guideline or your Timken engineer should be consulted for review and suggestions.

Precision class bearings should be mounted on shafts and in housings that are similarly finished to at least the same precision limits as the bearing bore and O.D.

In the machine-tool industry, where the majority of application shafts rotate, the general rule is to tight fit both the inner rings and outer rings for simple layouts to eliminate any undesirable radial clearance.

Non-ferrous housings

Care should be taken when pressing outer rings into aluminum or magnesium housings to avoid metal pickup. This may result in unsatisfactory fits, backing, and alignment from debris trapped between the outer ring and backing shoulder. It is recommended that the outer ring be frozen and/or the housing heated, during assembly. Also, a special lubricant may be used to ease assembly. In some cases, outer rings are mounted in steel inserts that are attached to the aluminum or magnesium housings. Table fits may then be used. Where the outer ring is fitted directly into an aluminum housing, it is suggested that a minimum tight fit of 1.0 µm per mm (0.0010 in. per in.) of outer ring outside diameter be used. For a magnesium housing, a minimum tight fit of 1.5 µm per mm (0.0015 in. per in.) of outer ring outside diameter is suggested.

Shaft and housing considerations tapered roller bearings

In general, machining bearing seats and shoulders in spindles and housings require careful consideration of the following form and orientation characteristics. The first four characteristics apply to the seats of bearing rings.

- **Circularity** (roundness) of each seat at every cross section.
- **Cylindricity** of each seat. Cylindricity includes the taper, roundness and other form characteristics of the seat.
- **Coaxiality** of the inner-ring seats on the spindle and coaxiality of the outer ring seats in the housing. Coaxiality includes offset misalignment and angular misalignment between seats.
- **Angularity** of each bearing ring seat. This is a consideration when a inner ring seat is tapered.

The following two characteristics apply to the shoulders corresponding to each bearing seat.

- **Perpendicularity** (squareness) of each shoulder to its corresponding bearing seat, or as a more practical measure, perpendicularity of each shoulder to the spindle or housing centerline established from the two bearing seats.
- **Flatness** of each shoulder. A practical way of assessing the combined perpendicularity and flatness of each shoulder is to measure the total runout of the shoulder relative to the spindle or housing centerline. The runout of the face of the adjusting nuts, if used, should also be measured.

The tolerances to which these characteristics should be held are dependent upon the class, size and application of the bearing. In general, these tolerances should be no greater than the total indicator reading (T.I.R.) of the assembled bearing.

Some of the characteristics can be difficult to measure precisely. The individual user may elect to measure a subset of these characteristics (roundness and taper as an alternative to cylindricity). The individual user must determine the degree of effort and expense to be invested in the measurements. That determination should be based on the intended application of the bearing and the level of confidence in the machining process employed to manufacture the spindle and housing.

Surface finishes – precision bearings

Precision class bearings should be mounted on shafts and in housings that are finished to at least the same precision limits as the bearing bore or outside diameter.

Furthermore, high-quality surface finishes together with close machining tolerances of bearing seats also must be provided as shown in table 53.

TABLE 53. SUGGESTED TAPERED ROLLER BEARING SHAFT AND HOUSING FINISHES

All Sizes	Bearing Class			
	C 3	B 0	A 00	AA 000
	µm µin	**µm** µin	**µm** µin	**µm** µin
Shaft - Ra	**0.8** 32	**0.6** 24	**0.4** 16	**0.2** 8
Housing - Ra	**1.6** 63	**0.8** 32	**0.6** 24	**0.4** 16

Ball bearings

Shaft fits

The main purpose of the shaft fit is to assure a proper attachment of the inner ring to the shaft. Under normal conditions of shaft rotation, a loosely fitted inner ring will creep on the shaft, leading to wear and fretting. This condition will be further aggravated by increase of load or speed. To prevent creeping or slipping, the inner ring should be mounted firmly in place and held securely against the shaft shoulder. However, it is important that the shaft fit should not result in any undue tightening of the bearing. An excessive interference fit of the bearing bore with the shaft could result in a proportionate expansion of the bearing inner ring, which could disturb the internal fit of the bearing and lead to heating and increased power consumption.

As a general rule, it is suggested that the shaft size and tolerance for seating super precision ball bearings (ISO P4/ABEC 7 and ISO P2/ABEC 9) be the same as the bearing bore. In the case of preloaded bearings, the suggested shaft fit is line-to-line, since an excessively tight fit expands the bearing inner ring and increases the bearing preload, which can lead to overheating. For example, a duplex pair of 2MM9111WI DUL bearings with 16 kg (35 lbs.) built-in preload, when mounted on a shaft that provides an interference fit of 0.010 mm (0.0004 in.), will increase the preload to approximately 86 kg (180 lbs.), which could result in elevated operating temperatures.

TABLE 54. SHAFT FIT EXAMPLE: MMV (ISO P4/ABEC 7)

Bore Size		Shaft Diameter		Resulting Mounting Fit	
Max	Min.	Max.	Min.	Loose	Tight
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
55.000 2.1654	**54.994** 2.1651	**55.000** 2.1654	**54.994** 2.1651	**0.004** 0.0002	**0.006** 0.0003

Housing fits

Under normal conditions of a rotating shaft, the outer ring is stationary and should be mounted with a hand push to a light tapping fit. Should the housing be the rotating member, the same fundamental considerations apply in mounting the outer ring as in the case of an inner ring mounted on a rotating shaft. Contact your Timken engineer for outer-ring rotation requirements.

As a general rule, the minimum housing bore tolerance for super precision ball bearings should be the same as the maximum bearing outside diameter tolerance. If the bearing O.D. tolerance is 0.008 mm (0.0003 in.), the housing bore tolerance should be 0.008 mm (0.0003 in.).

TABLE 55. HOUSING BORE FIT EXAMPLE: MMV (ISO P4/ABEC 7)

Outside Diameter		Housing Bore		Resulting Mounting Fit		Average Fit
Max	Min.	Max.	Min.	Loose	Tight	Loose
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
90.000 3.5433	**89.992** 3.5430	**90.008** 3.5436	**90.000** 3.5433	**0.015** 0.0006	**0.000** 0.0000	**0.008** 0.0003

Suggested shaft and housing geometry tolerances for precision ball bearings are listed on pages 121-122.

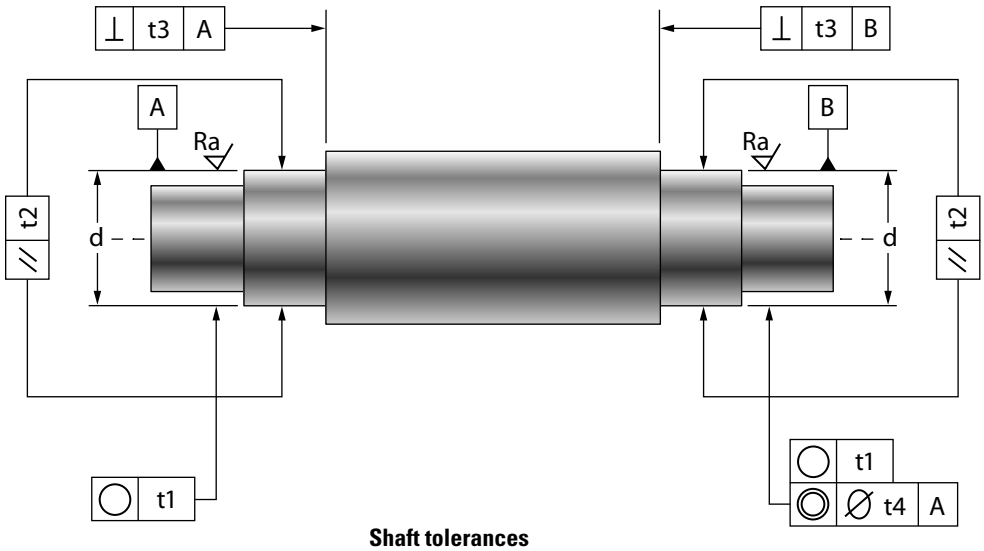
To accomplish the optimum mounting condition, it is important to follow the tabulated tolerances, except when deviations are suggested by your Timken engineer. It is equally important that all shaft and housing shoulders be square and properly relieved to assure accurate seating and positioning of the bearings in the mounting.

On high-speed applications where nearby heat input is along the shaft, it is extremely important that the floating bearings can move axially to compensate for thermal expansion. Ball bearings cannot float axially if they are restricted by tight housing bores or by the radial expansion of the bearing itself due to temperature differentials. Therefore, in such cases, the suggested housing mounting fit for the floating bearing is slightly looser than the tabulated average fit.

Likewise, in spring-loaded ball bearing applications, the housing mounting fit must be free enough to permit axial movement of the bearing under the spring pressure during all conditions of operation. The suggested housing dimensions to ensure proper float of the bearings under average conditions are listed in the Timken Super Precision Bearings for Machine Tool Applications Catalog (order no. 5918) found on www.timken.com.

Shaft and housing tolerances for precision ball bearings

Shaft geometry requirements



Shaft tolerances

Description	Symbol	Tolerance Value	MV ABEC 7 (ISO P4)	MMV/MM ABEC 7/9 (ISO P4S)	MMX ABEC 9 (ISO P2)
Roundness	○	t1	IT2	IT1	IT0
Parallelism	//	t2	IT2	IT1	IT0
Squareness	⊥	t3	IT2	IT1	IT0
Concentricity	◎	t4	IT3	IT2	IT2
Surface Finish	Ra		16 (µin.) or 0.4 µm	16 (µin.) or 0.4 µm	16 (µin.) or 0.4 µm

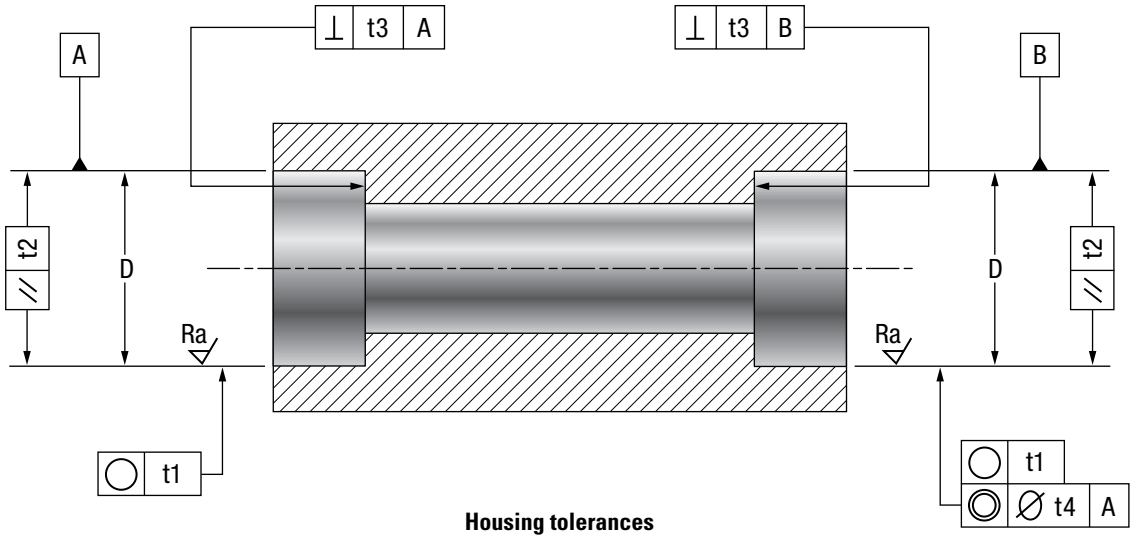
Shaft Journal Diameter d_{so} **mm**		Units – Micrometer (µm)			
>	≤	IT0	IT1	IT2	IT3
–	**10**	0.6	1.0	1.5	2.5
10	**18**	0.8	1.2	2.0	3.0
18	**30**	1.0	1.5	2.5	4.0
30	**50**	1.0	1.5	2.5	4.0
50	**80**	1.2	2.0	3.0	5.0
80	**120**	1.5	2.5	4.0	6.0
120	**180**	2.0	3.5	5.0	8.0
180	**250**	3.0	4.5	7.0	10.0
250	**315**	–	6.0	8.0	12.0

Shaft Journal Diameter d_{so} **mm**		Units – Microinches (µin.)			
>	≤	IT0	IT1	IT2	IT3
–	**10**	20	40	60	100
10	**18**	30	50	80	120
18	**30**	40	60	100	160
30	**50**	40	60	100	160
50	**80**	50	80	120	200
80	**120**	60	100	160	240
120	**180**	80	140	200	310
180	**250**	120	180	280	390
250	**315**	–	240	310	470

Reference ISO 286.

Shaft and housing tolerances for precision ball bearings

Housing geometry requirements



Housing tolerances

Description	Symbol	Tolerance Value	MV ABEC 7 (ISO P4)	MMV/MM ABEC 7/9 (ISO P4S)	MMX ABEC 9 (ISOP2)
Roundness	○	t1	IT2	IT1	IT0
Parallelism	\\	t2	IT2	IT1	IT0
Squareness	⊥	t3	IT2	IT1	IT0
Concentricity	◎	t4	IT3	IT2	IT2
Surface Finish	Ra		16 (µin.) or 0.4 µm	16 (µin.) or 0.4 µm	16 (µin.) or 0.4 µm

Housing Journal Diameter D **mm**		Units – Micrometer (µm)			
>	≤	IT0	IT1	IT2	IT3
10	**18**	0.8	1.2	2.0	3.0
18	**30**	1.0	1.5	2.5	4.0
30	**50**	1.0	1.5	2.5	4.0
50	**80**	1.2	2.0	3.0	5.0
80	**120**	1.5	2.5	4.0	6.0
120	**180**	2.0	3.5	5.0	8.0
180	**250**	3.0	4.5	7.0	10.0
250	**315**	3.5	6.0	8.0	12.0
315	**400**	4.5	6.0	8.0	12.0

Housing Journal Diameter D **mm**		Units – Microinches (µin.)			
>	≤	IT0	IT1	IT2	IT3
10	**18**	30	50	80	120
18	**30**	40	60	100	160
30	**50**	40	60	100	160
50	**80**	50	80	120	200
80	**120**	60	100	160	240
120	**180**	80	140	200	310
180	**250**	120	180	280	390
250	**315**	140	240	310	470
315	**400**	180	240	310	470

Reference ISO 286.

SETTING AND PRELOADING GUIDELINES

Tapered roller bearings

The operating setting of a bearing system has a direct influence on the operating temperature, dynamic stiffness, system accuracy or runout and bearing life. An example of a precision bearing application where setting is critical is machine tools. Spindle accuracy affects cutting performance and therefore maintaining optimum setting is critical.

Slight preload is generally the optimum operating setting for applications using TS or TSF bearings. In order to determine the cold-mounted setting that will provide the desired operating setting, the parameters that influence operating setting must be evaluated. These include:

- Rotating speed.
- Applied loads.
- Bearing configuration and spread.
- Lubrication type and flow.
- External heat sources.

Many of these parameters directly and interactively affect operating temperature which, in turn, affects bearing setting. If possible, it is best to evaluate these effects by conducting lab tests on the application. Temperature readings at various locations can confirm or provide additional input for the analysis tools.

A temperature gradient typically exists across the bearing due to the fact that the inner ring generates more heat than the outer ring. The inner and outer ring temperatures are transmitted to the shaft and housing. The temperature gradient between the shaft and the housing is typically 2° C to 5° C (4° F to 9° F). It is valid for any type of bearing and has a direct influence on the bearing setting.

In the case of pure radial bearings, such as cylindrical roller bearings, the radial setting will vary proportionally to the radial temperature gradient without any possibility for correction.

The use of tapered roller bearings allows the radial loss of endplay due to the gradient between the spindle and the housing to be compensated by the axial expansion of the spindle with respect to the housing through optimization of the bearing spread.

While temperature effects on setting are important, it also is necessary to consider the effects of bearing configuration and spread on operating setting. Steps can be taken to optimize the design so that the setting change is minimal during operation. Fig. 135 shows a graphical representation of optimum spread.

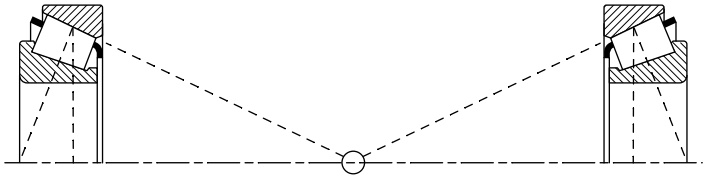


Fig. 135. Graphical determination of optimum thermal spread.

The following formula can be used to calculate the effect on operating setting for a given bearing spread. Fig.136 defines some of the variables used in the formula.

$$\text{Loss of endplay} = 12 \times 10^{-6}\ \Delta T \left[\left(\frac{K_1}{0.39} \right) \left(\frac{D_{o1}}{2} \right) + \left(\frac{K_2}{0.39} \right) \left(\frac{D_{o2}}{2} \right) - L \right]$$

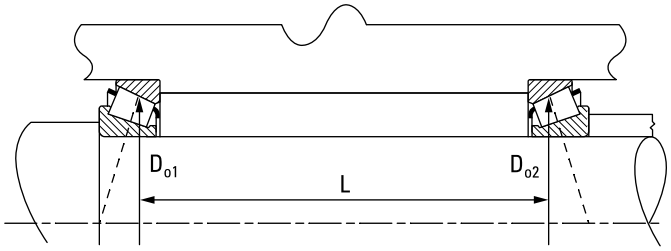
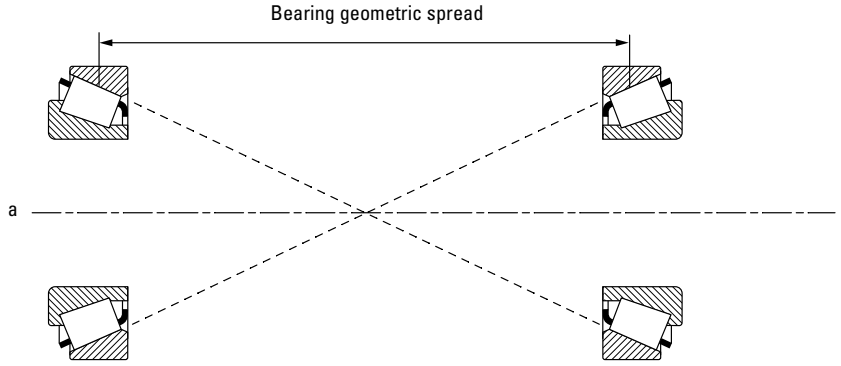


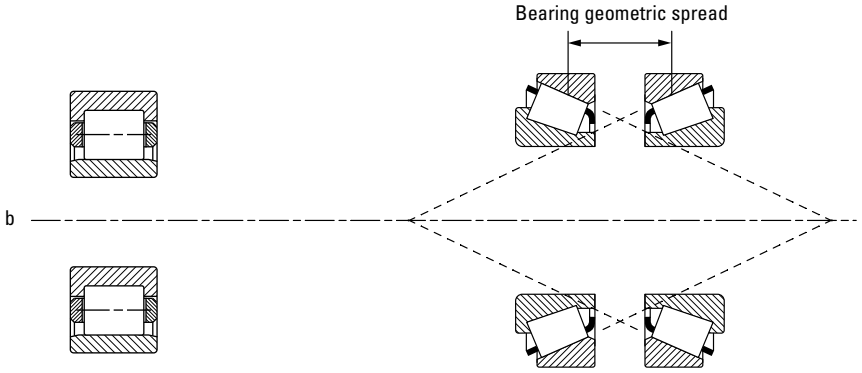
Fig. 136. Resulting distance between bearing geometric centerlines.

During the starting period, care must be taken because the radial thermal expansion is not immediately compensated by the axial expansion of the spindle. That occurs later. During this transient period, a decrease of the axial endplay or an increase of preload is generally recorded (fig. 138). The loss of endplay can be calculated by using the same formula on page 123, but ignoring the parameter L. For this reason, it is generally recommended to initially set the bearings with a light, cold endplay to avoid any bearing burn-up, due to excessive preload during the transient temperature rise. During the testing phase, it will be possible to modify this initial endplay to obtain the optimum setting for the application.

Fig. 138 shows that a three-support arrangement is more sensitive to thermal effects, leading to a higher temperature rise and loss of endplay than a simple arrangement because of the short bearing geometric spread at the fixed position (fig. 137).



Two-support mounting arrangement.



Three-support mounting arrangement.

Fig. 137. Mounting arrangements.

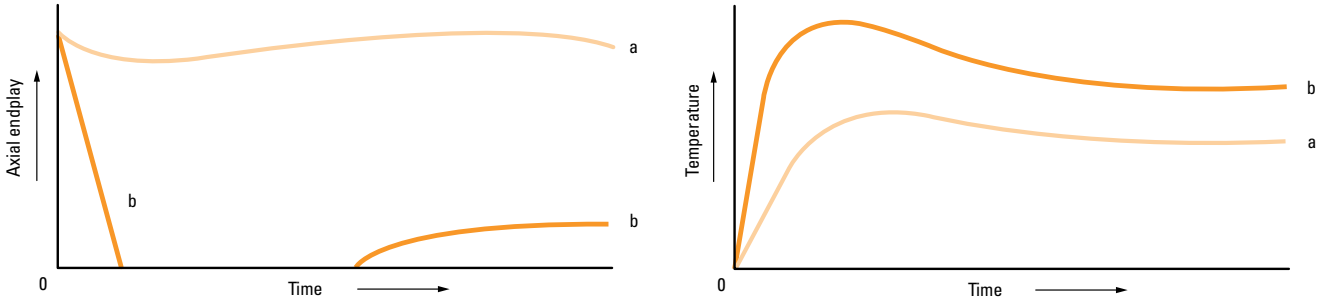


Fig. 138. System setting and temperature vs. time:
a) Two-support mounting.
b) Three-support mounting.

Ball bearings

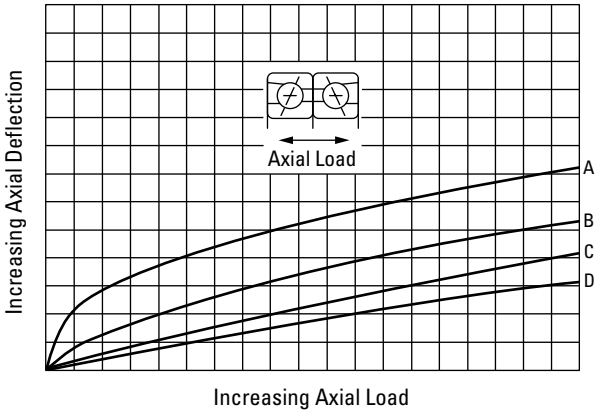
Precision ball bearings are designed to operate under a range of settings, from light endplay to heavy preload. Most commonly, they are designed to run in a preloaded condition.

Preloading is achieved for the different ball bearing mounting arrangements as described on page 115 and depicted in figs. 125-127. When the bearings are clamped, any initial clearance of the bearings is removed and an axial force is created within the bearing that brings the balls into contact with their respective raceways, resulting in compressive forces on the raceways. Under this condition, the bearing stiffness increases, thereby decreasing axial and radial deflections when application loads are applied to the bearing assembly.

The optimum setting for a given application is dependant upon the stiffness, life and operating speed requirements. These requirements are often in conflict when it comes to defining the best setting. For example, stiffness increases with preload while speed capability decreases with preload. High preload reduces the range of operating speeds by causing bearings to run hotter as speed increases, resulting in reduced bearing life. If high speed and high rigidity are required, the effects of preload on each of these parameters must be evaluated. Compromise between stiffness and speed capacity may be necessary. In other applications, bearing life may be critical. Life typically increases with increasing preload up to a certain point, then drops off rapidly under heavy preload.

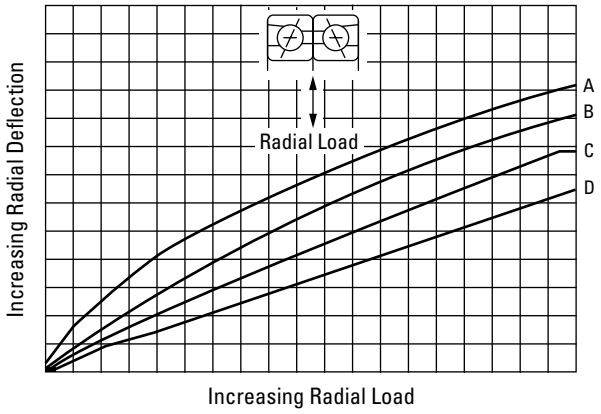
Three classes of ball bearing preload are commonly used – light, medium and heavy. Selection of the appropriate preload is based on specific application requirements. Preload values for these preload classes are listed in the dimension tables in the Timken Super Precision Bearings for Machine Tool Applications Catalog (order no. 5918) found on www.timken.com.

Axial deflection curves of various preload conditions for duplex pairs of 15-degree contact angle super precision ball bearings are shown in fig. 139, and the radial deflection curves for the same bearings are shown in fig. 140.



A No Preload
B Light Preload
C Medium Preload
D Heavy Preload

Fig. 139. Effect of most commonly used preloads on axial deflection.



A No Preload
B Light Preload
C Medium Preload
D Heavy Preload

Fig. 140. Effect of most commonly used preloads on radial deflection.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

FITTING PRACTICE TABLES
SPHERICAL ROLLER BEARINGS

TABLE 56. SPHERICAL ROLLER BEARING SHAFT FIT GUIDELINES

	Conditions	Examples	Shaft Diameter		Tolerance Symbol(1)	Remarks
			mm in.			
Stationary inner ring load	The inner ring to be easily displaced on the shaft	Two-bearing shaft mechanism	See table 58 for shaft size		s4	See table 58 for shaft size.
	The inner ring not to be easily displaced on the shaft	Wheel on non-rotating shaft	All diameters		g6	
		Tension pulleys and rope sheaves			h6	
Rotating inner ring load or indeterminate load direction	Light and variable loads P ≤ 0.07C	Electrical apparatus, machine tools, pumps, ventilators, industrial trucks	over	incl.	k6	In very accurate applications, k5 and m5 are used instead of k6 and m6 respectively.
			18 0.7087	**100** 3.9370		
			100 3.9370	**200** 7.8740	m6	
	Normal and heavy loads P > 0.07C ≤ 0.25C	Applications in general, electrical motors, turbines, pumps, combustion engines, gear transmissions, woodworking machines	**18** 0.7087	**65** 2.5590	m5	
			65 2.5590	**100** 3.9370	m6	
			100 3.9370	**140** 5.5118	n6	
			140 5.5118	**280** 11.0236	p6	
			280 11.0236	**500** 19.6850	r6	
			500 19.6850	**and up**	r7	
	Very heavy loads and shock loads P > 0.25C	Journal boxes for locomotives and other heavy rail vehicles, traction motors	**18** 0.7087	**65** 2.5590	m6	Bearings with greater clearance than normal must be used.
			65 2.5590	**100** 3.9370	n6	
			100 3.9370	**140** 5.5118	p6	
			140 5.5118	**200** 7.8740	r6	
			200 7.8740	**500** 19.6850	r7	
BEARINGS WITH TAPERED BORE AND ADAPTER SLEEVE						
	All loads	Applications in general	All diameters			See tables for Reduction of RIC on pages 86-87.

(1)For solid steel shaft. See tables on pages 132-135 for tolerance values.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

TABLE 57. SPHERICAL ROLLER BEARING HOUSING FIT GUIDELINES

Conditions			Examples	Tolerance Symbol[1]	Remarks
One-piece bearing housing	Rotating outer ring load	Variable load direction	Two-bearing eccentric shaft mechanism	P6	The outer ring is not displaceable axially.
		Heavy loads on bearings in thin-walled housings	Supporting wheels in cranes, wheel hubs, crank bearings	P7	
		Normal and heavy loads	Wheel hubs, crank bearings	N7	
		Light and variable loads	Conveyor rollers, rope sheaves, tension pulleys	M7	
	Indeterminate load direction	Heavy shock loads	Electrical traction motors		
		Heavy and normal loads, axial displacement of the outer ring not required	Electrical motors, pumps, crankshaft main bearings	K7	The outer ring is, as a rule, not displaceable axially.
		Normal and light loads, axial displacement of the outer ring is desirable	Electrical motors, pumps, crankshaft main bearings	J7	The outer ring is, as a rule, displaceable axially.
Split or one-piece bearing housing	Stationary outer ring load	Shock loads, temporarily complete unloading	Journal boxes for rail vehicles		
		All loads	Bearing applications in general, journal boxes for rail vehicles	H7	The outer ring is easily displaced axially.
		Normal and light loads, loads under simple operating conditions	Line shaftings	H8	
		Heat supplied through the shaft	Dryer cylinders	G7	
One-piece bearing housing	Applications requiring particular accuracy	Very accurate running and small deflections under variable loads	For main spindles in machine tools: O.D. less than 125 mm; O.D. 125 to 250 mm; O.D. over 250 mm	M6 N6 P6	The outer ring is not displaceable axially.
		Very accurate running under light loads and indeterminate load direction	Held bearings in high-speed centrifugal force compressors	K6	The outer ring is, as a rule, not displaceable axially.
		Very accurate running, axial displacement of outer ring desirable	Floating bearings in high-speed centrifugal force compressors	J6	The outer ring is easily displaced axially.

[1]Cast iron or steel housing. For tolerance values see tables on pages 138-145. For housings of light metal, tolerances generally are selected that give a slightly tighter fit than those given in the table.

Spherical roller bearing s4 fits

A centrifugal force load produces a rotating outer ring load and a stationary inner ring load, even though the inner ring rotates. This makes it desirable to fit the outer ring tight in the housing (using a P6 fit as shown in table 71), and the inner ring loose on the shaft using an s4 fit as listed in table 58. The standard W33 bearing with oil grooves and oil holes can be used.

The s4 fit designation as referenced on this page is a special fit tolerance developed by The Timken Company for centrifugal force load applications. It DOES NOT conform to ISO standards similarly published as s4 preferred shaft fits.

TABLE 58. s4 FITS

See Dimensional Tables for Nominal Bore.					
Bore		Variance From Nominal Bore			
			Shaft Diameter		
Over	Incl.	Tolerance[1]	Max.	Min.	Fit
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
50.000 1.9685	**80.000** 3.1496	**-0.015** -0.0006	**-0.025** -0.0010	**-0.036** -0.0014	**0.010L** **0.036L** 0.0004L 0.0014L
80.000 3.4196	**120.000** 4.7244	**-0.020** -0.0008	**-0.033** -0.0013	**-0.043** -0.0017	**0.013L** **0.043L** 0.0005L 0.0017L
120.000 4.7244	**180.000** 7.0866	**-0.025** -0.0010	**-0.041** -0.0016	**-0.053** -0.0021	**0.015L** **0.053L** 0.0006L 0.0021L
180.000 7.0866	**250.000** 9.8425	**-0.030** -0.0012	**-0.048** -0.0019	**-0.064** -0.0025	**0.018L** **0.064L** 0.0007L 0.0025L

[1]Tolerance range is from +0 to value listed.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

CYLINDRICAL ROLLER BEARINGS

TABLE 59. CYLINDRICAL ROLLER BEARINGS SHAFT FIT GUIDELINES (EXCEPT 5200 SERIES AND FOUR-ROW CYLINDRICALS)

Operating Conditions	Examples	Load Limit		Shaft Diameter		Shaft Tolerance
		Lower	Upper	**mm** in.	**mm** in.	Symbol[1]
INNER RING STATIONARY						
Inner ring to be easily displaced on shaft	Wheels Non-rotating shafts	0	C[2]	All	All	g6
Inner ring does not need to be easily displaced	Tension pulleys	0	C	All	All	h6
INNER RING ROTATION OR INDETERMINATE						
				Over	Incl.	
Light loads	Electircal apperatus Machine tools Pumps Ventilators Industrial trucks	0	0.08C	**0** 0	**40** 1.57	j6[6]
				40 1.57	**140** 5.51	k6[3]
				140 5.51	**320** 12.60	m6[4]
				320 12.60	**500** 19.68	n6
				500 19.68	– –	p6
Normal loads	Electrical motors Turbines Pumps Combustion engines Gear transmissions etc.	0.08C	0.18C	**0** 0	**40** 1.57	k5
				40 1.57	**100** 3.94	m5
				100 3.94	**140** 5.51	m6
				140 5.51	**320** 12.60	n6
				320 12.60	**500** 19.68	p6
				500 19.68	– –	r6
Heavy loads Shock loads	Rail vehicles Traction motors	0.18C	C	**0** 0	**40** 1.57	m5[5]
				40 1.57	**65** 2.56	m6[5]
				65 2.56	**140** 5.51	n6[5]
				140 5.51	**320** 12.60	p6[5]
				320 12.60	**500** 19.68	r6[5]
				500 19.68	– –	r7[5]
THRUST LOADS						
Pure thrust loads	All	Not suggested, consult your Timken engineer.				

[1]For solid shaft. See pages 132-135 for tolerance values.
[2]C = dynamic load rating.
[3]Use k5 for high-precision applications.
[4]Use m5 for high-precision applications.
[5]Bearings with greater than nominal clearance must be used.
[6]Use j5 for high-precision applications.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

TABLE 60. FOUR-ROW CYLINDRICAL ROLLER BEARING SHAFT FIT GUIDELINES

Load Limit		Shaft Diameter		Shaft Tolerance
Lower	Upper	**mm** in.	**mm** in.	Symbol[1]
All		**100** 3.93	**120** 4.72	n6
		120 4.72	**225** 8.85	p6
		225 8.85	**400** 15.75	r6
		400 15.75		s6

[1]For solid shaft. See pages 132-135 for tolerance values.

5200, A5200 METRIC SERIES SHAFT AND HOUSING FITS AND TOLERANCES

TABLE 61. CYLINDRICAL ROLLER BEARING HOUSING FIT GUIDELINES

	Operating Conditions		Examples	Housing Tolerance Symbol[1]	Outer Ring Displaceable Axially
	OUTER RING ROTATING				
	Heavy loads with thin-walled housing		Crane support wheels Wheel hubs (roller bearings) Crank bearings	P6	No
	Normal to heavy loads		Wheel hubs (ball bearings) Crank bearings	N6	No
	Light loads		Conveyor rollers Rope sheaves Tension pulleys	M6	No
	INDETERMINATE LOAD DIRECTION				
	Heavy shock loads		Electric traction motors	M7	No
	Normal to heavy loads, axial displacement of outer ring not required.		Electric motors Pumps Crankshaft main bearings	K6	No, normally
Below this line, housing can either be one piece or split. Above this line, a split housing is not suggested.	Light to normal loads, axial displacement of outer ring desired.		Electric motors Pumps Crankshaft main bearings	J6	Yes, normally
	OUTER RING STATIONARY				
	Shock loads, temporary complete unloading		Heavy rail vehicles	J6	Yes, normally
	All	One-piece housing	General applications Heavy rail vehicles	H6	Easily
		Radially split housing	Transmission drives	H7	Easily
	Heat supplied through shaft		Dryer cylinders	G7	Easily

[1]Cast iron steel housing. See pages 138-145 for numerical values. Where wider tolerances are permissible, P7, N7, M7, K7, J7 and H7 values may be used in place of P6, N6, M6, K6, J6 and H6 values, respectively.

CYLINDRICAL ROLLER BEARINGS

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

TABLE 62. SHAFT FITS[1]

Bearing Bore		Bore Tolerance[2]	Press Fit Rotating Inner Ring				Slip Fit Stationary Inner Ring			
			Shaft Diameter		Fit		Shaft Diameter		Fit	
Over	Incl.		Max.	Min.			Max.	Min.		
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
80 3.1496	**120** 4.7236	**-0.020** -0.0008	**+0.048** +0.0019	**+0.025** +0.0010	**0.025T** 0.0010T	**0.069T** 0.0027T	**0.000** 0.0000	**-0.023** -0.0009	**0.023L** 0.0009L	**0.020T** 0.0008T
120 4.7236	**140** 5.5108	**-0.025** -0.0010	**+0.056** +0.0022	**+0.030** +0.0012	**0.030T** 0.0012T	**0.081T** 0.0032T	**0.000** 0.0000	**-0.025** -0.0010	**0.025L** 0.0010L	**0.025T** 0.0010T
140 5.5108	**180** 7.0856	**-0.025** -0.0010	**+0.071** +0.0028	**+0.046** +0.0018	**0.046T** 0.0018T	**0.097T** 0.0038T	**0.000** 0.0000	**-0.025** -0.0010	**0.025L** 0.0010L	**0.025T** 0.0010T
180 7.0856	**240** 9.4476	**-0.030** -0.0012	**+0.081** +0.0032	**+0.051** +0.0020	**0.051T** 0.0020T	**0.112T** 0.0044T	**0.000** 0.0000	**-0.030** -0.0012	**0.030L** 0.0012L	**0.030T** 0.0012T

[1] When shaft is used as ring surface, hardness to be Rc58 minimum and surface finish to be 15 RMS.
[2] Tolerance range is from +0 to value listed.

TABLE 63. HOUSING FITS

Bearing O.D.		O.D. Tolerance[1]	Slip Fit Stationary Outer Ring				Press Fit Rotating Outer Ring			
			Housing Diameter		Fit		Housing Diameter		Fit	
Over	Incl.		Max.	Min.			Max.	Min.		
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
– –	**180** 7.0866	**-0.025** -0.0010	**+0.022** +0.0008	**-0.015** -0.0006	**0.015T** 0.0006T	**0.046L** 0.0018L	**-0.025** -0.0010	**-0.056** -0.0022	**0.056T** 0.0022T	**0.000L** 0.0000L
180 7.0866	**200** 7.8740	**-0.030** -0.0012	**+0.018** +0.0007	**-0.018** -0.0007	**0.018T** 0.0007T	**0.048L** 0.0019L	**-0.030** -0.0012	**-0.066** -0.0026	**0.066T** 0.0026T	**0.000L** 0.0000L
200 7.874	**230** 9.0551	**-0.030** -0.0012	**+0.023** +0.0009	**-0.018** -0.0007	**0.018T** 0.0007T	**0.053L** 0.0021L	**-0.030** -0.0012	**-0.066** -0.0026	**0.066T** 0.0026T	**0.000L** 0.0000L
230 9.0551	**250** 9.8425	**-0.030** -0.0012	**+0.028** +0.0011	**-0.018** -0.0007	**0.018T** 0.0007T	**0.058L** 0.0023L	**-0.030** -0.0012	**-0.066** -0.0026	**0.066T** 0.0026T	**0.000L** 0.0000L
250 9.8425	**270** 10.6299	**-0.036** -0.0014	**+0.028** +0.0011	**-0.018** -0.0007	**0.018T** 0.0007T	**0.064L** 0.0025L	**-0.030** -0.0012	**-0.071** -0.0028	**0.071T** 0.0028T	**0.005L** 0.0002L
270 10.6299	**310** 12.2047	**-0.036** -0.0014	**+0.033** +0.0013	**-0.018** -0.0007	**0.018T** 0.0007T	**0.069L** 0.0027L	**-0.036** -0.0014	**-0.071** -0.0028	**0.071T** 0.0028T	**0.005L** 0.0002L
310 12.2047	**400** 15.7480	**-0.041** -0.0016	**+0.038** +0.0015	**-0.018** -0.0007	**0.018T** 0.0007T	**0.079L** 0.0031L	**-0.036** -0.0014	**-0.076** -0.0030	**0.079T** 0.0030T	**0.005L** 0.0002L
400 15.748	**440** 17.3228	**-0.046** -0.0018	**+0.041** +0.0016	**-0.023** -0.0009	**0.023T** 0.0009T	**0.086L** 0.0034L	**-0.036** -0.0014	**-0.086** -0.0034	**0.086T** 0.0034T	**0.010L** 0.0004L

[1] Tolerance range is from +0 to value listed.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

TABLE 64. 5200 METRIC SERIES RADIAL INTERNAL CLEARANCE (R6)

Bearing Bore		Radial Internal Clearance	
Over	Incl.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.
– –	**100** 3.937	**0.183** 0.0072	**0.127** 0.005
100 3.937	**120** 4.7244	**0.188** 0.0074	**0.127** 0.005
120 4.7244	**140** 5.5118	**0.208** 0.0082	**0.142** 0.0056
140 5.5118	**170** 6.6929	**0.224** 0.0088	**0.152** 0.006
170 6.6929	**180** 7.0866	**0.229** 0.009	**0.152** 0.006
180 7.0866	**220** 8.6614	**0.254** 0.01	**0.173** 0.0068
220 8.6614	**240** 9.4488	**0.269** 0.0106	**0.183** 0.0072

TABLE 65. 5200 METRIC SERIES INNER RING TOLERANCES

Bearing Bore		Bore & Inner O.D.[1]	Width
Over	Incl.		+0
mm in.	**mm** in.	**mm** in.	**mm** in.
80 3.1496	**120** 4.7244	**-0.020** -0.0008	**-0.203** -0.0080
120 4.7244	**80** 7.0866	**-0.025** -0.0010	**-0.254** -0.0100
180 7.0866	**250** 9.8425	**-0.030** -0.0012	**-0.305** -0.0120

[1]Tolerance range is from +0 to value listed.

TABLE 66. 5200 METRIC SERIES OUTER RING TOLERANCES

Bearing Bore		O.D.[1]	Width
Over	Incl.		+0
mm in.	**mm** in.	**mm** in.	**mm** in.
150 5.9055	**180** 7.0866	**-0.025** -0.0010	**+0.036** +0.0014
180 7.0866	**250** 9.8425	**-0.030** -0.0012	**+0.041** +0.0016
250 9.8425	**315** 12.4016	**-0.036** -0.0014	**+0.046** +0.0018
315 12.4016	**400** 15.748	**-0.041** -0.0016	**+0.051** +0.0020
400 15.748	**500** 19.685	**-0.046** -0.0018	**+0.056** +0.0022

[1]Tolerance range is from +0 to value listed.

TABLE 67. 5200 BEARINGS WITHOUT INNER RING SHAFT DIMENSIONS

Bearing Number	Slip Fit Housing[1]		Press Fit Housing[1]	
	Max.	Min.	Max.	Min.
	mm in.	**mm** in.	**mm** in.	**mm** in.
5220 WS	**121.064** 4.7663	**121.044** 4.7655	**121.036** 4.7652	**121.016** 4.7644
5222 WS	**133.007** 5.2365	**132.987** 5.2357	**132.969** 5.235	**132.949** 5.2343
5224 WS	**145.194** 5.7163	**145.174** 5.7155	**145.156** 5.7148	**145.136** 5.714
5226 WS	**155.042** 6.104	**155.016** 6.103	**155.004** 6.1025	**154.978** 6.1015
5228 WS	**168.529** 6.635	**168.504** 6.634	**168.491** 6.6335	**168.466** 6.6325
5230 WS	**181.623** 7.1505	**181.597** 7.1495	**181.587** 7.149	**181.559** 7.148
5232 WS	**193.713** 7.6265	**193.688** 7.6255	**193.675** 7.625	**193.65** 7.624
5234 WS	**205.562** 8.093	**205.537** 8.092	**205.524** 8.0915	**205.499** 8.0905
5236 WS	**216.37** 8.5185	**216.344** 8.5175	**216.319** 8.5165	**216.294** 8.5155
5238 WS	**229.032** 9.017	**229.001** 9.0158	**228.994** 9.0155	**228.963** 9.0143
5240 WS	**242.296** 9.5392	**242.265** 9.538	**242.245** 9.5372	**242.214** 9.536
5244 WM	**266.02** 10.4725	**265.971** 10.4713	**265.951** 10.4705	**265.92** 10.4693
5248WM	**291.292** 11.4682	**291.262** 11.467	**291.241** 11.4662	**291.211** 11.465

[1]All shaft diameters are based on a housing bore to housing O.D. ratio of 0.7.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARINGS

SHAFT TOLERANCES

TABLE 68. RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARING SHAFT TOLERANCES

Bearing Bore			g6			h6			h5			j5		
Nominal (Max.)		Tolerance[1]	Shaft Diameter		Fit	Shaft Diameter		Fit	Shaft Diameter		Fit	Shaft Diameter		Fit
Over	Incl.		Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.	
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
3.000 0.1181	**6.000** 0.2362	**-0.008** -0.003	**-0.004** -0.0002	**-0.012** -0.0005	**0.012L** **0.004T** 0.0005L 0.0001T	**0.000** 0.0000	**-0.008** -0.003	**0.008L** **0.008T** 0.0003L 0.0003T	**0.000** 0.0000	**-0.005** -0.0002	**0.005L** **0.008T** 0.0002L 0.0003T	**+0.003** +0.0001	**-0.002** -0.0001	**0.002L** **0.011T** 0.0001L 0.0004T
6.000 0.2362	**10.000** 0.3937	**-0.008** -0.003	**-0.005** -0.0002	**-0.014** -0.0006	**0.014L** **0.003T** 0.0006L 0.0001T	**0.000** 0.0000	**-0.009** -0.0004	**0.009L** **0.008T** 0.0004L 0.0003T	**0.000** 0.0000	**-0.006** -0.0002	**0.006L** **0.008T** 0.0002L 0.0003T	**+0.004** +0.0002	**-0.002** -0.0001	**0.002L** **0.012T** 0.0001L -0.0005T
10.000 0.3937	**18.000** 0.7087	**-0.008** -0.003	**-0.006** -0.0002	**-0.017** -0.0007	**0.017L** **0.002T** 0.0007L -0.0001T	**0.000** 0.0000	**-0.011** -0.0004	**0.011L** **0.008T** 0.0004L 0.0003T	**0.000** 0.0000	**-0.008** -0.0003	**0.008L** **0.008T** 0.0003L 0.0003T	**+0.005** +0.0002	**-0.003** -0.0001	**0.003L** **0.013T** 0.0001L 0.0005T
18.000 0.7087	**30.000** 1.1811	**-0.010** -0.0004	**-0.007** -0.0003	**-0.020** -0.0008	**0.020L** **0.003T** 0.0008L 0.0001T	**0.000** 0.0000	**-0.013** -0.0005	**0.013L** **0.010T** 0.0005L 0.0004T	–	–	–	**+0.005** +0.0002	**-0.004** -0.0002	**0.004L** **0.015T** 0.0002L 0.0006T
30.000 1.1811	**50.000** 1.9685	**-0.012** -0.0005	**-0.009** -0.0004	**-0.025** -0.0010	**0.025L** **0.003T** 0.0010L 0.0001T	**0.000** 0.0000	**-0.016** -0.0006	**0.016L** **0.012T** 0.0006L 0.0005T	–	–	–	**+0.006** +0.0002	**-0.005** -0.0002	**0.005L** **0.018T** 0.0002L 0.0007T
50.000 1.9685	**80.000** 3.1496	**-0.015** -0.0006	**-0.010** -0.0004	**-0.029** -0.0011	**0.029L** **0.005T** 0.0011L 0.0002T	**0.000** 0.0000	**-0.019** -0.0007	**0.019L** **0.015T** 0.0007L 0.0006T	–	–	–	**+0.006** +0.0002	**-0.007** -0.0003	**0.007L** **0.021T** 0.0003L 0.0008T
80.000 3.1496	**120.000** 4.7244	**-0.020** -0.0008	**-0.012** -0.0005	**-0.034** -0.0013	**0.034L** **0.008T** 0.0013L 0.0003T	**0.000** 0.0000	**-0.022** -0.0009	**0.022L** **0.020T** 0.0009L 0.0008T	–	–	–	**+0.006** +0.0002	**-0.009** -0.0004	**0.009L** **0.026T** 0.0004L 0.0010T
120.000 4.7244	**180.000** 7.0866	**-0.025** -0.0010	**-0.014** -0.0006	**-0.039** -0.0015	**0.039L** **0.011T** 0.0015L 0.0004T	**0.000** 0.0000	**-0.025** -0.0010	**0.025L** **0.025T** 0.0010L 0.0010T	–	–	–	**+0.007** +0.0003	**-0.011** -0.0004	**0.011L** **0.032T** 0.0004L 0.0013T
180.000 7.0866	**200.000** 7.8740	**-0.030** -0.0012	**-0.015** -0.0006	**-0.044** -0.0017	**0.044T** **0.015T** 0.0017L 0.0006T	**0.000** 0.0000	**-0.029** -0.0011	**0.029L** **0.030T** 0.0011L 0.0012T	–	–	–	**+0.007** +0.0003	**-0.013** -0.0005	**0.013L** **0.037T** 0.0005L 0.0015T
200.000 7.8740	**225.000** 8.8583	**-0.030** -0.0012	**-0.015** -0.0006	**-0.044** -0.0017	**0.044T** **0.015T** 0.0017L 0.0006T	**0.000** 0.0000	**-0.029** -0.0011	**0.029L** **0.030T** 0.0011L 0.0012T	–	–	–	**+0.007** +0.0003	**-0.013** -0.0005	**0.013L** **0.037T** 0.0005L 0.0015T
225.000 8.8583	**250.000** 9.8425	**-0.030** -0.0012	**-0.015** -0.0006	**-0.044** -0.0017	**0.044T** **0.015T** 0.0017L 0.0006T	**0.000** 0.0000	**-0.029** -0.0011	**0.029L** **0.030T** 0.0011L 0.0012T	–	–	–	**+0.007** +0.0003	**-0.013** -0.0005	**0.013L** **0.037T** 0.0005L 0.0015T
250.000 9.8425	**280.000** 11.0236	**-0.035** -0.0014	**-0.017** -0.0007	**-0.049** -0.0019	**0.049L** **0.018T** 0.0019L 0.0007T	**0.000** 0.0000	**-0.032** -0.0013	**0.032L** **0.035T** 0.0013L 0.0014T	–	–	–	**+0.007** +0.0003	**-0.016** -0.0006	**0.016L** **0.042T** 0.0006L 0.0017T
280.000 11.0236	**315.000** 12.4016	**-0.035** -0.0014	**-0.017** -0.0007	**-0.049** -0.0019	**0.049L** **0.018T** 0.0019L 0.0007T	**0.000** 0.0000	**-0.032** -0.0013	**0.032L** **0.035T** 0.0013L 0.0014T	–	–	–	**+0.007** +0.0003	**-0.016** -0.0006	**0.016L** **0.042T** 0.0006L 0.0017T

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 68 continued.

j6			k5			k6			m5		
Shaft Diameter		Fit	Shaft Diameter		Fit	Shaft Diameter		Fit	Shaft Diameter		Fit
Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.	
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
+0.006 +0.0002	**-0.002** -0.0001	**0.002L** **0.014T** 0.0001L 0.0005T	**+0.006** +0.0002	**+0.001** +0.0000	**0.001T** **0.014T** 0.0000T 0.0005T	–	–	–	**+0.009** +0.0004	**+0.004** +0.0002	**0.004T** **0.017T** 0.0002T 0.0007T
+0.007 +0.0003	**-0.002** -0.0001	**0.002L** **0.015T** 0.0001L 0.0006T	**+0.007** +0.0003	**+0.001** +0.0000	**0.001T** **0.015T** 0.0000T 0.0006T	–	–	–	**+0.012** +0.0005	**+0.006** +0.0002	**0.006T** **0.020T** 0.0002T 0.0008T
+0.008 +0.0003	**-0.003** -0.0001	**0.003L** **0.016T** 0.0001L 0.0006T	**+0.009** +0.0004	**+0.001** +0.0000	**0.001T** **0.017T** 0.0000T 0.0007T	–	–	–	**+0.015** +0.0006	**+0.007** +0.0003	**0.007T** **0.023T** 0.0003T 0.0009T
+0.009 +0.0004	**-0.004** -0.0002	**0.004L** **0.019T** 0.0002L 0.0008T	**+0.011** +0.0004	**+0.002** +0.0001	**0.002T** **0.021T** 0.0001T 0.0008T	–	–	–	**+0.017** +0.0007	**+0.008** +0.0003	**0.008T** **0.027T** 0.0003T 0.0011T
+0.011 +0.0004	**-0.005** -0.0002	**0.005L** **0.023T** 0.0002L 0.00085T	**+0.013** +0.0005	**+0.002** +0.0001	**0.002T** **0.025T** 0.0001T 0.0010T	**+0.018** +0.0007	**+0.002** +0.0001	**0.002T** **0.030T** 0.0001T 0.0012T	**+0.020** +0.0008	**+0.009** +0.0004	**0.009T** **0.032T** 0.0004T 0.00125T
+0.012 +0.0005	**-0.007** -0.0003	**0.007L** **0.027T** 0.0003L 0.0011T	**+0.015** +0.0006	**+0.002** +0.0001	**0.002T** **0.030T** 0.0001T 0.0012T	**+0.021** +0.0008	**+0.002** +0.0001	**0.002T** **0.036T** 0.0001T 0.0014T	**+0.024** +0.0009	**+0.011** +0.0004	**0.011T** **0.039T** 0.0004T 0.0015T
+0.013 +0.0005	**-0.009** -0.0004	**0.009L** **0.033T** 0.0004L 0.0013T	**+0.018** +0.0007	**+0.003** +0.0001	**0.003T** **0.038T** 0.0001T 0.0015T	**+0.025** +0.0010	**+0.003** +0.0001	**0.003T** **0.045T** 0.0001T 0.0018T	**+0.028** +0.0011	**+0.013** +0.0005	**0.013T** **0.048T** 0.0005T 0.0019T
+0.014 +0.0006	**-0.011** -0.0004	**0.011L** **0.039T** 0.0004L 0.0016T	**+0.021** +0.0008	**+0.003** +0.0001	**0.003T** **0.046T** 0.0001T 0.0018T	**+0.028** +0.0011	**+0.003** +0.0001	**0.003T** **0.053T** 0.0001T 0.0021T	**+0.033** +0.0013	**+0.015** +0.0006	**0.015T** **0.058T** 0.0006T 0.0023T
+0.016 +0.0006	**-0.013** -0.0005	**0.013L** **0.046T** 0.0005L 0.0018T	**+0.024** +0.0009	**+0.004** +0.0002	**0.004T** **0.054T** 0.0002T 0.0021T	–	–	–	**+0.037** +0.0015	**+0.017** +0.0007	**0.017T** **0.067T** 0.0007T 0.0027T
+0.016 +0.0006	**-0.013** -0.0005	**0.013L** **0.046T** 0.0005L 0.0018T	**+0.024** +0.0009	**+0.004** +0.0002	**0.004T** **0.054T** 0.0002T 0.0021T	–	–	–	**+0.037** +0.0015	**+0.017** +0.0007	**0.017T** **0.067T** 0.0007T 0.0027T
+0.016 +0.0006	**-0.013** -0.0005	**0.013L** **0.046T** 0.0005L 0.0018T	**+0.024** +0.0009	**+0.004** +0.0002	**0.004T** **0.054T** 0.0002T 0.0021T	–	–	–	**+0.037** +0.0015	**+0.017** +0.0007	**0.017T** **0.067T** 0.0007T 0.0027T
+0.016 +0.0006	**-0.016** -0.0006	**0.016L** **0.051T** 0.0006L 0.0020T	**+0.027** +0.0011	**+0.004** +0.0002	**0.004T** **0.062T** 0.0002T 0.0025T	–	–	–	**+0.043** +0.0017	**+0.020** +0.0008	**0.020T** **0.078T** 0.0008T 0.0031T
+0.016 +0.0006	**-0.016** -0.0006	**0.016L** **0.051T** 0.0006L 0.0020T	**+0.027** +0.0011	**+0.004** +0.0002	**0.004T** **0.062T** 0.0002T 0.0025T	–	–	–	**+0.043** +0.0017	**+0.020** +0.0008	**0.020T** **0.078T** 0.0008T 0.0031T

RADIAL BALL, SPHERICAL ROLLER AND CYLINDRICAL ROLLER BEARINGS

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 68 continued.

Bearing Bore			g6			h6			h5			j5		
Nominal (Max.)		Tolerance[1]	Shaft Diameter		Fit	Shaft Diameter		Fit	Shaft Diameter		Fit	Shaft Diameter		Fit
Over	Incl.		Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.	
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
315.000 12.4016	**355.000** 13.9764	**-0.040** -0.0016	**-0.018** -0.0007	**-0.054** -0.0021	**0.054L** **0.022T** 0.0021L 0.0009T	**0.000** 0.0000	**-0.036** -0.0014	**0.036L** **0.040T** 0.0014L 0.0016T	–	–	–	**+0.007** +0.0003	**-0.018** -0.0007	**0.018L** **0.047T** 0.0007L 0.0019T
355.000 13.9764	**400.000** 15.7480	**-0.040** -0.0016	**-0.018** -0.0007	**-0.054** -0.0021	**0.054L** **0.022T** 0.0021L 0.0009T	**0.000** 0.0000	**-0.036** -0.0014	**0.036L** **0.040T** 0.0014L 0.0016T	–	–	–	**+0.007** +0.0003	**-0.018** -0.0007	**0.018L** **0.047T** 0.0007L 0.0019T
400.000 15.7480	**450.000** 17.7165	**-0.045** -0.0018	**-0.020** -0.0008	**-0.060** -0.0024	**0.060L** **0.025T** 0.0024L 0.0010T	**0.000** 0.0000	**-0.040** -0.0016	**0.040L** **0.045T** 0.0016L 0.0018T	–	–	–	**+0.007** +0.0003	**-0.020** -0.0008	**0.020L** **0.052T** 0.0008L 0.0021T
450.000 17.7165	**500.000** 19.6850	**-0.045** -0.0018	**-0.020** -0.0008	**-0.060** -0.0024	**0.060L** **0.025T** 0.0024L 0.0010T	**0.000** 0.0000	**-0.040** -0.0016	**0.040L** **0.045T** 0.0016L 0.0018T	–	–	–	**+0.007** +0.0003	**-0.020** -0.0008	**0.020L** **0.052T** 0.0008L 0.0020T
500.000 19.6850	**560.000** 22.0472	**-0.050** -0.0020	**-0.022** -0.0009	**-0.066** -0.0026	**0.066L** **0.028T** 0.0026L 0.0011T	**0.000** 0.0000	**-0.044** -0.0017	**0.044L** **0.050T** 0.0017L 0.0020T	–	–	–	**+0.008** 0.0003	**-0.022** -0.0009	**0.022L** **0.058T** 0.0009L 0.0023T
560.000 22.0472	**630.000** 24.8032	**-0.050** -0.0020	**-0.022** -0.0009	**-0.066** -0.0026	**0.066L** **0.028T** 0.0026L 0.0011T	**0.000** 0.0000	**-0.044** -0.0017	**0.044L** **0.050T** 0.0017L 0.0020T	–	–	–	**+0.008** +0.0003	**-0.022** -0.0009	**0.022L** **0.058T** 0.0009L 0.0023T
630.000 24.8032	**710.000** 27.9528	**-0.075** -0.0030	**-0.024** -0.0009	**-0.074** -0.0029	**0.074L** **0.051T** 0.0029L 0.0021T	**0.000** 0.0000	**-0.050** -0.0020	**0.050L** **0.075T** 0.0020L 0.0030T	–	–	–	**+0.010** +0.0004	**-0.025** -0.0010	**0.025L** **0.085T** 0.0010L 0.0035T
710.000 27.9528	**800.000** 31.4961	**-0.075** -0.0030	**-0.024** -0.0009	**-0.074** -0.0029	**0.074L** **0.051T** 0.0029L 0.0021T	**0.000** 0.0000	**-0.050** -0.0020	**0.050L** **0.075T** 0.0020L 0.0030T	–	–	–	**+0.010** +0.0004	**-0.025** -0.0010	**0.025L** **0.085T** 0.0010L 0.0035T
800.000 31.4961	**900.000** 35.4331	**-0.100** -0.0039	**-0.026** -0.0010	**-0.082** 0.0032	**0.082L** **0.074T** 0.0032L 0.0029T	**0.000** 0.0000	**-0.056** -0.0022	**0.056L** **0.100T** 0.0022L 0.0039T	–	–	–	**+0.012** +0.0005	**-0.028** -0.0011	**0.028L** **0.112T** 0.0011L 0.0044T
900.000 35.4331	**1000.000** 39.3701	**-0.100** -0.0039	**-0.026** -0.0010	**-0.082** 0.0032	**0.082L** **0.074T** 0.0032L 0.0029T	**0.000** 0.0000	**-0.056** -0.0022	**0.056L** **0.100T** 0.0022L 0.0039T	–	–	–	**+0.012** +0.0005	**-0.028** -0.0011	**0.028L** **0.112T** 0.0011L 0.0044T
1000.000 39.3701	**1120.000** 44.0945	**-0.125** -0.0049	**-0.028** -0.0011	**-0.094** -0.0037	**0.094L** **0.097T** 0.0037L 0.0038T	**0.000** 0.0000	**-0.066** -0.0026	**0.066L** **0.125T** 0.0022L 0.0039T	–	–	–	**+0.013** +0.0005	**-0.033** -0.0013	**0.033L** **0.138T** 0.0013L 0.0054T
1120.000 44.0945	**1250.000** 49.2126	**-0.125** -0.0049	**-0.028** -0.0011	**-0.094** -0.0037	**0.094L** **0.097T** 0.0037L 0.0038T	**0.000** 0.0000	**-0.066** -0.0026	**0.066L** **0.125T** 0.0022L 0.0039T	–	–	–	**+0.013** +0.0005	**-0.033** -0.0013	**0.033L** **0.138T** 0.0013L 0.0054T

NOTE: Tolerance and shaft diameters are shown in the table as variances from nominal bearing bore.
[1]Tolerance range is from +0 to value listed.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 68 continued.

j6			k5			k6			m5		
Shaft Diameter		Fit	Shaft Diameter		Fit	Shaft Diameter		Fit	Shaft Diameter		Fit
Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.	
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
+0.018 +0.0007	**-0.018** -0.0007	**0.018L** **w0.058T** 0.0007L 0.0023T	**+0.029** +0.0011	**+0.046** +0.0002	**0.004T** **0.069T** 0.0002T 0.0027T	–	–	–	**+0.046** +0.0018	**+0.021** +0.0008	**0.021T** **0.086T** 0.0008T 0.0034T
+0.018 +0.0007	**-0.018** -0.0007	**0.018L** **0.058T** 0.0007L 0.0023T	**+0.029** +0.0011	**+0.004** +0.0002	**0.004T** **0.069T** 0.0002T 0.0027T	–	–	–	**+0.046** +0.0018	**+0.021** +0.0008	**0.021T** **0.086T** 0.0008T 0.0034T
+0.020 +0.0008	**-0.020** -0.0008	**0.020L** **0.065T** 0.0008L 0.0026T	**+0.032** +0.0013	**+0.005** +0.0002	**0.005T** **0.077T** 0.0002T 0.0031T	–	–	–	**+0.050** +0.0020	**+0.023** +0.0009	**0.023T** **0.095T** 0.0009T 0.0037T
+0.020 +0.0008	**-0.020** -0.0008	**0.020L** **0.065T** 0.0008L 0.0026T	**+0.032** +0.0013	**+0.005** +0.0002	**0.005T** **0.077T** 0.0002T 0.0031T	–	–	–	**+0.050** +0.0020	**+0.023** +0.0009	**0.023T** **0.095T** 0.0009T 0.0037T
+0.022 +0.0009	**-0.022** -0.0009	**0.022L** **0.072T** 0.0009L 0.0029T	**+0.030** +0.0012	**0.000** 0.0000	**0.00T** **0.080T** 0.0000T 0.0032T	–	–	–	**+0.056** +0.0022	**+0.026** +0.0010	**0.026T** **0.106T** 0.0010T 0.0042T
+0.022 +0.0009	**-0.022** -0.0009	**0.022L** **0.072T** 0.0009L 0.0029T	**+0.030** +0.0012	**0.000** 0.0000	**0.00T** **0.080T** 0.0000T 0.0032T	–	–	–	**+0.056** +0.0022	**+0.026** +0.0010	**0.026T** **0.106T** 0.0010T 0.0042T
+0.025 +0.0010	**-0.025** -0.0010	**0.025L** **0.100T** 0.0010L 0.0040T	**+0.035** +0.0014	**0.000** 0.0000	**0.000T** **0.110T** 0.0000T 0.0044T	–	–	–	**+0.065** +0.0026	**+0.030** +0.0012	**0.030T** **0.140T** 0.0012T 0.0056T
+0.025 +0.0010	**-0.025** -0.0010	**0.025L** **0.100T** 0.0010L 0.0040T	**+0.035** +0.0014	**0.000** 0.0000	**0.000T** **0.110T** 0.0000T 0.0044T	–	–	–	**+0.065** +0.0026	**+0.030** +0.0012	**0.030T** **0.140T** 0.0012T 0.0056T
+0.025 +0.0010	**-0.025** -0.0010	**0.028L** **0.128T** 0.0011L 0.0050L	**+0.040** +0.0016	**0.000** 0.0000	**0.000T** **0.140T** 0.0000T 0.0055T	–	–	–	**+0.074** +0.0029	**+0.0030** +0.0012	**0.034T** **0.174T** 0.0012T 0.0056T
+0.028 +0.0011	**-0.028** -0.0011	**0.028L** **0.128T** 0.0011L 0.0050T	**+0.040** +0.0016	**0.000** 0.0000	**0.000T** **0.140T** 0.0000T 0.0055T	–	–	–	**+0.074** +0.0029	**+0.034** +0.0013	**0.034T** **0.174T** 0.0013T 0.0068T
+0.028 +0.0011	**-0.028** -0.0011	**0.033L** **0.158T** 0.0013L 0.0062T	**+0.046** +0.0018	**0.000** 0.0000	**0.000T** **0.171T** 0.0000T 0.0067T	–	–	–	**+0.086** +0.0034	**+0.040** +0.0016	**0.040T** **0.211T** 0.0016T 0.0083T
+0.033 +0.0013	**-0.033** -0.0013	**0.033L** **0.158T** 0.0013L 0.0062T	**+0.046** +0.0018	**0.000** 0.0000	**0.000T** **0.171T** 0.0000T 0.0067T	–	–	–	**+0.086** +0.0034	**+0.040** +0.0016	**0.040T** **0.211T** 0.0016T 0.0083T

NOTE: Tolerance and shaft diameters are shown in the table as variances from nominal bearing bore.
(1)Tolerance range is from +0 to value listed.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

TABLE 69. RADIAL BALL, SPHERICAL ROLLER AND CYLINDRICAL ROLLER BEARING SHAFT TOLERANCES

Bearing Bore			m6			n6			p6			r6			r7		
Nominal (Max.)		Tolerance[1]	Shaft Diameter		Fit	Shaft Diameter		Fit	Shaft Diameter		Fit	Shaft Diameter		Fit	Shaft Diameter		Fit
Over	Incl.		Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.	
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
3.000 0.1181	**6.000** 0.2362	**-0.008** -0.0003	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
6.000 0.2362	**10.000** 0.3937	**-0.008** -0.0003	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
10.000 0.3937	**18.000** 0.7087	**-0.008** -0.0003	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
18.000 0.7087	**30.000** 1.1811	**-0.010** -0.0004	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
30.000 1.1811	**50.000** 1.9685	**-0.012** -0.0005	**+0.025** +0.0010	**+0.009** +0.0004	**0.009T** **0.037T** 0.0004T 0.0145T	–	–	–	–	–	–	–	–	–	–	–	–
50.000 1.9685	**80.000** 3.1496	**-0.015** -0.0006	**+0.030** +0.0012	**+0.011** +0.0004	**0.011T** **0.045T** 0.0004T 0.0018T	**+0.039** +0.0015	**+0.020** +0.0008	**0.020T** **0.054T** 0.0008T 0.0021T	–	–	–	–	–	–	–	–	–
80.000 3.1496	**120.000** 4.7244	**-0.020** -0.0008	**+0.035** +0.0014	**+0.013** +0.0005	**0.013T** **0.055T** 0.0005T 0.0022T	**+0.045** +0.0018	**+0.023** +0.0009	**0.023T** **0.065T** 0.0009T 0.0026T	**+0.059** +0.0023	**+0.037** +0.0015	**0.037T** **0.079T** 0.0015T 0.0031T	–	–	–	–	–	–
120.000 4.7244	**180.000** 7.0866	**-0.025** -0.0010	**+0.040** +0.0016	**+0.015** +0.0006	**0.015T** **0.065T** 0.0006T 0.0026T	**+0.052** +0.0020	**+0.027** +0.0011	**0.027T** **0.077T** 0.0011T 0.0030T	**+0.068** +0.0027	**+0.043** +0.0017	**0.043T** **0.093T** 0.0017T 0.0037T	**+0.090** +0.0035	**+0.065** +0.0026	**0.065T** **0.115T** 0.0026T 0.0045T	–	–	–
180.000 7.0866	**200.000** 7.8740	**-0.030** -0.0012	**+0.046** +0.0018	**+0.017** +0.0007	**0.017T** **0.076T** 0.0007T 0.0030T	**+0.060** +0.0024	**+0.031** +0.0012	**0.031L** **0.090T** 0.0012L 0.0036T	**+0.079** +0.0031	**+0.050** +0.0020	**0.050T** **0.109T** 0.0020T 0.0043T	**+0.106** +0.0042	**+0.077** +0.0030	**0.077T** **0.136T** 0.0030T 0.0054T	–	–	–
200.000 7.8740	**225.000** 8.8583	**-0.030** -0.0012	**+0.046** +0.0018	**+0.017** +0.0007	**0.017T** **0.076T** 0.0007T 0.0030T	**+0.060** +0.0024	**+0.031** +0.0012	**0.031L** **0.090T** 0.0012L 0.0036T	**+0.079** +0.0031	**+0.050** +0.0020	**0.050T** **0.109T** 0.0020T 0.0043T	**+0.109** +0.0043	**+0.080** +0.0031	**0.080T** **0.139T** 0.0031T 0.0055T	**+0.126** +0.0050	**+0.080** +0.0031	**0.080T** **0.156T** 0.0031T 0.0062T
225.000 8.8583	**250.000** 9.8425	**-0.030** -0.0012	**+0.046** +0.0018	**+0.017** +0.0007	**0.017T** **0.076T** 0.0007T 0.0030T	**+0.060** +0.0024	**+0.031** +0.0012	**0.031L** **0.090T** 0.0012L 0.0036T	**+0.079** +0.0031	**+0.050** +0.0020	**0.050T** **0.109T** 0.0020T 0.0043T	**+0.113** +0.0044	**+0.084** +0.0033	**0.084T** **0.143T** 0.0033T 0.0056T	**+0.130** +0.0051	**+0.084** +0.0033	**0.084T** **0.160T** 0.0033T 0.0063T
250.000 9.8425	**280.000** 11.0236	**-0.035** -0.0014	**+0.052** +0.0020	**+0.020** +0.0008	**0.020T** **0.087T** 0.0008T 0.0034T	**+0.066** +0.0026	**+0.034** +0.0013	**0.034T** **0.101T** 0.0013T 0.0040T	**+0.088** +0.0035	**+0.056** +0.0022	**0.056T** **0.123T** 0.0022T 0.0049T	**+0.126** +0.0050	**+0.094** +0.0037	**0.094T** **0.161T** 0.0037T 0.0064T	**+0.146** +0.0057	**+0.094** +0.0037	**0.094T** **0.181T** 0.0037T 0.0071T
280.000 11.0236	**315.000** 12.4016	**-0.035** -0.0014	**+0.052** +0.0020	**+0.020** +0.0008	**0.020T** **0.087T** 0.0008T 0.0034T	**+0.066** +0.0026	**+0.034** +0.0013	**0.034T** **0.101T** 0.0013T 0.0040T	**+0.088** +0.0035	**+0.056** +0.0022	**0.056T** **0.123T** 0.0022T 0.0049T	**+0.130** +0.0051	**+0.098** +0.0039	**0.098T** **0.165T** 0.0039T 0.0065T	**+0.150** +0.0059	**+0.098** +0.0039	**0.098T** **0.185T** 0.0039T 0.0073T

NOTE: Tolerance and shaft diameters are shown in the table as variances from nominal bearing bore.

[1]Tolerance range is from +0 to value listed.

Continued on next page.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 69 continued.

Bearing Bore			m6			n6			p6			r6			r7		
Nominal (Max.)		Tolerance[1]	Shaft Diameter		Fit	Shaft Diameter		Fit	Shaft Diameter		Fit	Shaft Diameter		Fit	Shaft Diameter		Fit
Over	Incl.		Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.	
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
315.000 12.4016	**355.000** 13.9764	**-0.040** -0.0016	**+0.057** +0.0022	**+0.021** +0.0008	**0.021T** **0.097T** 0.0008T 0.0038T	**+0.073** +0.0029	**+0.037** +0.0015	**0.037T** **0.113T** 0.0015T 0.0045T	**+0.098** +0.0039	**+0.062** +0.0024	**0.062T** **0.138T** 0.0024T 0.0055T	**+0.144** +0.0057	**+0.108** +0.0043	**0.108T** **0.184T** 0.0043T 0.0073T	**+0.165** +0.0065	**+0.108** +0.0043	**0.108T** **0.205T** 0.0043T 0.0081T
355.000 13.9764	**400.000** 15.7480	**-0.040** -0.0016	–	–	–	**+0.073** +0.0029	**+0.037** +0.0015	**0.037T** **0.113T** 0.0015T 0.0045T	**+0.098** +0.0039	**+0.062** +0.0024	**0.062T** **0.138T** 0.0024T 0.0055T	**+0.150** +0.0059	**+0.114** +0.0045	**0.114T** **0.190T** 0.0045T 0.0075T	**+0.171** +0.0067	**+0.114** +0.0045	**0.114T** **0.211T** 0.0045T 0.0083T
400.000 15.7480	**450.000** 17.7165	**-0.045** -0.0018	–	–	–	**+0.080** +0.0031	**+0.040** +0.0016	**0.040T** **0.125T** 0.0016T 0.0049T	**+0.108** +0.0043	**+0.068** +0.0027	**0.068T** **0.153T** 0.0027T 0.0061T	**+0.166** +0.0065	**+0.126** +0.0050	**0.126T** **0.211T** 0.0050T 0.0083T	**+0.189** +0.0074	**+0.126** +0.0050	**0.126T** **0.234T** 0.0050T 0.0092T
450.000 17.7165	**500.000** 19.6850	**-0.045** -0.0018	–	–	–	**+0.080** +0.0031	**+0.040** +0.0016	**0.040T** **0.125T** 0.0016T 0.0049T	**+0.108** +0.0043	**+0.068** +0.0027	**0.068T** **0.153T** 0.0027T 0.0061T	**+0.172** +0.0068	**+0.132** +0.0052	**0.132T** **0.217T** 0.0052T 0.0086T	**+0.195** +0.0077	**+0.132** +0.0052	**0.132T** **0.240T** 0.0052T 0.0095T
500.000 19.6850	**560.000** 22.0472	**-0.050** -0.0020	–	–	–	–	–	–	**+0.122** +0.0048	**+0.078** +0.0031	**0.078T** **0.172T** 0.0031T 0.0068T	**+0.194** +0.0076	**+0.150** +0.0059	**0.150T** **0.244T** 0.0059T 0.0096T	**+0.220** +0.0087	**+0.150** +0.0059	**0.150T** **0.270T** 0.0059T 0.0107T
560.000 22.0472	**630.000** 24.8032	**-0.050** -0.0020	–	–	–	–	–	–	**+0.122** +0.0048	**+0.078** +0.0031	**0.078T** **0.172T** 0.0031T 0.0068T	**+0.199** +0.0078	**+0.155** +0.0061	**0.155T** **0.249T** 0.0061T 0.0098T	**+0.225** +0.0089	**+0.155** +0.0061	**0.155T** **0.275T** 0.0061T 0.0109T
630.000 24.8032	**710.000** 27.9528	**-0.075** -0.0030	–	–	–	–	–	–	**+0.138** +0.0054	**+0.088** +0.0035	**0.088T** **0.213T** 0.0035T 0.0084T	**+0.225** +0.0089	**+0.175** +0.0069	**0.175T** **0.300T** 0.0069T 0.0119T	**+0.255** +0.0100	**+0.175** +0.0069	**0.175T** **0.330T** 0.0069T 0.0130T
710.000 27.9528	**800.000** 31.4961	**-0.075** -0.0030	–	–	–	–	–	–	**+0.138** +0.0054	**+0.088** +0.0035	**0.088T** **0.213T** 0.0035T 0.0084T	**+0.235** +0.0093	**+0.185** +0.0073	**0.185T** **0.310T** 0.0073T 0.0123T	**+0.265** +0.0104	**+0.185** +0.0073	**0.185T** **0.340T** 0.0073T 0.0134T
800.000 31.4961	**900.000** 35.4331	**-0.100** -0.0039	–	–	–	–	–	–	**+0.156** +0.0061	**+0.100** +0.0039	**0.100T** **0.256T** 0.0039T 0.0100T	**+0.266** +0.0105	**+0.210** +0.0083	**0.210T** **0.366T** 0.0083T 0.0144T	**+0.300** +0.0118	**+0.210** +0.0083	**0.210T** **0.400T** 0.0083T 0.0157T
900.000 35.4331	**1000.000** 39.3701	**-0.100** -0.0039	–	–	–	–	–	–	**+0.156** +0.0061	**+0.100** +0.0039	**0.100T** **0.256T** 0.0039T 0.0100T	**+0.276** +0.0109	**+0.220** +0.0087	**0.220T** **0.366T** 0.0087T 0.0148T	**+0.0310** +0.0122	**+0.220** +0.0087	**0.220T** **0.410T** 0.0087T 0.0161T
1000.0001 39.3701	**1120.000** 44.0945	**-0.125** -0.0049	–	–	–	–	–	–	**+0.186** +0.0073	**+0.120** +0.0047	**0.120T** **0.311T** 0.0047T 0.0122T	**+0.316** +0.0124	**+0.250** +0.0098	**0.250T** **0.441T** 0.0098T 0.0173T	**+0.355** +0.0140	**+0.250** +0.0098	**0.250T** **0.480T** 0.0098T 0.0189T
1120.0001 44.0945	**1250.000** 49.2126	**-0.125** -0.0049	–	–	–	–	–	–	**+0.186** +0.0073	**+0.120** +0.0047	**0.120T** **0.311T** 0.0047T 0.0122T	**+0.326** +0.0128	**+0.260** +0.0102	**0.260T** **0.451T** 0.0102T 0.0177T	**+0.365** +0.0144	**+0.260** +0.0102	**0.260T** **0.490T** 0.0102T 0.0193T

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

HOUSING TOLERANCES

TABLE 70. RADIAL BALL, SPHERICAL ROLLER AND CYLINDRICAL ROLLER BEARING HOUSING TOLERANCES

Bearing O.D.			F7			G7			H6			H7		
Nominal (Max.)			Housing Bore			Housing Bore			Housing Bore			Housing Bore		
Over	Incl.	Tolerance[1]	Max.	Min.	Fit	Max.	Min.	Fit	Max.	Min.	Fit	Max.	Min.	Fit
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
10.000 0.3937	**18.000** 0.7087	**-0.008** -0.0003	**+0.034** +0.0013	**+0.016** +0.0006	**0.016L** **0.042L** 0.0006L 0.0016L	**+0.024** +0.0009	**+0.002** +0.0002	**0.006L** **0.032L** 0.0002L 0.0012L	**+0.011** +0.0004	**0.000** 0.0000	**0.000L** **0.019L** 0.0000L 0.0007L	**+0.018** +0.0007	**0.000** 0.0000	**0.000L** **0.026L** 0.0000L 0.0010L
18.000 0.7087	**30.000** 1.1811	**-0.009** -0.0035	**+0.041** +0.0016	**+0.020** +0.0008	**0.020L** **0.050L** 0.0008L 0.00195L	**+0.028** +0.0011	**+0.007** +0.0003	**0.007L** **0.037L** 0.0003L 0.00145L	**+0.013** +0.0005	**0.000** 0.0000	**0.000L** **0.022L** 0.0000L 0.00085L	**+0.021** +0.0008	**0.000** 0.0000	**0.000L** **0.030L** 0.0000L 0.00125L
30.000 1.1811	**50.000** 1.9685	**-0.011** -0.00045	**+0.050** +0.0020	**+0.025** +0.0010	**0.025L** **0.061L** 0.0010L 0.00245L	**+0.034** +0.0013	**+0.009** +0.0004	**0.009L** **0.045L** 0.0004L 0.00175L	**+0.016** +0.0006	**0.000** 0.0000	**0.000L** **0.027L** 0.0000L 0.00105L	**+0.025** +0.0010	**0.000** 0.0000	**0.000L** **0.036L** 0.0000L 0.00145L
50.000 1.9685	**80.000** 3.1496	**-0.013** -0.0005	**+0.060** +0.0024	**+0.030** +0.0012	**0.030L** **0.073L** 0.0012L 0.0029L	**+0.040** +0.0016	**+0.010** +0.0004	**0.010L** **0.053L** 0.0004L 0.0021L	**+0.019** +0.0007	**0.000** 0.0000	**0.000L** **0.032L** 0.0000L 0.0012L	**+0.030** +0.0012	**0.000** 0.0000	**0.000L** **0.043L** 0.0000L 0.0017L
80.000 3.1496	**120.000** 4.7244	**-0.015** -0.0006	**+0.071** +0.0028	**+0.036** +0.0014	**0.036L** **0.086L** 0.0014L 0.0034L	**+0.047** +0.0019	**+0.012** +0.0005	**0.012L** **0.062L** 0.0005L 0.0025L	**+0.022** +0.0009	**0.000** 0.0000	**0.000L** **0.037L** 0.0000L 0.0015L	**+0.035** +0.0014	**0.000** 0.0000	**0.000L** **0.050L** 0.0000L 0.0020L
120.000 4.7244	**150.000** 5.9055	**-0.018** -0.0007	**+0.083** +0.0033	**+0.043** +0.0017	**0.043L** **0.101L** 0.0017L 0.0040L	**+0.054** +0.0021	**+0.014** +0.0006	**0.014L** **0.072L** 0.0006L 0.0028L	**+0.025** +0.0010	**0.000** 0.0000	**0.000L** **0.043L** 0.0000L 0.0017L	**+0.040** +0.0016	**0.000** 0.0000	**0.000L** **0.058L** 0.0000L 0.0023L
150.000 5.9055	**180.000** 7.0866	**-0.025** -0.0010	**+0.083** +0.0033	**+0.043** +0.0017	**0.043L** **0.108L** 0.0017L 0.0043L	**+0.054** +0.0021	**+0.014** +0.0006	**0.014L** **0.079L** 0.0006L 0.0031L	**+0.025** +0.0010	**0.000** 0.0000	**0.000L** **0.050L** 0.0000L 0.0020L	**+0.040** +0.0016	**0.000** 0.0000	**0.000L** **0.065L** 0.0000L 0.0026L
180.000 7.0866	**250.000** 9.8425	**-0.030** -0.0012	**+0.096** +0.0038	**+0.050** +0.0020	**0.050L** **0.126L** 0.0020L 0.0050L	**+0.061** +0.0024	**+0.015** +0.0006	**0.015L** **0.091L** 0.0006L 0.0036L	**+0.029** +0.0011	**0.000** 0.0000	**0.000L** **0.059L** 0.0000L 0.0023L	**+0.046** +0.0018	**0.000** 0.0000	**0.000L** **0.076L** 0.0000L 0.0030L
250.000 9.8425	**315.000** 12.4016	**-0.035** -0.0014	**+0.108** +0.0043	**+0.056** +0.0022	**0.056L** **0.143L** 0.0022L 0.0057L	**+0.069** +0.0027	**+0.17** +0.0007	**0.017L** **0.104L** 0.0007L 0.0041L	**+0.032** +0.0013	**0.000** 0.0000	**0.000L** **0.067L** 0.0000L 0.0027L	**+0.052** +0.0020	**0.000** 0.0000	**0.000L** **0.087L** 0.0000L 0.0034L
315.000 12.4016	**400.000** 15.7480	**-0.040** -0.0016	**+0.119** +0.0047	**+0.062** +0.0024	**0.063L** **0.159L** 0.0024L 0.0063L	**+0.075** +0.0030	**+0.018** +0.0007	**0.018L** **0.115L** 0.0007L 0.0046L	**+0.035** +0.0014	**0.000** 0.0000	**0.000L** **0.0762L** 0.0000L 0.0030L	**+0.057** +0.0022	**0.000** 0.0000	**0.000L** **0.097L** 0.0000L 0.0038L
400.000 15.7480	**500.000** 19.6850	**-0.045** -0.0018	**+0.131** +0.0052	**+0.068** +0.0027	**0.068L** **0.176L** 0.0027L 0.0070L	**+0.083** +0.0033	**+0.020** +0.0008	**0.020L** **0.128L** 0.0008L 0.0051L	**+0.041** +0.0016	**0.000** 0.0000	**0.000L** **0.086L** 0.0000L 0.0034L	**+0.063** +0.0025	**0.000** 0.0000	**0.000L** **0.108L** 0.0000L 0.0043L
500.000 19.6850	**630.000** 24.8032	**-0.050** -0.0020	**+0.146** +0.0057	**+0.076** +0.0030	**0.076L** **0.196L** 0.0030L 0.0077L	**+0.092** +0.0036	**+0.022** +0.0009	**0.022L** **0.142L** 0.0009L 0.0056L	**+0.043** +0.0017	**0.000** 0.0000	**0.000L** **0.094L** 0.0000L 0.0037L	**+0.070** +0.0028	**0.000** 0.0000	**0.000L** **0.120L** 0.0000L 0.0048L

NOTE: Tolerance and shaft diameters are shown in the table as variances from nominal bearing O.D.
[1]Tolerance range is from +0 to value listed.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 70 continued.

H8			J6			J7			K6			K7		
Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit
Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.	
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
+0.027 +0.0011	**0.000** 0.0000	**0.000L** **0.035L** 0.0000L 0.0014L	**+0.006** +0.0002	**-0.005** -0.0002	**0.005T** **0.014L** 0.0002T 0.0005L	**+0.10** +0.004	**-0.008** -0.0003	**0.008T** **0.018L** 0.0003T 0.0007L	**+0.002** +0.0001	**-0.009** -0.0004	**0.009T** **0.010L** 0.0004T 0.0004L	**+0.006** +0.0002	**-0.012** -0.0005	**0.012T** **0.014L** 0.0005T 0.0005L
+0.033 +0.0013	**0.000** 0.0000	**0.000L** **0.030L** 0.0000L 0.00165L	**+0.008** +0.0003	**-0.005** -0.0002	**0.005T** **0.017L** 0.0002T 0.00065L	**+0.012** +0.0005	**-0.009** -0.0004	**0.009T** **0.021L** 0.0004T 0.00085L	**+0.002** +0.0001	**-0.011** -0.0004	**0.011T** **0.011L** 0.0004T 0.00045L	**+0.006** +0.0002	**-0.015** -0.0006	**0.015T** **0.015L** 0.0006T 0.00055L
+0.039 +0.0015	**0.000** 0.0000	**0.000L** **0.050L** 0.0000L 0.00195L	**+0.010** +0.0002	**-0.006** -0.0002	**0.006T** **0.021L** 0.0002T 0.00085L	**+0.014** +0.0006	**-0.011** -0.0004	**0.011T** **0.025L** 0.0004T 0.00105L	**+0.003** +0.0001	**-0.014** -0.0005	**0.013T** **0.014L** 0.0005T 0.00055L	**+0.007** +0.0003	**-0.018** -0.0007	**0.018T** **0.018L** 0.0007T 0.00065L
+0.046 +0.0018	**0.000** 0.0000	**0.000L** **0.059L** 0.0000L 0.0023L	**+0.013** +0.0005	**-0.006** -0.0002	**0.006T** **0.026L** 0.0002T 0.0010L	**+0.018** +0.0007	**-0.012** -0.0005	**0.012T** **0.031L** 0.0005T 0.0012L	**+0.004** +0.0002	**-0.015** -0.0006	**0.015T** **0.017L** 0.0006T 0.0007L	**+0.009** +0.0004	**-0.021** -0.0008	**0.021T** **0.022L** 0.0008T 0.0009L
+0.054 **+0.054** +0.0021	**0.000** **0.000** 0.0000	**0.000L** **0.069L** 0.0000L 0.0027L	**+0.016** +0.0006	**-0.006** -0.0002	**0.006T** **0.031L** 0.0002T 0.0012L	**+0.022** +0.0009	**-0.013** -0.0005	**0.013T** **0.037L** 0.0005T 0.0015L	**+0.004** +0.0002	**-0.018** -0.0007	**0.018T** **0.019L** 0.0007T 0.0008L	**+0.010** +0.0004	**-0.025** -0.0010	**0.025T** **0.025L** 0.0010T 0.0010L
+0.063 +0.0025	**0.000** 0.0000	**0.000L** **0.081L** 0.0000L 0.0032L	**+0.018** +0.0007	**-0.007** -0.0003	**0.007T** **0.036L** 0.0003T 0.0014L	**+0.026** +0.0010	**-0.014** -0.0006	**0.014T** **0.044L** 0.0006T 0.0017L	**+0.004** +0.0002	**-0.021** -0.0008	**0.021T** **0.022L** 0.0008T 0.0009L	**+0.012** +0.0005	**-0.028** -0.0011	**0.028T** **0.030L** 0.0011T 0.0012L
+0.063 +0.0025	**0.000** 0.0000	**0.000L** **0.088L** 0.0000L 0.0035L	**+0.018** +0.0007	**-0.007** -0.0003	**0.007T** **0.043L** 0.0003T 0.0017L	**+0.026** +0.0010	**-0.014** -0.0006	**0.014T** **0.051L** 0.0006T 0.0020L	**+0.004** +0.0002	**-0.021** -0.0008	**0.021T** **0.029L** 0.008T 0.0012L	**+0.012** +0.0005	**-0.033** -0.028	**0.028T** **0.037L** 0.0011T 0.0015L
+0.072 +0.0028	**0.000** 0.0000	**0.000L** **0.102L** 0.0000L 0.0040L	**+0.022** +0.0007	**-0.007** -0.0003	**0.007T** **0.052L** 0.0003T 0.0021L	**+0.030** +0.0012	**-0.016** -0.0006	**0.016T** **0.060L** 0.0006T 0.0024L	**+0.005** +0.0002	**-0.024** -0.0009	**0.024T** **0.035L** 0.0009T 0.0014L	**+0.013** +0.0005	**-0.0011** -0.0013	**0.033T** **0.043L** 0.0013T 0.0017L
+0.081 +0.0032	**0.000** 0.0000	**0.000L** **0.116L** 0.0000L 0.0046L	**+0.025** +0.0010	**-0.007** -0.0003	**0.007T** **0.060L** 0.0003T 0.0024L	**+0.036** +0.0014	**-0.016** -0.0006	**0.016T** **0.071L** 0.0006T 0.0028L	**+0.005** +0.0002	**-0.027** -0.0011	**0.027T** **0.040L** 0.0011T 0.0016L	**+0.016** +0.0006	**-0.036** -0.0014	**0.036T** **0.051L** 0.0014T 0.0020L
+0.036 +0.035	**0.000** 0.0000	**0.000L** **0.076L** 0.0000L 0.0051L	**+0.029** +0.0011	**-0.007** -0.0003	**0.007T** **0.069L** 0.0003T 0.0027L	**+0.039** +0.0015	**-0.018** -0.0007	**0.018T** **0.079L** 0.0007T 0.0031L	**+0.007** +0.0003	**-0.029** -0.0011	**0.029T** **0.047L** 0.0011T 0.0019L	**+0.017** +0.0007	**-0.040** -0.0016	**0.040T** **0.057L** 0.0016T 0.0023L
+0.040 +0.0038	**0.000** 0.0000	**0.000L** **0.085** 0.0000L 0.0056L	**+0.033** +0.0013	**-0.007** -0.0003	**0.007T** **0.078L** 0.0003T 0.0031L	**+0.043** +0.0017	**-0.020** -0.0008	**0.020T** **0.088L** 0.0008T 0.0035L	**+0.008** +0.0003	**-0.032** -0.0013	**0.032T** **0.053L** 0.0013T 0.0021L	**+0.018** +0.0007	**-0.045** -0.0018	**0.045T** **0.063L** 0.0018T 0.0025L
+0.044 +0.0043	**0.000** 0.0000	**0.000L** **0.094L** 0.0000L 0.0063L	**+0.037** +0.0015	**-0.007** -0.0003	**0.022T** **0.098L** 0.0003T 0.0035L	**+0.048** +0.0019	**-0.022** -0.0009	**0.022T** **0.098L** 0.0009T 0.0039L	**0.000** 0.0000	**-0.044** -0.0017	**0.044T** **0.050L** 0.0017T 0.0020L	**0.000** 0.0000	**-0.070** -0.0028	**0.070T** **0.050L** 0.0028T 0.0020L

Continued on next page.

RADIAL BALL, SPHERICAL ROLLER AND CYLINDRICAL ROLLER BEARINGS

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 70 continued.

Bearing O.D.			F7			G7			H6			H7		
Nominal (Max.)		Tolerance[1]	Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit
Over	Incl.		Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.	
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
630.000 24.8032	**800.000** 31.4961	**-0.075** -0.0030	**+0.160** +0.0063	**+0.080** +0.0031	**0.080L** **0.235L** 0.0031L 0.0093L	**+0.104** +0.0041	**+0.024** +0.0009	**0.024L** **0.179L** 0.0009L 0.0071L	**+0.051** +0.0020	**0.000** 0.0000	**0.000L** **0.076L** 0.0000L 0.0030L	**+0.080** +0.0031	**0.000** 0.0000	**0.000L** **0.155L** 0.0000L 0.0061L
800.000 31.4961	**1000.000** 39.3701	**-0.100** -0.0039	**+0.179** +0.0063	**+0.086** +0.0034	**0.086L** **0.276L** 0.0034L 0.0108L	**+0.116** +0.0046	**+0.026** +0.0010	**0.026L** **0.216L** 0.0010L 0.0085L	**+0.056** +0.0022	**0.000** 0.0000	**0.000L** **0.155L** 0.0000L 0.0061L	**+0.090** +0.0035	**0.000** 0.0000	**0.000L** **0.190L** 0.0000L 0.0074L
1000.000 39.3701	**1250.000** 49.2126	**-0.125** -0.0049	**+0.203** +0.0080	**+0.098** +0.0039	**0.098L** **0.328L** 0.0039L 0.0129L	**+0.133** +0.0052	**+0.028** +0.0011	**0.028L** **0.258L** 0.0011L 0.0101L	**+0.066** +0.0026	**0.000** 0.0000	**0.000L** **0.191L** 0.0000L 0.0075L	**+0.105** +0.0041	**0.000** 0.0000	**0.000L** **0.230L** 0.0000L 0.0090L
1250.000 49.2126	**1600.000** 62.9921	**-0.160** -0.0063	**+0.155** +0.0093	**+0.030** +0.0043	**0.110L** **0.395L** 0.0043L 0.0156L	**+0.155** +0.0061	**+0.030** +0.0012	**0.030L** **0.315L** 0.0012L 0.0124L	**+0.079** +0.0031	**0.000** 0.0000	**0.000L** **0.239L** 0.0000L 0.0094L	**+0.125** +0.0049	**0.000** 0.0000	**0.000L** **0.355L** 0.0000L 0.0112L
1600.000 62.9921	**2000.000** 78.7402	**-0.200** -0.0079	**+0.270** +0.0106	**+0.120** +0.0047	**0.120L** **0.470L** 0.0047L 0.0185L	**+0.182** +0.0072	**+0.032** +0.0013	**0.032L** **0.382L** 0.0013L 0.0151L	**+0.091** +0.0036	**0.000** 0.0000	**0.000L** **0.292L** 0.0000L 0.0115L	**+0.150** +0.0059	**0.000** 0.0000	**0.000L** **0.350L** 0.0000L 0.0138L
2000.000 78.7402	**2500.000** 98.4252	**-0.250** -0.0098	**+0.305** 0.0120	**+0.0130** +0.0051	**0.130L** **0.555L** 0.0051L 0.0218L	**+0.209** +0.0082	**+0.034** +0.0013	**0.034L** **0.459L** 0.0013L 0.0180L	**+1.092** +0.043	**0.000** 0.0000	**0.000L** **0.358L** 0.0000L 0.0141L	**+0.175** +0.0069	**0.000** 0.0000	**0.000L** **0.425L** 0.0000L 0.0167L

NOTE: Tolerance and shaft diameters are shown in the table as variances from nominal bearing O.D.
[1]Tolerance range is from +0 to value listed.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 70 continued.

H8			J6			J7			K6			K7		
Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit
Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.	
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
+0.050 +0.0049	**0.000** 0.0000	**0.000L** **0.125L** 0.0000L 0.0079L	**+0.040** +0.0016	**-0.010** -0.0004	**0.010T** **0.115L** 0.0004T 0.0046L	**+0.056** +0.0022	**-0.024** -0.0009	**0.024T** **0.131L** 0.0009T 0.0052L	**0.000** 0.0000	**-0.050** -0.0020	**0.050T** **0.075L** 0.0020T 0.0030L	**0.000** 0.0000	**-0.080** -0.0031	**0.080T** **0.075L** 0.0031T 0.0030L
+0.056 +0.0055	**0.000** 0.0000	**0.000L** **0.156L** 0.0000L 0.0094L	**+0.046** +0.0018	**-0.010** -0.0004	**0.010T** **0.146L** 0.0004T 0.0057L	**+0.064** +0.0025	**-0.026** -0.0010	**0.026T** **0.164L** 0.0010T 0.0064L	**0.000** 0.0000	**-0.056** -0.0022	**0.056T** **0.100L** 0.0022T 0.0039L	**0.000** 0.0000	**-0.090** -0.0035	**0.090T** **0.100L** 0.0035T 0.0039L
+0.066 +0.0065	**0.000** 0.0000	**0.000L** **0.191L** 0.0000L 0.0114L	**+0.056** +0.0022	**-0.010** -0.0004	**0.010T** **0.181L** 0.0004T 0.0071L	**+0.077** +0.0030	**-0.028** -0.0011	**0.028T** **0.202L** 0.0011T 0.0079L	**0.000** 0.0000	**-0.066** -0.0026	**0.066T** **0.125L** 0.0026T 0.0049L	**0.000** 0.0000	**-0.105** -0.0041	**0.105T** **0.125L** 0.0041T 0.0049L
+0.078 +0.0077	**0.000** 0.0000	**0.000L** **0.238L** 0.0000L 0.0104L	**+0.068** +0.0027	**-0.010** -0.0004	**0.010T** **0.228L** 0.0004T 0.0090L	**+0.095** +0.0037	**-0.030** -0.0012	**0.030T** **0.255L** 0.0012T 0.0100L	**0.000** 0.0000	**-0.078** -0.0031	**0.078T** **0.160L** 0.0031T 0.0063L	**0.000** 0.0000	**-0.125** -0.0049	**0.125T** **0.160L** 0.0049T 0.0063L
+0.092 +0.0091	**0.000** 0.0000	**0.000L** **0.292L** 0.0000L 0.0170L	**+0.082** +0.0032	**-0.010** -0.0004	**0.110T** **0.282L** 0.0004T 0.0111L	**+0.118** +0.0046	**-0.032** -0.0013	**0.032T** **0.318L** 0.0013T 0.0125L	**0.000** 0.0000	**-0.092** -0.0036	**0.092T** **0.200L** 0.0036T 0.0079L	**0.000** 0.0000	**-0.150** -0.0059	**0.150T** **0.200L** 0.0059T 0.0079L
+0.110 +0.0110	**0.000** 0.0000	**0.000L** **0.360L** 0.0000L 0.0208L	**+0.100** +0.0039	**-0.010** -0.0004	**0.010T** **0.350L** 0.0004T 0.0137L	**+0.141** +0.0056	**-0.034** -0.0013	**0.034T** **0.391L** 0.0013T 0.0154L	**0.000** 0.0000	**-0.110** -0.0043	**0.110T** **0.250L** 0.0043T 0.0098L	**0.000** 0.0000	**-0.175** -0.0069	**0.175T** **0.250L** 0.0069T 0.0098L

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

TABLE 71. RADIAL BALL, SPHERICAL ROLLER AND CYLINDRICAL ROLLER BEARING HOUSING TOLERANCES

Bearing O.D.			M6			M7			N6			N7		
Nominal (Max.)		Tolerance[1]	Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit
Over	Incl.		Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.	
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
10.000 0.3937	**18.000** 0.7087	**-0.008** -0.0003	**-0.004** -0.0002	**-0.015** -0.0006	**0.015T** **0.004L** 0.0006T 0.0001L	**0.000** 0.0000	**-0.018** -0.0007	**0.018T** **0.008L** 0.0007T 0.0003L	**-0.009** -0.0004	**-0.020** -0.0008	**0.020T** **0.001T** 0.0008T 0.0001T	**-0.005** -0.0002	**-0.023** -0.0009	**0.023T** **0.003L** 0.0009T 0.0001L
18.000 0.7087	**30.000** 1.1811	**-0.009** -0.0035	**-0.004** -0.0002	**-0.017** -0.0007	**0.017T** **0.005L** 0.0007T 0.00015L	**0.000** 0.0000	**-0.021** -0.0008	**0.021T** **0.009L** 0.0008T 0.0035L	**-0.007** -0.0004	**-0.028** -0.0009	**0.024T** **0.002T** 0.0009T 0.00005T	**-0.007** -0.0003	**-0.028** -0.0011	**0.028T** **0.002L** 0.0011T 0.00005L
30.000 1.1811	**50.000** 1.9685	**-0.011** -0.0045	**-0.004** -0.0002	**-0.020** -0.0008	**0.020T** **0.007L** 0.0008T 0.00025L	**0.000** 0.0000	**-0.025** -0.0010	**0.025T** **0.011L** 0.0010T 0.00045L	**-0.012** -0.0005	**-0.028** -0.0011	**0.028T** **0.001T** 0.0011T 0.00005T	**-0.008** -0.0003	**-0.033** -0.0013	**0.033T** **0.003L** 0.0013T 0.00015L
50.000 1.9685	**80.000** 3.1496	**-0.013** -0.0005	**-0.005** -0.0002	**-0.024** -0.0009	**0.024T** **0.008L** 0.0009T 0.0003L	**0.000** 0.0000	**-0.030** -0.0012	**0.030T** **0.013L** 0.0012T 0.0005L	**-0.014** -0.0006	**-0.033** -0.0013	**0.033T** **0.001T** 0.0013T 0.0001T	**-0.009** -0.0004	**-0.039** -0.0015	**0.039T** **0.004L** 0.0015T 0.0001L
80.000 3.1496	**120.000** 4.7244	**-0.015** -0.0006	**-0.006** -0.0002	**-0.028** -0.0011	**0.028T** **0.009L** 0.0011T 0.0004L	**0.000** 0.0000	**-0.035** -0.0014	**0.035T** **0.015L** 0.0014T 0.0006L	**-0.016** -0.0006	**-0.038** -0.0015	**0.038T** **0.001T** 0.0015T 0.0000T	**-0.010** -0.0004	**-0.045** -0.0018	**0.045T** **0.005L** 0.0018T 0.0002L
120.000 4.7244	**150.000** 5.9055	**-0.018** -0.0007	**-0.008** -0.0003	**-0.033** -0.0013	**0.033T** **0.010L** 0.0013T 0.0004L	**0.000** 0.0000	**-0.040** -0.0016	**0.040T** **0.018L** 0.0016T 0.0007L	**-0.020** -0.0008	**-0.045** -0.0018	**0.045T** **0.002T** 0.0018T 0.0001T	**-0.012** -0.0005	**-0.052** -0.0020	**0.061T** **0.018L** 0.0020T 0.0002L
150.000 5.9055	**180.000** 7.0866	**-0.025** -0.0010	**-0.008** -0.0003	**-0.033** -0.0013	**0.033T** **0.017L** 0.0013T 0.0007L	**0.000** 0.0000	**-0.040** -0.0016	**0.040T** **0.025L** 0.0016T 0.0010L	**-0.020** -0.0008	**-0.045** -0.0018	**0.045T** **0.005T** 0.0018T 0.0002T	**-0.012** -0.0005	**-0.052** -0.0020	**0.052T** **0.013L** 0.0020T 0.0005L
180.000 7.0866	**250.000** 9.8425	**-0.030** -0.0012	**-0.008** -0.0003	**-0.037** -0.0015	**0.037T** **0.022L** 0.0015T 0.0009L	**0.000** 0.0000	**-0.046** -0.0018	**0.046T** **0.030L** 0.0018T 0.0012L	**-0.022** -0.0009	**-0.051** -0.0020	**0.051T** **0.008T** 0.0020T 0.0003T	**-0.014** -0.0006	**-0.060** -0.0024	**0.060T** **0.016L** 0.0024T 0.0006L
250.000 9.8425	**315.000** 12.4016	**-0.035** -0.0014	**-0.009** -0.0004	**-0.041** -0.0016	**0.041T** **0.026L** 0.0016T 0.0010L	**0.000** 0.0000	**-0.052** -0.0020	**0.052T** **0.035L** 0.0020T 030014L	**-0.025** -0.0010	**-0.057** -0.0022	**0.057T** **0.010T** 0.0022T 0.0004T	**-0.014** -0.0006	**-0.066** -0.0026	**0.066T** **0.021L** 0.0025T 0.0008L
315.000 12.4016	**400.000** 15.7480	**-0.040** -0.0016	**-0.010** -0.0004	**-0.046** -0.0018	**0.046T** **0.030L** 0.0018T 0.0012L	**0.000** 0.0000	**-0.057** -0.0022	**0.057T** **0.040L** 0.0022T 0.0016L	**-0.026** -0.0006	**-0.062** -0.0029	**0.062T** **0.014T** 0.0024T 0.0006T	**-0.016** -0.0006	**-0.073** -0.0029	**0.073T** **0.024L** 0.0029T 0.0010L
400.000 15.7480	**500.000** 19.6850	**-0.045** -0.0018	**-0.010** -0.0004	**-0.050** -0.0020	**0.050T** **0.035L** 0.0020T 0.0014L	**0.000** 0.0000	**-0.063** -0.0025	**0.063T** **0.045L** 0.0025T 0.0018L	**-0.027** -0.0011	**-0.067** -0.0026	**0.067T** **0.018T** 0.0026T 0.0007T	**-0.017** -0.0007	**-0.080** -0.0031	**0.080T** **0.028L** 0.0031T 0.0011L
500.000 19.6850	**630.000** 24.8032	**-0.050** -0.0020	**-0.026** -0.0010	**-0.070** -0.0028	**0.070T** **0.024L** 0.0028T 0.0010L	**-0.026** -0.0010	**-0.096** -0.0038	**0.096T** **0.024L** 0.0038T 0.0010L	**-0.044** -0.0017	**-0.088** -0.0035	**0.088T** **0.006T** 0.0035T 0.0003T	**-0.044** -0.0017	**-0.114** -0.0045	**0.114T** **0.006L** 0.0045T 0.0003L

NOTE: Tolerance and shaft diameters are shown in the table as variances from nominal bearing O.D.
[1]Tolerance range is from +0 to value listed.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 71 continued.

P6			P7		
Housing Bore		Fit	Housing Bore		Fit
Max.	Min.		Max.	Min.	
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
-0.015 -0.0006	**-0.026** -0.0010	**0.026T** **0.007T** 0.0010T 0.0003T	**-0.011** -0.0004	**-0.029** -0.0011	**0.029T** **0.003T** 0.0011T 0.0001T
-0.018 -0.0007	**-0.031** -0.0012	**0.031T** **0.009T** 0.0012T 0.00035T	**-0.014** -0.0006	**-0.035** -0.0014	**0.035T** **0.005T** 0.0014T 0.0025T
-0.021 -0.0008	**-0.037** -0.0015	**0.037T** **0.010T** 0.0015T 0.00035T	**-0.017** -0.0007	**-0.042** -0.0017	**0.042T** **0.006T** 0.0017T 0.0025T
-0.026 -0.0010	**-0.045** -0.0018	**0.045T** **0.013T** 0.0018T 0.0005T	**-0.021** -0.0008	**-0.051** -0.0020	**0.051T** **0.008T** 0.0020T 0.0003T
-0.030 -0.0012	**-0.052** -0.0020	**0.052T** **0.015T** 0.0020T 0.0006T	**-0.024** -0.0009	**-0.059** -0.0023	**0.059T** **0.009T** 0.0023T 0.0003T
-0.036 -0.0014	**-0.061** -0.0024	**0.061T** **0.018T** 0.0024T 0.0007T	**-0.028** -0.0011	**-0.068** -0.0027	**0.068T** **0.010T** 0.0027T 0.0004T
-0.036 -0.0014	**-0.061** -0.0024	**0.061T** **0.011T** 0.0024T 0.0004T	**-0.028** -0.0011	**-0.068** -0.0027	**0.068T** **0.003T** 0.0027T 0.0001T
-0.041 -0.0016	**-0.070** -0.0028	**0.070T** **0.011T** 0.0028T 0.0004T	**-0.033** -0.0013	**-0.079** -0.0031	**0.079T** **0.003T** 0.0031T 0.0001T
-0.047 -0.0019	**-0.079** -0.0031	**0.079T** **0.012T** 0.0031T 0.0005T	**-0.036** -0.0014	**-0.088** -0.0035	**0.088T** **0.001T** 0.0035T 0.0000T
-0.051 -0.0020	**-0.087** -0.0034	**0.087T** **0.011T** 0.0034T 0.0004T	**-0.041** -0.0016	**-0.098** -0.0039	**0.098T** **0.001T** 0.0039T 0.0000T
-0.055 -0.0022	**-0.095** -0.0037	**0.095T** **0.010T** 0.0037T 0.0004T	**-0.045** -0.0018	**-0.108** -0.0043	**0.108T** **0.000T** 0.0043T 0.0000T
-0.078 -0.0031	**-0.122** -0.0048	**0.122T** **0.028T** 0.0048T 0.0011T	**-0.078** -0.0031	**-0.148** -0.0058	**0.148T** **0.028T** 0.0058T 0.0011T

Continued on next page.

RADIAL BALL, SPHERICAL ROLLER AND CYLINDRICAL ROLLER BEARINGS

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 71 continued.

Bearing O.D.			M6			M7			N6			N7		
Nominal (Max.)		Tolerance[1]	Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit
Over	Incl.		Max.	Min.		Max.	Min.		Max.	Min.		Max.	Min.	
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
630.000 24.8032	**800.000** 31.4961	**-0.075** -0.0030	**-0.030** -0.0012	**-0.080** -0.0031	**0.080T** **0.045L** 0.0031T 0.0018L	**-0.030** -0.0012	**-0.110** -0.0043	**0.110T** **0.045L** 0.0043T 0.0018L	**-0.050** -0.0020	**-0.100** -0.0039	**0.100T** **0.025T** 0.0039T 0.0010T	**-0.050** -0.0020	**-0.130** -0.0051	**0.130T** **0.025L** 00051T 0.0010L
800.000 31.4961	**1000.000** 39.3701	**-0.100** -0.0039	**-0.034** -0.0013	**-0.090** -0.0035	**0.090T** **0.066L** 0.0035T 0.0026L	**-0.034** -0.0013	**-0.124** -0.0049	**0.124T** **0.066L** 0.0049T 0.0026L	**-0.056** -0.0022	**-0.112** -0.0044	**0.112T** **0.044T** 0.0044T 0.0017T	**-0.056** -0.0022	**-0.146** -0.0057	**0.146T** **0.044L** 0.0057T 0.0017L
1000.000 39.3701	**1250.000** 49.2126	**-0.125** -0.0049	**-0.040** -0.0016	**-0.106** -0.0042	**0.106T** **0.085L** 0.0042T 0.0033L	**-0.040** -0.0016	**-0.145** -0.0057	**0.145T** **0.085L** 0.0057T 0.0033L	**-0.066** -0.0026	**-0.132** -0.0052	**0.132T** **0.059T** 0.0052T 0.0023T	**-0.066** -0.0026	**-0.171** -0.0067	**0.171T** **0.059L** 0.0067T 0.0023L
1250.000 49.2126	**1600.000** 62.9921	**-0.160** -0.0063	**-0.048** -0.0019	**-0.126** -0.0050	**0.126T** **0.112L** 0.0050T 0.0044L	**-0.048** -0.0019	**-0.173** -0.0068	**0.173T** **0.112L** 0.0068T 0.0044L	**-0.078** -0.0031	**-0.156** -0.0061	**0.156T** **0.082T** 0.0061T 0.0032T	**-0.078** -0.0031	**-0.203** -0.0080	**0.203T** **0.082L** 0.0080T 0.0023L
1600.000 62.9921	**2000.000** 78.7402	**-0.200** -0.0079	**-0.058** -0.0023	**-0.150** -0.0059	**0.150T** **0.142L** 0.0059T 0.0056L	**-0.058** -0.0023	**-0.208** -0.0082	**0.208T** **0.142L** 0.0082T 0.0056L	**-0.092** -0.0036	**-0.184** -0.0072	**0.184T** **0.108T** 0.0072T 0.0043T	**-0.092** -0.0036	**-0.242** -0.0095	**0.242T** **0.108L** 0.0095T 0.0043L
2000.000 78.7402	**2500.000** 98.4252	**-0.250** -0.0098	**-0.068** -0.0027	**-0.178** -0.0070	**0.178T** **0.182L** 0.0070T 0.0071L	**-0.068** -0.0027	**-0.243** -0.0096	**0.243** **0.182L** 0.0096T 0.0071L	**-0.110** -0.0043	**-0.220** -0.0087	**0.285T** **0.140T** 0.112T 0.055T	**-0.110** -0.0043	**-0.285** -0.0112	**0.285T** **0.140L** 0.0112T 0.0055L

NOTE: Tolerance and shaft diameters are shown in the table as variances from nominal bearing O.D.
[1]Tolerance range is from +0 to value listed.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 71 continued.

P6			P7		
Housing Bore		Fit	Housing Bore		Fit
Max.	Min.		Max.	Min.	
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
-0.088 -0.0035	**-0.138** -0.0054	**0.138T** **0.013T** 0.0054T 0.0005T	**-0.088** -0.0035	**-0.168** -0.0066	**0.168T** **0.013T** 0.0066T 0.0005T
-0.100 -0.0039	**-0.156** -0.0061	**0.156T** **0.000T** 0.0061T 0.0000T	**-0.100** -0.0039	**-0.190** -0.0075	**0.190T** **0.000T** 0.0075T 0.0000T
-0.120 -0.0047	**-0.186** -0.0073	**0.186T** **0.005L** 0.0073T 0.0002L	**-0.120** -0.0047	**-0.225** -0.0089	**0.225T** **0.005T** 0.0089T 0.0002T
-0.140 -0.0055	**-0.218** -0.0086	**0.218T** **0.020L** 0.0086T 0.0008L	**-0.140** -0.0055	**-0.265** -0.0104	**0.265T** **0.020L** 0.0104T 0.0008L
-0.170 -0.0067	**-0.262** -0.0103	**0.262T** **0.030L** 0.0103T 0.0012L	**-0.170** -0.0067	**-0.320** -0.0126	**0.320T** **0.030L** 0.0126T 0.0012L
-0.195 -0.0077	**-0.305** -0.0120	**0.305T** **0.055L** 0.0120T 0.0021L	**-0.195** -0.0077	**-0.370** -0.0146	**0.370T** **0.055L** 0.0146T 0.0021L

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

ANGULAR CONTACT BALL BEARINGS

SHAFT FITS

TABLE 72. 7000WN, 7200WU, 7300WN AND 7400WN SINGLE-ROW ANGULAR CONTACT BEARINGS SHAFT FITS

Basic Bearing Number	Bearing Bore Diameter		Shaft Rotating Load Stationary Shaft Diameter		Mean Fit Tight
	Max.	Min.	Max.	Min.	
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
00	**10** 0.3937	**9.992** 0.3934	**9.997** 0.3936	**10.005** 0.3939	**0.005** 0.0002
01	**12** 0.4724	**11.991** 0.4721	**11.996** 0.4723	**12.004** 0.4726	**0.005** 0.0002
02	**15** 0.5906	**14.994** 0.5903	**14.999** 0.5905	**15.006** 0.5908	**0.005** 0.0002
03	**17** 0.6693	**16.993** 0.6690	**16.998** 0.6692	**17.005** 0.6695	**0.005** 0.0002
04	**20** 0.7874	**19.992** 0.7871	**19.997** 0.7873	**20.005** 0.7876	**0.005** 0.0002
05	**25** 0.9843	**24.994** 0.9840	**24.999** 0.9842	**25.006** 0.9845	**0.005** 0.0002
06	**30** 1.1811	**29.992** 1.1808	**29.997** 1.1810	**30.005** 1.1813	**0.005** 0.0002
07	**35** 1.3780	**34.994** 1.3777	**34.999** 1.3779	**35.009** 1.3783	**0.006** 0.00025
08	**40** 1.5748	**39.992** 1.5745	**39.997** 1.5747	**40.008** 1.5751	**0.006** 0.00025
09	**45** 1.7717	**44.994** 1.7714	**44.999** 1.7716	**45.009** 1.7720	**0.006** 0.00025
10	**50** 1.9685	**49.992** 1.9682	**49.997** 1.9684	**50.008** 1.9688	**0.006** 0.00025
11	**55** 2.1654	**54.991** 2.1650	**54.999** 2.1653	**55.011** 2.1658	**0.009** 0.00035
12	**60** 2.3622	**59.990** 2.3618	**59.997** 2.3621	**60.010** 2.3626	**0.009** 0.00035
13	**65** 2.5591	**64.991** 2.5587	**64.999** 2.5590	**65.011** 2.5595	**0.009** 0.00035
14	**70** 2.7559	**69.990** 2.7555	**69.997** 2.7558	**70.010** 2.7563	**0.009** 0.00035
15	**75** 2.9528	**74.991** 2.9524	**74.999** 2.9527	**75.011** 2.9532	**0.009** 0.00035
16	**80** 3.1496	**79.990** 3.1492	**79.997** 3.1495	**80.010** 3.1500	**0.009** 0.00035
17	**85** 3.3465	**84.988** 3.3460	**84.999** 3.3464	**85.014** 3.3470	**0.011** 0.00045
18	**90** 3.5433	**89.987** 3.5428	**89.997** 3.5432	**90.013** 3.5438	**0.011** 0.00045
19	**95** 3.7402	**94.988** 3.7397	**94.999** 3.7401	**95.014** 3.7407	**0.011** 0.00045
20	**100** 3.9370	**99.987** 3.9365	**99.997** 3.9369	**100.013** 3.9375	**0.011** 0.00045
21	**105** 4.1339	**104.988** 4.1334	**104.999** 4.1338	**105.014** 4.1344	**0.011** 0.00045
22	**110** 4.3307	**109.987** 4.3302	**109.997** 4.3306	**110.012** 4.3312	**0.011** 0.00045
24	**120** 4.7244	**119.987** 4.7239	**119.997** 4.7243	**120.012** 4.7249	**0.011** 0.00045
26	**130** 5.1181	**129.982** 5.1174	**129.997** 5.1180	**130.015** 5.1187	**0.015** 0.0006
28	**140** 5.5118	**139.982** 5.5111	**139.997** 5.5117	**140.015** 5.5124	**0.015** 0.0006
30	**150** 5.9055	**149.982** 5.9048	**149.997** 5.9054	**150.015** 5.9061	**0.015** 0.0006

Continued in next column.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

RADIAL BALL BEARINGS

TABLE 73. RADIAL BALL BEARING HOUSING FIT GUIDELINES

	Operating Conditions	Examples	Housing Tolerance Symbol[1]	Outer Ring Displaceable Axially
	OUTER RING ROTATING			
	Heavy loads with thin-wall housing	Crane support wheels Wheel hubs (roller bearings) Crank bearings	P6	No
	Normal to heavy loads	Wheel hubs (ball bearings) Crank bearings	N6	No
	Light loads	Conveyor rollers Rope sheaves Tension pulleys	M6	No
	INDETERMINATE LOAD DIRECTION			
	Heavy shock loads	Electric traction motors	M7	No
	Normal to heavy loads, axial displacement of outer ring not required.	Electric motors Pumps Crankshaft main bearings	K6	No, normally
Below this line, housing can either be one piece or split. Above this line, a split housing is not suggested.	Light to normal loads, axial displacement of outer ring desired.	Electric motors Pumps Crankshaft main bearings	J6	Yes, normally
	OUTER RING STATIONARY			
	Shock loads, temporary complete unloading	Heavy rail vehicles	J6	Yes, normally
	All — One-piece housing	General applications Heavy rail vehicles	H6	Easily
	All — Radially split housing	Transmission drives	H7	Easily
	Heat supplied through shaft	Drier cylinders	G7	Easily

[1]Cast iron steel housing. See pages 138-145 for tolerance values. Where wider tolerances are permissible, P7, N7, M7, K7, J7 and H7 values may be used in place of P6, N6, M6, K6, J6 and H6 values respectively.

TABLE 74. RADIAL BALL BEARING SHAFT FIT GUIDELINES

Ball Bearings (For All Nominal Diameters)			Operating Conditions	Examples
Load Limit		Shaft		
Lower	Upper	Tolerance Symbol		
INNER RING STATIONARY				
0	C_e[1]	g6	Inner ring to be easily displaced on shaft	Wheels Non-rotating shafts
0	C_e	h6	Inner ring does not need to be easily displaced	Tension pulleys
INNER RING ROTATING OR INDETERMINATE				
0	0.07 C_e	j6[2]	Light loads	Electric apparatus machine tools Pumps Ventilators Industrial trucks
0.07 C_e	0.15 C_e	k5	Normal loads	Electrical motors Turbines Pumps Combustion engines Gear transmissions
0.15 C_e	C_e	m5	Heavy loads Shock loads	Rail vehicles Traction motors
THRUST LOADS				
0	C_e	j6[3]	Pure thrust loads	All

[1]C_e = Extended dynamic load rating (ball bearings). [2]Use j5 for high-precision applications. [3]Bearings with greater than nominal clearance must be used.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

RADIAL BALL AND ANGULAR CONTACT BEARINGS

HOUSING FITS

Note: These tables are to be used for applications where only one ring (either inner or outer) has an interference fit with its shaft and housing. The guidelines for operating conditions covering these tables are found in Tables 70 and 71. In cases where interference fits are used for both rings, bearings with a special internal clearance may be required. Housing bore diameter dimensions are for steel materials. Consult your Timken representative when using other housing materials.

TABLE 75. HOUSING FITS, ABEC 1, ABEC 3

Basic Bearing Number					Housing Stationary, Load Stationary or Housing Rotating, Load Rotating				Housing Rotating, Load Stationary or Housing Stationary, Load Rotating			
					Housing Bore		Mean Fit Loose		Housing Bore		Mean Fit Loose	
Extra Small	Extra Light	Light	Medium	Heavy	Min.	Max.	ABEC 1	ABEC 3	Min.	Max.	ABEC 1	ABEC 3
					mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
30, S, F, Series	9100, 9300 Series	200, 5200, 7200 Series	300, 5300, 7300 Series	400(2), 7400 Series								
33K3, F33K3	–	–	–	–	**9.525** 0.3750	**9.535** 0.3754	**0.010** 0.00040	**0.009** 0.00035	**9.507** 0.3743	**9.525** 0.3750	**0.004** 0.00015	**0.005** 0.00020
33K4	–	–	–	–	**12.700** 0.50000	**12.710** 0.5004	**0.010** 0.00040	**0.009** 0.00035	**12.682** .04993	**12.700** 0.5000	**0.004** 0.00015	**0.005** 0.00020
33K5, F33K5	–	–	–	–	**12.700** 0.5000	**12.710** 0.5004	**0.010** 0.00040	**0.009** 0.00035	**12.682** 0.4993	**12.700** 0.5000	**0.004** 0.00015	**0.005** 0.00020
34K	–	–	–	–	**15.999** 0.6299	**16.010** 0.6303	**0.010** 0.00040	**0.009** 0.00035	**15.982** 0.6292	**15.999** 0.6299	**0.004** 0.00015	**0.005** 0.00020
35K	–	–	–	–	**18.999** 0.7480	**19.012** 0.7485	**0.011** 0.00045	**0.010** 0.00040	**18.979** 0.7472	**18.999** 0.7480	**0.005** 0.00020	**0.006** 0.00025
36K	–	–	–	–	**18.999** 0.7480	**19.012** 0.7485	**0.011** 0.00045	**0.010** 0.00040	**18.979** 0.7472	**18.999** 0.7480	**0.005** 0.00020	**0.006** 0.00025
37K	–	–	–	–	**21.999** 0.8661	**22.012** 0.8666	**0.011** 0.00045	**0.010** 0.00040	**21.979** 0.8653	**29.999** 0.8661	**0.005** 0.00020	**0.006** 0.00025
38K	–	–	–	–	**21.999** 0.8661	**22.012** 0.8666	**0.011** 0.00045	**0.010** 0.00040	**21.979** 0.8653	**21.999** 0.8661	**0.005** 0.00020	**0.006** 0.00025
38KV	–	–	–	–	**24.000** 0.9449	**24.013** 0.9454	**0.011** 0.00045	**0.010** 0.00040	**23.980** 0.9441	**24.000** 0.9449	**0.005** 0.00020	**0.006** 0.00025
39K	9100	–	–	–	**25.999** 1.0236	**26.012** 1.0241	**0.011** 0.00045	**0.010** 0.00040	**25.979** 1.0228	**25.999** 1.0236	**0.005** 0.00020	**0.006** 0.00025
S1K7, FS1K7	–	–	–	–	**15.875** 0.6250	**15.885** 0.6254	**0.010** 0.00040	**0.009** 0.00035	**15.857** 0.6243	**15.875** 0.6250	**0.004** 0.00015	**0.005** 0.00020
S1K	–	–	–	–	**19.050** 0.7500	**19.063** 0.7505	**0.011** 0.00045	**0.010** 0.00040	**19.030** 0.7492	**19.050** 0.7500	**0.005** 0.00020	**0.006** 0.00025
S3K, FS3K	–	–	–	–	**22.225** 0.8750	**22.238** 0.8755	**0.011** 0.00045	**0.010** 0.00040	**22.205** 0.8742	**22.225** 0.8750	**0.005** 0.00020	**0.006** 0.00025
S5K	–	–	–	–	**28.575** 1.1250	**28.588** 1.1255	**0.011** 0.00045	**0.010** 0.00040	**28.555** 1.1242	**28.575** 1.1250	**0.005** 0.00020	**0.006** 0.00025
S7K	–	–	–	–	**34.925** 1.3750	**34.940** 1.3756	**0.014** 0.00055	**0.011** 0.00045	**34.900** 1.3740	**34.925** 1.3750	**0.006** 0.00025	**0.009** 0.00035
S8K	–	–	–	–	**41.275** 1.6250	**41.290** 1.6256	**0.014** 0.00055	**0.011** 0.00045	**41.250** 1.6240	**41.275** 1.6250	**0.006** 0.00025	**0.009** 0.00035
S9K	–	–	–	–	**47.625** 1.8750	**47.640** 1.8756	**0.014** 0.00055	**0.011** 0.00045	**47.600** 1.8740	**47.625** 1.8750	**0.006** 0.00025	**0.009** 0.00035
S10K	–	–	–	–	**50.800** 2.0000	**50.818** 2.0007	**0.015** 0.00060	**0.014** 0.00055	**50.770** 1.9988	**50.800** 2.0000	**0.009** 0.00035	**0.010** 0.00040
S11K	–	–	–	–	**53.975** 2.1250	**53.993** 2.1257	**0.015** 0.00060	**0.014** 0.00055	**53.945** 2.1238	**53.975** 2.1250	**0.009** 0.00035	**0.010** 0.00040
S12K	–	–	–	–	**57.150** 2.2500	**57.168** 2.2507	**0.015** 0.00060	**0.014** 0.00055	**57.120** 2.2488	**57.150** 2.2500	**0.009** 0.00035	**0.010** 0.00040

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 75 continued.

Basic Bearing Number					Housing Stationary, Load Stationary or Housing Rotating, Load Rotating				Housing Rotating, Load Stationary or Housing Stationary, Load Rotating			
Extra Small	Extra Light	Light	Medium	Heavy	Housing Bore		Mean Fit Loose		Housing Bore		Mean Fit Loose	
					Min.	Max.	ABEC 1	ABEC 3	Min.	Max.	ABEC 1	ABEC 3
					mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
30, S, F, Series	9100, 9300 Series	200, 5200, 7200 Series	300, 5300, 7300 Series	400(2), 7400 Series								
F2002	–	–	–	–	**9.525** 0.3750	**9.533** 0.3753	**0.000** 0.00000	**0.000** 0.00000	**9.522** 0.3749	**9.533** 0.3753	**0.000** 0.00000	**0.000** 0.00000
F2	–	–	–	–	**11.112** 0.4375	**11.120** 0.4378	**0.000** 0.00000	**0.000** 0.00000	**11.110** 0.4374	**11.120** 0.4378	**0.000** 0.00000	**0.000** 0.00000
F3	–	–	–	–	**14.285** 0.5624	**14.295** 0.5628	**0.000** 0.00000	**0.000** 0.00000	**14.285** 0.5624	**14.295** 0.5628	**0.000** 0.00000	**0.000** 0.00000
F4	–	–	–	–	**15.872** 0.6249	**15.883** 0.6253	**0.000** 0.00000	**0.000** 0.00000	**15.872** 0.6249	**15.883** 0.6253	**0.000** 0.00000	**0.000** 0.00000
F5	–	–	–	–	**17.460** 0.6874	**17.470** 0.6878	**0.000** 0.00000	**0.000** 0.00000	**17.460** 0.6874	**17.476** 0.6878	**0.000** 0.00000	**0.000** 0.00000
–	9101, 9302	–	–	–	**28.001** 1.1024	**28.014** 1.1029	**0.011** 0.00045	**0.000** 0.00040	**27.981** 1.1016	**28.001** 1.1024	**0.005** 0.00020	**0.006** 0.00025
–	9303	200	–	–	**30.000** 1.1811	**30.013** 1.1816	**0.011** 0.00045	**0.010** 0.00040	**29.980** 1.1803	**39.000** 1.1811	**0.005** 0.00020	**0.006** 0.00025
–	9102	201	–	–	**31.999** 1.2598	**32.014** 1.2604	**0.014** 0.00055	**0.011** 0.00045	**31.974** 1.2588	**31.999** 1.2598	**0.006** 0.00025	**0.009** 0.00035
–	9103	202	300	–	**35.001** 1.3780	**35.016** 1.3786	**0.014** 0.00055	**0.011** 0.00045	**34.976** 1.3770	**35.001** 1.3780	**0.006** 0.00025	**0.009** 0.00035
–	9304	–	301	–	**37.000** 1.4567	**37.015** 1.4573	**0.014** 0.00055	**0.011** 0.00045	**36.975** 1.4557	**37.000** 1.4567	**0.006** 0.00025	**0.009** 0.00035
–	–	203	–	–	**40.000** 1.5748	**40.015** 1.5754	**0.014** 0.00055	**0.011** 0.00045	**39.975** 1.5738	**40.000** 1.5748	**0.006** 0.00025	**0.009** 0.00035
–	9104, 9305	–	302	–	**41.999** 1.6535	**42.014** 1.6541	**0.014** 0.00055	**0.011** 0.00045	**41.974** 1.6525	**41.999** 1.6535	**0.006** 0.00025	**0.009** 0.00035
–	9105, 9306	204	303	–	**47.000** 1.8504	**47.015** 1.8510	**0.014** 0.00055	**0.011** 0.00045	**46.975** 1.8494	**47.000** 1.8504	**0.006** 0.00025	**0.009** 0.00035
–	–	205	304	–	**51.999** 2.0472	**52.017** 2.0479	**0.015** 0.00060	**0.014** 0.00055	**51.968** 2.0460	**51.999** 2.0472	**0.009** 0.00035	**0.010** 0.00040
–	9106, 9307	–	–	–	**55.001** 2.1654	**55.019** 2.1661	**0.015** 0.00060	**0.014** 0.00055	**54.971** 2.1642	**55.001** 2.1654	**0.009** 0.00035	**0.010** 0.00040
–	9107, 9308	206	305	403	**61.999** 2.4409	**62.017** 2.4416	**0.015** 0.00060	**0.014** 0.00055	**61.968** 2.4397	**61.999** 2.4409	**0.009** 0.00030	**0.010** 0.00040
–	9108	–	–	–	**68.001** 2.6772	**68.019** 2.6779	**0.015** 0.00060	**0.014** 0.00055	**67.970** 2.6760	**68.001** 2.6772	**0.009** 0.00030	**0.010** 0.00040
–	9310	207	306	404	**71.999** 2.8346	**72.017** 2.8353	**0.015** 0.00060	**0.014** 0.00055	**71.968** 2.8334	**71.999** 2.8346	**0.009** 0.00030	**0.010** 0.00040
–	9109	–	–	–	**75.001** 2.9528	**75.019** 2.9535	**0.015** 0.00060	**0.014** 0.00055	**74.971** 2.9516	**75.001** 2.9528	**0.009** 0.00030	**0.010** 0.00040
–	9110	208	307	405	**80.000** 3.1496	**80.018** 3.1503	**0.015** 0.00060	**0.014** 0.00055	**79.969** 3.1484	**80.000** 3.1496	**0.009** 0.00030	**0.010** 0.00040

RADIAL BALL AND ANGULAR CONTACT BEARINGS

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 75 continued.

Basic Bearing Number					Housing Stationary, Load Stationary or Housing Rotating, Load Rotating				Housing Rotating, Load Stationary or Housing Stationary, Load Rotating			
Extra Small	Extra Light	Light	Medium	Heavy	Housing Bore		Mean Fit Loose		Housing Bore		Mean Fit Loose	
					Min.	Max.	ABEC 1	ABEC 3	Min.	Max.	ABEC 1	ABEC 3
					mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
30, S, F, Series	9100, 9300 Series	200, 5200, 7200 Series	300, 5300, 7300 Series	400(2), 7400 Series								
–	9312	209	–	–	**85.001** 3.3465	**85.024** 3.3474	**0.019** 0.00080	**0.017** 0.00065	**84.966** 3.3451	**85.001** 3.3465	**0.010** 0.00040	**0.013** 0.00050
–	9111	210	308	406	**90.000** 3.5433	**90.023** 3.5442	**0.019** 0.00080	**0.017** 0.00065	**89.964** 3.5419	**90.000** 3.5433	**0.010** 0.00040	**0.013** 0.00050
–	9112	–	–	–	**95.001** 3.7402	**120.424** 3.7411	**0.019** 0.00080	**0.017** 0.00065	**94.965** 3.7388	**95.001** 3.7402	**0.010** 0.00040	**0.013** 0.00050
–	9113	211	309	407	**100.000** 3.9370	**100.023** 3.9379	**0.019** 0.00080	**0.017** 0.00065	**99.964** 3.9356	**100.000** 3.9370	**0.010** 0.00040	**0.013** 0.00050
–	9114	212	310	408	**110.000** 4.3307	**110.023** 4.3316	**0.019** 0.00080	**0.017** 0.00065	**109.964** 4.3293	**110.000** 4.3307	**0.010** 0.00040	**0.013** 0.00050
–	9115	–	–	–	**115.001** 4.5276	**115.024** 4.5285	**0.019** 0.0008	**0.017** 0.00065	**114.965** 4.5262	**115.001** 4.5276	**0.010** 0.0004	**0.013** 0.00050
–	–	213	311	409	**120.000** 4.7244	**120.023** 4.7253	**0.019** 0.0008	**0.017** 0.00065	**119.964** 4.7230	**120.000** 4.7244	**0.010** 0.0004	**0.013** 0.00050
–	–	214	–	–	**125.001** 4.9213	**125.026** 4.9223	**0.023** 0.0009	**0.019** 0.00075	**124.960** 4.9197	**125.001** 4.9213	**0.010** 0.0004	**0.014** 0.00055
–	9117	215	312	410	**130.000** 5.1181	**130.025** 5.1191	**0.023** 0.0009	**0.019** 0.00075	**129.959** 5.1165	**130.000** 5.1181	**0.010** 0.0004	**0.014** 0.00055
–	9118	216	313	411	**140.000** 5.5118	**140.025** 5.5128	**0.023** 0.0009	**0.019** 0.00075	**139.959** 5.5102	**140.000** 5.5118	**0.010** 0.0004	**0.014** 0.00055
–	9120	217	314	412	**150.000** 5.9055	**150.025** 5.9065	**0.023** 0.0009	**0.019** 0.00075	**149.959** 5.9039	**150.000** 5.9055	**0.010** 0.0004	**0.014** 0.00055
–	120-2	218	315	–	**160.000** 6.2992	**160.025** 6.3002	**0.025** 0.0010	**0.020** 0.00080	**159.959** 6.2976	**160.000** 6.2992	**0.008** 0.0003	**0.013** 0.00050
–	9121	–	–	413	**160.000** 6.2992	**160.025** 6.3002	**0.025** 0.0010	**0.020** 0.00080	**159.959** 6.2976	**160.000** 6.2992	**0.008** 0.0003	**0.013** 0.00050
–	9122	129	316	–	**170.000** 6.6929	**170.025** 6.6939	**0.025** 0.0010	**0.020** 0.00080	**169.959** 6.6913	**170.000** 6.6929	**0.008** 0.0003	**0.013** 0.00050
–	122	–	–	–	**175.000** 6.8898	**175.026** 6.8908	**0.025** 0.0010	**0.020** 0.00080	**174.960** 6.8882	**175.001** 6.8898	**0.008** 0.0003	**0.013** 0.00050
–	9124	220	317	414	**180.000** 7.0866	**180.025** 7.0876	**0.025** 0.0010	**0.020** 0.00080	**179.959** 7.0850	**180.000** 7.0866	**0.008** 0.0003	**0.013** 0.00050
–	124	221	318	415	**190.000** 7.4803	**190.028** 7.4815	**0.029** 0.0012	**0.023** 0.00090	**189.954** 7.4785	**190.000** 7.4803	**0.008** 0.0003	**0.014** 0.00055
–	9126	222	319	416	**200.000** 7.8740	**200.028** 7.8752	**0.029** 0.0012	**0.023** 0.00090	**199.954** 7.8722	**200.000** 7.8740	**0.008** 0.0003	**0.014** 0.00055

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 75 continued.

Basic Bearing Number					Housing Stationary, Load Stationary or Housing Rotating, Load Rotating				Housing Rotating, Load Stationary or Housing Stationary, Load Rotating			
Extra Small	Extra Light	Light	Medium	Heavy	Housing Bore		Mean Fit Loose		Housing Bore		Mean Fit Loose	
					Min.	Max.	ABEC 1	ABEC 3	Min.	Max.	ABEC 1	ABEC 3
					mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
30, S, F, Series	9100, 9300 Series	200, 5200, 7200 Series	300, 5300, 7300 Series	400(2), 7400 Series								
–	126	–	–	–	**205.001** 8.0709	**205.029** 8.0721	**0.029** 0.0012	**0.023** 0.00090	**204.955** 8.0691	**205.001** 8.0709	**0.008** 0.0003	**0.014** 0.00055
–	9128	–	–	–	**210.000** 8.2677	**210.028** 8.2689	**0.029** 0.0012	**0.023** 0.00090	**209.954** 8.2659	**210.000** 8.2677	**0.008** 0.0003	**0.014** 0.00055
–	–	224	320	–	**215.001** 8.4646	**215.029** 8.4658	**0.029** 0.0012	**0.023** 0.00090	**214.955** 8.4628	**215.001** 8.4646	**0.008** 0.0003	**0.014** 0.00055
–	128	–	–	–	**220.000** 8.6614	**220.028** 8.6626	**0.029** 0.0012	**0.023** 0.00090	**219.954** 8.6596	**220.000** 8.6614	**0.008** 0.0003	**0.014** 0.00055
–	9130	–	321	418	**225.001** 8.8583	**225.029** 8.8595	**0.029** 0.0012	**0.023** 0.00090	**224.955** 8.8565	**225.001** 8.8583	**0.008** 0.0003	**0.014** 0.00055
–	–	226	–	–	**230.000** 9.0551	**230.027** 9.0563	**0.029** 0.0012	**0.023** 0.00090	**229.954** 9.0533	**230.000** 9.0551	**0.008** 0.0003	**0.014** 0.00055
–	130	–	–	–	**235.001** 9.2520	**235.029** 9.2532	**0.029** 0.0012	**0.023** 0.00090	**234.955** 9.2502	**235.001** 9.2520	**0.008** 0.0003	**0.014** 0.00055
–	9132	–	322	–	**240.000** 9.4488	**240.027** 9.4506	**0.029** 0.0012	**0.023** 0.00090	**239.954** 9.4470	**240.000** 9.4488	**0.008** 0.0003	**0.014** 0.00055
–	132	228	–	–	**250.000** 9.8425	**250.027** 9.8437	**0.029** 0.0012	**0.023** 0.00090	**249.954** 9.8407	**250.000** 9.8425	**0.008** 0.0003	**0.014** 0.00055
–	9134	–	324	–	**259.999** 10.2362	**260.032** 10.2374	**0.033** 0.0013	**0.027** 0.00105	**259.942** 10.2342	**259.999** 10.2362	**0.008** 0.0003	**0.015** 0.00060
–	134	–	–	420	**265.001** 10.4331	**265.034** 10.4343	**0.033** 0.0013	**0.027** 0.00105	**264.950** 10.4311	**265.001** 10.4331	**0.008** 0.0003	**0.015** 0.00060
–	–	230	–	–	**269.999** 10.6299	**270.032** 10.6311	**0.033** 0.0013	**0.027** 0.00105	**269.949** 10.6279	**269.999** 10.6299	**0.008** 0.0003	**0.015** 0.00060
–	1,369,136	–	326	–	**279.999** 11.0236	**280.032** 11.0248	**0.033** 0.0013	**0.027** 0.00105	**279.949** 11.0216	**279.999** 11.0236	**0.008** 0.0003	**0.015** 0.00060
–	9138	232	–	–	**289.999** 11.4173	**290.039** 11.4185	**0.033** 0.0013	**0.027** 0.00105	**289.949** 11.4153	**289.999** 11.4173	**0.008** 0.0003	**0.015** 0.00060
–	138	–	328	–	**299.999** 11.8110	**300.032** 11.8122	**0.033** 0.0013	**0.027** 0.00105	**299.949** 11.8090	**299.999** 11.8110	**0.008** 0.0003	**0.015** 0.00060
–	9140	234	–	–	**309.999** 12.2047	**310.029** 12.2059	**0.033** 0.0013	– –	**309.949** 12.2027	**309.999** 12.2047	**0.008** 0.0003	– –
–	–	236	330	–	**319.999** 12.5984	**320.035** 12.5998	**0.038** 0.0015	– –	**319.943** 12.5962	**319.999** 12.5984	**0.008** 0.0003	– –
–	9144	238	–	–	**339.999** 13.3858	**340.035** 13.3872	**0.038** 0.0015	– –	**339.943** 13.3836	**339.999** 13.3858	**0.008** 0.0003	– –

RADIAL BALL AND ANGULAR CONTACT BEARINGS

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 75 continued.

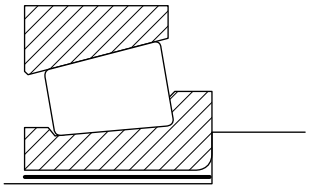
Basic Bearing Number					Housing Stationary, Load Stationary or Housing Rotating, Load Rotating				Housing Rotating, Load Stationary or Housing Stationary, Load Rotating			
Extra Small	Extra Light	Light	Medium	Heavy	Housing Bore		Mean Fit Loose		Housing Bore		Mean Fit Loose	
					Min.	Max.	ABEC 1	ABEC 3	Min.	Max.	ABEC 1	ABEC 3
					mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
30, S, F, Series	9100, 9300 Series	200, 5200, 7200 Series	300, 5300, 7300 Series	400(2), 7400 Series								
–	9146	240	–	–	**359.999** 14.1732	**360.035** 14.1746	**0.038** 0.0015	– –	**359.943** 14.1710	**359.999** 14.1732	**0.008** 0.0003	– –
–	–	242	336	–	**380.007** 14.9606	**380.035** 14.9620	**0.038** 0.0015	– –	**379.943** 14.9584	**379.999** 14.9606	**0.008** 0.0003	– –
–	9152	244	338	–	**399.999** 15.7480	**400.035** 15.7494	**0.038** 0.0015	– –	**399.943** 15.7458	**399.999** 15.7480	**0.008** 0.0003	– –
–	9156	246	340	–	**419.999** 16.5354	**420.040** 16.5370	**0.038** 0.0017	– –	**419.936** 16.5329	**419.999** 16.5354	**0.010** 0.0004	– –
–	–	248	342	–	**439.999** 17.3228	**440.040** 17.3244	**0.038** 0.0017	– –	**439.936** 17.3203	**439.999** 17.3228	**0.010** 0.0004	– –
–	9160	250	344	–	**459.999** 18.1102	**460.040** 18.1118	**0.038** 0.0017	– –	**459.936** 18.1077	**459.999** 18.1102	**0.010** 0.0004	– –
–	9164	252	–	–	**479.999** 18.8976	**480.040** 18.8992	**0.038** 0.0017	– –	**479.936** 18.8951	**479.999** 18.8976	**0.010** 0.0004	– –
–	–	256	348	–	**499.999** 19.6850	**500.040** 19.6866	**0.038** 0.0017	– –	**499.936** 19.6825	**499.999** 19.6850	**0.010** 0.0004	– –
–	–	260	352	–	**539.999** 21.2598	**540.042** 21.2615	**0.048** 0.0019	– –	**539.930** 21.2571	**539.999** 21.2598	**0.010** 0.0004	– –
–	–	264	356	–	**579.999** 22.8346	**580.042** 22.8363	**0.048** 0.0019	– –	**579.930** 22.8319	**579.999** 22.8346	**0.010** 0.0004	– –
–	9180	–	–	–	**599.999** 23.6220	**600.042** 23.6237	**0.048** 0.0019	– –	**599.930** 23.6193	**599.999** 23.6220	**0.010** 0.0004	– –

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

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TAPERED ROLLER BEARINGS

INNER RING – Industrial Equipment Classes K and N (Metric)



Deviation from nominal (maximum) bearing bore and resultant fit.

T= Tight
L = Loose

TABLE 76. TAPERED ROLLER BEARINGS – INNER RING
Industrial Equipment Classes K and N (Metric)

Inner Ring Bore		Tolerance	Rotating Inner Ring			Rotating or Stationary Inner Ring		
			Ground Seat			Unground Seat or Ground Seat		
Range			Constant Loads With Moderate Shock			Heavy Loads, High Speed or Shock		
Over	Incl.		Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.	
10.000 0.3937	**18.000** 0.7087	**-0.012** **0.000** -0.0005 0.0000	**+0.018** **+0.007** +0.0007 +0.0003	**0.030T** **0.007T** 0.0012T 0.0003T	m6	**+0.023** **+0.012** +0.0009 +0.0005	**0.035T** **0.012T** 0.0014T 0.0005T	n6
18.000 0.7087	**30.000** 1.1811	**-0.012** **0.000** -0.0005 0.0000	**+0.021** **0.008** +0.0008 +0.0003	**0.033T** **0.008T** 0.0013T 0.0003T	m6	**+0.028** **+0.015** +0.0011 +0.0006	**0.040T** **0.015T** 0.0016T 0.0006T	n6
30.000 1.1811	**50.000** 1.9685	**-0.012** **0.000** -0.0005 0.0000	**+0.025** **+0.009** +0.0010 +0.0004	**0.037T** **0.009T** 0.0015T 0.0004T	m6	**+0.033** **+0.017** +0.0013 +0.0007	**0.045T** **0.017T** 0.0018T 0.0007T	n6
50.000 1.9685	**80.000** 3.1496	**-0.015** **0.000** -0.0006 0.0000	**+0.030** **+0.011** +0.0012 +0.0004	**0.045T** **0.011T** 0.0018T 0.0004T	m6	**+0.039** **+0.020** +0.0015 +0.0008	**0.054T** **0.020T** 0.0021T 0.0008T	n6
80.000 3.1496	**120.000** 4.7244	**-0.020** **0.000** -0.0008 0.0000	**+0.035** **+0.013** +0.0014 +0.0005	**0.055T** **0.013T** 0.0022T 0.0005T	m6	**+0.045** **+0.023** +0.0019 +0.0010	**0.065T** **0.023T** 0.0027T 0.0010T	n6
120.000 4.7244	**180.000** 7.0866	**-0.025** **0.000** -0.0010 0.0000	**+0.052** **+0.027** +0.0020 +0.0011	**0.077T** **0.027T** 0.0030T 0.0011T	n6	**+0.068** **+0.043** +0.0027 +0.0017	**0.093T** **0.043T** 0.0037T 0.0017T	p6
180.000 7.0866	**200.000** 7.8740	**-0.030** **0.000** -0.0012 0.0000	**+0.060** **+0.031** +0.0024 +0.0012	**0.090T** **0.031T** 0.0035T 0.0012T	n6	**+0.106** **+0.077** +0.0042 +0.0030	**0.136T** **0.077T** 0.0054T 0.0030T	r6
200.000 7.8740	**225.000** 8.8583					**+0.109** **+0.080** +0.0043 +0.0031	**0.139T** **0.080T** 0.0055T 0.0031T	
225.000 8.8583	**250.000** 9.8425					**+0.113** **+0.084** 0.0044 +0.0033	**0.143T** **0.084T** 0.0056T 0.0033T	
250.000 9.8425	**280.000** 11.0236	**-0.035** **0.000** -0.0014 0.0000	**+0.066** **+0.033** +0.0026 +0.0013	**0.101T** **0.033T** 0.0040T 0.0013T	n6	**+0.146** **+0.094** +0.0057 +0.0037	**0.181T** **0.094T** 0.0071T 0.0037T	r7
280.000 11.0236	**315.000** 12.4016					**+0.150** **+0.098** +0.0059 +0.0039	**0.185T** **0.098T** 0.0073T 0.0039T	

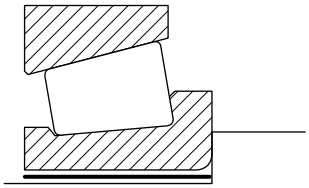
These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Stationary Inner Ring											
Unground Seat			Ground Seat			Unground Seat			Hardened and Ground Seat		
Moderate Loads, No Shock			Moderate Loads, No Shock			Sheaves, Wheels, Idlers			Wheel Spindles		
Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol
mm in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	
0.000 **-0.011** 0.0000 -0.0004	**0.012T** **0.011L** 0.0005T 0.0004L	h6	**-0.006** **-0.017** -0.0002 -0.0007	**0.006T** **0.017L** 0.0002T 0.0007L	g6	**-0.006** **-0.017** -0.00025 -0.00065	**0.006T** **0.017L** -0.00025T 0.00065L	g6	**-0.016** **-0.027** -0.0006 -0.0011	**0.004L** **0.027L** 0.0002L 0.0011L	f6
0.000 **-0.013** 0.0000 -0.0005	**0.012T** **0.013L** 0.0005T 0.0005L	h6	**-0.007** **-0.020** -0.0003 -0.0008	**0.005T** **0.020L** 0.0002T 0.0008L	g6	**-0.007** **-0.020** -0.0003 -0.0008	**0.005T** **0.020L** 0.0002T 0.0008L	g6	**-0.020** **-0.033** -0.0008 -0.0013	**0.008L** **0.033L** 0.0003L 0.0013L	f6
0.000 **-0.016** 0.0000 -0.0006	**0.012T** **0.016L** 0.0005T 0.0006L	h6	**-0.009** **-0.025** -0.0004 -0.0010	**0.003T** **0.025L** 0.0001T 0.0010L	g6	**-0.009** **-0.025** -0.0004 -0.0010	**0.003T** **0.025L** 0.0001T 0.0010L	g6	**-0.025** **-0.041** -0.0010 -0.0016	**0.013L** **0.041L** 0.0005L 0.0016L	f6
0.000 **-0.019** 0.0000 -0.0007	**0.015T** **0.019L** 0.0006T 0.0007L	h6	**-0.010** **-0.029** -0.0004 -0.0011	**0.005T** **0.029L** 0.0002T 0.0011L	g6	**-0.010** **-0.029** -0.0004 -0.0011	**0.005T** **0.029L** 0.0002T 0.0011L	g6	**-0.030** **-0.049** -0.0012 -0.0019	**0.015L** **0.049L** 0.0006L 0.0019L	f6
0.000 **-0.022** 0.0000 -0.0009	**0.020T** **0.022L** 0.0008T 0.0009L	h6	**-0.012** **-0.034** -0.0005 -0.0014	**0.008T** **0.034L** 0.0003T 0.0014L	g6	**-0.012** **-0.034** -0.0005 -0.0014	**0.008T** **0.034L** 0.0003T 0.0014L	g6	**-0.036** **-0.058** -0.0014 -0.0023	**0.016L** **0.058L** 0.0006L 0.0023L	f6
0.000 **-0.025** 0.0000 -0.0010	**0.025T** **0.025L** 0.0010T 0.0010L	h6	**-0.014** **-0.039** -0.0006 -0.0016	**0.011T** **0.039L** 0.0004T 0.0016L	g6	**-0.014** **-0.039** -0.0006 -0.0016	**0.011T** **0.039** 0.0004T 0.0016L	g6	**-0.043** **-0.068** -0.0016 -0.0026	**0.018L** **0.068L** 0.0006L 0.0026L	f6
0.000 **-0.029** 0.0000 -0.0011	**0.030T** **0.029L** 0.0012T 0.0011L	h6	**-0.015** **-0.044** -0.0006 -0.0017	**0.015T** **0.044L** 0.0006T 0.0017L	g6	**-0.015** **-0.044** -0.0006 -0.0017	**0.015T** **0.044L** 0.0006T 0.0017L	g6	**-0.050** **-0.079** -0.0020 -0.0031	**0.020L** **0.079L** 0.0008L 0.0031L	f6
0.000 **-0.032** 0.0000 -0.0012	**0.035T** **0.032L** 0.0014T 0.0012L	h6	**-0.017** **-0.049** -0.0007 -0.0019	**0.018T** **0.049L** 0.0007T 0.0019L	g6	**-0.017** **-0.049** -0.0007 -0.0019	**0.018T** **0.049L** 0.0007T 0.0019L	g6	**-0.056** **-0.068** -0.0022 -0.0027	**0.021L** **0.088L** 0.0008L 0.0035L	f6

Continued on next page.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

INNER RING – Industrial Equipment Classes K and N (Metric)



Deviation from nominal (maximum) bearing bore and resultant fit.

T= Tight
L = Loose

Table 76 continued.

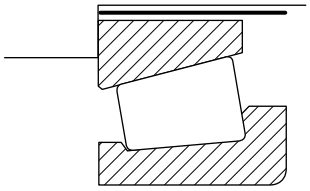
Inner Ring Bore		Tolerance	Rotating Inner Ring			Rotating or Stationary Inner Ring		
			Ground Seat			Unground Seat or Ground Seat		
Range			Constant Loads With Moderate Shock			Heavy Loads, High Speed or Shock		
Over	Incl.		Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.	
315.000 12.4016	**355.000** 13.9764	**-0.040** **0.000** -0.0016 0.0000	**+0.073** **+0.037** +0.0029 +0.0015	**0.113T** **0.037T** 0.0044T 0.0015T	n6	**+0.165** **+0.108** +0.0065 +0.0043	**0.205T** **0.108T** 0.0081T 0.0043T	r7
355.000 13.9764	**400.000** 15.7480					**+0.171** **+0.114** +0.0067 +0.0045	**0.211T** **0.114T** 0.0083T 0.0045T	
400.000 15.7580	**450.000** 17.7165	**-0.045** **0.000** -0.0018 0.0000	**+0.080** **+0.040** +0.0031 +0.0016	**0.0125T** **0.040T** 0.0049T 0.0016T	n6	**+0.189** **+0.126** +0.0074 +0.0092	**0.234T** **0.126T** 0.0092T 0.0050T	r7
450.000 17.7165	**500.000** 19.6850					**+0.195** **+0.132** +0.0077 +0.0052	**0.240T** **0.132T** 0.0094T 0.0052T	
500.000 29.6850	**630.000** 24.8032	**-0.050** **0.000** -0.0020 0.0000	**+0.100** **+0.050** +0.0039 +0.0020	**0.150T** **0.050T** 0.0059T 0.0020T	–	**+0.200** **+0.125** +0.0079 +0.0049	**0.250T** **0.125T** 0.0098T 0.0049T	–
630.000 24.8032	**800.000** 31.4961	**-0.080** **0.000** -0.0031 0.0000	**+0.125** **+0.050** +0.0049 +0.0020	**0.205T** **0.050T** 0.0081T 0.0020T	–	**+0.225** **+0.150** +0.0089 +0.0059	**0.305T** **0.105T** 0.0102T 0.0041T	–
800.000 31.4961	**1000.000** 39.3701	**-0.100** **0.000** -0.0039 0.0000	**+0.150** **+0.050** +0.0059 +0.0020	**0.250T** **0.050T** 0.0098T 0.0020T	–	**+0.275** **+0.175** +0.0108 +0.0069	**0.375T** **0.175T** 0.0148T 0.0069T	–

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Stationary Inner Ring											
Unground Seat			Ground Seat			Unground Seat			Hardened and Ground Seat		
Moderate Loads, No Shock			Moderate Loads, No Shock			Sheaves, Wheels, Idlers			Wheel Spindles		
Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol
mm in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	
0.000 **-0.036** 0.0000 -0.0014	**0.040T** **0.036L** 0.0016T 0.0014L	h6	**-0.018** **-0.075** -0.0007 -0.0030	**0.022T** **0.075L** 0.0009T 0.0030L	g7	**-0.018** **-0.075** -0.0007 -0.0029	**0.022T** **0.075L** 0.0009T 0.0029L	g7	–	–	–
0.000 **-0.040** 0.0000 -0.0020	**0.045T** **0.040L** 0.0018T 0.0016L	h6	**-0.020** **-0.083** -0.0008 -0.0033	**0.025T** **0.083L** 0.0008T 0.0033L	g7	**-0.020** **-0.083** -0.0008 -0.0033	**0.025T** **0.083L** **0.0008T** 0.0033L	g7	–	–	–
0.000 **-0.050** 0.0000 -0.0020	**0.050T** **0.050L** 0.0020T 0.0020L	–	**-0.050** **-0.100** -0.0020 -0.0039	**0.000** **0.100L** 0.0000 0.0039L	–	**-0.050** **-0.100** -0.0020 -0.0039	**0.000** **0.100L** 0.0000 0.0039L	–	–	–	–
0.000 **-0.075** 0.0000 -0.0030	**0.080T** **0.075L** 0.0031T 0.0030L	–	**-0.080** **-0.150** -0.0031 -0.0059	**0.000** **0.150L** 0.0000 0.0059L	–	**-0.080** **-0.150** -0.0031 -0.0059	**0.000** **0.150L** 0.0000 0.0059L	–	–	–	–
0.000 **-0.100** 0.0000 -0.0039	**0.100T** **0.100L** 0.0039T 0.0039L	–	**-0.100** **-0.200** -0.0039 -0.0079	**0.000** **0.200L** 0.0000 0.0079L	–	**-0.100** **-0.200** -0.0039 -0.0079	**0.000** **0.200L** 0.0000 0.0079L	–	–	–	–

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

OUTER RING – Industrial Equipment Classes K and N (Metric)



Deviation from nominal (maximum) bearing O.D. and resultant fit.

T= Tight
L = Loose

TABLE 77. TAPERED ROLLER BEARINGS – OUTER RING – Industrial Equipment Classes K and N (Metric)

Outer Ring O.D. Range Over	Outer Ring O.D. Range Incl.	Tolerance	Stationary Cup: Floating or Clamped — Outer Ring Seat Deviation	Stationary Cup: Floating or Clamped — Resultant Fit	Stationary Cup: Floating or Clamped — Symbol	Stationary Cup: Adjustable — Outer Ring Seat Deviation	Stationary Cup: Adjustable — Resultant Fit	Stationary Cup: Adjustable — Symbol	Stationary Cup: Nonadjustable or in Carriers — Outer Ring Seat Deviation	Stationary Cup: Nonadjustable or in Carriers — Resultant Fit	Stationary Cup: Nonadjustable or in Carriers — Symbol	Rotating Cup: Nonadjustable or in Carriers or Sheaves - Clamped — Outer Ring Seat Deviation	Rotating Cup: Nonadjustable or in Carriers or Sheaves - Clamped — Resultant Fit	Rotating Cup: Nonadjustable or in Carriers or Sheaves - Clamped — Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	
18.000 0.7087	**30.000** 1.1811	**0.000** **-0.012** 0.0000 -0.0005	**+0.007** **+0.028** +0.0003 +0.0011	**0.007L** **0.040L** 0.0003L 0.0016L	G7	**-0.009** **+0.012** -0.0004 +0.0005	**0.009T** **0.024L** 0.0004T 0.0009L	J7	**-0.035** **-0.014** -0.0014 -0.0005	**0.035T** **0.002T** 0.0014T 0.0001T	P7	**-0.041** **-0.020** -0.0016 -0.0009	**0.041T** **0.008T** 0.0016T 0.0003T	R7
30.000 1.1811	**50.000** 1.9685	**0.000** **-0.014** 0.0000 -0.0006	**+0.009** **+0.034** +0.0004 +0.0013	**0.009L** **0.048L** 0.0004L 0.0019L	G7	**-0.011** **+0.014** -0.0004 +0.0006	**0.011T** **0.028L** 0.0004T 0.0011L	J7	**-0.042** **-0.017** -0.0017 -0.0007	**0.042T** **0.003T** 0.0017T 0.0001T	P7	**-0.050** **-0.025** -0.0020 -0.0010	**0.050T** **0.011T** 0.0020T 0.0004T	R7
50.000 1.9685	**65.000** 2.5591	**0.000** **-0.016** 0.0000 -0.0006	**+0.010** **+0.040** +0.0004 +0.0016	**0.010L** **0.056L** 0.0004L 0.0022L	G7	**-0.012** **+0.018** -0.0005 +0.0007	**0.012T** **0.034L** 0.0005T 0.0013L	J7	**-0.051** **-0.021** -0.0020 -0.0008	**0.051T** **0.005T** 0.0020T 0.0002T	P7	**-0.060** **-0.030** -0.0024 -0.0012	**0.060T** **0.014T** 0.0024T 0.0006T	R7
65.000 2.5591	**80.000** 3.1496											**-0.062** **-0.032** -0.0021 -0.0013	**0.062T** **0.016T** 0.0024T 0.0006T	
80.000 3.1496	**100.000** 3.9370	**0.000** **-0.018** 0.0000 -0.0007	**+0.012** **+0.047** +0.0005 +0.0019	**0.012L** **0.065L** 0.0005L 0.0026L	G7	**-0.013** **+0.022** -0.0005 +0.0009	**0.013T** **0.040L** 0.0005T 0.0016L	J7	**-0.059** **-0.024** -0.0023 -0.0009	**0.059T** **0.006T** 0.0023T 0.0002T	P7	**-0.073** **-0.038** -0.0029 -0.0015	**0.073T** **0.020T** 0.0029T 0.0008T	R7
100.000 3.9370	**120.000** 4.7244											**-0.076** **-0.041** -0.0030 -0.0016	**0.076T** **0.023T** 0.0030T 0.0009T	
120.000 4.7244	**140.000** 5.5188	**0.000** **-0.020** 0.0000 -0.0008	**+0.014** **+0.054** +0.0006 +0.0021	**0.014L** **0.074L** 0.0006L 0.0029L	G7	**-0.014** **+0.026** -0.0006 +0.0010	**0.014T** **0.046L** 0.0006T 0.0018L	J7	**-0.068** **-0.028** -0.0027 -0.0011	**0.068T** **0.008T** 0.0027T 0.0003T	P7	**-0.088** **-0.048** -0.0035 -0.0019	**0.088T** **0.028T** 0.0035T 0.0011T	R7
140.000 5.5188	**150.000** 5.9055											**-0.090** **-0.050** -0.0035 -0.0020	**0.090T** **0.030T** 0.0035T 0.0012T	
150.000 5.9055	**160.000** 6.2992	**0.000** **-0.025** 0.0000 -0.0010	**+0.014** **+0.054** +0.0006 +0.0021	**0.014L** **0.079L** 0.0006L 0.0031L	G7	**-0.014** **+0.026** -0.0006 +0.0010	**-0.014T** **0.051L** 0.0006T 0.0020L	J7	**-0.068** **-0.028** -0.0027 -0.0011	**0.068T** **0.003T** 0.0027T 0.0001T	P7	**-0.090** **-0.050** -0.0035 -0.0020	**0.090T** **0.025T** 0.0035T 0.0010T	R7
160.000 6.2992	**180.000** 7.0866											**-0.093** **-0.053** -0.0037 -0.0021	**0.093T** **0.028T** 0.0037T 0.0011T	

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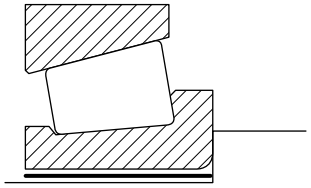
These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 77 continued.

Outer Ring O.D.		Tolerance	Stationary Cup									Rotating Cup		
Range			Floating or Clamped			Adjustable			Nonadjustable or in Carriers			Nonadjustable or in Carriers or Sheaves - Clamped		
Over	Incl.		Outer Ring Seat Deviation	Resultant Fit	Symbol	Outer Ring Seat Deviation	Resultant Fit	Symbol	Outer Ring Seat Deviation	Resultant Fit	Symbol	Outer Ring Seat Deviation	Resultant Fit	Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	
180.000 7.0866	**200.000** 7.8740											**-0.106** **-0.060** -0.0042 -0.0024	**0.106T** **0.030T** 0.0042T 0.0012T	
200.000 7.8740	**225.000** 8.8583	**0.000** **-0.030** 0.0000 -0.0012	**+0.015** **+0.061** +0.0006 +0.0024	**0.015L** **0.091L** 0.0006L 0.0036L	G7	**-0.016** **+0.030** -0.00076 +0.0012	**0.016T** **0.060L** 0.0006T 0.0024L	J7	**-0.079** **-0.033** -0.0031 -0.0014	**0.079T** **0.003T** 0.0031T 0.0001T	P7	**-0.109** **-0.063** -0.0043 -0.0025	**0.109T** **0.033T** 0.0043T 0.0013T	R7
225.000 8.8583	**250.000** 9.8425											**-0.113** **-0.067** -0.0044 -0.0026	**0.113T** **0.037T** 0.0044T 0.0015T	
250.000 9.8425	**280.000** 11.0236	**0.000** **-0.035** 0.0000 -0.0014	**+0.017** **+0.069** +0.0007 +0.0027	**0.017L** **0.104L** 0.0007L 0.0041L	G7	**-0.016** **+0.036** -0.0006 +0.0013	**0.016T** **0.071L** 0.0006T 0.0028L	J7	**-0.088** **-0.036** -0.0035 -0.0014	**0.088T** **0.001T** 0.0035T 0.0000	P7	**-0.126** **-0.074** -0.0050 -0.0029	**0.126T** **0.039T** 0.0050T 0.0015T	R7
280.000 11.0236	**315.000** 12.4016											**-0.130** **-0.078** -0.0051 -0.0031	**0.130T** **0.043T** 0.0051T 0.0017T	
315.000 12.4016	**355.000** 13.9764	**0.000** **-0.040** 0.0000 -0.0016	**+0.062** **+0.098** +0.0024 +0.0039	**0.062L** **0.138L** 0.0024L 0.0054L	F6	**-0.018** **+0.039** -0.0007 +0.0015	**0.018T** **0.079L** 0.0007T 0.0031L	J7	**-0.098** **-0.041** -0.0039 -0.0016	**0.098T** **0.001T** 0.0039T 0.0001T	P7	**-0.144** **-0.087** -0.0057 -0.0034	**0.144T** **0.047T** 0.0057T 0.0019T	R7
355.000 13.9764	**400.000** 15.7480											**-0.150** **-0.093** -0.0059 -0.0037	**0.150T** **0.053T** 0.0059T 0.0021T	
400.000 15.7480	**450.000** 17.7165	**0.000** **-0.045** 0.0000 -0.0018	**+0.068** **+0.095** +0.0027 +0.0037	**0.068L** **0.140L** 0.0027L 0.0055L	F5	**-0.020** **+0.043** -0.0008 +0.0017	**0.020T** **0.088L** 0.0008T 0.0035L	J7	**-0.108** **-0.045** -0.0043 -0.0018	**0.108T** **0.000** 0.0043T 0.0000	P7	**-0.166** **-0.103** -0.0065 -0.0041	**0.166T** **0.058T** 0.0065T 0.0023T	R7
450.000 17.7165	**500.000** 19.6850											**-0.172** **-0.109** -0.0068 -0.0043	**0.172T** **0.064T** 0.0068T 0.0025T	
500.000 19.6850	**630.000** 24.8032	**0.000** **-0.050** 0.0000 -0.0020	**+0.065** **+0.115** +0.0026 +0.0045	**0.065L** **0.165L** 0.0026L 0.0065L	–	**-0.022** **+0.046** -0.0009 +0.0018	**0.022T** **0.096L** 0.0009T 0.0038L	–	**-0.118** **-0.050** -0.0046 -0.0020	**0.118T** **0.000** 0.0046T 0.0000	–	**-0.190** **-0.120** -0.0075 -0.0047	**0.190T** **0.070T** 0.0075T 0.0028T	R7
630.000 24.8032	**800.000** 31.4961	**0.000** **-0.080** 0.0000 -0.0031	**+0.075** **+0.150** +0.0030 +0.0059	**0.075L** **0.225L** 0.0030L 0.0089L	–	**-0.025** **+0.050** -0.0098 +0.0020	**0.025T** **0.130L** 0.0098T 0.0051L	–	**-0.150** **-0.075** -0.0059 -0.0030	**0.150T** **0.000** 0.0059T 0.0000	–	–	–	R7
800.000 31.4961	**1000.000** 39.3701	**0.000** **-0.100** 0.0000 -0.0039	**+0.075** **+0.175** +0.0030 +0.0069	**0.075L** **0.275L** 0.0030L 0.0108L	–	**-0.025** **+0.075** -0.0098 +0.0030	**0.025T** **0.175L** 0.0098T 0.0069L	–	**-0.200** **-0.100** -0.0079 -0.0039	**0.200T** **0.000** 0.0079T 0.0000	–	–	–	R7

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

INNER RING – Industrial Equipment Classes 4 and 2 (Inch)



Deviation from nominal (minimum) bearing bore and resultant fit.

T= Tight
L = Loose

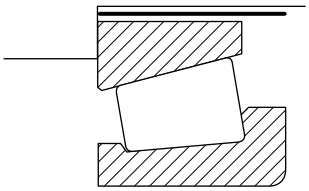
TABLE 78. TAPERED ROLLER BEARINGS – INNER RING – Industrial Equipment Classes 4 and 2 (Inch)

Inner Ring Bore			Rotating Inner Ring		Rotating or Stationary Inner Ring		Stationary Inner Ring							
Range		Tolerance[1]	Ground Seat		Unground or Ground Seat		Unground Seat		Ground Seat		Unground Seat		Hardened and Ground Seat	
			Constant Loads With Moderate Shock		Heavy Loads, or High Speed Or Shock		Moderate Loads, No Shock		Moderate Loads, No Shock		Sheaves, Wheels, Idlers		Wheel Spindles	
Over	Incl.		Inner Ring Seat Deviation	Resultant Fit	Inner Ring Seat Deviation	Resultant Fit	Inner Ring Seat Deviation	Resultant Fit	Inner Ring Seat Deviation	Resultant Fit	Inner Ring Seat Deviation	Resultant Fit	Inner Ring Seat Deviation	Resultant Fit
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0.000 0.0000	**76.200** 3.0000	**0.000** **+0.013** 0.0000 +0.0005	**+0.038**[2] **+0.026** +0.0015 +0.0010	**0.038T** **0.012T** 0.0015T 0.0005T	**+0.064** **+0.038** +0.0025 +0.0015	**0.064T** **0.025T** 0.0025T 0.0010T	**+0.013** **0.000** +0.0005T 0.0000	**0.013T** **0.013L** 0.0005T 0.0005L	**0.000** **-0.013** 0.0000 -0.0005	**0.000** **0.026L** 0.0000 0.0010L	**0.000** **-0.013** 0.0000 -0.0005	**0.000** **0.026L** 0.0000 0.0010L	**-0.005** **-0.018** -0.0002 -0.0007	**0.005L** **0.031L** 0.0002L 0.0012L
76.200 3.0000	**304.800** 12.0000	**0.000** **+0.025** 0.0000 +0.0010	**+0.064** **+0.038** +0.0025 +0.0015	**0.064T** **0.013T** 0.0025T 0.0005T	Use Average Tight Inner Ring Fit of 0.0005 mm/mm (0.0005in./in.) of Inner Ring Bore[3]		**+0.025** **0.000** +0.0010 0.0000	**0.025T** **0.025L** 0.0010T 0.0010L	**0.000** **-0.025** 0.0000 -0.0010	**0.000** **0.051L** 0.0000 0.0020L	**0.000** **-0.025** 0.0000 -0.0010	**0.000** **0.051L** 0.0000 0.0020L	**-0.005** **-0.031** -0.0002 -0.0012	**0.005L** **0.056L** 0.0002L 0.0022L
304.800 12.0000	**609.600** 24.0000	**0.000** **+0.051** 0.0000 +0.0020	**+0.127** **+0.076** +0.0050 +0.0030	**0.127T** **0.025T** 0.0050T 0.0010T			**+0.051** **0.000** +0.0020 0.0000	**0.051T** **0.051L** 0.0020T 0.0020L	**0.000** **-0.051** 0.0000 -0.0020	**0.000** **0.102L** 0.0000 0.0040L	**0.000** **-0.051** 0.0000 -0.0020	**0.000** **0.102L** 0.0000 0.0040L	–	–
609.600 24.0000	**914.400** 36.0000	**0.000** **+0.076** 0.0000 +0.0030	**+0.191** **+0.114** +0.0075 +0.0015T				**+0.076** **0.000** +0.0030 0.0000	**0.076T** **0.076L** 0.0030T 0.0030L	**0.000** **-0.076** 0.0000 -0.0030	**0.000** **0.152L** 0.0000 0.0060L	**0.000** **-0.076** 0.0000 -0.0030	**0.000** **0.152L** 0.0000 0.0060L	–	–

[1]Does not apply to TNASW and TNASWE type bearings.
[2]Example: If the minimum inner ring bore is 76.200 mm (3.0000 in.) the suggested shaft size = 76.238 mm (3.0015 in.) to 76.225 mm (3.0010 in.) for an inner ring fit of 0.038 mm (0.0015 in.) tight to 0.012 mm (0.0005 in.) tight.
[3]For inner ring bores between 76.200 mm (3.0000 in.) and 101.600 mm (4.0000 in.) use a minimum fit of 0.025 mm (0.0001 in.) tight.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

OUTER RING – Industrial Equipment Classes 4 and 2 (Inch)



Deviation from nominal (minimum) bearing O.D. and resultant fit.

T= Tight
L = Loose

TABLE 79. TAPERED ROLLER BEARINGS – OUTER RING – Industrial Equipment Classes 4 and 2 (Inch)

Outer Ring O.D.		Tolerance	Stationary Outer Ring				Stationary Or Rotating Outer Ring		Rotating Outer Ring	
Range			Floating or Clamped		Adjustable		Non-adjustable or In Carriers, Sheaves - Clamped		Sheaves - Unclamped[1]	
Over	Incl.		Outer Ring Seat Deviation	Resultant Fit	Outer Ring Seat Deviation	Resultant Fit	Outer Ring Seat Deviation	Resultant Fit	Outer Ring Seat Deviation	Resultant Fit
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0.000 0.0000	**76.200** 3.0000	**+0.025** **0.000** +0.0010 0.0000	**+0.050** **+0.076** +0.0020 +0.0030	**0.026L** **0.076L** 0.0010L 0.0030L	**0.000** **+0.025** 0.0000 +0.0010	**0.025T** **0.025L** 0.0010T 0.0010L	**-0.039** **-0.013** -0.0015 -0.0005	**0.064T** **0.013T** 0.0025T 0.0005T	**-0.077** **-0.051** -0.0030 -0.0020	**0.102T** **0.051T** 0.0040T 0.0020T
76.200 3.0000	**127.000** 5.0000	**+0.025** **0.000** +0.0010 0.0000	**+0.050** **+0.076** +0.0020 +0.0030	**0.026L** **0.076L** 0.0010L 0.0030L	**0.000** **+0.025** 0.0000 +0.0010	**0.025T** **0.025L** 0.0010T 0.0010L	**-0.051** **-0.025** -0.0020 -0.0010	**0.076T** **0.025T** 0.0030T 0.0010T	**-0.077** **-0.051** -0.0030 -0.0020	**0.102T** **0.051T** 0.0040T 0.0020T
127.000 5.0000	**304.800** 12.0000	**+0.025** **0.000** +0.0010 0.0000	**+0.050** **+0.076** +0.0020 +0.0030	**0.026L** **0.076L** 0.0010L 0.0030L	**0.000** **+0.051** 0.0000 +0.0020	**0.025T** **0.051L** 0.0010T 0.0020L	**-0.051** **-0.025** -0.0020 -0.0010	**0.076T** **0.025T** 0.0030T 0.0010T	**-0.077** **-0.051** -0.0030 -0.0020	**0.102T** **0.051T** 0.0040T 0.0020T
304.800 12.0000	**609.600** 24.0000	**+0.051** **0.000** +0.0020 0.0000	**+0.102** **+0.152** +0.0040 +0.0060	**0.051L** **0.152L** 0.0020L 0.0060L	**+0.026** **+0.076** +0.0010 +0.0030	**0.025T** **0.076L** 0.0010T 0.0030L	**-0.076** **-0.025** -0.0030 -0.0010	**0.127T** **0.025T** 0.0050T 0.0010T	**-0.102** **-0.051** -0.0040 -0.0020	**0.153T** **0.051T** 0.0060T 0.0020T
609.600 24.0000	**914.400** 36.0000	**+0.076** **0.000** +0.0030 0.0000	**+0.152** **+0.229** +0.0060 +0.0090	**0.076L** **0.229L** 0.0030L 0.0090L	**+0.051** **+0.127** +0.0020 +0.0050	**0.025T** **0.0127L** 0.0010T 0.0050L	**-0.102** **-0.025** -0.0040 -0.0010	**0.178T** **0.025T** 0.0070T 0.0010T	–	–

[1]Unclamped outer ring design is applicable only to sheaves with negligible fleet angle.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

INNER RING – Automotive Equipment Class 4 and 2 (Inch)

Deviation from nominal (minimum) bearing bore and resultant fit.

T= Tight
L = Loose

TABLE 80. TAPERED ROLLER BEARINGS – INNER RING
Automotive Equipment Classes 4 and 2 (Inch)

Shaft O.D.								
Inner Ring Bore		Tolerance	Stationary Inner Ring		Rotating Inner Ring			
			Front Wheels Rear Wheel (Full-Floating Axles) Trailer Wheels		Rear Wheels (Semi-Floating Axles)		Rear Wheels (Unit-Bearing) (Semi-Floating Axles)	
			Adjustable		Non-adjustable			
Over	Incl.		Shaft O.D. Deviation	Resultant Fit	Shaft O.D. Deviation	Resultant Fit	Shaft O.D. Deviation	Resultant Fit
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0.000 0.0000	**76.200** 3.0000	**0.000** **+0.013** 0.0000 +0.0005	**-0.005** **-0.018** -0.0002 -0.0007	**0.005L** **0.031L** 0.0002L 0.0012L	**+0.051** **+0.038** +0.0020 +0.0015	**0.051T** **0.025T** 0.0020T 0.0010T	**+0.056** **+0.038** +0.0022 +0.0015	**0.056T** **0.025T** 0.0022T 0.0010T
76.200 3.0000	**304.800** 12.0000	**0.000** **+0.025** 0.0000 +0.0010	**-0.0013** **-0.038** -0.0005 -0.0015	**0.013L** **0.063L** 0.0005L 0.0025L	**+0.076** **+0.051** +0.0030 +0.0020	**0.076T** **0.026T** 0.0030T 0.0010T	–	–

OUTER RING – Automotive Equipment Classes 4 and 2 (Inch)

TABLE 81. TAPERED ROLLER BEARINGS – OUTER RING
Automotive Equipment Classes 4 and 2 (Inch)

Housing Bore				
Outer Ring O.D.		Tolerance	Rotating Outer Ring	
			Front Wheels	Rear Wheels (Full-Floating Trailer Wheels)
			Non-adjustable	
Over	Incl.		Housing Bore Deviation	Resultant Fit
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0.000 0.0000	**76.200** 3.0000	**+0.025** **0.000** +0.0010 0.0000	**-0.051** **-0.013** -0.0020 -0.0005	**0.076T** **0.013T** 0.0030T 0.0005T
76.200 3.0000	**127.000** 5.0000	**+0.025** **0.000** +0.0010 0.0000	**-0.077** **-0.025** -0.0030 -0.0010	**0.102T** **0.025T** 0.0040T 0.0010T
127.000 5.0000	**304.800** 12.0000	**+0.025** **0.000** +0.0010 0.0000	**-0.077** **-0.025** -0.0030 -0.0010	**0.102T** **0.025T** 0.0040T 0.0010T

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Shaft O.D.									
Rotating Inner Ring									
Pinion						Differential		Transaxles Transmissions Transfer Cases Cross Shafts	
Clamped		Collapsible Spacer (Tail Bearing)		Non-adjustable (Head Bearing)		Non-adjustable		Non-adjustable	
Shaft O.D. Deviation	Resultant Fit	Shaft O.D. Deviation	Resultant Fit	Shaft O.D. Deviation	Resultant Fit	Shaft O.D. Deviation	Resultant Fit	Shaft O.D. Deviation	Resultant Fit
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
+0.025 **+0.013** +0.0015 +0.0010	**0.025T** **0.000** 0.0015 0.0005	**+0.030** **+0.018** +0.0012 +0.0007	**0.030T** **0.005T** 0.0012T 0.0002T	**+0.051** **+0.038** +0.0020 +0.0015	**0.051T** **0.025T** 0.0020T 0.0010T	**+0.102** **+0.064** +0.0040 +0.0025	**0.102T** **0.051T** 0.0040T 0.0020T	**+0.038** **+0.025** +0.0015 +0.0010	**0.038T** **0.012T** 0.0015T 0.0005T
+0.038 **+0.013** +0.0025 +0.0015	**0.038T** **0.012T** 0.0025 0.0005	–	–	**+0.076** **+0.051** +0.0030 +0.0020	**0.076T** **0.026T** 0.0030T 0.0010T	**+0.102** **+0.076** +0.0040 +0.0025	**0.102T** **0.051T** 0.0040T 0.0020T	**+0.064** **+0.038** +0.0025 +0.0015	**0.064T** **0.013T** 0.0025T 0.0005T

Housing Bore							
Stationary Outer Ring							
Rear Wheels (Semi-Floating Axles)		Differential (Split Seat)		Transmissions	Transfer Cases Cross Shafts	Pinion (Solid Seat) Transmission	Differential Transaxles Transfer Cases
Adjustable (TS) Clamped (TSU)		Adjustable		Adjustable		Non-adjustable	
Housing Bore Deviation	Resultant Fit	Housing Bore Deviation	Resultant Fit	Housing Bore Deviation	Resultant Fit	Housing Bore Deviation	Resultant Fit
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
+0.038 **+0.076** +0.0015 +0.0030	**0.013L** **0.076L** 0.0005L 0.0030L	**+0.025** **+0.051** +0.0010 +0.0020	**0.000** **0.051L** 0.0000 0.0020L	**0.000** **+0.025** 0.000 +0.0010	**0.025T** **0.025L** 0.0010T 0.0010L	**-0.038** **-0.013** -0.0015 -0.0005	**0.063T** **0.013T** 0.0025T 0.0005T
+0.038 **+0.076** +0.0015 +0.0030	**0.013L** **0.076L** 0.0005L 0.0030L	**+0.025** **+0.051** +0.0010 +0.0020	**0.000** **0.051L** 0.0000 0.0020L	**0.000** **+0.025** 0.0000 +0.0010	**0.025T** **0.025L** 0.0010T 0.0010L	**-0.051** **-0.025** -0.0020 -0.0010	**0.076T** **0.025T** 0.0030T 0.0010T
–	–	**0.000** **+0.051** 0.0000 +0.0020	**0.025T** **0.051L** 0.0010T 0.0020L	**0.000** **+0.051** 0.0000 +0.0020	**0.025T** **0.051L** 0.0010T 0.0020L	**-0.077** **-0.025** -0.0030 -0.0010	**0.102T** **0.025T** 0.0040T 0.0010T

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

INNER RING – Automotive Equipment Classes K and N (Metric)

TABLE 82. TAPERED ROLLER BEARINGS – INNER RING – Automotive Equipment Classes K and N (Metric)

Shaft O.D.												
Inner Ring Bore		Tolerance	Stationary Inner Ring			Rotating Inner Ring					
			Front Wheels Rear Wheel (Full-Floating Axles) Trailer Wheels			Rear Wheels (Semi-Floating Axles)			Rear Wheels (Unit-Bearing) (Semi-Floating Axles)		
			Adjustable			Non-adjustable			Non-adjustable		
Over	Incl.		Shaft O.D. Deviation	Resultant Fit	Symbol	Shaft O.D. Deviation	Resultant Fit	Symbol	Shaft O.D. Deviation	Resultant Fit	Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	
18.000 0.7087	**30.000** 1.1811	**-0.012** **0.000** -0.0005 0.0000	**-0.020** **-0.033** -0.0008 -0.0013	**0.008L** **0.033L** 0.0003L 0.0013L	f6	**+0.035** **+0.022** +0.0013 +0.0008	**0.047T** **0.022T** 0.0018T 0.0008T	p6	**+0.035** **+0.022** +0.0013 +0.0008	**0.047T** **0.022T** 0.0018T 0.0008T	p6
30.000 1.1811	**50.000** 1.9685	**-0.012** **0.000** -0.0005 0.0000	**-0.025** **-0.041** -0.0010 -0.0016	**0.013L** **0.041L** 0.0005L 0.0016L	f6	**+0.042** **+0.026** +0.0016 +0.0010	**0.054T** **0.026T** 0.0021T 0.0010T	p6	**+0.042** **+0.026** +0.0016 +0.0010	**0.054T** **0.026T** 0.0021T 0.0010T	p6
50.000 1.9685	**80.000** 3.1496	**-0.015** **0.000** -0.0006 0.0000	**-0.030** **-0.049** -0.0012 -0.0019	**0.015L** **0.049L** 0.0006L 0.0019L	f6	**+0.051** **+0.032** +0.0021 +0.0014	**0.066T** **0.032T** 0.0027T 0.0014T	p6	–	–	–
80.000 3.1496	**120.000** 4.7244	**-0.020** **0.000** -0.0008 0.0000	**-0.036** **-0.058** -0.0014 -0.0023	**0.016L** **0.058L** 0.0006L 0.0023L	f6	**+0.045** **+0.023** +0.0019 +0.0010	**0.065T** **0.023T** 0.0027T 0.0010T	n6	–	–	–
120.000 4.7244	**180.000** 7.0866	**-0.025** **0.000** -0.0010 0.0000	**-0.043** **-0.068** -0.0016 -0.0026	**0.018L** **0.068L** 0.0006L 0.0026L	f6	**+0.052** **+0.027** +0.0022 +0.0012	**0.077T** **0.029T** 0.0032T 0.0012T	n6	–	–	–

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Shaft O.D.												
Rotating Inner Ring												
Pinion									Differential		Transaxles, Transmissions Transfer Cases, Cross Shafts	
Clamped			Collapsible (Tail Bearing)			Non-adjustable (Head Bearing)			Non-adjustable		Non-adjustable	
Shaft O.D. Deviation	Resultant Fit	Symbol	Shaft O.D. Deviation	Resultant Fit	Symbol	Shaft O.D. Deviation	Resultant Fit	Symbol	Shaft O.D. Deviation	Resultant Fit	Shaft O.D. Deviation	Resultant Fit	Symbol
mm in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	**mm** in.	**mm** in.	
+0.015 **+0.002** +0.0006 +0.0001	**0.027T** **0.002T** 0.0011T 0.0001T	k6	**+0.015** **+0.002** +0.0006 +0.0001	**0.027T** **0.002T** 0.0011T 0.0001T	k6	**+0.035** **+0.022** +0.0013 +0.0009	**0.047T** **0.022T** 0.0018T 0.0009T	p6	**+0.056** **+0.035** +0.0022 +0.0014	**0.068T** **0.035T** 0.0027T 0.0014T	**+0.021** **+0.008** +0.0008 +0.0003	**0.033T** **0.008T** 0.0013T 0.0003T	m6
+0.018 **+0.002** +0.0007 +0.0001	**0.030T** **0.002T** 0.0012T 0.0001T	k6	**+0.018** **+0.002** +0.0007 +0.0001	**0.030T** **0.002T** 0.0012T 0.0001T	k6	**+0.042** **+0.026** +0.0016 +0.0010	**0.054T** **0.026T** 0.0021T 0.0010T	p6	**+0.068** **+0.043** +0.0028 +0.0018	**0.080T** **0.043T** 0.0033T 0.0018T	**+0.025** **+0.009** +0.0010 +0.0004	**0.037T** **0.009T** 0.0015T 0.0004T	m6
+0.021 **+0.002** +0.0008 -0.0001	**0.036T** **0.002T** 0.0014T 0.0001L	k6	**+0.021** **+0.002** +0.0008 +0.0001	**0.036T** **0.002T** 0.0014T 0.0001L	k6	**+0.051** **+0.032** +0.021 +0.014	**0.066T** **0.032T** 0.0027T 0.0014T	p6	**+0.0089** **+0.059** +0.0034 +0.0022	**0.104T** **0.059T** 0.0040T 0.0022T	**+0.030** **+0.011** +0.0012 +0.0004	**0.045T** **0.011T** 0.0018T 0.0004T	m6
+0.013 **-0.009** +0.0005 -0.0004	**0.033T** **0.009L** 0.0013T 0.0004L	j6	–	–	–	**+0.045** **+0.023** +0.0019 +0.0010	**0.065T** **0.023T** 0.0027T 0.0010T	n6	**+0.114** **+0.079** +0.0044 +0.0030	**0.134T** **0.079T** 0.0052T 0.0030T	**+0.035** **+0.013** +0.0014 +0.0005	**0.055T** **0.013T** 0.0022T 0.0005T	m6
+0.014 **-0.011** +0.0006 -0.0004	**0.039T** **0.011L** 0.0016T 0.0004L	j6	–	–	–	**+0.052** **+0.028** +0.0022 +0.0012	**0.077T** **0.029T** 0.0032T 0.0012T	n6	**+0.140** **+0.100** +0.0056 +0.0040	**0.165T** **0.100T** 0.0066T 0.0040T	**+0.040** **+0.015** +0.0016 +0.0006	**0.066T** **0.015T** 0.0026T 0.0006T	–

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

OUTER RING – Automotive Equipment Classes K and N (Metric)

Deviation from nominal (maximum) bearing bore and resultant fit.

T= Tight
L = Loose

TABLE 83. TAPERED ROLLER BEARINGS – OUTER RING – Automotive Equipment Classes K and N (Metric)

Outer Ring O.D.		Tolerance	Housing Bore															
			Rotating Outer Ring			Stationary Outer Ring												
			Front Wheels Rear Wheels (Full-Floating Trailer Wheels)			Rear Wheels (Semi-Floating Axles)			Differential (Split Seat)			Transmissions Transfer Cases Cross Shafts			Pinion Differential (Solid Seat) Transaxles Transmission[1] Transfer Cases		
			Non-adjustable			Adjustable (TS) Clamped (TSU)			Adjustable			Adjustable			Non-adjustable		
Over	Incl.		Housing Bore Deviation	Resultant Fit	Symbol	Housing Bore Deviation	Resultant Fit	Symbol	Housing Bore Deviation	Resultant Fit	Symbol	Housing Bore Deviation	Resultant Fit	Symbol	Housing Bore Deviation	Resultant Fit	Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	
30.000 1.1811	**50.000** 1.9685	**0.000** **-0.014** 0.0000 -0.0006	**-0.050** **-0.025** -0.0020 -0.0010	**0.050T** **0.011T** 0.0020T 0.0004T	R7	**+0.009** **+0.034** +0.0004 +0.0014	**0.009L** **0.048L** 0.0004L 0.0020L	G7	**0.000** **+0.025** 0.0000 +0.0010	**0.000** **0.039L** 0.0000 0.0016L	H7	**-0.013** **+0.003** -0.0005 +0.0001	**0.013T** **0.017L** 0.0005T 0.0007L	K6	**-0.050** **-0.025** -0.0020 -0.0010	**0.050T** **0.011T** 0.0020T 0.0004T	R7
50.000 1.9685	**65.000** 2.5591	**0.000** **-0.016** 0.0000 -0.0006	**-0.060** **-0.030** -0.0023 -0.0011	**0.060T** **0.014T** 0.0023T 0.0005T	R7	**+0.010** **+0.040** +0.0004 +0.0016	**0.010L** **0.056L** 0.0004L 0.0022L	G7	**0.000** **+0.030** 0.0000 +0.0012	**0.000** **0.046L** 0.0000 0.0018L	H7	**-0.015** **+0.004** -0.0006 +0.0001	**0.015T** **0.020L** 0.0006T 0.0007L	K6	**-0.060** **-0.030** -0.0023 -0.0011	**0.060** **0.014T** 0.0023T 0.0005T	R7
65.000 2.5591	**80.000** 3.1496	**0.000** **-0.016** 0.0000 -0.0006	**-0.062** **-0.032** -0.0023 -0.0011	**0.062T** **0.016T** 0.0023T 0.0005T											**-0.062** **-0.032** -0.0023 -0.0011	**0.062T** **0.016T** 0.0023T 0.0005T	
80.000 3.1496	**100.000** 3.9370	**0.000** **-0.018** 0.0000 -0.0007	**-0.073** **-0.038** -0.0029 -0.0015	**0.073T** **0.020T** 0.0029T 0.0008T	R7	**+0.012** **+0.047** +0.0005 +0.0029	**0.012L** **0.065L** 0.0005L 0.0026L	G7	**0.000** **+0.035** 0.0000 +0.0014	**0.000** **0.053L** 0.0000 0.0021L	H7	**-0.018** **+0.004** -0.0007 +0.0002	**0.018T** **0.022L** 0.0007T 0.0009L	K6	**-0.073** **-0.038** -0.0029 -0.0015	**0.073T** **0.020T** 0.0029T 0.0008T	R7
100.000 3.9370	**120.000** 4.7244	**0.000** **-0.018** 0.0000 -0.0007	**-0.076** **-0.041** -0.0029 -0.0015	**0.076T** **0.023T** 0.0029T 0.0008T											**-0.076** **-0.041** -0.0029 -0.0015	**0.076T** **0.023T** 0.0029T 0.0008T	
120.000 4.7244	**140.000** 5.5118	**0.000** **-0.020** 0.0000 -0.0008	**-0.088** **-0.048** -0.0035 -0.0019	**0.088T** **0.028T** 0.0035T 0.0011T	R7	**+0.014** **+0.054** +0.0006 +0.0022	**0.014L** **0.074L** 0.0006L 0.0030L	G7	**-0.014** **+0.026** -0.0006 +0.0010	**0.014T** **0.046L** 0.0006L 0.0018L	J7	**-0.021** **+0.004** -0.0008 +0.0002	**0.021T** **0.024L** 0.0008T 0.0010L	K6	**-0.088** **-0.048** -0.0035 -0.0019	**0.088T** **0.028T** 0.0035T 0.0011T	R7
140.000 5.5118	**150.000** 5.9055	**0.000** **-0.020** 0.0000 -0.0008	**-0.090** **-0.050** -0.0035 -0.0019	**0.090T** **0.030T** 0.0035T 0.0011T											**-0.090** **-0.050** -0.0035 -0.0019	**0.090T** **0.030T** 0.0035T 0.0011T	
150.000 5.9055	**160.000** 6.2992	**0.000** **-0.025** 0.0000 -0.0010	**-0.090** **-0.050** -0.0035 -0.0019	**0.090T** **0.025T** 0.0035T 0.0009T	R7	**+0.014** **+0.054** +0.0006 +0.0022	**0.014L** **0.079L** 0.0006L 0.0032L	G7	**-0.014** **+0.026** -0.0006 +0.0010	**0.014T** **0.051L** 0.0006T 0.0020L	J7	**-0.021** **+0.004** -0.0008 +0.0002	**0.021T** **0.029L** 0.0008T 0.0012L	K6	**-0.090** **-0.050** -0.0035 -0.0019	**0.090T** **0.025T** 0.0035T 0.0009T	R7
160.000 6.2992	**180.000** 7.0866	**0.000** **-0.025** 0.0000 -0.0010	**-0.093** **-0.053** -0.0035 -0.0019	**0.093T** **0.028T** 0.0035T 0.0009T											**-0.093** **-0.053** -0.0035 -0.0019	**0.093T** **0.028T** 0.0035T 0.0009T	

[1]Aluminum housings min. fit of 0.025 mm (0.001 in.) per inch of outer ring O.D. Magnesium housing min. fit of 0.038 mm (0.0015 in.) per inch of outer ring O.D.

Continued on next page.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 83 continued.

TABLE 83. TAPERED ROLLER BEARINGS – OUTER RING – Automotive Equipment Classes K and N (Metric)

Housing Bore																			
Outer Ring O.D.		Tolerance	Rotating Outer Ring			Stationary Outer Ring													
			Front Wheels Rear Wheels (Full-Floating Trailer Wheels)			Rear Wheels (Semi-Floating Axles)			Differential (Split Seat)			Transmissions Transfer Cases Cross Shafts			Pinion Differential (Solid Seat) Transaxles Transmission[1] Transfer Cases		
			Non-adjustable			Adjustable (TS) Clamped (TSU)			Adjustable			Adjustable			Non-adjustable		
Over	Incl.		Housing Bore Deviation	Resultant Fit	Symbol	Housing Bore Deviation	Resultant Fit	Symbol	Housing Bore Deviation	Resultant Fit	Symbol	Housing Bore Deviation	Resultant Fit	Symbol	Housing Bore Deviation	Resultant Fit	Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	
180.000 7.0866	**200.000** 7.8740	**0.000** **-0.030** 0.0000 -0.0012	**-0.106** **-0.060** -0.0042 -0.0024	**0.106T** **0.030T** 0.0042T 0.0012T											**-0.106** **-0.060** -0.0042 -0.0024	**0.106T** **0.030T** 0.0042T 0.0012T	
200.000 7.8740	**225.000** 8.8583	**0.000** **-0.030** 0.0000 -0.0012	**-0.109** **-0.063** -0.0042 -0.0024	**0.109T** **0.033T** 0.0042T 0.0012T	R7	–	–	–	**-0.016** **+0.030** -0.0007 +0.0011	**0.016T** **0.060L** 0.0007T 0.0023L	J7	**-0.016** **+0.030** -0.0007 +0.0011	**0.016T** **0.060L** 0.0007T 0.0023L	J7	**-0.109** **-0.063** -0.0042 -0.0024	**0.109T** **0.033T** 0.0042T 0.0012T	R7
225.000 8.8583	**250.000** 9.8425	**0.000** **-0.030** 0.0000 -0.0012	**-0.113** **-0.067** -0.0042 -0.0024	**0.113T** **0.037T** 0.0042T 0.0012T											**-0.113** **-0.067** -0.0042 -0.0024	**0.113T** **0.037T** 0.0042T 0.0012T	
250.000 9.8425	**280.000** 11.0236	**0.000** **-0.035** 0.0000 -0.0014	**-0.126** **-0.074** -0.0047 -0.0027	**0.126T** **0.039T** 0.0047T 0.0013T	R7	–	–	–	**-0.016** **+0.036** -0.0007 +0.0013	**0.016T** **0.071L** 0.0007T 0.0027L	J7	**-0.016** **+0.036** -0.0007 +0.0014	**0.016T** **0.071L** 0.0007T 0.0028L	J7	**-0.126** **-0.074** -0.0047 -0.0027	**0.126T** **0.039T** 0.0047T 0.0013T	R7
280.000 11.0236	**315.000** 12.4016	**0.000** **-0.035** 0.0000 -0.0014	**-0.130** **-0.078** -0.0047 -0.0027	**0.130T** **0.043T** 0.0047T 0.0013T											**-0.130** **-0.078** -0.0047 -0.0027	**0.130T** **0.043T** 0.0047T 0.0013T	

[1]Aluminum housings min. fit of 0.025 mm (0.001 in.) per inch of outer ring O.D. Magnesium housing min. fit of 0.038 mm (0.0015 in.) per inch of outer ring O.D.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

PRECISION TAPERED ROLLER BEARINGS

HYDRA-RIB

The Hydra-Rib outer ring is designed to be mounted either as a flanged outer ring or shouldered against the outer ring backface. The 50.000 mm (1.968 in.) bore assembly does not have a flanged outer ring and the outer ring backface must be mounted against the housing shoulder.

For heavy loads, high speed or shock, contact your Timken engineer for further information.

HYDRA-RIB Classes C and B (Metric)

Deviation from nominal (maximum) bearing bore and resultant fit.

T= Tight
L = Loose

TABLE 84. PRECISION TAPERED ROLLER BEARINGS – INNER RING HYDRA-RIB Classes C and B (Metric)

Bearing Bore Range Over	Bearing Bore Range Incl.	Class C Bearing Bore Tolerance	Class C Shaft O.D. Deviation	Class C Resultant Fit	Class C Symbol	Class B Bearing Bore Tolerance	Class B Shaft O.D. Deviation	Class B Resultant Fit	Class B Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.	**mm** in.	
30.000 1.1811	**50.000** 1.9685	**-0.010** **0.000** -0.0004 0.0000	**+0.013** **+0.002** +0.0005 +0.0001	**0.023T** **0.002T** 0.0009T 0.0001T	k5	**-0.010** **0.000** -0.0004 0.0000	**+0.013** **+0.002** +0.0005 +0.0001	**0.023T** **0.002T** 0.0009T 0.0001T	k5
50.000 1.9685	**80.000** 3.1496	**-0.013** **0.000** -0.0005 0.0000	**+0.015** **+0.002** +0.0006 +0.0001	**0.028T** **0.002T** 0.0011T 0.0001T	k5	**-0.010** **0.000** -0.0004 0.0000	**+0.015** **+0.002** +0.0006 +0.0001	**0.025T** **0.002T** 0.0010T 0.0001T	k5
80.000 3.1496	**120.000** 4.7244	**-0.013** **0.000** -0.0005 0.0000	**+0.018** **+0.003** +0.0007 +0.0001	**0.031T** **0.003T** 0.0012T 0.0001T	k5	**-0.010** **0.000** -0.0004 0.0000	**+0.018** **+0.003** +0.0007 +0.0001	**0.028T** **0.003T** 0.0011T 0.0001T	k5
120.000 4.7244	**180.000** 7.0866	**-0.013** **0.000** -0.0005 0.0000	**+0.021** **+0.003** +0.0008 +0.0001	**0.034T** **0.003T** 0.0013T 0.0001T	k5	**-0.010** **0.000** -0.0004 0.0000	**+0.021** **+0.003** +0.0008 +0.0001	**0.031T** **0.003T** 0.0012T 0.0001T	k5
180.000 7.0866	**250.000** 9.8425	**-0.015** **0.000** -0.0006 0.0000	**+0.024** **+0.004** +0.0010 +0.0002	**0.039T** **0.004T** 0.0016T 0.0002T		**-0.013** **0.000** -0.0005 0.0000	**+0.024** **+0.004** +0.0010 +0.0002	**0.037T** **0.004T** 0.0015T 0.0002T	k5

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

TABLE 85. PRECISION TAPERED ROLLER BEARINGS – OUTER RING HYDRA-RIB Classes C and B (Metric)

Bearing Bore Range		Class C				Class B			
Over	Incl.	Bearing Bore Tolerance	Shaft O.D. Deviation	Resultant Fit	Symbol	Bearing Bore Tolerance	Shaft O.D. Deviation	Resultant Fit	Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.	**mm** in.	
80.000 3.1496	**120.000** 4.7244	**0.000** **-0.013** 0.0000 -0.0005	**-0.023** **-0.008** -0.0009 -0.0003	**0.023T** **0.005L** 0.0009T 0.0002L	M5	**0.000** **-0.010** 0.0000 -0.0004	**-0.023** **-0.008** -0.0009 -0.0003	**0.023T** **0.002L** 0.0009T 0.0001L	M5
120.000 4.7244	**180.000** 7.0866	**0.000** **-0.013** 0.0000 -0.0005	**-0.027** **-0.009** -0.0011 -0.0004	**0.027T** **0.004L** 0.0011T 0.0001L	M5	**0.000** **-0.010** 0.0000 -0.0004	**-0.027** **-0.009** -0.0011 -0.0004	**0.027T** **0.001L** 0.0011T 0.0000	M5
180.000 7.0866	**250.000** 9.8425	**0.000** **-0.015** 0.0000 -0.0006	**-0.031** **-0.011** -0.0012 -0.0004	**0.031T** **0.004L** 0.0012T 0.0002L	M5	**0.000** **-0.013** 0.0000 -0.0005	**-0.031** **-0.011** -0.0012 -0.0004	**0.031T** **0.002L** 0.0012T 0.0001L	M5
250.000 9.8425	**315.000** 12.4016	**0.000** **-0.020** 0.0000 -0.0008	**-0.036** **-0.013** -0.0014 -0.0005	**0.036T** **0.007L** 0.0014T 0.0003L	M5	**0.000** **-0.015** 0.0000 -0.0006	**-0.036** **-0.013** -0.0014 -0.0005	**0.036T** **0.002L** 0.0014T 0.0001L	M5
315.000 12.4016	**400.000** 15.7480	**0.000** **-0.020** 0.0000 -0.0008	**-0.039** **-0.014** -0.0015 -0.0006	**0.039T** **0.006L** 0.0015T 0.0002L	M5	–	–	–	–

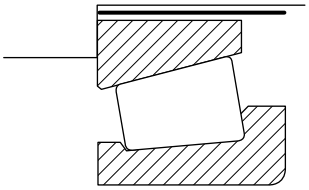
These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

PRECISION CLASS TAPERED ROLLER BEARINGS EXCEPT HYDRA-RIB AND TXR

Suggested fitting guidelines for ferrous shaft and housing

For heavy loads, high speed or shock, contact your Timken representative for further information.

ISO + J PREFIX CLASS B (METRIC)



Deviation from nominal (maximum) bearing bore and resultant fit.

T= Tight
L = Loose

TABLE 86. PRECISION CLASS TAPERED ROLLER BEARINGS – OUTER RING
ISO + J Prefix, Class B (Metric)

Outer Ring O.D. Range Over	Outer Ring O.D. Range Incl.	Tolerance	Stationary Inner Ring: Floating: Outer Ring Seat Deviation	Floating: Resultant Fit	Floating: Symbol	Stationary Inner Ring: Clamped: Outer Ring Seat Deviation	Clamped: Resultant Fit	Clamped: Symbol	Stationary Inner Ring: Adjustable: Outer Ring Seat Deviation	Adjustable: Resultant Fit	Adjustable: Symbol	Stationary Inner Ring: Non-adjustable or In Carriers: Outer Ring Seat Deviation	Non-adjustable or In Carriers: Resultant Fit	Non-adjustable or In Carriers: Symbol	Rotating Inner Ring: Non-adjustable or In Carriers: Outer Ring Seat Deviation	Non-adjustable or In Carriers: Resultant Fit	Non-adjustable or In Carriers: Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	
18.000 0.7087	**30.000** 1.1811	**0.000** **-0.006** 0.0000 -0.0002	**+0.007** **+0.016** +0.0003 +0.0007	**0.007L** **0.022L** 0.0003L 0.0009L	G5	**0.000** **+0.006** 0.0000 +0.0002	**0.000** **0.012L** 0.0000 0.0005L	H4	**-0.008** **0.001** -0.0004 0.0000	**0.008T** **0.007L** 0.0004T 0.0002L	K5	**-0.0140** **-0.0050** -0.0006 -0.0002	**0.0140T** **0.0010L** 0.0006T 0.00001L	M5	**-0.021** **-0.012** -0.0008 -0.0005	**0.021T** **0.006T** 0.0008T 0.0002T	N5
30.000 1.1811	**50.000** 1.9685	**0.000** **-0.007** 0.0000 -0.0003	**+0.009** **+0.020** +0.0004 +0.0008	**0.009L** **0.027L** 0.0004L 0.0011L	G5	**0.000** **+0.007** 0.0000 +0.0003	**0.000** **0.014L** 0.0000 0.0006L	H4	**-0.009** **0.002** -0.0004 0.0000	**0.009T** **0.009L** 0.0004T 0.0004L	K5	**-0.016** **-0.005** -0.0007 -0.0003	**0.016T** **0.002L** 0.0007T 0.0000	M5	**-0.024** **-0.013** -0.0010 -0.0006	**0.024T** **0.006T** 0.0010T 0.003T	N5
50.000 1.9685	**80.000** 3.1496	**0.000** **-0.009** 0.0000 -0.0004	**+0.010** **+0.023** +0.0004 +0.0009	**0.010L** **0.032L** 0.0004L 0.0013L	G5	**0.000** **+0.008** 0.0000 +0.0003	**0.000** **0.017L** 0.0000 0.0007L	H4	**-0.010** **+0.003** -0.0004 +0.0001	**0.010T** **0.012L** 0.0004T 0.0005L	K5	**-0.019** **-0.006** -0.0008 -0.0003	**0.0019T** **0.0003L** 0.0008T 0.0001L	M5	**-0.028** **-0.015** -0.0011 -0.0006	**0.028T** **0.006T** 0.0011T 0.0002T	N5
80.000 3.1496	**120.000** 4.7244	**0.000** **-0.010** 0.0000 -0.0004	**+0.012** **+0.027** +0.0005 +0.0011	**0.012L** **0.037L** 0.0005L 0.0015L	G5	**0.000** **+0.010** 0.0000 +0.0004	**0.000** **0.020L** 0.0000 0.0008L	H4	**-0.013** **+0.002** -0.0005 +0.0001	**0.013T** **0.012L** 0.0005T 0.0005L	K5	**-0.023** **-0.008** -0.0009 -0.0003	**0.023T** **0.002L** 0.0009T 0.0001L	M5	**-0.033** **-0.018** -0.0014 -0.0008	**0.033T** **0.008T** 0.0014T 0.0004T	N5
120.000 4.7244	**150.000** 5.9055	**0.000** **-0.011** 0.0000 -0.0004	**+0.014** **+0.032** +0.0006 +0.0013	**0.014L** **0.043L** 0.0006L 0.0017L	G5	**0.000** **+0.012** 0.0000 +0.0005	**0.000** **0.023L** 0.0000 0.0009L	H4	**-0.0125** **+0.0125** -0.0005 +0.0005	**0.0125T** **0.0235L** 0.0005T 0.0009L	Js6	**-0.027** **-0.009** -0.0011 -0.0004	**0.027T** **0.002L** 0.0011T 0.0000	M5	**-0.039** **-0.021** -0.0017 -0.0010	**0.039T** **0.010T** 0.0017T 0.0006T	N5
150.000 5.9055	**180.000** 7.0866	**0.000** **-0.013** 0.0000 -0.0005	**+0.014** **+0.032** +0.0006 +0.0013	**0.014L** **0.045L** 0.0006L 0.0018L	G5	**0.000** **+0.012** 0.0000 +0.0005	**0.000** **0.025L** 0.0000 0.0010L	H4	**-0.0125** **+0.0125** -0.0005 +0.0005	**0.0125T** **0.0255L** 0.0005T 0.0010L	Js6	**-0.027** **-0.009** -0.0011 -0.0004	**0.027T** **0.004L** 0.0011T 0.0002L	M5	**-0.039** **-0.021** -0.0017 -0.0010	**0.039T** **0.008T** 0.0017T 0.0005T	N5
180.000 7.0866	**250.000** 9.8425	**0.000** **-0.015** 0.0000 -0.0006	**+0.015** **+0.035** +0.0006 +0.0014	**0.015L** **0.050L** 0.0006L 0.0020L	G5	**0.000** **+0.014** 0.0000 +0.0006	**0.000** **0.029L** 0.0000 0.0012L	H4	**-0.010** **+0.010** -0.0004 +0.0004	**0.010T** **0.025L** 0.0004T 0.0010L	Js5	**-0.031** **-0.011** -0.0012 -0.0004	**0.031T** **0.004L** 0.0012T 0.0002L	M5	**-0.045** **-0.025** -0.0020 -0.0012	**0.045T** **0.010T** 0.00250T 0.0006T	N5
250.000 9.8425	**315.000** 12.4016	**0.000** **-0.018** 0.0000 -0.0007	**+0.017** **+0.040** +0.0007 +0.0016	**0.017L** **0.058L** 0.0007L 0.0023L	G5	**0.000** **+0.016** 0.0000 +0.0006	**0.000** **0.034L** 0.0000 0.0013L	H4	**-0.0115** **+0.0115** -0.0005 +0.0005	**0.0115T** **0.0295L** 0.0005T 0.0010L	Js5	**-0.036** **-0.013** -0.0014 -0.0005	**0.036L** **0.005L** 0.0014T 0.0002L	M5	**-0.050** **-0.027** -0.0020 -0.0011	**0.050T** **0.009T** 0.0020T 0.0004T	N5

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

TABLE 87. PRECISION CLASS TAPERED ROLLER BEARINGS – INNER RING
ISO + J Prefix, Class C (Metric)

Outer Ring O.D. Range		Tolerance	Stationary Outer Ring												Rotating Outer Ring		
			Floating			Clamped			Adjustable			Non-adjustable or In Carriers			Non-adjustable or In Carriers		
Over	Incl.		Outer Ring Seat Deviation	Resultant Fit	Symbol	Outer Ring Seat Deviation	Resultant Fit	Symbol	Outer Ring Seat Deviation	Resultant Fit	Symbol	Outer Ring Seat Deviation	Resultant Fit	Symbol	Outer Ring Seat Deviation	Resultant Fit	Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	
18.000 0.7087	**30.000** 1.1811	**0.000** **-0.008** 0.0000 -0.0003	**+0.007** **+0.016** +0.0003 +0.0007	**0.007L** **0.024L** 0.0003L 0.0010L	G5	**0.000** **+0.009** 0.0000 +0.0004	**0.000** **0.017L** 0.0000 0.0007L	H5	**-0.008** **+0.001** -0.0004 0.0000	**0.008T** **0.009L** 0.0004T 0.0003L	K5	**-0.021** **-0.012** -0.0010 -0.0005	**0.021T** **0.004T** 0.0010T 0.0002T	N5	**-0.024** **-0.011** -0.0010 -0.0005	**0.024T** **0.003T** 0.0010T 0.0002T	N6
30.000 1.1811	**50.000** 1.9685	**0.000** **-0.009** 0.0000 -0.0004	**+0.009** **+0.020** +0.0004 +0.0008	**0.009L** **0.029L** 0.0004L 0.0012L	G5	**0.000** **+0.011** 0.0000 +0.0004	**0.000** **0.020L** 0.0000 0.0008L	H5	**-0.009** **+0.002** -0.0004 0.0000	**0.009T** **0.011L** 0.0004T 0.0004L	K5	**-0.024** **-0.013** -0.0010 -0.0006	**0.024T** **0.004T** 0.0010T 0.0002T	N5	**-0.028** **-0.012** -0.0010 -0.0005	**0.028T** **0.003T** 0.0011T 0.0001T	N6
50.000 1.9685	**80.000** 3.1496	**0.000** **-0.011** 0.0000 -0.0004	**+0.010** **+0.023** +0.0004 +0.0009	**0.010L** **0.034L** 0.0004L 0.0013L	G5	**0.000** **+0.013** 0.0000 +0.0005	**0.000** **0.024L** 0.0000 0.0009L	H5	**-0.010** **+0.003** -0.0004 +0.0001	**0.010T** **0.014L** 0.0004T 0.0005L	K5	**-0.028** **-0.015** -0.0011 -0.0006	**0.028T** **0.004T** 0.0011T 0.0002T	N5	**-0.033** **-0.014** -0.0013 -0.0006	**0.033T** **0.003T** 0.0013T 0.0002T	N6
80.000 3.1496	**120.000** 4.7244	**0.000** **-0.013** 0.0000 -0.0005	**+0.012** **+0.027** +0.0005 +0.0011	**0.012L** **0.040L** 0.0005L 0.0016L	G5	**0.000** **+0.015** 0.0000 +0.0006	**0.000** **0.028L** 0.0000 0.0011L	H5	**-0.013** **+0.002** -0.0005 +0.0001	**0.013T** **0.015L** 0.0005T 0.0006L	K5	**-0.033** **-0.018** -0.0014 -0.0008	**0.033T** **0.005T** 0.0014T 0.0003T	N5	**-0.038** **-0.016** -0.0016 -0.0007	**0.038T** **0.003T** 0.0016T 0.0002T	N6
120.000 4.7244	**150.000** 5.9055	**0.000** **-0.015** 0.0000 -0.0006	**+0.014** **+0.032** +0.0006 +0.0013	**0.014L** **0.047L** 0.0006L 0.0019L	G5	**0.000** **+0.018** 0.0000 +0.0007	**0.000** **0.033L** 0.0000 0.0013L	H5	**-0.0125** **+0.0125** -0.0005 +0.0005	**0.0125T** **0.0275L** 0.0005T 0.0011L	Js6	**-0.039** **-0.021** -0.0017 -0.0010	**0.039T** **0.006T** 0.0017T 0.0004T	N5	**-0.045** **-0.020** -0.0019 -0.0009	**0.0045T** **0.005T** 0.0019T 0.0003T	N6
150.000 5.9055	**180.000** 7.0866	**0.000** **-0.018** 0.0000 -0.0007	**+0.014** **+0.032** +0.0006 +0.0013	**0.014L** **0.050L** 0.0006L 0.0020L	G5	**0.000** **+0.018** 0.0000 +0.0007	**0.000** **0.036L** 0.0000 0.0014L	H5	**-0.0125** **+0.0125** -0.0005 +0.0005	**0.0125T** **0.0305L** 0.0005T 0.0012L	Js6	**-0.039** **-0.021** -0.0017 -0.0010	**0.039T** **0.003T** 0.0017T 0.0003T	N5	**-0.045** **-0.020** -0.0019 -0.0009	**0.045T** **0.002T** 0.0019T 0.0002T	N6
180.000 7.0866	**250.000** 9.8425	**0.000** **-0.020** 0.0000 -0.0008	**+0.015** **+0.035** +0.0006 +0.0014	**0.015L** **0.055L** 0.0006L 0.0022L	G5	**0.000** **+0.020** 0.0000 +0.0008	**0.000** **0.040L** 0.0000 0.0016L	H5	**-0.0145** **+0.0145** -0.0006 +0.0006	**0.0145T** **0.0345L** 0.0006T 0.0014L	Js6	**-0.045** **-0.025** -0.0020 -0.0012	**0.045T** **0.005T** 0.0020T 0.0004T	N5	**-0.051** **-0.022** -0.0022 -0.0010	**0.051T** **0.002T** 0.0022T 0.0002T	N6
250.000 9.8425	**315.000** 12.4016	**0.000** **-0.025** 0.0000 -0.0010	**+0.017** **+0.040** +0.0007 +0.0016	**0.017L** **0.065L** 0.0007L 0.0026L	G5	**0.000** **+0.023** 0.0000 +0.0009	**0.000** **0.048L** 0.0000 0.0019L	H5	**-0.020** **+0.003** -0.0008 +0.0001	**0.020T** **0.028L** 0.0008T 0.0011L	K5	**-0.050** **-0.027** -0.0020 -0.0011	**0.050T** **0.002T** 0.0020T 0.0001T	N5	**-0.050** **-0.027** -0.0020 -0.0011	**0.050T** **0.002T** 0.0020T 0.0001T	N5
315.000 12.4016	**400.000** 15.7480	**0.000** **-0.028** 0.0000 -0.0011	**+0.018** **+0.043** +0.0007 +0.0017	**0.018L** **0.071L** 0.0007L 0.0028L	G5	**0.000** **+0.025** 0.0000 +0.0010	**0.000** **0.053L** 0.0000 0.0021L	H5	**-0.022** **+0.003** -0.0009 +0.0001	**0.022T** **0.031L** 0.0009T 0.0012L	K5	**-0.055** **-0.030** -0.0023 -0.0013	**0.055T** **0.002T** 0.0023T 0.0002T	N5	**-0.055** **-0.030** -0.0023 -0.0013	**0.055T** **0.002T** 0.0023T 0.0002T	N5
400.000 15.7480	**500.000** 19.6850	**0.000** **-0.030** 0.0000 -0.0012	**+0.020** **+0.047** +0.0008 +0.0018	**0.020L** **0.077L** 0.0008L 0.0030L	G5	**0.000** **+0.027** 0.0000 +0.0011	**0.000** **0.057L** 0.0000 0.0022L	H5	**-0.025** **+0.002** -0.0010 0.0000	**0.025T** **0.032L** 0.0010T 0.0012L	K5	**-0.060** **-0.033** -0.0026 -0.0016	**0.060T** **0.003T** 0.0026T 0.0004T	N5	**-0.060** **-0.033** -0.0026 -0.0016	**0.060T** **0.003T** 0.0026T 0.0004T	N5
500.000 19.6850	**630.000** 24.8032	**0.000** **-0.035** 0.0000 -0.0014	**+0.025** **+0.050** +0.0010 +0.0020	**0.025L** **0.085L** 0.0010L 0.0034L	–	**0.000** **+0.025** 0.0000 +0.0010	**0.000** **0.060L** 0.0000 0.0024L	–	**-0.025** **+0.000** -0.0010 0.0000	**0.025T** **0.035L** 0.0010T 0.0014L	–	**-0.065** **-0.040** -0.0026 -0.0016	**0.065T** **0.005T** 0.0026T 0.0002T	–	**-0.075** **-0.038** -0.0030 -0.0015	**0.075T** **0.003T** 0.0030T 0.0001T	–
630.000 24.8032	**800.000** 31.4961	**0.000** **-0.040** 0.0000 -0.0016	**+0.025** **+0.065** +0.0010 +0.0026	**0.025L** **0.105L** 0.0010L 0.0042L	–	**0.000** **+0.040** 0.0000 +0.0016	**0.000** **0.080L** 0.0000 0.0032L	–	**-0.040** **0.000** -0.0016 0.0000	**0.040T** **0.040L** 0.0016T 0.0016L	–	**-0.090** **-0.050** -0.0035 -0.0020	**0.090T** **0.010T** 0.0035T 0.0004T	–	**-0.095** **-0.050** -0.0037 -0.0020	**0.095T** **0.010T** 0.0037T 0.0006t	–
800.000 31.4961	**1000.000** 39.3701	**0.000** **-0.050** 0.0000 -0.020	**+0.025** **+0.075** +0.0010 +0.0030	**0.025L** **0.125L** 0.0010L 0.0050L	–	**0.000** **+0.050** 0.0000 +0.0020	**0.000** **0.100L** 0.0000 0.0040L	–	**-0.050** **0.000** -0.0020 0.0000	**0.050T** **0.050L** 0.0020T 0.0020L	–	**-0.100** **-0.050** -0.0039 -0.0020	**0.100T** **0.000** 0.0039T 0.0000	–	**-0.115** **-0.065** -0.0045 -0.0026	**0.115T** **0.015T** 0.0045T 0.0006T	–

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

ISO + J PREFIX
Classes 3 and 0 (Inch)

Deviation from nominal (maximum) bearing O.D. and resultant fit.

T= Tight
L = Loose

TABLE 88. PRECISION CLASS TAPERED ROLLER BEARINGS – OUTER RING
ISO + J Prefix, Classes 3 and 0 (Inch)

Outer Ring O.D.		Tolerance	Stationary Inner Ring								Rotating Inner Ring	
Range			Floating		Clamped		Adjustable		Non-adjustable or In Carriers		Non-adjustable or In Carriers	
Over	Incl.		Outer Ring Seat Deviation	Resultant Fit	Outer Ring Seat Deviation	Resultant Fit	Outer Ring Seat Deviation	Resultant Fit	Outer Ring Seat Deviation	Resultant Fit	Outer Ring Seat Deviation	Resultant Fit
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0.000 0.0000	**152.400** 6.0000	**+0.013** **0.000** +0.0005 0.0000	**+0.026** **+0.038** +0.0010 +0.0015	**0.013L** **0.038L** 0.0005L 0.0015L	**+0.013** **+0.025** +0.0005 +0.0010	**0.000** **0.025L** 0.0000 0.0010L	**0.000** **+0.013** 0.0000 +0.0005	**0.013T** **0.013L** 0.0005T 0.0005L	**-0.012** **0.000** -0.0005 0.0000	**0.025T** **0.000** 0.0015T 0.0000	**-0.025** **-0.013** -0.0010 -0.0005	**0.038T** **0.013T** 0.0015T 0.0005T
152.400 6.0000	**304.800** 12.0000	**+0.013** **0.000** +0.0005 0.0000	**+0.026** **+0.038** +0.0010 +0.0015	**0.013L** **0.038L** 0.0005L 0.0015L	**+0.013** **+0.025** +0.0005 +0.0010	**0.000** **0.025L** 0.0000 0.0010L	**0.000** **+0.025** 0.0000 +0.0010	**0.013T** **0.025L** 0.0005T 0.0010L	**-0.025** **0.000** -0.0010 0.0000	**0.038T** **0.000** 0.0015T 0.0000	**-0.038** **-0.013** -0.0015 -0.0005	**0.051T** **0.013T** 0.0020T 0.0005T
304.800 12.0000	**609.600** 24.0000	**+0.025** **0.000** +0.0010 0.0000	**+0.038** **+0.064** +0.0015 +0.0025	**0.013L** **0.064L** 0.0005L 0.0025L	**+0.025** **+0.051** +0.0010 +0.0020	**0.000** **0.051L** 0.0000 0.0020L	**0.000** **+0.025** 0.0000 +0.0010	**0.025T** **0.025L** 0.0010T 0.0010L	**-0.025** **0.000** -0.0010 0.0000	**0.051T** **0.000** 0.0020T 0.0000	**-0.038** **-0.013** -0.0015 -0.0005	**0.064T** **0.013T** 0.0025T 0.0005T
609.600 24.0000	**914.400** 36.0000	**+0.038** **0.000** +0.0015 0.0000	**+0.051** **+0.089** +0.0020 +0.0035	**0.013L** **0.089L** 0.0005L 0.0035L	**+0.038** **+0.076** +0.0015 +0.0030	**0.000** **0.076L** 0.0000 0.0030L	**0.000** **+0.038** 0.0000 +0.0015	**0.038T** **0.038L** 0.0015T 0.0015L	**-0.038** **0.000** -0.0015 0.0000	**0.076T** **0.000** 0.0030T 0.0000	**-0.051** **-0.013** -0.0020 -0.0005	**0.089T** **0.013T** 0.0035T 0.0005T

(1)Maximum outer ring O.D. for Class 0 product is 315.00 mm (12.406 in.).

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

ISO + J PREFIX
Classes A and AA (Metric)

Deviation from nominal (maximum) bearing O.D. and resultant fit.

T= Tight
L = Loose

TABLE 89. PRECISION CLASS TAPERED ROLLER BEARINGS – OUTER RING
Classes A and AA (Metric)

Outer Ring O.D. Range Over	Incl.	Tolerance	Stationary Outer Ring: Floating Outer Ring Seat Deviation	Floating Resultant Fit	Floating Symbol	Clamped Outer Ring Seat Deviation	Clamped Resultant Fit	Clamped Symbol	Adjustable Outer Ring Seat Deviation	Adjustable Resultant Fit	Adjustable Symbol	Non-adjustable or In Carriers Outer Ring Seat Deviation	Non-adjustable or In Carriers Resultant Fit	Non-adjustable or In Carriers Symbol	Rotating Outer Ring: Non-adjustable or In Carriers Outer Ring Seat Deviation	Non-adjustable or In Carriers Resultant Fit	Non-adjustable or In Carriers Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	
0.000 0.0000	**315.000** 12.4016	**0.000** **-0.008** 0.0000 -0.0003	**+0.008** **+0.016** +0.0003 +0.0006	**0.008L** **0.024L** 0.0003L 0.0009L	–	**0.000** **+0.008** 0.0000 +0.0003	**0.000** **0.016L** 0.0000 0.0006L	–	**-0.008** **0.000** -0.0003 0.0000	**0.008T** **0.008L** 0.0003T 0.0003L	–	**-0.016** **-0.008** -0.0006 -0.0003	**0.016T** **0.000** 0.0006T 0.0000	–	**-0.024** **-0.016** -0.0009 -0.0006	**0.024T** **0.008T** 0.0009T 0.0003T	–

ISO + J PREFIX
Classes 00 and 000 (Inch)

Deviation from nominal (maximum) bearing O.D. and resultant fit.

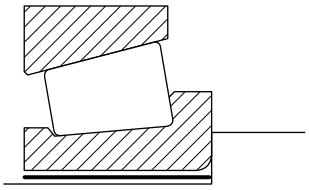
T= Tight
L = Loose

TABLE 90. PRECISION CLASS TAPERED ROLLER BEARINGS – OUTER RING
Classes 00 and 000 (Inch)

Outer Ring O.D. Range Over	Incl.	Tolerance	Stationary Outer Ring: Floating Outer Ring Seat Deviation	Floating Resultant Fit	Clamped Outer Ring Seat Deviation	Clamped Resultant Fit	Adjustable Outer Ring Seat Deviation	Adjustable Resultant Fit	Non-adjustable or In Carriers Outer Ring Seat Deviation	Non-adjustable or In Carriers Resultant Fit	Rotating Outer Ring: Non-adjustable or In Carriers Outer Ring Seat Deviation	Non-adjustable or In Carriers Resultant Fit
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0.000 0.0000	**315.000** 12.4016	**+0.008** **0.000** +0.0003 0.0000	**+0.016** **+0.023** +0.0006 +0.0009	**0.008L** **0.023L** 0.0003L 0.0009L	**+0.008** **+0.015** +0.0003 +0.0006	**0.000** **0.015L** 0.0000 0.0006L	**0.000** **+0.008** 0.0000 +0.0003	**0.008T** **0.008L** 0.0003T 0.0003L	**-0.007** **0.000** -0.0003 0.0000	**0.015T** **0.000** 0.0006T 0.0000	**-0.015** **-0.008** -0.0006 -0.0003	**0.023T** **0.008T** 0.0009T 0.0003T

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

ISO + J PREFIX
CLASS C (Metric)



Deviation from nominal (maximum) bearing bore and resultant fit.

T= Tight
L = Loose

TABLE 91. PRECISION CLASS TAPERED ROLLER BEARINGS – SHAFT O.D.
ISO + J Prefix, Classes C (Metric)

Inner Ring Bore		Tolerance	Ground Seat								
Range			Rotating Inner Ring						Stationary Inner Ring		
			Precision Machine Tool Spindles			Heavy Loads, High Speed or Shock			Moderate Loads, No Shock		
Over	Incl.		Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	
10.000 0.3937	**18.000** 0.7087	**-0.007** **0.000** -0.0003 0.0000	**+0.009** **+0.001** +0.0004 +0.0001	**0.016T** **0.001T** 0.0006T 0.0001T	k5	**+0.018** **+0.007** +0.0007 +0.0003	**0.025T** **0.007T** 0.0010T 0.0003T	m6	**+0.009** **+0.001** +0.0004 +0.0001	**0.016T** **0.001T** 0.0006T 0.0001T	k5
18.000 0.7087	**30.000** 1.1811	**-0.008** **0.000** -0.0003 0.0000	**+0.011** **+0.002** +0.0004 +0.0001	**0.019T** **0.002T** 0.0007T 0.0001T	k5	**+0.017** **+0.008** +0.0007 +0.0003	**0.025T** **0.008T** 0.0010T 0.0003T	m5	**+0.011** **+0.002** +0.0004 +0.0001	**0.019T** **0.002T** 0.0007T 0.0001T	k5
30.000 1.1811	**50.000** 1.9685	**-0.010** **0.000** -0.0004 0.0000	**+0.013** **+0.002** +0.0005 +0.0001	**0.023T** **0.002T** 0.0009T 0.0001T	k5	**+0.020** **+0.009** +0.0008 +0.0003	**0.030T** **0.009T** 0.0012T 0.0003T	m5	**+0.013** **+0.002** +0.0005 +0.0001	**0.023T** **0.002T** 0.0009T 0.0001T	k5
50.000 1.9685	**80.000** 3.1496	**-0.012** **0.000** -0.0005 0.0000	**+0.015** **+0.002** +0.0006 +0.0001	**0.027T** **0.002T** 0.0011T 0.0001T	k5	**+0.033** **+0.020** +0.0013 +0.0008	**0.045T** **0.020T** 0.0018T 0.0008T	n5	**+0.015** **+0.002** +0.0006 +0.0001	**0.027T** **0.002T** 0.0011T 0.0001T	k5
80.000 3.1496	**120.000** 4.7244	**-0.015** **0.000** -0.0006 0.0000	**+0.018** **+0.003** +0.0007 +0.0001	**0.033T** **0.003T** 0.0013T 0.0001T	k5	**+0.038** **+0.023** +0.0015 +0.0010	**0.053T** **0.023T** 0.0021T 0.0010T	n5	**+0.018** **+0.003** +0.0007 +0.0001	**0.033T** **0.003T** 0.0013T 0.0001T	k5
120.000 4.7244	**180.000** 7.0866	**-0.018** **0.000** -0.0007 0.0000	**+0.021** **+0.003** +0.0008 +0.0001	**0.038T** **0.003T** 0.0015T 0.0001T	k5	**+0.056** **+0.043** +0.0022 +0.0017	**0.073T** **0.043T** 0.0029T 0.0017T	p4	**+0.021** **+0.003** +0.0008 +0.0001	**0.039T** **0.003T** 0.0015T 0.0001T	k5
180.000 7.0866	**200.000** 7.8740					**+0.091** **+0.077** +0.0036 +0.0030	**0.113T** **0.077T** 0.0044T 0.0030T				
200.000 7.8740	**225.000** 8.8583	**-0.022** **0.000** -0.0009 0.0000	**+0.024** **+0.004** +0.0010 +0.0002	**0.046T** **0.004T** 0.0018T 0.0002T	k5	**+0.094** **+0.080** +0.0037 +0.0031	**0.116T** **0.080T** 0.0046T 0.0031T	r4	**+0.024** **+0.004** +0.0010 +0.0002	**0.046T** **0.004T** 0.0018T 0.0002T	k5
225.000 8.8583	**250.000** 9.8425					**+0.098** **+0.084** +0.0039 +0.0033	**0.120T** **0.084T** 0.0047T 0.0033T				

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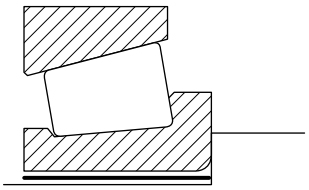
These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

Table 91 continued.

Inner Ring Bore		Tolerance	Ground Seat								
			Rotating Inner Ring						Stationary Inner Ring		
Range			Precision Machine Tool Spindles			Heavy Loads, High Speed or Shock			Moderate Loads, No Shock		
Over	Incl.		Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	
250.000 9.8425	**280.000** 11.0236	**-0.022** **0.000** -0.0009 0.0000	**+0.027** **+0.004** +0.0011 +0.0002	**0.048T** **0.004T** 0.0019T 0.0002T	k5	**+0.117** **+0.094** +0.0046 +0.0037	**0.139T** **0.094T** 0.0055T 0.0037T	r5	**+0.027** **+0.004** +0.0011 +0.0002	**0.049T** **0.004T** 0.0020T 0.0002T	k5
280.000 11.0236	**315.000** 12.4016					**+0.121** **+0.098** +0.0048 +0.0039	**0.143T** **0.098T** 0.0056T 0.0039T				
315.000 12.4016	**355.000** 13.9764	**-0.025** **0.000** -0.0010 0.0000	**+0.029** **+0.004** +0.0011 +0.0002	**0.054T** **0.004T** 0.0019T 0.0002T	k5	**+0.133** **+0.108** +0.0052 +0.0043	**0.154T** **0.108T** 0.0061T 0.0043T	r5	**+0.029** **+0.004** +0.0012 +0.0002	**0.054T** **0.004T** 0.0019T 0.0002T	k5
355.000 13.9764	**400.000** 15.7480					**+0.139** **+0.144** +0.0055 +0.0057	**0.164T** **0.114T** 0.0065T 0.0045T				
400.000 15.7480	**450.000** 17.7165	**-0.025** **0.000** -0.0010 0.0000	**+0.022** **+0.005** +0.0009 +0.0002	**0.057T** **0.005T** 0.0022T 0.0002T	k5	**+0.153** **+0.126** +0.0060 +0.0050	**0.178T** **0.126T** 0.0070T 0.0050T	r5	**+0.032** **+0.005** +0.0011 +0.0002	**0.057T** **0.005T** 0.0021T 0.0002T	k5
450.000 17.7165	**500.000** 19.6850					**+0.159** **+0.132** +0.0063 +0.0052	**0.184T** **0.132T** 0.0072T 0.0052T				
500.000 19.6850	**630.000** 24.8032	**-0.030** **0.000** -0.0012 0.0000	**+0.040** **+0.010** +0.0016 +0.0004	**0.070T** **0.010T** 0.0028T 0.0004T	–	**+0.185** **+0.150** +0.0073 +0.0059	**0.215T** **0.150T** 0.0085T 0.0059T	–	**+0.040** **+0.010** +0.0016 +0.0004	**0.070T** **0.010T** 0.0028T 0.0004T	–
630.000 24.8032	**800.000** 31.4961	**-0.040** **0.000** -0.0016 0.0000	**0.055** **+0.015** +0.0022 +0.0006	**0.095T** **0.015T** 0.0037T 0.0006T	–	**+0.220** **+0.175** +0.0087 +0.0069	**0.260T** **0.175T** 0.0102T 0.0069T	–	**0.055** **+0.015** +0.0022 +0.0006	**0.095T** **0.015T** 0.0037T 0.0006T	–
800.000 31.4961	**1000.000** 39.3701	**-0.050** **0.000** -0.0020 0.0000	**+0.065** **+0.015** +0.0026 +0.0006	**0.115T** **0.015T** 0.0045T 0.0006T	–	**+0.255** **+0.200** +0.0100 +0.0079	**0.305T** **0.200T** 0.0120T 0.0079T	–	**+0.065** **+0.015** +0.0026 +0.0006	**0.115T** **0.015T** 0.0045T 0.0006T	–

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

ISO + J PREFIX
Class B (Metric)



Deviation from nominal (maximum) bearing bore and resultant fit.

T= Tight
L = Loose

TABLE 92. PRECISION CLASS TAPERED ROLLER BEARINGS – SHAFT O.D.
ISO + J Prefix, Classes B (Metric)

Inner Ring Bore		Tolerance	Ground Seat								
			Rotating Inner Ring						Stationary Inner Ring		
Range			Moderate Loads, No Shock			Heavy Loads, High Speed or Shock			Moderate Loads, No Shock		
Over	Incl.		Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	
10.000 0.3937	**18.000** 0.7087	**-0.005** **0.000** -0.0002 0.0000	**+0.009** **+0.001** +0.0004 +0.0001	**0.014T** **0.001T** 0.0006T 0.0001T	k5	**+0.015** **+0.007** +0.0006 +0.0003	**0.020T** **0.007T** 0.0008T 0.0003T	m5	**+0.009** **+0.001** +0.0004 +0.0001	**0.014T** **0.001T** 0.0006T 0.0001T	k5
18.000 0.7087	**30.000** 1.1811	**-0.006** **0.000** -0.0002 0.0000	**+0.011** **+0.002** +0.0005 +0.0001	**0.017T** **0.002T** 0.0007T 0.0001T	k5	**+0.017** **+0.008** +0.0007 +0.0003	**0.023T** **0.008T** 0.0009T 0.0003T	m5	**+0.011** **+0.002** +0.0005 +0.0001	**0.017T** **0.002T** 0.0007T 0.0001T	k5
30.000 1.1811	**50.000** 1.9685	**-0.008** **0.000** -0.0003 0.0000	**+0.013** **+0.002** +0.0005 +0.0001	**0.021T** **0.002T** 0.0008T 0.0001T	k5	**+0.020** **+0.009** +0.0008 +0.0004	**0.028T** **0.009T** 0.0011T 0.0004T	m5	**+0.013** **+0.002** +0.0005 +0.0001	**0.021T** **0.002T** 0.0008T 0.0001T	k5
50.000 1.9685	**80.000** 3.1496	**-0.009** **0.000** -0.0004 0.0000	**+0.015** **+0.002** +0.0006 +0.0001	**0.024T** **0.002T** 0.0010T 0.0001T	k5	**+0.033** **+0.020** +0.0013 +0.0008	**0.042T** **0.020T** 0.0017T 0.0008T	n5	**+0.015** **+0.002** +0.0006 +0.0001	**0.024T** **0.002T** 0.0010T 0.0001T	k5
80.000 3.1496	**120.000** 4.7244	**-0.010** **0.000** -0.0004 0.0000	**+0.018** **+0.003** +0.0007 +0.0001	**0.028T** **0.003T** 0.0011T 0.0001T	k5	**+0.033** **+0.023** +0.0014 +0.0010	**0.043T** **0.023T** 0.0018T 0.0010T	n4	**+0.018** **+0.003** +0.0007 +0.0001	**0.028T** **0.003T** 0.0011T 0.0001T	k5
120.000 4.7244	**180.000** 7.0866	**-0.013** **0.000** -0.0005 0.0000	**+0.021** **+0.003** +0.0008 +0.0001	**0.034T** **0.003T** 0.0013T 0.0001T	k5	**+0.055** **+0.043** +0.0023 +0.0018	**0.068T** **0.043T** 0.0028T 0.0018T	p4	**+0.021** **+0.003** +0.0008 +0.0001	**0.034T** **0.003T** 0.0013T 0.0001T	k5
180.000 7.0866	**200.000** 7.8740	**-0.015** **0.000** -0.0006 0.0000	**+0.024** **+0.004** +0.0010 +0.0002	**0.039T** **0.004T** 0.0015T 0.0002T	k5	**+0.091** **+0.077** +0.0036 +0.0030	**0.106T** **0.077T** 0.0042T 0.0030T	r4	**+0.024** **+0.004** +0.0010 +0.0002	**0.046T** **0.004T** 0.0015T 0.0002T	k5
200.000 7.8740	**225.000** 8.8583					**+0.094** **+0.080** +0.0037 +0.0031	**0.109T** **0.084T** 0.0043T 0.0031T				
225.000 8.8583	**250.000** 9.8425					**+0.098** **+0.084** +0.0039 +0.0033	**0.113T** **0.084T** 0.0044T 0.0033T				
250.000 9.8425	**280.000** 11.0236	**-0.018** **0.000** -0.0007 0.00000	**+0.027** **+0.004** +0.0011 +0.0002	**0.045T** **0.004T** 0.0018T 0.0002T	k5	**+0.110** **+0.094** +0.0043 +0.0037	**0.128T** **0.094T** 0.0050T 0.0037T	r4	**+0.027** **+0.004** +0.0011 +0.0002	**0.045T** **0.004T** 0.0018T 0.0002T	k5
280.000 11.0236	**315.000** 12.4016					**+0.114** **+0.098** +0.0045 +0.0039	**0.132T** **0.098T** 0.0052T 0.0039T				

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

ISO + J PREFIX
Classes A and AA (Metric)

Deviation from nominal (maximum) bearing bore and resultant fit.

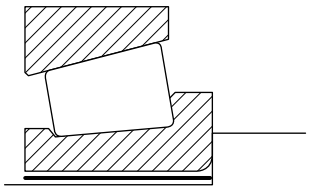
T= Tight

L = Loose

TABLE 93. PRECISION CLASS TAPERED ROLLER BEARINGS – SHAFT O.D.
ISO + J Prefix, Classes A and AA (Metric)

Inner Ring Bore		Tolerance	Ground Seat								
			Rotating Inner Ring						Stationary Inner Ring		
Range			Precision Machine Tool Spindles			Heavy Loads, High Speed or Shock			Moderate Loads, No Shock		
Over	Incl.		Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol	Inner Ring Seat Deviation	Resultant Fit	Symbol
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		**mm** in.	**mm** in.		**mm** in.	**mm** in.	
10.000 0.3937	**18.000** 0.7087	**-0.005 0.000** -0.0002 0.0000	**+0.013 +0.005** +0.0005 +0.0002	**0.018T 0.005T** 0.0007T 0.0002T	–	–	–	–	**+0.013 +0.005** +0.0005 +0.0002	**0.018T 0.005T** 0.0007T 0.0002T	–
18.000 0.7087	**30.000** 1.1811	**-0.006 0.000** -0.0002 0.0000	**+0.013 +0.005** +0.0005 +0.0002	**0.019T 0.005T** 0.0007T 0.0002T	–	–	–	–	**+0.013 +0.005** +0.0005 +0.0002	**0.019T 0.005T** 0.0007T 0.0002T	–
30.000 1.1811	**315.000** 12.4016	**-0.008 0.000** -0.0003 0.0000	**+0.013 +0.005** +0.0005 +0.0002	**0.021T 0.005T** 0.0008T 0.0002T	–	–	–	–	**+0.013 +0.005** +0.0005 +0.0002	**0.021T 0.005T** 0.0008T 0.0002T	–

ISO + J PREFIX
Classes 3 and 0, Classes 00 and 000 (Inch)



Deviation from nominal (minimum) bearing bore and resultant fit.

T= Tight

L = Loose

TABLE 94. PRECISION CLASS TAPERED ROLLER BEARINGS – SHAFT O.D.
ISO + J PREFIX, CLASSES 3 AND 0[1], AND 00 AND 000 (Inch)

Inner Ring Bore		Tolerance	Class 3 or 0[1]			Class 00 and 000		
			Rotating Inner Ring or Stationary Inner Ring					
Range			Moderate Loads, No Shock		Heavy Loads, High Speed or Shock	Tolerance	Shaft O.D. Deviation	Resultant Fit
Over	Incl.		Inner Ring Seat Deviation	Resultant Fit				
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0.000 0.0000	**304.800** 12.0000	**0.000 +0.013** 0.0000 +0.0005	**+0.031 +0.018** +0.0012 +0.0007	**0.031T 0.005T** 0.0012T 0.0002T	Use Minimum Tight Inner Ring Fit of 0.00025 mm/mm (0.00025 in./in.) of Inner Ring Bore	**0.000 +0.008** 0.0000 +0.0003	**+0.020 +0.013** +0.0008 +0.0005	**0.020T 0.005T** 0.0008T 0.0002T
304.800 12.0000	**609.600** 24.0000	**0.000 +0.025** 0.0000 +0.0010	**+0.064 +0.038** +0.0025 +0.0015	**0.064T 0.013T** 0.0025T 0.0005T		– –	– –	– –
609.600 24.0000	**914.400** 36.0000	**0.000 +0.038** 0.0000 +0.0015	**+0.102 +0.064** +0.0040 +0.0025	**0.102T 0.026T** 0.0040T 0.0010T		– –	– –	– –

[1]Maximum inner ring bore for class 0 is 241.300 (9.5000 in.).

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

TXR

Suggested fitting guidelines for ferrous shaft and housing

For heavy loads, high speed or shock, contact your Timken engineer for further information.

TXR
Classes S and P (Metric)

Deviation from nominal (maximum) bearing bore and resultant fit.

T= Tight
L = Loose

TABLE 95. PRECISION CLASS TXR TAPERED ROLLER BEARINGS – SHAFT O.D.
TXR Classes S and P (Metric)

Bearing Bore Range Over	Bearing Bore Range Incl.	Class S Max.	Class S Min.	Class P Max.	Class P Min.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
– –	**50.000** 1.9685	**0.020T** 0.0008T	**0.007T** 0.0003T	**0.014T** 0.0006T	**0.004T** 0.0002T
50.000 1.9685	**80.000** 3.1496	**0.025T** 0.0010T	**0.010T** 0.0004T	**0.017T** 0.0007T	**0.004T** 0.0002T
80.000 3.1496	**120.000** 4.7244	**0.033T** 0.0013T	**0.013T** 0.0005T	**0.017T** 0.0007T	**0.004T** 0.0002T
120.000 4.7244	**180.000** 7.0866	**0.052T** 0.0021T	**0.027T** 0.0011T	**0.017T** 0.0007T	**0.004T** 0.0002T
180.000 7.0866	**250.000** 9.8425	**0.060T** 0.0024T	**0.030T** 0.0012T	**0.020T** 0.0008T	**0.004T** 0.0002T
250.000 9.8425	**315.000** 12.4016	**0.070T** 0.0028T	**0.035T** 0.0014T	**0.022T** 0.0009T	**0.004T** 0.0002T
315.000 12.4016	**400.000** 15.7480	**0.077T** 0.0030T	**0.037T** 0.0015T	**0.024T** 0.0009T	**0.004T** 0.0002T
400.000 15.7480	**500.000** 19.6850	**0.085T** 0.0034T	**0.040T** 0.0016T	**0.030T** 0.0012T	**0.004T** 0.0002T

TABLE 96. PRECISION CLASS TXR TAPERED ROLLER BEARINGS – HOUSING BORE
TXR Classes S and P (Metric)

Bearing Bore Range Over	Bearing Bore Range Incl.	Class S Max.	Class S Min.	Class P Max.	Class P Min.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
– –	**50.000** 1.9685	**0.020T** 0.0008T	**0.007T** 0.0003T	**0.014T** 0.0006T	**0.004T** 0.0002T
50.000 1.9685	**80.000** 3.1496	**0.025T** 0.0010T	**0.010T** 0.0004T	**0.017T** 0.0007T	**0.004T** 0.0002T
80.000 3.1496	**120.000** 4.7244	**0.033T** 0.0013T	**0.013T** 0.0005T	**0.017T** 0.0007T	**0.004T** 0.0002T
120.000 4.7244	**180.000** 7.0866	**0.052T** 0.0021T	**0.027T** 0.0011T	**0.017T** 0.0007T	**0.004T** 0.0002T
180.000 7.0866	**250.000** 9.8425	**0.060T** 0.0024T	**0.030T** 0.0012T	**0.020T** 0.0008T	**0.004T** 0.0002T
250.000 9.8425	**315.000** 12.4016	**0.070T** 0.0028T	**0.035T** 0.0014T	**0.022T** 0.0009T	**0.004T** 0.0002T
315.000 12.4016	**400.000** 15.7480	**0.077T** 0.0030T	**0.037T** 0.0015T	**0.024T** 0.0009T	**0.004T** 0.0002T
400.000 15.7480	**500.000** 19.6850	**0.085T** 0.0034T	**0.040T** 0.0016T	**0.030T** 0.0012T	**0.004T** 0.0002T

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

TXR
Classes 3 and 0 (Inch)

Deviation from nominal (maximum) bearing bore and resultant fit.

T= Tight
L = Loose

TABLE 97. PRECISION CLASS TXR TAPERED ROLLER BEARINGS – SHAFT O.D.
TXR Classes 3 and 0 (Inch)

Bearing Bore Range Over	Bearing Bore Range Incl.	Class 3 Max.	Class 3 Min.	Class 0 Max.	Class 0 Min.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
– –	**304.800** 12.0000	**0.037T** 0.0015T	**0.013T** 0.0005T	**0.020T** 0.0008T	**0.007T** 0.0003T
304.800 12.0000	**609.600** 24.0000	**0.077T** 0.0030T	**0.025T** 0.0010T	**0.037T** 0.0015T	**0.013T** 0.0005T
609.600 24.0000	**914.400** 36.0000	**0.114T** 0.0045T	**0.037T** 0.0015T	– –	– –
914.400 36.0000	**1219.200** 48.0000	**0.152T** 0.0060T	**0.051T** 0.0020T	– –	– –
1219.200 48.0000	– –	**0.191T** 0.0075T	**0.064T** 0.0025T	– –	– –

TABLE 98. PRECISION CLASS TXR TAPERED ROLLER BEARINGS – HOUSING BORE
TXR Classes 3 and 0 (Inch)

Bearing Bore Range Over	Bearing Bore Range Incl.	Class 3 Max.	Class 3 Min.	Class 0 Max.	Class 0 Min.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
– –	**304.800** 12.0000	**0.037T** 0.0015T	**0.013T** 0.0005T	**0.020T** 0.0008T	**0.007T** 0.0003T
304.800 12.0000	**609.600** 24.0000	**0.077T** 0.0030T	**0.025T** 0.0010T	**0.037T** 0.0015T	**0.013T** 0.0005T
609.600 24.0000	**914.400** 36.0000	**0.114T** 0.0045T	**0.037T** 0.0015T	– –	– –
914.400 36.0000	**1219.200** 48.0000	**0.152T** 0.0060T	**0.051T** 0.0020T	– –	– –
1219.200 48.0000	– –	**0.191T** 0.0075T	**0.064T** 0.0025T	– –	– –

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

THRUST BEARINGS

THRUST BALL BEARINGS

Shaft and housing diameters shown as variance from nominal dimensions.

TABLE 99. THRUST BALL BEARINGS TYPE TVB – SHAFT FITS

Bearing Bore Nominal (Min.)		Shaft Diameter	
Over	Incl.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.
0.000 0.0000	**171.450** 6.7500	**+0.000** +0.0000	**-0.030** -0.0012
171.450 6.7500	**508.000** 20.0000	**+0.000** +0.0000	**-0.038** -0.0015

TABLE 100. THRUST BALL BEARINGS TYPE TVL AND DTVL – SHAFT FITS

Bearing Bore Nominal (Min.)		Shaft Diameter			
		Interference Fit[1]		Loose Fit[2]	
Over	Incl.	Max.	Min.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0.000 0.0000	**504.825** 19.8750	**+0.076** +0.0030	**+0.000** +0.0000	**-0.152** -0.0060	**-0.076** -0.0030
504.825 19.8750	**1524.000** 60.0000	**+0.127** +0.0050	**+0.000** +0.0000	**-0.254** -0.0100	**-0.127** -0.0050

TABLE 101. THRUST BALL BEARINGS TYPE TVB – HOUSING FITS

Bearing Bore Nominal (Min.)		Housing Diameter	
Over	Incl.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.
119.858 4.7188	**441.325** 17.3750	**+0.229** +0.0090	**+0.127** +0.0050
441.325 17.3750	**1000.000** 39.3701	**+0.254** +0.0100	**+0.152** +0.0060

TABLE 102. THRUST BALL BEARINGS TYPE TVL AND DTVL – HOUSING FITS

Bearing Bore Nominal (Min.)		Housing Diameter			
		Interference Fit[1]		Loose Fit[2]	
Over	Incl.	Max.	Min.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0.000 0.0000	**584.000** 23.0000	**-0.152** -0.0060	**-0.076** -0.0030	**+0.152** +0.0060	**0.076** 0.0030
584.000 23.0000	**1778.000** 70.0000	**-0.254** -0.0100	**-0.127** -0.0050	**+0.254** +0.0100	**0.127** 0.0050

[1]Dowel pin suggested.
[2]Dowel pin required.

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

THRUST SPHERICAL ROLLER BEARINGS

Tolerances for housing bore and for shaft diameters are shown as variance from nominal bearing dimension. When application calls for thrust loads only, the housing must be relieved by 1/16 in. on diameter so that no radial load is carried on the bearing.

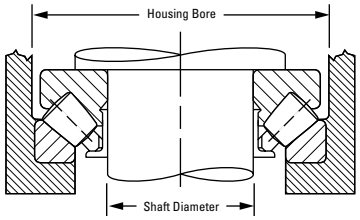


TABLE 103. THRUST SPHERICAL ROLLER BEARINGS SHAFT FITS

Bearing Bore Nominal (Max.) Inches		Shaft Diameter			
		Stationary Load		Rotation Load	
Over	Incl.	Max.	Min.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
80.000 3.1496	**120.000** 4.7244	**+0.013** +0.0005	**-0.010** -0.0004	**+0.025** +0.0010	**+0.003** +0.0001
120.000 4.7244	**180.000** 7.0866	**+0.015** +0.0006	**-0.010** -0.0004	**+0.028** +0.0011	**+0.003** +0.0001
180.000 7.0866	**200.000** 7.8740	**+0.018** +0.0007	**-0.013** -0.0005	**+0.036** +0.0014	**+0.005** +0.0002
200.000 7.8740	**240.000** 9.4488	**+0.018** +0.0007	**-0.013** -0.0005	**+0.046** +0.0018	**+0.015** +0.0006
240.000 9.4488	**315.000** 12.0416	**+0.018** +0.0007	**-0.015** -0.0006	**+0.051** +0.0020	**+0.020** +0.0008
315.000 12.0416	**400.000** 15.7480	**+0.018** +0.0007	**-0.018** -0.0007	**+0.056** +0.0022	**+0.020** +0.0008
400.000 15.7480	**500.000** 19.6850	**+0.023** +0.0009	**-0.018** -0.0007	**+0.086** +0.0034	**+0.046** +0.0018
500.000 19.6850	**630.000** 24.8031	**+0.023** +0.0009	**-0.020** -0.0008	**+0.086** +0.0034	**+0.043** +0.0017

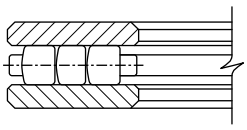
TABLE 104. THRUST SPHERICAL ROLLER BEARINGS HOUSING FITS

Bearing O.D. Nominal (Max.) Inches		Housing Bore					
		Springs in Housing Light Radial Load		Combined Axial & Radial Load			
				Stationary Outer Ring		Rotating Outer Ring	
Over	Incl.	Max.	Min.	Max.	Min.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
180.000 7.0866	**250.000** 9.8425	**+0.061** +0.0024	**+0.015** +0.0006	**+0.028** +0.0011	**-0.018** -0.0007	**+0.013** +0.0005	**-0.033** -0.0013
250.000 9.8425	**315.000** 12.0416	**+0.069** +0.0027	**+0.018** +0.0007	**+0.033** +0.0013	**-0.018** -0.0007	**+0.015** +0.0006	**-0.036** -0.0014
315.000 12.0416	**400.000** 15.7480	**+0.074** +0.0029	**+0.018** +0.0007	**+0.038** +0.0015	**-0.018** -0.0007	**+0.015** +0.0006	**-0.041** -0.0016
400.000 15.7480	**500.000** 19.6850	**+0.084** +0.0033	**+0.020** +0.0008	**+0.041** +0.0016	**-0.023** -0.0009	**+0.018** +0.0007	**-0.046** -0.0018
500.000 19.6850	**630.000** 24.8031	**+0.091** +0.0036	**+0.023** +0.0009	**+0.046** +0.018	**-0.023** -0.0009	**+0.020** +0.0008	**-0.048** -0.0019
630.000 24.8031	**800.000** 31.4960	**+0.102** +0.0040	**+0.023** +0.0009	**+0.051** +0.0020	**-0.023** -0.0009	**+0.023** +0.0009	**-0.051** -0.0020
800.000 31.4960	**1000.000** 39.3700	**+0.109** +0.0043	**+0.025** +0.0010	**+0.058** +0.0023	**-0.025** -0.0010	**+0.025** +0.0010	**-0.058** -0.0023
1000.000 39.3700	**1250.000** 49.2126	**+0.122** +0.0048	**+0.028** +0.0011	**+0.066** +0.0026	**-0.028** -0.0011	**+0.030** +0.0012	**-0.064** -0.0025

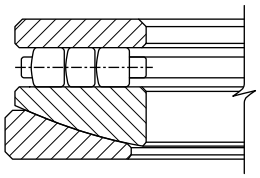
These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

THRUST CYLINDRICAL ROLLER BEARINGS

Tolerances for housing bore and for shaft diameters shown as variance from nominal bearing dimension.



TP



TPS

TABLE 105. TYPE TP AND TPS – SHAFT FITS

Bearing O.D. Nominal (Min.)		Shaft Diameter	
Over	Incl.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.
47.625 1.8750	**53.975** 2.1250	**-0.025** -0.0010	**-0.051** -0.0020
53.975 2.1250	**63.500** 2.5000	**-0.028** -0.0011	**-0.053** -0.0021
63.500 2.5000	**76.200** 3.0000	**-0.030** -0.0012	**-0.056** -0.0022
76.200 3.0000	**88.900** 3.5000	**-0.033** -0.0012	**-0.058** -0.0023
88.900 3.5000	**177.800** 7.0000	**-0.038** -0.0015	**-0.064** -0.0025
177.800 7.0000	**228.600** 9.0000	**-0.038** -0.0015	**-0.076** -0.0030
228.600 9.0000	**304.800** 12.0000	**-0.046** -0.0018	**-0.084** -0.0033
304.800 12.0000	**381.000** 15.0000	**-0.051** -0.0020	**-0.089** -0.0035
381.000 15.0000	**482.600** 19.0000	**-0.051** -0.0020	**-0.102** -0.0040
482.600 19.0000	**584.200** 23.0000	**-0.064** -0.0025	**-0.114** -0.0045
584.200 23.0000	**762.000** 30.0000	**-0.076** -0.0030	**-0.140** -0.0055

TABLE 106. TYPE TPS – HOUSING FITS

Bearing O.D. Nominal (Min.)		Housing Diameter Deviation from D	
Over	Incl.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.
50.800 2.0000	**60.325** 2.3750	**+0.038** +0.0015	**+0.013** +0.0005
60.325 2.3750	**82.550** 3.2500	**+0.043** +0.0017	**+0.018** +0.0007
82.550 3.2500	**93.663** 3.6875	**+0.048** +0.0019	**+0.023** +0.0009
93.663 3.6875	**101.600** 4.0000	**+0.053** +0.0021	**+0.028** +0.0011
101.600 4.0000	**115.092** 4.5312	**+0.071** +0.0028	**+0.033** +0.0013
115.092 4.5312	**254.000** 10.0000	**+0.076** +0.0030	**+0.038** +0.0015
254.000 10.0000	**457.200** 18.0000	**+0.102** +0.0040	**+0.051** +0.0020
457.200 18.0000	**558.800** 22.0000	**+0.127** +0.0050	**+0.064** +0.0025
558.800 22.0000	**660.400** 26.0000	**+0.140** +0.0055	**+0.064** +0.0025
660.400 26.0000	**711.200** 28.0000	**+0.152** +0.0060	**+0.076** +0.0030
711.200 28.0000	**863.600** 34.0000	**+0.178** +0.0070	**+0.076** +0.0030
863.600 34.0000	**965.200** 38.0000	**+0.203** +0.0080	**+0.089** +0.0035
965.200 38.0000	**1117.600** 44.0000	**+0.229** +0.0090	**+0.102** +0.0040

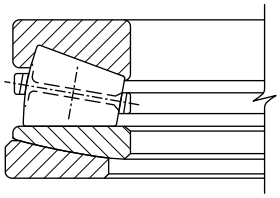
TABLE 107. TYPE TP – HOUSING FITS

Bearing O.D. Nominal (Min.)		Housing Diameter Deviation from D	
Over	Incl.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.
115.092 4.5312	**254.000** 10.0000	**+0.076** +0.0030	**+0.038** +0.0015
254.000 10.0000	**457.200** 18.0000	**+0.102** +0.0040	**+0.051** +0.002
457.200 18.0000	**558.800** 22.0000	**+0.127** +0.0050	**+0.064** +0.0025
558.800 22.0000	**660.400** 26.0000	**+0.140** +0.0055	**+0.064** +0.0025
660.400 26.0000	**711.200** 28.0000	**+0.152** +0.0060	**+0.076** +0.0030
711.200 28.0000	**863.600** 34.0000	**+0.178** +0.0070	**+0.076** +0.0030
863.600 34.0000	**965.200** 38.0000	**+0.203** +0.0080	**+0.089** +0.0035
965.200 38.0000	**1117.600** 44.0000	**+0.229** +0.0090	**+0.102** +0.0040

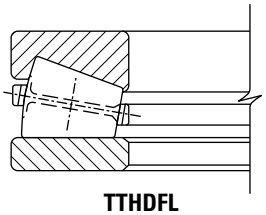
These charts are guidelines for specifying shaft and housing fits related to particular operating conditions. Please contact your Timken engineer for more information.

THRUST TAPERED ROLLER BEARINGS

Tolerances for housing bore and shaft diameters are shown as variance from nominal bearing dimension. When one ring is piloted by the housing, sufficient clearances must be allowed at the outside diameter of the other ring as well as at the bore of both rings to prevent cross-loading of the rollers. For most applications, this clearance is approximately 1/16 in. (1.588 mm, 0.0625 in.).



TTVS



TTHDFL

TABLE 108. THRUST TAPERED ROLLER BEARINGS TYPE TTVS AND TTHDFL – SHAFT DIAMETERS

Bearing Bore Nominal (Min.)		Shaft Diameter
Over	Incl.	Min.[1]
mm in.	**mm** in.	**mm** in.
0.000 0.0000	**304.800** 12.0000	**-0.051** -0.0020
304.800 12.0000	**508.000** 20.0000	**-0.051** -0.0020
508.000 20.0000	**711.200** 28.0000	**-0.076** -0.0030
711.200 28.0000	**1219.200** 48.0000	**-0.102** -0.0040
1219.200 48.0000	**1727.200** 68.0000	**-0.127** -0.0050

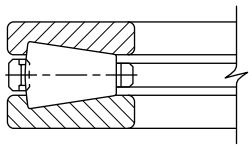
[1]Tolerance range is from +0 to value listed.

TABLE 109. THRUST TAPERED ROLLER BEARINGS TYPE TTVS AND TTHDFL – HOUSING DIAMETERS

Bearing Bore Nominal (Min.)		Housing Bore	
Over	Incl.	Max.	Min.
mm in.	**mm** in.	**mm** in.	**mm** in.
161.925 6.3750	**265.113** 10.4375	**+0.060** +0.0025	**+0.025** +0.0010
265.113 10.3475	**317.500** 12.5000	**+0.076** +0.0030	**+0.025** +0.0010
317.500 12.5000	**482.600** 19.0000	**+0.102** +0.0040	**+0.051** +0.0020
482.600 19.0000	**603.250** 23.7500	**+0.113** +0.0045	**+0.051** +0.0020
603.250 23.7500	**711.200** 28.0000	**+0.152** +0.0060	**+0.076** +0.0030
711.200 28.0000	**838.200** 33.0000	**+0.178** +0.0070	**+0.076** +0.0030

TABLE 110. THRUST TAPERED ROLLER BEARINGS – TTHD BEARINGS – FITTING GUIDELINES

Bore		Rotating Ring						Stationary Ring	
			Class 2			Class 3			
Over	Incl.	Tolerance	Shaft O.D. Deviation	Resultant Fit	Tolerance	Shaft O.D. Deviation	Resultant Fit	Class 2 and 3	
mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.		
0.000 0.0000	**304.800** 12.0000	**0.000** **+0.025** 0.0000 +0.0010	**+0.076** **+0.050** +0.0030 +0.0020	**0.076T** **0.025T** 0.0030T 0.0010T	**0.000** **+0.013** 0.0000 +0.0005	**+0.051** **+0.038** +0.0020 +0.0015	**0.051T** **0.025T** 0.0020T 0.0010T	All sizes	Provide a minimum radial clearance of 2.5 mm (0.1 in.) between ring bore and shaft O.D.
304.800 12.0000	**609.600** 24.0000	**0.000** **+0.051** 0.0000 +0.0020	**+0.152** **+0.102** +0.0060 +0.0040	**0.152T** **0.051T** 0.0060T 0.0020T	**0.000** **+0.025** 0.0000 +0.0010	**+0.102** **+0.076** +0.0040 +0.0030	**0.102T** **0.051T** 0.0040T 0.0020T		
609.600 24.0000	**914.400** 36.0000	**0.000** **+0.076** 0.0000 +0.0030	**+0.204** **+0.127** +0.0080 +0.0050	**0.204T** **0.051T** 0.0080T 0.0020T	**0.000** **+0.038** 0.0000 +0.0015	**+0.127** **+0.089** +0.0050 +0.0035	**0.127T** **0.051T** 0.0050T 0.0020T		
914.400 36.0000	**1219.200** 48.0000	**0.000** **+0.102** 0.0000 +0.0040	**+0.254** **+0.153** +0.0100 +0.0060	**0.254T** **0.051T** 0.0100T 0.0020T	**0.000** **+0.051** 0.0000 +0.0020	**+0.153** **+0.102** +0.0060 +0.0040	**0.153T** **0.051T** 0.0060T 0.0020T		
1219.200 48.0000		**0.000** **+0.127** 0.0000 +0.0050	**+0.305** **+0.178** +0.0120 +0.0070	**0.305T** **0.051T** 0.0120T 0.0020T	**0.000** **+0.076** 0.0000 +0.0030	**+0.204** **+0.127** +0.0080 +0.0050	**0.204T** **0.051T** 0.0080T 0.0020T		



TTHD

- Rotating ring O.D. must have a minimum radial clearance of 2.5 mm (0.1 in.).
- TTHD stationary ring O.D. must have a minimum loose fit of 0.25 to 0.37 mm (0.01 to 0.015 in.).
- TTHDFL ring when stationary may be loose fit on its O.D. (same as the TTHD) or may be 0.025 to 0.076 mm (0.001 to 0.003 in.) tight.

OPERATING TEMPERATURES

Bearings operate in a wide range of applications and environments. In most cases, bearing operating temperature is not an issue. Some applications, however, operate at extreme speeds or in extreme temperature environments. In these cases, care must be taken not to exceed the temperature limits of the bearing. Minimum temperature limits are primarily based on lubricant capability. Maximum temperature limits are most often based on material and/or lubricant constraints, but also may be based on accuracy requirements of the equipment that the bearings are built into. These constraints/limitations are discussed below.

BEARING MATERIAL LIMITATIONS

Standard bearing steels with a standard heat treatment cannot maintain a minimum hardness of 58 HRC much above 120° C (250° F).

Dimensional stability of Timken bearings is managed through the proper selection of an appropriate heat-treat process. Standard Timken tapered roller and ball bearings are dimensionally stabilized from -54° C (-65° F) up to 120° C (250° F), while standard spherical roller bearings are dimensionally stabilized up to 200° C (392° F) and standard cylindrical roller bearings are stabilized up to 150° C (302° F). Upon request, these bearings can be ordered to higher levels of stability as listed below. These designations are in agreement with DIN Standard 623.

TABLE 111.

Stability Designation	Maximum Operating Temperature	
	°C	°F
S0	**150**	302
S1	**200**	392
S2	**250**	482
S3	**300**	572
S4	**350**	662

With dimensionally stabilized product, there still may be some changes in dimensions during service as a result of microstructural transformations. These transformations include the continued tempering of martensite and decomposition of retained austenite. The magnitude of change depends on the operating temperature, the time at temperature and the composition and heat-treatment of the steel.

Temperatures exceeding the limits shown in Table 111 require special high-temperature steel. Consult your Timken engineer for availability of specific part numbers for non-standard heat stability or high-temperature steel grades.

Suggested materials for use in balls, rings and rollers at various operating temperatures are listed in table 112. Also listed are chemical composition recommendations, hardness recommendations and dimensional stability information.

Operating temperature affects lubricant film thickness and setting, both of which directly influence bearing life. Extremely high temperatures can result in a reduced film thickness that can lead to asperity contact between contacting surfaces.

Operating temperature also can affect performance of cages, seals and shields, which in turn can affect bearing performance. Materials for these components and their operating temperature ranges are shown in table 113.

LUBRICATION LIMITATIONS

Starting torque in grease-lubricated applications typically increases significantly at cold temperatures. Starting torque is not primarily a function of the consistency or channel properties of the grease. Most often, it is a function of the rheological properties of the grease.

The high-temperature limit for greases is generally a function of the thermal and oxidation stability of the base oil in the grease and the effectiveness of the oxidation inhibitors.

See the LUBRICATION AND SEALS section on page 199 for more information on lubrication limitations.

EQUIPMENT REQUIREMENTS

The equipment designer must evaluate the effects of temperature on the performance of the equipment being designed. Precision machine tool spindles, for example, can be very sensitive to thermal expansions. For some spindles, it is important that the temperature rise over ambient be held to 20° C to 35° C (36° F to 45° F).

Most industrial equipment can operate at considerably higher temperatures. Thermal ratings on gear drives, for example, are based on 93° C (200° F). Equipment such as gas turbines operates continuously at temperatures above 100° C (212° F). Running at high temperatures for extended periods of time, however, may affect shaft and housing fits, if the shaft and housing are not machined and heat-treated properly .

Although bearings can operate satisfactorily up to 120° C (250° F),

an upper temperature limit of 80° C to 95° C (176° F to 203° F) is more practical. Higher operating temperatures increase the risk of damage from transient temperature spikes. Prototype testing of the application can help define the operating temperature range and should be conducted if possible. It is the responsibility of the equipment designer to weigh all relevant factors and make the final determination of satisfactory operating temperature.

Tables 111 and 112 provide standard operating temperatures for common bearing component materials. They should be used for reference purposes only. Other bearing component materials are available on request. Contact your Timken engineer for more information.

TABLE 112. OPERATING TEMPERATURES FOR BEARING COMPONENT MATERIALS

Material	Approximate Chemical Analysis %	Temp. °F	Hardness HRC	-73° C -100° F	-54° C -65° F	-40° C -40° F	-17° C 0° F	121° C 250° F	204° C 400° F	316° C 600° F
Low-alloy carbon-chromium bearing steels. 52100 and others per ASTM A295	1C 0.5–1.5Cr 0.35Mn	70	60	STANDARD DIMENSIONAL STABILIZATION <0.0001 in./in dimensional change in 2500 hours at 100° C (212°F). Good oxidation resistance.						
Low-alloy carbon-chromium bearing steels. 52100 and others per ASTM A295	1C 0.5–1.5Cr 0.35Mn	70 350 450	58 56 54	Heat stabilized per FS136, <0.0001in./in dimensional change in 2500 hours at 149° C (300° F). When given a stabilizing heat treatment, A295 steel is suitable for many applications in the 177°-232° C (350-450° F) range; however, it is not as dimensionally stable as it is at temperatures below 177° C (350° F). If utmost stability is required, use materials in the 316° C (600° F) group below.						
Deep-hardening steels for heavy sections per ASTM A485	1C 1–1.8Cr 1–1.5Mn .06Si	70 450 600	58 55 52	As heat-treated and tempered, it is stabilized, <0.0001 in./in dimensional change in 2500 hours at 149° C (300° F).						
Carburizing steels per ASTM A534 a) low alloy 4118, 8X19, 5019, 8620 (Ni-Moly grades) b) high nickel 3310	Ni-Moly: 0.2C, 0.4-2.0Mn, 0.3-0.8Cr, 0-2.0Ni, 0-0.3Mo .0.1C, 1.5Cr, 0.4Mn, 3.5Ni	70	58			Nickel-Moly grades of steel frequently used to achieve extra ductility in inner rings for locking device bearings. 3311 and others used for extra-thick-section rings.				
Corrosion-resistant 440C stainless steel per ASTM A756	1C 18Cr	70	58		Excellent corrosion resistance.					
Corrosion-resistant 440C stainless steel per ASTM A756	1C 18Cr	70 450 600	58 55 52	As heat stabilized for maximum hardness at high temperatures (FS238). Good oxidation resistance at higher temperatures. Note load capacity drops off more rapidly at higher temperatures than M50 shown below, which should be considered if loads are high, <0.0001 in./in dimensional change in 1200 hours.						
M-50 medium high speed	4Cr 4Mo 1V 0.8C	70 450 600	60 59 57	Suggested where stable high hardness at elevated temperature is required, <0.0001 in./in dimensional change in 1200 hours at 316° C (600° F).						

Note: Dimensional stability data shown above is the permanent metallurgical growth and/or shrinkage only. Thermal expansion effects are not included. For operating temperatures above 427° C (800° F), consult your Timken engineer.

TABLE 113. OPERATING TEMPERATURES FOR BEARING COMPONENT MATERIALS

	-54° C / -65° F	-17° C / 0° F	38° C / 100° F	93° C / 200° F	149° C / 300° F	204° C / 400° F	260° C / 500° F	316° C / 600° F	371° C / 700° F	427° C / 800° F
CAGES										
Molded 6/6 nylon (PRB)		■	■	■	■					
Molded 6/6 fiberglass reinforced nylon (PRC)		■	■	■	■					
Phenolic resin laminate		■	■	■	■					
Low-carbon pressed steel		■	■	■	■	■	■			
Pressed stainless steel		■	■	■	■	■	■	■	■	
Machined bronze		■	■	■	■	■	■			
Machined iron-silicon bronze		■	■	■	■	■	■	■	■	
Machined steel		■	■	■	■	■	■	■	■	■
SHIELDS										
Low-carbon steel		■	■	■	■	■	■			
Stainless steel		■	■	■	■	■	■	■	■	■
Nylon			■	■	■					
SEALS										
Buna N			■	■						
Polyacrylic			■	■	■					
Fluoroelastomer			■	■	■	■				
Stabilized TFE fluorocarbon[1]		■	■	■	■	■	■	■		
TFE fluorocarbon[1] (with glass fabric)		■	■	■	■	■	■	■		

[1]Limited life above these temperatures.

HEAT GENERATION AND DISSIPATION

Bearing operating temperature is dependent upon a number of factors, including heat generation of all contributing heat sources, heat flow rate between sources and the ability of the system to dissipate the heat. Heat sources include such things as bearings, seals, gears, clutches and oil supply. Heat dissipation is affected by many factors, including shaft and housing materials and designs, lubricant circulation and external environmental conditions. These and other factors are discussed in the following sections.

HEAT GENERATION

Under normal operating conditions, most of the torque and heat generated by the bearing is caused by the elastohydrodynamic losses at the roller/ring contacts.

Heat generation is the product of bearing torque and speed. The following equation is used to calculate the heat generated.

$$Q_{gen} = k_4 n M$$

If the bearing is tapered, the torque can be calculated using the following equation.

$$M = k_1 G_1 (n\mu)^{0.62} (P_{eq})^{0.3}$$

Where:

k_1 = bearing torque constant
= 2.56×10^{-6} for M in N-m
= 3.54×10^{-5} for M in lbf-in.

k_4 = 0.105 for Q_{gen} in W when M in N-m
= 6.73 x 10-4 for Q_{gen} in Btu/min when M in lbf-in.

If the bearing is not a tapered bearing, the torque calculations are given in the subsequent sections.

HEAT DISSIPATION

The problem of determining the heat flow from a bearing in a specific application is rather complex. In general, it can be said that factors affecting the rate of heat dissipation include the following:

1. Temperature gradient from the bearing to the housing. This is affected by size configuration of the house and any external cooling such as fans, water cooling or fan action of the rotating components.
2. Temperature gradient from the bearing to the shaft. Any other heat sources, such as gears and additional bearings and their proximity to the bearing considered, will influence the temperature of the shaft.
3. The heat carried away by a circulating oil system.

To what extent nos. 1 and 2 can be controlled will depend on the application. The heat-dissipation modes include conduction through the system, convection along the inside and outside surfaces of the system, as well as radiation exchange to and from neighboring structures. In many applications, overall heat dissipation can be divided into two categories – heat removed by circulating oil and heat removed through the structure.

Heat dissipation by circulating oil

The amount of heat removed by the lubricant can be controlled more easily. In a splash lubrication system, cooling coils may be used to control the bulk oil temperature.

The amount of heat carried away in a circulating oil system by the lubricant can be approximated from the following equations.

$$Q_{oil} = k_6 C_p \rho f (\theta_o - \theta_i)$$

Where:

k_6 = 1.67×10^{-5} for Q_{oil} in W
= 1.67×10^{-2} for Q_{oil} in Btu/min

If the circulating lubricant is petroleum oil, the heat removed is further approximated by the following:

$$Q_{oil} = k_5 f (\theta_o - \theta_i)$$

The following factors apply to the heat generation and dissipation equations listed on this page.

Where:

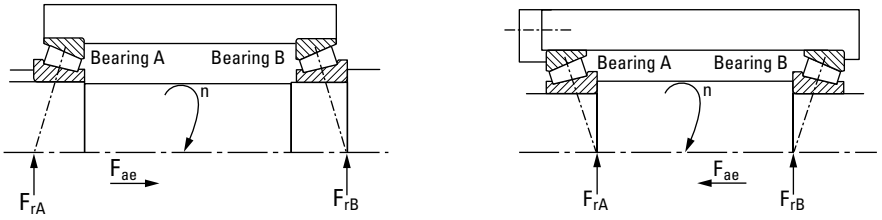
k_5 = 28 for Q_{oil} in W when f in L/min and θ in °C
= 0.42 for Q_{oil} in Btu/min when f in U.S. pt/min and θ in °F

TORQUE
TAPERED ROLLER BEARINGS

RUNNING TORQUE-M

The rotational resistance of a rolling bearing depends on load, speed, lubrication conditions and internal bearing characteristics.

The following formulas yield approximations to values of bearing running torque. The formulas apply to bearings lubricated by oil. For bearings lubricated by grease or oil mist, torque is usually lower, although for grease lubrication this depends on amount and consistency of the grease. The formulas also assume the bearing running torque has stabilized after an initial period referred to as running-in.



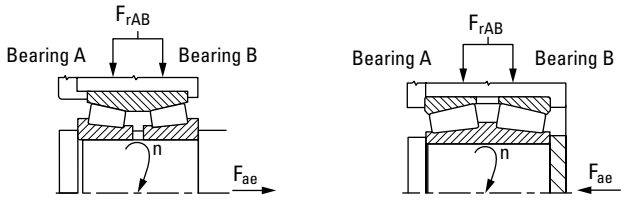
Design (external thrust, F_{ae}, onto bearing A)

Fig. 141. Single-row tapered roller bearing.

TABLE 114. VALUE APPROXIMATIONS OF BEARING RUNNING TORQUE

Thrust Condition	Net Bearing Thrust Load	
$\frac{0.47\,F_{rA}}{K_A} \le \frac{0.47\,F_{rB}}{K_B} + F_{ae}$	$F_{aA} = \frac{0.47\,F_{rB}}{K_B} + F_{ae}$ $F_{aB} = \frac{0.47\,F_{rB}}{K_B}$	$M = k_1 G_1 (n\mu)^{0.62} \left(\frac{f_3 F_r}{K}\right)^{0.3}$
$\frac{0.47\,F_{rA}}{K_A} > \frac{0.47\,F_{rB}}{K_B} + F_{ae}$	$F_{aA} = \frac{0.47\,F_{rA}}{K_A}$ $F_{aB} = \frac{0.47\,F_{rA}}{K_A} - F_{ae}$	$n_{min} = \frac{k_2}{G_2 \mu} \left(\frac{f_2 F_r}{K}\right)^{2/3}$

The torque equations will be underestimated if operating speed, n, is less than n_{min}. For values of f_1 and f_2, refer to fig. 144 on page 190.



Design (external thrust, F_{ae}, onto bearing A)

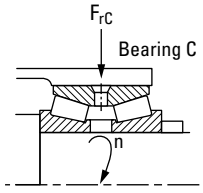
Fig. 142. Double-row tapered roller bearing.

TABLE 115. FIXED POSITION

Load Condition	Radial Load on Each Row F_r	
$F_{ae} > \frac{0.47\ F_{rAB}}{K_A}$	Bearing B is unloaded $F_{rA} = F_{rAB}$ $F_{aA} = F_{ae}$	$M = k_1\ G_1\ (n\mu)^{0.62} \left(\frac{f_3\ F_{rAB}}{K} \right)^{0.3}$ $n_{min} = \frac{k_2}{G_2\mu} \left(\frac{f_2\ F_{rAB}}{K} \right)^{2/3}$
$F_{ae} \leq \frac{0.47\ F_{rAB}}{K_A}$	$F_{rA} = \frac{F_{rAB}}{2} + 1.06\ K\ F_{ae}$ $F_{rB} = \frac{F_{rAB}}{2} - 1.06\ K\ F_{ae}$	$M = k_1\ G_1\ (n\mu)^{0.62} \left(\frac{0.060}{K} \right)^{0.3} (F_{rA}^{0.3} + F_{rB}^{0.3})$ $n_{minA} = \frac{k_2}{G_2\mu} \left(\frac{1.78F_{rA}}{K} \right)^{2/3}$; $n_{minB} = \frac{k_2}{G_2\mu} \left(\frac{1.78F_{rB}}{K} \right)^{2/3}$

$$M = 2\ k_1\ G_1\ (n\mu)^{0.62} \left(\frac{0.030\ F_{rC}}{K} \right)^{0.3}$$

$$n_{min} = \frac{k_2}{G_2\mu} \left(\frac{0.890\ F_r}{K} \right)^{2/3}$$

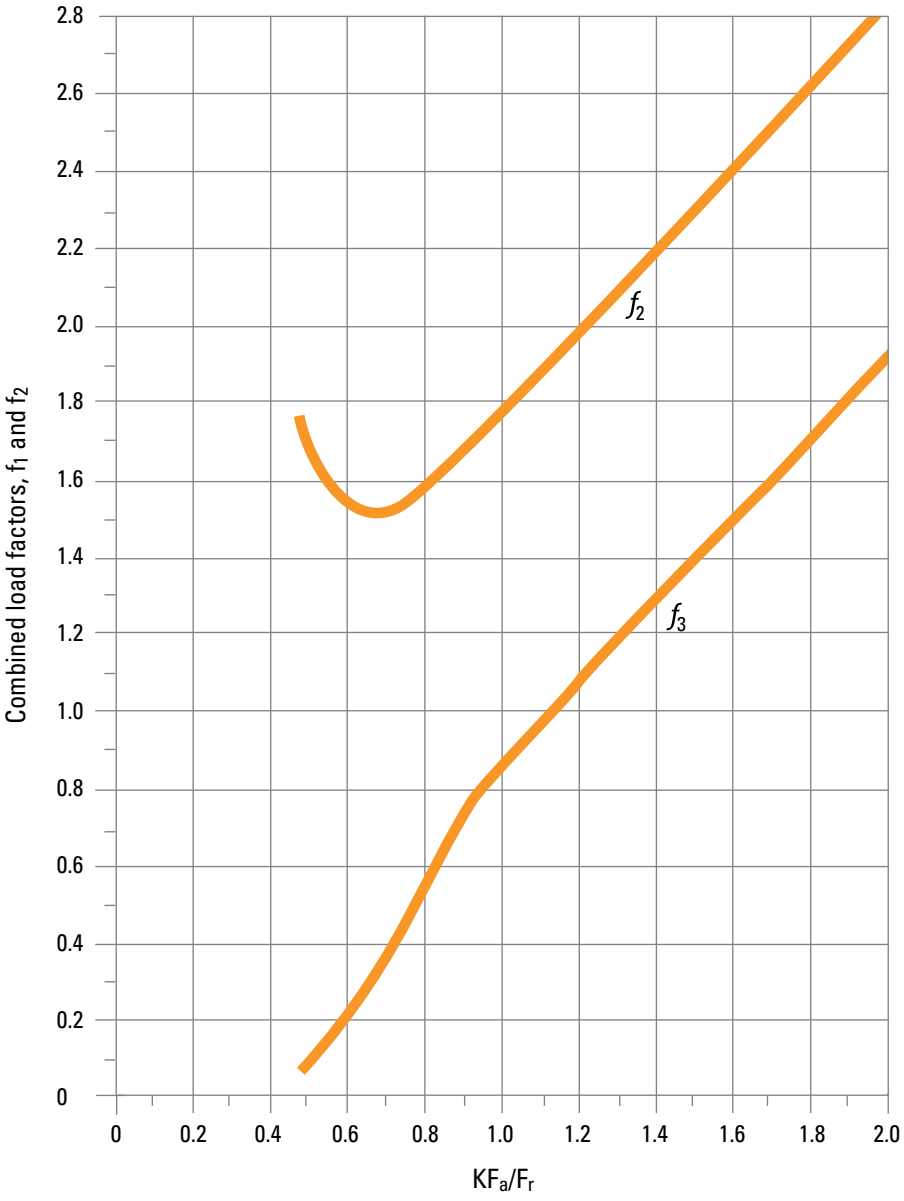


Floating bearing

The torque equations will be underestimated if operating speed, n, is less than n_{min}.
For values of f_1 and f_2, refer to Fig. 144 on page 190.

Fig. 143. Floating position.

k_1 = 2.56 x 10^{-6} (metric) or 3.54 x 10^{-5} (inch)
k_2 = 625 (metric) or 1700 (inch)
μ = lubricant dynamic viscosity at operating temperature centipoise
For grease, use the base oil viscosity.
f_3 = combined load factor, see fig. 144 on page 190
f_2 = combined load factor, see fig. 144 on page 190



Load Condition	f_3 and f_2
$KF_a/F_r > 2.0$	$f_3 = KF_a/F_r$ $f_2 = f_3 + 0.8$
$0.47 \le KF_a/F_r \le 2.0$	Use graph above
$KF_a/F_r < 0.47$	$f_3 = 0.06$ $f_3 = 1.78$

Fig. 144. Determination of combined load factors f_3 and f_2.

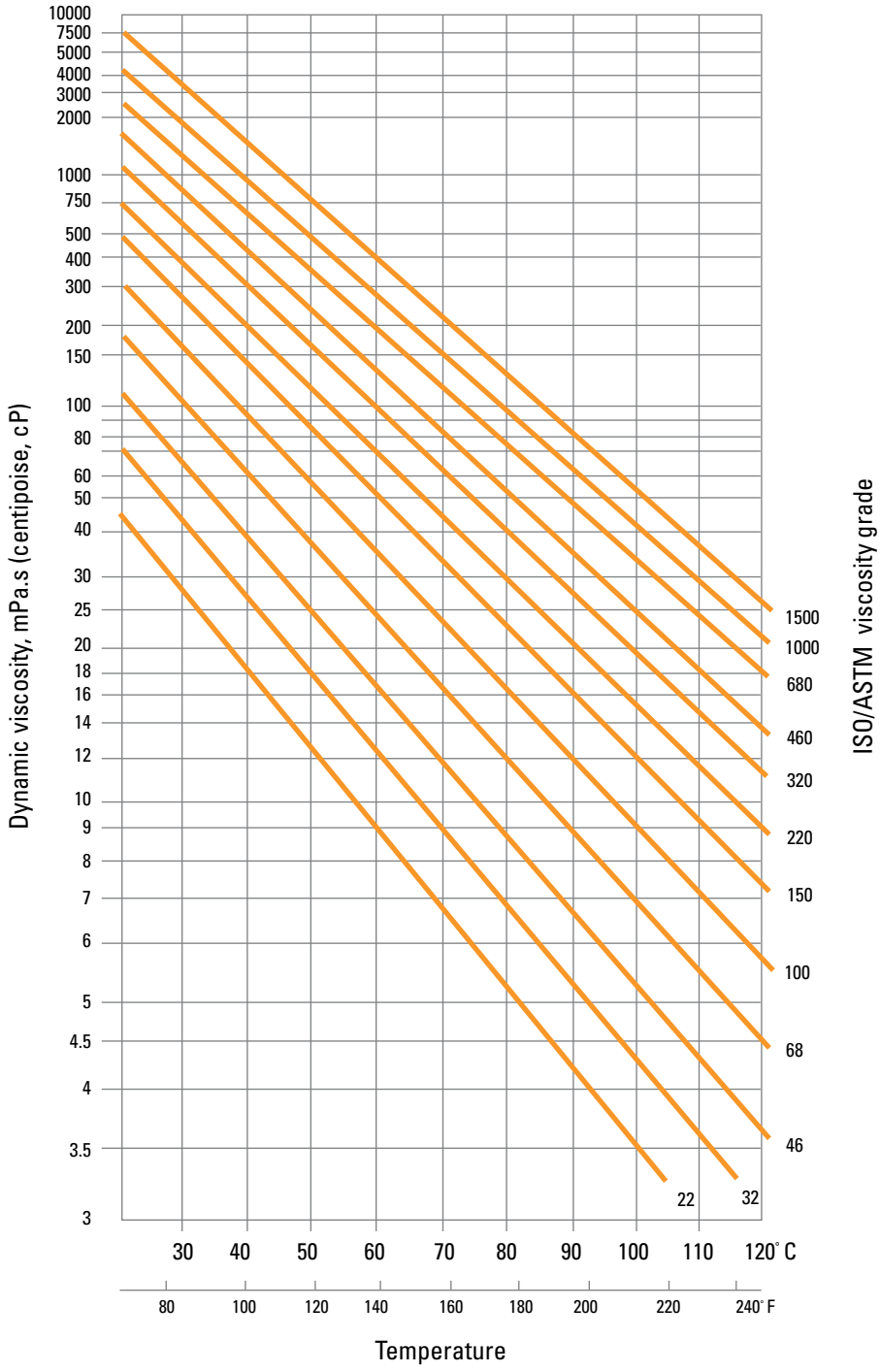


Fig. 145. Viscosities in mPa.s (centipoise, cP) for ISO/ASTM industrial fluid lubricant grade designations. Assumes: viscosity index 90; specific gravity 0.875 at 40° C (104° F).

CYLINDRICAL AND SPHERICAL ROLLER AND BALL BEARINGS

The torque equations for cylindrical and spherical roller bearings are given as follows, where the coefficients are based on series and found in the following table:

$$M = \begin{Bmatrix} f_1 F_\beta dm + 10^{-7} f_0 (v \times n)^{2/3} dm^3 \text{ if } (v \times n) \geq 2000 \\ f_1 F_\beta dm + 160 \times 10^{-7} f_0 dm^3 \text{ if } (v \times n) < 2000 \end{Bmatrix}$$

Note that the viscosity is in units of centistokes. The load term (F_β) depends on the bearing type as follows:

Radial ball:

$$F_\beta = \max \begin{pmatrix} 0.9F_a \cot \alpha - 0.1F_r \\ \text{or} \\ F_r \end{pmatrix}$$

Radial cylindrical and spherical roller:

$$F_\beta = \max \begin{pmatrix} 0.8F_a \cot \alpha \\ \text{or} \\ F_r \end{pmatrix}$$

Thrust ball and cylindrical and spherical roller:

$$F_\beta = F_a$$

TABLE 116. COEFFICIENTS FOR THE TORQUE EQUATION

Bearing Type	Dimension Series	f_0	f_1
Single-row deep groove ball bearings	18	1.7	0.00010
	28	1.7	0.00010
	38	1.7	0.00010
	39	1.7	0.00015
	00	1.7	0.00015
	02	2	0.00020
	03	2.3	0.00020
	04	2.3	0.00020
Single-row angular contact ball bearings $22^\circ < \alpha \leq 45^\circ$	02	2	0.00025
	03	3	0.00035
Double-row or paired single-row angular contact ball bearings	32	5	0.00035
	33	7	0.00035
Gothic Arch ball bearings	02	2	0.00037
	03	3	0.00037
Single-row cylindrical roller bearings with cage	10	2	0.00020
	02	2	0.00030
	22	3	0.00040
	03	2	0.00035
	23	4	0.00040
	04	2	0.00040
Single-row cylindrical roller bearings full complement	18	5	0.00055
	29	6	0.00055
	30	7	0.00055
	22	8	0.00055
	23	12	0.00055
Spherical roller bearings	30	4.5	0.00017
	39	4.5	0.00017
	40	6.5	0.00027
	31	5.5	0.00027
	41	7	0.00049
	22	4	0.00019
	32	6	0.00036
	03	3.5	0.00019
	23	4.5	0.00030
Double-row cylindrical roller bearings full complement	48	9	0.00055
	49	11	0.00055
	50	13	0.00055
Thrust cylindrical roller bearings	11	3	0.00150
	12	4	0.00150
Thrust spherical roller bearings	92	2.5	0.00023
	93	2.5	0.00023
	94	3	0.00030

SPEED RATINGS

RADIAL BALL BEARINGS

There is no precise method for determining the maximum speed at which a ball bearing may operate. Bearing characteristics and features of surrounding parts, shafts, housing and other components as well as basic service conditions are all variables dependent upon each other for continued satisfactory high-speed performance.

The safe operating speed of a bearing is often limited by the temperature within the bearing, which, in turn, is dependent upon the temperature surrounding the application, accuracy of bearings, shafts, housings, auxiliary parts, etc., and the type and amount of lubricant.

Radial bearings with proper internal refinements will operate at high speeds for long periods if properly installed and lubricated. Tolerance grade, cage design, and lubricant are bearing characteristics which affect speed limitations.

Bearings with ISO P0 tolerances are generally satisfactory for normal speeds with grease or oil lubrication.

Ball bearings with ISO P5 tolerances or better and ring-piloted composition cages lubricated with an efficient, non-churning, cooling oil-mist system have exceptional high-speed ability.

In the case of duplex mountings, as frequently used in high-speed machine tool spindles, bearing preload and contact angle affect the permissible speeds.

The values in table 116 may be used as a general guide for determining the safe maximum speed of standard types of Timken ball bearings. To obtain the speed value for any bearing size with inner ring rotating, multiply the pitch diameter in millimeters (or, in the case of extra-small inch dimension bearings, the nearest millimeter equivalent) by the speed in revolutions per minute. Refer to table 118 on page 194 for the most suitable bearing type, cage style, tolerance guide and type of lubrication.

For outer ring rotation of ball bearings, multiply the speed value (pitch or mean dia. in. mm x RPM of the outer ring) by the following factors before referring to the table of speed values.

TABLE 117. BALL BEARING SERIES FACTOR

Extra-small (30 and S) and extra-light (9100 and M9300)	1.3
Light (200, 5200 and 7200)	1.5
Medium (300, 5300 and 7300)	1.7

Although the speed values shown in the tables on the following page are based on many years of research and accumulated data, numerous applications of Timken bearings are successfully operating with speed values far in excess of those tabulated. Such applications require particular consideration of proper tolerance grade, lubrication, the effect of centrifugal force on rolling elements and other factors. For further information consult your Timken engineer.

Conversely, under certain application conditions of load, temperature, contamination, etc., speed ratings may be less than the figures shown. These values do not apply to certain special bearings, such as radial Tri-Ply series, square or hex bore bearings.

The speed capability of a bearing in any application is subject to a number of factors including:

- Temperature.
- Bearing setting or clearance.
- Lubrication.
- Bearing design.

The relative importance of each of these factors depends on the nature of the application. The effect of each factor is not isolated – each contributes in varying degrees, depending on the application and overall speed capability of the design.

An understanding of how each of these factors affects performance as speeds change is required to achieve the speed capabilities inherent in a bearing.

SPHERICAL AND CYLINDRICAL ROLLER BEARINGS

For Timken cylindrical roller and spherical roller bearings, the thermal speed ratings are listed in the bearing tables. These values have been determined by balancing the heat generated within the bearing with the heat dissipated from the bearing. In calculating these numbers, the following assumptions have been made:

- The radial load is five percent of the static load rating.
- For oil, it is assumed to be in a bath with the fill to the middle of the lowest rolling element. For grease it is assumed a 30 percent bearing cavity fill.

- The oil viscosity is assumed to be 12 cSt (ISO VG32) operated at 70˚ C (158˚ F) and the grease base oil viscosity is assumed to be 22 cSt operated at 70˚ C (158˚ F). The bearing and its components are at 70˚ C and the bearing environment is at 20˚ C (68˚ F).
- The housing and shaft are steel or cast iron.
- The bearing rotational axis is horizontal.
- The outer ring is stationary and the inner ring is rotating.
- The bearing radial internal clearance complies with class normal and standard fits are used.
- The bearing does not contain seals.
- The bearing does not experience misalignment or axial load.

The thermal speed ratings are for reference only and can be considerably lower or higher depending on your application. Consult your Timken engineer for more accurate information regarding a bearing's speed limitations in your application.

TABLE 118. RADIAL BALL BEARINGS
d_m X N VALUES (d_m* IN MILLIMETERS X RPM)

Bearing Type/Series	Cage Type	ISO P0		ISO P6			ISO P5 and 4		
		Grease	Oil[1]	Grease	Oil[1]	Grease	Grease	Circulating Oil[1]	Oil Mist
SINGLE-ROW									
Non-filling slot									
9300K, 9100K	Ball-piloted molded nylon (PRB)	250000	300000	250000	300000	—	300000	300000	300000
200K,	Pressed steel, brass	300000	350000	300000	350000	—	350000	400000	450000
300K,	Ring-piloted molded reinforced nylon (PRC)	350000	400000	350000	450000	—	400000	550000	650000
XLS, and variations	Composition (CR)								
Filling slot									
200W and variations	Ball-piloted molded nylon (PRB)	250000	250000	—	—	—	—	—	—
300W and variations	Pressed steel	250000	300000	—	—	—	—	—	—
Angular contact	Ball-piloted pressed steel, molded nylon (PRB)	200000	300000	300000	350000	—	—	—	—
7200WN	Ring-piloted brass (MBR), ball-piloted Br (MBR)	300000	400000	—	—	—	—	—	—
7300WN	Ring-piloted molded reinforced nylon (PRC)	350000	400000	350000	400000	—	—	—	—
Angular contact-extra precision									
2M9300WI, 2M200WI,									
2M300WI, 2M9100WI,	Ring-piloted composition (CR) or (PRC)	350000	400000	750000	1000000	1200000			
2MM9300WI, 2MM9100,							1000000	1400000	1700000
2MM200WI, 2MM300WI									
DOUBLE-ROW									
5200	Ball-piloted molded nylon (PRB), pressed steel	250000	300000	—	—	—	—	—	—
5300	Ball-piloted brass (BR)								

* $\frac{\text{Bore} + \text{O.D.}}{2}$

[1] For oil bath lubrication, oil level should be maintained covering between ⅓ to ½ up from the bottom of the lowest ball.

Note: Single or double normal contact (P or PP) sealed bearings should not exceed 300000 PDN.
Consult your Timken engineer for limiting speed of RR or Tri-Ply sealed bearings.

TAPERED ROLLER BEARINGS

The usual measure of the speed of a tapered roller bearing is the circumferential velocity at the midpoint of the inner ring large end rib, fig. 146. This may be calculated as:

Rib speed:

$$V_r = \frac{\pi D_m n}{60000} \quad \text{(m/s)}$$

$$= \frac{\pi D_m n}{12} \quad \text{(ft/min)}$$

Where:

D_m = Mean inner ring large rib diameter mm, in.

n = Bearing speed rev/min

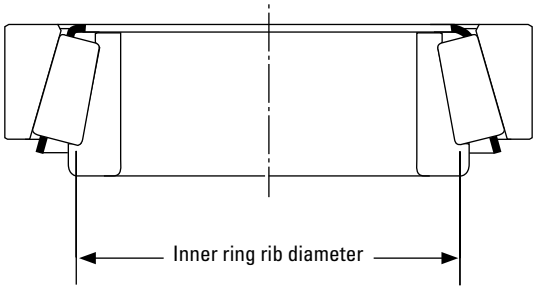


Fig. 146. Inner ring rib diameter. The inner ring rib diameter may be scaled from a print.

The mean large rib diameter at the midpoint of the roller end contact can be scaled from a drawing of the bearing, if available, or this diameter can be determined by consulting your Timken engineer. The inner, inner ring mean large rib diameter can be approximated by taking 99 percent of larger rib O.D.

DN values (the product of the inner ring bore in mm and the speed in rev/min) are often used as a measure of bearing speed by other bearing manufacturers. There is no direct relationship between the rib speed of a tapered roller bearing and DN value because of the wide variation in bearing cross sectional thickness. However, for rough approximation, one meter per second rib speed is about equal to 16000 DN for average section bearings. One foot per minute is equal to approximately 80 DN.

TABLE 119. SPEED CAPABILITY GUIDELINES FOR VARIOUS TYPES OF LUBRICATION SYSTEMS

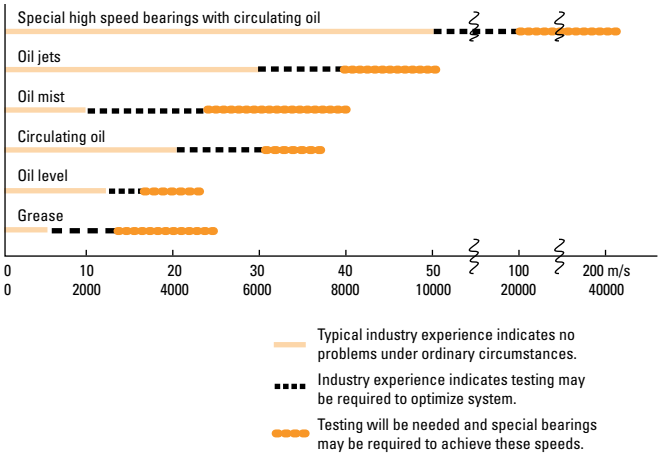


Table 118 is a summary of guidelines relating to speed and temperature based on customer experience, customer tests and research conducted by The Timken Company. Consult your Timken engineer with questions regarding high-speed capability.

CONVERSION TABLES

TABLE 120. VISCOSITY CONVERSION TABLE

Saybolt (Sec.) SUS	Redwood (Sec.) R′	Engler (Deg.) E	Centistokes cSt
35	32.2	1.18	2.7
40	36.2	1.32	4.3
45	40.6	1.46	5.9
50	44.9	1.60	7.4
55	49.1	1.75	8.9
60	53.5	1.88	10.4
65	57.9	2.02	11.8
70	62.3	2.15	13.1
75	67.6	2.31	14.5
80	71.0	2.42	15.8
85	75.1	2.55	17.0
90	79.6	2.68	18.2
95	84.2	2.81	19.4
100	88.4	2.95	20.6
110	97.1	3.21	23.0
120	105.9	3.49	25.0
130	114.8	3.77	27.5
140	123.6	4.04	29.8
150	132.4	4.32	32.1
160	141.1	4.59	34.3
170	150.0	4.88	36.5
180	158.8	5.15	38.8
190	167.5	5.44	41.0
200	176.4	5.72	43.2
220	194.0	6.28	47.5
240	212	6.85	51.9
260	229	7.38	56.5
280	247	7.95	60.5
300	265	8.51	64.9
325	287	9.24	70.3
350	309	9.95	75.8
375	331	10.7	81.2
400	353	11.4	86.8
425	375	12.1	92.0

Continued in next column.

Saybolt (Sec.) SUS	Redwood (Sec.) R′	Engler (Deg.) E	Centistokes cSt
450	397	12.8	97.4
475	419	13.5	103
500	441	14.2	108
550	485	15.6	119
600	529	17.0	130
650	573	18.5	141
700	617	19.9	152
750	661	21.3	163
800	705	22.7	173
850	749	24.2	184
900	793	25.6	195
950	837	27.0	206
1000	882	28.4	217
1200	1058	34.1	260
1400	1234	39.8	302
1600	1411	45.5	347
1800	1587	51	390
2000	1763	57	433
2500	2204	71	542
3000	2646	85	650
3500	3087	99	758
4000	3526	114	867
4500	3967	128	974
5000	4408	142	1082
5500	4849	156	1150
6000	5290	170	1300
6500	5730	185	1400
7000	6171	199	1510
7500	6612	213	1630
8000	7053	227	1740
8500	7494	242	1850
9000	7934	256	1960
9500	8375	270	2070
10000	8816	284	2200

TABLE 121. INCHES TO MILLIMETERS – UNITS

Inches		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0.0000	0.000	25.400	50.800	76.200	101.600	127.000	152.400	177.800	203.200	228.600	254.000	279.400	304.800	330.200	355.600	381.000
1/16	0.0625	1.588	26.988	52.388	77.788	103.188	128.588	153.988	179.388	204.788	230.188	255.588	280.988	306.388	331.788	357.188	382.588
1/8	0.1250	3.175	28.575	53.975	79.375	104.775	130.175	155.575	180.975	206.375	231.775	257.175	282.575	307.975	333.375	358.775	384.175
3/16	0.1875	4.763	30.162	55.562	80.962	106.362	131.762	157.162	182.562	207.962	233.362	258.762	284.162	309.562	334.962	360.362	385.762
1/4	0.2500	6.350	31.750	57.150	82.550	107.950	133.350	158.750	184.150	209.550	234.950	260.350	285.750	311.150	336.550	361.950	387.350
5/16	0.3125	7.938	33.338	58.738	84.138	109.538	134.938	160.338	185.735	211.138	236.538	261.938	287.338	312.738	338.138	363.538	388.938
3/8	0.3750	9.525	34.925	60.325	85.725	111.125	136.525	161.925	187.325	212.725	238.125	263.525	288.925	314.325	339.725	365.125	390.525
7/16	0.4375	11.112	36.512	61.912	87.312	112.712	138.112	163.512	188.912	214.312	239.712	265.112	290.512	315.912	341.312	366.712	392.112
1/2	0.5000	12.700	38.100	63.500	88.900	114.300	139.700	165.100	190.500	215.900	241.300	266.700	292.100	317.500	342.900	368.300	393.700
9/16	0.5625	14.288	39.688	65.088	90.488	115.888	141.288	166.688	192.088	217.488	242.888	268.288	293.688	319.088	344.488	369.888	395.288
5/8	0.6250	15.875	41.275	66.675	92.075	117.475	142.875	168.275	193.675	219.075	244.475	269.875	295.275	320.675	346.075	371.475	396.875
11/16	0.6875	17.462	42.862	68.262	93.662	119.062	144.462	169.862	195.262	220.662	246.062	271.462	296.862	322.262	347.662	373.062	398.462
3/4	0.7500	19.050	44.450	69.850	95.250	120.650	146.050	171.450	196.850	222.250	247.650	273.050	298.450	323.850	349.250	374.650	400.050
13/16	0.8125	20.638	46.038	71.438	96.838	122.238	147.638	173.038	198.438	223.838	249.238	274.638	300.038	325.438	350.838	376.238	401.638
7/8	0.8750	22.225	47.625	73.025	98.425	123.825	149.225	174.625	200.025	225.425	250.825	276.225	301.625	327.025	352.425	377.825	403.225
15/16	0.9375	23.812	49.212	74.612	100.012	125.412	150.812	176.212	201.612	227.012	252.412	277.812	303.212	328.612	354.012	379.412	404.812

B.S.I. Norm No. 350
A.S.A. Norm No. B48.1
} 1 inch = 25.400 mm (exact)

DIN 4890, 1 mm = $\frac{1}{25.4}$ inches

TABLE 122. UNITS

inches		10
0	—	254
1	25.4	279.4
2	50.8	304.8
3	76.2	330.2
4	101.6	355.6
5	127	381
6	152.4	406.4
7	177.8	431.8
8	203.2	457.2
9	228.6	482.6

TABLE 123. FRACTIONS

1/10 in.		1/100 in.		1/1000 in.		1/10000 in.	
in.	mm	in.	mm	in.	mm	in.	mm
0.1	2.54	0.01	0.254	0.001	0.0254	0.0001	0.00254
0.2	5.08	0.02	0.508	0.002	0.0508	0.0002	0.00508
0.3	7.62	0.03	0.762	0.003	0.0762	0.0003	0.00762
0.4	10.16	0.04	1.016	0.004	0.1016	0.0004	0.01016
0.5	12.70	0.05	1.270	0.005	0.1270	0.0005	0.01270
0.6	15.24	0.06	1.524	0.006	0.1524	0.0006	0.01524
0.7	17.78	0.07	1.778	0.007	0.1778	0.0007	0.01778
0.8	20.32	0.08	2.032	0.008	0.2032	0.0008	0.02032
0.9	22.86	0.09	2.286	0.009	0.2286	0.0009	0.02286

TABLE 124. FRACTIONS

1/10 mm		1/100 mm		1/1000 mm	
mm	in.	mm	in.	mm	in.
0.1	0.00394	0.01	0.00039	0.001	0.000039
0.2	0.00787	0.02	0.00079	0.002	0.000079
0.3	0.01181	0.03	0.00118	0.003	0.000118
0.4	0.01575	0.04	0.00157	0.004	0.000157
0.5	0.01969	0.05	0.00197	0.005	0.000197
0.6	0.02362	0.06	0.00236	0.006	0.000236
0.7	0.02756	0.07	0.00276	0.007	0.000276
0.8	0.03150	0.08	0.00315	0.008	0.000315
0.9	0.03543	0.09	0.00354	0.009	0.000354

TABLE 125. MILLIMETERS TO INCHES – UNITS

mm	10	20	30	40	50	60	70	80	90
0	–	0.39370	0.78740	1.18110	1.57480	1.96850	2.36220	2.75591	3.14961
1	0.03937	0.43307	0.82677	1.22047	1.61417	2.00787	2.40157	2.79528	3.18898
2	0.07874	0.47244	0.86614	1.25984	1.65354	2.04724	2.44094	2.83465	3.22835
3	0.11811	0.51181	0.90551	1.29921	1.69291	2.08661	2.48031	2.87402	3.26772
4	0.15748	0.55118	0.94488	1.33858	1.73228	2.12598	2.51969	2.91339	3.30709
5	0.19685	0.59055	0.98425	1.37795	1.77165	2.16535	2.55906	2.95276	3.34646
6	0.23622	0.62992	1.02362	1.41732	1.71102	2.20472	2.59843	2.99213	3.38583
7	0.27559	0.66929	1.06299	1.45669	1.85039	2.24409	2.63780	3.03150	3.42520
8	0.31496	0.70866	1.10236	1.49606	1.88976	2.28346	2.67717	3.07087	3.46457
9	0.35433	0.74803	1.14173	1.53543	1.92913	2.32283	2.71654	3.11024	3.50394

mm		100	200	300
0	–	3.93701	7.87402	11.81100
10	0.39370	4.33071	8.26772	12.20470
20	0.78740	4.72441	8.66142	12.59840
30	1.18110	5.11811	9.05512	12.99210
40	1.57480	5.51181	9.44882	13.38580
50	1.96850	5.90551	9.84252	13.77950
60	2.36220	6.29921	10.23620	14.17320
70	2.75591	6.69291	10.62990	14.56690
80	3.14961	7.08661	11.02360	14.96060
90	3.54331	7.48031	11.41730	15.35430

TABLE 126. STEEL HARDNESS NUMBERS[1]

Approximate Hardness Conversion Numbers for Steel, Based on Rockwell C													
		Brinell Hardness Number 10 mm Ball 3000 kg Load			Rockwell Hardness Number			Rockwell Superficial Hardness Number Superficial Brale Penetrator					
Rockwell C-Scale Hardness Number	Diamond Pyramid Hardness Number Vickers	Standard Ball	Hultgren Ball	Tungsten Carbide Ball	A-Scale 60 kg Load Penetrator	B-Scale 100 kg Load 1⁄16 in. Dia. Ball	D-Scale 100 kg Penetrator	15-N Scale 15 kg Load	30-N Scale 30 kg Load	45-N Scale 45 kg Load	Shore Scleroscope Hardness Number	Tensile Strength (approx.) 1000 psi	Rockwell C-Scale Hardness Number
68	940	–	–	–	85.6	–	76.9	93.2	84.4	75.4	97	–	68
67	900	–	–	–	85	–	76.1	92.9	83.6	74.2	95	–	67
66	865	–	–	–	84.5	–	75.4	92.5	82.8	73.3	92	–	66
65	832	–	–	739	83.9	–	74.5	92.2	81.9	72	91	–	65
64	800	–	–	722	83.4	–	73.8	91.8	81.1	71	88	–	64
63	772	–	–	705	82.8	–	73	91.4	80.1	69.9	87	–	63
62	746	–	–	688	82.3	–	72.2	91.1	79.3	68.8	85	–	62
61	720	–	–	670	81.8	–	71.5	90.7	78.4	67.7	83	–	61
60	697	–	613	654	81.2	–	70.7	90.2	77.5	66.6	81	–	60
59	674	–	599	634	80.7	–	69.9	89.8	76.6	65.5	80	326	59
58	653	–	587	615	80.1	–	69.2	89.3	75.7	64.3	78	315	58
57	633	–	575	595	79.6	–	68.5	88.9	74.8	63.2	76	305	57
56	613	–	561	577	79	–	67.7	88.3	73.9	62	75	295	56
55	595	–	546	560	78.5	–	66.9	87.9	73	60.9	74	287	55
54	577	–	534	543	78	–	66.1	87.4	72	59.8	72	278	54
53	560	–	519	525	77.4	–	65.4	86.9	71.2	58.6	71	269	53
52	544	500	508	512	76.8	–	64.6	86.4	70.2	57.4	69	262	52
51	528	487	494	496	76.3	–	63.8	85.9	69.4	56.1	68	253	51
50	513	475	481	481	75.9	–	63.1	85.5	68.5	55	67	245	50
49	498	464	469	469	75.2	–	62.1	85	67.6	53.8	66	239	49
48	484	451	455	455	74.7	–	61.4	84.5	66.7	52.5	64	232	48
47	471	442	443	443	74.1	–	60.8	83.9	65.8	51.4	63	225	47
46	458	432	432	432	73.6	–	60	83.5	64.8	50.3	62	219	46
45	446	421	421	421	73.1	–	59.2	83	64	49	60	212	45
44	434	409	409	409	72.5	–	58.5	82.5	63.1	47.8	58	206	44
43	423	400	400	400	72	–	57.7	82	62.2	46.7	57	201	43
42	412	390	390	390	71.5	–	56.9	81.5	61.3	45.5	56	196	42
41	402	381	381	381	70.9	–	56.2	80.9	60.4	44.3	55	191	41
40	392	371	371	371	70.4	–	55.4	80.4	59.5	43.1	54	186	40
39	382	362	362	362	69.9	–	54.6	79.9	58.6	41.9	52	181	39
38	372	353	353	353	69.4	–	53.8	79.4	57.7	40.8	51	176	38
37	363	344	344	344	68.9	–	53.1	78.8	56.8	39.6	50	172	37
36	354	336	336	336	68.4	(109)	52.3	78.3	55.9	38.4	49	168	36
35	345	327	327	327	67.9	(108.5)	51.5	77.7	55	37.2	48	163	35
34	336	319	319	319	67.4	(108)	50.8	77.2	54.2	36.1	47	159	34
33	327	311	311	311	66.8	(107.5)	50	76.6	53.3	34.9	46	154	33
32	318	301	301	301	66.3	(107)	49.2	76.1	52.1	33.7	44	150	32
31	310	294	294	294	65.8	(106)	48.4	75.6	51.3	32.5	43	146	31
30	302	286	286	286	65.3	(105.5)	47.7	75	50.4	31.3	42	142	30
29	294	279	279	279	64.7	(104.5)	47	74.5	49.5	30.1	41	138	29
28	286	271	271	271	64.3	(104)	46.1	73.9	48.6	28.9	41	134	28
27	279	264	264	264	63.8	(103)	45.2	73.3	47.7	27.8	40	131	27
26	272	258	258	258	63.3	(102.5)	44.6	72.8	46.8	26.7	38	127	26
25	266	253	253	253	62.8	(101.5)	43.8	72.2	45.9	25.5	38	124	25
24	260	247	247	247	62.4	(101)	43.1	71.6	45	24.3	37	121	24
23	254	243	243	243	62	100	42.1	71	44	23.1	36	118	23
22	248	237	237	237	61.5	99	41.6	70.5	43.2	22	35	115	22
21	243	231	231	231	61	98.5	40.9	69.9	42.3	20.7	35	113	21
20	238	226	226	226	60.5	97.8	40.1	69.4	41.5	19.6	34	110	20

[1] Source ASTM.



LUBRICATION

To help maintain a bearing's antifriction characteristics, lubrication is needed to:

- Minimize rolling resistance due to deformation of the rolling elements and raceway under load by separating the mating surfaces.
- Minimize sliding friction occurring between rolling elements, raceways and cage.
- Transfer heat (with oil lubrication).
- Protect from corrosion and, with grease lubrication, from contaminant ingress.



LUBRICATION

The wide range of bearing types and operating conditions precludes any simple, all-inclusive statement or guideline allowing the selection of the proper lubricant. At the design level, the first consideration is whether oil or grease is best for the particular operation. The advantages of oil and grease are outlined in the table below. When heat must be carried away from the bearing, oil must be used. It is almost always preferred for very high-speed applications. For speed ratings of grease and oil-lubricated bearings, see pages 193-195.

TABLE 127. ADVANTAGES OF OIL AND GREASE

Oil	Grease
Carries heat away from the bearings	Simplifies seal design and acts as a sealant
Carries away moisture and particulate matter	Permits prelubrication of sealed or shielded bearings
Easily controlled lubrication	Generally requires less frequent lubrication

European REACH compliance

Timken-branded lubricants, greases and similar products sold in stand-alone containers or delivery systems are subject to the European REACH (**R**egistration, **E**valuation, **A**uthorization and Restriction of **CH**emicals) directive. For import into the European Union, Timken can sell and provide only those lubricants and greases that are registered with ECHA (European CHemical Agency). For further information, please contact your Timken engineer.

OIL LUBRICATION

Oils used for bearing lubrication should be high-quality mineral oils or synthetic oils with similar properties. Selection of the proper type of oils depends on bearing speed, load, operating temperature and lubrication method. Some features and advantages of oil lubrication, in addition to the above are:

- Oil is a better lubricant for high speeds or high temperatures. It can be cooled to help reduce bearing temperature.
- It is easier to handle and control the amount of lubricant reaching the bearing. It is harder to retain in the bearing. Lubricant losses may be higher than with grease.
- Oil can be introduced to the bearing in many ways, such as drip-feed, wick-feed, pressurized circulating systems, oil bath or air-oil mist. Each is suited for certain types of applications.
- Oil is easier to keep clean for recirculating systems.

Oil may be introduced to the bearing housing in many ways. The most common systems are:

- **Oil bath.** The housing is designed to provide a sump through which the rolling elements of the bearing will pass. Generally, the oil level should be no higher than the center point of the lowest rolling element. If speed is high, lower oil levels should be used to reduce churning. Gages or controlled elevation drains are used to achieve and maintain the proper oil level.
- **Circulating system.** This system has the advantages of:
  - An adequate supply of oil for both cooling and lubrication.
  - Metered control of the quantity of oil delivered to each bearing.
  - Removal of contaminants and moisture from the bearing by flushing action.
  - Suitability for multiple bearing installations.
  - Large reservoir, which reduces deterioration. Increased lubricant life provides economical efficiency.
  - Incorporation of oil-filtering devices.
  - Positive control to deliver the lubricant where needed.
  - A typical circulating oil system consists of an oil reservoir, pump, piping and filter. A heat exchange may be required.
- **Oil-mist lubrication**. Oil-mist lubrication systems are used in high-speed, continuous-operation applications. This system permits close control of the amount of lubricant reaching the bearings. The oil may be metered, atomized by compressed air and mixed with air, or it may be picked up from a reservoir using a venturi effect. In either case, the air is filtered and supplied under sufficient pressure to assure adequate lubrication of the bearings. Control of this type of lubrication system is accomplished by monitoring the operating temperatures of the bearings being lubricated. The continuous passage of the pressurized air and oil through the labyrinth seals used in the system prevents the entrance of contaminants from the atmosphere to the system.

  The successful operation of this type of system is based upon the following factors:
  - Proper location of the lubricant entry ports in relation to the bearings being lubricated.
  - Avoidance of excessive pressure drops across void spaces within the system.
  - Proper air pressure and oil quantity ratio to suit the particular application.

- Adequate exhaust of the air-oil mist after lubrication has been accomplished.

To ensure "wetting" of the bearings, and to prevent possible damage to the rolling elements and rings, it is imperative that the oil-mist system be turned on for several minutes before the equipment is started. The importance of "wetting" the bearing before starting cannot be overstated, and it also has particular significance for equipment that has been idled for extended periods of time.

Lubricating oils are commercially available in many forms for automotive, industrial, aircraft and other uses. Oils are classified as either petroleum types (refined from crude oil) or synthetic types (produced by chemical synthesis).

PETROLEUM OILS

Petroleum oils are made from a petroleum hydrocarbon derived from crude oil, with additives to improve certain properties. Petroleum oils are used for nearly all oil-lubricated applications of bearings.

SYNTHETIC OILS

Synthetic oils cover a broad range of categories and include polyalphaolefins, silicones, polyglycols and various esters. In general, synthetic oils are less prone to oxidation and can operate at extreme hot or cold temperatures. Physical properties, such as pressure-viscosity coefficients, tend to vary between oil types; use caution when making oil selections.

The polyalphaolefins (PAO) have a hydrocarbon chemistry that parallels petroleum oil both in chemical structures and pressure-viscosity coefficients. Therefore, PAO oil is mostly used in the oil-lubricated applications of bearings when severe temperature environments (hot and cold) are encountered or when extended lubricant life is required.

The silicone, ester and polyglycol oils have an oxygen-based chemistry that is structurally quite different from petroleum oils and PAO oils. This difference has a profound effect on its physical properties where pressure-viscosity coefficients can be lower compared to mineral and PAO oils. This means that these types of synthetic oils may actually generate a smaller elastohydrodynamic (EHD) film thickness than a mineral or PAO oil of equal viscosity at operating temperature. Reductions in bearing fatigue life and increases in bearing wear could result from this reduction of lubricant film thickness.

VISCOSITY

The selection of oil viscosity for any bearing application requires consideration of several factors: load, speed, bearing setting, type of oil and environmental factors. Since oil viscosity varies inversely with temperature, a viscosity value must always be stated with the temperature at which it was determined. High-viscosity oil is used for low-speed or high-ambient-temperature applications. Low-viscosity oil is used for high-speed or low-ambient-temperature applications.

There are several classifications of oils based on viscosity grades. The most familiar are the Society of Automotive Engineers (SAE) classifications for automotive engine and gear oils. The American Society for Testing and Materials (ASTM) and the International Organization for Standardization (ISO) have adopted standard viscosity grades for industrial fluids. Fig. 147 shows the viscosity comparisons of ISO/ASTM with SAE classification systems at 40° C (104° F).

VISCOSITY CLASSIFICATION COMPARISON

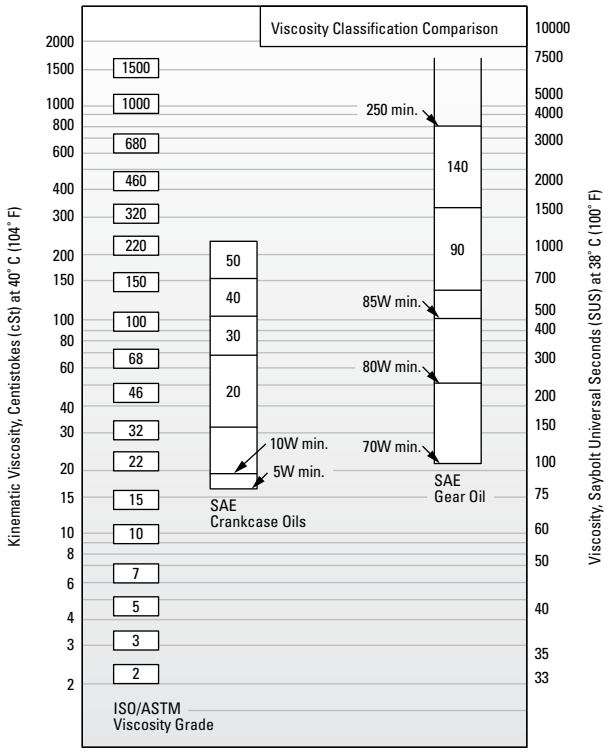


Fig. 147. Comparison between ISO/ASTM grades (ISO 3448/ASTM D2442) and SAE grades (SAE J 300-80 for crankcase oils, SAE J 306-81 for axle and manual transmission oils).

The ASTM/ISO viscosity grade system for industrial oils is depicted below.

ISO VISCOSITY SYSTEM

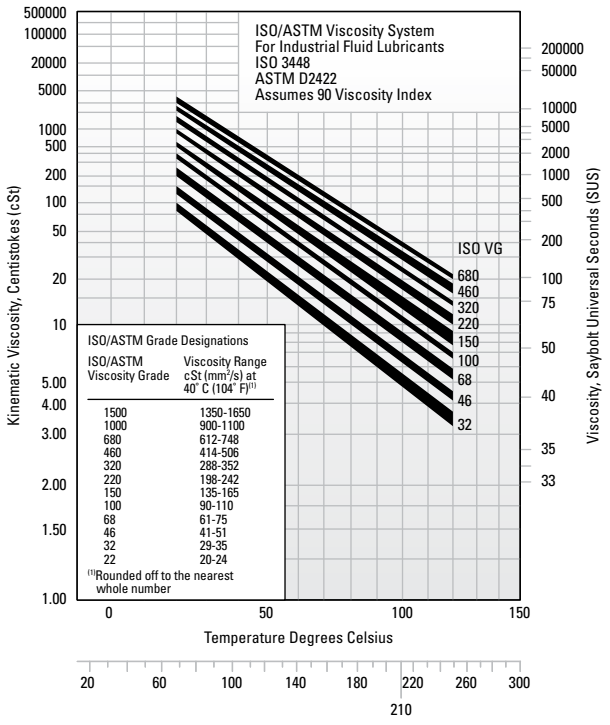


Fig. 148. Viscosity grade system for industrial oils.

TYPICAL BEARING LUBRICATION OILS

In this section, the properties and characteristics of lubricants for typical roller bearing applications are listed. These general characteristics are derived from successful performance in applications across all industries.

General-purpose rust and oxidation lubricating oil

General-purpose rust and oxidation (R&O) inhibited oils are the most common type of industrial lubricant. They are used to lubricate Timken® bearings in all types of industrial applications where conditions requiring special considerations do not exist.

TABLE 128. SUGGESTED GENERAL PURPOSE R&O LUBRICATING OIL PROPERTIES

	Properties
Base stock	Solvent-refined, high-viscosity-index petroleum oil
Additives	Corrosion and oxidation inhibitors
Viscosity index	80 min.
Pour point	-10° C max. (14° F)
Viscosity grades	ISO/ASTM 32 through 220

Some low-speed and/or high-ambient-temperature applications require the higher viscosity grades. High-speed and/or low-temperature applications require the lower viscosity grades.

Industrial extreme-pressure (EP) gear oil

Extreme-pressure gear oils are used to lubricate Timken bearings in most types of heavily loaded industrial equipment. They should be capable of withstanding abnormal shock loads that are common in heavy-duty equipment.

TABLE 129. SUGGESTED INDUSTRIAL EP GEAR OIL PROPERTIES

	Properties
Base stock	Solvent-refined, high-viscosity-index petroleum oil
Additives	Corrosion and oxidation inhibitors Extreme-pressure (EP) additive(1) - 15.8 kg (35 lb.) min.
Viscosity index	80 min.
Pour point	-10° C max. (14° F)
Viscosity grades	ISO/ASTM 100, 150, 220, 320, 460

(1) ASTM D 2782

Industrial EP gear oils should be composed of a highly refined petroleum oil-based stock plus appropriate inhibitors and additives. They should not contain materials that are corrosive or abrasive to bearings. The inhibitors should provide long-term protection from oxidation and protect the bearing from corrosion in the presence of moisture. The oils should resist foaming in service and have good water-separation properties. An EP additive protects against scoring under boundary-lubrication conditions. The viscosity grades suggested represent a wide range. High-temperature and/or slow-speed applications generally require the higher viscosity grades. Low temperatures and/or high speeds require the use of lower viscosity grades.

GREASE LUBRICATION

Grease lubrication is generally applicable to low-to-moderate speed applications that have operating temperatures within the limits of the grease. There is no universal anti-friction bearing grease. Each grease has limiting properties and characteristics.

Greases consist of a base oil, a thickening agent and additives. Conventionally, bearing greases have consisted of petroleum base oils thickened to the desired consistency by some form of metallic soap. More recently synthetic base oils have been used with organic and inorganic thickeners. Table 129 summarizes the composition of typical lubricating greases.

TABLE 130. COMPOSITION OF GREASES

Base Oil	Thickening Agents	Additives	Lubricating Grease
Mineral oil Synthetic hydrocarbon Esters Perfluorinated oil Silicone	Soaps and complex soaps (lithium, aluminum, barium, calcium) Non-Soap (inorganic) microgel (clay), carbon black, silica-gel, PTFE Non-Soap (organic) Polyurea compounds	Rust inhibitors Dyes Tactifiers Metal deactivates Oxidation inhibitors Anti-wear EP	

Calcium- and aluminum-based greases have excellent water resistance and are used in industrial applications where water ingress is an issue. Lithium-based greases are multi-purpose and are used in industrial applications and wheel bearings.

Synthetic base oils such as esters, organic esters and silicones used with conventional thickeners and additives typically have higher maximum operating temperatures than petroleum-based greases. Synthetic greases can be designed to operate in temperatures from -73° C (-100° F) to 288° C (550° F).

Below are the general characteristics of common thickeners used with petroleum base oils.

TABLE 131. GENERAL CHARACTERISTICS OF THICKENERS USED WITH PETROLEUM BASE OILS

Thickener	Typical Dropping Point		Maximum Temperature		Typical Water Resistance
	°C	°F	°C	°F	
Lithium soap	**193**	380	**121**	250	Good
Lithium complex	**260+**	500+	**149**	300	Good
Aluminum complex	**249**	480	**149**	300	Excellent
Calcium sulfonate	**299**	570	**177**	350	Excellent
Polyurea	**260**	500	**149**	300	Good

Use of the thickeners in table 130 with synthetic hydrocarbon or ester base oils increases the maximum operating temperature by approximately 10° C (50° F).

Using polyurea as a thickener for lubricating fluids is one of the most significant lubrication developments in more than 30 years. Polyurea grease performance is outstanding in a wide range of bearing applications and, in a relatively short time, it has gained acceptance as a factory-packed lubricant for ball bearings.

LOW TEMPERATURES

Starting torque in a grease-lubricated bearing at low temperatures can be critical. Some greases may function adequately as long as the bearing is operating, but resistance to initial movement may be excessive. In certain smaller machines, starting may be impossible when very cold. Under such operating circumstances, greases containing low-temperature characteristic oils are generally required.

If the operating temperature range is wide, synthetic greases offer advantages. Synthetic greases are available to provide very low starting and running torque at temperatures as low as -73° C (-100° F). In certain instances, these greases perform better in this respect than oil.

An important point concerning lubricating greases is that the starting torque is not necessarily a function of the consistency or the channel properties of the grease. Starting torque is more a function of the individual rheological properties of a particular grease and is best evaluated by application experience.

HIGH TEMPERATURES

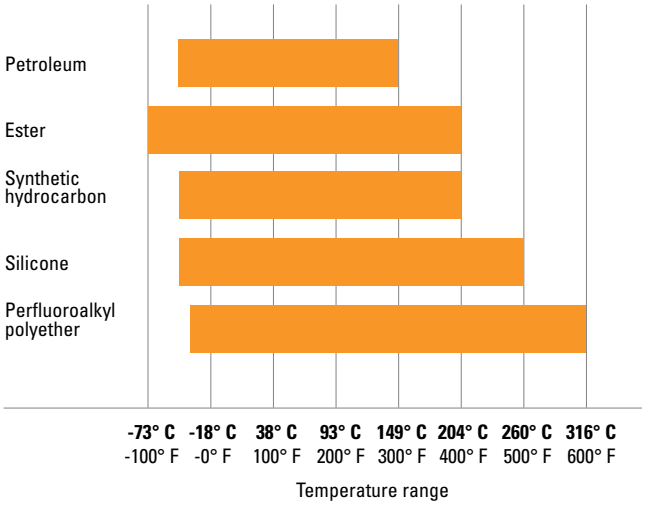
The high temperature limit for lubricating greases is generally a function of the thermal and oxidation stability of the fluid and the effectiveness of the oxidation inhibitors. Grease temperature ranges are defined by both the dropping point of the grease thickener and composition of the base oil. Table 131 shows the temperature ranges of various base oils used in grease formulations.

A rule of thumb, developed from years of testing grease-lubricated bearings, indicates that grease life is halved for every 10° C (50° F) increase in temperature. For example, if a particular grease provides 2000 hours of life at 90° C (194° F), by raising the temperature to 100° C (212° F), reduction in life to approximately 1000 hours would result. On the other hand, 4000 hours could be expected by lowering the temperature to 80° C (176° F).

Thermal stability, oxidation resistance and temperature limitations

must be considered when selecting greases for high-temperature applications. In non-relubricatable applications, highly refined mineral oils or chemically stable synthetic fluids are required as the oil component of greases for operation at temperatures above 121° C (250° F).

TABLE 132. TEMPERATURE RANGES FOR BASE OILS USED IN LUBRICATING GREASES



CONTAMINATION

Abrasive Particles

When roller bearings operate in a clean environment, the primary cause of damage is the eventual fatigue of the surfaces where rolling contact occurs. However, when particle contamination enters the bearing system, it is likely to cause damage such as bruising, which can shorten bearing life.

When dirt from the environment or metallic wear debris from some component in the application are allowed to contaminate the lubricant, wear can become the predominant cause of bearing damage. If bearing wear becomes significant, changes will occur to critical bearing dimensions that could adversely affect machine operation.

Bearings operating in a contaminated lubricant exhibit a higher initial rate of wear than those running in an uncontaminated lubricant. With no further contaminant ingress, this wear rate quickly diminishes. The contamination particles are reduced in size as they pass through the bearing contact area during normal operation.

Water

Water and moisture can be particularly conducive to bearing damage. Lubricating greases may provide a measure of protection from this contamination. Certain greases, such as calcium and aluminum-complex, are highly water-resistant.

Sodium-soap greases are water-soluble and should not be used in applications involving water.

Either dissolved or suspended water in lubricating oils can exert a detrimental influence on bearing fatigue life. Water can cause bearing etching that also can reduce bearing fatigue life. The exact mechanism by which water lowers fatigue life is not fully understood. It has been suggested that water enters micro-cracks in the bearing rings that are caused by repeated stress cycles. This leads to corrosion and hydrogen embrittlement in the micro-cracks, reducing the time required for these cracks to propagate to an unacceptable-sized spall.

Water-based fluids, such as water glycol and invert emulsions, also have shown a reduction in bearing fatigue life. Although water from these sources is not the same as contamination, the results support the previous discussion concerning water-contaminated lubricants.

GREASE SELECTION

The successful use of bearing grease depends on the physical and chemical properties of the lubricant as well as application and environmental conditions. Because the choice of grease for a particular bearing under certain service conditions is often difficult to make, you should consult with your lubricant supplier or equipment maker for specific questions about lubrication requirements for your application. You also can contact your Timken engineer for general lubrication guidelines for any application.

Grease must be carefully selected with regard to its consistency at operating temperature. It should not exhibit thickening, separation of oil, acid formation or hardening to any marked degree. It should be smooth, non-fibrous and entirely free from chemically active ingredients. Its dropping point should be considerably higher than the operating temperature.

Timken® application-specific lubricants were developed by leveraging our knowledge of tribology and anti-friction bearings, and how these two elements affect overall system performance. Timken lubricants help bearings and related components operate effectively in demanding industrial operations. High-temperature, anti-wear and water-resistant additives offer superior protection in challenging environments. Table 132 provides an overview of the Timken greases available for general applications. Contact your Timken engineer for a more detailed publication on Timken lubrication solutions.

TABLE 133. GREASE LUBRICATION SELECTION GUIDE

ENVIRONMENT		APPLICATION
High Wear • Moderate Loads Moderate Speeds Moderate Temperatures	Timken Premium All-Purpose Industrial Grease	Agriculture • Bushings/Ball Joints Truck and Auto Wheel Bearings Heavy-Duty Industrial
Extreme Heat • Heavy Loads High Sliding Wear Dirty Environments Slow Speeds • Shock Loading	Timken Construction and Off-Highway Grease	Agriculture/Mining • Cement Plants Construction/Off Road • Rock Quarry Earth-Moving Equipment Fleet Equipment • Heavy Industry Pivot Pins/Splined Shafts
Wet and Corrosive Conditions Quiet Environments • Light Loads Moderate to High Speeds Moderate Temperatures Light Load Moderate Water	Timken Ball Bearing Pillow Block Grease	Lightly Loaded Pillow Blocks Idler Pulleys • Oven Conveyors Electric Motors • Fans • Pumps Alternators • Generators
Corrosive Media • Extreme Heat Heavy Loads • Wet Conditions Slow to Moderate Speeds	Timken Mill Grease	Aluminum Mills • Paper Mills Steel Mills • Offshore Rigs Power Generation
Incidental Food Contact Hot and Cold Temperatures Moderate to High Speeds Medium Loads	Timken Food Safe Grease	Food and Beverage Industries Pharmaceuticals
Extreme Low and High Temperatures Severe Loads Corrosive Media Slow to Moderate Speeds	Timken Synthetic Industrial Grease	Wind Energy Main Bearing Pulp and Paper Machines General Heavy Industry Marine Applications Centralized Grease Systems
Moderate Speeds Light to Moderate Loads Moderate Temperatures Moderate Water	Timken Multi-Use Lithium Grease	General Industrial Applications Pins and Bushings • Track Rollers Water Pumps Plain and Anti-friction Bearings

This selection guide is not intended to replace the specifications by the equipment builder, who is responsible for its performance.

Many bearing applications require lubricants with special properties or lubricants formulated specifically for certain environments, such as:

- Friction oxidation (fretting corrosion).
- Chemical and solvent resistance.
- Food handling.
- Quiet running.
- Space and/or vacuum.
- Electrical conductivity.

For assistance with these or other areas requiring special lubricants, consult your Timken engineer.

GREASE USE GUIDELINES

It is important to use the proper amount of grease in the application. In typical industrial applications, the bearing cavity should be kept approximately one-third to one-half full. Less grease may result in the bearing being starved for lubrication. More grease may result in churning. Both conditions may result in excessive heat generation. As the grease temperature rises, viscosity decreases and the grease becomes thinner. This can reduce the lubricating effect and increase leakage of the grease from the bearing. It also may cause the grease components to separate, leading to a general breakdown of the lubricant properties. As the grease breaks down, bearing torque increases. In the case of excess grease resulting in churning, torque may also increase due to the resistance caused by the grease.

For best results, there should be ample space in the housing to allow room for excess grease to be thrown from the bearing. However, it is equally important that the grease be retained all around the bearing. If a large void exists between the bearings, grease closures should be used to prevent the grease from leaving the bearing area.

Only in low-speed applications may the housing be entirely filled with grease. This method of lubrication is a safeguard against the entry of foreign matter, where sealing provisions are inadequate for exclusion of contaminants or moisture.

During periods of non-operation, it is often wise to completely fill the housings with grease to protect the bearing surfaces. Prior to restarting operation, remove the excess grease and restore the proper level.

Applications utilizing grease lubrication should have a grease fitting and a vent at opposite ends of the housing near the top. A drain plug should be located near the bottom of the housing to allow the old grease to purge from the bearing.

Bearings should be relubricated at regular intervals to help prevent damage. Relubrication intervals are difficult to determine. If plant practice or experience with other applications is not available, consult your lubricant supplier.

Timken offers a range of lubricants to help bearings and related components operate effectively in demanding industrial operations. High-temperature, anti-wear and water-resistant additives offer greater protection in challenging environments. Timken also offers a line of single- and multi-point lubricators to simplify grease delivery.



Fig. 149. Grease can easily be packed by hand.



Fig. 150. Mechanical grease packer.

Grease application methods

Grease, in general, is easier to use than oil in industrial bearing lubrication applications. Most bearings that are initially packed with grease require periodic relubrication to operate efficiently.

Grease should be packed into the bearing so that it gets between the rolling elements – the rollers or balls. For tapered roller bearings, forcing grease through the bearing from the large end to the small end will ensure proper distribution.

Grease can be easily packed into small- and medium-size bearings by hand (fig. 149). In shops where bearings are frequently regreased, a mechanical grease packer that forces grease through the bearing under pressure may be appropriate (fig. 150). Regardless of the method, after packing the internal areas of the bearing, a small amount of grease also should be smeared on the outside of the rollers or balls.

The two primary considerations that determine the relubrication cycle are operating temperature and sealing efficiency. High-operating-temperature applications generally require more frequent regreasing. The less efficient the seals, the greater the grease loss and the more frequently grease must be added.

Grease should be added any time the amount in the bearing falls below the desired amount. The grease should be replaced when its lubrication properties have been reduced through contamination, high temperature, water, oxidation or any other factors. For additional information on appropriate regreasing cycles, consult with the equipment manufacturer or your Timken engineer.

Prelubricated bearings

Prelubricated shielded and sealed bearings are successfully used in applications where:

- Grease might be injurious to other parts of the mechanism.
- Cost and space limitations preclude the use of a grease-filled housing.
- Housings cannot be kept free of dirt and grit, water or other contaminants.
- Relubrication is impossible or would be a hazard to satisfactory use.

Prelubricated bearings are pre-packed with greases that have chemical and mechanical stability, and they have demonstrated long-life characteristics in rotating bearings. Greases are filtered several times to remove all harmful material, and they are accurately metered so that each bearing receives the proper amount of grease.

For ball bearings, polyurea and lithium-based greases are normally preferred for general-purpose bearing lubrication and are advantageous in high-moisture applications. Both greases have good water-resistant characteristics. For temperature ranges of standard greases, see table 133.

TABLE 134. TIMKEN BALL BEARING STANDARD LUBRICATION

Bearing Type	Grease Type	Grease Temperature Range
Radial bearings (Double shielded and single and double sealed)	Polyurea thickener Petroleum oil	**-34° C to +135° C** (-30° F to +275° F)
Wide inner ring bearings (Contact seal type)	Polyurea thickener Petroleum oil	**-34° C to +135° C** (-30° F to +275° F)
Wide inner ring bearings (Labyrinth seal types)	Synthetic thickener Synthetic hydrocarbon fluid	**-54° C to +163° C** (-65° F to +325° F)

CONSISTENCY

Greases may vary in consistency from semi-fluids that are hardly thicker than a viscous oil to solid grades almost as hard as a soft wood.

Consistency is measured by a penetrometer in which a standard weighted cone is dropped into the grease. The distance the cone penetrates (measured in tenths of a millimeter in a specific time) is the penetration number.

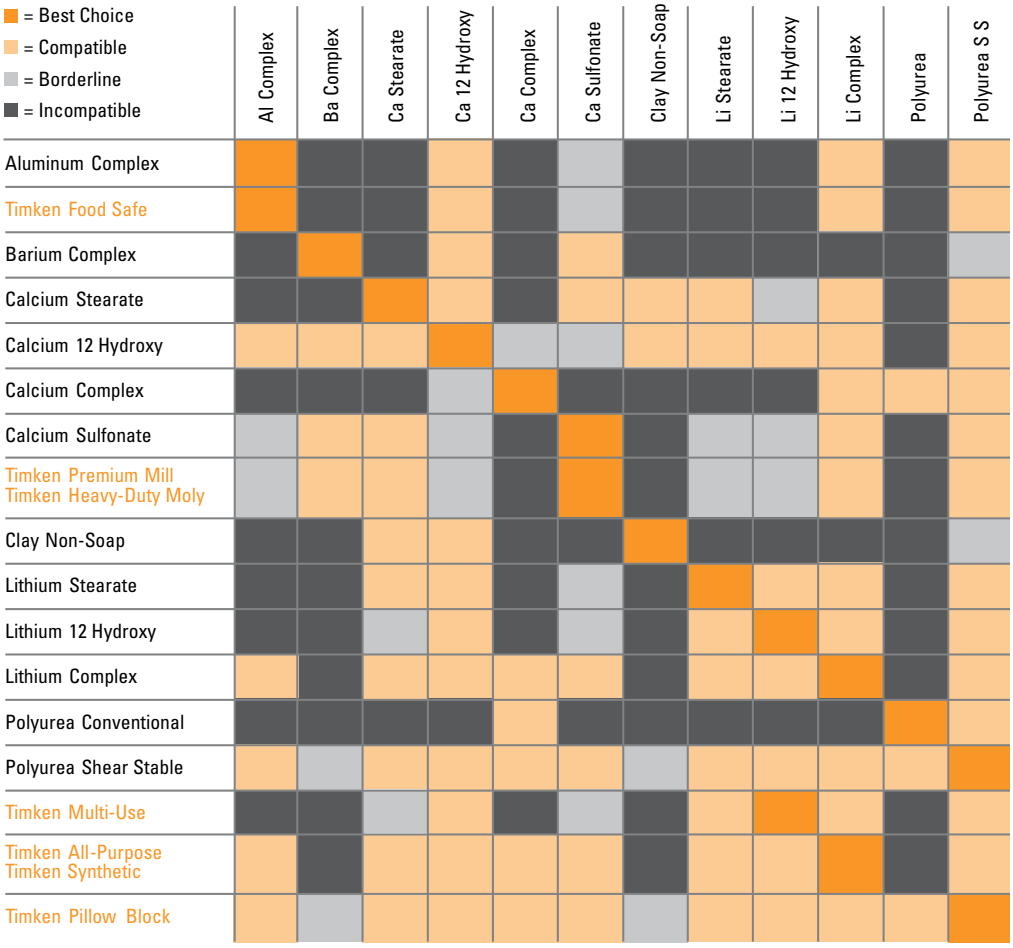
The National Lubricating Grease Institute (NLGI) classification of grease consistency is shown below:

TABLE 135. NLGI CLASSIFICATIONS

NLGI Grease Grades	Penetration Number
0	355-385
1	310-340
2	265-295
3	220-250
4	175-205
5	130-160
6	85-115

Grease consistency is not fixed; it normally becomes softer when sheared or “worked.” In the laboratory, this “working” is accomplished by forcing a perforated plate up and down through a closed container of grease. This “working” does not compare with the violent shearing action that takes place in a bearing and does not necessarily correlate with actual performance.

TABLE 136. GREASE COMPATIBILITY CHART



NOTE

Mixing greases can result in improper bearing lubrication.
Always follow the specific lubrication instructions of your equipment supplier.

SEALS

SELECTING THE RIGHT SEAL

When selecting the proper seal design for any Timken bearing application, it is necessary to consider the type of lubricant, the operation environment, the speed of the application and general operating conditions.

SHAFT FINISH

It is important to ensure that no spiral grooves result from machining the shaft surfaces since these will tend to draw lubricant out of, or contaminant into, the bearing cavity. Plunge grinding normally produces a satisfactory surface finish.

GREASE LUBRICATION – VENTING

Venting should be provided in the cavity between the two bearings when grease lubrication is used in conjunction with contacting or non-contacting seals. This will prevent an ingress of contamination past the seals in the event of a pressure differential between the bearing cavity and atmosphere.

VERTICAL SHAFT CLOSURES – OIL LUBRICATION

Lubricating vertical shaft bearings is a difficult task. Normally, grease, oil-mist or oil-air lubrication is used because of the simplicity. However, some high-speed and/or heavy load applications will use circulating oil. This requires a very good sealing system and a suction pump to remove the oil from the bottom bearing position.

NON-CONTACTING SEALS

METAL STAMPINGS

Metal stamping closures are effective in clean applications. When environmental conditions are dirty, stampings are used in combination with other closure elements to provide an effective labyrinth against the entry of foreign matter into the bearing chamber.

The stamping shown in fig. 151 is effective for applications that are grease lubricated and operate in clean conditions. The design illustrated in fig. 152 uses stampings on both sides of the bearing to keep the grease in close proximity to the bearing. The flinger mounted at the outer side of the bearing adds a labyrinth effect.

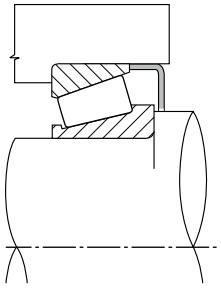


Fig. 151. Metal stamping.

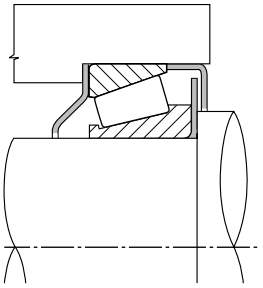


Fig. 152. Metal stampings.

Stampings should be designed to provide a clearance of 0.5 to 0.6 mm (0.020 to 0.025 in.) on diameters between rotating and stationary parts. A minimum axial clearance of 3 mm (0.125 in.) should be provided.

MACHINED FLINGERS

Machined parts, along with other closure elements, can be used in place of stampings when closer clearances are desired. This results in a more efficient retention of lubricant and exclusion of foreign matter from the bearing housing. Examples are shown in fig. 153 and fig. 154.

An umbrella-shaped flinger is shown in fig. 154 combined with an annular groove closure. This combination effectively retains oil and keeps out dirt at high shaft speeds.

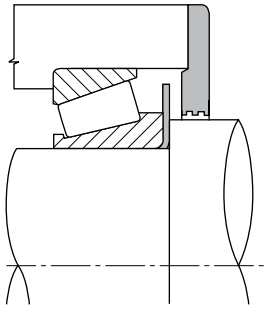


Fig. 153. Machined flinger combined with annular grooves.

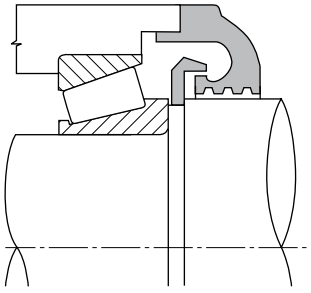


Fig. 154. Machined umbrella flinger combined with annular grooves.

ANNULAR GROOVES

Annular groove closures are often used with grease lubrication in place of radial lip seals when considerable grit and dust are encountered. The closure usually has several grooves machined in the bore or on the outside diameter depending on the design. They become filled with grease, which tends to harden and provide a tight closure. When used with oil, the grooves tend to interrupt the capillary action which would otherwise draw oil out of the bearing cavity. Annular grooves with a machined labyrinth effectively protect a grease-lubricated bearing when the unit is required to operate in an extremely dirty environment (fig. 155). This type of closure is most effective when applied with close-running clearances and the maximum possible number of grooves. Suggested dimensions are shown in table 136.

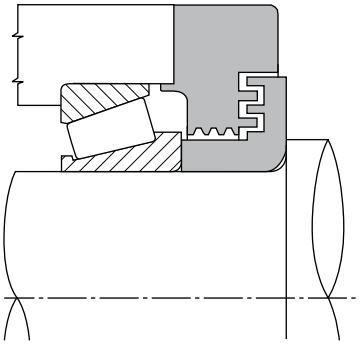
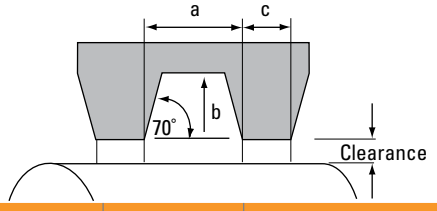


Fig. 155. Annular grooves combined with machined labyrinth.

TABLE 137. ANNULAR GROOVES SUGGESTED DIMENSIONS



	mm in.	
Dimension a	**3.20 - 4.80** 0.125 - 0.190	
Dimension b	**4.00 - 4.80** 0.160 - 0.190	
Dimension c	0.5a	
Diametral clearance	**0.25 - 0.40** 0.010 - 0.016	for diameters to 50 mm (2 in.)
	1.3 max. 0.05 max.	for diameters over 50 mm (2 in.)

CONTACTING SEALS

RADIAL LIP SEALS

Many types and styles of radial lip seals are commercially available to satisfy different sealing requirements. In clean environments, where the primary requirement is the retention of lubricant in the bearing housing, a single lip seal with the lip pointing inward is often used. When the critical concern is excluding contaminants, the lip is usually pointed outward (fig. 156).

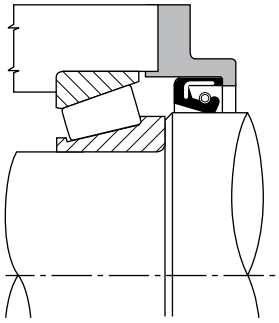


Fig. 156. Radial lip seals.

Lip seals are available with or without a spring-loaded lip. The spring maintains a constant pressure of the lip on the sealing surface, thereby providing a more efficient seal for a longer period of time. When environmental conditions require a seal to prevent contaminants from entering the bearing chamber as well as retaining the lubricant, a double or triple lip seal is often used. Additional flingers or shrouds should be used as primary seals when extremely dirty conditions are present. The seal lip and sealing surface are protected to avoid rapid wear and premature seal damage (fig. 157).

Seal wear surfaces are normally required to have a surface finish in the order of 0.25-0.40 µm (10-15 µin.) Ra. In general, for applications exposed to severe contamination, the seal wear surface should have a minimum surface hardness of HRC 45. The seal supplier should be consulted for more specific guidance.

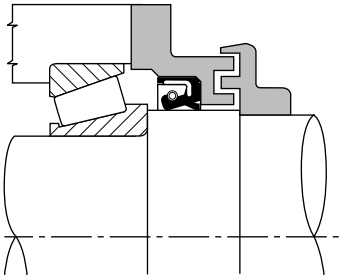


Fig. 157. Lip seal plus machined labyrinth.

DUO FACE®-PLUS SEALS

The DUO FACE-PLUS seal (fig. 158) has double lips that seal in the housing bore and the ground surface of the outer ring front face. This eliminates the need to machine a special seal surface. The DUO FACE-PLUS seal has proven successful in many different types of grease-lubricated applications.

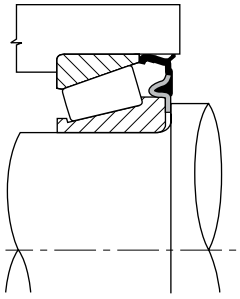


Fig. 158. DUO FACE®-PLUS seal.

DIAPHRAGM SEALS

Diaphragm seals (fig. 159) are commercially available. The metallic lip is designed to be spring-loaded against the narrow face of the outer ring. The type shown in fig. 160 has a second lip that seals against the housing.

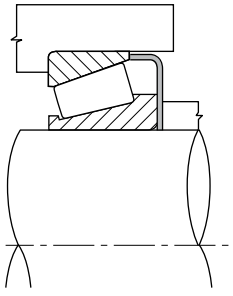


Fig. 159. Diaphragm seal.

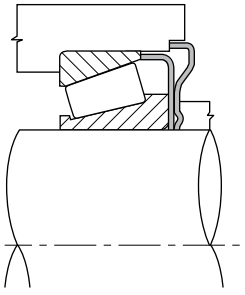


Fig. 160. Diaphragm seal with second lip.

MECHANICAL FACE SEALS

These are often used in extremely dirty environments when rotational speeds are low. Fig. 161 shows one of the available proprietary types of mechanical face seals. This type of seal generally needs to run in an oil bath. Designs also are available for high-speed and other special applications.

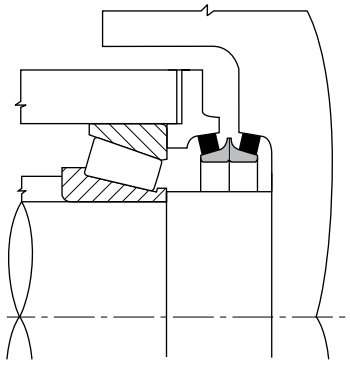


Fig. 161. Mechanical face seal for low speeds and contaminated environments.

V-RING SEALS

V-ring seals can be used in conjunction with grease or oil lubrication. As rotational speeds increase, the lip tends to pull away from the sealing surface and acts like a flinger. This seal may be used with either oil or grease lubrication (fig. 162). Consult your V-ring seal supplier for application restrictions.

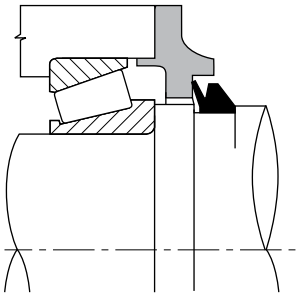


Fig. 162. V-ring seals.

BALL BEARINGS WITH SHIELDS AND SEALS

SHIELDS (D-TYPE)

Both K and W single-row radial types are available with one shield, designated by suffix D, or two shields, suffix DD. A shield on one side provides protection against the entrance of coarse dirt or chips and makes it possible to relubricate the bearing from the open side as shown (fig. 163).

Double-shielded bearings are prelubricated with the correct amount of Timken-suggested ball bearing grease and are designed for applications where relubrication is not required (fig. 164).

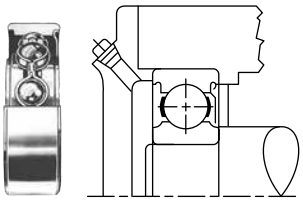


Fig. 163. One shield, suffix D.

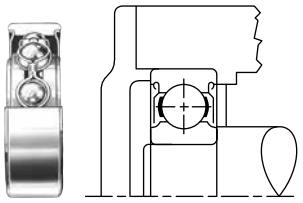


Fig. 164. Two shields, suffix DD.

LABYRINTH OR MECHANI-SEALS (L-TYPE)

Bearings with Mechani-Seals are made in the non-filling slot type only and are available with a single seal, designated by suffix L; one seal and one shield; suffix LD, and two seals, suffix LL. These bearings have standard bores, outside diameters and outer ring widths, but the inner ring is wider than standard unshielded and shielded sizes. As illustrated, in the L- and LD-types (figs. 165 and 166), the inner rings are offset slightly on the side opposite the seal in order to permit clearance when the bearings are mounted in blind housings.

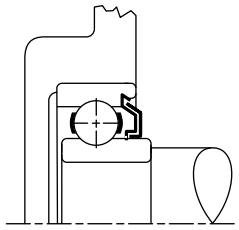


Fig. 165. Suffix L.

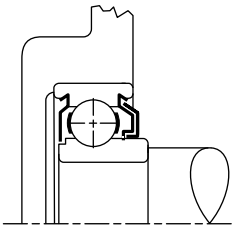


Fig. 166. Suffix LD.

Timken developed the Mechani-Seal to provide an ultra-low friction seal that also provides effective grease retention and contaminant exclusion. It consists of two dished steel members. The inner member is fixed to the outer ring which is typically stationary and provides a barrier which retains the grease. The outer member is pressed on the outside diameter of the inner ring and rotates as a flinger to throw off contaminants. Close running clearances between the inner and outer members ensure effective sealing under extremely severe conditions. This seal configuration is very effective under high speeds, because the non-contacting nature of the seal results in minimal friction and higher speed of the flinger deflects more contaminants. Mechani-Seal bearings are very popular in high-speed pneumatic tools, small electric motors, pumps, domestic appliances and similar high-speed applications. A typical mounting arrangement for the LL-type is shown (fig. 167).

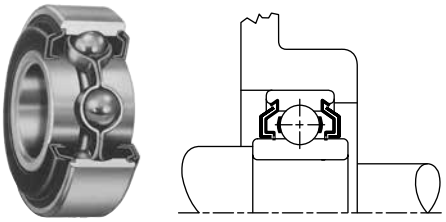


Fig. 167. Two Mechani-Seals suffix LL.

Wide-type radial bearings (W-LL-type) with Mechani-Seals are designated by the prefix W and suffix LL for two seals. They are made in standard bores and outside diameters, but in widths the same as those of corresponding size double-row bearings. The extra width affords greater space for long-life factory-filtered grease and provides extra support on shafts and in housings so that locknuts and lockwashers are not needed on applications such as electric motors. A typical mounting is shown (fig. 169).



Fig. 168. W-LL-type.

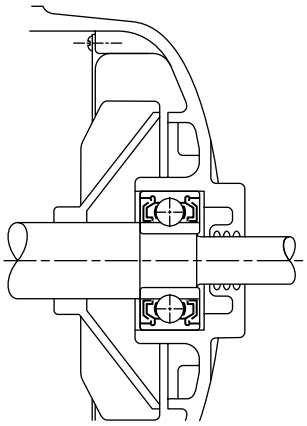


Fig. 169. Typical mounting.

FELT SEALS (T-TYPE)

The felt seal consists of two metal plates fixed in the outer ring of the bearing that enclose a felt ring. This felt ring, which is saturated with oil before assembly in the bearing, contacts the ground outside diameter of the inner ring to provide sealing with minimum friction drag.

Bearings with felt seals are made only in the non-filling slot type and are available with one seal (designated by the suffix T), one seal and one shield (identified by suffix TD), and two seals (suffix TT). Bores and outside diameters of these bearings are the same as standard unshielded and shielded types, but overall widths are greater. As illustrated, in the T- and TD-types (figs. 170 and 171), the inner rings are offset slightly on the opposite side of the seal to permit clearance when the bearings are mounted in blind housings.

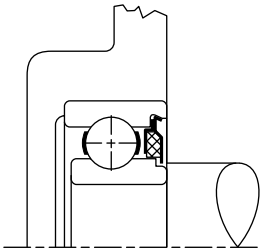


Fig. 170. Suffix T.

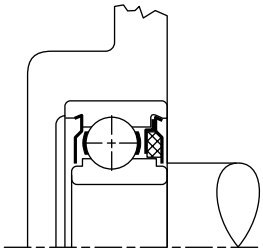


Fig. 171. Suffix TD.

RUBBER SEALS (P-TYPE)

Radial bearings with rubber seals having one or two seals are designated by the suffixes P and PP, respectively. With the exception of the extra-small sizes, they are dimensionally interchangeable with open-type and shielded bearings.

The P-type design is a positive contact seal using a molded synthetic rubber. Firmly fixed to the outer ring, the seal flares outward and rides on the inner ring. The flare-out of the seal against the inner ring radius ensures constant positive contact to provide an effective barrier against contaminant entry or lubricant loss.

Timken rubber seal bearings provide a convenient compact design because they interchange dimensionally with standard single-row radial types.

Wide-type radial rubber seal bearings (W-PP type) designated by prefix W and suffix PP for two seals are made with standard bores and outside diameters, but with widths the same as those as corresponding double-row bearings. This design also utilizes a molded seal.

The extra width offers a larger contact area for the shaft and housing and also provides additional space for grease displacement under agitation.

These wide-type rubber seal bearings are particularly well-suited for use by electric motor manufacturers; advantages of the bearing have helped simplify design. A typical example of motor design simplification is illustrated (fig. 173).

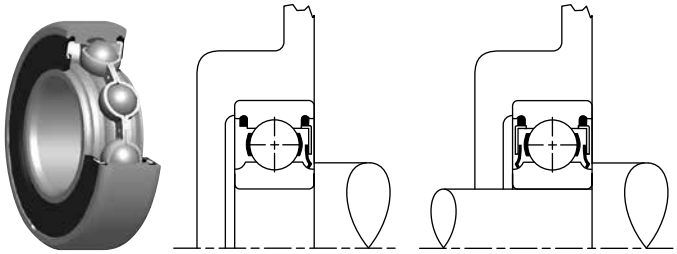


Fig. 172. Typical mounting arrangements.



Fig. 173. Electric motor assembly with W-PP type bearing.

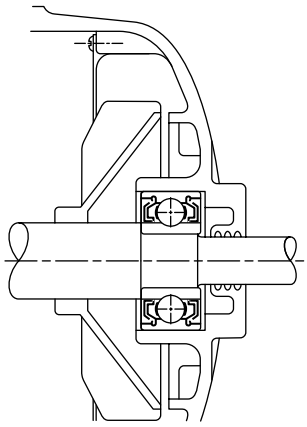


Fig. 174. W-PP type typical mounting.

RUBBER SEALS (R-TYPE)

One of the most advanced sealing designs introduced by Timken is the R-type rubber seal bearing. This is a positive-contact seal of three-piece construction, utilizing a synthetic rubber seal retained by two steel caps. The seal flares outward and rides or wipes on the ground land of the inner ring. In this design, the rubber sealing element is completely protected by a closely fitting outer cap or shroud, which nests tightly against the seal member following its flared-out shape at the inner ring of the outside diameter. The innermost member is crimped into a groove in the outer ring and encapsulates the seal and outside shroud. Providing firm seal contact, the back-up plate of the seal assembly has a close clearance with the outside diameter of the inner ring. This prevents the seal from being pushed inward.

The R-type seal provides improved lubricant retention, greater protection against contaminant ingress and protection against abrasive damage of the rubber seal, which is encountered in agricultural and textile applications. This seal construction also is available in standard and heavy series wide inner bearings.

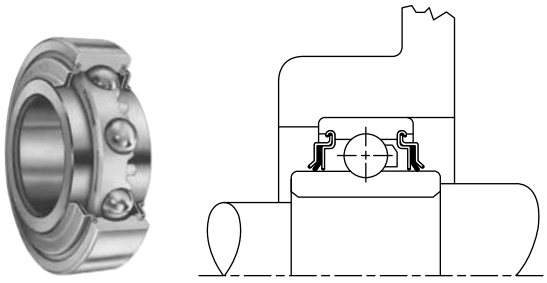


Fig. 175. Shroud seal suffix RR.

TRI-PLY SEALS

Tri-Ply Shroud Seal ball bearings are designed for bearing applications involving exceptionally severe contamination or abrasion environments. They are produced in many types and sizes, both in the radial and wide inner ring designs.

Each Tri-Ply seal consists of a triple-lip nitrile seal molded to a heavy metal shroud cap. All three seal lips have heavy flare-out contact with the inner ring outside diameter and provide exceptionally effective protection against lubricant loss and wet or abrasive contaminants entry. The shroud cap, which nests closely with the outside seal lip, helps protect the rubber seal members from abrasive damage.

A feature of these bearings is the balanced design, consisting of deep raceways, large ball size, and extra-wide or heavy inner rings. The use of Tri-Ply bearings simplifies housing designs, and their extra inner ring width provides greater support on the shaft. These bearings are widely used on conveyors and farm machinery such as disc harrows, hillers, tomato harvesters and cotton harvesters.

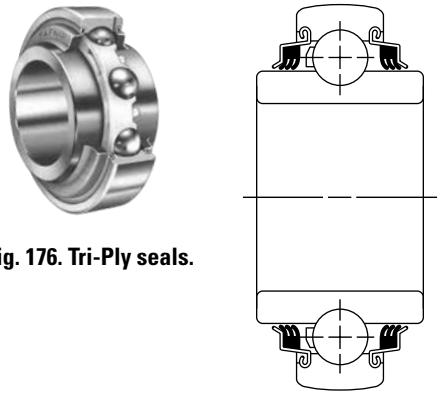


Fig. 176. Tri-Ply seals.

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