Ball and Roller Bearings

INTRODUCTION

For over 80 years, The Torrington Company has been a leader in the advancement of bearing technology to its present level of sophistication and precision. Expert craftsmen, well equipped production facilities and continuing research and development programs insure that our products are synonymous with quality and reliability. Today, our plants manufacture thousands of bearing types and sizes to handle a wide range of application requirements.

Anti-friction bearings possess capabilities involving 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 a totally comprehensive treatise but does serve as a useful guideline in bearing selection. Where more complex bearing applications are involved, The Torrington Company Engineering Department should be consulted. The following topics are covered within this section:

- Bearing Types
- Cages
- Internal clearances
- Tolerances
- Shaft and housing fits and shoulders
- Load ratings and life calculations
- Lubrication
- Materials
- Limiting speeds
- Duplex bearings and preloading

For aircraft control bearing engineering data refer to Control Bearings pages 40 - 48.

Bearing Types

RADIAL BALL BEARINGS

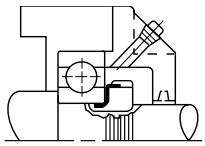
The basic types of Fafnir ball bearings are shown here. They are the non-filling slot or Conrad type, which is identified by the suffix K and the filling slot designated by the suffix W.

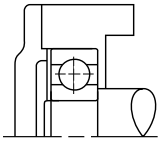
The non-filling slot or Conrad bearing has uninterrupted raceway shoulders and is capable of supporting radial, thrust, or combined loads. The filling slot type, which is assembled with more balls than a K type of the same size, has a greater capacity than the K type but has limited thrust capacity due to the filling slots in the raceway shoulders.

Both the K and W types can be mounted with or without locknuts and either fixed or floating in their housings as illustrated here.


Suffix K


Suffix W


Fixed Mounting

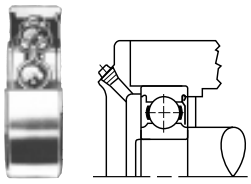

Floating Mounting

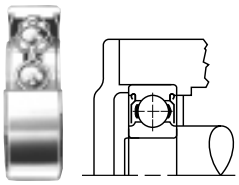
BALL BEARINGS WITH SHIELDS AND SEALS

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.

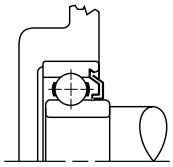
Double shielded bearings are prelubricated with the correct amount of Fafnir approved ball bearing grease, and are designed for applications where relubrication is not required. Typical mountings are shown.

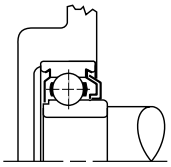

One Shield-Suffix D


Two Shields-Suffix DD

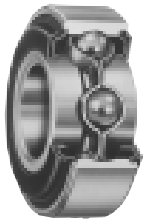
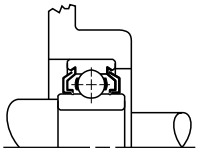
Labyrinth or Mechani-Seals (L-Type)

Bearing with Mechani-Seals are made in the non-filing 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, 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.


Suffix L

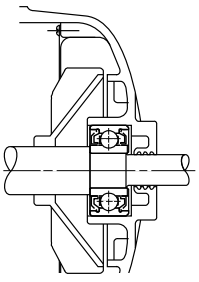

Suffix LD

The Mechani-Seal was developed by Fafnir to provide a frictionless seal for effective grease retention and exclusion of foreign material. Basically it consists of two “dished” steel plates. The inner member is fixed securely in the outer ring of the bearing and provides an ample grease chamber plus effective grease retention. The outer member is pressed on the outside diameter of the inner ring and rotates as a slinger to throw off contaminants. Close running clearances between the inner and outer members assures effective sealing under extremely severe conditions. This seal configuration is very effective under high speed, because it is virtually frictionless and utilizes slinger action. 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.



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.


W-LL Type

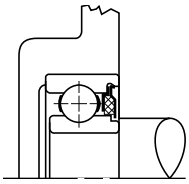

Typical Mounting

Bearing Types

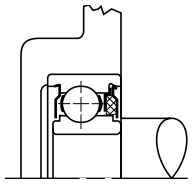
Felt Seals (T Type)

The felt seal consists of two metal plates fixed in the outer ring of the bearing which enclose a felt washer. This felt washer, 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, the inner rings are offset slightly on the opposite side of the seal to permit clearance when the bearings are mounted in blind housings as illustrated.



Suffix T



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 rabbet radius of the inner ring. The flareout of the seal against the inner rabbet radius assures constant positive contact to provide an effective barrier against the entrance of contaminants or loss of lubricants.

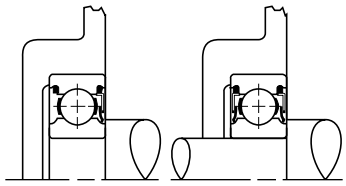
Because they interchange dimensionally with standard single row radial types, Fafnir rubber seal bearings provide a convenient compact design.

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 shaft and housing and also provides additional space for displacement of grease under agitation.

These wide type rubber seal bearings are particularly well suited for use by electric motor manufacturers where their advantages have helped simplify design. A typical example of motor design simplification is illustrated.

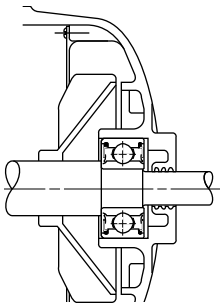
Suffix PP



P Type **PP Type**

Typical Mounting Arrangements

Electric Motor Assembly with W-PP Type Bearing

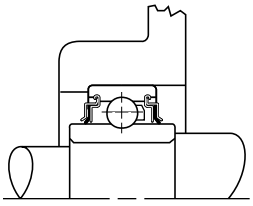


Rubber Seals (R-Type)

One of the most advanced sealing design introduced by Fafnir 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. Besides providing firm seal contact, the back-up plate of the seal assembly has a close clearance with the outside diameter of the inner ring thus preventing the seal from being pushed inward by external forces.

Laboratory tests have clearly established the superior performance of the shroud-type “R” seal. Along with improved lubricant retention and greater protection against contaminants, the shroud design guards the rubber seal against abrasive damage by dirt, and fiber wrap which may be prevalent in agriculture and textile applications. This seal construction is also available in standard and heavy series, wide inner ring bearings.

Shroud Seal suffix RR



Tri-Ply Seals

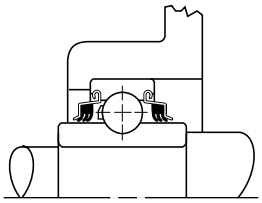
Tri-Ply, shroud seal ball bearings are designed for bearing applications involving exceptionally severe contamination or abrasion environments. They are produced in many types and sizes, both in the radial and wide inner ring designs.

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

Bearing Types

Tri-Ply Seals *(continued)*
the inner ring outside diameter and provides exceptionally effective protection against the loss of lubricant and the entrance of wet or abrasive contaminants. The shroud cap, which nests closely with the outside seal lip helps protect the rubber seal members from wrap and abrasion.

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, cotton harvesters, etc.



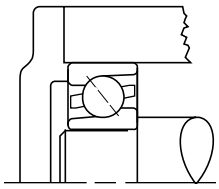
Tri-Ply Seals

ANGULAR-CONTACT BALL BEARINGS

Single Row Type
Single row, angular contact ball bearings are designed for combination loading with high thrust capacity in one direction and are recommended 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.

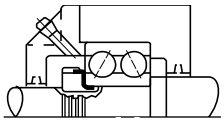
The angular contact ball bearing has a relatively large contact angle, high race depths, and a maximum complement of balls assembled through a counterbore in the outer ring. These features provide bearings with significantly more thrust capacity than radial bearings of the same size.

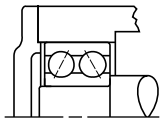
Angular contact bearings are used in such applications as gear reducers, pumps, worm drives, vertical shafts, and machine tool spindles, in which they are frequently mounted in various duplex arrangements as described in the duplex section (page E59).



Double Row Type
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 polymeric retainers.





Fixed Mounting **Floating Mounting**

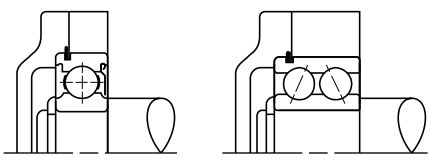
Typical Mountings for Double Row, Angular contact Ball Bearings

BALL BEARINGS WITH SNAP RINGS (WIRELOC TYPE)

Single row radial bearings including those with seals or shields and open and shielded double row types are available with snap rings which provide a shoulder integral with the bearing, 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 that opposite the shield or seal position.

These bearings are particularly 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 sacrifice in bearing capacity. The thrust capacity of the snap ring in shear is considerably above the thrust capacity of the bearing.

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



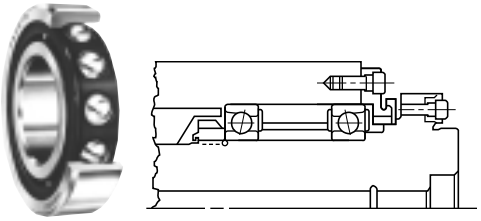
Typical Mounting For Snap Ring Bearing

Bearing Types

SUPERPRECISION BALL BEARINGS

Every Fafnir ball bearing manufactured is made to precision tolerances. The standard tolerances established by the Annular Bearing Engineers Committee (ABEC) are adhered to, and even the most liberal classification, ABEC-1 assures a precision product by nature. Many applications in numerous types of machinery can be satisfactorily operated with ABEC-1 tolerance bearings.

However, for applications involving high speeds, extreme accuracy and rigidity in such equipment as high-grade machine tools, woodworking machines, gas turbines, and sensitive precision instruments, a complete line of Fafnir superprecision ball bearings is manufactured to ABEC-7 and ABEC-9 tolerances.



Typical Application For Superprecision Bearing

BEARINGS FOR AIRCRAFT CONTROL SYSTEMS

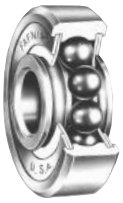
These bearings are primarily used for oscillating service and, although initially designed for aircraft control mechanisms, have found wide usage in industrial, textile and packaging machinery.

The important features of typical control bearings include a maximum complement of rolling elements, Teflon* or synthetic rubber contact seals, cadmium plated surfaces and MIL-G-81322 grease.

Other popular designs in these general categories are Rod Ends, Bell Cranks and Track Rollers.

Complete data and descriptions of the various aircraft control bearings are shown on pages 84 through152.

*Dupont registered trademark



KP-A Type

Rod End

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 which are bolted to pedestals or frames independent of each other.

Self-Locking (Eccentric) Collar

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

The locking collar has a counterbored recess which is 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 thus 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 of any kind are necessary. The collar setscrew provides supplementary locking.

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

Setscrew Series Bearings

The (G)YA-RR(B) and the GY-KRRB series relubricatable and non-relubricatable bearings are extended inner ring and wide inner ring type bearings with specially designed setscrews to lock on shafting. Positive contact landriding R seals provide protection against harmful contaminants and retain lubricant. Extended inner ring bearings are used when space is at a premium and over turning loads are not a problem. The new wide inner ring setscrew series is available when additional surface contact on the shaft is a requirement for added stability .

Concentric Collar

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

RA-RR Series
Extended Inner Ring
with Locking Collar

Shroud-Seal KRRB Series
Wide Inner Ring
with Locking Collar

YA-RR Series

GC-KRRB Series

Bearing Types

RADIAL SPHERICAL ROLLER BEARINGS

The principle styles of radial spherical roller bearings are offered by Torrington: BR, CJ, YM, YMB, VCF, VCSJ, VJ and VM.

BR bearings offer the greatest range of sizes in all series. They combine Torrington design experience with proven performance in many industries.

All of the newer styles (CJ, YM, YMB and VCF) offer higher load ratings for longer life. CJ and YM bearings incorporate the advanced features of Torrington Trac-Tru™ technology. CJ bearings include a stamped steel cage and are suitable for a broad range of general service applications. For extreme conditions of use, the YM, YMB style, with a machined bronze cage, should be considered.

The VCF- style spherical roller bearing uses a cage made of high performance glass-fiber reinforced polyamide. The maximum continuous operating temperature under normal working conditions is 250°F (120°C).

All styles are available in straight or tapered bores. Tapered bore bearings can be ordered by placing a “K” immediately after the numbers in the bearing description (i.e., 22311KYM).

Tapered bore bearings are available with adapter sleeve assemblies consisting of sleeve, locknut and washer. Adapter sleeve assemblies are designated SNW (i.e., SNW117).

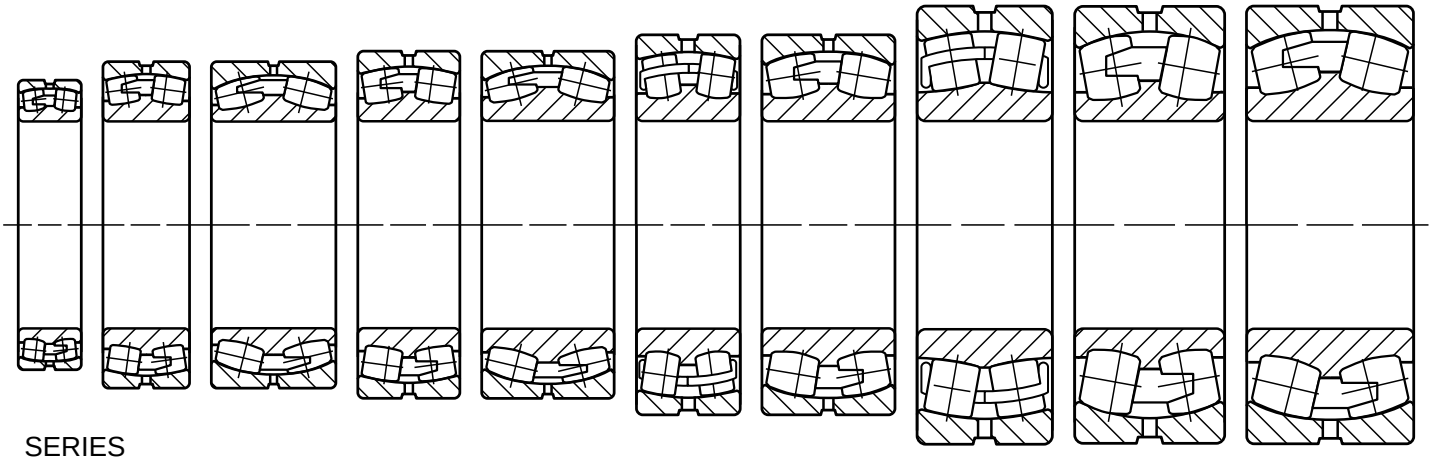
Torrington spherical roller bearings are available in 10 dimensional series conforming to ISO and ANSI/ABMA standards. A graphical illustration is presented below.

BR

Tapered Bore Bearing with Adapter Sleeve Assembly

CJ

YM / YMB



Optional features available with Torrington spherical roller bearings:

W33 Lubrication Groove and Oil Holes

A lubrication groove and three oil holes are provided in the bearing outer ring. This 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 (i.e.,22216W33).

W22 Selected Outside Diameter Bearings

Bearings with selected outside diameters are required in some applications. Torrington spherical roller bearings are available with reduced outside diameter tolerance. This allows a close control of the fit between the bearing and housing. To obtain the accuracy desired, the housing is usually ground or honed.

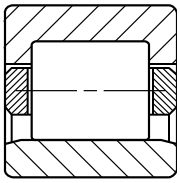
To specify this feature, add the suffix “W22” to the bearing number (i.e., 22216W22).

Additional features are available. Consult the Torrington engineering department.

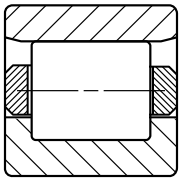
Bearing Types

RADIAL CYLINDRICAL ROLLER BEARINGS

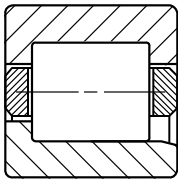
Standard Styles



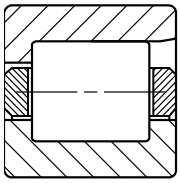
RIU, RU



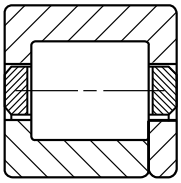
RIN, RN



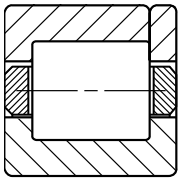
RIJ, RJ



RIF, RF



RIT, RT



RIP, RP

A Torrington cylindrical roller bearing consists 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, has one rib or none. The ring with two ribs locates axially 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 in the mating ring.

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

Types RU and RIU have double ribbed outer and straight inner rings. Types RN and RIN have double ribbed inner and straight outer rings. The use of either type at one position on a shaft is ideal for accommodating nominal 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.

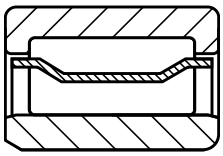
Types RJ and RIJ have double ribbed outer and single ribbed inner rings. Types RF and RIF have double ribbed inner and single ribbed outer rings. Both types can support heavy loads, as well as light unidirectional thrust loads up to 10 % of the radial loads. The thrust load is transmitted between the diagonally opposed rib faces in a sliding action rather than a rolling one. Thus, when limiting thrust conditions are approached, lubrication can become critical. The Torrington engineering department should be consulted for approval of 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 end play should be adjusted at time of assembly.

Types RT and RIT have double ribbed outer and single ribbed inner ring with a loose rib which allows the bearing to provide axial location in both directions. Types RP and RIP have a double ribbed inner and a single ribbed outer with a loose rib.

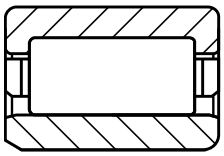
Types RT and RP (as well as RIT and RIP) can carry heavy radial loads and light thrust loads in both directions. Factors governing the thrust capacity are the same as for types RF and RJ bearings.

A type RT or RP bearing may be used in conjunction with a type RN or RU bearing for applications where axial shaft expansion is anticipated. In such cases the fixed bearing is usually placed nearest the drive end of the shaft to minimize alignment variations in the drive. shaft end play (or float) is determined by the axial clearance in the bearing.

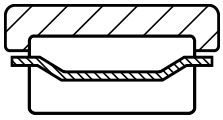
5200 Metric Series



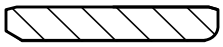
A-52xx-WS



A-52xx-WM



52xx-WS



A-52XX

This series features enhanced radial load rating 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 can also be furnished without an inner ring for applications where radial space is limited. When so used, the shaft journal must be hardened to R_c 58 minimum, and the surface finished to 15 RMS maximum.

The bearing is usually furnished with a rugged stamped steel cage (“S” designation) which 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 bronze (“M” designation) are available for applications where reversing loads or high speeds might indicate their need. Outer rings are made from vacuum treated high carbon chromium alloy steel. The inner rings are made from a vacuum treated carburized grade nickel alloy steel and are deep case carburized to R_c 58 to accommodate the hoop stresses caused by heavy press fits frequently encountered.

The Controlled Contour rollers are made from a through hardening grade vacuum treated steel . Proper roller guidance is assured by integral ribs and roller end clearance control.

The standard bearing is furnished with internal diameter clearances designated as R6 which are tabulated on page 291. Other internal clearances can be supplied upon request.

Bearing Types

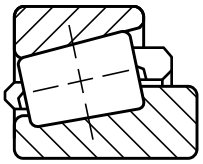
RADIAL TAPERED ROLLER BEARINGS

Single Row Tapered Roller Bearings

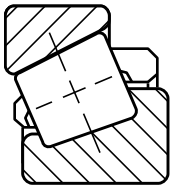
Two types (TS and TSS) of single row tapered roller bearings are offered. Each has a cup, and a cone with a cage and roller assembly. Type TS serves as the basic design for the others.

Since a single row tapered roller bearing supports thrust loads from only one direction, the preferred mounting is in opposed pairs. The proper internal clearance for the two bearings may be obtained by axial adjustment at the time of assembly.

The type TSS bearings are similar to type TS, but have a steeper angle of contact. These bearings are recommended for applications where thrust loads are predominant.



TS

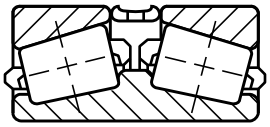


TSS

Two Row Tapered Roller Bearings

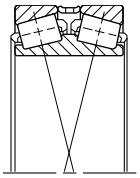
Two row tapered roller bearings have twice the radial capacity of single row bearings of the same series and are used in positions where radial loading is too severe for single row bearings. They have the further advantage that a two row bearing can take thrust loads in both directions, thus allowing all applied thrust and shaft location to be taken at one position. This often simplifies design and reduces the danger of bearing clearance changes due to axial shaft expansion.

The Torrington TDI bearing has adouble cone assembly, two single cups, and **is supplied with a cup spacer unless otherwise specified**. It is important to submit sufficient application information to allow determination of the proper clearance. The cup spacer for each bearing is face ground after accurate measurement of the distance between adjacent cup faces to determine internal clearance for the bearing assembly. Consequently, spacers or components may not be interchanged. A lubrication groove and oil holes are included in the spacer. The type TDI bearing is suitable for roll neck applications in light or medium duty rolling mills, and on many other types of industrial equipment.



TDI

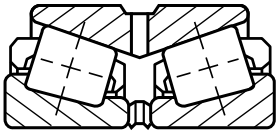
Contact angle lines **converge** toward axis



Less Rigid Mounting

The design of type TDI is such that the contact angles converge as they approach the axis of rotation. Consequently, the use of these bearings will not appreciably increase the rigidity of the shaft mounting and they should not be used singly on a shaft since they will not resist overturning moments.

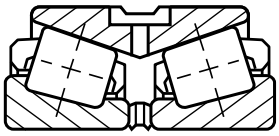
The Torrington Type TDO and TDOD bearings have a double cup, two single cone assemblies, and **are supplied with a shaft supported cone spacer unless otherwise specified**. Spacers for individual bearings are face ground to obtain the desired internal clearance for the assembly. Spacers and components may not be interchanged. It is important to submit sufficient application information to allow determination of the proper clearance. Type TDOD is primarily used in a floating cup mounting. The counterbored hole in the cup is for a drilled dowel pin which prevents rotation of the loose fitted cup. Lubrication may be introduced to the bearing through this hollow pin. All of these bearings may be lubricated through the shaft by use of oil holes in the cone spacer. Type TDO may be lubricated by the use of groove and oil holes in the double cup.



TDO

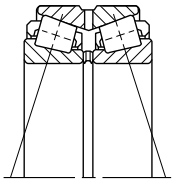
In types TDO and TDOD, the contact angle lines diverge as they approach the axis of rotation, thus increasing the rigidity of the shaft mounting. Therefore, these bearings are suited for resisting overturning moments. Due to increased bearing rigidity, housing bore alignment is somewhat more critical than with TDI types.

TDOC bearings incorporate all the design features of the TDO and TDOD styles. The one piece cup includes a lubrication groove and holes plus a dowel pin hole to prevent cup rotation.



TDOC

Contact angle lines **diverge** toward axis



More rigid mounting

Bearing Types

THRUST BEARINGS

Standard types of thrust bearings manufactured by Torrington are included in this section. Each type is designed to take thrust loads, but three types (TVL, DTVL 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 insure 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 race 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 TTVF – V-Flat thrust tapered roller bearing
Type TTVS – Self-aligning V-Flat thrust tapered roller bearing

Thrust Ball Bearings

Thrust ball bearings are used for lighter loads and higher speeds than thrust roller bearings.

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

The type TVB bearing provides axial rigidity in one direction, and its use to support radial loads is not recommended. It is very easily mounted. Usually the rotating washer is shaft mounted. The stationary washer should be housed with sufficient O.D. clearance to allow the bearing to assume its proper operating position. In most sizes both washers have the same bore and O.D. The housing must be designed to clear the O.D. of the rotating washer, and it is necessary to step the shaft to clear the bore of the stationary washer.

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.

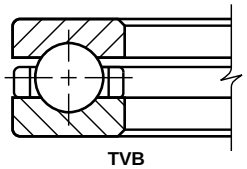
The bearing has two hardened and ground steel rings with ball grooves and a one-piece bronze cage which spaces the ball complement. Although not strictly an annular ball bearing, the larger ring is still called the outer ring, and the smaller the inner ring. Torrington Standard Tolerances for type TVL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

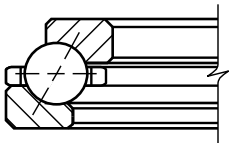
Usually the inner ring is the rotating member and is shaft mounted. The outer ring is normally stationary and should be mounted with O.D. clearance to allow the bearing to assume its proper operating position. If combined loads exist, the outer ring must be radially located in the housing.

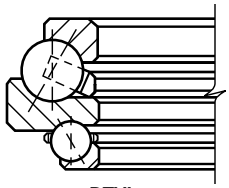
The type TVL bearing should always be operated under thrust load. Normally, this presents no problem as the bearing is usually applied on vertical shafts in oil field rotary tables and machine tool indexing tables. If constant thrust load is not present it should be imposed by springs or other built-in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

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

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


TVB


TVL


DTVL

Thrust Roller Bearings

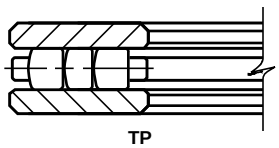
Thrust cylindrical roller bearings withstand heavy loads at relatively moderate speeds. Standard bearings can be operated at bearing O.D. peripheral speeds of 3000 fpm. Special design features can be incorporated into the bearing and mounting to attain higher operating speeds.

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

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

The type TP thrust cylindrical roller bearing has two hardened and ground steel washers, with a cage retaining one or more Controlled Contour roller 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 prolongs bearing life.

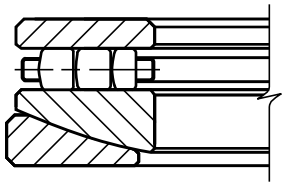
Because of the simplicity of their design, type TP bearings are economical. Since minor radial displacement of the raceways does not affect the operation of the bearing, its application is relatively simple and often results in manufacturing economies for the user. Shaft and housing seats, however, must be square to the axis of rotation to prevent initial misalignment problems.


TP

Bearing Types

Thrust Roller Bearings *(continued)*

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

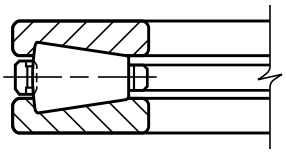


TPS

The type TTHD thrust tapered roller bearing has an identical pair of hardened and ground steel washers with conical raceways, and a complement of Controlled Contour tapered rollers equally spaced by a cage.

In the design of type TTHD, the raceways of both washers and the tapered rollers have a common vertex at the bearing center. This assures true rolling motion. The large end of each tapered roller is spherically ground to match the concave faces of both washer ribs. The pressure exerted under load by the roller ends at the rib surfaces accurately guides the rollers. The center of the large end of each roller is counterbored to improve lubrication at the guiding rib surfaces.

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, extremely heavily loaded applications, these bearings are supplied with a full complement of rollers for maximum capacity, and are identified in the table of dimensions by the suffix 278 of the bearing number. For application approval of the full complement type TTHD bearing, consult our engineering department.

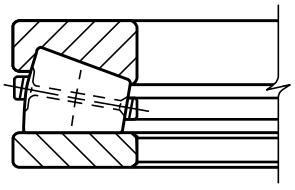


TTHD

TTVF V-Flat thrust tapered roller bearings combine the outstanding features of thrust tapered roller and cylindrical roller bearings to offer the highest possible capacity of any thrust bearing of its size. In the V-Flat design, one washer is perfectly flat, while the second includes a tapered raceway matching the rollers. The design was originally developed for screw-down applications in metal rolling mills where thrust loads exceeding one million pounds are common.

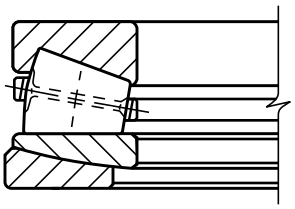
V-Flat bearings have exceptional dynamic capacity within a given envelope and provide superior static capacity. They have been highly successful in highly loaded extruders, in cone crushers, and other applications where a wide range of operating conditions are found.

Most sizes of V-Flat bearings utilize cages with hardened pins through the center of the rollers. This allows closer spacing of the rollers to maximize capacity. Smaller sizes have bronze cages, carefully machined to permit a full flow of lubricant.



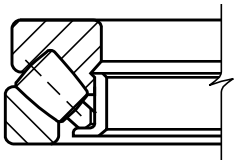
TTVF

TTVS self-aligning V-Flat bearing employs the same basic roller and raceway design, except that the lower assembly is composed of two washers with the contacting faces spherically ground to permit self-alignment under conditions of initial misalignment. **TTVS bearings should not be used, however, if dynamic misalignment (changing under load) is expected.**



TTVS

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. Higher speeds are obtainable with this design than with any of the other thrust roller bearings. Typical applications are air regenerators, centrifugal pumps, and deep well pumps. Maximum axial misalignment between inner and outer ring is ±2.5°.



TSR

Cages

Cages (sometimes referred to as rolling element separators or retainers) perform an important function in the proper operation of rolling bearings. They serve to maintain uniform rolling element spacing in the races of the inner and outer rings of the bearings as the rolling elements pass into and out of the load zones. Cage types in several materials and configurations have been developed by the Torrington Company to meet various service requirements. Temperature limitations are described later in this section.

Some of the materials from which cages are made include pressed steel, pressed bronze, machined bronze, machined steel and compositions of various synthetic materials.

RADIAL BALL BEARINGS

Steel Cages

Steel cages are generally ball-piloted and are available in the following types:

Pressed Steel Finger Type Cages (SR)

Light in weight and made from strong, cold rolled steel, the pressed steel cage because of its compactness is the optimum design for use in shielded and sealed bearings which must conform to ABEC boundary dimensions. This is a general purpose design and is frequently used for ABEC-1 ball bearing sizes.

Pressed Steel Welded Cages (WR)

The Fafnir developed, welded steel cage provides greater strength, increased rigidity, and better pocket alignment than the finger type. The projection welding of the cage halves eliminates weakening notches or holes and fingers or rivets. It assures better mating of cage halves circumferentially and radially.

This construction also provides more uniformity of ball to pocket clearance. Improved pocket geometry permits higher speeds, reduces cage wear, provides cooler operation, and improves and extends lubricant life. This cage is standard in most radial non-filling slot bearings of the open, shielded, and sealed types.

Molded Cages

Molded cages are either ball piloted or land piloted and are available in the following types:

Nylon (PRB)

One-piece molded snap-in 6/6 nylon cages are specially processed to provide:

- Toughness at moderately high and low temperatures
- Resistance to abrasion
- Resistance to organic solvents, oils and grease
- Natural lubricity
- Long term service at temperatures up to +250°F(+121°C)
- Dimensional stability

These cages offer superior performance in applications involving misalignment due to their greater flexibility.

PRB molded nylon cages provide uniformity of ball pocket clearances for consistent operation. They are suitable for temperatures up to +250°F(+121°C) continuous operation and can tolerate +300°F (+149°C) for short periods.

These cages are available in conrad (K) bearings and are standard for the more popular wide inner ring bearing series.

Cages

Molded Cages *(continued)*

Reinforced Nylon (PRC)

Molded 6/6 nylon reinforced with 30% (by weight) glass fibers. This material is used primarily for one-piece ring piloted cages used in precision grades of angular contact bearings.

PRC cages offer outstanding strength and long term temperature resistance. Molded to very close tolerances and uniformity, combined with light weight design, they permit higher speeds and reduced noise. They are suitable for temperatures up to +300°F (149°C).

PRC cages are usually the one piece outer piloted “L” type design, but are also available in one piece ball controlled designs.

Special Molded Cages

For very high speeds or very high temperature applications special materials can be used. Nylon with a PTFE additive is available for molded cages required for high speed applications. For applications involving high operating temperatures (up to +450°F, +232C) molded cages made of fiber reinforced polyphenelyene sulfide can be made.

For availability of these special cages please consult the engineering department.

Bronze and Steel Cages

Bronze cages are generally installed in bearings which are designed for use on heavily loaded applications, such as, deep well pumps, woodworking machinery, and heavy construction machinery. The following types of Fafnir bronze cages are available:

BR

MBR

Cast Bronze Cage (BR)

This cage, a ball piloted bronze retainer designated by the letters BR, utilizes two identical halves which are riveted together.

Machined Bronze Cage (MBR)

These cages are machined all over to provide ring riding surfaces and good static and dynamic balance. They are commonly incorporated as inner ring piloted designs in the 7000 angular contact series. Because of their superior strength, these cages are generally used on heavily loaded applications such as, deep well pumps, woodworking machinery, and heavy construction machinery.

Iron Silicon Bronze Cage (SMBR) and Machined Steel Cage (MSR)

The SMBR and MSR cages are ring piloted. The advantages of these cages are high strength even at elevated temperatures (see chart on page E64) as well as high-speed capability due to the ring piloted construction. In many cases these cages are silver plated for use in applications requiring high reliability.

They are available in both ball and roller bearings.

Composition Cages (CR)

Composition cages combine light weight, precision and oil-absorbing features which are particularly desirable for use on high speed applications. This (CR) cage, is a ring piloted type and is particularly associated with the outer-ring piloted , extraprecision WN series bearings.

Special Cages

For certain very high contact angle, light section aircraft bearings, molded nylon “snake” cages are employed. Cages are also made with high temperature materials (see page E64) in the various configurations described above.

For availability of special cages please contact our engineering department.

Continued on the next page.

Cages

SPHERICAL ROLLING BEARINGS

Bronze Cages

BR Bearing cages are land riding on the center guide flange and precision machined to assure dynamic balance for quiet and trouble free operation.

Roller pockets are cylindrically bored to close tolerances leaving adequate space for lubrication. The open end design of the cage allows the lubricant to reach all contact surfaces easily, assuring positive lubrication and a cooler running bearing.

Two independent cages, one for each row of rollers, are assembled in an individual bearing. Under conditions of thrust loading, the rotational speed of each row may vary slightly but since each row has its own cage there is no drag or skid resulting from this operating mode.

YM Bearing cages are one-piece design centrifugally cast and precision machined. It's rugged construction provides an advantage in more severe applications. Due to its design this cage permits YM bearings to incorporate greater load carrying capabilities.

The open end design permits lubricant to reach all surfaces easily assuring ample lubrication and a cooler running bearing.

BR Cage

YM Cage

Stamped Steel Cages (J)

These cages are used in CJ bearings and are designed to permit extra load carrying capabilities in the bearing.Two independent cages, one for each row of rollers, are assembled in an individual bearing.

Glass-fiber reinforced polyamide cages (F)

These high performance light weight cages are used in CF bearings. The maximum continuous operating temperature for these cages under normal operating conditions is 250°F (120°C). Intermittent temperatures up to 300°F (149°C) can be tolerated.

F Cage

Pin Type Cages

Large diameter spherical roller bearings can be supplied with these cages. The design of pin type cages permits an increased roller complement thus giving the bearing enhanced load carrying ability. Consult Torrington engineering for recommendations on the application of this cage.

RADIAL CYLINDRICAL ROLLER BEARINGS

Bronze Cages

These are primarily roller guided cages with cylindrical bored pockets. They are used with the standard style roller bearings.

Bronze Cage

Stamped Steel Cages

Stamped steel cages of varying designs are available in the standard style cylindrical roller bearings.

The stamped steel cage for the 5200 series is a land riding cage piloted by 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.

TAPERED ROLLER BEARINGS

Bronze Cages (B)

These heavy section ruggedly constructed cages are fully machined and are land riding on the thrust and toe flange O.D. of the cone (inner ring). The webs between the straight through machined roller pockets are staked above the pitch line to retain the rollers with the cone.

Stamped Steel Cages (S)

The cages are of compact space savings design and in some cases permit increased load carrying capabilities to be incorporated into the bearing. They are roller riding with webs positioned above the pitch line to retain the rollers within the cone.

Pin Type Cages (P)

This steel cage design features a pin which fits closely with a bored hole in the roller. The rollers can thus be retained with a minimum space between the rollers so that an increased complement of rollers can be incorporated. This results in greater load carrying capabilities in the bearing.

Internal Clearance

Radial Ball Bearings

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

Internal clearance is sometimes utilized 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 gaging radially or axially.

Radial measurement is accepted as the more significant characteristic because it is more directly related to shaft and housing fits. It also is the method prescribed by the American Bearing Manufacturers Association (ABMA).

Radial Internal Clearance

The radial internal clearance 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.

Radial internal clearance can be measured mechanically by moving the outer ring, horizontally as pictured in Figure 1. The total movement of the outer ring when the balls are properly seated in the raceways, determines the radial internal clearance. Several readings should be taken using different circumferential orientations of the rings in order to get a comprehensive average reading.

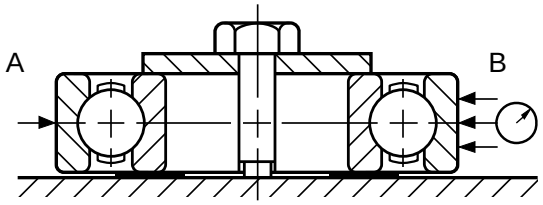


Figure 1

LIMITS FOR RADIAL INTERNAL CLEARANCE OF SINGLE ROW, RADIAL CONTACT BALL BEARINGS UNDER NO LOAD

(Applies to Bearings of ABEC-1, ABEC-3, ABEC-5, ABEC-7, and ABEC-9 Tolerances)

Tolerance Limits in ten-thousandths inches (.0001") and micrometers (μm)

Basic Bore Diameter MM		H (2)		R (0)		P (3)		J (4)		JJ (5)	
		Acceptance Limits		Acceptance Limits		Acceptance Limits		Acceptance Limits		Acceptance Limits	
Over	Incl.	low	high	low	high	low	high	low	high	low	high
2.5	10	0	3	1	5	3	9	6	11	8	15
		0	7	2	13	8	23	14	29	20	37
10	18	0	3.5	1	7	4	10	7	13	10	18
		0	9	3	18	11	25	18	33	25	45
18	24	0	4	2	8	5	11	8	14	11	19
		0	10	5	20	13	28	20	36	28	48
24	30	0.5	4.5	2	8	5	11	9	16	12	21
		1	11	5	20	13	28	23	41	30	53
30	40	0.5	4.5	2	8	6	13	11	18	16	25
		1	11	6	20	15	33	28	46	40	64
40	50	0.5	4.5	2.5	9	7	14	12	20	18	29
		1	11	6	23	18	36	30	51	45	73
50	65	0.5	6	3.5	11	9	17	15	24	22	35
		1	15	8	28	23	43	38	61	55	90
65	80	0.5	6	4	12	10	20	18	28	26	41
		1	15	10	30	25	51	46	71	65	105
80	100	0.5	7	4.5	14	12	23	21	33	30	47
		1	18	12	36	30	58	53	84	75	120
100	120	1	8	6	16	14	26	24	38	35	55
		2	20	15	41	36	66	61	97	90	140
120	140	1	9	7	19	16	32	28	45	41	63
		2	23	18	48	41	81	71	114	105	160
140	160	1	9	7	21	18	36	32	51	47	71
		2	23	18	53	46	91	81	130	120	180
160	180	1	10	8	24	21	40	36	58	53	79
		2	25	20	61	53	102	91	147	135	200
180	200	1	12	10	28	25	46	42	64	59	91
		2	30	25	71	63	117	107	163	150	230
200	240	1	14	12	32	29	54	50	76	72	105
		3	36	30	81	74	137	127	193	183	267

Continued on the next page.

Internal Clearances

Limits for radial internal clearance of single row, radial contact ball bearings under no load

(Applies to Bearings of ABEC-1, ABEC-3, ABEC-5, ABEC-7, and ABEC-9 Tolerances)
Tolerance Limits in ten-thousandths inches (.0001") and micrometers (μm)

Basic Bore Diameter MM		H (2) Acceptance Limits		R (0) Acceptance Limits		P (3) Acceptance Limits		J (4) Acceptance Limits		JJ (5) Acceptance Limits	
Over	Incl.	low	high	low	high	low	high	low	high	low	high
240	280	1	16	13	38	34	62	58	88	84	122
		3	41	33	97	86	157	147	224	213	310
280	320	2	19	16	45	41	71	67	101	97	139
		5	48	41	114	104	180	170	257	246	353
320	370	2	21	18	50	46	82	78	116	112	161
		5	53	46	127	117	208	198	295	284	409
370	430	3	25	22	58	54	95	91	134	130	187
		8	64	56	147	137	241	231	340	330	475
430	500	4	29	26	67	63	110	106	156	152	217
		10	74	66	170	160	279	269	396	386	551
500	570	4	32	29	76	72	125	121	177	173	248
		10	81	74	193	183	318	307	450	439	630
570	640	5	36	33	85	81	140	136	199	195	278
		13	91	85	216	206	356	345	505	495	706
640	710	8	45	42	94	90	155	151	222	218	307
		20	114	107	239	229	394	384	564	554	780
710	800	8	55	51	106	102	175	171	248	244	346
		20	140	130	269	259	445	434	630	620	879
800	1060	11	83	79	139	136	231	227	328	324	452
		28	211	201	353	345	587	577	833	823	1148

The Torrington Company radial clearance designations correlate with ABMA symbols as follows:

Fafnir Bearing Number Prefix	ABMA Symbol	Description
H	2	**Snug** fit; slight internal clearance; sometimes used to achieve a minimum of radial or axial play in an assembly, Example: H204K
R	0	**Medium** fit; internal clearance generally satisfactory with recommended shaft and housing fits shown on pages E36-40. Example: RMM204K.
P	3	**Loose** fit; 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** fit; large amount of internal clearance for applications involving large interference fits or temperature differentials. Example: J204K.
JJ	5	**Extra-Extra Loose** fit; extra large amount of internal clearance for applications with large temperature differential and interference fits on both rings.

End play

End play is an alternate method of measuring internal clearance and is rarely used except for certain special applications. End play is determined by mounting the bearing, as shown in Figure 2, 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. End play is the total movement of the unclamped ring when the load is applied first in one direction and then in the other.

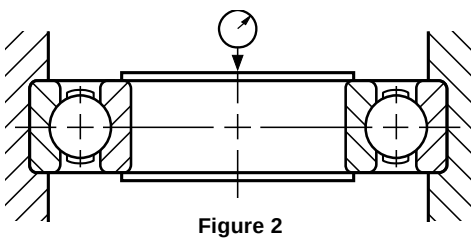


Figure 2

When the inner and outer ring raceway curvatures are accurately known, the free end play can readily be calculated from the values of no load radial clearance by the following formula:

$$E = \sqrt{4dR_D(K_O + K_i - 1) - R_D^2} \text{ or } \cong \sqrt{4dR_D(K_O + K_i - 1)}$$

(Where R_D^2 is generally a very small value and can be omitted for most calculations without introducing undue inaccuracy.)

E = Free end play where

K_O = outer race contour radius expressed as a decimal fraction of the ball diameter.

K_i = inner race contour radius expressed as a decimal fraction of the ball diameter

R_D = radial clearance (no load)

d = ball diameter

Contact Angle

The contact angle (α) is related to internal clearance as follows:

$$\alpha = \sin^{-1}\left(\frac{E}{2\,(Ko + Ki - 1)d}\right)$$

The contact angle (α) may also be accurately determined in a production bearing from its pitch diameter (P.D.) and by measuring the number of revolutions (N_c) of the ball and cage assembly relative to rotation (N_i) of the inner ring under a light thrust load.

$$(N_c) = .5N_i\left(1 - \frac{d}{P.D.}\cos\alpha\right)$$

$$\cos\alpha = \frac{P.D.}{d}\left(1 - \frac{N_c}{.5N_i}\right)$$

The accuracy of this method of measurement depends greatly upon the care taken in set-up. Balanced weight for thrust loading, vertical truing, slow turning, many turns, minimum lubricant of low viscosity and prerotation are all essential for instance. The races should not be radially restrained during the contact angle measurement.

Internal Clearances

RADIAL SPHERICAL ROLLER BEARINGS

Radial Internal Clearance (RIC) is the radial play within a bearing. Torrington bearing RIC's allow a tight fit, with sufficient internal clearance after installation for normal operating conditions.

Spherical Roller Bearings with tapered bore (K) require a slightly greater interference fit on the shaft than would a cylindrical bore bearing. The effect of this greater interference fit is a reduction of RIC. For tapered bore bearings, it is critical to select the RIC that allows for this reduction.

For example, bearing number 22328K C3 (140 mm bore with C3 clearance) is to be mounted on a tapered shaft. By feeler gauging, RIC is found to be 0.007" (0.178mm). The chart indicates that the proper fit will be obtained when RIC is reduced by 0.0025" to 0.0035" (0.064 to 0.089 mm). Clearance after mounting is computed: 0.007"- 0.003"= 0.004" (0.178-0.076=0.102mm). The locknut should be tightened until RIC reaches 0.004" (0.102mm).

Several factors influence RIC reduction. Inner rings pressed into solid steel shafts expand approximately 80% of the interference fit. Outer rings pressed into steel or cast iron housings reduce RIC by about 60%, of the interference fit. For RIC reduction on hollow shafts or non-steel materials consult Torrington sales engineers.

Torrington bearings are supplied with NORMAL RIC, unless otherwise specified. The desired RIC code must be added to the bearing number, FOLLOWING ALL OTHER SUFFIXES.

Min./max. values for each RIC are shown in the two adjacent columns directly beneath the selected RIC. Each single column represents a boundary between adjacent RIC's. For example, the minimum values shown for C5 are also the maximum values for C4; minimum values for C4 are also the maximum values for C3; etc.

Radial Internal Clearance Limits

All data on this page, except Bore I.D. are in inches/millimeters

Bore (nominal) mm		Cylindrical Bore						Tapered Bore						Recommended Reduction of RIC Due to Installation		Recommended RIC after Installation[1]
			Normal (Standard)		C4				Normal (Standard)		C4					
			min.	max.	min.	max.			min.	max.	min.	max.				
		C2		C3		C5		C2		C3		C5				
		min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
over	incl.	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm
24	30	0.0006 0.015	0.0010 0.025	0.0016 0.040	0.0022 0.055	0.0030 0.075	0.0037 0.095	0.0008 0.020	0.0012 0.030	0.0016 0.040	0.0022 0.055	0.0030 0.075	0.0037 0.095	0.0006 0.015	0.0008 0.020	0.0006 0.015
30	40	0.0006 0.015	0.0012 0.030	0.0018 0.045	0.0024 0.060	0.0031 0.080	0.0039 1.000	0.0010 0.025	0.0014 0.035	0.0020 0.050	0.0026 0.065	0.0033 0.085	0.0041 0.105	0.0008 0.020	0.0010 0.025	0.0006 0.015
40	50	0.0008 0.020	0.0014 0.035	0.0022 0.055	0.0030 0.075	0.0039 0.100	0.0049 0.125	0.0012 0.030	0.0018 0.045	0.0024 0.060	0.0031 0.080	0.0039 0.100	0.0051 0.130	0.0010 0.025	0.0012 0.030	0.0008 0.020
50	65	0.0008 0.020	0.0016 0.040	0.0026 0.065	0.0035 0.090	0.0047 0.120	0.0059 0.150	0.0016 0.040	0.0022 0.055	0.0030 0.075	0.0037 0.095	0.0047 0.120	0.0063 0.160	0.0012 0.030	0.0015 0.038	0.0010 0.025
65	80	0.0012 0.030	0.0020 0.050	0.0031 0.080	0.0043 0.110	0.0057 0.145	0.0071 0.180	0.0020 0.050	0.0028 0.070	0.0037 0.095	0.0047 0.120	0.0059 0.150	0.0079 0.200	0.0015 0.038	0.0020 0.051	0.0010 0.025
80	100	0.0014 0.035	0.0024 0.060	0.0039 0.100	0.0053 0.135	0.0071 0.180	0.0089 0.225	0.0022 0.055	0.0030 0.080	0.0043 0.110	0.0055 0.140	0.0071 0.180	0.0091 0.230	0.0018 0.046	0.0025 0.064	0.0014 0.036
100	120	0.0016 0.040	0.0030 0.075	0.0047 0.120	0.0063 0.160	0.0083 0.210	0.0102 0.260	0.0026 0.065	0.0039 0.100	0.0053 0.135	0.0067 0.170	0.0087 0.220	0.0110 0.280	0.0020 0.051	0.0028 0.071	0.0020 0.051
120	140	0.0020 0.050	0.0037 0.095	0.0057 0.145	0.0075 0.190	0.0094 0.240	0.0118 0.300	0.0031 0.080	0.0047 0.120	0.0063 0.160	0.0079 0.200	0.0102 0.260	0.0130 0.330	0.0025 0.064	0.0035 0.089	0.0022 0.056
140	160	0.0024 0.060	0.0043 0.110	0.0067 0.170	0.0087 0.220	0.0110 0.280	0.0138 0.350	0.0035 0.090	0.0051 0.130	0.0071 0.180	0.0091 0.230	0.0118 0.300	0.0150 0.380	0.0030 0.076	0.0040 0.102	0.0022 0.056
160	180	0.0026 0.065	0.0047 0.120	0.0071 0.180	0.0094 0.240	0.0122 0.310	0.0154 0.390	0.0039 0.100	0.0055 0.140	0.0079 0.200	0.0102 0.260	0.0134 0.340	0.0169 0.430	0.0030 0.076	0.0045 0.114	0.0024 0.061
180	200	0.0028 0.070	0.0051 0.130	0.0079 0.200	0.0102 0.260	0.0134 0.340	0.0169 0.430	0.0043 0.110	0.0063 0.160	0.0087 0.220	0.0114 0.290	0.0146 0.370	0.0185 0.470	0.0035 0.089	0.0050 0.127	0.0028 0.071
200	225	0.0031 0.080	0.0055 0.140	0.0087 0.220	0.0114 0.290	0.0150 0.380	0.0185 0.470	0.0047 0.120	0.0071 0.180	0.0098 0.250	0.0126 0.320	0.0161 0.410	0.0205 0.520	0.0040 0.102	0.0055 0.140	0.0030 0.076
225	250	0.0035 0.090	0.0059 0.150	0.0094 0.240	0.0126 0.320	0.0165 0.420	0.0205 0.520	0.0055 0.140	0.0079 0.200	0.0106 0.270	0.0138 0.350	0.0177 0.450	0.0224 0.570	0.0045 0.114	0.0060 0.152	0.0035 0.089
250	280	0.0039 0.100	0.0067 0.170	0.0102 0.260	0.0138 0.350	0.0181 0.460	0.0224 0.570	0.0059 0.150	0.0087 0.220	0.0118 0.300	0.0154 0.390	0.0139 0.490	0.0244 0.620	0.0045 0.114	0.0065 0.165	0.0040 0.102
280	315	0.0043 0.110	0.0075 0.190	0.0110 0.280	0.0146 0.370	0.0197 0.500	0.0248 0.630	0.0067 0.170	0.0094 0.240	0.0130 0.330	0.0169 0.430	0.0213 0.540	0.0268 0.680	0.0050 0.127	0.0070 0.178	0.0040 0.102
315	355	0.0047 0.120	0.0079 0.200	0.0122 0.310	0.0161 0.410	0.0217 0.550	0.0272 0.690	0.0075 0.190	0.0106 0.270	0.0142 0.360	0.0185 0.470	0.0232 0.590	0.0291 0.740	0.0055 0.140	0.0075 0.190	0.0045 0.114
355	400	0.0051 0.130	0.0087 0.220	0.0134 0.340	0.0177 0.450	0.0236 0.600	0.0295 0.750	0.0083 0.210	0.0118 0.300	0.0157 0.400	0.0205 0.520	0.0256 0.650	0.0323 0.820	0.0060 0.152	0.0080 0.203	0.0050 0.127

[1] For bearings with normal initial clearance

Continued on the next page

Internal Clearances

Radial Spherical Roller Bearings *(continued)*

Min./Max. values for each RIC are shown in the two adjacent columns directly beneath the selected RIC. Each single column represents a boundary between adjacent RIC's. For example, the minimum values shown for C5 are also the maximum values for C4 ; minimum values for C4 are also the maimum values for C3; etc.

Radial Internal Clearance Units
All data on this page, except Bore I.D., are in inches/Millimeters

Bore (nominal) mm over	incl.	Cylindrical Bore C2 min.	C2 max.	Normal (Standard) C3 min.	C3 max.	C4 C5 min.	C5 max.	Tapered Bore C2 min.	C2 max.	Normal (Standard) C3 min.	C3 max.	C4 C5 min.	C5 max.	Recommended Reduction of RIC Due to Installation min.	max.	Recommended RIC after Installation[1] min.
		inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch
		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
400	450	0.0055	0.0094	0.0146	0.0197	0.0260	0.0323	0.0091	0.0130	0.0173	0.0224	0.0283	0.0358	0.0065	0.0085	0.0060
		0.140	0.240	0.370	0.500	0.660	0.820	0.230	0.330	0.440	0.570	0.720	0.910	0.165	0.216	0.152
450	500	0.0055	0.0102	0.0161	0.0217	0.0283	0.0354	0.0102	0.0146	0.0193	0.0248	0.0311	0.0394	0.0070	0.0090	0.0065
		0.140	0.260	0.410	0.550	0.720	0.900	0.260	0.370	0.490	0.630	0.790	1.000	0.178	0.229	0.165
500	560	0.0059	0.0110	0.0173	0.0236	0.0307	0.0394	0.0114	0.0161	0.0213	0.0268	0.0343	0.0433	0.0080	0.0100	0.0070
		0.150	0.280	0.440	0.600	0.780	1.000	0.290	0.410	0.540	0.680	0.870	1.100	0.203	0.254	0.178
560	630	0.0067	0.0122	0.0189	0.0256	0.0335	0.0433	0.0126	0.0181	0.0236	0.0299	0.0386	0.0484	0.0090	0.0110	0.0080
		0.170	0.310	0.480	0.650	0.850	1.100	0.320	0.460	0.600	0.760	0.980	1.230	0.229	0.279	0.203
630	710	0.0075	0.0138	0.0209	0.0276	0.0362	0.0469	0.0138	0.0201	0.0264	0.0335	0.0429	0.0535	0.0100	0.0120	0.0080
		0.190	0.350	0.530	0.700	0.920	1.190	0.350	0.510	0.670	0.850	1.090	1.360	0.254	0.305	0.203
710	800	0.0083	0.0154	0.0228	0.0303	0.0398	0.0512	0.0154	0.0224	0.0295	0.0378	0.0480	0.0591	0.0110	0.0140	0.0090
		0.210	0.390	0.580	0.770	1.010	1.300	0.390	0.570	0.750	0.960	1.220	1.500	0.279	0.356	0.229
800	900	0.0091	0.0169	0.0256	0.0339	0.0441	0.0567	0.0173	0.0252	0.0331	0.0421	0.0539	0.0665	0.0120	0.0150	0.0100
		0.230	0.430	0.650	0.860	1.120	1.440	0.440	0.640	0.840	1.070	1.370	1.690	0.305	0.381	0.252
900	1000	0.0102	0.0189	0.0280	0.0366	0.0480	0.0618	0.0193	0.0280	0.0366	0.0469	0.0598	0.0732	0.0140	0.0170	0.0110
		0.260	0.480	0.710	0.930	1.220	1.57	0.490	0.710	0.930	1.190	1.520	1.860	0.356	0.432	0.279

[1]For bearings with normal initial clearance

SPHERICAL ROLLER BEARING END PLAY

In certain applications such as vane pumps, rubber mill rotor shafts or where it is necessary to take axial expansion within the bearing, knowledge of the bearing end play relationship to mounted radial internal clearance may be required. The following table showing the ratio of approximate end play to radial internal clearance in spherical roller bearings can be used to calculate approximate end play in the bearing.

Example: 22320CJW33C3 bearing has a radial internal clearance after installation of .002. The total end play would be approximately .0086". (±.0043 from center)

series	E.P / RIC
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

Internal Clearances

Radial Cylindrical Roller Bearings

Min./Max. values for each RIC are shown in the two adjacent columns directly beneath the selected RIC. Each single column represents a boundary between adjacent RIC's. For example, the minimum values shown for R5 are also the maximum values for R4 ; minimum values for R4 are also the maimum values for R3; etc. The desired RIC code (R1, R2, etc.) must be added to the bearing number, FOLLOWING ALL OTHER SUFFIXES.

RADIAL INTERNAL CLEARANCE LIMITS

All data on this chart are in inches/millimeters.

Bore (nominal)			R2		R4		
			min.	max.	min.	max	
		R1		R3		R5	
Over	Incl.	min.	max.	min.	max.	min.	max.
in.	in.	in.	in.	in	in.	in.	in.
mm	mm	mm	mm	mm	mm	mm	mm
3.1496	3.9370	0.0005	0.0016	0.0032	0.0051	0.0077	0.0107
80	100	0.013	0.041	0.081	0.130	0.196	0.272
3.9370	4.7244	0.0005	0.0018	0.0036	0.0060	0.0089	0.0122
100	120	0.013	0.046	0.091	0.152	0.226	0.310
4.7244	5.5118	0.0009	0.0022	0.0041	0.0067	0.0101	0.0139
120	140	0.023	0.056	0.104	0.170	0.256	0.353
5.5118	6.2992	0.0010	0.0026	0.0049	0.0077	0.0112	0.0151
140	160	0.025	0.066	0.124	0.196	0.284	0.384
6.2992	7.0866	0.0011	0.0027	0.0052	0.0082	0.0118	0.0158
160	180	0.028	0.069	0.132	0.208	0.300	0.401
7.0866	7.8740	0.0014	0.0032	0.0060	0.0092	0.0130	0.0172
180	200	0.036	0.081	0.152	0.234	0.330	0.437
7.8740	8.6614	0.0016	0.0034	0.0062	0.0094	0.0132	0.0174
200	220	0.041	0.086	0.157	0.239	0.335	0.4421
8.6614	10.2362	0.0022	0.0040	0.0068	0.0100	0.0138	0.0180
220	260	0.056	0.102	0.173	0.254	0.351	0.455
10.2362	11.8110	0.0024	0.0042	0.0070	0.0102	0.0140	0.0182
260	300	0.061	0.107	0.178	0.259	0.356	0.462

Bore (nominal)			R2		R4		
			min.	max.	min.	max	
		R1		R3		R5	
Over	Incl.	min.	max.	min.	max.	min.	max.
in.	in.	in.	in.	in	in.	in.	in.
mm	mm	mm	mm	mm	mm	mm	mm
11.8110	13.7795	0.0032	0.0050	0.0078	0.0110	0.0148	0.0190
300	350	0.081	0.127	0.198	0.279	0.376	0.483
13.7795	15.7480	0.0042	0.0065	0.0093	0.0125	0.0163	0.0205
350	400	0.107	0.165	0.236	0.318	0.414	0.521
15.7480	17.7165	0.0055	0.0080	0.0110	0.0142	0.0180	0.0222
400	450	0.14	0.203	0.279	0.361	0.457	0.564
17.7165	19.6850	0.0060	0.0085	0.0115	0.0150	0.0200	0.0254
450	500	0.152	0.216	0.292	0.381	0.508	0.645
19.6850	22.0472	0.0065	0.0090	0.0120	0.0160	0.0210	0.0264
500	560	0.165	0.229	0.305	0.406	0.533	0.671
22.0472	24.8031	0.0070	0.0100	0.0140	0.0190	0.0240	0.0294
560	630	0.178	0.254	0.356	0.483	0.610	0.747
24.8031	27.9528	0.0075	0.0110	0.0150	0.0200	0.0250	0.0304
630	710	0.190	0.279	0.381	0.508	0.635	0.772
27.9528	31.4961	0.0085	0.0130	0.0180	0.2300	0.0280	0.0334
710	800	0.216	0.330	0.457	0.584	0.711	0.848

Internal Clearances

RADIAL TAPERED ROLLER BEARINGS - TWO ROW

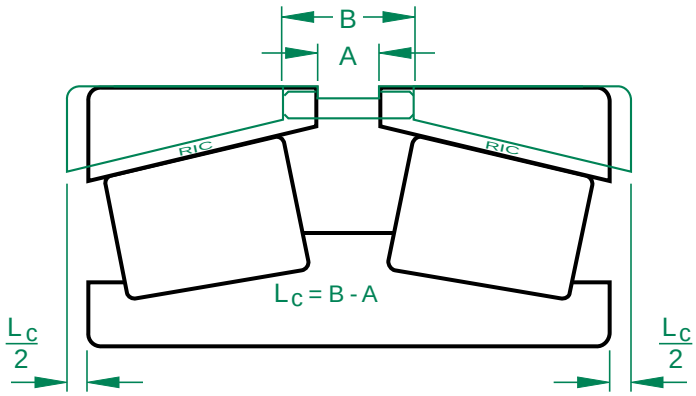
In two row tapered roller bearings, Internal Clearance is usually defined as Lateral Clearance (L_C) or end play, which is related to Radial Internal Clearance (RIC) by the formula:

$$L_C = \frac{RIC \times K}{0.39}$$

K being a thrust factor which is different for every bearing and is included in the table of dimensions.

Lc is determined by the relative axial position of cup and cone, and is a function of spacer width in the two element member (cup or cone). In the illustration , the cups shown in black are positioned for zero RIC, allowing no end play. The cups shown in green provide lateral clearance equal to (B-A).

The desired Lc must be specified by adding designation codes G1, G2, etc. to the bearing number, FOLLOWING ALL OTHER SUFFIXES..



Bore		Nominal Clearance (Lc) Tolerance: ±0.001 inch (±0.025 mm)								
Over	Incl.	G1	G2	G3	G4	G5	G6	G7	G8	G9
in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm
7.5000 190.500	12.0000 304.800	0.006 0.15	0.009 0.23	0.018 0.46	0.021 0.53	0.024 0.61	0.027 0.69	0.030 0.76	0.033 0.84	0.036 0.91
12.0000 304.800	24.0000 609.600	0.007 0.18	0.018 0.46	0.021 0.53	0.024 0.61	0.027 0.69	0.030 0.76	0.034 0.86	0.040 1.02	0.046 1.17
24.0000 609.600	36.0000 914.400	0.019 0.48	0.023 0.58	0.027 0.69	0.031 0.79	0.035 0.89	0.039 0.99	0.042 1.07	0.046 1.17	0.050 1.27

	Nominal Clearance (Lc) for Straight Bore Bearings		
All Sizes	H1	H2	H4
	0.010 - 0.012" 0.254 - 0.305mm	0.014 -0.016" 0.356 - 0.406mm	0.006 - 0.008" 0.152 - 0.203mm

Tolerances

RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARINGS

Depending upon requirements, various degrees of bearing accuracy may be required.

Amoung the tolerance classes, ABEC-1 applies to ball bearings for normal useage. The other classes ABEC-3, 5, 7, 9 apply to ball bearings of increased precision as required.

RBEC-1 applies to roller bearings for normal usage. RBEC-3 and 5 apply to roller bearings of increased precision as required.

ABMA/ISO Symbols - Inner Ring

- $^{\Delta}$**dmp** Single plane mean bore diameter deviation from basic bore diameter, i.e. bore tolerance for a basically tapered bore, $^{\Delta}$dmp refers only to the theoretical small bore end of the bore
- K_{ia} Radial runout of assembled bearing inner ring, i.e., radial runout of raceway
- V_{Bs} Inner ring width variation, i.e. parallelism
- S_d Inner ring reference face runout with bore, i.e., squareness - bore to face
- S_{ia} Axial runout of assembled bearing inner ring, i.e. lateral (axial) runout of raceway
- $^{\Delta}B_s$ Single inner ring width deviation from basic, i.e., width tolerance

ABMA/ISO Symbols - Outer Ring

- $^{\Delta}$**Dmp** Single plane mean outside diameter deviation from basic outside diameter, i.e. O.D. tolerance
- K_{ea} Radial runout of assembled bearing inner ring, i.e., radial runout of raceway
- V_{Cs} Inner ring width variation, i.e. parallelism
- S_D Outside cylindrical surface runout with outer ring reference face, i.e., squareness - O.D. to face
- S_{ea} Axial runout of assembled bearing outer ring, i.e. lateral (axial) runout of raceway
- $^{\Delta}C_s$ Outer ring width deviation from basic, i.e., width tolerance

STANDARD ABEC/RBEC TOLERANCES – INNER RING

Bearing Bore mm over	Bearing Bore mm incl.	Bore Numbers Reference	Bore Diameter(1) Δdmp +0.000" +0.00 mmTo ABEC RBEC 1	3	5	7	9	Width Variation (Parallelism) VBs ABEC RBEC 1	3	5	7	9	Raceway Radial Runout Kia ABEC RBEC 1	3	5	7	9	Face Runout With Bore (Squareness) Sd ABEC RBEC 5	7	9	Raceway Axial Runout Sia ABEC RBEC 5	7	9	Width Inner & Outer Rings ΔBs &ΔCs +0.000" +0.00 mm To ABEC RBEC 1,3	5,7,9
			in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
			mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
0	10	30-39	-3	-3	-2	-1.5	-1	6	6	2	1	0.5	4	2.5	1.5	1	0.5	3	1	0.5	3	1	0.5	-50	-15
			-8	-7	-5	-4	-2.5	15	15	5	2.5	1.5	10	6	4	2.5	1.5	7	3	1.5	7	3	1.5	-120	-40
10	18	00-03	-3	-3	-2	-1.5	-1	8	8	2	1	0.5	4	3	1.5	1	0.5	3	1	0.5	3	1	0.5	-50	-30
			-8	-7	-5	-4	-2.5	20	20	5	2.5	1.5	10	7	4	2.5	1.5	7	3	1.5	7	3	1.5	-120	-80
18	30	04-06	-4	-3	-2.5	-2	-1	8	8	2	1	0.5	5	3	1.5	1	1	3	1.5	0.5	3	1.5	1	-50	-50
			-10	-8	-6	-5	-2.5	20	20	5	2.5	1.5	13	8	4	3	2.5	8	4	1.5	8	4	2.5	-120	-120
30	50	07-10	-4.5	-4	-3	-2.5	-1	8	8	2	1	0.5	6	4	2	1.5	1	3	1.5	0.5	3	1.5	1	-50	-50
			-12	-10	-8	-6	-2.5	20	20	5	3	1.5	15	10	5	4	2.5	8	4	1.5	8	4	2.5	-120	-120
50	80	11-16	-6	-4.5	-3.5	-3	-1.5	10	10	2.5	1.5	0.5	8	4	2	1.5	1	3	2	0.5	3	2	1	-60	-60
			-15	-12	-9	-7	-4	25	25	6	4	1.5	20	10	5	4	2.5	8	5	1.5	8	5	2.5	-150	-150
80	120	17-24	-8	-6	-4	-3	-2	10	10	3	1.5	1	10	5	2.5	2	1	3.5	2	1	3.5	2	1	-80	-80
			-20	-15	-10	-8	-5	25	25	7	4	2.5	25	13	6	5	2.5	9	5	2.5	9	5	2.5	-200	-200
120	150	26-30	-10	-7	-5	-4	-3	12	12	3	2	1	12	7	3	2.5	1	4	2.5	1	4	3	1	-100	-100
			-25	-18	-13	-10	-7	30	30	8	5	2.5	30	18	8	6	2.5	10	6	2.5	10	7	2.5	-250	-250
150	180	32-36	-10	-7	-5	-4	-3	12	12	3	2	1.5	12	7	3	2.5	2	4	2.5	1.5	4	3	2	-100	-100
			-25	-18	-13	-10	-7	30	30	8	5	4	30	18	8	6	5	10	6	4	10	7	5	-250	-250
180	250	38-50	-12	-8.5	-6	-4.5	-3	12	12	4	2.5	2	16	8	4	3	2	4.5	3	2	5	3	2	-120	-120
			-30	-22	-15	-12	-8	30	30	10	6	5	40	20	10	8	5	11	7	5	13	8	5	-300	-300
250	315	52-60	-14	-10	-7	—	—	14	14	5	—	—	20	10	5	—	—	5	—	—	6	—	—	-140	-140
			-35	-25	-18	—	—	35	35	13	—	—	50	25	13	—	—	13	—	—	15	—	—	-350	-350
315	400	64-80	-16	-12	-9	—	—	16	16	6	—	—	24	12	6	—	—	6	—	—	8	—	—	-160	-160
			-40	-30	-23	—	—	40	40	15	—	—	60	30	15	—	—	15	—	—	20	—	—	-400	-400
400	500		-18	-14	—	—	—	20	18	—	—	—	26	14	—	—	—	—	—	—	—	—	—	-180	—
			-45	-35	—	—	—	50	45	—	—	—	65	35	—	—	—	—	—	—	—	—	—	-450	—
500	630		-20	-16	—	—	—	24	20	—	—	—	28	16	—	—	—	—	—	—	—	—	—	-200	—
			-50	-40	—	—	—	60	50	—	—	—	70	40	—	—	—	—	—	—	—	—	—	-500	—
630	800		-30	—	—	—	—	28	—	—	—	—	31	—	—	—	—	—	—	—	—	—	—	-300	—
			-75	—	—	—	—	70	—	—	—	—	80	—	—	—	—	—	—	—	—	—	—	-750	—

The tolerances in this table are in conformance with ANSI ABMA Standard 20 - 1987.

(1) D min. (the smallest single diameter of a bore.) and dmax (the largest single diameter of a bore.) may fall outside limits shown $\frac{^{D}\text{min} + {}^{D}\text{max}}{2}$ must be within outside diameter tabulated.

For further details see ABMA Standard 20.

Tolerances

RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARINGS

Depending upon requirements, various degrees of bearing accuracy may be required.

Amoung the tolerance classes, ABEC-1 applies to ball bearings for normal useage. The other classes ABEC-3, 5, 7, 9 apply to ball bearings of increased precision as required.

RBEC-1 applies to roller bearings for normal usage. RBEC-3 and 5 apply to roller bearings of increased precision as required.

ABMA / ISO Symbols - Inner Ring

- $^{\Delta}$**dmp** Single plane mean bore diameter deviation from basic bore diameter, i.e. bore tolerance for a basically tapered bore, $^{\Delta}$dmp refers only to the theoretical small bore end of the bore
- K_{ia} Radial runout of assembled bearing inner ring, i.e., radial runout of raceway
- V_{Bs} Inner ring width variation, i.e. parallelism
- S_d Inner ring reference face runout with bore, i.e., squareness - bore to face
- S_{ia} Axial runout of assembled bearing inner ring, i.e. lateral (axial) runout of raceway
- $^{\Delta}B_s$ Single inner ring width deviation from basic, i.e., width tolerance

ABMA / ISO Symbols – Outer Ring

- $^{\Delta}$**Dmp** Single plane mean outside diameter deviation from basic outside diameter, i.e. O.D. tolerance
- K_{ea} Radial runout of assembled bearing inner ring, i.e., radial runout of raceway
- V_{Cs} Inner ring width variation, i.e. parallelism
- S_D Outside cylindrical surface runout with outer ring reference face, i.e., squareness - O.D. to face
- S_{ea} Axial runout of assembled bearing outer ring, i.e. lateral (axial) runout of raceway
- $^{\Delta}C_s$ Outer ring width deviation from basic, i.e., width tolerance

STANDARD ABEC / RBEC TOLERANCES – OUTER RING

All tolerances in number of ten-thousanths inches (.0001") and micrometers (μm)

Bearing O.D. mm over	Bearing O.D. mm incl.	Ball Bearing Sizes	Outside Diameter(1) Δ_{Dmp} +0.0000" +0.000 mm To					Width Variation (Parallelism) V_{Cs}				Raceway Radial Runout K_{ea}					Raceway Axial Runout S_{ea}			Outside Diameter Runout With Face (Squareness) S_D		
			ABEC / RBEC					ABEC / RBEC				ABEC / RBEC					ABEC / RBEC			ABEC / RBEC		
			1	3	5	7	9	1, 3	5	7	9	1	3	5	7	9	5	7	9	5	7	9
			in. / mm																			
0	18	30-39	-3 -8	-3 -7	-2 -5	-1.5 -4	-1 -2.5	6 15	2 5	1 2.5	0.5 1.5	6 15	4 8	2 5	1 3	0.5 1.5	3 8	2 5	0.5 1.5	3 8	1.5 4	0.5 1.5
18	30	9100-9101 200 9300-9303	-3.5 -9	-3 -8	-2.5 -6	-2 -5	-1.5 -4	8 20	2 5	1 2.5	0.5 1.5	6 15	4 9	2.5 6	1.5 4	1 2.5	3 8	2 5	1 2.5	3 8	1.5 4	0.5 1.5
30	50	9304-9306 9102-9105 200-204 300-303	-4.5 -11	-3.5 -9	-3 -7	-2.5 -6	-1.5 -4	8 20	2 5	1 2.5	0.5 1.5	8 20	4 10	3 7	2 5	1 2.5	3 8	2 5	1 2.5	3 8	1.5 4	0.5 1.5
50	80	9307-9312 9106-9110 205-208 304-307	-5 -13	-4.5 -11	-3.5 -9	-3 -7	-1.5 -4	10 25	2.5 6	1 3	0.5 1.5	10 25	5 13	3 8	2 5	1.5 4	4 10	2 5	1.5 4	3 8	1.5 4	0.5 1.5
80	120	9313-9317 9111-9115 209-213 308-311	-6 -15	-5 -13	-4 -10	-3 -8	-2 -5	10 25	3 8	1.5 4	1 2.5	14 35	7 18	4 10	2.5 6	2 5	4.5 11	2.5 6	2 5	3.5 9	2 5	1 2.5
120	150	9318-9322 9116-9120 214-217 312-314	-7 -18	-6 -15	-4.5 -11	-3.5 -9	-2 -5	12 30	3 8	2 5	1 2.5	16 40	8 20	4.5 11	3 7	2 5	5 13	3 7	2 5	4 10	2 5	1 2.5
150	180	9323-9326 9121-9326 218-220 315-317	-10 -25	-7 -18	-5 -13	-4 -10	-3 -7	12 30	3 8	2 5	1 2.5	18 45	9 23	5 13	3 8	2 5	5.5 14	3 8	2 5	4 10	2 5	1 2.5
180	250	9126-9132 220-228 318-322	-12 -30	-8 -20	-6 -15	-4.5 -11	-3 -8	12 30	4 10	3 7	1.5 4	20 50	10 25	6 15	4 10	3 7	6 15	4 10	3 7	4.5 11	3 7	1.5 4
250	315	9134-9140 230-234 324-328	-14 -35	-10 -25	-7 -18	-5 -13	-3 -8	14 35	4.5 11	3 7	2 5	24 60	12 30	7 18	4.5 11	3 7	7 18	4 10	3 7	5 13	3 8	2 5
315	400	9144-9152 236-244 330-338	-16 -40	-11 -28	-8 -20	-6 -15	-4 -10	16 40	5 13	3 8	3 7	28 70	14 35	8 20	5 13	3 8	8 20	5 13	3 8	5 13	4 10	3 7
400	500	9156-9164 246-256 340-348	-18 -45	-13 -33	-9 -23	— —	— —	18 45	6 15	— —	— —	31 80	16 40	9 23	— —	— —	9 23	— —	— —	6 15	— —	— —
500	630	9180 260-264 352-356	-20 -50	-15 -38	-11 -28	— —	— —	20 50	7 18	— —	— —	39 100	20 50	10 25	— —	— —	10 25	— —	— —	7 18	— —	— —
630	800		-30 -75	-18 -45	-14 -35	— —	— —	— —	8 20	— —	— —	47 120	24 60	12 30	— —	— —	12 30	— —	— —	8 20	— —	— —
800	1000		-40 -100	-24 -60	— —	— —	— —	— —	— —	— —	— —	55 140	30 75	— —	— —	— —	— —	— —	— —	— —	— —	— —
1000	1250		-50 -125	— —	— —	— —	— —	— —	— —	— —	— —	63 160	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —

The tolerances in this table are in conformance with ANSI ABMA Standard 20 - 1987.

(1) D min. (the smallest single diameter of an O.D.) and Dmax (the largest single diameter of an O.D.) may fall outside limits shown $\frac{^{D}\text{min} + {}^{D}\text{max}}{2}$ must be within outside diameter tabulated.

For further details see ABMA Standard 20.

Tolerances

Radial Tapered Roller Bearings

All data on this page are in inches/millimeters.

Cone Bore Cup O.D.		Cone Bore	Cup O.D.		Radial Runout Assembled Bearing (Based on Cup O.D.)		Cone and Cup Width (Based on Cone Bore)							
							Bearing Types							
							TS TSS				TDI,TDO TDOC, TDOD			
		Tolerance	Tolerance				Tolerance				Tolerance			
							Class 2		Class 4		Class 2		Class 4	
over	incl.	Class 2&4 -0	Class 4 -0	Class 2 -0	Class 4	Class 2	plus	minus	plus	minus	plus	minus	plus	minus
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
7.5000	12.0000	+0.0010	+0.0010	+0.0010	0.0020	0.0015	0.008	0	0.014	0.010	0.016	0.008	0.028	0.020
190.500	304.800	+0.025	+0.025	+0.025	0.051	0.038	0.203	0	0.356	0.254	0.406	0.203	0.711	0.508
12.0000	24.0000	+0.0020	+0.0020	+0.0020	0.0020	0.0015	0.015	0.015	0.015	0.015	0.030	0.030	0.030	0.030
304.800	609.600	+0.051	+0.051	+0.051	0.051	0.038	0.381	0.381	0.381	0.381	0.762	0.762	0.762	0.762
24.0000	36.0000	+0.0030	+0.0030	+0.0020	0.0030	0.0020	—	—	0.015	0.015	—	—	0.030	0.030
609.600	914.400	+0.076[1]	+0.076	+0.051	0.076	0.051	—	—	0.381	0.381	—	—	0.762	0.762
36.0000	48.0000	+0.0040	+0.0040	—	0.0030	—	—	—	0.015	0.015	—	—	0.030	0.030
914.400	1219.200	+0.102[1]	+0.102	—	0.076	—	—	—	0.381	0.381	—	—	0.762	0.762
48.0000	—	+0.0050	+0.0050	—	0.0030	—	—	—	0.015	0.015	—	—	0.030	0.030
1219.200	—	+0.127[1]	+0.127	—	0.076	—	—	—	0.381	0.381	—	—	0.762	0.762

The tolerances in this table conform to ANSI/ABMA Standard 19.

(1)Applies to class 4 only.

Thrust Ball Bearings

TYPE TVB										TYPES TVL & DTVL								
Bore			O.D.			Height				Bore			O.D.			Height		
Bearing over	Bore incl.	Tolerance -0	Bearing over	O.D. incl.	Tolerance +0.0	Bearing over	Bore incl.	Tolerance max.	Tolerance min.	Bearing over	Bore incl.	Tolerance -0	Bearing over	O.D. incl.	Tolerance +0.0	Bearing	Bore	Tolerance
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
0.0000	6.7500	+0.0050	0.0000	5.3125	-0.0020	0.0000	1.8125	+0.0050	-0.0050	0.0000	19.8750	-0.0030	0.0000	23.0000	-0.0030	All Sizes		±.0150
0.000	171.450	+0.127	0.000	134.938	-0.051	0.000	46.038	+0.127	-0.127	0.000	504.825	-0.076	0.000	584.000	-0.076			±.381
6.7500	20.0000	+0.0070	5.3125	17.3750	-0.0030	1.8125	12.0000	+0.0100	-0.0100	19.8750	60.0000	-0.0050	23.0000	70.0000	-0.0050			
171.450	508.000	+0.178	134.938	441.325	-0.076	46.038	304.800	+0.254	-0.254	504.825	1524.000	-0.127	584.000	1778.000	-0.127			
			17.3750	39.3701	-0.0040	12.0000	20.0000	+0.0150	-0.0150									
			441.325	1000.000	-0.102	304.800	508.000	+0.381	-0.381									

The tolerance in this table conforms to ANSI/ABMA Standard 21.2.

Thrust Spherical Roller Bearings

Inner Ring			
Bore		Tolerance	
		Bore	Radial Runout
over	incl.	+0.0000 -0.000mm	
in. mm	in. mm	in. mm	in. mm
3.1496	4.7244	-0.0008	0.0010
80.000	120.000	-0.020	0.025
4.7244	7.0866	-0.0010	0.0012
120.000	180.000	-0.025	0.030
7.0866	9.8425	-0.0012	0.0016
180.000	250.000	-0.030	0.041
9.8425	12.4016	-0.0014	0.0020
250.000	315.000	-0.036	0.051
12.4016	15.7480	-0.0016	0.0024
315.000	400.000	-0.041	0.061
15.7480	19.6850	-0.0018	0.0026
400.000	500.000	-0.046	0.066
19.6850	24.8031	-0.0020	0.0028
500.000	630.000	-0.051	0.071
24.8031	31.4961	-0.0030	0.0032
630.000	800.000	-0.076	0.081
31.4961	39.3701	-0.0040	0.0035
800.000	1000.000	-0.102	0.089
39.3701	49.2126	-0.0050	0.0040
1000.000	1250.000	-0.127	0.102

Outer Ring			
O.D.		Tolerance	
		O.D.	Radial Runout
over	incl.	+0.0000 -0.000mm	
in. mm	in. mm	in. mm	in. mm
4.7244	5.9055	-0.0080	0.0016
120.000	150.000	-0.020	0.041
5.9055	7.0866	-0.0010	0.0018
150.000	180.000	-0.025	0.046
7.0866	9.8425	-0.0012	0.0020
180.000	250.000	-0.030	0.051
9.8425	12.4016	-0.0014	0.0024
250.000	315.000	-0.036	0.061
12.4016	15.7480	-0.0016	0.0028
315.000	400.000	-0.041	0.071
15.7480	19.6850	-0.0018	0.0032
400.000	500.000	-0.046	0.081
19.6850	24.8031	-0.0020	0.0040
500.000	630.000	-0.051	0.102
24.8031	31.4961	-0.0030	0.0047
630.000	800.000	-0.076	0.119
31.4961	39.3701	-0.0040	0.0055
800.000	1000.000	-0.102	0.140
39.3701	49.2126	-0.0050	0.0064
1000.000	1250.000	-0.127	0.163
49.2126	62.9921	-0.0065	0.0076
1250.000	1600.000	-0.165	0.193
62.9921	78.7402	-0.0080	0.0090
1600.000	2000.000	-0.203	0.229

Height			
Bore Diameter		Tolerance	
over	incl.	plus	minus
in. mm	in. mm	in. mm	in. mm
3.1496	4.7244	0.0037	0.0100
80.000	120.000	0.094	0.254
4.7244	7.0866	0.0043	0.0118
120.000	180.000	0.109	0.300
7.0866	9.8425	0.0051	0.0144
180.000	250.000	0.130	0.366
9.8425	12.4016	0.0061	0.0171
250.000	315.000	0.155	0.434
12.4016	15.7480	0.0067	0.0189
315.000	400.000	0.170	0.480
15.7480	19.6850	0.0073	0.0207
400.000	500.000	0.185	0.526
19.6850	and up	0.0080	0.0230
500.000		0.203	0.584

Tolerances

THRUST ROLLER BEARINGS

The tolerances in this table conform to ANSI/ABMA Standard 21.2.

Certain applications for Torrington cylindrical roller bearings may require special precision tolerances. Torrington has for many years offered two high precision tolerance standards which augment the ABMA tolerance system. If your application requires precision beyond ABMA tolerances, ask a Torrington sales engineer about Torrington extraprecision and ultraprecision tolerances.

THRUST CYLINDRICAL ROLLER BEARINGS

TYPE TP

Bore			O.D.			Height		
Bearing Bore over	Bore incl.	Tolerance +0.0	Bearing O.D. over	O.D. incl.	Tolerance -0	Bearing Bore over	Bore incl.	Tolerance +0.0
in.	in.	in.	in.	in.	in.	in.	in.	in.
mm	mm	mm	mm	mm	mm	mm	mm	mm
2.0000	3.0000	-0.0010	5.0000	10.0000	+0.0015	0.0000	2.0000	-0.0060
50.800	76.200	-0.025	127.000	254.000	+0.038	0.000	50.800	-0.152
3.0000	3.5000	-0.0012	10.0000	18.0000	+0.0020	2.0000	3.0000	-0.0080
76.200	88.900	-0.030	254.000	457.200	+0.051	50.800	76.200	-0.203
3.5000	9.0000	-0.0015	18.0000	26.0000	+0.0025	3.0000	6.0000	-0.0100
88.900	228.600	-0.038	457.200	660.400	+0.640	76.200	152.400	-0.254
9.0000	12.0000	-0.0018	26.0000	34.0000	+0.0030	6.0000	10.0000	-0.0150
228.600	304.800	-0.046	660.400	863.600	+0.076	152.400	254.000	-0.381
12.0000	18.0000	-0.0020	34.0000	44.0000	+0.0040	10.0000	18.0000	-0.0200
304.800	457.200	-0.051	863.600	1117.600	+0.102	254.000	457.200	-0.508
18.0000	22.0000	-0.0025				18.0000	30.0000	-0.0250
457.200	558.800	-0.064				457.200	762.000	-0.635
22.0000	30.0000	-0.0030						
558.800	762.000	-0.076						

The tolerances in this table conform to ANSI/ABMA Standard 21.2.

TYPES TPS

Bore			O.D.			Height		
Bearing Bore over	Bore incl.	Tolerance +0.0	Bearing O.D. over	O.D. incl.	Tolerance -0	Bearing Bore over	Bore incl.	Tolerance +0.0
in.	in.	in.	in.	in.	in.	in.	in.	in.
mm	mm	mm	mm	mm	mm	mm	mm	mm
2.0000	3.0000	-0.0010	5.0000	10.5000	+0.0019	0.0000	2.0000	-0.0080
50.800	76.200	-0.025	127.000	266.700	+0.048	0.000	50.800	-0.203
3.0000	3.5000	-0.0012	10.5000	12.7500	+0.0021	2.0000	3.0000	-0.0100
76.200	88.900	-0.030	266.700	323.850	+0.053	50.800	76.200	-0.254
3.5000	9.0000	-0.0015	12.7500	17.0000	+0.0023	3.0000	6.0000	-0.0150
88.900	228.600	-0.038	323.850	431.800	+0.058	76.200	152.400	-0.381
9.0000	12.0000	-0.0018	17.0000	27.0000	+0.0025	6.0000	10.0000	-0.0200
228.600	304.800	-0.046	431.800	685.800	+0.064	152.400	254.000	-0.508
12.0000	18.0000	-0.0020	27.0000	35.0000	+0.0030	10.0000	18.0000	-0.0250
304.800	457.200	-0.051	685.800	889.000	+0.076	254.000	457.200	-0.635
18.0000	22.0000	-0.0025				18.0000	30.0000	-0.0300
457.200	558.800	-0.064				457.200	762.000	-0.762
22.0000	30.0000	-0.0030						
558.800	762.000	-0.076						

Thrust Tapered Roller Bearings

TYPE TTHD

Bore			O.D.			Height	
Bearing Bore over	Bore incl.	Tolerance -0	Bearing O.D. over	O.D. incl.	Tolerance -0	Bearing Bore	Tolerance
in.	in.	in.	in.	in.	in.		in.
mm	mm	mm	mm	mm	mm		mm
0.0000	12.0000	+0.0010	0.0000	12.0000	+0.0010	All Sizes	±0150
0.000	304.800	+0.025	0.000	304.800	+0.025		±.381
12.0000	24.0000	+0.0020	12.0000	24.0000	+0.0020		
304.800	609.600	+0.051	304.800	609.600	+0.051		
24.0000	36.0000	+0.0030	24.0000	36.0000	+0.0030		
609.600	914.400	+0.076	609.600	914.400	+0.076		
36.0000	48.0000	+0.0040	36.0000	48.0000	+0.0040		
914.400	1219.200	+0.102	914.400	1219.200	+0.102		
48.0000	—	+0.0050	48.0000	—	+0.0050		
1219.200	—	+0.127	1219.200	—	+0.127		

The tolerances in this table conform to ANSI/ABMA Standard 21.2.

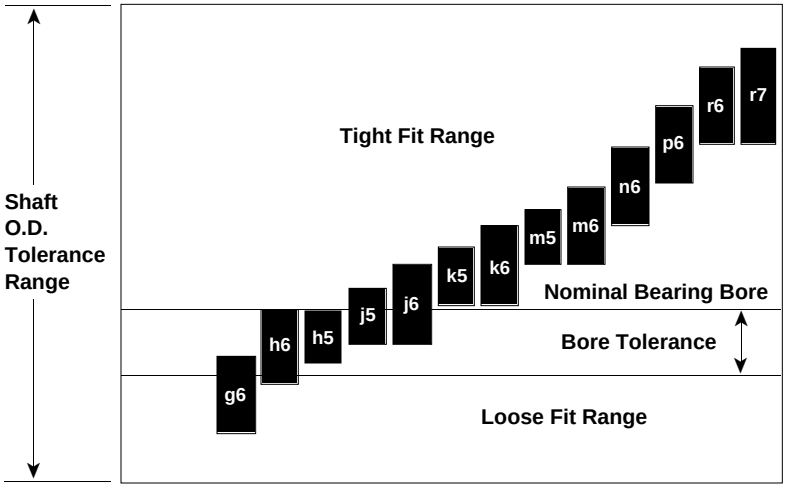
TYPE TTVS & TTVF

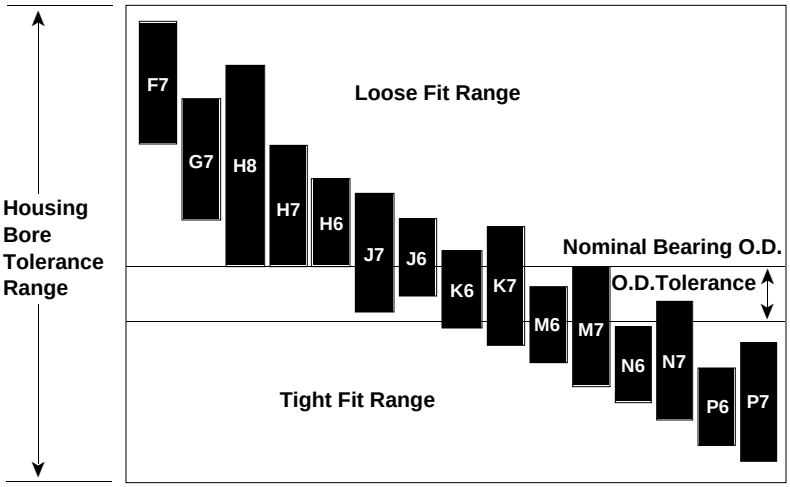
Bore			O.D.			Height	
Bearing Bore over	Bore incl.	Tolerance -0	Bearing O.D. over	O.D. incl.	Tolerance -0	Bearing Bore	Tolerance
in.	in.	in.	in.	in.	in.		in.
mm	mm	mm	mm	mm	mm		mm
0.0000	12.0000	+0.0010	0.0000	12.0000	+0.0010	All Sizes	±0150
0.000	304.800	+0.025	0.000	304.800	+0.025		±.381
12.0000	28.0000	+0.0020	12.0000	24.0000	+0.0020		
304.800	711.200	+0.051	304.800	609.600	+0.051		
28.0000	48.0000	+0.0030	24.0000	42.0000	+0.0030		
711.200	1219.200	+0.076	609.600	1066.800	+0.076		
48.0000	68.0000	+0.0040	42.0000	60.0000	+0.0040		
1219.200	1727.200	+0.102	1066.800	1524.000	+0.102		
68.0000	—	+0.0050	60.0000	—	+0.0050		
1727.200	—	+0.127	1524.000	—	+0.127		

Shaft and Housing Fits

RADIAL BALL, SPHERICAL,CYLINDRICAL ROLLER BEARINGS

Below is a graphical representation of shaft and housing fit selection for these bearings conforming to ANSI/ABMA Standard 7. The bars designated by 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.





Shaft and Housing Fits

RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARINGS

Tolerance and shaft diameters shown as variance from nominal bearing bore, using the symbols in the graph. All data except nominal dimensions are in ten-thousands of an inch (5 = 0.0005") and thousandths of a millimeter or micrometer (5 = 0.005mm).

See pages E32 through E37 for actual shaft and housing diameters for normal loading of ABEC-1 and ABEC-3 radial ball bearings and 7000WN Series angular contact ball bearings.

For particular operating conditions of radial ball, spherical and cylindrical roller bearings, see pages E38, E39 and E40.

SHAFT

Bearing Bore			g6			h6			h5			j5			j6			k5			k6			m5		
Nominal (max.) Over	Incl.	Tol. +0 To	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
mm		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
3	6	-3	-2	-5	5L 1T	0	-3	3L 3T	0	-2	2L 3T	+1	-1	1L 4T	+2	-1	1L 5T	+2	+0	0T 5T				+4	+2	2T 7T
		-8	-4	-12	12L 4T	0	-8	8L 8T	0	-5	5L 8T	+3	-2	2L 11T	+6	-2	2L 14T	+6	+1	1T 14T				+9	+4	4T 17T
6	10	-3	-2	-6	6L 1T	0	-4	4L 3T	0	-2	2L 3T	+2	-1	1L 5T	+3	-1	1L 6T	+3	+0	0T 6T				+5	+2	2T 8T
		-8	-5	-14	14L 3T	0	-9	9L 8T	0	-6	6L 8T	+4	-2	2L 12T	+7	-2	2L 15T	+7	+1	1T 15T				+12	+6	6T 20T
10	18	-3	-2	-7	7L 1T	0	-4	4L 3T	0	-3	3L 3T	+2	-1	1L 5T	+3	-1	1L 6T	+4	+0	0T 7T				+6	+3	3T 9T
		-8	-6	-17	17L 2T	0	-11	11L 8T	0	-8	8L 8T	+5	-3	3L 13T	+8	-3	3L 16T	+9	+1	1T 17T				+15	+7	7T 23T
18	30	-4	-3	-8	8L 1T	0	-5	5L 4T				+2	-2	2L 6T	+4	-2	2L 8T	+4	+1	1T 8T				+7	+3	3T 11T
		-10	-7	-20	20L 3T	0	-13	13L 10T				+5	-4	4L 15T	+9	-4	4L 19T	+11	+2	2T 21T				+17	+8	8T 27T
30	50	-4.5	-4	-10	10L 0.5T	0	-6	6L 4.5T				+2	-2	2L 6.5T	+4	-2	2L 8.5T	+5	+1	1T 9.5T	+7	+1	1T 11.5T	+8	+4	4T 12.5T
		-12	-9	-25	25L 3T	0	-16	16L 12T				+6	-5	5L 18T	+11	-5	5L 23T	+13	+2	2T 25T	+18	+2	2T 30T	+20	+9	9T 32T
50	80	-6	-4	-11	11L 2T	0	-7	7L 6T				+2	-3	3L 8T	+5	-3	3L 11T	+6	+1	1T 12T	+8	+1	1T 14T	+9	+4	4T 15T
		-15	-10	-29	29L 5T	0	-19	19L 15T				+6	-7	7L 21T	+12	-7	7L 27T	+15	+2	2T 30T	+21	+2	2T 36T	+24	+11	11T 39T
80	120	-8	-5	-13	13L 3T	0	-9	9L 8T				+2	-4	4L 10T	+5	-4	4L 13T	+7	+1	1T 15T	+10	+1	1T 18T	+11	+5	5T 19T
		-20	-12	-34	34L 8T	0	-22	22L 20T				+6	-9	9L 26T	+13	-9	9L 33T	+18	+3	3T 38T	+25	+3	3T 45T	+28	+13	13T 48T
120	180	-10	-6	-15	15L 4T	0	-10	10L 10T				+3	-4	4L 13T	+6	-4	4L 16T	+8	+1	1T 18T	+11	+1	1T 21T	+13	+6	6T 23T
		-25	-14	-39	39L 11T	0	-25	25L 25T				+7	-11	11L 32T	+14	-11	11L 39T	+21	+3	3T 46T	+28	+3	3T 53T	+33	+15	15T 58T
180	200	-12	-6	-17	17L 6T	0	-11	11L 12T				+3	-5	5L 15T	+6	-5	5L 18T	+9	+2	2T 21T				+15	+7	7T 27T
		-30	-15	-44	44L 15T	0	-29	29L 30T				+7	-13	13L 37T	+16	-13	13L 46T	+24	+4	4T 54T				+37	+17	17T 67T
200	225	-12	-6	-17	17L 6T	0	-11	11L 12T				+3	-5	5L 15T	+6	-5	5L 18T	+9	+2	2T 21T				+15	+7	7T 27T
		-30	-15	-44	44L 15T	0	-29	29L 30T				+7	-13	13L 37T	+16	-13	13L 46T	+24	+4	4T 54T				+37	+17	17T 67T
225	250	-12	-6	-17	17L 6T	0	-11	11L 12T				+3	-5	5L 15T	+6	-5	5L 18T	+9	+2	2T 21T				+15	+7	7T 27T
		-30	-15	-44	44L 15T	0	-29	29L 30T				+7	-13	13L 37T	+16	-13	13L 46T	+24	+4	4T 54T				+37	+17	17T 67T
250	280	-14	-7	-19	19L 7T	0	-13	13L 14T				+3	-6	6L 17T	+6	-6	6L 20T	+11	+2	2T 25T				+17	+8	8T 31T
		-35	-17	-49	49L 18T	0	-32	32L 35T				+7	-16	16L 42T	+16	-16	16L 51T	+27	+4	4T 62T				+43	+20	20T 78T
280	315	-14	-7	-19	19L 7T	0	-13	13L 14T				+3	-6	6L 17T	+6	-6	6L 20T	+11	+2	2T 25T				+17	+8	8T 31T
		-35	-17	-49	49L 18T	0	-32	32L 35T				+7	-16	16L 42T	+16	-16	16L 51T	+27	+4	4T 62T				+43	+20	20T 78T

The tolerances in this table are in conformance with ANSI/ABMA Standard 7-1988

Shaft and Housing Fits

RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARINGS

Tolerance and shaft diameters shown as variance from nominal bearing bore, using the symbols in the graph . All data except nominal dimensions are in ten-thousands of an inch (5 = 0.0005") and thousandths of a millimeter or micrometer (5 = 0.005mm).

See pages E32 through E37 for actual shaft and housing diameters for normal loading of ABEC-1 and ABEC-3 radial ball bearings and 7000WN Series angular contact ball bearings.

For particular operating conditions of radial ball, spherical and cylindrical roller bearings, see pages E38, E39 and E40.

SHAFT

Bearing Bore			m6			n6			p6			r6			r7		
Nominal (max.) Over	Incl.	Tol. + 0 To	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. 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. mm	in. mm
3	6	-3 -8															
6	10	-3 -8															
10	18	-3 -8															
18	30	-4 -10															
30	50	-5 -12	+10 +25	+4 +9	4T 14.5T 9T 37T												
50	80	-6 -15	+12 +30	+4 +11	4T 18T 11T 45T	+15 +39	+8 +20	8T 21T 20T 54T									
80	120	-8 -20	+14 +35	+5 +13	5T 22T 13T 55T	+18 +45	+9 +23	9T 26T 23T 65T	+23 +59	+15 +37	15T 31T 37T 79T						
120	180	-10 -25	+16 +40	+6 +15	6T 26T 15T 65T	+20 +52	+11 +27	11T 30T 27T 77T	+27 +68	+17 +43	17T 37T 43T 93T	+35 +90	+26 +65	26T 45T 65T 115T			
180	200	-12 -30	+18 +46	+7 +17	7T 30T 17T 76T	+24 +60	+12 +31	12T 36T 31T 90T	+31 +79	+20 +50	20T 43T 50T 109T	+42 +106	+30 +77	30T 54T 77T 136T			
200	225	-12 -30	+18 +46	+7 +17	7T 30T 17T 76T	+24 +60	+12 +31	12T 36T 31T 90T	+31 +79	+20 +50	20T 43T 50T 109T	+43 +109	+31 +80	31T 55T 80T 139T	+50 +126	+31 +80	31T 62T 80T 156T
225	250	-12 -30	+18 +46	+7 +17	7T 30T 17T 76T	+24 +60	+12 +31	12T 36T 31T 90T	+31 +79	+20 +50	20T 43T 50T 109T	+44 +113	+33 +84	33T 56T 84T 143T	+51 +130	+33 +84	33T 63T 84T 160T
250	280	-14 -35	+20 +52	+8 +20	8T 34T 20T 87T	+26 +66	+13 +34	13T 40T 34T 101T	+35 +88	+22 +56	22T 49T 56T 123T	+50 +126	+37 +94	37T 64T 94T 161T	+57 +146	+37 +94	37T 71T 94T 181T
280	315	-14 -35	+20 +52	+8 +20	8T 34T 20T 87T	+26 +66	+13 +34	13T 40T 34T 101T	+35 +88	+22 +56	22T 49T 56T 123T	+51 +130	+39 +98	39T 65T 98T 165T	+59 +150	+39 +98	39T 73T 98T 185T

The tolerances in this table are in conformance with ANSI/ABMA Standard 7-1988

Continued on the next page

Shaft and Housing Fits

RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARINGS

Tolerance and shaft diameters shown as variance from nominal bearing bore, using the symbols in the graph . All data except nominal dimensions are in ten-thousands of an inch (5 = 0.0005") and thousandths of a millimeter or micrometer (5 = 0.005mm).

See pages E32 through E37 for actual shaft and housing diameters for normal loading of ABEC-1 and ABEC-3 radial ball bearings and 7000WN Series angular contact ball bearings.

For particular operating conditions of radial ball, spherical and cylindrical roller bearings, see pages E38, E39 and E40.

SHAFT

Bearing Bore			g6			h6			h5			j5			j6			k5			k6			m5		
Nominal (max.) Over	Incl.	Tol. +0 To	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. 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. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm
315	355	-16 -40	-7 -18	-21 -54	21L 9T 54L 22T	0 0	-14 -36	14L 16T 36L 40T				+3 +7	-7 -18	7L 19T 18L 47T	+7 +18	-7 -18	7L 23T 18L 58T	+11 +29	+2 +4	2T 27T 4T 69T				+18 +46	+8 +21	8T 34T 21T 86T
355	400	-16 -40	-7 -18	-21 -54	21L 9T 54L 22T	0 0	-14 -36	14L 16T 36L 40T				+3 +7	-7 -18	7L 19T 18L 47T	+7 +18	-7 -18	7L 23T 18L 58T	+11 +29	+2 +4	2T 27T 4T 69T				+18 +46	+8 +21	8T 34T 21T 86T
400	450	-18 -45	-8 -20	-24 -60	24L 10T 60L 25T	0 0	-16 -40	16L 18T 40L 45T				+3 +7	-8 -20	8L 21T 20L 52T	+8 +20	-8 -20	8L 26T 20L 65T	+13 +32	+2 +5	2T 31T 5T 77T				+20 +50	+9 +23	9T 38T 23T 95T
450	500	-18 -45	-8 -20	-24 -60	24L 10T 60L 25T	0 0	-16 -40	16L 18T 40L 45T				+3 +7	-8 -20	8L 21T 20L 52T	+8 +20	-8 -20	8L 26T 20L 65T	+13 +32	+2 +5	2T 31T 5T 77T				+20 +50	+9 +23	9T 38T 23T 95T
500	560	-20 -50	-9 -22	-26 -66	26L 11T 66L 28T	0 0	-17 -44	17L 20T 44L 50T				+3 +8	-9 -22	9L 23T 22L 58T	+9 +22	-9 -22	9L 29T 22L 72T	+12 +30	0 0	0T 32T 0T 80T				+22 +56	+10 +26	10T 42T 26T 106T
560	630	-20 -50	-9 -22	-26 -66	26L 11T 66L 28T	0 0	-17 -44	17L 20T 44L 50T				+3 +8	-9 -22	9L 23T 22L 58T	+9 +22	-9 -22	9L 29T 22L 72T	+12 +30	0 0	0T 32T 0T 80T				+22 +56	+10 +26	10T 42T 26T 106T
630	710	-30 -75	-9 -24	-29 -74	29L 21T 74L 51T	0 0	-20 -50	20L 30T 50L 75T				+4 +10	-10 -25	10L 34T 25L 85T	+10 +25	-10 -25	10L 40T 25L 100T	+14 +35	0 0	0T 44T 0T 110T				+26 +65	+12 +30	12T 56T 30T 140T
710	800	-30 -75	-9 -24	-29 -74	29L 21T 74L 51T	0 0	-20 -50	20L 30T 50L 75T				+4 +10	-10 -25	10L 34T 25L 85T	+10 +25	-10 -25	10L 40T 25L 100T	+14 +35	0 0	0T 44T 0T 110T				+26 +65	+12 +30	12T 56T 30T 140T
800	900	-39 -100	-10 -26	-32 -82	32L 29T 82L 74T	0 0	-22 -56	22L 39T 56L 100T				+5 +12	-11 -28	11L 44T 28L 112T	+11 +28	-11 -28	11L 50T 28L 128T	+16 +40	0 0	0T 55T 0T 140T				+29 +74	+13 +34	13T 68T 34T 174T
900	1000	-39 -100	-10 -26	-32 -82	32L 29T 82L 74T	0 0	-22 -56	22L 39T 56L 100T				+5 +12	-11 -28	11L 44T 28L 112T	+11 +28	-11 -28	11L 50T 28L 128T	+16 +40	0 0	0T 55T 0T 140T				+29 +74	+13 +34	13T 68T 34T 174T
1000	1120	-49 -125	-11 -28	-37 -94	37L 38T 94L 97T	0 0	-26 -66	26L 49T 66L 125T				+5 +13	-13 -33	13L 54T 33L 138T	+13 +33	-13 -33	13L 62T 33L 158T	+18 +46	0 0	0T 67T 0T 171T				+34 +86	+16 +40	16T 83T 40T 211T
1120	1250	-49 -125	-11 -28	-37 -94	37L 38T 94L 97T	0 0	-26 -66	26L 49T 66L 125T				+5 +13	-13 -33	13L 54T 33L 138T	+13 +33	-13 -33	13L 62T 33L 158T	+18 +46	0 0	0T 67T 0T 171T				+34 +86	+16 +40	16T 83T 40T 211T

The tolerances in this table are in conformation with ANSI/ABMA Standard 7-1988

Shaft and Housing Fits

RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARINGS

Tolerance and shaft diameters shown as variance from nominal bearing bore, using the symbols in the graph . All data except nominal dimensions are in ten-thousands of an inch (5 = 0.0005") and thousandths of a millimeter or micrometer (5 = 0.005mm).

See pages E32 through E37 for actual shaft and housing diameters for normal loading of ABEC-1 and ABEC-3 radial ball bearings and 7000WN Series angular contact ball bearings.

For particular operating conditions of radial ball, spherical and cylindrical roller bearings, see pages E38, E39 and E40.

SHAFT

Bearing Bore			m6			n6			p6			r6			r7		
Nominal (max.) Over	Incl.	Tol. + 0 To	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. min.	Fit	Shaft Dia. max.	Shaft Dia. 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. mm	in. mm
315	355	-16	+22	+8	8T 38T	+29	+15	15T 45T	+39	+24	24T 55T	+57	+43	43T 73T	+65	+43	43T 81T
		-40	+57	+21	21T 97T	+73	+37	37T 113T	+98	+62	62T 138T	+144	+108	108T 184T	+165	+108	108T 205T
355	400	-16				+29	+15	15T 45T	+39	+24	24T 55T	+59	+45	45T 75T	+67	+45	45T 83T
		-40				+73	+37	37T 113T	+98	+62	62T 138T	+150	+114	114T 190T	+171	+114	114T 211T
400	450	-18				+31	+16	16T 49T	+43	+27	27T 61T	+65	+50	50T 83T	+74	+50	50T 92T
		-45				+80	+40	40T 125T	+108	+68	68T 153T	+166	+126	126T 211T	+189	+126	126T 234T
450	500	-18				+31	+16	16T 49T	+43	+27	27T 61T	+68	+52	52T 86T	+77	+52	52T 95T
		-45				+80	+40	40T 125T	+108	+68	68T 153T	+172	+132	132T 217T	+195	+132	132T 240T
500	560	-20							+48	+31	31T 68T	+76	+59	59T 96T	+87	+59	59T 107T
		-50							+122	+78	78T 172T	+194	+150	150T 244T	+220	+150	150T 270T
560	630	-20							+48	+31	31T 68T	+78	+61	61T 98T	+89	+61	61T 109T
		-50							+122	+78	78T 172T	+199	+155	155T 249T	+225	+155	155T 275T
630	710	-30							+54	+35	35T 84T	+89	+69	69T 119T	+100	+69	69T 130T
		-75							+138	+88	88T 213T	+225	+175	175T 300T	+255	+175	175T 330T
710	800	-30							+54	+35	35T 84T	+93	+73	73T 123T	+104	+73	73T 134T
		-75							+138	+88	88T 213T	+235	+185	185T 310T	+265	+185	185T 340T
800	900	-39							+61	+39	39T 100T	+105	+83	83T 144T	+118	+83	83T 157T
		-100							156	+100	100T 256T	+266	+210	210T 366T	+300	+210	210T 400T
900	1000	-39							+61	+39	39T 100T	+109	+87	87T 148T	+122	+87	87T 161T
		-100							+156	+100	100T 256T	+276	+220	220T 376T	+310	+220	220T 410T
1000	1120	-49							+73	+47	47T 122T	+124	+98	98T 173T	+140	+98	98T 189T
		-125							+186	+120	120T 311T	+316	+250	250T 441T	+355	+250	250T 480T
1120	1250	-49							+73	+47	47T 122T	+128	+102	102T 177T	+144	+102	102T 193T
		-125							+186	+120	120T 311T	+326	+260	260T 451T	+365	+260	260T 490T

The tolerances in this table are in conformance with ANSI/ABMA Standard 7– 1988.

Shaft and Housing Fits

RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARINGS

Tolerance and housing bore shown as variance from nominal bearing O.D. All data except nominal dimensions are in ten-thousands of an inch (5 = 0.0005") and thousandths of a millimeter or micrometer (5 = 0.005mm).

See pages E32 through E37 for actual shaft and housing diameters for normal loading of ABEC-1 and ABEC-3 radial ball bearings and 7000WN Series angular contact ball bearings.

For particular operating conditions of radial ball , spherical and cylindrical roller bearings, see pages E38, E39 and E40.

HOUSING

Bearing O.D.			F7			G7			H8			H7			H6			J6			J7			K6			K7		
Nominal (max.) Over	Incl.	Tol. +0 To	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
mm		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
10	18	-3	+6	+13	6L 16L	+2	+9	2L 12L	0	+11	0L 14L	0	+7	0L 10L	0	+4	0L 7L	-2	+2	2T 5L	-3	+4	3T 7L	-4	+1	4L 4T	-5	+2	5T 5L
		-8	+16	+34	16L 42L	+6	+24	6L 32L	0	+27	0L 35L	0	+18	0L 26L	0	+11	0L 19L	-5	+6	5T 14L	-8	+10	8T 18L	-9	+2	9T 10L	-12	+6	12T 14L
18	30	-3.5	+8	+16	8L 19.5L	+3	+11	3L 14.5L	0	+13	0L 16.5L	0	+8	0L 11.5L	0	+5	0L 8.5L	-2	+3	2T 6.5L	-4	+5	4T 8.5L	-4	+1	4T 4.5L	-6	+2	6T 5.5L
		-9	+20	+41	20L 50L	+7	+28	7L 37L	0	+33	0L 42L	0	+21	0L 30L	0	+13	0L 22L	-5	+8	5T 17L	-9	+12	9T 21L	-11	+2	11T 11L	-15	+6	15T 15L
30	50	-4.5	+10	+20	10L 24.5L	+4	+13	4L 17.5L	0	+15	0L 19.5L	0	+10	0L 14.5L	0	+6	0L 10.5L	-2	+4	2T 8.5L	-4	+6	4T 10.5L	-5	+1	5T 5.5L	-7	+3	7T 7.5L
		-11	+25	+50	25L 61L	+9	+34	9L 45L	0	+39	0L 50L	0	+25	0L 36L	0	+16	0L 27L	-6	+10	6T 21L	-11	+14	11T 25L	-13	+3	13T 14L	-18	+7	18T 18L
50	80	-5	+12	+24	12L 29L	+4	+16	4L 21L	0	+18	0L 23L	0	+12	0L 17L	0	+7	0L 12L	-2	+5	2T 10L	-5	+7	5T 12L	-6	+2	6T 7L	-8	+4	8T 9L
		-13	+30	+60	30L 73L	+10	+40	10L 53L	0	+46	0L 59L	0	+30	0L 43L	0	+19	0L 32L	-6	+13	6T 26L	-12	+18	12T 31L	-15	+4	15T 17L	-21	+9	21T 22L
80	120	-6	+14	+28	14L 34L	+5	+19	5L 25L	0	+21	0L 27L	0	+14	0L 20L	0	+9	0L 15L	-2	+6	2T 12L	-5	+9	5T 15L	-7	+2	7T 8L	-10	+4	10T 10L
		-15	+36	+71	36L 86L	+12	+47	12L 62L	0	+54	0L 69L	0	+35	0L 50L	0	+22	0L 37L	-6	+16	6T 31L	-13	+22	13T 37L	-18	+4	18T 19L	-25	+10	25T 25L
120	150	-7	+17	+33	17L 40L	+6	+21	6L 28L	0	+25	0L 32L	0	+16	0L 23L	0	+10	0L 17L	-3	+7	3T 14L	-6	+10	6T 17L	-8	+2	8T 9L	-11	+5	11T 12L
		-18	+43	+83	43L 101L	+14	+54	14L 72L	0	+63	0L 81L	0	+40	0L 58L	0	+25	0L 43L	-7	+18	7T 36L	-14	+26	14T 44L	-21	+4	21T 22L	-28	+12	28T 30L
150	180	-10	+17	+33	17L 43L	+6	+21	6L 31L	0	+25	0L 35L	0	+16	0L 26L	0	+10	0L 20L	-3	+7	3T 17L	-6	+10	6T 20L	-8	+2	8T 12L	-11	+5	11T 15L
		-25	+43	+83	43L 108L	+14	+54	14L 79L	0	+63	0L 88L	0	+40	0L 65L	0	+25	0L 50L	-7	+18	7T 43L	-14	+26	14T 51L	-21	+4	21T 29L	-28	+12	28T 37L
180	250	-12	+20	+38	20L 50L	+6	+24	6L 36L	0	+28	0L 40L	0	+18	0L 30L	0	+11	0L 23L	-3	+9	3T 21L	-6	+12	6T 24L	-9	+2	9T 14L	-13	+5	13T 17L
		-30	+50	+96	50L 126L	+15	+61	15L 91L	0	+72	0L 102L	0	+46	0L 76L	0	+29	0L 59L	-7	+22	7T 52L	-16	+30	16T 60L	-24	+5	24T 35L	-33	+13	33T 43L
250	315	-14	+22	+43	22L 57L	+7	+27	7L 41L	0	+32	0L 46L	0	+20	0L 34L	0	+13	0L 27L	-3	+10	3T 24L	-6	+14	6T 28L	-11	+2	11T 16L	-14	+6	14T 20L
		-35	+56	+108	56L 143L	+17	+69	17L 104L	0	+81	0L 116L	0	+52	0L 87L	0	+32	0L 67L	-7	+25	7T 60L	-16	+36	16T 71L	-27	+5	27T 40L	-36	+16	36T 51L

The tolerances in this table are in conformance with ANSI/ABMA Standard 7– 1988.

Shaft and Housing Fits

RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARINGS

Tolerance and housing bore shown as variance from nominal bearing O.D. All data except nominal dimensions are in ten-thousands of an inch (5 = 0.0005") and thousandths of a millimeter or micrometer (5 = 0.005mm).

See pages E32 through E37 for actual shaft and housing diameters for normal loading of ABEC-1 and ABEC-3 radial ball bearings and 7000WN Series angular contact ball bearings.

For particular operating conditions of radial ball, spherical and cylindrical roller bearings, see pages E38, E39 and E40.

Housing

Bearing O.D.			M6			M7			N6			N7			P6			P7		
Nominal (max.) Over	Incl.	Tol. +0 To	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	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. mm	in. mm	in. mm	in. mm	in. mm
10	18	-3	-6	-2	6T 1L	-7	0	7T 3L	-8	-4	8T 1T	-9	-2	9T 1L	-10	-6	10T 3T	-11	-4	11T 1T
		-8	-15	-4	15T 4L	-18	0	18T 8L	-20	-9	20T 1T	-23	-5	23T 3L	-26	-15	26T 7T	-29	-11	29T 3T
18	30	-3.5	-7	-2	7T 1.5L	-8	0	8T 3.5L	-9	-4	9T 0.5T	-11	-3	11T 0.5L	-12	-7	12T 3.5T	-14	-6	14T 2.5T
		-9	-17	-4	17T 5L	-21	0	21T 9L	-24	-11	24T 2T	-28	-7	28T 2L	-31	-18	31T 9T	-35	-14	35T 5T
30	50	-4.5	-8	-2	8T 2.5L	-10	0	10T 4.5L	-11	-5	11T 0.5T	-13	-3	13T 1.5L	-15	-8	15T 3.5T	-17	-7	17T 2.5T
		-11	-20	-4	20T 7L	-25	0	25T 11L	-28	-12	28T 1T	-33	-8	33T 3L	-37	-21	37T 10T	-42	-17	42T 6T
50	80	-5	-9	-2	9T 3L	-12	0	12T 5L	-13	-6	13T 1T	-15	-4	15T 1L	-18	-10	18T 5T	-20	-8	20T 3T
		-13	-24	-5	24T 8L	-30	0	30T 13L	-33	-14	33T 1T	-39	-9	39T 4L	-45	-26	45T 13T	-51	-21	51T 8T
80	120	-6	-11	-2	11T 4L	-14	0	14T 6L	-15	-6	15T 0T	-18	-4	18T 2L	-20	-12	20T 6T	-23	-9	23T 3T
		-15	-28	-6	28T 9L	-35	0	35T 15L	-38	-16	38T 1T	-45	-10	45T 5L	-52	-30	52T 15T	-59	-24	59T 9T
120	150	-7	-13	-3	13T 4L	-16	0	16T 7L	-18	-8	18T 1T	-20	-5	20T 2L	-24	-14	24T 7T	-27	-11	27T 4T
		-18	-33	-8	33T 10L	-40	0	40T 18L	-45	-20	45T 2T	-52	-12	52T 6L	-61	-36	61T 18T	-68	-28	68T 10T
150	180	-10	-13	-3	13T 7L	-16	0	16T 10L	-18	-8	18T 2L	-20	-5	20T 5L	-24	-14	24T 4T	-27	-11	27T 1T
		-25	-33	-8	33T 17L	-40	0	40T 25L	-45	-20	45T 5L	-52	-12	52T 13L	-61	-36	61T 11T	-68	-28	68T 3T
180	250	-12	-15	-3	15T 9L	-18	0	18T 12L	-20	-9	20T 3L	-24	-6	24T 6L	-28	-16	28T 4T	-31	-13	31T 1T
		-30	-37	-8	37T 22L	-46	0	46T 30L	-51	-22	51T 8L	-60	-14	60T 16L	-70	-41	70T 11T	-79	-33	79T 3T
250	315	-14	-16	-4	16T 10L	-20	0	20T 14L	-22	-10	22T 4L	-26	-6	25T 8L	-31	-19	31T 5T	-35	-14	35T 0L
		-35	-41	-9	41T 26L	-52	0	52T 35L	-57	-25	57T 10L	-66	-14	66T 21L	-79	-47	79T 12T	-88	-36	88T 1T

The tolerances in this table are in conformance with ANSI/ABMA Standard 7 – 1988.

Continued on the next page

Shaft and Housing Fits

RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARINGS

Tolerance and housing bore shown as variance from nominal bearing O.D. All data except nominal dimensions are in ten-thousands of an inch (5 = 0.0005") and thousandths of a millimeter or micrometer (5 = 0.005mm).

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For particular operating conditions of radial ball, spherical and cylindrical roller bearings, see pages E38, E39 and E40.

HOUSING

Bearing O.D.			F7			G7			H8			H7			H6			J6			J7			K6			K7		
Nominal (max.) Over	Incl.	Tol. + 0 To	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
mm		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
315	400	-16	+24	+47	24L 63L	+7	+30	7L 46L	0	+35	0L 51L	0	+22	0L 38L	0	+14	0L 30L	-3	+11	3T 27L	-7	+15	7T 31L	-11	+3	11T 19L	-16	+7	16T 23L
		-40	+62	+119	62L 159L	+18	+75	18L 115L	0	+89	0L 129L	0	+57	0L 97L	0	+36	0L 76L	-7	+29	7T 69L	-18	+39	18T 79L	-29	+7	29T 47L	-40	+17	40T 57L
400	500	-18	+27	+52	27L 70L	+8	+33	8L 51L	0	+38	0L 56L	0	+25	0L 43L	0	+16	0L 34L	-3	+13	3T 31L	-8	+17	8T 35L	-13	+3	13T 21L	-18	+7	18T 25L
		-45	+68	+131	68L 176L	+20	+83	20L 128L	0	+97	0L 142L	0	+63	0L 108L	0	+40	0L 85L	-7	+33	7T 78L	-20	+43	20T 88L	-32	+8	32T 53L	-45	+18	45T 63L
500	630	-20	+30	+57	30L 77L	+9	+36	9L 56L	0	+43	0L 63L	0	+28	0L 48L	0	+17	0L 37L	-3	+15	3T 35L	-9	+19	9T 39L	-17	0	17T 20L	-28	0	28T 20L
		-50	+76	+146	76L 196L	+22	+92	22L 142L	0	+110	0L 160L	0	+70	0L 120L	0	+44	0L 94L	-7	+37	7T 87L	-22	+48	22T 98L	-44	0	44T 50L	-70	0	70T 50L
630	800	-30	+31	+63	31L 93L	+9	+41	9L 71L	0	+49	0L 79L	0	+31	0L 61L	0	+20	0L 50L	-4	+16	4T 46L	-9	+22	9T 52L	-20	0	20T 30L	-31	0	31T 30L
		-75	+80	+160	80L 235L	+24	+104	24L 179L	0	+125	0L 200L	0	+80	0L 155L	0	+50	0L 125L	-10	+40	10T 115L	-24	+56	24T 131L	-50	0	50T 75L	-80	0	80T 75L
800	1000	-39	+34	+69	34L 108L	+10	+46	10L 85L	0	+55	0L 94L	0	+35	0L 74L	0	+22	0L 61L	-4	+18	4T 57L	-10	+25	10T 64L	-22	0	22T 39L	-35	0	35T 39L
		-100	+86	+176	86L 276L	+26	+116	26L 216L	0	+140	0L 240L	0	+90	0L 190L	0	+56	0L 156L	-10	+46	10T 146L	-26	+64	26T 164L	-56	0	56T 100L	-90	0	90T 100L
1000	1250	-49	+39	+80	39L 129L	+11	+52	11L 101L	0	+65	0L 114L	0	+41	0L 90L	0	+26	0L 75L	-4	+22	4T 71L	-11	+30	11T 79L	-26	0	26T 49L	-41	0	41T 49L
		-125	+98	+203	98L 328L	+28	+133	28L 258L	0	+165	0L 290L	0	+105	0L 230L	0	+66	0L 191L	-10	+56	10T 181L	-28	+77	28T 202L	-66	0	66T 125L	-105	0	105T 125L
1250	1600	-63	+43	+93	43L 156L	+12	+61	12L 124L	0	+77	0L 140L	0	+49	0L 112L	0	+31	0L 94L	-4	+27	4T 90L	-12	+37	12T 100L	-31	0	31T 63L	-49	0	49T 63L
		-160	+110	+235	110L 395L	+30	+155	30L 315L	0	+195	0L 355L	0	+125	0L 285L	0	+78	0L 238L	-10	+68	10T 228L	-30	+95	30T 255L	-78	0	78T 160L	-125	0	125T 160L
1600	2000	-79	+47	+106	47L 185L	+13	+72	13L 151L	0	+91	0L 170L	0	+59	0L 138L	0	+36	0L 115L	-4	+32	4T 111L	-13	+46	13T 125L	-36	0	36T 79L	-59	0	59T 79L
		-200	+120	+270	120L 470L	+32	+182	32L 382L	0	+230	0L 430L	0	+150	0L 350L	0	+92	0L 292L	-10	+82	10T 282L	-32	+118	32T 318L	-92	0	92T 200L	-150	0	150T 200L
2000	2500	-98	+51	+120	51L 218L	+13	+82	13L 180L	0	+110	0L 208L	0	+69	0L 167L	0	+43	0L 141L	-4	+39	4T 137L	-13	+56	13T 154L	-43	0	43T 98L	-69	0	69T 98L
		-250	+130	+305	130L 555L	+34	+209	34L 459L	0	+280	0L 530L	0	+175	0L 425L	0	+110	0L 360L	-10	+100	10T 350L	-34	+141	34T 391L	-110	0	110T 250L	-175	0	175T 250L

The tolerances in this table are in conformance with ANSI/ABMA Standard 7 – 1988.

Shaft and Housing Fits

RADIAL BALL, SPHERICAL AND CYLINDRICAL ROLLER BEARINGS

Tolerance and housing bore shown as variance from nominal bearing O.D. All data except nominal dimensions are in ten-thpusands of an inch (5 = 0.0005") and thousandths of a millimeter or micrometer (5 = 0.005mm).

See pages E32 through E37 for actual shaft and housing diameters for normal loading of ABEC-1 and ABEC-3 radial ball bearings and 7000WN Series angular contact ball bearings.

For particular operating conditions of radial ball, spherical and cylindrical roller bearings, see pages E38, E39 and E40.

HOUSING

Bearing O.D.			M6			M7			N6			N7			P6			P7		
Nominal (max.) Over	Incl.	Tol. + 0 To	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	Fit	Housing Bore min.	max	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. mm	in. mm	in. mm	in. mm	in. mm
315	400	-16 -40	-18 -46	-4 -10	18T 12L 46T 30L	-22 -57	0 0	22T 16L 57T 40L	-24 -62	-10 -26	24T 6L 62T 14L	-29 -73	-6 -16	29T 10L 73T 24L	-34 -87	-20 -51	34T 4T 87T 11T	-39 -98	-16 -41	39T 0T 98T 1T
400	500	-18 -45	-20 -50	-4 -10	20T 14L 50T 35L	-25 -63	0 0	25T 18L 63T 45L	-26 -67	-11 -27	26T 7L 67T 18L	-31 -80	-7 -17	31T 11L 80T 28L	-37 -95	-22 -55	37T 4T 95T 10T	-43 -108	-18 -45	43T 0T 108T 0T
500	630	-20 -50	-28 -70	-10 -26	28T 10L 70T 24L	-38 -96	-10 -26	38T 10L 96T 24L	-35 -88	-17 -44	35T 3L 88T 6L	-45 -114	-17 -44	45T 3L 114T 6L	-48 -122	-31 -78	48T 11T 122T 28T	-58 -148	-31 -78	58T 11T 148T 28T
630	800	-30 -75	-31 -80	-12 -30	31T 18L 80T 45L	-43 -110	-12 -30	43T 18L 110T 45L	-39 -100	-20 -50	39T 10L 100T 25L	-51 -130	-20 -50	51T 10L 130T 25L	-54 -138	-35 -88	54T 5T 138T 13T	-66 -168	-35 -88	66T 5T 168T 13T
800	1000	-39 -100	-35 -90	-13 -34	35T 26L 90T 66L	-49 -124	-13 -34	49T 26L 124T 66L	-44 -112	-22 -56	44T 17L 112T 44L	-57 -146	-22 -56	57T 17L 146T 44L	-61 -156	-39 -100	61T 0T 156T 0T	-75 -190	-39 -100	75T 0T 190T 0T
1000	1250	-49 -125	-42 -106	-16 -40	42T 33L 106T 85L	-57 -145	-16 -40	57T 33L 145T 85L	-52 -132	-26 -66	52T 23L 132T 59L	-67 -171	-26 -66	67T 23L 171T 59L	-73 -186	-47 -120	73T 2L 186T 5L	-89 -225	-47 -120	89T 2L 225T 5L
1250	1600	-63 -160	-50 -126	-19 -48	50T 44L 126T 112L	-68 -173	-19 -48	68T 44L 173T 112L	-61 -156	-31 -78	61T 32L 156T 82L	-80 -203	-31 -78	80T 23L 203T 82L	-86 -218	-55 -140	86T 8L 218T 20L	-104 -265	-55 -140	104T 8L 265T 20L
1600	2000	-79 -200	-59 -150	-23 -58	59T 56L 150T 142L	-82 -208	-23 -58	82T 56L 208T 142L	-72 -184	-36 -92	72T 43L 184T 108L	-95 -242	-36 -92	95T 43L 242T 108L	-103 -262	-67 -170	103T 12L 262T 30L	-126 -320	-67 -170	126T 12L 320T 30L
2000	2500	-98 -250	-70 -178	-27 -68	70T 71L 178T 182L	-96 -243	-27 -68	96T 71L 243T 182L	-87 -220	-43 -110	87T 55L 220T 140L	-112 -285	-43 -110	112T 55L 285T 140L	-120 -305	-77 -195	120T 21L 305T 55L	-146 -370	-77 -195	146T 21L 370T 55L

The tolerances in this table are in conformance with ANSI/ABMA Standard 7 – 1988.

Shaft and Housing Fits

RADIAL BALL BEARINGS

ABEC-1 AND ABEC-3 BALL BEARINGS

Shaft and Housing Fits

The tables on the following pages show information supplemental to and coherent with that found on pages E27 through E35 as applied to ball bearings. Actual shaft and housing diameters are listed for ABEC-1, ABEC-3 and angular contact 7000WN series. These recommendations can be used for most applications having light to normal loads. Shaft and housing fits for wide inner ring ball bearings are found on page E53.

ABEC-7 BALL BEARINGS

Shaft fits;

As a general rule, it is recommended that the shaft size and tolerance for seating ABEC-7 superprecision bearings be the same as the bearing bore thus producing an average line-to-line fit. For larger shaft sizes the average fit increases to a slight interference.

Example:

Bore Size, Inches	Shaft Diameter, Inches	Resultant Mounting Fits, Inches	Average Fit
max. 2.1654	min. 2.1652	.0002 tight	line-to-line
min. 2.1652	max. 2.1654	.0002 loose	

Housing fits;

Under normal conditions of rotating shaft, the outer ring is stationary and should be mounted with a hand push or light tapping fit. Should the housing be the rotating member, the same fundamental considerations apply in mounting the outer race as in the case of an inner ring mounted on a rotating shaft.

As a general rule, the minimum housing bore dimensions for superprecision bearings may be established as the same as the maximum bearing outside diameter. If the bearing O.D. tolerance is .0003 inch, the maximum housing bore should be established as .0003 inch larger than the minimum housing bore dimension.

Example:

Outside Diameter, Inches	Housing Bore, Inches	Resultant Mounting Fits, Inches	Average Fit, Inches
max. 3.5433	min. 3.5433	.0000 tight	.0003 loose
min. 3.5430	max. 3.5436	.0006 loose	

On high-speed applications, it is extremely important that the floating bearing or pair can move axially to compensate for thermal changes. It cannot float laterally if restricted by a tight housing bore or by the radial expansion of the bearing itself. Cases involving unusual conditions should be submitted to the Fafnir Engineering Department for complete recommendations.

It is equally important that all shaft and housing shoulders be absolutely square, and that the faces of the spacers be square and parallel.

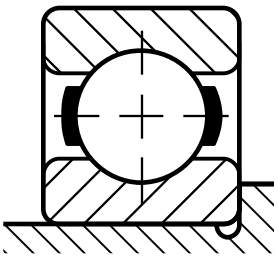
SELECTIVE ASSEMBLY

Under certain conditions it may be desirable to control fits more accurately without the added expense of using closer-tolerence bearings and mating parts. This can be accomplished by selective assembly of bearings, shafts and housings after they have been sized and grouped according to bores and outside diameters. Generally, however, it is more satisfactory for production and servicing to use closer shaft and housing tolerences with bearings having a higher degree of precision.

Bearings with coded bores and O.D.'s are available on special order to facilitate this selective assembly process.

SHAFTS AND HOUSING FILLETS

The recommended shaft and housing fillet radii listed in the dimension tables of the product catalogs should be used to assure proper seating of the bearings against shaft and housing shoulders. The manufacturing tolerences on bearing corner radii are such that the corners will clear the cataloged fillet radii when the bearings are tightly seated against shoulders. Shaft and housing radii and shoulders should be free from nicks and burrs. Whenever possible, undercutting of bearing seats and adjacent shoulders per figure below is advisable to help avoid tapered bearing seats, and assure clearing corners.



FINISH OF SHAFTS AND HOUSINGS

For ABEC-1 bearing applications shaft finish should be 32 micro inches AA maximum for shafts under 2 inches and 63 micro inches AA maximum for shafts over 2 inches. Housing bores should be 125 micro inches AA maximum regardless of size.

These figures are to be used as a guide only. Special situations may demand better finishes.

Shaft and Housing Fits

RADIAL BALL BEARING

SHAFT FITS, ABEC-1, ABEC-3

NOTE: These tables are to 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 on page E42. 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 the Torrington Company when using hollow shafts.

These diameters result in shaft to bearing bore fit which closely conforms to k5 listed on pages E28 and E29.

These diameters result in shaft to bearing bore fit which closely conforms to g6 listed on pages E28 and E30.

SHAFT FITS, ABEC-1, ABEC-3

Basic Bearing Number	Bore Tolerance				Shaft Rotating, Load Stationary or Shaft Stationary, Load Rotating								Shaft Stationary, Load Stationary or Shaft Rotating, Load Rotating							
					shaft diameter				mean fit tight				shaft diameter				mean fit loose			
	max.		min.		max.		min.		ABEC-1		ABEC-3		max.		min.		ABEC-1		ABEC-3	
	in.	mm	in	mm	in.	mm	in	mm	in.	mm	in.	mm	in.	mm	in	mm	in.	mm	in.	mm
EXTRA-SMALL 30, S, F-FLANGED SERIES																				
33K3, F33K3	0.1250	3.175	0.1247	3.167	0.1252	3.180	0.1250	3.175	0.00025	0.006	0.00020	0.005	0.1248	3.170	0.1245	3.162	0.00020	0.005	0.00025	0.006
33K4	0.1250	3.175	0.1247	3.167	0.1252	3.180	0.1250	3.175	0.00025	0.006	0.00020	0.005	0.1248	3.170	0.1245	3.162	0.00020	0.005	0.00025	0.006
33K5	0.1875	4.762	0.1872	3.754	0.1877	4.768	0.1875	4.762	0.00025	0.006	0.00020	0.005	0.1873	4.752	0.1870	4.750	0.00020	0.005	0.00025	0.006
34K	0.1575	4.000	0.1572	3.992	0.1577	4.006	0.1575	4.001	0.00025	0.006	0.00020	0.005	0.1573	3.995	0.1570	3.988	0.00020	0.005	0.00025	0.006
35K	0.1969	5.000	0.1966	4.992	0.1971	5.006	0.1969	5.001	0.00025	0.006	0.00020	0.005	0.1967	4.996	0.1964	4.989	0.00020	0.005	0.00025	0.006
36K	0.2362	6.000	0.2359	5.992	0.2364	6.005	0.2362	5.999	0.00025	0.006	0.00020	0.005	0.2360	5.994	0.2357	5.987	0.00020	0.005	0.00025	0.006
37K	0.2756	7.000	0.2753	6.992	0.2758	7.005	0.2755	6.998	0.00020	0.005	0.00015	0.004	0.2754	6.995	0.2750	6.985	0.00025	0.006	0.00030	0.008
38K,38KV	0.3150	8.000	0.3147	7.992	0.3152	8.006	0.3149	7.998	0.00020	0.005	0.00015	0.004	0.3148	7.996	0.3144	7.986	0.00025	0.006	0.00030	0.008
39K	0.3543	9.000	0.3540	8.992	0.3545	9.004	0.3542	8.997	0.00020	0.005	0.00015	0.004	0.3541	8.994	0.3537	8.984	0.00025	0.006	0.00030	0.008
S1K,S1K7,FS1K7	0.2500	6.350	0.2497	6.342	0.2502	6.355	0.2499	6.347	0.00020	0.005	0.00015	0.004	0.2498	6.345	0.2494	6.335	0.00025	0.006	0.00030	0.008
S3K,FS3K	0.3750	9.525	0.3747	9.517	0.3752	9.530	0.3749	9.522	0.00020	0.005	0.00015	0.004	0.3748	9.520	0.3744	9.510	0.00025	0.006	0.00030	0.008
S5K	0.5000	12.700	0.4997	12.692	0.5002	12.705	0.4999	12.697	0.00020	0.005	0.00015	0.004	0.4998	12.695	0.4993	12.682	0.00030	0.008	0.00035	0.009
S7K	0.6250	15.875	0.6247	15.867	0.6252	15.880	0.6249	15.872	0.00020	0.005	0.00015	0.004	0.6248	15.870	0.6243	15.857	0.00030	0.008	0.00035	0.009
S8K	0.7500	19.050	0.7496	19.040	0.7504	19.060	0.7501	19.053	0.00045	0.011	0.00035	0.009	0.7497	19.042	0.7492	19.030	0.00035	0.009	0.00045	0.011
S9K	0.8750	22.225	0.8746	22.215	0.8754	22.235	0.8751	22.228	0.00045	0.011	0.00035	0.009	0.8747	22.217	0.8742	22.205	0.00035	0.009	0.00045	0.011
S10K	1.0000	25.400	0.9996	25.390	1.0004	25.410	1.0001	25.403	0.00045	0.011	0.00035	0.009	0.9997	25.392	0.9992	25.380	0.00035	0.009	0.00045	0.011
S11K	1.1250	28.575	1.1246	28.565	1.1254	28.585	1.1251	28.578	0.00045	0.011	0.00035	0.009	1.1247	28.567	1.1242	28.555	0.00035	0.009	0.00045	0.011
S12K	1.2500	31.750	1.2495	31.737	1.2505	31.763	1.2501	31.753	0.00055	0.014	0.00045	0.011	1.2496	31.740	1.2490	31.725	0.00045	0.011	0.00055	0.014
F2DD-2	0.1253	3.183	0.1250	3.175	0.1250	3.175	0.1247	3.167	0.00030	0.008[(1)]	0.00025	0.006[(1)]	0.1250	3.175	0.1247	3.167	0.00030	0.008	0.00025	0.006
F2	0.1878	4.770	0.1875	4.762	0.1875	4.762	0.1872	4.755	0.00030	0.008[(1)]	0.00025	0.006[(1)]	0.1875	4.762	0.1872	4.755	0.00030	0.008	0.00025	0.006
F3	0.1878	4.770	0.1875	4.762	0.1875	4.762	0.1872	4.755	0.00030	0.008[(1)]	0.00025	0.006[(1)]	0.1875	4.762	0.1872	4.755	0.00030	0.008	0.00025	0.006
F4	0.2503	6.358	0.2500	6.350	0.2500	6.350	0.2497	6.342	0.00030	0.008[(1)]	0.00025	0.006[(1)]	0.2500	6.350	0.2497	6.342	0.00030	0.008	0.00025	0.006
F5	0.3128	7.946	0.3125	7.938	0.3125	7.938	0.3122	7.930	0.00030	0.008[(1)]	0.00025	0.006[(1)]	0.3125	7.938	0.3122	7.930	0.00030	0.008	0.00025	0.006

[(1)]Mean fit loose. These sizes have plus bore tolerances.

Shaft and Housing Fits

RADIAL BALL BEARING

SHAFT FITS, ABEC-1, ABEC-3

NOTE: These tables are to 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 on page E42. 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 the Torrington Company when using hollow shafts.

SHAFT FITS, ABEC-1, ABEC-3

These diameters result in shaft to bearing bore fit which closely conforms to k5 listed on pages E28 and E30.

These diameters result in shaft to bearing bore fit which closely conforms to g6 listed on pages E28 and E30.

Basic Bearing Number	Bore Tolerance				Shaft Rotating, Load Stationary or Shaft Stationary, Load Rotating								Shaft Stationary, Load Stationary or Shaft Rotating, Load Rotating							
					shaft diameter				(mean fit) tight				shaft diameter				(mean fit) loose			
	max.		min.		max.		min.		ABEC-1		ABEC-3		max.		min.		ABEC-1		ABEC-3	
	in.	mm	in	mm	in.	mm	in	mm	in.	mm	in.	mm	in.	mm	in	mm	in.	mm	in.	mm
9100, 9300, 200, 300, 5200, 5300 SERIES																				
00	0.3937	10	0.3934	9.992	0.3939	10.005	0.3936	9.997	0.0002	0.005	0.00015	0.004	0.3935	9.995	0.3931	9.985	0.00025	0.006	0.00030	0.008
01	0.4724	12	0.4721	11.992	0.4726	12.004	0.4723	11.996	0.0002	0.005	0.00015	0.004	0.4722	11.994	0.4717	11.981	0.00030	0.008	0.00035	0.009
02	0.5906	15	0.5903	14.992	0.5908	15.006	0.5905	14.999	0.0002	0.005	0.00015	0.004	0.5904	14.996	0.5899	14.983	0.00030	0.008	0.00035	0.009
03	0.6693	17	0.6690	16.992	0.6695	17.005	0.6692	16.998	0.0002	0.005	0.00015	0.004	0.6691	16.995	0.6686	16.982	0.00030	0.008	0.00035	0.009
04	0.7874	20	0.7870	19.990	0.7879	20.010	0.7875	20.002	0.0005	0.013	0.00035	0.009	0.7871	19.992	0.7866	19.980	0.00035	0.009	0.00045	0.011
05	0.9843	25	0.9839	24.990	0.9848	25.014	0.9844	25.004	0.0005	0.013	0.00035	0.009	0.9840	24.994	0.9835	24.981	0.00035	0.009	0.00045	0.011
06	1.1811	30	1.1807	29.990	1.1816	30.010	1.1812	30.002	0.0005	0.013	0.00035	0.009	1.1808	29.992	1.1803	29.980	0.00035	0.009	0.00045	0.011
07	1.3780	35	1.3775	34.987	1.3785	35.014	1.3781	35.004	0.0006	0.014	0.00045	0.011	1.3776	34.991	1.3770	34.976	0.00045	0.011	0.00055	0.014
08	1.5748	40	1.5743	39.987	1.5753	40.013	1.5749	40.002	0.0006	0.014	0.00045	0.011	1.5744	39.990	1.5738	39.975	0.00045	0.011	0.00055	0.014
09	1.7717	45	1.7712	44.987	1.7722	45.014	1.7718	45.004	0.0006	0.014	0.00045	0.011	1.7713	44.991	1.7707	44.976	0.00045	0.011	0.00055	0.014
10	1.9685	50	1.9680	49.987	1.9690	50.013	1.9686	50.002	0.0006	0.014	0.00045	0.011	1.9681	49.990	1.9675	49.974	0.00045	0.011	0.00055	0.014
11	2.1654	55	2.1648	54.985	2.1660	55.016	2.1655	55.004	0.0007	0.017	0.00055	0.014	2.1650	54.991	2.1643	54.973	0.00045	0.011	0.00055	0.014
12	2.3622	60	2.3616	59.985	2.3628	60.015	2.3623	60.002	0.0007	0.017	0.00055	0.014	2.3618	59.990	2.3611	59.972	0.00045	0.011	0.00055	0.014
13	2.5591	65	2.5585	64.985	2.5597	65.016	2.5592	65.004	0.0007	0.017	0.00055	0.014	2.5587	64.991	2.5580	64.973	0.00045	0.011	0.00055	0.014
14	2.7559	70	2.7553	69.985	2.7565	70.015	2.7560	70.002	0.0007	0.017	0.00055	0.014	2.7555	69.990	2.7548	69.972	0.00045	0.011	0.00055	0.014
15	2.9528	75	2.9552	74.985	2.9534	75.016	2.9529	75.004	0.0007	0.017	0.00055	0.014	2.9524	74.991	2.9517	74.973	0.00045	0.011	0.00055	0.014
16	3.1496	80	3.1490	79.985	3.1502	80.015	3.1497	80.002	0.0007	0.017	0.00055	0.014	3.1492	79.990	3.1485	79.972	0.00045	0.011	0.00055	0.014
17	3.3465	85	3.3457	84.980	3.3472	85.019	3.3466	85.004	0.0008	0.020	0.00065	0.017	3.3460	84.988	3.3452	84.968	0.00050	0.013	0.00065	0.017
18	3.5433	90	3.5425	89.980	3.5440	90.018	3.5434	90.002	0.0008	0.020	0.00065	0.017	3.5428	89.987	3.5420	89.967	0.00050	0.013	0.00065	0.017
19	3.7402	95	3.7394	94.980	3.7409	95.019	3.7403	95.004	0.0008	0.020	0.00065	0.017	3.7397	94.988	3.7389	94.968	0.00050	0.013	0.00065	0.017
20	3.9370	100	3.9362	99.980	3.9377	100.018	3.9371	100.002	0.0008	0.020	0.00065	0.017	3.9365	99.987	3.9357	99.967	0.00050	0.013	0.00065	0.017
21	4.1339	105	4.1331	104.980	4.1346	105.019	4.1340	105.004	0.0008	0.020	0.00065	0.017	4.1334	104.988	4.1326	104.968	0.00050	0.013	0.00065	0.017
22	4.3307	110	4.3299	109.980	4.3314	110.018	4.3308	110.002	0.0008	0.020	0.00065	0.017	4.3302	109.987	4.3294	109.967	0.00050	0.013	0.00065	0.017
EXTRA-LARGE SERIES																				
124, 224, 324	4.7244	120	4.7236	119.980	4.7251	120.018	4.7245	120.002	0.0008	0.020	0.00065	0.017	4.7239	119.987	4.7231	119.967	0.00050	0.013	0.00065	0.017
126, 226, 326	5.1181	130	5.1171	129.975	5.1189	130.020	5.1182	130.002	0.0010	0.024	0.00075	0.019	5.1175	129.984	5.1166	129.962	0.00055	0.014	0.00075	0.019
128, 228, 328	5.5118	140	5.5108	139.975	5.5126	140.020	5.5119	140.002	0.0010	0.024	0.00075	0.019	5.5112	139.984	5.5103	139.962	0.00055	0.014	0.00075	0.019
9130, 130, 230, 330	5.9055	150	5.9045	149.975	5.9063	150.020	5.9056	150.002	0.0010	0.024	0.00075	0.019	5.9049	149.984	5.9040	149.962	0.00055	0.014	0.00075	0.019
9132, 132, 232	6.2992	160	6.2982	159.975	6.3000	160.020	6.2993	160.002	0.0010	0.024	0.00075	0.019	6.2986	159.984	6.2977	159.962	0.00055	0.014	0.00075	0.019
9134, 134, 234	6.6929	170	6.6919	169.975	6.6937	170.020	6.6930	170.002	0.0010	0.024	0.00075	0.019	6.6923	169.984	6.6914	169.962	0.00055	0.014	0.00075	0.019
9136, 136, 236, 336	7.0866	180	7.0856	179.975	7.0874	180.020	7.0867	180.002	0.0010	0.024	0.00075	0.019	7.0860	179.984	7.0851	179.962	0.00055	0.014	0.00075	0.019
9138, 138, 238, 338	7.4803	190	7.4791	189.970	7.4813	190.025	7.4805	190.005	0.0012	0.030	0.00095	0.024	7.4797	189.984	7.4786	189.956	0.00055	0.014	0.00080	0.020
9140, 240, 340	7.8740	200	7.8728	199.969	7.8750	200.025	7.8742	200.005	0.0012	0.030	–	–	7.8734	199.984	7.8722	199.954	0.00060	0.015	–	–
9142, 242, 342	8.2677	210	8.2665	212.509	8.2587	209.771	8.2678	210.002	0.0012	0.030	–	–	8.2672	209.987	8.2658	209.951	0.00060	0.015	–	–
9144, 244, 344	8.6614	220	8.6602	219.969	8.6624	220.025	8.6616	220.005	0.0012	0.030	–	–	8.6608	219.984	8.6596	219.954	0.00060	0.015	–	–
9146, 246	9.0551	230	9.0539	229.969	9.0561	230.025	9.0553	230.005	0.0012	0.030	–	–	9.0545	230.022	9.0533	229.951	0.00060	0.015	–	–
248, 348	9.4488	240	9.4476	239.969	9.4498	240.025	9.4490	240.005	0.0012	0.030	–	–	9.4482	239.984	9.4470	239.954	0.00060	0.015	–	–
250	9.8425	250	9.8411	249.964	9.8434	250.020	9.8426	250.005	0.0012	0.030	–	–	9.8418	250.022	9.8406	249.972	0.00060	0.015	–	–
9152, 252, 352	10.2362	260	10.2348	259.964	10.2373	260.027	10.2364	260.005	0.0014	0.036	–	–	10.2355	259.982	10.2343	259.951	0.00060	0.015	–	–
9156, 256, 356	11.0236	280	11.0222	279.964	11.0247	280.027	11.0238	280.005	0.0014	0.036	–	–	11.0229	279.982	11.0217	279.951	0.00060	0.015	–	–
9160, 260	11.8110	300	11.8096	299.964	11.8121	300.027	11.8112	300.005	0.0014	0.036	–	–	11.8103	299.982	11.8091	299.951	0.00060	0.015	–	–
9164, 264	12.5984	320	12.5970	319.964	12.5996	320.030	12.5986	320.005	0.0015	0.038	–	–	12.5977	319.982	12.5963	319.946	0.00060	0.015	–	–
9180	15.7480	400	15.7464	399.969	15.7492	400.030	15.7482	400.005	0.0015	0.038	–	–	15.7473	399.982	15.7459	399.946	0.00060	0.015	–	–

Shaft and Housing Fits

RADIAL BALL BEARING

SHAFT FITS, 7000 WN

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 on page E42. 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 the Torrington Company when using hollow shafts.

SHAFT FITS, 7000 WN
Single Row Angular Contact Bearings

These diameters result in shaft to bearing bore fit which closely conforms to j5 listed on pages E28 and E30.

Bearing Bore Number	Bearing Bore Diameter				Shaft Rotating, Load Stationary shaft diameter				Mean Tight Fit	
	max.		min.		min.		max.			
	in.	mm	in	mm	in.	mm	in	mm	in.	mm
00	0.3937	10	0.3934	9.992	0.3936	9.997	0.3939	10.005	0.0002	0.005
01	0.4724	12	0.4721	11.991	0.4723	11.996	0.4726	12.004	0.0002	0.005
02	0.5906	15	0.5903	14.994	0.5905	14.999	0.5908	15.006	0.0002	0.005
03	0.6693	17	0.6690	16.993	0.6692	16.998	0.6695	17.005	0.0002	0.005
04	0.7874	20	0.7871	19.992	0.7873	19.997	0.7876	20.005	0.0002	0.005
05	0.9843	25	0.9840	24.994	0.9842	24.999	0.9845	25.006	0.0002	0.005
06	1.1811	30	1.1808	29.992	1.1810	29.997	1.1813	30.005	0.0002	0.005
07	1.3780	35	1.3777	34.994	1.3779	34.999	1.3783	35.009	0.00025	0.006
08	1.5748	40	1.5745	39.992	1.5747	39.997	1.5751	40.008	0.00025	0.006
09	1.7717	45	1.7714	44.994	1.7716	44.999	1.7720	45.009	0.00025	0.006
10	1.9685	50	1.9682	49.992	1.9684	49.997	1.9688	50.008	0.00025	0.006
11	2.1654	55	2.1650	54.991	2.1653	54.999	2.1658	55.011	0.00035	0.009
12	2.3622	60	2.3618	59.990	2.3621	59.997	2.3626	60.010	0.00035	0.009
13	2.5591	65	2.5587	64.991	2.5590	64.999	2.5595	65.011	0.00035	0.009
14	2.7559	70	2.7555	69.990	2.7558	69.997	2.7563	70.010	0.00035	0.009
15	2.9528	75	2.9524	74.991	2.9527	74.999	2.9532	75.011	0.00035	0.009
16	3.1496	80	3.1492	79.990	3.1495	79.997	3.1500	80.010	0.00035	0.009
17	3.3465	85	3.3460	84.988	3.3464	84.999	3.3470	85.014	0.00045	0.011
18	3.5433	90	3.5428	89.987	3.5432	89.997	3.5438	90.013	0.00045	0.011
19	3.7402	95	3.7397	94.988	3.7401	94.999	3.7407	95.014	0.00045	0.011
20	3.9370	100	3.9365	99.987	3.9369	99.997	3.9375	100.013	0.00045	0.011
21	4.1339	105	4.1334	104.988	4.1338	104.999	4.1344	105.014	0.00045	0.011
22	4.3307	110	4.3302	109.987	4.3306	109.997	4.3312	110.012	0.00045	0.011
24	4.7244	120	4.7239	119.987	4.7243	119.997	4.7249	120.012	0.00045	0.011
26	5.1181	130	5.1174	129.982	5.1180	129.997	5.1187	130.015	0.0006	0.015
28	5.5118	140	5.5111	139.982	5.5117	139.997	5.5124	140.015	0.0006	0.015
30	5.9055	150	5.9048	149.982	5.9054	149.997	5.9061	150.015	0.0006	0.015

Shaft and Housing Fits

RADIAL BALL BEARING

HOUSING FITS, ABEC-1, ABEC-3

NOTE: These tables are to 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 on page E42. 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 the Torrington Company when using other housing materials.

HOUSING FITS, ABEC-1, ABEC-3

These diameters result in a bearing O.D. to to housing bore fit which closely conforms to H6 listed on pages E32 and E34.

These diameters result in a bearing O.D. housing bore fit which closely conforms to M7 listed on pages E33 and E35.

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 Tight			
Extra Small	Extra Light	Light[1]	Medium	Heavy	minimum		maximum		ABEC–1		ABEC–3		minimum		maximum		ABEC–1		ABEC–3	
30, S, F SERIES	9100, 9300 SERIES	200, SERIES	300, SERIES	400[2], 7400 SERIES	in.	mm	in	mm	in.	mm	in.	mm	in.	mm	in	mm	in.	mm	in.	mm
33K3, F33K3	–	–	–	–	0.3750	9.525	0.3754	9.535	0.00040	0.010	0.00035	0.009	0.3743	9.507	0.3750	9.525	0.00015	0.004	0.00020	0.005
33K4	–	–	–	–	0.5000	12.700	0.5004	12.710	0.00040	0.010	0.00035	0.009	0.4993	12.682	0.5000	12.700	0.00015	0.004	0.00020	0.005
33K5, F33K5	–	–	–	–	0.5000	12.700	0.5004	12.710	0.00040	0.010	0.00035	0.009	0.4993	12.682	0.5000	12.700	0.00015	0.004	0.00020	0.005
34K	–	–	–	–	0.6299	15.999	0.6303	16.010	0.00040	0.010	0.00035	0.009	0.6292	15.982	0.6299	15.999	0.00015	0.004	0.00020	0.005
35K	–	–	–	–	0.7480	18.999	0.7485	19.012	0.00045	0.011	0.00040	0.010	0.7472	18.979	0.7480	18.999	0.00020	0.005	0.00025	0.006
36K	–	–	–	–	0.7480	18.999	0.7485	19.012	0.00045	0.011	0.00040	0.010	0.7472	18.979	0.7480	18.999	0.00020	0.005	0.00025	0.006
37K	–	–	–	–	0.8661	21.999	0.8666	22.012	0.00045	0.011	0.00040	0.010	0.8653	21.979	0.8661	29.999	0.00020	0.005	0.00025	0.006
38K	–	–	–	–	0.8661	21.999	0.8666	22.012	0.00045	0.011	0.00040	0.010	0.8653	21.979	0.8661	21.999	0.00020	0.005	0.00025	0.006
38KV	–	–	–	–	0.9449	24.000	0.9454	24.013	0.00045	0.011	0.00040	0.010	0.9441	23.980	0.9449	24.000	0.00020	0.005	0.00025	0.006
39K	**9100**	–	–	–	1.0236	25.999	1.0241	26.012	0.00045	0.011	0.00040	0.010	1.0228	25.979	1.0236	25.999	0.00020	0.005	0.00025	0.006
S1K7, FS1K7	–	–	–	–	0.6250	15.875	0.6254	15.885	0.00040	0.010	0.00035	0.009	0.6243	15.857	0.6250	15.875	0.00015	0.004	0.00020	0.005
S1K	–	–	–	–	0.7500	19.050	0.7505	19.063	0.00045	0.011	0.00040	0.010	0.7492	19.030	0.7500	19.050	0.00020	0.005	0.00025	0.006
S3K, FS3K	–	–	–	–	0.8750	22.225	0.8755	22.238	0.00045	0.011	0.00040	0.010	0.8742	22.205	0.8750	22.225	0.00020	0.005	0.00025	0.006
S5K	–	–	–	–	1.1250	28.575	1.1255	28.588	0.00045	0.011	0.00040	0.010	1.1242	28.555	1.1250	28.575	0.00020	0.005	0.00025	0.006
S7K	–	–	–	–	1.3750	34.925	1.3756	34.940	0.00055	0.014	0.00045	0.011	1.3740	34.900	1.3750	34.925	0.00025	0.006	0.00035	0.009
S8K	–	–	–	–	1.6250	41.275	1.6256	41.290	0.00055	0.014	0.00045	0.011	1.6240	41.250	1.6250	41.275	0.00025	0.006	0.00035	0.009
S9K	–	–	–	–	1.8750	47.625	1.8756	47.640	0.00055	0.014	0.00045	0.011	1.8740	47.600	1.8750	47.625	0.00025	0.006	0.00035	0.009
S10K	–	–	–	–	2.0000	50.800	2.0007	50.818	0.00060	0.015	0.00055	0.014	1.9988	50.770	2.0000	50.800	0.00035	0.009	0.00040	0.010
S11K	–	–	–	–	2.1250	53.975	2.1257	53.993	0.00060	0.015	0.00055	0.014	2.1238	53.945	2.1250	53.975	0.00035	0.009	0.00040	0.010
S12K	–	–	–	–	2.2500	57.150	2.2507	57.168	0.00060	0.015	0.00055	0.014	2.2488	57.120	2.2500	57.150	0.00035	0.009	0.00040	0.010
F2002	–	–	–	–	0.3750	9.525	0.3753	9.533	0.00000	0.000	0.00000	0.000	0.3749	9.522	0.3753	9.533	0.00000	0.000	0.00000	0.000
F2	–	–	–	–	0.4375	11.112	0.4378	11.120	0.00000	0.000	0.00000	0.000	0.4374	11.110	0.4378	11.120	0.00000	0.000	0.00000	0.000
F3	–	–	–	–	0.5624	14.285	0.5628	14.295	0.00000	0.000	0.00000	0.000	0.5624	14.285	0.5628	14.295	0.00000	0.000	0.00000	0.000
F4	–	–	–	–	0.6249	15.872	0.6253	15.883	0.00000	0.000	0.00000	0.000	0.6249	15.872	0.6253	15.883	0.00000	0.000	0.00000	0.000
F5	–	–	–	–	0.6874	17.460	0.6878	17.470	0.00000	0.000	0.00000	0.000	0.6874	17.460	0.6878	17.476	0.00000	0.000	0.00000	0.000
–	**9101, 9302**	–	–	–	1.1024	28.001	1.1029	28.014	0.00045	0.011	0.00040	0.010	1.1016	27.981	1.1024	28.001	0.00020	0.005	0.00025	0.006
–	**9303**	**200**	–	–	1.1811	30.000	1.1816	30.013	0.00045	0.011	0.00040	0.010	1.1803	29.980	1.1811	39.000	0.00020	0.005	0.00025	0.006
–	**9102**	**201**	–	–	1.2598	31.999	1.2604	32.014	0.00055	0.014	0.00045	0.011	1.2588	31.974	1.2598	31.999	0.00025	0.006	0.00035	0.009
–	**9103**	**202**	**300**	–	1.3780	35.001	1.3786	35.016	0.00055	0.014	0.00045	0.011	1.3770	34.976	1.3780	35.001	0.00025	0.006	0.00035	0.009
–	**9304**	–	**301**	–	1.4567	37.000	1.4573	37.015	0.00055	0.014	0.00045	0.011	1.4557	36.975	1.4567	37.000	0.00025	0.006	0.00035	0.009
–	–	**203**	–	–	1.5748	40.000	1.5754	40.015	0.00055	0.014	0.00045	0.011	1.5738	39.975	1.5748	40.000	0.00025	0.006	0.00035	0.009
–	**9104, 9305**	–	**302**	–	1.6535	41.999	1.6541	42.014	0.00055	0.014	0.00045	0.011	1.6525	41.974	1.6535	41.999	0.00025	0.006	0.00035	0.009
–	**9105, 9306**	**204**	**303**	–	1.8504	47.000	1.8510	47.015	0.00055	0.014	0.00045	0.011	1.8494	46.975	1.8504	47.000	0.00025	0.006	0.00035	0.009
–	–	**205**	**304**	–	2.0472	51.999	2.0479	52.017	0.00060	0.015	0.00055	0.014	2.0460	51.968	2.0472	51.999	0.00035	0.009	0.00040	0.010
–	**9106, 9307**	–	–	–	2.1654	55.001	2.1661	55.019	0.00060	0.015	0.00055	0.014	2.1642	54.971	2.1654	55.001	0.00035	0.009	0.00040	0.010
–	**9107, 9308**	**206**	**305**	**403**	2.4409	61.999	2.4416	62.017	0.00060	0.015	0.00055	0.014	2.4397	61.968	2.4409	61.999	0.00030	0.009	0.00040	0.010
–	**9108**	–	–	–	2.6772	68.001	2.6779	68.019	0.00060	0.015	0.00055	0.014	2.6760	67.970	2.6772	68.001	0.00030	0.009	0.00040	0.010
–	**9310**	**207**	**306**	**404**	2.8346	71.999	2.8353	72.017	0.00060	0.015	0.00055	0.014	2.8334	71.968	2.8346	71.999	0.00030	0.009	0.00040	0.010
–	**9109**	–	–	–	2.9528	75.001	2.9535	75.019	0.00060	0.015	0.00055	0.014	2.9516	74.971	2.9528	75.001	0.00030	0.009	0.00040	0.010
–	**9110**	**208**	**307**	**405**	3.1496	80.000	3.1503	80.018	0.00060	0.015	0.00055	0.014	3.1484	79.969	3.1496	80.000	0.00030	0.009	0.00040	0.010
–	**9312**	**209**	–	–	3.3465	85.001	3.3474	85.024	0.00080	0.019	0.00065	0.017	3.3451	84.966	3.3465	85.001	0.00040	0.010	0.00050	0.013
–	**9111**	**210**	**308**	**406**	3.5433	90.000	3.5442	90.023	0.00080	0.019	0.00065	0.017	3.5419	89.964	3.5433	90.000	0.00040	0.010	0.00050	0.013
–	**9112**	–	–	–	3.7402	95.001	3.7411	120.424	0.00080	0.019	0.00065	0.017	3.7388	94.965	3.7402	95.001	0.00040	0.010	0.00050	0.013
–	**9113**	**211**	**309**	**407**	3.9370	100.000	3.9379	100.023	0.00080	0.019	0.00065	0.017	3.9356	99.964	3.9370	100.000	0.00040	0.010	0.00050	0.013
–	**9114**	**212**	**310**	**408**	4.3307	110.000	4.3316	110.023	0.00080	0.019	0.00065	0.017	4.3293	109.964	4.3307	110.000	0.00040	0.010	0.00050	0.013

[1] Includes 5000 & 7000 Series.
[2] 400 Series are "specials", consult Fafnir Engieering Department.

Shaft and Housing Fits

RADIAL BALL BEARING

HOUSING FITS, ABEC-1, ABEC-3

NOTE: These tables are to 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 on page E42. 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 the Torrington Company when using other housing materials.

HOUSING FITS, ABEC-1, ABEC-3

These diameters result in a bearing O.D. to housing bore fit which closely conforms to H6 listed on pages E32 and E34.

These diameters result in a bearing O.D. to housing bore fit which closely conforms to M7 listed on pages E33 and E35.

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 tight			
30,S,F	9100,9300	200,7200	300,7300	7400	minimum		maximum		ABEC–1		ABEC–3		minimum		maximum		ABEC–1		ABEC–3	
SERIES	SERIES	SERIES	SERIES	SERIES	in.	mm	in	mm	in.	mm	in.	mm	in.	mm	in	mm	in.	mm	in.	mm
–	9115	–	–	–	4.5276	115.001	4.5285	115.024	0.0008	0.019	0.00065	0.017	4.5262	114.965	4.5276	115.001	0.0004	0.010	0.00050	0.013
–	–	213	311	409	4.7244	120.000	4.7253	120.023	0.0008	0.019	0.00065	0.017	4.7230	119.964	4.7244	120.000	0.0004	0.010	0.00050	0.013
–	–	214	–	–	4.9213	125.001	4.9223	125.026	0.0009	0.023	0.00075	0.019	4.9197	124.960	4.9213	125.001	0.0004	0.010	0.00055	0.014
–	9117	215	312	410	5.1181	130.000	5.1191	130.025	0.0009	0.023	0.00075	0.019	5.1165	129.959	5.1181	130.000	0.0004	0.010	0.00055	0.014
–	9118	216	313	411	5.5118	140.000	5.5128	140.025	0.0009	0.023	0.00075	0.019	5.5102	139.959	5.5118	140.000	0.0004	0.010	0.00055	0.014
–	9120	217	314	412	5.9055	150.000	5.9065	150.025	0.0009	0.023	0.00075	0.019	5.9039	149.959	5.9055	150.000	0.0004	0.010	0.00055	0.014
–	120–2	218	315	–	6.2992	160.000	6.3002	160.025	0.0010	0.025	0.00080	0.020	6.2976	159.959	6.2992	160.000	0.0003	0.008	0.00050	0.013
–	9121	–	–	413	6.2992	160.000	6.3002	160.025	0.0010	0.025	0.00080	0.020	6.2976	159.959	6.2992	160.000	0.0003	0.008	0.00050	0.013
–	9122	129	316	–	6.6929	170.000	6.6939	170.025	0.0010	0.025	0.00080	0.020	6.6913	169.959	6.6929	170.000	0.0003	0.008	0.00050	0.013
–	122	–	–	–	6.8898	175.000	6.8908	175.026	0.0010	0.025	0.00080	0.020	6.8882	174.960	6.8898	175.001	0.0003	0.008	0.00050	0.013
–	9124	220	317	414	7.0866	180.000	7.0876	180.025	0.0010	0.025	0.00080	0.020	7.0850	179.959	7.0866	180.000	0.0003	0.008	0.00050	0.013
–	124	221	318	415	7.4803	190.000	7.4815	190.028	0.0012	0.029	0.00090	0.023	7.4785	189.954	7.4803	190.000	0.0003	0.008	0.00055	0.014
–	9126	222	319	416	7.8740	200.000	7.8752	200.028	0.0012	0.029	0.00090	0.023	7.8722	199.954	7.8740	200.000	0.0003	0.008	0.00055	0.014
–	126	–	–	–	8.0709	205.001	8.0721	205.029	0.0012	0.029	0.00090	0.023	8.0691	204.955	8.0709	205.001	0.0003	0.008	0.00055	0.014
–	9128	–	–	–	8.2677	210.000	8.2689	210.028	0.0012	0.029	0.00090	0.023	8.2659	209.954	8.2677	210.000	0.0003	0.008	0.00055	0.014
–	–	224	320	–	8.4646	215.001	8.4658	215.029	0.0012	0.029	0.00090	0.023	8.4628	214.955	8.4646	215.001	0.0003	0.008	0.00055	0.014
–	128	–	–	–	8.6614	220.000	8.6626	220.028	0.0012	0.029	0.00090	0.023	8.6596	219.954	8.6614	220.000	0.0003	0.008	0.00055	0.014
–	9130	–	321	418	8.8583	225.001	8.8595	225.029	0.0012	0.029	0.00090	0.023	8.8565	224.955	8.8583	225.001	0.0003	0.008	0.00055	0.014
–	–	226	–	–	9.0551	230.000	9.0563	230.027	0.0012	0.029	0.00090	0.023	9.0533	229.954	9.0551	230.000	0.0003	0.008	0.00055	0.014
–	130	–	–	–	9.2520	235.001	9.2532	235.029	0.0012	0.029	0.00090	0.023	9.2502	234.955	9.2520	235.001	0.0003	0.008	0.00055	0.014
–	9132	–	322	–	9.4488	240.000	9.4506	240.027	0.0012	0.029	0.00090	0.023	9.4470	239.954	9.4488	240.000	0.0003	0.008	0.00055	0.014
–	132	228	–	–	9.8425	250.000	9.8437	250.027	0.0012	0.029	0.00090	0.023	9.8407	249.954	9.8425	250.000	0.0003	0.008	0.00055	0.014
–	9134	–	324	–	10.2362	259.999	10.2374	260.032	0.0013	0.033	0.00105	0.027	10.2342	259.942	10.2362	259.999	0.0003	0.008	0.00060	0.015
–	134	–	–	420	10.4331	265.001	10.4343	265.034	0.0013	0.033	0.00105	0.027	10.4311	264.950	10.4331	265.001	0.0003	0.008	0.00060	0.015
–	–	230	–	–	10.6299	269.999	10.6311	270.032	0.0013	0.033	0.00105	0.027	10.6279	269.949	10.6299	269.999	0.0003	0.008	0.00060	0.015
–	136,9136	–	326	–	11.0236	279.999	11.0248	280.032	0.0013	0.033	0.00105	0.027	11.0216	279.949	11.0236	279.999	0.0003	0.008	0.00060	0.015
–	9138	232	–	–	11.4173	289.999	11.4185	290.039	0.0013	0.033	0.00105	0.027	11.4153	289.949	11.4173	289.999	0.0003	0.008	0.00060	0.015
–	138	–	328	–	11.8110	299.999	11.8122	300.032	0.0013	0.033	0.00105	0.027	11.8090	299.949	11.8110	299.999	0.0003	0.008	0.00060	0.015
–	9140	234	–	–	12.2047	309.999	12.2059	310.029	0.0013	0.033	–	–	12.2027	309.949	12.2047	309.999	0.0003	0.008	–	–
–	–	236	330	–	12.5984	319.999	12.5998	320.035	0.0015	0.038	–	–	12.5962	319.943	12.5984	319.999	0.0003	0.008	–	–
–	9144	238	–	–	13.3858	339.999	13.3872	340.035	0.0015	0.038	–	–	13.3836	339.943	13.3858	339.999	0.0003	0.008	–	–
–	9146	240	–	–	14.1732	359.999	14.1746	360.035	0.0015	0.038	–	–	14.1710	359.943	14.1732	359.999	0.0003	0.008	–	–
–	–	242	336	–	14.9606	380.007	14.9620	380.035	0.0015	0.038	–	–	14.9584	379.943	14.9606	379.999	0.0003	0.008	–	–
–	9152	244	338	–	15.7480	399.999	15.7494	400.035	0.0015	0.038	–	–	15.7458	399.943	15.7480	399.999	0.0003	0.008	–	–
–	9156	246	340	–	16.5354	419.999	16.5370	420.040	0.0017	0.038	–	–	16.5329	419.936	16.5354	419.999	0.0004	0.010	–	–
–	–	248	342	–	17.3228	439.999	17.3244	440.040	0.0017	0.038	–	–	17.3203	439.936	17.3228	439.999	0.0004	0.010	–	–
–	9160	250	344	–	18.1102	459.999	18.1118	460.040	0.0017	0.038	–	–	18.1077	459.936	18.1102	459.999	0.0004	0.010	–	–
–	9164	252	–	–	18.8976	479.999	18.8992	480.040	0.0017	0.038	–	–	18.8951	479.936	18.8976	479.999	0.0004	0.010	–	–
–	–	256	348	–	19.6850	499.999	19.6866	500.040	0.0017	0.038	–	–	19.6825	499.936	19.6850	499.999	0.0004	0.010	–	–
–	–	260	352	–	21.2598	539.999	21.2615	540.042	0.0019	0.048	–	–	21.2571	539.930	21.2598	539.999	0.0004	0.010	–	–
–	–	264	356	–	22.8346	579.999	22.8363	580.042	0.0019	0.048	–	–	22.8319	579.930	22.8346	579.999	0.0004	0.010	–	–
–	9180	–	–	–	23.6220	599.999	23.6237	600.042	0.0019	0.048	–	–	23.6193	599.930	23.6220	599.999	0.0004	0.010	–	–

Shaft and Housing Fits

Radial Ball and cylindrical roller bearings

These charts are guidelines for specifying shaft and housing fits related to particular operating conditions.

Shaft

Ball Bearings (For all nominal diameters)			Operating Conditions	Examples	Cylindrical Roller Bearings (Except 5200 Series)						
Loads		Shaft			Loads		Shaft		Shaft	Shaft	
Lower Load Limit	Upper Load Limit	Tolerance Symbol			Lower Load Limit	Upper Load Limit	Diameter mm		Tolerance Symbol[1]	Diameter inch	
INNER RING STATIONARY											
0	C_e [7]	**g6**	Inner ring to be easily dislaced on shaft	Wheels Non-rotating shafts	0	C[6]	All	g6	All		
0	C_e	**h6**	Inner ring does not need to be easily displaced	Tension pulleys	0	C	All	h6	All		
INNER RING ROTATING, OR INDETERMINATE							Over	Incl.		Over	Incl.
0	$0.07C_e$	**j6**[2]	Light loads	Electrical apparatus Machine tools Pumps Ventilators Industrial trucks	0	0.08C	100 140 320 500	140 320 500 –	k6[4] m6[5] n6 p6	3.94 5.51 12.60 19.68	5.51 12.60 19.68 –
$0.07C_e$	$0.15C_e$	**k5**	Normal loads	Electrical motors Turbines Pumps Combustion engines Gear transmissions etc.	0.08C	0.18C	100 140 320 500	140 320 500 –	m6 n6 p6 r6	3.94 5.51 12.60 19.68	5.51 12.60 19.68 –
$0.15C_e$	C_e	**m5**	Heavy loads Shock loads	Rail vehicles Traction motors	0.18C	C	100 140 320 500	140 320 500 –	n6[3] p6[3] r6[3] r7[3]	3.94 5.51 12.60 19.68	5.51 12.60 19.68 –
THRUST LOADS											
0	C_e	**j6**[3]	Pure thrust loads	All	Not recommended, consult Torrington district office.						

[1] For solid shaft. See pages E28 to E31 for numerical values.
[2] Use j5 for accurate applications.
[3] Bearings with greater than nominal clearance must be used.
[4] Use k5 for accurate applications.
[5] Use m5 for accurate applications.
[6] C = Dynamic Load Rating.
[7] C_e = Extended Dynamic Load Rating (Ball Bearings).

HOUSING

Operating Conditions		Examples	Housing Tolerence 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
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 loads	One-piece housing	General applications Heavy rail vehicles	H6	Easily
	Radially split housing	Transmission drives	H7	Easily
Heat supplied through shaft		Drier cylinders	G7	Easily

* Below this line, housing can either be one – piece or split; above this line, a split housing is not recommended.

[1] Cast iron steel housing. See pages E32 to E35 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.

Shaft and Housing Fits

Radial spherical roller bearings
These charts are guidelines for specifying shaft and housing fits related to particular operating conditions.

SHAFT

	Conditions	Examples	Shaft Diameter mm	Tolerance Symbol[1]	Remarks
BEARINGS WITH STRAIGHT BORE					
Stationary inner ring load	The inner ring to be easily displaced on the shaft	Two-bearing shaft mechanism	All diameters	**s4**	See table below for shaft size.
	The inner ring not to be easily displaced on the shaft	Wheel on non-rotating shaft		**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 18 / Incl. 100	**k6**	In very accurate applications k5 and m5 are used instead of k6 and m6 respectively.
			Over 100 / Incl. 200	**m6**	
	Normal and heavy loads P > 0.07C ≤ 0.25C	Applications in general, electrical motors, turbines, pumps, combustion engines, gear transmissions, woodworking machines	18 – 65	**m5**	
			65 – 100	**m6**	
			100 – 140	**n6**	
			140 – 280	**p6**	
			280 – 500	**r6**	
			500 and up	**r7**	
	Very heavy loads and shock loads P > 0.25C	Journal boxes for locomotives and other heavy rail vehicles, traction motors	18 – 65	**m6**	Bearings with greater clearance than normal must be used.
			65 – 100	**n6**	
			100 – 140	**p6**	
			140 – 200	**r6**	
			200 – 500	**r7**	
BEARINGS WITH TAPERED BORE ANDADAPTER SLEEVE					
	All loads	Applications in general	All diameters		See tables for Reduction of RIC on page E20

[1]For solid steel shaft. See tables on pages E28 to E31 for numerical value.

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 on page E34), and the inner ring loose on the shaft using an s4 fit as listed in the table. The standard W33 bearing with oil groove and oil holes can be used.

Data shown in ten-thousandths of an inch (6=.0006") or thousandths of a millimeter (15=0.015 mm.). See dimensional tables for nominal bore.

s4 FITS

Bore mm Over	Bore mm Incl.	Variance fromNominal Bore Tolerence +0	Shaft Diameter max.	Shaft Diameter min.	Fit
		in. / mm	in. / mm	in. / mm	in. / mm
50	80	-6 / -15	-10 / -25	-14 / -36	4L / 14L / 10L / 36L
80	120	-8 / -20	-13 / -33	-17 / -43	5L / 17L / 13L / 43L
120	180	-10 / -25	-16 / -41	-21 / -53	6L / 21L / 15L / 53L
180	250	-12 / -30	-19 / -48	-25 / -64	7L / 25L / 18L / 64L

Shaft and Housing Fits

RADIAL SPHERICAL ROLLER BEARINGS

This chart is a guideline for specifying housing fits for particular operating conditions.

Housing

Conditions			Examples	Tolerance Symbol[2]	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 outer ring not required	Electrical motors, pumps, crankshaft main bearings	**K7**	The outer ring is, as a rule not displaceable axially.
Split or one piece bearing housing		Normal and light loads, axial displacement of the outer ring desirable	Electrical motors, pumps, crankshaft main bearings	**J7**	The outer ring is, as a rule displaceable axially.
	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 125mm / O.D. 125 to 250 mm / O.D. over 250mm	**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.

[2] Cast iron or steel housing. For numerical values see tables on pages E32 to E35. For housings of light metal, tolerances generally are selected which give a slightly tighter fit than those given in the table.

Shaft and Housing Fits

RADIAL TAPERED ROLLER BEARINGS

Tolerences, shaft diameters and housing bores are shown as variances from the nominal bearing dimension. All data except nominal dimensions are in ten-thousanths of an inch (5=0.0005) and thousandths of a millimeter or micrometers (5=0.005mm).

Shaft and housing data shown in inches over millimeters.

Shaft

Bearing Bore			t_1			t_2			t_3			t_4			t_5			
Nominal (min.)		Tol.	Shaft Diam.			Shaft Diam.			Shaft Diam.			Shaft Diam.			Shaft Diam.			
Over	Incl.	–0	max.	min.	Fit	max.	min.	Fit	max.	min.	Fit	max.	min.	Fit	max.	min.	Fit	
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. mm	
7.5000	12.0000	+10	+25	+15	5T 25T			—	+10	0	10L 10T	0	-10	0L 20L	-2	-12	2L 22L	For Class 2 or Class 4 bearings
190.500	304.800	+25	+64	+38	13T 64T				+25	0	25L 25T	0	-25	0L 51L	-5	-30	5L 56L	
12.0000	24.0000	+20	+50	+30	10T 50T			—	+20	0	20L 20T	0	-20	0L 40L		—		
304.800	609.600	+51	+127	+76	25T 127T				+51	0	51L 51T	0	-51	0L 102L				
24.0000	36.0000	+30	+75	+45	15T 75T	+150	+120	90T 150T	+30	0	30L 30T	0	-30	0L 60L		—		For Class 4 bearings only
609.600	914.400	+76	+191	+114	38T 191T	+381	+305	229T 381T	+76	0	76L 76T	0	-76	0L 152L				

HOUSING

Bearing O.D.			T_1			T_2			T_3			T_4			T_5			
Nominal (min.)		Tol.	Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit	Housing Bore		Fit	
Over	Incl.	–0	max.	min.		max.	min.		max.	min.		max.	min.		max.	min.		
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. mm	
10.5000	12.0000	+10	+20	+30	10L 30L	+10	+20	0L 20L	0	+20	10T 20L	-20	-10	10T 30T	-30	-20	20T 40T	For Class 2 or Class 4 bearings
266.700	304.800	+25	+51	+76	25L 76L	+25	+51	0L 51L	0	+51	25T 51L	-51	-25	25T 76T	-76	-51	51T 102T	
12.0000	24.0000	+20	+40	+60	20L 60L	+20	+40	0L 40L	+10	+30	10T 30L	-30	-10	10T 50T	-40	-20	20T 60T	
304.800	609.600	+51	+102	+152	51L 152L	+51	+102	0L 102L	+25	+76	25T 76L	-76	-25	25T 127T	-102	-51	51T 152T	
24.0000	36.0000	+30	+60	+90	30L 90L	+30	+60	0L 60L	+20	+50	10T 50L	-40	-10	10T 70T		—		For Class 4 bearings only
609.600	914.400	+76	+152	+229	76L 229L	+76	+152	0L 152L	+51	+127	25T 127L	-102	-25	25T 178T				

Shaft and Housing Fits

RADIAL TAPERED ROLLER BEARINGS

These charts are guidelines for specifying shaft and housing fits for ABMA class 2 and 4 bearings used under particular operating conditions.

SHAFT

Shaft and housing diameter are shown in inches over millimeters with millimeters printed in green.

Mounting Conditions	Service	Shaft Finish	Shaft Diameter Over	Shaft Diameter Incl.	Shaft Tolerance Symbol
Rotating Cone	Steady load moderate shock	Ground	7.5 190.5	36.0 914.0	t_1
Rotating or Stationary Cone	Heavy loads, high speeds or shock	Ground or Turned	7.5 190.5	24.0 610.0	*
		Ground	24.0 610.0	36.0 914.0	t_2
Stationary Cone	Moderate loads, no shock	Turned	7.5 190.5	36.0 914.0	t_3
		Ground	7.5 190.5	36.0 914.0	t_4
	Sheaves, wheels, etc.	Turned			
	Wheel spindles	Hardened	7.5 190.5	12.0 305.0	t_5

*Use "Turned Shaft Fitting Practice, " an average cone interference fit of 0.0005 inches (0.013mm) per inch (25.4mm) of bore diameter.

Housing

Mounting Conditions	Service	Housing Diameter Over	Housing Diameter Incl.	Housing Tolerance Symbol
Stationary Cup	Clamped or floating (TD0) styles	10.5 266.7	36.0 914.0	T_1
	Alternate clamp only (TD0, TD0C, TD0D)	10.5 266.7	36.0 914.0	T_2
	Adjustable	10.5 266.7	36.0 914.0	T_3
Rotating Cup	Sheaves unclamped (TD0C)	10.5 266.7	24.0 160.0	T_5

Shaft and Housing Fits

THRUST BALL BEARINGS

Shaft and housing diameters shown as variance from nominal dimensions. Shaft and housing data shown in inches over millimeters.

TYPE TVB SHAFT

Bearing Bore nominal (min.)		Shaft Diameter	
Over	Incl.	Max.	Min.
in. mm	in. mm	in. mm	in. mm
0.0000 0.000	6.7500 171.450	+0 +0	-0.0012 -0.030
6.7500 171.450	20.0000 508.000	+0 +0	-0.0015 -0.038

HOUSING

Bearing O.D. nominal (max.)		Housing Bore	
Over	Incl.	Max.	Min.
in. mm	in. mm	in. mm	in. mm
4.7188 119.858	17.3750 441.325	+0.0090 +0.229	+0.0050 +0.127
17.3750 441.325	39.3701 1000.000	+0.0100 +0.254	+0.0060 +0.152

TYPE TVL AND DTVL SHAFT

Bearing Bore nominal (max.)		Shaft Diameter			
		Interference Fit*		Loose Fit**	
Over	Incl.	Max.	Min.	Max.	Min.
in. mm	in. mm	in. mm	in. mm	in. mm	in. mm
0.0000 0.000	19.8750 504.825	+0.0030 +0.076	+0 +0	-0.0060 -0.152	-0.0030 -0.076
19.8750 504.825	60.0000 1524.000	+0.0050 +0.127	+0 +0	-0.0100 -0.254	-0.0050 -0.127

* Dowel pin suggested. ** Dowel pin required.

HOUSING

Bearing O.D. nominal (max.)		Shaft Diameter			
		Loose Fit**		Interference Fit*	
Over	Incl.	Max.	Min.	Max.	Min.
in. mm	in. mm	in. mm	in. mm	in. mm	in. mm
0.0000 0.000	23.0000 584.000	+0.0060 +0.152	0.0030 0.076	-0.0060 -0.152	-0.0030 -0.076
23.0000 584.000	70.0000 1778.000	+0.0100 +0.254	0.0050 0.127	-0.0100 -0.254	-0.0050 -0.127

* Dowel pin suggested. ** Dowel pin required.

THRUST CYLINDRICAL ROLLER BERARINGS

TYPE TP AND TPS SHAFT

Bearing Bore nominal (max.)		Shaft Diameter	
Over	Incl.	Max.	Min.
in. mm	in. mm	in. mm	in. mm
1.8750 47.625	2.1250 53.975	-0.0010 -0.025	-0.0020 -0.051
2.1250 53.975	2.5000 63.500	-0.0011 -0.028	-0.0021 -0.053
2.5000 63.500	3.0000 76.200	-0.0012 -0.030	-0.0022 -0.056
3.0000 76.200	3.5000 88.900	-0.0012 -0.033	-0.0023 -0.058
3.5000 88.900	7.0000 177.800	-0.0015 -0.038	-0.0025 -0.064
7.0000 177.800	9.0000 228.600	-0.0015 -0.038	-0.0030 -0.076
9.0000 228.600	12.0000 304.800	-0.0018 -0.046	-0.0330 -0.084
12.0000 304.800	15.0000 381.000	-0.0020 -0.051	-0.0035 -0.089
15.0000 381.000	19.0000 482.600	-0.0020 -0.051	-0.0040 -0.102
19.0000 482.600	23.0000 584.200	-0.0025 -0.064	-0.0045 -0.114
23.0000 584.200	30.0000 762.000	-0.0030 -0.076	-0.0055 -0.140

TYPE TP HOUSING

Bearing O.D. nominal (min.)		Housing Bore	
Over	Incl.	Max.	Min.
in. mm	in. mm	in. mm	in. mm
4.5312 115.092	10.0000 254.000	+0.0030 +0.076	+0.0015 +0.038
10.0000 254.000	18.0000 457.200	+0.0040 +0.102	+0.002 +0.051
18.0000 457.200	22.0000 558.800	+0.0050 +0.127	+0.0025 +0.064
22.0000 558.800	26.0000 660.400	+0.0055 +0.140	+0.0025 +0.064
26.0000 660.400	28.0000 711.200	+0.0060 +0.152	+0.0030 +0.076
28.0000 711.200	34.0000 863.600	+0.0070 +0.178	+0.0030 +0.076
34.0000 863.600	38.0000 965.200	+0.0080 +0.203	+0.0035 +0.089
38.0000 965.200	44.0000 1117.600	+0.0090 +0.229	+0.0040 +0.102

Note: Housing fits for Type TPS are on the following page.

Shaft and Housing Fits

THRUST cylindrical Roller Bearings

Tolerances for housing bore and for shaft diameters shown as variance from nominal bearing dimension.

Data shown in inches over millimeters.

TYPE TPS
HOUSING Deviations in 0.0001 inches/0.001 micrometers

Bearing O.D. nominal (min.)		Housing Diameter Deviation from D	
Over	Incl.	High	Low
in. mm	in. mm	in. mm	in. mm
2.0000 50.800	2.3750 60.325	+15 +38	+5 +13
2.3750 60.325	3.2500 82.550	+17 +43	+7 +18
3.2500 82.550	3.6875 93.663	+19 +48	+9 +23
3.6875 93.663	4.0000 101.600	+21 +53	+11 +28
4.0000 101.600	4.5312 115.092	+28 +71	+13 +33
4.5312 115.092	10.0000 254.000	+30 +76	+15 +38
10.0000 254.000	18.0000 457.200	+40 +102	+20 +51
18.0000 457.200	22.0000 558.800	+50 +127	+25 +64
22.0000 558.800	26.0000 660.400	+55 +140	+25 +64
26.0000 660.400	28.0000 711.200	+60 +152	+30 +76
28.0000 711.200	34.0000 863.600	+70 +178	+30 +76
34.0000 863.600	38.0000 965.200	+80 +203	+35 +89
38.0000 965.200	44.0000 1117.600	+90 +229	+40 +102

THRUST TAPERED ROLLER BEARINGS

TYPE TTHD SHAFT

Bearing Bore nominal (min.)			Shaft Diameter	
		Spring Loaded Max.+0	Rolling Mill Screwdown & Piercing Mill Thrust Blocks	
Over	Incl.	Min.	Max.	Min.
in. mm	in. mm	in. mm	in. mm	in. mm
0.0000 0.000	6.8750 174.625	-0.0010 -0.025	+0.0030 +0.076	+0.0020 +0.051
6.8750 174.625	7.9999 203.197	-0.0010 -0.025	+0.0040 +0.102	+0.0030 +0.076
7.9999 203.197	12.0000 304.800	-0.0015 -0.038	+0.0050 +0.127	+0.0040 +0.102
12.0000 304.800	24.0000 609.600	-0.0020 -0.051	+0.0070 +0.178	+0.0050 +0.127
24.0000 609.600	36.0000 914.400	-0.0025 -0.064	+0.0095 +0.241	+0.0070 +0.178
36.0000 914.400	48.0000 1219.200	-0.0030 -0.076	+0.0120 +0.304	+0.0090 +0.229

TYPE TTHD HOUSING

Bearing O.D. nominal (min.)		Housing Bore	
Over	Incl.	max.	min.
in. mm	in. mm	in. mm	in. mm
6.3750 161.925	10.5000 266.700	+0.0025 +0.064	+0.0010 +0.025
10.5000 266.700	13.0000 330.200	+0.0030 +0.076	+0.0010 +0.025
13.0000 330.200	20.0000 508.000	+0.0040 +0.102	+0.0020 +0.051
20.0000 508.000	25.0000 635.000	+0.0045 +0.114	+0.0020 +0.051
25.0000 635.000	30.0000 762.000	+0.0060 +0.152	+0.0030 +0.076
30.0000 762.000	35.0000 889.000	+0.0070 +0.178	+0.0030 +0.076

Shaft and Housing Fits

THRUST TAPERED ROLLER BEARINGS

Tolerences for housing bore and shaft diameters shown as variance from nominal bearing dimension.

Data shown in inches over millimeters.

TYPES TTVS AND TTVF
SHAFT

Bearing Bore nominal (min.) Over	Incl.	Shaft Diameter Max. +O Min.
in. mm	in. mm	in. mm
0.0000 0.000	12.0000 304.800	-0.0020 -0.051
12.0000 304.800	20.0000 508.000	-0.0020 -0.051
20.0000 508.000	28.0000 711.200	-0.0030 -0.076
28.0000 711.200	48.0000 1219.200	-0.0040 -0.102
48.0000 1219.200	68.0000 1727.200	-0.0050 -0.127

When one washer is piloted by the housing, sufficient clearances must be allowed at the outside diameter of the other washer as well as at the bore of both washers to prevent cross-threading of the rollers. For most applications, this clearance is approximately 1/16" (.0625",.1588mm).

HOUSING

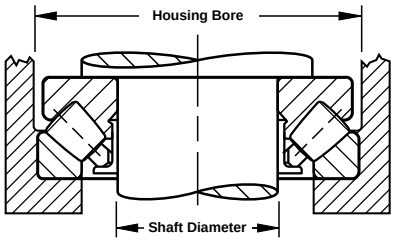
Bearing Bore nominal (min.) Over	Incl.	Housing Bore max.	min.
in. mm	in. mm	in. mm	in. mm
6.3750 161.925	10.4375 265.113	+0.0025 +0.060	+0.0010 +0.025
10.3475 265.113	12.5000 317.500	+0.0030 +0.076	+0.0010 +0.025
12.5000 317.500	19.0000 482.600	+0.0040 +0.102	+0.0020 +0.051
19.0000 482.600	23.7500 603.250	+0.0045 +0.113	+0.0020 +0.051
23.7500 603.250	28.0000 711.200	+0.0060 +0.152	+0.0030 +0.076
28.0000 711.200	33.0000 838.200	+0.0070 +0.178	+0.0030 +0.076

THRUST SPHERICAL ROLLER BEARING

Tolerances for housing bore and for shaft diameters shown as variance from nominal bearing dimension.

Data shown in inches over millimeters.

When application calls for thrust loads only, the housing must be relieved by 1/16" on diameter so that no radial load is carried on the bearing.



SHAFT

Tolerances are 1/10,000 of an inch (5 =.0005") and 1/1000 of a millimeter(μm)

Bearing Bore nominal (max.) inches Over	Incl.	Shaft Diameter Stationary Load max.	min.	Rotating Load max.	min.
in. mm	in. mm	in. mm	in. mm	in. mm	in. mm
3.1496 80	4.7244 120	+5 +13	-4 -10	+10 +25	+1 +3
4.7244 120	7.0866 180	+6 +15	-4 -10	+11 +28	+1 +3
7.0866 180	7.8740 200	+7 +18	-5 -13	+14 +36	+2 +5
7.8740 200	9.4488 240	+7 +18	-5 -13	+18 +46	+6 +15
9.4488 240	12.4016 315	+7 +18	-6 -15	+20 +51	+8 +20
12.4016 315	15.7480 400	+7 +18	-7 -18	+22 +56	+8 +20
15.7480 400	19.6850 500	+9 +23	-7 -18	+34 +86	+18 +46
19.6850 500	24.8031 630	+9 +23	-8 -20	+34 +86	+17 +43

HOUSING

Tolerances are 1/10,000 of an inch (5 =.0005") and 1/1000 of a millimeter(μm)

Bearing O.D. nominal (max.) inches Over	Incl.	Housing Bore Springs in Housing Light Radial Load min.	max.	Combined Axial &Radial Load Stationary Outer Ring min.	max.	Rotating Outer Ring min.	max.
in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm	in. mm
7.0866 180	9.8425 250	+6 +15	+24 +61	-7 -18	+11 +28	-13 -33	+5 +13
9.8425 250	12.4016 315	+7 +18	+27 +69	-7 -18	+13 +33	-14 -36	+6 +15
12.4016 315	15.7480 400	+7 +18	+29 +74	-7 -18	+15 +38	-16 -41	+6 +15
15.7480 400	19.6850 500	+8 +20	+33 +84	-9 -23	+16 +41	-18 -46	+7 +18
19.6850 500	24.8031 630	+9 +23	+36 +91	-9 -23	+18 +46	-19 -48	+8 +20
24.8031 630	31.4960 800	+9 +23	+40 +102	-9 -23	+20 +51	-20 -51	+9 +23
31.4960 800	39.3700 1000	+10 +25	+43 +109	-10 -25	+23 +58	-23 -58	+10 +25
39.3700 1000	49.2126 1250	+11 +28	+48 +122	-11 -28	+26 +66	-25 -64	+12 +30

Shaft and Housing Shoulders

Shaft and housing shoulder diameters for radial roller and thrust ball and thrust ball and roller bearings are also found in the respective dimension tables. Shaft and Housing shoulders for ball bearings are shown below.

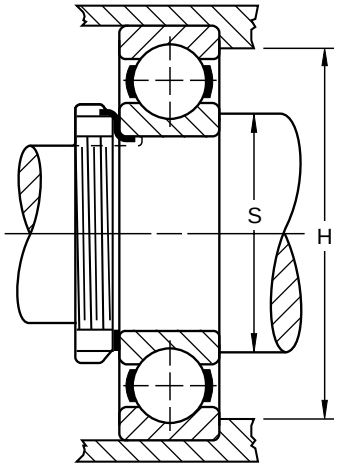
RADIAL BALL BEARINGS

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 , and small enough to permit bearing removal with proper pullers.

These tables give the recommended maximum and minimum shaft and housing shoulder diameters for the majority of applications. Where design limitations do not permit conformance to these recommended diameters, the Engineering department should be consulted.

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

Shaft and housing diameters for radial ball bearings are shown below and on the following two pages. For radial cylindrical, spherical and tapered roller bearings refer to the respective dimension tables. Housing shoulders for wide inner ring bearings are shown on page E53.



EXTRA LIGHT 9300 Series

Basic Bearing Number	shaft shoulder ±.010", ± 25 mm		housing shoulder ±.010", ± 25 mm	
	in.	mm	in.	mm
9301K	0.58	14.7	0.85	21.6
9302K	0.70	17.8	1.00	25.4
9303K	0.78	19.8	1.08	27.4
9304K	0.94	23.9	1.32	33.5
9305K	1.14	29.0	1.52	38.6
9306K	1.32	33.5	1.71	43.4
9307K	1.56	39.6	2.00	50.8
9308K	1.77	45.0	2.26	57.4
9309K	1.98	50.3	2.49	63.2
9310K	2.16	54.9	2.66	67.6
9311K	2.40	61.0	2.94	74.7
9312K	2.59	65.8	3.14	79.8

EXTRA-SMALL SERIES

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

Shaft and Housing Shoulders

RADIAL BALL BEARINGS

Extra-Light • 9100 Series

Basic Bearing Number	Shoulder Diameters shaft, S max. in.	mm.	min. in.	mm.	housing, H max. in.	mm.	min. in.	mm.
9100	0.52	13.2	0.47	11.9	0.95	24.1	0.91	23.1
9101	0.71	18.0	0.55	14.0	1.02	25.9	0.97	24.6
9102	0.75	19.0	0.67	17.0	1.18	30.0	1.13	28.7
9103	0.81	20.6	0.75	19.0	1.30	33.0	1.25	31.8
9104	0.98	24.9	0.89	22.6	1.46	37.1	1.41	35.8
9105	1.18	30.0	1.08	27.4	1.65	41.9	1.60	40.6
9106	1.38	35.1	1.34	34.0	1.93	49.0	1.88	47.8
9107	1.63	41.4	1.53	38.9	2.21	56.1	2.15	54.6
9108	1.81	46.0	1.73	43.9	2.44	62.0	2.39	60.7
9109	2.03	51.6	1.94	49.3	2.72	69.1	2.67	67.8
9110	2.22	56.4	2.13	54.1	2.91	73.9	2.86	72.6
9111	2.48	63.0	2.33	59.2	3.27	83.1	3.22	81.8
9112	2.67	67.8	2.53	64.3	3.47	88.1	3.42	86.9
9113	2.84	72.1	2.72	69.1	3.66	93.0	3.61	81.7
9114	3.11	79.0	2.91	73.9	4.06	103.1	3.97	100.8
9115	3.31	84.1	3.11	79.0	4.25	108.0	4.16	105.7
9116	3.56	90.4	3.31	84.1	4.65	118.1	4.50	114.3
9117	3.75	95.2	3.50	88.9	4.84	122.9	4.71	119.6
9118	4.03	102.4	3.84	97.5	5.16	131.1	5.13	130.3
9120	4.38	111.3	4.23	107.4	5.55	141.0	5.44	138.2
9121	4.66	118.4	4.53	115.1	5.91	150.1	5.75	146.0
9122	4.91	124.7	4.72	119.9	6.30	160.0	6.18	157.0
9124	5.28	134.1	5.12	130.0	6.69	169.9	6.50	165.1
9126	5.81	147.6	5.51	140.0	7.48	190.0	7.25	184.1
9128	6.06	153.9	5.81	147.6	7.88	200.2	7.68	195.1
9130	6.59	167.4	6.38	162.1	8.39	213.1	8.13	206.5
9132	6.96	176.8	6.56	166.6	9.00	228.6	8.75	222.2
9134	7.56	192.0	7.17	182.1	9.76	247.9	9.44	239.8
9138	8.38	212.9	7.95	201.9	10.95	278.1	10.50	266.7
9140	8.84	224.5	8.35	212.1	11.73	297.9	11.22	285.0
9144	9.70	246.4	9.21	233.9	12.84	326.1	12.24	310.9
9148	10.50	266.7	10.00	254.0	13.62	345.9	13.02	330.7
9152	11.49	291.8	10.95	278.1	15.04	382.0	14.44	366.8
9156	12.33	313.2	11.73	297.9	15.83	402.1	15.23	386.8
9160	13.36	339.3	12.52	318.0	17.40	442.0	16.60	421.6
9164	14.19	360.4	13.31	338.1	18.19	462.0	17.39	441.7
9180	18.00	457.2	17.00	431.8	22.12	561.8	21.62	549.1

Light • 200, 5200, 7200WN Series

Basic Bearing Number	Shoulder Diameters shaft, S max. in.	mm.	min. in.	mm	housing, H max. in.	mm.	min. in.	mm.
200	0.56	14.2	0.50	12.7	0.98	24.9	0.97	24.6
201	0.64	16.3	0.58	14.7	1.06	26.9	1.05	26.7
202	0.75	19.0	0.69	17.5	1.18	30.0	1.15	29.2
203	0.84	21.3	0.77	19.6	1.34	34.0	1.31	33.3
204	1.00	25.4	0.94	23.9	1.61	40.9	1.58	40.1
205	1.22	31.0	1.14	29.0	1.81	46.0	1.78	45.2
206	1.47	37.3	1.34	34.0	2.21	56.1	2.16	54.9
207	1.72	43.7	1.53	38.9	2.56	65.0	2.47	62.7
208	1.94	49.3	1.73	43.9	2.87	72.9	2.78	70.6
209	2.13	54.1	1.94	49.3	3.07	78.0	2.97	75.4
210	2.34	59.4	2.13	54.1	3.27	83.1	3.17	80.5
211	2.54	64.5	2.41	61.2	3.68	93.5	3.56	90.4
212	2.81	71.4	2.67	67.8	3.98	101.1	3.87	98.3
213	3.03	77.0	2.86	72.6	4.37	111.0	4.19	106.4
214	3.22	81.8	3.06	77.7	4.57	116.1	4.41	112.0
215	3.44	87.4	3.25	82.6	4.76	120.9	4.59	116.6
216	3.69	93.7	3.55	90.2	5.12	130.0	4.93	125.2
217	3.88	98.6	3.75	95.2	5.51	140.0	5.31	134.9
218	4.16	105.7	3.94	100.1	5.91	150.1	5.62	142.7
219	4.38	111.3	4.21	106.9	6.22	158.0	6.06	153.9
220	4.63	117.6	4.41	112.0	6.61	167.9	6.31	160.3
221	4.88	124.0	4.61	117.1	7.01	178.1	6.88	174.8
222	5.13	130.3	4.80	121.9	7.40	188.0	7.06	179.3
224	5.63	143.0	5.20	132.1	7.99	202.9	7.56	192.0
226	6.00	152.4	5.67	144.0	8.50	215.9	8.13	206.5
228	6.50	165.1	6.06	153.9	9.29	236.0	8.81	223.8
230	6.97	177.0	6.46	164.1	10.08	256.0	9.50	241.3
232	7.36	186.9	6.85	174.0	10.87	276.1	10.25	260.4
234	7.98	202.7	7.40	188.0	11.50	292.1	10.88	276.4
236	8.38	212.9	7.80	198.1	11.89	302.0	11.09	281.7
238	8.77	222.8	8.19	208.0	12.68	322.1	11.88	301.8
240	9.42	239.3	8.58	217.9	13.47	342.1	12.57	319.3
242	9.69	246.1	8.87	225.3	14.26	362.2	13.26	336.8
244	10.14	257.6	9.37	238.0	15.04	382.0	14.04	356.6
246	10.58	268.7	9.76	247.9	15.83	402.1	14.60	370.8
248	11.16	283.5	10.16	258.1	16.61	421.9	15.18	385.6
250	11.55	293.4	10.55	268.0	17.40	442.0	15.70	398.8

Medium • 300, 5300, 7300WN Series

Basic Bearing Number	Shoulder Diameters shaft, S max. in.	mm.	min. in.	mm	housing, H max. in.	mm.	min. in.	mm.
300	0.59	15.0	0.50	12.7	1.18	30.0	1.15	29.2
301	0.69	17.5	0.63	16.0	1.22	31.0	1.21	30.7
302	0.81	20.6	0.75	19.0	1.42	36.1	1.40	35.6
303	0.91	23.1	0.83	21.1	1.61	40.9	1.60	40.6
304	1.06	26.9	0.94	23.9	1.77	45.0	1.75	44.4
305	1.31	33.3	1.14	29.0	2.17	55.1	2.09	53.1
306	1.56	39.6	1.34	34.0	2.56	65.0	2.44	62.0
307	1.78	45.2	1.69	42.9	2.80	71.1	2.72	69.1
308	2.00	50.8	1.93	49.0	3.19	81.0	3.06	77.7
309	2.28	57.9	2.13	54.1	3.58	90.9	3.41	86.6
310	2.50	63.5	2.36	59.9	3.94	100.1	3.75	95.2
311	2.75	69.8	2.56	65.0	4.33	110.0	4.13	104.9
312	2.94	74.7	2.84	72.1	4.65	118.1	4.44	112.8
313	3.19	81.0	3.03	77.0	5.04	128.0	4.81	122.2
314	3.44	87.4	3.23	82.0	5.43	137.9	5.13	130.3
315	3.88	98.6	3.43	87.1	5.83	148.1	5.50	139.7
316	3.94	100.1	3.62	91.9	6.22	158.0	5.88	149.4
317	4.13	104.9	3.90	99.1	6.54	166.1	6.19	157.2
318	4.38	111.3	4.09	103.9	6.93	176.0	6.50	165.1
319	4.63	117.6	4.29	109.0	7.32	185.9	6.88	174.8
320	4.88	124.0	4.49	114.0	7.91	200.9	7.38	187.4
321	5.13	130.3	4.69	119.1	8.31	211.1	7.75	196.8
322	5.50	139.7	4.88	124.0	8.90	226.1	8.25	209.6
324	6.00	152.4	5.28	134.1	9.69	246.1	8.93	226.8
326	6.44	163.6	5.83	148.1	10.32	262.1	9.69	246.1
328	6.93	176.0	6.22	158.0	11.10	281.9	10.38	263.7
330	7.44	189.0	6.61	167.9	11.89	302.0	11.06	280.9
332	7.84	188.0	7.01	178.0	12.68	322.1	11.58	294.1
334	8.40	213.4	7.40	188.0	13.47	342.1	12.27	311.7
336	8.80	223.5	7.80	198.1	14.25	362.0	13.05	331.5
338	9.35	237.5	8.35	212.1	14.89	378.2	13.59	345.2
340	9.84	249.9	8.74	222.0	15.67	398.0	14.37	365.0
342	10.24	260.1	9.14	232.2	16.47	418.3	15.17	385.3
344	10.73	272.5	9.53	242.1	17.24	437.9	15.96	405.4
348	11.52	292.6	10.32	262.1	18.82	478.0	17.32	439.9
352	12.54	318.5	11.34	288.0	20.16	512.1	18.66	474.0
356	13.43	341.1	12.13	308.1	21.73	551.9	20.13	511.3

Shaft and Housing Shoulders

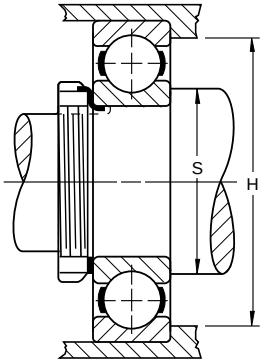
RADIAL BALL BEARINGS

Heavy • 400, 7400 Series

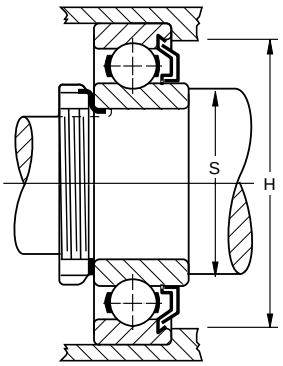
Basic Bearing Number	shaft, S max.	shaft, S min.	housing, H max.	housing, H min.
	in	in.	in	in.
	mm	mm	mm	mm
7405	1.47	1.34	2.80	2.63
	37.3	34.0	71.1	66.8
7406	1.72	1.54	3.19	3.00
	43.7	39.1	81.0	76.2
7407	1.93	1.73	3.58	3.38
	49.0	43.9	90.9	85.9
7408	2.19	1.97	3.94	3.69
	55.6	50.0	100.1	93.7
7409	2.44	2.17	4.33	4.00
	62.0	55.1	110.0	101.6
7410	2.69	2.44	4.65	4.38
	68.3	62.0	118.1	111.3

Heavy • 400, 7400 Series (Continued)

Basic Bearing Number	shaft, S max.	shaft, S min.	housing, H max.	housing, H min.
	in	in.	in	in.
	mm	mm	mm	mm
7411	2.93	2.64	5.04	4.75
	74.4	67.1	128.0	120.7
7412	3.19	2.84	5.43	5.13
	81.0	72.1	137.9	130.3
7413	3.50	3.03	5.83	5.50
	88.9	77.0	148.1	139.7
7414	3.69	3.31	6.54	6.13
	93.7	84.1	166.1	155.7
7415	3.93	3.50	6.93	6.44
	99.8	88.9	176.0	163.6
7416	4.13	3.70	7.32	6.81
	104.9	94.0	185.9	173.0
7418	4.69	4.25	8.15	7.75
	119.1	108.0	207.0	196.9
7420	5.17	4.72	9.21	8.79
	131.3	119.9	233.9	223.3



Non-Standard Extra-Large



Mechani-Seal KL, KLD, KLL Types

Housing shoulder diamters 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.

Non-Standard Extra-Large

Basic Bearing Number	Shoulder Diameters shaft, S max.		shaft, S min.		housing, H max.		housing, H min	
	in.	mm	in.	mm	in.	mm	in.	mm
120W2	4.63	117.6	4.40	111.8	5.91	150.1	5.75	146.0
122W	4.91	124.7	4.73	120.1	6.41	162.8	6.25	158.8
124W	5.28	134.1	5.12	130.0	7.01	178.1	6.87	174.5
126W	5.82	147.8	5.50	139.7	7.60	193.0	7.31	185.7
128W	6.19	157.2	5.91	150.1	8.18	207.8	7.96	202.2
130W	6.59	167.4	6.38	162.1	8.78	223.0	8.51	216.2
132W	7.44	189.0	6.85	174.0	9.24	234.7	8.81	223.8
134W	7.52	191.0	7.29	185.2	9.83	249.7	9.61	244.1
136W	8.00	203.2	7.69	195.3	10.42	264.7	10.15	257.8
138W	8.44	214.4	8.08	205.2	11.21	284.7	10.87	276.1
224W	5.63	143.0	5.20	132.1	8.00	203.2	7.56	192.0
226	6.00	152.4	5.67	144.0	8.50	215.9	8.13	206.5
228	6.50	165.1	6.06	153.9	9.29	236.0	8.81	223.8
276–2	15.82	401.8	15.75	400.1	18.25	463.6	18.17	461.5

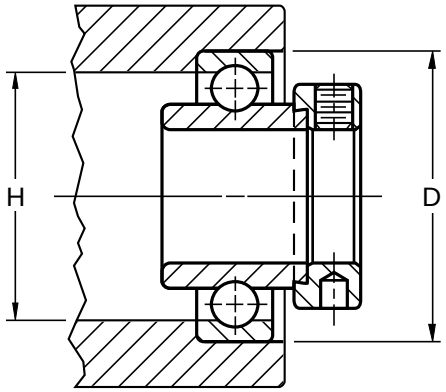
Mechani-Seal KL, KLD, KLLTypes

Basic Bearing Number	housing shoulder diameter,H max.		min.	
	in.	mm	in.	mm
36	0.67	17.0	0.66	16.8
36V	0.67	17.0	0.66	16.8
37	0.79	20.1	0.77	19.6
37V	0.79	20.1	0.77	19.6
34	0.79	20.1	0.77	19.6
38V	0.79	20.1	0.77	19.6
39	0.91	23.1	0.89	22.6
39V	0.91	23.1	0.89	22.6
200	1.09	27.7	1.03	26.2
201	1.16	29.5	1.09	27.7
201–2	1.16	29.5	1.09	27.7
201–3	1.16	29.5	1.09	27.7
202	1.28	32.5	1.22	31.0
202–2	1.28	32.5	1.22	31.0
202–3	1.28	32.5	1.22	31.0
202–4	1.28	32.5	1.22	31.0
203	1.44	36.6	1.41	35.8
204	1.72	43.7	1.62	41.1
204–2	1.72	43.7	1.62	41.1
205	1.91	48.5	1.84	46.7
205–2	1.91	48.5	1.84	46.7
206	2.28	57.9	2.22	56.4
207	2.66	67.6	2.53	64.3
208	2.97	75.4	2.81	71.4
209	3.16	80.3	3.03	77.0
209–2	3.16	80.3	3.03	77.0
211	3.69	93.7	3.56	90.4

Shaft and Housing Fits and Shoulders

WIDE INNER RING BALL BEARINGS

When shafts are selected for use with wide inner ring bearings, a minimum slip fit is very desirable for the most satisfactory mounting. Special shaft limits are required in certain cases, and a variety of standard fits can be used, even including a press fit. The recommended figures are noted below. In some applications it may be permissable to use increased shaft tolerances. In such cases, applications should be forwarded to our Engineering Department for complete recommendations.



Bearing bore tolerance: ½" - 2 3⁄16" = nominal to +.0005", +.013mm;
2 ¼" - 3 3⁄16" = nominal to +.0006", +.015mm;
3 7⁄16" - 3 15⁄16" = nominal to +.0007", +.018mm.
Recommended shaft tolerances: ½" - 1 15⁄16" = nominal to -.0005", -.013mm;
2" - 3 15⁄16" = nominal to -.0010", -.025mm.

HOUSING, SHOULDERS AND SHAFT DIAMETERS

Bearing Number					Shaft Size	Basic Outer Ring Size	Housing Stationary[1]			Shoulder Diameter H	
KRR Type	G-KRR Type	RA-RR Type	GRA-RR Type	GYA-RR* Type			Housing Bore, D min.	max	mean fit loose	max.	min.
					in.		in.	in.	in.	in.	in.
					mm		mm	mm	mm	mm	mm
1008KRR	–	RA008RR	GRA008RR	GYA0008RR	½						
–	–	RA009RR	GRA009RR	GYA009RR	9⁄16	203					
1010KRR(KR)	G1010KRR	RA010RR	GRA010RR	GYA010RR	5⁄8		1.5748	1.5754	0.0005	1.37	1.34
1011KRR	G1011KRR	–	–	–	11⁄16		40.000	40.015	0.013	34.8	34.0
E17KRR	GE17KRR	RAE17RR	GRAE17RR	GYAE17RR	17						
1012KRR(KR)	G1012KRR	RA012RR	GRA012RR	GYA012RR	¾	204	1.8504	1.8510	0.0005	1.61	1.60
E20KRR	GE20KRR	RAE20RR	GRAE20RR	GYAE20RR	20		47.000	47.015	0.013	40.9	40.6
1013KRR	–	RA013RR	GRA013RR	GYA013RR	13⁄16						
1014KRR	G1014KRR	RA014RR	GRA014RR	GYA014RR	⅞	205					
1015KRR(KR)	G1015KRR	RA015RR	GRA015RR	GYA015RR	15⁄16		2.0472	2.0479	0.0006	1.81	1.80
1100KRR(KR)	G1100KRR	RA100RR	GRA100RR	GYA100RR	1		51.999	52.017	0.015	46.0	45.7
E25KRR	GE25KRR	RAE25RR	GRAE25RR	GYAE25RR	25						
–	G1101KRR	RA101RR	GRA101RR	GYA101RR	1 1⁄16						
1102KRR(KR)	G1102KRR	RA102RR	GRA102RR	GYA102RR	1 1⁄8	206					
1103KRR(KR)	G1103KRR	RA103RR	GRA103RR	GYA103RR	1 3⁄16		2.4409	2.4416	0.0006	2.21	2.16
–	–	–	–	GYA103RR2	1¼		61.999	62.017	0.015	56.1	54.9
E30KRR	GE30KRR	RAE30RR	GRAE30RR	GYAE30RR	30						
1104KRR(KR)	G1104KRR	RA104RR	GRA104RR	GYA104RR	1¼						
1105KRR	–	RA105RR	GRA105RR	GYA105RR	1 5⁄16	207					
1106KRR	G1106KRR	RA106RR	GRA106RR	GYA106RR	1⅜		2.8346	2.8353	0.0006	2.21	2.16
1107KRR(KR)	G1107KRR	RA107RR	GRA107RR	GYA107RR	1 7⁄16		71.999	72.017	0.015	56.1	54.9
E35KRR	GE35KRR	RAE35RR	GRAE35RR	GYAE35RR	35						
1108KRR(KR)	G1108KRR	RA108RR	GRA108RR	GYA108RR	1½	208					
–	–	RA106RR	GRA109RR	GYA109RR	1 9⁄16		3.1496	3.1503	0.0006	2.87	2.78
–	–	–	GRAE40RR	GYAE40RR	40		80.000	80.018	0.015	72.9	70.6
1110KRR	G1110KRR	RA110RR	GRA110RR	GYA110RR	1⅝						
1111KRR(KR)	G1111KRR	RA111RR	GRA111RR	GYA111RR	1 11⁄16	209	3.3465	3.3474	0.0008	3.07	2.97
1112KRR(KR)	G1112KRR	RA112RR	GRA112RR	GYA112RR	1¾		85.001	85.024	0.020	78.0	75.4
E45KRR	–	–	GRAE45RR	GYAE45RR	45						
–	–	RA113RR	GRA113RR	GYA113RR	1 13⁄16						
1114KRR	–	RA114RR	GRA114RR	GYA114RR	1⅞	210					
1115KRR(KR)	G1115KRR	RA115RR	GRA115RR	GYA115RR	1 15⁄16		3.5433	3.5442	0.0008	3.27	3.19
–	–	–	GRA115RR2	–	2		90.000	90.023	0.020	83.1	81.0
E50KRR	GE50KRR	RAE50RR	GRAE50RR	GYAE50RR	50						
1200KRR(KR)	G1200KRR	RA200RR	GRA200RR	GYA200RR	2						
–	–	RA201RR	GRA201RR	GYA201RR	2 1⁄16	211					
1202KRR	–	RA202RR	GRA202RR	GYA202RR	2⅛		3.9370	3.9379	0.0008	3.58	3.56
1203KRR(KR)	G1203KRR	RA203RR	GRA203RR	GYA203RR	2 3⁄16		100.000	100.023	0.020	90.9	90.4
E55KRR	GE55KRR	RAE55RR	GRAE55RR	GYAE55RR	55						
1204KRR	–	–	–	–	2¼						
1207KRR(KR)	G1207KRR	–	–	–	2 7⁄16	212	4.3307	4.3316	0.0008	3.98	3.87
E60KRR	GE60KRR	–	–	–	60		110.000	110.023	0.020	101.1	98.3
1215KRR	–	–	–	–	2 15⁄16	215	5.1181	5.1191	0.0009	4.76	4.59
E75KRR	–	–	–	–	75		130.000	130.025	0.023	120.9	116.6

[1] When the housing revolves in relation to the shaft, housing bore dimensions shown on page E30 should be used. Outer ring tolerances and housing fillet radii correspond to equivalent 200 Series single row radial bearings.
*Available as non-relubricatable Type (omit Prefix "G").

Load Ratings And Life Calculations

BALL BEARINGS

Fatigue Life

Because of the dispersion in life of identical bearings operating under identical conditions, a statistical result will be obtained for bearing fatigue life. For most calculations life is expressed as the number of hours that 90% of a group of identical bearings will exceed under a given set of conditions, and is referred to as the L_{10} life. For life values of greater reliability than 90% refer to Table 4.

The basic equation for radial ball bearings is:

$$L_n = \frac{16667 \times a_1 \times a_2 \times a_3}{N} \left[\frac{f_B \times C_E}{P}\right]^3 \quad \text{Hours} \quad \textbf{1}$$

The basic life equation for radial roller bearings is:

$$L_n = \frac{16667 \times a_1 \times a_2 \times a_3}{N} \left[\frac{f_B \times C}{P}\right]^{10/3} \quad \text{Hours} \quad \textbf{2}$$

Notations Used in this Section:

- C = Basic Dynamic Load Rating – Radial Roller bearings – Pounds or Newtons
- C_N = Radial Load Rating of Bearings at Operating Speed "N" – Pounds or Newtons = ($N_f \times C_e$)
- C_E = Extended Basic Dynamic Load Rating – Radial Ball bearings Pounds or Newtons
- C_o = Basic Static Load Rating – Radial Bearings Pounds or Newtons
- C_{oa} = Basic Static Thrust Load Rating – Pounds or Newtons
- C_t = Basic Thrust Dynamic Load Rating – Pounds or Newtons
- K = Thrust Rating Calculation Factor
- K_T = Relative Thrust Load Factor – Ball Bearings
- L_f = Life factor
- L_r = Fatigue Life for Reliability Level "r" – Hours
- N = Operating Speed – R.P.M.
- N_f = Speed Factor
- R = Applied Radial Load on Bearing Pounds or Newtons
- P = Equivalent Radial Load on Bearing Pounds or Newtons
- T = Applied Thrust Load on Bearings Pounds or Newtons
- T_e = Equivalent Thrust Load – Thrust Ball or Roller Bearings – Pounds or Newtons
- X = Radial Load Factors
- Y, Y_1, Y_2, Y_3 = Thrust load Factors
- a_1 = Life adjustment Factor for reliability
- a_2 = Life adjustment Factor for Bearing Material
- a_3 = Life adjustment Factor for Application Conditions
- f_B = Dynamic Load rating Adjustment factor for Number of Adjacently Mounted Bearings
- i_B = Number of Adjacently Mounted Bearings
- $P_1 \ldots P_n$ = Proportion of time at Load/Speed Conditions 1 through n
- r = Percent reliability of Survival Life
- μ = Operating Viscosity – Centistokes
- μ_R = Reference Viscosity – Centistokes

Load Ratings – Radial Ball Bearings

The load ratings published in this catalog are based on ABMA Standard Section 9, but are increased to reflect improvements in materials and processing. These ratings are referred to as EXTENDED BASIC DYNAMIC LOAD RATINGS, C_E. Care must be taken that the EXTENDED BASIC DYNAMIC LOAD RATINGS only be used in equations containing C_E, and should not be used in any equations in prior published catalogs.

NOTE: C_E does not represent the maximum permissible radial load which in general is equal to C_o the Static Radial Load Ratings.

Life - Radial Ball Bearings

Equation **1** in the case of single row bearings and where a, a2, a3 can be considered equal to one, may be simplified for general purpose as follows:

$$L_{10} = \frac{16667}{N} \left[\frac{C_E}{P}\right]^3 \quad \text{Hours} \quad \textbf{3}$$

Equivalent Radial Load - Radial Ball Bearings

Calculate equivalent radial load (P) by using Table 1 and required Y factors from table 2.

Table 1

Bearing Description	Single Row Bearings and Tandem Mountings	Double Row Bearings and Preload Pair Mountings
Bearing Type and or Series	$K_T = \frac{T}{i_B C_o}$	$K_T = \frac{T}{C_o}$
RADIAL TYPE BALL BEARINGS USE LARGER OF RESULTING "P" VALUE		
M9300K,MM9300K M9100K,MM9100K M200K,MM200K M300K,MM300K	P = R or P = 0.56R + Y_1T	P = R + 1.20Y_1T or P = 0.78R + 1.625Y_1T
Small inch and Matric 9300,9100,200,300 and derivatives XLS' Large Inch W" and "GW Tri-Ply	P = R or P = 0.56R + Y_1T	
WIDE INNER RING BALL BEARINGS HOUSED UNITS	P = R or P = 0.56R + Y_1T	
ANGULAR CONTACT BALL BEARINGS USE LARGER OF RESULTING "P" VALUE		
7201K-7202W-7206W 7303W 5200K-5205K,5218W,5220W 5302K-5305K 5311W-5318W,5320W 5322W,5328W	P = R or P = 0.43R + T	P = R + 1.09T or P = 0.70R + 1.63T
5206K-5208K 5206W-5212W 5213-5217,5219,5222 5306W-5310W,5319,5324	P = R or P = 0.39R +0.76T	P = R + 0.78T or P = 0.63R + 1.24T
7207WN-7230WN 7304WN-7330WN 7412WN and 7415WN	P = R or P = 0.35R +0.57T	P = R + 0.55T or P = 0.57R + 0.93T
2M9300WI 2M9100WI,2MM9100WI 2M200WI, 2MM9100WI 2MM300WI	P = R or P = 0.44R +Y_2T	P = R + 1.124Y_2T or P = 0.72R + 1.625Y_2T
2MM9100W0	P = R or P = 0.44R +Y_3T	P = R + 1.124Y_2T or P = 0.72R + 1.625Y_2T
2MM93000	P = R or P = 0.43R +1.06T	P = R + 1.16T or P = 0.70R + 1.72T
3M9300WI 3M9100WI,3MM9100WI 3M200WI,3MM200WI 3MM300WI	P = R or P = 0.41R +0.87T	P = R + 0.92T or P = 0.67R + 1.41T

Table 2

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

Dynamic Load Rating Adjustment Factor f_B

Obtain the DYNAMIC LOAD RATING ADJUSTMENT FACTOR, f_B, from Table 3. This factor accounts for the number of active bearings (i_B) mounted adjacent to one another.

$$f_B = (i_B)^{0.7}$$

Table 3

i_B	1	2	3	4	5
f_B	1.00	1.62	2.16	2.64	3.09

Life Adjustment Factors a_1, a_2, a_3 – Radial Ball Bearings

a_1, Life Adjustment Factor for Reliability

The most commonly used reliability level for bearing life calculations is 90%. This is referred to as, L_{10}, or rating life, and is the life based upon 90% survival of a group of bearings at the specified load and speed. Should the application require a higher degree of reliability, the a_1, life adjustment factors can be selected from Table 4.

Table 4

Reliability % (r)	L_n	Life Adjustment Factor For Reliability – a_1
90	L_{10} (RATING LIFE)	1
95	L_5	0.62
96	L_4	0.53
97	L_3	0.44
98	L_2	0.33
99	L_1	0.21

a_2, Life Adjustment Factor for Bearing Material

In previous catalogs Fafnir used a Factor of 3 for material and processing for Fafnir Superior Steel. This factor has now been incorporated in the C_E value and accordingly, the a_2 factor for Fafnir superior steel now is 1. Factors for other materials, contact the Torrington Engineering Department.

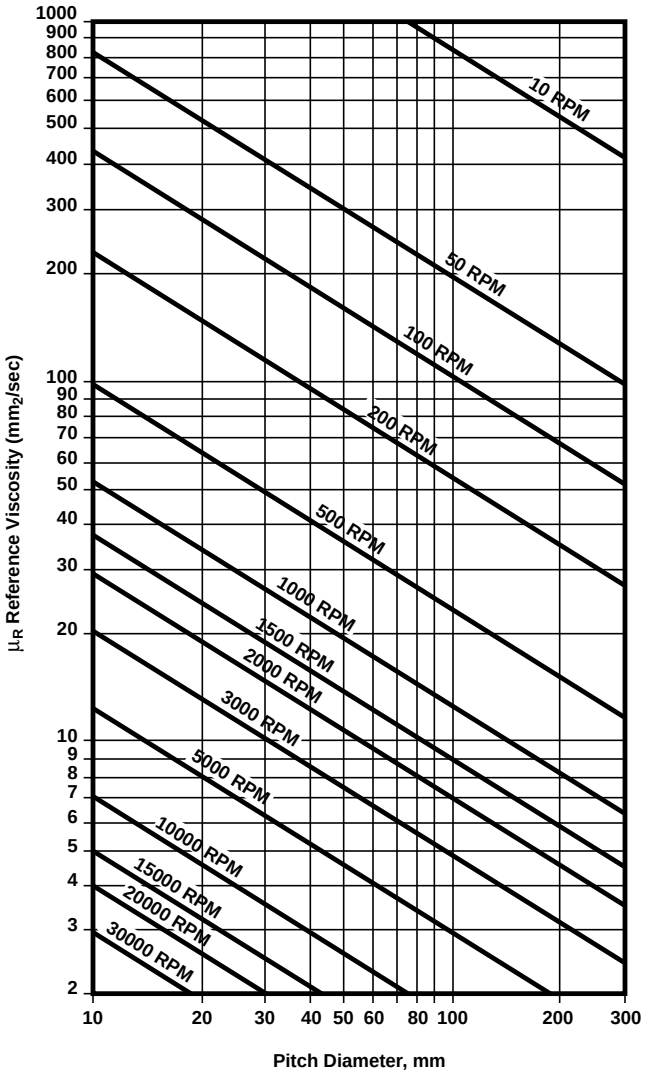
a_3. Life adjustment Factor for Application Conditions

Many bearing users will find that they are able to calculate bearing life with acceptable accuracy using an Application Factor, a_3, of 1. The a_3 factor can be made up of any number of application factors based upon the degree of detail the user wishes to employ in analysis. Such factors as lubrication, alignment, mounting stiffness and temperature can be considered. The factors are multiplied together to develop the final a3 factor.

The engineering department will assist in developing various application factors when requested by the user. The following may be used as guide to determine the a_3 factor based on lubrication considerations.

In order to obtain a_3, it is necessary to compare the actual lubricant operating viscosity, μ, centistokes (mm^2/sec.) to a Reference Viscosity, μ_R, which is based on requirements determined by the application speed and bearing pitch diameter.

Figure 1



Load Ratings and Life Calculations

LIFE ADJUSTMENT FACTORS - RADIAL BALL BEARINGS

a3 Adjustment Factor (*continued*)

Determine the Reference Viscosity from Figure 1 (page E51) by entering the bearing pitch diameter, which is equal to the outer diameter plus the bore divided by 2 and the bearing speed.

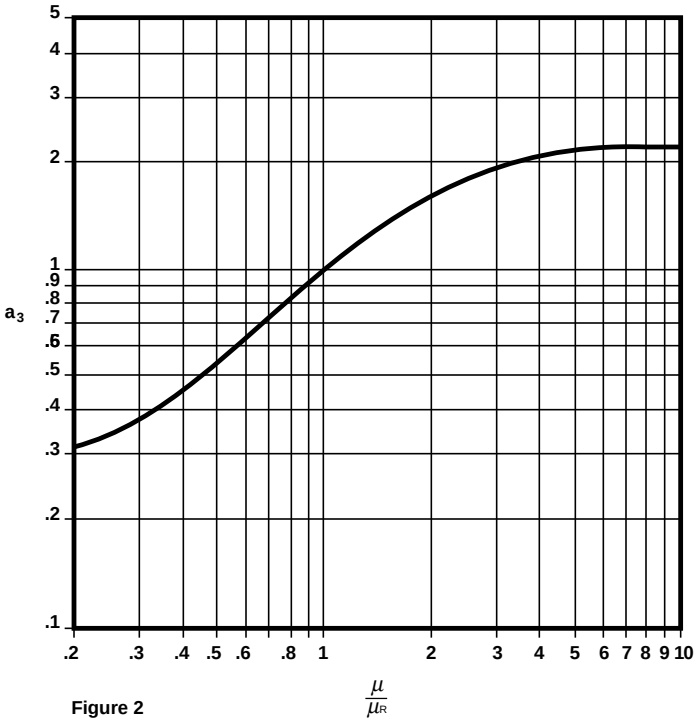


Figure 2

Obtain the value of, a_3, the Life Adjustment factor For Lubrication, from Fig. 2 by entering the value of, μ/μ_R. The value of, μ, the actual viscosity of the lubricant in the bearing must be obtained from the lubricant manufacturers viscosity index specification for the temperature of the oil in the bearing at operating conditions. Where the operating temperature of the oil is unknown considerable care is necessary to estimate this temperature, since it depends on loading, speed, lubricant flow and heat transfer characteristics of the shaft and housing.

The factor ,a_3, is a multiplier of the bearing life., L_n, reflecting lubricant effectiveness in an adequately filtered lubrication system. The values of, a_3, are a consequence of the direct contact between the bearing rolling elements and the bearing rings. Contaminants in the lubricant, exceeding lubricant film thickness, result in shorter lives than would be computed using the values of, a_3. The use of the a_3 factor is also based on the adequate supply of lubricant which will not deteriorate over the life of the bearing.

When bearings are grease lubricated determine the a_3 factor using the specifications for the oil used in the grease, however, the maximum value of a_3 should not exceed 1. One reason for this limitation is the question on grease maintenance over long periods which is out of control of the designer.

NOTE:
a_3 = .33 for wide inner ring bearings due to the type of mounting.

BEARING LIFE UNDER VARYING LOADS AND SPEEDS

In many applications, bearings are required to run at a number of different loads and speeds. If the different loads and speeds and the portions of time they are in effect are known, the life can be found from the following relation:

$$Ln = \frac{1}{\frac{p_1}{Ln_1} + \frac{p_2}{Ln_2} + \frac{p_3}{Ln_3} + \ldots + \frac{p_n}{Ln_n}}$$

Note: $p_1 + p_2 + p_3 + \ldots + p_n = 1.0$

Load Ratings and Life Calculations

LIFE - RADIAL ROLLER BEARINGS

The L_{10} (expected minimum life for 90% of the bearings of a given size and type in a given population) is calculated by the following formula which is condensed version of equation **2**.

$$L_{10} = \frac{16667}{N} \left[\frac{C}{P}\right]^{10/3} \text{ (Hours)} \qquad \textbf{4}$$

Equation **4** is applicable to all radial cylindrical, spherical, and tapered roller bearings in this catalog.

The calculation of bearing life can also be performed by using logarithmic factors for rotational speed (N_f) and life (L_f) based on the formula

$$L_{10} = 500\,(L_f)^{10/3} \text{ (Hours)} \qquad \textbf{5}$$

$$\text{where} \quad L_f = \left[\frac{CN_f}{P}\right] \qquad \textbf{6}$$

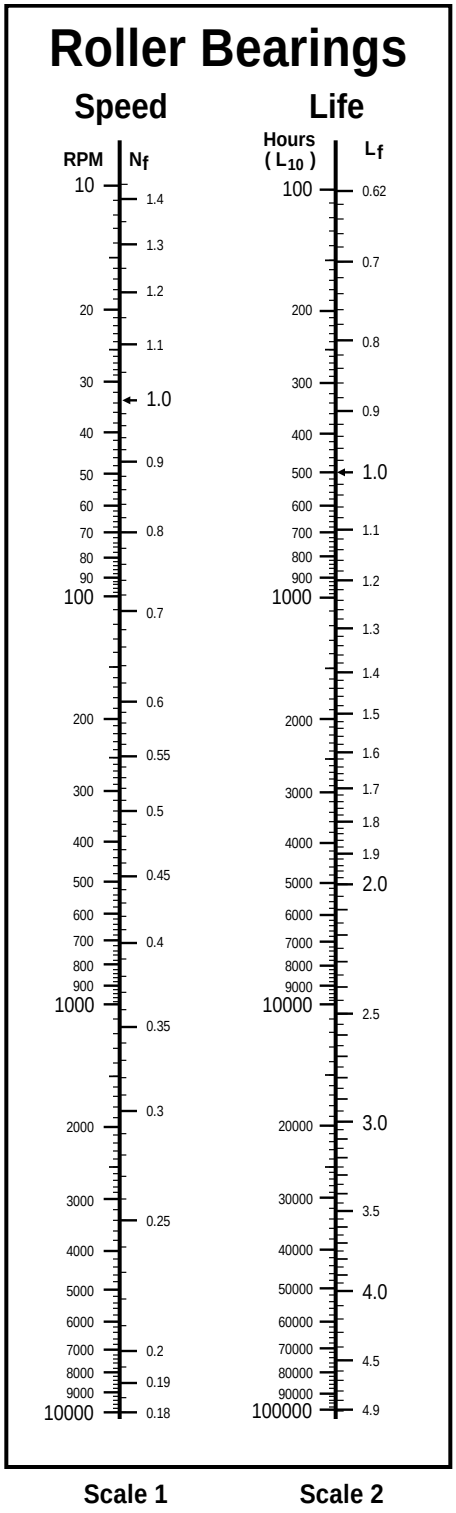
$$\text{where} \quad N_f = \left[\frac{1}{.03N}\right]^{3/10} \qquad \textbf{7}$$

These factors and L_{10} values can be read directly from the scales. N_f which is based on formula 7 is read directly from the Speed scale 1. Then calculate the life factor L_f from equation **6** which can be converted directly to hours on Life scale 2.

Referring back to equation **4** it may be advisable under certain operating conditions to include application factor a_3 and calculate life according to the formula.

$$L_{10} = \frac{16667}{N}\left[\frac{C}{P}\right]^{10/3} \quad \text{or} \quad L_{10} = 500\,a_3\,[L_f]^{10/3} \text{ (Hours)} \qquad \textbf{8}$$

a_3 is the life factor based on application conditions. Under optimum conditions $a_3 = 1$. Depending on lubrication, contamination, temperatures, impact loading and load reversals a_3 may be less than 1 and as low as .05. Consult Torrington engineering department for recommendations.



Load Ratings and Life Calculations

EQUIVALENT RADIAL LOAD – RADIAL CYLINDRICAL ROLLER BEARINGS

Cylindrical roller bearings are designed to carry radial load with the thrust load zero under normal conditions. Torrington engineering should be consulted on any applications where thrust load is involved. With the thrust load equal to zero, equivalent radial load, P, will be equal to the design radial load.

EQUIVALENT RADIAL LOAD – RADIAL SPHERICAL ROLLER BEARINGS

Equivalent Radial Load (P) based on a combination of applied radial load (R) and axial load (T) must then be calculated for that bearing.

$$P = XR + YT \qquad \textbf{9}$$

X = Radial Load Factor Y = Axial Load Factor

The X and Y factors for spherical roller bearings are found in the tables of dimensions.

STATIC EQUIVALENT RADIAL LOAD – RADIAL SPHERICAL ROLLER BEARINGS

For bearings subjected to static load conditions permanent deformation at the roller-race contact areas should be considered. As a general guideline static radial loads should not exceed 0.5 times static load rating (C_o). Under combined radial and thrust static loads an equivalent radial load is calculated by the following formula:

$$P_o = X_o R + Y_o T$$

Factors X_o and Y_o are found in the dimension tables.

P_o obtained by this formula should not exceed 0.5 times static load rating (C_o).

EQUIVALENT RADIAL LOAD – RADIAL TAPERED ROLLER BEARINGS

Thrust Factor (K)

Tapered roller bearings can accommodate radial loads, thrust loads or combined loads. In the data tables, a thrust factor (K) is shown for each bearing. This K value is used to compute the thrust load rating C_t of the bearing. The K value shown is the ratio of the single-row radial load rating (C) of the bearing to its thrust load rating.

$$K = \frac{\text{Radial Load Rating C,}}{\text{Thrust Load Rating } C_t} \quad \text{or} \quad C_t = \frac{C}{K} \qquad \textbf{10}$$

A TS (single row) bearing with a radial dynamic load rating (C) of 300,000 pounds and a K value of 0.74, would thus have a dynamic thrust load rating.

$$C_t = \frac{300{,}000}{0.74} \quad \text{or} \quad 405{,}000 \text{ pounds}$$

For two-row bearings, the radial load ratings shown are for the entire bearing, and must be divided by two to obtain the single-row capacity used in computing the thrust load rating. A TDI or TDO bearing, for instance, with a listed load rating of 348,000 pounds and a K factor of 0.74, would have a thrust load rating of $\frac{348{,}000}{(2)\ 0.74}$ or 235,000 pounds.

Some of the tapered roller bearings offered by Torrington are designed primarily for thrust loading (principally by increasing the angle of the roller axis in relation to the bearing axis.) These high thrust capacity bearings can be identified by K factors which are less than 1.0.

P, or Equivalent Radial Load, is one of the more crucial computations to be made in determining L_{10} life for tapered roller radial bearings.

P is defined as the radial load which results from the actual radial and thrust loads acting simultaneously. The calculation of P will depend on the style of bearing under investigation.

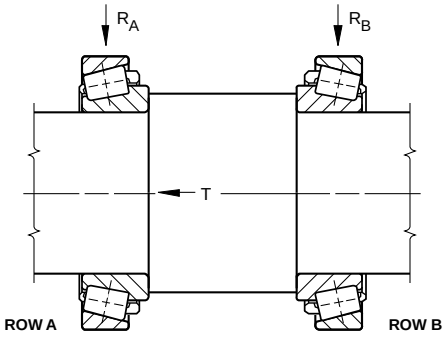
Four general cases, all involving the application of a radial external thrust load, represent the majority of loading situations for the tapered radial roller bearings presented in this catalog.

Case 1 involves two single-row bearings with the same K value. Radial loads are R_A and R_B; thrust load is T.

For Row A, $P = 0.4\ R_A + 0.47\ R_B + KT$

For Row B, $P = 0.4\ R_B + 0.47\ R_A - KT$

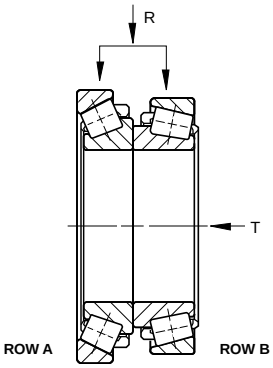
In both cases, if P<R, use R for the Equivalent radial load.



In Case 2, the bearings A and B have different K values. Other conditions are the same as Case 1.

Row	Equivalent Radial Load Formula	If	Then
A	$P = 0.4\ R_A + K_A \left[\frac{0.47\ R_B}{K_B} + T \right]$	$P < R_A$	Use $P = R_A$
		$P > R_A$	Use computed value of P
B	$P = 0.4\ R_B + K_B \left[\frac{0.47\ R_A}{K_A} - T \right]$	P < RB	Use $P = R_B$
		P > RB	Use computed value of P

Case 3 involves dissimilar single-row bearings, with different K values, mounted with a unified radial load (R). Two conditions must be considered, involving the relationship between thrust load (T) and radial load (R).

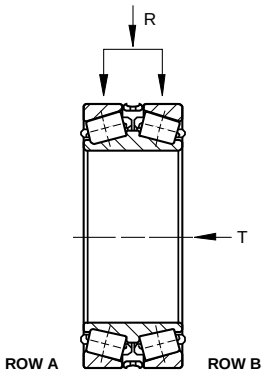


Condition	Row	Equivalent Radial Load Formulas
$T \le \frac{0.6R}{K_A}$	A	$P = \frac{K_A}{K_A + K_B} \left[R + 1.67 K_B T \right]$
	B	$P = \frac{K_B}{K_A + K_B} \left[R - 1.67\ K_A T \right]$
$T > \frac{0.6R}{K_A}$	A	$P = 0.4P + K_A T$
	B	$P = 0$

Load Ratings and Life Calculations

EQUIVALENT RADIAL LOAD – RADIAL TAPERED ROLLER BEARINGS *(continued)*

Case 4 involves a two-row bearing with identical K values. Again, the two conditions involving thrust load (T) and radial load (R) must be considered.



Condition	Row	Equivalent Radial Load Formulas
$T \le \frac{0.6R}{K}$	A	P = 0.5R + 0.83KT
	B	P = 0.5R - 0.83KT
$T > \frac{0.6R}{K}$	A	P = 0.4R + KT
	B	P = 0

Note that in both Cases 3 and 4, the single-row Basic Dynamic Load Rating must be used for L10 computations. Ratings given for two-row bearings must be divided by two. In effect, separate L_{10} computations must be made for each row. For two-row, the lower L_{10} figure will become the design limit.

Should a particular installation involve tapered roller bearings in a configuration which does not fit any of the cases above, consult a Torrington sales engineer for assistance in determining L_{10} life.

K factors for the tapered roller bearings are found in the dimensional tables on Roller Bearings pages 72 through 81.

LIFE - THRUST SPHERICAL, CYLINDRICAL AND TAPERED ROLLER BEARINGS

The life formula, equation **11**, is equation **4** restated in terms of thrust instead of radial ratings and radial equivalent loads.

$$L_{10} = \frac{16667}{N}\left[\frac{C_t}{T_e}\right]^{10/3} \text{ (Hours)} \qquad \textbf{11}$$

The calculations of bearing life may also be performed by using logarithmic factors for rotational speed (N_f) and life (L_f) based on the formula:

$$L_{10} = 500\,(L_f)^{10/3} \text{ (Hours)} \qquad \textbf{12}$$

$$\text{where } L_f = \left[\frac{C_t\, N_f}{T_e}\right] \qquad \textbf{13}$$

$$\text{where } N_f = \left[\frac{1}{.03N}\right]^{3/10} \qquad \textbf{14}$$

These factors can be derived from the scales shown on page E53. Referring back to equation **11** it may be advisable, as previously noted with radial bearings, under certain operating conditions to include an application factor a_3 and calculate life according to the formula:

$$L_{10} = \frac{16667}{N}\, a_3 \left[\frac{C_t}{T_e}\right]^{10/3} \text{ or } L_{10} = 500\, a_3\,(L_f)^{10/3} \text{ (Hours)} \qquad \textbf{15}$$

a^3 is the factor based on application conditions. Under optimum conditions $a_3 = 1$. Depending on lubricant contamination, temperatures, impact loading and load reversals a_3 may be less than 1 and as low as .05. Consult Torrington engineering department for recommendations.

Life – Thrust Ball Bearings

$$L_{10} = \frac{16667}{N}\left[\frac{C_t}{T_e}\right]^{3} \text{ (Hours)}$$

It may be advisable under certain operating conditions to include an application factor a_3 and calculate life according to the formula:

$$L_{10} = \frac{16667}{N}\, a_3 \left[\frac{C_t}{T_e}\right]^{3} \text{ (Hours)}$$

a_3, the life factor based on application conditions, can be assigned values as described above.

Equivalent Thrust Load

• Thrust ball, cylindrical and tapered roller bearings

For thrust ball, cylindrical and tapered roller bearings the existence of radial loads introduces complex load calculations which must be carefully considered. If radial load is zero the equivalent thrust load (T_e) will be equal to the applied thrust load (T). If any radial load is expected in the application, consult a Torrington sales engineer for advise on bearing selection.

• Thrust spherical roller bearings

$$T_e = T + 1.2R$$

Note: Radial load (R) of the thrust bearing is proportional to the applied axial load (T) with $R \le 0.55T$. Because of the steep roller angle and the fact that the bearing is separable, a radial load will induce a thrust component ($T_i = 1.2R$), which must be resisted by another thrust bearing on the shaft or by an axial load greater than T_i.

Centrifugal force tends to propel the rollers outwardly. The bearing geometry converts this force to another induced thrust component which must be overcome by an axial load. This induced thrust (T_c) is given by the formula:

$$T_c = kn^2 \times 10^{-5}$$

where k = centrifugal force constant and n= speed in rpm.

The minimum required working thrust (T_{min}) is then computed:

$$T_{min} = T_i + T_c \ge \frac{\text{Static Load Rating}}{1000}$$

In addition to meeting the above calculated value, the minimum required working thrust (T_{min}) should be equal to or greater than 0.1% of the static load rating.

Equivalent Static Thrust Load

• Thrust spherical roller thrust bearings

$$T_{oe} = T + 2.7R$$

T_{oe} should not be greater than 0.5 C_{oa}. If conditions exceed this, consult the Torrington engineering department.

Equivalent Thrust Load

• Angular contact thrust ball bearings

T_e = XR + YT

X = radial load factor

Y = thrust load factor

Minimum permissible $\frac{t}{r}$ ratios and X and Y Factors are listed in the dimension tables in the thrust bearing section.

Lubrication

In order to help maintain a rolling bearing's anti-friction characteristics, lubrication is needed to minimize rolling resistance due to deformation of the rolling elements and raceway under load, and to minimize sliding friction occurring between rolling elements, raceways and cage. Modern lubricants do this very effectively, although in many applications the means by which they accomplish this are extremely complex and not completely understood. Because the principles involved with lubricating rolling element bearings are complex and do not have to be known to employ lubricants successfully, this discussion will stress the practical rather than the theoretical aspects of lubrication.

LUBRICATION SELECTION

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 the best for the particular operation. The advantages of oil and grease are outlined in Table 1. Where heat must be carried away fro the bearing, oil must be used, and it is nearly always preferred for very high speed applications. For limiting speeds of grease and oil lubricated bearings refer to the section entitled "Limiting Speeds".

Table 1
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 particular matter	Permits prelubrication of sealed or shielded bearings
Easily controlled lubrication	Generally requires less frequent lubrication

OIL LUBRICATION

Oils used for bearing lubrication should be high quality, non-oxidizing mineral oils. Selection of the proper type of oils depends on bearing speed, load, operating temperature, and method of lubrication.

Some features and advantages of oil lubrication in addition to the above are as follows:

(1) Oil is a better lubricant for high speeds or high temperatures. It can be cooled to help reduce bearing temperature.

(2) Oil 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.

(3) As a liquid, 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 to certain types of applications.

(4) 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:

(1) **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. Gauges or controlled elevation drains are used to achieve and maintain the proper oil level.

(2) **Circulating system**. This system has the advantages of:

(a) An adequate supply of oil for both cooling and lubrication.

(b) Metered control of the quantity of oil delivered to each bearing.

(c) Removal of contaminants and moisture from the bearing by flushing action.

(d) Suitability for multiple bearing installations.

(e) Large reservoir which reduces deterioration; increased lubricant life provides economical efficiency.

(f) Incorporation of oil filtering devices.

(g) Positive control to deliver the lubricant where needed.

A typical circulating oil system consists of an oil reservoir, pump, piping, and filter. A cooler 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, the proper air pressure and oil quantity ratio to suit the particular application, the adequate exhaust of the air-oil mist after lubrication has been accomplished.

To insure "wetting" of the bearings and to prevent possible damage to the rolling elements and races, 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 has particular significance for equipment that has been idled for extended periods of time.

Lubrication

LUBRICATING GREASES

DEFINITION

According to the ASTM definition, lubricating grease is a “solid to semi-fluid product of the dispersion of a thickening agent in a liquid lubricant; other ingredients imparting special properties may be included.” If this definition were laid out in the manner a chemist would use to illustrate a chemical reaction, the composition of a grease could be described by the formula below.

Fluids	+ Thickening Agents	+ Special Ingredients	= Lubricating Grease

By expanding this formula, it is possible to show the combinations possible for formulating greases to meet a wide range of operating conditions.

Fluids	+ Thickening Agents	+ Special Ingredients	= Lubricating Greases
Mineral Oils	Soaps	Oxidation Inhibitors	
Esters	Lithium, Sodium	Rust Inhibitors	
Organic	Barium, Calcium	VI Improver	
Esters	Strontium	Tackiness	
Glycols	Non-Soap (Inorganic)	Perfumes	
Silicones	Microgel (Clay)	Dyes	
	Carbon Black	Metal Deactivator	
	Silica-gel		
	Non-Soap (Organic)		
	Urea compounds		
	Terepthlamate		
	Organic Dyes		

At this time there is no known universal anti-friction bearing grease. Each individual grease has certain limiting properties and characteristics.

Synthetic lubricating fluids, such as esters, organic esters and silicones, are used with conventional thickeners or chemical additives to provide greases capable of performing over an extremely wide range of temperatures, from as low as -100°F (-73°C) to a high of 550°F (288°C).

The successful use of lubricating grease in roller bearings depends on the physical and chemical properties of the lubricant as they pertain to the bearing, its application, installation and general environmental factors. Because the choice of a lubricating grease for a particular bearing under certain service conditions is often difficult to make, our engineering department should be consulted for proper recommendations.

CHARACTERISTICS AND OPERATING ENVIRONMENTS

Table 1 lists general characteristics of prominent rolling bearing greases.

Table 1

Thickener	Typical Dropping PT F	Typical Dropping PT C	Usable** Temperature F	Usable** Temperature C	Typical Water Resistance
Sodium Soap	500 +	260 +	250	121	Poor
Lithium Soap	380	193	220	104	Good
Polyurea	460	238	300	149	Excellent
Lithium Complex Soap	500 +	260 +	325	163	Good

* The properties of a grease may vary considerably depending on the particular oil, thickener and additives used in the formulation.

** Continuous operation with no relubrication. Depending upon the formulation the service limits may vary. The usable limit can be extended significantly with relubrication.

Polyurea as a thickener for lubricating fluids is one of the most significant lubrication developments in over 30 years. Polyurea grease performance in a wide range of bearing applications is outstanding, and in a relatively short time it has gained acceptance as a factory packed lubricant for ball bearings.

Consistency

Greases may vary in consistency from semifluids, hardly thicker than a viscous oil, to solid grades almost as hard as a soft wood.

Consistency is measured by a pentrometer in which a standard weighted cone is dropped into the grease. The distance the cone penetrates (measured in millimeters in a specific time) is the penetration number.

The National Lubricating Grease Institute (N.L.G.I.) classification of grease consistency is shown below:

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 this grease. This “working” does not compare with the violent shearing action that takes place in a ball bearing and does not necessarily correlate with actual performance.

Low Temperatures

Starting torque in a grease lubricated ball bearing at low temperatures can be critical. Some greases may function adequately as long as the bearing is operating, but resistance to initial movement is such that the starting torque is excessive. In certain smaller machines, starting is an impossibility when very cold. Under such operating circumstances the greases containing low temperature characteristic oils are generally required.

If the operating temperature range is wide, synthetic fluid greases offer definite advantages. Greases are available to provide very low starting and running torque at temperatures as low as -100°F (173°C). 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 either the consistency or the channeling properties of the grease. It appears to be more a function of the individual properties of the particular grease and is difficult to measure. Experience alone will indicate whether one grease is superior to another in this respect.

High Temperatures

The high temperature limit for modern grease is generally a function of the thermal and oxidation stability of the fluid and the effectiveness of the oxidation inhibitors. The graph, page E62, was prepared using military specification greases to illustrate the thermal limitations of mineral oil, ester, silicone, and flouronated ether greases. the limits as shown apply only to prelubricated bearings or to applications where relubrication is not possible. Where provisions have been made for relubrication the temperature limits may be extended providing the interval between cycles is reduced accordingly.

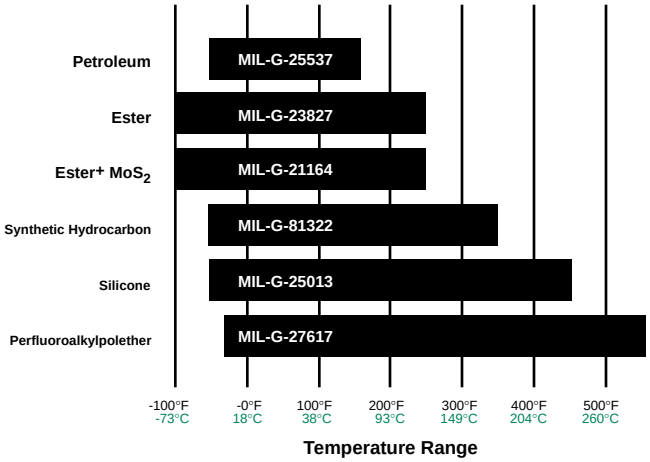
A rule of thumb, developed from years of testing grease lubricated bearings, indicates that grease life is halved for every 25°F (14°C) increase in temperature. For example, if a particular grease is providing, say 2000 hours of life at 200°F (93°C) by raising the temperature to 225°F (107°C) reduction in life to approximately 1000 hours would result. On the other hand, 4000 hours could be expected by lowering the temperature to 175°F (79°C).

It becomes obvious that the reactions started by the normal reaction of lubricant with oxygen increases rapidly at higher temperatures. The lubricants undergo a series of chemical reactions which ultimately result in the development of viscous or hard residues which interfere with the operation of the bearing.

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 250° F (121°C).

Lubrication

LUBRICATION GREASE TEMPERATURE RANGES



Wet Conditions

Water and moisture can be particularly conducive to bearing failure. Lubricating greases may provide a measure of protection from this contamination. Certain greases, the calcium, lithium and non-soap type, for example, are highly water resistant. However, these greases exhibit poor rut preventative characteristics unless properly inhibited.

Sodium soap greases emulsify with small amounts of moisture that may be present and prevent the moisture from coming in contact with the bearing surfaces. In certain applications this characteristic may be advantageous; however, emulsions are generally considered undesirable.

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, contact the Torrington engineering department.

GREASES - APPLICATIONS AND LUBRICATING METHODS

Grease lubrication is generally applicable to the following conditions, and features low to moderate speed applications within operating temperature limits of the grease:

(1) Easily confined in the housing. This is important in the food, textile and chemical industries.

(2) Bearing enclosure and seal design simplified.

(3) Improves the efficiency of external mechanical seals to give better protection to the bearing.

(4) Successfully used for integrally-sealed prelubricated ball bearings.

Advantages of prelubricated ball Bearings

Prelubricated shielded and sealed bearings are extensively used with much success on applications where:

1. Grease might be injurious to other parts of the mechanism.
2. Costs and space limitations preclude the use of a grease filled housing.
3. Housings cannot be kept free of dirt and grit, water or other contaminants.
4. Relubrication is impossible or would be a hazard to satisfactory use.

Prelubricated Torrington bearings are prepacked with greases which have chemical and mechanical stability and have demonstrated long life characteristics in rotating bearings. Greases are filtered several times to remove all harmful material and accurately metered so that each bearing receives the proper amount of grease.

GREASE LUBRICATION FOR BEARING/HOUSING ASSEMBLIES

Polyurea and lithium base 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 chart below.

The 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 melting point should be considerably higher than the operating temperature.

Frictional torque is influenced by the quantity and the quality of lubricant present. Excessive quantities of grease cause churning. This results in excessive temperatures, separation of the grease components, and break down in lubrication values. On normal speed applications the housings should be kept approximately ⅓ to ½ full.

Only on 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 subsequent operation, the excess grease should be removed and the proper level restored.

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 purging the old grease from the bearing.

Relubricate at regular intervals to prevent damage to the bearing. Relubrication intervals are difficult to determine. If plant practice or experience with other applications is not available, consult your lubricant supplier.

STANDARD LUBRICATION - FAFNIR BALL BEARINGS

Bearing Type	Grease type	Grease Temperature Range
Radial Bearings		
(Double shielded and	Polyurea thickener	
Single and Double Sealed)	Petroleum oil	-30° to +275°F
Wide Inner Ring Bearings	Polyurea thickener	
(Contact Seal Types)	Petroleum oil	-30° to +275°F
Wide Inner Ring Bearings	Synthetic thickener	
(Labyrinth Seal Types)	Synthetic hydrocarbon fluid	-65° to +325°F
Airframe Control Bearings		
(MIL-B-7949)		
Bearing Suffix FS428	MIL-G-23827	-100° to +250°F
Bearing Suffix FS464	MIL-G-81322	-65° to +325°F
Bearing Suffix FS235	MIL-G-25537	-65° to +160°F

Note: Open type bearings and single shielded types are NOT prelubricated. They have a rust preventative coating only and must be lubricated by the customer or end-user before operation.

Duplex Bearings and Preloading

Two single row bearings manufactured specially for use as a unit are known as a duplex bearing. It may be considered analogous to a double row bearing having the same bore and outside diameter, but twice the single row bearing width.

The main purpose of duplex bearings in an application is to achieve greater axial and radial rigidity than is possible with one single row bearing. The extra “stiffness” in these bearings is obtained by “preloading”. Preloading is incorporated into bearings by selective face grinding which is described in detail below.

Although angular contact bearings, such as the 7000, M-WI and MM-WI types, are more commonly used in duplex arrangements, other types of bearings such as radial single row open, shielded and sealed types, can duplexed where required to meet specific conditions.

PRELOADING

Preloading to a predetermined value is accomplished by grinding a certain amount of material off inner or outer ring faces so that before mounting the two single bearings as a duplex pair, the faces on abutting sides are offset an amount equal to the deflection under the “preload”. When mounted, these faces are clamped together so that the bearings are subjected to an internal load caused by one bearing opposing the other. This “preloading” materially decreases subsequent deflection due to external loads applied to the clamped-up pair.

Torrington has established, for each bearing size, standard preload levels which are considered proper for most duplex bearing applications. Special preloads can also 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. It must be remembered, however, that 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 expres -sion is:

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

where δ = axial deflection
K = a constant based on bearing geometry
T = thrust load applied
n = number of balls
d = ball diameter

A typical axial deflection curve for an unpreloaded single row angular-contact bearing is shown in Figure 1, below, as curve A. This curve represents the deflection characteristics of bearing “A” being subjected to thrust load T. The amount of deflection due to load T_1 is much greater than the increase in deflection caused by doubling the thrust load to T_2. This illustrates the non-linear deflection of a ball bearing.

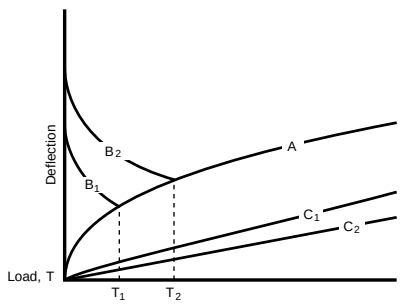
Curves C_1 and C_2 show the deflection of bearings A and B flushmounted as a pair, shown below, with each bearing having a preload of T_1 and T_2 lbs. respectively. Comparing curves C_1 and C_2 with A shows the deflection of the preloaded pair is much less then that of a single unpreloaded bearing. This has been accomplished essentially by eliminating the “high deflection” points of curve A (from no load to T_1 or T_2 lbs.).

Curves B_1 and B_2 show the axial deflection of bearing B as mounted in Figure 2 below from the preloaded conditions T_1 or T_2 to a no preload condition.

Preloading can be accomplished by the use of springs or spacer width adjustment, but our engineering department should be consulted for design review.

Figure 1

Axial load-deflection curve of back-to-back monted angular-contact bearings. Curve A is for Bearing A, B is for bearing B, and C1 and C2 are preload curves.



TYPICAL APPLICATIONS

Deep well pumps, marine propeller shafts, machine tool spindles, gear shafts, speed reducers, elevator worm drives, and similar applications often require the use of preloaded duplex bearings.

WIDTH TOLERANCES

To allow for face grinding of single bearings to specified preload for use in duplex pairs or other multiple bearing units, the inner and outer ring width tolerance of each bearing is greater than that for a standard single bearing as follows:

Bearing Bore mm over	Bearing Bore mm incl.	Width Tolerance ABEC 1,3	Width Tolerance ABEC 5,7,9
0	50	+.000" -.010"	+.000" -.010"
50	80	+.000" -.015"	+.000" -.010"
80	120	+.000" -.015"	+.000" -.015"
120	180	+.000" -.020"	+.000" -.015"
180	315	+.000" -.020"	+.000" -.020"
315	400	+.000" -.025"	+.000" -.025"

The inner and outer ring width tolerances of duplex pairs and other multiple bearing units equal the tolerances listed above times the number of bearings in the unit. Example: a duplex pair of 2MM9115 WI DUL bearings has an inner and outer ring width tolerance of .010" x 2 or .020".

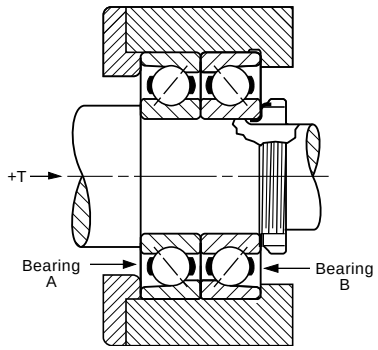
MOUNTINGS

Duplex bearings may be used with spacers between the matching faces in order to increase the system’s resistance to moment loading or to increase the system rigidity by using the bearings to minimize shaft deflection. Shaft and housing spacers should be ground together on a surface grinder to obtain exactly equal lengths to assure that the built-in preload will be maintained.

Since duplex bearings provide a very rigid mounting, it is important that special attention be given to correct shaft and housing fits, squareness of shaft and housing shoulders and alignment of all mating parts. In order to prevent cramping of bearings and an abnormal increase in preload which could result in excessive heat and possible premature failure, recommended shaft and housing tolerances must be followed, shaft and housing shoulders must be square, bearing spacers must be of equal length and all parts must be free of nicks and burrs.

Typical preloaded mountings are shown on the next page.

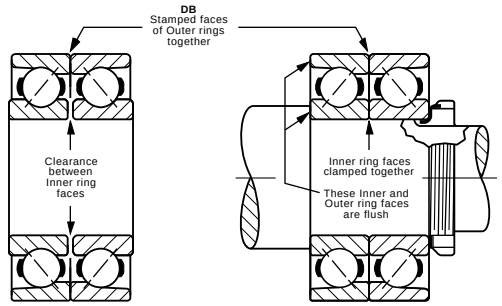
Figure 2



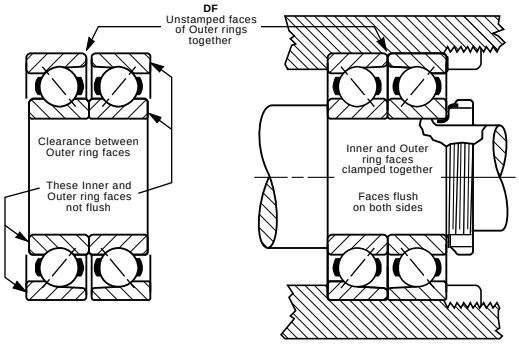
Duplex Bearings and Preloading

TYPICAL MOUNTINGS OF DUPLEX BEARINGS

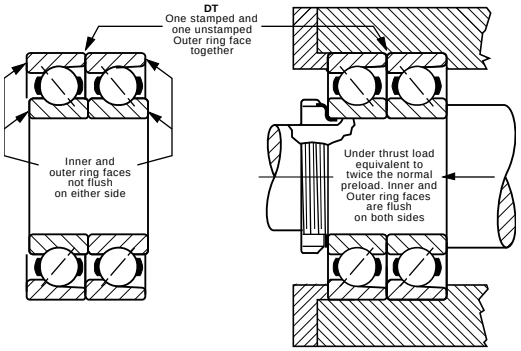
Back-to-Back Mounting, DB or (“O”)
(Contact angles diverging toward shaft centerline)
Before mounting, there is clearance between the two adjacent inner ring faces the bearings. After mounting, these faces are clamped together to provide an internal preload on each bearing. This arrangement is well suited for pulleys, sheaves and in other applications where there are overturning loads and also in all floating positions where thermal expansion of shaft occurs. It also 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. Specify bearing number followed by suffix DU. Examples: 7207W-DU, 2MM207WI-DU. Also available as two single flush-ground bearings, i.e., 7207W SU (2 bearings).



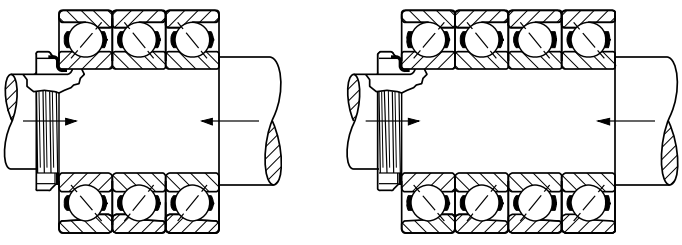
Face-to-Face Mounting, DF or (“X”)
(Contact angles converging toward shaft centerline)
Before mounting, there is clearance between the two adjacent outer ring faces. After mounting, these faces are clamped together between the housing shoulder and cover plate shoulder providing an internal preload on each bearing. This arrangement provides equal 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. Fafnir pairs for face-to-face mounting should be ordered as DU.Examples: 7212W-DU, 2M212WI-DU. Also available as two single flush-ground bearings, i.e., 7212W SU
(2 bearings).



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. Fafnir pairs for tandem mounting should be specified as DU. Examples: 7205W-DU, 2M205WI-DU. Also available as two single flush-ground bearings with suffix SU, i.e., 7210W SU (2 bearings).



Other Mountings
Flush ground (DU) pairs may be mounted in combination with a single flush-ground bearing as a “triplex” (TU) set shown in Figure A. Figure B illustrates 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.



Limiting Speeds

RADIAL BALL AND ROLLER BEARINGS

There is no precise method for determining the maximum speed at which a ball or roller bearing may operate. Bearing characteristics and features of surrounding parts, shafts, housings and other components, as well as basic service conditions, are all variables which are 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 ABEC-1 and RBEC-1 tolerances are generally satisfactory for normal speeds with grease or oil lubrication.

Ball bearings with ABEC-5 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 toll spindles, bearing preload and contact angle affect the permissible speeds.

The values in the accompanying table on page E66, may be used as a general guide for determining the safe maximum speed of standard types of Torrington and Fafnir 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 the table 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 dia. in mm x r.p.m. of the outer ring) by the following factors before referring to the table of speed values.

Ball Bearing Series	Factor
extra-small (30and S) and extra-light (9100 and M9300)	1.3
light (200, 5200 and 7200)	1.5
medium (300, 5300 and 7300)	1.7

For roller bearings under outer rotation, consult Torrington engineering for information concerning speed limitations.

Although the speed values shown in the table on the following page are based on many years of research and accumulated data, numerous application of Torrington and Fafnir 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, and should be reviewed carefully by our engineering department.

Conversely, under certain application conditions of load, temperature, contamination, etc., limiting speeds may be less than the figures shown. These values do not apply to certain special bearings, such as radial triply series, square or hex bore bearings in the catalog are substantially comparable to the values in the chart. In some cases the dimension tables show larger values in the chart. In some cases the dimension tables show larger values particularly on spherical roller bearings where variations in cage designs may permit higher speeds.

Limiting Speeds

RADIAL BALL AND ROLLER BEARINGS
P.D. X N VALUES (PD* IN MILLIMETERS X R.P.M.)

Bearing Type / Series	Cage Type	ABEC-1 RBEC-1		ABMA Class 2,4		ABEC-3			ABEC 5 and 7 Circulating		
		Grease	Oil[1]	Grease	Oil[1]	Grease	Oil[1]	Oil Mist	Grease	Oil	Oil Mist
BALL BEARINGS											
SINGLE ROW											
Non-Filling Slot	Ball Piloted Molded Nylon(PRB)	250,000	300,000	—	—	250,000	300,000	—	300,000	300,000	300,000
9300K, 9100K											
200K,	Pressed Steel, Bronze	300,000	350,000	—	—	300,000	350,000	—	350,000	400,000	450,000
300K,	Ring Piloted Molded Reinforced Nylon(PRC)	350,000	400,000	—	—	350,000	450,000	—	400,000	550,000	650,000
XLS, and variations	Composition (CR)										
Filling Slot	Ball Piloted Molded Nylon(PRB)	250,000	250,000	—	—	—	—	—	—	—	—
200W and variations	Pressed Steel	250,000	300,000	—	—	—	—	—	—	—	—
300W and variations											
Angular Contact	Ball Piloted Pressed Steel, Molded Nylon (PRB)	250,000	300,000	—	—	300,000	350,000	—	—	—	—
7200WN	Ring Piloted Bronze(MBR),BallPilotedBr(MBR)	300,000	400,000	—	—	—	—	—	—	—	—
7300WN	Ring Piloted Molded Reinforced Nylon (PRC)	350,000	400,000	—	—	350,000	400,000	—	—	—	—
Angular Contact-Extra precision											
2M9300WI, WN, 2M200WI,											
2M300WI, 2M9100WI,	Ring Piloted Composition (CR) or (PRC)	350,000	400,000	—	—	750,000	1,000,000	1,200,000			
2MM9300WI WN, 2MM9100,									1,000,000	1,400,000	1,700,000
2MM200WI, 2MM300WI											
Double Row											
5200	Ball Piloted Molded Nylon(PRB), Pressed Steel	250,000	300,000	—	—	—	—	—	—	—	—
5300	Ball Piloted Bronze (BR)										
CYLINDRICAL ROLLER BEARINGS											
RU,RIU	Bronze	150,000	300,000	—	—	—	—	—	—	—	—
RN,RIN											
RJ,RIJ											
RF,RIF											
RT,RIT											
RP,RIP											
5200WS	RollerPiloted Pressed steel	150,000	300,000	—	—	—	—	—	—	—	—
SPHERICAL ROLLER BEARINGS											
239,230	Pressed steel	150,000	300,000	—	—	—	—	—	—	—	—
240,231	Bronze										
241,222	Molded Reinforced Nylon										
232,213											
223,233											
TAPERED ROLLER BEARINGS											
TS,TSS	Pressed steel	—	—	150,000	300,000	—	—	—	—	—	—
TDI,	Bronze										
TDO, TDOC, TDOD											

*Bore + O.D.
2

[1] For oil bath lubrication, oil level should be maintained between ⅓ to ½ from the bottom of the lowest ball.

Note: Single or double normal contact (P or PP) sealed bearings, should not exceed 350,000 PDN. Consult our Engineering Department for limiting speed of RR or Tri-Ply sealed bearings.

Materials

TEMPERATURE RANGES, RESISTANCE TO CORROSION AND OTHER ENVIRONMENTS

In order to accommodate the needs of our rapidly expanding industrial world and space age technology, the capability of bearings in various extreme environments becomes vitally important. No general recommendations can be made to cover all such applications. Each installation must be studied to determine peak and average operating temperatures, length of time at these temperatures, load, oscillation or rotation, and any other factors affecting bearing operation.

High temperature problems are most often encountered in aircraft applications but also occur in industrial equipment such as furnaces and oven conveyors, hot air blowers, and flue dampers in exhaust systems. Aircraft design has reached a point where supersonic speeds are commonplace. These flight speeds create structural temperatures as high as 650°F (343°C) due to aerodynamic heating. Many airframe bearing installations are subjected to these extreme temperatures and control bearings located in or near the power plants may be subjected to temperatures as high as 1000°F(538°C).

Atmosphere reentry of space vehicles creates even greater temperatures than those encountered in conventional aircraft at supersonic speeds. To help solve some of the high temperature problems mentioned above, special materials for the rings and rolling elements may be required as well as variations in seals, retains, and lubricants.

RINGS, BALLS, AND ROLLERS

Suggested materials for use in rings, balls and rollers at various operating temperatures are listed in Chart I together with data on chemical composition, hardness and dimensional stability. A temperature of 800°F (427°C) is generally the top limit for successful bearing operation using steels. Above 800°F (427°C), or below where lubricant is not permitted, cast or wrought cobalt alloys are generally used. Although chosen primarily for their good retention of physical properties, they also possess good oxidation resistance at elevated temperatures.

CAGES, SHIELDS, AND SEALS

Recommended materials for cages, shields, and seals are tabulated in Chart II with their temperature capabilities.

DIMENSIONAL STABILITY

Dimensional stability of rings and balls is achieved by tempering the hardened steel until any further growth by transformation of austenite to martensite is balanced by shrinkage from tempering martensite. This balance is never perfect, and some size change will always occur, the amount depending upon the operating time and temperature of the bearings and the composition of and heat treatment of the steel. The ABMA definition for stabilized rings and balls permits a change of less than .0001 inch per inch after exposure to a temperature of 300°F for 2500 hours. Rings and balls used at elevated temperatures are defined as stable by ABMA where there is a size change of less than .00015 inch per inch after 1500 hours exposure at temperatures of 450°, 600° and 800°F.

CORROSION RESISTANCE

Fafnir developed a premium coating named FAFNIR-TDC® which has excellent corrosion resistance as well as other properties leading to improved bearing life. FAFNIR-TDC® (Thin Dense Chromium) coated bearings are intended for use in applications where unprotected bearings do not survive. This proprietary coating emanating from years of research and testing is a real problem solver.

Besides its corrosion resistance feature this coating has a high hardness (Rc 70-72), reduced coefficient of friction, and a dense modular texture.

FAFNIR-TDC® is resistant to most organic and inorganic compounds. The normal thin coating of less than .0001 inch will outlast 440C stainless steel. The very high hardness, lower coefficient of friction, and surface texture, provide extra resistance to wear under less than ideal lubrication and thus longer bearing life.

Under normal lubrication conditions, FAFNIR-TDC® coated races can provide increased fatigue life in the order of two times the life of standard bearings.

To order ball bearings with FAFNIR-TDC® coated races, stainless steel balls, and nylon retainers, specify suffix FS80000 (i.e.,205PP FS80000). This coating can also be readily applied to various types of tapered, cylindrical, and spherical roller bearings.

To assure proper application of FAFNIR-TDC®, the engineering department should be consulted.

In addition to the above bearings, the Torrington Company is able to supply specially coated housings for applications involving particularly harsh environments or where F.D.A. and U.S.D.A. regulations apply. These housings are available as zinc or electroless nickel plated depending on the situation. The zinc plated unit is intended for general use where corrosion and/or appearance are of special concern. The electroless nickel units are required for food processing, medical, and other applications. These Survivor® units are ordered by adding an -NT suffix to the part number.

Both coatings offer excellent protection to a broad variety of corrosive environments and are vulnerable only to a very few aggressive materials.

A complete review of operating conditions is essential before applying corrosion resistance housed units and/or FAFNIR-TDC® coated bearings. Consult our engineering department for comprehensive recommendations.

OTHER CONSIDERATIONS

Installations which operate at high temperatures for extended periods may lose the quality of shaft and housing fits. Carefully machined and heat treated shafts and housings will minimize trouble from this source.

In some applications the internal clearance of bearings may be partially absorbed. For example, during the first few seconds of rotation a massive housing may keep the outer race cooler than the inner race and balls even if the housing is already at some elevated temperature and, also, during heat soakback when rotation stops heat may flow back to the bearing along the shaft. If, while stationary, the effects of heat soakback more than removes the radial internal clearance, radial brinell of the races may occur and the bearing will be rough during subsequent rotation. Bearings with extra internal looseness may be required to compensate for the above conditions. Consult our engineering department for recommendations.

Operating Temperatures For Bearing Component Materials

CHART I - RINGS, BALLS AND ROLLERS

Material	Approximate Chemical Analysis-%	Temp. °F	Hardness R_c	Operating Temperature
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 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 <.0001in./in dimensional change in 2500 hours at 300°F When given a stabilizing heat treatment, A295 steel is suitable for many applications in the 350-450°F range; however ,it is not as stable dimensionally as it is at temperatures below 350°F. If utmost stability is required, use materials in the 600°F group below.
Deep hardening steels for heavy sections perASTM A485	1C 1-1.8Cr 1-1.5 Mn .06Si	70 450 600	58 55 52	As heat treated and tempered, it is stabilized, <.0001 in/in dimensional change in 2500 HR at 300 °F (149°C).
Carburizing steels per ASTM A534 (a) low alloy 4118 (b) 8620 (c) high nickel 3310	.2C, .5Cr, .80Mn, .12Mo .2C, .5Cr, .80 Mn, .20 Mo, .55Ni .10C, 1.60Cr, .50Mn, 3.50Ni	70	58	4118,8620 steel frequently used to achieve extra ductility in inner rings for locking devise bearings. 3310 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. <.0001 in/in dimensional change in 1200 hours.
M-50 Medium High Speed	4 Cr. 4 Mo 1V 0.8C	70 450 600	60 59 57	Recommended where stable high hardness at elevated temperature is required. <.0001 in/in dimensional change in 1200 hours at 600°F.

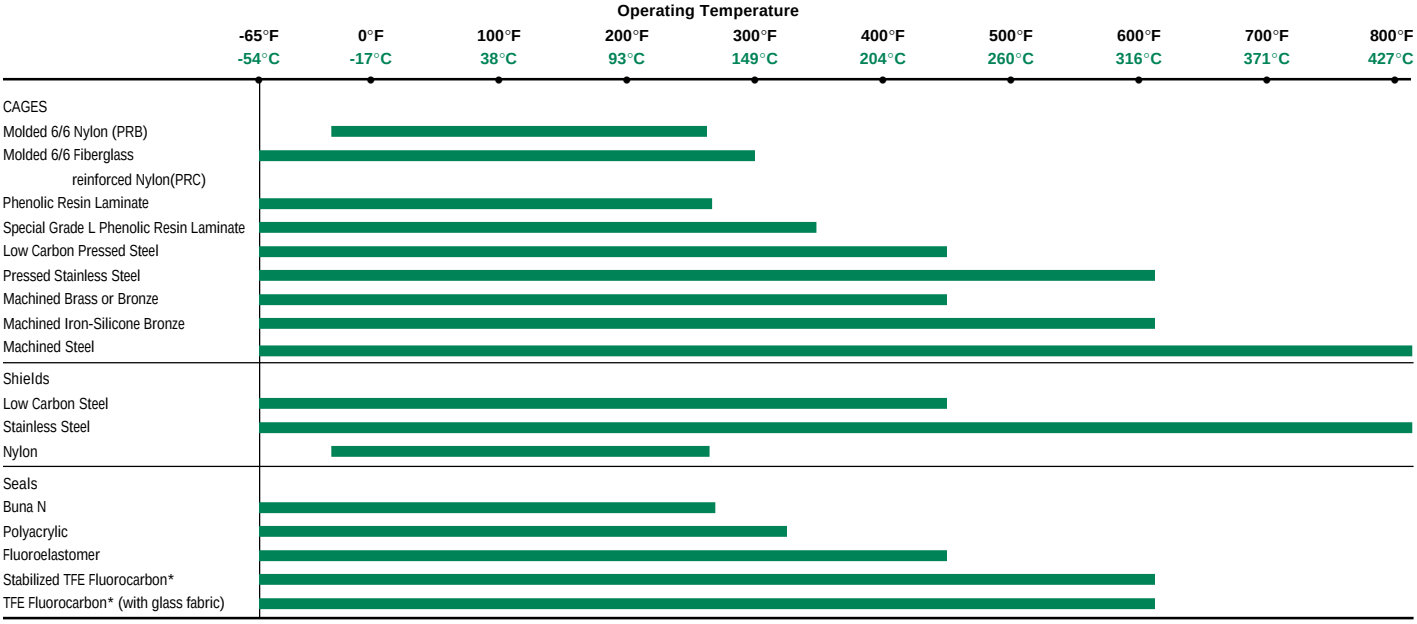
-100°F -73°C | -65°F | 0°F -17°C | 100°F 38°C | 200°F 93°C | 250°F | 300°F 149°C | 400°F 204°C | 500°F 260°C | 600°F 316°C | 700°F 371°C | 800°F 427°C

Note: ASTM A295 bearing steels are suitable for many applications up to 250°F but are not as dimensionally stable as they are at temperatures below 212°F.

Dimensional stability data shown above is the permanent metallurgical growth and/or shrinkage only. Thermal expansion effects are not included.

Bearings have been made of special material for operation at temperatures above 800°F consult Torrington engineers regarding the application.

CHART II – CAGES, SHIELDS AND SEALS



* Limited Life above these temperatures.

nd^2 VALUES FOR BALL DIAMETERS 1/32" TO 3"

BALL DIAM. d inches	d^2	Number of balls (n) 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1/32	0.00098	0.00586	0.00684	0.00782	0.00879	0.00977	0.0107	0.0117	0.0127	0.0137	0.0147	0.0156	0.0166	0.0176	0.0186	0.0195
1/16	0.00391	0.0234	0.0273	0.0312	0.0352	0.0391	0.043	0.0469	0.0508	0.0547	0.0586	0.0625	0.0664	0.0703	0.0742	0.0781
3/32	0.00879	0.0527	0.0615	0.0703	0.0791	0.0879	0.0967	0.105	0.114	0.123	0.132	0.141	0.149	0.158	0.167	0.176
1/8	0.01562	0.0938	0.109	0.125	0.141	0.156	0.172	0.188	0.203	0.219	0.234	0.25	0.266	0.281	0.297	0.312
5/32	0.02441	0.146	0.171	0.195	0.22	0.244	0.269	0.293	0.317	0.342	0.366	0.391	0.415	0.439	0.464	0.488
3/16	0.03516	0.211	0.246	0.281	0.316	0.351	0.386	0.421	0.457	0.492	0.527	0.563	0.598	0.633	0.668	0.703
7/32	0.04786	0.287	0.335	0.383	0.431	0.479	0.526	0.574	0.622	0.67	0.718	0.766	0.814	0.861	0.909	0.957
1/4	0.06250	0.375	0.438	0.5	0.562	0.625	0.688	0.75	0.813	0.875	0.938	1	1.06	1.13	1.18	1.25
9/32	0.07910	0.475	0.554	0.633	0.712	0.791	0.87	0.95	1.03	1.11	1.19	1.27	1.34	1.42	1.5	1.58
5/16	0.09766	0.586	0.684	0.78	0.878	0.976	1.07	1.17	1.27	1.37	1.46	1.56	1.66	1.76	1.86	1.95
11/32	0.1182	0.708	0.826	0.945	1.06	1.18	1.3	1.42	1.53	1.65	1.77	1.89	2.01	2.13	2.25	2.36
3/8	0.1406	0.847	0.988	1.13	1.27	1.41	1.55	1.69	1.83	1.97	2.11	2.26	2.4	2.54	2.67	2.81
13/32	0.1650	0.99	1.16	1.32	1.49	1.65	1.81	1.98	2.14	2.31	2.48	2.64	2.81	2.97	3.14	3.3
7/16	0.1914	1.15	1.34	1.53	1.72	1.91	2.1	2.29	2.48	2.68	2.87	3.06	3.25	3.44	3.64	3.83
15/32	0.2197	1.32	1.54	1.76	1.98	2.2	2.42	2.64	2.86	3.08	3.3	3.52	3.74	3.96	4.17	4.39
1/2	0.2500	1.5	1.75	2	2.25	2.5	2.75	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5
17/32	0.2822	1.69	1.97	2.26	2.54	2.82	3.1	3.38	3.67	3.95	4.23	4.51	4.8	5.08	5.36	5.64
9/16	0.3164	1.9	2.21	2.53	2.84	3.16	3.48	3.79	4.11	4.42	4.74	5.06	5.37	5.69	6.01	6.33
19/32	0.3525	2.11	2.46	2.82	3.17	3.52	3.87	4.23	4.58	4.93	5.28	5.64	5.98	6.34	6.7	7.05
5/8	0.3906	2.35	2.74	3.13	3.52	3.91	4.3	4.68	5.08	5.47	5.87	6.26	6.65	7.04	7.42	7.81
21/32	0.4307	2.58	3.02	3.45	3.88	4.31	4.74	5.17	5.6	6.03	6.46	6.89	7.33	7.76	8.18	8.61
11/16	0.4727	2.84	3.31	3.78	4.25	4.73	5.2	5.67	6.15	6.62	7.09	7.57	8.04	8.52	8.98	9.45
23/32	0.5166	3.1	3.62	4.13	4.65	5.17	5.68	6.2	6.72	7.23	7.75	8.27	8.78	9.3	9.82	10.3
3/4	0.5625	3.38	3.94	4.5	5.07	5.63	6.2	6.75	7.32	7.88	8.45	9.01	9.57	10.1	10.7	11.3
25/32	0.6104	3.66	4.27	4.88	5.49	6.1	6.71	7.32	7.93	8.54	9.15	9.77	10.4	11	11.6	12.2
13/16	0.6602	3.96	4.62	5.28	5.94	6.6	7.26	7.92	8.58	9.24	9.9	10.6	11.2	11.9	12.5	13.2
27/32	0.7119	4.27	4.98	8.7	6.41	7.12	7.83	8.54	9.25	9.97	10.7	11.4	12.1	12.8	13.5	14.2
7/8	0.7656	4.59	5.36	6.12	6.89	7.66	8.42	9.19	9.95	10.7	11.4	12.2	13	13.8	14.5	15.3
29/32	0.8213	4.93	5.75	6.57	7.39	8.21	9.03	9.86	10.7	11.5	12.3	13.1	14	14.8	15.6	16.4
15/16	0.8789	5.28	6.15	7.04	7.9	8.79	9.67	10.5	11.4	12.3	13.2	14.1	14.9	15.8	16.7	17.6
31/32	0.9385	5.63	6.57	7.51	8.44	9.39	10.3	11.3	12.2	13.1	14.1	15	16	16.9	17.8	18.8
1	1.0000	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1 1/16	1.1289	6.77	7.9	9.03	10.2	11.3	12.4	13.5	14.7	15.8	16.9	18.1	19.2	20.3	21.4	22.6
1 1/8	1.2656	7.59	8.86	10.1	11.4	12.7	13.9	15.2	16.5	17.7	19	20.2	21.5	22.8	24	25.3
1 3/16	1.4102	8.46	9.87	11.3	12.7	14.1	15.5	16.9	18.3	19.7	21.2	22.6	23.9	25.3	26.8	28.2
1 1/4	1.5625	9.38	10.9	12.5	14.1	15.6	17.2	18.7	20.3	21.9	23.4	25	26.6	28.1	29.7	31.3
1 5/16	1.7226	10.3	12.1	13.8	15.5	17.2	18.9	20.7	22.4	24.1	25.8	27.6	29.3	31	32.7	34.4
1 3/8	1.8906	11.3	13.2	15.1	17	18.9	20.8	22.7	24.6	26.5	28.4	30.2	32.1	34	35.9	37.8
1 7/16	2.0664	12.4	14.5	16.5	18.6	20.7	22.7	24.8	26.9	28.9	31	33.1	35.1	37.2	39.2	41.3
1 1/2	2.2500	13.5	15.8	18	20.3	22.5	24.8	27	29.3	31.5	33.8	36	38.3	40.5	42.8	45
1 9/16	2.4414	14.6	17.1	19.5	22	24.4	26.9	29.3	31.7	34.2	36.6	39.1	41.5	43.9	46.4	48.8
1 5/8	2.6406	15.8	18.5	21.1	23.8	26.4	29	31.7	34.3	37	39.6	42.2	44.9	47.6	50.2	52.8
1 11/16	2.8476	17.1	19.9	22.8	25.6	28.5	31.3	34.2	37	39.9	42.7	45.6	48.4	51.3	54.1	57
1 3/4	3.0625	18.4	21.4	24.5	27.6	30.6	33.7	36.8	39.8	42.9	45.9	49	52.1	55.1	58.2	61.3
1 13/16	3.2851	19.7	23	26.3	29.6	32.9	36.1	39.4	42.7	46	49.3	52.6	55.8	59.1	62.4	65.7
1 7/8	3.5156	21.1	24.6	28.1	31.6	35.2	38.7	42.2	45.7	49.2	52.7	56.2	59.8	63.3	66.8	70.3
1 15/16	3.7539	22.5	26.3	30	33.8	37.5	41.3	45	48.8	52.6	56.3	60.1	63.8	67.6	71.3	75.1
2	4.0000	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
2 1/16	4.2539	25.5	29.8	34	38.3	42.5	46.8	51	55.3	59.6	63.8	68.1	72.3	76.6	80.8	85.1
2 1/8	4.5156	27.1	31.6	36.1	40.6	45.2	49.7	54.2	58.7	63.2	67.7	72.2	76.8	81.3	85.8	90.3
2 3/16	4.7851	28.7	33.5	38.3	43.1	47.9	52.6	57.4	62.2	67	71.8	76.6	81.3	86.1	90.9	95.7
2 1/4	5.0625	30.4	35.4	40.5	45.6	50.6	55.7	60.8	65.8	70.9	75.9	81	86.1	91.1	96.2	101
2 5/16	5.3476	32.1	37.4	42.8	48.1	53.5	58.8	64.2	69.5	74.9	80.2	85.6	90.9	96.3	101	107
2 3/8	5.6406	33.8	39.5	45.1	50.8	55.4	62	67.7	73.3	79	84.6	90.2	95.9	102	107	113
2 7/16	5.9414	35.6	41.6	47.5	53.5	59.4	65.4	71.3	77.2	83.2	89.1	95.1	101	107	113	119
2 1/2	6.2500	37.5	43.8	50	56.3	62.5	68.8	75	81.3	87.5	93.8	100	106	112	119	125
2 9/16	6.5664	39.4	46	52.5	59.1	65.7	72.2	78.8	85.4	91.9	98.5	105	112	118	125	131
2 5/8	6.8906	41.3	48.2	55.1	62	68.9	75.8	82.7	89.6	96.5	103	110	117	124	131	138
2 11/16	7.2226	43.3	50.6	57.8	65	72.2	79.4	86.7	92.9	101	108	116	123	130	137	144
2 3/4	7.5625	45.4	52.9	60.5	68.1	75.6	83.2	90.7	98.3	106	113	121	129	136	144	151
2 13/15	7.9101	47.5	55.3	63.3	71.2	79.1	87	94.9	103	111	119	127	134	142	150	158
2 7/8	8.2656	49.6	57.9	66.1	74.3	82.7	90.9	99.2	107	116	124	132	141	149	157	165
2 15/16	8.6289	51.8	60.4	69	77.7	86.3	94.9	104	112	121	129	138	146	155	163	173
3	9.0000	54	63	72	81	90	99	108	117	126	135	144	153	162	171	180