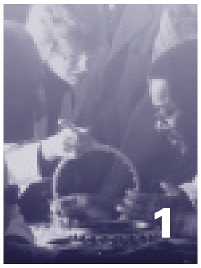
TIMKEN®

Fafnir®

Super Precision Bearings

- Machine Tool Spindle
- Ball Screw Support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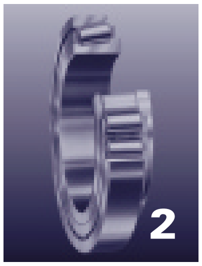
Bearing Selection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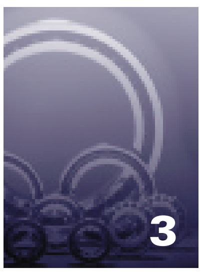
Precision Tapered Roller Bearings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Super Precision Ball Bearings


4


Engineering Data


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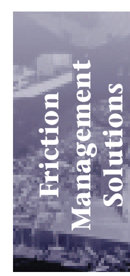
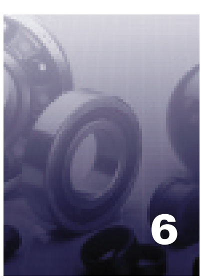

Friction Management Solutions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About The Timken Company

The Timken Company was founded in St. Louis in 1899 by Henry Timken with his patented design for the tapered roller bearing. Five generations of Timken family members have led the company as it developed an ever-increasing number of tapered roller bearing designs and applications.

In 1917, the company entered the steel business to ensure an uninterrupted supply of bearing-quality steel.

Through international acquisitions in the 1990's, the company expanded its product offering to include other bearing types, including ball bearings, and cylindrical and spherical roller bearings.

Timken's acquisition of The Torrington Company in 2003 combined two organizations sharing a very similar heritage, brand promise and market approach. Both companies have demonstrated traditions of quality, technology and innovation. Further, both have earned the respect of their customers due to a collaborative, customer-centric approach to identifying and implementing solutions.

Through the acquisition, Timken is providing a broader range of friction-management products and services. Timken has expanded its position as a leading global manufacturer of alloy steel and tapered and needle roller bearings for the aerospace, automotive, industrial and rail markets. Specifically, its industry credentials now include:

- Largest tapered roller bearing manufacturer worldwide
- Third largest bearings manufacturer worldwide
- Largest North American bearings manufacturer
- A leading manufacturer of needle bearings
- Second largest global supplier of aftermarket industrial bearings

Using This Catalog

We are committed to providing our customers with maximum service and quality. The part number of the product supplied may differ from those listed in these pages. This catalog contains dimensions, tolerances and load ratings, as well as an engineering section describing fitting practices for shafts and housings, internal clearances, materials, and other features of bearings. It can provide valuable assistance in the initial consideration of the type and characteristics of the bearing which may be most suitable for particular needs.

This data is intended for reference purposes only and will assist the customer in part number and external bearing dimension identification.

Every effort has been made to ensure the accuracy of the information contained but no liability can be accepted for errors, omissions or any other reason.

ISO, DIN, and ABMA, as used in this catalog, refer to the International Organization for Standardization, Deutsches Institut für Normung EV and the American Bearing Manufacturers Association, respectively.

Sales Engineering Services

Turn to Timken and its highly trained sales engineers who are available to work toward solving new or unusual problems. Timken may have already solved a similar problem to yours and can offer a speedy, cost-effective solution.

To get the best performance out of the application, especially when operating conditions are critical, contact your Timken sales representative to discuss the application.

Special Applications

Some products, such as for aerospace applications, are made to special standards, and only the original equipment manufacturer can determine if a particular bearing is suitable for use in their equipment. Timken engineers are able to provide technical assistance upon request.

TIMKEN

Bearing Shelf Life and Storage

Please note this policy listed in its complete form at the beginnning of the Engineering section of this catalog on page 183.

Terms and Conditions of Sale

All products described in this catalog are subject to Timken's Terms and Conditions of Sale, copies of which are available from any Timken Sales Office.

It is understood that the buyer, in selecting and ordering from this catalog which supersedes all previous editions, accepts all terms and conditions of sale including the following:

Limited Warranty

We warrant, for a period of one year from the date of shipment of our product to you that our products shall be free of defects in material and workmanship, as shall be determined by our manufacturing standards, and shall conform to the description on the face of this order acknowledgment. THE WARRANTY DESCRIBED HEREIN SHALL BE IN LIEU OF ANY OTHER WARRANTY, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. The terms contained herein constitute the entire agreement of the parties and the warranty representations of the seller. There are no other representations, warranties, or guarantees applicable to the sale of our products unless otherwise expressly agreed to by us in writing.

Purchaser's Exclusive Remedy/ Seller's Express Limit of Liability

Purchaser's exclusive remedy for any warranty claim, or for any claim arising out of the purchase or use of our products, shall be the replacement of said products. We will replace our products, without charge to the purchaser, f.o.b. our point of shipment. We will not be liable for any consequential, incidental, or other damages sustained by purchaser, including but not limited to, loss of profits or revenue, loss of use of product, cost of capital, cost of substituted product, facilities, services, or claims of purchaser's customers for any damages. Any warranty claim of purchaser must be made within one year of the date of shipment of the product. This exclusive remedy applies regardless of the nature of purchaser's claim, whether in contract, tort, express or implied warranty, negligence or strict liability, upon which damages are claimed and regardless of whether the same is due to our negligence or any defect in our product.

WARNING:

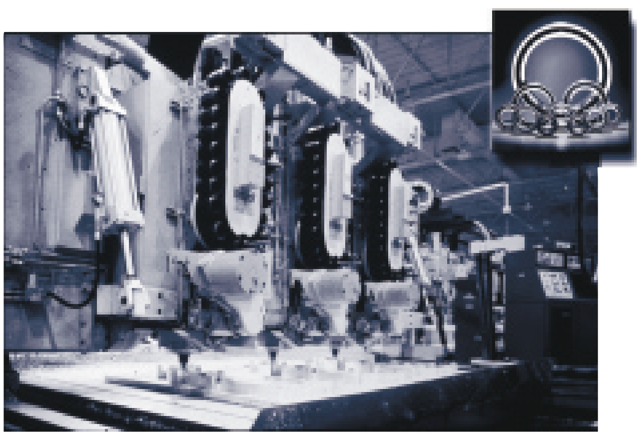
Failure to observe the following warnings could lead to a risk of serious bodily harm:

- **Proper maintenance and handling practices are critical. Follow equipment manufacturer's installation instructions. Failure to follow installation instructions and to maintain proper lubrication can result in equipment failure.**
- **Never spin a bearing with compressed air. The components may be forcefully expelled.**

The Bearing Selection Process

Timken provides such a wide variety of rolling bearing types and sizes – to the extent that the customer need not have to look elsewhere. Knowing that the bearing is perhaps the single most cost-effective and critical component within a moving assembly, Timken engineers have taken great steps to ensure the customer is receiving maximum value when a Timken bearing is specified to perform a given function. With the acquisition of the Torrington® and Fafnir® brands, Timken provides the proper bearing for virtually any motion control application. With over a century of proven experience in bearing technology, Timken is truly a world leader in the rolling bearing industry.

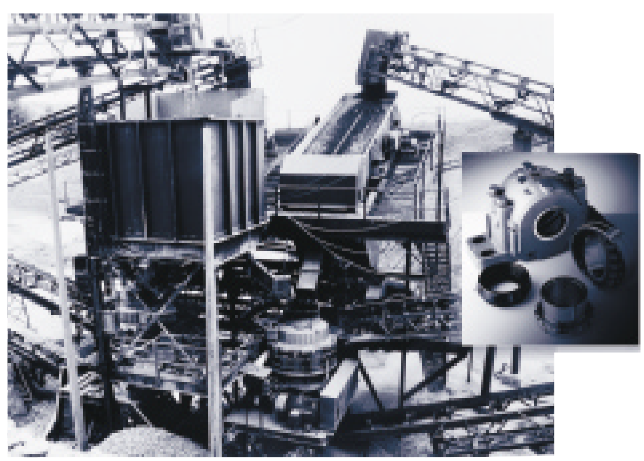
The Timken Company has an experienced, highly skilled staff of trained engineers, located around the world to assist the customer in bringing new, mechanized products to market. Timken engineers are a logical resource for customers to turn to when they must perform the appropriate selection of bearings in cases where the following considerations are needed:



- higher technical demands or higher levels of application experience
- higher levels of machine complexity
- serious, or critical applications where system failure must be avoided (or is paramount) for all modes of operation
- potential exposure to personal injury
- costly damge or downtime resulting from the use of an inappropriate bearing for a given task

Since Timken offers so many bearing configurations manufactured to serve specific situations, a recommended starting point in the selection process should focus on the assessment of some basic criteria. The bearing selection process includes comparing various key design parameters – besides those discussed here; trade-offs or compromises must be addressed such that the final choice is a reasonable balance of these factors. It's a wise practice to examine factors critical to the success of the device and possibly prioritize these, as in many cases a less-than-ideal solution is often found. A "perfect" bearing might carry an offsetting feature – such as high price or custom design. Each choice can affect performance, reliability and total (life cycle) cost.

Since the rolling bearing is an integral part of the machine, looking at the key operating parameters of the machine will help focus in on the most viable bearing solution. Typical considerations include: the lubrication type and delivery system; the bearing shaft and housing arrangement and material(s); the presence of adequate sealing to protect the rolling bearing components from outside contamination.



A sound selection procedure should first examine such basic service requirements as:

- rotational accuracy and repeatability (ie: service precision level)
- radial load, axial (thrust) load or their separate component forces
- speed, operating range or limits, acceleration and deceleration levels
- operating temperature range (including practical extreme limits)
- system rigidity

Secondary bearing selection criteria come from system application constraints to be considered, such as:

- maintenance procedures and intervals
- lubricating method (oil vs. grease)
- exclusion of contaminants; types of foreign materials possible (pressing between rolling element and raceway – where the bearing steel hardness requirement becomes significant)
- installation (handling requirements of the bearing, as well as shaft and housing preparation)
- other driveline dynamics; ex: thermal expansion, vibration control, shock loads, etc.

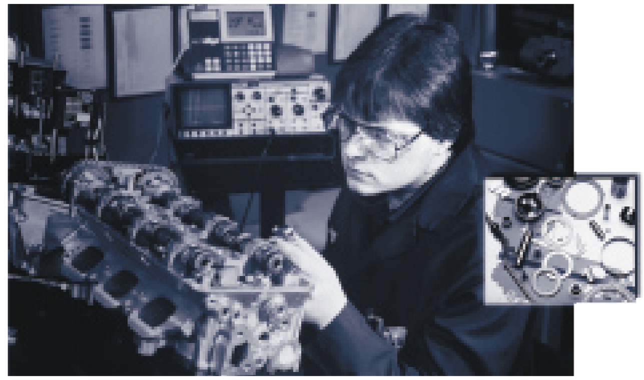
The bearing selection procedure should also include these steps:

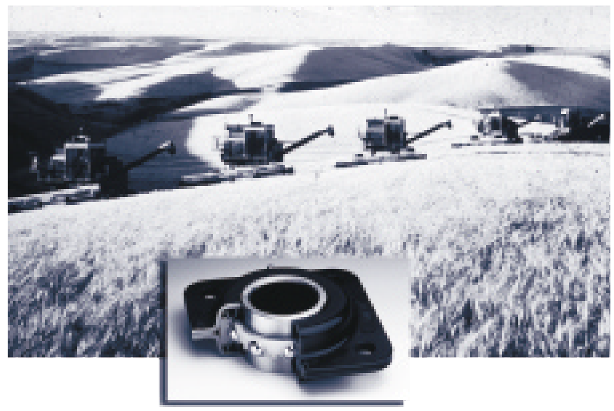
1) determine the bearing types which meet initial/basic requirements

2) final selection based on addressing various systems factors and performance goals

3) review bearing selection options and machine design basics with an experienced bearing sales engineer

4) optimization of controllable variables affecting bearing life (ex.: lubrication, maintenance, loading forces, etc.)





Size Selection

In the majority of cases, bearing bore size and shape will be dictated by the design of the machine (although alterations should be considered to facilitate not only the rolling bearing selection, but its installation and servicing). As a general rule: small shafts receive ball bearing supports while larger shafts might operate better with roller types. Other influencing properties regarding available space which affect bearing selection:

- the bearing cross section may be dependent on the dimensions of the machine cavity
- a separable bearing design might prove to be a preferred option
- using the machine's housing or shaft (or both) as a finished rolling element raceway. This is especially true of some roller or needle bearing types[1].

1) Sufficient surface finish and material hardness are usually necessary for this option.

Bearing Conditions

Pure radial loads typically warrant full complement bearings, due to their higher capacity, sacrificing higher speed capability. In situations where the loading forces are combined in axial and radial directions, some roller and needle bearing choices become excluded. If the thrust load is bi-directional, a pair of adjacent rolling bearings or a unitized bearing with two or more rows of opposing rolling elements could be a logical candidate for the given application.

Combined loads are typically managed using angular contact type rolling bearings (contact angle selection is determined by the ratio of axial to radial loads) – although a second, purely thrust loaded bearing may be introduced to handle higher thrust force components – apart from the radial bearing. "Universal" designs of this nature can easily be converted to a specially matched "set" for unique applications by Timken.

Some controllable factors having a significant impact on bearing performance include: mounting fits, internal clearances, lubricant type and integrity. For example, when using radial ball bearings, appropriate internal clearance is needed to ensure proper operation.

Other issues, such as axial displacement, must be addressed where shaft length differentials must be tolerated when thermal expansion occurs. For these (common) situations, the rotating component supports include a fixed (locating) and floating (non-locating) bearing arrangement.

The "fixed" bearing is subject to combination loads and is usually placed nearest the "working end" of the shaft to minimize axial motion and thereby maintain workpiece accuracy. Installation considerations for the typical fixed bearing positions should note the fitting recommendations listed in this catalog. These are compiled from a wealth of experience in a wide range of operating conditions.

Where "floating" bearings are necessary, the spindle design must allow for axial displacement of the shaft. This can be accomplished by allowing the bearing to "slide" its set of rolling elements laterally, (within one of its own raceways, as with separable type bearings) – or having the set of rolling elements in direct contact with an appropriately finished shaft (common with some cylindrical or heavy duty needle roller bearings) – sometimes achieved with a full complement set of rollers alone. For these cases, the bearing raceways (rings) should be mounted with an interference fit to prevent ring slippage (where slippage can lead to problems when the machine returns to its thermal resting state). This "separable" bearing choice also facilitates bearing installation. If a non-separable type is selected (such as a typical ball bearing), further machining of the shaft or housing cavity is required to achieve a looser fit. This not only alleviates the axial stresses on this end of the assembly, but will also facilitate bearing and shaft installation as well. When allowable, cylindrical bore bearing installation can be simplified with a choice of the "separable" design. An alternative might be to use a tapered bore design on a matching tapered shaft (or an adapter sleeve, if space permits – thus avoiding shaft modifications).

When the size of the machine increases, so do concerns about alignment. Shaft bending or additional loading can impart moment loads that need to be considered. Bearing selection must further consider installation practices with distant machined (bearing) housing cavities. Manufacturing limitations to position housing bores might encourage the choice of a self-aligning bearing type. These can help compensate for machining variations and manage dynamic forces by featuring a spherical outside diameter or thrust face.

With so many factors to consider for the successful operation of any device incorporating rolling element bearings, The Timken Company brings to its customers over a century of talent and experience to assist with these choices. Though the content in this catalog is an excellent start in the rolling bearing selection process, it should by no means be considered the final word. Timken bearing expertise is only a phone call away.

		Relative Operating Characteristics			Resistance to Elastic Deformation	
Rolling Element	**Bearing Type**	**Radial Capacity**	**Thrust Capacity**	**Limiting Speed**	**Radial**	**Axial**
Radial ball	Deep groove	fair	fair	high	fair	fair
	Maximum capacity	good	fair*	high	good	fair*
	Angular contact	fair	good*	excellent	fair	good*
	Double Row	high	fair	good	high	fair
Radial roller	Cylindrical roller (double flanged)	excellent	poor	high	excellent	poor
	Cylindrical roller (single flanged)	excellent	poor*	high	excellent	poor*
Radial needle roller	Drawn cup	good	unsuitable	good	good	unsuitable
	Heavy duty (with inner ring)	high	unsuitable	high	high	unsuitable
	Caged radial assembly	high	unsuitable	high	high	unsuitable
	Loose roller complement	excellent	unsuitable	poor	excellent	unsuitable
	Track roller	good	poor	fair	good	poor
Tapered roller	Single row	high	good*	good	high	good*
	1-row, steep angle	good	high*	good	good	high*
	Double row	excellent	good	fair	excellent	good
Spherical roller	Spherical radial roller	high	fair	good	high	fair
Thrust	Angular contact (ball)	poor	fair*	good	poor	fair*
	Ball thrust	unsuitable	good*	good	unsuitable	good*
	Cylindrical thrust	unsuitable	excellent*	fair	unsuitable	excellent*
	Tapered roller	poor	excellent*	fair	unsuitable	excellent*
	Spherical Thrust	poor	excellent*	fair	poor	excellent*
	Needle roller	unsuitable	excellent*	poor	unsuitable	excellent*

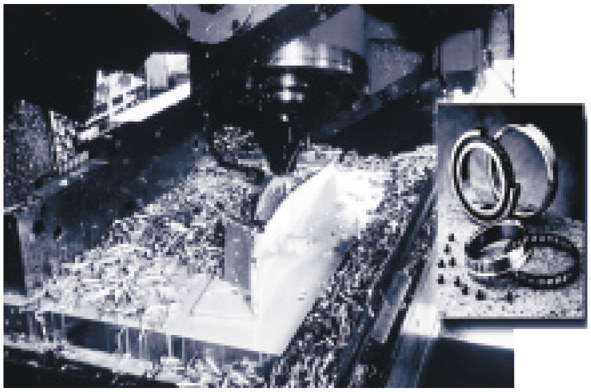
*Single-row bearings accept thrust load in one direction only.

The above matrix should be viewed only as a general recommendation for the customer to consider a reasonable area to begin the selection process. Bearing selection is not a clearcut, simplistic procedure, but rather a sequence of interdependent tasks which must take into consideration: customer goals, manufacturing economics, design expectations, and above all, human safety. It is always prudent to enlist the assistance of your local Timken sales engineer for achieving optimum results.

Timken
Super Precision Bearings

Catalog Benefits

This catalog will help design engineers select the right Timken bearing for new applications and guide them in their choice of the most suitable mounting arrangement for machine tool and other high precision applications. Furthermore, the catalog will assist our customers and their end users to specify the correct Timken product, should a bearing need to be replaced in future service intervals. In addition to manufacturing a superior product, Timken also provides unsurpassed technical services. Our highly qualified teams of Sales, Application and Service Engineers are willing to assist in all aspects of bearing design and application that contribute to the ultimate success of your operation. Considerable detailed information is also given in the Engineering chapter of this catalog.



Timken offers a wide range of products targeted for improving machining efficiency, cutting accuracy, and productivity. Qualified Sales and Service Engineers are available to help determine the appropriate solution for individual applications.

Super Precision Bearings

Manufacturers require machine tools that are extremely accurate, reliable, and capable of high levels of productivity. A major contribution to the performance of any machine tool is supplied by the anti-friction bearings used to support the spindles, rotating tables, ball screw and other critical, precision positions. A manufactured bearing's precision level has a major influence on the bearing's ability to perform in high speed applications – commonly seen in shop floor machining environments.

High speed bearings must manage the natural limits imposed by elevated operating temperatures. Current designs use strategies to lower friction (ex.: smoother raceway, better ball or roller grade, extreme control of dimensional variances, etc.) to lower operating temperatures. Another by-product of these measures of reduced friction and heat generation is quietness of operation and reduced vibration. When seeking a bearing design that minimizes noise, radial ball bearings are best suited to this challenge. Further enhancements in bearing noise and temperature control can be achieved by the use of ceramic rolling elements. Please contact your Timken sales or service engineer for your applications in which noise is a concern.

The rolling element retainer design also plays a significant role in high speed bearing selection. Because these components can contribute to friction and heat generation, cage material/design options should be evaluated when selecting a bearing.

Stiffness is not normally a critcal factor in common motion control applications. However, it becomes much more significant in precision machining applications. This impacts machine repeatability and running accuracy. Bearing stiffness is determined by the movement, or microscopic deflection under load within the bearing assembly. When high levels of stiffness are sought, roller bearings offer more stiffness than ball bearings. The stiffness characteristic of a given bearing can often be improved by adding a preloading force within the bearing assembly. Caution must be used as preloading can generate additional heat in the bearing system.

System		Bearing Type	Precision Bearing Class			
Metric	Timken	Tapered Roller Bearings	C	B	A	AA
	ISO/DIN	All bearing types	P5	P4	P2	—
Inch	ABMA	Tapered Roller Bearings	3	0	00	000
		Roller Bearings	RBEC5	—	—	—
		Ball Bearings	ABEC5	ABEC7	ABEC9	—

Which type of Timken bearing is most appropriate for your super precision application?

In addition to precision level the majority of machine tool related bearing applications must primarily address three major performance requirements: *speed*, *stiffness*, and *load handling capability*.

Today's industrial machining environments stress maximum production rates. To reach these high metal-removal goals, machines are running at maximum speeds with working spindles tuned to provide premium running accuracy. Apart from the spindle system configuration, the designer should choose a high-speed, Timken super precision bearing which will help achieve the target job requirements and provide the essential number of production hours.

Tapered Roller Bearing vs Ball Bearing Maximum Permissible Speed (with synthetic high speed grease)

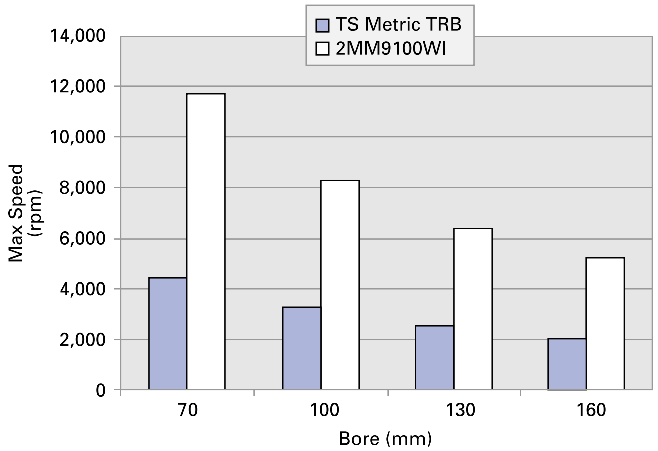


Figure 1-1

Tapered Roller Bearing vs Ball Bearing Radial Stiffness Comparison

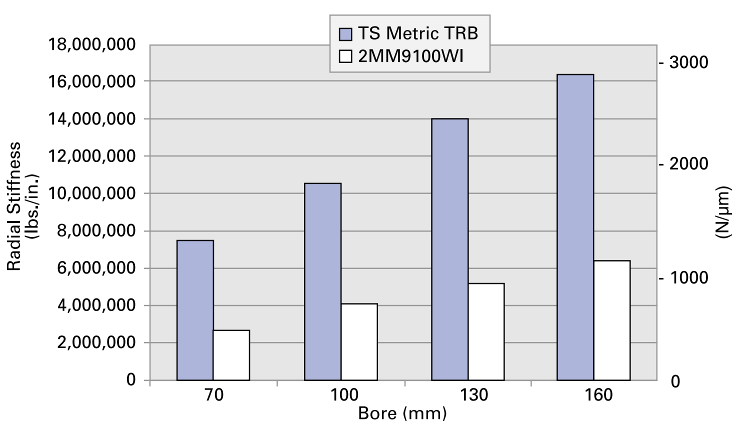


Figure 1-2

Precaution: because the bearing selection process is so critical to the success of your business operation, one can always enlist the technical assistance of a qualified Timken engineering professional when needed to determine the specific Timken® bearing most appropriate for your specific application.

Speed

Achievable spindle rotating speeds can be adversely affected by heat generation within the bearing assembly. The bearing's ability to not only minimize heat buildup, but also expel excess heat is a crucial consideration in the bearing selection process. Because of the differences in rolling element contact geometry, ball bearings are superior in minimizing heat generation where higher speeds are an issue. Figure 1-1 compares the relative difference of similar cross-section ball and tapered roller bearings (both using synthetic grease as a baseline lubricant). Therefore, where applications concerned with higher rpms levels as the primary issue, ball bearings have a distinct advantage. Some relative guidelines concerning *dN* values (ball bearing) and *rib speed* (tapered roller bearings) that have been established and are used by Timken engineers to focus on the relationship of speed and rotating mass are further described in later chapters of this catalog.

Consult the topics addressing speed capability in the respective chapters of this catalog for more detailed information regarding ball bearings or roller bearings for more information to refine your choice.

Bearing Stiffness

Because the bearing's stiffness contribution to the global system stiffness can be a major factor, it is of prime importance to consider the effect of the bearing selection and geometrical characteristics of the bearing. A tapered roller bearing is a line contact bearing with a high number of rolling elements. Compared to other popular bearings in spindle applications such as angular contact ball bearings (point contact) or cylindrical roller bearings (line contact), the preloaded tapered roller bearing (line contact) has a significantly higher radial stiffness in the same given envelope.

Comparisons (fig. 1-2) show that a tapered roller bearing has as much as 4 to 6 times more radial stiffness than a comparable size angular contact ball bearing, and twice as much as a comparable size cylindrical roller bearing, for a zero clearance condition. Therefore, for most spindle applications only two tapered roller bearings are required, which can result in a more economical solution.

Bearing stiffness also depends on bearing load zone, which is directly related to bearing setting, clearances, and applied loads. A bearing with zero endplay/zero preload has a load zone close to 180°, while a bearing with preload can reach 360° load zone. Fig. 1-3 shows the effect of load zone on tapered roller bearing stiffness. The curves show that the amount of load on the bearing has a relatively small influence on bearing stiffness, compared to the influence of setting. This applies to ball and cylindrical roller bearings as well. It can be seen that changes of setting due to changes of thermal expansion of the spindle - bearing - housing system play a very important role in the resulting static and dynamic stiffness of a spindle system.

An inherent advantage of the tapered roller bearing is that it can be adjusted after mounting. This means that the optimum stiffness can be obtained either by determining the proper setting during the mounting phase for a simple bearing arrangement (2TS), or during running by the use of a variable preload bearing design (see page 211).

Housing Stiffness

Experience and basic calculations show that good axial and radial housing stiffness are required to support the loads that are transmitted through the bearings. In most machine tool designs, the housing is normally adequate. However, when light sections or nonferrous housings are used, the axial and radial housing stiffnesses should be verified.

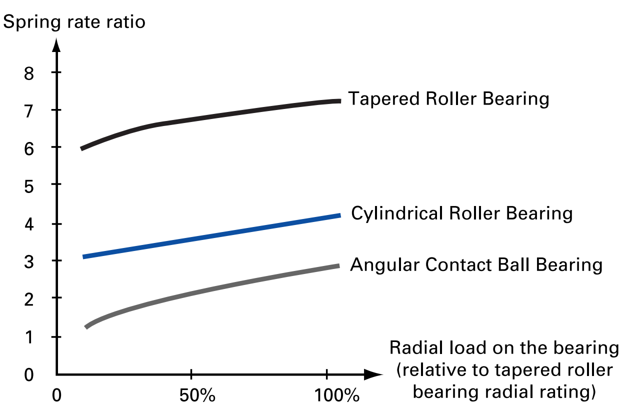


Fig. 1-4
Radial spring rate comparison between popular machine tool bearings of a comparable size under zero internal clearance.

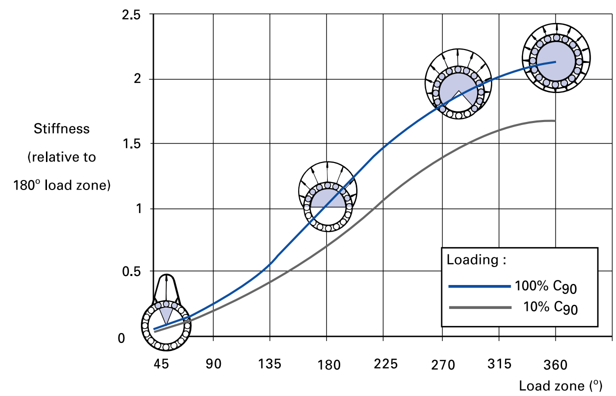


Fig. 1-3
Effect of load zone on bearing stiffness

Stiffness

Bearings have a significant effect on spindle stiffness because of the deflection they experience while under cutting loads. Being able to minimize this deflection is paramount in achieving the required levels of cutting accuracy needed to produce finished parts within specified tolerances. Less variance in finished parts demonstrates better quality and keeps scrap levels at a minimum. Because of their internal geometry and rolling element type, tapered roller bearings provide considerably higher stiffness levels as shown in Figure 1-4 and 1-5 (adjacent page).

To better manage the load sharing of the set of rolling elements, Timken offers various preload levels for ball bearings, plus a self-compensating "variable preload" type of roller bearing style. Be conservative with the addition of preloading as these forces will contribute to heat generation and thereby reduce the maximum permissible speed of either bearing design.

Consult the topics addressing bearing stiffness in the respective chapters of this catalog for more detailed information regarding ball bearings or roller bearings for more information to refine your choice.

Load Capacity

The ability for spindle bearings to carry high loads will be important in certain applications. These loads can be properly distributed among the rolling elements by providing a permanent force called *preload*. While Timken posts its load capacities in the product tables within this catalog, many applications often approach only a fraction of those limits. For example, workpiece finish may determine the feed rates needed in an application thereby minimizing the importance of bearing capacity.

Figure 1-6 compares the levels of static capacity of ball vs. tapered roller bearings for the benefit of contrasting basic load capability of both bearing types.

Consult the topics addressing static and dynamic load capacity in the respective chapters of this catalog for more detailed information regarding ball bearings and roller bearings to refine your choice.

Conclusion

From this brief discussion and the additional, supporting technical content within the respective chapters of this catalog, one now has an indication which rolling element type should be further investigated to meet the given set of production goals and performance expectations. Timken cannot overemphasize its willingness to participate in the final bearing selection to help you achieve your precision machining production goals. Timken's staff of application engineers are ready to put their vast experience to any test for assisting our customers when it comes to challenging bearing applications commonly found in the machine tool industry. To refine your search, please turn to the chapter covering Timken tapered roller bearings (Chapter 2) or Fafnir ball bearings (Chapter 3) for more information needed to obtain a complete Timken part number specification.

Timken Precision Tapered Roller Bearings

Some applications require a level of precision that cannot be acheived with standard tapered roller bearings. Timken precision tapered roller bearings promote and maintain the operating accuracy required of today's machine tool industry and various related, specialized markets. Precision class tapered roller bearings offer machine tool builders an economical design solution that exceeds most application needs for rotational accuracy and rigidity.

The Timken Company manufactures all of its precision tapered roller bearings (below 315 mm OD) in a plant dedicated exclusively for that mission. This includes high speed designs with a variable preload capability for optimum machining, and Precision Plus™ bearings – having an overall radial runout less than a single micron. Timken's high precision tapered roller bearings consist of carefully matched components which also offer an added degree of fine tuning in the bearing setting and adjustment procedure to maximize customer machine productivity.

The application of precision tapered roller bearings is not just limited to machine tools. Wherever spindles turn and rotational accuracy is essential to the machine's performance, precision tapered roller bearings can prove an excellent choice. Other typical applications are printing presses, optical grinders, profile cutters, indexing tables, precision drives, measuring gauges and ball screw drive applications.

The significance of the machine tool market segment is matched by Timken's commitment to having a plant focused on manufacturing only premium precision bearings. With this level of dedicated resources, the precision quality is built into the bearing during manufacture and is not achieved by selecting from standard bearings. To further increased service reliability, Timken precision tapered roller bearings are manufactured from high-quality, carburized-steel alloys.

Tapered Roller Bearing vs Ball Bearing
Axial Stiffness Comparison

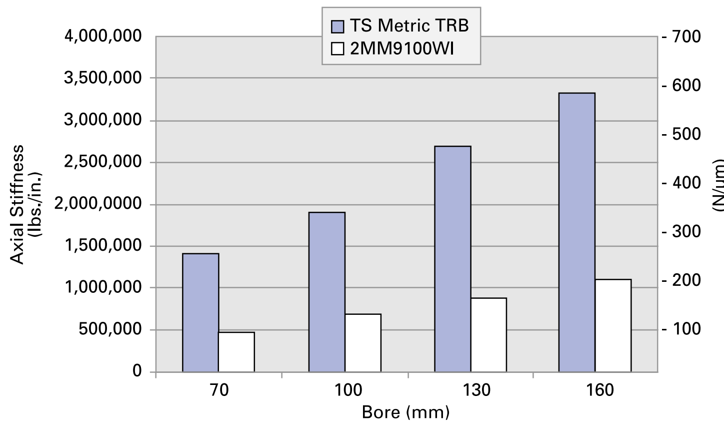


Figure 1-5

Tapered Roller Bearing vs Ball Bearing
Static Capacities

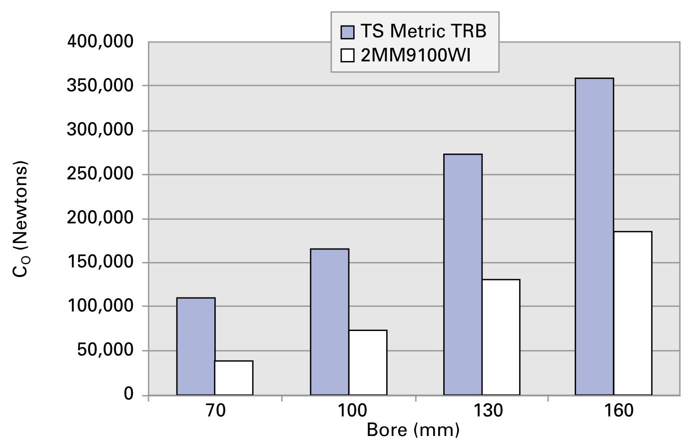


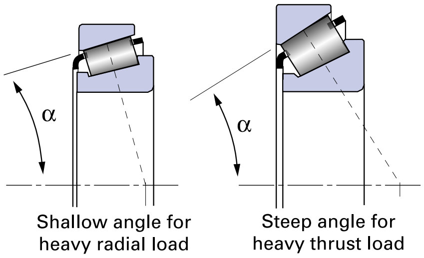
Figure 1-6

Basic Tapered Roller Bearing Design

The fundamental design principles of the tapered roller bearing make it an ideal solution for low speed/high load or low speed/high stiffness requirement machine tool applications.

Combined Radial and Thrust Load Capability

The angled raceways allow the tapered roller bearing to carry combinations of radial and thrust loads. The angularity of the bearing is often described by a factor called "K". This factor is the ratio of Timken basic dynamic radial load rating (C_{90}) to Timken basic dynamic thrust load rating (C_{a90}) in a single row bearing. For a bearing with a ribbed cone (the most common design), it is a function of the half-included cup angle α and can be found listed with the bearing part numbers in chapter 2. The smaller the K factor, the steeper the bearing angle. (See figure 1-7).



$$K = \frac{C_{90}}{C_{a90}} = \frac{0.39}{\tan(\alpha)}$$

Fig. 1-7
Designs to support radial and thrust loads in any combination.

True Rolling Motion

True rolling motion of the rollers and line contact on the raceway allows the bearing to run cooler and improves spindle stiffness and accuracy as compared with other roller bearing types. The true rolling motion is the result of two design features: the taper of the roller and the contact between the spherical surface ground on the large end of the rollers and the race rib. The rollers are designed in such a way that extensions of the lines along the roller body converge towards the centerline of the bearing and meet at an apex on this centerline (fig. 1-8). As a result, there is no relative slip between the rollers and races.

The tapered configuration of the roller not only ensures that the surface speeds of the rollers and races match at every point along the roller body, but also generates a seating force which pushes the rollers' spherical ends against the race rib. This desirable seating force is a function of the different angles of the outer and inner races (fig. 1-9 – vector diagram) and prevents rollers from skewing off apex. No skew means positive roller alignment, thereby enhancing bearing life, stiffness and accuracy.

Precision Classes for Tapered Roller Bearing Applications

• Low precision machines • Drilling machines • Conventional lathes • Milling machines • Precision gear drives	Class C or 3	• Grinding machines • Jig boring machines • Work piece spindles (of cylindrical grinders)	Class A or 00
• NC lathes • Milling / boring machines • Machining centers	Class B or 0	• High accuracy machines • Precision measuring instruments • Special applications	Class AA or 000

Manufacturers of precision machines have at their disposal vast resources of engineering data and application information to select the right bearing class and tune the critical components so that the machine tool achieves its performance objectives. The adjacent table can be considered as a general guideline.

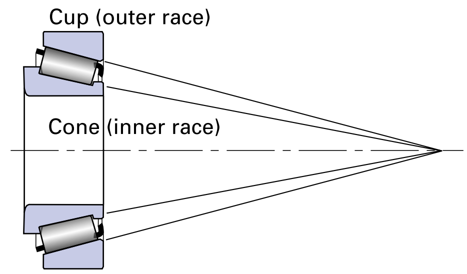


Fig. 1-8
On-apex design results in true rolling motion at all points along the roller body.

Precision Tapered Roller Bearing Types

The size range of Timken precision bearings starts from less than 20 mm bore and extends to over 2000 mm OD, depending on bearing type. The most popular tapered roller bearing types made in precision classes are the single row bearings: Timken types **TS** and **TSF** as shown in chapter 2. These bearing types are supported by a range of special bearings which have been designed for machine tool applications, such as the variable preload **Hydra-Rib** bearing, the high speed **TSMA** bearing, and the compact **TXR** crossed roller bearing – which are available only in precision classes. Timken also offers a selection of 2-row precision tapered roller bearings: types **TDO** and **TNASWH**.

To further minimize the influence of variations, Timken offers a level of precision bearing manufacture so tightly controlled that it goes beyond the grade levels of both ISO and ABMA standards. Timken's Precision Plus™ line offers (inch-nominal) *000* and (metric-nominal) *AA* level tapered roller bearings in various sizes and styles.

Crossed Roller Bearings

A crossed roller, or **TXR** bearing, is effectively two sets of bearing races and rollers brought together at right angle to each other, with alternate rollers facing opposite directions, within a section height not much greater than that of a single row bearing. Also, the steep angle, tapered geometry of the bearing causes the load-carrying center of each of the races to be projected along the axis, resulting in a total effective bearing spread many times greater than the width of the bearing itself.

Because of the ability of the crossed roller bearing to withstand high overturning moments, it is ideal for the table bearing of machine tools such as vertical boring and grinding machines, and numerous other pivot and pedestal applications where space is limited or the lowest possible center of gravity of a rotating mass is required.

Crossed roller bearings are available in two precision classes:

- Metric system Class S and P
- Inch system Class 3 and 0

The most usual form of the bearing is type **TXRDO**, which has a double outer race and two inner races, with rollers spaced by separators.

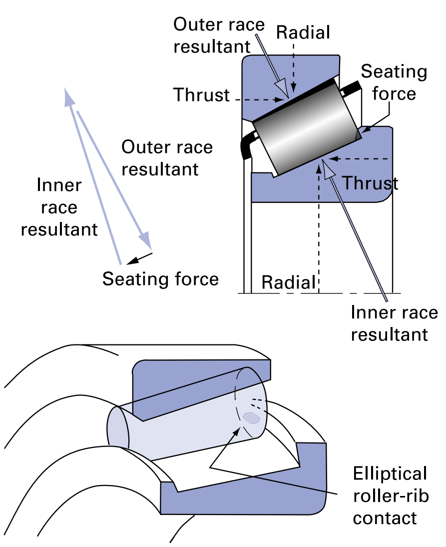
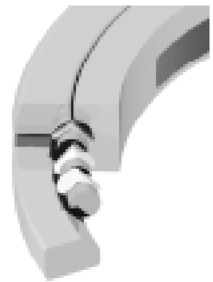


Fig. 1-9
Small seating force from the inner race rib keeps rollers aligned on the raceway.

TXRDO



TXR

Other mounting configurations and sizes of crossed roller bearings can be supplied to meet particular assembly or setting requirements. Please contact a Timken Company Sales Engineer for further information. Also, refer to chapter 2 for more details.

Timken Fafnir® Super Precision Ball Bearings

Fafnir Super Precision Bearing Design

The Timken Fafnir line of Super Precision machine tool ball bearings is manufactured to ABEC7/9 (ISO P4/P2) tolerance levels. Timken manufactures all Super Precision ball bearings to surpass ISO/ABMA criteria to ensure that the end users receive only the highest quality product to maximize machine performance. Super Precision ball bearings can be classified within two distinct categories:

- Spindle Bearings: angular contact radial and deep groove radial ball bearings
- Ball Screw Support Bearings: angular contact thrust ball bearings

Spindle Bearings are the most popular type of super precision ball bearing in use in the machine tool industry. These angular contact bearings are used primarily in precision, high-speed machine tool spindles. Timken manufactures Super Precision machine tool bearings in four metric ISO dimensional series. In addition, because of specialized variations of bearing design and geometry, Timken offers a total of seven bearing types within these four basic series:

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

WI-type bearings are designed to maximize load carrying capacity of the various bearing cross-sections (WI, WN, HX) and are used in low to moderate speeds. The HX is Fafnir®'s proven high speed design. It has a significant advantage at higher speeds, generating less heat and less centrifugal loading forces. The 99100WN series is generally a compromise between the WI and HX as it offers higher speed capability than the WI, but lower capacity and higher stiffness than the HX design, with lower speed capability.

Most of the bearing types are available in either 15° (2MM) or 25° (3MM) contact angles. In addition, Timken now stocks more ceramic ball sizes than ever before. With our "Quick Change" program (see chapter 5) we now have the ability to supply almost every bearing with the ceramic complement option. Contact your local Timken Sales Engineer for availability.

The Conrad Super Precision radial machine tool bearing is generally used on applications where capacity and stiffness do not require a duplex set of bearings. By virtue of the single row, radial deep groove construction, and super precision level tolerances, these are capable of carrying thrust loads in either direction and have a relatively high-speed capability — especially if a light axial preload is applied. Timken offers Conrad Super Precision radial machine tool bearings in the following ISO dimensional series:

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

Ball Screw Support Bearings

To meet the demands of the servo-controlled machinery field, the Timken Fafnir ball screw support bearings are specially designed with steep contact angles and offer high levels of stiffness for ball screw application requirements. Timken's most recent product offering in this area is a series of double-row, sealed, flanged (or cartridge) units which use a integral double row outer ring to help simplify installation procedures. Timken offers the following ball screw support bearing products:

- Inch Series bearings (MM9300)
- Metric Series bearings (MMBS)
- Flanged Cylindrical Cartridge housings (BSBU)
- Pillow Block housings (BSPB)
- Integral Double Row units (MMN, MMF)

Performance

The performance of a super precision bearing is not completely defined by the ABEC/ISO classes. The latitude of these classes allows for a significant range of variability in product performance among bearing manufacturers. Characteristics such as raceway curvature and uniformity;

the balls' conformance to sphericity; race and ball surface finish; waviness of contact areas; preload offset tolerance; cleanliness; calibration of envelope dimensions; matching of bearings within a set; cage design and material; lubricant; radial play; contact angle and precision of ball complement **are not** defined by ABEC/ISO. All have a direct impact on the service life and performance of a bearing. The lack of a comprehensive standard allows inferior bearings to be marketed as ABEC7 (or 9)/ISO P4 (or P2) without the ability to produce superior performance. **All** Timken MM, MMV, and MMX precision grades comply with strict controls over these non-specified parameters, to provide premium performance.

Optimized Grades of Precision

MM, MMV – Super Precision, Super High Precision

(ABEC7/9; ISO P2/P4)

Super precision bearings manufactured to the MM(V) tolerance class operate with running accuracy and performance levels meeting ABEC9 (ISO P2) yet maintain noncritical features at ABEC7 (ISO P4) level for cost-effectiveness. Bore and O.D. surfaces are coded in micron units for the convenience of the discriminating machine tool builder striving for optimum fitting of crucial spindle components.

MMX – Ultraprecision

(ABEC9, ISO P2)

Super Precision bearings with closer tolerances and running accuracies than ABEC7 (ISO P4) bearings are made to ABEC9 (ISO P2) tolerances. Bearings produced to these tolerances are generally used on ultra-high speed grinding spindles designed for tight dimensional tolerances and super-fine surface finishes. Contact your local Timken Sales Engineer for availability of product range.

Superior Bearings from Timken

Dimensional tolerance limits 100 times finer than a human hair (and for ultra-critical requirements: less than a single micron) are consistently reached with state of the art manufacturing technology pioneered through the Timken, Torrington and Fafnir brands. For over 50 years, Timken has produced a wide range of machine tool precision class bearings delivering superior accuracy and operation control for critical applications. The Timken Company offers a wide range of advanced engineered products with specific value-added features designed to meet our customers' application requirements. This includes a full line of bearing types of the highest industry precision levels - in ball bearings, tapered roller bearings and crossed roller bearings.

The Timken Difference

The impact of advancements in Timken Super Precision bearing technology cannot be overstated. Consider the vast differences in the quality, efficiency, and precision in industries such as the automobile and computer hardware over the past twenty years. The driving forces in these and many other industries have leveraged the incremental improvements seen in Super Precision bearings to their advantage. The significantly enhanced running accuracy of the machines used to manufacture everything from finished engine blocks to ultra-precise laser disk drives enable industrialized nations to enjoy a standard of living and accessibility unimagined only a generation ago. Timken truly helps shape the world of tomorrow, today.

Timken Precision Tapered Roller Bearings

The Timken bearing numbering system has evolved over the years to accomodate the various international standards put forth by both the ISO and ABMA organizations. To retain the integrity of Timken's proven, initial designs and to support its extensive customer base, Timken honors the key numbering schemes as they have developed in the tapered roller bearing industry and as indicated here.

Original Timken System

(cone) - (cup)

Ex:399A-394A (see common component/suffix)

- Family -design bearing group around a common roller (qty. & angle CAN vary)
- Components (cups, cones, rollers) get unique part numbers

	Ex.I	Ex.II	Comment
Cup	399	52618	Component # > series #
Series	395	52500	
Cone	394	52400	Component # < series #
Roller	300		Common, basic roller design

ISO 355 (Application Oriented) Numbering System

(cone) - (cup)

Ex: JP10049-JP10010-B

10-B: see common Component & Suffix Fields

"J" Prefix
metric nominal bearings

Duty (alpha) field
[C/D/F]: general purpose
[N]: gen'l.purpose+pinion
[P]: high speed
[S/T]: pinions
[W]: high thrust loading

Cone bore (in mm)

Component Field (final 2 digits of PN)

Series	00 (indicated by zeroes) Ex: 870**00**; 366**00**
Cups	10 thru 19; 20 **up** thru 29 (thinnest cup section is #10)
Cones	30 thru 49; 29 **down** thru 20 (thinnest cone section is #49)
Rollers	01 thru 04
Cage	05 thru 09

[Overflow numbers: 50 thru 99 as needed]

Suffix Code Field (1 to 3 letters max.)
Examples typical in Super Precision applications:

[B]:	flanged cup
[HR(A)]:	HydraRib design; (modified cup from std.)
[P(H)]:	Customized for performance; (non-interchangeable component)
[E]:	(exclusive) non-interchangeable component

All members in a Series use the same roller and included angle; interchangeable components can occur

ABMA Numbering System (for inch and metric radial bearings)

(cone) - (cup)

Ex: JLM722948-JLM722912

12: see common Component & Suffix Fields

"J" Prefix
metric nominal bearings

Duty Code Field
EL: Extra light
LL: Lighter than light
L: Light
LM: Light-medium
M: Medium
HM: Heavy medium
H: Heavy
HH: Heavier than heavy
EH: Extra heavy
T: Thrust ONLY

Angularity Code Field

1	0 < 24º
2	24º < 25.5º
3	25.5º < 27º
5	28.5º < 30.5º
6	30.5º < 32.5º
7	32.5º < 36º
8	36º < 45º
9	45º+ (excluding pure thrust)
0	(thrust only)

Series Code Field

(Cone bore) over-incl.

inches	mm	Code
<1"	<25.4	00 to 19
1-2	25.4-50.8	20 to 99;000 to 029
2-3	50.8-76.2	030 to 129
3-4	76.2-101.6	130 to 189
4-5	101.6-127.0	190 to 239
5-6	127.0-152.4	240 to 289
6-7	152.4-177.8	290 to 339
7-8	177.8-203.2	340 to 389
8-9	203.2-228.6	390 to 429
9-10"	228.6-254.0	430 to 469
10-11	254.0-279.4	470 to 509
11-12	279.4-304.8	510 to 549
12-13	304.8-330.2	550 to 570
13-14	330.2-355.6	580 to 609
14-15	355.6-381.0	610 to 639
15-16	381.0-406.4	640 to 659
16-17	406.4-431.8	660 to 679
17-18	431.8-457.2	680 to 694
18-19	457.2-482.6	695 to 709
19-20	482.6-508.0	710 to 724
20-21	508.0-534.4	725 to 739
21-22	534.4-558.8	740 to 754
22-23	558.8-584.2	755 to 769
23-24	584.2-609.6	770 to 784
24-25	609.6-635.0	785 to 799
25-30	635.0-762.0	800 to 829
30-35	762.0-889.0	830 to 859
35-40	889.0-1016.0	860 to 879
40-50	1016.0-1270.0	880 to 889
50-72.5	1270.0-1841.0	890 to 899
>72.5	>1841.0mm	900 to 999

ISO/DIN	MM	P5	P4	P2	–
TIMKEN	MM	C	B	A	AA
	IN.	3	0	00	000
		ABMA			

Assemblies (Suffix Codes)

- 5 digit code:

[Assy.No.]+[Timken code]+[Component list code(1st field is Precision class)]

Ex: 90B01 [Timken (internal) numbering system]

- (code is created at entry of initial custom order)
- For dedicated component assemblies: Cone PN+5-digit code; Ex: LM48548-9K2A7
- For interchangeable capable components: [cone PN]-[cup PN]; Ex: 29585-29520

Inspection Codes

- 5 characters (as 3 fields)

Component: [Precision Class]+[Timken code]+[Perf.code]

Ex: C0030

Special Packaging

Timken Precision tapered roller bearings are shipped in boxes which employ a white colored box flap (vs. orange for standard bearings).

Identification Tags

(see the adjacent page for a detailed description of the use and purpose of component or assembly attached identification tags)

Precision Level

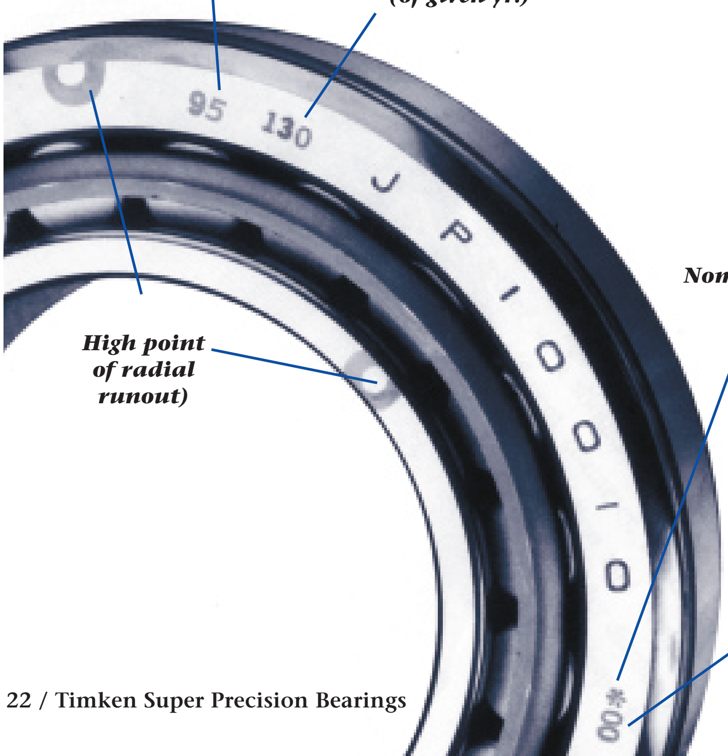
- Indicated at Inspection code designation (see next)
- Each component gets Precision level assignment code (tolerance and runout values are given in chapter 4)

  Note tolerance structure differences within nominal inch and metric bearings

Performance Codes

- printed on bearing box
- 3 digits; 900+ variations (Contact Timken Engineering)
- indicates non-standard requirements of the given Precision Class
- given to individual components (by Timken Customer Engineering Department)
- organized by Precision class or letter

Other Markings



[For non-tagged products]
Nominal(Bore or OD) deviation indicator:

	Inch	Metric
Symbol	(Over/Incl.)	(Over/Incl.)
*	0/+.0001	0/-2.5µm
**	+.0001/+.0002	-2.5µm/5µm

Tag Markings

Bearings tag markings are a device to indicate accuracy of bearings and facilitate selective assembly.

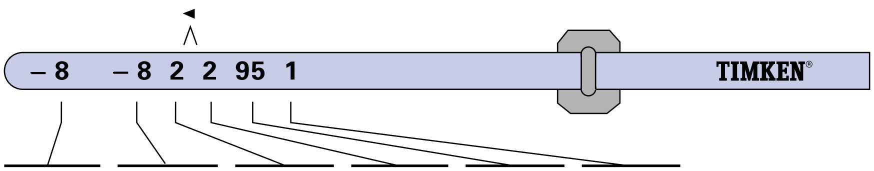
The information given on the tag varies by metric and inch systems, bearing class and type.

All components more precise than Class C or 3 cones and cups are supplied as matched assemblies and are shipped as complete bearings.

1. Metric system precision bearing tag markings

◀ Tag markings on class A only

Tags shown below are supplied with all Class A single row matched assemblies. Class B cups and cones are tagged if indicated on the performance code.



FIRST NUMBER Indicates average deviation in cone bore from nominal dimension. *Use Chart 1 (Appendix)*

SECOND NUMBER Indicates average deviation in cup OD from nominal dimension. *Use Chart 1 (Appendix)*

THIRD NUMBER Indicates runout (total indicator reading) of cone assembly. *Use Chart 2 (Appendix)*

FOURTH NUMBER Indicates runout (total indicator reading) of cup. *Use Chart 2 (Appendix)*

FIFTH NUMBER Indicates year of manufacture: 95 ..... 1995 96 ..... 1996 etc. *Found only on matched assemblies.*

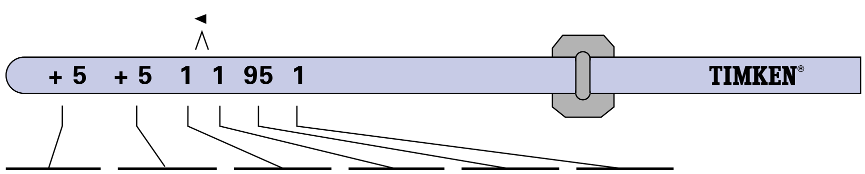
SIXTH NUMBER Indicates numerical number of bearing in yearly manufacture. *Found only on matched assemblies.*

TS-TSF

2. Inch system precision bearing tag markings

◀ Tag markings on class 00 only

Tags shown below are supplied with all Class 00 cups and cones. Class 0 cups and cones are tagged if indicated on the performance code.



FIRST NUMBER Indicates average deviation in cone bore from nominal dimension. *Use Chart 3 (Appendix)*

SECOND NUMBER Indicates average deviation in cup OD from nominal dimension. *Use Chart 3 (Appendix)*

THIRD NUMBER Indicates runout (total indicator reading) of cone assembly. *Use Chart 4 (Appendix)*

FOURTH NUMBER Indicates runout (total indicator reading) of cup. *Use Chart 4 (Appendix)*

FIFTH NUMBER Indicates year of manufacture: 95 ..... 1995 96 ..... 1996 etc. *Found only on matched assemblies.*

SIXTH NUMBER Indicates numerical number of bearing in yearly manufacture. *Found only on matched assemblies.*

TS-TSF

* Second number marked only on Class 3 product over 304.8 mm (12 inches) cup O.D.

Introduction

Timken tapered roller bearings have been used for many years in machine tool applications due to their widely recognized advantages in stiffness, load carrying capacity, precision and reliability over other bearing designs.

The use of new ceramic and CBN cutting tools, together with increased spindle motor powers has allowed much higher cutting speeds to be achieved in many applications. To maintain the same global accuracy level at the higher cutting speeds poses a challenge to develop optimum spindle designs. The Timken Company has met this challenge by developing:

- Special internal bearing geometry
- Innovative bearing designs
- Progressive range of layouts for high speeds

Technical information is provided in the Engineering chapter of this catalog to assist the designer to select the right bearing arrangement for a given application.

Because of their high capability to carry loads together with a relatively low level of applied loads in the machine tool industry, precision tapered roller bearings are rarely replaced for fatigue failure. As a consequence, the bearings are mainly replaced when a global loss of precision of the machine is observed leading to a complete refurbishment of the machine. At this stage, it is advisable to replace the bearings, even if they may appear to be in good condition; they may be worn to a point where the accuracy is no longer effective.

Bearing Replacement

The best practice is to install a bearing of an equivalent precision class to the original equipment recommended by the builder.

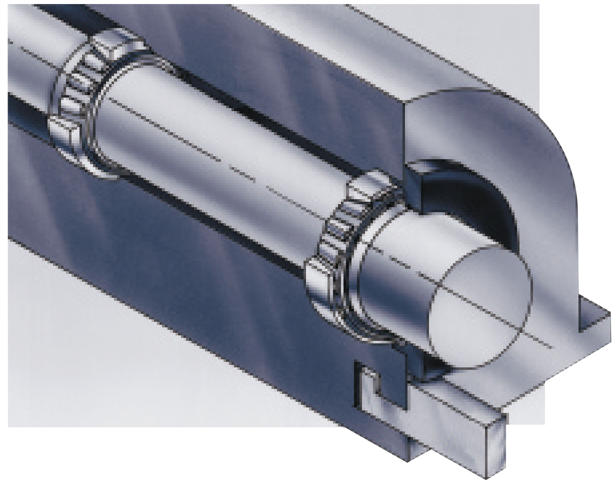
Both inner and outer races have to be replaced to guarantee the same accuracy level as the original equipment.

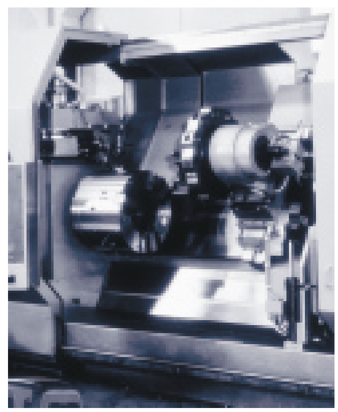
Even if a machine is judged as an old machine after several years of service, it is not recommended to fit standard class bearings in place of the original precision ones; this practice would probably result in uncontrolled movements of the spindle due to the higher bearing runout of standard bearings, leading to poor accuracy of machined pieces and premature tool wear.

Inspection

The replacement of the bearings on any precision equipment is not necessarily sufficient to restore the original accuracy. If the surrounding components (spindle, housing, nut, spacer) show drastic defects in size or form, the bearing will simply transmit the consecutive default to the work-piece. The total runout of the system is the combination of the runout of each component. A precision bearing will add no more runout than is specified by the bearing class, but it will not reduce any runout already present from the spindle and housing.

Careful inspection of the adjacent components followed by an appropriate refurbishment, if needed, must be made before remounting. Particular points to be checked are geometry (roundness, cylindricity, concentricity), surface finishes (nicks, burrs), sizes and resultant fitting practice.





Remounting

The rules described in the Engineering section apply exactly in the same way for replacement purposes as for original equipment.

Precision Bearing Types

The most popular bearing types made in precision classes are the single row bearings, types TS and TSF and the two-row bearings, types TDO and TNASWH.

These bearing types are supported by a range of special bearings, which have been designed for machine tool applications such as the variable preload Hydra-Rib™ bearing, the high speed TSMA bearing and the compact TXR crossed roller bearing, which are available only in precision classes.

The size range of Timken precision bearings starts from less than 20 mm bore and extends to over 2,000 mm outside diameter, depending upon bearing type.

The importance of this market segment is demonstrated by The Timken Company's commitment to having a dedicated precision plant. This simply means that the precision quality is built into the bearing during manufacture, and is not achieved by selecting from standard bearings. For increased reliability, Timken bearings are manufactured from high quality alloy carburizing steels.

The application of precision tapered roller bearings is not just limited to machine tools. Wherever spindles turn and rotational accuracy is essential to the machine's performance, precision tapered roller bearings are encountered. Other typical applications are printing presses, optical grinders, profile cutters, indexing tables, precision drives and measuring gauges.

Bearing types marked * are described in detail in the bearing data tables at the end of this publication.

Single row bearings

TS – single row*

This is the basic and the most widely used type of tapered roller bearing. It comprises two main, separable parts: the inner race assembly and the outer race. It is usually fitted as one of an opposing pair.

During equipment assembly single row bearings can be "set" to the required clearance (endplay) or preload condition to optimize performance.

TSF – single row, with flanged outer race*

Variation on the basic single row bearing, type TSF has a flanged outer race to facilitate axial location and accurately aligned seats in a through-bored housing.

Two-row bearings

TDO – double outer race

This has a one-piece (double) outer race and two single inner races and is usually supplied complete with an inner race spacer as a pre-set assembly. This configuration gives a wide effective bearing spread and is, therefore, frequently chosen for applications where overturning moments are a significant load component. TDO bearings can be used in fixed (locating) positions or allowed to float in the housing bore, for instance to compensate for shaft expansion.

TNASWH – non adjustable, heavy duty, double outer race

This is a two-row bearing assembly with two inner races and a one piece outer race. The outer race has a heavy wall section, which is self-supporting, allowing the bearings themselves to be used directly, for example, as steady-rest rollers, in sheet and strip levellers. The outer race is extended at both ends and counterbored to accept stamped closures, and the bearings can be supplied with these ready fitted as a unit assembly (but not pre-lubricated). Rubbing seals are also available for certain sizes.

High speed bearings

For many applications, notably in the machine tool industry, bearings are required to run at speeds in excess of those for which standard bearings are designed.

TSMA – single row, with axial oil provision

The TSMA type is a single row bearing with a special provision for lubrication of the critical roller-rib contact area to ensure adequate lubrication at high speeds. The concept works by capturing oil in a manifold (attached to the inner race), which is then directed to the rib-roller contact area through holes drilled axially in the inner race.

HR – Hydra-Rib™ bearing with preload adjustment device*

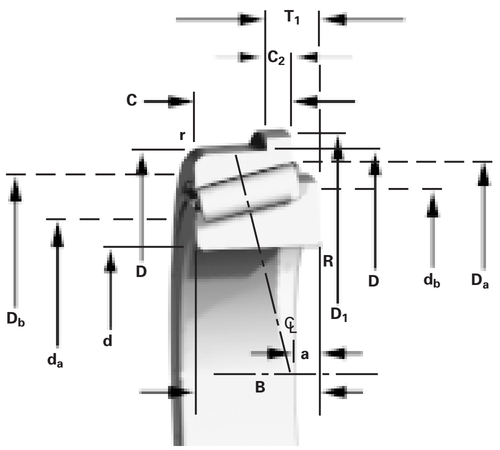
The Hydra-RibTM bearing has a "floating" outer race rib controlled by hydraulic or pneumatic pressure which ensures that the required preload is maintained irrespective of the differential expansions or changes in loading taking place within the system.

Crossed roller bearing*

A crossed roller bearing is, effectively, two sets of bearing races and rollers brought together at right angles to each other - with alternate rollers facing opposite directions - within a section height not much greater than that of a single bearing housing. Also, the steep angle, tapered geometry of the bearing causes the load-carrying center of each of the races to be projected along the axis, resulting in a total effective bearing spread many times greater than the physical depth of the bearing itself. This type of bearing offers a high resistance to overturning moments for a minimal bearing effective spread.

The most usual form of the bearing is type TXRDO, which has a double outer race and two inner races, with rollers spaced by polymer separators.

The list of part numbers in the following tables for TS and TSF design styles is not exhaustive. These represent most of the common selections for the precision machine tool industry. Many tapered roller bearings currently are manufactured to "standard" precision classes (Class 2 or 4/ C or B) but can be readily produced to higher precision levels. Bearing modifications such as conversion to a two row design, a high speed TSMA, or use of ceramic rolling elements to meet specific application demands can usually be accommodated. Please contact your local Timken Sales Engineer for more information.



- Flanged outer ring facilitates axial location
- Features to enhance spindle operation:
  - matched components
  - runout high point markings
  - bearing assembly adjustment tuning (setting)
- Performance options:
  - high speed version (TSMA)

d Bore	D O.D.	T_1 Offset	D_1 Flange Dia.	C_2 Flange Width	B Cone Width	C Cup Width	a Eff. Center	Max. Shaft Fillet Rad. at Cone Backface R	(Shaft Backing Dia.) d_a	d_b	Max. Shaft Fillet Rad. at Cup Backface r	(Housing Backing Dia.) D_a	D_b
mm/tol: +0; -(µm)*						kg	mm[1]	mm	mm		mm	mm	
60 (12)	100 (13)	8.5	105.0	3.00	20.000	15.500	1.3	2	66	69	2	95.5	91
70 (12)	110 (13)	8.5	116.0	3.00	20.000	15.500	2.5	2	76	80	2	105	101
80 (12)	125 (15)	10.5	132.0	4.00	22.500	17.500	2.3	2	86	89	2	120	115
90 (15)	135 (15)	10.5	142.0	4.00	22.500	17.500	5.6	2	97	100	2	130	125
95 (15)	145 (15)	10.5	152.0	4.00	22.500	17.500	6.1	3	102	108	3	140	134
100 (15)	145 (15)	10.5	152.0	4.00	22.500	17.500	6.1	3	106	112	3	140	134
130 (18)	185 (20)	13.0	192.0	5.00	27.000	21.000	8.9	3	137	143	3	179	172
140 (18)	195 (20)	13.0	202.0	5.00	27.000	21.000	11.9	3	148	153	3	198	182
150 (18)	205 (20)	12.0	210.0	4.86	28.575	21.438	11.4	3.3	158	164	3.3	198	190

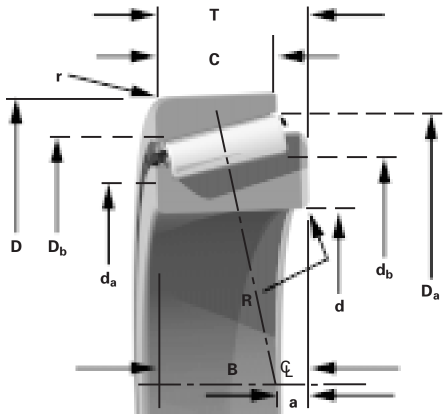
Notes

1) Negative value indicates effective center within the backface of the cone.
2) ISO calculation based on one million revolutions for L_{10} life.
3) Timken Company life calculations based on 90 million revolutions for L_{10} life. C_{90} is radial load component force; C_{a90} is axial component.
4) For synthetic high speed grease, in appropriate fill quantities, service interval and appropriate setting, other methods may further improve speed by as much as 60% or more.
5) Other sizes not shown may be possible. Call for availability.
6) Nearly any TS style from tables above can be converted to TSF upon request.

*Tighter tolerances are possible on any of the part numbers shown for higher precision requirements.

Metric
TSF Style
Precision Level C*

cone-cup	Wt.	Load Ratings[3] (Stat) C_0	(dyn) C_1[2]	(dyn) C_{90}	(dyn) C_{a90}	Lim. Speed[4]	Stiffness Kr (10^6)	Fr	Ka (10^6)	Fa
	kg	kN				rpm	N/mm	kN	N/mm	kN
JP6049-JP6010-B	0.61	101.0	80.9	21.0	17.0	5,100	1.22	2.1	0.231	1.7
JP7049-JP7010-B	0.69	112.0	84.8	22.0	17.4	4,500	1.33	2.2	0.239	1.7
JP8049-JP8010-B	0.95	141.0	105.0	27.2	21.0	3,900	1.53	2.7	0.264	2.1
JP9049-JP9010-B	1.09	155.0	110.0	28.4	24.0	3,600	1.64	2.8	0.338	2.4
JP10044-JP10010-B	1.27	172.0	116.0	30.1	24.4	3,300	1.80	3.0	0.341	2.4
JP10049-JP10010-B	1.13	172.0	116.0	30.1	24.4	3,300	1.80	3.0	0.341	2.4
JP13049-JP13010-B	2.20	283.0	181.0	47.0	38.1	2,600	2.45	4.7	0.464	3.8
JP14049-JP14010-B	2.31	304.0	188.0	48.8	42.0	2,400	2.60	4.9	0.556	4.2
JL730646-JL730612-B	2.69	339.0	179.0	46.5	36.5	2,200	3.30	4.6	0.588	3.6



- Features to enhance spindle operation:
  - – matched components
  - – runout high points marked
  - – bearing assembly adjustments tuning (setting)
- Performance options:
  - – high speed version (TSMA)

Precision Level 3 Bearings

d Bore	D O.D.	T Width	B Cone Width	C Cup Width	Wt.	a Eff. Center	Load Ratings[3] (Stat) C_0	(Stat) C_1	(dyn) C_{90}	(dyn) C_{a90}	cone-cup
in./tol: -0; +.000(x)					lbs.	in.[1]	lbs.				
2.5000 (5)	4.2500 (5)	1.0000	1.0000	0.750	2.01	-0.03	35,500	22,900	5,950	4,670	**29585-29520**
2.6875 (5)	4.3307 (5)	0.8661	0.8660	0.741	1.59	-0.03	28,300	20,600	5,340	3,670	**399A-394A**
2.8750 (5)	4.4375 (5)	1.0000	1.0000	0.750	1.94	0.03	37,300	23,000	5,960	4,980	**29685-29620**
3.0000 (5)	4.7812 (5)	0.9688	0.9060	0.687	2.07	0.05	30,800	21,300	5,510	4,260	**34301-34478**
3.3750 (5)	5.3750 (5)	1.1875	1.1720	0.875	3.33	-0.03	48,500	32,100	8,330	6,340	**497-493**
3.6210 (5)	5.6250 (5)	1.1811	1.1811	0.866	3.57	0.07	54,000	34,100	8,830	7,230	**LM718947-LM718910**
4.0000 (5)	6.1875 (5)	1.4375	1.4219	1.031	5.27	-0.02	77,100	46,500	12,100	9,800	**52400-52618**
4.6250 (5)	7.1250 (5)	1.3750	1.2500	1.000	6.04	0.20	60,900	40,700	10,600	8,980	**68462-68712**
5.7500 (5)	7.6250 (5)	1.1250	1.1250	0.906	4.98	0.18	91,500	40,900	10,600	6,690	**36690-36620**
7.0000 (5)	8.9375 (5)	1.1875	1.1875	0.906	6.37	0.50	105,600	43,500	11,300	8,510	**36990-36920**
7.5000 (5)	11.1250 (5)	2.0000	1.8750	1.437	20.77	0.15	155,100	89,400	23,200	16,500	**87750-87111**
8.1250 (5)	11.1250 (5)	1.8125	1.8125	1.437	18.39	0.63	198,000	88,300	22,900	19,900	**67985-67920**
8.5000 (5)	11.4177 (5)	1.2500	1.2500	0.875	12.19	0.51	102,700	49,800	12,900	8,510	**543085-543114**

Notes
1) Negative value indicates effective center within the width of the inner ring.
2) ISO calculation based on one million revolutions for L_{10} life.
3) Timken Company life calculations based on 90 million revolutions for L_{10} life. C_{90} is radial load component force; C_{a90} is axial component.
4) For synthetic high speed grease; other methods may further improve speed by as much as 60% or more.
5) Other sizes not shown may be possible. Call for availability.

*Tighter tolerances are possible on any of the part numbers shown for higher precision requirements.

Inch
TS Style
Precision Level 3*

Precision Level 3 Bearings

Stiffness K_r	Stiffness F_r	Stiffness K_a	Stiffness F_a	Lim. Speed[4]	Mounting Dimensions Shaft (R)	Mounting Dimensions Shaft (d_a)	Mounting Dimensions Shaft (d_b)	Mounting Dimensions Hsg-r	Mounting Dimensions Hsg-D_a	Mounting Dimensions Hsg-D_b
(10^6lbs/in) N/µm	lbs. kN	(10^6lbs/in) N/µm	lbs. kN	(rpm)	in.					
12.30 215.4	595 2.67	2.20 38.5	466 2.1	4,500	0.14	2.80	3.03	0.13	4.06	3.78
8.73 152.9	534 2.39	1.19 20.84	367 1.6	4,600	0.09	2.91	3.07	0.05	4.09	3.98
12.50 218.9	596 2.67	2.51 43.96	497 2.2	4,200	0.14	3.15	3.39	0.13	4.29	3.98
9.25 162.0	551 2.47	1.59 27.85	425 1.9	4,100	0.14	3.27	3.50	0.08	4.57	4.33
13.20 231.2	834 3.74	2.21 38.70	633 2.8	3,700	0.14	3.66	3.90	0.13	5.12	4.80
14.40 252.2	883 3.96	2.79 48.86	722 3.2	3,400	0.14	3.94	4.17	0.13	5.43	5.08
18.90 331.0	1206 5.41	3.60 63.05	979 4.4	3,100	0.14	4.37	4.61	0.13	5.98	5.59
13.20 231.2	1055 4.73	2.77 48.51	897 4.0	2,800	0.14	4.92	5.20	0.13	6.77	6.42
26.00 455.3	1060 4.75	2.99 52.36	667 3.0	2,300	0.06	6.02	6.10	0.06	7.40	7.17
29.30 513.1	1128 5.06	4.81 84.24	850 3.8	1,900	0.06	7.32	7.40	0.06	8.70	8.43
25.80 451.8	2318 10.39	3.77 66.02	1646 7.4	1,700	0.14	7.99	8.23	0.13	10.51	10.28
39.50 691.8	2288 10.26	8.68 152.01	1992 8.9	1,600	0.14	8.62	8.82	0.13	10.83	10.24
22.40 392.3	1291 5.79	2.82 49.39	850 3.8	1,600	0.14	8.90	9.13	0.13	10.87	10.71

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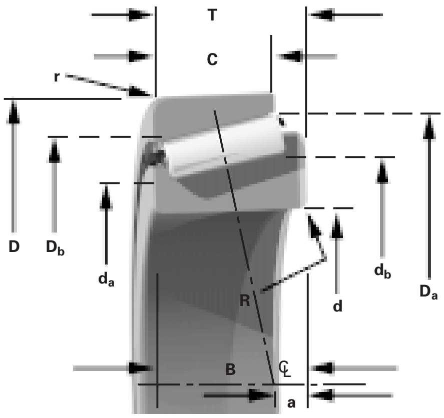
ISO/DIN	MM	P5	P4	P2	–
TIMKEN	MM	C	B	A	AA
	IN.	3	0	00	000
		ABMA			



- Features to enhance spindle operation:
  - matched components
  - runout high points marked
  - bearing assembly adjustments tuning (setting)
- Performance options:
  - high speed version (TSMA)

Precision Level C Bearings

d Bore	D O.D.	T Width	B Cone Width	C Cup Width	Wt.	a Eff. Center	Load Ratings[3] (Stat) C_0	(Stat) C_1	(dyn) C_{90}	(dyn) C_{a90}	cone-cup
mm/tol: +0; -(μm)*					kg	mm[1]	kN				
60 (12)	100 (13)	21.000	20.000	15.500	0.61	1.3	101.0	80.9	21.0	17.0	**JP6049-JP6010**
65 (12)	105 (13)	24.000	23.000	18.500	0.72	-0.3	139.0	100.0	26.0	20.2	**JLM710949C-JLM710910**
70 (12)	110 (13)	21.000	20.000	15.500	0.69	2.5	112.0	84.8	22.0	17.4	**JP7049-JP7010**
80 (12)	125 (15)	24.000	22.500	17.500	0.95	2.3	141.0	105.0	27.2	21.0	**JP8049-JP8010**
85 (15)	130 (15)	30.000	29.000	24.000	1.35	-0.3	245.0	149.0	38.7	29.4	**JM716649-JM716610**
90 (15)	135 (15)	24.000	22.500	17.500	1.09	5.6	155.0	110.0	28.4	24.0	**JP9049-JP9010**
95 (15)	145 (15)	24.000	22.500	17.500	1.27	6.1	172.0	116.0	30.1	24.4	**JP10044-JP10010**
95 (15)	150 (15)	35.000	34.000	27.000	2.17	-1.5	317.0	199.0	51.5	39.0	**JM719149-JM719113**
100 (15)	145 (15)	24.000	22.500	17.500	1.13	6.1	172.0	116.0	30.1	24.4	**JP10049-JP10010**
110 (15)	165 (18)	35.000	35.000	26.500	2.45	3	357.0	210.0	54.5	46.4	**JM822049-JM822010**

Notes
1) Negative value indicates effective center within the width of the inner ring.
2) ISO calculation based on one million revolutions for L_{10} life.
3) Timken Company life calculations based on 90 million revolutions for L_{10} life. C_{90} is radial load component force; C_{a90} is axial component.
4) For synthetic high speed grease, other methods may further improve speed by as much as 60% or more.
5) Other sizes not shown may be possible. Call for availability.

*Tighter tolerances are possible on any of the part numbers shown for higher precision requirements.

Metric
TS Style
Precision Level C*

Precision Level C Bearings

Stiffness					Mounting Dimensions					
K_r (10^6)	F_r	K_a (10^6)	F_a	Lim. Speed[4]	Shaft (R)	Shaft (d_a)	Shaft (d_b)	Hsg-r	Hsg-D_a	Hsg-D_b
N/mm	kN	N/mm	kN	(rpm)	mm					
1.22	2.1	0.231	1.7	5,100	2	66	69	2	95.5	91
1.70	2.6	0.297	2.0	4,800	3	71	77	1	101.0	96
1.33	2.2	0.239	1.7	4,500	2	76	80	2	105.0	101
1.53	2.7	0.264	2.1	3,900	2	86	89	2	120.0	115
2.82	3.8	0.472	2.9	3,700	3	92	98	2.5	125.0	117
1.64	2.8	0.338	2.4	3,600	2	97	100	2	130.0	125
1.80	3.0	0.341	2.4	3,300	3	102	108	3	140.0	134
3.11	5.1	0.513	3.9	3,300	3	104	109	2.5	143.0	135
1.80	3.0	0.341	2.4	3,300	3	106	112	3	140.0	134
3.39	5.4	0.710	4.6	2,900	3	119	124	2.5	159.0	149

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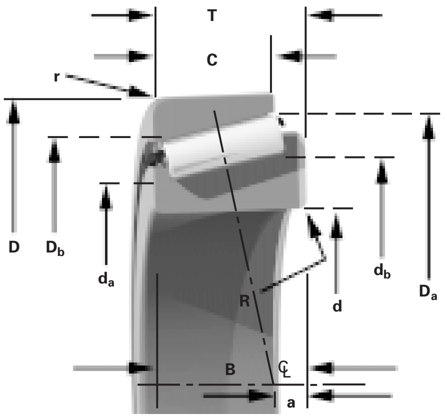


- Features to enhance spindle operations:
  - – matched components
  - – runout high points marked
  - – bearing assembly adjustments tuning (setting)
- Performance options:
  - – high speed version (TSMA)

Precision Level C Bearings

d Bore	D O.D.	T Width	B Cone Width	C Cup Width	Wt.	a Eff. Center	Load Ratings[3] (Stat) C_0	(Stat) C_1	(dyn) C_{90}	(dyn) C_{a90}	cone-cup
mm/tol: +0; -(µm)*					kg	mm[1]	kN				
115 (15)	165 (18)	28.000	27.000	21.000	1.76	5.6	245.0	148.0	38.3	30.1	JLM722948-JLM722912
120 (15)	170 (18)	25.400	25.400	19.050	1.66	7.9	231.0	134.0	34.8	27.3	JL724348-JL724314
125 (18)	175 (18)	25.400	25.400	18.288	1.7	9.1	246.0	139.0	36.0	29.4	JL725346-JL725316
130 (18)	185 (20)	29.000	27.000	21.000	2.2	8.9	283.0	181.0	47.0	38.1	JP13049-JP13010
140 (18)	195 (20)	29.000	27.000	21.000	2.31	11.9	304.0	188.0	48.8	42.0	JP14049-JP14010
150 (18)	205 (20)	28.575	28.575	21.438	2.69	11.4	339.0	179.0	46.5	36.5	JL730646-JL730612
160 (18)	220 (20)	32.000	30.000	23.000	3.17	13	372.0	224.0	58.1	48.4	JP16049-JP16010
170 (18)	230 (20)	32.000	30.000	23.000	3.39	13	398.0	232.0	60.1	47.5	JP17049-JP17010
180 (18)	240 (20)	32.000	30.000	23.000	3.59	16	409.0	234.0	60.6	50.3	JP18049-JP18010
180 (18)	250 (20)	47.000	45.000	37.000	6.66	8.9	786.0	401.1	104.0	85.5	JM736149-JM736110

Notes

1) Negative value indicates effective center within the width of the inner ring.
2) ISO calculation based on one million revolutions for L_{10} life.
3) Timken Company life calculations based on 90 million revolutions for L_{10} life. C_{90} is radial load component force; C_{a90} is axial component.
4) For synthetic high speed grease, other methods may further improve speed by as much as 60% or more.
5) Other sizes not shown may be possible. Call for availability.

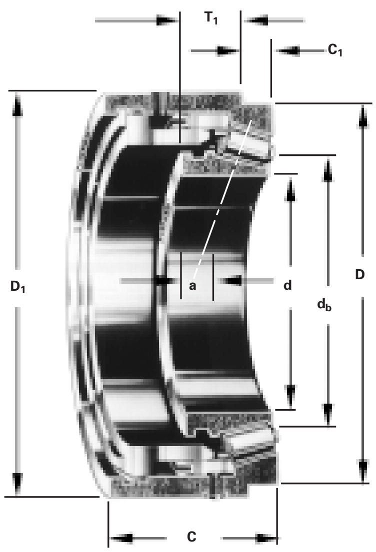
*Tighter tolerances are possible on any of the part numbers shown for higher precision requirements.

Metric
TS Style
Precision Level C*

Precision Level C Bearings

Stiffness					Mounting Dimensions					
K_r (10^6)	F_r	K_a (10^6)	F_a	Lim. Speed[4]	Shaft (R)	Shaft (d_a)	Shaft (d_b)	Hsg-r	Hsg-D_a	Hsg-D_b
N/mm	kN	N/mm	kN	(rpm)	mm					
2.53	3.8	0.450	3.0	2,900	3.3	121	127	3	158.0	151
2.47	3.5	0.440	2.7	2,800	3.3	127	132	3.3	163.0	156
2.60	3.6	0.499	2.9	2,700	3.3	133	138	3.3	168.0	161
2.45	4.7	0.464	3.8	2,600	3	137	143	3	179.0	172
2.60	4.9	0.556	4.2	2,400	3	148	153	3	189.0	182
3.30	4.6	0.588	3.6	2,200	3.3	158	164	3.3	198.0	190
2.94	5.8	0.589	4.8	2,100	3	169	174	3	213.1	206
3.15	6.0	0.568	4.7	2,000	3	179	184	3	223.0	217
3.21	6.0	0.638	5.0	1,900	3	189	194	3	233.0	227
5.90	10.4	1.150	8.5	1,800	3	190	196	2.5	243.0	232

ISO/DIN	MM	P5	P4	P2	–
TIMKEN	MM	C	B	A	AA
	IN.	3	0	00	000
		ABMA			



Timken Hydra-Rib™ Bearing

- Precision metric bearing available in any precision class
- Floating outer race rib maintains preload using fluid pressure
- Unique design allows for thermal expansion of spindle while maintaining desired preload
- Ideal choice for floating position bearing set
- Only minor modifications needed on existing spindles to install

Timken Spring-Rib™ Bearing

- Bearing preload maintained using spring pressure
- Available in JP5000, JP8500, JP11000 and JP17000 series
- Ideal choice for applications with relatively constant load and speed
- Choices of light, medium, or heavy preload settings (medium is standard)
- Call for available sizes

Hydra-Rib™	d Bore	D_1 Flange Dia.	D Seat Dia.	T_1 Width	C Cup Width	C_1 Seat Width	a (Eff. Load Center[1])	Shaft R Radius	Shaft Shoulder dia.	Housing r Radius	Load Ratings[2]	K_r (10^6)	F_r	K_a (10^6)	F_a
Part Number	mm							mm			kN	N/mm	kN	N/mm	kN
JP5049P-JP5019HR	50.000	103.500	104.000	31.000	66.000	15.000	-13	3.0	61.0	1.0	20.6	1.13	2.10	0.23	1.70
JP5049P-JP5020HR	50.000	103.175	104.000	31.000	66.000	15.000	-13	3.0	61.0	1.0	20.6	1.13	2.10	0.23	1.70
JP5049PH-JP5017HR	50.000	103.175	104.000	31.000	66.000	15.000	-13	3.0	61.0	1.0	20.6	1.13	2.10	0.23	1.70
JP5049PH-JP5020HR	50.000	103.175	104.000	31.000	66.000	15.000	-13	3.0	61.0	1.0	20.6	1.13	2.10	0.23	1.70
JP7548P-JP7520HR	75.000	130.000	122.000	22.000	65.000	10.000	-10.2	3.0	85.0	2.0	23.1	1.38	2.30	0.27	1.90
JP7549P-JP7519HR	75.000	130.000	122.000	22.000	65.000	10.000	-10.2	3.0	85.0	2.0	23.1	1.38	2.30	0.27	1.90
JP8548-JP8518HR	85.000	148.000	140.000	23.500	66.000	10.000	-9.1	3.0	96.0	2.0	30.1	1.72	3.00	0.33	2.40
JP8549P-JP8519HR	85.000	148.000	140.000	23.500	66.000	10.000	-9.1	3.0	96.0	2.0	30.1	1.72	3.00	0.33	2.40
JP10048-JP10019HR	95.000	158.000	145.000	21.000	70.000	10.000	-4.3	3.0	107.0	1.5	29.5	1.71	2.90	0.32	2.40
JP10048-JP10019HRA	95.000	158.000	145.000	21.000	70.000	10.000	-4.3	3.0	107.0	1.5	29.5	1.71	2.90	0.32	2.40
JP11035-JP11019HR	100.000	178.000	170.000	27.000	70.000	12.000	-10.4	3.0	114.0	1.0	34.1	2.00	3.40	0.33	2.60
JP11048-JP11019HR	110.000	178.000	170.000	27.000	70.000	12.000	-10.4	3.0	122.0	1.0	34.1	2.00	3.40	0.33	2.60
JP12043P-JP12019HR	115.000	190.000	180.000	26.000	70.000	12.000	-7.1	3.0	128.0	1.0	42.0	2.35	4.20	0.44	3.40
JP12049P-JP12019HR	120.000	190.000	180.000	26.000	70.000	12.000	-7.1	3.0	132.0	1.0	42.0	2.35	4.20	0.44	3.40

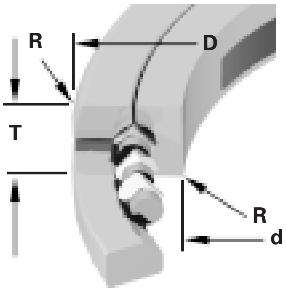
Notes

1) Negative value indicates effective center within the width of the inner ring.
2) Timken Company life calculations based on 90 million revolutions for L_{10} life. C_{90} is radial load component force; C_{a90} is axial component.
3) Limiting speeds for Hydra-Rib & Spring-Rib bearings are significantly higher than standard ribbed-cone designs. Consult the Engineering chapter for greater detail or contact Timken.

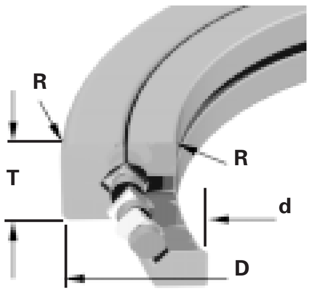
TSHR Style

Hydra-Rib™ and Spring Rib™

Hydra-Rib™	d Bore	D_1 Flange Dia.	D Seat Dia.	T_1 Width	C Cup Width	C_1 Seat Width	a (Eff. Load Center[1])	Shaft R Radius	Shaft Shoulder dia.	Housing r Radius	Load Ratings[2]	Kr 10^6	Fr	Ka 10^6	Fa
Part Number	mm							mm			kN	N/mm	kN	N/mm	kN
JP13043P-JP13016HR	125.000	200.000	190.000	29.000	72.000	12.000	-7.6	3.0	138.0	1.0	49.9	2.60	5.00	0.49	4.00
JP13049P-JP13016HR	130.000	200.000	190.000	29.000	72.000	12.000	-7.6	3.0	138.0	1.0	49.9	2.60	5.00	0.49	4.00
JP14043P-JP14019HR	135.000	213.000	205.000	27.000	72.000	13.000	-3.8	3.0	148.0	1.0	50.6	2.67	5.10	0.57	4.30
JP14049P-JP14019HR	140.000	213.000	205.000	27.000	72.000	13.000	-3.8	3.0	152.0	1.0	50.6	2.67	5.10	0.57	4.30
JP16043P-JP16019HR	155.000	235.000	227.000	30.000	76.000	15.000	-5.1	3.0	169.0	1.0	60.9	3.07	6.10	0.61	5.10
JP16049P-JP16019HR	160.000	235.000	227.000	30.000	79.000	15.000	-5.1	3.0	172.0	1.0	60.9	3.07	6.10	0.61	5.10
JP17049P-JP17019HR	170.000	248.000	240.000	30.000	79.000	15.000	-4.8	3.0	182.0	1.0	62.9	3.28	6.30	0.59	5.00
JP18049P-JP18019HR	180.000	268.000	260.000	30.000	84.000	15.000	-1.8	3.0	193.0	1.0	63.9	3.35	6.40	0.67	5.30
JP20049P-JP20019HR	200.000	290.000	282.000	32.000	83.000	17.000	-0.8	3.0	213.0	1.0	74.6	3.39	7.40	0.64	6.00
JP22049E-JP22019HR	220.000	316.000	308.000	32.000	83.000	17.000	+5.3	3.0	233.0	1.0	80.8	3.82	8.10	0.85	7.10
JL555235-JL55512HR	270.000	385.000	375.000	40.000	105.000	20.000	0	4.0	293.0	4.0	114.0	6.11	11.40	0.84	7.80
JL555239-JL55512HR	285.750	385.000	375.000	40.000	105.000	20.000	0	4.0	293.0	4.0	114.0	6.11	11.40	0.84	7.80



Config. 1



Config. 2

Timken Crossed Roller Bearing

- Stability of bearing greatly enhanced by effective spread of double roller set
- Ideal choice for table bearing for vertical machining operations
- Compact design offers lowest possible center of gravity in precision rotational applications
- Provides low starting torque
- Simplified construction facilitates installation and adjustments

Precision Level S

	D O.D.	d Bore	T Width	R Radius	Load Ratings[4] Radial[1]	Thrust	K[2]	Preload[5,3]	
Config.	mm/tol: +0; -(µm)				kN			mm	Part Number
2	400.000 (40)	300.000 (35)	37.000	1.5	63.0	80.1	0.45	.025 to .040	**JXR637050**
2	425.000 (50)	310.000 (35)	45.000	2.5	82.2	102.0	0.46	.025 to .040	**JXR652050**
2	495.000 (50)	370.000 (40)	50.000	3.0	93.6	119.0	0.45	.040 to. 050	**JXR699050**

Precision Level P

	D O.D.	d Bore	T Width	R Radius	Load Ratings[4] Radial[1]	Thrust	K[2]	Preload[5,3]	
Config.	mm/tol: +0; -(µm)				kN			mm	Part Number
2	400.000 (20)	300.000 (18)	37.000	1.5	63.0	80.1	0.45	.025 to .040	**JXR637050**
2	425.000 (25)	310.000 (18)	45.000	2.5	82.2	102.0	0.46	.025 to .040	**JXR652050**
2	495.000 (25)	370.000 (20)	50.000	3.0	93.6	119.0	0.45	.040 to. 050	**JXR699050**

Notes
1) Two row radial load rating shown.
2) K-factor is a ratio of radial load to thrust load – see Engineering section for usage.
3) Preload set by adjustments to top inner race clamping spacer plate.
4) Load calculations based on 500 rpm for 3,000 hours.
5) Values listed apply to lower speed applications. Other preload values are available on request. Contact your local Timken Sales Engineer.
*Application of these preload values assumes suggested fitting practice in Engineering chapter is used.

TXR Style

Metric Precision Level S,P
Inch Precision Level 3,0

Precision Level 3

		D O.D.	d Bore	T Width	R Radius	Load Ratings[4] Radial[1]	Thrust	K[2]	Preload[5]
Part Number	Config.	in./tol: +0; -(.000x)				lbs.			in.
XR496051	2	11.0000 (10)	8.0000 (10)	1.2500	0.06	11,500	13,800	0.48	.001 to .0015
XR678052	2	18.0000 (19)	13.0000 (19)	2.5000	0.13	22,500	27,600	0.47	.0015 to .002
XR766051	2	24.0000 (19)	18.0000 (19)	2.5000	0.13	31,600	40,100	0.45	.0015 to .002
XR820060	2	29,9213 (28)	22.8346 (19)	3.150	0.25	12,100	15,100	0.46	.003 to .004
XR855053	2	36.0000 (28)	27.0000 (28)	3.1250	0.13	60,700	77,200	0.45	.003 to .004
XR882055	2	44.0000 (38)	35.5000 (28)	3.2500	0.13	67,400	88,900	0.44	.004 to .006
XR889058	1	52.2500 (48)	40.5000 (38)	4.5000	0.13	91,000	120,000	0.44	.005 to .007
XR897051	2	72.0000 (48)	61.0000 (48)	4.0000	0.13	116,000	157,000	0.43	.006 to .008

Precision Level 0

		D O.D.	d Bore	T Width	R Radius	Load Ratings[4] Radial[1]	Thrust	K[2]	Preload[5]
Part Number	Config.	in./tol: +0; -(.000x)				lbs.			in.
XR496051	2	11.0000 (5)	8.0000 (5)	1.2500	0.06	11,500	13,800	0.48	.001 to .0015
XR678052	2	18.0000 (10)	13.0000 (10)	2.5000	0.13	22,500	27,600	0.47	.0015 to .002
XR766051	2	24.0000 (10)	18.0000 (10)	2.5000	0.13	31,600	40,100	0.45	.0015 to .002

ISO/DIN	P5	P4	–	P2
Fafnir®	V x.xx	–	MM(V)	MMX x.xxxx

Timken Fafnir® Super Precision Ball Bearings

2

H, R, J, P† internal fit
† P fit is standard in Conrad Bearings
Contact Angle:
2 = 15°
3 = 25°

MMV

Precision Class:
MM/MMV super high precision (HG) between ABEC-7 (ISO P4) and ABEC-9 (ISO P2)
MMX ultraprecision • ABEC-9 (ISO P2)

C

Hybrid Ceramic

91

Series:
9300 ultra light
9100 extra light
99100 extra light
200 light
300 medium

14

Bore Size:
(04 and up, multiply these last two numbers by 5 to get bore in millimeters:)
00 10mm
01 12mm
02 15mm
03 17mm
04 20mm

HX

Construction:
WI angular contact; low shoulder on outer ring
HX angular contact; low shoulder on both rings
WO angular contact; low shoulder on inner ring
WN angular contact; low shoulder on both rings
K Conrad

CR

Retainer:
PRB molded nylon cage
PRC molded reinforced nylon cage
CR phenolic (composition) – Fafnir standard

VV

high speed seals

DUL

Bearing Set Quantity and Preload Level

S	single bearing
D	duplex pair of bearings
T	triplex set of bearings
Q	quadruplex set of bearings

U
universally ground

extra light preload	**X**
light preload	**L**
medium preload	**M**
heavy preload	**H**

…A3188

an example of a specification number for other than standard

Introduction

Workload and tool spindles are the most important components of machine tools. Consequently, to reach the requirements for spindle speed, work accuracy and finish, selection of the proper size and type of ball bearings to support these spindles is a critical design problem.

Of all the anti-friction bearing types, super precision ball bearings have proved to be the best value for the wide variety of bearing applications covering broad ranges of operating loads, speeds and lubrication conditions. Duplexed, preloaded, angular-contact bearings with one-piece composition retainers, have excellent capacity and provide maximum spindle rigidity. These bearings are widely used in achieving faster speeds, greater accuracy, smoother finishes and higher production rates.

Many considerations are involved in the choice of bearings for precision applications. Among those which influence the performance of machine tool spindles are the internal fit-up and geometry of the bearings, the mounting arrangement, the shaft and housing mounting fits, the balance and alignment of the rotating parts, and last, but equally important, the lubrication. While many of these factors are significant in slow-speed applications, all of them must be considered for high-speed spindles.

To minimize deflection under load, shafts for machine tool spindles are designed to have a minimum unsupported length and maximum cross-section. For the same reason, spindle housings are designed heavy enough to carry the work load. Their cross-sections are made as uniform as possible to reduce stress concentration during uneven deflection of the frame due to thermal changes. In addition, heavy, well-proportioned housings can function as sinks to conduct heat away from ball bearings.

Selective Assembly

Under certain conditions it may be desirable to control fits more accurately without the added expense of using closer tolerance bearings and assembly parts. This can be accomplished by selective assembly of the bearings, shafts, and housings, after they have been sized and sorted according to bores and outside diameters. Timken provides bore and O.D. micron coding as standard practice for super precision angular contact radial ball bearings. This improved fit-up at assembly provides a higher degree of precision from the spindle.

Successful Applications

Detailed assembly drawings on the following pages are representative of successful applications of Timken Fafnir precision bearings on such equipment as gear drive assemblies; automatic screw machines; high-cycle wheel heads; high-speed internal grinding spindles; super precision work heads; and high-speed router spindles. It is hoped that these arrangements will stimulate questions regarding your particular application problems which will promptly be addressed by Timken Engineering.

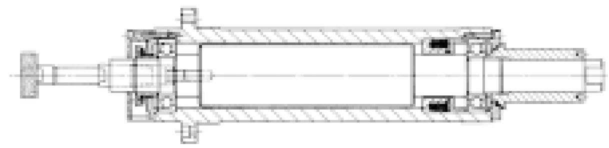
Special Requirements

High-speed grease-lubricated spindles and heavy precision work heads requiring unusual rigidity and running accuracy are a few of the many special problems involving precision bearings. These and many other applications generally require design features which will be reviewed by Timken Engineering on request.

Applications

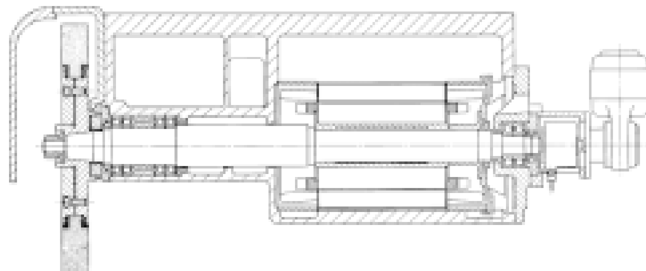
High-Speed Internal Grinding Spindle

Designed for internal precision grinding, this spindle incorporates 2MM9106WO-CR super precision bearings, preloaded by a nest of coiled helical springs mounted in a cartridge. Thrust load exerted by the springs assures intimate contact of the balls with the bearing raceways under all operating conditions. The sealed construction provides highly effective protection against intrusion of coolant and foreign matter. Grease, packed in each bearing prior to assembly, is sealed-in for life. Operating speed of this spindle is 25,000 rpm.



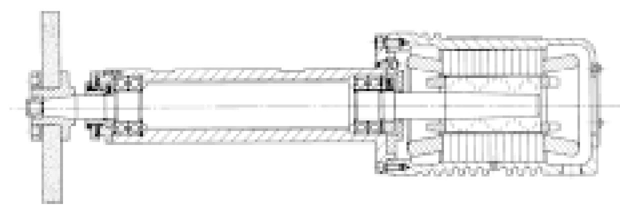
Ultra-Precision Surface Grinding Spindle

2MMX9122WI-DUM super precision bearings, produced to ABEC9 tolerances, are employed in this horizontal surface grinding spindle for maximum rigidity and accuracy. A back-to-back pair of 2MM312WI-CR-DUL super precision bearings are used as the floating location. This spindle grinds surfaces that are accurate within .000025 inch, flat, parallel and square within .000010 inch, and to a surface finish of 5 rms, or better. The spindle, driven by a 30 hp motor, operates at 900 rpm. Bearings are packed with grease prior to assembly.



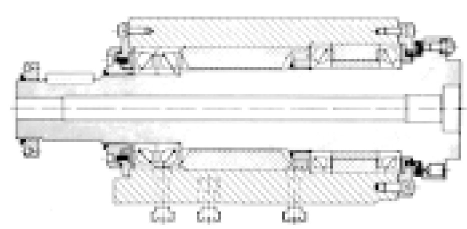
Precision Surface Grinding Spindle

This motorized surface grinding spindle, operating at 3600 rpm, uses 2MM9107WI-DUM duplex super precision preloaded bearings at both locations, mounted back-to-back, with one pair floating. Labyrinth slinger-type sealing prevents entry of contaminants and seals in the lubrication. Bearings are grease lubricated for life.



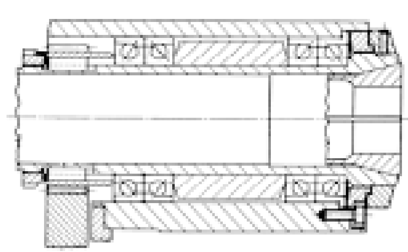
Heavy-Duty Precision Boring Spindle

Super precision, duplexed, preloaded bearings mounted back-to-back are used at each location in this boring spindle to assure smooth performance and a high degree of radial and axial rigidity. Operating speeds vary between 200 and 3000 rpm. Equal-length spacers between the bearings at the work-end increase spindle rigidity. When the bearings are properly positioned on the shaft and the respective rings securely clamped, the preload is reproduced and no subsequent adjustment is required. Just prior to assembly, each bearing is packed with grease for life.



Six-Spindle Automatic Screw Machine

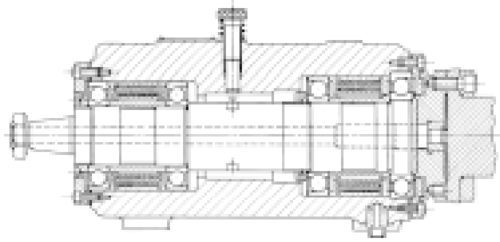
This bearing arrangement meets the demand for a high-speed, heavy-duty, multiple-spindle screw machine to operate with constant accuracy at maximum production. Because of the hollow shaft construction and the short distance between bearings, extra-light series duplex pairs are used at each location. This affords a high degree of radial rigidity and adds stiffness to the shaft. By mounting a duplex pair of flanged (3MMF) bearing with a 2MM super precision bearing, back-to-back, under a predetermined preload at the front end, accuracy and rigidity of the spindle are assured and permit a straight housing bore. The rear pair of back-to-back bearings is allowed to float in the housing, making an outer-ring spacer unnecessary. Lubrication is by pressure-feed oil circulation.



Applications (continued)

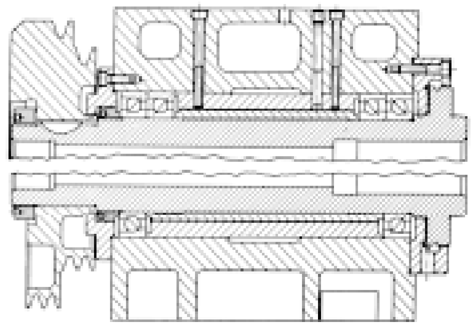
High-Speed Precision Boring Head

This high-speed boring head operates at 2500 to 3000 rpm, employing angular-contact, super precision bearings. The front bearings are of different sizes. The outer ring of the larger bearing abuts and is clamped against the housing shoulder. The inboard bearing is permitted to move axially in its housing under spring load. At the rear location two bearings, of the same size and spring loaded, are allowed to float in the housing as temperature differentials occur in the operation spindle. With this head, interference shafts may be permitted without affecting bearing preload. Excessive heat generation is prevented, resulting in low operating temperatures. Bearings are grease lubricated.



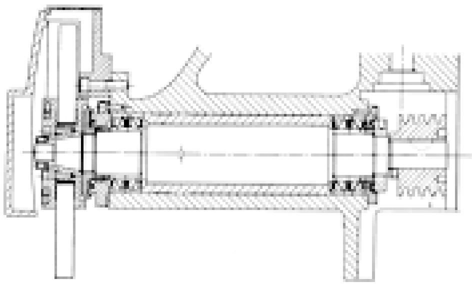
Ultra-Precision Grinding Workhead

This workhead must maintain straightness and roundness accuracy within ten millionths (.000010) of an inch. To meet such rigid requirements for extremely close dimensional control, ultra-precision ball bearings and a shaft of extra stiffness are used. The bearings for such applications are manufactured to tolerances closer than those for ABEC9 specifications. Equally important is the high degree of workmanship and accuracy with which the shaft, housing and component parts of the workhead must be made. Upper section shows a four-bearing arrangement for heavy work. Lower half shows a two-bearing mounting for lighter work. In either case, the bearings are packed with grease, prior to mounting.



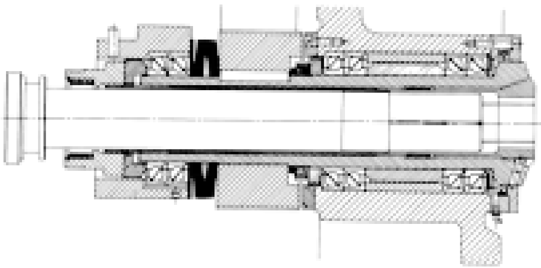
Precision Toolroom Surface Grinder Spindle

Fafnir duplexed, super precision, preloaded bearings used in this spindle provide the high degree of rigidity in both directions necessary to meet requirements for modern surface grinding and to assure efficient performance at a low operating temperature. The housing is bored straight-through to assure true alignment – the housing shoulders are eliminated. The precision ground outer sleeve is doweled to the housing to provide the means for stabilizing the spindle axially at the work end bearing location. The rear pair of bearings floats to compensate for thermal changes. Bearings are grease lubricated for life just prior to assembly.



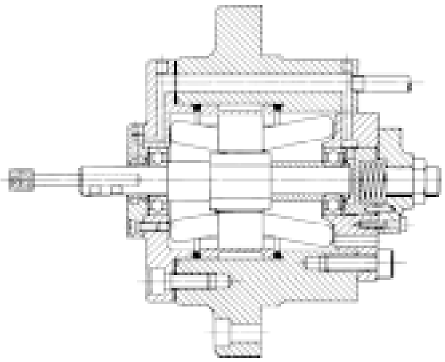
Single Bar Machine

This spindle is supported by two pairs of 2MM9124WI-DUM super precison bearings, mounted back-to-back in tandem pairs. Operating speeds vary from 78 to 1500 rpm. A pair of 2MM9122WI-DUM bearings mounted in tandem carry a 25,000 pound thrust load during the unchucking operation. The bearings are grease packed for life prior to assembly.



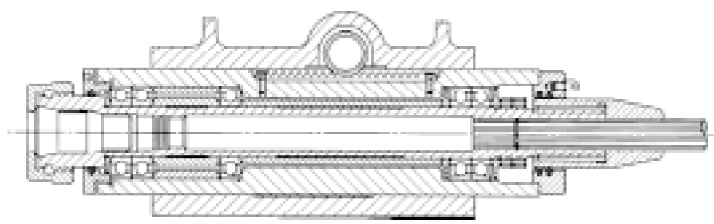
100,000 RPM High-Cycle Wheelhead

Super precision 2MMX9101WO-CR bearings produced to ABEC9 tolerances are spring-loaded in this wheelhead which operates at 100,000 rpm at 1660 cycles. Oil mist lubrication is employed and the motor is water cooled.



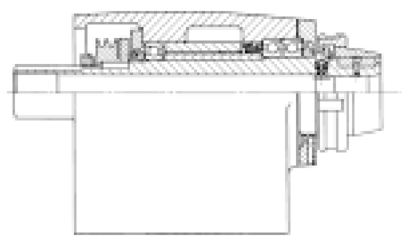
Precision Jig-Boring Spindle

This jig-boring spindle delivers extreme accuracy over a wide range of speeds. Excellently designed, it is supported with 2MM210WI-DUM grease lubricated super precision Bearings. With this spindle, holes located to an accuracy of one ten-thousandth (.0001) of an inch are bore ground straight and to size limits of better than two ten-thousandths (.0002) of an inch.



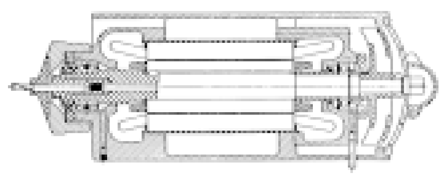
Superprecision Lathe Headstock

This lathe spindle produces work held to a roundness of 35 millionths (.000035) of an inch. Maximum operating speed is 4800 rpm. Tandem pair of 3MM9114WI-DUL bearings is opposed by a spring-loaded 3MM9113WI bearing, resulting in excellent spindle rigidity. Bearings are prelubricated with grease.



High Speed Motorized Router

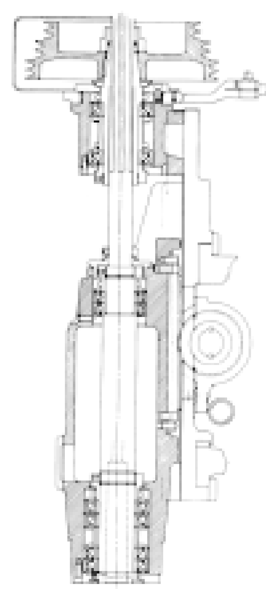
A specially matched duplex pair of Fafnir 2MM210WI-DU-FS223 super precision ball bearings, mounted back-to-back at the work-end, affords the necessary bearing rigidity to permit routing through aluminum plate one inch thick with a single pass. The upper bearing is spring-loaded and permitted to float. Router is driven by a 30 hp motor at speeds up to 15,000 rpm, and uses oil mist lubrication.

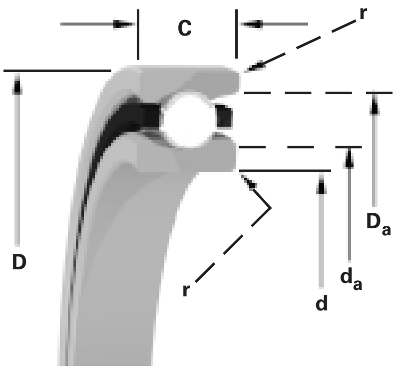


Precision Vertical Milling Spindle

This spindle operates at 12 different speeds ranging from 260 to 6200 rpm under a wide variety of conditions. At the work end, two duplex pairs of Fafnir 2MM212WI-DUL preloaded bearings are mounted in tandem pairs in a back-to-back arrangement, separated by spacers of equal length. This affords extremely high radial and axial rigidity. At the center, a pair of Fafnir 2MM210WI-DUL bearings mounted back-to-back permit axial float of the spindle to compensate for thermal changes.

The driving pulley shaft is rigidly supported by a widely spaced duplex pair of Fafnir 2MM212WI-DUL preloaded bearings. All bearings are grease packed for life.





Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WI Construction:
- Incorporates low shoulder on non-thrust side of outer rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (in.)	Wt	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	d_a (Shaft) min.	D_a (Housing) max.	D_a (Housing) min.
	in/tol: +0; -.000(X)				lbs	lbs.		rpm	lbs.		rpm	in.				
9300WI	0.3937 (1.5)	0.8661 (2)	0.2362 (16)	12 x 1/8	0.02	370 *330*	790 *790*	77,500 *93,000*	360 *320*	760 *760*	69,800 *83,760*	0.012	0.52	0.51	0.77	0.76
9301WI	0.4724 (1.5)	0.9449 (2)	0.2362 (31)	13 x 1/8	0.03	410 *370*	830 *830*	67,200 *80,640*	400 *350*	800 *800*	60,500 *79,800*	0.012	0.60	0.59	0.85	0.84
9302WI	0.5906 (1.5)	1.1024 (2)	0.2756 (31)	13 x 9/64	0.04	530 *470*	1,030 *1,030*	55,600 *66,720*	510 *460*	980 *980*	50,000 *60,000*	0.012	0.72	0.71	1.00	0.99
9303WI	0.6693 (1.5)	1.1811 (2)	0.2756 (31)	14 x 9/64	0.04	630 *560*	1,120 *1,120*	50,100 *60,120*	600 *540*	1,070 *1,070*	45,100 *54,120*	0.012	0.80	0.79	1.08	1.07
9304WI	0.7874 (2)	1.4567 (2.5)	0.3543 (47)	14 x 3/16	0.08	1,020 *910*	1,820 *1,820*	42,100 *50,520*	920 *870*	1,730 *1,730*	37,900 *49,920*	0.012	0.95	0.94	1.33	1.32
9305WI	0.9843 (2)	1.6535 (2.5)	0.3543 (47)	17 x 3/16	0.1	1,290 *1,150*	2,030 *2,030*	34,800 *41,760*	1,230 *1,090*	1,930 *1,930*	31,300 *37,560*	0.012	1.15	1.14	1.52	1.51
9306WI	1.1811 (2)	1.8504 (2.5)	0.3543 (47)	19 x 3/16	0.11	1,490 *1,320*	2,150 *2,150*	29,700 *35,640*	1,410 *1,260*	2,030 *2,030*	26,700 *32,040*	0.012	1.34	1.33	1.72	1.71
9307WI	1.378 (2.5)	2.1654 (3)	0.3937 (47)	19 x 7/32	0.17	2,030 *1,800*	2,830 *2,830*	25,400 *30,480*	1,920 *1,710*	2,680 *2,680*	22,900 *27,480*	0.024	1.57	1.55	2.01	1.99
9308WI	1.5748 (2.5)	2.4409 (3)	0.4724 (47)	19 x 1/4	0.25	2,640 *2,350*	3,600 *3,600*	22,400 *26,880*	2,500 *2,220*	3,400 *3,400*	20,200 *24,240*	0.024	1.78	1.76	2.28	2.26
9309WI	1.7717 (2.5)	2.6772 (3)	0.4724 (47)	21 x 1/4	0.29	2,960 *2,640*	3,785 *3,785*	20,000 *24,000*	2,810 *2,500*	3,560 *3,560*	18,000 *21,600*	0.024	1.99	1.97	2.50	2.48
9310WI	1.9685 (2.5)	2.8346 (3)	0.4724 (47)	23 x 1/4	0.3	3,290 *2,930*	3,950 *3,950*	18,300 *21,960*	3,100 *2,760*	3,730 *3,730*	16,500 *19,800*	0.024	2.17	2.15	2.67	2.65
9311WI	2.1654 (3)	3.1496 (3)	0.5118 (59)	23 x 9/32	0.41	4,150 *3,700*	4,900 *4,900*	16,600 *19,920*	3,920 *3,490*	4,620 *4,620*	14,900 *17,880*	0.039	2.40	2.38	2.96	2.94
9312WI	2.3622 (3)	3.3465 (3)	0.5118 (59)	25 x 9/32	0.44	4,540 *4,040*	5,100 *5,100*	15,300 *18,360*	4,270 *3,800*	4,820 *4,820*	13,800 *16,560*	0.039	2.59	2.57	3.16	3.14

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Ultra-Light
2(3)MM9300WI (ISO 19) Series
Inch Dimensional Sizes

				Fixed				Floating				
Shaft Diameter		Mounting Fits		Housing Bore (Stationary)		Mounting Fits		Housing Bore (Stationary)		Housing Clearance		
min.	max.	loose	tight	min.	max	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
0.3935	0.3937	0.0002	0.00015	0.8661	0.8663	0.0000	0.0004	0.86650	0.86630	0.00060	0.00020	**9300WI**
0.4722	0.4724	0.0002	0.00015	0.9449	0.9451	0.0000	0.0004	0.94530	0.94510	0.00060	0.00020	**9301WI**
0.5904	0.5906	0.0002	0.00015	1.0236	1.0238	0.0000	0.0004	1.02400	1.02380	0.00060	0.00020	**9302WI**
0.6691	0.6693	0.0002	0.00015	1.1811	1.1813	0.0000	0.0004	1.18150	1.18130	0.00060	0.00020	**9303WI**
0.7872	0.7874	0.0002	0.0002	1.4567	1.4570	0.0000	0.0005	1.45710	1.45690	0.00070	0.00020	**9304WI**
0.9841	0.9843	0.0002	0.0002	1.6535	1.6538	0.0000	0.0005	1.65390	1.65370	0.00070	0.00020	**9305WI**
1.1809	1.1811	0.0002	0.0002	1.8504	1.8507	0.0000	0.0005	1.85090	1.85070	0.00080	0.00030	**9306WI**
1.3778	1.3780	0.0002	0.00025	2.1654	2.1657	0.0000	0.0006	2.16590	2.16570	0.00080	0.00030	**9307WI**
1.5746	1.5748	0.0002	0.00025	2.4409	2.4412	0.0000	0.0006	2.44140	2.44120	0.00080	0.00030	**9308WI**
1.7715	1.7717	0.0002	0.00025	2.6772	2.6775	0.0000	0.0006	2.67770	2.67750	0.00080	0.00030	**9309WI**
1.9683	1.9685	0.0002	0.00025	2.8346	2.8349	0.0000	0.0006	2.83510	2.83490	0.00080	0.00030	**9310WI**
2.1652	2.1654	0.0002	0.0003	3.1496	3.1499	0.0000	0.0006	3.15010	3.14990	0.00080	0.00030	**9311WI**
2.3620	2.3622	0.0002	0.0003	3.3465	3.3468	0.0000	0.0006	3.34710	3.34680	0.00090	0.00030	**9312WI**

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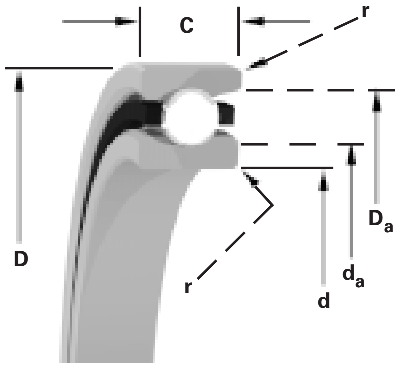


Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

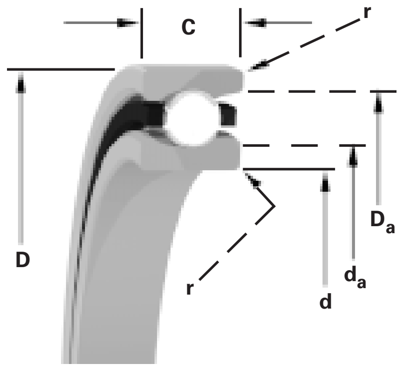
WI Construction:
- Incorporates low shoulder on non-thrust side of outer rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (in.)	Wt	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	in/tol: +0; -.000(X)				lbs	lbs.		rpm	lbs.		rpm	in.				
9313WI	2.5591 (3)	3.5433 (3)	0.5118 (5)9	27 x 9/32	0.47	4,910 *4,370*	5,290 *5,290*	14,200 *17,040*	4,580 *4,080*	4,990 *4,990*	12,800 *15,360*	0.039	2.79	2.77	3.35	3.33
9314WI	2.7559 (3)	3.937 (3)	0.6299 (59)	24 x 11/32	0.76	6,510 *5,800*	7,200 *7,200*	13,100 *15,720*	6,130 *5,450*	6,790 *6,790*	11,800 *14,160*	0.039	3.02	3.00	3.71	3.69
9315WI	2.9528 (3)	4.1339 (3)	0.6299 (59)	25 x 11/32	0.8	6,810 *6,060*	7,310 *7,310*	12,300 *14,760*	6,380 *5,670*	6,890 *6,890*	11,100 *13,320*	0.039	3.22	3.19	3.91	3.88
9316WI	3.1496 (3)	4.3307 (3)	0.6299 (59)	27 x 11/32	0.85	7,350 *6,540*	7,600 *7,600*	11,600 *13,920*	6,860 *6,100*	7,170 *7,170*	10,400 *12,480*	0.039	3.42	3.39	4.11	4.08
9317WI	3.3465 (3)	4.7244 (3)	0.7087 (79)	26 x 3/8	1.23	8,440 *7,510*	8,700 *8,700*	10,800 *12,960*	7,880 *7,010*	8,200 *8,200*	9,700 *11,640*	0.039	3.69	3.66	4.44	4.41
9318WI	3.5433 (3)	4.9213 (3.5)	0.7087 (79)	26 x 13/32	1.26	9,900 *8,810*	10,100 *10,100*	10,300 *12,360*	9,270 *8,250*	9,540 *9,540*	9,300 *11,160*	0.039	3.85	3.82	4.66	4.63
9319WI	3.7402 (3)	5.1181 (3.5)	0.7087 (79)	28 x 13/32	1.33	10,700 *9,480*	10,500 *10,500*	9,800 *11,760*	9,930 *8,840*	9,910 *9,910*	8,800 *10,560*	0.039	4.05	4.02	4.86	4.83
9320WI	3.937 (3)	5.5118 (3.5)	0.7874 (79)	29 x 13/32	1.87	11,000 *9,760*	10,600 *10,600*	9,100 *10,920*	10,200 *9,100*	9,900 *9,900*	8,200 *9,840*	0.039	4.34	4.31	5.16	5.13
9322WI	4.3307 (3)	5.9055 (3.5)	0.7874 (79)	31 x 13/32	2.02	11,600 *10,300*	10,900 *10,900*	8,400 *10,080*	10,800 *9,650*	10,200 *10,200*	7,600 *9,120*	0.039	4.74	4.71	5.55	5.52
9324WI	4.7244 (3)	6.4961 (4)	0.8661 (79)	30 x 15/32	2.74	15,000 *13,400*	13,900 *13,900*	7,700 *9,240*	14,000 *12,500*	13,100 *13,100*	6,900 *8,280*	0.039	5.16	5.13	6.10	6.07
9326WI	5.1181 (4)	7.0866 (4)	0.9449 (98)	30 x 17/32	3.63	19,400 *17,300*	17,600 *17,600*	7,100 *8,520*	18,100 *16,100*	16,600 *16,600*	6,400 *7,680*	0.059	5.60	5.57	6.66	6.63
9328WI	5.5118 (4)	7.4803 (4.5)	0.9449 (98)	32 x 17/32	3.85	20,600 *18,300*	18,200 *18,200*	6,600 *7,920*	19,200 *17,100*	17,100 *17,100*	5,900 *7,080*	0.059	5.99	5.96	7.05	7.02
9330WI	5.9055 (4)	8.2677 (4.5)	1.1024 (98)	27 x 11/16	5.75	20,400 *26,200*	26,805 *26,805*	6,200 *7,440*	21,600 *24,500*	25,300 *25,300*	5,600 *6,720*	0.079	6.42	6.39	7.80	7.77
9332WI	6.2992 (4)	8.6614 (4.5)	1.1024 (98)	27 x 23/32	6.06	32,200 *28,600*	29,000 *29,000*	5,800 *6,960*	30,100 *26,800*	27,300 *27,300*	5,800 *6,960*	0.079	6.82	6.79	8.20	8.17
9334WI	6.6929 (4)	9.0551 (4.5)	1.1024 (98)	29 x 23/32	6.34	34,500 *30,700*	30,100 *30,100*	5,500 *6,600*	32,200 *28,700*	28,300 *28,300*	5,000 *6,000*	0.079	7.30	7.27	8.51	8.48
9340WI	7.874 (4.5)	11.0236 (5)	1.4961 (118)	27 x 15/16	13.87	54,600 *48,600*	47,100 *47,100*	4,600 *5,520*	51,400 *45,800*	44,400 *44,400*	4,100 *4,920*	0.083	8.54	8.51	10.41	10.38

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Ultra-Light
2(3)MM9300WI (ISO 19) Series
Inch Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
2.5589	2.5591	0.0002	0.0003	3.5433	3.5436	0.0000	0.0006	3.54390	3.54360	0.00090	0.00030	9313WI
2.7557	2.7559	0.0002	0.0003	3.9370	3.9373	0.0000	0.0006	3.93770	3.93740	0.00100	0.00040	9314WI
2.9526	2.9530	0.0002	0.0005	4.1339	4.1342	0.0000	0.0006	4.13460	4.13430	0.00100	0.00040	9315WI
3.1494	3.1498	0.0002	0.0005	4.3307	4.3310	0.0000	0.0006	4.33140	4.33110	0.00100	0.00040	9316WI
3.3463	3.3467	0.0002	0.0005	4.7244	4.7247	0.0000	0.0006	4.72510	4.72480	0.00100	0.00040	9317WI
3.5431	3.5435	0.0002	0.0005	4.9213	4.9216	0.0000	0.0007	4.92210	4.92170	0.00120	0.00040	9318WI
3.7400	3.7404	0.0002	0.0005	5.1181	5.1185	0.0000	0.0007	5.11890	5.11850	0.00110	0.00040	9319WI
3.9368	3.9372	0.0002	0.0005	5.5118	5.5122	0.0000	0.0007	5.51260	5.51220	0.00110	0.00040	9320WI
4.3305	4.3309	0.0002	0.0005	5.9055	5.9059	0.0000	0.0007	5.90640	5.90600	0.00120	0.00050	9322WI
4.7242	4.7246	0.0002	0.0005	6.4961	6.4965	0.0000	0.0008	6.49700	6.49660	0.00130	0.00050	9324WI
5.1179	5.1183	0.0002	0.0006	7.0866	7.0870	0.0000	0.0008	7.08750	7.08710	0.00130	0.00050	9326WI
5.5116	5.5120	0.0002	0.0006	7.4803	7.4807	0.0000	0.0008	7.48120	7.48080	0.00140	0.00050	9328WI
5.9053	5.9057	0.0002	0.0006	8.2677	8.2682	0.0000	0.0009	8.26870	8.26830	0.00150	0.00060	9330WI
6.2990	6.2994	0.0002	0.0006	8.6614	8.6619	0.0000	0.0009	8.6624	8.6620	0.00150	0.00060	9332WI
6.6927	6.6931	0.0002	0.0006	9.0551	9.0556	0.0000	0.0009	9.05610	9.05570	0.00150	0.00060	9334WI
7.8737	7.8743	0.0003	0.0008	11.0236	11.0241	0.0000	0.0010	11.02490	11.02440	0.00180	0.00080	9340WI



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WI Construction:
- Incorporates low shoulder on non-thrust side of outer rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (mm)	Wt	(2MM) Load Ratings (steel ball & *ceramic ball*) C_o (stat)	C_e(dyn)	Limiting Speed	(3MM) Load Ratings (steel ball & *ceramic ball*) C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	Recommended Shoulder Diameters d_a (Shaft) max.	d_a (Shaft) min.	D_a (Housing) max.	D_a (Housing) min.
	mm/tol: +0; -(μm)				kg.	N		rpm	N		rpm	mm				
9300WI	10 (4)	22 (5)	6 (40)	12 x 3.2	0.01	1,640 *1,460*	3,510 *3,510*	77,500 *93,000*	1,580 *1,410*	3,380 *3,008*	69,800 *83,760*	0.3	13.2	13	19.6	19.3
9301WI	12 (4)	24 (5)	6 (80)	13 x 3.2	0.01	1,840 *1,640*	3,690 *3,690*	67,200 *80,640*	1,770 *1,580*	3,550 *3,550*	66,500 *79,800*	0.3	15.2	14.9	21.6	21.3
9302WI	15 (4)	28 (5)	7 (80)	13 x 3.6	0.02	2,370 *2,110*	4,560 *4,560*	55,600 *66,720*	2,280 *2,030*	4,360 *4,360*	50,000 *60,000*	0.3	18.3	18.1	25.5	25.2
9303WI	17 (4)	30 (5)	7 (80)	14 x 3.6	0.02	2,800 *2,500*	4,970 *4,970*	50,100 *60,120*	2,680 *2,380*	4,740 *4,740*	45,100 *54,120*	0.3	20.3	20	27.5	27.2
9304WI	20 (5)	37 (6)	9 (120)	14 x 4.8	0.04	4,560 *4,050*	8,080 *8,080*	42,100 *50,520*	4,360 *3,880*	7,700 *7,700*	41,600 *49,920*	0.3	24.1	23.9	33.7	33.4
9305WI	25 (5)	42 (6)	9 (120)	17 x 4.8	0.04	5,750 *5,120*	9,040 *9,040*	34,800 *41,760*	5,470 *4,860*	8,590 *8,590*	31,300 *37,500*	0.3	29.1	28.9	38.7	38.4
9306WI	30 (5)	47 (6)	9 (120)	19 x 4.8	0.05	6,610 *5,890*	9,540 *9,540*	29,700 *35,640*	6,270 *5,580*	9,040 *9,040*	26,700 *32,000*	0.3	34.1	33.9	43.7	43.4
9307WI	35 (6)	55 (7)	10 (120)	19 x 5.6	0.08	9,020 *8,020*	12,600 *12,600*	25,400 *30,480*	8,530 *7,590*	11,600 *11,600*	22,900 *27,500*	0.6	40	39.5	51.1	50.6
9308WI	40 (6)	62 (7)	12 (120)	19 x 6.4	0.11	11,700 *10,400*	16,000 *16,000*	22,400 *26,880*	11,100 *9,890*	15,100 *15,100*	20,200 *24,250*	0.6	45.1	44.6	57.9	57.4
9309WI	45 (6)	68 (7)	12 (120)	21 x 6.4	0.13	13,200 *11,700*	16,800 *16,800*	20,000 *24,000*	12,500 *11,100*	15,900 *15,900*	18,000 *21,600*	0.6	50.7	50.1	63.4	62.9
9310WI	50 (6)	72 (7)	12 (120)	23 x 6.4	0.14	14,600 *13,000*	17,600 *17,600*	18,300 *21,960*	13,800 *12,300*	16,600 *16,600*	16,500 *14,800*	0.6	55.1	54.6	67.9	67.4
9311WI	55 (7)	80 (7)	13 (150)	23 x 7.1	0.19	18,500 *16,400*	21,800 *21,800*	16,600 *19,920*	17,400 *15,500*	20,600 *20,600*	14,900 *17,900*	1	60.9	60.4	75.2	74.7
9312WI	60 (7)	85 (8)	13 (150)	25 x 7.1	0.20	20,200 *18,000*	22,700 *22,700*	15,300 *18,360*	19,000 *16,900*	21,400 *21,400*	13,800 *16,500*	1	65.8	65.3	80.2	79.7

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Ultra-Light
2(3)MM9300WI (ISO 19) Series
Metric Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
9.995	10.000	0.005	0.004	22	22.005	0.000	0.010	22.010	22.005	0.015	0.005	**9300WI**
11.995	12.000	0.005	0.004	24	24.005	0.000	0.010	24.010	24.005	0.015	0.005	**9301WI**
14.995	15.000	0.005	0.004	28	28.005	0.000	0.010	28.010	28.005	0.015	0.005	**9302WI**
16.995	17.000	0.005	0.004	30	30.005	0.000	0.010	30.010	30.005	0.015	0.005	**9303WI**
19.995	20.000	0.005	0.005	37	37.006	0.000	0.012	37.010	37.005	0.016	0.005	**9304WI**
24.995	25.000	0.005	0.005	42	42.006	0.000	0.012	42.010	42.005	0.016	0.005	**9305WI**
29.995	30.000	0.005	0.005	47	47.006	0.000	0.012	47.012	47.007	0.018	0.007	**9306WI**
34.995	35.000	0.005	0.006	55	55.008	0.000	0.015	55.012	55.007	0.019	0.007	**9307WI**
39.995	40.000	0.005	0.006	62	62.008	0.000	0.015	62.012	62.007	0.019	0.007	**9308WI**
44.995	45.000	0.005	0.006	68	68.008	0.000	0.015	68.012	68.007	0.019	0.007	**9309WI**
49.995	50.000	0.005	0.006	72	72.008	0.000	0.015	72.011	72.007	0.019	0.007	**9310WI**
54.995	55.000	0.005	0.007	80	80.008	0.000	0.015	80.012	80.008	0.020	0.008	**9311WI**
59.995	60.000	0.005	0.007	85	85.008	0.000	0.016	85.016	85.009	0.024	0.009	**9312WI**

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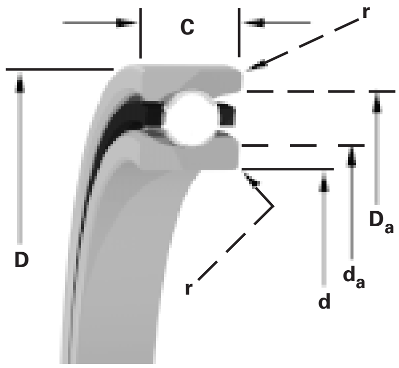


Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WI Construction:

- Incorporates low shoulder on non-thrust side of outer rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

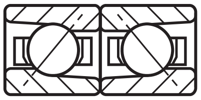
						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (mm)	Wt	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	d_a (Shaft) min.	D_a (Housing) max.	D_a (Housing) min.
	mm/tol: +0; -(µm)				kg.	N		rpm	N		rpm	mm				
9313WI	65	90	13	27 x 7.1	0.22	21,900	23,600	14,200	20,400	22,200	12,800	1	70.8	70.3	85.2	84.7
	(7)	(8)	(150)			*19,500*	*23,600*	*17,040*	*18,100*	*22,200*	*15,300*					
9314WI	70	100	16	24 x 8.7	0.34	29,000	32,000	13,100	27,300	30,200	11,800	1	76.8	76.3	94.3	93.8
	(7)	(8)	(150)			*25,800*	*32,000*	*15,720*	*24,300*	*30,200*	*14,100*					
9315WI	75	105	16	25 x 8.7	0.36	30,300	32,500	12,300	28,400	30,600	11,100	1	81.9	81.1	99.4	98.6
	(7)	(8)	(150)			*26,900*	*32,500*	*14,760*	*25,200*	*30,600*	*13,300*					
9316WI	80	110	16	27 x 8.7	0.39	32,700	33,800	11,600	30,500	31,900	10,400	1	86.9	86.1	104.4	103.6
	(7)	(8)	(150)			*29,100*	*33,800*	*13,920*	*27,100*	*31,900*	*12,500*					
9317WI	85	120	18	26 x 9.5	0.56	37,500	38,700	10,800	35,000	36,500	9,700	1	93.6	92.8	112.7	111.9
	(8)	(8)	(200)			*33,400*	*38,700*	*12,960*	*31,200*	*36,500*	*11,600*					
9318WI	90	125	18	26 x 10.3	0.57	44,000	45,000	10,300	41,200	42,400	9,300	1	97.8	97	118.5	117.7
	(8)	(9)	(200)			*39,200*	*45,000*	*12,360*	*36,700*	*42,400*	*11,100*					
9319WI	95	130	18	28 x 10.3	0.60	47,400	46,800	9,800	44,200	44,100	8,800	1	102.8	102	123.5	122.7
	(8)	(9)	(200)			*42,200*	*46,800*	*11,760*	*39,300*	*44,100*	*10,500*					
9320WI	100	140	20	29 x 10.3	0.85	48,800	47,200	9,100	45,500	44,400	8,200	1	110.3	109.5	131	130.2
	(8)	(9)	(200)			*43,400*	*47,200*	*10,920*	*40,500*	*44,400*	*9,800*					
9322WI	110	150	20	31 x 10.3	0.92	51,700	48,400	8,400	48,200	45,600	7,600	1	120.3	119.5	141	140.2
	(8)	(9)	(200)			*46,000*	*48,400*	*10,080*	*42,900*	*45,600*	*9,100*					
9324WI	120	165	22	30 x 11.9	1.24	66,900	62,000	7,700	62,300	58,300	6,900	1	131.2	130.4	155	154.3
	(8)	(10)	(200)			*59,500*	62,000	*9,240*	*55,500*	*58,300*	*8,300*					
9326WI	130	180	24	30 x 13.5	1.65	86,400	78,500	7,100	80,500	73,900	6,400	1.5	142.1	141.4	169.2	168.4
	(10)	(10)	(250)			*76,900*	*78,500*	*8,520*	*71,700*	*73,900*	*7,700*					
9328WI	140	190	24	32 x 13.5	1.75	91,600	80,700	6,600	85,400	76,000	5,900	1.5	152.1	151.4	179.2	178.4
	(10)	(10)	(250)			*81,500*	*80,700*	*7,920*	*76,000*	*76,000*	*7,000*					
9330WI	150	210	28	27 x 17.5	2.61	130,800	119,200	6,200	122,700	112,400	5,600	2	163.1	162.4	198.2	197.4
	(10)	(10)	(250)			*116,400*	*119,200*	*7,440*	*109,200*	*112,400*	*6,700*					
9332WI	160	220	28	27 x 18.3	2.75	143,100	128,900	5,800	134,100	121,600	5,800	2	173.2	172.4	208.2	207.4
	(10)	(10)	(250)			*127,300*	*128,900*	*6,960*	*119,300*	*121,600*	*6,690*					
9334WI	170	230	28	29 x 18.3	2.88	153,600	133,700	5,500	143,200	126,000	5,000	2	185.4	184.7	216.1	215.4
	(10)	(11)	(250)			*13,670*	*133,700*	*6,600*	*127,500*	*126,000*	*6,000*					
9340WI	200	280	38	27 x 23.8	6.29	243,300	209,400	4,600	228,800	197,700	4,100	2.1	216.8	216	264.5	263.7
	(12)	(13)	(300)			*216,300*	*209,400*	*5,520*	*203,600*	*197,700*	*4,900*					

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

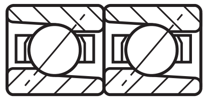
Fafnir Ultra-Light 2(3)MM9300WI (ISO 19) Series
Metric Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
64.995	65.000	0.005	0.007	90	90.008	0.000	0.016	90.015	90.007	0.023	0.007	9313WI
69.995	70.000	0.005	0.007	100	100.008	0.000	0.016	100.018	100.010	0.025	0.010	9314WI
74.995	75.005	0.005	0.012	105	105.008	0.000	0.016	105.019	105.011	0.026	0.011	9315WI
79.995	80.005	0.005	0.012	110	110.008	0.000	0.016	110.018	110.010	0.025	0.010	9316WI
84.995	85.005	0.005	0.012	120	120.008	0.000	0.016	120.018	120.010	0.025	0.010	9317WI
89.995	90.005	0.005	0.013	125	125.008	0.000	0.017	125.021	125.011	0.030	0.011	9318WI
94.995	95.005	0.005	0.013	130	130.009	0.000	0.018	130.020	130.010	0.029	0.010	9319WI
99.995	100.005	0.005	0.013	140	140.009	0.000	0.018	140.020	140.010	0.029	0.010	9320WI
109.995	110.005	0.005	0.013	150	150.009	0.000	0.018	150.023	150.012	0.032	0.012	9322WI
119.995	120.005	0.005	0.013	165	165.01	0.000	0.020	165.022	165.012	0.032	0.012	9324WI
129.995	130.005	0.005	0.015	180	180.01	0.000	0.020	180.022	180.012	0.032	0.012	9326WI
139.995	140.005	0.005	0.015	190	190.01	0.000	0.021	190.022	190.012	0.033	0.012	9328WI
149.995	150.005	0.005	0.015	210	210.011	0.000	0.022	210.025	210.015	0.036	0.015	9330WI
159.995	160.005	0.005	0.015	220	220.011	0.000	0.022	220.025	220.015	0.036	0.015	9332WI
169.995	170.005	0.005	0.015	230	230.011	0.000	0.022	230.025	230.015	0.036	0.015	9334WI
199.993	200.008	0.007	0.019	280	280.013	0.000	0.026	280.031	280.018	0.044	0.018	9340WI

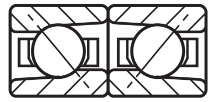
Mounting Arrangements



Recommended
DB



Tandem
DT



Special Applications
DF

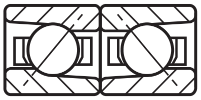
	Preload				Axial Stiffness[1]				Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	X-light	Light	Medium	Heavy	Light	Medium	Heavy	X-Light to Light	Light to Medium	Medium to Heavy
	lbs.				10^6lbs./in.				10^6lbs./in.			in.		
2MM9300WI	—	3	6	12	0.081	0.094	0.124	0.167	0.418	0.527	0.66	0.00005	0.00011	0.00016
2MM9301WI	—	3	6	12	0.085	0.099	0.13	0.175	0.44	0.557	0.697	0.00004	0.0001	0.00016
2MM9302WI	—	5	10	20	0.094	0.115	0.153	0.209	0.561	0.705	0.88	0.00008	0.00015	0.00022
2MM9303WI	—	5	15	30	0.102	0.125	0.198	0.273	0.617	0.886	1.102	0.00007	0.00025	0.00025
2MM9304WI	—	10	20	35	0.104	0.151	0.204	0.264	0.848	1.064	1.272	0.00019	0.00023	0.00026
2MM9305WI	—	10	25	40	0.118	0.169	0.251	0.312	0.965	1.305	1.516	0.00017	0.00029	0.00021
2MM9306WI	—	10	25	40	0.126	0.18	0.266	0.331	1.038	1.407	1.636	0.00016	0.00027	0.00020
2MM9307WI	—	10	25	55	0.145	0.189	0.276	0.393	1.083	1.479	1.907	0.00012	0.00026	0.00036
2MM9308WI	5	15	35	70	0.156	0.223	0.317	0.435	1.31	1.742	2.177	0.00019	0.00030	0.00037
2MM9309WI	10	20	40	80	0.176	0.265	0.356	0.488	1.545	1.945	2.433	0.00023	0.00026	0.00038
2MM9310WI	10	20	45	90	0.196	0.28	0.394	0.542	1.64	2.151	2.687	0.00020	0.0003	0.00038
2MM9311WI	10	25	55	110	0.222	0.316	0.44	0.603	1.831	2.384	2.979	0.00022	0.00032	0.00042
2MM9312WI	10	25	55	115	0.25	0.333	0.461	0.644	1.933	2.522	3.199	0.00018	0.0003	0.00043
2MM9313WI	15	30	60	120	0.286	0.375	0.501	0.684	2.166	2.733	3.417	0.00018	0.00027	0.00041
2MM9314WI	15	40	80	160	0.284	0.397	0.532	0.729	2.382	3.004	3.755	0.00027	0.00034	0.00051
2MM9315WI	20	40	85	170	0.304	0.407	0.559	0.767	2.446	3.15	3.937	0.00024	0.00037	0.00051
2MM9316WI	20	45	90	180	0.331	0.447	0.598	0.821	2.68	3.38	4.225	0.00025	0.00034	0.00051
2MM9317WI	25	60	120	240	0.351	0.491	0.662	0.915	2.98	3.745	4.674	0.00032	0.00042	0.00061
2MM9318WI	25	60	120	240	0.372	0.516	0.689	0.943	3.021	3.812	4.767	0.00031	0.00040	0.00059
2MM9319WI	30	65	130	260	0.401	0.557	0.744	1.018	3.26	4.113	5.143	0.00031	0.00040	0.00059
2MM9320WI	30	80	160	330	0.431	0.619	0.832	1.162	3.582	4.507	5.68	0.00036	0.00044	0.00068
2MM9322WI	40	90	180	360	0.504	0.719	0.969	1.339	3.896	4.899	6.111	0.00036	0.00045	0.00067
2MM9324WI	45	110	220	440	0.559	0.826	1.102	1.518	4.305	5.415	6.758	0.00042	0.00052	0.00076
2MM9326WI	50	140	275	550	0.61	0.858	1.152	1.603	4.84	6.054	7.559	0.00051	0.00056	0.00084
2MM9328WI	60	140	280	575	0.601	0.913	1.226	1.7	5.052	6.361	8.012	0.00044	0.00056	0.00086
2MM9330WI	65	190	380	775	0.686	1.039	1.395	1.899	5.46	6.88	8.649	0.00066	0.00071	0.00108
2MM9332WI	110	220	445	890	0.753	0.991	1.337	1.839	5.787	7.315	9.135	0.00050	0.00078	0.00112
2MM9334WI	80	230	460	900	0.934	1.23	1.651	2.27	6.209	7.82	9.699	0.00069	0.00076	0.00107
2MM9340WI	175	350	700	1,400	0.943	1.241	1.664	2.286	7.414	9.344	11.68	0.00064	0.00096	0.00142

Notes
1) For DB or DF arrangements only. For other mounting arrangements contact Timken Engineering.

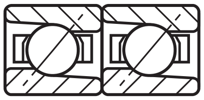
Fafnir Ultra-Light
2(3)MM9300WI (ISO 19) Series
Inch Duplex Performance Data

	Preload				Axial Stiffness[1]			Radial Stiffness[1]			Spacer Offsets[1]	
	DUX	DUL	DUM	DUH	Light	Medium	Heavy	Light	Medium	Heavy	Light to Medium	Medium to Heavy
	lbs.				10^6lbs./in.			10^6lbs./in.			in.	
3MM9300WI	—	5	10	20	0.187	0.242	0.316	0.403	0.507	0.634	0.00010	0.00015
3MM9301WI	—	5	10	20	0.197	0.254	0.332	0.425	0.535	0.670	0.00008	0.00015
3MM9302WI	—	10	20	35	0.265	0.344	0.430	0.554	0.695	0.830	0.00013	0.00016
3MM9303WI	—	10	30	55	0.290	0.440	0.564	0.609	0.872	1.055	0.00022	0.00020
3MM9304WI	—	10	35	60	0.296	0.472	0.585	0.642	0.974	1.157	0.00026	0.00020
3MM9305WI	—	15	40	70	0.388	0.560	0.700	0.839	1.160	1.388	0.00021	0.00019
3MM9306WI	—	15	40	70	0.417	0.602	0.747	0.902	1.251	1.498	0.00020	0.00018
3MM9307WI	10	20	55	95	0.484	0.705	0.872	1.045	1.462	1.743	0.00023	0.00020
3MM9308WI	15	30	70	125	0.582	0.797	1.000	1.251	1.657	1.997	0.00023	0.00024
3MM9309WI	20	35	80	150	0.656	0.893	1.142	1.408	1.852	2.266	0.00023	0.00027
3MM9310WI	20	35	90	150	0.695	0.998	1.206	1.495	2.046	2.399	0.00026	0.00022
3MM9311WI	20	45	110	190	0.793	1.108	1.371	1.684	2.266	2.702	0.00027	0.00026
3MM9312WI	20	45	115	200	0.839	1.187	1.472	1.779	2.432	2.907	0.00027	0.00026
3MM9313WI	25	50	120	240	0.913	1.265	1.658	1.940	2.598	3.426	0.00026	0.00033
3MM9314WI	30	65	160	290	0.981	1.369	1.725	2.095	2.829	3.426	0.00032	0.00034
3MM9315WI	35	70	170	300	1.034	1.437	1.792	2.205	2.966	3.561	0.00032	0.00032
3MM9316WI	40	75	180	310	1.114	1.540	1.902	2.377	3.183	3.793	0.00031	0.00030
3MM9317WI	50	100	240	420	1.229	1.705	2.126	2.642	3.528	4.221	0.00038	0.00038
3MM9318WI	50	90	210	375	1.216	1.661	2.076	2.603	3.460	4.175	0.00033	0.00035
3MM9319WI	50	105	260	450	1.348	1.886	2.333	2.882	3.900	4.655	0.00038	0.00036
3MM9320WI	70	135	330	575	1.511	2.111	2.629	3.213	4.315	5.154	0.00043	0.00041
3MM9322WI	75	150	360	625	1.638	2.275	2.829	3.480	4.643	5.538	0.00043	0.00041
3MM9324WI	90	180	440	775	1.782	2.409	3.110	3.795	5.099	6.113	0.00048	0.00048
3MM9326WI	115	230	550	975	2.016	2.792	3.496	4.295	5.730	6.855	0.00053	0.00054
3MM9328WI	120	240	575	1000	2.130	2.950	3.660	4.548	6.073	7.253	0.00052	0.00052
3MM9330WI	160	325	775	1350	2.296	3.172	3.939	4.886	6.519	7.793	0.00066	0.00064
3MM9332WI	180	355	890	1560	2.388	3.363	4.192	5.119	6.943	8.312	0.00074	0.00070
3MM9334WI	180	360	900	1560	2.512	3.530	4.342	5.392	7.313	8.674	0.00072	0.00064
3MM9340WI	280	700	1400	2800	3.317	4.294	5.632	6.987	8.788	10.980	0.00074	0.00113

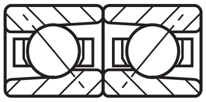
Mounting Arrangements



Recommended
DB



Tandem
DT



Special Applications
DF

	Preload				Axial Stiffness[1]				Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	X-light	Light	Medium	Heavy	Light	Medium	Heavy	X-Light to Light	Light to Medium	Medium to Heavy
	N				N/µm				N/µm			µm		
2MM9300WI	—	15	25	55	14.17	16.44	21.69	29.21	73.11	92.17	115.43	1.3	2.8	4.1
2MM9301WI	—	15	25	55	14.87	17.32	22.74	30.61	76.96	97.42	121.91	1.0	2.5	4.1
2MM9302WI	—	20	45	90	16.44	20.11	26.76	36.55	98.12	123.30	153.91	2.0	3.8	5.6
2MM9303WI	—	20	65	130	17.84	21.86	34.63	47.75	107.91	154.96	192.74	1.8	6.4	6.4
2MM9304WI	—	45	90	160	18.19	26.41	35.68	46.17	148.32	186.09	222.47	4.8	5.8	6.6
2MM9305WI	—	45	110	180	20.64	29.56	43.90	54.57	168.78	228.24	265.15	4.3	7.4	5.3
2MM9306WI	—	45	110	180	22.04	31.48	46.52	57.89	181.55	246.08	286.14	4.1	6.9	5.1
2MM9307WI	—	45	110	240	25.36	33.06	48.27	68.74	189.42	258.68	333.53	3.0	6.6	9.1
2MM9308WI	30	65	160	310	27.28	39.00	55.44	76.08	229.12	304.68	380.76	4.8	7.6	9.4
2MM9309WI	30	90	180	360	30.78	46.35	62.26	85.35	270.22	340.18	425.53	5.8	6.6	9.7
2MM9310WI	40	90	200	400	34.28	48.97	68.91	94.80	286.84	376.21	469.96	5.1	7.6	9.7
2MM9311WI	40	110	240	490	38.83	55.27	76.96	105.46	320.24	416.96	521.03	5.6	8.1	10.7
2MM9312WI	40	110	240	510	43.73	58.24	80.63	112.64	338.08	441.10	559.51	4.6	7.6	10.9
2MM9313WI	70	130	270	530	50.02	65.59	87.62	119.63	378.83	478.00	597.63	4.6	6.9	10.4
2MM9314WI	70	180	360	710	49.67	69.44	93.05	127.50	416.61	525.40	656.75	6.9	8.6	13.0
2MM9315WI	90	180	380	760	53.17	71.18	97.77	134.15	427.81	550.94	688.58	6.1	9.4	13.0
2MM9316WI	90	200	400	800	57.89	78.18	104.59	143.59	468.73	591.16	738.95	6.4	8.6	13.0
2MM9317WI	110	270	530	1,070	61.39	85.88	115.78	160.03	521.20	655.00	817.48	8.1	10.7	15.5
2MM9318WI	110	270	530	1,070	65.06	90.25	120.51	164.93	528.37	666.72	833.75	7.9	10.2	15.0
2MM9319WI	130	290	580	1,160	70.13	97.42	130.13	178.05	570.17	719.36	899.51	7.9	10.2	15.0
2MM9320WI	130	360	710	1,470	75.38	108.26	145.52	203.23	626.49	788.27	993.43	9.1	11.2	17.3
2MM9322WI	180	400	800	1,600	88.15	125.75	169.48	234.19	681.41	856.84	1,068.81	9.1	11.4	17.0
2MM9324WI	200	490	980	1,960	97.77	144.47	192.74	265.50	752.94	947.08	1,181.97	10.7	13.2	19.3
2MM9326WI	220	620	1,220	2,450	106.69	150.06	201.48	280.36	846.52	1,058.84	1,322.07	13.0	14.2	21.3
2MM9328WI	270	620	1,250	2,560	105.11	159.68	214.43	297.33	883.59	1,112.54	1,401.30	11.2	14.2	21.8
2MM9330WI	290	850	1,690	3,450	119.98	181.72	243.99	332.14	954.95	1,203.31	1,512.71	16.8	18.0	27.4
2MM9332WI	489	980	1,980	3,960	131.9	173.6	234.1	322.1	1,013.5	1,281.0	1,600.0	12.70	19.80	28.45
2MM9334WI	360	1,020	2,050	4,000	163.36	215.13	288.76	397.02	1,085.95	1,367.72	1,696.36	17.5	19.3	27.2
2MM9340WI	778	1,560	3,110	6,230	164.93	217.05	291.03	399.82	1,296.71	1,634.27	2,042.83	16.3	24.4	36.1

Notes
1) For DB or DF arrangements only. For other mounting arrangements contact Timken Engineering.

Fafnir Ultra-Light
2(3)MM9300WI (ISO 19) Series
Metric Duplex Performance Data

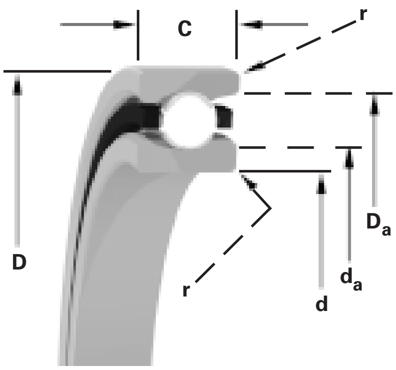
	Preload				Axial Stiffness[1]			Radial Stiffness[1]			Spacer Offsets[1]	
	DUX	DUL	DUM	DUH	Light	Medium	Heavy	Light	Medium	Heavy	Light to Medium	Medium to Heavy
	N				N/µm			N/µm			µm	
3MM9300WI	—	20	45	90	32.7	42.3	55.3	70.5	88.7	110.9	2.54	3.81
3MM9301WI	—	20	45	90	34.5	44.5	58.14	74.4	93.7	117.3	2.03	3.81
3MM9302WI	—	45	90	160	46.4	60.2	75.2	96.9	121.6	145.2	3.30	4.06
3MM9303WI	—	45	130	240	50.7	77.0	98.6	106.5	152.5	184.5	5.59	5.08
3MM9304WI	—	45	155	265	51.8	82.7	102.4	112.4	170.6	202.6	6.60	5.08
3MM9305WI	—	65	180	310	67.9	97.9	122.4	146.7	202.9	242.8	5.33	4.83
3MM9306WI	—	70	180	310	72.9	105.3	130.7	157.8	218.8	262.0	5.08	4.57
3MM9307WI	45	90	240	420	84.6	123.3	152.5	182.8	255.7	304.9	5.84	5.08
3MM9308WI	65	130	310	560	101.8	139.4	174.9	218.8	289.8	349.3	5.84	6.10
3MM9309WI	90	160	360	670	114.7	156.2	199.7	246.3	323.9	396.3	5.84	6.86
3MM9310WI	90	160	400	670	121.5	174.6	210.9	261.5	357.8	419.6	6.60	5.59
3MM9311WI	90	200	490	850	138.7	193.8	239.8	294.5	396.3	472.6	6.86	6.60
3MM9312WI	90	200	510	890	146.7	207.6	257.5	311.1	425.4	508.4	6.86	6.60
3MM9313WI	110	220	530	1,070	159.7	221.2	290.0	339.3	454.4	599.2	6.60	8.38
3MM9314WI	130	290	710	1,290	171.6	239.4	301.7	366.4	494.8	599.2	8.13	8.64
3MM9315WI	155	310	760	1,330	180.8	251.3	313.4	385.7	518.8	622.8	8.13	8.13
3MM9316WI	180	330	800	1,380	194.8	269.3	332.7	415.7	556.7	663.4	7.87	7.62
3MM9317WI	220	440	1070	1,870	214.9	298.2	371.8	462.1	617.0	738.3	9.65	9.65
3MM9318WI	220	400	930	1,670	212.7	290.5	363.1	455.3	605.2	730.2	8.38	8.89
3MM9319WI	220	470	1,160	2,000	235.8	329.9	408.0	504.1	682.1	814.2	9.65	9.14
3MM9320WI	310	600	1,470	2,560	264.3	369.2	459.8	562.0	754.7	901.4	10.92	10.41
3MM9322WI	330	670	1,600	2,780	286.5	397.9	494.8	608.7	812.1	968.6	10.92	10.41
3MM9324WI	400	800	1,960	3,450	311.7	421.3	543.9	663.7	891.8	1,069.2	12.19	12.19
3MM9326WI	510	1,020	2,450	4,340	352.6	488.3	611.5	751.2	1,002.2	1,198.9	13.46	13.72
3MM9328WI	530	1,070	2,560	4,450	373.1	516.8	642.1	795.4	1,062.2	1,268.5	13.21	13.21
3MM9330WI	710	1,450	3,450	6,000	401.1	551.1	688.2	854.6	1,144.0	1,363.0	16.76	16.26
3MM9332WI	800	1,580	3,950	6,940	418.2	588.9	734.1	876.5	1,215.9	1,455.7	18.80	17.78
3MM9334WI	800	1,600	4,000	6,940	440.0	618.2	760.4	944.3	1,280.7	1,519.0	18.29	16.26
3MM9340WI	1,250	3,110	6,230	12,460	580.1	751.0	985.0	1,222.0	1,537.0	1,920.4	18.80	28.70

	Grease Capacity		Kluber Isoflex NBU15		Operating Speeds[2] (DB Mounting) [1]					
					Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams				rpm			rpm		
2MM9300WI	0.09	0.15	0.06	0.08	62,000	46,500	31,000	105,400	79,100	52,700
2MM9301WI	0.11	0.17	0.07	0.10	53,800	40,300	26,900	91,500	68,500	45,700
2MM9302WI	0.17	0.28	0.12	0.15	44,500	33,400	22,200	75,700	56,800	37,700
2MM9303WI	0.19	0.30	0.12	0.16	40,100	30,100	20,000	68,200	51,200	34,000
2MM9304WI	0.40	0.60	0.25	0.34	33,700	25,300	16,800	57,300	43,000	28,600
2MM9305WI	0.40	0.70	0.29	0.39	27,800	20,900	13,900	47,300	35,500	23,600
2MM9306WI	0.50	0.80	0.34	0.45	23,800	17,800	11,900	40,500	30,300	20,200
2MM9307WI	0.80	1.20	0.51	0.68	20,300	15,200	10,200	34,500	25,800	17,300
2MM9308WI	1.20	1.90	0.80	1.07	17,900	13,400	9,000	30,400	22,800	15,300
2MM9309WI	1.30	2.10	0.88	1.18	16,000	12,000	8,000	27,200	20,400	13,600
2MM9310WI	1.40	2.30	0.95	1.27	14,600	11,000	7,300	24,800	18,700	12,400
2MM9311WI	1.90	3.00	1.30	1.70	13,300	10,000	6,600	22,600	17,000	11,200
2MM9312WI	2.00	3.20	1.40	1.80	12,200	9,200	6,100	20,700	15,600	10,400
2MM9313WI	2.10	3.40	1.40	1.90	11,400	8,500	5,700	19,400	14,500	9,700
2MM9314WI	3.60	5.70	2.40	3.20	10,500	7,900	5,200	17,900	13,400	8,800
2MM9315WI	3.80	6.10	2.50	3.40	9,800	7,400	4,900	16,700	12,600	8,300
2MM9316WI	4.00	6.40	2.70	3.50	9,300	7,000	4,600	15,800	11,900	7,800
2MM9317WI	5.30	8.60	3.60	4.80	8,600	6,500	4,300	14,600	11,100	7,300
2MM9318WI	5.90	9.40	3.90	5.20	8,200	6,200	4,100	13,900	10,500	7,000
2MM9319WI	6.10	9.70	4.10	5.40	7,800	5,900	3,900	13,300	10,000	6,600
2MM9320WI	7.50	12.00	5.00	6.70	7,300	5,500	3,600	12,400	9,400	6,100
2MM9322WI	8.10	13.00	5.40	7.30	6,700	5,000	3,400	11,400	8,500	5,800
2MM9324WI	11.10	17.80	7.40	9.90	6,200	4,600	3,100	10,500	7,800	5,300
2MM9326WI	14.60	23.30	9.70	13.00	5,700	4,300	2,800	9,700	7,300	4,800
2MM9328WI	15.50	24.80	10.40	13.80	5,300	4,000	2,600	9,000	6,800	4,400
2MM9330WI	24.80	39.70	16.60	22.10	5,000	3,700	2,500	8,500	6,300	4,300
2MM9332WI	26.20	41.90	17.50	23.30	4,600	3,500	2,300	7,900	5,900	3,900
2MM9334WI	28.20	45.20	18.90	25.10	4,400	3,300	2,200	7,500	5,600	3,700
2MM9340WI	56.80	90.90	37.90	50.60	3,700	2,800	1,800	6,300	4,700	3,100

Notes
1) For other mounting arrangement configurations refer to Engineering chapter on Fafnir Permissible Speed calculation methods.
2) For ceramic ball complements use 120% of speeds shown.

Fafnir Ultra-Light
2(3)MM9300WI (ISO 19) Series
Speed Capability Data

	Grease Capacity		Kluber Isoflex NBU15		Operating Speeds[2] (DB Mounting)					
					Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams				rpm			rpm		
3MM9300WI	0.09	0.15	0.06	0.08	55,800	41,850	27,900	94,860	71,190	47,430
3MM9301WI	0.11	0.17	0.07	0.10	48,420	36,270	24,210	82,350	61,650	41,130
3MM9302WI	0.17	0.28	0.12	0.15	40,050	30,060	19,980	68,130	51,120	33,930
3MM9303WI	0.19	0.30	0.12	0.16	36,090	27,090	18,000	61,380	46,080	30,600
3MM9304WI	0.40	0.60	0.25	0.34	30,330	22,770	15,120	51,570	38,700	25,740
3MM9305WI	0.40	0.70	0.29	0.39	25,020	18,810	12,510	42,570	31,950	21,240
3MM9306WI	0.50	0.80	0.34	0.45	21,420	16,020	10,710	36,450	27,270	18,180
3MM9307WI	0.80	1.20	0.51	0.68	18,270	13,680	9,180	31,050	23,220	15,570
3MM9308WI	1.20	1.90	0.80	1.07	16,110	12,060	8,100	27,360	20,520	3,770
3MM9309WI	1.30	2.10	0.88	1.18	14,400	10,800	7,200	24,480	18,360	12,240
3MM9310WI	1.40	2.30	0.95	1.27	13,140	9,900	6,570	22,320	16,830	11,160
3MM9311WI	1.90	3.00	1.30	1.70	11,970	9,000	5,940	20,340	15,300	10,080
3MM9312WI	2.00	3.20	1.40	1.80	10,980	8,280	5,490	18,630	14,040	9,360
3MM9313WI	2.10	3.40	1.40	1.90	10,260	7,650	5,130	17,460	13,050	8,730
3MM9314WI	3.60	5.70	2.40	3.20	9,450	7,110	4,680	16,110	12,060	7,920
3MM9315WI	3.80	6.10	2.50	3.40	8,820	6,660	4,410	15,030	11,340	7,470
3MM9316WI	4.00	6.40	2.70	3.50	8,370	6,300	4,140	14,220	10,710	7,020
3MM9317WI	5.30	8.60	3.60	4.80	7,740	5,850	3,870	13,140	9,990	6,570
3MM9318WI	5.90	9.40	3.90	5.20	7,380	5,580	3,690	12,510	9,450	6,300
3MM9319WI	6.10	9.70	4.10	5.40	7,020	5,310	3,510	11,970	9,000	5,940
3MM9320WI	7.50	12.00	5.00	6.70	6,570	4,950	3,240	11,160	8,460	5,490
3MM9322WI	8.10	13.00	5.40	7.30	6,030	4,500	3,060	10,260	7,650	5,220
3MM9324WI	11.10	17.80	7.40	9.90	5,580	4,140	2,790	9,450	7,020	4,770
3MM9326WI	14.60	23.30	9.70	13.00	5,130	3,870	2,520	8,730	6,570	4,320
3MM9328WI	15.50	24.80	10.40	13.80	4,770	3,600	2,340	8,100	6,120	3,960
3MM9330WI	24.80	39.70	16.60	22.10	4,500	3,330	2,250	7,650	5,670	3,870
3MM9332WI	26.20	41.90	17.50	23.30	4,140	3,150	2,070	7,110	5,310	3,510
3MM9334WI	28.20	45.20	18.90	25.10	3,960	2,970	1,980	6,750	5,040	3,330
3MM9340WI	56.80	90.90	37.90	50.60	3,330	2,520	1,620	5,670	4,230	2,790



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WN Construction:
- Incorporates low shoulder on non-thrust side of both outer and inner rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (mm)	Wt.	C_0 (stat)	C_e(dyn)	Limiting Speed	C_0 (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	mm/tol: +0; -(μm)				kg.	N		rpm	N		rpm	mm	mm			
9300HX	10 (4)	22 (5)	6 (40)	12 x 3.2	0.01	534 *489*	1,468 *1,468*	91,700 *110,040*	534 *489*	1,379 *1,379*	82,500 *99,000*	0.3	13.2	13	19.6	19.3
9301HX	12 (4)	24 (5)	6 (80)	13 x 3.2	0.01	623 *534*	1,512 *1,512*	80,000 *96,000*	580 *520*	1,420 *1,420*	72,000 *86,400*	0.3	15.2	14.9	21.6	21.3
9302HX	15 (4)	28 (5)	7 (80)	13 x 3.6	0.02	979 *890*	2,091 *2,091*	66,800 *80,160*	890 *801*	2,046 *2,046*	60,100 *72,120*	0.3	18.3	18.1	25.5	25.2
9303HX	17 (4)	30 (5)	7 (80)	14 x 3.6	0.02	1,023 *934*	2,224 *2,224*	60,400 *72,480*	979 *890*	2,091 *2,091*	54,400 *65,280*	0.3	20.3	20	27.5	27.2
9304HX	20 (5)	37 (6)	9 (120)	14 x 4.8	0.04	1,690 *1,512*	3,514 *3,514*	50,200 *60,240*	1,601 *1,423*	3,336 *3,336*	45,200 *54,240*	0.3	24.1	23.9	33.7	33.4
9305HX	25 (5)	42 (6)	9 (120)	17 x 4.8	0.04	2,046 *1,824*	3,781 *3,781*	41,800 *50,160*	1,913 *1,735*	3,603 *3,603*	37,600 *45,120*	0.3	29.1	28.9	38.7	38.4
9306HX	30 (5)	47 (6)	9 (120)	19 x 4.8	0.05	2,402 *2,135*	4,048 *4,048*	35,900 *43,080*	2,224 *1,957*	3,825 *3,825*	32,300 *38,760*	0.3	34.1	33.9	43.7	43.4
9307HX	35 (6)	55 (7)	10 (120)	19 x 5.6	0.08	3,158 *2,847*	5,115 *5,115*	30,500 *36,600*	2,980 *2,624*	4,804 *4,804*	27,500 *33,000*	0.6	40	39.5	51.1	50.6
9308HX	40 (6)	62 (7)	12 (120)	19 x 6.4	0.11	6,005 *5,338*	10,675 *10,675*	28,000 *33,600*	5,693 *5,071*	10,097 *10,097*	25,200 *30,240*	0.6	45.1	44.6	57.9	57.4
9309HX	45 (6)	68 (7)	12 (120)	21 x 6.4	0.13	6,716 *6,005*	11,164 *11,164*	25,000 *30,000*	6,405 *5,693*	10,586 *10,586*	22,500 *27,000*	0.6	50.7	50.1	63.4	62.9
9310HX	50 (6)	72 (7)	12 (120)	23 x 6.4	0.14	7,473 *6,672*	11,698 *11,698*	22,900 *27,480*	7,072 *6,405*	11,031 *11,031*	20,600 *24,720*	0.6	55.1	54.6	67.9	67.4
9311HX	55 (7)	80 (7)	13 (150)	23 x 7.1	0.19	9,430 *8,407*	14,500 *14,500*	20,700 *24,840*	8,896 *7,917*	13,700 *13,700*	18,600 *22,320*	1.0	60.9	60.4	75.2	74.7
9312HX	60 (7)	85 (8)	13 (150)	25 x 7.1	0.2	10,319 *9,207*	15,123 *15,123*	19,200 *23,040*	9,697 *8,629*	14,278 *14,278*	17,300 *20,760*	1.0	65.8	65.3	80.2	79.7

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

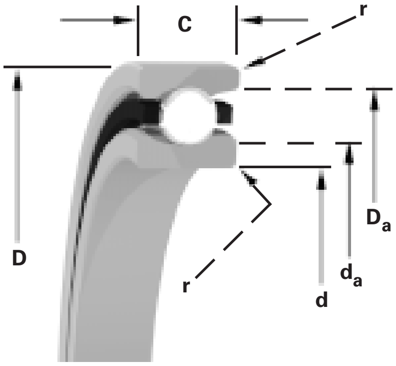
Fafnir Ultra-Light 2(3)MMV9300HX (ISO 19) Series

Metric Dimensional Sizes

High Speed Seal Option
Available with non-contact seals. Add VV suffix to part number (in place of CR cage designation). Ex: 2MMV9106HXVV SUL

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
9.995	10.000	0.005	0.004	22.000	22.005	0.0000	0.010	22.010	22.005	0.015	0.005	**9300HX**
11.995	12.000	0.005	0.004	24.000	24.005	0.000	0.010	24.010	24.005	0.015	0.005	**9301HX**
14.995	15.000	0.005	0.004	28.000	28.005	0.000	0.010	28.010	28.005	0.015	0.005	**9302HX**
16.995	17.000	0.005	0.004	30.000	30.005	0.000	0.010	30.010	30.005	0.015	0.005	**9303HX**
19.995	20.000	0.005	0.005	37.000	37.006	0.000	0.012	37.010	37.005	0.016	0.005	**9304HX**
24.995	25.000	0.005	0.005	42.000	42.006	0.000	0.012	42.010	42.005	0.016	0.005	**9305HX**
29.995	30.000	0.005	0.005	47.000	47.006	0.000	0.012	47.012	47.007	0.018	0.007	**9306HX**
34.995	35.000	0.005	0.006	55.000	55.008	0.000	0.015	55.012	55.007	0.019	0.007	**9307HX**
39.995	40.000	0.005	0.006	62.000	62.008	0.000	0.015	62.012	62.007	0.019	0.007	**9308HX**
44.995	45.000	0.005	0.006	68.000	68.008	0.000	0.015	68.012	68.007	0.019	0.007	**9309HX**
49.995	50.000	0.005	0.006	72.000	72.008	0.000	0.015	72.011	72.007	0.019	0.007	**9310HX**
54.995	55.000	0.005	0.007	80.000	80.008	0.000	0.015	80.012	80.008	0.020	0.008	**9311HX**
59.995	60.000	0.005	0.007	85.000	85.008	0.000	0.016	85.016	85.009	0.024	0.009	**9312HX**

(continued)



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WN Construction:

- Incorporates low shoulder on non-thrust side of both outer and inner rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (mm)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	mm/tol: +0; -(μm)				kg.	N		rpm	N		rpm	mm	mm			
9313HX	65	90	13	27 x 7.1	0.22	11,164	15,701	17,800	10,400	14,800	16,000	1.0	70.8	70.3	85.2	84.7
	(7)	(8)	(150)			*9,919*	*15,701*	*21,360*	*9,250*	*14,800*	*19,200*					
9314HX	70	100	16	24 x 8.7	0.34	14,767	21,306	16,400	13,922	20,105	14,800	1.0	76.8	76.3	94.3	93.8
	(7)	(8)	(150)			*13,166*	*21,306*	*19,680*	*12,365*	*20,105*	*17,760*					
9315HX	75	105	16	25 x 8.7	0.36	15,435	21,617	15,400	14,500	20,416	13,900	1.0	81.9	81.1	99.4	98.6
	(7)	(8)	(150)			*13,744*	*21,617*	*18,480*	*12,899*	*20,416*	*16,680*					
9316HX	80	110	16	27 x 8.7	0.39	16,680	22,507	14,500	15,568	21,217	13,100	1.0	86.9	86.1	104.4	103.6
	(7)	(8)	(150)			*14,856*	*22,507*	*17,400*	*13,833*	*21,217*	*15,720*					
9317HX	85	120	18	26 x 9.5	0.56	19,171	25,754	13,500	17,836	24,242	12,200	1.0	93.6	92.8	112.7	111.9
	(8)	(8)	(200)			*17,036*	*25,754*	*16,200*	*15,879*	*24,242*	*14,640*					
9318HX	90	125	18	26 x 10.3	0.57	22,462	29,935	12,900	20,995	28,200	11,600	1.0	97.8	97.0	118.5	117.7
	(8)	(9)	(200)			*19,972*	*29,935*	*15,480*	*18,682*	*28,200*	*13,920*					
9319HX	95	130	18	28 x 10.3	0.6	24,197	31,136	12,300	22,507	29,312	10,300	1.0	102.8	102.0	123.5	122.7
	(8)	(9)	(200)			*21,528*	*31,136*	*14,760*	*20,060*	*29,312*	*12,360*					
9320HX	100	140	20	29 x 10.3	0.85	24,864	31,403	11,400	23,174	29,535	9,900	1.0	110.3	109.5	131	130.2
	(8)	(9)	(200)			*22,151*	*31,403*	*13,680*	*20,639*	*29,535*	*11,800*					
9322HX	110	150	20	31 x 10.3	0.92	26,377	32,204	10,500	24,597	30,291	9,500	1.0	120.3	119.5	141	140.2
	(8)	(9)	(200)			*23,485*	*32,204*	*12,600*	*21,884*	*30,291*	*11,400*					
9324HX	120	165	22	30 x 11.9	1.24	34,161	41,277	9,600	31,803	38,831	8,600	1.0	131.2	130.4	155	154.3
	(8)	(10)	(200)			*30,424*	*41,277*	*11,520*	*28,334*	*38,831*	*10,320*					
9326HX	130	180	24	30 x 13.5	1.65	44,035	52,042	8,900	41,055	48,928	8,000	1.5	142.1	141.4	169.2	168.4
	(10)	(10)	(250)			*39,187*	*52,042*	*10,680*	*36,518*	*48,928*	*9,600*					
9328HX	140	190	24	32 x 13.5	1.75	46,704	53,821	8,300	43,501	50,707	7,500	1.5	152.1	151.4	179.2	178.4
	(10)	(10)	(250)			*41,544*	*53,821*	*9,960*	*38,742*	*50,707*	*9,000*					
9330HX	150	210	28	27 x 17.5	2.61	66,720	79,174	7,700	62,717	74,726	6,900	2.0	163.1	162.4	198.2	197.4
	(10)	(10)	(250)			*59,603*	*79,174*	*9,240*	*55,600*	*74,726*	*8,280*					

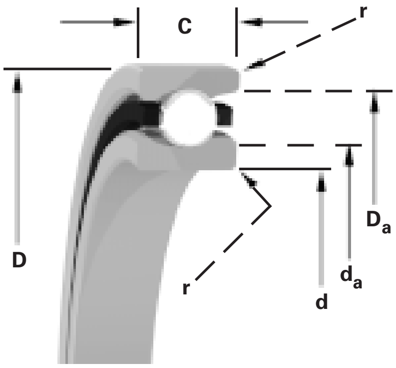
Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Ultra-Light 2(3)MMV9300HX (ISO 19) Series

Metric Dimensional Sizes

High Speed Seal Option
Available with non-contact seals. Add VV suffix to part number (in place of CR cage designation). Ex: 2MMV9106HXVV SUL

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
64.995	65.000	0.005	0.007	90.000	90.008	0.0000	0.016	90.015	90.007	0.023	0.007	**9313WI**
69.995	70.000	0.005	0.007	100.000	100.008	0.0000	0.016	100.018	100.010	0.025	0.010	**9314WI**
74.995	75.005	0.005	0.012	105.000	105.008	0.0000	0.016	105.019	105.011	0.026	0.011	**9315WI**
79.995	80.005	0.005	0.012	110.000	110.008	0.0000	0.016	110.018	110.010	0.025	0.010	**9316WI**
84.995	85.005	0.005	0.012	120.000	120.008	0.0000	0.016	120.018	120.010	0.025	0.010	**9317WI**
89.995	90.005	0.005	0.013	125.000	125.008	0.0000	0.017	125.021	125.011	0.030	0.011	**9318WI**
94.995	95.005	0.005	0.013	130.000	130.009	0.0000	0.018	130.020	130.010	0.029	0.010	**9319WI**
99.995	100.005	0.005	0.013	140.000	140.009	0.0000	0.018	140.020	140.010	0.029	0.010	**9320WI**
109.995	110.005	0.005	0.013	150.000	150.009	0.0000	0.018	150.023	150.012	0.032	0.012	**9322WI**
119.995	120.005	0.005	0.013	165.000	165.010	0.0000	0.020	165.022	165.012	0.032	0.012	**9324WI**
129.995	130.005	0.005	0.015	180.000	180.010	0.0000	0.020	180.022	180.012	0.032	0.012	**9326WI**
139.995	140.005	0.005	0.015	190.000	190.010	0.0000	0.021	190.022	190.012	0.033	0.012	**9328WI**
149.995	150.005	0.005	0.015	210.000	210.011	0.0000	0.022	210.025	210.015	0.036	0.015	**9330WI**



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WN Construction:

- Incorporates low shoulder on non-thrust side of both outer and inner rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

	d Bore	D O.D.	C Width[1]	Ball Qty. x Dia. (in.)	Wt.	(2MM) Load Ratings (steel ball & *ceramic ball*) C_o (stat)	(2MM) C_e(dyn)	(2MM) Limiting Speed	(3MM) Load Ratings (steel ball & *ceramic ball*) C_o (stat)	(3MM) C_e(dyn)	(3MM) Limiting Speed	r Rad.[2]	Recommended Shoulder Diameters d_a (Shaft) max.	d_a (Shaft) min.	D_a (Housing) max.	D_a (Housing) min.
	in/tol: +0; -.000(X)				lbs.	lbs.		rpm	lbs.		rpm	in.	in.			
9300HX	0.3937 (1.5)	0.8661 (2)	0.2362 (16)	13 x 3/32	0.02	120 *110*	330 *330*	91,700 *110,040*	120 *110*	310 *310*	82,500 *99,000*	0.012	0.52	0.51	0.77	0.76
9301HX	0.4724 (1.5)	0.9449 (2)	0.2362 (31)	13 x 3/32	0.03	140 *120*	340 *340*	80,000 *96,000*	130 *120*	320 *320*	72,000 *86,400*	0.012	0.6	0.59	0.85	0.84
9302HX	0.5906 (1.5)	1.1024 (2)	0.2756 (31)	16 x 7/64	0.04	220 *200*	470 *470*	66,800 *80,160*	200 *180*	460 *460*	60,100 *72,120*	0.012	0.72	0.71	1	0.99
9303HX	0.6693 (1.5)	1.1811 (2)	0.2756 (31)	17 x 7/64	0.04	230 *210*	500 *500*	60,400 *72,480*	220 *200*	470 *470*	54,400 *65,280*	0.012	0.8	0.79	1.08	1.07
9304HX	0.7874 (2)	1.4567 (2.5)	0.3543 (47)	17 x 9/64	0.08	380 *340*	790 *790*	50,200 *60,240*	360 *320*	750 *750*	45,200 *54,240*	0.012	0.95	0.94	1.33	1.32
9305HX	0.9843 (2)	1.6535 (2.5)	0.3543 (47)	20 x 9/64	0.1	460 *410*	850 *850*	41,800 *50,160*	430 *390*	810 *810*	37,600 *45,120*	0.012	1.15	1.14	1.52	1.51
9306HX	1.1811 (2)	1.8504 (2.5)	0.3543 (47)	23 x 9/64	0.11	540 *480*	910 *910*	35,900 *43,080*	500 *440*	860 *860*	32,300 *38,760*	0.012	1.34	1.33	1.72	1.71
9307HX	1.378 (2.5)	2.1654 (3)	0.3937 (47)	25 x 5/32	0.18	710 *640*	1,150 *1,150*	30,500 *36,600*	670 *590*	1,080 *1,080*	27,500 *33,000*	0.024	1.57	1.55	2.01	1.99
9308HX	1.5748 (2.5)	2.4409 (3)	0.4724 (47)	19 x 1/4	0.25	1,350 *1,200*	2,400 *2,400*	28,000 *33,600*	1,280 *1,140*	2,270 *2,270*	25,200 *30,240*	0.024	1.78	1.76	2.28	2.26
9309HX	1.7717 (2.5)	2.6772 (3)	0.4724 (47)	21 x 1/4	0.29	1,510 *1,350*	2,510 *2,510*	25,000 *30,000*	1,440 *1,280*	2,380 *2,380*	22,500 *27,000*	0.024	1.99	1.97	2.5	2.48
9310HX	1.9685 (2.5)	2.8346 (3)	0.4724 (47)	23 x 1/4	0.3	1,680 *1,500*	2,630 *2,630*	22,900 *27,480*	1,590 *1,440*	2,480 *2,480*	20,600 *24,720*	0.024	2.17	2.15	2.67	2.65
9311HX	2.1654 (3)	3.1496 (3)	0.5118 (59)	23 x 9/32	0.39	2,120 *1,890*	3,260 *3,260*	20,700 *24,840*	2,000 *1,780*	3,080 *3,080*	18,600 *22,320*	0.039	2.4	2.38	2.96	2.94
9312HX	2.3622 (3)	3.3465 (3)	0.5118 (59)	25 x 9/32	0.43	2,320 *2,070*	3,400 *3,400*	19,200 *23,040*	2,180 *1,940*	3,210 *3,210*	17,300 *20,760*	0.039	2.59	2.57	3.16	3.14

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

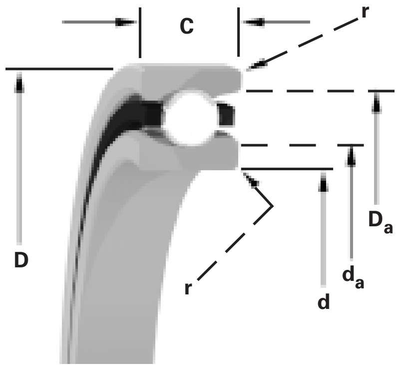
Fafnir Ultra-Light 2(3)MMV9300HX (ISO 19) Series

Inch Dimensional Sizes

High Speed Seal Option
Available with non-contact seals. Add VV suffix to part number (in place of CR cage designation). Ex: 2MMV9106HXVV SUL

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
0.3935	0.3937	0.0002	0.00015	0.8661	0.8663	0.0000	0.0004	0.8665	0.8663	0.0006	0.0002	**9300HX**
0.4722	0.4724	0.0002	0.00015	0.9449	0.9451	0.0000	0.0004	0.9453	0.9451	0.0006	0.0002	**9301HX**
0.5904	0.5906	0.0002	0.00015	1.0236	1.0238	0.0000	0.0004	1.0240	1.0238	0.0006	0.0002	**9302HX**
0.6691	0.6693	0.0002	0.00015	1.1811	1.1813	0.0000	0.0004	1.1815	1.1813	0.0006	0.0002	**9303HX**
0.7872	0.7874	0.0002	0.0002	1.4567	1.4570	0.0000	0.0005	1.4571	1.4569	0.0007	0.0002	**9304HX**
0.9841	0.9843	0.0002	0.0002	1.6535	1.6538	0.0000	0.0005	1.6539	1.6537	0.0007	0.0002	**9305HX**
1.1809	1.1811	0.0002	0.0002	1.8504	1.8507	0.0000	0.0005	1.8509	1.8507	0.0008	0.0003	**9306HX**
1.3778	1.3780	0.0002	0.00025	2.1654	2.1657	0.0000	0.0006	2.1659	2.1657	0.0008	0.0003	**9307HX**
1.5746	1.5748	0.0002	0.00025	2.4409	2.4412	0.0000	0.0006	2.4414	2.4412	0.0008	0.0003	**9308HX**
1.7715	1.7717	0.0002	0.00025	2.6772	2.6775	0.0000	0.0006	2.6777	2.6775	0.0008	0.0003	**9309HX**
1.9683	1.9685	0.0002	0.00025	2.8346	2.8349	0.0000	0.0006	2.8351	2.8349	0.0008	0.0003	**9310HX**
2.1652	2.1654	0.0002	0.0003	3.1496	3.1499	0.0000	0.0006	3.1501	3.1499	0.0008	0.0003	**9311HX**
2.3620	2.3622	0.0002	0.0003	3.3465	3.3468	0.0000	0.0006	3.3471	3.3468	0.0009	0.0003	**9312HX**

(continued)



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WN Construction:

- Incorporates low shoulder on non-thrust side of both outer and inner rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (in.)	Wt.	(2MM) Load Ratings (steel ball & *ceramic ball*) C_o (stat)	C_e(dyn)	Limiting Speed	(3MM) Load Ratings (steel ball & *ceramic ball*) C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	Recommended Shoulder Diameters d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	in/tol: +0; -.000(X)				lbs.	lbs.		rpm	lbs.		rpm	in.	in.			
9313HX	2.5591 (3)	3.5433 (3)	0.5118 (59)	27 x 9/32	0.45	2,510 *2,230*	3,530 *3,530*	17,800 *21,360*	2,340 *2,080*	3,320 *3,320*	16,000 *19,200*	0.039	2.79	2.77	3.35	3.33
9314HX	2.7559 (3)	3.937 (3)	0.6299 (59)	24 x 11/32	0.75	3,320 *2,960*	4,790 *4,790*	16,400 *19,680*	3,130 *2,780*	4,520 *4,520*	14,800 *17,760*	0.039	3.02	3	3.71	3.69
9315HX	2.9528 (3)	4.1339 (3)	0.6299 (59)	25 x 11/32	0.8	3,470 *3,090*	4,860 *4,860*	15,400 *18,480*	3,260 *2,900*	4,590 *4,590*	13,900 *16,680*	0.039	3.22	3.19	3.91	3.88
9316HX	3.1496 (3)	4.3307 (3)	0.6299 (59)	27 x 11/32	0.8	3,750 *3,340*	5,060 *5,060*	14,500 *17,400*	3,500 *3,110*	4,770 *4,770*	13,100 *15,720*	0.039	3.42	3.39	4.11	4.08
9317HX	3.3465 (3)	4.7244 (3)	0.7087 (79)	26 x 3/8	1.16	4,310 *3,830*	5,790 *5,790*	13,500 *16,200*	4,010 *3,570*	5,450 *5,450*	12,200 *14,640*	0.039	3.69	3.66	4.44	4.41
9318HX	3.5433 (3)	4.9213 (3.5)	0.7087 (79)	26 x 13/32	1.2	5,050 *4,490*	6,730 *6,730*	12,900 *15,480*	4,720 *4,200*	6,340 *6,340*	11,600 *13,920*	0.039	3.85	3.82	4.66	4.63
9319HX	3.7402 (3)	5.1181 (3.5)	0.7087 (79)	28 x 13/32	1.26	5,440 *4,840*	7,000 *7,000*	12,300 *14,760*	5,060 *4,510*	6,590 *6,590*	10,300 *12,360*	0.039	4.05	4.02	4.86	4.83
9320HX	3.937 (3)	5.5118 (3.5)	0.7874 (79)	29 x 13/32	1.8	5,590 *4,980*	7,060 *7,060*	11,400 *13,680*	5,210 *4,640*	6,640 *6,640*	10,000 *12,000*	0.039	4.34	4.31	5.16	5.13
9322HX	4.3307 (3)	5.9055 (3.5)	0.7874 (79)	31 x 13/32	1.92	5,930 *5,280*	7,240 *7,240*	10,500 *12,600*	5,530 *4,920*	6,810 *6,810*	9,500 *11,400*	0.039	4.74	4.71	5.55	5.52
9324HX	4.7244 (3)	6.4961 (4)	0.8661 (79)	30 x 15/32	2.6	7,680 *6,840*	9,280 *9,280*	9,600 *11,520*	7,150 *6,370*	8,730 *8,730*	8,600 *10,320*	0.039	5.16	5.13	6.1	6.07
9326HX	5.1181 (4)	7.0866 (4)	0.9449 (98)	30 x 17/32	3.63	9,900 *8,810*	11,700 *11,700*	8,900 *10,680*	9,230 *8,210*	11,000 *11,000*	8,000 *9,600*	0.059	5.6	5.57	6.66	6.63
9328HX	5.5118 (4)	7.4803 (4.5)	0.9449 (98)	32 x 17/32	3.85	10,500 *9,340*	12,100 *12,100*	8,300 *9,960*	9,780 *8,710*	11,400 *11,400*	7,500 *9,000*	0.059	5.99	5.96	7.05	7.02
9330HX	5.9055 (4)	8.2677 (4.5)	1.1024 (98)	27 x 11/16	5.75	15,000 *13,400*	17,800 *17,800*	7,700 *9,240*	14,100 *12,500*	16,800 *16,800*	6,900 *8,200*	0.079	6.42	6.39	7.8	7.77

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

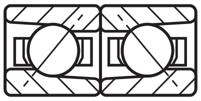
Fafnir Ultra-Light 2(3)MMV9300HX (ISO 19) Series

Inch Dimensional Sizes

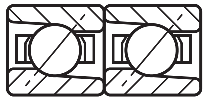
High Speed Seal Option
Available with non-contact seals. Add VV suffix to part number (in place of CR cage designation). Ex: 2MMV9106HXVV SUL

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
2.5589	2.5591	0.0002	0.0003	3.5433	3.5436	0.0000	0.0006	3.5439	3.5436	0.0009	0.0003	**9313HX**
2.7557	2.7559	0.0002	0.0003	3.9370	3.9373	0.0000	0.0006	3.9377	3.9374	0.0010	0.0004	**9314HX**
2.9526	2.9530	0.0002	0.0005	4.1339	4.1342	0.0000	0.0006	4.1346	4.1343	0.0010	0.0004	**9315HX**
3.1494	3.1498	0.0002	0.0005	4.3307	4.3310	0.0000	0.0006	4.3314	4.3311	0.0010	0.0004	**9316HX**
3.3463	3.3467	0.0002	0.0005	4.7244	4.7247	0.0000	0.0006	4.7251	4.7248	0.0010	0.0004	**9317HX**
3.5431	3.5435	0.0002	0.0005	4.9213	4.9216	0.0000	0.0007	4.9221	4.9217	0.0012	0.0004	**9318HX**
3.7400	3.7404	0.0002	0.0005	5.1181	5.1185	0.0000	0.0007	5.1189	5.1185	0.0011	0.0004	**9319HX**
3.9368	3.9372	0.0002	0.0005	5.5118	5.5122	0.0000	0.0007	5.5126	5.5122	0.0011	0.0004	**9320HX**
4.3305	4.3309	0.0002	0.0005	5.9055	5.9059	0.0000	0.0007	5.9064	5.906	0.0012	0.0005	**9322HX**
4.7242	4.7246	0.0002	0.0005	6.4961	6.4965	0.0000	0.0008	6.4970	6.4966	0.0013	0.0005	**9324HX**
5.1179	5.1183	0.0002	0.0006	7.0866	7.0870	0.0000	0.0008	7.0875	7.0871	0.0013	0.0005	**9326HX**
5.5116	5.5120	0.0002	0.0006	7.4803	7.4807	0.0000	0.0008	7.4812	7.4808	0.0014	0.0005	**9328HX**
5.9053	5.9057	0.0002	0.0006	8.2677	8.2682	0.0000	0.0009	8.2687	8.2683	0.0015	0.0006	**9330HX**

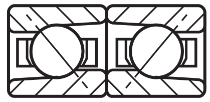
Mounting Arrangements



Recommended DB



Tandem DT



Special Applications DF

	Preload			Axial Stiffness[1]			Radial Stiffness[1]			Spacer Offsets[1]	
	Light	Medium	Heavy	Light	Light	Medium	Medium	Heavy	Heavy	DUL to DUM	DUM to DUH
	lbs.			10^6lbs./in			10^6lbs./in			in.	
2MMV9300HX	2	6	12	0.0581	0.3489	0.0894	0.5059	0.1202	0.6337	.00022	.00022
2MMV9301HX	2	6	12	0.0614	0.3506	0.0957	0.5044	0.1301	0.6300	.00020	.00022
2MMV9302HX	5	10	20	0.0972	0.5509	0.1297	0.6912	0.1770	0.8627	.00018	.00026
2MMV9303HX	5	10	20	0.0966	0.5769	0.1275	0.7266	0.1718	0.9097	.00018	.00026
2MMV9304HX	5	15	30	0.1043	0.6269	0.1627	0.9029	0.2213	1.1280	.00030	.00032
2MMV9305HX	5	15	30	0.1154	0.6977	0.1787	1.0080	0.2417	1.2610	.00028	.00028
2MMV9306HX	5	15	30	0.1258	0.7644	0.1940	1.1070	0.2611	1.3870	.00024	.00026
2MMV9307HX	10	25	50	0.1759	1.0620	0.2550	1.4390	0.3460	1.7990	.00028	.00034
2MMV9308HX	10	30	60	0.1688	1.0170	0.2576	1.4840	0.3437	1.8620	.00038	.00040
2MMV9309HX	10	35	70	0.1799	1.0830	0.2910	1.6700	0.3889	2.0950	.00042	.00042
2MMV9310HX	15	40	80	0.2214	1.3300	0.3243	1.8560	0.4340	2.3270	.00036	.00042
2MMV9311HX	15	45	90	0.2260	1.3790	0.3449	2.0140	0.4603	2.5270	.00042	.00044
2MMV9312HX	15	50	100	0.2382	1.4530	0.3783	2.2050	0.5051	2.7670	.00046	.00046
2MMV9313HX	15	50	100	0.2501	1.5250	0.3962	2.3220	0.5278	2.9150	.00044	.00044
2MMV9314HX	25	75	150	0.2915	1.8100	0.4465	2.6370	0.5977	3.3070	.00054	.00058
2MMV9315HX	25	75	150	0.2991	1.8580	0.4575	2.7100	0.6117	3.4000	.00052	.00056
2MMV9316HX	25	75	150	0.3140	1.9510	0.4790	2.8530	0.6390	3.5820	.00050	.00054
2MMV9317HX	30	90	180	0.3339	2.0880	0.5104	3.0480	0.6820	3.8260	.00056	.00060
2MMV9318HX	30	90	180	0.3396	2.1330	0.5167	3.1340	0.6874	3.9390	.00056	.00060
2MMV9319HX	30	90	180	0.3559	2.2330	0.5403	3.2930	0.7174	4.1410	.00054	,00058
2MMV9320HX	35	110	220	0.3852	2.4210	0.5978	3.6050	0.7975	4.5270	.00060	.00062
2MMV9322HX	40	120	240	0.4221	2.6530	0.6444	3.8800	0.8601	4.8710	.00060	.00064
2MMV9324HX	50	150	300	0.4624	2.9370	0.7057	4.3000	0.9418	5.3990	.00068	.00072
2MMV9326HX	55	165	330	0.5028	3.1210	0.7627	4.6040	1.0120	5.7900	.00070	.00074
2MMV9328HX	60	180	360	0.5408	3.3590	0.8209	4.9480	1.0900	6.2220	.00070	.00076
2MMV9330HX	80	240	480	0.5694	3.6020	0.8640	5.3220	1.1470	6.6940	.00088	.00096

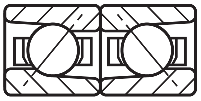
Notes

1) For DB or DF arrangements only. For other mounting arrangements contact Timken Engineering.

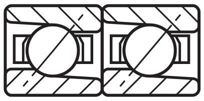
Fafnir Ultra-Light
2(3)MMV9300HX (ISO 19) Series
Inch Duplex Performance Data

	Preload			Axial Stiffness[1]			Radial Stiffness[1]			Spacer Offsets[1]	
	Light	Medium	Heavy	Light	Medium	Heavy	Light	Medium	Heavy	DUL to DUM	DUM to DUH
	lbs.			10^6lbs./in.			10^6lbs./in			in.	
3MMV9300HX	5	10	20	0.163	0.211	0.275	0.344	0.432	0.540	.00011	.00016
3MMV9301HX	5	10	20	0.171	0.221	0.288	0.362	0.455	0.568	.00010	.00016
3MMV9302HX	5	15	30	0.195	0.290	0.378	0.416	0.599	0.749	.00016	.00018
3MMV9303HX	5	15	30	0.203	0.301	0.392	0.433	0.624	0.781	.00016	.00017
3MMV9304HX	10	25	50	0.279	0.389	0.506	0.594	0.804	1.006	.00018	.00022
3MMV9305HX	10	25	50	0.310	0.431	0.559	0.661	0.898	1.124	.00016	.00020
3MMV9306HX	10	25	50	0.339	0.471	0.609	0.725	0.986	1.236	.00014	.00018
3MMV9307HX	15	40	80	0.426	0.606	0.787	0.910	1.262	1.580	.00020	.00022
3MMV9308HX	15	50	100	0.404	0.618	0.797	0.883	1.336	1.677	.00028	.00028
3MMV9309HX	20	55	110	0.476	0.682	0.880	1.044	1.474	1.851	.00024	.00028
3MMV9310HX	20	60	120	0.506	0.746	0.962	1.107	1.613	2.025	.00026	.00028
3MMV9311HX	25	75	150	0.567	0.836	1.079	1.239	1.805	2.267	.00028	.00032
3MMV9312HX	25	75	150	0.599	0.882	1.137	1.307	1.909	2.398	.00026	.00030
3MMV9313HX	25	75	150	0.630	0.927	1.193	1.372	2.009	2.526	.00026	.00028
3MMV9314HX	35	110	220	0.699	1.047	1.349	1.518	2.253	2.831	.00034	.00036
3MMV9315HX	35	110	220	0.718	1.074	1.384	1.558	2.315	2.910	.00034	.00036
3MMV9316HX	35	110	220	0.756	1.129	1.453	1.635	2.437	3.065	.00032	.00034
3MMV9317HX	45	140	280	0.826	1.232	1.588	1.792	2.651	3.331	.00036	.00040
3MMV9318HX	45	140	280	0.848	1.262	1.622	1.828	2.720	3.422	.00036	.00038
3MMV9319HX	45	140	280	0.890	1.324	1.700	1.913	2.858	3.597	.00034	.00036
3MMV9320HX	55	165	330	0.976	1.436	1.847	2.110	3.091	3.887	.00036	.00040
3MMV9322HX	60	180	360	1.051	1.546	1.990	2.273	3.327	4.183	.00036	.00040
3MMV9324HX	70	210	420	1.135	1.668	2.144	2.444	3.591	4.519	.00040	.00044
3MMV9326HX	80	240	480	1.237	1.814	2.329	2.646	3.912	4.927	.00042	.00046
3MMV9328HX	90	270	540	1.344	1.972	2.533	2.882	4.249	5.349	.00042	.00048
3MMV9330HX	120	360	720	1.424	2.090	2.683	3.091	4.569	5.755	.00054	.00060

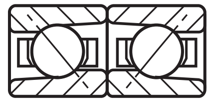
Mounting Arrangements



Recommended
DB



Tandem
DT



Special Applications
DF

	Preload			Axial Stiffness[1]			Radial Stiffness[1]			Spacer Offsets[1]	
	Light	Medium	Heavy	Light	Medium	Heavy	Light	Medium	Heavy	DUL to DUM	DUM to DUH
	lbs.			10^6N/m			10^6N/m			µm	
2MMV9300HX	9	25	55	10.2	15.6	21.0	61.0	88.5	110.8	5.6	5.6
2MMV9301HX	9	25	55	10.7	16.7	22.8	61.3	88.2	110.2	5.1	5.6
2MMV9302HX	20	45	85	17.0	22.7	31.0	96.4	120.9	150.9	4.6	6.6
2MMV9303HX	20	45	85	16.9	22.3	30.0	100.9	127.1	159.1	4.6	6.6
2MMV9304HX	20	65	135	18.2	28.5	38.7	109.6	157.9	197.3	7.6	8.1
2MMV9305HX	20	65	135	20.2	31.3	42.3	122.0	176.3	220.5	7.1	7.1
2MMV9306HX	20	65	135	22.0	33.9	45.7	133.7	193.6	242.6	6.1	6.6
2MMV9307HX	45	110	225	30.8	44.6	60.5	185.7	251.7	314.6	7.1	8.6
2MMV9308HX	45	135	265	29.5	45.1	60.1	177.9	259.6	325.7	9.7	10.2
2MMV9309HX	45	155	310	31.5	50.9	68.0	189.4	292.1	366.4	10.7	10.7
2MMV9310HX	65	175	355	38.7	56.7	75.9	232.6	324.6	407.0	9.1	10.7
2MMV9311HX	65	200	400	39.5	60.3	80.5	241.2	352.2	442.0	10.7	11.2
2MMV9312HX	65	225	445	41.7	66.2	88.3	254.1	385.7	483.9	11.7	11.7
2MMV9313HX	65	225	445	43.7	69.3	92.3	266.7	406.1	509.8	11.2	11.2
2MMV9314HX	110	335	665	51.0	78.1	104.5	316.6	461.2	578.4	13.7	14.7
2MMV9315HX	110	335	665	52.3	80.0	107.0	325.0	474.0	594.7	13.2	14.2
2MMV9316HX	110	335	665	54.9	83.8	111.8	341.2	499.0	626.5	12.7	13.7
2MMV9317HX	135	400	800	58.4	89.3	119.3	365.2	533.1	669.2	14.2	15.2
2MMV9318HX	135	400	800	59.4	90.4	120.2	373.1	548.1	688.9	14.2	15.2
2MMV9319HX	135	400	800	62.2	94.5	125.5	390.6	575.9	724.3	13.7	14.7
2MMV9320HX	155	490	975	67.4	104.6	139.5	423.4	630.5	791.8	15.2	15.7
2MMV9322HX	175	535	1065	73.8	112.7	150.4	464.0	678.6	851.9	15.2	16.3
2MMV9324HX	225	665	1335	80.9	123.4	164.7	513.7	752.1	944.3	17.3	18.3
2MMV9326HX	245	735	1465	87.9	133.4	177.0	545.9	805.2	1012.7	17.8	18.8
2MMV9328HX	265	800	1600	94.6	143.6	190.6	587.5	865.4	1088.2	17.8	19.3
2MMV9330HX	355	1065	2135	99.6	151.1	200.6	630.0	930.8	1170.8	22.4	24.4

Notes
1) For DB or DF arrangements only. For other mounting arrangements contact Timken Engineering.

Fafnir Ultra-Light 2(3)MMV9300HX (ISO 19) Series

Metric Duplex Performance Data

	Preload			Axial Stiffness[1]			Radial Stiffness[1]			Spacer Offsets[1]	
	Light	Medium	Heavy	Light	Medium	Heavy	Light	Medium	Heavy	DUL to DUM	DUM to DUH
	N			10^6N/m			10^6N/m			µm	
3MMV9300HX	22	45	90	28.53	36.82	48.06	60.22	75.61	94.48	2.79	4.06
3MMV9301HX	22	45	90	29.93	38.58	50.28	63.30	79.51	99.41	2.54	4.06
3MMV9302HX	22	65	135	34.07	50.72	66.06	72.78	104.78	131.04	4.06	4.57
3MMV9303HX	22	65	135	35.45	52.71	68.60	75.75	109.14	136.54	4.06	4.32
3MMV9304HX	45	110	225	48.76	67.98	88.46	103.86	140.69	175.95	4.57	5.59
3MMV9305HX	45	110	225	54.17	75.33	97.75	115.68	156.99	196.59	4.06	5.08
3MMV9306HX	45	110	225	59.33	82.33	106.58	126.87	172.47	216.18	3.56	4.57
3MMV9307HX	65	175	355	74.51	106.06	137.72	159.18	220.72	276.34	5.08	5.59
3MMV9308HX	65	225	445	70.62	108.04	139.41	154.45	233.67	293.31	7.11	7.11
3MMV9309HX	90	245	490	83.32	119.21	153.84	182.60	257.80	323.74	6.10	7.11
3MMV9310HX	90	265	535	88.43	130.41	168.25	193.61	282.11	354.17	6.60	7.11
3MMV9311HX	110	335	665	99.24	146.29	188.72	216.70	315.69	396.50	7.11	8.13
3MMV9312HX	110	335	665	104.80	154.33	198.86	228.59	333.88	419.41	6.60	7.62
3MMV9313HX	110	335	665	110.22	162.15	208.66	239.96	351.37	441.80	6.60	7.11
3MMV9314HX	155	490	980	122.31	183.12	235.94	265.50	394.05	495.14	8.64	9.14
3MMV9315HX	155	490	980	125.63	187.84	242.06	272.49	404.89	508.96	8.64	9.14
3MMV9316HX	155	490	980	132.14	197.46	254.13	285.96	426.23	536.07	8.13	8.64
3MMV9317HX	200	625	1245	144.52	215.48	277.74	313.42	463.66	582.59	9.14	10.16
3MMV9318HX	200	625	1245	148.32	220.72	283.69	319.72	475.73	598.51	9.14	9.65
3MMV9319HX	200	625	1245	155.70	231.57	297.33	334.58	499.86	629.12	8.64	9.14
3MMV9320HX	245	735	1465	170.75	251.16	323.04	369.04	540.62	679.84	9.14	10.16
3MMV9322HX	265	800	1600	183.82	270.40	348.05	397.55	581.89	731.61	9.14	10.16
3MMV9324HX	310	935	1870	198.51	291.73	374.99	427.46	628.07	790.37	10.16	11.18
3MMV9326HX	355	1065	2135	216.35	317.27	407.34	462.79	684.21	861.73	10.67	11.68
3MMV9328HX	400	1200	2400	235.07	344.90	443.02	504.06	743.15	935.54	10.67	12.19
3MMV9330HX	535	1600	3200	249.06	365.54	469.26	540.62	799.12	1,006.55	13.72	15.24

	Grease Capacity		Kluber Isoflex NBU15		Operating Speeds[2] (DB Mounting)					
					Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams				rpm			rpm		
2MMV9300HX	0.11	0.18	0.06	0.09	73,360	55,020	36,680	123,795	93,534	62,310
2MMV9301HX	0.13	0.20	0.07	0.11	64,000	48,000	32,000	108,000	81,600	54,360
2MMV9302HX	0.20	0.33	0.12	0.17	53,440	40,080	26,720	90,180	68,136	45,391
2MMV9303HX	0.23	0.36	0.12	0.18	48,320	36,240	24,160	81,540	61,608	41,042
2MMV9304HX	0.48	0.71	0.25	0.39	40,160	30,120	20,080	67,770	51,204	34,111
2MMV9305HX	0.48	0.83	0.29	0.44	33,440	25,080	16,720	56,430	42,636	28,403
2MMV9306HX	0.60	0.95	0.34	0.51	28,720	21,540	14,360	48,465	36,618	24,394
2MMV9307HX	0.95	1.43	0.51	0.77	24,400	18,300	12,200	41,175	31,110	20,725
2MMV9308HX	1.43	2.26	0.8	1.22	22,400	16,800	11,200	37,800	28,560	19,026
2MMV9309HX	1.55	2.50	0.88	1.34	20,000	15,000	10,000	33,750	25,500	16,988
2MMV9310HX	1.67	2.74	0.95	1.44	18,320	13,740	9,160	30,915	23,358	15,561
2MMV9311HX	2.26	3.57	1.3	1.93	16,560	12,420	8,280	27,945	21,114	14,066
2MMV9312HX	2.38	3.81	1.4	2.05	15,360	11,520	7,680	25,920	19,584	13,046
2MMV9313HX	2.50	4.05	1.4	2.16	14,240	10,680	7,120	24,030	18,156	12,095
2MMV9314HX	4.29	6.79	2.4	3.64	13,120	9,840	6,560	22,140	16,728	11,144
2MMV9315HX	4.52	7.26	2.5	3.86	12,320	9,240	6,160	20,790	15,708	10,464
2MMV9316HX	4.76	7.62	2.7	3.98	11,600	8,700	5,800	19,575	14,790	9,853
2MMV9317HX	6.31	10.24	3.6	5.45	10,800	8,100	5,400	18,225	13,770	9,173
2MMV9318HX	7.02	11.19	3.9	5.91	10,320	7,740	5,160	17,415	13,158	8,766
2MMV9319HX	7.26	11.55	4.1	6.14	9,840	7,380	4,920	16,605	12,546	8,358
2MMV9320HX	8.93	14.29	5	7.61	9,120	6,840	4,560	15,390	11,628	7,746
2MMV9322HX	9.64	15.48	5.4	8.30	8,400	6,300	4,200	14,175	10,710	7,135
2MMV9324HX	13.21	21.19	7.4	11.25	7,680	5,760	3,840	12,960	9,792	6,523
2MMV9326HX	17.38	27.74	9.7	14.77	7,088	5,316	3,540	11,960	9,037	6,020
2MMV9328HX	18.45	29.52	10.4	15.68	6,616	4,962	3,300	11,165	8,435	5,619
2MMV9330HX	29.52	47.26	16.6	25.11	6,168	4,626	3,080	10,410	7,864	5,239

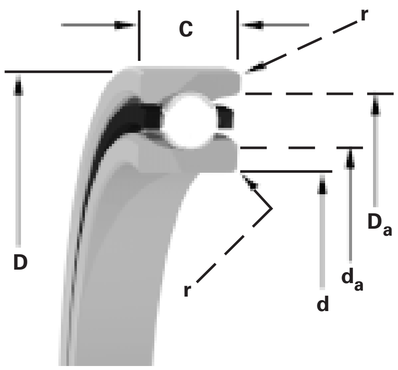
Notes
1) For other mounting arrangement configurations refer to Engineering chapter on Fafnir Permissible Speed calculation methods.
2) For ceramic ball complements use 120% of speeds shown.

Fafnir Ultra-Light 2(3)MMV9300HX (ISO 19) Series
Speed Capability Data

Super Precision Ball Bearings

	Grease Capacity		Kluber Isoflex NBU15		Operating Speeds[2] (DB Mounting)					
					Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams				rpm			rpm		
3MMV9300HX	0.11	0.18	0.06	0.08	66,080	49,560	33,040	111,510	84,250	56,125
3MMV9301HX	0.13	0.20	0.07	0.10	57,600	43,200	28,800	97,200	73,440	48,900
3MMV9302HX	0.20	0.33	0.12	0.15	48,080	36,060	24,040	81,135	61,300	40,850
3MMV9303HX	0.23	0.36	0.12	0.16	43,440	32,580	21,720	73,305	55,390	36,900
3MMV9304HX	0.48	0.71	0.25	0.34	36,160	27,120	18,080	61,020	46,100	30,700
3MMV9305HX	0.48	0.83	0.29	0.39	30,080	22,560	15,040	50,760	38,350	25,550
3MMV9306HX	0.60	0.95	0.34	0.45	25,840	19,380	12,920	43,605	32,950	21,950
3MMV9307HX	0.95	1.43	0.51	0.69	22,000	16,500	11,000	37,125	28,050	18,690
3MMV9308HX	1.43	2.26	0.8	1.08	20,160	15,120	10,080	34,020	25,700	17,125
3MMV9309HX	1.55	2.50	0.88	1.19	18,000	13,500	9,000	30,375	22,950	15,290
3MMV9310HX	1.67	2.74	0.95	1.28	16,480	12,360	8,240	27,810	21,000	14,000
3MMV9311HX	2.26	3.57	1.3	1.72	14,960	11,220	7,480	25,245	19,075	12,700
3MMV9312HX	2.38	3.81	1.4	1.82	13,760	10,320	6,880	23,220	17,500	11,690
3MMV9313HX	2.50	4.05	1.4	1.92	12,800	9,600	6,400	21,600	16,320	10,875
3MMV9314HX	4.29	6.79	2.4	3.23	11,840	8,880	5,920	19,980	15,100	10,060
3MMV9315HX	4.52	7.26	2.5	3.43	11,120	8,340	5,560	18,765	14,175	9,450
3MMV9316HX	4.76	7.62	2.7	3.54	10,480	7,860	5,240	17,685	13,360	8,900
3MMV9317HX	6.31	10.24	3.6	4.85	9,680	7,260	4,840	16,335	12,350	8,225
3MMV9318HX	7.02	11.19	3.9	5.25	9,280	6,960	4,640	15,660	11,825	7,880
3MMV9319HX	7.26	11.55	4.1	5.45	8,800	6,600	4,400	14,850	11,220	7,475
3MMV9320HX	8.93	14.29	5	6.77	8,240	6,180	4,120	13,905	10,500	7,000
3MMV9322HX	9.64	15.48	5.4	7.37	7,544	5,658	3,772	12,731	9,620	6,400
3MMV9324HX	13.21	21.19	7.4	10.00	6,912	5,184	3,456	11,664	8,810	5,875
3MMV9326HX	17.38	27.74	9.7	13.13	6,376	4,782	3,188	10,760	8,130	5,415
3MMV9328HX	18.45	29.52	10.4	13.94	5,960	4,470	2,980	10,058	7,600	5,050
3MMV9330HX	29.52	47.26	16.6	22.32	5,552	4,164	2,776	9,369	7,080	4,710

ISO/DIN	P5	P4	–	P2
Fafnir®	V x.xx	–	MM(V)	MMX x.xxxx



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WI Construction:

- Incorporates low shoulder on non-thrust side of outer rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

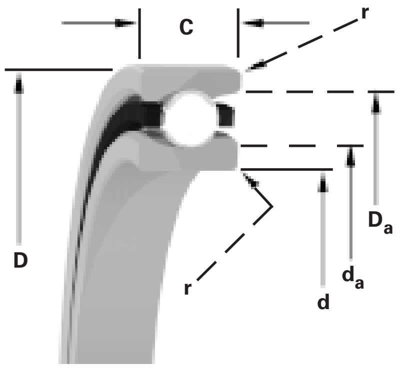
						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (in.)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	in/tol: +0; -.000(X)				lbs.	lbs.		rpm	lbs.		rpm	in.				
9100WI	0.3937 (1.5)	1.0236 (2)	0.315 (16)	8 x 3/16	0.04	490 *436*	1,210 *1,210*	68,500 *82,200*	480 *427*	1,190 *1,190*	61,700 *74,040*	0.012	0.54	0.53	0.92	0.91
9101WI	0.4724 (1.5)	1.1024 (2)	0.315 (31)	10 x 3/16	0.04	650 *579*	1,430 *1,430*	57,300 *68,760*	630 *561*	1,390 *1,390*	51,600 *61,920*	0.012	0.64	0.63	1.01	1.00
9102WI	0.5906 (1.5)	1.2598 (2.5)	0.3543 (31)	12 x 3/16	0.07	820 *730*	1,630 *1,630*	48,600 *58,320*	790 *703*	1,580 *1,580*	43,700 *52,440*	0.012	0.76	0.75	1.13	1.12
9103WI	0.6693 (1.5)	1.378 (2.5)	0.3937 (31)	11 x 3/16	0.08	770 *685*	1,530 *1,530*	43,100 *51,720*	750 *668*	1,480 *1,480*	38,800 *46,560*	0.012	0.86	0.85	1.23	1.22
9104WI	0.7874 (2)	1.6535 (2.5)	0.4724 (47)	11 x 1/4	0.15	1,350 *1,202*	2,600 *2,600*	37,100 *44,520*	1,290 *1,148*	2,500 *2,500*	33,400 *40,080*	0.024	0.99	0.98	1.49	1.48
9105WI	0.9843 (2)	1.8504 (2.5)	0.4724 (47)	13 x 1/4	0.17	1,660 *1,477*	2,900 *2,900*	30,900 *37,080*	1,590 *1,415*	2,770 *2,770*	27,800 *33,360*	0.024	1.19	1.18	1.68	1.67
9106WI	1.1811 (2)	2.1654 (3)	0.5118 (47)	14 x 9/32	0.25	2,310 *2,056*	3,770 *3,770*	25,500 *30,600*	2,200 *1,958*	3,600 *3,600*	23,000 *27,600*	0.039	1.43	1.42	2.00	1.99
9107WI	1.378 (2.5)	2.4409 (3)	0.5512 (47)	15 x 5/16	0.33	3,070 *2,732*	4,760 *4,760*	22,600 *27,120*	2,930 *2,608*	4,540 *4,540*	20,300 *24,360*	0.039	1.62	1.60	2.23	2.21
9108WI	1.5748 (2.5)	2.6772 (3)	0.5906 (47)	16 x 5/16	0.41	3,360 *2,990*	4,920 *4,920*	19,900 *23,880*	3,190 *2,839*	4,670 *4,670*	17,900 *21,480*	0.039	1.82	1.80	2.45	2.43
9109WI	1.7717 (2.5)	2.9528 (3)	0.6299 (47)	17 x 11/32	0.53	4,330 *3,854*	6,080 *6,080*	17,900 *21,480*	4,110 *3,658*	5,760 *5,760*	16,100 *19,320*	0.039	2.04	2.02	2.73	2.71
9110WI	1.9685 (2.5)	3.1496 (3)	0.6299 (47)	18 x 11/32	0.57	4,670 *4,156*	6,270 *6,270*	16,300 *19,560*	4,430 *3,943*	5,910 *5,910*	14,700 *17,640*	0.039	2.23	2.21	2.92	2.90
9111WI	2.1654 (3)	3.5433 (3)	0.7087 (59)	18 x 13/32	0.84	6,420 *5,714*	8,500 *8,500*	14,700 *17,640*	6,110 *5,438*	8,080 *8,080*	13,200 *15,840*	0.039	2.47	2.45	3.28	3.26
9112WI	2.3622 (3)	3.7402 (3)	0.7087 (59)	19 x 13/32	0.90	6,860 *6,105*	8,730 *8,730*	13,600 *16,320*	7,470 *6,648*	8,290 *8,290*	12,200 *14,640*	0.039	2.67	2.65	3.47	3.45
9113WI	2.5591 (3)	3.937 (3)	0.7087 (59)	20 x 13/32	0.96	7,330 *6,524*	8,950 *8,950*	12,700 *15,240*	6,970 *6,203*	8,480 *8,480*	11,400 *13,680*	0.039	2.86	2.84	3.67	3.65
9114WI	2.7559 (3)	4.3307 (3)	0.7874 (59)	19 x 15/32	1.33	9,150 *8,144*	11,300 *11,300*	11,700 *14,040*	8,730 *7,770*	10,700 *10,700*	10,500 *12,600*	0.039	3.08	3.06	4.03	4.01

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Extra-Light 2(3)MM9100WI (ISO 10) Series
Inch Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed: Housing Bore (Stationary)		Fixed: Mounting Fits		Floating: Housing Bore (Stationary)		Floating: Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
0.3935	0.3937	0.0002	0.00015	1.0236	1.0238	0.0000	0.0004	1.02400	1.02380	0.00060	0.00020	**9100WI**
0.4722	0.4724	0.0002	0.00015	1.1024	1.1026	0.0000	0.0004	1.10280	1.10260	0.00060	0.00020	**9101WI**
0.5904	0.5906	0.0002	0.00015	1.2598	1.2600	0.0000	0.00045	1.26020	1.26000	0.00070	0.00020	**9102WI**
0.6691	0.6693	0.0002	0.00015	1.3780	1.3783	0.0000	0.0005	1.37840	1.37820	0.00070	0.00020	**9103WI**
0.7872	0.7874	0.0002	0.0002	1.6535	1.6538	0.0000	0.0005	1.65390	1.65370	0.00070	0.00020	**9104WI**
0.9841	0.9843	0.0002	0.0002	1.8504	1.8507	0.0000	0.0005	1.85090	1.85070	0.00080	0.00030	**9105WI**
1.1809	1.1811	0.0002	0.0002	2.1654	2.1657	0.0000	0.0006	2.16590	2.16570	0.00080	0.00030	**9106WI**
1.3778	1.378	0.0002	0.00025	2.4409	2.4412	0.0000	0.0006	2.44140	2.44120	0.00080	0.00030	**9107WI**
1.5746	1.5748	0.0002	0.00025	2.6772	2.6775	0.0000	0.0006	2.67770	2.67750	0.00080	0.00030	**9108WI**
1.7715	1.7717	0.0002	0.00025	2.9528	2.9531	0.0000	0.0006	2.95330	2.95310	0.00080	0.00030	**9109WI**
1.9683	1.9685	0.0002	0.00025	3.1496	3.1499	0.0000	0.0006	3.15010	3.14990	0.00080	0.00030	**9110WI**
2.1652	2.1654	0.0002	0.0003	3.5433	3.5436	0.0000	0.0006	3.54390	3.54360	0.00090	0.00030	**9111WI**
2.362	2.3622	0.0002	0.0003	3.7402	3.7405	0.0000	0.0006	3.74080	3.74050	0.00090	0.00030	**9112WI**
2.5589	2.5591	0.0002	0.0003	3.9370	3.9373	0.0000	0.0006	3.93770	3.93740	0.00100	0.00040	**9113WI**
2.7557	2.7559	0.0002	0.0003	4.3307	4.3310	0.0000	0.0006	4.33140	4.33110	0.00100	0.00040	**9114WI**

(continued)



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WI Construction:
- Incorporates low shoulder on non-thrust side of outer rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

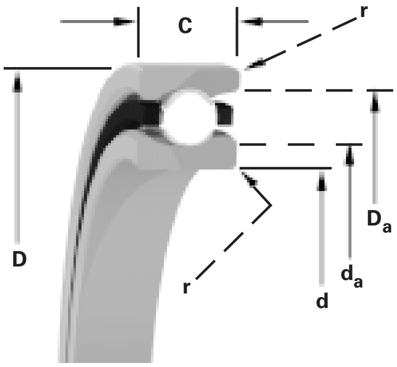
						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (in.)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	in/tol: +0; -.000(X)				lbs.	lbs.		rpm	lbs.		rpm	in.				
9115WI	2.9528 (3)	4.5276 (3)	0.7874 (59)	20 x 15/32	1.41	9,790 *8,713*	11,600 *11,600*	11,000 *13,200*	9,260 *8,241*	11,000 *11,000*	9,900 *11,880*	0.039	3.29	3.26	4.23	4.20
9116WI	3.1496 (3)	4.9213 (3.5)	0.8661 (59)	20 x 17/32	1.89	12,400 *11,036*	14,600 *14,600*	10,300 *12,360*	11,800 *10,502*	13,800 *13,800*	9,300 *11,160*	0.039	3.52	3.49	4.59	4.56
9117WI	3.3465 (3)	5.1181 (3.5)	0.8661 (79)	21 x 17/32	1.99	13,200 *11,748*	15,000 *15,000*	9,700 *11,640*	12,500 *11,125*	14,200 *14,200*	8,700 *10,440*	0.039	3.74	3.71	4.81	4.78
9118WI	3.5433 (3)	5.5118 (3.5)	0.9449 (79)	20 x 19/32	2.58	15,500 *13,795*	17,900 *17,900*	9,200 *11,040*	14,800 *13,172*	16,900 *16,900*	8,300 *9,960*	0.059	3.96	3.93	5.16	5.13
9119WI	3.7402 (3)	5.7087 (3.5)	0.9449 (79)	21 x 19/32	2.69	16,500 *14,685*	18,300 *18,300*	8,700 *10,440*	15,600 *13,884*	17,400 *17,400*	7,800 *9,360*	0.059	4.16	4.13	5.35	5.32
9120WI	3.937 (3)	5.9055 (3.5)	0.9449 (79)	22 x 19/32	2.86	17,400 *15,486*	18,800 *18,800*	8,300 *9,960*	16,500 *14,685*	17,800 *17,800*	7,500 *9,000*	0.059	4.36	4.33	5.55	5.52
9121WI	4.1339 (3)	6.2992 (4)	1.0236 (79)	21 x 21/32	3.57	20,100 *17,889*	22,000 *22,000*	7,900 *9,480*	19,000 *16,910*	20,700 *20,700*	7,100 *8,520*	0.079	4.59	4.56	5.91	5.88
9122WI	4.3307 (3)	6.6929 (4)	1.1024 (79)	22 x 11/16	4.50	23,100 *20,559*	24,600 *24,600*	7,500 *9,000*	21,900 *19,491*	23,200 *23,200*	6,800 *8,160*	0.079	4.85	4.82	6.24	6.21
9124WI	4.7244 (3)	7.0866 (4)	1.1024 (79)	23 x 11/16	4.81	24,400 *21,716*	25,000 *25,000*	6,900 *8,280*	23,200 *20,648*	23,600 *23,600*	6,200 *7,440*	0.079	5.25	5.22	6.63	6.60
9126WI	5.1181 (4)	7.874 (4.5)	1.2992 (98)	21 x 13/16	7.21	30,800 *27,412*	32,200 *32,200*	6,400 *7,680*	29,200 *25988*	30,500 *30,500*	5,800 *6,960*	0.079	5.71	5.68	7.35	7.32
9128WI	5.5118 (4)	8.2677 (4.5)	1.2992 (98)	22 x 13/16	7.62	32,600 *29,014*	32,900 *32,900*	5,900 *7,080*	30,900 *27,501*	31,100 *31,100*	5,300 *6,360*	0.079	6.11	6.08	7.74	7.71
9130WI	5.9055 (4)	8.8583 (4.5)	1.378 (98)	22 x 7/8	9.26	37,800 *33,642*	37,600 *37,600*	5,600 *6,720*	35,800 *31,862*	35,500 *35,500*	5,000 *6,000*	0.079	6.54	6.51	8.30	8.27
9132WI	6.2992 (4)	9.4488 (4.5)	1.4961 (98)	22 x 15/16	11.44	43,300 *38,537*	42,600 *42,600*	5,200 *6,240*	41,100 *36,579*	40,300 *40,300*	4,700 *5,640*	0.079	6.97	6.94	8.85	8.82
9134WI	6.6929 (4)	10.2362 (5)	1.6535 (98)	22 x 1-1/16	15.43	55,200 *49,128*	52,600 *52,600*	4,900 *5,880*	52,300 *46,547*	49,700 *49,700*	4,400 *5,280*	0.079	7.43	7.40	9.56	9.53
9136WI	7.0866 (4)	11.0236 (5)	1.811 (98)	20 x 1-3/16	20.40	62,100 *55,269*	58,100 *58,100*	4,600 *5,520*	59,000 *52,510*	55,000 *55,000*	4,200 *5,040*	0.079	7.90	7.87	10.28	10.25
9140WI	7.874 (4.5)	12.2047 (5)	2.0079 (118)	20 x 1-5/16	26.78	75,800 *67,462*	66,700 *66,700*	4,100 *4,920*	72,200 *64258*	63,200 *63,200*	3,700 *4,440*	0.079	8.76	8.73	11.39	11.36

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Extra-Light 2(3)MM9100WI (ISO 10) Series
Inch Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
2.9526	2.953	0.0002	0.0005	4.5276	4.5279	0.0000	0.0006	4.52830	4.52800	0.00100	0.00040	**9115WI**
3.1494	3.1498	0.0002	0.0005	4.9213	4.9216	0.0000	0.0007	4.92210	4.92170	0.00120	0.00040	**9116WI**
3.3463	3.3467	0.0002	0.0005	5.1181	5.1185	0.0000	0.0007	5.11890	5.11850	0.00110	0.00040	**9117WI**
3.5431	3.5435	0.0002	0.0005	5.5118	5.5122	0.0000	0.0007	5.51260	5.51220	0.00110	0.00040	**9118WI**
3.74	3.7404	0.0002	0.0005	5.7087	5.7091	0.0000	0.0007	5.70950	5.70910	0.00110	0.00040	**9119WI**
3.9368	3.9372	0.0002	0.0005	5.9055	5.9059	0.0000	0.0007	5.90640	5.90600	0.00120	0.00050	**9120WI**
4.1337	4.1341	0.0002	0.0005	6.2992	6.2996	0.0000	0.0008	6.30010	6.29970	0.00130	0.00050	**9121WI**
4.3305	4.3309	0.0002	0.0005	6.6929	6.6933	0.0000	0.0008	6.69380	6.69340	0.00130	0.00050	**9122WI**
4.7242	4.7246	0.0002	0.0005	7.0866	7.0870	0.0000	0.0008	7.08750	7.08710	0.00130	0.00050	**9124WI**
5.1179	5.1183	0.0002	0.0006	7.8740	7.8745	0.0000	0.0009	7.87500	7.87460	0.00150	0.00060	**9126WI**
5.5116	5.512	0.0002	0.0006	8.2677	8.2682	0.0000	0.0009	8.26870	8.26830	0.00150	0.00060	**9128WI**
5.9053	5.9057	0.0002	0.0006	8.8583	8.8588	0.0000	0.0009	8.85930	8.85890	0.00150	0.00060	**9130WI**
6.299	6.2994	0.0002	0.0006	9.4488	9.4493	0.0000	0.0009	9.45000	9.44940	0.00160	0.00060	**9132WI**
6.6927	6.6931	0.0002	0.0006	10.2362	10.2367	0.0000	0.0010	10.23750	10.23700	0.00180	0.00080	**9134WI**
7.0863	7.0869	0.0003	0.0007	11.0236	11.0241	0.0000	0.0010	11.02490	11.02440	0.00180	0.00080	**9136WI**
7.8737	7.8743	0.0003	0.0008	12.2047	12.2052	0.0000	0.0010	12.20600	12.20550	0.00180	0.00080	**9140WI**

ISO/DIN	P5	P4	–	P2
Fafnir®	V x.xx	–	MM(V)	MMX x.xxxx



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WI Construction:
- Incorporates low shoulder on non-thrust side of outer rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (mm)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	mm/tol: +0; -(µm)				kg.	N		rpm	N		rpm	mm	mm			
9100WI	10 (4)	26 (5)	8 (40)	8 x 4.8	0.018	2,200 *1,958*	5,400 *5,400*	68,500 *82,200*	2,100 *1,869*	5,300 *5,300*	61,700 *74,040*	0.3	13.6	13.3	23.2	23.0
9101WI	12 (4)	28 (5)	8 (80)	10 x 4.8	0.020	2,900 *2,581*	6,400 *6,400*	57,300 *68,760*	2,800 *2,492*	6,200 *6,200*	51,600 *61,920*	0.3	16.1	15.9	25.5	25.3
9102WI	15 (4)	32 (6)	9 (80)	12 x 4.8	0.030	3,600 *3,204*	7,300 *7,300*	48,600 *58,320*	3,530 *3,142*	7,020 *7,020*	43,700 *52,440*	0.3	19.2	18.9	28.6	28.3
9103WI	17 (4)	35 (6)	10 (80)	11 x 4.8	0.038	3,400 *3,026*	6,800 *6,800*	43,100 *51,720*	3,300 *2,937*	6,600 *6,600*	38,800 *46,560*	0.3	21.7	21.5	31.1	30.9
9104WI	20 (5)	42 (6)	12 (120)	11 x 6.4	0.067	6,000 *5,340*	11,600 *11,600*	37,100 *44,520*	5,700 *5,073*	11,100 *11,100*	33,400 *40,080*	0.6	25.0	24.8	37.7	37.5
9105WI	25 (5)	47 (6)	12 (120)	13 x 6.4	0.077	7,400 *6,586*	12,900 *12,900*	30,900 *37,080*	7,100 *6,319*	12,300 *12,300*	27,800 *33,360*	0.6	30.1	29.9	42.6	42.3
9106WI	30 (5)	55 (7)	13 (120)	14 x 7.1	0.113	10,300 *9,167*	16,800 *16,800*	25,500 *30,600*	9,900 *8,811*	16,000 *16,000*	23,000 *27,600*	1.0	36.2	35.9	50.7	50.4
9107WI	35 (6)	62 (7)	14 (120)	15 x 7.9	0.151	13,700 *12,193*	21,200 *21,200*	22,600 *27,120*	13,000 *11,570*	20,200 *20,200*	20,300 *24,360*	1.0	41.2	40.6	56.6	56.1
9108WI	40 (6)	68 (7)	15 (120)	16 x 7.9	0.187	14,900 *13,261*	21,900 *21,900*	19,900 *23,880*	14,200 *12,638*	20,800 *20,800*	17,900 *21,480*	1.0	46.2	45.7	62.2	61.7
9109WI	45 (6)	75 (7)	16 (120)	17 x 8.7	0.240	19,300 *17,177*	27,000 *27,000*	17,900 *21,480*	18,300 *16,287*	25,600 *25,600*	16,100 *19,320*	1.0	51.8	51.3	69.3	68.8
9110WI	50 (6)	80 (7)	16 (120)	18 x 8.7	0.258	20,800 *18,512*	27,900 *27,900*	16,300 *19,560*	19,700 *17,533*	26,300 *26,300*	14,700 *17,640*	1.0	56.6	56.1	74.2	73.7
9111WI	55 (7)	90 (8)	18 (150)	18 x 10.3	0.383	28,600 *25,454*	37,800 *37,800*	14,700 *17,640*	27,200 *24,208*	35,900 *35,900*	13,200 *15,840*	1.0	62.7	62.2	83.3	82.8
9112WI	60 (7)	95 (8)	18 (150)	19 x 10.3	0.409	30,500 *27,145*	38,800 *38,800*	13,600 *16,320*	33,200 *29,548*	36,900 *36,900*	12,200 *14,640*	1.0	67.8	67.3	88.1	87.6
9113WI	65 (7)	100 (8)	18 (150)	20 x 10.3	0.435	32,600 *29,014*	39,800 *39,800*	12,700 *15,240*	31,000 *27,590*	37,700 *37,700*	11,400 *13,680*	1.0	72.6	72.1	93.2	92.7
9114WI	70 (7)	110 (8)	20 (150)	19 x 11.9	0.604	40,700 *36,223*	50,300 *50,300*	11,700 *14,040*	38,800 *34,532*	47,600 *47,600*	10,500 *12,600*	1.0	78.2	77.7	102.4	101.9
9115WI	75 (7)	115 (9)	20 (150)	20 x 11.9	0.638	43,500 *38,715*	51,600 *51,600*	11,000 *13,200*	41,200 *36,668*	48,900 *48,900*	9,900 *11,880*	1.0	83.4	82.7	107.3	106.6

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)
2) ABMA Std. 20 ($r_{as\ max}$)

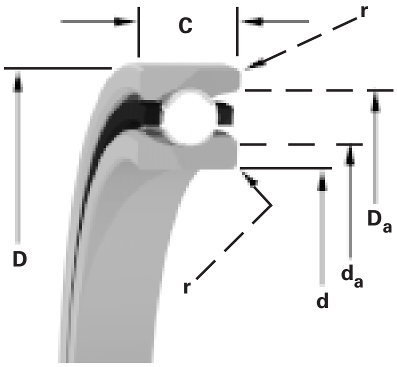
Fafnir Extra-Light 2(3)MM9100WI (ISO 10) Series

Metric Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
9.995	10.000	0.005	0.004	26	26.005	0.000	0.010	26.010	26.005	0.015	0.005	**9100WI**
11.995	12.000	0.005	0.004	28	28.005	0.000	0.010	28.010	28.005	0.015	0.005	**9101WI**
14.995	15.000	0.005	0.004	32	32.005	0.000	0.011	32.010	32.005	0.016	0.005	**9102WI**
16.995	17.000	0.005	0.004	35	35.006	0.000	0.012	35.010	35.005	0.016	0.005	**9103WI**
19.995	20.000	0.005	0.005	42	42.006	0.000	0.012	42.010	42.005	0.016	0.005	**9104WI**
24.995	25.000	0.005	0.005	47	47.006	0.000	0.012	47.012	47.007	0.018	0.007	**9105WI**
29.995	30.000	0.005	0.005	55	55.008	0.000	0.015	55.012	55.007	0.019	0.007	**9106WI**
34.995	35.000	0.005	0.006	62	62.008	0.000	0.015	62.012	62.007	0.019	0.007	**9107WI**
39.995	40.000	0.005	0.006	68	68.008	0.000	0.015	68.012	68.007	0.019	0.007	**9108WI**
44.995	45.000	0.005	0.006	75	75.008	0.000	0.015	75.014	75.009	0.022	0.009	**9109WI**
49.995	50.000	0.005	0.006	80	80.008	0.000	0.015	80.012	80.008	0.020	0.008	**9110WI**
54.995	55.000	0.005	0.007	90	90.008	0.000	0.016	90.015	90.007	0.023	0.007	**9111WI**
59.995	60.000	0.005	0.007	95	95.008	0.000	0.016	95.016	95.009	0.024	0.009	**9112WI**
64.995	65.000	0.005	0.007	100	100.008	0.000	0.016	100.018	100.010	0.025	0.010	**9113WI**
69.995	70.000	0.005	0.007	110	110.008	0.000	0.016	110.018	110.010	0.025	0.010	**9114WI**
74.995	75.005	0.005	0.012	115	115.008	0.000	0.016	115.019	115.011	0.026	0.010	**9115WI**

(continued)

ISO/DIN	P5	P4	–	P2
Fafnir®	V *x.xx*	–	MM(V)	MMX *x.xxxx*



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WI Construction:
- Incorporates low shoulder on non-thrust side of outer rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (mm)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	mm/tol: +0; -(μm)				kg.	N		rpm	N		rpm	mm	mm			
9116WI	80 (8)	125 (9)	22 (200)	20 x 13.5	0.859	55,200 *49,128*	64,900 *64,900*	10,300 *12,360*	52,500 *46,725*	61,400 *61,400*	9,300 *11,160*	1.0	89.3	88.5	116.5	115.7
9117WI	85 (8)	130 (9)	22 (200)	21 x 13.5	0.901	58,700 *52,243*	66,700 *66,700*	9,700 *11,640*	55,600 *49,484*	63,200 *63,200*	8,700 *10,440*	1.0	94.9	94.1	122.1	121.3
9118WI	90 (8)	140 (9)	24 (200)	20 x 15.1	1.170	68,900 *61,321*	79,600 *79,600*	9,200 *11,040*	65,800 *58,562*	75,200 *75,200*	8,300 *9,960*	1.5	100.5	99.7	130.9	130.2
9119WI	95 (8)	145 (9)	24 (200)	21 x 15.1	1.222	73,400 *65,326*	81,400 *81,400*	8,700 *10,440*	69,400 *61,766*	77,400 *77,400*	7,800 *9,360*	1.5	105.5	104.8	135.8	135.0
9120WI	100 (8)	150 (10)	24 (200)	22 x 15.1	1.299	77,400 *68,886*	83,600 *83,600*	8,300 *9,960*	73,400 *65,326*	79,200 *79,200*	7,500 *9,000*	1.5	110.6	109.9	140.8	140.1
9121WI	105 (8)	160 (10)	26 (200)	21 x 16.7	1.617	89,400 *79,566*	97,900 *97,900*	7,900 *9,480*	84,500 *75,205*	92,100 *92,100*	7,100 *8,520*	2.0	116.5	115.7	150.0	149.2
9122WI	110 (8)	170 (10)	28 (200)	22 x 17.5	2.043	102,700 *91,403*	109,400 *109,400*	7,500 *9,000*	97,400 *86,686*	103,200 *103,200*	6,800 *8,160*	2.0	123.1	122.3	158.4	157.6
9124WI	120 (8)	180 (10)	28 (200)	23 x 17.5	2.180	108,500 *96,565*	111,200 *111,200*	6,900 *8,280*	103,200 *91,848*	105,000 *105,000*	6,200 *7,440*	2.0	133.2	132.5	168.3	167.5
9126WI	130 (10)	200 (11)	33 (250)	21 x 20.6	3.273	137,000 *121,930*	143,200 *143,200*	6,400 *7,680*	129,900 *115,611*	135,700 *135,700*	5,800 *6,960*	2.0	144.9	144.2	186.6	185.8
9128WI	140 (10)	210 (11)	33 (250)	22 x 20.6	3.454	145,000 *129,050*	146,300 *146,300*	5,900 *7,080*	137,400 *122,286*	138,300 *138,300*	5,300 *6,360*	2.0	155.1	154.3	196.5	195.7
9130WI	150 (10)	225 (11)	35 (250)	22 x 22.2	4.200	168,100 *149,609*	167,200 *167,200*	5,600 *6,720*	159,200 *141,688*	157,900 *157,900*	5,000 *6,000*	2.0	166.0	165.2	210.7	209.9
9132WI	160 (10)	240 (11)	38 (250)	22 x 23.8	5.188	192,600 *171,414*	189,500 *189,500*	5,200 *6,240*	182,800 *162,692*	179,300 *179,300*	4,700 *5,640*	2.0	176.9	176.2	224.7	223.9
9134WI	170 (10)	260 (13)	42 (250)	22 x 27.0	6.999	245,500 *218,495*	234,000 *234,000*	4,900 *5,880*	232,600 *207,014*	221,100 *221,100*	4,400 *5,280*	2.0	188.6	187.8	242.7	241.9
9136WI	180 (10)	280 (13)	46 (250)	20 x 27.0	9.250	276,200 *245,818*	258,400 *258,400*	4,600 *5,520*	262,400 *233,536*	244,400 *244,400*	4,200 *5,040*	2.0	200.5	199.8	261.0	260.2
9140WI	200 (12)	310 (13)	51 (300)	20 x 33.3	12.148	337,200 *300,108*	296,700 *296,700*	4,100 *4,920*	321,100 *285,779*	281,100 *281,100*	3,700 *4,440*	2.0	222.4	221.6	289.2	288.4

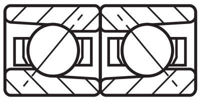
Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Extra-Light 2(3)MM9100WI (ISO 10) Series

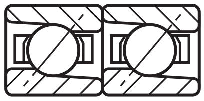
Metric Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
79.995	80.005	0.005	0.012	125	125.008	0.000	0.017	125.021	125.011	0.030	0.011	**9116WI**
84.995	85.005	0.005	0.012	130	130.009	0.000	0.018	130.020	130.010	0.029	0.010	**9117WI**
89.995	90.005	0.005	0.013	140	140.009	0.000	0.018	140.020	140.010	0.029	0.010	**9118WI**
94.995	95.005	0.005	0.013	145	145.009	0.000	0.018	145.021	145.011	0.030	0.011	**9119WI**
99.995	100.005	0.005	0.013	150	150.009	0.000	0.018	150.023	150.012	0.032	0.012	**9120WI**
104.995	105.005	0.005	0.013	160	160.009	0.000	0.022	160.022	160.012	0.033	0.012	**9121WI**
109.995	110.005	0.005	0.013	170	170.010	0.000	0.020	170.022	170.012	0.032	0.012	**9122WI**
119.995	120.005	0.005	0.013	180	180.010	0.000	0.020	180.022	180.012	0.032	0.012	**9124WI**
129.995	130.005	0.005	0.015	200	200.011	0.000	0.022	200.025	200.015	0.036	0.015	**9126WI**
139.995	140.005	0.005	0.015	210	210.011	0.000	0.022	210.025	210.015	0.036	0.015	**9128WI**
149.995	150.005	0.005	0.015	225	225.011	0.000	0.022	225.025	225.015	0.036	0.015	**9130WI**
159.995	160.005	0.005	0.015	240	240.011	0.000	0.022	240.025	240.015	0.041	0.018	**9132WI**
169.995	170.005	0.005	0.015	260	260.011	0.000	0.024	260.030	260.015	0.044	0.018	**9134WI**
179.993	180.008	0.007	0.018	280	280.013	0.000	0.026	280.031	280.018	0.044	0.018	**9136WI**
199.993	200.008	0.007	0.019	310	310.013	0.000	0.026	310.031	310.018	0.044	0.018	**9140WI**

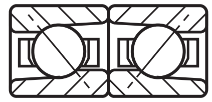
Mounting Arrangements



Recommended
DB



Tandem
DT



Special Applications
DF

	Preload				Axial Stiffness[1]				Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	X-light	Light	Medium	Heavy	Light	Medium	Heavy	X-Light to light	Light to Medium	Medium to Heavy
	lbs.				10^6lbs./in.				10^6lbs./in			in.		
2MM9100WI	—	3	6	12	0.808	0.939	0.123	0.163	0.3754	0.4790	0.6020	0.00005	0.00011	0.00017
2MM9101WI	—	5	10	20	0.108	0.131	0.172	0.230	0.5209	0.6592	0.8255	0.00007	0.00013	0.00020
2MM9102WI	—	5	15	30	0.115	0.139	0.215	0.290	0.5539	0.8028	1.0017	0.00006	0.00023	0.00024
2MM9103WI	—	5	20	35	0.115	0.139	0.243	0.311	0.554	0.8809	1.0512	0.00006	0.00031	0.00022
2MM9104WI	—	10	20	40	0.012	0.159	0.213	0.290	0.8278	1.0441	1.3041	0.00014	0.00021	0.00032
2MM9105WI	—	10	25	60	0.161	0.176	0.258	0.384	0.9229	1.2568	1.6608	0.00005	0.00028	0.00044
2MM9106WI	—	15	30	75	0.173	0.204	0.274	0.420	1.1599	1.4649	1.9641	0.00011	0.00025	0.00052
2MM9107WI	—	20	50	90	0.194	0.246	0.364	0.479	1.3877	1.8841	2.2724	0.00016	0.00039	0.00038
2MM9108WI	—	20	50	100	0.221	0.255	0.377	0.521	1.4473	1.9681	2.4551	0.00010	0.00038	0.00045
2MM9109WI	—	30	60	125	0.240	0.310	0.418	0.590	1.7883	2.2539	2.8499	0.00020	0.00033	0.00052
2MM9110WI	20	30	60	150	0.261	0.320	0.431	0.664	1.8566	2.3423	3.1380	0.00017	0.00032	0.00066
2MM9111WI	25	35	75	150	0.303	0.358	0.493	0.676	2.0492	2.6558	3.3225	0.00015	0.00038	0.00051
2MM9112WI	25	40	75	200	0.323	0.390	0.508	0.799	2.2246	2.7537	3.7753	0.00017	0.00031	0.00077
2MM9113WI	25	50	100	200	0.344	0.441	0.594	0.820	2.4856	3.1325	3.9105	0.00023	0.00039	0.00057
2MM9114WI	30	60	125	250	0.357	0.477	0.652	0.899	2.6839	3.4307	4.2828	0.00030	0.00046	0.00065
2MM9115WI	30	60	125	275	0.382	0.491	0.671	0.967	2.7754	3.5512	4.5710	0.00026	0.00045	0.00073
2MM9116WI	35	70	150	350	0.408	0.531	0.732	1.084	3.0301	3.9221	5.1481	0.00029	0.00051	0.00088
2MM9117WI	40	80	175	375	0.429	0.577	0.806	1.150	3.2774	4.2628	5.4399	0.00033	0.00055	0.00082
2MM9118WI	40	100	200	400	0.424	0.606	0.817	1.130	3.5589	4.4902	5.6092	0.00046	0.00056	0.00082
2MM9119WI	45	110	220	445	0.453	0.648	0.876	1.221	3.7973	4.7869	5.9979	0.00047	0.00058	0.00086
2MM9120WI	50	125	250	450	0.485	0.703	0.952	1.257	4.0905	5.1492	6.2139	0.00050	0.00060	0.00072
2MM9121WI	55	135	275	550	0.510	0.730	0.993	1.375	4.2128	5.3415	6.6668	0.00051	0.00065	0.00093
2MM9122WI	60	150	300	600	0.545	0.790	1.065	1.471	4.5288	5.7138	7.1380	0.00054	0.00065	0.00095
2MM9124WI	65	175	350	650	0.588	0.865	1.170	1.565	4.9166	6.1909	7.5465	0.00059	0.00069	0.00088
2MM9126WI	75	200	400	825	0.601	0.884	1.192	1.674	5.1327	6.4744	8.1656	0.00067	0.00077	0.00119
2MM9128WI	85	225	450	875	0.646	0.954	1.290	1.764	5.5106	6.9421	8.5876	0.00070	0.00080	0.00111
2MM9130WI	100	250	550	1,000	0.703	1.017	1.433	1.898	5.8567	7.6158	9.2186	0.00070	0.00098	0.00108
2MM9132WI	110	300	600	1,200	0.744	1.111	1.500	2.078	6.3811	8.0375	10.0299	0.00082	0.00092	0.00134
2MM9134WI	130	375	750	1,500	0.809	1.234	1.667	2.309	7.2290	9.1064	11.3637	0.00096	0.00103	0.00151
2MM9136WI	150	390	780	1,560	0.819	1.198	1.616	2.233	7.0951	8.9538	11.1864	0.00095	0.00111	0.00162
2MM9140WI	210	500	1,000	2,000	0.972	1.375	1.853	2.561	7.9862	10.0685	12.5714	0.00099	0.00124	0.00181

Notes

1) DB (back-to-back) or DF (face-to-face) arrangement only. For other mounting arrangements contact Timken Engineering

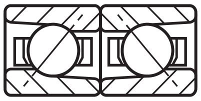
2) For ceramic ball complements, use 120% of listed operating speeds.

Fafnir Extra-Light 2(3)MM9100WI (ISO 10) Series

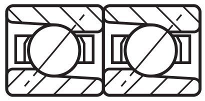
Inch Duplex Performance Data

	Preload				Axial Stiffness[1]				Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	X-light	Light	Medium	Heavy	Light	Medium	Heavy	X-Light to light	Light to Medium	Medium to Heavy
	lbs.				10^6lbs./in.				10^6lbs./in			in.		
3MM9100WI	—	5	10	20	0.123	0.142	0.182	0.236	0.3626	0.4597	0.5767	0.00003	0.00007	0.00011
3MM9101WI	—	10	20	40	0.164	0.197	0.253	0.329	0.5333	0.6709	0.8374	0.00004	0.00009	0.00014
3MM9102WI	—	10	20	40	0.175	0.209	0.313	0.409	0.5680	0.7154	0.8939	0.00004	0.00015	0.00017
3MM9103WI	—	15	35	50	0.175	0.210	0.349	0.435	0.6509	0.8569	0.9589	0.00004	0.00021	0.00015
3MM9104WI	—	20	40	75	0.231	0.295	0.379	0.492	0.7882	0.9912	1.2121	0.00008	0.00012	0.00018
3MM9105WI	—	20	50	90	0.303	0.328	0.457	0.638	0.8801	1.193	1.4395	0.00003	0.00015	0.00025
3MM9106WI	—	30	65	120	0.346	0.400	0.514	0.728	1.1170	1.4427	1.7551	0.00005	0.00013	0.00029
3MM9107WI	—	35	80	160	0.393	0.485	0.678	0.848	1.2722	1.6754	2.0918	0.00008	0.00021	0.00021
3MM9108WI	—	40	100	170	0.446	0.506	0.706	0.919	1.3894	1.8814	2.2285	0.00005	0.00020	0.00025
3MM9109WI	—	50	125	220	0.503	0.629	0.809	1.068	1.6065	2.1765	2.6070	0.00010	0.00017	0.00028
3MM9110WI	25	55	150	240	0.628	0.812	1.187	1.433	1.7232	2.3994	2.7864	0.00015	0.00038	0.00027
3MM9111WI	30	75	175	300	0.688	0.935	1.287	1.595	2.0264	2.6839	3.1895	0.00021	0.00036	0.00035
3MM9112WI	35	80	200	325	0.743	0.991	1.402	1.702	2.1466	2.9068	3.3944	0.00021	0.00040	0.00032
3MM9113WI	40	80	200	350	0.804	1.023	1.446	1.808	2.2203	3.0095	3.5989	0.00017	0.00039	0.00037
3MM9114WI	45	100	250	450	0.848	1.130	1.595	2.015	2.4192	3.2798	3.9577	0.00022	0.00044	0.00044
3MM9115WI	50	110	275	475	0.910	1.209	1.708	2.123	2.5851	3.5019	4.1696	0.00023	0.00045	0.00042
3MM9116WI	55	140	350	600	0.975	1.373	1.939	2.402	2.9056	3.9372	4.6774	0.00029	0.00050	0.00046
3MM9117WI	60	150	375	650	1.039	1.452	2.052	2.554	3.0720	4.1611	4.9599	0.00029	0.00051	0.00048
3MM9118WI	65	170	400	750	1.052	1.502	2.071	2.659	3.2347	4.2995	5.2579	0.00033	0.00051	0.00059
3MM9119WI	65	185	445	775	1.109	1.597	2.224	2.774	3.4382	4.5999	5.4929	0.00035	0.00054	0.00053
3MM9120WI	75	190	450	800	1.184	1.661	2.298	2.888	3.5775	4.7639	5.7276	0.00032	0.00052	0.00054
3MM9121WI	80	215	460	920	1.243	1.763	2.342	3.075	3.7315	4.8099	6.0097	0.00035	0.00048	0.00068
3MM9122WI	90	250	600	1,100	1.330	1.932	2.684	3.412	4.1088	5.497	6.6740	0.00039	0.00060	0.00066
3MM9124WI	100	275	650	1,150	1.437	2.058	2.845	3.568	4.3708	5.8135	6.9773	0.00040	0.00061	0.00062
3MM9126WI	115	340	825	1,500	1.481	2.183	3.048	3.866	4.6588	6.2531	7.5702	0.00049	0.00074	0.00078
3MM9128WI	130	350	875	1,550	1.585	2.273	3.208	4.028	4.8513	6.5769	7.8963	0.00046	0.00076	0.00075
3MM9130WI	145	400	1,000	1,800	1.699	2.448	3.454	4.361	5.1953	7.0453	8.5025	0.00049	0.00081	0.00082
3MM9132WI	170	500	1,200	2,000	1.827	2.691	3.745	4.588	5.7275	7.6534	9.0115	0.00058	0.00087	0.00077
3MM9134WI	210	625	1,300	2,600	2.055	3.036	3.995	5.251	6.4240	8.198	10.2407	0.00065	0.00077	0.00112
3MM9136WI	230	700	1,400	2,800	2.050	3.052	3.956	5.196	6.4927	8.1819	10.2263	0.00073	0.00080	0.00122
3MM9140WI	280	850	2,000	3,600	2.262	3.366	4.644	5.864	7.1552	9.5082	11.4776	0.00080	0.00114	0.00122

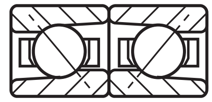
Mounting Arrangements



Recommended
DB



Tandem
DT



Special Applications
DF

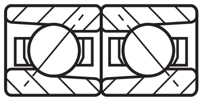
	Preload				Axial Stiffness[1]				Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	X-light	Light	Medium	Heavy	Light	Medium	Heavy	X-Light to light	Light to Medium	Medium to Heavy
	N				N/µm				N/µm			µm		
2MM9100WI	—	13	25	55	14.13	16.42	21.51	28.51	65.66	83.78	105.29	1.27	2.79	4.32
2MM9101WI	—	20	45	90	18.89	22.91	30.08	40.23	91.11	115.29	144.38	1.78	3.30	5.08
2MM9102WI	—	20	65	130	20.11	24.31	37.60	50.72	96.88	140.41	175.20	1.52	5.84	6.10
2MM9103WI	—	20	90	160	20.11	24.31	42.50	54.39	96.89	154.07	183.85	1.52	7.87	5.59
2MM9104WI	—	45	90	180	2.10	27.81	37.25	50.72	144.78	182.61	228.09	3.56	5.33	8.13
2MM9105WI	—	45	110	270	28.16	30.78	45.12	67.16	161.42	219.81	290.47	1.27	7.11	11.18
2MM9106WI	—	65	130	330	30.26	35.68	47.92	73.46	202.87	256.21	343.52	2.79	6.35	13.21
2MM9107WI	—	90	220	400	33.93	43.03	63.66	83.78	242.71	329.53	397.44	4.06	9.91	9.65
2MM9108WI	—	90	220	440	38.65	44.60	65.94	91.12	253.13	344.22	429.40	2.54	9.65	11.43
2MM9109WI	—	130	270	560	41.98	54.22	73.11	103.19	312.77	394.21	498.45	5.08	8.38	13.21
2MM9110WI	89	130	270	670	45.65	55.97	75.38	116.13	324.72	409.67	548.84	4.32	8.13	16.76
2MM9111WI	110	160	330	670	52.99	62.61	86.23	118.23	358.41	464.50	581.11	3.81	9.65	12.95
2MM9112WI	110	180	330	890	56.49	68.21	88.85	139.75	389.08	481.62	660.30	4.32	7.87	19.56
2MM9113WI	110	220	440	890	60.17	77.13	103.89	143.42	434.73	547.87	683.95	5.84	9.91	14.48
2MM9114WI	130	270	560	1,110	62.44	83.43	114.03	157.24	469.41	600.03	749.06	7.62	11.68	16.51
2MM9115WI	130	270	560	1,220	66.81	85.88	117.36	169.13	485.42	621.10	799.47	6.60	11.43	18.54
2MM9116WI	160	310	670	1,560	71.36	92.87	128.03	189.59	529.96	685.98	900.40	7.37	12.95	22.35
2MM9117WI	180	360	780	1,670	75.03	100.92	140.97	201.14	573.22	745.56	951.44	8.38	13.97	20.83
2MM9118WI	180	440	890	1,780	74.16	105.99	142.89	197.64	622.45	785.34	981.05	11.68	14.22	20.83
2MM9119WI	200	490	980	1,980	79.23	113.34	153.21	213.55	664.15	837.23	1,049.03	11.94	14.73	21.84
2MM9120WI	220	560	1,110	2,000	84.83	122.95	166.50	219.85	715.43	900.60	1,086.81	12.70	15.24	18.29
2MM9121WI	240	600	1,220	2,450	89.20	127.68	173.68	240.49	736.82	934.23	1,166.02	12.95	16.51	23.62
2MM9122WI	270	670	1,330	2,670	95.32	138.17	186.27	257.28	792.09	999.34	1,248.44	13.72	16.51	24.13
2MM9124WI	290	780	1,560	2,890	102.84	151.29	204.63	273.72	859.91	1,082.79	1,319.88	14.99	17.53	22.35
2MM9126WI	330	890	1,780	3,670	105.11	154.61	208.48	292.78	897.71	1,132.37	1,428.16	17.02	19.56	30.23
2MM9128WI	380	1,000	2,000	3,890	112.99	166.85	225.62	308.52	963.80	1,214.17	1,501.97	17.78	20.32	28.19
2MM9130WI	440	1,110	2,450	4,450	122.95	177.87	250.63	331.96	1,024.34	1,332.00	1,612.33	17.78	24.89	27.43
2MM9132WI	490	1,330	2,670	5,340	130.13	194.31	262.35	363.44	1,116.05	1,405.76	1,754.23	20.83	23.37	34.04
2MM9134WI	580	1,670	3,340	6,670	141.49	215.83	291.56	403.84	1,264.35	1,592.71	1,987.51	24.38	26.16	38.35
2MM9136WI	670	1,730	3,470	6,940	143.24	209.53	282.64	390.55	1,240.93	1,566.02	1,956.50	24.13	28.19	41.15
2MM9140WI	930	2,220	4,450	8,900	170.00	240.49	324.09	447.92	1,396.79	1,760.98	2,198.74	25.15	31.50	45.97

Notes
1) DB (back-to-back) or DF (face-to-face) arrangement only. For other mounting arrangements contact Timken Engineering
2) For ceramic ball complements, use 120% of listed operating speeds.

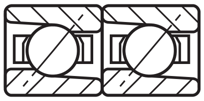
Fafnir Extra-Light 2(3)MM9100WI (ISO 10) Series
Metric Duplex Performance Data

	Preload				Axial Stiffness[1]				Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	X-light	Light	Medium	Heavy	Light	Medium	Heavy	X-Light to light	Light to Medium	Medium to Heavy
	N				N/µm				N/µm			µm		
3MM9100WI	—	20	45	90	21.51	24.84	31.83	41.28	63.42	80.40	100.86	0.76	1.78	2.79
3MM9101WI	—	45	90	180	28.68	34.46	44.25	57.54	93.27	117.34	146.46	1.02	2.29	3.56
3MM9102WI	—	45	90	180	30.61	36.55	54.74	71.53	99.34	125.12	156.34	1.02	3.81	4.32
3MM9103WI	—	65	160	220	30.61	36.73	61.04	76.08	113.84	149.87	167.71	1.02	5.33	3.81
3MM9104WI	—	90	180	330	40.40	51.60	66.29	86.05	137.86	173.36	212.00	2.03	3.05	4.57
3MM9105WI	—	90	220	400	52.99	57.37	79.93	111.59	153.93	208.66	251.77	0.76	3.81	6.35
3MM9106WI	—	130	290	530	60.52	69.96	89.90	127.33	195.36	252.33	306.97	1.27	3.30	7.37
3MM9107WI	—	160	360	710	68.74	84.83	118.58	148.32	222.51	293.03	365.86	2.03	5.33	5.33
3MM9108WI	—	180	440	760	78.01	88.50	123.48	160.73	243.01	329.06	389.76	1.27	5.08	6.35
3MM9109WI	—	220	560	980	87.97	110.01	141.49	186.79	280.98	380.67	455.96	2.54	4.32	7.11
3MM9110WI	110	240	670	1,070	109.84	142.02	207.61	250.63	301.39	419.66	487.34	3.81	9.65	6.86
3MM9111WI	130	330	780	1,330	120.33	163.53	225.10	278.97	354.42	469.41	557.84	5.33	9.14	8.89
3MM9112WI	160	360	890	1,450	129.95	173.33	245.21	297.68	375.44	508.40	593.68	5.33	10.16	8.13
3MM9113WI	180	360	890	1,560	140.62	178.92	252.91	316.22	388.33	526.36	629.45	4.32	9.91	9.40
3MM9114WI	200	440	1,110	2,000	148.32	197.64	278.97	352.42	423.12	573.64	692.20	5.59	11.18	11.18
3MM9115WI	220	490	1,220	2,110	159.16	211.45	298.73	371.31	452.13	612.48	729.26	5.84	11.43	10.67
3MM9116WI	240	620	1,560	2,670	170.53	240.14	339.13	420.11	508.19	688.62	818.08	7.37	12.70	11.68
3MM9117WI	270	670	1,670	2,890	181.72	253.95	358.89	446.69	537.29	727.78	867.49	7.37	12.95	12.19
3MM9118WI	270	760	1,780	3,340	183.99	262.70	362.22	465.06	565.75	751.98	919.61	8.38	12.95	14.99
3MM9119WI	290	820	1,980	3,450	193.96	279.32	388.98	485.17	601.34	804.52	960.71	8.89	13.72	13.46
3MM9120WI	330	850	2,000	3,560	207.08	290.51	401.92	505.11	625.70	833.21	1001.76	8.13	13.21	13.72
3MM9121WI	360	960	2,050	4,090	217.40	308.35	409.62	537.82	652.64	841.25	1051.10	8.89	12.19	17.27
3MM9122WI	400	1,110	2,670	4,890	232.62	337.91	469.43	596.76	718.63	961.43	1167.28	9.91	15.24	16.76
3MM9124WI	440	1,220	2,890	5,120	251.33	359.94	497.59	624.04	764.45	1016.78	1220.33	10.16	15.49	15.75
3MM9126WI	510	1,510	3,670	6,670	259.03	381.81	533.10	676.16	814.82	1093.67	1324.03	12.45	18.80	19.81
3MM9128WI	580	1,560	3,890	6,890	277.22	397.55	561.08	704.50	848.49	1150.30	1381.06	11.68	19.30	19.05
3MM9130WI	640	1,780	4,450	8,010	297.16	428.16	604.10	762.74	908.66	1232.22	1487.09	12.45	20.57	20.83
3MM9132WI	760	2,220	5,340	8,900	319.54	470.66	655.00	802.44	1001.74	1338.58	1576.11	14.73	22.10	19.56
3MM9134WI	930	2,780	5,780	11,560	359.42	531.00	698.73	918.40	1123.56	1433.83	1791.10	16.51	19.56	28.45
3MM9136WI	1,020	3,110	6,230	12,460	358.55	533.79	691.90	908.78	1135.57	1431.01	1788.58	18.54	20.32	30.9
3MM9140WI	1,250	3,780	8,900	16,010	395.62	588.71	812.24	1,025.61	1251.44	1662.98	2007.43	20.32	28.96	30.99

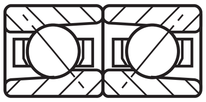
Mounting Arrangements



Recommended
DB



Tandem
DT



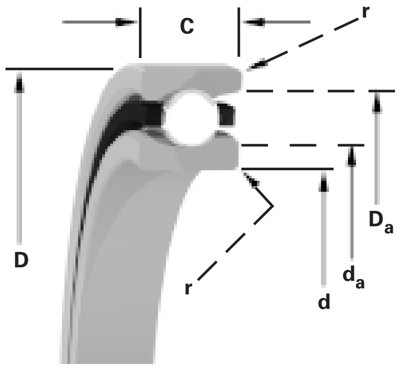
Special Applications
DF

	Grease Capacity		Kluber Isoflex NBU15		Operating Speeds[2] (DB Mounting)					
					Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams				rpm			rpm		
2MM9100WI	0.2	0.4	0.2	0.2	54,800	41,100	27,400	93,200	69,900	46,600
2MM9101WI	0.3	0.4	0.2	0.2	45,800	34,400	22,900	77,900	58,500	38,900
2MM9102WI	0.3	0.5	0.2	0.3	38,900	29,200	19,400	66,100	49,600	33,000
2MM9103WI	0.4	0.7	0.3	0.4	34,500	25,900	17,200	58,700	44,000	29,200
2MM9104WI	0.7	1.2	0.5	0.7	29,700	22,300	14,800	50,500	37,900	25,200
2MM9105WI	0.9	1.4	0.6	0.8	24,700	18,500	12,400	42,000	31,500	21,100
2MM9106WI	1.3	2.0	0.8	1.1	20,400	15,300	10,200	34,700	26,000	17,300
2MM9107WI	1.6	2.6	1.1	1.5	18,100	13,600	9,000	30,800	23,100	15,300
2MM9108WI	2.0	3.2	1.4	1.8	15,900	11,900	8,000	27,000	20,200	13,600
2MM9109WI	2.5	4.0	1.7	2.2	14,300	10,000	7,200	24,300	18,200	12,200
2MM9110WI	2.8	4.4	1.9	2.5	13,000	9,800	6,500	22,100	16,700	11,100
2MM9111WI	4.0	6.4	2.7	3.5	11,800	8,800	5,900	20,100	15,000	10,000
2MM9112WI	4.2	6.8	2.8	3.8	10,900	8,200	5,400	18,500	13,900	9,200
2MM9113WI	4.5	7.2	3.0	4.0	10,200	7,600	5,100	17,300	12,900	8,700
2MM9114WI	6.3	10.0	4.2	5.6	9,400	7,000	4,700	16,000	11,900	8,000
2MM9115WI	6.6	10.6	4.4	5.9	8,800	6,600	4,400	15,000	11,200	7,500
2MM9116WI	8.6	13.8	5.8	7.7	8,200	6,200	4,100	13,900	10,500	7,000
2MM9117WI	9.1	14.5	6.0	8.1	7,800	5,800	3,900	13,300	9,900	6,600
2MM9118WI	11.7	18.8	7.8	10.4	7,400	5,500	3,700	12,600	9,400	6,300
2MM9119WI	12.2	19.5	8.1	10.9	7,000	5,200	3,500	11,900	8,800	6,000
2MM9120WI	12.1	19.4	8.1	10.8	6,600	5,000	3,300	11,200	8,500	5,600
2MM9121WI	15.9	25.4	10.6	14.1	6,300	4,700	3,200	10,700	8,000	5,400
2MM9122WI	18.9	30.2	12.6	16.8	6,000	4,500	3,000	10,200	7,700	5,100
2MM9124WI	20.5	32.8	13.7	18.2	5,500	4,100	2,800	9,400	7,000	4,800
2MM9126WI	31.7	50.7	21.1	28.2	5,100	3,800	2,600	8,700	6,500	4,400
2MM9128WI	33.8	54.0	22.5	30.1	4,700	3,500	2,400	8,000	6,000	4,100
2MM9130WI	41.1	65.7	27.4	36.5	4,500	3,400	2,200	7,700	5,800	3,700
2MM9132WI	51.0	81.6	34.1	45.4	4,200	3,100	2,100	7,100	5,300	3,600
2MM9134WI	66.3	106.0	44.2	59.0	3,900	2,900	2,000	6,600	4,900	3,400
2MM9136WI	88.4	141.5	59.0	78.7	3,700	2,800	1,800	6,200	4,700	3,100
2MM9140WI	121.0	193.5	80.7	107.6	3,300	2,500	1,600	5,600	4,300	2,700

Notes
1) For other mounting arrangement configurations refer to Engineering chapter on Fafnir Permissible Speed calculation methods.
2) For ceramic ball complements use 120% of speeds shown.

Fafnir Extra-Light 2(3)MM9100WI (ISO 10) Series
Speed Capability

	Grease Capacity		Kluber Isoflex NBU15		Operating Speeds[2] (DB Mounting)					
					Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams				rpm			rpm		
3MM9100WI	0.2	0.4	0.2	0.2	49,320	36,990	24,660	83,880	62,910	41,940
3MM9101WI	0.3	0.4	0.2	0.2	41,220	30,960	20,610	70,110	52,650	35,010
3MM9102WI	0.3	0.5	0.2	0.3	35,010	26,280	17,460	59,490	44,640	29,700
3MM9103WI	0.4	0.7	0.3	0.4	31,050	23,310	15,480	52,830	39,600	26,280
3MM9104WI	0.7	1.2	0.5	0.7	26,730	20,070	13,320	45,450	34,110	22,680
3MM9105WI	0.9	1.4	0.6	0.8	22,230	16,650	11,160	37,800	28,350	18,990
3MM9106WI	1.3	2.0	0.8	1.1	18,360	13,770	9,180	31,230	23,400	15,570
3MM9107WI	1.6	2.6	1.1	1.5	16,290	12,240	8,100	27,720	20,790	13,770
3MM9108WI	2.0	3.2	1.4	1.8	14,310	10,710	7,200	24,300	18,180	12,240
3MM9109WI	2.5	4.0	1.7	2.2	12,870	9,000	6,480	21,870	16,380	10,980
3MM9110WI	2.8	4.4	1.9	2.5	11,700	8,820	5,850	19,890	15,030	9,990
3MM9111WI	4.0	6.4	2.7	3.5	10,620	7,920	5,310	18,090	13,500	9,000
3MM9112WI	4.2	6.8	2.8	3.8	9,810	7,380	4,860	16,650	12,510	8,280
3MM9113WI	4.5	7.2	3.0	4.0	9,180	6,840	4,590	15,570	11,610	7,830
3MM9114WI	6.3	10.0	4.2	5.6	8,460	6,300	4,230	14,400	10,710	7,200
3MM9115WI	6.6	10.6	4.4	5.9	7,920	5,940	3,960	13,500	10,080	6,750
3MM9116WI	8.6	13.8	5.8	7.7	7,380	5,580	3,690	12,510	9,450	6,300
3MM9117WI	9.1	14.5	6.0	8.1	7,020	5,220	3,510	11,970	8,910	5,940
3MM9118WI	11.7	18.8	7.8	10.4	6,660	4,950	3,330	11,340	8,460	5,670
3MM9119WI	12.2	19.5	8.1	10.9	6,300	4,680	3,150	10,710	7,920	5,400
3MM9120WI	12.1	19.4	8.1	10.8	5,940	4,500	2,970	10,080	7,650	5,040
3MM9121WI	15.9	25.4	10.6	14.1	5,670	4,230	2,880	9,630	7,200	4,860
3MM9122WI	18.9	30.2	12.6	16.8	5,400	4,050	2,700	9,180	6,930	4,590
3MM9124WI	20.5	32.8	13.7	18.2	4,950	3,690	2,520	8,460	6,300	4,320
3MM9126WI	31.7	50.7	21.1	28.2	4,590	3,420	2,340	7,830	5,850	3,960
3MM9128WI	33.8	54.0	22.5	30.1	4,230	3,150	2,160	7,200	5,400	3,690
3MM9130WI	41.1	65.7	27.4	36.5	4,050	3,060	1,980	6,930	5,220	3,330
3MM9132WI	51.0	81.6	34.1	45.4	3,780	2,790	1,890	6,390	4,770	3,240
3MM9134WI	66.3	106.0	44.2	59.0	3,510	2,610	1,800	5,940	4,410	3,060
3MM9136WI	88.4	141.5	59.0	78.7	3,330	2,520	1,620	5,580	4,230	2,790
3MM9140WI	121.0	193.5	80.7	107.6	2,970	2,250	1,440	5,040	3,870	2430



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WN Construction:

- Incorporates low shoulder on non-thrust side of both outer and inner rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (in.)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	in/tol: +0; -.000(X)				lbs.	lbs.		rpm	lbs.		rpm	in.	in.			
9100HX	0.3937 (1.5)	1.0236 (2)	0.315 (16)	10 x 5/32	0.04	270 *240*	740 *740*	85,800 *102,960*	260 *230*	710 *710*	77,200 *92,640*	0.012	0.54	0.53	0.92	0.91
9101HX	0.4724 (1.5)	1.1024 (2)	0.315 (31)	10 x 3/16	0.04	370 *330*	1,030 *1,030*	78,900 *94,680*	360 *320*	990 *990*	71,000 *85,200*	0.012	0.64	0.63	1.01	1.00
9102HX	0.5906 (1.5)	1.2598 (2.5)	0.3543 (31)	12 x 3/16	0.06	470 *420*	1,170 *1,170*	64,300 *77,160*	450 *400*	1,120 *1,120*	57,900 *69,480*	0.012	0.76	0.75	1.13	1.12
9103HX	0.6693 (1.5)	1.378 (2.5)	0.3937 (31)	12 x 7/32	0.08	630 *560*	1,540 *1,540*	58,900 *70,680*	610 *540*	1,480 *1,480*	53,000 *63,600*	0.012	0.86	0.85	1.23	1.22
9104HX	0.7874 (2)	1.6535 (2.5)	0.4724 (47)	12 x 1/4	0.14	840 *750*	1,960 *1,960*	48,900 *58,680*	800 *710*	1,880 *1,880*	44,000 *52,800*	0.024	0.99	0.98	1.49	1.48
9105HX	0.9843 (2)	1.8504 (2.5)	0.4724 (47)	13 x 1/4	0.16	950 *850*	2,070 *2,070*	40,700 *48,840*	910 *810*	1,970 *1,970*	36,600 *43,920*	0.024	1.19	1.18	1.68	1.67
9106HX	1.1811 (2)	2.1654 (3)	0.5118 (47)	14 x 9/32	0.23	1,320 *1,170*	2,680 *2,680*	33,600 *40,320*	1,260 *1,120*	2,550 *2,550*	30,200 *36,240*	0.039	1.43	1.42	2.00	1.99
9107HX	1.378 (2.5)	2.4409 (3)	0.5512 (47)	15 x 5/16	0.32	1,750 *1,560*	3,380 *3,380*	29,800 *35,760*	1,670 *1,490*	3,220 *3,220*	26,800 *32,160*	0.039	1.62	1.60	2.23	2.21
9108HX	1.5748 (2.5)	2.6772 (3)	0.5906 (47)	16 x 5/16	0.40	1,910 *1,700*	3,490 *3,490*	26,200 *31,440*	1,820 *1,620*	3,310 *3,310*	23,600 *28,320*	0.039	1.82	1.80	2.45	2.43
9109HX	1.7717 (2.5)	2.9528 (3)	0.6299 (47)	15 x 3/8	0.48	2,540 *2,260*	4,690 *4,690*	23,900 *28,680*	2,420 *2,160*	4,460 *4,460*	21,500 *25,800*	0.039	2.04	2.02	2.73	2.71
9110HX	1.9685 (2.5)	3.1496 (3)	0.6299 (47)	16 x 3/8	0.52	2,760 *2,450*	4,850 *4,850*	21,800 *26,160*	2,620 *2,330*	4,600 *4,600*	19,600 *23,500*	0.039	2.23	2.21	2.92	2.90
9111HX	2.1654 (3)	3.5433 (3)	0.7087 (59)	24 x 5/16	0.88	3,030 *2,700*	4,360 *4,360*	18,700 *22,400*	2,880 *2,560*	4,120 *4,120*	16,900 *20,280*	0.039	2.47	2.45	3.28	3.26

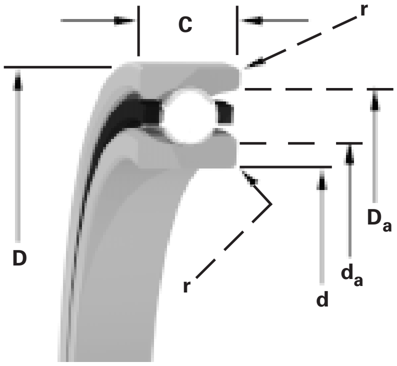
Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Extra-Light 2(3)MMV9100HX (ISO 10) Series
Inch Dimensional Sizes

High Speed Seal Option
Available with non-contact seals. Add VV suffix to part number (in place of CR cage designation). Ex: 2MMV9106HXVV SUL

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
0.3935	0.3937	0.0002	0.00015	1.0236	1.0238	0.0000	0.0004	1.02400	1.02380	0.00060	0.00020	**9100HX**
0.4722	0.4724	0.0002	0.00015	1.1024	1.1026	0.0000	0.0004	1.10280	1.10260	0.00060	0.00020	**9101HX**
0.5904	0.5906	0.0002	0.00015	1.2598	1.2600	0.0000	0.00045	1.26020	1.26000	0.00070	0.00020	**9102HX**
0.6691	0.6693	0.0002	0.00015	1.3780	1.3783	0.0000	0.0005	1.37840	1.37820	0.00070	0.00020	**9103HX**
0.7872	0.7874	0.0002	0.0002	1.6535	1.6538	0.0000	0.0005	1.65390	1.65370	0.00070	0.00020	**9104HX**
0.9841	0.9843	0.0002	0.0002	1.8504	1.8507	0.0000	0.0005	1.85090	1.85070	0.00080	0.00030	**9105HX**
1.1809	1.1811	0.0002	0.0002	2.1654	2.1657	0.0000	0.0006	2.16590	2.16570	0.00080	0.00030	**9106HX**
1.3778	1.3780	0.0002	0.00025	2.4409	2.4412	0.0000	0.0006	2.44140	2.44120	0.00080	0.00030	**9107HX**
1.5746	1.5748	0.0002	0.00025	2.6772	2.6775	0.0000	0.0006	2.67770	2.67750	0.00080	0.00030	**9108HX**
1.7715	1.7717	0.0002	0.00025	2.9528	2.9531	0.0000	0.0006	2.95330	2.95310	0.00080	0.00030	**9109HX**
1.9683	1.9685	0.0002	0.00025	3.1496	3.1499	0.0000	0.0006	3.15010	3.14990	0.00080	0.00030	**9110HX**
2.1652	2.1654	0.0002	0.0003	3.5433	3.5436	0.0000	0.0006	3.54390	3.54360	0.00090	0.00030	**9111HX**

(continued)



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WN Construction:
- Incorporates low shoulder on non-thrust side of outer and inner rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (in.)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	d_a (Shaft) min.	D_a (Housing) max.	D_a (Housing) min.
	in/tol: +0; -.000(X)				lbs.	lbs.		rpm	lbs.		rpm	in.	in.			
9112HX	2.3622 (3)	3.7402 (3)	0.7087 (59)	25 x 5/16	0.94	3,190 *2,840*	4,420 *4,420*	17,400 *20,880*	3,010 *2,680*	4,180 *4,180*	15,700 *18,840*	0.039	2.67	2.65	3.47	3.45
9113HX	2.5591 (3)	3.937 (3)	0.7087 (59)	25 x 11/32	0.98	3,850 *3,430*	5,280 *5,280*	16,400 *19,680*	3,640 *3,240*	4,990 *4,990*	14,800 *17,760*	0.039	2.86	2.84	3.67	3.65
9114HX	2.7559 (3)	4.3307 (3)	0.7874 (59)	25 x 3/8	1.38	4,580 *4,080*	6,180 *6,180*	15,000 *18,000*	4,330 *3,850*	5,830 *5,830*	13,500 *16,200*	0.039	3.08	3.06	4.03	4.01
9115HX	2.9528 (3)	4.5276 (3)	0.7874 (59)	26 x 3/8	1.45	4,790 *4,260*	6,270 *6,270*	14,200 *17,040*	4,520 *4,020*	5,930 *5,930*	12,700 *15,240*	0.039	3.29	3.26	4.23	4.20
9116HX	3.1496 (3)	4.9213 (3.5)	0.8661 (59)	25 x 7/16	1.93	6,210 *5,530*	8,210 *8,210*	13,200 *15,840*	5,880 *5,240*	7,740 *7,740*	11,900 *14,280*	0.039	3.52	3.49	4.59	4.56
9117HX	3.3465 (3)	5.1181 (3.5)	0.861 (79)	26 x 7/16	2.02	6,510 *5,790*	8,330 *8,330*	12,600 *15,120*	6,140 *5,460*	7,870 *7,870*	11,300 *13,560*	0.039	3.74	3.71	4.81	4.78
9118HX	3.5433 (3)	5.5118 (3.5)	0.9449 (79)	28 x 7/16	2.71	7,040 *6,260*	8,630 *8,630*	11,700 *14,040*	6,600 *5,880*	8,150 *8,150*	10,500 *12,600*	0.059	3.96	3.93	5.16	5.13
9119HX	3.7402 (3)	5.7087 (3.5)	0.9449 (79)	26 x 1/2	2.73	8,470 *7,540*	10,600 *10,600*	11,300 *13,560*	8,000 *7,120*	10,100 *10,100*	10,200 *12,240*	0.059	4.16	4.13	5.35	5.32
9120HX	3.937 (3)	5.9055 (3.5)	0.9449 (79)	27 x 1/2	2.84	8,840 *7,870*	108,00 *108,00*	10,800 *12,960*	8,330 *7,410*	10,200 *10,200*	9,700 *11,640*	0.059	4.36	4.33	5.55	5.52
9121HX	4.1339 (3)	6.2992 (4)	1.0236 (79)	28 x 1/2	3.69	9,200 *8,180*	110,000 *110,000*	10,100 *12,120*	8,610 *7,670*	10,300 *10,300*	9,100 *10,920*	0.079	4.59	4.56	5.91	5.88
9122HX	4.3307 (3)	6.6929 (4)	1.1024 (79)	30 x 1/2	4.70	9,840 *8,760*	113,000 *113,000*	9,500 *11,400*	9,180 *8,170*	10,700 *10,700*	8,560 *10,270*	0.079	4.85	4.82	6.24	6.21
9124HX	4.7244 (3)	7.0866 (4)	1.1024 (79)	29 x 9/16	4.89	12,100 *10,700*	139,000 *139,000*	8,900 *10,680*	11,300 *10,000*	13,100 *13,100*	8,030 *9,640*	0.079	5.25	5.22	6.63	6.60

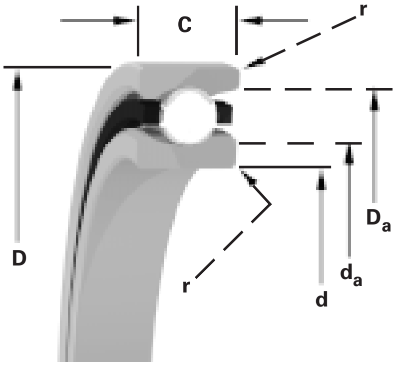
Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Extra-Light 2(3)MMV9100HX (ISO 10) Series

Inch Dimensional Sizes

High Speed Seal Option
Available with non-contact seals. Add VV suffix to part number (in place of CR cage designation). Ex: 2MMV9106HXVV SUL

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
2.3620	2.3622	0.0002	0.0003	3.7402	3.7405	0.0000	0.0006	3.74080	3.74050	0.00090	0.00030	**9112HX**
2.5589	2.5591	0.0002	0.0003	3.9370	3.9373	0.0000	0.0006	3.93770	3.93740	0.00100	0.00040	**9113HX**
2.7557	2.7559	0.0002	0.0003	4.3307	4.3310	0.0000	0.0006	4.33140	4.33110	0.00100	0.00040	**9114HX**
2.9526	2.9530	0.0002	0.0005	4.5276	4.5279	0.0000	0.0006	4.52830	4.52800	0.00100	0.00040	**9115HX**
3.1494	3.1498	0.0002	0.0005	4.9213	4.9216	0.0000	0.0007	4.92210	4.92170	0.00120	0.00040	**9116HX**
3.3463	3.3467	0.0002	0.0005	5.1181	5.1185	0.0000	0.0007	5.11890	5.11850	0.00110	0.00040	**9117HX**
3.5431	3.5435	0.0002	0.0005	5.5118	5.5122	0.0000	0.0007	5.51260	5.51220	0.00110	0.00040	**9118HX**
3.7400	3.7404	0.0002	0.0005	5.7087	5.7091	0.0000	0.0007	5.70950	5.70910	0.00110	0.00040	**9119HX**
3.9368	3.9372	0.0002	0.0005	5.9055	5.9059	0.0000	0.0007	5.90640	5.90600	0.00120	0.00050	**9120HX**
4.1337	4.1341	0.0002	0.0005	6.2992	6.2996	0.0000	0.0008	6.30010	6.29970	0.00130	0.00050	**9121HX**
4.3305	4.3309	0.0002	0.0005	6.6929	6.6933	0.0000	0.0008	6.69380	6.69340	0.00130	0.00050	**9122HX**
4.7242	4.7246	0.0002	0.0005	7.0866	7.0870	0.0000	0.0008	7.08750	7.08710	0.00130	0.00050	**9124HX**



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WN Construction:

- Incorporates low shoulder on non-thrust side of outer and inner rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (mm)	Wt.	(2MM) Load Ratings (steel ball & *ceramic ball*) C_o (stat)	C_e(dyn)	Limiting Speed	(3MM) Load Ratings (steel ball & *ceramic ball*) C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	Recommended Shoulder Diameters d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	mm/tol: +0; -(µm)				kg	N		rpm	N		rpm	mm	mm			
9100HX	10	26	8	10 x 4.0	0.018	1,180	3,310	85,800	1,140	3,170	77,200	0.3	13.6	13.3	23.2	23.0
	(4)	(5)	(40)			*1,050*	*3,310*	*102,960*	*1,010*	*3,170*	*92,640*					
9101HX	12	28	8	10 x 4.8	0.020	1,650	4,560	78,900	1,590	4,390	71,000	0.3	16.1	15.9	25.5	25.3
	(4)	(5)	(80)			*1,470*	*4,560*	*94,680*	*1,420*	*4,390*	*85,200*					
9102HX	15	32	9	12 x 4.8	0.027	2,110	5,210	64,300	2,010	4,980	57,900	0.3	19.2	18.9	28.6	28.3
	(4)	(6)	(80)			*1,880*	*5,210*	*77,160*	*1,790*	*4,980*	*69,480*					
9103HX	17	35	10	12 x 5.6	0.038	2,810	6,860	58,900	2,700	6,580	53,000	0.3	21.7	21.5	31.1	30.9
	(4)	(6)	(80)			*2,500*	*6,860*	*70,680*	*2,410*	*6,580*	*63,600*					
9104HX	20	42	12	12 x 6.4	0.064	3,740	8,730	48,900	3,570	8,370	44,000	0.6	25.0	24.8	37.7	37.5
	(5)	(6)	(130)			*3,330*	*8,730*	*58,680*	*3,180*	*8,370*	*52,800*					
9105HX	25	47	12	13 x 6.4	0.073	4,240	9,190	41,800	4,030	8,760	36,600	0.6	30.1	29.9	42.6	42.3
	(5)	(6)	(130)			*3,770*	*9,190*	*50,160*	*3,590*	*8,760*	*43,920*					
9106HX	30	55	13	13 x 7.1	0.104	5,850	11,900	34,900	5,600	11,300	30,200	1.0	36.2	35.9	50.7	50.4
	(5)	(7)	(130)			*5,210*	*11,900*	*41,880*	*4,990*	*11,300*	*36,240*					
9107HX	35	62	14	15 x 7.9	0.145	7,770	15,000	29,800	7,430	14,300	26,800	1.0	41.2	40.6	56.6	56.1
	(6)	(7)	(130)			*6,920*	*15,000*	*35,760*	*6,620*	*14,300*	*32,160*					
9108HX	40	68	15	16 x 7.9	0.181	8,510	15,500	26,200	8,090	14,700	23,600	1.0	46.2	45.7	62.2	61.7
	(6)	(7)	(130)			*7,580*	*15,500*	*31,440*	*7,200*	*14,700*	*28,320*					
9109HX	45	75	16	15 x 9.5	0.218	11,300	20,800	23,900	10,800	19,800	21,500	1.0	51.8	51.3	69.3	68.8
	(6)	(7)	(130)			*10,100*	*20,800*	*28,680*	*9,590*	*19,800*	*25,800*					
9110HX	50	80	16	16 x 9.5	0.236	12,300	21,600	21,800	11,700	20,500	19,600	1.0	56.6	56.1	74.2	73.7
	(6)	(7)	(130)			*10,900*	*21,600*	*26,160*	*10,400*	*20,500*	*23,500*					
9111HX	55	90	18	24 x 7.9	0.399	13,500	19,400	18,700	12,800	18,300	16,900	1.0	62.7	62.2	83.3	82.8
	(7)	(8)	(150)			*12,000*	*19,400*	*22,440*	*11,400*	*18,300*	*20,280*					

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

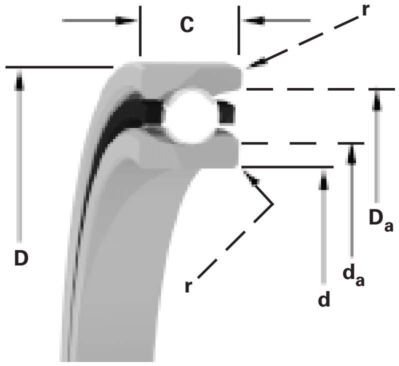
Fafnir Extra-Light 2(3)MMV9100HX (ISO 10) Series

Metric Dimensional Sizes

High Speed Seal Option
Available with non-contact seals. Add VV suffix to part number (in place of CR cage designation). Ex: 2MMV9106HXVV SUL

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
9.995	10.000	0.005	0.004	26	26.005	0.000	0.010	26.010	26.005	0.015	0.005	**9100HX**
11.995	12.000	0.005	0.004	28	28.005	0.000	0.010	28.010	28.005	0.015	0.005	**9101HX**
14.995	15.000	0.005	0.004	32	32.005	0.000	0.011	32.010	32.005	0.016	0.005	**9102HX**
16.995	17.000	0.005	0.004	35	35.006	0.000	0.012	35.010	35.005	0.016	0.005	**9103HX**
19.995	20.000	0.005	0.005	42	42.006	0.000	0.012	42.010	42.005	0.016	0.005	**9104HX**
24.995	25.000	0.005	0.005	47	47.006	0.000	0.012	47.012	47.007	0.018	0.007	**9105HX**
29.995	30.000	0.005	0.005	55	55.008	0.000	0.015	55.012	55.007	0.019	0.007	**9106HX**
34.995	35.000	0.005	0.006	62	62.008	0.000	0.015	62.012	62.007	0.019	0.007	**9107HX**
39.995	40.000	0.005	0.006	68	68.008	0.000	0.015	68.012	68.007	0.019	0.007	**9108HX**
44.995	45.000	0.005	0.006	75	75.008	0.000	0.015	75.014	75.009	0.022	0.009	**9109HX**
49.995	50.000	0.005	0.006	80	80.008	0.000	0.015	80.012	80.008	0.020	0.008	**9110HX**
54.995	55.000	0.005	0.007	90	90.008	0.000	0.016	90.015	90.007	0.023	0.007	**9111HX**

(continued)



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WN Construction:

- Incorporates low shoulder on non-thrust side of outer and inner rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (mm)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	d_a (Shaft) min.	D_a (Housing) max.	D_a (Housing) min.
	mm/tol: +0; -(μm)				kg	N		rpm	N		rpm	mm	mm			
9112HX	60 (7)	95 (8)	18 (150)	25 x 7.9	0.426	14,200 *12,600*	19,700 *19,700*	17,400 *20,880*	13,400 *11,900*	18,600 *18,600*	15,700 *18,840*	1.0	67.8	67.3	88.1	87.6
9113HX	65 (7)	100 (8)	18 (150)	25 x 8.7	0.445	17,100 *15,200*	23,500 *23,500*	16,400 *19,680*	16,200 *14,400*	22,200 *22,200*	14,800 *17,760*	1.0	72.6	72.1	93.2	92.7
9114HX	70 (7)	110 (8)	20 (150)	25 x 9.5	0.626	20,400 *18,100*	27,500 *27,500*	15,000 *18,000*	19,200 *17,100*	85,900 *85,900*	13,500 *16,200*	1.0	78.2	77.7	102.4	101.9
9115HX	75 (7)	115 (8)	20 (150)	26 x 9.5	0.658	21,300 *19,000*	27,900 *27,900*	14,200 *17,040*	20,100 *17,900*	26,408 *26,408*	12,700 *15,240*	1.0	83.4	82.7	107.3	106.6
9116HX	80 (7)	125 (9)	22 (150)	25 x 11.1	0.875	27,600 *24,600*	36,500 *36,500*	13,200 *15,840*	26,200 *23,300*	34,400 *34,400*	11,900 *14,280*	1.0	89.3	88.5	116.5	115.7
9117HX	85 (8)	130 (9)	22 (210)	26 x 11.1	0.916	29,000 *25,800*	37,100 *37,100*	12,600 *15,120*	27,300 *24,300*	35,000 *35,000*	11,300 *13,560*	1.0	94.9	94.1	122.1	121.3
9118HX	90 (8)	140 (9)	24 (210)	28 x 11.1	1.229	31,300 *27,900*	38,400 *38,400*	11,700 *14,040*	29,400 *26,100*	36,200 *36,200*	10,500 *12,600*	1.5	100.5	99.7	130.9	130.2
9119HX	95 (8)	145 (9)	24 (210)	26 x 12.7	1.238	37,700 *33,500*	47,400 *47,400*	11,300 *13,560*	35,600 *31,700*	44,700 *44,700*	10,200 *12,240*	1.5	105.5	104.8	135.8	135.0
9120HX	100 (8)	150 (9)	24 (210)	27 x 12.7	1.288	39,300 *35,000*	48,200 *48,200*	10,800 *12,960*	37,000 *33,000*	45,500 *45,500*	9,700 *11,640*	1.5	110.6	109.9	140.8	140.1
9121HX	105 (8)	160 (10)	26 (210)	28 x 12.7	1.674	40,900 *36,400*	48,700 *48,700*	10,100 *12,120*	38,300 *34,100*	46,000 *46,000*	9,100 *10,920*	2.0	116.5	115.7	150.0	149.2
9122HX	110 (8)	170 (10)	28 (210)	30 x 12.7	2.132	43,800 *38,900*	50,400 *50,400*	9,500 *11,400*	40,800 *36,300*	47,500 *47,500*	8,560 *10,270*	2.0	123.1	122.3	158.4	157.6
9124HX	120 (8)	180 (10)	28 (210)	29 x 14.3	2.218	53,700 *47,800*	61,700 *61,700*	8,900 *10,680*	50,200 *44,700*	58,100 *58,100*	8,030 *9,640*	2.0	133.2	132.5	168.3	167.5

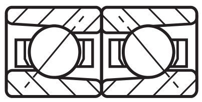
Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Extra-Light 2(3)MMV9100HX (ISO 10) Series
Metric Dimensional Sizes

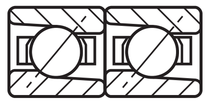
High Speed Seal Option
Available with non-contact seals. Add VV suffix to part number (in place of CR cage designation). Ex: 2MMV9106HXVV SUL

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
59.995	60.000	0.005	0.007	95	95.008	0.000	0.016	95.016	95.009	0.024	0.009	**9112HX**
64.995	65.000	0.005	0.007	100	100.008	0.000	0.016	100.018	100.010	0.025	0.010	**9113HX**
69.995	70.000	0.005	0.007	110	110.008	0.000	0.016	110.018	110.010	0.025	0.010	**9114HX**
74.995	75.005	0.005	0.012	115	115.008	0.000	0.016	115.019	115.011	0.026	0.010	**9115HX**
79.995	80.005	0.005	0.012	125	125.008	0.000	0.017	125.021	125.011	0.030	0.011	**9116HX**
84.995	85.005	0.005	0.012	130	130.009	0.000	0.018	130.020	130.010	0.029	0.010	**9117HX**
89.995	90.005	0.005	0.013	140	140.009	0.000	0.018	140.020	140.010	0.029	0.010	**9118HX**
94.995	95.005	0.005	0.013	145	145.009	0.000	0.018	145.021	145.011	0.030	0.011	**9119HX**
99.995	100.005	0.005	0.013	150	150.009	0.000	0.018	150.023	150.012	0.032	0.012	**9120HX**
104.995	105.005	0.005	0.013	160	160.009	0.000	0.022	160.022	160.012	0.033	0.012	**9121HX**
109.995	110.005	0.005	0.013	170	170.01	0.000	0.020	170.022	170.012	0.032	0.012	**9122HX**
119.995	120.005	0.005	0.013	180	180.01	0.000	0.020	180.022	180.012	0.032	0.012	**9124HX**

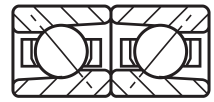
Mounting Arrangements



Recommended
DB



Tandem
DT



Special Applications
DF

	Preload				Axial Stiffness[1]			Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	Light	Medium	Heavy	Light	Medium	Heavy	Extra Light to Light	Light to Medium	Medium to Heavy
	lbs.				10^6lbs./in.			10^6lbs./in			in.		
2MMV9100HX	—	5	15	30	0.0860	0.1345	0.1834	0.4690	0.6743	0.8414	—	0.00038	0.00040
2MMV9101HX	—	5	15	30	0.0824	0.1290	0.1760	0.4924	0.7094	0.8860	—	0.00038	0.00040
2MMV9102HX	—	5	15	30	0.0923	0.1434	0.1943	0.5552	0.8029	1.0042	—	0.00034	0.00036
2MMV9103HX	—	5	15	30	0.0958	0.1471	0.1974	0.5803	0.8462	1.0610	—	0.00032	0.00034
2MMV9104HX	5	10	30	60	0.1287	0.2010	0.2735	0.7711	1.1124	1.3900	0.00018	0.00034	0.00051
2MMV9105HX	5	10	30	60	0.1399	0.2154	0.2896	0.8471	1.2328	1.5450	0.00016	0.00046	0.00048
2MMV9106HX	10	15	45	90	0.1665	0.2586	0.3504	1.0017	1.4486	1.8119	0.00019	0.00056	0.00059
2MMV9107HX	10	15	45	90	0.1820	0.2811	0.3792	1.0995	1.5956	1.9980	0.00017	0.00052	0.00055
2MMV9108HX	10	15	45	90	0.1895	0.2920	0.3930	1.1464	1.6666	2.0882	0.00017	0.00056	0.00052
2MMV9109HX	10	20	60	120	0.2122	0.3268	0.4396	1.2837	1.8669	2.3394	0.00021	0.00059	0.00063
2MMV9110HX	10	20	60	120	0.2209	0.3395	0.4558	1.3380	1.9498	2.4445	0.00020	0.00056	0.00060
2MMV9111HX	15	25	75	150	0.2960	0.4578	0.6183	1.7862	2.5895	3.2417	0.00018	0.00053	0.00056
2MMV9112HX	15	25	75	150	0.3036	0.4689	0.6324	1.8341	2.6618	3.3332	0.00018	0.00052	0.00055
2MMV9113HX	15	30	90	180	0.3329	0.5140	0.6930	2.0115	2.9198	3.6566	0.00020	0.00056	0.00060
2MMV9114HX	20	35	105	210	0.3604	0.5561	0.7493	2.1789	3.1645	3.9637	0.00021	0.00061	0.00064
2MMV9115HX	20	35	105	210	0.3694	0.5691	0.7658	2.2347	3.2491	4.0710	0.00021	0.00059	0.00063
2MMV9116HX	25	45	135	270	0.4011	0.6192	0.8349	2.5122	3.6526	4.5762	0.00025	0.00070	0.00074
2MMV9117HX	25	50	150	300	0.4388	0.6773	0.9130	2.6524	3.8513	4.8236	0.00026	0.00071	0.00075
2MMV9118HX	25	50	150	300	0.4596	0.7075	0.9513	2.7819	4.0479	5.0729	0.00025	0.00068	0.00072
2MMV9119HX	30	60	180	360	0.4857	0.7474	1.0047	2.9406	4.2802	5.3645	0.00028	0.00077	0.00082
2MMV9120HX	30	60	180	360	0.4974	0.7643	1.0261	3.0125	4.3899	5.5038	0.00027	0.00076	0.00080
2MMV9121HX	30	60	180	360	0.5088	0.7809	1.0473	3.0831	4.4984	5.6416	0.00026	0.00074	0.00079
2MMV9122HX	35	65	195	390	0.5475	0.8405	1.1276	3.3169	4.8377	6.0665	0.00027	0.00075	0.00079
2MMV9124HX	40	80	240	480	0.6213	0.9503	1.2707	3.5654	5.2038	6.5275	0.00029	0.00081	0.00086

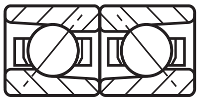
Notes
1) For DB or DF arrangements only. For other mounting arrangements contact Timken Engineering.

Fafnir Extra-Light 2(3)MMV9100HX (ISO 10) Series

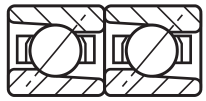
Inch Duplex Performance Data

	Preload				Axial Stiffness[1]				Radial Stiffness[1]				Spacer Offsets[1]		
	X-light	Light	Medium	Heavy	X-light	Light	Medium	Heavy	X-light	Light	Medium	Heavy	DUX to DUL	DUL to DUM	DUM to DUH
	lbs.				10^6lbs./in.				10^6lbs./in				μin.		
3MMV9100HX	5	10	30	60	0.163	0.209	0.315	0.415	0.348	0.440	0.629	0.783	100	300	320
3MMV9101HX	5	10	30	60	0.171	0.218	0.326	0.426	0.369	0.469	0.674	0.842	100	300	320
3MMV9102HX	5	10	30	60	0.192	0.245	0.365	0.476	0.414	0.529	0.763	0.954	100	260	280
3MMV9103HX	5	10	30	60	0.200	0.255	0.378	0.490	0.430	0.557	0.807	1.011	80	260	280
3MMV9104HX	10	20	60	120	0.264	0.337	0.504	0.659	0.580	0.739	1.063	1.327	140	380	420
3MMV9105HX	10	20	60	120	0.283	0.361	0.538	0.702	0.606	0.773	1.113	1.391	120	360	380
3MMV9106HX	15	30	90	180	0.345	0.440	0.656	0.856	0.749	0.957	1.379	1.725	160	440	480
3MMV9107HX	15	30	90	180	0.379	0.483	0.718	0.934	0.820	1.052	1.519	1.902	140	400	440
3MMV9108HX	15	30	90	180	0.396	0.504	0.748	0.972	0.853	1.097	1.587	1.987	140	380	420
3MMV9109HX	20	40	120	240	0.440	0.560	0.832	1.081	0.958	1.233	1.784	2.234	160	460	500
3MMV9110HX	20	40	120	240	0.459	0.584	0.866	1.125	0.995	1.287	1.863	2.334	160	440	480
3MMV9111HX	25	50	150	300	0.616	0.784	1.167	1.519	1.333	1.708	2.465	3.085	140	400	440
3MMV9112HX	25	50	150	300	0.632	0.806	1.197	1.558	1.367	1.754	2.534	3.172	140	400	440
3MMV9113HX	30	60	180	360	0.691	0.880	1.309	1.702	1.501	1.928	2.785	3.486	160	440	480
3MMV9114HX	35	70	210	420	0.755	0.962	1.428	1.857	1.618	2.080	3.006	3.764	160	460	520
3MMV9115HX	35	70	210	420	0.766	0.975	1.448	1.882	1.668	2.147	3.104	3.887	160	460	500
3MMV9116HX	45	90	270	540	0.858	1.092	1.622	2.106	1.852	2.387	3.453	4.325	180	520	580
3MMV9117HX	50	100	300	600	0.913	1.163	1.728	2.248	1.977	2.540	3.670	4.594	200	540	600
3MMV9118HX	50	100	300	600	0.959	1.220	1.811	2.352	2.068	2.666	3.858	4.832	180	520	580
3MMV9119HX	60	120	360	720	1.017	1.294	1.921	2.494	2.181	2.814	4.072	5.101	200	600	660
3MMV9120HX	60	120	360	720	1.043	1.327	1.967	2.552	2.230	2.884	4.177	5.234	200	580	640
3MMV9121HX	60	120	360	720	1.068	1.358	2.013	2.610	2.277	2.953	4.280	5.365	200	560	620
3MMV9122HX	65	130	390	780	1.149	1.461	2.166	2.809	2.452	3.176	4.603	5.769	200	560	620
3MMV9124HX	80	160	480	960	1.246	1.585	2.350	3.048	2.679	3.470	5.027	6.299	220	640	700

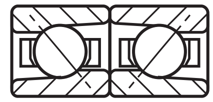
Mounting Arrangements



Recommended
DB



Tandem
DT



Special Applications
DF

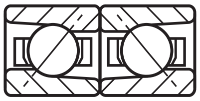
	Preload				Axial Stiffness[1]			Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	Light	Medium	Heavy	Light	Medium	Heavy	DUX to DUL	DUL to DUM	DUM to DUH
	N				N/µm			N/µm			µm		
2MMV9100HX	—	20	70	130	15.04	23.52	32.08	82.03	117.94	147.16	—	9.60	10.16
2MMV9101HX	—	20	70	130	14.41	22.56	30.78	86.12	124.07	154.96	—	9.60	10.16
2MMV9102HX	—	20	70	130	16.14	25.08	33.98	97.10	140.43	175.63	—	8.64	9.15
2MMV9103HX	—	20	70	130	16.76	25.73	34.53	101.49	148.00	185.57	—	8.13	8.64
2MMV9104HX	20	40	90	270	22.51	35.15	47.84	134.87	194.56	243.11	4.57	8.64	12.95
2MMV9105HX	20	40	130	270	24.47	37.67	50.65	148.16	215.62	270.22	4.06	11.68	12.19
2MMV9106HX	40	70	200	400	29.12	45.23	61.28	175.20	253.36	316.90	4.83	14.22	14.99
2MMV9107HX	40	70	200	400	31.83	49.16	66.32	192.30	279.07	349.45	4.32	13.21	13.97
2MMV9108HX	40	70	200	400	33.14	51.07	68.74	200.51	291.49	365.23	4.32	14.22	13.21
2MMV9109HX	40	90	270	530	37.11	57.16	76.89	224.52	326.52	409.16	5.33	14.99	16.00
2MMV9110HX	40	90	270	530	38.64	59.38	79.72	234.02	341.02	427.54	5.08	14.22	15.24
2MMV9111HX	75	110	330	670	51.77	80.07	108.14	312.41	452.90	566.97	4.57	13.46	14.22
2MMV9112HX	75	110	330	670	53.10	82.01	110.61	320.78	465.55	582.98	4.57	13.21	13.97
2MMV9113HX	75	130	400	800	58.22	89.90	121.21	351.81	510.67	639.54	5.08	14.22	15.24
2MMV9114HX	90	160	470	930	63.03	97.26	131.05	381.09	553.47	693.25	5.33	15.49	16.26
2MMV9115HX	90	160	470	930	64.61	99.54	133.94	390.85	568.27	712.02	5.33	14.99	16.00
2MMV9116HX	110	200	600	1,200	70.15	108.30	146.02	439.38	638.84	800.38	6.35	17.78	18.80
2MMV9117HX	110	220	670	1,330	76.75	118.46	159.68	463.90	673.59	843.65	6.60	18.03	19.05
2MMV9118HX	110	220	670	1,330	80.38	123.74	166.38	486.55	707.98	887.25	6.35	17.27	18.29
2MMV9119HX	130	270	800	1,600	84.95	130.72	175.72	514.31	748.61	938.25	7.11	19.56	20.83
2MMV9120HX	130	270	800	1,600	87.00	133.68	179.46	526.89	767.79	962.61	6.86	19.30	20.32
2MMV9121HX	130	270	800	1,600	88.99	136.58	183.17	539.23	786.77	986.72	6.60	18.80	20.07
2MMV9122HX	160	290	870	1,730	95.76	147.00	197.22	580.13	846.11	1,061.03	6.86	19.05	20.07
2MMV9124HX	180	360	1,070	2,140	108.67	166.21	222.25	623.59	910.14	1,141.66	7.37	20.57	21.84

Notes
1) For DB or DF arrangements only. For other mounting arrangements contact Timken Engineering.

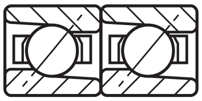
Fafnir Extra-Light 2(3)MMV9100HX (ISO 10) Series
Metric Duplex Performance Data

	Preload				Axial Stiffness[1]				Radial Stiffness[1]				Spacer Offsets[1]		
	X-light	Light	Medium	Heavy	X-light	Light	Medium	Heavy	X-light	Light	Medium	Heavy	DUX to DUL	DUL to DUM	DUM to DUH
	N				10^6N/m				10^6N/m				µm		
3MMV9100HX	20	45	135	265	28.53	36.54	55.09	72.65	60.85	76.89	110.03	137.02	2.54	7.62	8.13
3MMV9101HX	20	45	135	265	29.84	38.09	56.98	74.58	64.50	82.01	117.87	147.20	2.54	7.62	8.13
3MMV9102HX	20	45	135	265	33.62	42.87	63.87	83.30	72.48	92.56	133.40	166.80	2.54	6.60	7.11
3MMV9103HX	20	45	135	265	35.01	44.56	66.06	85.70	75.19	97.38	141.07	176.82	2.03	6.60	7.11
3MMV9104HX	45	90	265	535	46.14	58.91	88.06	115.19	101.49	129.20	185.92	232.09	3.56	9.65	10.67
3MMV9105HX	45	90	265	535	49.51	63.14	94.13	122.81	105.90	135.11	194.66	243.29	3.05	9.14	9.65
3MMV9106HX	65	135	400	800	60.38	76.97	114.73	149.66	131.07	167.38	241.19	301.70	4.06	11.18	12.19
3MMV9107HX	65	135	400	800	66.30	84.46	125.56	163.34	143.33	183.99	265.67	332.66	3.56	10.16	11.18
3MMV9108HX	65	135	400	800	69.19	88.08	130.79	169.95	149.12	191.87	277.57	347.53	3.56	9.65	10.67
3MMV9109HX	90	175	535	1065	76.94	97.94	145.46	189.07	167.50	215.65	312.02	390.73	4.06	11.68	12.70
3MMV9110HX	90	175	535	1065	80.28	102.16	151.53	196.76	174.06	225.10	325.84	408.22	4.06	11.18	12.19
3MMV9111HX	110	225	665	1335	107.69	137.19	204.11	265.67	233.14	298.73	431.13	539.57	3.56	10.16	11.18
3MMV9112HX	110	225	665	1335	110.61	140.88	209.36	272.49	239.09	306.77	443.20	554.78	3.56	10.16	11.18
3MMV9113HX	135	265	800	1600	120.89	153.96	228.94	297.68	262.52	337.21	487.10	609.70	4.06	11.18	12.19
3MMV9114HX	155	310	935	1870	132.07	168.17	249.76	324.79	282.99	363.79	525.75	658.32	4.06	11.68	13.21
3MMV9115HX	155	310	935	1870	133.90	170.48	253.26	329.16	291.73	375.51	542.89	679.84	4.06	11.68	12.70
3MMV9116HX	200	400	1200	2400	150.08	190.99	283.69	368.34	323.91	417.49	603.93	756.44	4.57	13.21	14.73
3MMV9117HX	225	445	1335	2670	159.70	203.41	302.23	393.18	345.78	444.25	641.88	803.49	5.08	13.72	15.24
3MMV9118HX	225	445	1335	2670	167.66	213.38	316.74	411.36	361.69	466.28	674.76	845.12	4.57	13.21	14.73
3MMV9119HX	265	535	1600	3200	177.87	226.32	335.98	436.20	381.46	492.17	712.19	892.16	5.08	15.24	16.76
3MMV9120HX	265	535	1600	3200	182.42	232.09	344.03	446.34	390.03	504.41	730.56	915.43	5.08	14.73	16.26
3MMV9121HX	265	535	1600	3200	186.79	237.51	352.07	456.49	398.25	516.48	748.57	938.34	5.08	14.22	15.75
3MMV9122HX	290	575	1735	3470	200.96	255.53	378.83	491.29	428.85	555.48	805.06	1,009.00	5.08	14.22	15.75
3MMV9124HX	355	710	2135	4270	217.93	277.22	411.02	533.10	468.56	606.90	879.22	1,101.70	5.59	16.26	17.78

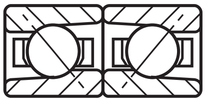
Mounting Arrangements



Recommended
DB



Tandem
DT



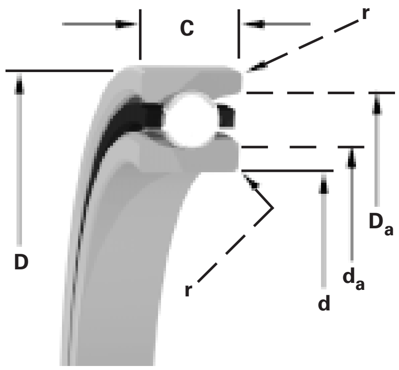
Special Applications
DF

	Grease Capacity		Kluber Isoflex NBU15		Operating Speeds[2] (DB Mounting)					
					Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams				rpm			rpm		
2MMV9100HX	0.3	0.4	0.2	0.2	70,400	52,800	35,200	119,700	89,800	59,800
2MMV9101HX	0.3	0.5	0.2	0.2	63,100	47,300	31,600	107,300	80,400	53,700
2MMV9102HX	0.4	0.7	0.3	0.3	51,400	38,600	25,700	87,400	65,600	43,700
2MMV9103HX	0.6	0.9	0.3	0.4	47,100	35,300	23,600	80,100	60,000	40,100
2MMV9104HX	1.0	1.6	0.6	0.8	39,100	29,300	19,600	66,500	49,800	33,300
2MMV9105HX	1.2	1.9	0.7	0.9	33,400	25,100	16,700	56,800	42,700	28,400
2MMV9106HX	1.7	2.7	1.0	1.3	27,900	20,900	14,000	47,400	35,500	23,800
2MMV9107HX	2.1	3.4	1.3	1.7	23,800	17,900	11,900	40,500	30,400	20,200
2MMV9108HX	2.7	4.3	1.5	2.1	21,000	15,700	10,500	35,700	26,700	17,900
2MMV9109HX	3.5	5.6	2.1	2.8	19,100	14,300	9,600	32,500	24,300	16,300
2MMV9110HX	3.9	6.2	2.3	3.1	17,400	13,100	8,700	29,600	22,300	14,800
2MMV9111HX	4.6	7.3	2.5	3.3	15,000	11,200	7,500	25,500	19,000	12,800
2MMV9112HX	4.9	7.9	2.7	3.6	13,900	10,400	7,000	23,600	17,700	11,900
2MMV9113HX	5.5	8.8	3.1	4.1	13,100	9,800	6,600	22,300	16,700	11,200
2MMV9114HX	7.3	11.7	4.1	5.4	12,000	9,000	6,000	20,400	15,300	10,200
2MMV9115HX	7.7	12.4	4.3	5.7	11,400	8,500	5,700	19,400	14,500	9,700
2MMV9116HX	10.3	16.5	5.8	7.7	10,600	7,900	5,300	18,000	13,400	9,000
2MMV9117HX	10.8	17.3	6.1	8.1	10,100	7,600	5,000	17,200	12,900	8,500
2MMV9118HX	13.2	21.0	7.2	9.7	9,400	7,000	4,700	16,000	11,900	8,000
2MMV9119HX	14.6	23.4	8.3	11.1	9,000	6,800	4,500	15,300	11,600	7,700
2MMV9120HX	15.2	24.4	8.6	11.5	8,600	6,500	4,300	14,600	11,100	7,300
2MMV9121HX	18.3	29.3	10.2	13.6	8,100	6,100	4,000	13,800	10,400	6,800
2MMV9122HX	21.5	34.3	11.8	15.7	7,600	5,700	3,800	12,900	9,700	6,500
2MMV9124HX	24.4	39.1	13.7	18.3	7,100	5,300	3,600	12,100	9,000	6,100

Notes
1) For other mounting arrangement configurations refer to Engineering chapter on Fafnir Permissible Speed calculation methods.
2) For ceramic ball complements use 120% of speeds shown.

Fafnir Extra-Light 2(3)MMV9100HX (ISO 10) Series
Speed Capability

	Grease Capacity		Kluber Isoflex NBU15		Operating Speeds[2] (DB Mounting)					
					Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams				rpm			rpm		
3MMV9100HX	0.3	0.4	0.2	0.2	61,760	46,320	30,880	104,220	81,060	53,850
3MMV9101HX	0.3	0.5	0.2	0.2	56,800	42,600	28,400	95,850	74,550	49,525
3MMV9102HX	0.4	0.7	0.3	0.3	46,320	34,740	23,160	78,165	60,795	40,385
3MMV9103HX	0.6	0.9	0.3	0.4	42,400	31,800	21,200	71,550	55,650	36,970
3MMV9104HX	1.0	1.6	0.6	0.8	35,200	26,400	17,600	59,400	46,200	30,690
3MMV9105HX	1.2	1.9	0.7	0.9	29,280	21,960	14,640	49,410	38,430	25,530
3MMV9106HX	1.7	2.7	1.0	1.3	24,160	18,120	12,080	40,770	31,710	21,065
3MMV9107HX	2.1	3.4	1.3	1.7	21,440	16,080	10,720	36,180	28,140	18,690
3MMV9108HX	2.7	4.3	1.5	2.1	18,880	14,160	9,440	31,860	24,780	16,460
3MMV9109HX	3.5	5.6	2.1	2.8	17,200	12,900	8,600	29,025	22,575	15,000
3MMV9110HX	3.9	6.2	2.3	3.1	15,680	11,760	7,840	26,460	20,580	13,675
3MMV9111HX	4.6	7.3	2.5	3.3	13,520	10,140	6,760	22,815	17,745	11,788
3MMV9112HX	4.9	7.9	2.7	3.6	12,560	9,420	6,280	21,195	16,485	10,950
3MMV9113HX	5.5	8.8	3.1	4.1	11,840	8,880	5,920	19,980	15,540	10,325
3MMV9114HX	7.3	11.7	4.1	5.4	10,800	8,100	5,400	18,225	14,175	9,415
3MMV9115HX	7.7	12.4	4.3	5.7	10,160	7,620	5,080	17,145	13,335	8,860
3MMV9116HX	10.3	16.5	5.8	7.7	9,520	7,140	4,760	16,065	12,495	8,300
3MMV9117HX	10.8	17.3	6.1	8.1	9,040	6,780	4,520	15,255	11,865	7,880
3MMV9118HX	13.2	21.0	7.2	9.7	8,400	6,300	4,200	14,175	11,025	7,325
3MMV9119HX	14.6	23.4	8.3	11.1	8,160	6,120	4,080	13,770	10,710	7,115
3MMV9120HX	15.2	24.4	8.6	11.5	7,760	5,820	3,880	13,095	10,185	6,770
3MMV9121HX	18.3	29.3	10.2	13.6	7,280	5,460	3,640	12,285	9,555	6,350
3MMV9122HX	21.5	34.3	11.8	15.7	6,850	5,135	3,425	11,560	8,990	5,970
3MMV9124HX	24.4	39.1	13.7	18.3	6,425	4,820	3,210	10,840	8,430	5,600



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WN Construction:
- Incorporates low shoulder on non-thrust side of both outer and inner rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (in.)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	min.	D (Housing) max.	min.
	in/tol: +0; -.000(X)				lbs.	lbs.		rpm	lbs.		rpm	in.	in.			
99101WN	0.4724 (1.5)	1.1024 (2)	0.315 (31)	9 x 3/16	0.04	390 *360*	1,020 *1,020*	75,800 *90,960*	380 *340*	980 *980*	68,200 *81,840*	0.012	0.62	0.61	0.99	0.98
99102WN	0.5906 (1.5)	1.2598 (2.5)	0.3543 (31)	11 x 3/16	0.06	500 *450*	1,170 *1,170*	64,300 *77,160*	480 *430*	1,120 *1,120*	57,900 *69,480*	0.012	0.76	0.75	1.13	1.12
99103WN	0.6693 (1.5)	1.378 (2.5)	0.3937 (31)	13 x 3/16	0.08	560 *500*	1,240 *1,240*	56,900 *68,280*	540 *480*	1,190 *1,190*	51,200 *61,440*	0.012	0.86	0.85	1.23	1.22
99104WN	0.7874 (2)	1.6535 (2.5)	0.4724 (47)	11 x 1/4	0.14	1,050 *940*	2,190 *2,190*	43,800 *52,560*	1000 *890*	2,090 *2,090*	39,400 *47,280*	0.024	0.99	0.98	1.49	1.48
99105WN	0.9843 (2)	1.8504 (2.5)	0.4724 (47)	13 x 1/4	0.16	1,300 *1,160*	2,450 *2,450*	36,500 *43,800*	1,240 *1,100*	2,330 *2,330*	32,900 *39,480*	0.024	1.19	1.18	1.69	1.68
99106WN	1.1811 (2)	2.1654 (3)	0.5118 (47)	16 x 1/4	0.25	1,680 *1,490*	2,770 *2,770*	29,500 *35,400*	1,590 *1,410*	2,620 *2,620*	26,600 *31,920*	0.039	1.44	1.43	1.94	1.93
99107WN	1.378 (2.5)	2.4409 (3)	0.5512 (47)	21 x 7/32	0.37	1,760 *1,570*	2,510 *2,510*	25,300 *30,360*	1,670 *1,490*	2,360 *2,360*	22,800 *27,360*	0.039	1.71	1.70	2.15	2.14
99108WN	1.5748 (2.5)	2.6772 (3)	0.5906 (47)	24 x 7/32	0.46	2,060 *1,830*	2,670 *2,670*	22,000 *26,400*	1,930 *1,720*	2,510 *2,510*	19,800 *23,760*	0.039	1.93	1.92	2.36	2.35
99109WN	1.7717 (2.5)	2.9528 (3)	0.6299 (47)	23 x 1/4	0.57	2,570 *2,280*	3,340 *3,340*	20,200 *24,240*	2,410 *2,150*	3,140 *3,140*	18,200 *21,840*	0.039	2.13	2.12	2.63	2.62
99110WN	1.9685 (2.5)	3.1496 (3)	0.6299 (47)	25 x 1/4	0.62	2,810 *2,500*	3,470 *3,470*	18,500 *22,200*	2,630 *2,340*	3,260 *3,260*	16,700 *20,040*	0.039	2.33	2.32	2.83	2.82
99111WN	2.1654 (3)	3.5433 (3)	0.7087 (59)	25 x 9/32	0.92	3,550 *3,160*	4,290 *4,290*	16,600 *19,920*	3,330 *2,960*	4,040 *4,040*	14,900 *17,880*	0.039	2.59	2.58	3.16	3.15
99112WN	2.3622 (3)	3.7402 (3)	0.7087 (59)	26 x 9/32	0.98	3,700 *3,290*	4,340 *4,340*	15,400 *18,480*	3,440 *3,060*	4,080 *4,080*	13,900 *16,680*	0.039	2.79	2.78	3.35	3.34
99113WN	2.5591 (3)	3.937 (3)	0.7087 (59)	28 x 9/32	1.05	3,960 *3,520*	4,500 *4,500*	14,400 *17,280*	3,680 *3,280*	4,230 *4,230*	13,000 *15,600*	0.039	2.99	2.98	3.55	3.54

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Extra-Light
2(3)MMV99100WN (ISO 10) Series
Inch Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
0.4722	0.4724	0.0002	0.00015	1.1024	1.1026	0.0000	0.0004	1.1028	1.1026	0.0006	0.0002	**99101WN**
0.5904	0.5906	0.0002	0.00015	1.2598	1.2600	0.0000	0.00045	1.2602	1.2600	0.0007	0.0002	**99102WN**
0.6691	0.6693	0.0002	0.00015	1.3780	1.3783	0.0000	0.0005	1.3784	1.3782	0.0007	0.0002	**99103WN**
0.7872	0.7874	0.0002	0.00020	1.6535	1.6538	0.0000	0.0005	1.6539	1.6537	0.0007	0.0002	**99104WN**
0.9841	0.9843	0.0002	0.00020	1.8504	1.8507	0.0000	0.0005	1.8509	1.8507	0.0008	0.0003	**99105WN**
1.1809	1.1811	0.0002	0.00020	2.1654	2.1657	0.0000	0.0006	2.1659	2.1657	0.0008	0.0003	**99106WN**
1.3778	1.378	0.0002	0.00025	2.4409	2.4412	0.0000	0.0006	2.4414	2.4412	0.0008	0.0003	**99107WN**
1.5746	1.5748	0.0002	0.00025	2.6772	2.6775	0.0000	0.0006	2.6777	2.6775	0.0008	0.0003	**99108WN**
1.7715	1.7717	0.0002	0.00025	2.9528	2.9531	0.0000	0.0006	2.9533	2.9531	0.0008	0.0003	**99109WN**
1.9683	1.9685	0.0002	0.00025	3.1496	3.1499	0.0000	0.0006	3.1501	3.1499	0.0008	0.0003	**99110WN**
2.1652	2.1654	0.0002	0.00030	3.5433	3.5436	0.0000	0.0006	3.5439	3.5436	0.0009	0.0003	**99111WN**
2.362	2.3622	0.0002	0.00030	3.7402	3.7405	0.0000	0.0006	3.7408	3.7405	0.0009	0.0003	**99112WN**
2.5589	2.5591	0.0002	0.00030	3.9370	3.9373	0.0000	0.0006	3.9377	3.9374	0.0010	0.0004	**99113WN**

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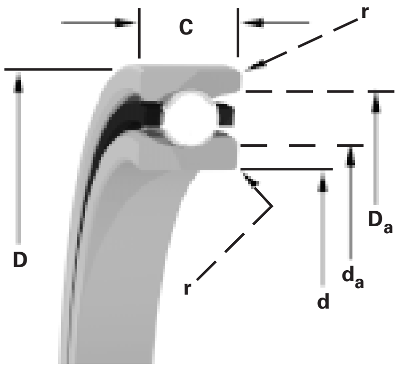


Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WN Construction:

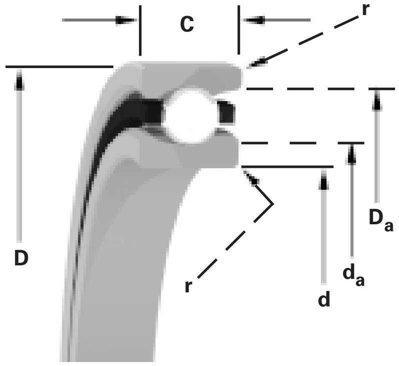
- Incorporates low shoulder on non-thrust side of both outer and inner rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (in.)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	d_a (Shaft) min.	D (Housing) max.	D (Housing) min.
	in/tol: +0; -.000(X)				lbs.	lbs.		rpm	lbs.		rpm	in.	in.			
99114WN	2.7559 (3)	4.3307 (3)	0.7874 (59)	28 x 5/16	1.47	4,890 *4,350*	5,450 *5,540*	13,200 *15,840*	4,569 *4,060*	5,140 *5,140*	11,900 *14,280*	0.039	3.25	3.24	3.88	3.87
99115WN	2.9528 (3)	4.5276 (3)	0.7874 (59)	30 x 5/16	1.54	5,200 *4,630*	5,620 *5,620*	12,300 *14,760*	4,850 *4,320*	5,290 *5,290*	11,100 *13,320*	0.039	3.45	3.44	4.07	4.06
99116WN	3.1496 (3)	4.9213 (3.5)	0.8661 (59)	29 x 11/32	2.08	6,110 *5,440*	6,580 *6,580*	11,600 *13,920*	5,690 *5,070*	6,190 *6,190*	10,400 *12,480*	0.039	3.71	3.70	4.40	4.39
99117WN	3.3465 (3)	5.1181 (3.5)	0.8661 (79)	31 x 11/32	2.18	6,490 *5,770*	6,780 *6,780*	11,000 *13,200*	6,040 *5,380*	6,380 *6,380*	9,900 *11,880*	0.039	3.91	3.90	4.60	4.59
99118WN	3.5433 (3)	5.5118 (3.5)	0.9449 (79)	28 x 13/32	2.79	8,270 *7,360*	8,780 *8,780*	10,400 *13,480*	7,720 *6,870*	8,280 *8,280*	9,400 *11,280*	0.059	4.14	4.13	4.95	4.94
99119WN	3.7402 (3)	5.7087 (3.5)	0.9449 (79)	29 x 13/32	2.87	8,530 *7,590*	8,890 *8,890*	9,900 *11,880*	7,970 *7,090*	8,390 *8,390*	8,900 *10,680*	0.059	4.34	4.33	5.15	5.14
99120WN	3.937 (3)	5.9055 (3.5)	0.9449 (79)	31 x 13/32	3.03	9,070 *8,080*	9,190 *9,190*	9,400 *11,280*	8,480 *7,540*	8,660 *8,660*	8,500 *10,200*	0.059	4.54	4.53	5.35	5.34
99121WN	4.1339 (3)	6.2992 (4)	1.0236 (79)	30 x 7/16	3.81	10,200 *9,080*	10,300 *10,300*	8,900 *10,680*	9,540 *8,490*	9,750 *9,750*	8,000 *9,600*	0.079	4.80	4.79	5.67	5.66
99122WN	4.3307 (3)	6.6929 (4)	1.1024 (79)	30 x 15/32	4.82	11,700 *10,400*	11,700 *11,700*	8,500 *10,200*	11,000 *9,760*	11,100 *11,100*	7,700 *8,880*	0.079	5.06	5.05	6.00	5.99
99124WN	4.7244 (3)	7.0866 (4)	1.1024 (79)	32 x 15/32	5.17	12,400 *11,100*	12,000 *12,000*	7,900 *9,480*	11,600 *10,300*	11,400 *11,400*	7,100 *8,520*	0.079	5.46	5.45	6.39	6.38
99126WN	5.1181 (4)	7.874 (4.5)	1.2992 (98)	32 x 17/32	7.85	16,000 *14,300*	15,200 *15,200*	7,100 *8,520*	15,000 *13,300*	14,300 *14,300*	6,400 *7,680*	0.079	5.98	5.97	7.05	7.04
99128WN	5.5118 (4)	8.2677 (4.5)	1.2992 (98)	34 x 17/32	8.32	16,900 *15,100*	15,600 *15,600*	6,600 *7,920*	15,800 *14,100*	14,700 *14,700*	5,900 *7,080*	0.079	6.38	6.37	7.44	7.43
99130WN	5.9055 (4)	8.8583 (4.5)	1.378 (98)	34 x 19/32	9.94	20,600 *18,300*	18,800 *18,800*	6,200 *7,440*	19,300 *17,100*	17,800 *17,800*	5,600 *6,720*	0.079	6.81	6.80	8.00	7.99

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Extra-Light 2(3)MMV99100WN (ISO 10) Series
Inch Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
2.7557	2.7559	0.0002	0.00030	4.3307	4.3310	0.0000	0.0006	4.3314	4.3311	0.0010	0.0004	**99114WN**
2.9526	2.9530	0.0002	0.00050	4.5276	4.5279	0.0000	0.0006	4.5283	4.5280	0.0010	0.0004	**99115WN**
3.1494	3.1498	0.0002	0.00050	4.9213	4.9216	0.0000	0.0007	4.9221	4.9217	0.0012	0.0004	**99116WN**
3.3463	3.3467	0.0002	0.00050	5.1181	5.1185	0.0000	0.0007	5.1189	5.1185	0.0011	0.0004	**99117WN**
3.5431	3.5435	0.0002	0.00050	5.5118	5.5122	0.0000	0.0007	5.5126	5.5122	0.0011	0.0004	**99118WN**
3.7400	3.7404	0.0002	0.00050	5.7087	5.7091	0.0000	0.0007	5.7095	5.7091	0.0011	0.0004	**99119WN**
3.9368	3.9372	0.0002	0.00050	5.9055	5.9059	0.0000	0.0007	5.9064	5.9060	0.0012	0.0005	**99120WN**
4.1337	4.1341	0.0002	0.00050	6.2992	6.2996	0.0000	0.0008	6.3001	6.2997	0.0013	0.0005	**99121WN**
4.3305	4.3309	0.0002	0.00050	6.6929	6.6933	0.0000	0.0008	6.6938	6.6934	0.0013	0.0005	**99122WN**
4.7242	4.7246	0.0002	0.00050	7.0866	7.0870	0.0000	0.0008	7.0875	7.0871	0.0013	0.0005	**99124WN**
5.1179	5.1183	0.0002	0.00060	7.8740	7.8745	0.0000	0.0009	7.8750	7.8746	0.0015	0.0006	**99126WN**
5.5116	5.5120	0.0002	0.00060	8.2677	8.2682	0.0000	0.0009	8.2687	8.2683	0.0015	0.0006	**99128WN**
5.9053	5.9057	0.0002	0.00060	8.8583	8.8588	0.0000	0.0009	8.8593	8.8589	0.0015	0.0006	**99130WN**



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WN Construction:

- Incorporates low shoulder on non-thrust side of both outer and inner rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (mm)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	mm/tol: +0; -(μm)				kg.	N		rpm	N		rpm	mm	mm			
99101WN	12 (4)	28 (5)	8 (80)	9 x 4.76	0.019	1,740 *1,550*	4,540 *4,540*	75,800 *90,960*	1,670 *1,490*	4,360 *4,360*	68,200 *81,840*	0.3	15.64	15.44	24.56	24.36
99102WN	15 (4)	32 (6)	9 (80)	11 x 4.76	0.028	2,240 *1,990*	5,220 *5,220*	64,300 *77,160*	2,140 *1,900*	5,000 *5,000*	57,900 *69,480*	0.3	19.14	18.94	28.06	27.86
99103WN	17 (4)	35 (6)	10 (80)	13 x 4.76	0.038	2,510 *2,230*	5,530 *5,530*	56,900 *68,280*	2,400 *2,140*	5,280 *5,280*	51,200 *61,440*	0.3	21.64	21.44	30.56	30.36
99104WN	20 (5)	42 (6)	12 (120)	11 x 6.35	0.064	4,690 *4,180*	9,760 *9,760*	43,800 *52,200*	4,470 *3,980*	9,310 *9,310*	39,400 *47,280*	0.6	25.05	24.85	37.15	36.95
99105WN	25 (5)	47 (6)	12 (120)	13 x 6.35	0.074	5,800 *5,160*	10,900 *10,900*	36,500 *43,800*	5,510 *4,900*	10,300 *10,300*	32,900 *39,480*	0.6	30.05	29.85	42.15	41.95
99106WN	30 (5)	55 (7)	13 (120)	16 x 6.35	0.116	7,460 *6,640*	12,300 *12,300*	29,500 *35,400*	7,060 *6,280*	11,600 *11,600*	26,600 *31,920*	1	36.55	36.35	48.65	48.45
99107WN	35 (6)	62 (7)	14 (120)	21 x 5.56	0.167	7,840 *6,980*	11,100 *11,100*	25,300 *30,360*	7,440 *6,620*	10,500 *10,500*	22,800 *27,360*	1	43.34	43.14	53.86	53.66
99108WN	40 (6)	68 (7)	15 (120)	24 x 5.56	0.207	9,150 *8,140*	11,900 *11,900*	22,000 *26,400*	8,590 *7,650*	11,200 *11,200*	19,800 *23,760*	1	48.84	48.64	59.36	59.16
99109WN	45 (6)	75 (7)	16 (120)	23 x 6.35	0.259	11,400 *10,200*	14,800 *14,800*	20,200 *24,240*	10,700 *9,560*	14,000 *14,000*	18,200 *21,840*	1	54.05	53.85	66.15	65.95
99110WN	50 (6)	80 (7)	16 (120)	25 x 6.35	0.281	12,500 *11,100*	15,400 *15,400*	18,500 *22,200*	11,700 *10,400*	14,500 *14,500*	16,700 *20,040*	1	59.05	58.85	71.15	70.95
99111WN	55 (7)	90 (8)	18 (150)	25 x 7.14	0.417	15,800 *14,100*	19,100 *19,100*	16,600 *19,920*	14,800 *13,200*	18,000 *18,000*	14,900 *17,880*	1	65.76	65.56	79.44	79.24
99112WN	60 (7)	95 (8)	18 (150)	26 x 7.14	0.445	16,400 *14,600*	19,300 *19,300*	15,400 *18,480*	15,300 *13,600*	18,200 *18,200*	13,900 *16,680*	1	70.76	70.56	84.44	84.24
99113WN	65 (7)	100 (8)	18 (150)	28 x 7.14	0.474	17,600 *15,700*	20,000 *20,000*	14,400 *17,280*	16,400 *14,600*	18,800 *18,800*	13,000 *15,600*	1	75.76	75.56	89.44	89.24

Notes

1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)

2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Extra-Light 2(3)MMV99100WN (ISO 10) Series
Metric Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
11.995	12.000	0.005	0.004	28	28.005	0.0000	0.010	28.010	28.005	0.015	0.005	**99101WN**
14.995	15.000	0.005	0.004	32	32.005	0.0000	0.011	32.010	32.005	0.016	0.005	**99102WN**
16.995	17.000	0.005	0.004	35	35.006	0.0000	0.012	35.010	35.005	0.016	0.005	**99103WN**
19.995	20.000	0.005	0.005	42	42.006	0.0000	0.012	42.010	42.005	0.016	0.005	**99104WN**
24.995	25.000	0.005	0.005	47	47.006	0.0000	0.012	47.012	47.007	0.018	0.007	**99105WN**
29.995	30.000	0.005	0.005	55	55.008	0.0000	0.015	55.012	55.007	0.019	0.007	**99106WN**
34.995	35.000	0.005	0.006	62	62.008	0.0000	0.015	62.012	62.007	0.019	0.007	**99107WN**
39.995	40.000	0.005	0.006	68	68.008	0.0000	0.015	68.012	68.007	0.019	0.007	**99108WN**
44.995	45.000	0.005	0.006	75	75.008	0.0000	0.015	75.014	75.009	0.022	0.009	**99109WN**
49.995	50.000	0.005	0.006	80	80.008	0.0000	0.015	80.012	80.008	0.020	0.008	**99110WN**
54.995	55.000	0.005	0.007	90	90.008	0.0000	0.016	90.015	90.007	0.023	0.007	**99111WN**
59.995	60.000	0.005	0.007	95	95.008	0.0000	0.016	95.016	95.009	0.024	0.009	**99112WN**
64.995	65.000	0.005	0.007	100	100.008	0.0000	0.016	100.016	100.009	0.024	0.009	**99113WN**

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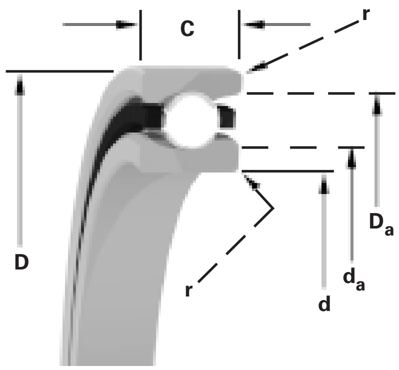


Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WN Construction:
- Incorporates low shoulder on non-thrust side of both outer and inner rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

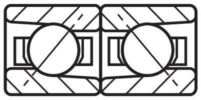
						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (mm)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	mm/tol: +0; -(μm)				kg.	N		rpm	N		rpm	mm	mm			
99114WN	70	110	20	28 x 7.94	0.665	21,700	24,300	13,200	20,300	22,900	11,900	1	82.46	82.26	97.74	97.54
	(7)	(8)	(150)			*19,300*	*24,300*	*15,840*	*18,000*	*22,900*	*14,280*					
99115WN	75	115	20	30 x 7.94	0.699	23,100	25,000	12,300	21,600	23,500	11,100	1	87.46	87.26	102.74	102.54
	(7)	(8)	(150)			*20,600*	*25,000*	*14,760*	*19,200*	*23,500*	*13,320*					
99116WN	80	125	22	29 x 8.73	0.944	27,200	29,300	11,600	25,300	27,500	10,400	1	94.17	93.97	111.03	110.83
	(7)	(9)	(150)			*24,200*	*29,300*	*13,920*	*22,500*	*27,500*	*12,480*					
99117WN	85	130	22	31 x 8.73	0.991	28,900	30,200	11,000	26,900	28,400	9,900	1	99.17	98.97	116.03	115.83
	(8)	(9)	(200)			*25,700*	*30,200*	*13,200*	*23,900*	*28,400*	*11,880*					
99118WN	90	140	24	28 x 10.32	1.266	36,100	39,000	10,400	34,400	36,800	9,400	1.5	105.08	104.88	125.12	124.92
	(8)	(9)	(200)			*32,700*	*39,000*	*12,480*	*30,600*	*36,800*	*11,280*					
99119WN	95	145	24	29 x 10.32	1.303	37,900	39,600	9,900	35,400	37,300	8,900	1.5	110.08	109.88	130.12	129.92
	(8)	(9)	(200)			*33,800*	*39,600*	*11,880*	*31,500*	*37,300*	*10,680*					
99120WN	100	150	24	31 x 10.32	1.374	40,400	40,900	9,400	37,700	38,500	8,500	1.5	115.08	114.88	135.12	134.92
	(8)	(9)	(200)			*35,900*	*40,900*	*11,280*	*33,600*	*38,500*	*10,200*					
99121WN	105	160	26	30 x 11.11	1.729	45,400	45,900	8,900	42,400	43,400	8,000	2	121.79	121.59	143.41	143.21
	(8)	(10)	(200)			*40,400*	*45,900*	*10,680*	*37,800*	*43,400*	*9,600*					
99122WN	110	170	28	30 x 11.91	2.188	52,100	52,200	8,500	48,800	49,300	7,700	2	128.49	128.29	151.71	151.51
	(8)	(10)	(200)			*46,400*	*52,200*	*10,200*	*43,400*	*49,300*	*8,880*					
99124WN	120	180	28	32 x 11.91	2.343	55,200	53,500	7,900	51,700	50,600	7,100	2	138.49	138.29	161.71	161.51
	(8)	(10)	(200)			*49,200*	*53,500*	*9,480*	*46,000*	*50,600*	*8,520*					
99126WN	130	200	33	32 x 13.49	3.563	71,200	67,500	7,100	66,600	63,700	6,400	2	151.91	151.71	178.29	178.09
	(10)	(11)	(250)			*63,400*	*67,500*	*8,520*	*59,200*	*63,700*	*7,680*					
99128WN	140	210	33	34 x 13.49	3.776	75,200	69,300	6,600	70,300	65,300	5,900	2	161.91	161.71	188.29	188.09
	(10)	(11)	(250)			*67,000*	*69,300*	*7,920*	*62,600*	*65,300*	*7,080*					
99130WN	150	225	35	34 x 15.08	4.509	91,500	83,800	6,200	85,600	79,100	5,600	2	172.82	172.62	202.38	202.18
	(10)	(11)	(250)			*81,400*	*83,800*	*7,440*	*76,200*	*79,100*	*6,720*					

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

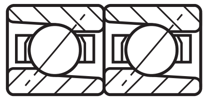
Fafnir Extra-Light 2(3)MMV99100WN (ISO 10) Series
Metric Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
69.995	70.000	0.005	0.007	110	110.008	0.0000	0.016	110.018	110.010	0.025	0.010	**99114WN**
74.995	75.005	0.005	0.012	115	115.008	0.0000	0.016	115.019	115.011	0.026	0.010	**99115WN**
79.995	80.005	0.005	0.012	125	125.008	0.0000	0.017	125.021	125.011	0.030	0.011	**99116WN**
84.995	85.005	0.005	0.012	130	130.009	0.0000	0.018	130.020	130.010	0.029	0.010	**99117WN**
89.995	90.005	0.005	0.013	140	140.009	0.0000	0.018	140.020	140.010	0.029	0.010	**99118WN**
94.995	95.005	0.005	0.013	145	145.009	0.0000	0.018	145.021	145.011	0.030	0.011	**99119WN**
99.995	100.005	0.005	0.013	150	150.009	0.0000	0.018	150.023	150.012	0.032	0.012	**99120WN**
104.995	105.005	0.005	0.013	160	160.009	0.0000	0.022	160.022	160.012	0.033	0.012	**99121WN**
109.995	110.005	0.005	0.013	170	170.010	0.0000	0.020	170.022	170.012	0.032	0.012	**99122WN**
119.995	120.005	0.005	0.013	180	180.010	0.0000	0.020	180.022	180.012	0.032	0.012	**99124WN**
129.995	130.005	0.005	0.015	200	200.011	0.0000	0.022	200.025	200.015	0.036	0.015	**99126WN**
139.995	140.005	0.005	0.015	210	210.011	0.0000	0.022	210.025	210.015	0.036	0.015	**99128WN**
149.995	150.005	0.005	0.015	225	225.011	0.0000	0.022	225.025	225.015	0.036	0.015	**99130WN**

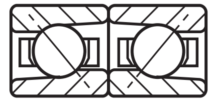
Mounting Arrangements



Recommended
DB



Tandem
DT



Special Application
DF

	Preload				Axial Stiffness[1]				Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	X-light	Light	Medium	Heavy	Light	Medium	Heavy	X-Light to light	Light to Medium	Medium to Heavy
	lbs.				10⁶lbs./in.				10⁶lbs./in			in.		
2MMV99101WN	—	5	10	20	—	0.077	0.102	0.138	0.347	0.450	0.569	—	0.00022	0.00033
2MMV99102WN	—	5	10	20	—	0.087	0.115	0.155	0.513	0.651	0.800	—	0.00020	0.00030
2MMV99103WN	—	5	10	20	—	0.097	0.127	0.170	0.570	0.727	0.896	—	0.00018	0.00027
2MMV99104WN	5	10	20	40	0.098	0.128	0.171	0.233	0.719	0.891	1.118	0.00018	0.00027	0.00040
2MMV99105WN	5	15	30	60	0.123	0.167	0.224	0.308	0.801	0.996	1.252	0.00022	0.00031	0.00045
2MMV99106WN	5	15	30	60	0.140	0.189	0.252	0.344	0.992	1.259	1.581	0.00019	0.00027	0.00040
2MMV99107WN	10	20	40	80	0.191	0.252	0.338	0.464	1.199	1.538	1.927	0.00018	0.00027	0.00040
2MMV99108WN	15	25	50	100	0.223	0.298	0.401	0.553	1.413	1.786	2.237	0.00020	0.00029	0.00042
2MMV99109WN	15	30	60	120	0.237	0.313	0.422	0.582	1.599	2.018	2.526	0.00022	0.00033	0.00048
2MMV99110WN	15	30	60	120	0.249	0.329	0.442	0.608	1.689	2.134	2.673	0.00021	0.00031	0.00046
2MMV99111WN	20	40	80	160	0.292	0.384	0.516	0.711	1.998	2.518	3.150	0.00024	0.00036	0.00052
2MMV99112WN	20	40	80	160	0.299	0.393	0.528	0.725	2.050	2.586	3.235	0.00023	0.00035	0.00051
2MMV99113WN	25	50	100	200	0.341	0.450	0.607	0.839	2.152	2.718	3.403	0.00025	0.00038	0.00055
2MMV99114WN	25	50	100	200	0.356	0.467	0.624	0.854	2.439	3.077	3.580	0.00024	0.00037	0.00054
2MMV99115WN	30	60	120	240	0.398	0.524	0.703	0.966	2.552	3.223	4.036	0.00026	0.00039	0.00058
2MMV99116WN	35	70	140	280	0.001	0.547	0.735	1.012	2.799	3.531	4.417	0.00029	0.00044	0.00044
2MMV99117WN	40	80	160	320	0.455	0.601	0.810	1.117	2.924	3.692	4.623	0.00030	0.00045	0.00066
2MMV99118WN	45	90	180	360	0.461	0.607	0.815	1.121	3.071	3.880	4.860	0.00034	0.00051	0.00074
2MMV99119WN	45	90	180	360	0.471	0.620	0.831	1.142	3.142	3.972	4.978	0.00033	0.00050	0.00050
2MMV99120WN	50	100	200	400	0.511	0.673	0.904	1.244	3.462	4.371	5.472	0.00034	0.00051	0.00075
2MMV99121WN	55	110	220	440	0.538	0.708	0.948	1.315	3.613	4.561	4.709	0.00035	0.00053	0.00081
2MMV99122WN	60	120	240	480	0.571	0.749	1.001	1.397	3.674	4.649	5.829	0.00036	0.00055	0.00087
2MMV99124WN	70	140	280	560	0.630	0.829	1.111	1.512	4.141	5.226	6.542	0.00038	0.00058	0.00082
2MMV99126WN	90	180	360	720	0.695	0.916	1.231	1.672	4.634	5.852	7.328	0.00045	0.00067	0.00094
2MMV99128WN	95	190	380	760	0.736	0.970	1.304	1.783	5.084	6.412	7.976	0.00044	0.00067	0.00096
2MMV99130WN	100	200	400	800	0.773	1.014	1.355	1.851	5.363	6.771	8.520	0.00045	0.00067	0.00100

Fafnir Extra-Light 2(3)MMV99100WN (ISO 10) Series

Inch Duplex Performance Data

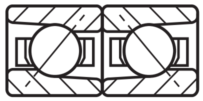
	Preload				Axial Stiffness[1]				Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	X-light	Light	Medium	Heavy	Light	Medium	Heavy	X-Light to light	Light to Medium	Medium to Heavy
	lbs.				10^6lbs./in.				10^6lbs./in			in.		
3MMV99101WN	—	10	20	40	—	0.205	0.263	0.343	0.336	0.429	0.529	—	0.00017	0.00026
3MMV99102WN	—	10	20	40	—	0.233	0.299	0.388	0.490	0.606	0.760	—	0.00015	0.00023
3MMV99103WN	—	10	20	40	—	0.259	0.332	0.430	0.546	0.677	0.851	—	0.00013	0.00021
3MMV99104WN	10	20	40	80	0.274	0.351	0.453	0.591	0.659	0.832	1.044	0.00013	0.0002	0.00031
3MMV99105WN	15	30	60	120	0.353	0.452	0.586	0.768	0.735	0.931	1.169	0.00015	0.00023	0.00035
3MMV99106WN	15	30	60	120	0.403	0.516	0.667	0.870	0.93	1.177	1.476	0.00013	0.0002	0.00031
3MMV99107WN	20	40	80	160	0.515	0.661	0.857	1.125	1.148	1.448	1.813	0.00014	0.00021	0.00032
3MMV99108WN	25	50	100	200	0.608	0.781	1.013	1.333	1.334	1.681	2.105	0.00014	0.00022	0.00034
3MMV99109WN	30	60	120	240	0.652	0.837	1.086	1.428	1.498	1.886	2.360	0.00016	0.00025	0.00038
3MMV99110WN	30	60	120	240	0.688	0.883	1.144	1.501	1.582	1.994	2.497	0.00015	0.00024	0.00036
3MMV99111WN	40	80	160	320	0.784	1.007	1.306	1.716	1.890	2.378	2.973	0.00018	0.00028	0.00042
3MMV99112WN	40	80	160	320	0.804	1.032	1.338	1.757	1.940	2.441	3.053	0.00017	0.00027	0.00041
3MMV99113WN	50	100	200	400	0.913	1.174	1.525	2.010	2.037	2.566	3.211	0.00019	0.0003	0.00045
3MMV99114WN	50	100	200	400	0.935	1.201	1.555	2.040	2.328	2.930	3.664	0.00019	0.00029	0.00044
3MMV99115WN	60	120	240	500	1.043	1.341	1.740	2.327	2.437	3.069	3.840	0.0002	0.00031	0.00051
3MMV99116WN	70	140	280	550	1.109	1.425	1.848	2.413	2.654	3.340	3.176	0.00022	0.00034	0.00051
3MMV99117WN	80	160	320	600	1.214	1.561	2.027	2.601	2.773	3.493	4.370	0.00023	0.00036	0.00048
3MMV99118WN	90	180	360	700	1.236	1.588	2.060	2.677	2.918	3.677	4.603	0.00025	0.00039	0.00057
3MMV99119WN	90	180	360	700	1.265	1.624	2.105	2.733	2.987	3.765	4.714	0.00025	0.00039	0.00056
3MMV99120WN	100	200	400	800	1.371	1.761	2.284	3.002	3.289	4.142	5.152	0.00025	0.00039	0.0006
3MMV99121WN	110	220	450	900	1.410	1.811	2.369	3.116	3.452	4.346	5.463	0.00027	0.00044	0.00065
3MMV99122WN	120	240	500	1,000	1.484	1.905	2.507	3.295	3.532	4.454	5.606	0.00028	0.00047	0.00069
3MMV99124WN	140	280	550	1,100	1.634	2.100	2.706	3.559	3.976	5.004	6.259	0.0003	0.00045	0.0007
3MMV99126WN	180	360	700	1,400	1.852	2.381	3.056	4.018	4.410	5.554	6.928	0.00034	0.0005	0.00079
3MMV99128WN	190	380	750	1,500	1.963	2.523	3.258	4.284	4.836	6.049	7.566	0.00034	0.00051	0.00079
3MMV99130WN	200	400	800	1,600	2.014	2.584	3.347	4.390	5.148	6.515	8.150	0.00035	0.00054	0.00083

Notes

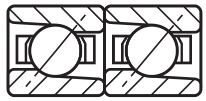
1) DB (back-to-back) or DF (face-to-face) arrangement only. For other mounting arrangements contact Timken Engineering

2) For ceramic ball complements, use 120% of listed operating speeds.

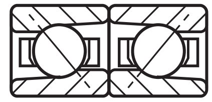
Mounting Arrangements



Recommended
DB



Tandem
DT



Special Application
DF

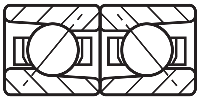
	Preload				Axial Stiffness[1]				Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	X-light	Light	Medium	Heavy	Light	Medium	Heavy	X-Light to light	Light to Medium	Medium to Heavy
	N				N/μm				N/μm			μm		
2MMV99101WN	—	5	10	20	—	0.077	0.102	0.138	0.347	0.450	0.569	—	5.59	8.38
2MMV99102WN	—	5	10	20	—	0.087	0.115	0.155	0.513	0.651	0.800	—	5.08	7.62
2MMV99103WN	—	5	10	20	—	0.097	0.127	0.170	0.570	0.727	0.896	—	4.57	6.86
2MMV99104WN	5	10	20	40	0.098	0.128	0.171	0.233	0.719	0.891	1.118	4.57	6.86	10.16
2MMV99105WN	5	15	30	60	0.123	0.167	0.224	0.308	0.801	0.996	1.252	5.59	7.87	11.43
2MMV99106WN	5	15	30	60	0.140	0.189	0.252	0.344	0.992	1.259	1.581	4.83	6.86	10.16
2MMV99107WN	10	20	40	80	0.191	0.252	0.338	0.464	1.199	1.538	1.927	4.57	6.86	10.16
2MMV99108WN	15	25	50	100	0.223	0.298	0.401	0.553	1.413	1.786	2.237	5.08	7.37	10.67
2MMV99109WN	15	30	60	120	0.237	0.313	0.422	0.582	1.599	2.018	2.526	5.59	8.39	12.20
2MMV99110WN	15	30	60	120	0.249	0.329	0.442	0.608	1.689	2.134	2.673	5.33	7.87	11.69
2MMV99111WN	20	40	80	160	0.292	0.384	0.516	0.711	1.998	2.518	3.150	6.10	9.15	13.21
2MMV99112WN	20	40	80	160	0.299	0.393	0.528	0.725	2.050	2.586	3.235	5.84	8.89	12.96
2MMV99113WN	25	50	100	200	0.341	0.450	0.607	0.839	2.152	2.718	3.403	6.35	9.66	13.98
2MMV99114WN	25	50	100	200	0.356	0.467	0.624	0.854	2.439	3.077	3.580	6.10	9.40	13.72
2MMV99115WN	30	60	120	240	0.398	0.524	0.703	0.966	2.552	3.223	4.036	6.60	9.91	14.74
2MMV99116WN	35	70	140	280	0.001	0.547	0.735	1.012	2.799	3.531	4.417	7.37	11.18	11.18
2MMV99117WN	40	80	160	320	0.455	0.601	0.810	1.117	2.924	3.692	4.623	7.62	11.43	14.23
2MMV99118WN	45	90	180	360	0.461	0.607	0.815	1.121	3.071	3.880	4.860	8.64	12.96	18.80
2MMV99119WN	45	90	180	360	0.471	0.620	0.831	1.142	3.142	3.972	4.978	8.38	12.71	12.71
2MMV99120WN	50	100	200	400	0.511	0.673	0.904	1.244	3.462	4.371	5.472	8.64	12.96	19.06
2MMV99121WN	55	110	220	440	0.538	0.708	0.948	1.315	3.613	4.561	4.709	8.89	13.47	20.58
2MMV99122WN	60	120	240	480	0.571	0.749	1.001	1.397	3.674	4.649	5.829	9.15	13.98	22.11
2MMV99124WN	70	140	280	560	0.630	0.829	1.111	1.512	4.141	5.226	6.542	9.66	14.74	20.84
2MMV99126WN	90	180	360	720	0.695	0.916	1.231	1.672	4.634	5.852	7.328	11.43	17.03	23.89
2MMV99128WN	95	190	380	760	0.736	0.970	1.304	1.783	5.084	6.412	7.976	11.18	17.03	24.39
2MMV99130WN	100	200	400	800	0.773	1.014	1.355	1.851	5.363	6.771	8.520	11.43	17.03	25.41

Fafnir Extra-Light
2(3)MMV99100WN (ISO 10) Series
Metric Duplex Performance Data

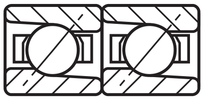
	Preload				Axial Stiffness[1]				Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	X-light	Light	Medium	Heavy	Light	Medium	Heavy	X-Light to light	Light to Medium	Medium to Heavy
	N				N/µm				N/µm			µm		
3MMV99101WN	—	40	90	180	—	35.85	46.00	59.99	58.77	75.03	92.52	—	4.32	6.60
3MMV99102WN	—	40	90	180	—	40.75	52.30	67.86	85.70	105.99	132.92	—	3.81	5.84
3MMV99103WN	—	40	90	180	—	45.30	58.07	75.21	95.50	118.41	148.84	—	3.30	5.33
3MMV99104WN	40	90	180	360	47.92	61.39	79.23	103.37	115.26	145.52	182.60	3.30	5.08	7.87
3MMV99105WN	70	130	270	530	61.74	79.05	102.49	134.32	128.55	162.83	204.46	3.81	5.84	8.89
3MMV99106WN	70	130	270	530	70.48	90.25	116.66	152.16	162.66	205.86	258.15	3.30	5.08	7.87
3MMV99107WN	90	180	360	710	90.07	115.61	149.89	196.76	200.79	253.26	317.09	3.56	5.33	8.13
3MMV99108WN	110	220	440	890	106.34	136.60	177.17	233.14	233.32	294.01	368.16	3.56	5.59	8.64
3MMV99109WN	130	270	530	1,070	114.03	146.39	189.94	249.76	262.00	329.86	412.76	4.06	6.35	9.65
3MMV99110WN	130	270	530	1,070	120.33	154.44	200.09	262.52	276.69	348.75	436.73	3.81	6.10	9.14
3MMV99111WN	180	360	710	1,420	137.12	176.12	228.42	300.13	330.56	415.91	519.98	4.57	7.11	10.67
3MMV99112WN	180	360	710	1,420	140.62	180.50	234.02	307.30	339.31	426.93	533.97	4.32	6.86	10.41
3MMV99113WN	220	440	890	1,780	159.68	205.33	266.72	351.55	356.27	448.79	561.60	4.83	7.62	11.43
3MMV99114WN	220	440	890	1,780	163.53	210.05	271.97	356.80	407.17	512.46	640.83	4.83	7.37	11.18
3MMV99115WN	270	530	1,070	2,220	182.42	234.54	304.33	406.99	426.23	536.77	671.62	5.08	7.87	12.95
3MMV99116WN	310	620	1,250	2,450	193.96	249.23	323.22	422.03	464.18	584.17	555.48	5.59	8.64	12.95
3MMV99117WN	360	710	1,420	2,670	212.33	273.02	354.52	454.91	485.00	610.93	764.31	5.84	9.14	12.19
3MMV99118WN	400	800	1,600	3,110	216.18	277.74	360.29	468.21	510.36	643.11	805.06	6.35	9.91	14.48
3MMV99119WN	400	800	1,600	3,110	221.25	284.04	368.16	478.00	522.43	658.50	824.48	6.35	9.91	14.22
3MMV99120WN	440	890	1,780	3,560	239.79	308.00	399.47	525.05	575.25	724.44	901.08	6.35	9.91	15.24
3MMV99121WN	490	980	2,000	4,000	246.61	316.74	414.34	544.99	603.75	760.12	955.48	6.86	11.18	16.51
3MMV99122WN	530	1,070	2,220	4,450	259.55	333.18	438.47	576.30	617.75	779.00	980.49	7.11	11.94	17.53
3MMV99124WN	620	1,250	2,450	4,890	285.79	367.29	473.28	622.47	695.40	875.20	1,094.70	7.62	11.43	17.78
3MMV99126WN	800	1,600	3,110	6,230	323.91	416.44	534.49	702.75	771.31	971.39	1,211.71	8.64	12.70	20.07
3MMV99128WN	850	1,690	3,340	6,670	343.33	441.27	569.82	749.27	845.82	1,057.97	1,323.29	8.64	12.95	20.07
3MMV99130WN	890	1,780	3,560	7,120	352.25	451.94	585.39	767.81	900.39	1,139.47	1,425.44	8.89	13.72	21.08

Notes
1) DB (back-to-back) or DF (face-to-face) arrangement only. For other mounting arrangements contact Timken Engineering
2) For ceramic ball complements, use 120% of listed operating speeds.

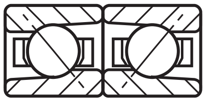
Mounting Arrangements



Recommended
DB



Tandem
DT



Special Application
DF

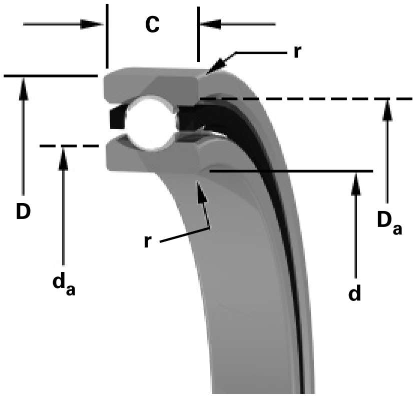
	Grease Capacity		Kluber Isoflex NBU15		Operating Speeds[2] (DB Mounting)					
					Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams				rpm			rpm		
2MMV99101WN	0.3	0.5	0.2	0.27	68,200	60,600	45,500	116,000	103,000	77,400
2MMV99102WN	0.4	0.6	0.24	0.32	57,900	51,400	38,600	98,400	98,400	65,600
2MMV99103WN	0.5	0.7	0.31	0.41	51,200	45,500	34,100	87,100	87,100	58,000
2MMV99104WN	0.9	1.4	0.58	0.77	39,400	35,000	26,300	67,000	67,000	44,700
2MMV99105WN	1	1.6	0.67	0.9	32,900	29,200	21,900	55,800	55,800	37,200
2MMV99106WN	1.3	2.1	0.87	1.17	26,600	23,600	17,700	45,100	45,100	30,100
2MMV99107WN	1.4	2.2	0.91	1.22	22,800	20,200	15,200	38,700	38,700	25,800
2MMV99108WN	1.7	2.7	1.14	1.52	19,800	17,600	13,200	33,700	33,700	22,400
2MMV99109WN	2.2	3.5	1.47	1.96	18,200	16,200	12,100	30,900	30,900	20,600
2MMV99110WN	2.4	3.8	1.58	2.11	16,700	14,800	11,100	28,300	28,300	18,900
2MMV99111WN	3.4	5.4	2.2	3	14,900	13,300	10,000	25,400	25,400	17,000
2MMV99112WN	3.6	5.8	2.4	3.2	13,900	12,300	9,200	23,600	23,600	15,600
2MMV99113WN	3.8	6.1	2.6	3.4	13,000	11,500	8,600	22,000	22,000	14,600
2MMV99114WN	5.1	8.2	3.4	4.6	11,900	10,600	7,900	20,200	20,200	13,400
2MMV99115WN	5.5	8.8	3.7	4.9	11,100	9,800	7,400	18,800	18,800	12,600
2MMV99116WN	7.1	11.3	4.7	6.3	10,400	9,300	7,000	17,700	17,700	11,900
2MMV99117WN	7.4	11.8	4.9	6.6	9,900	8,800	6,600	16,800	16,800	11,200
2MMV99118WN	9.7	15.6	6.5	8.7	9,400	8,300	6,200	15,900	15,900	10,500
2MMV99119WN	13.3	21.3	7.1	9.5	8,900	7,900	5,900	15,100	15,100	10,000
2MMV99120WN	10.6	17	7.4	9.9	8,500	7,500	5,600	14,400	14,400	9,500
2MMV99121WN	17.1	27.4	9.1	12.2	8,000	7,100	5,300	13,600	13,600	9,000
2MMV99122WN	16	25.6	10.7	14.2	7,700	6,800	5,100	13,000	13,000	8,700
2MMV99124WN	17.1	27.4	11.4	15.3	7,100	6,300	4,700	12,100	12,100	8,000
2MMV99126WN	25.8	41.3	17.2	23	6,400	5,700	4,300	10,900	10,900	7,300
2MMV99128WN	27.5	43.9	18.3	24.4	5,900	5,300	4,000	10,100	10,100	6,800
2MMV99130WN	43.9	70.3	29.3	39.1	5,600	5,000	3,700	9,500	9,500	6,300

Notes
1) For other mounting arrangement configurations refer to text on Fafnir Permissible Speed calculation methods.
2) For ceramic ball complements use 120% of speeds shown.

Fafnir Ultra-Light Series
2(3)MMV99100WN Series
Speed Capability

	Grease Capacity		Kluber Isoflex NBU15		Operating Speeds[2] (DB Mounting)					
					Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams				rpm			rpm		
3MMV99101WN	0.3	0.5	0.2	0.3	58,000	47,700	34,100	86,900	71,600	51,100
3MMV99102WN	0.4	0.6	0.2	0.3	49,000	40,500	28,900	73,800	60,800	43,400
3MMV99103WN	0.5	0.7	0.3	0.4	43,500	35,800	25,600	65,300	53,800	38,400
3MMV99104WN	0.9	1.4	0.6	0.8	33,500	27,600	19,700	50,200	41,400	29,500
3MMV99105WN	1.0	1.6	0.7	0.9	27,900	23,000	16,400	41,800	34,400	24,600
3MMV99106WN	1.3	2.1	0.9	1.2	22,500	18,500	13,200	33,800	27,800	19,900
3MMV99107WN	1.4	2.2	0.9	1.2	19,300	15,900	11,300	28,900	23,800	17,000
3MMV99108WN	1.7	2.7	1.1	1.5	16,800	13,900	9,900	25,200	20,800	14,800
3MMV99109WN	2.2	3.5	1.5	2.0	15,500	12,700	9,100	23,200	19,100	13,600
3MMV99110WN	2.4	3.8	1.6	2.1	14,200	11,700	8,300	21,300	17,500	12,500
3MMV99111WN	3.4	5.4	2.2	3.0	12,700	10,400	7,400	19,000	15,600	11,200
3MMV99112WN	3.6	5.8	2.4	3.2	11,800	9,700	6,900	17,700	14,600	10,400
3MMV99113WN	3.8	6.1	2.6	3.4	11,000	9,100	6,500	16,600	13,600	9,700
3MMV99114WN	5.1	8.2	3.4	4.6	10,100	8,300	5,900	15,200	12,500	8,900
3MMV99115WN	5.5	8.8	3.7	4.9	9,400	7,800	5,500	14,100	11,700	8,300
3MMV99116WN	7.1	11.3	4.7	6.3	8,800	7,300	5,200	13,300	10,900	7,800
3MMV99117WN	7.4	11.8	4.9	6.6	8,400	6,900	4,900	12,600	10,400	7,400
3MMV99118WN	9.7	15.6	6.5	8.7	7,900	6,500	4,700	11,900	9,800	7,000
3MMV99119WN	13.3	21.3	7.1	9.5	7,600	6,200	4,500	11,400	9,400	6,700
3MMV99120WN	10.6	17.0	7.4	9.9	7,200	5,900	4,200	10,800	8,900	6,300
3MMV99121WN	17.1	27.4	9.1	12.2	6,800	5,600	4,000	10,300	8,500	6,000
3MMV99122WN	16.0	25.6	10.7	14.2	6,500	5,300	3,800	9,700	8,000	5,700
3MMV99124WN	17.1	27.4	11.4	15.3	6,000	4,900	3,500	9,000	7,400	5,300
3MMV99126WN	25.8	41.3	17.2	23.0	5,400	4,500	3,200	8,100	6,700	4,800
3MMV99128WN	27.5	43.9	18.3	24.4	5,100	4,200	3,000	7,600	6,300	4,500
3MMV99130WN	43.9	70.3	29.3	39.1	4,800	3,900	2,800	7,200	5,900	4,200

ISO/DIN	P5	P4	–	P2
Fafnir®	V *x.xx*	–	MM(V)	MMX *x.xxxx*



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

Conrad Construction:
- Maximum complement of balls separated by two-piece land piloted cage.

						Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width	Ball x Dia. Qty. (in.)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[1]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	in/tol: +0; -.000(X)				lbs.	lbs.		rpm	in.	in.			
MM9101K	0.4724 (1.5)	1.1024 (2)	0.3150 (31)	8 x 3/16	0.04	540 *480*	1,280 *1,280*	52,800 *63,400*	0.012	0.64	0.63	1.01	1.00
MM9103K	0.6693 (1.5)	1.3780 (2.5)	0.3937 (31)	10 x 3/16	0.08	735 *650*	1,500 *1,500*	39,600 *47,500*	0.012	0.86	0.85	1.23	1.22
MM9104K	0.7874 (2)	1.6535 (2.5)	0.4724 (47)	8 x 1/4	0.14	1,000 *890*	2,160 *2,160*	34,000 *40,800*	0.024	0.99	0.98	1.49	1.48
MM9105K	0.9843 (2)	1.8504 (2.5)	0.4724 (47)	10 x 1/4	0.16	1,320 *1,170*	2,510 *2,510*	28,300 *34,000*	0.024	1.19	1.18	1.68	1.67
MM9106K	1.1811 (2)	2.1654 (3)	0.5118 (47)	11 x 9/32	0.24	1,860 *1,660*	3,300 *3,300*	23,300 *28,000*	0.039	1.43	1.42	2.00	1.99
MM9107K	1.3780 (2.5)	2.4409 (3)	0.5512 (47)	11 x 5/16	0.32	2,320 *2,060*	3,980 *3,980*	20,700 *24,800*	0.039	1.62	1.60	2.23	2.21
MM9108K	1.5748 (2.5)	2.6772 (3)	0.5906 (47)	12 x 5/16	0.40	2,600 *2,310*	4,180 *4,180*	18,300 *21,800*	0.039	1.82	1.80	2.45	2.43
MM9109K	1.7717 (2.5)	2.9528 (3)	0.6299 (47)	13 x 11/32	0.51	3,400 *3,030*	5,230 *5,230*	16,300 *19,600*	0.039	2.04	2.02	2.73	2.71
MM9110K	1.9685 (2.5)	3.1496 (3)	0.6299 (47)	14 x 11/32	0.55	3,750 *3,310*	5,440 *5,440*	14,900 *17,900*	0.039	2.23	2.21	2.92	2.90
MM9111K	2.1654 (3)	3.5433 (3)	0.7087 (59)	13 x 13/32	0.80	4,800 *4,250*	7,050 *7,050*	13,500 *16,200*	0.039	2.47	2.45	3.28	3.26
MM9112K	2.3622 (3)	3.7402 (3)	0.7087 (59)	14 x 13/32	0.95	5,210 *4,630*	7,340 *7,340*	12,500 *15,000*	0.039	2.67	2.65	3.47	3.45

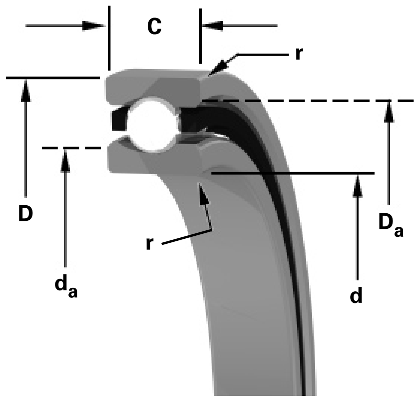
Notes
1) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Extra-Light MM9100K (ISO 10) Series

Inch Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	min.	max.	max.	min.	
in.				in.				in.				
0.4722	0.4724	0.0002	0.00015	1.1024	1.1026	0.0000	0.0004	1.1028	1.1026	0.00060	0.00020	**MM9101K**
0.6691	0.6693	0.0002	0.00015	1.3780	1.3783	0.0000	0.0005	1.3784	1.3782	0.00070	0.00020	**MM9103K**
0.7872	0.7874	0.0002	0.0002	1.6535	1.6538	0.0000	0.0005	1.6539	1.6537	0.00070	0.00020	**MM9104K**
0.9841	0.9843	0.0002	0.0002	1.8504	1.8507	0.0000	0.0005	1.8509	1.8507	0.00080	0.00030	**MM9105K**
1.1809	1.1811	0.0002	0.0002	2.1654	2.1657	0.0000	0.0006	2.1659	2.1657	0.00080	0.00030	**MM9106K**
1.3778	1.3780	0.0002	0.00025	2.4409	2.4412	0.0000	0.0006	2.4414	2.4412	0.00080	0.00030	**MM9107K**
1.5746	1.5748	0.0002	0.00025	2.6772	2.6775	0.0000	0.0006	2.6777	2.6775	0.00080	0.00030	**MM9108K**
1.7715	1.7717	0.0002	0.00025	2.9528	2.9531	0.0000	0.0006	2.9533	2.9531	0.00080	0.00030	**MM9109K**
1.9683	1.9685	0.0002	0.00025	3.1496	3.1499	0.0000	0.0006	3.1501	3.1499	0.00080	0.00030	**MM9110K**
2.1652	2.1654	0.0002	0.0003	3.5433	3.5436	0.0000	0.0006	3.5439	3.5436	0.00090	0.00030	**MM9111K**
2.3620	2.3622	0.0002	0.0003	3.7402	3.7405	0.0000	0.0006	3.7408	3.7405	0.00090	0.00030	**MM9112K**

(continued)



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

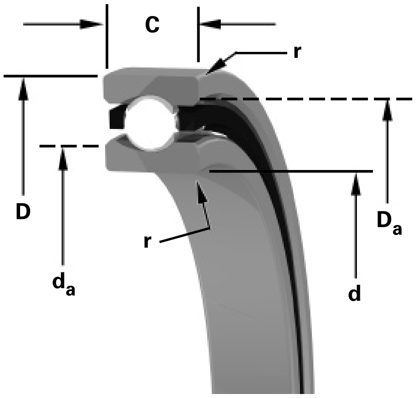
Conrad Construction:
- Maximum complement of balls separated by two-piece land piloted cage.

	d Bore	D O.D.	C Width	Ball x Dia. Qty. (in.)	Wt.	Load Ratings (steel ball & *ceramic ball*) C_0 (stat)	C_e(dyn)	Limiting Speed	r Rad.[1]	Recommended Shoulder Diameters d_a (Shaft) max.	d_a (Shaft) min.	D_a (Housing) max.	D_a (Housing) min.
	in/tol: +0; -.000(X)				lbs.	lbs.		rpm	in.	in.			
MM9113K	2.5591 (3)	3.9370 (3)	0.7087 (59)	15 x 13/32	0.99	5,650 *5,030*	7,610 *7,610*	11,600 *13,900*	0.039	2.86	2.84	3.67	3.65
MM9114K	2.7559 (3)	4.3307 (3)	0.7874 (59)	14 x 15/32	1.37	6,940 *6,180*	9,490 *9,490*	10,700 *12,800*	0.039	3.08	3.06	4.03	4.01
MM9115K	2.9528 (3)	4.5276 (3)	0.7874 (59)	15 x 15/32	1.34	7,500 *6,700*	9,850 *9,850*	10,100 *12,100*	0.039	3.29	3.26	4.23	4.20
MM9116K	3.1496 (3)	4.9213 (3.5)	0.8661 (59)	14 x 17/32	1.77	9,000 *7,940*	11,900 *11,900*	9,420 *11,300*	0.039	3.52	3.49	4.59	4.56
MM9117K	3.3465 (3)	5.1181 (3.5)	0.8661 (79)	15 x 17/32	1.86	9,650 *8,600*	12,300 *12,300*	8,900 *10,700*	0.039	3.74	3.71	4.81	4.78
MM9118K	3.5433 (3)	5.5118 (3.5)	0.9449 (79)	14 x 19/32	2.41	11,200 *9,920*	14,500 *14,500*	8,390 *10,100*	0.059	3.96	3.93	5.16	5.13
MM9120K	3.9370 (3)	5.9055 (3.5)	0.9449 (79)	15 x 19/32	2.66	12,200 *10,800*	15,000 *15,000*	7,630 *9,160*	0.059	4.36	4.33	5.55	5.52
MM9122K	4.3307 (3)	6.6929 (4)	1.1024 (79)	14 x 11/16	4.15	15,000 *13,500*	18,700 *18,700*	6,840 *8,210*	0.079	4.85	4.82	6.24	6.21
MM9124K	4.7244 (3)	7.0866 (4)	1.1024 (79)	15 x 11/16	4.45	16,300 *14,600*	19,400 *19,400*	6,320 *7,580*	0.079	5.25	5.22	6.63	6.60
MM9126K	5.1181 (4)	7.8740 (4.5)	1.2992 (98)	14 x 13/16	6.70	21,200 *18,800*	25,300 *25,300*	5,810 *6,975*	0.079	5.71	5.68	7.35	7.32

Notes
1) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Extra-Light
MM9100K (ISO 10) Series
Inch Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed: Housing Bore (Stationary)		Fixed: Mounting Fits		Floating: Housing Bore (Stationary)		Floating: Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	min.	max.	max.	min.	
in.				in.				in.				
2.5589	2.5591	0.0002	0.0003	3.9370	3.9373	0.0000	0.0006	3.9377	3.9374	0.00100	0.00040	**MM9113K**
2.7557	2.7559	0.0002	0.0003	4.3307	4.3310	0.0000	0.0006	4.3314	4.3311	0.00100	0.00040	**MM9114K**
2.9526	2.9530	0.0002	0.0005	4.5276	4.5279	0.0000	0.0006	4.5283	4.5280	0.00100	0.00040	**MM9115K**
3.1494	3.1498	0.0002	0.0005	4.9213	4.9216	0.0000	0.0007	4.9221	4.9217	0.00120	0.00040	**MM9116K**
3.3463	3.3467	0.0002	0.0005	5.1181	5.1185	0.0000	0.0007	5.1189	5.1185	0.00110	0.00040	**MM9117K**
3.5431	3.5435	0.0002	0.0005	5.5118	5.5122	0.0000	0.0007	5.5126	5.5122	0.00110	0.00040	**MM9118K**
3.9368	3.9372	0.0002	0.0005	5.9055	5.9059	0.0000	0.0007	5.9064	5.9060	0.00120	0.00050	**MM9120K**
4.3305	4.3309	0.0002	0.0005	6.6929	6.6933	0.0000	0.0008	6.6938	6.6934	0.00130	0.00050	**MM9122K**
4.7242	4.7246	0.0002	0.0005	7.0866	7.0870	0.0000	0.0008	7.0875	7.0871	0.00130	0.00050	**MM9124K**
5.1179	5.1183	0.0002	0.0006	7.8740	7.8745	0.0000	0.0009	7.8750	7.8746	0.00150	0.00060	**MM9126K**



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

Conrad Construction:
- Maximum complement of balls separated by two-piece land piloted cage.

	d Bore	D O.D.	C Width	Ball x Dia. Qty. (mm)	Wt.	Load Ratings (steel ball & *ceramic ball*) C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[1]	Recommended Shoulder Diameters d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	mm/tol: +0; -(μm)				kg.	N		rpm	mm	mm			
MM9101K	12 (4)	28 (5)	8 (80)	8 x 4.76	0.020	2,400 *2,130*	5,670 *5,670*	52,800 *63,400*	0.3	16.1	15.9	25.5	25.3
MM9103K	17 (4)	35 (6)	10 (80)	10 x 4.76	0.038	3,300 *2,890*	6,660 *6,660*	39,600 *47,500*	0.3	21.7	21.5	31.1	30.9
MM9104K	20 (5)	42 (6)	12 (120)	8 x 6.35	0.064	4,400 *3,980*	9,620 *9,620*	34,000 *40,800*	0.6	25.0	24.8	37.7	37.5
MM9105K	25 (5)	47 (6)	12 (120)	10 x 6.35	0.074	5,900 *5,210*	11,200 *11,200*	28,300 *34,000*	0.6	30.1	29.9	42.6	42.3
MM9106K	30 (5)	55 (7)	13 (120)	11 x 7.14	0.109	8,300 *7,390*	14,700 *14,700*	23,300 *28,000*	1.0	36.2	35.9	50.7	50.4
MM9107K	35 (6)	62 (7)	14 (120)	11 x 7.94	0.144	10,300 *9,150*	17,700 *17,700*	20,700 *24,800*	1.0	41.2	40.6	56.6	56.1
MM9108K	40 (6)	68 (7)	15 (120)	12 x 7.94	0.180	11,600 *10,300*	18,600 *18,600*	18,200 *21,800*	1.0	46.2	45.7	62.2	61.7
MM9109K	45 (6)	75 (7)	16 (120)	13 x 8.73	0.230	15,100 *13,500*	23,300 *23,300*	16,300 *19,600*	1.0	51.8	51.3	69.3	68.8
MM9110K	50 (6)	80 (7)	16 (120)	14 x 8.73	0.248	16,700 *14,700*	24,200 *24,200*	14,900 *17,900*	1.0	56.6	56.1	74.2	73.7
MM9111K	55 (7)	90 (8)	18 (150)	13 x 10.32	0.362	21,400 *18,900*	31,400 *31,400*	13,500 *16,200*	1.0	62.7	62.2	83.3	82.8
MM9112K	60 (7)	95 (8)	18 (150)	14 x 10.32	0.430	23,200 *20,600*	32,600 *32,600*	12,500 *15,000*	1.0	67.8	67.3	88.1	87.6

Notes
1) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Extra-Light MM9100K (ISO 10) Series

Metric Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	min.	max.	max.	min.	
mm				mm				mm				
11.995	12.000	0.005	0.004	28	28.005	0.000	0.010	28.010	28.005	0.015	0.005	**MM9101K**
16.995	17.000	0.005	0.004	35	35.006	0.000	0.012	35.010	35.005	0.016	0.005	**MM9103K**
19.995	20.000	0.005	0.005	42	42.006	0.000	0.012	42.010	42.005	0.016	0.005	**MM9104K**
24.995	25.000	0.005	0.005	47	47.006	0.000	0.012	47.012	47.007	0.018	0.007	**MM9105K**
29.995	30.000	0.005	0.005	55	55.008	0.000	0.015	55.012	55.007	0.019	0.007	**MM9106K**
34.995	35.000	0.005	0.006	62	62.008	0.000	0.015	62.012	62.007	0.019	0.007	**MM9107K**
39.995	40.000	0.005	0.006	68	68.008	0.000	0.015	68.012	68.007	0.019	0.007	**MM9108K**
44.995	45.000	0.005	0.006	75	75.008	0.000	0.015	75.014	75.009	0.022	0.009	**MM9109K**
49.995	50.000	0.005	0.006	80	80.008	0.000	0.015	80.012	80.008	0.020	0.008	**MM9110K**
54.995	55.000	0.005	0.007	90	90.008	0.000	0.016	90.015	90.007	0.023	0.007	**MM9111K**
59.995	60.000	0.005	0.007	95	95.008	0.000	0.016	95.016	95.009	0.024	0.009	**MM9112K**

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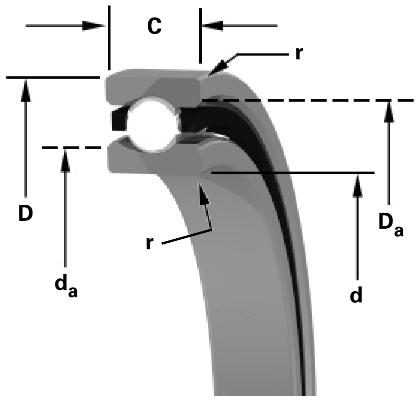


Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

Conrad Construction:
- Maximum complement of balls separated by two-piece land piloted cage.

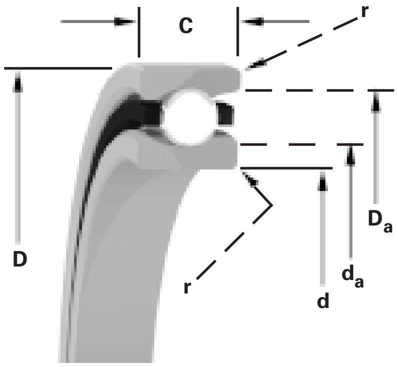
	d Bore	D O.D.	C Width	Ball x Dia. Qty. (mm)	Wt.	Load Ratings (steel ball & *ceramic ball*) C_o (stat)	C_e(dyn)	Limiting Speed	r^1 Rad.	Recommended Shoulder Diameters d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	mm/tol: +0; -(μm)				kg.	N		rpm	mm	mm			
MM9113K	65 (7)	100 (8)	18 (150)	15 x 10.32	0.450	25,200 *22,400*	33,900 *33,900*	11,600 *13,900*	1.0	72.6	72.1	93.2	92.7
MM9114K	70 (7)	110 (8)	20 (150)	14 x 11.91	0.620	30,900 *27,500*	42,200 *42,200*	10,700 *12,800*	1.0	78.2	77.7	102.4	101.9
MM9115K	75 (7)	115 (8)	20 (150)	15 x 11.91	0.606	33,400 *29,800*	43,800 *43,800*	10,100 *12,100*	1.0	83.4	82.7	107.3	106.6
MM9116K	80 (7)	125 (9)	22 (150)	14 x 13.49	0.804	40,000 *35,300*	52,800 *52,800*	9,420 *11,300*	1.0	89.3	88.5	116.5	115.7
MM9117K	85 (8)	130 (9)	22 (200)	15 x 13.49	0.845	42,900 *38,300*	54,900 *54,900*	8,900 *10,700*	1.0	94.9	94.1	122.1	121.3
MM9118K	90 (9)	140 (9)	24 (200)	14 x 15.08	1.092	49,800 *44,100*	64,500 *64,500*	8,390 *10,100*	1.5	100.5	99.7	130.9	130.2
MM9120K	100 (8)	150 (9)	24 (200)	15 x 15.08	1.208	54,300 *48,200*	66,700 *66,700*	7,630 *9,160*	1.5	110.6	109.9	140.8	140.1
MM9122K	110 (8)	170 (10)	28 (200)	14 x 17.46	1.882	66,700 *59,900*	83,400 *83,400*	6,840 *8,240*	2.0	123.1	122.3	158.4	157.6
MM9124K	120 (8)	180 (10)	28 (200)	15 x 17.46	2.019	72,500 *65,000*	86,300 *86,300*	6,320 *7,500*	2.0	133.2	132.5	168.3	167.5
MM9126K	130 (10)	200 (11)	33 (250)	14 x 20.64	3.041	94,300 *83,600*	112,600 *112,600*	5,810 *6,975*	2.0	144.9	144.2	186.6	185.8

Notes
1) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Extra-Light MM9100K (ISO 10) Series
Metric Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	min.	max.	max.	min.	
mm				mm				mm				
64.995	65.000	0.005	0.007	100	100.008	0.000	0.016	100.018	100.010	0.025	0.010	**MM9113K**
69.995	70.000	0.005	0.007	110	110.008	0.000	0.016	110.018	110.010	0.025	0.010	**MM9114K**
74.995	75.005	0.005	0.012	115	115.008	0.000	0.016	115.019	115.011	0.026	0.010	**MM9115K**
79.995	80.005	0.005	0.012	125	125.008	0.000	0.017	125.021	125.011	0.030	0.011	**MM9116K**
84.995	85.005	0.005	0.012	130	130.009	0.000	0.018	130.020	130.010	0.029	0.010	**MM9117K**
89.995	90.005	0.005	0.013	140	140.009	0.000	0.018	140.020	140.010	0.029	0.010	**MM9118K**
99.995	100.005	0.005	0.013	150	150.009	0.000	0.018	150.023	150.012	0.032	0.012	**MM9120K**
109.995	110.005	0.005	0.013	170	170.010	0.000	0.020	170.022	170.012	0.032	0.012	**MM9122K**
119.995	120.005	0.005	0.013	180	180.010	0.000	0.020	180.022	180.012	0.032	0.012	**MM9124K**
129.995	130.005	0.005	0.015	200	200.011	0.000	0.022	200.025	200.015	0.036	0.015	**MM9126K**

ISO/DIN	P5	P4	–	P2
Fafnir®	V *x.xx*	–	MM(V)	MMX *x.xxxx*



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WI Construction:

- Incorporates low shoulder on non-thrust side of outer rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (in.)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d (Shaft) max.	d (Shaft) min.	D_a (Housing) max.	D_a (Housing) min.
	in/tol: +0; -.000(X)				lbs.	lbs.		rpm	lbs.		rpm	in.	in.			
200WI	0.3937 (1.5)	1.1811 (2)	0.3543 (16)	8 x 7/32	0.07	660 *590*	1,600 *1,600*	62,800 *75,400*	640 *570*	1,550 *1,550*	56,500 *67,800*	0.024	0.60	0.59	1.03	1.02
201WI	0.4724 (1.5)	1.2598 (2.5)	0.3937 (31)	9 x 15/64	0.08	860 *770*	1,970 *1,970*	56,700 *68,000*	830 *750*	1,910 *1,910*	51,000 *61,200*	0.024	0.66	0.65	1.11	1.10
202WI	0.5906 (1.5)	1.378 (2.5)	0.4331 (31)	10 x 15/64	0.1	1,010 *900*	2,200 *2,200*	47,800 *57,400*	980 *870*	2,080 *2,080*	43,000 *51,600*	0.024	0.76	0.75	1.23	1.22
203WI	0.6693 (1.5)	1.5748 (2.5)	0.4724 (31)	10 x 17/64	0.14	1,320 *1,160*	2,750 *2,750*	41,900 *50,300*	1,270 *1,120*	2,600 *2,600*	37,700 *45,200*	0.024	0.86	0.85	1.41	1.40
204WI	0.7874 (2)	1.8504 (2.5)	0.5512 (47)	10 x 5/16	0.23	1,810 *1,610*	3,620 *3,620*	35,700 *42,800*	1,730 *1,550*	3,490 *3,490*	32,100 *38,500*	0.039	1.03	1.02	1.64	1.63
205WI	0.9843 (2)	2.0472 (3)	0.5906 (47)	12 x 5/16	0.28	2,320 *2,050*	4,130 *4,130*	29,800 *35,800*	2,200 *1,950*	3,950 *3,950*	26,800 *32,100*	0.039	1.23	1.22	1.86	1.85
206WI	1.1811 (2)	2.4409 (3)	0.6299 (47)	12 x 3/8	0.43	3,310 *2,940*	5,740 *5,740*	25,100 *30,100*	3,150 *2,810*	5,490 *5,490*	22,600 *27,100*	0.039	1.45	1.44	2.21	2.20
207WI	1.378 (2.5)	2.8346 (3)	0.6693 (47)	12 x 7/16	0.62	4,490 *4,000*	7,580 *7,580*	21,600 *25,900*	4,300 *3,820*	7,240 *7,240*	19,400 *23,300*	0.039	1.68	1.66	2.57	2.55
208WI	1.5748 (2.5)	3.1496 (3)	0.7087 (47)	11 x 1/2	0.78	5,340 *4,750*	9,070 *9,070*	19,300 *23,200*	5,100 *4,550*	8,690 *8,690*	17,400 *20,900*	0.039	1.88	1.86	2.88	2.86
209WI	1.7717 (2.5)	3.3465 (3)	0.748 (47)	13 x 1/2	0.9	6,470 *5,760*	10,200 *10,200*	17,500 *21,000*	6,200 *5,500*	9,700 *9,700*	15,800 *19,000*	0.039	2.08	2.06	3.08	3.06
210WI	1.9685 (2.5)	3.5433 (3)	0.7874 (47)	14 x 1/2	1.01	7,130 *6,340*	10,700 *10,700*	16,000 *19,200*	6,800 *6,050*	10,200 *10,200*	14,400 *17,300*	0.039	2.28	2.26	3.28	3.26
211WI	2.1654 (3)	3.937 (3)	0.8268 (59)	14 x 9/16	1.34	9,000 *7,980*	13,200 *13,200*	14,500 *17,400*	8,650 *7,640*	12,600 *12,600*	13,100 *15,700*	0.059	2.51	2.49	3.63	3.61
212WI	2.3622 (3)	4.3307 (3)	0.8661 (59)	14 x 5/8	1.74	11,000 *9,810*	16,000 *16,000*	13,200 *15,800*	10,600 *9,400*	15,200 *15,200*	11,900 *14,300*	0.059	2.75	2.73	3.99	3.97

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Light
2(3)MM200WI (ISO 02) Series
Inch Dimensional Series

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
0.3935	0.3937	0.0002	0.00015	1.1811	1.1813	0.0000	0.0004	1.18150	1.18130	0.00060	0.00020	**200WI**
0.4722	0.4724	0.0002	0.00015	1.2598	1.2600	0.0000	0.00045	1.26020	1.26000	0.00070	0.00020	**201WI**
0.5904	0.5906	0.0002	0.00015	1.3780	1.3783	0.0000	0.0005	1.37840	1.37820	0.00070	0.00020	**202WI**
0.6691	0.6693	0.0002	0.00015	1.5748	1.5751	0.0000	0.0005	1.57520	1.57500	0.00070	0.00020	**203WI**
0.7872	0.7874	0.0002	0.0002	1.8504	1.8507	0.0000	0.0005	1.85090	1.85070	0.00080	0.00030	**204WI**
0.9841	0.9843	0.0002	0.0002	2.0472	2.0475	0.0000	0.00055	2.04770	2.04750	0.00080	0.00030	**205WI**
1.1809	1.1811	0.0002	0.0002	2.4409	2.4412	0.0000	0.0006	2.44140	2.44120	0.00080	0.00030	**206WI**
1.3778	1.3780	0.0002	0.00025	2.8346	2.8349	0.0000	0.0006	2.83510	2.83490	0.00080	0.00030	**207WI**
1.5746	1.5748	0.0002	0.00025	3.1496	3.1499	0.0000	0.0006	3.15010	3.14990	0.00080	0.00030	**208WI**
1.7715	1.7717	0.0002	0.00025	3.3465	3.3468	0.0000	0.0006	3.34710	3.34680	0.00090	0.00030	**209WI**
1.9683	1.9685	0.0002	0.00025	3.5433	3.5436	0.0000	0.0006	3.54390	3.54360	0.00090	0.00030	**210WI**
2.1652	2.1654	0.0002	0.0003	3.9370	3.9373	0.0000	0.0006	3.93770	3.93740	0.00100	0.00040	**211WI**
2.3620	2.3622	0.0002	0.0003	4.3307	4.3310	0.0000	0.0006	4.33140	4.33110	0.00100	0.00040	**212WI**

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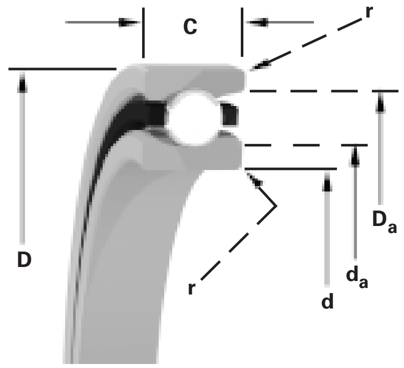


Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

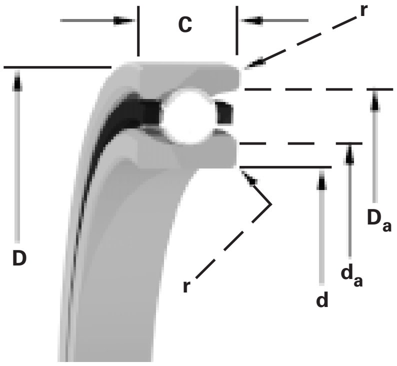
WI Construction:
- Incorporates low shoulder on non-thrust side of outer rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (in.)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	in/tol: +0; -.000(X)				lbs.	lbs.		rpm	lbs.		rpm	in.	in.			
213WI	2.5591 (3)	4.7244 (3)	0.9055 (59)	14 x 21/32	2.2	12,300 *11,000*	17,400 *17,400*	12,100 *14,500*	11,800 *10,400*	16,600 *16,600*	10,900 *13,100*	0.059	3.00	2.98	4.32	4.30
214WI	2.7559 (3)	4.9213 (3.5)	0.9449 (59)	14 x 11/16	2.37	13,400 *12,100*	18,900 *18,900*	11,400 *13,700*	12,900 *11,500*	18,000 *18,000*	10,300 *12,400*	0.059	3.18	3.16	4.56	4.54
215WI	2.9528 (3)	5.1181 (3.5)	0.9843 (59)	15 x 11/16	2.59	14,600 *13,100*	19,800 *19,800*	10,800 *13,000*	14,000 *12,500*	18,800 *18,800*	9,700 *11,600*	0.059	3.39	3.36	4.76	4.73
216WI	3.1496 (3)	5.5118 (3.5)	1.0236 (59)	15 x 3/4	3.19	17,300 *15,500*	23,100 *23,100*	10,100 *12,100*	16,600 *14,800*	22,000 *22,000*	9,100 *10,900*	0.079	3.60	3.57	5.12	5.09
217WI	3.3465 (3)	5.9055 (3.5)	1.1024 (79)	15 x 13/16	4.01	20,400 *18,200*	26,700 *26,700*	9,400 *11,300*	19,300 *17,300*	25,500 *25,500*	8,500 *10,200*	0.079	3.84	3.81	5.47	5.44
218WI	3.5433 (3)	6.2992 (4)	1.1811 (79)	14 x 7/8	4.84	22,000 *19,600*	29,200 *29,200*	8,900 *10,700*	20,800 *18,600*	27,800 *27,800*	8,000 *9,600*	0.079	4.08	4.05	5.83	5.8
219WI	3.7402 (3)	6.6929 (4)	1.2598 (79)	14 x 15/16	5.88	25,000 *22,400*	33,100 *33,100*	8,400 *10,100*	24,000 *21,300*	31,500 *31,500*	7,600 *9,100*	0.079	4.31	4.28	6.19	6.16
220WI	3.937 (3)	7.0866 (4)	1.3386 (79)	14 x 1	7.07	28,500 *25,400*	37,100 *37,100*	8,000 *9,600*	27,000 *24,200*	35,400 *35,400*	7,200 *8,600*	0.079	4.54	4.51	6.54	6.51
222WI	4.3307 (3)	7.874 (4.5)	1.4961 (79)	14 x 1-1/8	9.89	36,000 *31,900*	43,800 *43,800*	7,200 *8,600*	34,500 *30,600*	41,800 *41,800*	6,500 *7,800*	0.079	5.01	4.98	7.26	7.23
224WI	4.7244 (3)	8.4646 (4.5)	1.5748 (79)	14 x 1-3/16	11.81	40,500 *35,900*	47,200 *47,200*	6,700 *8,000*	39,000 *34,300*	45,100 *45,100*	6,000 *7,200*	0.079	5.44	5.41	7.82	7.79
226WI	5.1181 (4)	9.0551 (4.5)	1.5748 (98)	17 x 1-3/16	14.26	50,000 *44,400*	53,500 *53,500*	6,100 *7,300*	47,500 *42,500*	51,000 *51,000*	5,500 *6,600*	0.098	5.93	5.9	8.31	8.28
230WI	5.9055 (4)	10.6299 (5)	1.7717 (98)	15 x 1-1/2	22	68,000 *61,200*	68,600 *68,600*	5,300 *6,400*	65,500 *58,400*	65,400 *65,400*	4,800 *5,800*	0.098	6.8	6.77	9.8	9.77

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Light
2(3)MM200WI (ISO 02) Series
Inch Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
2.5589	2.5591	0.0002	0.0003	4.7244	4.7247	0.0000	0.0006	4.72510	4.72480	0.00100	0.00040	**213WI**
2.7557	2.7559	0.0002	0.0003	4.9213	4.9216	0.0000	0.0007	4.92210	4.92170	0.00120	0.00040	**214WI**
2.9526	2.9530	0.0002	0.0005	5.1181	5.1185	0.0000	0.0007	5.11890	5.11850	0.00110	0.00040	**215WI**
3.1494	3.1498	0.0002	0.0005	5.5118	5.5122	0.0000	0.0007	5.51260	5.51220	0.00110	0.00040	**216WI**
3.3463	3.3467	0.0002	0.0005	5.9055	5.9059	0.0000	0.0007	5.90640	5.90600	0.00120	0.00050	**217WI**
3.5431	3.5435	0.0002	0.0005	6.2992	6.2996	0.0000	0.0008	6.30010	6.29970	0.00130	0.00050	**218WI**
3.7400	3.7404	0.0002	0.0005	6.6929	6.6933	0.0000	0.0008	6.69380	6.69340	0.00130	0.00050	**219WI**
3.9368	3.9372	0.0002	0.0005	7.0866	7.0870	0.0000	0.0008	7.08750	7.08710	0.00130	0.00050	**220WI**
4.3305	4.3309	0.0002	0.0005	7.8740	7.8745	0.0000	0.0009	7.87500	7.87460	0.00150	0.00060	**222WI**
4.7242	4.7246	0.0002	0.0005	8.4646	8.4651	0.0000	0.0009	8.46560	8.46520	0.00150	0.00060	**224WI**
5.1179	5.1183	0.0002	0.0006	9.0551	9.0556	0.0000	0.0009	9.05610	9.05570	0.00150	0.00060	**226WI**
5.9053	5.9057	0.0002	0.0006	10.6299	10.6304	0.0000	0.0010	10.63120	10.63070	0.00180	0.00080	**230WI**



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WI Construction:

- Incorporates low shoulder on non-thrust side of outer rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

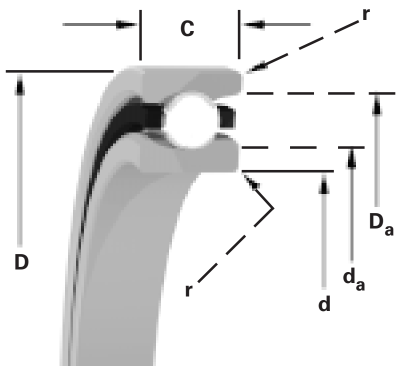
						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (mm)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	d_a (Shaft) min.	D_a (Housing) max.	D_a (Housing) min.
	mm/tol: +0; -(μm)				kg.	N		rpm	N		rpm	mm	mm			
200WI	10 (3.8)	30 (5.1)	9 (40)	8 x 5.56	0.03	2,900 *2,610*	7,100 *7,100*	62,800 *75,400*	2,800 *2,540*	6,900 *6,900*	56,500 *67,800*	0.6	15.1	14.9	26	25.8
201WI	12 (3.8)	32 (6.4)	10 (80)	9 x 5.95	0.036	3,800 *3,410*	8,760 *8,760*	56,700 *68,000*	3,700 *3,320*	8,500 *8,500*	51,000 *61,200*	0.6	16.6	16.4	28.1	27.8
202WI	15 (3.8)	35 (6.4)	11 (80)	10 x 5.95	0.044	4,500 *4,010*	9,580 *9,580*	47,800 *57,400*	4,400 *3,880*	9,250 *9,250*	43,000 *51,600*	0.6	19.2	18.9	31.1	30.9
203WI	17 (3.8)	40 (6.4)	12 (80)	10 x 6.75	0.064	5,900 *5,170*	12,000 *12,000*	41,900 *50,300*	5,600 *5,000*	11,600 *11,600*	37,700 *45,200*	0.6	21.7	21.5	35.7	35.4
204WI	20 (5.1)	47 (6.4)	14 (130)	10 x 7.94	0.103	8,100 *7,160*	16,100 *16,100*	35,700 *42,800*	7,700 *6,900*	15,500 *15,500*	32,100 *38,500*	1	26	25.8	41.5	41.3
205WI	25 (5.1)	52 (7.7)	15 (130)	12 x 7.94	0.127	10,200 *9,110*	18,400 *18,400*	29,800 *35,800*	9,800 *8,690*	17,600 *17,600*	26,800 *32,200*	1	31.1	30.9	47.1	46.9
206WI	30 (5.1)	62 (7.7)	16 (130)	12 x 9.53	0.195	14,700 *13,100*	25,500 *25,500*	25,100 *30,100*	14,000 *12,500*	24,400 *24,400*	22,600 *27,100*	1	36.7	36.5	56	55.8
207WI	35 (6.4)	72 (7.7)	17 (130)	12 x 11.11	0.282	20,000 *17,800*	33,700 *33,700*	21,600 *25,900*	19,100 *17,100*	32,200 *32,200*	19,400 *23,300*	1	42.7	42.2	65.3	64.8
208WI	40 (6.4)	80 (7.7)	18 (130)	11 x 12.70	0.352	23,800 *21,100*	40,400 *40,400*	19,300 *23,100*	22,700 *20,200*	38,700 *38,700*	17,400 *20,900*	1	47.8	47.2	73.2	72.6
209WI	45 (6.4)	85 (7.7)	19 (130)	13 x 12.70	0.408	28,800 *25,600*	45,200 *45,200*	17,500 *21,000*	27,600 *24,500*	43,100 *43,100*	15,800 *19,000*	1	52.8	52.3	78.2	77.7
210WI	50 (6.4)	90 (7.7)	20 (130)	14 x 12.70	0.457	31,700 *28,200*	47,400 *47,400*	16,000 *19,200*	30,200 *26,900*	45,200 *45,200*	14,400 *17,300*	1	57.9	57.4	83.3	82.8
211WI	55 (7.7)	100 (7.7)	21 (150)	14 x 14.29	0.608	40,000 *35,500*	58,700 *58,700*	14,500 *17,400*	38,500 *34,000*	55,900 *55,900*	13,100 *15,700*	1.5	63.8	63.3	92.2	91.7
212WI	60 (7.7)	110 (7.7)	22 (150)	14 x 15.88	0.787	48,900 *43,600*	71,000 *71,000*	13,200 *15,800*	47,100 *41,800*	67,700 *67,700*	11,900 *14,300*	1.5	69.9	69.3	101.4	100.8

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Light
2(3)MM200WI (ISO 02) Series
Metric Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
9.995	10.000	0.005	0.004	30	30.005	0.000	0.010	30.010	30.005	0.015	0.005	**200WI**
11.995	12.000	0.005	0.004	32	32.005	0.000	0.011	32.010	32.005	0.016	0.005	**201WI**
14.995	15.000	0.005	0.004	35	35.006	0.000	0.012	35.010	35.005	0.016	0.005	**202WI**
16.995	17.000	0.005	0.004	40	40.006	0.000	0.012	40.010	40.005	0.016	0.005	**203WI**
19.995	20.000	0.005	0.005	47	47.006	0.000	0.012	47.012	47.007	0.018	0.007	**204WI**
24.995	25.000	0.005	0.005	52	52.006	0.000	0.013	52.012	52.007	0.019	0.007	**205WI**
29.995	30.000	0.005	0.005	62	62.008	0.000	0.015	62.012	62.007	0.019	0.007	**206WI**
34.995	35.000	0.005	0.006	72	72.008	0.000	0.015	72.011	72.007	0.019	0.007	**207WI**
39.995	40.000	0.005	0.006	80	80.008	0.000	0.015	80.012	80.008	0.020	0.008	**208WI**
44.995	45.000	0.005	0.006	85	85.008	0.000	0.016	85.016	85.009	0.024	0.009	**209WI**
49.995	50.000	0.005	0.006	90	90.008	0.000	0.016	90.015	90.007	0.023	0.007	**210WI**
54.995	55.000	0.005	0.007	100	100.008	0.000	0.016	100.018	100.010	0.025	0.010	**211WI**
59.995	60.000	0.005	0.007	110	110.008	0.000	0.016	110.018	110.010	0.025	0.010	**212WI**

(continued)



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WI Construction:

- Incorporates low shoulder on non-thrust side of outer rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

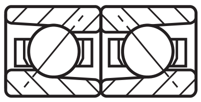
						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (mm)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	d_a (Shaft) min.	D_a (Housing) max.	D_a (Housing) min.
	mm/tol: +0; -(μm)				kg	N		rpm	N		rpm	mm	mm			
213WI	65 (7.7)	120 (7.7)	23 (150)	14 x 16.67	0.998	54,700 *48,700*	77,400 *77,400*	12,100 *14,300*	52,500 *46,500*	73,700 *73,700*	10,900 *13,100*	1.5	76.2	75.7	109.7	109.2
214WI	70 (7.7)	125 (9)	24 (150)	14 x 17.46	1.074	60,000 *53,600*	84,200 *84,200*	11,400 *13,700*	57,400 *51,100*	80,200 *80,200*	10,300 *12,400*	1.5	80.8	80.3	115.8	115.3
215WI	75 (7.7)	130 (9)	25 (150)	15 x 17.46	1.174	64,900 *58,200*	87,900 *87,900*	10,800 *13,000*	62,300 *55,600*	83,700 *83,700*	9,700 *11,600*	1.5	86	85.2	120.8	120
216WI	80 (7.7)	140 (9)	26 (150)	15 x 19.05	1.448	77,000 *69,000*	102,900 *102,900*	10,100 *12,100*	73,800 *65,800*	98,000 *98,000*	9,100 *10,900*	2	91.3	90.6	129.9	129.2
217WI	85 (7.7)	150 (9)	28 (200)	15 x 20.64	1.817	90,700 *80,700*	118,900 *118,900*	9,400 *11,300*	85,800 *76,800*	113,300 *113,300*	8,500 *10,200*	2	97.4	96.7	138.8	138.1
218WI	90 (7.7)	160 (10.3)	30 (200)	14 x 22.23	2.196	97,900 *87,100*	129,900 *129,900*	8,900 *10,700*	92,500 *82,900*	123,700 *123,700*	8,000 *9,600*	2	103.5	102.7	148	147.2
219WI	95 (7.7)	170 (10.3)	32 (200)	14 x 23.81	2.669	111,200 *99,600*	147,100 *147,100*	8,400 *10,100*	106,800 *94,900*	140,100 *140,100*	7,600 *9,100*	2.1	109.4	108.6	157.1	153.3
220WI	100 (7.7)	180 (10.3)	34 (200)	14 x 25.40	3.209	126,800 *112,900*	165,200 *165,200*	8,000 *9,600*	120,100 *107,800*	157,500 *157,500*	7,200 *8,600*	2.1	115.2	114.4	166	165.2
222WI	110 (7.7)	200 (11.5)	38 (200)	14 x 28.58	4.486	160,100 *142,000*	194,900 *194,900*	7,200 *8,600*	153,500 *135,900*	185,800 *185,800*	6,500 *7,800*	2.1	127.1	126.4	184.3	183.5
224WI	120 (7.7)	215 (11.5)	40 (200)	14 x 30.16	5.358	180,100 *159,600*	210,100 *210,100*	6,700 *8,000*	173,500 *152,400*	200,500 *200,500*	6,000 *7,200*	2.1	138.1	137.3	198.5	197.7
226WI	130 (10.3)	230 (11.5)	40 (250)	17 x 30.16	6.468	222,400 *197,400*	238,200 *238,200*	6,100 *7,300*	211,300 *188,800*	226,800 *226,800*	5,500 *6,600*	2.5	150.5	149.7	211	210.2
230WI	150 (10.3)	270 (12.8)	45 (250)	15 x 38.10	9.98	302,500 *272,100*	305,200 *305,200*	5,300 *6,400*	291,300 *259,900*	290,900 *290,900*	4,800 *5,800*	2.5	172.6	171.8	248.8	248

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

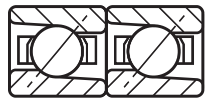
Fafnir Light
2(3)MM200WI (ISO 02) Series
Metric Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
64.995	65.000	0.005	0.007	120	120.008	0.000	0.016	120.018	120.010	0.025	0.010	**213WI**
69.995	70.000	0.005	0.007	125	125.008	0.000	0.017	125.021	125.011	0.030	0.011	**214WI**
74.995	75.005	0.005	0.012	130	130.009	0.000	0.018	130.020	130.010	0.029	0.010	**215WI**
79.995	80.005	0.005	0.012	140	140.009	0.000	0.018	140.020	140.010	0.029	0.010	**216WI**
84.995	85.005	0.005	0.012	150	150.009	0.000	0.018	150.023	150.012	0.032	0.012	**217WI**
89.995	90.005	0.005	0.013	160	160.009	0.000	0.022	160.022	160.012	0.033	0.012	**218WI**
94.995	95.005	0.005	0.013	170	170.010	0.000	0.020	170.022	170.012	0.032	0.012	**219WI**
99.995	100.005	0.005	0.013	180	180.010	0.000	0.020	180.022	180.012	0.032	0.012	**220WI**
109.995	110.005	0.005	0.013	200	200.011	0.000	0.022	200.025	200.015	0.036	0.015	**222WI**
119.995	120.005	0.005	0.013	215	215.011	0.000	0.022	215.025	215.015	0.036	0.015	**224WI**
129.995	130.005	0.005	0.015	230	230.011	0.000	0.022	230.025	230.015	0.036	0.015	**226WI**
149.995	150.005	0.005	0.015	270	270.013	0.000	0.026	270.031	270.018	0.044	0.018	**230WI**

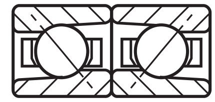
Mounting Arrangements



Recommended
DB



Tandem
DT



Special Applications
DF

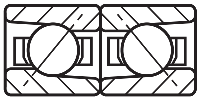
	Preload				Axial Stiffness[1]				Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	Extra Light	Light	Medium	Heavy	Light	Medium	Heavy	Extra Light to Light	Light to Medium	Medium to Heavy
	lbs.				10^6lbs./in.				10^6lbs./in.			in.		
2MM200WI	—	5	20	35	—	0.106	0.189	0.245	0.491	0.778	0.927	—	0.00041	0.00028
2MM201WI	—	5	20	35	—	0.110	0.195	0.252	0.549	0.878	1.048	—	0.00039	0.00027
2MM202WI	—	5	20	40	—	0.118	0.207	0.284	0.587	0.943	1.175	—	0.00037	0.00033
2MM203WI	—	10	30	75	—	0.146	0.235	0.365	0.784	1.129	1.504	—	0.00042	0.0006
2MM204WI	—	15	40	80	—	0.172	0.264	0.368	0.963	1.332	1.657	—	0.00046	0.00051
2MM205WI	—	20	50	90	—	0.215	0.323	0.428	1.198	1.619	1.949	—	0.00045	0.00043
2MM206WI	—	20	50	125	—	0.219	0.323	0.498	1.272	1.733	2.320	—	0.00044	0.00073
2MM207WI	—	30	90	175	—	0.270	0.434	0.597	1.540	2.219	2.737	—	0.00068	0.00066
2MM208WI	—	30	100	200	—	0.259	0.433	0.603	1.496	2.245	2.797	—	0.00081	0.00077
2MM209WI	25	40	125	250	0.266	0.321	0.525	0.733	1.846	2.702	3.364	0.0002	0.0008	0.0008
2MM210WI	30	50	125	275	0.295	0.367	0.547	0.798	2.094	2.841	3.647	0.00025	0.00066	0.00089
2MM211WI	35	50	175	350	0.310	0.362	0.626	0.879	2.189	3.330	4.143	0.00019	0.00101	0.00093
2MM212WI	40	75	200	425	0.338	0.444	0.681	0.980	2.609	3.615	4.588	0.00038	0.00089	0.00109
2MM213WI	45	100	225	475	0.358	0.505	0.722	1.036	2.926	3.823	4.840	0.00053	0.00082	0.00114
2MM214WI	50	100	250	500	0.388	0.513	0.766	1.069	2.972	4.024	5.010	0.00044	0.00094	0.00109
2MM215WI	55	125	275	550	0.417	0.586	0.831	1.161	3.356	4.349	5.411	0.00057	0.00085	0.00111
2MM216WI	60	150	325	625	0.444	0.647	0.910	1.245	3.659	4.718	5.801	0.00067	0.0009	0.00112
2MM217WI	65	175	375	750	0.461	0.682	0.957	1.339	3.961	5.089	6.336	0.00075	0.00098	0.00131
2MM218WI	75	175	400	800	0.472	0.668	0.962	1.344	3.880	5.097	6.346	0.00071	0.0011	0.00139
2MM219WI	80	200	450	900	0.496	0.721	1.029	1.435	4.156	5.333	6.764	0.00079	0.00114	0.00146
2MM220WI	85	250	500	1,000	0.508	0.787	1.070	1.494	4.550	5.718	7.124	0.00102	0.00108	0.00156
2MM222WI	100	300	600	1,200	0.564	0.880	1.192	1.657	5.039	6.336	7.898	0.00111	0.00116	0.00169
2MM224WI	110	330	660	1,320	0.588	0.908	1.233	1.716	5.300	6.667	8.311	0.00116	0.00123	0.00179
2MM226WI	125	370	740	1,480	0.693	1.066	1.443	2.003	6.229	7.847	9.793	0.0011	0.00118	0.00172
2MM230WI	155	425	850	1,700	0.745	1.102	1.480	2.036	6.500	8.218	10.280	0.00116	0.00132	0.00194

Notes
1) For DB or DF arrangements only. For other mounting arrangements contact Timken Engineering.

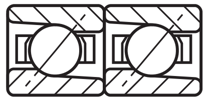
Fafnir Light
2(3)MM200WI (ISO 02) Series
Inch Duplex Performance Data

	Preload				Axial Stiffness[1]			Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	Light	Medium	Heavy	Light	Medium	Heavy	Extra Light to Light	Light to Medium	Medium to Heavy
	lbs.				10^6lbs./in.			10^6lbs./in.			in.		
3MM200WI	—	10	30	60	0.225	0.343	0.456	0.484	0.694	0.863	—	0.00028	0.00030
3MM201WI	—	10	30	60	0.256	0.386	0.508	0.538	0.777	0.969	—	0.00025	0.00027
3MM202WI	—	15	40	80	0.317	0.460	0.609	0.663	0.916	1.140	—	0.00026	0.00026
3MM203WI	—	20	75	100	0.365	0.606	0.682	0.760	1.169	1.280	—	0.00045	0.00016
3MM204WI	—	30	80	125	0.430	0.627	0.751	0.912	1.258	1.448	—	0.00038	0.00026
3MM205WI	—	35	90	150	0.510	0.733	0.902	1.084	1.478	1.738	—	0.00035	0.00029
3MM206WI	—	50	125	200	0.607	0.862	1.043	1.298	1.754	2.036	—	0.00041	0.00031
3MM207WI	30	70	175	300	0.723	1.027	1.278	1.529	2.064	2.449	0.00027	0.00048	0.00048
3MM208WI	35	80	200	300	0.758	1.074	1.263	1.576	2.131	2.424	0.00028	0.00052	0.00034
3MM209WI	40	100	250	400	0.914	1.297	1.568	1.899	2.564	2.976	0.00031	0.00054	0.00042
3MM210WI	45	110	275	450	0.993	1.409	1.719	2.059	2.780	3.249	0.00030	0.00055	0.00045
3MM211WI	50	140	350	550	1.107	1.572	1.888	2.329	3.143	3.627	0.00038	0.00062	0.00046
3MM212WI	55	170	425	650	1.222	1.736	2.061	2.573	3.473	3.974	0.00044	0.00069	0.00047
3MM213WI	60	190	475	750	1.290	1.832	2.205	2.713	3.662	4.232	0.00047	0.00073	0.00054
3MM214WI	65	200	500	800	1.323	1.878	2.272	2.818	3.806	4.417	0.00048	0.00075	0.00058
3MM215WI	80	220	550	850	1.431	2.034	2.425	3.046	4.112	4.720	0.00046	0.00076	0.00054
3MM216WI	90	250	625	1,000	1.543	2.190	2.646	3.261	4.406	5.115	0.00049	0.00080	0.00062
3MM217WI	100	270	675	1,100	1.603	2.272	2.764	3.433	4.645	5.427	0.00049	0.00083	0.00067
3MM218WI	110	300	700	1,250	1.636	2.257	2.848	3.481	4.603	5.537	0.00054	0.00082	0.00086
3MM219WI	125	350	700	1,400	1.774	2.304	3.036	3.749	4.715	5.885	0.00060	0.00068	0.00105
3MM220WI	135	390	780	1,560	1.877	2.438	3.211	3.969	4.994	6.235	0.00064	0.00072	0.00110
3MM222WI	155	460	920	1,840	2.058	2.669	3.510	4.359	5.489	6.858	0.00070	0.00078	0.00119
3MM224WI	185	505	1,010	2,020	2.160	2.802	3.682	4.607	5.802	7.249	0.00069	0.00081	0.00124
3MM226WI	220	575	1,150	2,300	2.562	3.319	4.356	5.455	6.808	8.599	0.00065	0.00078	0.00120
3MM230WI	290	700	1,400	2,800	2.708	3.501	4.580	5.774	7.297	9.138	0.00069	0.00090	0.00138

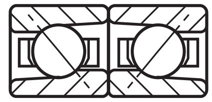
Mounting Arrangements



Recommended
DB



Tandem
DT



Special Applications
DF

	Preload				Axial Stiffness[1]				Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	Extra Light	Light	Medium	Heavy	Light	Medium	Heavy	Extra Light to Light	Light to Medium	Medium to Heavy
	N				N/µm				N/µm			µm		
2MM200WI	—	20	90	160	—	18.54	33.06	42.85	85.88	136.07	162.13	—	10.41	7.11
2MM201WI	—	20	90	160	—	19.24	34.11	44.07	96.02	153.56	183.30	—	9.91	6.86
2MM202WI	—	20	90	180	—	20.64	36.20	49.67	102.67	164.93	205.51	—	9.40	8.38
2MM203WI	—	40	130	330	—	25.54	41.10	63.84	137.12	197.46	263.05	—	10.67	15.24
2MM204WI	—	70	180	360	—	30.08	46.17	64.36	168.43	232.97	289.81	—	11.68	12.95
2MM205WI	—	90	220	400	—	37.60	56.49	74.86	209.53	283.16	340.88	—	11.43	10.92
2MM206WI	—	90	220	560	—	38.30	56.49	87.10	222.47	303.10	405.77	—	11.18	18.54
2MM207WI	—	130	400	780	—	47.22	75.91	104.42	269.35	388.10	478.70	—	17.27	16.76
2MM208WI	—	130	440	890	—	45.30	75.73	105.46	261.65	392.65	489.20	—	20.57	19.56
2MM209WI	110	180	560	1,110	46.52	56.14	91.82	128.20	322.87	472.58	588.36	5.08	20.32	20.32
2MM210WI	130	220	560	1,220	51.60	64.19	95.67	139.57	366.24	496.89	637.86	6.35	16.76	22.61
2MM211WI	160	220	780	1,560	54.22	63.31	109.49	153.74	382.86	582.42	724.61	4.83	25.65	23.62
2MM212WI	180	330	890	1,890	59.12	77.66	119.11	171.40	456.31	632.26	802.44	9.65	22.61	27.69
2MM213WI	200	440	1,000	2,110	62.61	88.32	126.28	181.20	511.76	668.64	846.52	13.46	20.83	28.96
2MM214WI	220	440	1,110	2,220	67.86	89.72	133.97	186.97	519.80	703.80	876.25	11.18	23.88	27.69
2MM215WI	240	560	1,220	2,450	72.93	102.49	145.34	203.06	586.96	760.64	946.38	14.48	21.59	28.19
2MM216WI	270	670	1,450	2,780	77.66	113.16	159.16	217.75	639.96	825.18	1,014.59	17.02	22.86	28.45
2MM217WI	290	780	1,670	3,340	80.63	119.28	167.38	234.19	692.78	890.07	1,108.17	19.05	24.89	33.27
2MM218WI	330	780	1,780	3,560	82.55	116.83	168.25	235.07	678.61	891.47	1,109.92	18.03	27.94	35.31
2MM219WI	360	890	2,000	4,000	86.75	126.10	179.97	250.98	726.88	932.74	1,183.02	20.07	28.96	37.08
2MM220WI	380	1,110	2,220	4,450	88.85	137.65	187.14	261.30	795.80	1,000.08	1,245.99	25.91	27.43	39.62
2MM222WI	440	1,330	2,670	5,340	98.64	153.91	208.48	289.81	881.32	1,108.17	1,381.36	28.19	29.46	42.93
2MM224WI	490	1,470	2,940	5,870	102.84	158.81	215.65	300.13	926.97	1,166.06	1,453.59	29.46	31.24	45.47
2MM226WI	560	1,650	3,290	6,580	121.21	186.44	252.38	350.32	1,089.45	1,372.44	1,712.80	27.94	29.97	43.69
2MM230WI	690	1,890	3,780	7,560	130.30	192.74	258.85	356.10	1,136.85	1,437.33	1,797.97	29.46	33.53	49.28

Notes
1) For DB or DF arrangements only. For other mounting arrangements contact Timken Engineering.

Fafnir Light
2(3)MM200WI (ISO 02) Series
Metric Duplex Performance Data

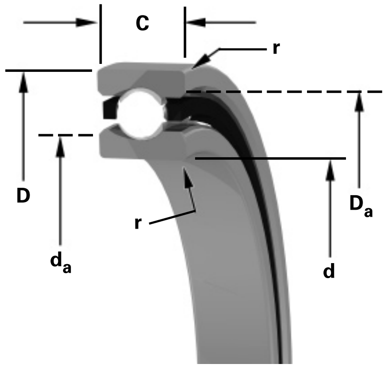
	Preload				Axial Stiffness[1]			Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	Light	Medium	Heavy	Light	Medium	Heavy	Extra Light to Light	Light to Medium	Medium to Heavy
	N				N/µm			N/µm			µm		
3MM200WI	—	40	130	270	39.35	59.99	79.75	84.65	121.38	150.94	—	7.11	7.62
3MM201WI	—	40	130	270	44.77	67.51	88.85	94.10	135.90	169.48	—	6.35	6.86
3MM202WI	—	70	180	360	55.44	80.45	106.51	115.96	160.21	199.39	—	6.60	6.60
3MM203WI	—	90	330	440	63.84	105.99	119.28	132.92	204.46	223.87	—	11.43	4.06
3MM204WI	—	130	360	560	75.21	109.66	131.35	159.51	220.02	253.26	—	9.65	6.60
3MM205WI	—	160	400	670	89.20	128.20	157.76	189.59	258.50	303.98	—	8.89	7.37
3MM206WI	—	220	560	890	106.16	150.76	182.42	227.02	306.77	356.10	—	10.41	7.87
3MM207WI	130	310	780	1,330	126.45	179.62	223.52	267.42	360.99	428.33	6.86	12.19	12.19
3MM208WI	160	360	890	1,330	132.57	187.84	220.90	275.64	372.71	423.96	7.11	13.21	8.64
3MM209WI	180	440	1,110	1,780	159.86	226.85	274.24	332.14	448.44	520.50	7.87	13.72	10.67
3MM210WI	200	490	1,220	2,000	173.68	246.43	300.65	360.12	486.22	568.25	7.62	13.97	11.43
3MM211WI	220	620	1,560	2,450	193.61	274.94	330.21	407.34	549.71	634.36	9.65	15.75	11.68
3MM212WI	240	760	1,890	2,890	213.73	303.63	360.47	450.02	607.43	695.05	11.18	17.53	11.94
3MM213WI	270	850	2,110	3,340	225.62	320.42	385.65	474.50	640.48	740.18	11.94	18.54	13.72
3MM214WI	290	890	2,220	3,560	231.39	328.46	397.37	492.87	665.67	772.53	12.19	19.05	14.73
3MM215WI	360	980	2,450	3,780	250.28	355.75	424.13	532.75	719.19	825.53	11.68	19.30	13.72
3MM216WI	400	1,110	2,780	4,450	269.87	383.03	462.79	570.35	770.61	894.61	12.45	20.32	15.75
3MM217WI	440	1,200	3,000	4,890	280.36	397.37	483.42	600.43	812.41	949.18	12.45	21.08	17.02
3MM218WI	490	1,330	3,110	5,560	286.14	394.75	498.12	608.83	805.06	968.42	13.72	20.83	21.84
3MM219WI	560	1,560	3,110	6,230	310.27	402.97	531.00	655.70	824.65	1,029.29	15.24	17.27	26.67
3MM220WI	600	1,730	3,470	6,940	328.29	426.41	561.60	694.18	873.45	1,090.50	16.26	18.29	27.94
3MM222WI	690	2,050	4,082	8,180	359.94	466.81	613.90	762.39	960.03	1,199.46	17.78	19.81	30.23
3MM224WI	820	2,250	4,480	8,980	377.78	490.07	643.98	805.76	1,014.77	1,267.85	17.53	20.57	31.50
3MM226WI	980	2,560	5,120	10,230	448.09	580.49	761.86	954.08	1,190.72	1,503.97	16.51	19.81	30.48
3MM230WI	1,290	3,110	6,230	12,450	473.63	612.32	801.04	1,009.87	1,276.25	1,598.24	17.53	22.86	35.05

	Grease Capacity		Kluber Isoflex NBU15		Operating Speeds[2] (DB Mounting)[1]					
					Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams				rpm			rpm		
2MM200WI	0.30	0.50	0.20	0.27	50,200	37,700	25,100	85,300	64,100	42,700
2MM201WI	0.40	0.60	0.25	0.33	45,400	34,000	22,200	79,100	57,800	39,400
2MM202WI	0.50	0.80	0.32	0.43	38,200	28,700	19,100	66,300	48,800	33,200
2MM203WI	0.70	1.10	0.45	0.59	33,500	25,100	16,500	58,100	42,700	29,100
2MM204WI	1.10	1.70	0.72	0.96	28,600	21,400	14,300	48,600	36,400	24,300
2MM205WI	1.30	2.10	0.88	1.18	23,800	17,900	11,900	40,500	30,400	20,200
2MM206WI	2.00	3.10	1.31	1.74	20,000	15,100	10,000	34,200	25,600	17,000
2MM207WI	2.70	4.40	1.82	2.43	17,300	13,000	8,600	29,400	22,000	14,600
2MM208WI	3.70	6.00	2.49	3.32	15,400	11,600	7,700	26,200	19,700	13,100
2MM209WI	4.20	6.60	2.77	3.70	14,000	10,500	7,000	22,800	17,900	11,900
2MM210WI	4.80	7.60	3.20	4.30	12,500	9,600	6,400	21,800	16,300	10,900
2MM211WI	6.10	9.70	4.10	5.40	11,600	8,700	5,800	19,700	14,800	9,900
2MM212WI	7.50	12.00	5.00	6.70	10,600	7,920	5,300	18,000	13,500	9,000
2MM213WI	9.20	14.60	6.10	8.10	9,700	7,260	4,800	16,500	12,300	8,200
2MM214WI	10.60	16.90	7.00	9.40	9,100	6,840	4,600	15,500	11,600	7,800
2MM215WI	11.60	18.60	7.80	10.30	8,600	6,480	4,300	14,600	11,020	7,300
2MM216WI	13.70	22.00	9.20	12.20	8,100	6,060	4,000	13,800	10,300	6,800
2MM217WI	16.90	27.10	11.30	15.10	7,500	5,640	3,800	12,800	9,590	6,500
2MM218WI	21.50	34.40	14.40	19.10	7,100	5,340	3,600	12,100	9,080	6,100
2MM219WI	25.80	41.40	17.30	23.00	6,700	5,040	3,400	11,400	8,570	5,800
2MM220WI	30.70	49.10	20.50	27.30	6,400	4,800	3,200	10,900	8,160	5,400
2MM222WI	42.30	67.60	28.20	37.60	5,800	4,320	2,900	9,900	7,340	4,900
2MM224WI	51.40	82.30	34.30	45.80	5,400	4,020	2,700	9,200	6,830	4,600
2MM226WI	50.80	81.30	33.90	45.20	4,900	3,660	2,400	8,300	6,220	4,100
2MM230WI	82.40	131.90	55.00	73.40	4,200	3,180	2,160	7,100	5,410	3,600

Notes
1) For other mounting arrangement configurations refer to Engineering chapter on Fafnir Permissible Speed calculation methods.
2) For ceramic ball complements use 120% of speeds shown.

Fafnir Light
2(3)MM200WI (ISO 02) Series
Speed Capability

	Grease Capacity		Kluber Isoflex NBU15		Operating Speeds[2] (DB Mounting)					
					Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams				rpm			rpm		
3MM200WI	0.30	0.50	0.20	0.27	45,180	33,930	22,590	76,770	57,690	38,430
3MM201WI	0.40	0.60	0.25	0.33	40,860	30,600	19,980	71,190	52,020	35,460
3MM202WI	0.50	0.80	0.32	0.43	34,380	25,830	17,190	59,670	43,920	29,880
3MM203WI	0.70	1.10	0.45	0.59	30,150	22,590	14,850	52,290	38,430	26,190
3MM204WI	1.10	1.70	0.72	0.96	25,740	19,260	12,870	43,740	32,760	21,870
3MM205WI	1.30	2.10	0.88	1.18	21,420	16,110	10,710	36,450	27,360	18,180
3MM206WI	2.00	3.10	1.31	1.74	18,000	13,590	9,000	30,780	23,040	15,300
3MM207WI	2.70	4.40	1.82	2.43	15,570	11,700	7,740	26,460	19,800	13,140
3MM208WI	3.70	6.00	2.49	3.32	13,860	10,440	6,930	23,580	17,730	11,790
3MM209WI	4.20	6.60	2.77	3.70	12,600	9,450	6,300	20,520	16,110	10,710
3MM210WI	4.80	7.60	3.20	4.30	11,250	8,640	5,760	19,620	14,670	9,810
3MM211WI	6.10	9.70	4.10	5.40	10,440	7,830	5,220	17,730	13,320	8,910
3MM212WI	7.50	12.00	5.00	6.70	9,540	7,128	4,770	16,200	12,150	8,100
3MM213WI	9.20	14.60	6.10	8.10	8,730	6,534	4,320	14,850	11,070	7,380
3MM214WI	10.60	16.90	7.00	9.40	8,190	6,156	4,140	13,950	10,440	7,020
3MM215WI	11.60	18.60	7.80	10.30	7,740	5,832	3,870	13,140	9,918	6,570
3MM216WI	13.70	22.00	9.20	12.20	7,290	5,454	3,600	12,420	9,270	6,120
3MM217WI	16.90	27.10	11.30	15.10	6,750	5,076	3,420	11,520	8,631	5,850
3MM218WI	21.50	34.40	14.40	19.10	6,390	4,806	3,240	10,890	8,172	5,490
3MM219WI	25.80	41.40	17.30	23.00	6,030	4,536	3,060	10,260	7,713	5,220
3MM220WI	30.70	49.10	20.50	27.30	5,760	4,320	2,880	9,810	7,344	4,860
3MM222WI	42.30	67.60	28.20	37.60	5,220	3,888	2,610	8,910	6,606	4,410
3MM224WI	51.40	82.30	34.30	45.80	4,860	3,618	2,430	8,280	6,147	4,140
3MM226WI	50.80	81.30	33.90	45.20	4,410	3,294	2,160	7,470	5,598	3,690
3MM230WI	82.40	131.90	55.00	73.40	3,780	2,862	1,944	6,390	4,869	3,240



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

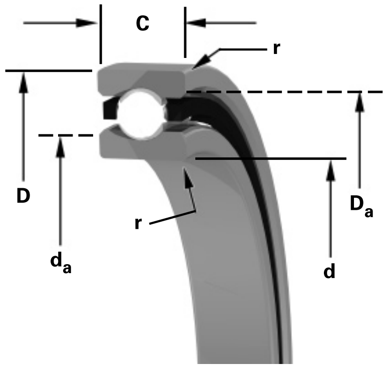
Conrad Construction:
- Maximum complement of balls separated by two piece land piloted cage.

						Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width	Ball x Dia. Qty. (in.)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[1]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	in/tol: +0; -.000(X)				lbs.	lbs.		rpm	in.	in.			
MM201K	0.4724 (1.5)	1.2598 (2.5)	0.394 (31)	7 x 15/64	0.08	680 *610*	1,700 *1,700*	52,200 *62,600*	0.024	0.66	0.65	1.11	1.10
MM202K	0.5906 (1.5)	1.378 (2.5)	0.4331 (31)	8 x 15/64	0.09	830 *740*	1,900 *1,900*	44,000 *52,800*	0.024	0.76	0.75	1.23	1.22
MM203K	0.6693 (1.5)	1.5748 (2.5)	0.4724 (31)	8 x 17/64	0.14	1,060 *950*	2,380 *2,380*	38,500 *46,200*	0.024	0.86	0.85	1.41	1.40
MM204K	0.7874 (2)	1.8504 (2.5)	0.5512 (47)	8 x 5/16	0.22	1,460 *1,320*	3,190 *3,190*	32,800 *39,400*	0.039	1.03	1.02	1.64	1.63
MM205K	0.9843 (2)	2.0472 (3)	0.5906 (47)	9 x 5/16	0.27	1,760 *1,570*	3,490 *3,490*	27,400 *32,900*	0.039	1.23	1.22	1.86	1.85
MM206K	1.1811 (2)	2.4409 (3)	0.6299 (47)	9 x 3/8	0.41	2,550 *2.250*	4,850 *4,850*	23,000 *27,600*	0.039	1.45	1.44	2.21	2.20
MM207K	1.378 (2.5)	2.8346 (3)	0.6693 (47)	9 x 7/16	0.59	3,450 *3,060*	6,400 *6,400*	19,800 *23,800*	0.039	1.68	1.66	2.57	2.55
MM208K	1.5748 (2.5)	3.1496 (3)	0.7087 (47)	9 x 1/2	0.74	4,500 *3,970*	8,130 *8,130*	17,700 *21,200*	0.039	1.88	1.86	2.88	2.86
MM209K	1.7717 (2.5)	3.3465 (3)	0.748 (47)	9 x 1/2	0.83	4,550 *4,090*	8,160 *8,160*	16,000 *19,200*	0.039	2.08	2.06	3.08	3.06
MM210K	1.9685 (2.5)	3.5433 (3)	0.7874 (47)	10 x 1/2	0.94	5,200 *4,640*	8,740 *8,740*	14,600 *17,500*	0.039	2.28	2.26	3.28	3.26
MM211K	2.1654 (3)	3.937 (3)	0.8268 (59)	10 x 9/16	1.24	6,550 *5,850*	10,800 *10,800*	13,300 *16,000*	0.059	2.51	2.49	3.63	3.61
MM212K	2.3622 (3)	4.3307 (3)	0.8661 (59)	10 x 5/8	1.60	8,150 *7,190*	13,100 *13,100*	12,100 *14,500*	0.059	2.75	2.73	3.99	3.97
MM213K	2.5591 (3)	4.7244 (3)	0.9055 (59)	10 x 21/32	2.05	9,000 *8,000*	14,300 *14,300*	11,100 *13,300*	0.059	3.00	2.98	4.32	4.30
MM214K	2.7559 (3)	4.9213 (3.5)	0.9449 (59)	10 x 11/16	2.19	9,800 *8,800*	15,500 *15,500*	10,500 *12,600*	0.059	3.18	3.16	4.56	4.54
MM215K	2.9528 (3)	5.1181 (3.5)	0.9843 (59)	10 x 11/16	2.37	10,000 *8,960*	15,500 *15,500*	9,900 *11,900*	0.059	3.39	3.36	4.76	4.73
MM216K	3.1496 (3)	5.5118 (3.5)	1.0236 (59)	10 x 3/4	2.90	12,000 *10,600*	18,100 *18,100*	9,200 *11,000*	0.079	3.60	3.57	5.12	5.09

Notes
1) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Light
MM200K (ISO 02) Series
Inch Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
0.4722	0.4724	0.0002	0.00015	1.2598	1.2600	0.0000	0.00045	1.26020	1.26000	0.00070	0.00020	**MM201K**
0.5904	0.5906	0.0002	0.00015	1.3780	1.3783	0.0000	0.0005	1.37840	1.37820	0.00070	0.00020	**MM202K**
0.6691	0.6693	0.0002	0.00015	1.5748	1.5751	0.0000	0.0005	1.57520	1.57500	0.00070	0.00020	**MM203K**
0.7872	0.7874	0.0002	0.0002	1.8504	1.8507	0.0000	0.0005	1.85090	1.85070	0.00080	0.00030	**MM204K**
0.9841	0.9843	0.0002	0.0002	2.0472	2.0475	0.0000	0.00055	2.04770	2.04750	0.00080	0.00030	**MM205K**
1.1809	1.1811	0.0002	0.0002	2.4409	2.4412	0.0000	0.0006	2.44140	2.44120	0.00080	0.00030	**MM206K**
1.3778	1.3780	0.0002	0.00025	2.8346	2.8349	0.0000	0.0006	2.83510	2.83490	0.00080	0.00030	**MM207K**
1.5746	1.5748	0.0002	0.00025	3.1496	3.1499	0.0000	0.0006	3.15010	3.14990	0.00080	0.00030	**MM208K**
1.7715	1.7717	0.0002	0.00025	3.3465	3.3468	0.0000	0.0006	3.34710	3.34680	0.00090	0.00030	**MM209K**
1.9683	1.9685	0.0002	0.00025	3.5433	3.5436	0.0000	0.0006	3.54390	3.54360	0.00090	0.00030	**MM210K**
2.1652	2.1654	0.0002	0.0003	3.9370	3.9373	0.0000	0.0006	3.93770	3.93740	0.00100	0.00040	**MM211K**
2.3620	2.3622	0.0002	0.0003	4.3307	4.3310	0.0000	0.0006	4.33140	4.33110	0.00100	0.00040	**MM212K**
2.5589	2.5591	0.0002	0.0003	4.7244	4.7247	0.0000	0.0006	4.72510	4.72480	0.00100	0.00040	**MM213K**
2.7557	2.7559	0.0002	0.0003	4.9213	4.9216	0.0000	0.0007	4.92210	4.92170	0.00120	0.00040	**MM214K**
2.9526	2.9530	0.0002	0.0005	5.1181	5.1185	0.0000	0.0007	5.11890	5.11850	0.00110	0.00040	**MM215K**
3.1494	3.1498	0.0002	0.0005	5.5118	5.5122	0.0000	0.0007	5.51260	5.51220	0.00110	0.00040	**MM216K**



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

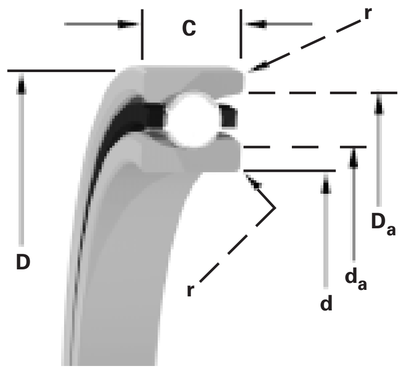
Conrad Construction:
- Maximum complement of balls separated by two piece land piloted cage.

						Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width	Ball x Dia. Qty. (mm)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[1]	d_a (Shaft) max.	 min.	D_a (Housing) max.	 min.
	mm/tol: +0; -(µm)				kg.	N		rpm	mm	mm			
MM201K	12 (4)	32 (6)	10 (80)	7 x 5.95	0.035	3,000 *2,710*	7,550 *7,550*	52,200 *62,600*	0.6	16.6	16.4	28.1	27.8
MM202K	15 (4)	35 (6)	11 (80)	8 x 5.95	0.043	3,700 *3,290*	8,450 *8,450*	44,000 *52,800*	0.6	19.2	18.9	31.1	30.9
MM203K	17 (4)	40 (6)	12 (80)	8 x 6.75	0.062	4,700 *4,230*	10,600 *10,600*	38,500 *46,200*	0.6	21.7	21.5	35.7	35.4
MM204K	20 (5)	47 (6)	14 (130)	8 x 7.94	0.1	6,500 *5,860*	14,200 *14,200*	32,800 *39,400*	1	26	25.8	41.5	41.3
MM205K	25 (5)	52 (7)	15 (130)	9 x 7.94	0.122	7,800 *6,980*	15,500 *15,500*	27,400 *32,900*	1	31.1	30.9	47.1	46.9
MM206K	30 (5)	62 (7)	16 (130)	9 x 9.53	0.185	11,300 *10,000*	21,600 *21,600*	23,000 *27,600*	1	36.7	36.5	56	55.8
MM207K	35 (6)	72 (7)	17 (130)	9 x 11.11	0.267	15,300 *13,600*	28,500 *28,500*	19,800 *23,800*	1	42.7	42.2	65.3	64.8
MM208K	40 (6)	80 (7)	18 (130)	9 x 12.70	0.337	20,000 *17,700*	36,200 *36,200*	17,700 *21,200*	1	47.8	47.2	73.2	72.6
MM209K	45 (6)	85 (8)	19 (130)	9 x 12.70	0.377	20,200 *18,200*	36,300 *36,300*	16,000 *19,200*	1	52.8	52.3	78.2	77.7
MM210K	50 (6)	90 (8)	20 (130)	10 x 12.70	0.425	23,100 *20,600*	38,900 *38,900*	14,600 *17,500*	1	57.9	57.4	83.3	82.8
MM211K	55 (7)	100 (8)	21 (150)	10 x 14.29	0.564	29,100 *26,000*	48,100 *48,100*	13,300 *16,000*	1.5	63.8	63.3	92.2	91.7
MM212K	60 (7)	110 (8)	22 (150)	10 x 15.88	0.727	36,300 *32,000*	58,200 *58,200*	12,100 *14,500*	1.5	69.9	69.3	101.4	100.8
MM213K	65 (7)	120 (8)	23 (150)	10 x 16.67	0.928	40,000 *35,600*	63,400 *63,400*	11,100 *13,300*	1.5	76.2	75.7	109.7	109.2
MM214K	70 (7)	125 (9)	24 (150)	10 x 17.46	0.994	43,600 *39,200*	69,000 *69,000*	10,500 *12,600*	1.5	80.8	80.3	115.8	115.3
MM215K	75 (7)	130 (9)	25 (150)	10 x 17.46	1.074	44,500 *39,900*	68,900 *68,900*	9,900 *11,900*	1.5	86	85.2	120.8	120
MM216K	80 (7)	140 (9)	26 (150)	10 x 19.05	1.317	53,400 *47,200*	80,600 *80,600*	9,200 *11,000*	2	91.3	90.6	129.9	129.2

Notes
1) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Light
MM200K (ISO 02) Series
Metric Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
11.9950	12.000	0.005	0.004	32	32.005	0.000	0.011	32.010	32.005	0.016	0.005	**MM201K**
14.9950	15.000	0.005	0.004	35	35.006	0.000	0.012	35.010	35.005	0.016	0.005	**MM202K**
16.9950	17.000	0.005	0.004	40	40.006	0.000	0.012	40.010	40.005	0.016	0.005	**MM203K**
19.9950	20.000	0.005	0.005	47	47.006	0.000	0.012	47.012	47.007	0.018	0.007	**MM204K**
24.9950	25.000	0.005	0.005	52	52.006	0.000	0.013	52.012	52.007	0.019	0.007	**MM205K**
29.9950	30.000	0.005	0.005	62	62.008	0.000	0.015	62.012	62.007	0.019	0.007	**MM206K**
34.9950	35.000	0.005	0.006	72	72.008	0.000	0.015	72.011	72.007	0.019	0.007	**MM207K**
39.9950	40.000	0.005	0.006	80	80.008	0.000	0.015	80.012	80.008	0.020	0.008	**MM208K**
44.9950	45.000	0.005	0.006	85	85.008	0.000	0.016	85.016	85.009	0.024	0.009	**MM209K**
49.9950	50.000	0.005	0.006	90	90.008	0.000	0.016	90.015	90.007	0.023	0.007	**MM210K**
54.9950	55.000	0.005	0.007	100	100.008	0.000	0.016	100.018	100.010	0.025	0.010	**MM211K**
59.9950	60.000	0.005	0.007	110	110.008	0.000	0.016	110.018	110.010	0.025	0.010	**MM212K**
64.9950	65.000	0.005	0.007	120	120.008	0.000	0.016	120.018	120.010	0.025	0.010	**MM213K**
69.9950	70.000	0.005	0.007	125	125.008	0.000	0.017	125.021	125.011	0.030	0.011	**MM214K**
74.9950	75.005	0.005	0.012	130	130.009	0.000	0.018	130.020	130.010	0.029	0.010	**MM215K**
79.9950	80.005	0.005	0.012	140	140.009	0.000	0.018	140.020	140.010	0.029	0.010	**MM216K**



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

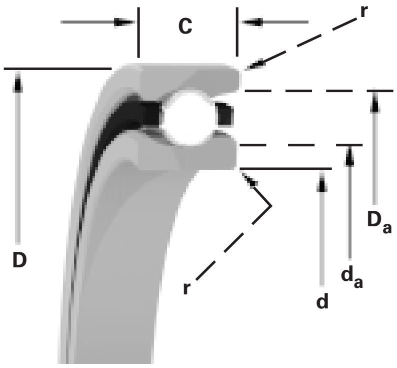
WI Construction:
- Incorporates low shoulder on non-thrust side of outer rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (in.)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	d_a (Shaft) min.	D_a (Housing) max.	D_a (Housing) min.
	in/tol: +0; -.000(X)				lbs	lbs.		rpm	lbs.		rpm	in.	in.			
301WI	0.4724 (1.5)	1.4567 (2.5)	0.4724 (31)	8 x 9/32	0.13	1,060 *950*	2,450 *2,450*	47,600 *57,100*	1,040 *920*	2,450 *2,450*	42,800 *51,400*	0.039	0.7	0.69	1.27	1.26
302WI	0.5906 (1.5)	1.6535 (2.5)	0.5118 (31)	10 x 17/64	0.19	1,320 *1,160*	2,700 *2,700*	38,100 *45,700*	1,270 *1,120*	2,600 *2,600*	34,300 *41,200*	0.039	0.88	0.87	1.41	1.4
303WI	0.6693 (1.5)	1.8504 (2.5)	0.5512 (31)	7 x 3/8	0.23	1,630 *1,460*	3,900 *3,900*	36,800 *44,100*	1,600 *1,420*	3,690 *3,690*	33,100 *39,700*	0.039	0.9	0.89	1.66	1.65
304WI	0.7874 (2)	2.0472 (3)	0.5906 (47)	8 x 13/32	0.30	2,200 *2,000*	4,840 *4,840*	32,200 *38,600*	2,160 *1,930*	4,700 *4,700*	29,000 *34,800*	0.039	1.19	1.18	1.84	1.83
305WI	0.9843 (2)	2.4409 (3)	0.6693 (47)	9 x 15/32	0.49	3,450 *3,060*	6,850 *6,850*	26,200 *31,400*	3,350 *2,970*	6,630 *6,630*	23,600 *28,300*	0.039	1.27	1.26	2.2	2.19
306WI	1.1811 (2)	2.8346 (3)	0.7480 (47)	10 x 17/32	0.72	4,990 *4,440*	9,270 *9,270*	22,100 *26,500*	4,820 *4,290*	8,960 *8,960*	19,900 *23,900*	0.039	1.49	1.48	2.57	2.56
307WI	1.3780 (2.5)	3.1496 (3)	0.8268 (47)	10 x 9/16	0.98	5,700 *5,130*	10,400 *10,400*	19,200 *23,000*	5,600 *4,940*	10,000 *10,000*	17,300 *20,800*	0.059	1.72	1.7	2.84	2.82
308WI	1.5748 (2.5)	3.5433 (3)	0.9055 (47)	11 x 5/8	1.34	7,800 *7,010*	13,400 *13,400*	16,900 *20,300*	7,600 *6,770*	12,900 *12,900*	15,200 *18,200*	0.059	1.96	1.94	3.2	3.18
309WI	1.7717 (2.5)	3.9370 (3)	0.9843 (47)	10 x 11/16	1.78	8,650 *7,750*	15,000 *15,000*	15,100 *18,100*	8,500 *7,480*	14,400 *14,400*	13,600 *16,300*	0.059	2.2	2.18	3.55	3.53
310WI	1.9685 (2.5)	4.3307 (3)	1.0630 (47)	10 x 3/4	2.31	10,400 *9,250*	17,500 *17,500*	13,600 *16,300*	10,000 *8,940*	16,900 *16,900*	12,200 *14,600*	0.079	2.41	2.39	3.93	3.91
311WI	2.1654 (3)	4.7244 (3)	1.1417 (59)	10 x 13/16	2.94	12,200 *10,900*	20,300 *20,300*	12,400 *14,900*	11,800 *10,500*	19,500 *19,500*	11,200 *13,400*	0.079	2.65	2.63	4.28	4.26
312WI	2.3622 (3)	5.1181 (3.5)	1.2205 (59)	10 x 7/8	3.67	14,300 *12,700*	23,200 *23,200*	11,400 *13,700*	13,700 *12,200*	22,300 *22,300*	10,300 *12,400*	0.079	2.88	2.86	4.64	4.62
313WI	2.5591 (3)	5.5118 (3.5)	1.2992 (59)	11 x 15/16	4.63	18,000 *16,100*	28,000 *28,000*	10,500 *12,600*	17,300 *15,500*	26,900 *26,900*	9,500 *11,400*	0.079	3.16	3.14	4.99	4.97
314WI	2.7559 (3)	5.9055 (3.5)	1.3780 (59)	11 x 1	5.62	20,800 *18,400*	31,500 *31,500*	9,800 *11,800*	20,000 *17,700*	30,200 *30,200*	8,800 *10,600*	0.079	3.36	3.34	5.34	5.32

Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Medium
2(3)MM300WI (ISO 03) Series
Inch Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
0.4722	0.4724	0.0002	0.00015	1.4567	1.4570	0.0000	0.0005	1.45710	1.45690	0.00070	0.00020	**301WI**
0.5904	0.5906	0.0002	0.00015	1.6535	1.6538	0.0000	0.0005	1.65390	1.65370	0.00070	0.00020	**302WI**
0.6691	0.6693	0.0002	0.00015	1.8504	1.8507	0.0000	0.0005	1.85090	1.85070	0.00080	0.00030	**303WI**
0.7872	0.7874	0.0002	0.00020	2.0472	2.0475	0.0000	0.00055	2.04770	2.04750	0.00080	0.00030	**304WI**
0.9841	0.9843	0.0002	0.00020	2.4409	2.4412	0.0000	0.0006	2.44140	2.44120	0.00080	0.00030	**305WI**
1.1809	1.1811	0.0002	0.00020	2.8346	2.8349	0.0000	0.0006	2.83510	2.83490	0.00080	0.00030	**306WI**
1.3778	1.3780	0.0002	0.00025	3.1496	3.1499	0.0000	0.0006	3.15010	3.14990	0.00080	0.00030	**307WI**
1.5746	1.5748	0.0002	0.00025	3.5433	3.5436	0.0000	0.0006	3.54390	3.54360	0.00090	0.00030	**308WI**
1.7715	1.7717	0.0002	0.00025	3.9370	3.9373	0.0000	0.0006	3.93770	3.93740	0.00100	0.00040	**309WI**
1.9683	1.9685	0.0002	0.00025	4.3307	4.3310	0.0000	0.0006	4.33140	4.33110	0.00100	0.00040	**310WI**
2.1652	2.1654	0.0002	0.00030	4.7244	4.7247	0.0000	0.0006	4.72510	4.72480	0.00100	0.00040	**311WI**
2.3620	2.3622	0.0002	0.00030	5.1181	5.1185	0.0000	0.0007	5.11890	5.11850	0.00110	0.00040	**312WI**
2.5589	2.5591	0.0002	0.00030	5.5118	5.5122	0.0000	0.0007	5.51260	5.51220	0.00110	0.00040	**313WI**
2.7557	2.7559	0.0002	0.00030	5.9055	5.9059	0.0000	0.0007	5.90640	5.90600	0.00120	0.00050	**314WI**



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

WI Construction:
- Incorporates low shoulder on non-thrust side of outer rings.
- Maximum complement of balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

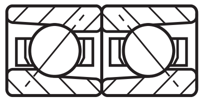
						(2MM) Load Ratings (steel ball & *ceramic ball*)			(3MM) Load Ratings (steel ball & *ceramic ball*)				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Ball x Dia. Qty. (mm)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[2]	d_a (Shaft) max.	d_a (Shaft) min.	D_a (Housing) max.	D_a (Housing) min.
	mm/tol: +0; -(µm)				kg.	N		rpm	N		rpm	mm	mm			
301WI	12 (4)	37 (6)	12 (80)	8 x 7.14	0.061	4,700 *4,230*	11,000 *11,000*	47,600 *57,100*	4,600 *4,060*	10,900 *10,900*	42,800 *51,400*	1	17.7	17.4	32.1	31.9
302WI	15 (4)	42 (6)	13 (80)	10 x 6.75	0.087	5,810 *5,170*	12,900 *12,900*	38,100 *45,700*	5,600 *5,000*	11,600 *11,600*	34,300 *41,200*	1	22.2	22.0	35.7	35.4
303WI	17 (4)	47 (6)	14 (80)	7 x 9.53	0.104	7,280 *6,480*	16,900 *16,900*	36,800 *44,200*	7,100 *6,300*	16,400 *16,400*	33,100 *39,700*	1	22.7	22.5	42.0	41.8
304WI	20 (5)	52 (7)	15 (120)	8 x 10.32	0.137	10,000 *8,900*	21,500 *21,500*	32,200 *38,600*	9,650 *8,590*	20,900 *20,900*	29,000 *34,800*	1	30.1	29.9	46.6	46.4
305WI	25 (5)	62 (7)	17 (120)	9 x 11.91	0.221	15,300 *13,600*	30,500 *30,500*	26,200 *31,400*	14,800 *13,200*	29,500 *29,500*	23,600 *28,300*	1	32.1	31.9	55.8	55.5
306WI	30 (5)	72 (7)	19 (120)	10 x 13.49	0.328	22,200 *19,800*	34,120 *34,120*	22,100 *26,500*	21,500 *19,100*	39,900 *39,900*	19,900 *23,900*	1	37.7	37.5	65.2	64.9
307WI	35 (6)	80 (7)	21 (120)	10 x 14.29	0.443	25,600 *22,800*	46,200 *46,200*	19,200 *23,000*	24,700 *22,000*	44,500 *44,500*	17,300 *20,800*	1.5	43.7	43.2	72.1	71.6
308WI	40 (6)	90 (8)	23 (120)	11 x 15.88	0.608	35,000 *31,200*	59,700 *59,700*	16,900 *20,300*	38,900 *30,100*	57,500 *57,500*	15,200 *18,200*	1.5	49.8	49.3	81.3	80.8
309WI	45 (6)	100 (8)	25 (120)	10 x 17.46	0.809	38,700 *34,500*	66,500 *66,500*	15,100 *18,100*	37,400 *33,300*	64,100 *64,100*	13,600 *16,300*	1.5	55.9	55.4	90.2	89.7
310WI	50 (6)	110 (8)	27 (120)	10 x 19.05	1.046	46,200 *41,200*	77,900 *77,900*	13,600 *16,300*	44,700 *39,800*	75,100 *75,100*	12,200 *14,600*	2	61.2	60.7	99.8	99.3
311WI	55 (7)	120 (8)	29 (150)	10 x 20.64	1.332	54,600 *48,600*	90,200 *90,200*	12,400 *14,900*	52,600 *46,800*	86,700 *86,700*	11,200 *13,400*	2	67.3	66.8	108.7	108.2
312WI	60 (7)	130 (9)	31 (150)	10 x 22.23	1.665	63,500 *56,600*	103,100 *103,100*	11,400 *13,700*	61,100 *54,400*	99,100 *99,100*	10,300 *12,400*	2	43.2	72.6	117.9	117.3
313WI	65 (7)	140 (9)	33 (150)	11 x 23.81	2.101	80,500 *71,700*	124,400 *124,400*	10,500 *12,600*	77,400 *68,900*	119,700 *119,700*	9,500 *11,400*	2	80.3	79.8	126.8	126.2
314WI	70 (7)	150 (9)	35 (150)	11 x 25.40	2.548	91,900 *81,800*	139,900 *139,900*	9,800 *11,800*	88,300 *78,500*	134,500 *134,500*	8,800 *10,600*	2	85.3	84.8	135.6	135.1

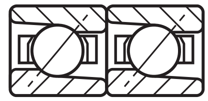
Notes
1) Width tolerance of preloaded bearing (set):+0/-0.25mm. (Refer to Engineering chapter for width tolerance of preloaded duplex sets.)
2) ABMA Std. 20 ($r_{as\ max}$)

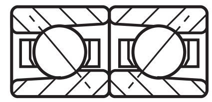
Fafnir Medium
2(3)MM300WI (ISO 03) Series
Metric Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
11.995	12.000	0.005	0.004	37.000	37.006	0.000	0.012	37.010	37.005	0.016	0.005	**301WI**
14.995	15.000	0.005	0.004	42.000	42.006	0.000	0.012	42.010	42.005	0.016	0.005	**302WI**
16.995	17.000	0.005	0.004	47.000	47.006	0.000	0.012	47.012	47.007	0.018	0.007	**303WI**
19.995	20.000	0.005	0.005	52.000	52.006	0.000	0.013	52.012	52.007	0.019	0.007	**304WI**
24.995	25.000	0.005	0.005	62.000	62.008	0.000	0.015	62.012	62.007	0.019	0.007	**305WI**
29.995	30.000	0.005	0.005	72.000	72.008	0.000	0.015	72.011	72.007	0.019	0.007	**306WI**
34.995	35.000	0.005	0.006	80.000	80.008	0.000	0.015	80.012	80.008	0.020	0.008	**307WI**
39.995	40.000	0.005	0.006	90.000	90.008	0.000	0.016	90.015	90.007	0.023	0.007	**308WI**
44.995	45.000	0.005	0.006	100.000	100.008	0.000	0.016	100.018	100.010	0.025	0.010	**309WI**
49.995	50.000	0.005	0.006	110.000	110.008	0.000	0.016	110.018	110.010	0.025	0.010	**310WI**
54.995	55.000	0.005	0.007	120.000	120.008	0.000	0.016	120.018	120.010	0.025	0.010	**311WI**
59.995	60.000	0.005	0.007	130.000	130.009	0.000	0.018	130.020	130.010	0.029	0.010	**312WI**
64.995	65.000	0.005	0.007	140.000	140.009	0.000	0.018	140.020	140.010	0.029	0.010	**313WI**
69.995	70.000	0.005	0.007	150.000	150.009	0.000	0.018	150.023	150.012	0.032	0.012	**314WI**

Mounting Arrangements


Recommended
DB


Tandem
DT


Special Application
DF

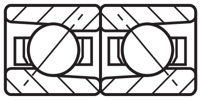
	Preload				Axial Stiffness[1]				Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	Extra Light	Light	Medium	Heavy	Light	Medium	Heavy	Extra Light to Light	Light to Medium	Medium to Heavy
	N				N/µm				N/µm			µm		
2MM301WI	—	20	70	180	—	17.49	27.81	44.25	98.82	153.56	183.30	—	7.87	12.45
2MM302WI	20	40	110	220	—	27.46	40.93	57.19	143.24	164.93	205.51	—	7.87	9.14
2MM303WI	40	70	160	310	—	26.58	38.83	54.57	147.44	197.46	263.05	—	10.92	13.46
2MM304WI	40	90	220	400	—	33.06	49.85	66.46	181.72	232.97	289.81	—	12.95	121.92
2MM305WI	90	160	330	620	—	46.17	65.24	88.50	247.83	283.16	340.88	—	12.70	14.99
2MM306WI	90	180	440	780	—	49.50	74.68	98.47	271.27	303.10	405.77	—	17.27	15.49
2MM307WI	110	220	560	1000	—	55.97	85.18	114.38	323.91	388.10	478.70	—	18.80	17.78
2MM308WI	130	290	670	1220	—	64.71	94.62	127.85	364.67	392.65	489.20	—	19.05	20.07
2MM309WI	180	330	780	1560	—	70.13	103.02	145.17	393.18	472.58	588.36	—	20.57	25.15
2MM310WI	220	440	1000	1780	—	81.15	117.36	156.01	366.24	496.89	637.86	—	22.35	22.86
2MM311WI	270	560	1110	2110	—	88.15	121.38	167.20	382.86	582.42	724.61	—	21.34	27.69
2MM312WI	270	560	1330	2450	—	89.72	133.80	180.85	456.31	632.26	802.44	—	27.94	28.19
2MM313WI	330	670	1670	3000	—	104.24	157.93	211.28	511.76	668.64	846.52	—	30.48	28.96
2MM314WI	400	780	1890	3450	—	110.89	166.33	224.22	519.80	703.80	876.25	—	32.26	32.00
2MM319WI	670	1330	3110	6230	—	140.44	206.03	290.33	726.88	932.74	1183.02	—	10.16	14.99

Notes
1) For DB or DF arrangements only. For other mounting arrangements contact Timken Engineering.

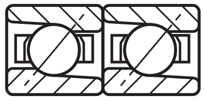
Fafnir Medium
2(3)MM300WI (ISO 03) Series
Metric Duplex Performance Data

	Preload				Axial Stiffness[1]				Radial Stiffness[1]			Spacer Offsets[1]		
	DUX	DUL	DUM	DUH	X-light	Light	Medium	Heavy	Light	Medium	Heavy	X-Light to light	Light to Medium	Medium to Heavy
	N				N/µm				N/µm			µm		
3MM301WI	40	90	180	310	—	58.59	76.61	96.37	94.10	135.90	169.48	—	5.33	6.10
3MM302WI	40	90	180	360	—	66.46	86.75	115.08	115.96	160.21	199.39	—	4.57	7.11
3MM303WI	40	110	270	440	—	63.66	89.02	109.49	132.92	204.46	223.87	—	8.13	7.11
3MM304WI	90	160	360	620	—	79.23	108.96	136.77	159.51	220.02	253.26	—	8.38	8.64
3MM305WI	110	220	530	890	—	101.62	142.19	174.90	189.59	258.50	303.98	—	10.16	8.89
3MM306WI	135	270	670	1110	—	112.29	159.33	196.06	227.02	306.77	356.10	—	11.68	9.91
3MM307WI	180	360	850	1560	—	134.85	187.84	241.01	267.42	360.99	428.33	—	12.19	13.21
3MM308WI	220	440	1110	1780	—	150.41	214.08	259.20	275.64	372.71	423.96	—	14.48	11.18
3MM309WI	270	530	1330	2220	—	165.98	235.94	290.51	332.14	448.44	520.50	—	15.75	13.46
3MM310WI	310	620	1560	2670	—	178.75	254.13	316.57	360.12	486.22	568.25	—	17.27	15.49
3MM311WI	400	780	1780	3110	—	198.16	272.32	342.10	407.34	549.71	634.36	—	17.02	17.27
3MM312WI	450	890	2000	3560	—	213.38	291.21	367.81	450.02	607.43	695.05	—	17.53	18.80
3MM313WI	560	1110	2670	4450	—	249.23	348.93	429.55	474.50	640.48	740.18	—	20.83	18.29
3MM314WI	620	1220	2890	5120	—	262.52	365.02	460.34	492.87	665.67	772.53	—	21.08	21.59
3MM319WI	1,070	2110	4890	8900	—	328.81	453.52	578.22	655.70	824.65	1029.29	—	28.19	30.99

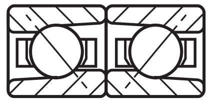
Mounting Arrangements



Recommended
DB



Tandem
DT



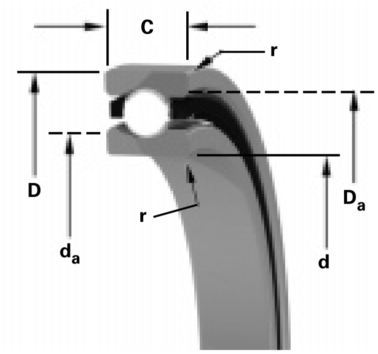
Special Application
DF

	Grease Capacity		Kluber Isoflex NBU15		Operating Speeds[2] (DB Mounting)[1]					
					Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams				rpm			rpm		
2MM301WI	0.6	1.0	0.40	0.53	35,700	28,600	19,000	60,700	48,600	32,400
2MM302WI	0.7	1.2	0.49	0.65	28,600	22,900	15,200	48,600	38,900	25,900
2MM303WI	1.2	2.0	0.83	1.10	27,600	22,100	14,700	46,900	37,500	25,000
2MM304WI	1.5	2.5	1.03	1.38	24,200	19,300	12,900	41,100	32,800	21,900
2MM305WI	2.3	3.8	1.57	2.09	19,700	15,700	10,500	33,400	26,700	17,800
2MM306WI	3.5	5.6	2.35	3.14	16,600	13,300	8,800	28,200	22,500	15,000
2MM307WI	4.6	7.4	3.07	4.10	14,400	11,500	7,700	24,500	19,600	13,100
2MM308WI	6.4	10.2	4.25	5.66	12,700	10,100	6,800	21,500	17,200	11,500
2MM309WI	8.5	13.6	5.68	7.58	11,300	9,100	6,000	19,300	15,400	10,300
2MM310WI	11.1	17.8	7.40	9.90	10,200	8,200	5,400	17,300	13,900	9,200
2MM311WI	14.2	22.7	9.50	12.60	9,300	7,400	5,000	15,800	12,600	8,400
2MM312WI	17.7	28.3	11.80	15.80	8,600	6,800	4,600	14,500	11,600	7,800
2MM313WI	20.7	33.2	13.80	18.50	7,900	6,300	4,200	13,400	10,700	7,100
2MM314WI	25.2	40.3	16.80	22.40	7,400	5,900	3,900	12,500	10,000	6,700
2MM319WI	60.9	97.4	40.60	54.10	5,600	4,400	3,000	9,400	7,500	5,000

Notes
1) For other mounting arrangement configurations refer to Engineering chapter on Fafnir Permissible Speed calculation methods.
2) For ceramic ball complements use 120% of speeds shown.

Fafnir Medium
2(3)MM300WI (ISO 03) Series
Speed Capability

	Grease Capacity		Kluber Isoflex NBU15		Operating Speeds[2] (DB Mounting)					
					Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams				rpm			rpm		
3MM301WI	0.6	1.0	0.40	0.53	32,130	25,740	17,100	54,630	43,740	29,160
3MM302WI	0.7	1.2	0.49	0.65	25,740	20,610	13,680	43,740	35,010	23,310
3MM303WI	1.2	2.0	0.83	1.10	24,840	19,890	13,230	42,210	33,750	22,500
3MM304WI	1.5	2.5	1.03	1.38	21,780	17,370	11,610	36,990	29,520	19,710
3MM305WI	2.3	3.8	1.57	2.09	17,730	14,130	9,450	30,060	24,030	16,020
3MM306WI	3.5	5.6	2.35	3.14	14,940	11,970	7,920	25,380	20,250	13,500
3MM307WI	4.6	7.4	3.07	4.10	12,960	10,350	6,930	22,050	17,640	11,790
3MM308WI	6.4	10.2	4.25	5.66	11,430	9,090	6,120	19,350	15,480	10,350
3MM309WI	8.5	13.6	5.68	7.58	10,170	8,190	5,400	17,370	13,860	9,270
3MM310WI	11.1	17.8	7.40	9.90	9,180	7,380	4,860	15,570	12,510	8,280
3MM311WI	14.2	22.7	9.50	12.60	8,370	6,660	4,500	14,220	11,340	7,560
3MM312WI	17.7	28.3	11.80	15.80	7,740	6,120	4,140	13,050	10,440	7,020
3MM313WI	20.7	33.2	13.80	18.50	7,110	5,670	3,780	12,060	9,630	6,390
3MM314WI	25.2	40.3	16.80	22.40	6,660	5,310	3,510	11,250	9,000	6,030
3MM319WI	60.9	97.4	40.60	54.10	5,040	3,960	2,700	8,460	6,750	4,500



Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

Conrad Construction:
- Maximum complement of balls separated by two piece land piloted cage.

						Load Ratings				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width	Ball x Dia. Qty. (in.)	Wt.	C_o(stat)	C_e(dyn)	Limiting Speed	r Rad.[1]	d_a (Shaft) max.	d_a (Shaft) min.	D_a (Housing) max.	D_a (Housing) min.
	in/tol: +0; -.000(X)				lbs.	lbs.		rpm	in.	in.			
MM305K	0.9843 (2)	2.4409 (3)	0.6693 (47)	7 x 15/32	0.49	2,750	6,000	26,500	0.039	1.27	1.26	2.2	2.19
MM306K	1.1811 (2)	2.8346 (3)	0.748 (47)	7 x 17/32	0.72	3,550	7,650	22,300	0.039	1.49	1.48	2.57	2.56
MM307K	1.378 (2.5)	3.1496 (3)	0.8268 (47)	7 x 9/16	0.95	4,150	8,500	19,400	0.059	1.72	1.7	2.84	2.82
MM308K	1.5748 (2.5)	3.5433 (3)	0.9055 (47)	8 x 5/8	1.31	5,100	10,400	17,100	0.059	1.96	1.94	3.2	3.18
MM309K	1.7717 (2.5)	3.937 (3)	0.9843 (47)	8 x 11/16	1.78	7,100	13,400	15,200	0.059	2.2	2.18	3.55	3.53
MM310K	1.9685 (2.5)	4.3307 (3)	1.063 (47)	8 x 3/4	2.32	8,500	15,600	13,800	0.059	2.41	2.39	3.93	3.91
MM311K	2.1654 (3)	4.7244 (3)	1.1417 (59)	8 x 13/16	2.93	10,000	18,300	12,500	0.079	2.65	2.63	4.28	4.26
MM312K	2.3622 (3)	5.1181 (3.5)	1.2205 (59)	8 x 7/8	3.67	11,600	20,800	11,500	0.079	2.88	2.86	4.64	4.62
MM313K	2.5591 (3)	5.5118 (3.5)	1.2992 (59)	8 x 15/16	4.51	13,400	23,600	10,700	0.079	3.16	3.14	4.99	4.97
MM314K	2.7559 (3)	5.9055 (3.5)	1.378 (59)	8 x 1	5.48	15,300	26,000	9,900	0.079	3.36	3.34	5.34	5.32

Notes
1) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Medium MM300K (ISO 03) Series

Inch Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
in.				in.				in.				
0.9841	0.9843	0.0002	0.0002	2.4409	2.4412	0.0000	0.0006	2.44140	2.44120	0.00080	0.00030	**MM305K**
1.1809	1.1811	0.0002	0.0002	2.8346	2.8349	0.0000	0.0006	2.83510	2.83490	0.00080	0.00030	**MM306K**
1.3778	1.3780	0.0002	0.00025	3.1496	3.1499	0.0000	0.0006	3.15010	3.14990	0.00080	0.00030	**MM308K**
1.5746	1.5748	0.0002	0.00025	3.5433	3.5436	0.0000	0.0006	3.54390	3.54360	0.00090	0.00030	**MM308K**
1.7715	1.7717	0.0002	0.00025	3.9370	3.9373	0.0000	0.0006	3.93770	3.93740	0.00100	0.00040	**MM309K**
1.9683	1.9685	0.0002	0.00025	4.3307	4.3310	0.0000	0.0006	4.33140	4.33110	0.00100	0.00040	**MM310K**
2.1652	2.1654	0.0002	0.0003	4.7244	4.7247	0.0000	0.0006	4.72510	4.72480	0.00100	0.00040	**MM311K**
2.3620	2.3622	0.0002	0.0003	5.1181	5.1185	0.0000	0.0007	5.11890	5.11850	0.00110	0.00040	**MM312K**
2.5589	2.5591	0.0002	0.0003	5.5118	5.5122	0.0000	0.0007	5.51260	5.51220	0.00110	0.00040	**MM313K**
2.7557	2.7559	0.0002	0.0003	5.9055	5.9059	0.0000	0.0007	5.90640	5.90600	0.00120	0.00050	**MM314K**

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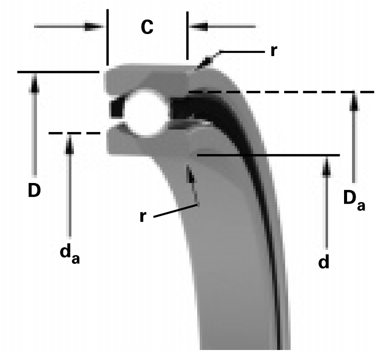


Super Precision MM:
Running accuracy and performance meet ABEC 9 (ISO P2) levels. Non-critical features conform to ABEC 7 (ISO P4) requirements.

Conrad Construction:
- Maximum complement of balls separated by two piece land piloted cage.

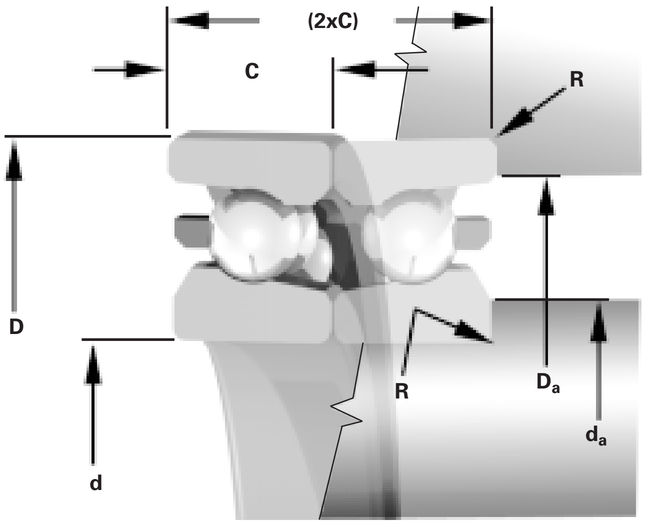
						Load Ratings				Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width	Ball x Dia. Qty. (mm)	Wt.	C_o (stat)	C_e(dyn)	Limiting Speed	r Rad.[1]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	mm/tol: +0; -(µm)				kg.	N		rpm	mm	mm			
MM305K	25 (5)	62 (7)	17 (130)	7 x 11.9	0.222	12,200	26,700	26,500	1	32.1	31.9	55.8	55.5
MM306K	30 (5)	72 (7)	19 (130)	7 x 13.5	0.327	15,800	34,000	22,300	1	37.7	37.5	65.2	64.9
MM307K	35 (6)	80 (7)	21 (130)	7 x 14.3	0.431	18,500	37,800	19,400	1.5	43.7	43.2	72.1	71.6
MM308K	40 (6)	90 (8)	23 (130)	8 x 15.9	0.594	22,700	46,300	17,100	1.5	49.8	49.3	81.3	80.8
MM309K	45 (6)	100 (8)	25 (130)	8 x 17.5	0.807	31,600	59,600	15,200	1.5	55.9	55.4	90.2	89.7
MM310K	50 (6)	110 (8)	27 (130)	8 x 19.1	1.052	37,800	69,400	13,800	1.5	61.2	60.7	99.8	99.3
MM311K	55 (7)	120 (8)	29 (150)	8 x 20.6	1.329	44,500	81,400	12,500	2	67.3	66.8	108.7	108.2
MM312K	60 (7)	130 (9)	31 (150)	8 x 22.2	1.665	51,600	92,500	11,500	2	43.2	72.6	117.9	117.3
MM313K	65 (7)	140 (9)	33 (150)	8 x 23.8	2.046	59,600	105,000	10,700	2	80.3	79.8	126.8	126.2
MM314K	70 (7)	150 (9)	35 (150)	8 x 25.4	2.486	68,100	115,600	9,900	2	85.3	84.8	135.6	135.1

Notes
1) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Medium MM300K (ISO 03) Series

Metric Dimensional Sizes

Shaft Diameter		Mounting Fits		Fixed Housing Bore (Stationary)		Fixed Mounting Fits		Floating Housing Bore (Stationary)		Floating Housing Clearance		
min.	max.	loose	tight	min.	max.	tight	loose	max.	min.	max.	min.	
mm				mm				mm				
24.995	25.000	0.005	0.005	62	62.008	0.000	0.015	62.012	62.007	0.019	0.007	**MM305K**
29.995	30.000	0.005	0.005	72	72.008	0.000	0.015	72.011	72.007	0.019	0.007	**MM306K**
34.995	35.000	0.005	0.006	80	80.008	0.000	0.015	80.012	80.008	0.020	0.008	**MM307K**
39.995	40.000	0.005	0.006	90	90.008	0.000	0.016	90.015	90.007	0.023	0.007	**MM308K**
44.995	45.000	0.005	0.006	100	100.008	0.000	0.016	100.018	100.010	0.025	0.010	**MM309K**
49.995	50.000	0.005	0.006	110	110.008	0.000	0.016	110.018	110.010	0.025	0.010	**MM310K**
54.995	55.000	0.005	0.007	120	120.008	0.000	0.016	120.018	120.010	0.025	0.010	**MM311K**
59.995	60.000	0.005	0.007	130	130.009	0.000	0.018	130.020	130.010	0.029	0.010	**MM312K**
64.995	65.000	0.005	0.007	140	140.009	0.000	0.018	140.020	140.010	0.029	0.010	**MM313K**
69.995	70.000	0.005	0.007	150	150.009	0.000	0.018	150.023	150.012	0.032	0.012	**MM314K**



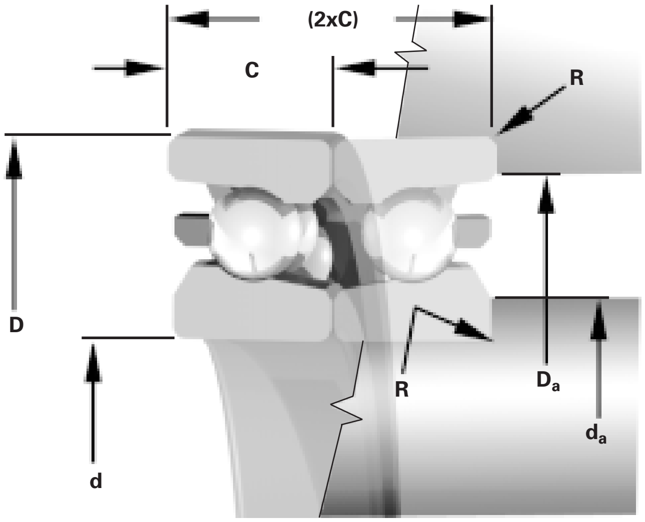
- Designed for maximum axial rigidity, low drag torque, and extreme control of lateral eccentricity
- Manufactured to ABEC9 axial tolerances
- Nonseparable angular-contact type design (60° contact angle)
- Manufactured to ABEC7 radial and envelope dimensions
- Maximum complement of balls
- Supplied prelubricated with heavy duty grease NLGI #2
- Packaged in *DB* arrangement [can be mounted in duplexed pairs and in multiplexed sets in either Back-to-Back (*DB*), Face-to-Face (*DF*) or Tandem (*DT*) arrangements]

							Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Wt.	Ball x Dia. Qty. (in.)	r Rad.[3]	d_a (Shaft) max.	d_a (Shaft) min.	D_a (Housing) max.	D_a (Housing) min.
	in/tol: +0; -.000(X)			lbs.		in.	in.			
MM9306WI2H	0.7874 (2)	1.8504 (2.5)	0.6250 (50)	0.14	12 x 5/16	0.031	1.083	1.073	1.641	1.631
MM9308WI2H	0.9385 (2)	2.4409 (3)	0.6250 (50)	0.28	17 x 5/16	0.031	1.321	1.311	2.179	2.169
MM9310WI2H	1.5000 (2.5)	2.8346 (3)	0.6250 (50)	0.31	18 x 11/32	0.031	1.865	1.855	2.479	2.469
MM9311WI3H	1.7510 (2.5)	3.0000 (3)	0.6250 (50)	0.32	20 x 11/32	0.031	2.057	2.047	2.672	2.662
MM9313WI5H	2.2500 (3)	3.5433 (3)	0.6250 (60)	0.40	24 x 11/32	0.031	2.577	2.567	3.196	3.186
MM9316WI3H	3.0000 (3)	4.3307 (3)	0.6250 (60)	0.52	30 x 11/32	0.031	3.380	3.370	4.000	3.990
MM9321WI3	4.0000 (3)	5.7087 (3.5)	0.8750 (80)	1.30	37 x 3/8	0.039	4.418	4.408	5.301	5.291
MM9326WI6H	5.0000 (3)	7.0866 (4)	0.8750 (100)	1.93	35 x 1/2	0.039	5.669	5.659	6.611	6.601

Notes
1) Single bearing specifications
2) Refer to Engineering section for width tolerance of preloaded ball screw support bearings.
3) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Ball Screw Support Series
Inch Dimensional Sizes

Shaft Diameters		Housing Diameters		
max.	min.	max.	min.	
in.		in.		
0.7872	0.7870	1.8507	1.8504	**MM9306WI2H**
0.9383	0.9381	2.4412	2.4409	**MM9308WI2H**
1.4997	1.4994	2.8349	2.8346	**MM9310WI2H**
1.7507	1.7504	3.0003	3.0000	**MM9311WI3H**
2.2497	2.2494	3.5436	3.5433	**MM9313WI5H**
2.9997	2.9994	4.3310	4.3307	**MM9316WI3H**
3.9997	3.9994	5.7091	5.7087	**MM9321WI3**
4.9997	4.9994	7.0870	7.0866	**MM9326WI6H**



- Designed for maximum axial rigidity, low drag torque, and extreme control of lateral eccentricity
- Manufactured to ABEC9 axial tolerances
- Nonseparable angular-contact type design (60° contact angle)
- Manufactured to ABEC7 radial and envelope tolerances
- Maximum complement of balls
- Supplied prelubricated with heavy duty grease NLGI #2
- Packaged in *DB* arrangement [can be mounted in duplexed pairs and in multiplexed sets in either Back-to-Back (*DB*), Face-to-Face (*DF*) or Tandem (*DT*) arrangements]

							Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Wt.	Ball x Dia. Qty. (mm)	r Rad.[3]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	mm/tol: +0; -(μm)			kgs.		mm	mm			
MM17BS47	17 (4)	47 (6)	15 (80)	0.07	12 x 7.9	0.8	23.13	22.87	41.63	41.37
MM20BS47	20 (5)	47 (6)	15 (130)	0.06	12 x 7.9	0.8	26.13	25.87	41.63	41.37
MM25BS62	25 (5)	62 (7)	15 (130)	0.12	17 x 7.9	0.8	35.13	34.87	56.13	55.87
MM30BS62	30 (5)	62 (7)	15 (130)	0.10	17 x 7.9	0.8	40.13	39.87	56.13	55.87
MM30BS72	30 (5)	72 (7)	15 (130)	0.16	18 x 8.7	0.8	40.13	39.87	56.13	55.87
MM35BS72	35 (6)	72 (7)	15 (130)	0.14	18 x 8.7	0.8	42.13	41.87	64.13	63.87
MM35BS100	35 (6)	100 (8)	20 (130)	0.13	18 x 12.7	0.8	42.13	41.87	90.13	89.87
MM40BS72	40 (6)	72 (7)	15 (130)	0.12	18 x 8.7	0.8	47.13	46.87	64.13	63.87
MM40BS90	40 (6)	90 (8)	15 (130)	0.25	24 x 8.7	0.8	47.13	46.87	82.13	81.87

Notes
1) Single bearing specifications
2) Refer to Engineering section for width tolerance of preloaded ball screw support bearings.
3) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Ball Screw Support Series

Metric Dimensional Sizes

Shaft Diameters		Housing Diameters		
max.	min.	max.	min.	
mm		mm		
16.996	16.992	47.006	47	**MM17BS47**
19.995	19.99	47.006	47	**MM20BS47**
24.995	24.99	62.007	62	**MM25BS62**
29.995	29.99	62.007	62	**MM30BS62**
29.995	29.99	72.007	72	**MM30BS72**
34.994	34.988	72.007	72	**MM35BS72**
39.994	39.988	72.007	72	**MM40BS72**
44.994	44.988	75.007	75	**MM45BS75**
39.994	39.988	90.008	90	**MM40BS90**

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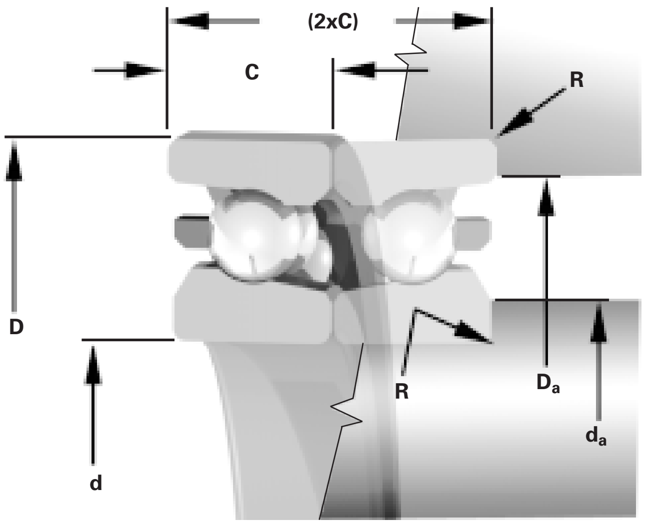


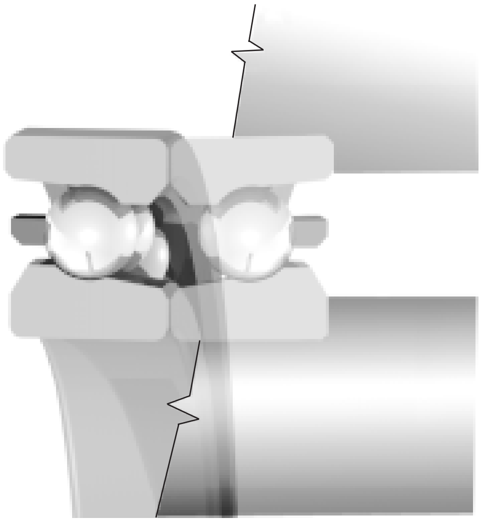
- Designed for maximum axial rigidity, low drag torque, and extreme control of lateral eccentricity
- Manufactured to ABEC9 axial tolerances
- Nonseparable angular-contact type design (60° contact angle)
- Manufactured to ABEC7 radial and envelope tolerances
- Maximum complement of balls
- Supplied prelubricated with heavy duty grease NLGI #2
- Packaged in *DB* arrangement [can be mounted in duplexed pairs and in multiplexed sets in either Back-to-Back (*DB*), Face-to-Face (*DF*) or Tandem (*DT*) arrangements]

							Recommended Shoulder Diameters			
	d Bore	D O.D.	C Width[1]	Wt.	Ball x Dia. Qty. (mm)	r Rad.[3]	d_a (Shaft) max.	min.	D_a (Housing) max.	min.
	mm./tol: +0; -(μm)			kgs.		mm	mm			
MM40BS100	40 (6)	100 (8)	20 (130)	0.21	18 x 12.7	0.8	47.13	46.87	90.13	89.87
MM45BS75	45 (6)	75 (7)	15 (130)	0.18	20 x 8.7	0.8	52.13	51.87	69.13	68.87
MM45BS100	45 (6)	100 (8)	20 (130)	0.43	18 x 12.7	0.8	54.13	53.87	90.13	89.87
MM50BS90	50 (6)	90 (8)	15 (130)	0.41	24 x 8.7	0.8	59.13	58.87	82.13	81.87
MM50BS100	50 (6)	100 (8)	20 (130)	0.38	18 x 12.7	0.8	59.13	58.87	90.13	89.87
MM55BS90	55 (7)	90 (8)	15 (150)	0.35	24 x 8.7	0.8	63.13	62.87	82.13	81.87
MM55BS120	55 (7)	120 (8)	20 (150)	0.23	21 x 12.7	1	65.13	64.87	110.13	109.87
MM60BS120	60 (7)	120 (8)	20 (150)	0.56	21 x 12.7	1	70.13	69.87	110.13	109.87
MM75BS110	75 (7)	110 (8)	15 (150)	0.53	30 x 8.7	0.8	84.13	83.87	102.13	101.87
MM100BS150	100 (8)	150 (9)	20 (150)	0.64	26 x 12.7	1	110.13	109.87	138.13	137.87

Notes
1) Single bearing specifications
2) Refer to Engineering section for width tolerance of preloaded ball screw support bearings.
3) ABMA Std. 20 ($r_{as\ max}$)

Fafnir Ball Screw Support Series
Metric Dimensional Sizes

Shaft Diameters		Housing Diameters		
max.	min.	max.	min.	
mm		mm		
49.994	49.988	90.008	90	**MM50BS90**
54.993	54.986	90.008	90	**MM55BS90**
34.994	34.988	100.008	100	**MM35BS100**
39.994	39.988	100.008	100	**MM40BS100**
44.994	44.988	100.008	100	**MM45BS100**
49.994	49.988	100.008	100	**MM50BS100**
74.993	74.986	110.008	110	**MM75BS110**
54.993	54.986	120.008	120	**MM55BS120**
59.993	59.986	120.008	120	**MM60BS120**
99.992	99.984	150.009	150	**MM100BS150**

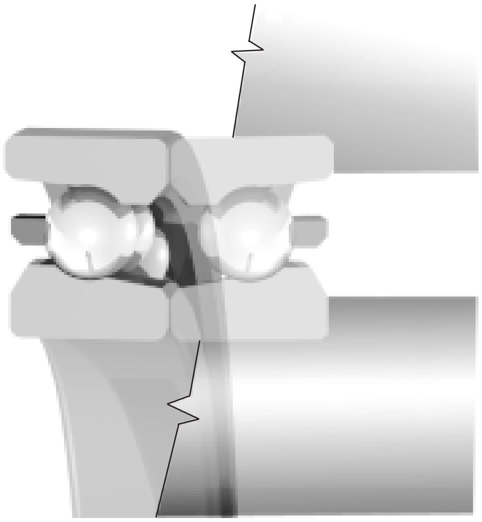


	Static Limiting Thrust Capacity	Dynamic Axial Thrust Load Rating [1] C_{ae}	Max. Speed	Axial Spring Constant	Drag Torque (preloaded set)	Preload[2] (Heavy)
Duplex Set	lbs.		rpm	10^6 lbs./in.	in.- lbs.	lbs.
MM9306WI2HDUH	5,600	5,600	4,400	4.30	2.83	700
MM9308WI2HDUH	8,000	6,700	3,200	6.00	3.89	1,000
MM9310WI2HDUH	10,200	8,150	2,500	7.20	3.89	1,400
MM9311WI3HDUH	11,400	8,650	2,100	7.90	4.96	1,500
MM9313WI5HDUH	13,700	9,300	2,000	9.50	7.26	1,800
MM9316WI3HDUH	17,300	10,000	1,400	11.90	8.85	2,200
MM9321WI3DUH	26,000	12,900	1,000	19.40	19.3	4,800
MM9326WI6HDUH	42,000	21,200	750	20.70	35.1	6,000

Notes:
1) Based on 1500 hours L_{10} life and permissible speed.
2) Heavy Preload is standard.

Fafnir Ball Screw Support Series
Inch Performance Data

	Static Limiting Thrust Capacity	Dynamic Axial Thrust Load Rating[1] C_{ae}	Max. Speed	Axial Spring Constant	Drag Torque (preloaded set)	Preload[2] (Heavy)
Quadruplex Set	lbs.		rpm	10^6 lbs./in.	in.- lbs.	lbs.
MM9306WI2HQUH	11,200	9,100	3,700	8.60	5.66	1,400
MM9308WI2HQUH	16,000	10,900	2,700	12.00	7.78	2,000
MM9310WI2HQUH	20,400	13,200	2,100	14.40	7.78	2,800
MM9311WI3HQUH	22,800	14,100	1,800	15.80	9.92	3,000
MM9313WI5HQUH	27,400	15,100	1,700	19.00	14.52	3,600
MM9316WI3HQUH	34,600	16,200	1,200	23.80	17.70	4,400
MM9321WI3QUH	52,000	21,000	900	38.80	38.60	9,600
MM9326WI6HQUH	84,000	34,400	600	41.40	70.20	12,000

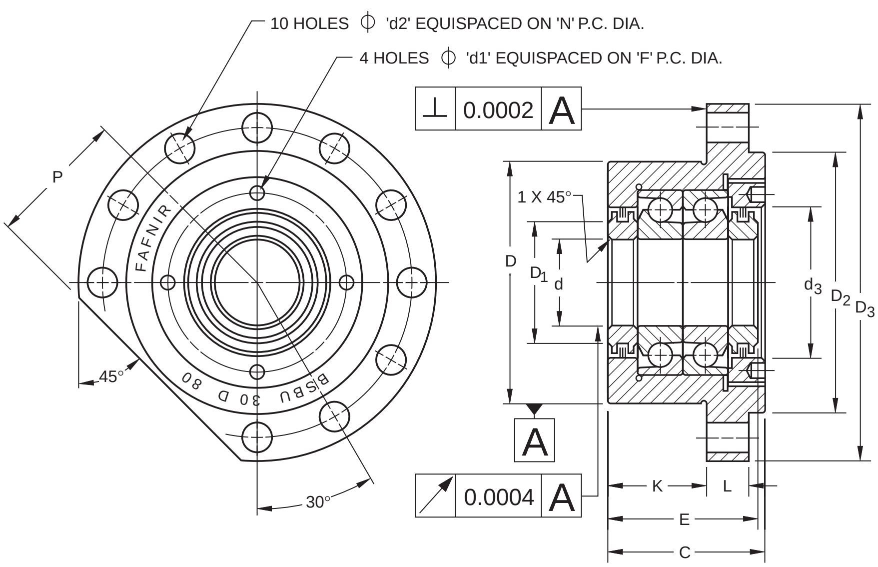


Duplex Set	Static Limiting Thrust Capacity (N)	Dynamic Axial Thrust Load Rating[1] C_{ae} (N)	Max. Speed (rpm)	Axial Spring Constant (10^6 N/m)	Drag Torque (preloaded set) (N-m)	Preload[2] (Heavy) (N)
MM17BS47DUH	24,900	24,900	4,400	750	0.32	3,110
MM20BS47DUH	24,900	24,900	4,400	750	0.32	3,110
MM25BS62DUH	35,600	29,800	3,200	1,050	0.44	4,450
MM30BS62DUH	35,600	29,800	3,200	1,050	0.44	4,450
MM30BS72DUH	45,400	36,300	2,500	1,260	0.44	6,230
MM35BS72DUH	45,400	36,300	2,500	1,260	0.44	6,230
MM40BS72DUH	45,400	36,300	2,500	1,260	0.44	6,230
MM45BS75DUH	50,700	38,500	2,100	1,380	0.56	6,670
MM40BS90DUH	60,900	41,400	2,000	1,660	0.82	8,010
MM50BS90DUH	60,900	41,400	2,000	1,660	0.82	8,010
MM55BS90DUH	60,900	41,400	2,000	1,660	0.82	8,010
MM35BS100DUH	93,400	71,200	1,700	1,750	1.02	12,900
MM40BS100DUH	93,400	71,200	1,700	1,750	1.02	12,900
MM45BS100DUH	93,400	71,200	1,700	1,750	1.02	12,900
MM50BS100DUH	93,400	71,200	1,700	1,750	1.02	12,900
MM75BS110DUH	77,000	44,500	1,400	2,080	1.00	9,790
MM55BS120DUH	133,400	75,600	1,400	2,150	1.36	15,570
MM60BS120DUH	133,400	75,600	1,400	2,150	1.36	15,570
MM100BS150DUH	115,600	57,400	1,000	3,400	2.18	21,350

Notes:
1) Based on 1500 hours L_{10} life and permissible speed.
2) Heavy Preload is standard.

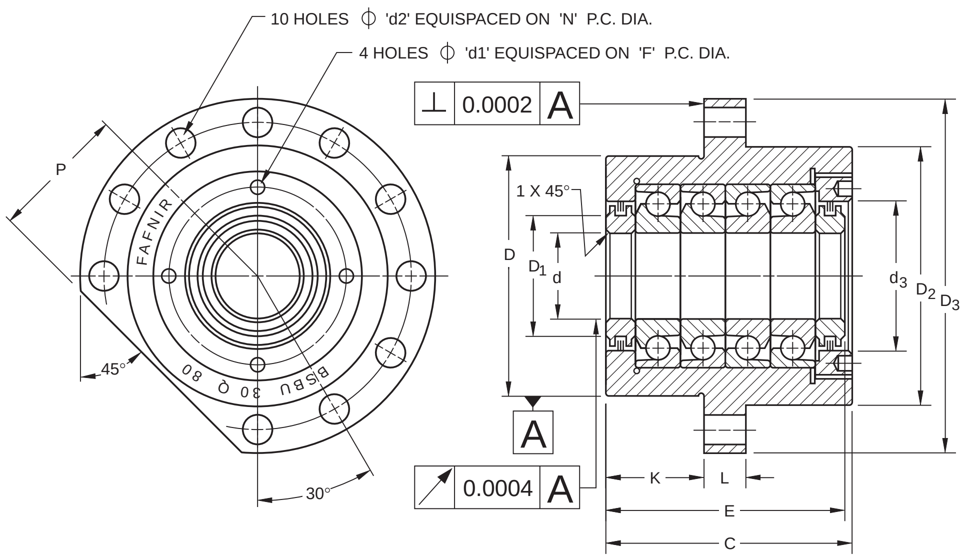
Fafnir Ball Screw Support Series
Metric Performance Data

	Static Limiting Thrust Capacity	Dynamic Axial Thrust Load Rating[1] C_{ae}	Max. Speed	Axial Spring Constant	Drag Torque (preloaded set)	Preload[2] (Heavy)
Quadruplex Set	N		rpm	10^6 N/m	N-m	N
MM17BS47QUH	49,800	40,500	3,700	1,510	0.64	6,230
MM20BS47QUH	49,800	40,500	3,700	1,510	0.64	6,230
MM25BS52QUH	54,300	42,300	3,700	1,560	0.49	5,400
MM30BS62QUH	71,200	48,500	2,700	2,100	0.88	8,900
MM30BS72QUH	90,700	58,700	2,100	2,520	0.88	12,450
MM35BS72QUH	90,700	58,700	2,100	2,520	0.88	12,450
MM40BS72QUH	90,700	58,700	2,100	2,520	0.88	12,450
MM45BS75QUH	101,400	62,700	1,800	2,770	1.12	13,340
MM40BS90QUH	121,900	67,200	1,700	3,330	1.64	16,010
MM50BS90QUH	121,900	67,200	1,700	3,330	1.64	16,010
MM55BS90QUH	121,900	67,200	1,700	3,330	1.64	16,010
MM35BS100QUH	186,800	115,600	1,400	3,500	2.04	25,800
MM40BS100QUH	186,800	115,600	1,400	3,500	2.04	25,800
MM45BS100QUH	186,800	115,600	1,400	3,500	2.04	25,800
MM50BS100QUH	186,800	115,600	1,400	3,500	2.04	25,800
MM75BS110QUH	153,900	72,100	1,200	4,170	2.00	19,570
MM55BS120QUH	266,900	122,800	1,200	4,310	2.72	31,140
MM60BS120QUH	266,900	122,800	1,200	4,310	2.72	31,140
MM100BS150QUH	231,300	93,400	900	6,790	4.36	42,700

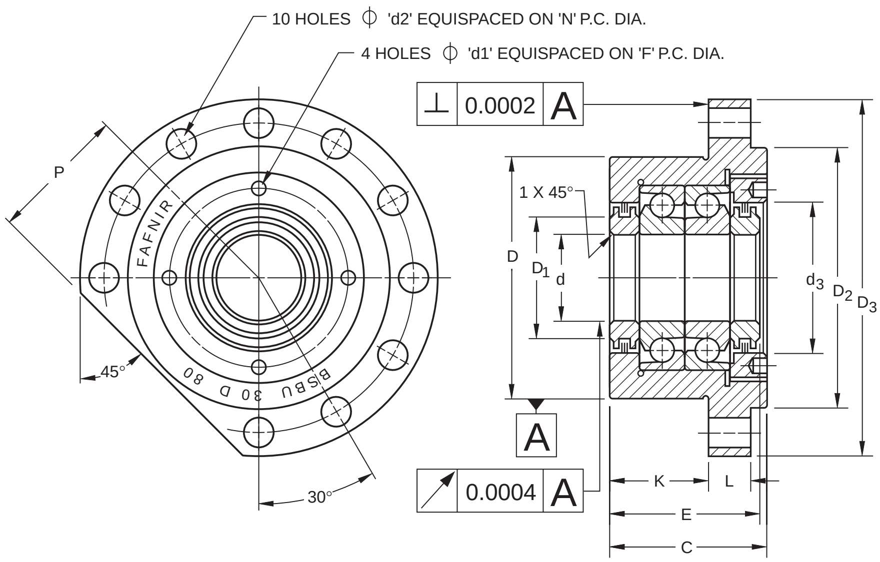


Shaft Dia.	Unit Number	C	d(max)	d(min)	d_1	d_2	d_3	D(max)	D(min)	D_1	D_2
mm		in.	in.		in.			in.		in.	
17	**BSBU17D60** **BSBU17Q60**	1.85 3.03	0.6693	0.6691	0.17	0.26	1.42	2.3622	2.3617	1.02	2.52
20	**BSBU20D60** **BSBU20Q60**	1.85 3.03	0.7874	0.7872	0.17	0.26	1.42	2.3622	2.3617	1.02	2.52
25	**BSBU25D80** **BSBU25Q80**	2.05 3.23	0.9842	0.9841	0.17	0.36	1.97	3.1496	3.1491	1.57	3.46
30	**BSBU30D80** **BSBU30Q80**	2.05 3.23	1.1811	1.1809	0.17	0.36	1.97	3.1496	3.1491	1.57	3.46
35	**BSBU35D90** **BSBU35Q90**	2.05 3.23	1.3780	1.3778	0.17	0.36	2.36	3.5433	3.5427	1.81	3.86
35	**BSBU35D124** **BSBU35Q124**	2.60 4.17	1.3780	1.3778	0.21	0.45	2.99	4.8819	4.8812	2.60	5.04
40	**BSBU40D90** **BSBU40Q90**	2.05 3.23	1.5748	1.5746	0.17	0.36	2.36	3.5433	3.5427	1.81	3.86
40	**BSBU40D124** **BSBU40Q124**	2.60 4.17	1.5748	1.5746	0.21	0.45	2.99	4.8819	4.8812	2.60	5.04
45	**BSBU45D124** **BSBU45Q124**	2.60 4.17	1.7716	1.7714	0.21	0.45	2.99	4.8819	4.8812	2.60	5.04
50	**BSBU50D124** **BSBU50Q124**	2.60 4.17	1.9685	1.9683	0.21	0.45	2.99	4.8819	4.8812	2.60	5.04

Fafnir Ball Screw Support Bearing Cartridge Units
Inch Dimensional Sizes



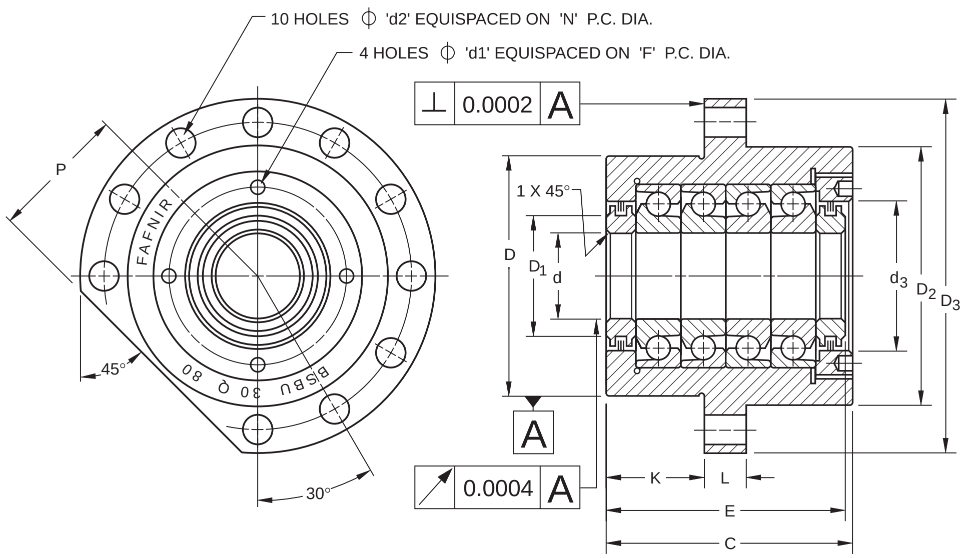
D_3	E(max)	E(min)	F	K	L	N	P	Wt.	Unit Number	Shaft Dia.
in.	in.		in.					lbs.		mm
3.54	1.742 2.924	1.702 2.864	1.67	1.26	0.51	2.99	1.26	2.42 3.74	**BSBU17D60** **BSBU17Q60**	17
3.54	1.742 2.924	1.702 2.864	1.67	1.26	0.51	2.99	1.26	2.42 3.74	**BSBU20D60** **BSBU20Q60**	20
4.72	1.979 3.160	1.938 3.100	2.34	1.26	0.59	4.02	1.73	5.06 7.7	**BSBU25D80** **BSBU25Q80**	25
4.72	1.979 3.160	1.938 3.100	2.34	1.26	0.59	4.02	1.73	4.84 7.48	**BSBU30D80** **BSBU30Q80**	30
5.12	1.979 3.160	1.938 3.100	2.62	1.26	0.59	4.45	1.93	7.04 10.12	**BSBU35D90** **BSBU35Q90**	35
6.50	2.530 4.105	2.490 4.045	3.54	1.71	0.67	5.75	2.52	13.86 22.22	**BSBU35D124** **BSBU35Q124**	35
5.12	1.979 3.160	1.938 3.100	2.62	1.26	0.59	4.45	1.93	6.82 9.90	**BSBU40D90** **BSBU40Q90**	40
6.50	2.530 4.105	2.490 4.045	3.54	1.71	0.67	5.75	2.52	13.42 21.34	**BSBU40D124** **BSBU40Q124**	40
6.50	2.530 4.105	2.490 4.045	3.54	1.71	0.67	5.75	2.52	13.20 20.90	**BSBU45D124** **BSBU45Q124**	45
6.50	2.530 4.105	2.490 4.045	3.54	1.71	0.67	5.75	2.52	12.90 20.46	**BSBU50D124** **BSBU50Q124**	50



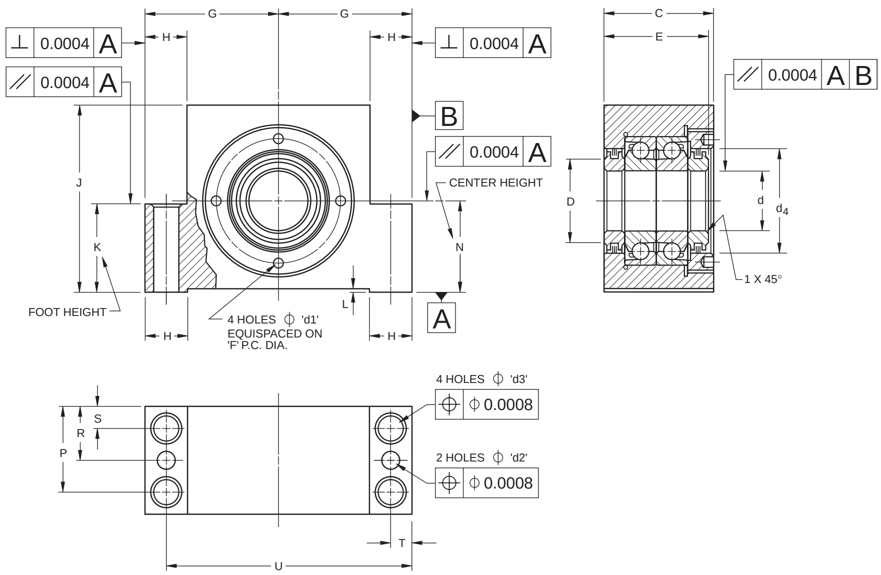
Shaft Dia.	Unit Number	C	d(max)	d(min)	d_1	d_2	d_3	D(max)	D(min)	D_1	D_2
mm		mm	mm		mm			mm		mm	
17	**BSBU17D60** **BSBU17Q60**	47 77	17.000	16.996	4.3	6.6	36	60	59.987	26	64
20	**BSBU20D60** **BSBU20Q60**	47 77	20.000	19.996	4.3	6.6	36	60	59.987	26	64
25	**BSBU25D80** **BSBU25Q80**	52 82	25.000	24.996	4.3	9.2	50	80	79.987	40	88
30	**BSBU30D80** **BSBU30Q80**	52 82	30.000	29.996	4.3	9.2	50	80	79.987	40	88
35	**BSBU35D90** **BSBU35Q90**	52 82	35.000	34.995	4.3	9.2	60	90	89.985	46	98
35	**BSBU35D124** **BSBU35Q124**	66 106	35.000	34.995	5.3	11.4	76	124	123.982	66	128
40	**BSBU40D90** **BSBU40Q90**	52 82	40.000	39.995	4.3	9.2	60	90	89.985	46	98
40	**BSBU40D124** **BSBU40Q124**	66 106	40.000	39.995	5.3	11.4	76	124	123.982	66	128
45	**BSBU45D124** **BSBU45Q124**	66 106	45.000	44.995	5.3	11.4	76	124	123.982	66	128
50	**BSBU50D124** **BSBU50Q124**	66 106	50.000	49.995	5.3	11.4	76	124	123.982	66	128

Fafnir Ball Screw Support Bearing Cartridge Units

Metric Dimensional Sizes



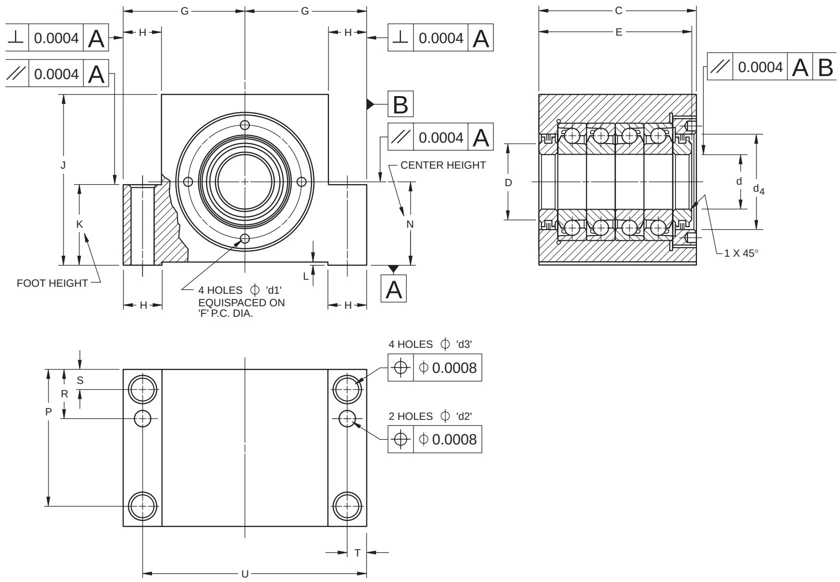
D_3	E(max)	E(min)	F	K	L	N	P	Wt.	Unit Number	Shaft Dia.
mm	mm		mm					kg.		mm
90	44.26 74.26	43.24 72.74	42.5	32.0	13	76	32	1.1 1.7	**BSBU17D60** **BSBU17Q60**	17
90	44.26 74.26	43.24 72.74	42.5	32.0	13	76	32	1.1 1.7	**BSBU20D60** **BSBU20Q60**	20
120	50.26 80.26	49.24 78.74	59.5	32.0	15	102	44	2.3 3.5	**BSBU25D80** **BSBU25Q80**	25
120	50.26 80.26	49.24 78.74	59.5	32.0	15	102	44	2.2 3.4	**BSBU30D80** **BSBU30Q80**	30
130	50.26 80.26	49.24 78.74	66.5	32.0	15	113	49	3.2 4.6	**BSBU35D90** **BSBU35Q90**	35
165	64.26 104.26	63.24 102.74	90.0	43.5	17	146	64	6.3 10.1	**BSBU35D124** **BSBU35Q124**	35
130	50.26 80.26	49.24 78.74	66.5	32.0	15	113	49	3.1 4.5	**BSBU40D90** **BSBU40Q90**	40
165	64.26 104.26	63.24 102.74	90.0	43.5	17	146	64	6.1 9.7	**BSBU40D124** **BSBU40Q124**	40
165	64.26 104.26	63.24 102.74	90.0	43.5	17	146	64	6.0 9.5	**BSBU45D124** **BSBU45Q124**	45
165	64.26 104.26	63.24 102.74	90.0	43.5	17	146	64	5.9 9.3	**BSBU50D124** **BSBU50Q124**	50



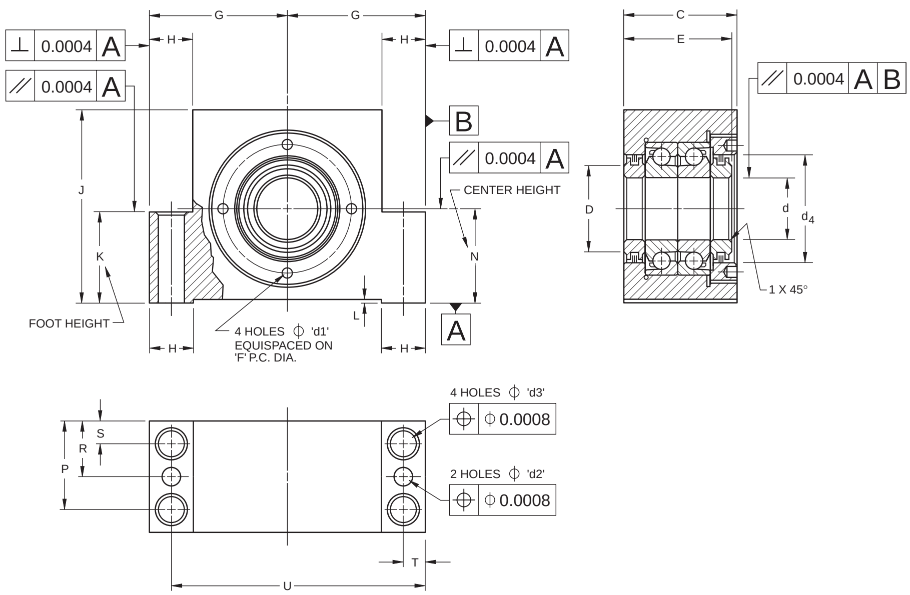
Shaft Dia.	Unit Number	C(max)	C(min)	d(max)	d(min)	d_1	d_2	d_3	d_4	D	E(max)	E(min)	F
mm		in.				in.					in.		
17	**BSPB17D32** **BSPB17Q32**	1.850 3.031	1.848 3.030	0.6693 0.6693	0.6691 0.6691	0.17	0.31	0.35	1.42	1.02	1.742 2.924	1.702 2.864	1.67
20	**BSPB20D32** **BSPB20Q32**	1.850 3.031	1.848 3.030	0.7874 0.7874	0.7872 0.7872	0.17	0.31	0.35	1.42	1.02	1.742 2.924	1.702 2.864	1.67
25	**BSPB25D42** **BSPB25Q42**	2.047 3.228	2.045 3.226	0.9842 0.9842	0.9841 0.9841	0.17	0.39	0.43	1.97	1.57	1.979 3.160	1.938 3.100	2.34
30	**BSPB30D42** **BSPB30Q42**	2.047 3.228	2.045 3.226	1.1811 1.1811	1.1809 1.1809	0.17	0.39	0.43	1.97	1.57	1.979 3.160	1.938 3.100	2.34
35	**BSPB35D50** **BSPB35Q50**	2.047 3.228	2.045 3.226	1.3780 1.3780	1.3778 1.3778	0.17	0.51	0.51	2.36	1.81	1.979 3.160	1.938 3.100	2.62
35	**BSPB35D65** **BSPB35Q65**	2.598 4.173	2.596 4.171	1.3780 1.3780	1.3778 1.3778	0.21	0.46	0.71	2.99	2.6	2.530 4.105	2.490 4.045	3.54
40	**BSPB40D50** **BSPB40Q50**	2.047 3.228	2.045 3.226	1.5748 1.5748	1.5746 1.5746	0.17	0.51	0.51	2.36	1.81	1.979 3.160	1.938 3.100	2.62
40	**BSPB40D65** **BSPB40Q65**	2.598 4.173	2.596 4.171	1.5748 1.5748	1.5746 1.5746	0.21	0.46	0.71	2.99	2.6	2.530 4.105	2.490 4.045	3.54
45	**BSPB45D65** **BSPB45Q65**	2.598 4.173	2.596 4.171	1.7716 1.7716	1.7714 1.7714	0.21	0.46	0.71	2.99	2.6	2.530 4.105	2.490 4.045	3.54
50	**BSPB50D65** **BSPB50Q65**	2.598 4.173	2.596 4.171	1.9685 1.9685	1.9683 1.9683	0.21	0.46	0.71	2.99	2.6	2.530 4.105	2.490 4.045	3.54

Notes:
1) Step "L" = 0.04"

Fafnir Ball Screw Support Bearing Pillow Block Units
Inch Dimensional Sizes



G(max)	G(min)	H	J	K	N(max)	N(min)	P	R	S	T	U	Wt.	Unit Number	Shaft Dia.
in.		in.			in.		in.					lbs.		mm
1.8504	1.8499	0.67	2.44	1.26	1.2598	1.2593	1.5	0.87	0.35	0.33	3.37	3.30	**BSPB17D32**	17
1.8504	1.8499				1.2598	1.2593						5.72	**BSPB17Q32**	
1.8504	1.8499	0.67	2.44	1.65	1.2598	1.2593	1.5	0.87	0.35	0.33	3.37	3.30	**BSPB20D32**	20
1.8504	1.8499				1.2598	1.2593						5.50	**BSPB20Q32**	
2.4606	2.4601	0.79	3.35	1.65	1.6535	1.6530	1.65	0.98	0.39	0.39	4.53	6.16	**BSPB25D42**	25
2.4606	2.4601				1.6535	1.6530						10.12	**BSPB25Q42**	
2.4606	2.4601	0.79	3.35	1.97	1.6535	1.6530	1.65	0.98	0.39	0.39	4.53	5.94	**BSPB30D42**	30
2.4606	2.4601				1.6535	1.6530						9.90	**BSPB30Q42**	
2.6772	2.6767	0.81	3.74	1.97	1.9685	1.9680	1.65	0.98	0.39	0.39	4.96	8.36	**BSPB35D50**	35
2.6772	2.6767				1.9685	1.9680						13.64	**BSPB35Q50**	
3.7402	3.7396	1.18	5.12	2.56	2.5590	2.5585	2.09	1.26	0.51	0.59	6.89	21.34	**BSPB35D65**	35
3.7402	3.7396				2.5590	2.5585						34.98	**BSPB35Q65**	
2.6772	2.6767	0.81	3.74	1.26	1.9685	1.9680	1.65	0.98	0.39	0.39	4.96	8.14	**BSPB40D50**	40
2.6772	2.6767				1.9685	1.9680						13.20	**BSPB40Q50**	
3.7402	3.7396	1.18	5.12	2.56	2.5590	2.5585	2.09	1.26	0.51	0.59	6.89	20.90	**BSPB40D65**	40
3.7402	3.7396				2.5590	2.5585						34.54	**BSPB40Q65**	
3.7402	3.7396	1.18	5.12	2.56	2.5590	2.5585	2.09	1.26	0.51	0.59	6.89	20.46	**BSPB45D65**	45
3.7402	3.7396				2.5590	2.5585						33.88	**BSPB45Q65**	
3.7402	3.7396	1.18	5.12	2.56	2.5590	2.5585	2.09	1.26	0.51	0.59	6.89	20.02	**BSPB50D65**	50
3.7402	3.7396				2.5590	2.5585						33.22	**BSPB50Q65**	

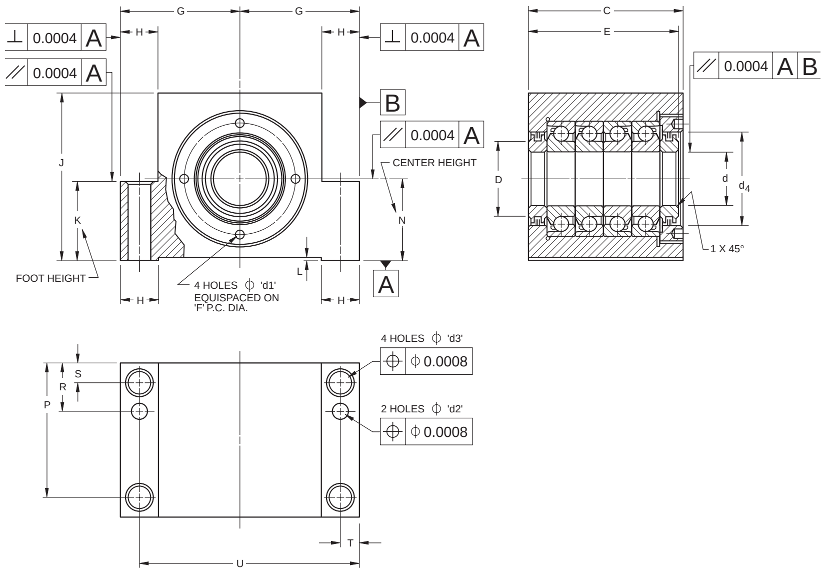


Shaft Dia.	Unit Number	C(max)	C(min)	d(max)	d(min)	d_1	d_2	d_3	d_4	D	E(max)	E(min)	F
mm		mm				mm					mm		
17	**BSPB17D32** **BSPB17Q32**	47.00 77.00	46.95 76.95	17.000 17.000	16.996 16.996	4.3	7.8	9.0	36	26	44.26 74.26	43.24 72.74	42.5
20	**BSPB20D32** **BSPB20Q32**	47.00 77.00	46.95 76.95	20.000 20.000	19.996 19.996	4.3	7.8	9.0	36	26	44.26 74.26	43.24 72.74	42.5
25	**BSPB25D42** **BSPB25Q42**	52.00 82.00	51.95 81.95	25.000 25.000	24.996 24.995	4.3	9.8	11.0	50	40	50.26 80.26	49.24 78.74	59.5
30	**BSPB30D42** **BSPB30Q42**	52.00 82.00	51.92 81.95	30.000 30.000	29.996 29.996	4.3	9.8	11.0	50	40	50.26 80.26	49.24 78.74	59.5
35	**BSPB35D50** **BSPB35Q50**	52.00 82.00	51.95 81.95	35.000 35.000	34.995 34.995	4.3	13.0	13.0	60	46	50.26 80.26	49.24 78.74	66.5
35	**BSPB35D65** **BSPB35Q65**	66.00 106.00	65.95 105.95	35.000 35.000	34.995 34.995	5.3	11.8	18.0	76	66	64.26 104.26	63.24 102.74	90.0
40	**BSPB40D50** **BSPB40Q50**	52.00 82.00	51.95 81.95	40.000 40.000	39.995 39.995	4.3	13.0	13.0	60	46	50.26 80.26	49.24 78.74	66.5
40	**BSPB40D65** **BSPB40Q65**	66.00 106.00	65.95 105.95	40.000 40.000	39.995 39.995	5.3	11.8	18.0	76	66	64.26 104.26	63.24 102.74	90.0
45	**BSPB45D65** **BSPB45Q65**	66.00 106.00	65.95 105.95	45.000 45.000	44.995 44.995	5.3	11.8	18.0	76	66	64.26 104.26	63.24 102.74	90.0
50	**BSPB50D65** **BSPB50Q65**	66.00 106.00	65.95 105.95	50.000 50.000	49.995 49.995	5.3	11.8	18.0	76	66	64.26 104.26	63.24 102.74	90.0

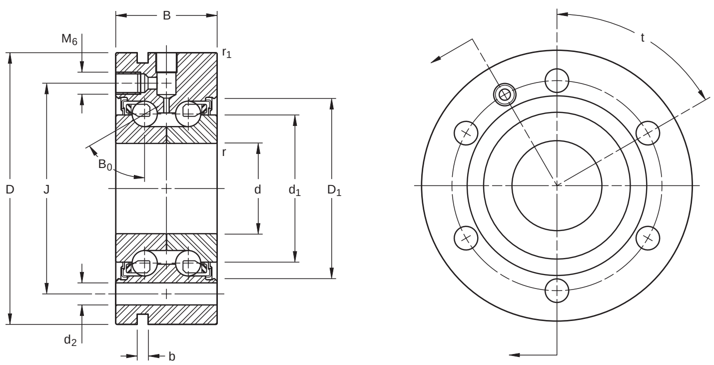
Notes:
1) Step "L" = 1.0 mm

Fafnir Ball Screw Support Bearing Pillow Block Units

Metric Dimensional Sizes



G(max)	G(min)	H	J	K	N(max)	N(min)	P	R	S	T	U	Wt.	Unit Number	Shaft Dia.
mm		mm			mm		mm					kg		mm
47.000 47.000	46.987 46.987	17.0	62.0	32.0	32.000 32.000	31.987 31.987	38	22	9	8.5	85.5	1.5 2.6	**BSPB17D32** **BSPB17Q32**	17
47.000 47.000	46.987 46.987	17.0	62.0	42.0	32.000 32.000	31.987 31.987	38	22	9	8.5	85.5	1.5 2.5	**BSPB20D32** **BSPB20Q32**	20
62.500 62.500	62.487 62.487	20.0	85.0	42.0	42.000 42.000	41.987 41.987	42	25	10	10.0	115.0	2.8 4.6	**BSPB25D42** **BSPB25Q42**	25
62.500 62.500	62.487 62.487	20.0	85.0	50.0	42.000 42.000	41.987 41.987	42	25	10	10.0	115.0	2.7 4.5	**BSPB30D42** **BSPB30Q42**	30
68.000 68.000	67.987 67.987	20.5	95.0	50.0	50.000 50.000	49.987 49.987	42	25	10	10.0	126.0	3.8 6.2	**BSPB35D50** **BSPB35Q50**	35
95.000 95.000	94.987 94.987	30.0	130.0	65.0	65.000 65.000	64.987 65.987	53	32	13	15.0	175.0	9.7 15.9	**BSPB35D65** **BSPB35Q65**	35
68.000 68.000	67.987 67.987	20.5	95.0	32.0	50.000 50.000	49.987 49.987	42	25	10	10.0	126.0	3.7 6.0	**BSPB40D50** **BSPB40Q50**	40
95.000 95.000	94.987 94.987	30.0	130.0	65.0	65.000 65.000	64.987 65.987	53	32	13	15.0	175.0	9.5 15.7	**BSPB40D65** **BSPB40Q65**	40
95.000 95.000	94.987 94.987	30.0	130.0	65.0	65.000 65.000	64.987 65.987	53	32	13	15.0	175.0	9.3 15.4	**BSPB45D65** **BSPB45Q65**	45
95.000 95.000	94.987 94.987	30.0	130.0	65.0	65.000 65.000	64.987 65.987	53	32	13	15.0	175.0	9.1 15.1	**BSPB50D65** **BSPB50Q65**	50

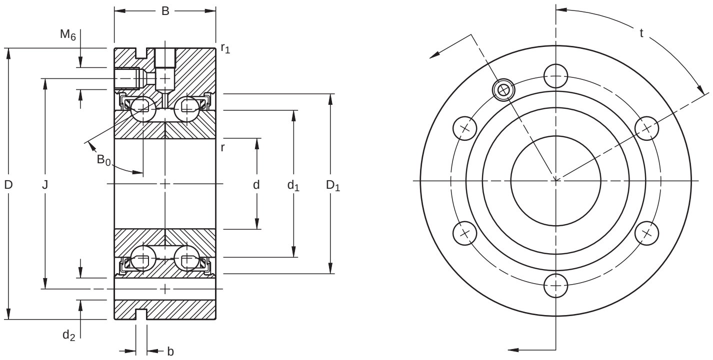


MMF Series Flanged

	Bore d/Tol	OD D/Tol	Width B/Tol	Wt.	Outer Rs1	Inner Rs	Min. D1	Max. d1
	in. +0/-(x)			lbs.	inch		inch	
MMF512BS55PP DM	0.4724 (0.00015)	2.1654 (0.0003)	0.9843 (0.0100)	0.88	0.024	0.012	1.304	0.905
MMF515BS60PP DM	0.5906 (0.00015)	2.3622 (0.0003)	0.9843 (0.0100)	1.04	0.024	0.012	1.456	1.088
MMF517BS62PP DM	0.6693 (0.00015)	2.4409 (0.0003)	0.9843 (0.0100)	1.08	0.024	0.012	1.490	1.117
MMF520BS68PP DM	0.7874 (0.0002)	2.6772 (0.0003)	1.1024 (0.0100)	1.42	0.024	0.012	1.700	1.357
MMF525BS75PP DM	0.9843 (0.0002)	2.9528 (0.0003)	1.1024 (0.0100)	1.68	0.024	0.012	1.943	1.599
MMF530BS80PP DM	1.1811 (0.0002)	3.1496 (0.0003)	1.1024 (0.0100)	1.86	0.024	0.012	2.138	1.795
MMF540BS100PP DM	1.5748 (0.00025)	3.9370 (0.0003)	1.3386 (0.0100)	3.41	0.024	0.012	2.704	2.264
MMF550BS115PP DM	1.9685 (0.00025)	4.5276 (0.0003)	1.3386 (0.0100)	4.37	0.024	0.012	3.250	2.815
MMF550BS140PP DM	1.9685 (0.00025)	5.5118 (0.00035)	2.1260 (0.0100)	10.78	0.024	0.024	3.919	3.192
MMF560BS145PP DM	2.3622 (0.0003)	5.7087 (0.00035)	1.7717 (0.0100)	9.43	0.024	0.024	3.938	3.308

Sealed, Double Row
Ball Screw Support Bearings
Flanged Style – MMF Series
Inch Dimensional Sizes

Housing Shoulder Diameter D_a	Shaft Shoulder Diameter d_a	Hole Dia.	Holes	Pitch Circle J	Hole Spacing t	Contact Angle B_0	Heavy Series	
inch			Qty.	inch	degrees	degrees		
1.260	0.748	0.256	3	1.654	120	60		MMF512BS55PP DM
1.358	0.846	0.256	3	1.811	120	60		MMF515BS60PP DM
1.437	0.925	0.256	3	1.890	120	60		MMF517BS62PP DM
1.673	1.083	0.256	4	2.087	90	60		MMF520BS68PP DM
1.890	1.319	0.256	4	2.283	90	60		MMF525BS75PP DM
2.106	1.516	0.256	6	2.480	60	60		MMF530BS80PP DM
2.638	1.929	0.335	4	3.150	90	60		MMF540BS100PP DM
3.189	2.408	0.335	6	3.701	60	60		MMF550BS115PP DM
3.878	2.598	0.413	12	4.449	30	60	H	MMF550BS140PP DM
3.858	2.835	0.335	8	4.724	45	60		MMF560BS145PP DM

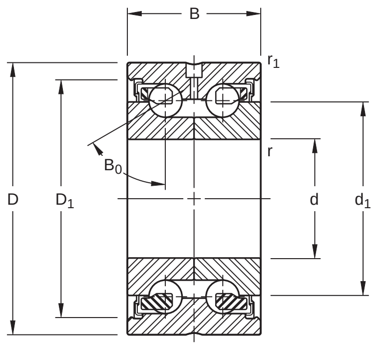


MMF Series Flanged

	Bore d/Tol	OD D/Tol	Width B/Tol	Wt.	Outer Rs1	Inner Rs	Min. D1	Max. d1
	mm +0/ -(μm)			kg	mm		mm	
MMF512BS55PP DM	12 (3.8)	55 (7.6)	25 (254)	0.40	0.6	0.3	33.1	25.0
MMF515BS60PP DM	15 (3.8)	60 (7.6)	25 (254)	0.47	0.6	0.3	37.0	27.6
MMF517BS62PP DM	17 (3.8)	62 (7.6)	25 (254)	0.49	0.6	0.3	37.8	28.4
MMF520BS68PP DM	20 (5.1)	68 (7.6)	28 (254)	0.64	0.6	0.3	43.2	34.5
MMF525BS75PP DM	25 (5.1)	75 (7.6)	28 (254)	0.76	0.6	0.3	49.5	40.6
MMF530BS80PP DM	30 (5.1)	80 (7.6)	28 (254)	0.84	0.6	0.3	54.3	45.6
MMF540BS100PP DM	40 (6.4)	100 (7.6)	34 (254)	1.50	0.6	0.3	68.7	57.5
MMF550BS115PP DM	50 (6.4)	115 (7.6)	34 (254)	1.37	0.6	0.3	82.6	71.5
MMF550BS140PP DM	50 (6.4)	140 (8.9)	54 (254)	4.89	0.6	0.6	99.6	81.1
MMF560BS145PP DM	60 (7.6)	145 (8.9)	45 (254)	4.28	0.6	0.6	100.0	89.0

Sealed, Double Row
Ball Screw Support Bearings
Flanged Style – MMF Series
Metric Dimensional Sizes

Housing Shoulder Diameter D_a	Shaft Shoulder Diameter d_a	Hole Dia.	Holes	Pitch Circle J	Hole Spacing t	Contact Angle B_0	Heavy Series	
mm			Qty.	mm	degrees	degrees		
32.0	19.0	6.5	3	42	120	60		**MMF512BS55PP DM**
34.5	21.5	6.5	3	46	120	60		**MMF515BS60PP DM**
36.5	23.5	6.5	3	48	120	60		**MMF517BS62PP DM**
42.5	27.5	6.5	4	53	90	60		**MMF520BS68PP DM**
48.0	33.5	6.5	4	58	90	60		**MMF525BS75PP DM**
53.5	38.5	6.5	6	63	60	60		**MMF530BS80PP DM**
67.0	49.0	8.5	4	80	90	60		**MMF540BS100PP DM**
81.0	63.0	8.5	6	94	60	60		**MMF550BS115PP DM**
98.5	66.0	10.5	12	113	30	60	**H**	**MMF550BS140PP DM**
98.0	72.0	8.5	8	120	45	60		**MMF560BS145PP DM**



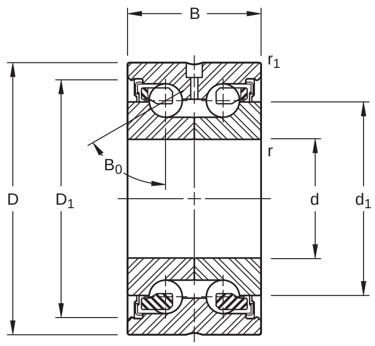
MMN Series

	Bore d/Tol	OD D/Tol	Width B/Tol	Wt.	Outer Rs1	Inner Rs
	in. +0/-(x)			lbs.	inch	
MMN512BS42PP DM	0.4724 (0.00015)	1.6535 (0.00025)	0.9843 (.0100)	0.44	0.024	0.012
MMN515BS45PP DM	0.5906 (0.00015)	1.7717 (0.00025)	0.9843 (.0100)	0.50	0.024	0.012
MMN517BS47PP DM	0.6693 (0.00015)	1.8504 (0.00025)	0.9843 (.0100)	0.54	0.024	0.012
MMN520BS52PP DM	0.7874 (0.0002)	2.0472 (0.0003)	1.1024 (.0100)	0.70	0.024	0.012
MMN525BS57PP DM	0.9843 (0.0002)	2.2441 (0.0003)	1.1024 (.0100)	0.78	0.024	0.012
MMN530BS62PP DM	1.1811 (0.0002)	2.4409 (0.0003)	1.1024 (.0100)	0.88	0.024	0.012
MMN540BS75PPDM	1.5748 (0.00025)	2.9528 (0.0003)	1.3386 (.0100)	1.42	0.024	0.012
MMN550BS90PP DM	1.9685 (0.00025)	3.5433 (0.0003)	1.3386 (.0100)	2.02	0.024	0.012
MMN550BS110PP DM	1.9685 (0.00025)	4.3307 (0.00035)	2.1260 (.0100)	5.34	0.024	0.024
MMN560BS110PP DM	2.3622 (0.0003)	4.3307 (0.00035)	1.7717 (.0100)	4.02	0.024	0.024

Sealed, Double Row Ball Screw Support Bearings Cartridge Style – MMN Series

Inch Dimensional Sizes

Min. D_1	Max. d_1	Housing Shoulder diameter D_a	Shaft Shoulder diameter d_a	Contact Angle B_0	Heavy Series	
inch		inch	inch	degrees		
1.304	0.985	1.259	0.748	60		MMN512BS42PP DM
1.456	1.088	1.358	0.846	60		MMN515BS45PP DM
1.490	1.117	1.437	0.925	60		MMN517BS47PP DM
1.700	1.357	1.673	1.083	60		MMN520BS52PP DM
1.943	1.599	1.890	1.319	60		MMN525BS57PP DM
2.138	1.795	2.106	1.516	60		MMN530BS62PP DM
2.704	2.264	2.638	1.929	60		MMN540BS75PPDM
3.250	2.815	3.189	2.408	60		MMN550BS90PP DM
3.919	3.192	3.878	2.598	60	H	MMN550BS110PP DM
3.938	3.308	3.858	2.835	60		MMN560BS110PP DM



MMN Series

	Bore d/Tol	OD D/Tol	Width B/Tol	Wt.	Outer Rs1	Inner Rs
	mm +0/ -(μm)			kg	mm	
MMN512BS42PP DM	12 (3.8)	42 (6.4)	25 (254)	0.20	0.6	0.3
MMN515BS45PP DM	15 (3.8)	45 (6.4)	25 (254)	0.23	0.6	0.3
MMN517BS47PP DM	17 (3.8)	47 (6.4)	25 (254)	0.24	0.6	0.3
MMN520BS52PP DM	20 (5.1)	52 (7.6)	28 (254)	0.32	0.6	0.3
MMN525BS57PP DM	25 (5.1)	57 (7.6)	28 (254)	0.35	0.6	0.3
MMN530BS62PP DM	30 (5.1)	62 (7.6)	28 (254)	0.40	0.6	0.3
MMN540BS75PPDM	40 (6.4)	75 (7.6)	34 (254)	0.64	0.6	0.3
MMN550BS90PP DM	50 (6.4)	90 (7.6)	34 (254)	0.91	0.6	0.3
MMN550BS110PP DM	50 (6.4)	110 (8.9)	54 (254)	2.42	0.6	0.6
MMN560BS110PP DM	60 (7.6)	110 (8.9)	45 (254)	1.82	0.6	0.6

Sealed, Double Row
Ball Screw Support Bearings
Cartridge Style – MMN Series
Metric Dimensional Sizes

Min. D_1	Max. d_1	Housing Shoulder diameter D_a	Shaft Shoulder diameter d_a	Contact Angle B_0	Heavy Series	
mm		mm	mm	degrees		
33.1	25.0	32	19.0	60		**MMN512BS42PP DM**
37.0	27.6	34.5	21.5	60		**MMN515BS45PP DM**
37.8	28.4	36.5	23.5	60		**MMN517BS47PP DM**
43.2	34.5	42.5	27.5	60		**MMN520BS52PP DM**
49.3	40.6	48.0	33.5	60		**MMN525BS57PP DM**
54.3	45.6	53.5	38.5	60		**MMN530BS62PP DM**
68.7	57.5	67.0	49.0	60		**MMN540BS75PPDM**
82.6	71.5	81.0	63.0	60		**MMN550BS90PP DM**
99.6	81.1	98.5	66.0	60	**H**	**MMN550BS110PP DM**
100.0	84.0	98.0	72.0	60		**MMN560BS110PP DM**

Ex-Cell-O Spindle Bearings

- "EX" series (Fafnir WI construction) designed to meet Ex-Cell-O replacement requirements for inch nominal spindles with bore and O.D. tolerances nominal to *plus*
- "XWO" series (Fafnir WO separable construction) designed to meet Ex-Cell-O replacement requirements for inch nominal spindles with bore and O.D. tolerances nominal to *minus*
- Measurement of shafts and housings (or reconditioning of parts) should determine replacement bearing style
- Shafts and housings should be checked (and reworked) to avoid improper shaft and housing fits.
- Preload selection should be based on operating speed and lubrication system of spindle.

	Ex-Cell-O		Bore (in)		OD (in)		Width -pair (in)		Max. speed
	No.	Preload (lbs)	Max.	Min.	Max.	Min.	Max.	Min.	(rpm)
MM20EXCR DU FS223	20	0	0.3752	0.3750	1.1252	1.1250	0.6875	0.6775	65,000
MM30EXCR DU	30	0	0.6252	0.6250	1.5002	1.5000	1.0000	0.9900	35,000
MM30EXCR DU 5	30	5	0.6252	0.6250	1.5002	1.5000	1.0000	0.9900	25,000
MM50EXCR DU FS223	50	0	0.8127	0.8125	2.0002	2.0000	1.0000	0.9900	30,000
MM50EXCR DU 10	50	10	0.8127	0.8125	2.0002	2.0000	1.0000	0.9900	18,000
MM50EXCR DU 50	50	50	0.8127	0.8125	2.0002	2.0000	1.0000	0.9900	5,000
***MM55EXCR DU 10**	55	10	0.8127	0.8125	2.0002	2.0000	1.0000	0.9900	22,000
MM57EXCR DU FS223	57	0	1.0627	1.0625	2.2502	2.2500	1.0000	0.9900	30,000
MM57EXCR DU 10	57	10	1.0627	1.0625	2.2502	2.2500	1.0000	0.9900	15,000
MM57EXCR DU 50	57	50	1.0627	1.0625	2.2502	2.2500	1.0000	0.9900	5,000
MM67EXCR DU FS223	67	0	1.2502	1.2500	2.4377	2.4375	1.2500	1.2400	30,000
MM67EXCR DU 10	67	10	1.2502	1.2500	2.4377	2.4375	1.2500	1.2400	12,500
MM67EXCR DU 30	67	30	1.2502	1.2500	2.4377	2.4375	1.2500	1.2400	7,500
MM67EXCR DU 75	67	75	1.2502	1.2500	2.4377	2.4375	1.2500	1.2400	4,500
MM90EXCR DU 20	90	20	1.6252	1.6250	3.4377	3.4375	1.6250	1.6150	10,000
MM90EXCR DU 100	90	100	1.6252	1.6250	3.4377	3.4375	1.6250	1.6150	4,500
MM90EXCR DU 150	90	150	1.6252	1.6250	3.4377	3.4375	1.6250	1.6150	2,700
MM90EXCR DU 250	90	250	1.6252	1.6250	3.4377	3.4375	1.6250	1.6150	900
****MM92EXCR DU 20**	92	20	1.7502	1.7500	3.4377	3.4375	1.6250	1.6150	12,000
****MM92EXCR DU 100**	92	100	1.7502	1.7500	3.4377	3.4375	1.6250	1.6150	4,500
****MM92EXCR DU 150**	92	150	1.7502	1.7500	3.4377	3.4375	1.6250	1.6150	2,700
****MM92EXCR DU 250**	92	250	1.7502	1.7500	3.4377	3.4375	1.6250	1.6150	900
MM115EXCR DU 30	115	30	2.2502	2.2500	4.7502	4.7500	2.2500	2.2400	5,000
MM115EXCR DU 250	115	250	2.2502	2.2500	4.7502	4.7500	2.2500	2.2400	3,600
MM115EXCR DU 350	115	350	2.2502	2.2500	4.7502	4.7500	2.2500	2.2400	1,800
MM135EXCR DU 20	135	20	1.2502	1.2500	2.6877	2.6875	1.2500	1.2400	8,000
MM135EXCR DU 75	135	75	1.2502	1.2500	2.6877	2.6875	1.2500	1.2400	4,000
MM155EXCR DU 150	155	150	2.7502	2.7500	4.7502	4.7500	2.2500	2.2400	4,000
MM155EXCR DU 300	155	300	2.7502	2.7500	4.7502	4.7500	2.2500	2.2400	1,800
MM165EXCR DU 200	165	200	3.5002	3.5000	6.3127	6.3125	3.0000	2.9900	2,800
MM165EXCR DU 400	165	400	3.5002	3.5000	6.3127	6.3125	3.0000	2.9900	1,200

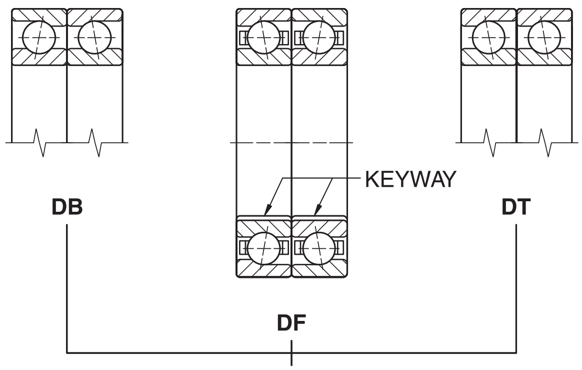
These bearings not intended for new design applications. Consult your local Timken Engineering Sales office.

Do not interchange with MM-XWO.

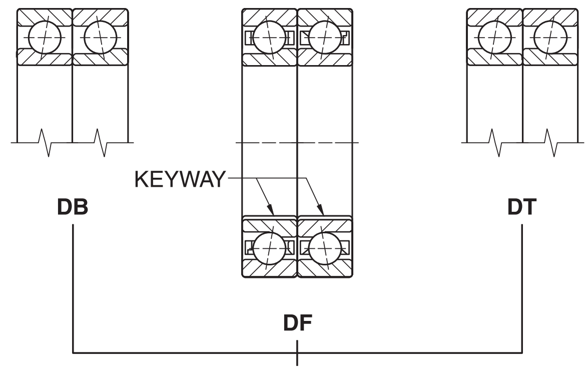
(*) Four slots in outer ring faces.

(**) No keyway in bore.

FS-223 Zero to negative preload.



Old Design, MM-EX
Bore and O.D. Tolerance
Nominal + Tolerance
"WI" Construction



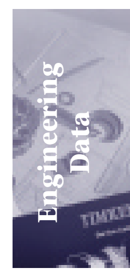
New Design, MM-XWO
Bore and O.D. Tolerance
Nominal - Tolerance
"WO" Construction

	Ex-Cell-O	Preload	Bore (in.)		OD (in.)		Width - pair (in)		Max. Speed (rpm)		
	No.	(lbs)	Max.	Min.	Max.	Min.	Max.	Min.	Grease	Oil	Mist
MM20XWOCRDU E9103A	XLO 20-107	0	0.37500	0.37485	1.1250	1.1248	0.6875	0.6675	40,000	65,000	80,000
MM30XWOCRDU E9103C	XLO 30-57	10	0.62500	0.62485	1.5000	1.4998	1.0000	0.9800	27,000	30,000	35,000
MM30XWOCRDU E9103A	XLO 30-107	0	0.62500	0.62485	1.5000	1.4998	1.0000	0.9800	35,000	40,000	60,000
MM55XWOCRDU E9103E	XLO 55-27	50	0.81250	0.81235	2.0000	1.9998	1.0000	0.9800	5,000	8,000	12,000
MM55XWOCRDU E9103C	XLO 55-57	20	0.81250	0.81235	2.0000	1.9998	1.0000	0.9800	20,000	22,000	24,000
MM55XWOCRDU E9103A	XLO 55-107	0	0.81250	0.81235	2.0000	1.9998	1.0000	0.9800	24,000	27,000	45,000
MM57XWOCRDU E9103F	XLO 57-17	100	1.06250	1.06235	2.2500	2.2498	1.0000	0.9800	2,000	4,000	6,000
MM57XWOCRDU E9103C	XLO 57-57	20	1.06250	1.06235	2.2500	2.2498	1.0000	0.9800	18,000	20,000	22,000
MM57XWOCRDU E9103A	XLO 57-107	0	1.06250	1.06235	2.2500	2.2498	1.0000	0.9800	22,000	25,000	35,000
MM67XWOCRDU E9103F	XLO 67-17	90	1.25000	1.24980	2.4375	2.4373	1.2500	1.2300	36,000	4,500	6,000
MM67XWOCRDU E9103C	XLO 67-57	20	1.25000	1.24980	2.4375	2.4373	1.2500	1.2300	12,500	15,000	20,000
MM67XWOCRDU E9103A	XLO 67-107	0	1.25000	1.24980	2.4375	2.4373	1.2500	1.2300	16,000	20,000	30,000
MM90XWOCRDU E9103F	XLO 90-17	250	1.62500	1.62480	3.4375	3.4372	1.6250	1.6050	1,000	2,000	4,000
MM90XWOCRDU E9103D	XLO 90-47	175	1.62500	1.62480	3.4375	3.4372	1.6250	1.6050	3,000	5,000	8,000
MM90XWOCRDU E9103C	XLO 90-57	100	1.62500	1.62480	3.4375	3.4372	1.6250	1.6050	5,000	7,000	11,000
MM90XWOCRDU E9103A	XLO 90-77	20	1.62500	1.62480	3.4375	3.4372	1.6250	1.6050	10,000	14,000	20,000
MM115XWOCRDU E9103E	XLO 115-27	300	2.25000	2.24980	4.7500	4.7496	2.2500	2.2300	1,000	2,000	3,000
MM115XWOCRDU E9103C	XLO 115-47	150	2.25000	2.24980	4.7500	4.7496	2.2500	2.2300	3,000	4,500	7,000
MM115XWOCRDU E9103A	XLO 115-77	30	2.25000	2.24980	4.7500	4.7496	2.2500	2.2300	6,000	8,000	15,000
MM135XWOCRDU E9103C	XLO 135-67	50	1.25000	1.24980	2.6875	2.6873	1.2500	1.2300	6,000	7,000	12,000
MM135XWOCRDU E9103A	XLO 135-10	70	1.25000	1.24980	2.6875	2.6873	1.2500	1.2300	15,000	19,000	28,000
MM155XWOCRDU E9103D	XLO 155-37	300	2.75000	2.74980	4.7500	4.7496	2.2500	2.2300	1,000	2,000	3,000
MM155XWOCRDU E9103B	XLO 155-67	150	2.75000	2.74980	4.7500	4.7496	2.2500	2.2300	4,000	5,000	6,500
MM155XWOCRDU E9103A	XLO 155-87	50	2.75000	2.74980	4.7500	4.7496	2.2500	2.2300	6,000	7,000	10,000
MM165XWOCRDU E9103E	XLO 165-27	800	3.50000	3.49975	6.3125	6.3121	3.0000	2.9800	500	1,000	2,000
MM165XWOCRDU E9103C	XLO 165-57	250	3.50000	3.49975	6.3125	6.3121	3.0000	2.9800	2,000	3,000	5,000
MM165XWOCRDU E9103A	XLO 165-87	50	3.50000	3.49975	6.3125	6.3121	3.0000	2.9800	5,000	6,500	9,000

Do not interchange with MM-EX

MM-XWO produced to nominal minus tolerance.


TIMKEN
Service Catalog


Engineering
Data

INTRODUCTION

Timken has long been a pioneer and leader in the advancement of bearing technology as demonstrated by its present level of sophistication and precision. Expert craftsmen, world class production facilities and ground breaking research and development programs insure that Timken products are synonymous with quality and reliability. Today, Timken plants manufacture thousands of bearing types and sizes to handle a broad range of application requirements.

Today's antifriction bearings possess capabilities involving a wide range of speeds, plus various combinations of radial and thrust loads. Other important environmental conditions, such as low and high temperature operation, dust and dirt, moisture, and unusual mounting conditions affect successful bearing operation.

This engineering section is not intended to be a totally comprehensive manual but to help serve as a useful guideline in bearing selection. Where more complex bearing applications are involved, Timken Engineering should be consulted.

SHELF LIFE AND STORAGE OF GREASE LUBRICATED BEARINGS AND COMPONENTS SHELF LIFE POLICY:

The Timken Policy for the Shelf Life of Grease Lubricated Rolling Element Bearings, Components and Assemblies is set forth below. The Shelf Life values are based on test data and experience. Shelf Life should be distinguished from lubricated bearing/component Service Life as follows:

Shelf Life

The Shelf Life of the grease lubricated bearing/component is the maximum allowable time interval from date of original manufacture/packaging to the removal from the original packaging (hereinafter referred to as "Shelf Life").

Service Life

The Service Life of the grease lubricated bearing/component is a measure of the anticipated aggregate usage (hereinafter referred as "Service Life"). Variations in lubricant bleed rates, oil migration, operating conditions, installation conditions, temperature, humidity and extended storage make it difficult to accurately predict Service Life.

The Bearing Shelf Life is related primarily to the lubricant's ability to maintain the bearing's original manufactured radial internal clearance and freedom to rotate.

The Component Shelf Life is related to the ability of the component to function as originally intended.

The Shelf Life values, available from a Timken Sales Office, represent the period of time prior to use or installation. Due to the broad range of applications, Timken cannot anticipate the performance of the grease lubricant after the bearing or component is installed or placed in service.

These Shelf Life values are to be used as a maximum limit – assuming adherence to the Timken recommended storage and handling policy. Deviations from Timken's Storage and Handling Policy may reduce Shelf Life. Any specification or operating practice that defines a shorter Shelf Life should be used.

TIMKEN DISCLAIMS RESPONSIBILITY FOR THE SHELF LIFE OF ANY BEARING/COMPONENT LUBRICATED BY ANOTHER PARTY.

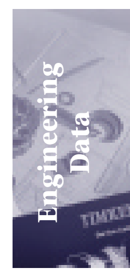
STORAGE POLICY:

The Timken policy recommends the following storage guidelines for finished products (bearings, components, and assemblies, hereinafter referred to as "Products"):

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

In as much as Timken is not familiar with a customer's particular storage conditions, these guidelines are strongly recommended. However, the customer may very well be required by circumstance, applicable government requirements, and the like to adhere to stricter storage requirements.

Any questions concerning the Shelf Life or Storage Policy should be directed to the local Sales Office.



Warning: A bearing/component should not be put into service if its shelf life has been exceeded. Failure to adhere to this warning, or to follow the instructions on storage, can result in equipment failure, creating a risk of serious bodily harm.

SPINDLE SYSTEM CHARACTERISTICS

The bearing characteristics which often concern machine tool builders beyond bearing precision are:

- Vibration characteristics
- Heat generation
- Noise level
- Stiffness

A machine tool designer's goal is to build a precise spindle with the least possible vibration and with the optimum heat generation and dissipation characteristics. This will then produce the best surface finish, dimensional accuracy and optimum production rates. Bearing noise has become important as far as work safety legislation is concerned, but has little or no effect on either machine performance or finished product.

Due to the increase in cutting speeds, and in some cases the cutting forces, machine tool builders are developing spindle designs to improve dynamic stiffness.

Dynamic stiffness depends upon:

- Static stiffness
- Damping
- Mass

From a design standpoint, the bearing selection has little effect on mass, but static stiffness and damping can be altered by bearing and application design criteria. The natural frequency of a system can be radically altered by any change in the static stiffness. On the other hand, damping will determine the magnitude of displacement of a system in the chatter mode. Tests have shown that the damping varies with the type of anti-friction bearing used.

Static Stiffness

The static stiffness or "spring rate" of a system is defined as the ratio of the amount of load, to the deflection of the spindle at the point of load, and is expressed in N/mm.

In conventional spindle designs, the load is usually applied at the end of the spindle nose.

In a spindle system, several factors contribute to the total static stiffness:

- Bare spindle stiffness
- Bearing stiffness
- Housing stiffness

Bare Spindle Stiffness

Fig. 4-1 illustrates the important elements that need to be considered to determine the bare spindle stiffness:

- Diameter of the spindle
- Overhung distance from the nose bearing to the load
- Bearing spread

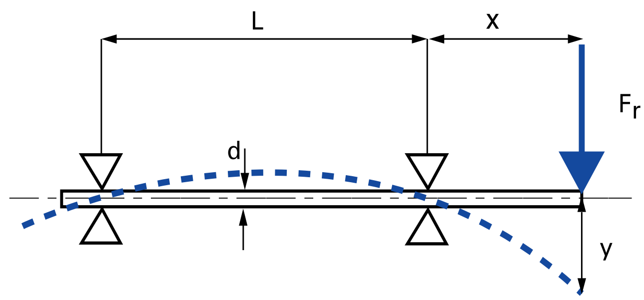


Fig. 4-1
Deflection of the bare spindle on two supports

The maximum value of the spindle deflection at the point of load is:

$$y = \frac{F_r \times X^2 \times (X + L)}{3 \times E \times I} \text{ (mm)} \qquad \text{with } I = \frac{\pi \times d^4}{64} \text{ (N)}$$

where:

F_r = radial load applied at spindle nose (N)
L = bearing spread (mm)
X = overhung distance (mm)
I = moment of inertia (mm^4)
y = deflection at point of load (mm)
d = diameter of spindle (mm)
E = modulus of elasticity (N/mm^2)

Therefore, the static stiffness of the bare spindle at this point is:

$$K = \frac{F_r}{y} = \frac{3 \times E \times I}{X^2 \times (X + L)} = \frac{3 \times E \times \pi \times d^4}{64 \times X^2 \times (X + L)} \text{ (N/mm)}$$

The previous formula shows that the diameter of a shaft is considered to the fourth power. Thus, any increase in spindle diameter will significantly increase stiffness. For example: a 19 % increase in shaft diameter results in a 100 % increase of the bare spindle stiffness. From a design standpoint, this means that the selected bearings should have as large a bore diameter as practical for a given outside diameter (fig. 4-2).

The overhung distance from the nose bearing to the applied loads is generally fixed by design constraints (or load cycles). However, the stiffness of the bare spindle can be increased by determining the optimum spread between the two supports. For a given overhung distance "x," the bearing spread has an optimum value for minimum deflection at the cutting point (fig. 4-3).

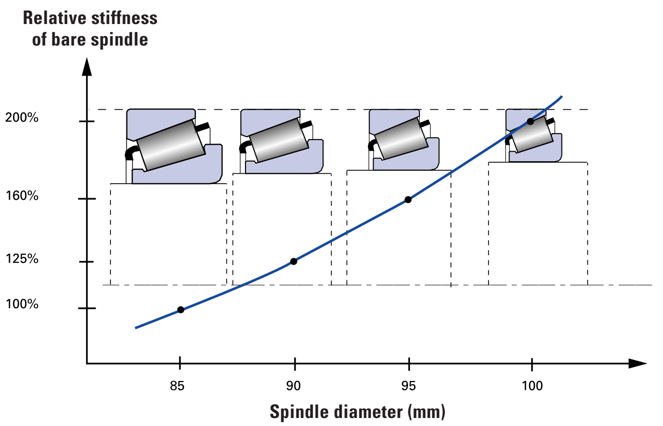


Fig. 4-2
Influence of spindle diameter on its stiffness for different tapered roller bearings sections within same envelope (85 mm bore taken as reference)

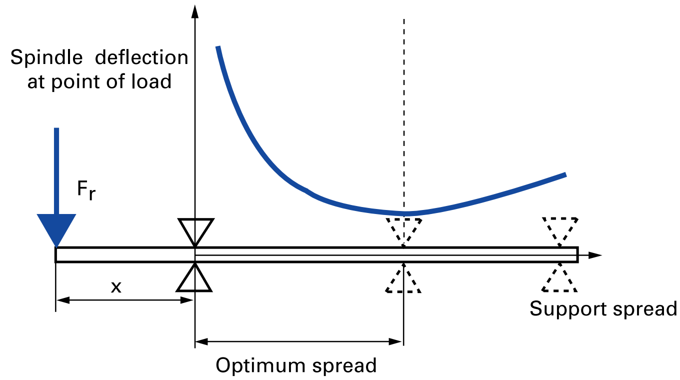


Fig. 4-3
Influence of spread on bare spindle deflection at point of load

Spindle System Dynamic Stiffness

Dynamic stiffness is influenced to a large degree by the damping characteristics and the static stiffness of the system.

Fig. 4-4 demonstrates that bearing setting plays a major role in the static stiffness of a spindle-bearing-housing system. As the preload is increased,the static stiffness increases.

A load that would cause very little static deflection can cause, however, very high dynamic

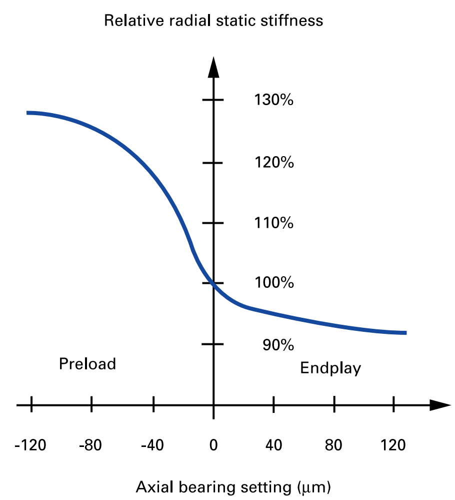


Fig. 4-4
Effect of bearing setting on spindle system static stiffness

(continued)

deflections if the frequency of the dynamic load is the same as the natural frequency of the spindle. To control the dynamic stiffness, the damping characteristics of the system are very important.

Damping can be visualized as resistance to vibration. It can be seen on fig. 4-5 that the damping ratio of a spindle system is higher when bearings are preloaded. The optimum value is, however, obtained around the zero clearance condition.

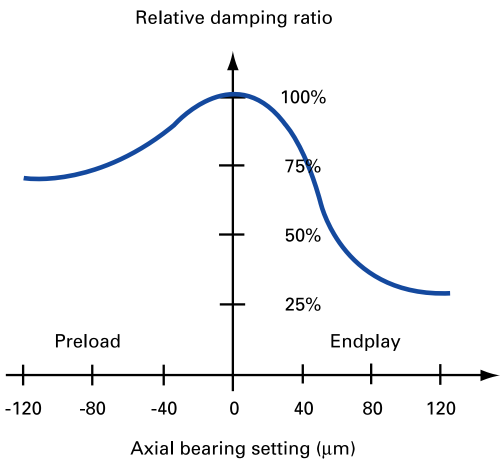


Fig. 4-5
Effect of bearing setting on spindle system damping ratio

Finally, the resulting dynamic stiffness characteristics of a spindle system are directly affected by the bearing setting. The curve plotted in fig. 4-6 shows an optimum setting slightly in the preload region. This gives the least compliance, or maximum dynamic stiffness, of a spindle system since the damping decreases as preload increases. As previously explained, any preload increase beyond the optimum setting will reduce the dynamic spindle characteristics.

Extensive research by The Timken Company has resulted in a better knowledge of machine tool spindle behavior. It was identified that higher accuracy and

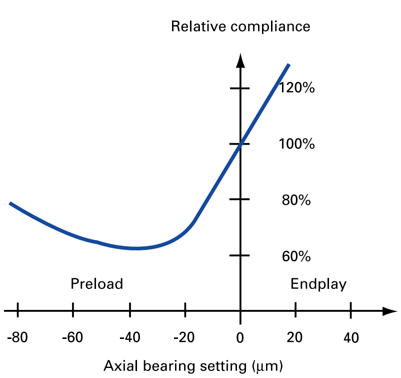


Fig. 4-6
Effect of bearing setting on spindle system dynamic stiffness

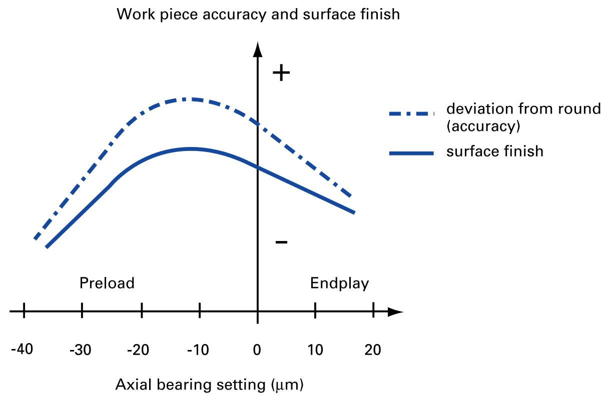


Fig. 4-7
Effect of bearing setting on surface finish and accuracy of the workpieces

improved surface finish can be achieved at an optimum preload setting (fig. 4-7).

The unique design of a tapered roller bearing with its line contact produces a damping characteristic which is not necessarily inherent to other bearing designs (fig. 4-8). This is due to the bending mode of the spindle and bearing centerline caused by dynamic deflection is resisted inside the bearing through a shearing action of the viscous lubricant between the rollers and the cup and cone races.

It is the combination of the tapered roller bearing construction and proper bearing setting which results in improved damping characteristics.

An extension of this insight culminated in the development of a new bearing system called the Hydra-Rib™, specifically designed to provide the optimum bearing preload and thus the ultimate dynamic stability for the spindle system under any operating conditions.

Proper selection of the preload for a given application must not focus only on stiffness and damping characteristics. The lubrication method, operating speeds and loads must be reviewed to determine the optimum setting/preload to maximize performance. Consult the appropriate topic in this engineering section for more details.

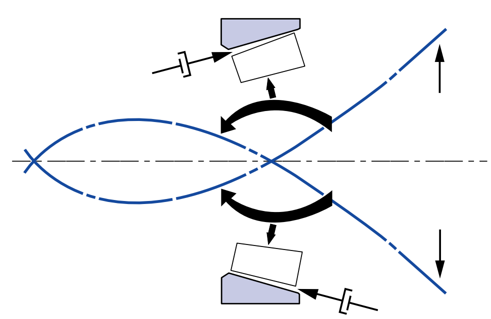


Fig. 4-8
Damping in a tapered roller bearing

BEARING SELECTION

In selecting the proper size and type of bearing, consideration is given to the operating speeds, lubrication method, size and construction of the spindle, and the type of mounting (since this relates directly to the spindle rigidity and deflection characteristics). In general, where the operating load is primarily radial, low contact angle type bearings are used. However, when maximum axial rigidity is required in combination with heavy thrust loads (or when high ambient temperatures are common), bearings with higher contact angles are preferred.

As described in the very beginning of this catalog, the process for selecting the proper type of anti-friction bearing, design style and ultimately the full part number and code/specification can be complex and iterative in nature. This Engineering section, along with the discussion in the introductory section (pgs. 8-9) is intended to act as a guide to assist in the selection process. Please contact Timken for clarification, concerns, and further guidance with your selection.

Selecting the Appropriate Precision Tapered Roller Bearing

As noted in the Spindle System Characteristics section, optimizing stiffness is often a customer's primary design goal. This usually results in the determination of a desired spindle diameter. Therefore, meeting a given envelope narrows the choices for the tapered roller bearing selection.

The next most common criteria are the speed capability/limitations of the remaining potential candidates. This can be challenging, since the limiting speed of a tapered roller bearing is a function of its internal geometry, the axial setting under operation conditions, the lubricant used and method of delivery. The Appendix contains a speed guideline matrix that will aid in determining the limiting speed and suggested lubricant/delivery method for your tapered roller bearing application. Also included in the Appendix is a table listing the G1 and G2 factors that can be utilized to compare the relative speed capability and heat generation between the various tapered roller bearing selections. Please refer to the section on speedability and heat generation for further discussion.

Most precision and machine tool applications that are maintained properly and well designed do not reach their limits of service life from the same causes seen in common industrial bearing applications (such as spalling damage). However, the fatigue life should be an important consideration, since the bearing load capacities are intrinsically linked to the stiffnesses of the bearing. In fatigue life or stiffness requirements, the selection of the most appropriate tapered roller bearing cup angle can help optimize the bearing selection for a given application.

Typically, once the most appropriate bearing part number has been identified for a particular application, the final parameter is the desired precision level. The suggested assembly and/or inspection code (precision class & performance code) can be applied to the chosen part number to obtain the necessary precision level.

Consult Timken for suggestions related to appropriate bearing enchancements that improve the performance of your application. Such enhancements might include unique precision levels; conversion of a TS-style design to a (flanged) TSF or (multi-row) TDO; or possibly ceramic rolling elements for better stiffness and speedability.

Selecting the Appropriate Super Precision Ball Bearing

For each bore size there are three preload levels available: light, medium and heavy. The three established preload values are necessarily higher for high contact angle bearings than for those having low contact angles. The axial and radial deflection characteristics of low angular-contact, light series, preloaded ball bearings of a standard size are shown in Figure 4-9. Curves C and D, which are for a preloded tandem pair of such bearings, indicate the greatly reduced axial and radial deflections as compared to those for a preloaded single bearing of the same size (Curves A and B). For example, a tandem pair of bearings under a thrust load of 600 pounds would have an axial defection of 0.0009 inch, while that for a single bearing would be about 0.0017 inch. Similarly, the radial deflections for these bearings operated under 600 pounds radial loads would be 0.00024 inch and 0.00049 inch.

Timken-Fafnir angular-contact precision ball bearings are available with high (25°) and low (15°) contact angles. Each type has inherent characteristics that are desirable for machine tool spindles. Low contact angle bearings are more rigid radially and less rigid axially than high contact angle bearings. A bearing having a low contact angle allows more axial yield and less radial deflection than one having a high contact angle.

Axial deflection curves for the standard preload levels for both the 2MM (15° contact angle) and the

Effect of Single and Tandem Mounting on Axial and Radial Rigidity

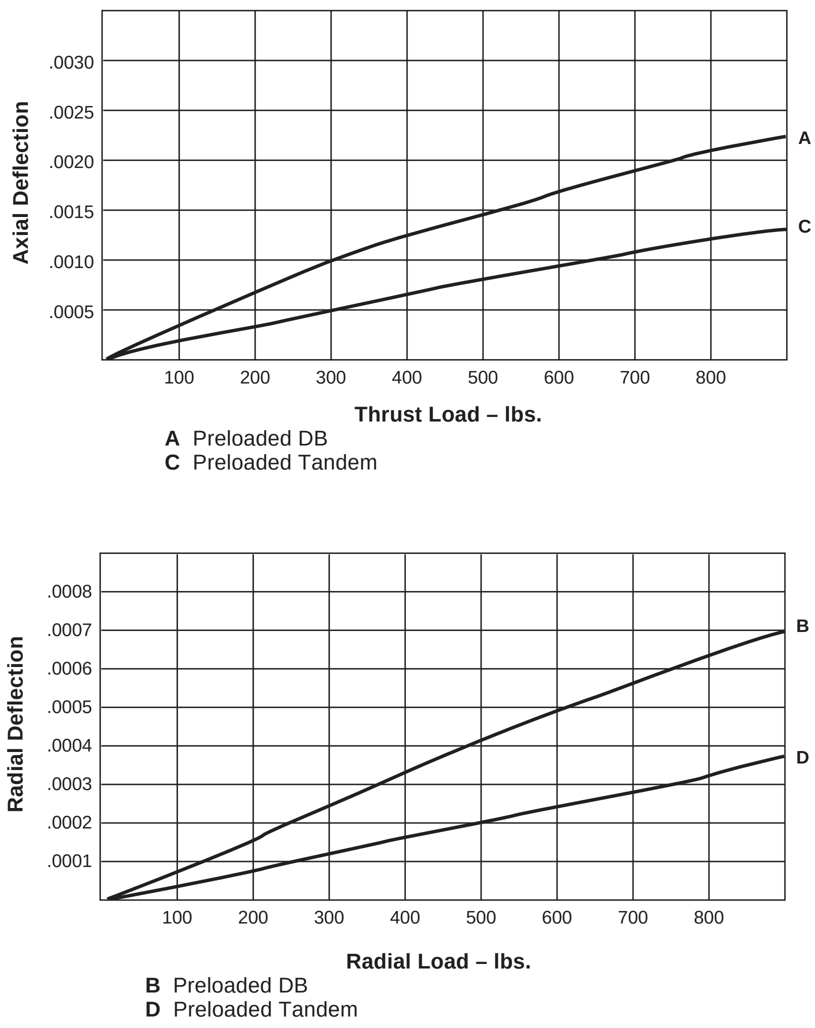


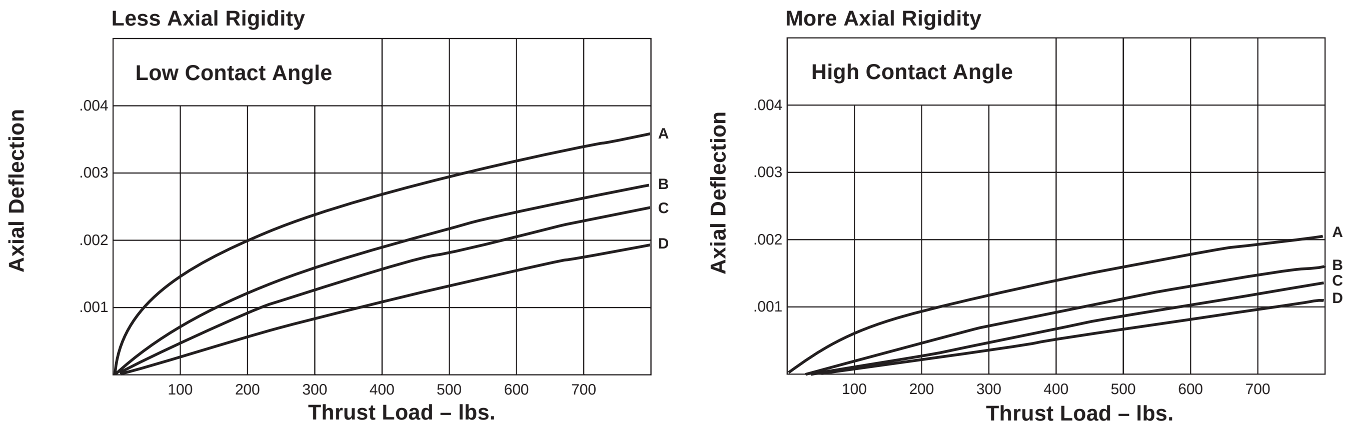
Figure 4-9 – Axial vs Radial Deflections

3MM (25° contact angle) are shown in Figure 4-10. Please note the force for the equivalent preload level for a 2MM bearing is about one-half that of the preload level for a 3MM bearing. Preload values for all Fafnir machine tool grade angular-contact bearings have been calculated to give optimum performance over a wide range of applications.

A comparison of the curves in Figure 4-10 shows the 25° contact angle bearing to be more rigid under axial loads than the 15° contact angle bearing. Note that the axial deflection for the 2MM 15° contact angle preloaded pair of bearings with a medium preload (60 pounds) is 0.0013" under a 300 pound thrust load. The 3MM 25° contact angle preloaded pair with a light preload (60 pounds) deflects 0.0008" under the same 300 pound thrust load.

Similar comparisons of the radial deflection characteristics of the same two types of angular-contact ball bearings can be made from the two graphs shown in Figure 4-11. These curves show that increased radial deflections result when bearings having the higher contact angle are used. The indicated radial deflections are for one bearing. When employing duplex pairs of bearings under equal, applied loads, the radial deflections would be approximately one-half of the values shown.

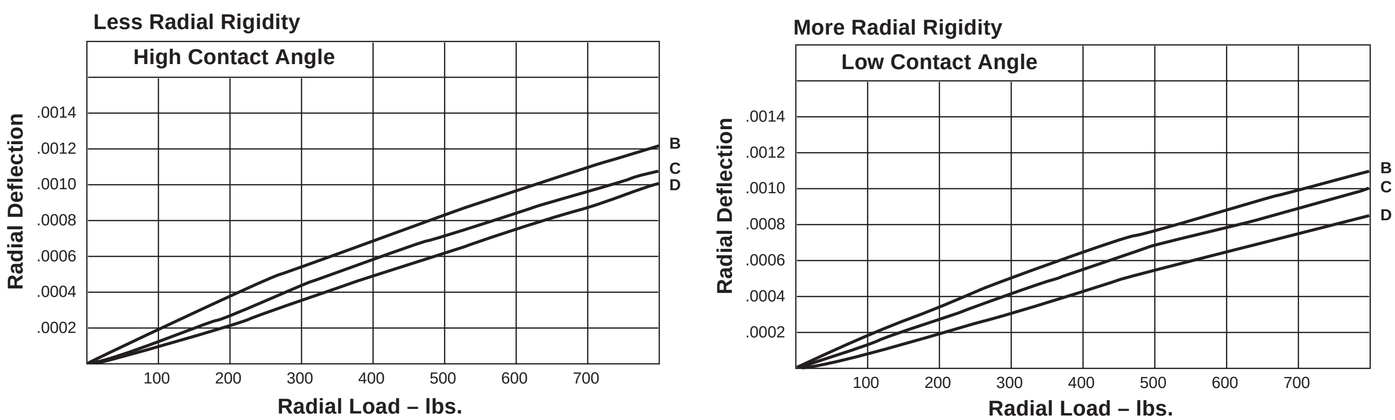
Effects of Contact Angle on Axial Deflection



A No Preload
B Light Preload 40lbs.
C Medium Preload 125lbs.
D Heavy Preload 250lbs.

Figure 4-10 – Axial Deflections

Effect of Contact Angle on Radial Deflection



B Light Preload 40 lbs.
C Medium Preload 125 lbs.
D Heavy Preload 250 lbs.

Figure 4-11 – Radial Deflections

TOLERANCES

Timken Tapered Roller Bearings

Runout

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

The maximum assembled radial runout (T.I.R.) for the different classes of Timken bearings are listed in the following tables for both metric and inch-dimension bearings. For comparison purposes, the maximum radial runout of standard class bearings are included in the tabulation. These bearings are identified as Class 4 and 2 in the inch system, and Class K and N in the metric system.

Metric System Tapered Roller Bearings

Assembled Bearing Maximum Radial Runout (T.I.R.)
Deviation in micrometers (µm) and inches

Cup O.D.		Precision Class				Standard Class	
Over mm/inch	Incl. mm/inch	C	B	A	AA	K	N
18 0.7087	30 1.1811	5 0.0002	3 0.0001	1.9 0.00007	1 0.00004	18 0.0007	18 0.0007
30 1.1811	50 1.9685	6 0.0002	3 0.0001	1.9 0.00007	1 0.00004	20 0.0008	20 0.0008
50 1.9685	80 3.1496	6 0.0002	4 0.0002	1.9 0.00007	1 0.00004	25 0.0010	25 0.0010
80 3.1496	120 4.7244	6 0.0002	4 0.0002	1.9 0.00007	1 0.00004	35 0.0013	35 0.0014
120 4.7244	150 5.9055	7 0.0003	4 0.0002	1.9 0.00007	1 0.00004	40 0.0016	40 0.0016
150 5.9055	180 7.0866	8 0.0003	4 0.0002	1.9 0.00007	1 0.00004	45 0.0018	45 0.0018
180 7.0866	250 9.8425	10 0.0004	5 0.0002	1.9 0.00007	1 0.00004	50 0.0020	50 0.0020
250 9.8425	315 12.4016	11 0.0004	5 0.0002	1.9 0.00007	1 0.00004	60 0.0024	60 0.0024
315 12.4016	400 15.7480	13 0.0005	5 0.0002	— —	— —	70 0.0028	70 0.0028
400 15.7480	500 19.6850	18 0.0007	— —	— —	— —	80 0.0031	80 0.0031
500 19.6850	630 24.8031	25 0.0010	— —	— —	— —	100 0.0039	— —
630 24.8031	800 31.4961	35 0.0014	— —	— —	— —	120 0.0047	— —
800 31.4961	1000 39.3701	50 0.0020	— —	— —	— —	140 0.0055	— —
1000 39.3701	1200 47.2441	60 0.0024	— —	— —	— —	160 0.0063	— —
1200 47.2441	1600 62.9921	80 0.0031	— —	— —	— —	180 0.0070	— —
1600 62.9921	— —	— —	— —	— —	— —	200 0.0079	— —

Inch System Tapered Roller Bearings

Assembled Bearing Maximum Radial Runout (T.I.R.)
Deviation in micrometers (µm) and inches

Cup O.D.		Precision Class				Standard Class	
Over (mm/inch)	Incl. (mm/inch)	3	0	00	000	4	2
— —	315.000 12.4016	8 .0003	4 .00015	2 .000075	1 .000040	51 .0020	38 .0015
315.000 12.4016	609.600 24.0000	18 .0007	— —	— —	— —	51 .0020	38 .0015
609.600 24.0000	914.400 36.0000	51 .0020	— —	— —	— —	76 .0030	51 .0020
914.400 36.0000	— —	76 0.0030	— —	— —	— —	76 .0030	— —

Ball Bearings

The Annular Bearing Engineers' Committee has established four classes of tolerances for ball bearings, known as ABEC1, ABEC5, ABEC7, and ABEC9. The highest number indicates the class with the most exacting tolerances. Every ball bearing manufactured by The Timken Company is made to close tolerances, adhering to the established ABEC standards.

Applications involving high speeds, extreme accuracy and rigidity in such equipment as high-grade machine tools, precision wheelheads and workheads, woodworking machines, superchargers, jet engines, sensitive precision instruments and digital computers, Timken manufactures a complete line of super
precision ball bearings made to ABEC7&9 tolerances.

Basically single row construction, these ball bearings are available in four series, named ultra-light (9300/ISO-19), extra-light (9100/ISO-10), light (200/ISO-02) and medium (300/ISO-03), providing a considerable range in external dimension relationships.

The chart below shows the various classes of tolerances for 35-millimeter bore size, light series bearings (207). To meet the exacting requirements of the machine tool industry, even ABEC9 tolerances do not represent the ultimate, since some special applications require even higher precision.

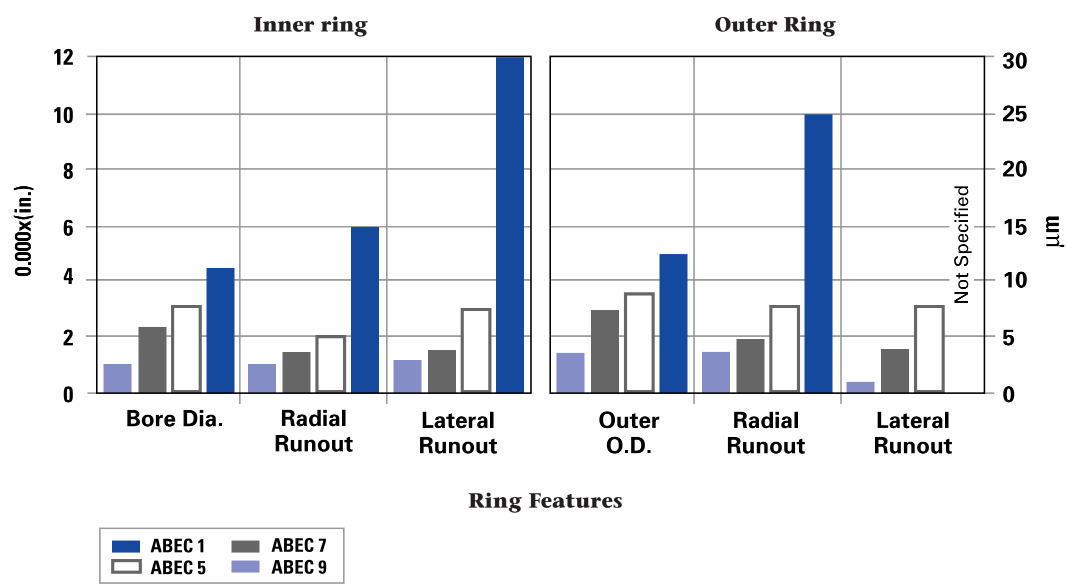
ABEC Tolerances

Before it can be determined which type and classification of Fafnir precision ball bearing is the best suited for a particular application, all details of the bearing mounting, bearing tolerances and eccentricities as listed in the dimension tables – and cost – must be thoroughly explored. Obviously, it is not economical to attempt the use of low precision bearings on an application where extra-high speeds and ultra-precision bearings are required.

Assuring consistent performance and interchangeability, Fafnir precision bearings are manufactured to close tolerances. To take full advantage of this precision product, it is expected that equally close tolerances be used in the production of mounting components (housings, shafts, spacers, etc.). Therefore, special consideration must be given to the particular details relating to proper shaft and housing fits and the housing design.

Values of standard tolerances ABEC7 and ABEC9, for super precision ball bearings used in machine tool applications are shown on the following pages.

ABEC Tolerances (Light Series, 35mm Bore Type)



Standard Tolerances (Ball Bearings)

Outer, Inner Rings ABEC7,9 – ISO P4, P2

Values of tolerances ABEC7 and ABEC9 for super precision ball bearings are shown below. All Timken Fafnir sizes in this catalog are manufactured to MMV levels (even if marked and packaged only as MM.)

ABMA/ISO Symbols – Outer Ring

ΔDmp Single plane mean outside diameter deviation from basic outside diameter,i.e.,O.D. tolerance.

K_{ea} Radial runout of assembled bearing outer ring, i.e., radial runout of raceway.

V_{Cs} Outer ring width variation, i.e. parallelism.

S_D Outside cylindrical surface runout with outer ring refernece face, i.e., squareness O.D. to face.

S_{ea} Axial runout af assembled bearing outer ring, i.e. lateral (axial) runout of raceway.

ΔC_s Single outer ring width deviation from basic, i.e., width tolerance.

Standard Fafnir Tolerances – Outer Ring

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

D Bearing O.D.		ΔDmp Outside Diameter(1) +.0000",+0.0µm to minus µ		V_{Cs} Width Variation (Parallelism)	K_{ea} Raceway Radial Runout	S_{ea} Raceway Axial Runout	S_D Outside Diameter Runout With Face (Squareness)	Δ_{Cs} Width Outer Rings +.0000",+0.0µm to minus
		MM(V) ABEC 7	ABEC[2] 9	*MM(V)* ABEC 9	*MM(V)* ABEC 9	*MM(V)* ABEC 9	*MM(V)* ABEC 9	ABEC 9
Over mm	Incl. mm	inch µm	inch µm	inch µm	inch µm	inch µm	inch µm	inch µm
0	**18**	-1 1/2 **-4**	-1 **-2 1/2**	1/2 **1 1/2**	1/2 **1 1/2**	1/2 **1 1/2**	1/2 **1 1/2**	16 **40**
18	**30**	-2 **-5**	-1 1/2 **-4**	1/2 **1 1/2**	1 **2 1/2**	1 **2 1/2**	1/2 **1 1/2**	31 **80**
30	**50**	-2 1/2 **-6**	-1 1/2 **-4**	1/2 **1 1/2**	1 **2 1/2**	1 **2 1/2**	1/2 **1 1/2**	47 **120**
50	**80**	-3 **-7**	-1 1/2 **-4**	1/2 **1 1/2**	1 1/2 **4**	1 1/2 **4**	1/2 **1 1/2**	47 **120**
80	**120**	-3 **-8**	-2 **-5**	1 **2 1/2**	2 **5**	2 **5**	1 **2 1/2**	59 **150**
120	**150**	-3 1/2 **-9**	-2 **-5**	1 **2 1/2**	2 **5**	2 **5**	1 **2 1/2**	79 **200**
150	**180**	-4 **-10**	-3 **-7**	1 **2 1/2**	2 **5**	2 **5**	1 **2 1/2**	98 **250**
180	**250**	-4 1/2 **-11**	-3 **-8**	1 1/2 **4**	3 **7**	3 **7**	1 1/2 **4**	98 **250**
250	**315**	-5 **-13**	-3 **-8**	2 **5**	3 **7**	3 **7**	2 **5**	118 **300**
315	**400**	-6 **-15**	-4 **-10**	3 **7**	3 **8**	3 **8**	3 **7**	

(1) D**MIN** and D**MAX** (the smallest single diameter and the largest single diameter of a O.D. in a single radial plane, respectively) may fall outside limits shown.

$\frac{\text{DMIN + DMAX}}{2}$ in a single radial plane must be within O.D. diameter tabulated. For further details see ABMA Standard 20 and Standard 4.

(2) Bearings can be produced with ABEC9/ISO P2 level tolerances. Call for availability.

ABMA/ISO Symbols – Inner Ring

Δdmp Single plane mean bore diameter deviation from the basic bore diameter,i.e.,bore tolerance.

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 af assembled bearing inner ring, i.e., lateral (axial) runout of raceway.

Δ_{Bs} Single inner ring width deviation from basic, i.e., width tolerance.

Width Tolerances:

The width tolerances for individual inner and outer rings are shown in the table below. To allow for the preload grinding on bearings for various preloads, the total width tolerances of duplex sets are as shown. The total width tolerance is proportional to the number of bearings. Note how the Timken Fafnir values are significantly tighter than ABMA/ ISO requirements.

Preloaded Duplex Set Width Tolerance

Nominal bore Millimeters		Width Tolerance (Duplex Set)			
		ABMA/ISO		Timken/Fafnir	
Over	Inclusive	Max.	Min.	Max.	Min.
0	80	.000" .00mm	-.0196" -.50mm	.000" .00mm	-.0100" -.25mm
80	180	.000" .00mm	-.0300" -.76mm	.000" .00mm	-.0100" -.25mm
180	250	.000" .00mm	-.0394" -1.00mm	.000" .00mm	-.0100" -.25mm

Standard Fafnir Tolerances – Inner Ring

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

d Bearing Bore		Δdmp Bore Diameter(1) +.0000",+.0.0µm to minus		V_{Bs} Width Variation (Parallelism)	K_{ia} Raceway Radial Runout	S_d Face Runout With Bore (Squareness)	S_{ia} Raceway Axial Runout	Δ_{Bs} Width Inner +.0000"+0.0µm to minus
		MM(V) ABEC 7	ABEC[2] 9	MM(V) ABEC 9	MM(V) ABEC 9	MM(V) ABEC 9	MM(V) ABEC 9	ABEC 9
Over mm	Incl. mm	inch µm	inch µm	inch µm	inch µm	inch µm	inch µm	inch µm
0	10	-1 1/2 -4	-1 -2 1/2	1/2 1 1/2	1/2 1 1/2	1/2 1 1/2	1/2 1 1/2	16 40
10	18	-1 1/2 -4	-1 -2 1/2	1/2 1 1/2	1/2 1 1/2	1/2 1 1/2	1/2 1 1/2	31 80
18	30	-2 -5	-1 -2 1/2	1/2 1 1/2	1 2 1/2	1/2 1 1/2	1 2 1/2	47 120
30	50	-2 1/2 -6	-1 -2 1/2	1/2 1 1/2	1 2 1/2	1/2 1 1/2	1 2 1/2	47 120
50	80	-3 -7	-1 1/2 -4	1/2 1 1/2	1 2 1/2	1/2 1 1/2	1 2 1/2	59 150
80	120	-3 -8	-2 -5	1 2 1/2	1 2 1/2	1 2 1/2	1 2 1/2	79 200
120	150	-4 -10	-3 -7	1 2 1/2	1 2 1/2	1 2 1/2	1 2 1/2	98 250
150	180	-4 -10	-3 -7	1 1/2 4	2 5	1 1/2 4	2 5	98 250
180	250	-4 1/2 -12	-3 -8	2 5	2 5	2 5	2 5	118 300

(1) d**MIN** and d**MAX** (the smallest single diameter and the largest single diameter of a bore in a single radial plane, respectively) may fall outside limits shown.

$\frac{dMIN + dMAX}{2}$ in a single radial plane must be within bore diameter tabulated. For further details see ABMA Standard 20 and Standard 4.

Micron Bore & O.D. Coding (Ball Bearings)

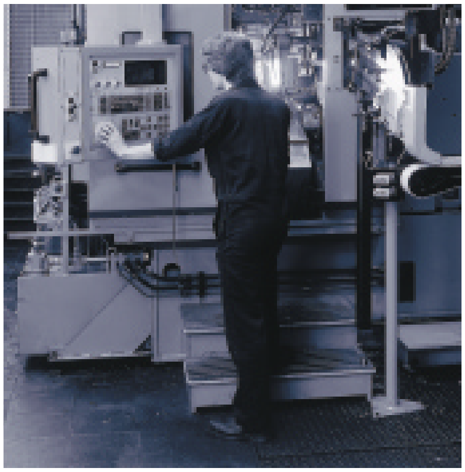
To better match machine tool bearings to spindles, Timken offers micron coding for its Timken Fafnir Super Precision ball bearing line. (Micron coding is standard on all products except ball screw support bearings and Ex-Cell-O bearings.)

Micron coding is based on average bore and O.D. diameters. This type of coding indicates the deviation from the nominal size in microns.

The coding is marked on the inner and outer rings and on the box label.

Deviation From Nominal

Micron Coding	Micron Over	Micron Incl.	Inch Over	Inch Incl.
1	0	-1	0.000000	-0.000039
2	-1	-2	-0.000039	-0.000079
3	-2	-3	-0.000079	-0.000118
4	-3	-4	-0.000118	-0.000157
5	-4	-5	-0.000157	-0.000197
6	-5	-6	-0.000197	-0.000236
7	-6	-7	-0.000236	-0.000276
8	-7	-8	-0.000276	-0.000315
9	-8	-9	-0.000315	-0.000354
10	-9	-10	-0.000354	-0.000394
11	-10	-11	-0.000394	-0.000433
12	-11	-12	-0.000433	-0.000472
13	-12	-13	-0.000472	-0.000512



Fitting Practices

General Guidelines for Tapered Roller Bearings

The design of a tapered roller bearing permits the setting to be achieved during installation (or during running when using a Hydra-Rib™), irrespective of the inner and outer race fits on shaft and housing. This allows the use of the widest possible machining tolerances for shaft and housing and the use of the best possible fits for the inner and outer races to match the duty of the bearing.

The fitting practice will depend upon the following parameters:

- Precision class of the bearing
- Type of layout
- Type and direction of loads
- Running conditions (vibrations, high speeds)
- Shaft and housing sections and materials
- Mounting and setting conditions.

In the machine tool industry, where almost 100% of cases are rotating shaft applications, the general rule is to tight-fit both the cones and cups for simple 2TS(F) layouts in order to eliminate any undesirable radial clearance.

Note: Tapered roller bearing envelope tolerances can be adjusted to the needs of a specific application.

Fitting Guidelines For Metric Tapered Roller Bearings (except TXR bearings)

Suggested precision application limits and fitting guidelines for ferrous shaft and housing.

HOUSING BORE – Deviation from nominal (maximum) bearing OD and resultant fit, expressed in micrometers (µm) and inches

Bearing O.D.		Class C									
			Non-adjustable or in carrier			Floating			Adjustable		
Range mm/inch Over	Incl.	Bearing O.D. Tol.	Symbol Fit	Housing Bore Deviation	Resultant Fit	Symbol Fit	Housing Bore Deviation	Resultant Fit	Symbol Fit	Housing Bore Deviation	Resultant Fit
18 0.7087	30 1.1811	0 -8 0 -0.00031	N5	-21 -12 -0.00085 -0.00045	21T 4T .00085T .0014T	G5	+7 +16 +0.0003 +0.0001	7L 24L .0003L .00041L	K5	-8 +1 -0.0004 0	8T 9L .0004T .00031L
30 1.1811	50 1.9685	0 -9 0 -0.00035	N5	-24 -13 -0.0010 -0.0006	24T 4L .0010T .00025T	G5	+9 +20 +0.0004 +0.0008	9L 29L .0004L .0015L	K5	-9 +2 -0.0004 0	9T 11L .0004T .00035L
50 1.9685	80 3.1496	0 -11 0 -0.00043	N5	-28 -15 -0.0011 -0.0006	28T 4T .0011T .00017T	G5	+10 +23 +0.0004 +0.0009	10L 34L .0004L .00133L	K5	-10 +3 -0.0004 +0.0001	10T 14L .0004T .00053L
80 3.1496	120 4.7244	0 -13 0 -0.00051	N5	-33 -18 -0.0014 -0.0008	33T 5T .0014T .00029T	G5	+12 +27 +0.0005 +0.0011	12L 40L .0005L .00161L	K5	-13 +2 -0.0005 +0.0001	13T 15L .0005T .00061L
120 4.7244	150 5.9055	0 -15 0 -0.00059	N5	-39 -21 -0.0017 -0.0010	39T 6T .0017T .00041T	G5	+14 +32 +0.0006 +0.0013	14L 47L .0006L .00189L	K5	-15 +3 -0.0006 +0.0001	15T 18L .0006T .00069L
150 5.9055	180 7.0866	0 -18 0 -0.00070	N5	-39 -21 -0.0017 -0.0010	39T 3T .0017T .0003T	G5	+14 +32 +0.0006 +0.0013	14L 50L .0006L .0020L	K5	-15 +3 -0.0006 +0.0001	15T 21L .0006T .0008L
180 7.0866	250 9.8425	0 -20 0 -0.00078	N5	-45 -25 -0.0020 -0.0012	45T 5T .0020T .00042T	G5	+15 +35 +0.0006 +0.0014	15L 55L .0006L .00218L	K5	-18 +2 -0.0007 +0.0001	18T 22L .0007T .00088L
250 9.8425	315 12.4016	0 -25 0 -0.00098	N5	-50 -27 -0.0020 -0.0011	50T 2T .0020T .00012T	G5	+17 +40 +0.0007 +0.0016	17L 65L .0007L .00258L	K5	-20 +3 -0.0008 +.0001	20T 28L .0008T .00108L

T= Tight L=Loose

Class B										Class A and AA						
	Non-adjustable or in carrier			Floating			Adjustable				Non-adjustable or in carrier		Floating		Adjustable	
Bearing O.D. Tol.	Symbol Fit	Housing Bore Deviation	Resultant Fit	Symbol Fit	Housing Bore Deviation	Resultant Fit	Symbol Fit	Housing Bore Deviation	Resultant Fit	Bearing O.D. Tol.	Housing Bore Deviation	Resultant Fit	Housing Bore Deviation	Resultant Fit	Housing Bore Deviation	Resultant Fit
0 -6 0 -0.00023	M5	-14 -5 -0.00055 -0.00015	14T 1L .00055T .00008L	G5	+7 +16 +0.0003 +0.0007	7L 22L .0003L .00093L	K5	-8 +1 -0.0004 0	8T 7L .0004T .00023L	0 -8 0 -0.00031	-16 -8 -0.0006 -0.0003	16T 0 .0006T 0	+8 +16 +.0003 +.0006	8L 24L .0003L .0009L	-8 0 -0.0003 0	8T 8L .0003T .0003L
0 -7 0 -0.00027	M5	-16 -5 -0.0007 -0.0003	16T 2L .0007T .00007T	G5	+9 +20 +0.0004 +0.0008	9L 27L .0004L .00107L	K5	-9 +2 -0.0004 0	9T 9L .0004T .00027L	0 -8 0 -0.00031	-16 -8 -0.0006 -0.0003	16T 0 .0006T 0	+8 +16 +.0003 +.0006	8L 24L .0003L .0009L	-8 0 -0.0003 0	8T 8L .0003T .0003L
0 -9 0 -0.00035	M5	-19 -6 -0.0008 -0.0003	19T 3L .0008T .00005L	G5	+10 +23 +0.0004 +0.0009	10L 32L .0004L .00125L	K5	-10 +3 -0.0004 +0.0001	10T 12L .0004T .00045L	0 -8 0 -0.00031	-16 -8 -0.0006 -0.0003	16T 0 .0006T 0	+8 +16 +.0003 +.0006	8L 24L .0003L .0009L	-8 0 -0.0003 0	8T 8L .0003T .0003L
0 -10 0 -0.00039	M5	-23 -8 -0.0009 -0.0003	23T 2L .0009T .00009L	G5	+12 +27 +0.0005 +0.0011	12L 37L .0005L .00149L	K5	-13 +2 -0.0005 +0.0001	13T 12L .0005T .00049L	0 -8 0 -0.00031	-16 -8 -0.0006 -0.0003	16T 0 .0006T 0	+8 +16 +.0003 +.0006	8L 24L .0003L .0009L	-8 0 -0.0003 0	8T 8L .0003T .0003L
0 -11 0 -0.00043	M5	-27 -9 -0.0011 -0.0004	27T 2L .0011T .00003L	G5	+14 +32 +0.0006 +0.0013	14L 43L .0006L .00173L	K5	-15 +3 -0.0006 +0.0001	15T 12L .0006T .00043L	0 -8 0 -0.00031	-16 -8 -0.0006 -0.0003	16T 0 .0006T 0	+8 +16 +.0003 +.0006	8L 24L .0003L .0009L	-8 0 -0.0003 0	8T 8L .0003T .0003L
0 -13 0 -0.00051	M5	-27 -9 -0.0011 -0.0004	27T 4L .0011T .00011L	G5	+14 +32 +0.0006 +0.0013	14L 45L .0006L .00181L	K5	-15 +3 -0.0006 +0.0001	15T 16L .0006T .00061L	0 -8 0 -0.00031	-16 -8 -0.0006 -0.0003	16T 0 .0006T 0	+8 +16 +.0003 +.0006	8L 24L .0003L .0009L	-8 0 -0.0003 0	8T 8L .0003T .0003L
0 -15 0 -0.00059	M5	-31 -11 -0.0012 -0.0004	31T 4L .0012T .00019L	G5	+15 +35 +0.0006 +0.0014	15L 50L .0006L .00199L	K5	-18 +2 -0.0001 +0.0001	18T 17L .0007T .00069L	0 -8 0 -0.00031	-16 -8 -0.0006 -0.0003	16T 0 .0006T 0	+8 +16 +.0003 +.0006	8L 24L .0003L .0009L	-8 0 -0.0003 0	8T 8L .0003T .0003L
0 -18 0 -0.00070	M5	-36 -13 -0.0014 -0.0005	36T 5L .0014T .0002L	G5	+17 +40 +0.0001 +0.0016	17L 58L .0001L .0023L	K5	-20 +3 -0.0008 +.0001	20T 21L .0008T .0008L	0 -8 0 -0.00031	-16 -8 -0.0006 -0.0003	16T 0 .0006T 0	+8 +16 +.0003 +.0006	8L 24L .0003L .0009L	-8 0 -0.0003 0	8T 8L .0003T .0003L

Fitting Guidelines For Metric Tapered Roller Bearings (except TXR bearings)

Suggested precision application limits and fitting guidelines for ferrous shaft and housing.

SHAFT O.D. – Deviation from nominal (maximum) bearing bore and resultant fit, expressed in micrometers (μm) and inches.

Bearing Bore Range		Class C			
mm/inch over	incl	Bearing Bore Tolerance	Fit Symbol	Shaft O.D. Deviation	Resultant Fit
10 0.3937	18 0.7087	-7 0 -0.00027 0	k5	+9 +1 +0.0004 +0.0001	16T 1T .00067T .0001T
18 0.7087	30 1.1811	-8 0 -0.00031 0	k5	+11 +2 +0.0005 +0.0001	19T 2T .00081T .0001T
30 1.1811	50 1.9685	-10 0 -0.00039 0	k5	+13 +2 +0.0005 +0.0001	23T 2T .00089T .0001T
50 1.9685	80 3.1496	-12 0 -0.00047 0	k5	+15 +2 +0.0006 +0.0001	27T 2T .00107T .0001T
80 3.1496	120 4.7244	-15 0 -0.00059 0	k5	+18 +3 +0.0007 +0.0001	33T 3T .00129T .0001T
120 4.7244	180 7.0866	-18 0 -0.00070 0	k5	+21 +3 +0.0008 +0.0001	39T 3T .0015T .0001T
180 7.0866	250 9.8425	-22 0 -0.00086 0	k5	+24 +4 +0.0010 +0.0002	46T 4T .00186T .0002T
250 9.8425	315 12.4016	-22 0 -0.00086 0	k5	+27 +4 +0.0011 +0.0002	49T 4T .00196T .0002T

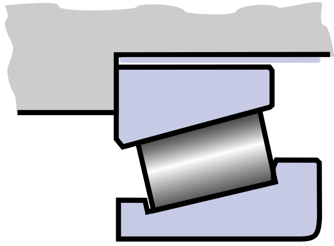
T=Tight L=Loose

Class B			
Bearing bore Tolerance	**Symbol Fit**	**Shaft O.D. Deviation**	**Resultant Fit**
-5 0 -0.00019 0	k5	+9 +1 +0.0004 +0.0001	14T 1T .00059T .0001T
-6 0 -0.00023 0	k5	+11 +2 +0.0005 +0.0001	17T 2T .00073T .0001T
-8 0 -0.00031 0	k5	+13 2 +0.0005 +0.0001	21T 2T .00081T .0001T
-9 0 -0.00035 0	k5	+15 +2 +0.0006 +0.0001	24T 2T .00095T .0001T
-10 0 -0.00039 0	k5	+18 +3 +0.0007 +0.0001	28T 3T .00109T .0001T
-13 0 -0.00051 0	k5	+21 +3 +0.0008 +0.0001	34T 3T .00131T .0001T
-15 0 -0.00059 0	k5	+24 +4 +0.0010 +0.0002	39T 4T .00159T .0002T
-15 0 -0.00059 0	k5	+27 +4 +0.0011 +0.0002	42T 4T .00169T .0002T

Class A and AA			
Bearing bore Tolerance	**Symbol Fit**	**Shaft O.D. Deviation**	**Resultant Fit**
-5 0 -0.00019 0	k4	+13 +5 +0.0005 +0.0002	18T 5T .00069T .0002T
-6 0 -0.00023 0	k4	+13 +5 +0.0005 +0.0002	19T 5T .00073T .0002T
-8 0 -0.00031 0		+13 +5 +0.0005 +0.0002	21T 5T .00081T .0002T
-8 0 -0.00031 0		+13 +5 +0.0005 +0.0002	21T 5T .00081T .0002T
-8 0 -0.00031 0		+13 +5 =0.0005 +0.0002	21T 5T .00081T .0002T
-8 0 -0.00031 0		+13 +5 +0.0005 +0.0002	21T 5T .00081T .0002T
-8 0 -0.00031 0		+13 +5 +0.0005 +0.0002	21T 5T .00081T .0002T
-8 0 -0.00031 0		+13 +5 +0.0005 +0.0002	21T 5T .00081T .0002T

Fitting Guidelines For Inch Bearings (except TXR bearings)

Suggested precision application limits and fitting guidelines for ferrous shaft and housing.

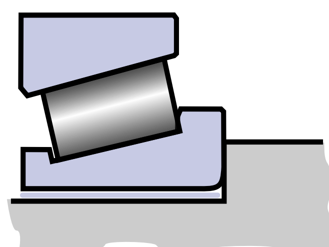


HOUSING BORE

Deviation from nominal (minimum) bearing outer diameter (O.D.) and resultant fit: All metric tolerances are in micrometers (µm). All inch tolerances are in inches.

T=Tight L= Loose

Bearing O.D. Range mm/inch		Class 3 and 0							Class 00 and 000						
			Non-adjustable or in carrier		Floating		Adjustable			Non-adjustable or in carrier		Floating		Adjustable	
Over	Incl.	Bearing O.D. tolerance	Housing bore deviation	Resultant fit	Housing bore deviation	Resultant fit	Housing bore deviation	Resultant fit	Bearing O.D. tolerance	Housing bore	Resultant fit deviation	Housing bore	Resultant fit deviation	Housing bore	Resultant fit deviation
0.000	152.400	+13	-13	26T	+25	12L	0	13T	+8	-8	16T	+15	7L	0	8T
		0	0	0	+38	38L	+13	13L	0	0	0	+23	23L	+8	8L
0	6.0000	+.0005	-.0005	.0010T	+.0010	.0005L	0	.0005T	+.0003	+.0003	.0006T	+.0006	.0003L	0	.0003T
		0	0	0	+.0015	.0015L	+.0005	.0005L	0	0	0	+.0009	.0009L	+.0003	.0003L
152.400	304.800	+13	-25	38T	+25	12L	0	13T	+8	-8	16T	+15	7L	0	8T
		0	0	0	+38	38L	+25	25L	0	0	0	+23	23L	+8	8L
6.0000	12.0000	+.0005	-.0010	.0015T	+.0010	.0005L	0	.0005T	+.0003	+.0003	.0006T	+.0006	.0003L	0	.0003T
		0	0	0	+.0015	.0015L	+.0010	.0010L	0	0	0	+.0009	.0009L	+.0003	.0003L
304.800	609.600	+25	-25	50T	+38	13L	0	25T	—	—	—	—	—	—	—
		0	0	0	+64	64L	+25	25L	—	—	—	—	—	—	—
12.0000	24.0000	+.0010	-.0010	.0020T	+.0015	.0005L	0	.0010T	—	—	—	—	—	—	—
		0	0	0	+.0025	.0025L	+.0010	.0010L	—	—	—	—	—	—	—
609.600	914.400	+38	-38	76T	+51	13L	0	38T	—	—	—	—	—	—	—
		0	0	0	+89	89L	+38	38L	—	—	—	—	—	—	—
24.0000	36.0000	+.0015	-.0015	.0030T	+.0020	.0005L	0	.0015T	—	—	—	—	—	—	—
		0	0	0	+.0035	.0035L	+.0015	.0015L	—	—	—	—	—	—	—



SHAFT O.D.

Deviation from nominal (minimum) bearing bore and resultant fit: All metric tolerances are in micrometers (µm). All inch tolerances are in inches

Tight=Tight L=Loose

Bore Bore Range mm /inch		Class 3 and 0			Class 00 and 000		
Over	Incl.	Bearing Tolerance	Shaft O.D. Deviation	Resultant Fit	Bearing Tolerance	Shaft O.D. Deviation OD dev.	Resultant Fit
0.000	304.800	0	+30	30T	0	+20	20T
		+13	+18	5T	+8	+13	5T
0	12.0000	0	+.0012	.0012T	0	+.0008	.0008T
		+.0005	+.0007	.0002T	+.0003	+.0005	.0002T
304.800	609.600	0	+64	64T	—	—	—
		+25	+38	13T	—	—	—
12.0000	24.0000	0	+.0025	.0025T	—	—	—
		+.0010	+.0015	.0005T	—	—	—
609.600	914.400	0	+102	102T	—	—	—
		+38	+64	26T	—	—	—
24.0000	36.0000	0	+.0040	.0040T	—	—	—
		+.0015	+.0010	.0010T	—	—	—

TXR Shaft Fitting Practices — Metric (Interference Fit)

Bearing Bore Over	Incl.	Class S Min.	Class S Max	Class P Min.	Class P Max
mm		mm		mm	
—	50	7T	20T	4T	14T
50	80	10T	25T	4T	17T
80	120	13T	33T	4T	17T
120	180	27T	52T	4T	17T
180	250	30T	60T	4T	20T
250	315	35T	70T	4T	22T
315	400	37T	77T	4T	24T
400	500	40T	85T	4T	30T

TXR Housing Fitting Practices — Metric (Interference Fit)

Bearing O.D. Over	Incl.	Class S Min.	Class S Max.	Class P Min.	Class P Max.
mm		mm		mm	
—	50	7T	20T	4T	14T
50	80	10T	25T	4T	17T
80	120	13T	33T	4T	17T
120	180	27T	52T	4T	17T
180	250	30T	60T	4T	20T
250	315	35T	70T	4T	22T
315	400	37T	77T	4T	24T
400	500	40T	85T	4T	30T

TXR Shaft Fitting Practices — Inch (Interference Fit)

Bearing Bore Over	Incl.	Class 3 Min.	Class 3 Max.	Class 0 Min.	Class 0 Max.
in.		in.		in.	
—	12.0000	0.0005T	0.0015T	0.0003T	0.0008T
12.0000	24.0000	0.0010T	0.0030T	0.0005T	0.0015T
24.0000	36.0000	0.0015T	0.0045T	—	—
36.0000	48.0000	0.0020T	0.0060T	—	—
48.0000	—	0.0025T	0.0075T	—	—

TXR Housing Fitting Practices — Inches (Interference Fit)

Bearing O.D. Over	Incl.	Class 3 Min.	Class 3 Max.	Class 0 Min.	Class 0 Max.
in.		in.		in.	
—	12.0000	0.0005T	0.0015T	0.0003T	0.0008T
12.0000	24.0000	0.0010T	0.0030T	0.0005T	0.0015T
24.0000	36.0000	0.0015T	0.0045T	—	—
36.0000	48.0000	0.0020T	0.0060T	—	—
48.0000	—	0.0025T	0.0075T	—	—

Recommended Shaft and Housing Tolerances

Shaft Fits (Ball Bearings)

The main purpose of the shaft fit is to assure a proper attachment of the inner ring to the shaft. Under normal conditions of shaft rotation, a loosely fitted inner ring will creep on the shaft, leading to wear and fretting. This condition will be further aggravated by increase of load or speed. To prevent creeping or slipping, the inner ring should be mounted firmly in place and held securely against the shaft shoulder. However, it is important that the shaft fit should not result in any undue tightening of the bearing. An excessive interference fit of the bearing bore with the shaft could result in a proportionate expansion of the bearing inner ring which could disturb the internal fit of the bearing and lead to heating and increased power consumption.

As a general rule, it is recommended that the shaft size and tolerance for seating super precision bearings (ISO P4/ABEC7 and ISO P2/ABEC9) be the same as the bearing bore. In the case of preloaded bearings, the ideal shaft fit to strive for is line-to-line fit, since an excessively tight fit expands the bearing inner ring and increases the bearing preload which can lead to overheating. For example, a duplex pair of 2MM9111WI DUL bearings, with 35 pounds built-in preload, when mounted on a shaft that provides an interference fit of .0004 inch, will increase the preload to approximately 180 pounds which could result in elevated operating temperatures.

Example: MMV(ABEC7, ISO P4)

Bore size Inches	Shaft Diameter Inches	Resulting Mounting Fit, Inches
max. 2.1654	min. 2.1652	.0002 loose
min. 2.1651	max. 2.1654	.0003 tight

Housing Fits (Ball Bearings)

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

As a general rule, the minimum housing bore dimension for super precision bearings may be established as the same as the maximum bearing outside diameter. If the bearing O.D. tolerance is .0003 inch (.0080mm), the maximum housing bore should be established as .0003 inch (.0080mm) larger than the minimum housing bore dimensions.

Example: MMV(ABEC7/ISO P4)

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

Tables covering recommended shaft and housing seat dimensions for super precision (ABEC-7) ball bearings are shown with part numbers in the previous chapter.

To accomplish this, the optimum mounting condition, it is important to follow the tabulated tolerances, except when deviations are recommended by Timken Engineering. It is equally important that all shaft and housing shoulders be square and properly relieved to assure accurate seating and positioning of the bearings in the mounting.

On high-speed applications where nearby heat input is along the shaft, it is extremely important that the floating bearings can move axially to compensate for thermal changes. Ball bearings cannot float axially if they are restricted by tight housing bores or by the radial expansion of the bearing itself due to temperature differentials. Therefore, in such cases, the recommended housing mounting fit for the floating bearings is slightly looser than the tabulated average fit.

Likewise, in spring-loaded ball bearing applications the housing mounting fit must be free enough to permit axial movement of the bearings under the spring pressure, during all conditions of operation. The recommended housing dimensions to ensure proper "float" of the bearings under average conditions are listed with the pages of part numbers, also.

Shaft and Housing Geometry

Tapered Roller Bearings

In general, machining bearing seats and shoulders in spindles and housings requires careful consideration of the following form and orientation characteristics. The first four characteristics apply to the seats of bearing races.

- **Circularity** (roundness) of each seat at every cross section.
- **Cylindricity** of each seat. Cylindricity includes the taper, roundness and other form characteristics of the seat.
- **Coaxiality** of the inner race seats on the spindle and coaxiality of the outer race seats in the housing. Coaxiality includes offset misalignment and angular misalignment between seats.
- **Angularity** of each bearing race seat. This is a consideration when an inner race seat is tapered.

The following two characteristics apply to the shoulders corresponding to each bearing seat.

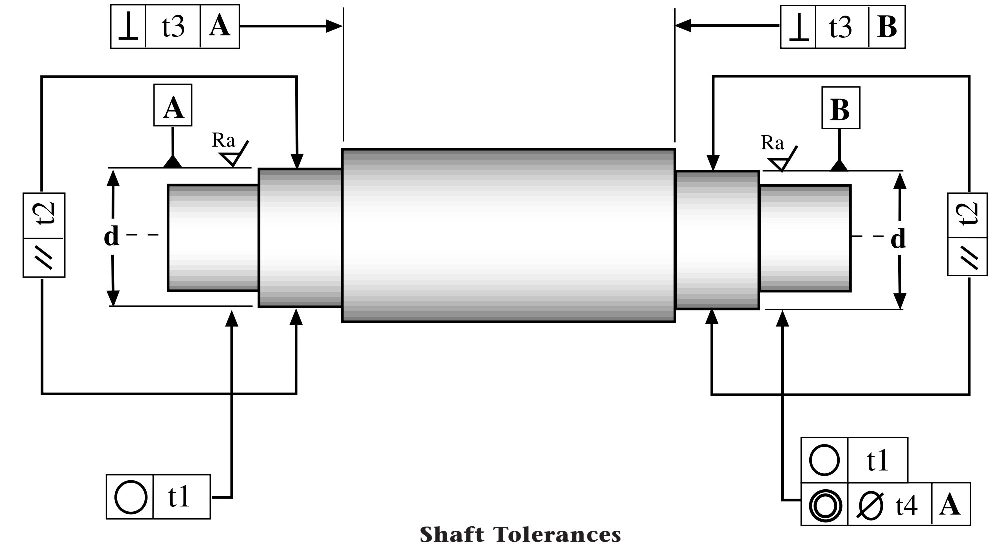
- **Perpendicularity** (squareness) of each shoulder to its corresponding bearing seat, or as a more practical measure, perpendicularity of each shoulder to the spindle or housing centerline established from the two bearing seats.
- **Flatness** of each shoulder. A practical way of assessing the combined perpendicularity and flatness of each shoulder is to measure the total runout of the shoulder relative to the spindle or housing centerline. The runout of the face of the adjusting nuts, if used, should also be measured.

The tolerances to which these characteristics should be held are dependant upon the class, size and application of the bearing. *In general, these tolerances should be no greater than the total indicator runout (TIR) of the assembled bearing.*

Some of the characteristics can be difficult to measure precisely. The individual user may elect to measure a subset of these characteristics (roundness and taper as an alternative to cylindricity). The individual user must determine the degree of effort and expense to be invested in the measurements. That determination should be based on the intended application of the bearing and the level of confidence in the machining process employed to manufacture the spindle and housing.

All Sizes	Bearing class			
	C 3	B 0	A 00	AA 000
Shaft - Ra (µm)	0.8	0.6	0.4	0.2
Housing - Ra (µm)	1.6	0.8	0.6	0.4

Shaft Geometry Requirements (Ball Bearings)



Shaft Tolerances

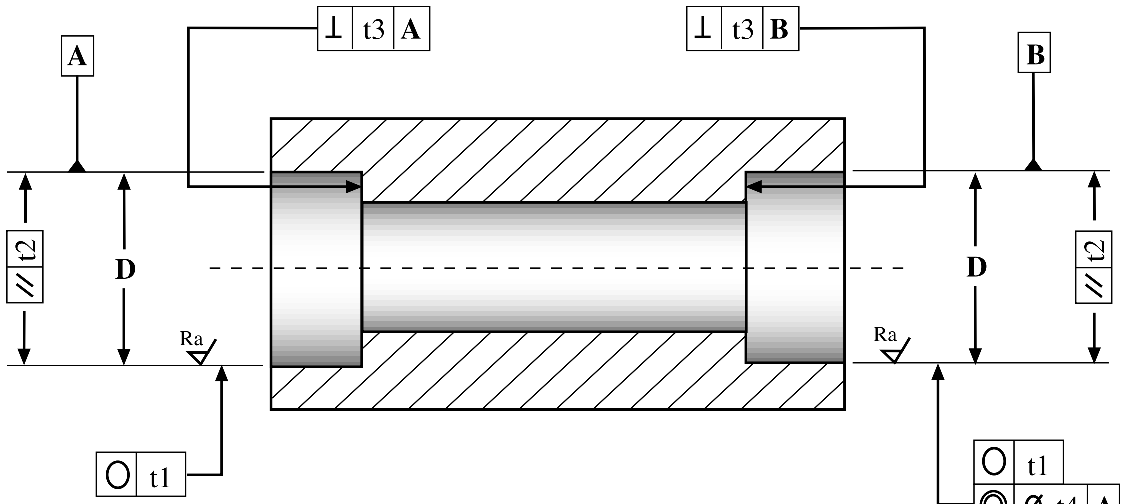
Description	Symbol	Tolerance Value	ABEC 7/ISO P4	MMV/MM (9/7)	MMX ABEC 9/ISO P2
Roundness	○	t1	IT2	IT1	IT0
Parallelism	//	t2	IT2	IT1	IT0
Squareness	⊥	t3	IT2	IT1	IT0
Concentricity	◎	t4	IT3	IT2	IT2
Surface Finish	Ra		16 (µin.)	or	0.4 µm

Shaft Journal Diameter (d) mm >		Units – Micrometer (µm)			
		IT0	IT1	IT2	IT3
—	10	0.6	1.0	1.5	2.5
10	18	0.8	1.2	2.0	3.0
18	30	1.0	1.5	2.5	4.0
30	50	1.0	1.5	2.5	4.0
50	80	1.2	2.0	3.0	5.0
80	120	1.5	2.5	4.0	6.0
120	180	2.0	3.5	5.0	8.0
180	250	3.0	4.5	7.0	10.0
250	315	—	6.0	8.0	12.0

Reference ISO 286.

Shaft Journal Diameter d mm >		Units – Microinches (µin.)			
		IT0	IT1	IT2	IT3
—	10	20	40	60	100
10	18	30	50	80	120
18	30	40	60	100	160
30	50	40	60	100	160
50	80	50	80	120	200
80	120	60	100	160	240
120	180	80	140	200	310
180	250	120	180	280	390
250	315	—	240	310	470

Housing Geometry Requirements (Ball Bearings)



Housing Tolerances

Description	Symbol	Tolerance Value	ABEC 7/ISO P4	MMV/MM (9/7)	MMX ABEC 9/ISO P2
Roundness	○	t1	IT2	IT1	IT0
Parallelism	\\	t2	IT2	IT1	IT0
Squareness	⊥	t3	IT2	IT1	IT0
Concentricity	◎	t4	IT3	IT2	IT2
Surface Finish	Ra		16 (µin.)	or	0.4 µm

Housing Journal Diameter (D) mm >		Units – Micrometer (µm)			
		IT0	IT1	IT2	IT3
10	18	0.8	1.2	2.0	3.0
18	30	1.0	1.5	2.5	4.0
30	50	1.0	1.5	2.5	4.0
50	80	1.2	2.0	3.0	5.0
80	120	1.5	2.5	4.0	6.0
120	180	2.0	3.5	5.0	8.0
180	250	3.0	4.5	7.0	10.0
250	315	3.5	6.0	8.0	12.0
315	400	4.5	6.0	8.0	12.0

Reference ISO 286.

Housing Journal Diameter D mm >		Units – Microinches (µin.)			
		IT0	IT1	IT2	IT3
10	18	30	50	80	120
18	30	40	60	100	160
30	50	40	60	100	160
50	80	50	80	120	200
80	120	60	100	160	240
120	180	80	140	200	310
180	250	120	180	280	390
250	315	140	240	310	470
315	400	180	240	310	470

Mounting Designs

Obtaining good spindle accuracy depends not only on selecting the proper precision bearings but also on the following factors:

- Good design and machining of the components that support the bearing (roundness and alignment of the seats, squareness of backing shoulders of both the spindle and the housing, and surface finish)
- Correct use of information given on bearings
- Correct fitting practices
- Appropriate bearing setting

Selection of the most appropriate mounting design is largely dictated by optimizing the stiffness, speedability and ease of assembly.

Design and Accuracy of Mounting Surfaces

It should be noticed that the total runout of a spindle-bearing-housing system is a combination of the runout of each component. A precision bearing will assume the shape of the spindle and perpetuate whatever runout is present. If the runout is caused by a defective housing, the spindle and bearing will simply transmit the error to the work-piece. Therefore, particular attention needs to be paid to the design and accuracy of the mounting surfaces.

The primary function of either the inner or outer race seat and abutment is to positively establish the location and alignment of the bearing under all loading and operating conditions. It is essential for the bearing performance that round and aligned spindle and housing seats together with abutments, square with the spindle axis and of sufficient diameter, be designed. Shoulders must be of sufficient section and design to resist axial deflection under load. The shoulder diameters indicated in the preferred bearing list must be respected to assure optimum bearing performance.

Housing Design

Housings are usually made of cast iron or steel and generally heat treated to lessen possible distortion. For the smaller high-speed applications, steel housings are preferable.

The bore of the housing should be ground or bored and checked at a number of points throughout its length and diameter to assure that it is round and does not taper.

It is preferable to mount the bearings in one casting; this permits machining the two housing bores in one setting and assures accurate alignment of the bearings.

In many cases of machine design, it is advantageous to employ a sub-housing or a steel sleeve between the outer ring of the bearing and the machine frame, thus allowing assembly of the bearings on the shaft and insertion of the entire unit into the machine frame. This method also provides a surface of proper hardness where machine frames are made of a material that has a low Brinell value, such as aluminum and other soft metals.

Shaft shoulders and housing shoulders should be square and true, and should be of such diameters as to meet the recommendations shown with the part numbers given. The choice between fillets and undercut reliefs rests with the individual shaft design and conditions surrounding its normal use. Recommended housing geometry requirements are discussed previously on page 203 and 205.

Where screws are used to fasten end caps into the main housing, adequate section should be left between the screw hole and the hosing bore. This is required to prevent distortion of the housing bore when the screws are tightened and the covers or others parts pulled tightly into place.

Prior to assembly, shafts and housings, as well as all lubricant holes and channels, should be cleaned thoroughly, in order to remove all chips and particles which may be carried by the lubricant into the bearings and cause bearing damage.

Housing Seals

A labyrinth combination of slinger and end cover provides a highly effective seal against the intrusion of foreign matter. This seal is recommended for use over a wide range of speeds. For slower-speed applications, a combination of slinger and commercial contact-type seal is usually employed.

Slingers should be machined all over to assure true-running. Their diameters should be concentric with the bore. The outside diameter of the slinger is often tapered to throw off cutting compounds, coolants, etc., from the point at which such liquids may enter the spindle. A drip or run-off groove adjacent to the open lip of the end cover is highly desirable and practical.

The axial clearances of the internal faces between slinger and end cover should be about $^{1}/_{16}$ inch (1.6mm). The first radial clearance opening on any design through which liquid may pass should be made very close, about .0035 inch (.089mm) on a side. The inner radial clearances should be between 0.015 inch (.38mm) and .0075 inch (.190mm).

Shafts

Shafts are preferably made from steel hardened and ground; and where not otherwise unsuitable, a hardness of 45-50 Rockwell C has been successful. When designing a spindle or shaft it is highly desirable to plan so that it can be ground all over in one setting as a final operation. This promotes true balance and running accuracy, which is critical in high-speed. Recommended shaft geometry can be found earlier on pages 203 and 204.

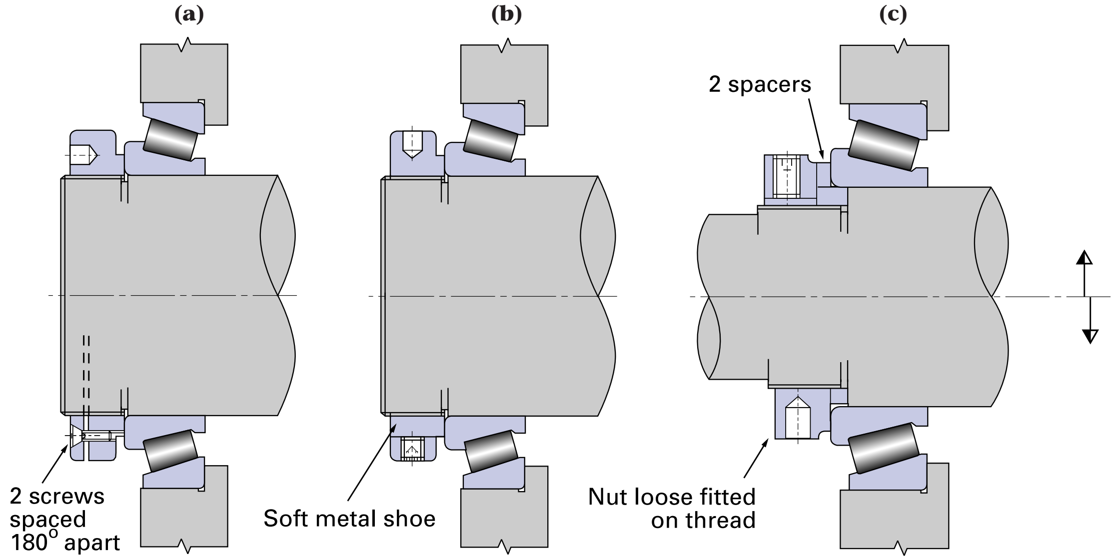


Fig. 4-12
Locking devices

In most cases, simple 2TS(F) spindle layouts are adjusted by correct positioning of the tail bearing cone. A commonly used device is a precision adjusting nut. A locking device must be provided to properly maintain the nut after setting, either axially, by means of two screws 180° opposite pinching the threads (fig. 4-12a), or radially, by pressure of a screw on a soft metal shoe (fig. 4-12b).

For improved accuracy, a ground spacer in conjunction with a square ground spindle shoulder and a locking precision nut can also be used (fig. 4-13). A good parallelism of the ground spacer faces as well as the squareness of the spindle shoulder will ensure a perfect positioning of the cone backface. This mounting configuration also offers assurance that the initially defined setting cannot be interfered with by the final user. Fig. 4-12c shows two different solutions with ground spacers. Note the practicality of the above centerline solution which allows the spacer to both increase or decrease the initial setting.

A well-known method of providing good spindle alignment, roundness, and backing squareness is to grind the cone seats and the backing shoulders during the same operation (fig. 4-14). In this method, the grinding of the square backing of the adjusting nut (if any) can also be achieved by locking the nut on its thread. This eliminates any possible default of the nut due to internal thread clearance.

Tapered roller bearings are generally used in two fundamental spindle design configurations:

- Three-support mountings for heavily loaded or long spindles
- Simple mounting of two single row bearings

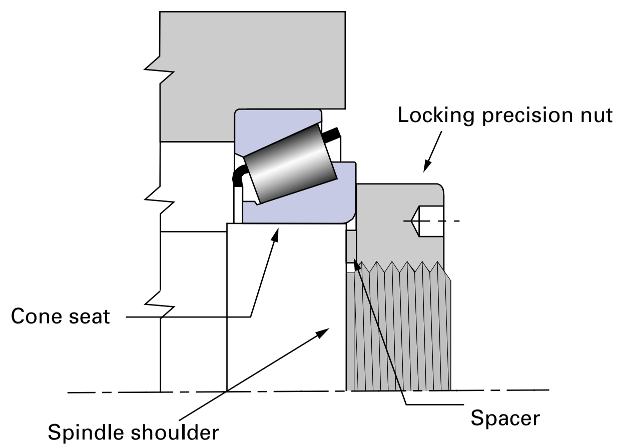


Fig. 4-13
Using ground spacer and spindle shoulder together with a precision nut for improved accuracy

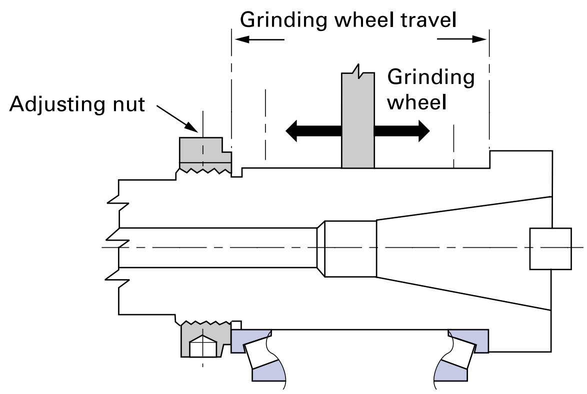


Fig. 4-14
Grinding of cone shaft and backing shoulders

Three-support Mounting

Fig. 4-15 shows the "box type" mounting using three bearings. The two nose bearings are located axially (fixed position) and accept axial forces in both directions, while the tail bearing is fitted as a floating position to accommodate the thermal expansion of the spindle. The floating position can be assured either by a tapered roller bearing or a cylindrical roller bearing.

This kind of arrangement is mainly used for special heavy machines running at low or medium speeds, or for long spindle designs.

Simple Mounting

The evolution of two single row bearing arrangements for spindles, discussed below, is directly related to the speed requirements, and consequently the lubrication modes (see page 218).

TS + TSF Arrangement

The spindle is supported by one bearing at the nose position and a second one at the tail position. This layout offers the advantage of being a simple isostatic design that allows easy machining of adjacent parts. The mounting and setting procedures can be achieved without any specific tooling.

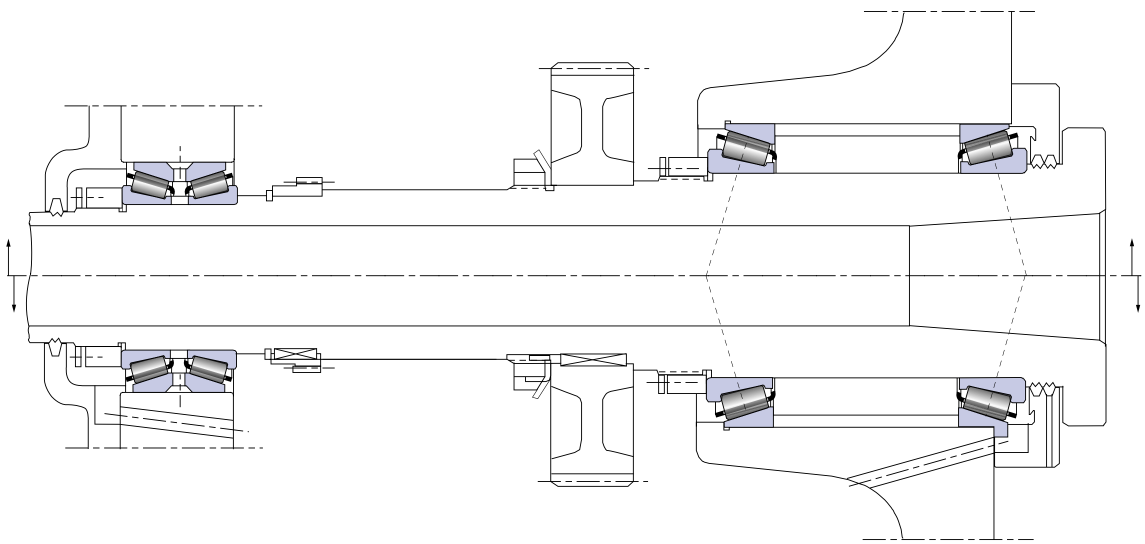


Fig. 4-15
"Box type" mounting with a TDO at the floating position

Static stiffness calculations of the spindle-bearing system allows the optimum bearing spread to be determined precisely for each mounting, as a function of the overhung value of the spindle nose. A good approximation, however, is to consider that the distance between bearing centers should be of 2.5 to 3 times the spindle nose diameter. This represents an optimum value not only for stiffness, but also for thermal equilibrium.

Fig. 4-16 represents the simplest layout of a two single row bearing concept. The view above the centerline shows flanged cups (type TSF) allowing a through-bore machining concept for the housing which offers increased accuracy with no need for cup backing shoulders. The arrangement shown below the centerline uses two single row bearings (type TS).

The bearings are adjusted by means of a ground spacer locked by a precision nut. Lubrication is often achieved by oil circulation, which enters through radial oil inlets or special high speed grease.

As shown below, the next evolution of this arrangement consists of improving the lubrication system by using appropriate jets for oil inlets and cooling (fig. 4-17 & fig. 4-18).

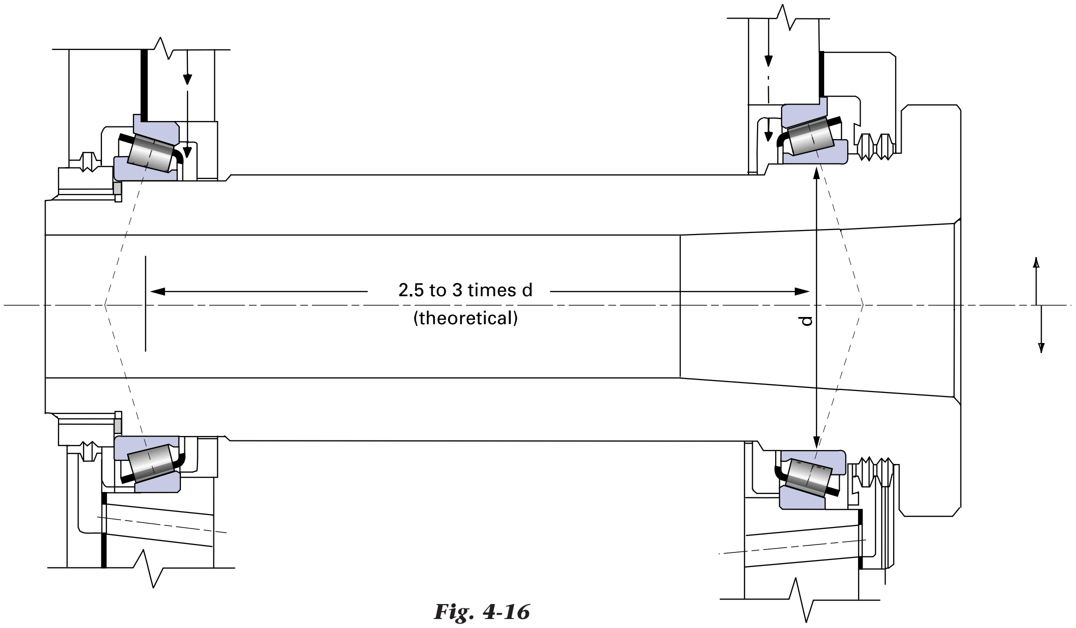


Fig. 4-16
Simple mounting with a pair of TS or TSF bearings

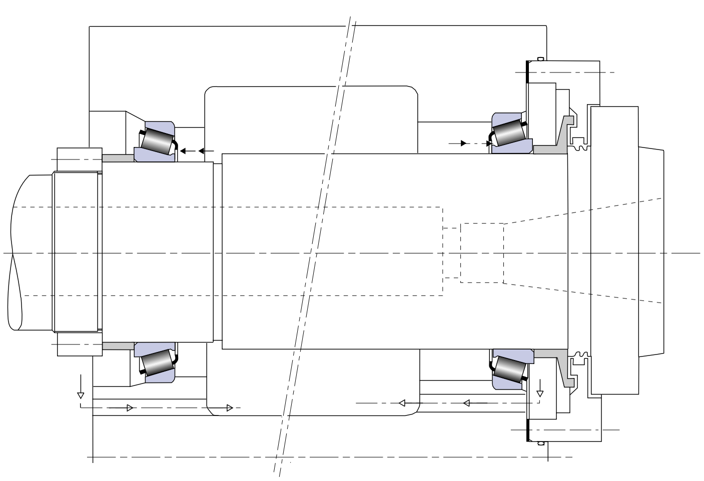


Fig. 4-17
Simple paired TS mounting with oil inlet at the small end of the rollers

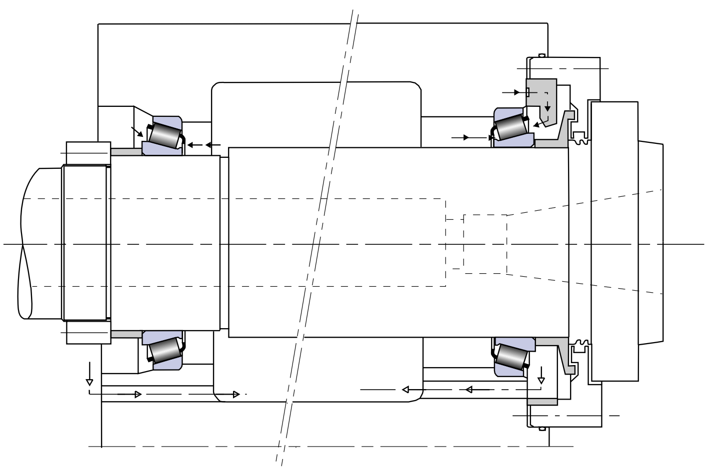


Fig. 4-18
Simple paired TS mounting with oil jets at both ends of the rollers for inlet and cooling

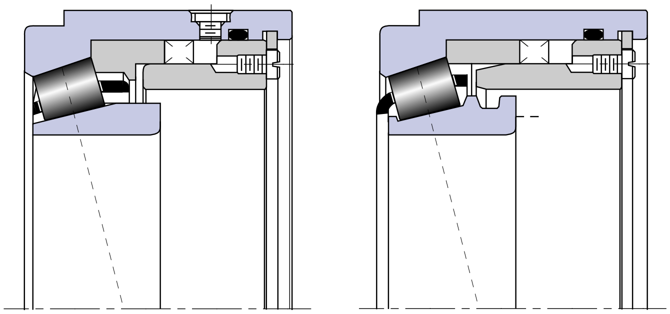


Fig. 4-19
Two designs of the Hydra-Rib™ bearing

TS(F) + Hydra-Rib™

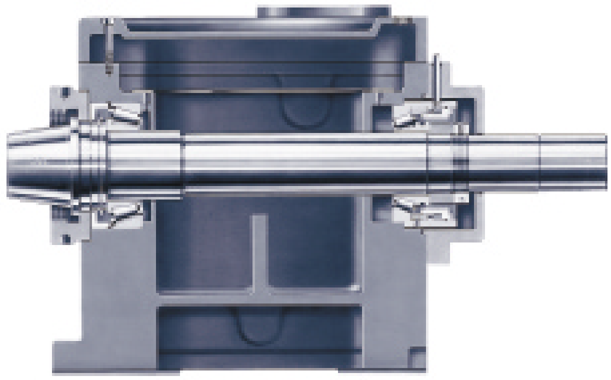
Experience has demonstrated that by optimizing the design parameters of bearing geometry, spindle diameter, bearing spread, lubrication system and mounting, the two single row bearing layout gives very good results over a large range of speeds and power.

However for very wide variations of speed and load, the variable preload Hydra-Rib™ bearing concept developed by The Timken Company is the optimum solution.

The Hydra-Rib™ bearing (fig. 4-19) has a floating outer race rib in contact with the large roller ends instead of the usual fixed inner race rib. This floating rib operates within a sealed cavity at a given pressure controlled by an appropriate hydraulic or pneumatic pressure system. Changing the pressure consequently changes the preload in the bearing system.

The controlled pressure enables the floating rib to maintain constant spindle preload even through differential thermal expansion occurs in the spindle system during the working cycle. By changing the pressure, a variable preload setting can readily be achieved. This unique bearing concept allows the operator to control any machining condition by simply changing the pressure to optimize the dynamic stiffness and damping characteristics of the spindle. Furthermore, the hydraulic or pneumatic pressure control system can easily be monitored by the numerical control of the machine. In the case of oil pressure control, the hydraulic circuit of the machine can be used.

A list of the preferred Hydr-Rib™ bearings (in Class B) is available in the Precision Tapered Roller Bearings chapter. Other assemblies are available up to a maximum of 285mm bore diameter.



A Timken Company Sales Engineer should be consulted to determine the optimum bearing selection as well as the pressure figures, as a function of the given running conditions.

A typical arrangement is the combination of a Hydra-Rib™ bearing with a single row TS bearing (fig. 4-21). The Hydra-Rib™ bearing is fitted at the tail position, and the TS bearing at the nose position of the spindle. The outer race rib simplifies the lubrication at high speed since the natural flow of the oil under centrifugal effect feeds the oil to the rib. A simple axial oil inlet above the cage on the small roller end is therefore sufficient for lubricating the Hydra-Rib™ bearing.

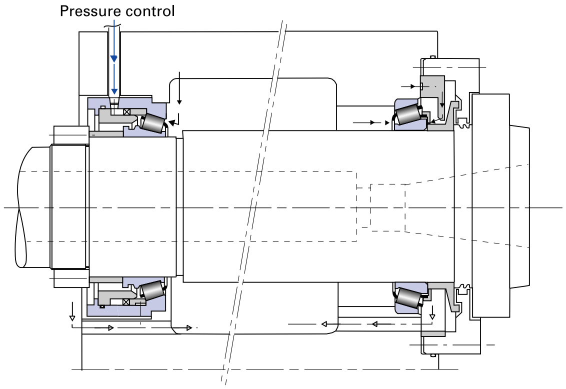


Fig. 4-20
Simple mounting with a Hydra-Rib™ bearing cooled by an axial oil inlet and a TSMA bearing with oil jets at both ends of the rollers for inlet and cooling

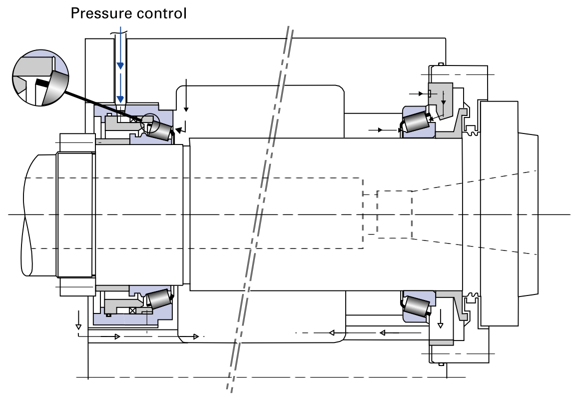


Fig. 4-21
Simple mounting with a Hydra-Rib™ cooled by an axial oil inlet and a TS bearing with oil jets at both end of the rollers for inlet and cooling

TSMA + Hydra-Rib™

Fig. 4-20 shows the same arrangement with a TSMA bearing. This arrangement allows the widest range of operating speeds, under optimum preload.

TXR(DO)

A typical mounting arrangement for the type TXRDO crossed roller bearing is shown in fig. 4-21a.

The arrangement shown is for lubrication by oil circulation in conjunction with an oil level. It can, however, be designed for grease lubrication with appropriate sealing arrangements.

The bore of the housing (DH) and the diameter of the spigot (DS) (fig. 4-21b) should be machined to give a mean of the suggested interference fits (pg. 201).

The bearing is adjusted externally by segments beneath the top inner race clamping plate (fig 4-21b), to get the required preload.

A Timken Company Sales Engineer should be consulted for more details about the use of crossed roller bearings.

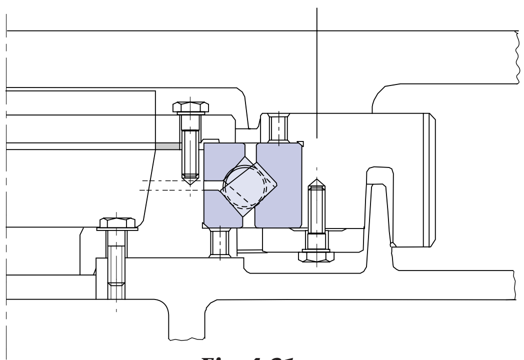


Fig. 4-21a
Typical mounting arrangement of a TXRDO bearing

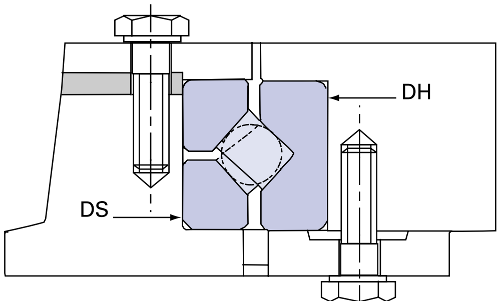
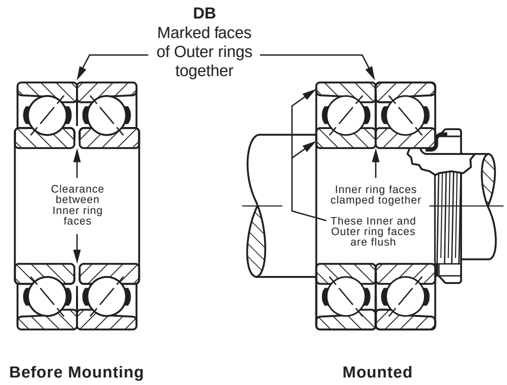


Fig 4-21b
Fitting and setting of TXR bearings

Mounting Combinations of Duplex Ball Bearings

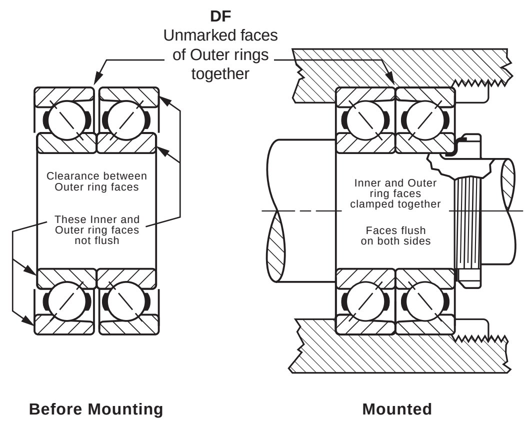
Back-to-Back Mounting, DB or ("O") (Contact angles diverging toward shaft centerline)

Before mounting, there is clearance between the two adjacent inner ring faces of 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 the 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. Example: 2MM207WI-DU.



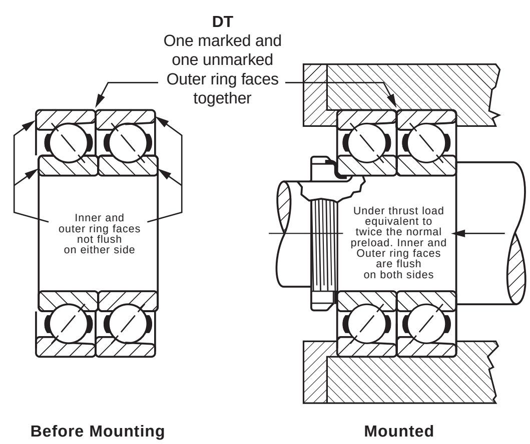
Face-to-Face Mounting, DF or ("X") (Contact angles converging toward shaft centerline)

Before mounting, there is clearance between the two adjacent outer ring faces. After mounting, these faces are clamped together between the housing shoulder and the 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 with its use. Fafnir pairs for face-to-face mounting should be ordered as DU. Example: 2MM212WI-DU.



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. Example: 2MM205WI-DU.



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.

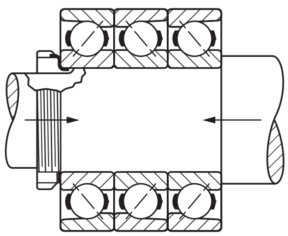


Figure A

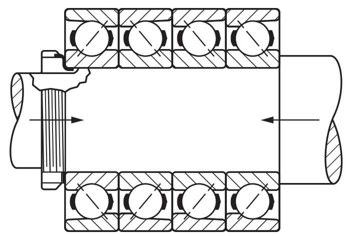


Figure B

Engineering Data

Back-To-Back Versus Face-To-Face Mountings

Mountings having bearings applied in any of the face-to-face (DF) arrangements are objectionable because they provide the least rigidity. Furthermore, when the operating speeds are comparatively high, such mountings may build up bearing preload excessively because the temperature gradient between the housings, bearings, and shafts. As this gradient increases, the bearing preload builds up, starting a detrimental cycle which may lead to premature spindle failure.

In spindle mountings, the shaft temperature usually changes at a faster rate than the housing, creating temperature differentials between the two members. These are due to their difference in mass and their respective abilities to act as heat sinks. Thus, the shaft and the inner-ring spacer expand at a faster rate rather than the housing and the outer-ring spacer. As the shaft expands longitudinally and the inner-ring spacer lengthens, a thrust load builds up on each bearing and continues to increase until the equilibrium temperature is reached. This occurs when the temperature at the housing levels off and the heat transferred from the bearings balances the heat generated within the system. Therefore, if the housing attains an excessively high temperature, the initial bearing temperature is built up considerably.

In a face-to-face mounting, Figure 4-22, the shaft expands radially and longitudinally and the inner ring spacer lengthens, but at a faster rate than the outer ring spacer. This thermal expansion causes an additional thrust to be imposed on both inner rings, increasing the preload of the bearings. Conversely, in back-to-back mounting, Figure 4-23, the longitudinal expansion of the inner ring spacer tends to relieve, rather than build up, the bearing preload.

The two back-to back pairs, shown in Figure 4-24, are mounted so that the two middle bearings are face-to-face. As previously observed, temperature differentials cause the preload of these inner bearings to increase during operation. This mounting operation is not suggested. In bearing mountings of the system seen in Figure 4-25, undue thrust loads are put on the two outer bearings as the temperature along the shaft becomes higher than at the housing. The two inner bearings unload, starting a vicious cycle of increasing temperature, preload build-up, and lubricant breakdown. This is also an unacceptable mounting arrangement, and is not recommended. The same bearings are shown correctly mounted in tandem and arranged back-to-back in Figure 4-26. Lateral expansion of the shaft and inner ring spacer of such mountings increase neither thrust loading nor bearing preload.

Therefore, in order to prevent increases in preload due to the thermal expansion, back-to-back mountings are preferred for bearings on machine tool spindles. When two pairs are used, each pair should be mounted in tandem but the combination should be arranged back-to-back as in Figure 4-26.

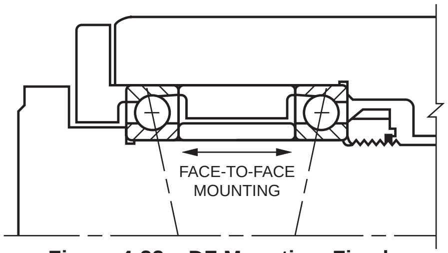


Figure 4-22 – DF Mounting, Fixed (Not Suggested)

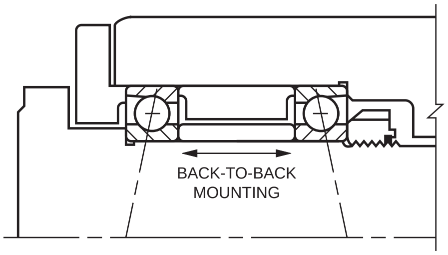


Figure 4-23 – DB Mounting, Fixed (Suggested)

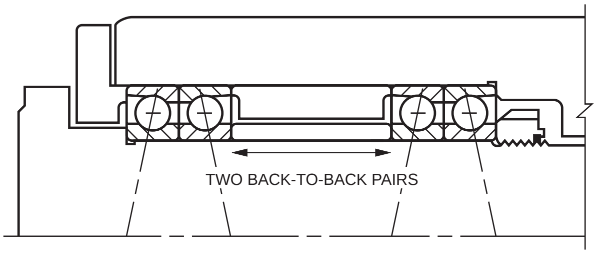


Figure 4-24 – DB-DB Mounting, Fixed (Not Suggested)

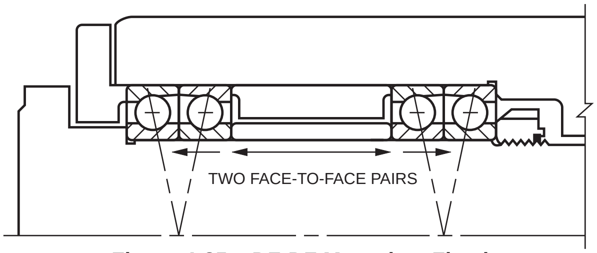


Figure 4-25 – DF-DF Mounting, Fixed (Not Suggested)

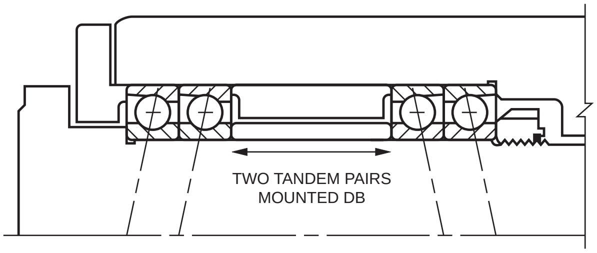


Figure 4-26 – DT-DB Mounting, Fixed (Suggested)

Spring Loaded Mountings

For high speed applications, radial and axial rigidity and smooth spindle performance may be obtained by spring loading the ball bearings with a predetermined thrust load. Spring loading allows the spindle to float laterally during temperature changes without appreciably increasing or decreasing the original spring thrust load.

As the inner ring heats up during operation it expands radially. This radial expansion applies an increasing load through the ball and outer ring and finally to the preload springs. The preload springs deflect slightly to compensate for the loads due to thermal expansion and maintain a consistent load on the spindle system.

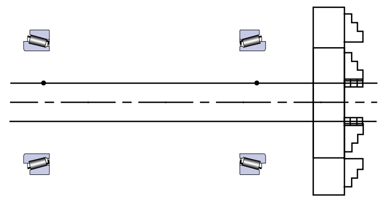
In some applications, single, spring-loaded bearings are employed at the front and rear locations, mounted in back-to-back arrangement. Other mountings, similarly spring loaded, have a pair of bearings installed in tandem at each end of the spindle in back-to-back arrangement (DT-DB). In either case, the spring pressure is applied to the pulley-end or rear bearing position, placing the shaft in tension between the two bearing locations.

High Points of Runout

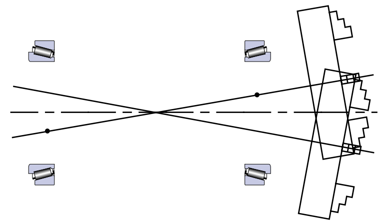
The correct use of the high point of runout etched on the bearing components allows the accuracy of the spindle to be optimized. The components should be mounted in the housing and on the spindle so that the high points are aligned with each other. In other words, the inner race are fitted on the spindle so the high point of the rear race is aligned with the high point of the nose bearing. Similarly, the high points of the outer race are aligned in the housing.

To obtain maximum precision, and when the high points of runout of both the spindle and the housing are known, the respective high points of the bearing components should be 180° opposite to those of the spindle and the housing. This will tend to neutralize the eccentricity and minimize the effect of the high spots of all components. *Fig. 4-27* shows typical examples of the right and wrong use of the high point of runout of bearings.

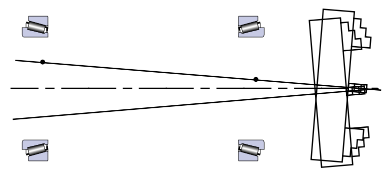
The greatest accuracy can be provided by grinding the spindle nose after the bearings are installed. This procedure will produce spindle runout considerably smaller than the bearing runout.



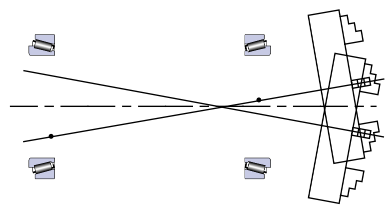
☑ ***Correct: high points of runout in line***



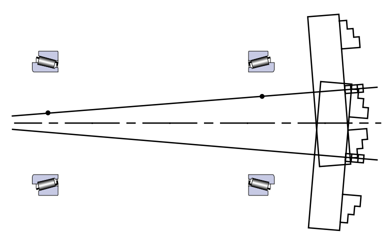
☒ ***Incorrect: high points of runout not in line***



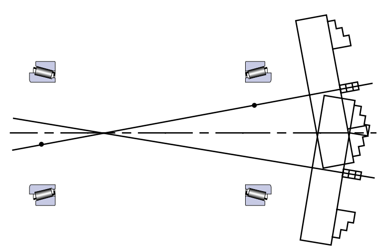
☑ ***Correct: bearing having largest runout at rear. High points of runout in line***



☒ ***Incorrect: bearing having largest runout at rear. High points of runout not in line***



☒ ***Incorrect: bearing having largest runout at nose. High points of runout in line***



☒ ***Incorrect: bearing having largest runout at nose. High points of runout not in line***

Fig 4-27

Setting Guidelines for Tapered Bearings

It has been demonstrated that optimum operating setting of a bearing system has a direct influence on the spindle performance as far as accuracy, dynamic stiffness, operating temperature, and cutting capabilities are concerned.

An operating setting range between zero and light preload is generally the optimum value for simple dual TS or TSF layouts.

To reach this range,it is important to evaluate the different parameters that will directly influence the operating setting in order to determine the cold mounted setting:

- Rotating speed
- Applied loads
- Spindle layout
- Lubrication system
- External sources of heat

This evaluation occurs generally during the testing phase of the spindle because of the complexity of each individual parameter and the interaction of all of them during running conditions. At the same time, it is also important to consider the bearing layout and particularly the bearing spread to evaluate its effect on bearing setting.

It has been demonstrated that an optimum bearing spread for stiffness exists. In the same way, an optimum spread for thermal stability can be determined should this be the overriding factor.

Under steady-state temperature conditions, the spindle and housing temperature is not uniformly distributed. Generally, a temperature gradient of 2 to 5°C exists between the spindle and housing. This phenomenon is valid for any type of bearing and has a direct influence on the bearing setting. In the case of pure radial bearings, such as cylindrical roller bearings, the radial setting will vary proportionally to the radial temperature gradient without any possibility for correction. The use of tapered roller bearings allows the radial loss of endplay due to the gradient between the spindle and the housing to be compensated by the axial expansion of the spindle with respect to the housing through optimization of the bearing spread.

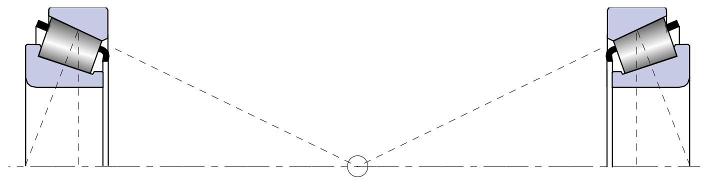
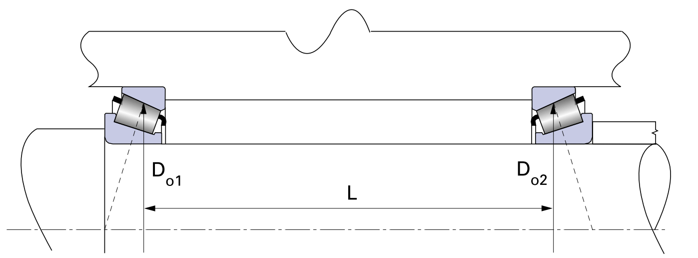


Fig. 4-28
Graphical determination of optimum thermal spread

Fig. 4-28 shows a graphical way to determine this optimum spread. To define the optimum spread for thermal compensation or to calculate the effect on setting for a given spread in a simple 2TS(F) bearing system, the designer can use the formula below for ferrous housings and spindles.



$$\text{Loss of endplay} = 12 \times 10^{-6} \times t \times \left[\left(\frac{K_1}{0.39} \times \frac{D_{o1}}{2}\right) + \left(\frac{K_2}{0.39} \times \frac{D_{o2}}{2}\right) - L\right]$$

where:

t	= temperature difference between shaft / inner race rollers and housing / outer race (θs - θh)	(°C)
K_1 and K_2	= respective K factor of bearings 1 and 2 from bearing tables	
D_{o1} and D_{o2}	= respective outer race mean diameter	(mm)
L	= distance between bearings geometric centerlines	(mm)

During the starting period, care must be taken, because the radial thermal expansion is not immediately compensated by the axial expansion of the spindle. That only occurs slightly later. During this “transient period,” a decrease of the axial end play or an increase of preload is generally recorded *(fig. 4-29)*. The loss of endplay can be calculated by using the same formula but ignoring the parameter “L”. *For this reason, it is generally recommended to initially set the bearings with a light, cold endplay to avoid any bearing burn-up, due to excessive preload during the transient temperature raise.* During the testing phase, it will be possible to modify this initial endplay to obtain the optimum setting for the application.

Fig. 4-29 shows also that a three-support layout is more sensitive to thermal effects leading to a higher temperature raise and loss of endplay than a simple arrangement because of the short bearing geometric spread at the fixed position.

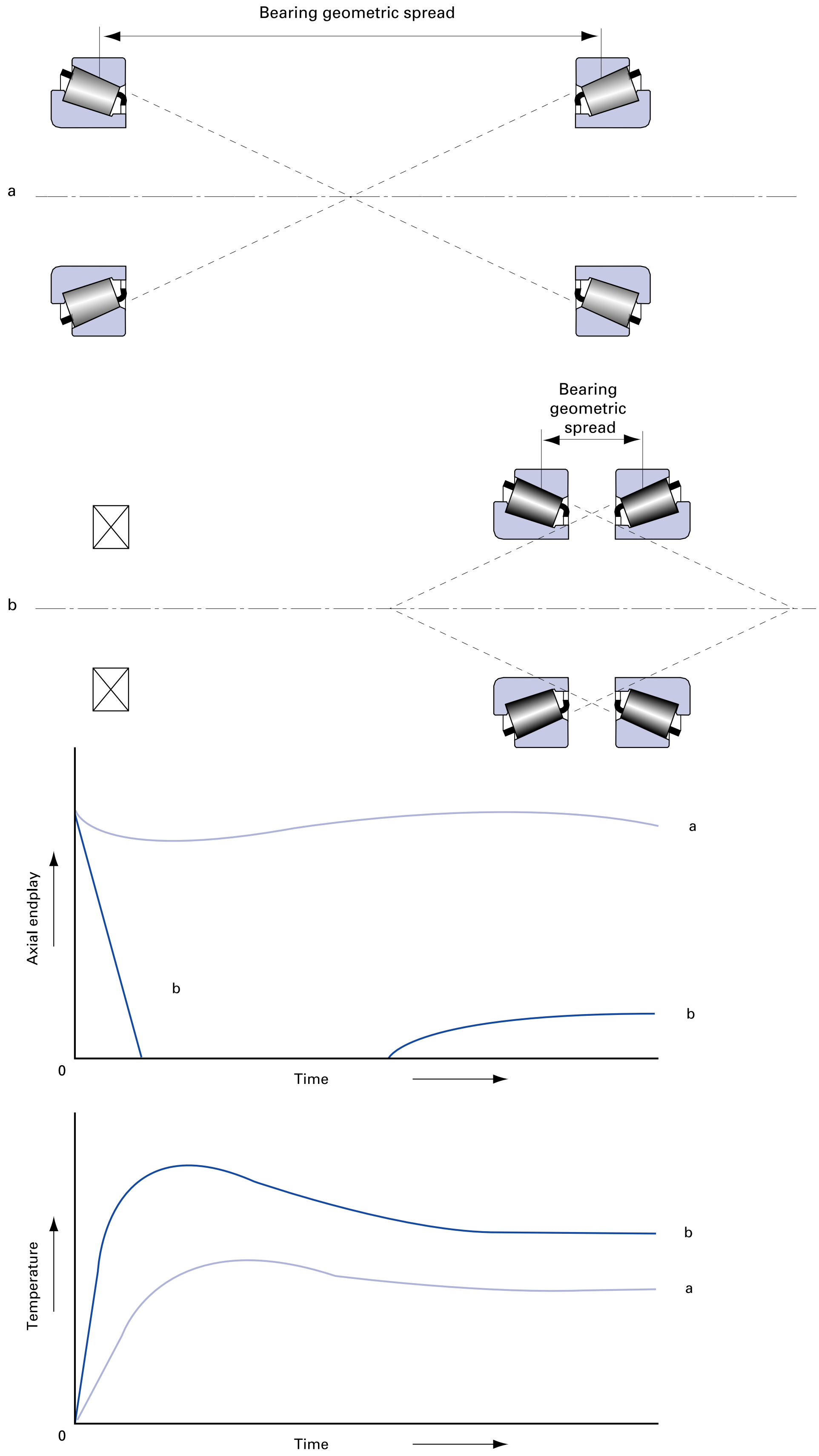


Fig 4-29
Evolution of the spindle system setting and temperature during the transient period: a) Simple mounting b) Three-support mounting

Preloading

Ball Bearings

Preloading of precision ball bearings to a predetermined thrust load for "universal" mounting is accomplished by grinding a certain amount of stock off faces of the inner and outer rings so that before mounting the bearing, faces on the abutting side are offset an amount equal to the deflection under "preload". When mounted, these faces are clamped together, the opposite bearing faces become flush and the bearing parts are subjected to compressive forces, bringing the balls into contact with their respective raceways, to take up the initial clearances of the bearings. Thus, the preload built into the bearings is automatically obtained. The condition of a preloaded ball bearing is similar to that of one in operation under thrust load. This initial thrust load serves to decrease the axial and radial deflections when subsequent operational loads are imposed on the bearing assembly.

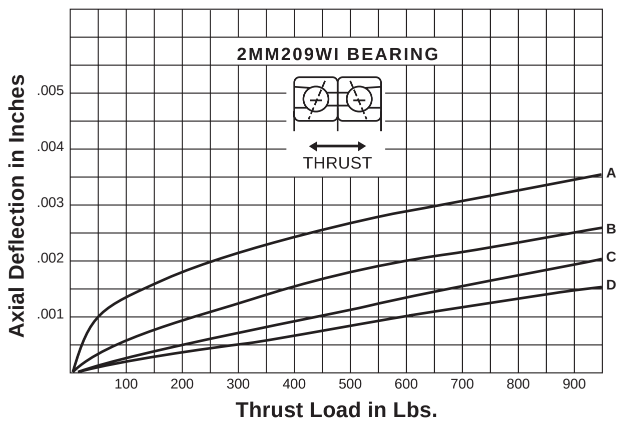
Bearings are preloaded no more than necessary. Excessive preload adds little to the rigidity of the spindle but appreciably reduces the range of operating speeds by causing bearings to run hot at higher speeds. To meet conditions of speed, mounting arrangement and maximum rigidity consistent with low operating temperatures, Fafnir precision ball bearings are designed and produced with preloads varying from light to heavy and, in some instances, with negative preload.

In many cases, the amount of bearing preload is a trade-off between having the desired degree of rigidity and reducing any adverse effect preloading has on the equipment. If the operating speed is high, a heavy preload can lead to excessively high operating temperatures, resulting in early bearing failure. For these reasons, three classes of ball-bearing preloads are used – Light, Medium and Heavy. In certain applications, such as high-speed motorized router spindles, specially preloaded, super precision ball bearings are required. Such bearings are "zero" preloaded – that is, the faces of the inner and outer rings are ground flush under negligible load.

The Light, Medium and Heavy standard preload values for Fafnir super precision angular-contact ball bearings and for both high and low contact angles are located with the dimension tables in chapter 3.

Axial deflection curves of various preload conditions for duplex pairs of 2MM209WI superprecision ball bearings are shown in Figure 4-30 and the radial deflection curves for the same bearings are shown in Figure 4-31.

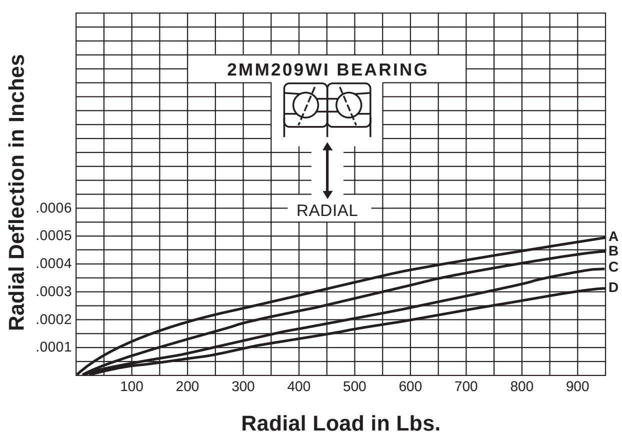
Effect of Preload on Axial Deflection



A No Preload
B Light Preload 40 lbs.
C Medium Preload 125 lbs.
D Heavy Preload 250 lbs.

Figure 4-30 – Axial Deflection Curves

Effect of Preload on Radial Deflection



A No Preload
B Light Preload 40 lbs.
C Medium Preload 125 lbs.
D Heavy Preload 250 lbs.

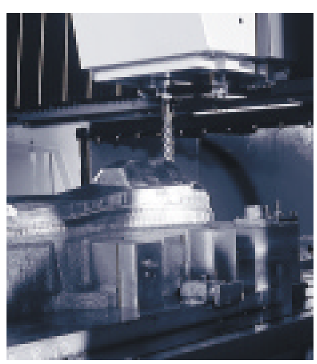
Figure 4-31 – Radial Deflection Curves

LUBRICATION
Tapered roller bearings

The selection of the lubricant and lubricant delivery method is directly linked with the speedability of a bearing. It is strongly suggested that the section on speedability is reviewed by the customer in addition to this section on lubrication.

Grease

Grease lubrication speed limits are lower than limits for oil lubrication because all the heat must be carried away by conduction through the shaft and housing.



Mineral Grease

When conventional (mineral) greases are used, the rib speed should be limited to 5 m/s. This limit can be increased under pure radial loads up to 13 m/s provided that the bearings remain in endplay under all operating conditions. Generally, N°2 consistency greases are used with medium to low viscosity base oils.

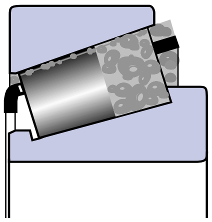


Fig. 4-32
Filling a bearing with synthetic grease

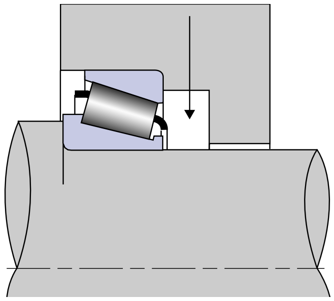


Fig. 4-33
Simple radial oil inlet hole with oil collector

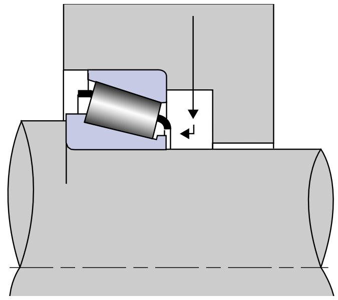


Fig. 4-34
Axial oil jet to direct oil at small end of the rollers

$$V_{mg} = f_{mg} \times V = f_{mg} \times \left[\frac{\pi}{4} \times T \times (D^2 - d^2) \times 10^{-3} - \frac{M}{7.8 \times 10^{-3}}\right] \ (cm^3)$$

where:

f_{mg}	= factor depending on speed: $0.3 < f_{mg} < 0.5$	
V	= free volume of the bearing	(cm^3)
T	= overall bearing width	(mm)
D	= cup outer diameter	(mm)
d	= cone bore	(mm)
M	= bearing weight	(kg)

Synthetic Grease

The use of “low torque” greases (or synthetic greases) can be considered for rib speeds over 13 m/s, up to a maximum of 25 m/s. Experience has shown that stabilized temperatures, around 15 to 20° above ambient, can be obtained at the maximum permissible speed.

The following procedures must be respected to achieve the above performance:

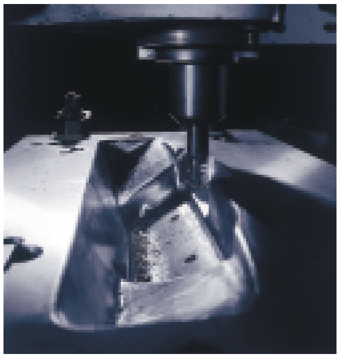
- All corrosion protection is removed from the bearing surfaces by using an organic solvent
- Very small initial quantity of grease is applied to prevent excessive churning
- Initial run-in period to evacuate unnecessary grease from the bearing
- Good spindle design to retain grease around the bearings
- Efficient sealing to protect against external contamination

$$V_{sg} = f_{sg} \times V = f_{sg} \times \left[\frac{\pi}{4} \times T \times (D^2 - d^2) \times 10^{-3} - \frac{M}{7.8 \times 10^{-3}}\right] \ (cm^3)$$

where:
fsg = factor depending on speed: $0.15 < fsg < 0.3$

When using synthetic greases, the limiting factor is the “lubrication for life” concept (without re-greasing). Depending on load and speed conditions the grease life will typically be limited to 5,000 to 8,000 hours.

The Timken Company’s suggestions for the use and run-in of synthetic greases are illustrated at the end of this chapter.



A normal way to fill the bearing with grease is to do it by hand before heating and fitting the components. For the cone, the free volume corresponding to the first third of the rollers starting from their large end, is filled with grease; an additional quantity is provided below the cage. For the cup, a thin film of grease is spread all around the race. See Figure 4-32.

Grease lubrication of spindle bearings is generally preferred by machine tool builders over oil circulation lubrication due to its simplicity and low heat generation. For high loads or high speeds, however, circulating oil is probably the most widely used method because of its capability to remove heat from the spindle.

Oil Circulation

Many parameters have to be considered in designing an efficient oil circulation lubrication system:

- Oil characteristics
- Oil flow rates
- Oil feed and drain systems
- Heat dissipation rate of the bearing system

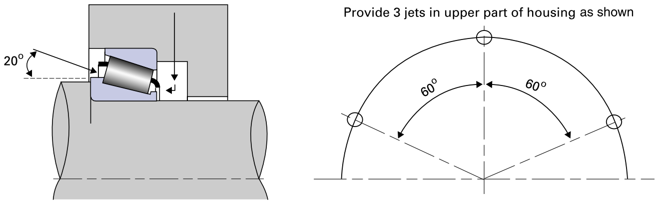


Fig. 4-36
Cooling jets in top part of the housing for speed above 25 m/s

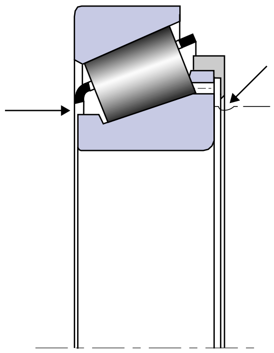


Fig. 4-37
The TSMA bearing

The latter is affected by factors such as conduction through the housing walls and convection by the circulating lubricant.

Oil Characteristics

A low viscosity mineral oil in the range of ISO VG10 to ISO VG22 is generally specified for the bearings. This choice will minimize heat generation, particularly at high speeds, where the lowest practical viscosity is required. Care must be taken, however, if gears are used for the power transmission because the choice of the common lubricant will be systematically dictated by the needs of the gears. High quality mineral oils having suitable additives for lubricating both the gears and bearings are available with a relatively low viscosity.

Oil Feed System

Forced-feed oil systems are generally used in the machine tool industry. In a typical system, oil is pumped from a central reservoir to each bearing separately. Oil is introduced at the small end of the rollers and drained away at the large end to take advantage of the natural pumping action of tapered roller bearings.

Circulating oil allows a continuous regulated oil flow. Apart from providing the advantages of maximum heat dissipation, it also has the added benefit of removing any contamination or debris which could possibly cause bearing wear.

Heat exchangers can be included in a circulating system to reduce oil inlet temperature and better regulate the running temperature of the system. Filters of 40 µm size are also generally provided to remove debris.

Experience has shown that for speeds up to 20 m/s, a simple radial oil inlet hole in the top part of the housing in conjunction with an oil collector is sufficient (fig. 4-33). For speeds over 20 m/s, an axial oil jet should be positioned to direct oil at the small end of the roller at the gap between the cage and the inner race (fig. 4-34). For high speeds or in case of large size bearings, additional oil jets can be arranged about the circumference to better distribute the oil within the bearings.

With increasing speeds (approximately 25 m/s and above), the effect of centrifugal force will throw the oil to the outside along the cup race. To prevent lubricant starvation at the inner race rib, and consequent bearing burn-up, additional oil jets have to be provided in the top part of the housing (fig. 4-36).

For rib speeds of over 40 m/s, special high speed TSMA bearings have been developed. A special provision for lubrication of the roller rib contact area is provided to ensure adequate lubrication. The concept works by capturing oil in a manifold attached to the inner race and directing it to the rib-roller contact area through holes drilled axially in the inner race (fig. 4-37).

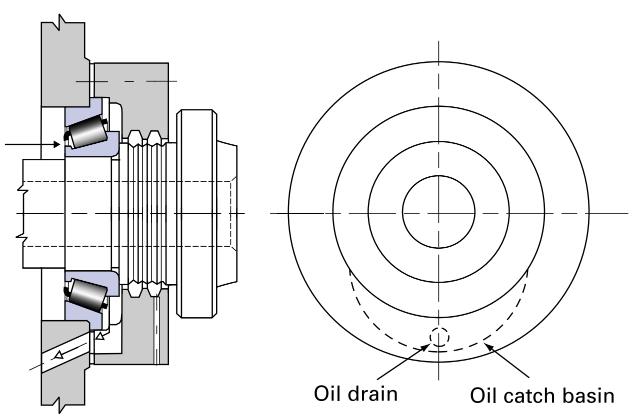


Fig. 4-38
Oil drain design

Oil Drainage System

An effective circulating oil system requires adequate drainage to prevent an oil build-up which would cause excessive churning and unnecessary heat generation. Oil passing through a high speed bearing will exit the bearing at a high velocity and will also swirl around the housing in the direction of rotation of the bearing. To effectively drain the oil away, the high velocity must be slowed and the swirling action stopped so that the oil will fall down into the drain area. A drain catch basin is required to break up the flow of oil and direct the oil to the drain hole (fig. 4-38). Oil drain sections must be adequately dimensioned in order to ease the rapid evacuation of the oil.

LUBRICATION – Ball Bearings

Even though ball bearings have the least amount of friction of any of the common anti-friction bearings, lubrication is required to minimize rolling resistance due to deformation of the balls in the raceways under load, and to minimize any sliding friction that occurs between the balls, the raceway and the retainer. Lubrication also serves to protect the accurately ground and polished surfaces from corrosion. In addition, lubrication, in general, dissipates generated heat and can help protect the bearing from the entry of foreign matter.

Only enough lubrication to accomplish these purposes should be used since another source of heat may become present, namely friction between the lubricant and the moving parts, in the form of churning or internal shear of the lubricant itself.

Regardless of the method of lubrication or type of lubricant, it is important that quality lubricants be used to minimize oxidation, gumming or sludging and that the lubricant be clean and free of moisture to minimize wear.

In the lubrication of ball bearings, it is important to realize that a small quantity of oil or grease will, if constantly present in the bearing, suffice for its requirements. It should be noted that trouble can result from excessive lubrication as it can from too little. Either condition should be avoided. Excessive oil or grease will result in high temperature and possibly failure. When grease is used, it is especially necessary to take into consideration the maximum operating temperature. Also particular attention must be given the housing design relating to the proximity of the grease to the bearing, in order to assure adequate purge room and grease retention.

Depending upon operating speeds, loads and temperatures, machine tool ball bearings are lubricated with grease, oil or oil mist. In general, oils are required when bearings operate at high speeds as they provide greater cooling than is possible with grease.

Grease

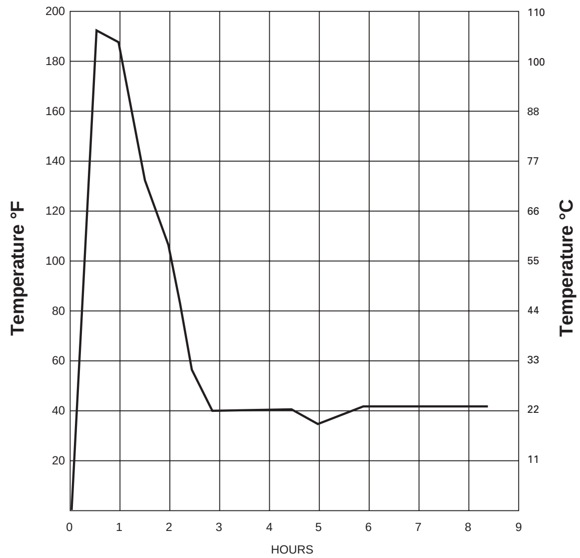
The use of grease as a lubricant for Timken Fafnir Super Precision ball bearings on various spindle applications is becoming more popular due to the development of better ball bearing greases, simplification of design and elimination of the "human maintenance factor" which is frequently responsible for too much lubrication, not enough lubrication, or the wrong kind of lubrication. Prelubricating the bearings at assembly with the correct amount of the right grease and thus eliminating all grease fittings has increased bearing life in many instances.

For successful lubrication, grease for ball bearings should have good mechanical and chemical stability with low torque characteristics. Two different types of grease, one soft and the other firmer, have proved to be suitable lubricants for machine tool spindle bearings. The "soft" greases have a worked penetration factor corresponding to NLGI of 2 or less. The firmer grease has a worked penetration factor of 3 or more and is of the channeling type. All greases show a very slight change in consistency after operation in a bearing. As the softer grease has a tendency to churn, particular attention should be given to the quantity packed into the bearing. Because the firmer grease is of the channeling type, the amount used is not as critical.

For super precision ball bearings below a 400,000 DN value, which is equivalent to a 40mm bore bearing rotating at 10,000 rpm, either a light consistency grease or the channeling grease may be used.

At continuous speeds above a dN value of 400,000, the operating temperature is generally lower when the bearings are lubricated with a lower consistency grease and after sufficient break in.

Bearing Temperature Increase Due to Break-In Procedure



Typical Temperature After Break-In Procedure

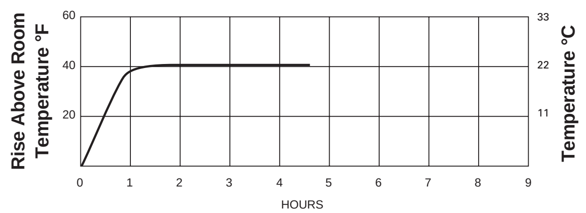


Figure 4-39 – Temperature vs Time

However, the grease quantity in each bearing must be limited. At these higher speeds, an excessive amount of grease in the bearing may result in greatly increased operating temperatures, due to churning action. This condition, if uncontrolled, may lead to premature bearing failure.

The top graph in Figure 4-39 shows bearing temperature increase due to break-in procedure. The peaking temperature followed by the leveling off is a result of the new grease being worked and then stabilized for a particular condition of load and speed.

It is important that the peak temperature not exceed 100°F/55°C above room temperature since the chemical consistency and characteristics of the grease can be permanently altered. Thus, the proper break-in procedure is to run the machine until the spindle temperature rises to 150°F/65°C and then turn it off to allow the grease to cool. Repeat until the spindle temperature stabilizes at a temperature below 130°F/54°C.

The bottom graph in Figure 4-39 shows the typical temperature rise of the bearing once the grease has been worked in for the specific speed and load.

Oil

Although several grease products have been successful at DN values as high as one million, oils are generally required for bearings operating at high speeds or to provide more cooling and dissipation of heat than is possible with grease. High-grade spindle oil having a viscosity of 100 seconds Saybolt at 100°F/37°C is recommended for use in drip-feed oilers, oil bath lubrication arrangements and oil mist systems. In heavily-loaded applications, oil in relatively large quantities must be supplied, and where temperatures run higher than normal, oil coolers will be required. Churning of a large pool of oil is to be avoided if speed is significant.

Oil Bath

The conventional oil-bath system for lubricating the bearings is satisfactory for low and moderate speeds. The static oil level must never be higher than the center of the lowermost ball. When the shaft is rotating, the running level may drop considerably below the standstill level, depending on the speed of the revolving parts. A sight gauge or other suitable means should be provided to permit an easy check.

Drip-Feed Oil

Where the speeds are considered high for oil bath and the bearings are moderately loaded, oil, introduced through a filter-type, sight-feed oiler, is recommended. This assures a constant supply of lubricant. The feed in drops-per-minute is determined by closely observing the operating temperatures.

Oil Jet

In applications where the ball bearing is heavily loaded and operating at high speed and high temperatures or where the operating conditions are severe with high ambient temperatures encountered, oil jet lubrication may be required. In such cases it is necessary to lubricate each bearing location individually, and to provide adequately large drain openings to prevent excessive accumulation of oil after it has passed through the bearings.

Oil Mist

Oil mist lubrication is recommended for spindles running continuously at high speeds. With this method of lubrication, oil of the proper viscosity is atomized into finely divided particles, mixed with clean, filtered, dry compressed air and directed to pass through the bearings in a constant stream. This oil is metered into the air under pressure. Thus, the system not only lubricates the bearings but it affords some cooling due to the air flow. This continuous passage of air and oil through the bearings and the labyrinth seals also serves to prevent the entrance of contaminants into the bearings.

To insure the “wetting” of the bearings and to prevent possible damage to the balls and raceways, it is imperative that the oil mist system be turned on for several minutes before the spindle is started. The importance of wetting the bearings before starting cannot be over stressed and has particular significance for spindles that have been idle for extended periods of time. To avoid such effects, most oil mist systems have interlocks which make it impossible to start the spindle until the lubricating system is working properly and the bearings are thoroughly wetted.

Metered Air/Oil

This method is similar to the oil mist; however, the oil is fed by periodic pulses to the lubrication line providing a higher air to oil ratio. Therefore, this method lowers the operating bearing temperature and lubricant shear effects, enabling higher operating speeds.

Lube System Comparison

	System Cost	Typical * Speed (dN)
Grease	Low	500,000
High Speed Grease	Low	750,000
Oil Bath	Low	400,000
Oil Drip	Low	600,000
Oil Mist	Medium	1,000,000
Metered Air/Oil	High	>1,000,000
Oil Jet	High	>1,000,000

* Speed value is an approximation and assumes proper mounting and preload techniques along with average loading conditions. For more specific guidance contact your local Timken sales engineer.

The Speed, “dN”, value is obtained by multiplying the bearing bore size in millimeters by the shaft RPM.

Synthetic Grease Run-in Cycles
(Tapered Roller Bearings)

The aim of run-in cycles is to correctly spread the grease inside the bearing, in order to avoid churning of the grease and excessive bearing temperature.

During run-in operations the bearing temperature must be constantly monitored and immediately plotted on a graph so that any tendency of the curve toward a vertical asymptote can be averted. Temperature probes placed closest to the bearings, will provide better control of the run-in operations.

The other advantage of the graph is to help determine the running-in time at a given speed. When the curve becomes horizontal, it shows that the temperature has stabilized. It is then possible to proceed to the next speed.

The indicated times may vary depending on the speeds and heat dissipation capacity of the spindles.

According to the results obtained on the prototype, it may be possible to reduce either the number or the length (or both) of the run-in steps for production spindles. In any event, temperature control should be retained for safety reasons.

When running-in multi-speed spindles, reduced speeds must be chosen at start-up of the cycles. The speed can be progressively increased until the bearings evacuate any excessive quantities of grease.

Single-speed Spindles

Time	Action
10 s	Run
1 min	Stop
20 s	Run
1 min	Stop
30 s	Run
1 min	Stop
40 s	Run
1 min	Stop
50 s	Run
1 min	Stop
1 min	Run
1 min	Stop
90 s	Run
1 min	Stop
2 min	Run
1 min	Stop
3 min	Run*
1 min	Stop
4 min	Run*
1 min	Stop
6 min	Run*
1 min	Stop
10 min	Run*
20 min	Stop

⟹ Then run until temperature stabilizes. At this step of the cycle, as well as at the other steps marked *, closely watch the curve's shape. If it tends to be vertical, stop 15 minutes and run again at 75% of max. speed until the temperature stabilizes again. Then restart the cycle from the beginning at max. speed.

Multi-speed Spindles

25% max. speed		50% max. speed		75% max. speed		Max. speed	
Time	Action	Time	Action	Time	Action	Time	Action
1 min	Run	1 min	Run	1 min	Run	1 min	Run
1 min	Stop	1 min	Stop	1 min	Stop	1 min	Stop
1 min	Run	1 min	Run	1 min	Run	1 min	Run
1 min	Stop	1 min	Stop	1 min	Stop	1 min	Stop
2 min	Run	2 min	Run	2 min	Run	2 min	Run
1 min	Stop	1 min	Stop	1 min	Stop	1 min	Stop
3 min	Run	3 min	Run	3 min	Run	3 min	Run
5 min	Stop	5 min	Stop	5 min	Stop	5 min	Stop
⟹ Then run until temperature stabilizes.		⟹ Then run until temperature stabilizes.		⟹ Then run and closely watch the curve's shape during running, until stabilization. If it tends to be vertical, stop 15 min and run again at same speed.		⟹ ⟹ Then run until temperature stabilizes. At this step of the cycle, as well as at the other steps marked *, closely watch the curve's shape. If it tends to be vertical, stop 15 minutes and run again at 75% of max. speed until the temperature stabilizes again. Then restart the cycle from the beginning at max. speed.	

Table 4-58
Run-in recommendations for synthetic grease lubricated tapered roller bearings

Run-In Procedure For Greased Ball Bearings
(for speeds > 500,000 dN)

A proper run-in procedure will provide the following results:

- Expel the excess grease from the bearings
- Orient the lubricating film on each contact surface
- Establish a low equilibrium operating temperature

Run-In Procedure

1. Install proper quantity of grease as indicated.
2. Start at a reasonable low speed, typically 10% of the maximum operating speed.
3. Increase speed with small, reasonable increments when a stable temperature is reached.
4. Continue incremental increase in speed as described. If a rapid temperature increase occurs (temperature exceeds 70°C/170°F), stop the run-in process.

Maximum bearing temperatures should not exceed 70°C (170°F). Temperatures in excess of 70°C will cause excessive bearing preloads and possible permanent grease or bearing damage.

5. Allow the system to cool to room temperature.
6. Restart procedure at the last speed prior to the temperature spike.
7. Continue repeating the above cycle until an equilibrium temperature is reached at the maximum operating speed of the application. *The ideal equilibrium operating temperature is 35°C to 46°C (95°F to 115°F).*

Alternative Run-In Procedure
(when unable to control incremental speeds)

Run-in at constant speed is also possible. In this operation, the bearing should run at full speed for about 30 seconds. After stopping, the heat in the bearing dissipates. In this way, a dangerous temperature rise is prevented. The non-running time depends on the various design factors, but it should be at least 5 times greater than the running time. This process is repeated until the bearing temperature becomes constant.

Vertical Spindles

For vertical axis spindles, special attention must be paid to the lubrication and sealing. Modified sealing is required to prevent the coolant from contaminating the lubricant when the spindle nose bearing is at the upper position (fig 4-40).

In the case of grease lubrication, deflectors have to be installed to prevent grease migration away from the bearing cavity. Alternatively, when oil lubrication is adopted and the nose bearing is at the lower position, a system to collect and extract the oil has to be provided to prevent leakage (fig. 4-41).

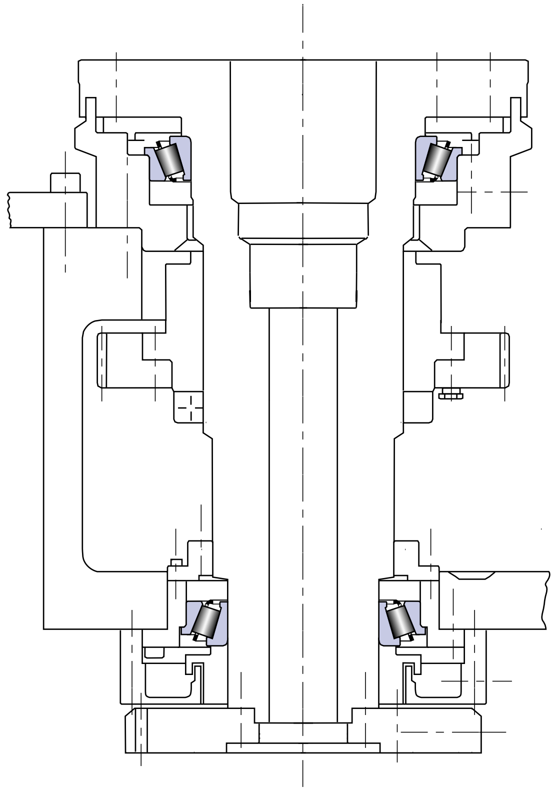


Fig. 4-40

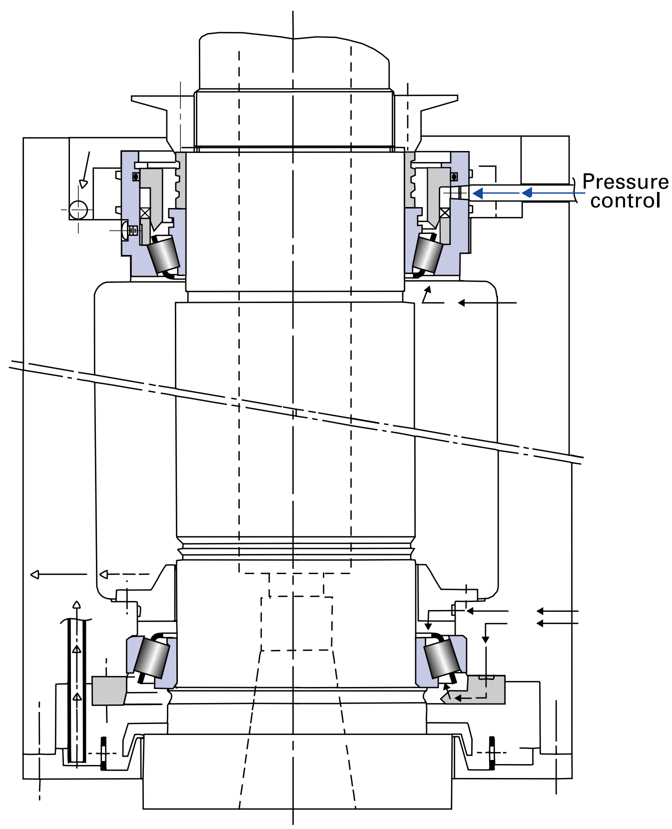


Fig. 4-41

HEAT GENERATION

When ball bearing spindles are grease lubricated, the heat generated is removed only by conduction through the surrounding parts. With jet or circulating oil lubrication, generated heat is dissipated by the oil passing through the bearings as well as by conduction through the shaft and housing. Both means of removing heat from the bearings are important but, generally, dissipation through conduction is less obvious.

As an example, in an oil mist lubricated grinding spindle the nose or wheel-end bearings are fixed and close to the grinding coolant. The pulley-end or rear bearings are secured axially on the shaft but permitted to float laterally in the housing to compensate for size variations due to thermal changes. Heat is conducted away from the front bearings at a faster rate because of the mass of the spindle nose and the intimate contact of the outer rings with the housing shoulder, the end cover, and the housing bore. This condition, coupled with oil mist lubrication and the proximity of the grinding coolant, takes away generated heat efficiently.

The rear or floating pair of bearings are not so favored. Usually, the mass of the shaft at the pulley-end is not so great. The pulley possesses some heat-conduction ability but also receives heat generated by belt friction. The absence of grinding coolant and the reduced area of conduction usually results in a slightly higher operating temperature.

Low operating temperatures, combined with adequate spindle rigidity, are important and highly desirable for precision machine tools. This is particularly true for high-speed grinding spindles where the preload of the bearings is the principle load imposed upon them. Some of the benefits derived from low operating temperatures are: better dimensional stability of the processed work, less need for bearing lubrication, prevention of objectionable heat at the external surfaces of the spindle housing, and elimination of troubles due to thermal effects on mounting fits and preloads.

The heat developed at the bearings under load is a function of the operating speed and the bearing preload. Preloading is necessary for maximum axial and radial rigidity. Unfortunately, if speeds are increased, the bearing preload may have to be lessened to maintain proper operating temperatures at the bearing.

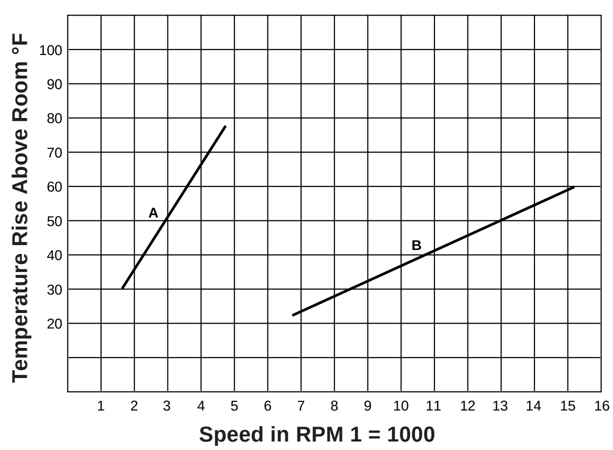
For high-speed operation, the bearing preload should be sufficient to maintain proper rolling friction for the balls but not so high as to generate excessive heat. In cases where lower operating speeds are desired, bearing preloads may be increased to obtain additional bearing rigidity, provided the proper operating temperatures are maintained. Thus, a balance between heat generation and spindle rigidity dictates the amount of bearing preload that is used, commensurate with the operational speed and the bearing life required.

Ball Bearings

How bearing preload affects the operating temperature is illustrated in Figure 4-51. This graph applies to 207 size, angular-contact, duplexed super precision ball bearings, mounted back-to-back. Curve A is a plot of operating temperature at the bearing outside diameter for the speeds indicated, using bearings with a 150 pound built-in preload. Curve B is for bearings having a 30 pound preload. The slope of Curve A is much steeper than that of Curve B. Using bearings with a 150 pound preload, the temperature rise at the bearing outside diameter is 60° F when operating at 3600 rpm. For the same temperature rise, using bearings with 30 pounds preload, an operating speed of 15,300 rpm is indicated. Therefore it is evident that for higher-speed operation the bearing preload should be kept to the minimum necessary to assure sufficient bearing rigidity.

For workhead spindles, the operating speeds are generally low and the loading conditions heavy. Maximum radial and axial spindle rigidity is required under these loads, making increased bearing preload mandatory.

Effect of Preload on Temperature Rise



A High Preload
B Low Preload

Figure 4-51 — Temperature vs Speed

Bearing Geometry vs Heat Generation

It should be noted that a bearings' internal geometry has a major impact on heat generation. High speed designs such as Timken Fafnir's HX Series incorporates "optimized" internal geometries that balance load carrying capacity, stiffness and heat generation.

Heat Generation and Dissipation

(Tapered Roller Bearings)

One of the major benefits of oil lubricated systems is that most of the heat generated by the bearings is carried away by the circulating oil.

Heat Generation

Under normal operating conditions most of the torque and heat generated by the bearing is due to the elasto hydrodynamic losses at the contact area between rollers and races.

The following equation is used to calculate the heat generated by the bearing :

$$Q_{gen} = 2.68 \times 10^{-7} (G_1) (n)^{1.62} (\mu)^{0.62} (P_{eq})^{0.3} \quad \textbf{(1)}$$

where :

Q_{gen}	= generated heat	(W)
n	= rotational speed	(rev/min)
G_1	= geometry factor from appendix tables	
μ	= viscosity at operating temperature	(cP)
P_{eq}	= equivalent dynamic load can be determined using table 4-52 and fig. 4-53	(N)

The generated heat will be underestimated if operating speed:

$$n \leq \frac{k_2}{G_2 \times \mu} \left(\frac{f_2 \times F_r}{K} \right)^{0.66} \quad \text{RPM}$$

where:

G_2	= geometry factor from Appendix tables
k_2	= 625
K	= K factor of the bearing (Appendix)
f_2	= combined load factor (fig. 4-53).

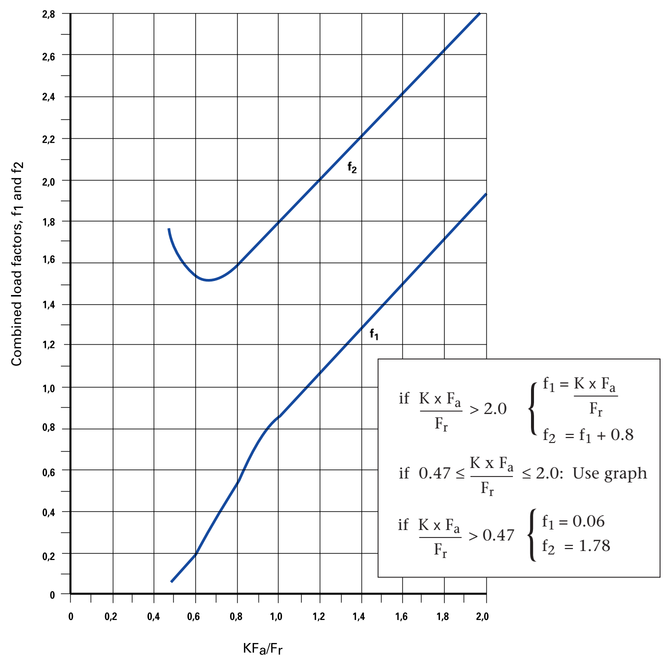
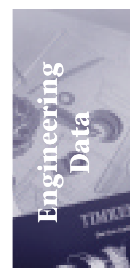


Table 4-53
Determination of combined load factors f_1 and f_2



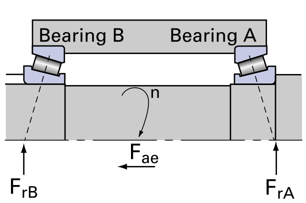
Design (thrust F_{ae} onto A)	Thrust condition	Net thrust load	Equivalent dynamic load P_{eq}
	$\frac{0.47 \times F_{rA}}{K_A} \leq \frac{0.47 \times F_{rB}}{K_B} + F_{ae}$	$F_{aA} = \frac{0.47 \times F_{rB}}{K_B} + F_{ae}$ $F_{aB} = \frac{0.47 \times F_{rB}}{K_B}$	$P_{eq} = \left(\frac{f_1 \times F_r}{K}\right)$ f_1 = combined load factor *(see fig. 4-53)*
	$\frac{0.47 \times F_{rA}}{K_A} > \frac{0.47 \times F_{rB}}{K_B} + F_{ae}$	$F_{aA} = \frac{0.47 \times F_{rA}}{K_A}$ $F_{aB} = \frac{0.47 \times F_{rA}}{K_A} - F_{ae}$	

Table 4-52
Determination of equivalent dynamic load P_{eq}

Heat Dissipation

The heat dissipation rate of a bearing system is affected by many factors and the modes of heat transfer need to be considered. Major heat transfer modes in most systems are conduction through the housing walls, convection at the inside and outside surfaces of the housing, and convection by the circulating lubricant. In many applications, overall heat dissipation can be divided into two categories: heat removed by circulating oil and heat removed through the housing.

Heat Dissipation by Circulating Oil

Heat dissipated by a circulating oil system is:

$$Q_{oil} = k_5 \times f \times (\theta_o - \theta_i) \quad \textbf{(2)}$$

If a circulating lubricant other than petroleum oil is used, the heat carried away by that lubricant will be:

$$Q_{oil} = k_6 \times C_p \times P \times f \times (\theta_o - \theta_i) \quad \textbf{(3)}$$

If lubricant flow is unrestricted on the outlet side of a bearing, the flow rate which can freely pass through the bearing depends on bearing size and internal geometry, direction of oil flow, bearing speed,and lubricant properties.

A tapered roller bearing has a natural tendency to pump oil from the small to the large end of the rollers. For maximum oil flow and heat dissipation, the oil inlet should be adjacent to the small end of the rollers.

In a splash or oil level lubrication system, heat will be carried by convection to the inner walls of the housing. The heat dissipation rate with this lubrication method can be enhanced by using cooling coils in the housing sump.

k_5 = dimensional factor to calculate heat carried away by a petroleum oil in equation **(2)** $k_5 = 28$

k_6 = dimensional factor to calculate heat carried away by a circulating fluid in equation **(3)** $k_6 = 1.67 \times 10^{-5}$

Q_{oil} = heat dissipation rate of circulating oil (W)

0_i = oil inlet temperature (°C)

0_o = oil outlet temperature (°C)

C_p = specific heat of lubricant (J/[kg °C])

f = lubricant flow rate (l/min)

p = lubricant density (kg/m^3)

Heat Dissipation Through Housing

Heat removed through the housing is, in most cases, difficult to determine analytically. If the steady-state bearing temperature is known for one operating condition, the following method can be used to estimate the housing heat dissipation rate.

At the steady-state temperature, the total heat dissipation rate from the bearing must equal the heat generation rate of the bearing. The difference between the heat generation rate and heat dissipation rate of the oil is the heat dissipation rate of the housing at the known temperature.

Heat losses from housings are primarily by conduction and convection and are, therefore, nearly linearly related to temperature difference. Thus, the housing heat dissipation rate is:

$$Q_{hsg} = C\,(\theta_o - \theta_{ambt}) \quad \textbf{(4)}$$

At the operating condition where the steady-state temperature is known, the housing heat dissipation factor can be estimated as:

$$C = \frac{Q_{gen} - Q_{oil}}{\theta_o - \theta_{ambt}} \quad \textbf{(5)}$$

Temperature Estimation

The operating temperature of the bearing system depends upon the heat generation and dissipation rates. Steady-state temperature of a bearing occurs when the heat generation and dissipation rates are equal. A graphical analysis can be used either to estimate steady-state operating temperature of a system or to fine-tune the oil flow rates of the system during the testing period. The approach is described as follows (fig. 4-54):

- Plot the curve of bearing heat generation as a function of the running temperature by using equation **(1)**
- Evaluate the heat dissipation rate of the housing by plotting a straight line (a) between two known points:

  Point 1 - Zero at ambient temperature

  Point 2 - Determined by equation **(4)** for a known steady-state temperature under one operating condition
- Plot the curve (b) of heat dissipation of the circulating oil by using equation **(2)** for arbitrary values of oil flow rate and gradient (θ_o - θ_i)
- Add (a) and (b) to determine the total heat dissipation curve
- Undertake iterations to determine the suitable values of oil flow rates, gradient, oil viscosity (fig. 4-55)

It should be noted, in the above approach, that the oil outlet temperature is considered to be equal to the steady-state temperature. When the heat dissipation rate of the housing is difficult to calculate or to appreciate by measurement, an approximation can be done by considering that 15 to 20% of the heat is removed by the housing. Alternatively, all the heat should be considered to be removed by the oil; in this case, the calculated oil flow rates will be over-estimated.

The above can be used to provide an initial estimate, for the starting tests, of the parameters that will have to be fine-tuned as a function of the performance obtained.

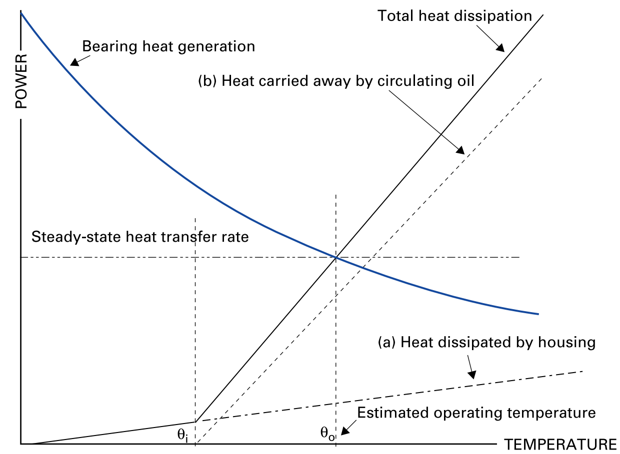


Fig. 4-54

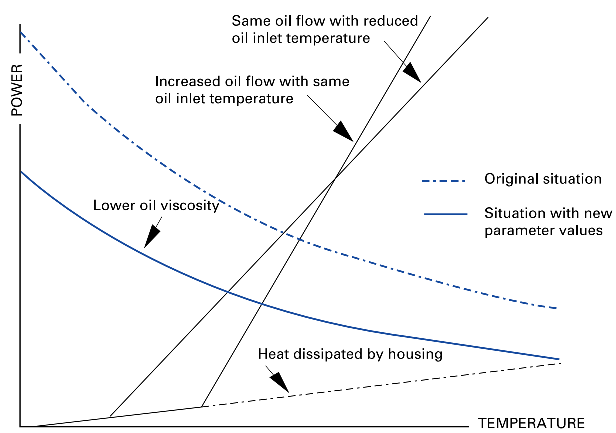


Fig. 4-55

LIFE CALCULATIONS – Tapered Roller Bearings

Bearings are normally selected to carry a given load for a given duration.

The traditional approach to bearing selection begins with the determination of applied forces and calculation of a bearing dynamic equivalent radial load (P). Using the "design life" (established from experience of successful performance of similar equipment L_{10}) and bearing speed (n), a "required dynamic radial load rating" (C_{90}) can be calculated and used to select a bearing part number from the bearing data tables.

It is suggested that the traditional approach to bearing selection be expanded to include life adjustment factors relating to a number of variables such as lubrication, load zone, alignment and useful life. Equations are included to permit a designer to do this on a limited basis.

C_{90} = required dynamic radial rating
L_{10} = design life
n = speed in rpm
P = dynamic equivalent radial load
a = life adjustment factor

$$C_{90} = \left(\frac{L_{10} \text{ x } n}{a \text{ x } 3000 \text{ x } 500} \right)^{\frac{1}{10/3}} \text{ x } P$$

Basic Dynamic Load Rating

The basic philosophy of the Timken Company is to provide the most realistic bearing rating to assist our customers in the tapered roller bearing selection process.

Since 1915, The Timken Company has developed specific rating methods for its tapered roller bearings. Customers gained from periodic bearing rating revisions which have been published only after thorough verification by extensive research effort and testing programs. The testing schedule, which is now established as an international "Quality Audit Program", randomly samples bearings as packaged in Timken distribution centers. The latest revision of Timken bearing ratings as printed in this publication was adopted in 1986. The revision was due to a significant improvement in bearing steel quality.

With the continued improvement of ratings, the environment in which the bearing operates must be carefully considered in the bearing selection process. In addition, the demand for greater energy efficiency and productivity requires more exacting specifications and places more stringent requirements on bearings. Therefore, it is essential that the designer is able to compare the reference conditions under which the ratings are established to those of the real-world environment.

The environmental reference conditions that relate to Timken published ratings are:

Load:
$F_r = C_{90}$ or $F_a = C_{a90}$

Speed:
n = 500 rev/min

Lubrication:
Oil viscosity, 33 cSt @ 55°C
(155 SUS @ 130°F)

Bearing operating temperature:
θ = 55°C (130°F)

Setting:
Equivalent to 150° load zone

Alignment:
An angle between the cone and cup centerlines of less than 0.0005 radians

Fatigue spall size:
6 mm^2 (0.01 in^2)

Actual bearing operating environmental conditions may vary from one or all of these reference conditions. Therefore, it is necessary in the application design analysis and the bearing selection process to be able to evaluate and compensate for these differences. The traditional approach to bearing analysis and selection has been expanded in this publication to include certain environmental variables over and above load and speed that affect bearing life expectancy.

In addition to bearing material and the controlled environmental conditions that exist in the testing programs, a bearing's rating is a function of its internal geometry – including cup raceway angle, roller diameter, and effective contact length between raceways and rollers. It also depends on the number of rollers in each row and the number of rows in the bearing. These parameters and a geometry-material factor are the basis of the equation from which the rating for each bearing is determined.

Timken Dynamic Load Rating

Published ratings for Timken bearings include the basic dynamic load rating, C_{90} and $C_{90(2)}$, for single-row and two-row bearings respectively, and the basic dynamic thrust load rating, C_{a90}. These are based on a basic rating life of 90 million revolutions or 3000 hours at 500 rpm.

The bearing rating method published by the International Organization for Standardization (ISO) and American Bearing Manufacturers Association (ABMA) is presently based on a rating life of one million revolutions. The ISO/ABMA rating is considered a reference value only, since applied loads equal to this rating could produce plastic deformation within a bearing. To determine the bearing load rating that will provide 90 million revolutions life, divide the ISO/ABMA roller bearing rating by:

$$\left(\frac{90{,}000{,}000}{1{,}000{,}000}\right)^{\frac{1}{10/3}} \quad \text{or } 3.857$$

However, a direct comparison between ratings of various manufacturers can be misleading because of differences in rating philosophy, material, manufacturing, and design.

Note: for the convenience of users, the bearing data tables show both the 90 million revolutions rating (C_{90}) and the 1 million revolutions rating (C_1) when possible.

Timken bearing load ratings are based on data obtained from standardized laboratory life tests.

K Factor

The Timken Company also publishes K factors for its bearings. The K factor is the ratio of basic dynamic radial load rating to basic dynamic thrust load rating of a single row bearing.

This ratio assumes a 180° load zone for the basic dynamic radial load rating:

$$K = C_{90}/C_{a90}$$

The smaller the K factor, the steeper the bearing cup angle becomes. This relationship is:

$$K = 0.398 \cot(\alpha)$$

Rating Life (L_{10})

Rating life, L_{10}, is the life that 90 percent of a group of identical bearings will complete or exceed before the area of fatigue spalling reaches a defined criterion. The L_{10} life is also associated with 90 percent reliability for a single bearing under a certain load.

The life of a properly applied and lubricated tapered roller bearing is normally reached after repeated stressing produces a fatigue spall of a specific size on one of the contact surfaces. The limiting criterion for fatigue used in Timken laboratories is a spalled area of $6mm^2$ (0.01 sq.in.). This is an arbitrary designation and, depending upon the application, bearing useful life may extend considerably beyond this point.

If a sample of apparently identical bearings is run under specified laboratory conditions until a material associated spall of $6mm^2$ (0.01 sq.in.) develops on each bearing, 90 percent of these bearings are expected to exhibit lives greater than the rating life. Then, only 10 percent would have lives less than the rating life.

To assure consistent quality, worldwide, The Timken Company conducts extensive bearing fatigue life tests in its own state-of-the-art laboratories. This testing results in confidence in Timken ratings.

BEARING LIFE EQUATIONS

Traditionally, the L_{10} life has been calculated as follows for bearings under radial or combined loading where the dynamic equivalent radial load (P) has been determined:

$$L_{10} = \left(\frac{C_{90}}{P}\right)^{10/3} (90 \times 10^6) \text{ revolutions} \qquad \textbf{(1)}$$

or,

$$L_{10} = \left(\frac{C_{90}}{P}\right)^{10/3} \frac{(1.5 \times 10^6)}{n} \text{ hours} \qquad \textbf{(2)}$$

The following factors also help to visualize the effects of load and speed on bearing life:

- Doubling the load reduces life to approximately one-tenth. Reducing the load by one-half increases life approximately ten times.
- Doubling the speed reduces hours of life by one-half. Reducing the speed by one-half doubles hours of life.

Technology permits the quantitative evaluation of environmental differences, such as lubrication, load zone and alignment, in the form of various life adjustment factors. These factors, plus a factor for useful life, are considered in the bearing analysis and selection approach by The Timken Company.

Bearing life adjustment equations are:

$$L_{na} = a_1\, a_2\, a_3\, a_4\, (C_{90} / P)^{10/3}\, (90 \times 10^6) \quad \text{(revolutions)}$$

or

$$L_{na} = a_1\, a_2\, a_3\, a_4\, (C_{90} / P)^{10/3}\, (1.5 \times 10^6) / n \quad \text{(hours)}$$

where:

a_1 = life adjustment factor for reliability
a_2 = life adjustment factor for bearing material
a_3 = life adjustment factor for environmental conditions
a_4 = life adjustment factor for useful life (spall size)

Traditional L_{10} life calculations are based on bearing capacity, dynamic equivalent radial load and speed. The Timken Company method of calculating L_{10} life is based on a C_{90} load rating, which is the load under which populations of bearings will achieve an L_{10} life of 90 million revolutions. The ISO method is based on a C_1 load rating, which produces a population L_{10} life of one million revolutions. While these two methods correctly account for differences in basis, other differences can affect the calculation of bearing life. For instance, the two methods of calculating dynamic equivalent radial load can yield

slight differences that are accentuated in the life equations by the exponent 10/3. In addition, it is important to distinguish between the ISO L_{10} life calculation method and the ISO bearing rating. Comparisons between bearing lives should only be made for values calculated on the same basis (C_1 or C_{90}) and the same rating formula (Timken or ISO).

Note: for pure thrust loading and for thrust bearings, equations 1 and 2 become:

$L_{10} = (C_{a90} / F_{ae})^{10/3} (90 \times 10^6)$ (revolutions) **(1a)**

$L_{10} = (C_{a90} / F_{ae})^{10/3} (1.5 \times 10^6)/n$ (hours) **(2a)**

where:
C_{a90} = basic dynamic thrust rating for an L_{10} life of 90 million revolutions
F_{ae} = external thrust load

The ISO Method (ISO 281)

$L_{10} = (C_1 / P)^{10/3} (1 \times 10^6)$ (revolutions) **(3)**
$L_{10} = (C_1 / P)^{10/3} (1 \times 10^6) / 60n$ (hours) **(4)**

where:
C_1 = basic dynamic radial load rating for an L_{10} life of 1 million revolutions

Note: The C_1 ratings used in equations 3 and 4 and in the bearing dimensional tables listed in this catalog are Timken C_{90} ratings modified for an L_{10} of 1 million revolutions and not ISO 281 ratings.

Bearing Equivalent Loads and Required Ratings

Tapered roller bearings are ideally suited to carry all types of loadings – radial, thrust and any combination of both. Due to the tapered design of the bearing, a radial load will induce a thrust reaction within the bearing that must be opposed by an equal or greater thrust reaction to keep the cones and cups from separating. The number of rollers in contact as a result of this ratio determines the load zone in the bearing. If all the rollers are in contact, the load zone is referred to as being 360 degrees.

When only a radial load is applied to a tapered roller bearing, it is assumed that half the rollers support the load and the load zone is 180 degrees. In this case, induced bearing thrust is:

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

The equations for determining thrust reactions and equivalent radial loads in a system of 2 single-row bearings are based on the assumption of a 180-degree load zone in one of the bearings and 180 degrees or more in the opposite bearing.

Dynamic Equivalent Radial Load

The basic dynamic radial load rating (C_{90}) is assumed to be the radial load carrying capacity with a 150° load zone in the bearing. When the thrust load on a bearing exceeds the induced thrust, $F_{a(180)}$, a dynamic equivalent radial load must be used to calculate bearing life.

The dynamic equivalent radial load is that radial load which, if applied to a bearing, will give the same life as the bearing will attain under the actual loading (combined axial and thrust). The equations presented on the opposite page give close approximations of the dynamic equivalent radial load assuming a 180-degree load zone in one bearing and 180 degrees or more in the opposite bearing. More exact calculations using computer programs can be used to account for parameters such as bearing spring rate, setting, and supporting housing stiffness.

The approximation equation is:
$P = XF_r + YF_a$

Adjusted Life

With the increased emphasis on the relationship between rating reference conditions and the actual environment in which the bearing operates, the traditional life equations have been expanded to include certain additional variables that affect bearing performance. The expanded bearing life equation becomes:

$L_{na} = a_1 a_2 a_3 a_4 L_{10}$
L_{na} = adjusted rating life
a_1 = life adjustment factor for reliability
a_2 = life adjustment factor for material
a_3 = life adjustment factor for environmental conditions
a_4 = life adjustment factor for useful life
L_{10} = rating life from equations 1 to 4

Factor for Reliability – (a_1)

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

Rating life, L_{10}, for an individual bearing, or a group of bearings operating under the same conditions, is the life associated with 90 percent reliability. Some bearing applications require a reliability other than 90 percent. A life adjustment factor for determining a reliability other than 90 percent is:

$a_1 = 4.48 [\ln (100 / R)]^{2/3}$ ln = natural logarithm (Base e)

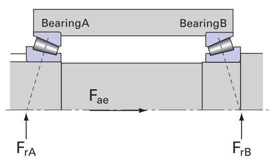
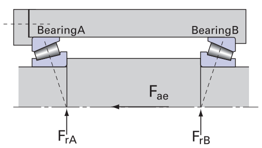
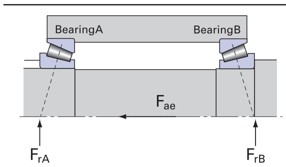
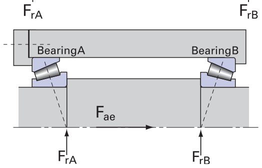
Multiply the calculated L_{10} rating life by a_1 to obtain the L_n life, which is the life for reliability of R percent.

By definition, $a_1 = 1.0$ for a reliability of 90 percent, so for reliabilities greater than 90 percent, $a_1 < 1.0$ and for reliabilities less than 90 percent, $a_1 > 1.0$.

Procedure to Calculate Dynamic Equivalent Load (P):

1) Examine the 2 sets of paired diagrams to determine the mounting arrangement and thrust load direction in the given application to select the (upper or lower) table to use in the following step.
2) Using the appropriate table (upper or lower), determine which inequality holds true for the Thrust Condition equations listed.
3) Use the adjacent Thrust Load equations adjacent the accurate inequality to determine reaction forces F_{aA} and F_{aB}.
4) Likewise, use the Dynamic Equivalent Radial Load equations to determine P_A and P_B. Note that the Dynamic Equivalent Radial Load cannot be less than the corresponding radial reaction force (see footnote).

Dynamic Equivalent Radial Load Equations Single-Row Mounting

Design	Thrust Conditions	Thrust Load	Dynamic Equivalent Radial Load
	$\frac{0.47\ F_{rA}}{K_A} \leq \left(\frac{0.47\ F_{rB}}{K_B} + F_{ae}\right)$	$F_{aA} = \frac{0.47\ F_{rB}}{K_B} + F_{ae}$ $F_{aB} = \frac{0.47\ F_{rB}}{K_B}$	* $P_A = 0.4\ F_{rA} + K_A\ F_{aA}$ $P_B = F_{rB}$
	$\frac{0.47\ F_{rA}}{K_A} > \left(\frac{0.47\ F_{rB}}{K_B} + F_{ae}\right)$	$F_{aA} = \frac{0.47\ F_{rA}}{K_A}$ $F_{aB} = \frac{0.47\ F_{rA}}{K_A} - F_{ae}$	$P_A = F_{rA}$ * $P_B = 0.4\ F_{rB} + K_B\ F_{aB}$
	$\frac{0.47\ F_{rB}}{K_B} \leq \left(\frac{0.47\ F_{rA}}{K_A} + F_{ae}\right)$	$F_{aA} = \frac{0.47\ F_{rA}}{K_A}$ $F_{aB} = \frac{0.47\ F_{rA}}{K_A} + F_{ae}$	$P_A = F_{rA}$ * $P_B = 0.4\ F_{rB} + K_B\ F_{aB}$
	$\frac{0.47\ F_{rB}}{K_B} > \left(\frac{0.47\ F_{rA}}{K_A} + F_{ae}\right)$	$F_{aA} = \frac{0.47\ F_{rB}}{K_B} - F_{ae}$ $F_{aB} = \frac{0.47\ F_{rB}}{K_B}$	* $P_A = 0.4\ F_{rA} + K_A\ F_{aA}$ $P_B = F_{rB}$

* If $P_A < F_{rA}$, use $P_A = F_{rA}$ and if $P_B < F_{rB}$, use $P_B = F_{rB}$.

Factor for Material (a_2)

For Timken bearings manufactured from electric-arc furnace, ladle refined, bearing quality alloy steel, a_2 is generally = 1.0.

Bearings can also be manufactured from premium steels that contain fewer and smaller inclusion impurities than standard bearing steels and provide the benefit of extending bearing fatigue life where it is limited by non-metallic inclusions. A higher value can then be applied for the factor a_2.

Factor for Environmental Conditions (a_3)

Calculated life can be modified to take into account different conditions, on a comparative basis, by using the factor a_3, which is composed of four separate factors:

$a_3 = a_{3k}\ a_{3m}\ a_{3l}\ a_{3p}$

a_{3k} = life adjustment factor for load zone

a_{3m} = life adjustment factor for alignment

a_{3l} = life adjustment factor for lubrication

a_{3p} = life adjustment factor for low loads

a_{3k} – load zone factor

Load zone is the loaded portion of the raceway measured in degrees. It is a direct indication of how many rollers share the applied load.

Load zone is a function of the amount of endplay (internal clearance) or preload with the bearing system. This, in turn, is a function of the initial setting, internal geometry of the bearing, the load applied and deformation of components (shaft, bearing, housing).

a_{3k} = 1.0: The nominal or "catalog" L_{10} life assumes a minimum of 180 degrees load zone in the bearing.

$a_{3k} \neq$ 1.0: Depending on endplay or preload, to quantify a_{3k} requires computer analysis by The Timken Company.

a_{3m} – alignment factor

For optimum performance and life, the races of a tapered roller bearing should be perfectly aligned. However, this is generally impractical due to misalignment between shaft and housing seats and also deflection under load.

$a_{3m} = 1.0$: For catalog life calculations, it is assumed that alignment is equivalent to the rating reference condition of 0.0005 radians.

$a_{3m} < 1.0$

If misalignment is greater than 0.0005 radians, then bearing performance will be affected. However, the predicted life is dependent on such factors as bearing internal geometry, load zone and applied load. Quantifying a_{3m} for actual operating conditions requires a computer analysis by Timken.

$a_{3\ell}$ – lubrication factor

Ongoing research conducted by The Timken Company has demonstrated that bearing life calculated from only speed and load may be very different from actual life when operating environment differs perceptibly from laboratory conditions. Historically, The Timken Company has calculated the catalog life adjustment factor for lubrication ($a_{3\ell}$) as a function of three parameters:

- Bearing speed
- Bearing operating temperature
- Oil viscosity

These parameters are needed to determine the thickness of the elastohydrodynamic lubricant film (EHL) in the rolling contact region of rolling element bearings. During the last decade, extensive testing has been done to quantify the effects of other lubrication-related parameters on bearing life. Roller and raceway surface finish relative to lubricant film thickness have the most notable effect. Other factors include bearing geometry, material, loads and load zone. The following equation provides a simple method to calculate the lubrication factor for prediction of the influence of lubrication on bearing life (L_{10a}).

$$a_{3l} = C_g\, C_\ell\, C_i\, C_s\, C_v C_{gr}$$

where:

C_g = geometry factor
C_ℓ = load factor
C_i = load zone factor
C_s = speed factor
C_v = viscosity factor
C_{gr} = grease lubrication factor

[Note: the a_{3l} maximum is 2.88 for all bearings. The $a_{3\ell}$ minimum is 0.20 for case carburized bearings.

A lubricant contamination factor is not included in the lubrication factor because Timken's endurance tests are run with a 40 µm filter to provide a realistic level of lubricant cleanliness.

Geometry factor – C_g

C_g is available in the Appendix of this catalog for the precision tapered roller bearing assemblies listed herein.

Load factor – C_ℓ

The C_ℓ factor is obtained from Figure 4-41a

F_a is the thrust load on each bearing which is determined from the calculation method as done in the process of determining P. Separate curves are given for loads measured in Newtons and pounds.

It is necessary to resolve all loads on the shaft into bearing radial loads (F_{rA}, F_{rB}) and one external thrust load (F_{ae}) before calculating the thrust load for each bearing.

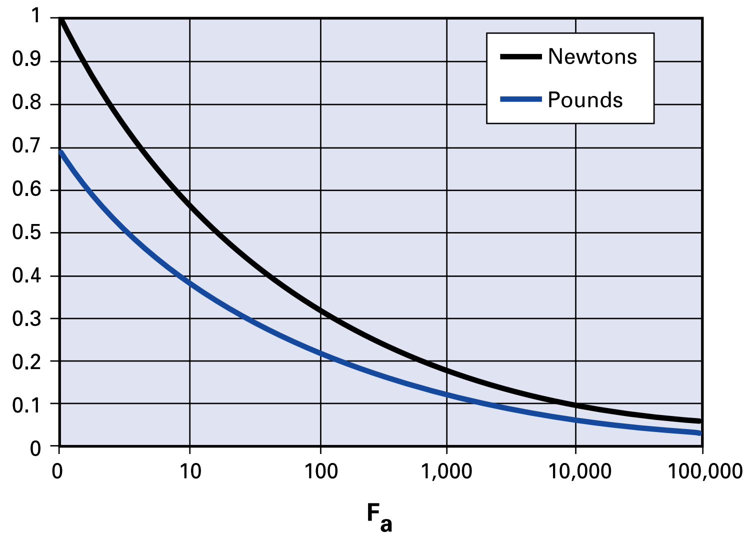


Figure 4-41a
Load factor (C_ℓ) for case-carburized bearings

Load zone factor – C_i

Calculate X, where:

$X = F_r / (F_{aK})$

If X > 2.13, the bearing load zone is less than 180°, then:

$C_i = 0.747$

If X < 2.13, the bearing load zone is larger than 180° and C_i can be determined from figure 4-41b.

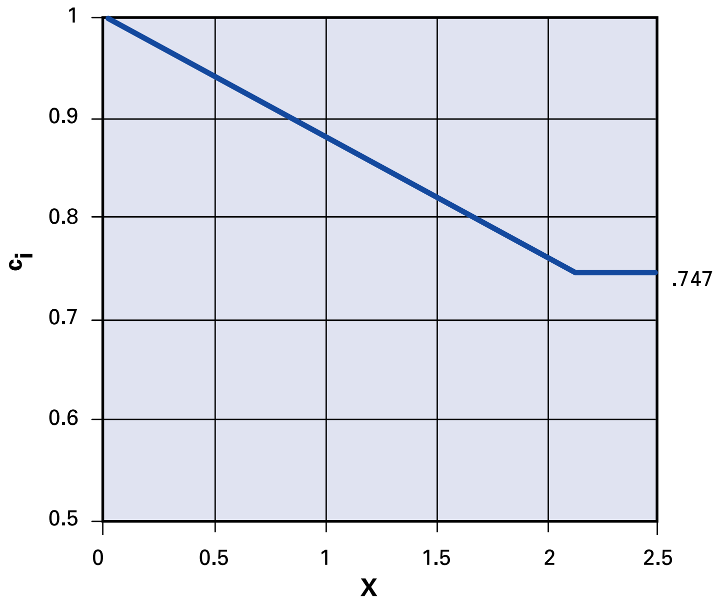


Figure 4-41b
Load zone factor (C_l) for case-carburized bearings.

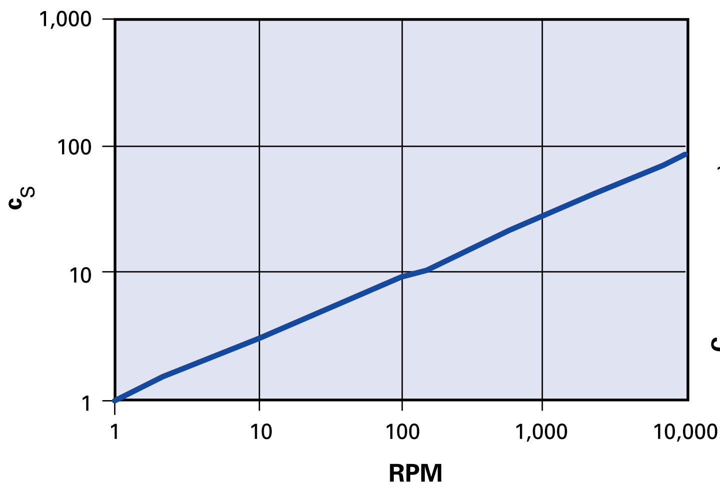


Figure 4-41c
Speed factor (C_s) for case-carburized bearings.

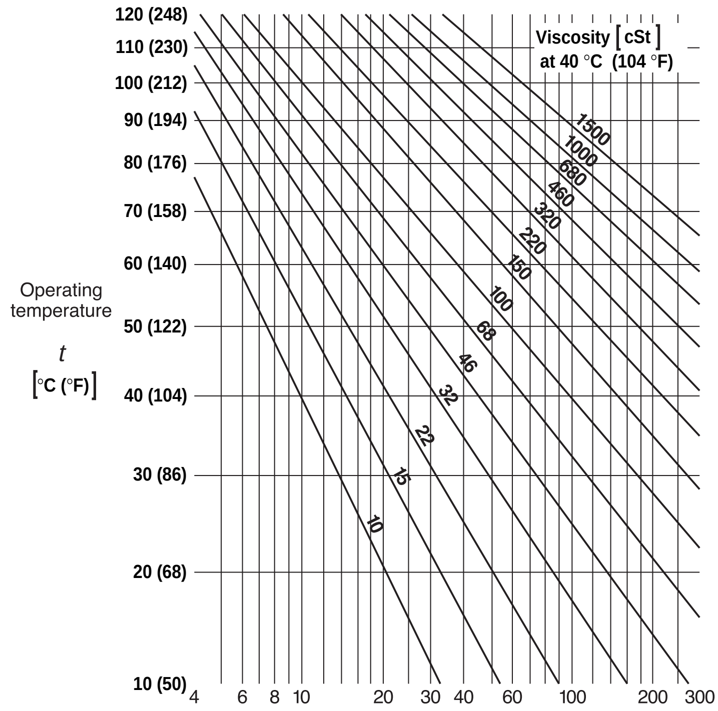


Figure 4-41d
Operating viscosity v [mm^2 / s]

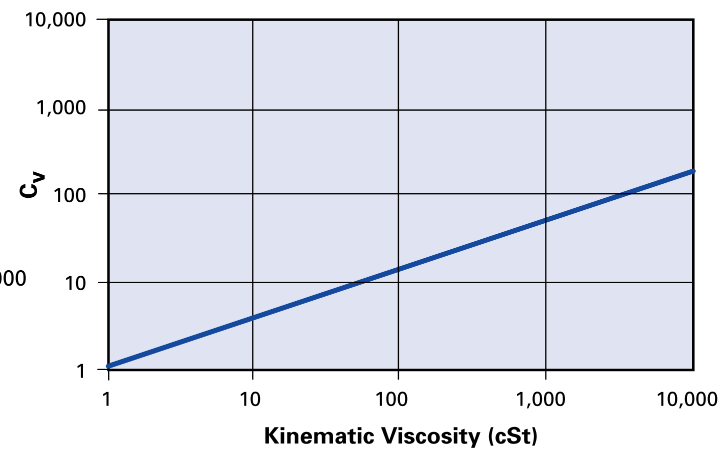


Figure 4-41e
Viscosity factor (Cv) for case-carburized bearings.

Speed factor – C_s

C_s is determined from Figure 4-41c where RPM is the rotational speed of the inner race.

Viscosity factor – C_v

The kinematic viscosity lubricant [centistokes (cSt)] is taken at the operating temperature of the bearings. The operating viscosity can be estimated by using Figure 4-41d. Viscosity factor (C_v) can then be determined from Figure 4-41e.

Grease lubrication factor – C_{gr}

For grease lubrication, the EHL lubrication film becomes depleted of oil over time and is reduced in thickness. Consequently, a reduction factor (C_{gr}) should be used to adjust for this effect. Contact Timken Engineering for suggested recommendations for this value.

a_{3p} – low load life factor

Bearing life testing at Timken Research has shown that extended bearing fatigue life is achievable when the bearing contact stresses are low and the lubrication film is sufficient to fully separate the asperities on the contacting surfaces. Mating test data with sophisticated computer programs for predicting bearing performance, The Timken Company developed a low load factor for use in this catalog to help predict the life increase expected when operating under low bearing loads. Figure 4-41f (following page) shows the low load factor (a_{3p}) as a function of the lubricant life factor (a_{3l}) and the ratio of bearing dynamic rating to the bearing dynamic equivalent load (axial or radial).

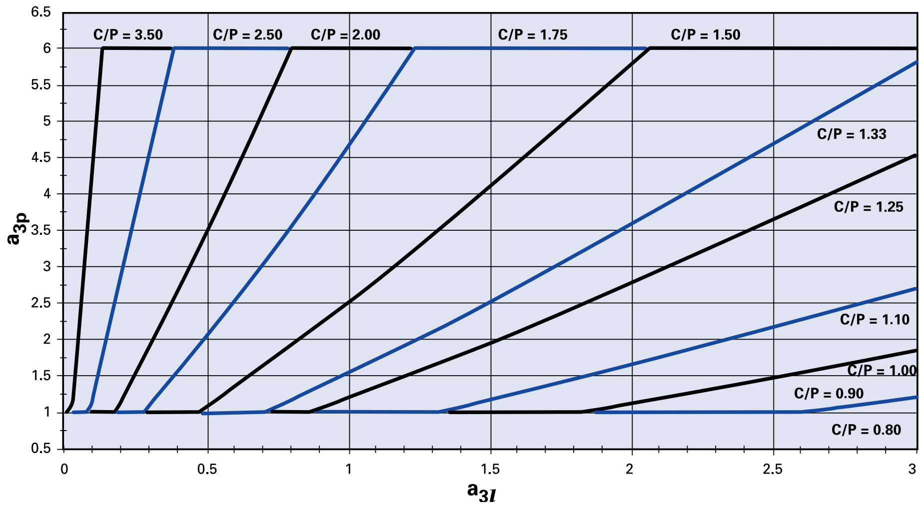


Figure 4-41f

Low Load Factor (a_{3p}) vs. Lubricant Life Factor (a_{3l}) and C90/Pr Ratio

Care must be exercised when using the low load factor, as the contact stresses within the bearing during operation must be uniform across the contact. Misalignment within the bearings causes an uneven distribution of load along the roller-raceway contact surfaces and thus large, localized contact stresses. Also, debris damage on contact surfaces causes shoulders or raised material to form around the dents – again, leading to larger than expected, localized contact stresses. In this situation, a detailed Bearing System Analysis™ (BSA) should be performed to better understand the contact stresses and thus, expected fatigue life of the bearing(s). To perform a BSA for your application, or for more information on the low load factor, contact your local Timken Sales Engineer.

Factor For Useful Life – a_4

The limiting criterion for fatigue is a spalled area of 6mm^2 (0.01 sq.in.). This is the reference condition in The Timken Company rating, establishing $a_4 = 1.0$. If a larger limit for area of fatigue spall can be reasonably established for a particular application, then a higher value of a_4 can be applied.

Bearing System Analysis™ BSA

Bearing System Analysis analyzes the effect many real life variables have on bearing performance, in addition to the load and speed considerations used in the traditional catalog life calculation approach.

The Timken Company's unique computer program adds sophisticated bearing selection logic to that analytical tool. Bearing System Analysis allows the designer to quantify differences in bearing performance due to changes in the operating environment. The selection procedure can be either performance or price oriented.

SYSTEM LIFE AND WEIGHTED AVERAGE LOAD AND LIFE

System Life

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

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

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

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

Weighted Average Life and Load Equations

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

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

Weighted Average Load

Variable speed, load and proportion time:

$$F_{wt} = \left[(n_1\, T_1\, F_1^{\,10/3} + \ldots n_n\, T_n\, F_n^{\,10/3}) \,/\, n_a\right]^{0.3}$$

where during each condition in a load cycle:
T = proportion of total time
F = load applied
n = rpm
n_a = assumed (arbitrary) speed of rotation for use in bearing life equations. For convenience, 500 rpm is normally used by The Timken Company.

Uniformly increasing load, constant speed:

$$F_w = \left[(3/13)\,(F_{max}^{\,13/3} - F_{min}^{\,13/3}) \,/\, (F_{max} - F_{min})\right]^{0.3}$$

where, during a load cycle:
F_{max} = maximum applied load
F_{min} = minimum applied load

NOTE: The above formulae do not allow the use of the life modifying factor for lubrication a_{3l}, except in the case of constant speed. Therefore, when these equations are used in the bearing selection process, the design L_{10} bearing life should be based on a similar successful machine that operates in the same environment. Life calculations for both machines must be performing on the same basis. To allow for varying lubrication conditions in a load cycle, it is necessary to perform the weighted average life calculation:

Weighted Average Life

$$L_{10wt} = 1/\left\{\left[T_1 / (L_{10})_1\right] + \left[T_2 / (L_{10})_2\right] + \ldots \left[T_n / (L_{10})_n\right]\right\}$$

where, during a load cycle:
T = proportion of total time
L_{10} = calculated L_{10} bearing life for each condition

Ratios of Bearing Life to Loads, Power, and Speeds

In applications subjected to variable conditions of loading, bearing life is calculated for one condition. Life for any other condition can easily be calculated by taking the ratio of certain variables. To use these ratios, the bearing load must vary proportionally with power, speed, or both. Nevertheless, this applies only to "catalog" lives or adjusted lives by any life adjustment factor(s). The following relationships hold under stated specific conditions (life ratio equations):

Condition	Equation
Variable load Variable speed	$(L_{10})_2 = (L_{10})_1 \, (P_1 / P_2)^{10/3} \, (n_1 / n_2)$
Variable power Variable speed	$(L_{10})_2 = (L_{10})_1 \, (H_1 / H_2)^{10/3} \, (n_2 / n_1)^{7/3}$
Constant load Variable speed	$(L_{10})_2 = (L_{10})_1 \, (n_1 / n_2)$

Condition	Equation
Constant power Variable speed	$(L_{10})_2 = (L_{10})_1 \, (n_2 / n_1)^{7/3}$
Variable load Constant speed	$(L_{10})_2 = (L_{10})_1 \, (P_1 / P_2)^{10/3}$
Variable power Constant speed	$(L_{10})_2 = (L_{10})_1 \, (H_1 / H_2)^{10/3}$
[P = Load, torque or tangential gear force]	

Note: To calculate system weighted life Timken determines the weighted life for each bearing separately and then calculates a system weighted life.

STATIC CONDITIONS

Static rating

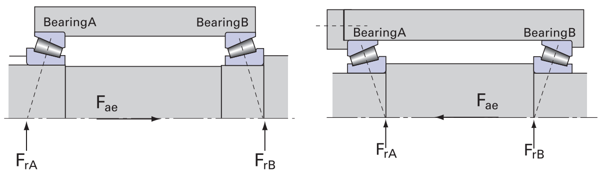
The static radial load rating C_0 is based on a maximum contact stress within a non-rotating bearing of 4,000MPa (580,000psi) at the center of contact and a 180° load zone (loaded portion of the raceway).

The 4,000MPa (580,000psi) stress level may cause visible, light brinell marks on the bearing raceways. This degree of marking will not have a measurable effect on fatigue life when the bearing is subsequently rotating under a lower application load. If noise, vibration, or torque are critical, a lower load limit may be required.

The following formulae may be used to calculate the static equivalent radial load on a bearing under a particular loading condition. This is then compared with the static radial rating as a criterion for selection of bearing size. However, it is advisable to consult The Timken Company for qualification of bearing selection in applications where static loads prevail.

Static Equivalent Radial Load (Single Row Bearings)

The static equivalent radial load is the static radial load (no rotation or oscillation) that produces the same maximum stress, at the center of contact or a roller, as the actual combined radial and thrust applied load. The equations presented give an approximation of the static equivalent radial load assuming a 180° load zone (loaded portion of the raceway) in one bearing and 180° or more in the opposing bearing.



$0.47\ F_{rA} / K_A \leq 0.47\ F_{rB} / K_B + F_{ae}$	$F_{aA} = 0.47\ F_{rB} / K_B + F_{ae}$ $F_{aB} = 0.47\ F_{rB} / K_B$	$P_{0B} = F_{rB}$ for $F_{aA} < 0.6\ F_{rA} / K_A$: $P_{0A} = 1.6F_{rA} - 1.269\ K_A\ F_{aA}$ for $F_{aA} > 0.6F_{rA} / K_A$: $P_{0A} = 0.5F_{rA} + 0.564\ K_A\ F_{aA}$
$0.47\ F_{rA} / K_A > 0.47\ F_{rB} / K_B + F_{ae}$	$F_{aA} = 0.47\ F_{rA} / K_A$ $F_{aB} = 0.47\ F_{rA} / K_A - F_{ae}$	for $F_{aB} > 0.6F_{rB} / K_B$: $P_{0B} = 0.5F_{rB} + 0.564\ K_B\ F_{aB}$ for $F_{aB} < 0.6F_{rB} / K_B$: $P_{0B} = 1.6F_{rB} - 1.269\ K_B\ F_{aB}$ $P_{0A} = F_{rA}$

Note: use the values of P_0 calculated for comparison with the static rating C_0, even if P_0 is less than the radial applied load (F_r).
F_r = applied radial load
F_a = net bearing thrust load [F_{aA} and F_{aB} calculated from equations]

LIFE CALCULATIONS – Radial Ball Bearings

Load Ratings

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 TIMKEN DYNAMIC LOAD RATINGS, C_E. Care must be taken that the EXTENDED TIMKEN DYNAMIC LOAD RATINGS only be used in equations containing C_E, and should not be used in any equations in prior published catalogs.

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 4-45 (pg. 240).

The basic equation for radial ball bearings is:

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

Calculate EQUIVALENT RADIAL LOAD (P) by using Table 4-42 and required Y factors from Table 4-43.

Notations Used in this Section:

C = Dynamic Radial Load Rating – Radial Ball Bearings Pounds or Newtons

C_E = Extended Timken Dynamic Radial Load Rating – Radial Ball Bearings Pounds or Newtons
NOTE: C_E does not represent the maximum permissible radial load which in general is equal to C_o (the Static Radial Load) Rating.

C_o = Static Radial Load Rating – Radial Ball Bearings Pounds or Newtons

K_T = Relative Thrust Load Factor – Ball Bearings

L_f = Life Factor

L_n = Fatigue Life for Reliability Level "r" – Hours

L_v = Fatigue Life for Varying Loads and Speeds

N = Operating Speed – R.P.M.

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

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

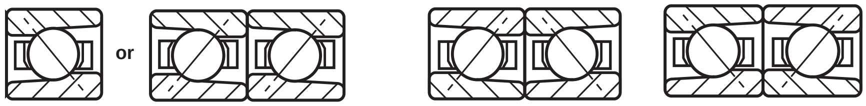


Table 4-42

Bearing Description	Single Row Bearings and Tandem Mountings	Double Row Bearings and Preload Pair Mountings
Bearing Type and/or Series	$K_T = \frac{T}{i_B C_0}$	$K_T = \frac{T}{C_0}$
RADIAL TYPE BALL BEARINGS	Use larger of Resulting "P" Values	
MM9300K MM9100K MM200K MM300K	$P = R$ or $P = 0.56R + Y_1T$	$P = R + 1.20Y_1T$ or $P = 0.78R + 1.625Y_1T$
ANGULAR CONTACT BALL BEARINGS		
2MM9100WI 2MMV99100WN 2MMV9100HX 2MM9300WI 2MMV9300HX 2MM200WI 2MM300WI	$P = R$ or $P = 0.44R + Y_2T$	$P = R + 1.124Y_2T$ or $P = 0.72R + 1.625Y_2T$
2MM9100WO	$P = R$ or $P = 0.44R + Y_3T$	$P = R + 1.124Y_3T$ or $P = 0.72R + 1.625Y_3T$
3MM9100WI 3MMV99100WN 3MMV9100HX 3MM200WI 3MM300WI 3MMV9300HX	$P = R$ or $P = 0.41R + 0.87T$	$P = R + 0.92T$ or $P = 0.67R + 1.41T$

Table 4-43

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

Obtain the DYNAMIC LOAD RATING ADJUSTMENT FACTOR, f_B, from Table 4-44. This factor accounts for the number of active bearings (i_B) mounted adjacent to one another.

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

Table 4-44

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

Life Adjustment Factors

Determine the Life Adjustment Factors a_1, a_2, a_3:

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 identical 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 4-45.

Table 4-45

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 are given in Table 4-46.

Table 4-46

Bearing Steel	Life Adjustment Factor For Material: a_2
Fafnir Superior Steel (standard material)	1
Vacuum Melted (VIM-VAR) 52100	4*

*In certain applications this factor can exceed 4. Consult our 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 a_3 factor.

The Engineering Department will assist in developing various application factors when requested by the user. The following may be used as a 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.

Determine the Reference Viscosity from Figure 4-47 (opposite page) by entering the bearing pitch diameter, which is equal to the outer diameter plus the bore divided by 2, and the bearing speed.

In order to obtain the value of, a_3, the Life Adjustment factor for Lubrication, from Fig. 4-48 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 beyond the control of the designer.

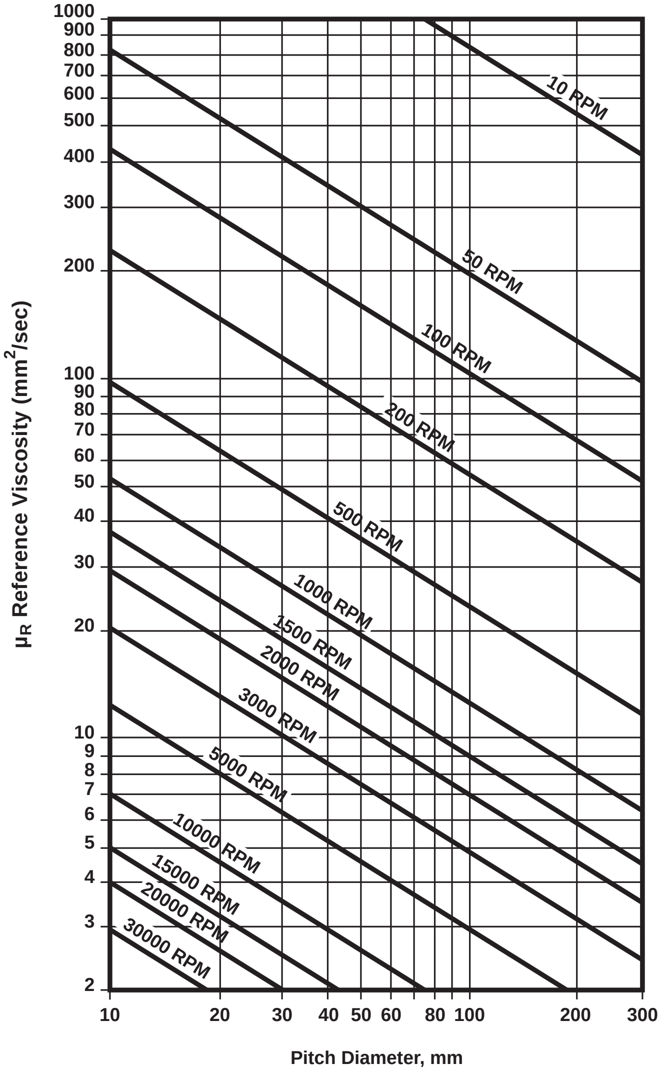


Figure 4-47 – Determining the Reference Viscosity

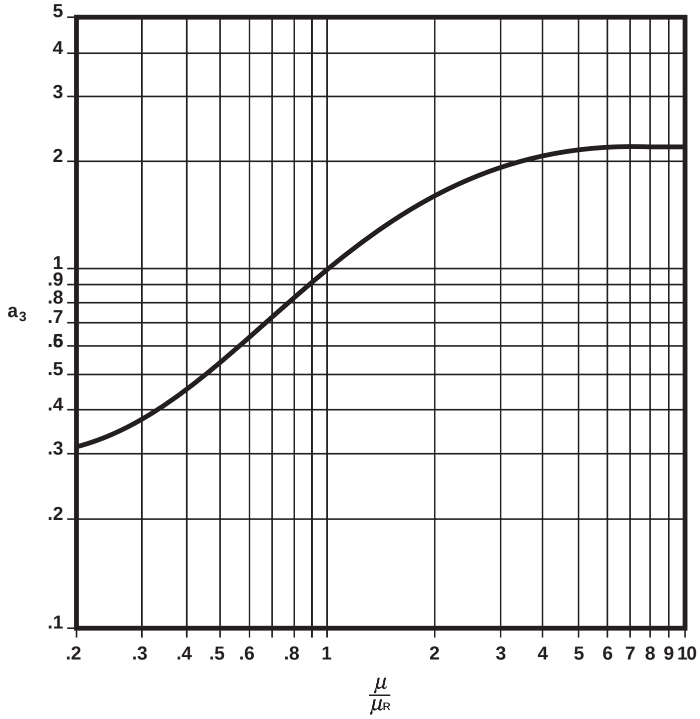


Figure 4-48 – Determining the Value of a_3 the Life adjustment Factor for Lubrication.

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:

$$L_v = \frac{1}{\frac{p_1}{L_{n_1}} + \frac{p_2}{L_{n_2}} + \frac{p_3}{L_{n_3}} + \ldots + \frac{p_n}{L_{n_n}}}$$

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

Permissible Operating Speed

When determining the permissible operating speeds corresponding to the bearing preloads used in machine tool spindles, many influencing factors are involved. Among those considered are spindle mass and construction, type of mounting, spindle rigidity and accuracy requirements, spindle loads' service life, type of service, (intermittent or continuous), and method of lubrication.

Bearing temperatures, generally, *vary directly with both speed and load.* However, high speed applications must have sufficient thrust loading on the bearings to prevent heat generation due to rolling element skidding. The amount of bearing preload is determined primarily from these operating conditions. At lower speeds, the operating loads are heavier and the bearing deflections are greater. Therefore, the bearing preload must be high enough to provide adequate bearing rigidity under the heaviest loads and still maintain reasonable temperatures when the spindle is operated at high speeds.

Measuring Speed

The speed guidelines for tapered roller bearings are based on the bearing rib speed, which is the circumferential velocity calculated at the midpoint of contact between the roller end and the race large end rib expressed in m/s (fig. 4-49). Suggested rib speed guidelines are shown in the Appendix of this catalog.

Rib speed :

$$V_r = \frac{\pi \times d_m \times n}{60\,000} \quad \text{(m/s)}$$

where :

d_m = inner race rib diameter (mm)
n = bearing speed (rev/min)

The rib diameter can be scaled from a drawing of the bearing, or can be approximated as the average of the bearing inner and outer diameter (see fig. 4-49).

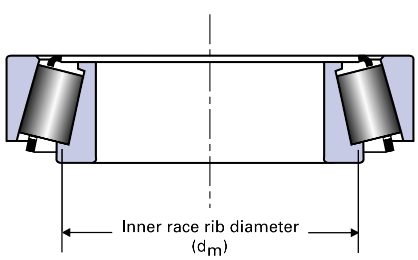


Fig. 4-49

Another commonly used unit is the dN value which represents the product of the nose bearing bore (d) in mm and the rotational speed (N) in rev/min (fig. 4-50).

Likewise, there is no direct relationship between the rib speed of a tapered roller bearing and dN values, since the cone cross section varies by part number. However, the following approximation can be used:

dN value = rib speed (m/s) x 16 000

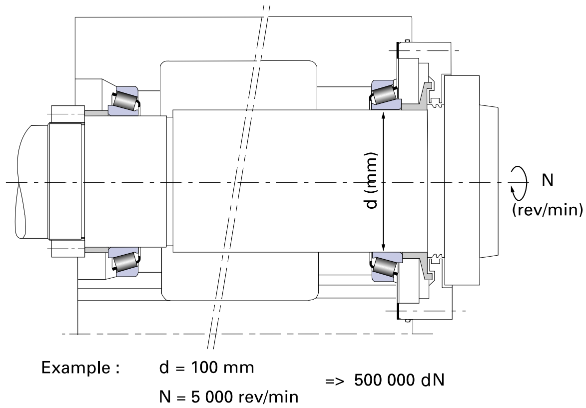
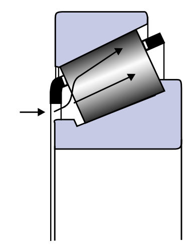


Fig. 4-50
Parameters used to determine the dN value

The design of the tapered roller bearing results in a natural pumping effect on the lubricant, where the lubricant is forced from the small end of the roller end, heading toward the wider end. As speed increases the lubricant begins to move outward due to centrifugal effects. At excessive speed, the contact between the roller large ends and the cone's rib face can become a concern. This is the primary reason for suggestions on the use of oil jets at this large end, ribbed cup designs, or high speed TSMA designs as operating speeds increase. Refer to the speed matrix in the Appendix for more details.



Pumping effect of a tapered roller bearing

Effect of Lubrication on Speed Capability

There are no clear-cut speed limitations for tapered roller bearings since performance depends on the bearing design and lubrication system. The guidelines given in fig. 4-50a are based on typical industrial experiences relating to speed and temperature for various types of lubrication systems, with bearings having low G_1 factor.

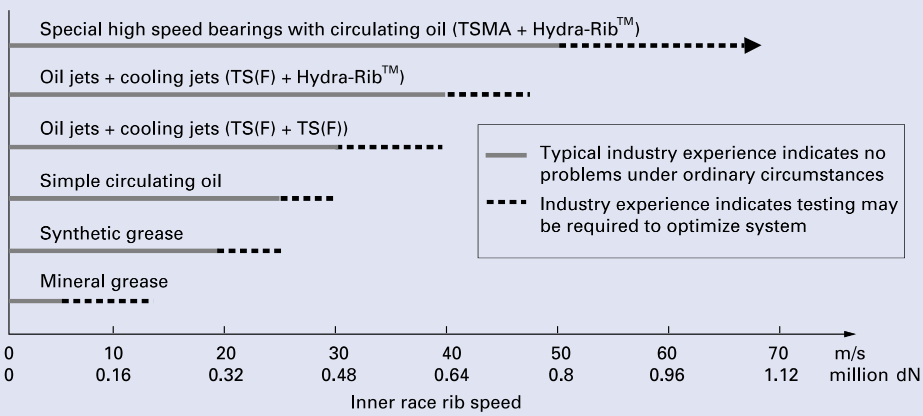


Fig. 4-50a
Speed capability guidelines for various types of lubrication systems

The Timken Company recommends that testing be performed for all new high speed applications. See Appendix for suggested tapered roller bearing speed guidelines.

Both the lubricant and lubrication system have an effect on heat-generation and heat-dissipation rates and thus are important to the speed capabilities of a bearing.

The choice of lubrication will depend on:

- Maximum speed requirement
- Heat dissipation rate of the system
- Spindle layout
- Orientation of the spindle

Lubrication Guidelines for Higher Speed Bearings

A precision tapered roller bearing can meet almost any level of speed required by the machine tool industry with the TSMA and Hydra-Rib™ high speed bearing designs, providing circulating oil lubrication can be accommodated.

Ball Bearing

The following relationship may be used to estimate the effect of preload and lubrication method on the Permissible Operating Speed. (S_P)

$$S_P = F_L \times F_P \times F_B \times N_G$$

Where

F_L is Lubrication Factor

F_P is Preload Factor

F_B is Ball Material Factor

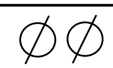
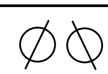
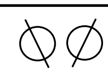
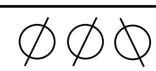
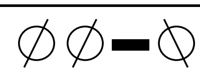
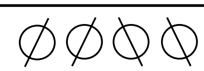
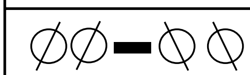
N_G is Permissible Speed for single, grease lubricated bearing with inner ring rotation. This value is found with the part number tables.

Factors are as follows:

Lubrication Factor (F_L)

Grease	F_L = 1.00
Oil Bath	F_L = 1.50
Oil Mist	F_L = 1.70
Oil Jet	F_L = 2.00

Bearing Preload Factors = (F_P)

Bearing Mounting	Bearing Preload L	M	H
	0.85	0.70	0.50
	0.80	0.60	0.40
	0.65	0.50	0.30
	0.65	0.50	0.30
	0.70	0.60	0.35
	0.60	0.40	0.20
	0.65	0.45	0.25

Ball Material Factor = (F_B)

Steel Balls	F_B = 1.00
*Ceramic Balls	F_B = 1.20

** Ceramic balls allow 20% increase to speed factor.*

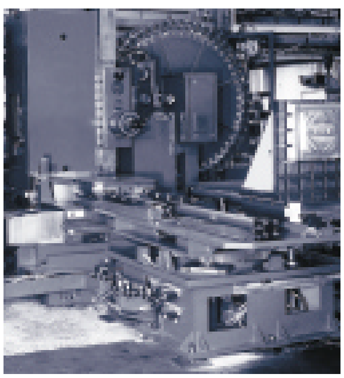
Grease and Speed Capability

Before selecting a grease, it is important to define a relative speed capability of the application. *There is no precise method that can be applied to determine the operating speed of a bearing*. Over the years, designers of machine tool systems have been guided by their own experiences from which many basic "rules of thumb" have been established. One such rule is the "dN" speed value.

dN = Bore in millimeters * RPM

The four most common spindle greases that Timken recommends for Fafnir spindle ball bearings are:

Unirex N3	– Vertical applications < 500,000 dN
Mobil 28	– Light loads < 600,000 dN
Chevron SRI	– Medium to heavy loads < 350,000 dN
Kluber Isoflex NBU 15	– Light loads, vertical or horizontal applications
Kluber Isoflex NCA 15	> 500,000 dN
Kluber BF-7222	> 750,000 dN



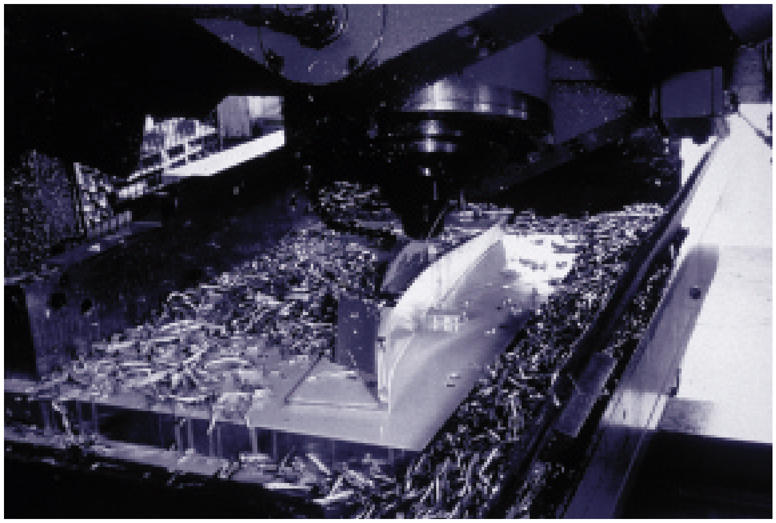
Internal Bearing Design

G_1 factor

Internal bearing geometry has a direct influence on torque and therefore on heat generation. In order to rate the torque/heat generation characteristics of its bearings and to assist designers in selecting appropriate bearings, The Timken Company developed a factor called G_1: the lower the G_1 factor, the lower the heat generation. The G_1 factor is published in Timken engineering catalogs and are listed in the Appendix of this manual for the precision bearing part numbers listed in chapter 2.

This G_1 factor is of prime importance to a designer because of the influence of operating temperature on spindle accuracy.

Notes



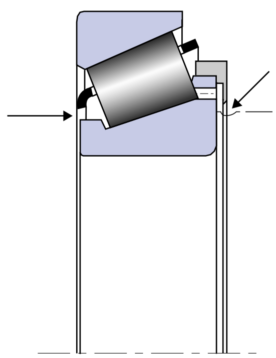
Timken Friction Management Solutions for Super Precision Applications

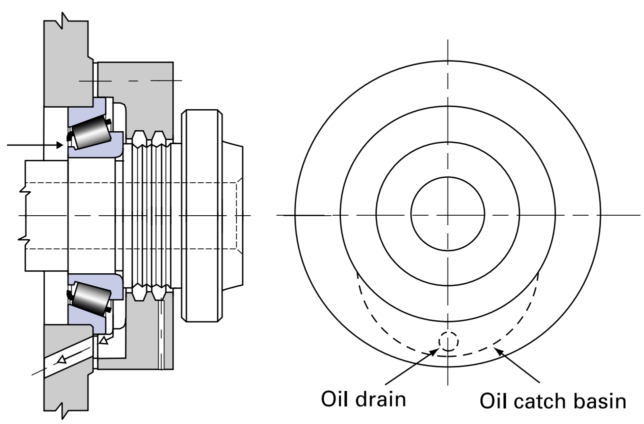
Timken® Fafnir® Friction Management Solutions for Super Precision Applications

Timken Services for Super Precision Applications

Timken Friction Management Solutions

Timken can globally assist its customers to leverage their machine tool bearing investments with an array of related products and services designed to provide excellent value and impressive results. With its long, successful history of innovation and leadership, Timken works with its customers to pursue key production goals with unique antifriction solutions such as these:





TSMA/TSMR Bearings

- Single-row tapered roller design
- Unique feature design used to prevent oil starvation during high speeds
  - TSM**A: axial** lube lines in inner ring enable customers to employ a manifold-type lubricant reservoir for circulation to critical surfaces.
  - TSM**R: radial** lube lines in inner ring allow oil movement from the equipment's shaft or housing design structure.
- Conceived for high speed, high stiffness requirement applications.

See Timken publication Order No. 5722 for more information.

Engineered Surfaces

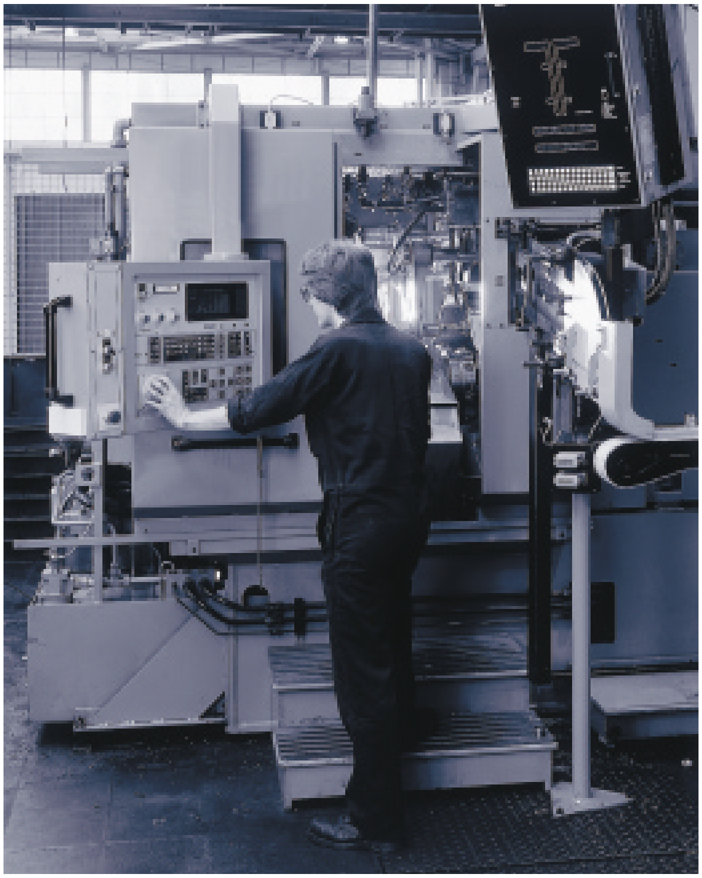
- Improve wear and fatigue resistance from a variety of applied surface treatments developed through years of research by Timken tribologists.
- Engineered surface treatments and finishes provide significant improvements to surface material or design properties.
- Treatment options include varying degrees of wear resistance/friction reduction and surface hardness.
- Surface treatments may be added to other contact surfaces (beyond bearing components).

See Timken publication Order No. 5673 for more information.

Precision Plus

- Overall (total) radial runout less than a single micron (40 millionths of an inch).
- Ultra precision application requirements for aerospace, automotive and military markets.
- Timken's ultimate Level 000 (AA) precision grade.
- Available for sizes up to 315mm OD (12 ½ inches).
- Combines high stiffness features of tapered roller bearing with superior precision of ball bearing.
- Optimized manufacturing process created to produce finished product tolerance requirements (including heat treating phase).

See Timken publication Order No. 5722 for more information.



Timken and its Fafnir super precision line offer innovative products for the machine tool industry. Our customers benefit from Timken's leadership role in the quest for improving machining accuracy and productivity from solutions beyond Timken's traditional expertise in tapered roller bearing technology.

MMN/MMF Sealed Ball Screw Support Bearings

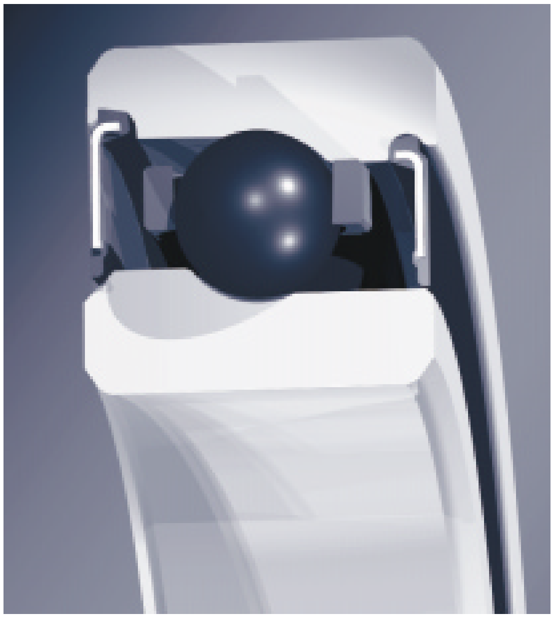
- Sealed, integral double-row bearings for ball screw support locations.
- Options for higher speeds using ceramic ball complement and selective grease.
- Flanged and cartridge mount designs for more flexible installation arrangements.
- ABEC9/ISO P2 level axial runout tolerances promote smooth, clean machining paths.
- Consistent, repeatable performance provided by preloaded ring assembly.
- Low torque, positive-contact seals minimize drag friction.

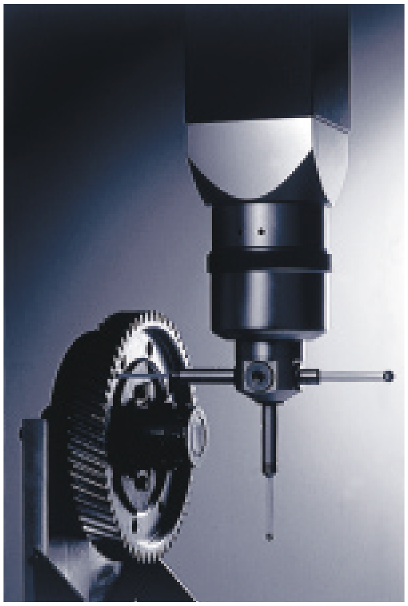
See pages 170-177 or Timken publication Order No. 5920 for more information.

THSS (True High Speed Sealed) Spindle Bearings

- Maintenance free service provided by dynamic non-contact, high speed seals.
- Effects of elevated operating temperatures minimized with standard ceramic ball complement offering.
- Seal configuration significantly reduces problems arising from outside contaminants.
- Built upon the proven Fafnir HX design geometry.

See Timken publication Order No. 5916 for more information.





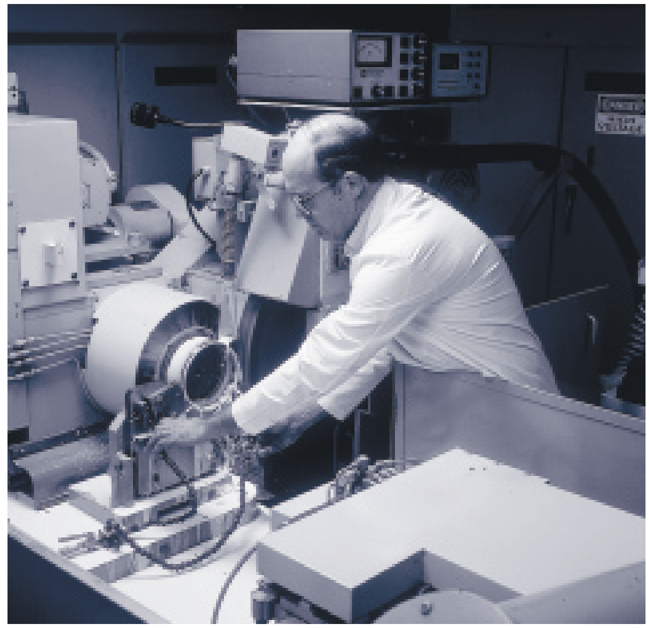
Continuous Improvements in Manufacturing

Timken has invested millions of dollars into its super precision ball bearing product line to provide the highest possible level of quality in every bearing Timken ships to every customer:

- Using the world's most perfectly shaped, ultra-clean spherical grade 5 balls.
- Applying superfinish process to unloaded bearing surfaces to further minimize contamination.
- Extensive program of ultrasonic cleaners and demagnetizers.
- Filtration of contaminants from all airborne and machining fluids.
- Continuous monitoring of temperature, humidity, and atmospheric particulate content controls.
- Ultimately, Timken Super Precision ball bearings operate with lower vibration levels, which generate less heat while extending service life and enhancing cutting accuracy.

Services

Timken's wide array of friction management services help maximize machine tool productivity, including:



Bearing Repair Center

- One-year limited warranty.
- Diagnostic wear pattern analysis.
- Servicing all sizes, styles and brands.
- Supplying new or remanufactured components when necessary.
- Extends bearing service life at only a fraction of replacement cost.

See Timken publication Order No. 5653 for more information.

Integrated Packages

- Optimized bearing/housing systems specified for more demanding customer application requirements.
- Integrated packages of seals, housings, and lubrication selection are matched to deliver the most favorable results in product performance.
- Single source saves time and reduces effort searching for multiple suppliers.

See Timken publication Order No. 5722 for more information

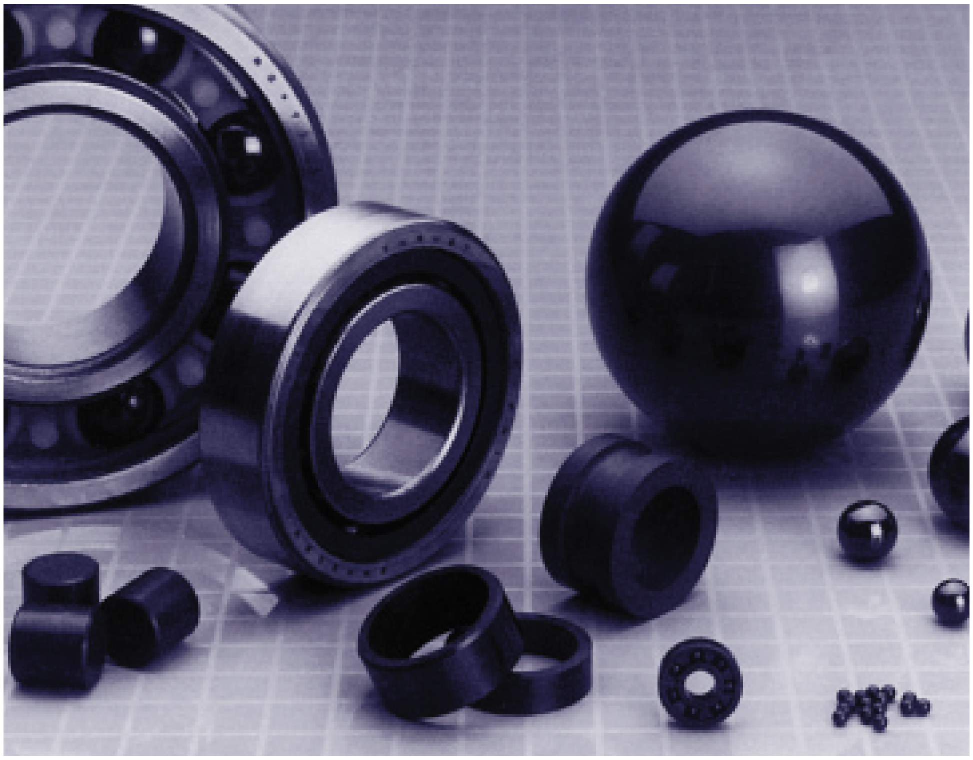
Bearing Kitting

- Assemble optimized, matched bearings and related components into a single inventory item – saving lost time in supplier research and purchasing efforts.
- Carefully specified items eliminate wasted efforts consulting with several manufacturers for compatibility issues.
- Significantly reduces inventory items and purchase order generation.
- Highly trained and knowledgeable Timken application engineers put years of experience to work on assembling required products from multiple suppliers to meet specific customer performance goals.

“Quick Change” Program

- Fast conversion of idle spindle bearing stock to suit immediate, specific customer shop floor requirements.
- Delivery times in three to five business days (24 hrs. to meet special, emergency needs).
- Extends flexibility of unused spindle bearings by applying customer requested enhancements.
- Original Timken Fafnir bearings will be covered by conditions of the initial warranty.
- Assortment of possible service can help alleviate production bottlenecks by providing needed machine performance from existing bearing inventory without the delay of purchasing custom bearings.
    - Lubrication Changes
    - Preload Changes
    - Repackaging
    - Recertification
    - Noise Testing
    - Bore and OD Coding
    - Special Marking Requirements
    - Reworking Competitor Bearings

Timken application engineering expertise is only a phone call away. Highly skilled technical assistance can be reached by calling (US and Canada): 1-800-223-1954. Outside this region, call 330-438-3000, or visit our website at: www.timken.com/industries/superprecision.



Appendix

Index

2MMV99100WN Series
Frequency Coefficients

FTF: Fundamental Train Frequency: the frequency at which the retainer will operate.

BSF: Ball Spin Frequency: the frequency at which a single defect on a rolling element will be detected.

BPFO: Ball Pass Frequency Outer: the frequency at which a single defect in the outer race will be detected.

BPFI: Ball Pass Frequency Inner: the frequency at which a single defect in the inner race will be detected.

FTF-inner[1]	BSF	BPFO	BPFI	FTF-outer[2]	
0.3887	2.0593	3.4985	5.5015	0.6113	**2MMV99101WN**
0.4023	2.3729	4.4250	6.5750	0.5977	**2MMV99102WN**
0.4115	2.6389	5.3494	7.6506	0.5885	**2MMV99103WN**
0.4011	2.3455	4.4120	6.5880	0.5989	**2MMV99104WN**
0.4148	2.7523	5.3928	7.6072	0.5852	**2MMV99105WN**
0.4288	3.3241	6.8615	9.1385	0.5712	**2MMV99106WN**
0.4448	4.3111	9.3403	11.6597	0.5552	**2MMV99107WN**
0.4512	4.8947	10.8295	13.1705	0.5488	**2MMV99108WN**
0.4489	4.6750	10.3246	12.6754	0.5511	**2MMV99109WN**
0.4528	5.0724	11.3207	13.6793	0.5472	**2MMV99110WN**
0.4525	5.0285	11.3121	13.6879	0.5475	**2MMV99111WN**
0.4556	5.3815	11.8443	14.1557	0.5444	**2MMV99112WN**
0.4582	5.7340	12.8308	15.1692	0.5418	**2MMV99113WN**
0.4575	5.6283	12.8104	15.1896	0.5425	**2MMV99114WN**
0.4602	6.0120	13.8057	16.1943	0.5398	**2MMV99115WN**
0.4589	5.8300	13.3085	15.6915	0.5411	**2MMV99116WN**
0.4610	6.1310	14.2906	16.7094	0.5390	**2MMV99117WN**
0.4568	5.5308	12.7902	15.2098	0.5432	**2MMV99118WN**
0.4586	5.7748	13.2992	15.7008	0.5414	**2MMV99119WN**
0.4606	6.0708	14.2782	16.7218	0.5394	**2MMV99120WN**
0.4596	5.9229	13.7892	16.2108	0.5404	**2MMV99121WN**
0.4591	5.8399	13.7729	16.2271	0.5409	**2MMV99122WN**
0.4618	6.2625	14.7784	17.2216	0.5382	**2MMV99124WN**
0.4610	6.1362	14.7512	17.2488	0.5390	**2MMV99126WN**
0.4633	6.5243	15.7513	18.2487	0.5367	**2MMV99128WN**
0.4616	6.2346	15.2336	17.7664	0.5384	**2MMV99130WN**

1) For inner ring rotation.

2) For outer ring rotation.

3MMV99100WN Series
Frequency Coefficients

FTF: Fundamental Train Frequency: the frequency at which the retainer will operate.

BSF: Ball Spin Frequency: the frequency at which a single defect on a rolling element will be detected.

BPFO: Ball Pass Frequency Outer: the frequency at which a single defect in the outer race will be detected.

BPFI: Ball Pass Frequency Inner: the frequency at which a single defect in the inner race will be detected.

FTF-inner[1]	BSF	BPFO	BPFI	FTF-outer[2]	
0.4083	2.3842	4.4911	6.5089	0.5917	**3MMV99102WN**
0.4169	2.6491	5.4201	7.5799	0.5831	**3MMV99103WN**
0.4075	2.3575	4.4829	6.5171	0.5925	**3MMV99104WN**
0.4204	2.7627	5.4648	7.5352	0.5796	**3MMV99105WN**
0.4335	3.3327	6.9356	9.0644	0.5665	**3MMV99106WN**
0.4483	4.3177	9.4149	11.5851	0.5517	**3MMV99107WN**
0.4544	4.9006	10.9048	13.0952	0.5456	**3MMV99108WN**
0.4522	4.6813	10.4011	12.5989	0.5478	**3MMV99109WN**
0.4559	5.0782	11.3974	13.6026	0.5441	**3MMV99110WN**
0.4555	5.0341	11.3872	13.6128	0.5445	**3MMV99111WN**
0.4584	5.3867	11.9173	14.0827	0.5416	**3MMV99112WN**
0.4609	5.7389	12.9047	15.0953	0.5391	**3MMV99113WN**
0.4601	5.6332	12.8838	15.1162	0.5399	**3MMV99114WN**
0.4626	6.0166	13.8794	16.1206	0.5374	**3MMV99115WN**
0.4615	5.8348	13.3829	15.6171	0.5385	**3MMV99116WN**
0.4634	6.1356	14.3663	16.6337	0.5366	**3MMV99117WN**
0.4594	5.5357	12.8631	15.1369	0.5406	**3MMV99118WN**
0.4611	5.7794	13.3715	15.6285	0.5389	**3MMV99119WN**
0.4630	6.0753	14.3518	16.6482	0.5370	**3MMV99120WN**
0.4620	5.9273	13.8611	16.1389	0.5380	**3MMV99121WN**
0.4615	5.8444	13.8448	16.1552	0.5385	**3MMV99122WN**
0.4641	6.2667	14.8500	17.1500	0.5359	**3MMV99124WN**
0.4633	6.1406	14.8262	17.1738	0.5367	**3MMV99126WN**
0.4655	6.5284	15.8262	18.1738	0.5345	**3MMV99128WN**
0.4639	6.2388	15.3080	17.6920	0.5361	**3MMV99130WN**

2MM9100WI Series
Frequency Coefficients

FTF: Fundamental Train Frequency: the frequency at which the retainer will operate.

BSF: Ball Spin Frequency: the frequency at which a single defect on a rolling element will be detected.

BPFO: Ball Pass Frequency Outer: the frequency at which a single defect in the outer race will be detected.

BPFI: Ball Pass Frequency Inner: the frequency at which a single defect in the inner race will be detected.

FTF-inner[1]	BSF	BPFO	BPFI	FTF-outer[2]	
0.3740	1.7697	2.9924	5.0076	0.6260	**2MM9100WI**
0.3902	2.0621	3.9015	6.0985	0.6098	**2MM9101WI**
0.4035	2.3754	4.8424	7.1576	0.5965	**2MM9102WI**
0.4126	2.6411	4.5390	6.4610	0.5874	**2MM9103WI**
0.4013	2.3458	4.4140	6.5860	0.5987	**2MM9104WI**
0.4150	2.7526	5.3947	7.6053	0.5850	**2MM9105WI**
0.4201	2.9387	5.8807	8.1193	0.5799	**2MM9106WI**
0.4210	2.9789	6.3157	8.6843	0.5790	**2MM9107WI**
0.4291	3.3332	6.8655	9.1345	0.5709	**2MM9108WI**
0.4298	3.3682	7.3063	9.6937	0.5702	**2MM9109WI**
0.4352	3.6596	7.8332	10.1668	0.5648	**2MM9110WI**
0.4314	3.4469	7.7648	10.2352	0.5686	**2MM9111WI**
0.4358	3.6934	8.2803	10.7197	0.5642	**2MM9112WI**
0.4397	3.9394	8.7939	11.2061	0.5603	**2MM9113WI**
0.4362	3.7179	8.2875	10.7125	0.5638	**2MM9114WI**
0.4395	3.9312	8.7908	11.2092	0.5605	**2MM9115WI**
0.4365	3.7369	8.7306	11.2694	0.5635	**2MM9116WI**
0.4396	3.9332	9.2317	11.7683	0.5604	**2MM9117WI**
0.4367	3.7517	8.7350	11.2650	0.5633	**2MM9118WI**
0.4394	3.9200	9.2271	11.7729	0.5606	**2MM9119WI**
0.4418	4.0881	9.7198	12.2802	0.5582	**2MM9120WI**
0.4393	3.9167	9.2256	11.7744	0.5607	**2MM9121WI**
0.4399	3.9507	9.6778	12.3222	0.5601	**2MM9122WI**
0.4439	4.2417	10.2102	12.7898	0.5561	**2MM9124WI**
0.4397	3.9394	9.2336	11.7664	0.5603	**2MM9126WI**
0.4431	4.1850	9.7491	12.2509	0.5569	**2MM9128WI**
0.4428	4.1640	9.7426	12.2574	0.5572	**2MM9130WI**
0.4426	4.1450	9.7367	12.2633	0.5574	**2MM9132WI**
0.4394	3.9247	9.6660	12.3340	0.5606	**2MM9134WI**
0.4369	3.7645	8.7378	11.2622	0.5631	**2MM9140WI**

1) For inner ring rotation. 2) For outer ring rotation.

3MM9100WI Series
Frequency Coefficients

FTF: Fundamental Train Frequency: the frequency at which the retainer will operate.

BSF: Ball Spin Frequency: the frequency at which a single defect on a rolling element will be detected.

BPFO: Ball Pass Frequency Outer: the frequency at which a single defect in the outer race will be detected.

BPFI: Ball Pass Frequency Inner: the frequency at which a single defect in the inner race will be detected.

FTF-inner[1]	BSF	BPFO	BPFI	FTF-outer[2]	
0.3740	1.7697	2.9924	5.0076	0.6260	**3MM9100WI**
0.3957	2.0724	3.9569	6.0431	0.6043	**3MM9101WI**
0.4084	2.3844	4.4924	6.5076	0.5916	**3MM9102WI**
0.4170	2.6493	4.5875	6.4125	0.5830	**3MM9103WI**
0.4074	2.3573	4.4816	6.5184	0.5926	**3MM9104WI**
0.4203	2.7625	5.4635	7.5365	0.5797	**3MM9105WI**
0.4243	2.9475	5.9467	8.0533	0.5752	**3MM9106WI**
0.4258	2.9877	6.3864	8.6136	0.5742	**3MM9107WI**
0.4333	3.3411	6.9332	9.0668	0.5667	**3MM9108WI**
0.4340	3.3761	7.3782	9.6218	0.5660	**3MM9109WI**
0.4391	3.6669	7.9036	10.0964	0.5609	**3MM9110WI**
0.4354	3.4544	7.8373	10.1627	0.5646	**3MM9111WI**
0.4396	3.7005	8.3519	10.6481	0.5604	**3MM9112WI**
0.4432	3.9461	8.8647	11.1353	0.5568	**3MM9113WI**
0.4400	3.7251	8.3599	10.6401	0.5600	**3MM9114WI**
0.4432	3.9379	8.8630	11.1370	0.5568	**3MM9115WI**
0.4404	3.7441	8.8074	11.1926	0.5596	**3MM9116WI**
0.4433	3.9400	9.3085	11.6915	0.5567	**3MM9117WI**
0.4405	3.7587	8.8101	11.1899	0.5595	**3MM9118WI**
0.4430	3.9267	9.3026	11.6974	0.5570	**3MM9119WI**
0.4453	4.0945	9.7958	12.2042	0.5547	**3MM9120WI**
0.4430	3.9235	9.3021	11.6979	0.5570	**3MM9121WI**
0.4434	3.9573	9.7557	12.2443	0.5566	**3MM9122WI**
0.4472	4.2479	10.2861	12.7139	0.5528	**3MM9124WI**
0.4433	3.9462	9.3096	11.6904	0.5567	**3MM9126WI**
0.4466	4.1914	9.8241	12.1759	0.5534	**3MM9128WI**
0.4463	4.1705	9.8186	12.1814	0.5537	**3MM9130WI**
0.4461	4.1515	9.8135	12.1865	0.5539	**3MM9132WI**
0.4431	3.9318	9.7492	12.2508	0.5569	**3MM9134WI**
0.4406	3.7588	8.8114	11.1886	0.5594	**3MM9136WI**
0.4408	3.7719	8.8164	11.1836	0.5592	**3MM9140WI**

2MM9300WI Series
Frequency Coefficients

FTF: Fundamental Train Frequency: the frequency at which the retainer will operate.

BSF: Ball Spin Frequency: the frequency at which a single defect on a rolling element will be detected.

BPFO: Ball Pass Frequency Outer: the frequency at which a single defect in the outer race will be detected.

BPFI: Ball Pass Frequency Inner: the frequency at which a single defect in the inner race will be detected.

FTF-inner[1]	BSF	BPFO	BPFI	FTF-outer[2]	
0.4054	2.4294	4.8649	7.1351	0.5946	**2MM9300WI**
0.4159	2.7546	5.4070	7.5930	0.5841	**2MM9301WI**
0.4204	2.9335	5.4650	7.5350	0.5796	**2MM9302WI**
0.4272	3.2198	6.4074	8.5926	0.5728	**2MM9303WI**
0.4194	2.9144	5.8719	8.1281	0.5806	**2MM9304WI**
0.4314	3.4509	7.3346	9.6654	0.5686	**2MM9305WI**
0.4404	3.9846	8.3667	10.6333	0.5596	**2MM9306WI**
0.4405	3.9924	8.3695	10.6305	0.5595	**2MM9307WI**
0.4399	3.9578	8.3586	10.6414	0.5601	**2MM9308WI**
0.4458	4.3966	9.3612	11.6388	0.5542	**2MM9309WI**
0.4498	4.7547	10.3448	12.6552	0.5502	**2MM9310WI**
0.4490	4.6752	10.3262	12.6738	0.5510	**2MM9311WI**
0.4525	5.0286	11.3121	13.6879	0.5475	**2MM9312WI**
0.4556	5.3816	12.2999	14.7001	0.5444	**2MM9313WI**
0.4504	4.8196	10.8092	13.1908	0.5496	**2MM9314WI**
0.4531	5.1086	11.3285	13.6715	0.5469	**2MM9315WI**
0.4556	5.3974	12.3014	14.6986	0.5444	**2MM9316WI**
0.4557	5.3371	11.8322	14.1678	0.5449	**2MM9317WI**
0.4537	5.1643	11.7957	14.2043	0.5463	**2MM9318WI**
0.4557	5.4085	12.7607	15.2393	0.5443	**2MM9319WI**
0.4585	5.7746	13.2966	15.7034	0.5415	**2MM9320WI**
0.4617	6.2622	14.3126	16.6874	0.5383	**2MM9322WI**
0.4596	5.9438	13.7888	16.2112	0.5404	**2MM9324WI**
0.4580	5.7028	13.7392	16.2608	0.5420	**2MM9326WI**
0.4605	6.0759	14.7367	17.2633	0.5395	**2MM9328WI**
0.4531	5.1086	12.2348	14.7652	0.5469	**2MM9330WI**
0.4536	5.1589	12.2480	14.7520	0.5464	**2MM9332WI**
0.4559	5.4349	13.2209	15.7791	0.5441	**2MM9334WI**
0.4521	4.9931	12.2062	14.7938	0.5479	**2MM9340WI**

1) For inner ring rotation.

2) For outer ring rotation.

3MM9300WI Series
Frequency Coefficients

FTF: Fundamental Train Frequency: the frequency at which the retainer will operate.

BSF: Ball Spin Frequency: the frequency at which a single defect on a rolling element will be detected.

BPFO: Ball Pass Frequency Outer: the frequency at which a single defect in the outer race will be detected.

BPFI: Ball Pass Frequency Inner: the frequency at which a single defect in the inner race will be detected.

FTF-inner[1]	BSF	BPFO	BPFI	FTF-outer[2]	
0.4100	2.4380	4.9204	7.0796	0.5900	**3MM9300WI**
0.4248	2.9417	5.5225	7.4775	0.5752	**3MM9302WI**
0.4312	3.2273	6.4681	8.5319	0.5688	**3MM9303WI**
0.4356	3.4586	7.4044	9.5956	0.5644	**3MM9305WI**
0.4439	3.9913	8.4346	10.5654	0.5561	**3MM9306WI**
0.4440	3.9990	8.4366	10.5634	0.5560	**3MM9307WI**
0.4437	3.9648	8.4295	10.5705	0.5563	**3MM9308WI**
0.4491	4.4029	9.4320	11.5680	0.5509	**3MM9309WI**
0.4529	4.7606	10.4166	12.5834	0.5471	**3MM9310WI**
0.4521	4.6811	10.3983	12.6017	0.5479	**3MM9311WI**
0.4554	5.0340	11.3851	13.6149	0.5446	**3MM9312WI**
0.4583	5.3867	12.3736	14.6264	0.5417	**3MM9313WI**
0.4535	4.8255	10.8839	13.1161	0.5465	**3MM9314WI**
0.4561	5.1141	11.4020	13.5980	0.5439	**3MM9315WI**
0.4584	5.4026	12.3766	14.6234	0.5416	**3MM9316WI**
0.4579	5.3423	11.9047	14.0953	0.5421	**3MM9317WI**
0.4565	5.1696	11.8699	14.1301	0.5435	**3MM9318WI**
0.4585	5.4136	12.8371	15.1629	0.5415	**3MM9319WI**
0.4611	5.7794	13.3708	15.6292	0.5389	**3MM9320WI**
0.4641	6.2666	14.3858	16.6142	0.5359	**3MM9322WI**
0.4622	5.9485	13.8645	16.1355	0.5378	**3MM9324WI**
0.4606	5.7077	13.8171	16.1829	0.5394	**3MM9326WI**
0.4630	6.0804	14.8147	17.1853	0.5370	**3MM9328WI**
0.4561	5.1141	12.3141	14.6859	0.5439	**3MM9330WI**
0.4586	5.4401	13.3007	15.6993	0.5414	**3MM9334WI**
0.4551	4.9987	12.2879	14.7121	0.5449	**3MM9340WI**

2MM200WI Series
Frequency Coefficients

FTF: Fundamental Train Frequency: the frequency at which the retainer will operate.

BSF: Ball Spin Frequency: the frequency at which a single defect on a rolling element will be detected.

BPFO: Ball Pass Frequency Outer: the frequency at which a single defect in the outer race will be detected.

BPFI: Ball Pass Frequency Inner: the frequency at which a single defect in the inner race will be detected.

FTF-inner[1]	BSF	BPFO	BPFI	FTF-outer[2]	
0.3668	1.6722	2.9345	5.0655	0.6332	**2MM200WI**
0.3699	1.7226	3.3290	5.6710	0.6301	**2MM201WI**
0.3855	1.9898	3.8552	6.1448	0.6145	**2MM202WI**
0.3861	2.0025	3.8609	6.1391	0.6139	**2MM203WI**
0.3857	2.0000	3.8570	6.1430	0.6143	**2MM204WI**
0.4008	2.3347	4.8091	7.1909	0.5992	**2MM205WI**
0.4001	2.3182	4.8007	7.1993	0.5999	**2MM206WI**
0.3997	2.3104	4.7965	7.2035	0.6003	**2MM207WI**
0.3980	2.2638	4.3777	6.6223	0.6020	**2MM208WI**
0.4058	2.4683	5.2757	7.7243	0.5942	**2MM209WI**
0.4126	2.6716	5.7757	8.2243	0.5874	**2MM210WI**
0.4110	2.6263	5.7543	8.2457	0.5890	**2MM211WI**
0.4098	2.5901	5.7376	8.2624	0.5902	**2MM212WI**
0.4130	2.6906	5.7818	8.2182	0.5870	**2MM213WI**
0.4135	2.7082	5.7891	8.2109	0.5865	**2MM214WI**
0.4177	2.8554	6.2659	8.7341	0.5823	**2MM215WI**
0.4164	2.8064	6.2462	8.7538	0.5836	**2MM216WI**
0.4152	2.7649	6.2281	8.7719	0.5848	**2MM217WI**
0.4142	2.7301	5.7984	8.2016	0.5858	**2MM218WI**
0.4132	2.6992	5.7853	8.2147	0.5868	**2MM219WI**
0.4125	2.6714	5.7744	8.2256	0.5875	**2MM220WI**
0.4110	2.6263	5.7543	8.2457	0.5890	**2MM222WI**
0.4131	2.6927	5.7830	8.2170	0.5869	**2MM224WI**
0.4192	2.9059	7.1260	9.8740	0.5808	**2MM226WI**
0.4124	2.6714	6.1865	8.8135	0.5876	**2MM230WI**

1) For inner ring rotation.

2) For outer ring rotation.

3MM200WI Series
Frequency Coefficients

FTF: Fundamental Train Frequency: the frequency at which the retainer will operate.

BSF: Ball Spin Frequency: the frequency at which a single defect on a rolling element will be detected.

BPFO: Ball Pass Frequency Outer: the frequency at which a single defect in the outer race will be detected.

BPFI: Ball Pass Frequency Inner: the frequency at which a single defect in the inner race will be detected.

FTF-inner[1]	BSF	BPFO	BPFI	FTF-outer[2]	
0.3668	1.6722	2.9345	5.0655	0.6332	**3MM200WI**
0.3774	1.7366	3.3966	5.6034	0.6226	**3MM201WI**
0.3921	2.0021	3.9212	6.0788	0.6079	**3MM202WI**
0.3928	2.0150	3.9277	6.0723	0.6072	**3MM203WI**
0.3929	2.0134	3.9290	6.0710	0.6071	**3MM204WI**
0.4070	2.3463	4.8841	7.1159	0.5930	**3MM205WI**
0.4064	2.3301	4.8769	7.1231	0.5936	**3MM206WI**
0.4061	2.3224	4.8734	7.1266	0.5939	**3MM207WI**
0.4043	2.2757	4.4476	6.5524	0.5957	**3MM208WI**
0.4117	2.4793	5.3519	7.6481	0.5883	**3MM209WI**
0.4180	2.6818	5.8519	8.1481	0.5820	**3MM210WI**
0.4166	2.6367	5.8323	8.1677	0.5834	**3MM211WI**
0.4155	2.6007	5.8171	8.1829	0.5845	**3MM212WI**
0.4185	2.7009	5.8587	8.1413	0.5815	**3MM213WI**
0.4189	2.7182	5.8639	8.1361	0.5811	**3MM214WI**
0.4228	2.8649	6.3421	8.6579	0.5772	**3MM215WI**
0.4216	2.8162	6.3241	8.6759	0.5784	**3MM216WI**
0.4205	2.7748	6.3076	8.6924	0.5795	**3MM217WI**
0.4196	2.7402	5.8738	8.1262	0.5804	**3MM218WI**
0.4187	2.7094	5.8618	8.1382	0.5813	**3MM219WI**
0.4179	2.6816	5.8506	8.1494	0.5821	**3MM220WI**
0.4166	2.6367	5.8323	8.1677	0.5834	**3MM222WI**
0.4184	2.7026	5.8573	8.1427	0.5816	**3MM224WI**
0.4241	2.9151	7.2100	9.7900	0.5759	**3MM226WI**
0.4179	2.6815	6.2681	8.7319	0.5821	**3MM230WI**

2MM300WI Series
Frequency Coefficients

FTF: Fundamental Train Frequency: the frequency at which the retainer will operate.

BSF: Ball Spin Frequency: the frequency at which a single defect on a rolling element will be detected.

BPFO: Ball Pass Frequency Outer: the frequency at which a single defect in the outer race will be detected.

BPFI: Ball Pass Frequency Inner: the frequency at which a single defect in the inner race will be detected.

FTF-inner[1]	BSF	BPFO	BPFI	FTF-outer[2]	
0.3594	1.5791	2.8751	5.1249	0.6406	**2MM301WI**
0.3861	2.0024	3.8609	6.1391	0.6139	**2MM302WI**
0.3564	1.5411	2.4946	4.5054	0.6436	**2MM303WI**
0.3618	1.6111	2.8941	5.1059	0.6382	**2MM304WI**
0.3681	1.6997	3.3127	5.6873	0.6319	**2MM305WI**
0.3722	1.7663	3.7221	6.2779	0.6278	**2MM306WI**
0.3799	1.8962	3.7990	6.2010	0.6201	**2MM307WI**
0.3801	1.9333	4.2025	6.7975	0.6180	**2MM308WI**
0.3837	1.9636	3.8373	6.1627	0.6163	**2MM309WI**
0.3851	1.9889	3.8510	6.1490	0.6149	**2MM310WI**
0.3861	2.0099	3.8606	6.1394	0.6139	**2MM311WI**
0.3870	2.0281	3.8704	6.1296	0.6130	**2MM312WI**
0.3879	2.0440	4.2665	6.7335	0.6121	**2MM313WI**
0.3884	2.0576	4.2729	6.7271	0.6116	**2MM314WI**
0.3857	2.0013	3.8570	6.1430	0.6143	**2MM319WI**

1) For inner ring rotation.

2) For outer ring rotation.

3MM300WI Series
Frequency Coefficients

FTF: Fundamental Train Frequency: the frequency at which the retainer will operate.

BSF: Ball Spin Frequency: the frequency at which a single defect on a rolling element will be detected.

BPFO: Ball Pass Frequency Outer: the frequency at which a single defect in the outer race will be detected.

BPFI: Ball Pass Frequency Inner: the frequency at which a single defect in the inner race will be detected.

FTF-inner[1]	BSF	BPFO	BPFI	FTF-outer[2]	
0.3678	1.5949	2.9425	5.0575	0.6322	**3MM301WI**
0.3928	2.0149	3.9277	6.0723	0.6072	**3MM302WI**
0.3653	1.5578	2.5571	4.4429	0.6347	**3MM303WI**
0.3701	1.6268	2.9611	5.0389	0.6299	**3MM304WI**
0.3761	1.7147	3.3850	5.6150	0.6239	**3MM305WI**
0.3801	1.7811	3.8010	6.1990	0.6199	**3MM306WI**
0.3874	1.9101	3.8736	6.1264	0.6126	**3MM307WI**
0.3893	1.9469	4.2826	6.7174	0.6107	**3MM308WI**
0.3910	1.9772	3.9096	6.0904	0.6090	**3MM309WI**
0.3920	2.0019	3.9205	6.0795	0.6080	**3MM310WI**
0.3931	2.0231	3.9314	6.0686	0.6069	**3MM311WI**
0.3941	2.0412	3.9405	6.0595	0.6059	**3MM312WI**
0.3947	2.0567	4.3415	6.6585	0.6053	**3MM313WI**
0.3954	2.0705	4.3491	6.6509	0.6046	**3MM314WI**
0.3927	2.0144	3.9270	6.0730	0.6073	**3MM319WI**

Ball Screw Support Series Frequency Coefficients

FTF: Fundamental Train Frequency: the frequency at which the retainer will operate.

BSF: Ball Spin Frequency: the frequency at which a single defect on a rolling element will be detected.

BPFO: Ball Pass Frequency Outer: the frequency at which a single defect in the outer race will be detected.

BPFI: Ball Pass Frequency Inner: the frequency at which a single defect in the inner race will be detected.

FTF-inner[1]	BSF	BPFO	BPFI	FTF-outer[2]	
0.4362	2.1044	5.2349	6.7651	0.5638	**MM9306WI2H**
0.4362	2.1044	5.2349	6.7651	0.5638	**MM17BS47**
0.4362	2.1044	5.2349	6.7651	0.5638	**MM20BS47**
0.4423	2.3307	5.7494	7.2506	0.5577	**MM25BS52**
0.4554	3.0307	7.7410	9.2590	0.5446	**MM9308WI2H**
0.4554	3.0307	7.7410	9.2590	0.5446	**MM25BS62**
0.4554	3.0307	7.7410	9.2590	0.5446	**MM30BS62**
0.4569	3.1286	8.2244	9.7756	0.5431	**MM9310WI2H**
0.4569	3.1286	8.2244	9.7756	0.5431	**MM30BS72**
0.4569	3.1286	8.2244	9.7756	0.5431	**MM35BS72**
0.4569	3.1286	8.2244	9.7756	0.5431	**MM40BS72**
0.4605	3.4145	9.2094	10.7906	0.5395	**MM9311WI3H**
0.4605	3.4145	9.2094	10.7906	0.5395	**MM45BS75**
0.4676	4.1773	11.2230	12.7770	0.5324	**MM9313WI5H**
0.4676	4.1773	11.2230	12.7770	0.5324	**MM40BS90**
0.4676	4.1773	11.2230	12.7770	0.5324	**MM50BS90**
0.4676	4.1773	11.2230	12.7770	0.5324	**MM55BS90**
0.4564	3.0983	8.2159	9.7841	0.5436	**MM35BS100**
0.4564	3.0983	8.2159	9.7841	0.5436	**MM40BS100**
0.4564	3.0983	8.2159	9.7841	0.5436	**MM45BS100**
0.4564	3.0983	8.2159	9.7841	0.5436	**MM50BS100**
0.4747	5.3492	14.2402	15.7598	0.5253	**MM9316WI3H**
0.4747	5.3492	14.2402	15.7598	0.5253	**MM75BS110**
0.4644	3.7967	9.7516	11.2484	0.5356	**MM55BS120**
0.4644	3.7967	9.7516	11.2484	0.5356	**MM60BS120**
0.4794	6.4615	17.7378	19.2622	0.5206	**MM9321WI3**
0.4790	6.4611	17.7226	19.2774	0.5210	**MM100BS150**
0.4778	6.1209	16.7239	18.2761	0.5222	**MM9326WI6H**

1) For inner ring rotation.

2) For outer ring rotation.

2MMV9100HX Series
Frequency Coefficients

FTF: Fundamental Train Frequency : the frequency at which the retainer will operate.

BSF: Ball Spin Frequency: the frequency at which a single defect on a rolling element will be detected.

BPFO: Ball Pass Frequency Outer: the frequency at which a single defect in the outer race will be detected.

BPFI: Ball Pass Frequency Inner: the frequency at which a single defect in the inner race will be detected.

FTF-inner[1]	BSF	BPFO	BPFI	FTF-outer[2]	
0.3834	1.9496	3.8344	6.1656	0.6166	**2MMV9100HX**
0.3852	1.9890	3.8517	6.1483	0.6148	**2MMV9101HX**
0.4023	2.3729	4.8273	7.1727	0.5977	**2MMV9102HX**
0.3969	2.2403	4.7634	7.2366	0.6031	**2MMV9103HX**
0.4012	2.3457	4.8147	7.1853	0.5988	**2MMV9104HX**
0.4043	2.4274	5.2560	7.7440	0.5957	**2MMV9105HX**
0.4099	2.5903	5.3292	7.6708	0.5901	**2MMV9106HX**
0.4211	2.9789	6.3162	8.6838	0.5789	**2MMV9107HX**
0.4291	3.3332	6.8659	9.1341	0.5709	**2MMV9108HX**
0.4234	3.0758	6.3517	8.6483	0.5766	**2MMV9109HX**
0.4293	3.3440	6.8694	9.1306	0.5707	**2MMV9110HX**
0.4472	4.5160	10.7329	13.2671	0.5528	**2MMV9111HX**
0.4506	4.8343	11.2653	13.7347	0.5494	**2MMV9112HX**
0.4490	4.6751	11.2241	13.7759	0.5510	**2MMV9113HX**
0.4490	4.6752	11.2241	13.7759	0.5510	**2MMV9114HX**
0.4517	4.9403	11.7429	14.2571	0.5483	**2MMV9115HX**
0.4477	4.5613	11.1913	13.8087	0.5523	**2MMV9116HX**
0.4502	4.7888	11.7039	14.2961	0.5498	**2MMV9117HX**
0.4534	5.1295	12.6953	15.3047	0.5466	**2MMV9118HX**
0.4490	4.6752	11.6731	14.3269	0.5510	**2MMV9119HX**
0.4510	4.8740	12.1772	14.8228	0.5490	**2MMV9120HX**
0.4538	5.1719	12.7058	15.2942	0.5462	**2MMV9121HX**
0.4563	5.4696	13.6877	16.3123	0.5437	**2MMV9122HX**
0.4542	5.2052	13.1707	15.8293	0.5458	**2MMV9124HX**

Precision Bearing Tag Deviation and Runout Charts

Bearing tag markings include indication of bearing accuracy which can assist with selective assembly and installation.

Refer to diagrams 2-1 and 2-2 on page 23 in Chapter 2.

Metric System

Chart 1

Class	Des. No.	Deviation	
		mm over incl.	in. over incl.
All	-2	0.000 to -0.002	0.0000 to -0.0001
	-4	-0.002 to -0.004	-0.0001 to -0.0002
	-8	-0.004 to -0.008	-0.0002 to -0.0003
	-12	-0.008 to -0.012	-0.0003 to -0.0004
	-16	-0.012 to -0.016	-0.0004 to -0.0006
	-20	-0.016 to -0.020	-0.0006 to -0.0008
	-25	-0.020 to -0.025	-0.0008 to -0.0010
	-30	-0.025 to -0.030	-0.0010 to -0.0012
	-35	-0.030 to -0.035	-0.0012 to -0.0014
	-40	-0.035 to -0.040	-0.0014 to -0.0016
	-45	-0.040 to -0.045	-0.0016 to -0.0018
	-50	-0.045 to -0.050	-0.0018 to -0.0020
	-55	-0.050 to -0.055	-0.0020 to -0.0022
	-60	-0.055 to -0.060	-0.0022 to -0.0024
	-65	-0.060 to -0.065	-0.0024 to -0.0026
	-70	-0.065 to -0.070	-0.0026 to -0.0028
	-75	-0.070 to -0.075	-0.0028 to -0.0030
	-80	-0.075 to -0.080	-0.0030 to -0.0031

Chart 2

Class	Des. No.	Deviation	
		mm over incl.	in. over incl.
C & B	2	0.000 to 0.002	0.0000 to 0.0001
	4	0.002 to 0.004	0.0001 to 0.0002
	8	0.004 to 0.008	0.0002 to 0.0003
	12	0.008 to 0.012	0.0003 to 0.0004
	16	0.012 to 0.016	0.0004 to 0.0006
	20	0.016 to 0.020	0.0006 to 0.0008
	25	0.020 to 0.025	0.0008 to 0.0010
	30	0.025 to 0.030	0.0010 to 0.0012
	35	0.030 to 0.035	0.0012 to 0.0014
	40	0.035 to 0.040	0.0014 to 0.0016
	45	0.040 to 0.045	0.0016 to 0.0018
	50	0.045 to 0.050	0.0018 to 0.0020
	55	0.050 to 0.055	0.0020 to 0.0022
	60	0.055 to 0.060	0.0022 to 0.0024
	65	0.060 to 0.065	0.0024 to 0.0026
	70	0.065 to 0.070	0.0026 to 0.0028
	75	0.070 to 0.075	0.0028 to 0.0030
	80	0.075 to 0.080	0.0030 to 0.0031
A	actual amount	0.0000 to 0.0019	0.00000 to 0.000075
AA	actual amount	0.0000 to 0.0010	0.00000 to 0.00004

Inch System

Chart 3

Class	Des. No.	Deviation	
		mm over incl.	in. over incl.
All	+1	0.000 to 0.003	.0000 to .0001
	+2	0.003 to 0.005	.0001 to .0002
	+3	0.005 to 0.008	.0002 to .0003
	etc. up to +30	0.074 to 0.076	.0029 to .0030

Chart 4

Class	Des. No.	Deviation	
		mm over incl.	in. over incl.
3 & 0	1	0.000 to 0.003	.0000 to .0001
	2	0.003 to 0.005	.0001 to .0002
	3	0.005 to 0.008	.0002 to .0003
	etc. up to 30	0.074 to 0.076	.0029 to .0030
00	act. amt. in microinches	0.0000 to 0.0019	0.0000 to 0.000075
000	act. amt. in microinches	0.0000 to 0.0010	0.000000 to 0.000040

Geometry Factors for Tapered Roller Bearings

The tables below list the C_g, G1, G2, and K factors for tapered roller bearings covered in this catalog. These constants are used in heat generation estimates, influence of application operating speed, and other calculations relating to the bearing's internal geometry details.

TS Style

Part Number	C_g	G1	G2	K
JP6049-JP6010	0.0240	39.5	22.5	1.24
29585-29520	0.0303	70.3	25.8	1.27
JLM710949C-JLM710910	0.0273	55.5	24.5	1.29
399A-394A	0.0260	56.0	21.4	1.45
JP7049-JP7010	0.0264	51.1	31.0	1.27
29685-29620	0.0323	77.7	43.3	1.20
34301-34478	0.0297	69.3	27.0	1.30
JP8049-JP8010	0.0297	69.7	37.4	1.29
JM716649-JM716610	0.0371	117.1	38.4	1.31
497-493	0.0352	104.6	29.3	1.31
JP9049-JP9010	(Call)	83.8	46.1	1.18
LM718947-LM718910	0.0389	124.2	37.6	1.22
JP10044-JP10010	0.0357	104.0	40.9	1.24
JM719149-JM719113	0.0410	150.5	36.1	1.32
JP10049-JP10010	0.0357	104.0	40.9	1.24
52400-52618	0.0450	175.4	41.7	1.23
JM822049-JM822010	0.0474	191.5	45.8	1.18
JLM722948-JLM722912	0.0424	161.0	57.2	1.27
68462-68712	0.0274	163.1	51.7	1.18
JL724348-JL724314	0.0432	170.2	70.6	1.27
JL725346-JL725316	0.0455	186.6	77.7	1.23
JP13049-JP13010	0.0287	192.2	60.3	1.24
JP14049-JP14010	0.0311	219.5	68.2	1.16
36690-36620	0.0544	366.1	152.0	1.59
JL730646-JL730612	0.0542	295.2	104.0	1.27
JP16049-JP16010	0.0346	294.4	123.0	1.20
JP17049-JP17010	0.0266	339.3	147.0	1.27
36990-36920	0.0418	514.8	241.0	1.33
JP18049-JP18010	(Call)	369.2	162.0	1.21
JM736149-JM736110	0.0343	589.4	128.0	1.22
87750-87111	0.0318	574.6	131.0	1.41
67985-67920	0.0401	819.5	172.0	1.15
543085-543114	0.0311	608.5	232.0	1.52

TSF Style

Part Number	C_g	G1	G2	K
JP6049-JP6010-B	0.0240	39.5	22.5	1.24
JP7049-JP7010-B	0.0264	51.1	31.0	1.27
JP8049-JP8010-B	0.0297	69.7	37.4	1.29
JP9049-JP9010-B	(Call)	83.8	46.1	1.18
JP10044-JP10010-B	0.0357	104.0	40.9	1.24
JP10049-JP10010-B	0.0357	104.0	40.9	1.24
JP13049-JP13010-B	0.0287	192.2	60.3	1.24
JP14049-JP14010-B	0.0311	219.5	68.2	1.16
JL730646-JL730612-B	0.0542	295.2	104.0	1.27

Crossed Roller Style

Part Number	G1	G2	K
XR496051	—	—	0.48
JXR637050	—	—	0.45
JXR678054	—	—	0.47
JXR652050	—	—	0.46
XR678052	—	—	0.47
JXR699050	—	—	0.45
XR766051	—	—	0.45
XR820060	—	—	0.46
XR855053	—	—	0.45
XR882055	—	—	0.44
XR882054	—	—	0.44
XR889058	—	—	0.44
XR897051	—	—	0.43

Hydra-Rib Style

Part Number	G1	G2	K
JP5049P-JP5019HR	32.5	6.4	1.65
JP5049P-JP5020HR	32.5	6.4	1.65
JP5049PH-JP5017HR	32.5	6.4	1.65
JP5049PH-JP5020HR	32.5	6.4	1.65
JP7548P-JP7520HR	60.5	23.3	1.52
JP7549P-JP7519HR	60.5	23.3	1.52
JP8548-JP8518HR	86.4	15.7	1.56
JP8549P-JP8519HR	86.4	15.7	1.56
JP10048-JP10019HR	106.0	45.5	1.24
JP10048-JP10019HRA	106.0	45.5	1.24
JP11035-JP11019HR	140.4	56.1	1.63
JP11048-JP11019HR	140.4	56.1	1.63
JP12043P-JP12019HR	172.0	34.6	1.50
JP12049P-JP12019HR	172.0	34.6	1.50
JP13043P-JP13016HR	212.0	39.0	1.50
JP13049P-JP13016HR	212.0	39.0	1.50
JP14043P-JP14019HR	235.0	44.8	1.40
JP14049P-JP14019HR	235.0	44.8	1.40
JP16043P-JP16019HR	319.0	58.9	1.44
JP16049P-JP16019HR	319.0	58.9	1.44
JP17049P-JP17019HR	365.4	62.9	1.50
JP18049P-JP18019HR	397.8	70.2	1.42
JP20049P-JP20019HR	479.5	140.8	1.46
JP22049E-JP22019HR	588.1	184.9	1.33
JL555235-JL55512HR	1305.0	393.0	1.64
JL555239-JL55512HR	1305.0	393.0	1.64

Tapered Roller Bearings
Speed Guidelines for Machine Tool Spindles

Bearing Type & Position	Cone Rib Speed (feet/minute)					
	0 - 2500	2500 - 4000	4000 - 6000	6000 - 8000	8000 - 10000	10000 - 20000
TS Bearing at Nose Position						
w/Standard Stamped Cage	Yes	Yes	Yes	No		
w/Thermal Compensating Device	N/R	N/R	Consider [1]	Yes [1]		
w/Internal Geometry Modifications	N/R	N/R	Consider	Yes	NO	NO
w/Cage Modifications	N/R	N/R	N/R	Yes		
w/Silver Plated Cage	N/R	N/R	N/R	Consider		
w/Machined Cage	N/R	N/R	N/R	N/R		
w/Improved Finish	N/R	N/R	N/R	Consider		
TSMA Bearing at Nose Position						
TSMA	N/R	N/R	N/R	Consider [1]	Yes [1]	Yes [1]
w/Internal Geometry Modifications	N/R	N/R	N/R	Yes	Yes	Yes
w/Cage Modifications	N/R	N/R	N/R	Yes	Yes	Yes
w/Silver Plated Cage	N/R	N/R	N/R	Consider	Yes	Yes
w/Machined Cage	N/R	N/R	N/R	N/R	Consider	Yes
w/Improved Finish	N/R	N/R	N/R	Consider	Consider	Yes
Ribbed Cup Bearing at Nose Position						
Ribbed Cup					Yes	Yes
w/Internal Geometry Modifications					Yes	Yes
w/Silver Plated Cage					Yes	Yes
w/Machined Cage					Consider	Yes
w/Oil Drainage Holes in Cup					Consider	Yes
w/Improved Finish					Consider	Yes
Hydra-Rib Bearing at Rear Position						
Standard Hydra-Rib	Consider	Consider	Consider	Yes	No	No
Modified Hydra-Rib	N/R	N/R	N/R	N/R	Yes	Yes
w/Internal Geometry Modifications	N/R	N/R	N/R	Yes	Yes	Yes
w/Silver Plated Cage	N/R	N/R	N/R	Consider	Yes	Yes
w/Machined Cage	N/R	N/R	N/R	N/R	Consider	Yes
w/Oil Drainage Holes in Cup	N/R	N/R	N/R	N/R	Consider	Yes
w/Improved Finish	N/R	N/R	N/R	Consider	Consider	Yes
Lubrication System						
Standard Spindle Grease	Yes	No	No	No	No	No
Special High Speed Grease	N/R	Yes [2]	No	No	No	No
Oil Level	Yes [4]	Yes [4]	No	No	No	No
Air/Oil or Mist	N/R	Consider	Yes [1]	Yes [1][8]	No	No
Circulating Oil	N/R	N/R	Yes [5]	Yes [5]	Yes [6]	Yes [6]
Oil Jets Required under Cage	N/R	N/R	N/R	Yes [7]	Yes [7]	Yes [7]
Oil Jets Required to Backface Rib	N/R	N/R	N/R	Yes [4][7]	Yes [3][7]	Yes [3][7]

Notes

1) Requires use of Hydra-Rib, Spring-Rib, or spring loaded design at rear position
2) Kluber NBU15, Mobil 28, or equivalent
3) Only for TSMA bearings
4) Use ISO VG32 or equivalent for oil level
5) Do not use greater than ISO VG32 or equivalent for circulating oil. Preferred is ISO VG22 or equivalent
6) Same as (9) except water jackets in housing would also be required.
7) 3 Jets @120 degrees
8) Not to be used with TSMA design
9) Normally used for operating speeds less than 2500 fpm

Tapered Roller Bearing Designs

2TS mounting (standard design)
2TS + TDO at rear (box mounting) (9)
2TS mounting w/spring mounting
TS mounting + Hydra-Rib
2 TSMA mounting front & rear
TSMA mounting + Hydra-Rib
2 TS ribbed cup mounting
Ribbed cup mounting + Hydra-Rib

Spindle Bearing Design Factors

K-Factor of 1.00 to 1.80 preferred.

Look at G-Factor for indication of heat generation characteristics.

Thin Section L & LL type bearings should be given primary consideration.

Consult with Sales Engineer to insure bearings selected have good high speed characteristics.

Rib Speed Calculations:

Vr (fpm) = (3.1416) x (Dm) x (S)/12

Where:
Dm = Cone Rib Diameter (inches)
S = Bearing Speed (rpm)

The cone rib diameter at the midpoint of the roller end contact can be scaled from a drawing of the bearing, if available, or this diameter can be approximated as the average of the bearing ID and OD.

Radial Internal Clearance (Ball Bearings)

Deep groove radial type bearings may be matched to various radial internal clearances to meet specific design and performance requirements. The following chart lists the clearances options available.

Conrad bearings ordered without a prefix for clearance specification will be supplied with a "P" fit (ISO C3) as standard.

Values Shown in Ten-Thousandths Inches (.0001") and Micrometers (µ m)

Bearing Size	"H" Fit Snug (C2)		"R" Fit regular (C0)		"P" Fit Loose (C3)-Std.		"J" Fit Extra-loose (C4)	
	0.0000"	µm	0.0000"	µm	0.0000"	µm	0.0000"	µm
00	1-3	3-8	2-5	5-13	4-8	10-20	7-10	18-25
01	1-4	3-10	2-6	5-15	5-9	13-23	8-12	20-30
02	1-4	3-10	2-6	5-15	5-9	13-23	8-12	20-30
03	1-4	3-10	2-6	5-15	5-9	13-23	8-12	20-30
04	1-4	3-10	3-7	8-18	6-10	15-25	9-13	23-33
05	1-4	3-10	3-7	8-18	6-10	15-25	10-15	25-38
06	1-4	3-10	3-7	8-18	6-10	15-25	10-15	25-38
07	1-4	3-10	3-7	8-18	7-12	18-30	12-17	30-43
08	1-4	3-10	3-7	8-18	7-12	18-30	12-17	30-43
09	1-4	3-10	3-8	8-20	8-13	20-33	13-19	33-48
10	1-4	3-10	3-8	8-20	8-13	20-33	13-19	33-48
11	1-5	3-13	4-10	10-25	10-16	25-40	16-23	40-58
12	1-5	3-13	4-10	10-25	10-16	25-40	16-23	40-58
13	1-5	3-13	4-10	10-25	10-16	25-40	16-23	40-58
14	1-5	3-13	5-11	13-28	11-19	28-48	19-27	48-68
15	1-5	3-13	5-11	13-28	11-19	28-48	19-27	48-68
16	1-5	3-13	5-11	13-28	11-19	28-48	19-27	48-68
17-20	1-6	3-15	5-13	13-33	13-22	33-55	22-32	55-80
21-24	1-6	3-15	7-15	18-38	15-25	38-63	25-37	63-93
25-28	2-8	5-20	8-18	20-45	17-31	43-79	29-50	74-127

Bearing Spacers

Spacers are used to increase shaft rigidity, moment stiffness and decrease deflection. Spacers, mounted between units of a pair of bearings, are preferably made of alloy steel, hardened and ground and should be sturdy in cross-section and equal in length. Equal lengths can be produced by grinding the inner-ring spacer and outer-ring spacer together. It is important that the faces of the spacers be square and that their parallelism be the best possible. All corners should be broken to remove sharp edges and burrs.

The inside diameter of the inner-ring spacers should clear the shaft but not be so loose as to make it possible to mount and run them eccentrically. For short spacers and high operating speeds, clearance of not more than .0010 inch (.025mm) over the maximum shaft diameter has been found generally acceptable. For long spacers and low speeds, this clearance may be increased to prevent the shaft from disturbing the face parallelism of the spacer. The spacer outside diameter should match the shaft shoulder diameter of the bearing.

The outside diameter of the outer-ring spacers should be about .0010 inch (.025mm) smaller than the minimum bore of the housing. These should have lubricant holes and grooves where necessary and are usually centrally located.

Spacer end parallelism should be the same as the parallelism tolerance for the adjacent bearing.

Bearing Locknuts

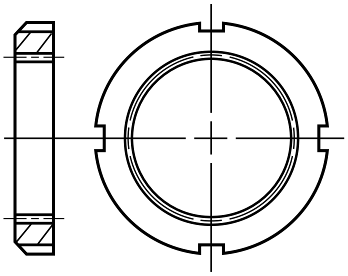
To position precision bearings on spindle shafts, precision manufactured self locking bearing locknuts are recommended rather than the conventional locknuts and lockwashers used for bearings made to ABEC1 standard class tolerances.

This precision bearing nut incorporates a locking feature in its design. The nut threads deform slightly as the locking setscrews are tightened. This slight deformation creates an interference with the shaft threads which prevents further rotation of the locknut. The precision threads of this locknut are cut square with the face to provide the necessary true-running clamping surface against the inner-ring face of the bearings.

Locknut Torque* (Ball Bearings)

General guidelines for Locknut torques are shown in the table below for dry thread engagement. Bearing locknuts shall be tightened using a torque wrench and a two-point locknut wrench or other suitable torque wrench adapter.

Reference MIL-B-17931



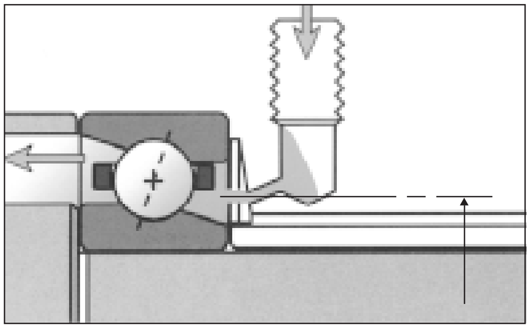
Bearing Bore	Locknut Torque		Approximate Clamping Force	
(mm)	(ft-lb)	(N-m)	(lb)	kN
10	10-20	14-27	1,620-3,240	7.2-14.4
12	10-20	14-27	1,340-2,680	5.9-11.9
15	10-20	14-27	1,070-2,140	4.8-9.5
17	10-20	14-27	940-1,880	4.1-8.3
20	12-35	16-47	950-2,770	4.2-12.3
25	23-50	31-68	1,450-3,170	6.4-14.1
30	32-60	43-81	1,690-3,170	7.5-14.1
35	39-70	53-95	1,750-3,140	7.8-14.0
40	50-80	68-108	1,970-3,140	8.7-14.0
45	64-90	87-122	2,220-3,120	9.9-13.9
50	67-100	91-136	2,090-3,120	9.3-13.9
55	82-125	111-169	2,330-3,540	10.4-15.7
60	99-150	134-203	2,560-3,880	11.4-17.3
65	131-175	178-237	3,130-4,190	13.9-18.6
70	152-200	206-271	3,360-4,430	14.9-19.7
75	173-250	235-339	3,610-5,220	16.0-23.2
80	197-275	267-373	3,840-5,350	17.0-23.8
85	222-325	301-441	4,060-5,940	18.0-26.4
90	248-375	336-508	4,280-6,480	19.0-28.8
95	277-425	376-576	4,520-6,950	20.1-30.9
100	345-475	468-644	5,360-7,380	23.8-32.8
105	380-550	515-746	5,620-8,120	25.0-36.1
110	380-550	515-746	5,340-7,740	23.7-34.4
120	380-550	515-746	4,900-7,080	21.8-31.5
130	380-550	515-746	4,510-6,540	20.0-29.1
140	380-550	515-746	4,190-6,070	18.6-27.0
150	380-550	515-746	3,910-5,660	17.4-25.2
160	380-550	515-746	3,680-5,330	16.4-23.7

* Spindle bearings only: contact Timken Engineering for use with tapered roller bearings.
Valid in all preloaded bearing mounting arrangements.

Lube Specs (Ball Bearings)

Timken recommends and provides the following lubricants and rust preservatives with their bearings. Equivalents may be substituted. Note: Rust preservatives are only for temporary storage of the bearings prior to installation.

Quantity of Grease:
25% to 40% pack for Normal Speed (< 500,000 DN)
15% to 20% pack for High Speed (> 500,000 DN)



LUBE CODE	LUBE	FS SPEC
160	AEROSHELL 22	FS381B-P
436	ANTICORIT L-245XBF	FS890
078*	CHEVRON SRI	FS545
037	DOW CORNING 44	FS137A
125	FERROCOTE 5856 BF	FS639
162*	ISOFLEX NBU 15	FS637
443*	ISOFLEX NCA 15	FS905
422	ISOFLEX SUPERLDS18	FS735
115	ISOFLEX TOPAS NB52	FS737
149	ISOFLEX TOPAS NCA52	FS883
076	KRYTOX 240AB	FS452
161	KRYTOX 240AC	FS433
—	LUBCON L252	FS915
086*	MOBIL 28	FS381A
456	MOBILITH SHC15	FS919
095	MOBILTEMP SHC 32	FS612
167	WINSOR LUBE L1018	FS179A
052	UNIREX N3	FS118 OR FS743
457	THERMOPLEX 2TML	FS920
477	KLUBERSPEED BF72-22	FS934
176	POLYREX EM	FS615
150	ASONIC GLY32	FS889
801	PETAMO GHY133N	—

* Common recommendations for spindle grease

Lube Inlet Location Diameters

Bore No.	200		9100		99100		300		9300		9100HX	
	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
0	0.695	17.65	0.6290	15.98	—	—	—	—	—	—	—	—
1	0.766	19.46	0.7200	18.29	—	—	0.8520	21.64	—	—	—	—
2	0.885	22.48	0.8490	21.56	—	—	1.0120	25.70	0.784	19.91	—	—
3	1.102	27.98	0.9420	23.93	0.9370	23.80	1.0910	27.71	0.863	21.92	—	—
4	1.189	30.21	1.1200	28.45	1.1080	28.14	1.2328	31.31	1.0458	26.56	1.1140	28.30
5	1.394	35.40	1.3120	33.32	1.3050	33.15	1.5238	38.70	1.2093	30.72	1.3060	33.17
6	1.661	42.18	1.5690	39.85	1.5955	40.53	1.7908	45.49	1.4393	36.56	1.5490	39.34
7	1.931	49.06	1.7840	45.31	1.8108	45.99	2.0363	51.72	1.6828	42.74	1.7850	45.34
8	2.162	54.92	1.9953	50.68	2.0635	52.41	2.3043	58.53	1.9063	48.42	2.0010	50.83
9	2.359	59.93	2.2248	56.51	2.2495	57.14	2.5768	65.45	2.0308	51.58	2.2120	56.18
10	2.555	64.92	2.4218	61.51	2.4465	62.14	2.8473	72.32	2.2998	58.41	2.4080	61.16
11	2.826	71.79	2.6918	68.37	2.7283	69.30	3.1173	79.18	2.5418	64.56	2.7300	69.34
12	3.096	78.65	2.8888	73.38	2.9258	74.32	3.3848	85.97	2.7383	69.55	2.9260	74.32
13	3.379	85.83	3.0858	78.38	3.1218	79.29	3.6573	92.90	2.9363	74.58	3.1110	79.02
14	3.564	90.52	3.3558	85.24	3.4033	86.44	3.9268	99.74	3.2068	81.45	3.3930	86.18
15	3.761	95.52	3.5533	90.25	3.6413	92.49			3.4033	86.44	3.5900	91.19
16	4.031	102.38	3.8233	97.11	3.8810	98.58			3.5993	91.42	3.8610	98.07
17	4.301	109.25	4.0285	102.32	4.0868	103.80			3.8828	98.62	—	—
18	4.570	116.09	4.2900	108.97	4.3453	110.37			4.0683	103.33	4.3550	110.62
19	4.841	122.96	4.4870	113.97	4.5403	115.32			—	—	—	—
20	5.112	129.83	4.7135	119.72	4.7813	121.45			—	—	4.7450	120.52
21	5.406	137.31	4.9610	126.01	5.3008	134.64			—	—	—	—
22	5.654	143.61	5.2360	132.99	5.6948	144.65			—	—	5.3350	135.51
24	6.119	155.42	5.6325	143.07	—	—			—	—	5.7080	144.98
26	6.385	162.18	6.1710	156.74	6.321	160.55			—	—		
28	—	—	6.5750	167.01	—				6.1985	157.44		
30	7.816	198.53	7.0320	178.61	—							
32	—	—	7.5000	190.50	—							
34	—	—	7.8460	199.29	—							
40	—	—	9.5150	241.68	—							

Operating Temperatures For Bearing Component Materials

CHART I – RINGS, BALLS AND ROLLERS

Operating Temperature: -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)

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 per ASTM 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 .2C, .5Cr, .80Mn, .12Mo (b) 8620 .2C, .5Cr, .80 Mn, .20 Mo, .55Ni (c) high nickel 3310 .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.

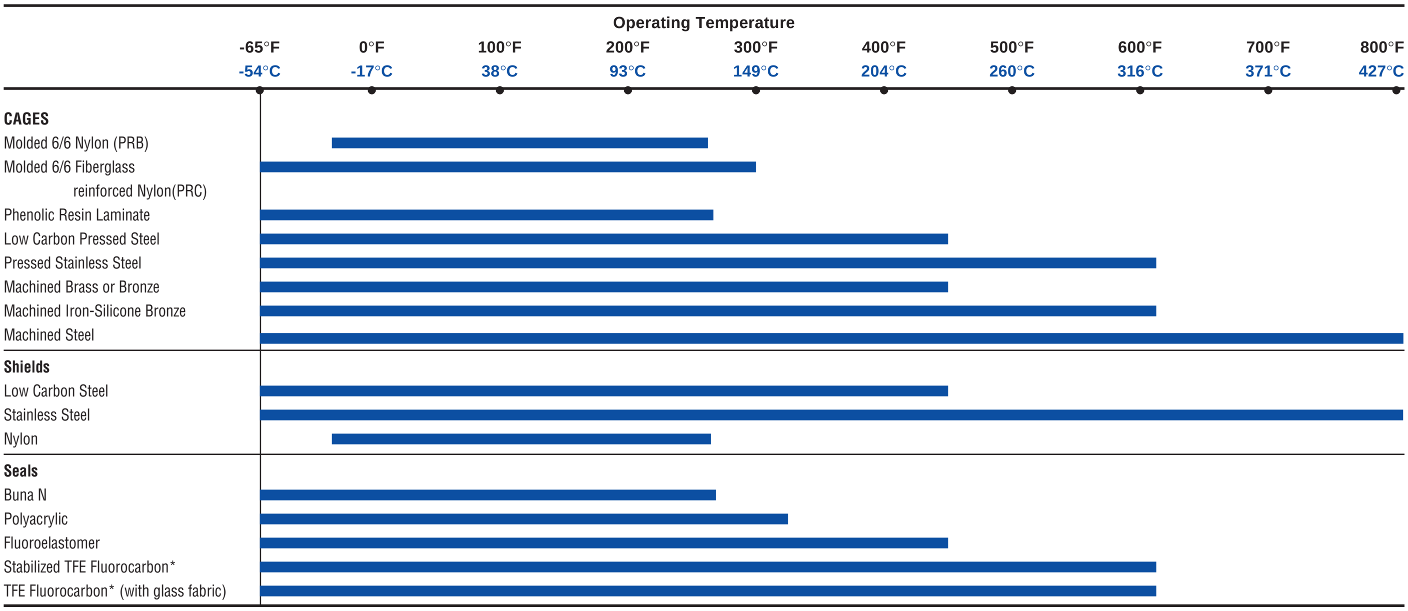
Note: ASTM A295 bearing steels are suitable for many applications up to 250°F but are not as dimensionally stable as they are at temperatures below 212°F.

-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

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 Timken Engineering regarding the application.

CHART II – CAGES, SHIELDS AND SEALS



* Limited Life above these temperatures.

Super Precision Customer Engineering Request Form

General Information

CUSTOMER: ______________________ CCR/RGA #: ______________________

BEARING USER: ______________ QTY: ________ DATE REQ'D: ______________________

SALES ENGINEER: ______________________ DISTRICT OFFICE: ______________________

REASON FOR ANALYSIS REQUEST: ______________________

REPAIRABILITY AND COST TO REPAIR REQUIRED: ☐ YES ☐ NO

☐ HOLD BEARING UNTIL FURTHER NOTICE ☐ SCRAP 30 DAYS AFTER ANALYSIS ☐ RETURN TO D.O.

Bearing Information

BRG. NO: ____________ TYPE: ____________ DATE CODE: ________ S. N.: ____________

☐ NEW BEARING ☐ REPAIRED BEARING DATE INSTALLED: ____________ SERVICE LIFE: ____________

Application Information

EQUIPMENT/MODEL NO.: ______________________ JOB NO.: ______________

LOADS: RADIAL ________ (lb) AXIAL ________ (lb) MOMENT ________ (ft-lb) ROTATION ☐ I.R. ☐ O.R.

SPEED: ________ (rpm) OSCILLATION ANGLE: ________ (Total Degrees) FREQ.: ________ (opm)

LUBRICATION METHOD: ______________________ BRAND: ______________________

TEMP: AMBIENT ______ (°F) HOUSING ______ (°F) BEARING ______ (°F) LUBRICANT ______ (°F)

SHAFT FIT/SIZE: ______________________ HOUSING FIT/SIZE: ______________________

INSTALLATION METHOD: ☐ HYDRAULIC ☐ MECHANICAL ☐ THERMAL OTHER ____________

REMOVAL METHOD: ☐ HYDRAULIC ☐ MECHANICAL ☐ THERMAL OTHER ____________

Operating Equipment Condition

INITIAL INDICATION OF BEARING DAMAGE: ☐ VIBRATION ☐ NOISE ☐ HEAT OTHER ____________

SHAFT CONDITION: ______________________

HOUSING CONDITION: ______________________

LUBRICANT CONDITION: ______________________

INNER RING CONDITION: ______________________

OUTER RING CONDITION: ______________________

CAGE CONDITION: ______________________

ROLLING ELEMENTS CONDITION: ______________________

GENERAL COMMENTS: ______________________

Conversion Tables

TO CONVERT FROM	TO		MULTIPLY BY
Acceleration			
foot/second^2	meter/second^2	m/s^2	0.3048
inch/second^2	meter/second^2	m/s^2	0.0254
Area			
foot^2	meter^2	m^2	0.09290304
inch^2	meter^2	m^2	0.00064516
inch^2	millimeter^2	mm^2	645.16
yard^2	meter^2	m^2	0.836127
mile^2 (U S. statute)	meter^2	m^2	2589988
Bending Moment or Torque			
dyne-centimeter	newton-meter	N • m	0.0000001
kilogram-force-meter	newton-meter	N • m	9.806650
pound-force-inch	newton-meter	N • m	0.1129848
pound-force-foot	newton-meter	N • m	1.355818
Energy			
B.T.U. (International Table)	joule	J	1055.056
foot-pound-force	joule	J	1.355818
kilowatt-hour	megajoule	MJ	3.6
Force			
kilogram-force	newton	N	9.806650
kilopond-force	newton	N	9.806650
pound-force (lbf avoirdupois)	newton	N	4.448222
Length			
fathom	meter	m	1.8288
foot	meter	m	0.3048
inch	millimeter	mm	25.4
microinch	micrometer	um	0.0254
micron (μm)	millimeter	mm	0.0010
mile (U.S. statute)	meter	m	1609.344
yard	meter	m	0.9144
nautical mile (UK)	meter	m	1853.18
Mass			
kilogram-force-second^2/meter (mass)	kilogram	kg	9.806650
kilogram-mass	kilogram	kg	1.0
pound-mass (Ibm avoirdupois)	kilogram	kg	0.4535924
ton (long, 2240 Ibm)	kilogram	kg	1016.047
ton (short, 2000 Ibm)	kilogram	kg	907.1847
tonne	kilogram	kg	1000.000
Power			
BTU (International Table)/hour	watt	W	0.293071
8TU (International Table)/minute	watt	W	17.58427
horsepower (550 ft lbf/s)	kilowatt	kW	0.745700
BTU (therrnochemical)/minute	watt	W	17.57250
Pressure or Stress (Force/Area)			
newton/meter^2	pascal	Pa	1 .0000
kilogram-force/centimeter^2	pascal	Pa	98066.50
kilogram-force/meter^2	pascal	Pa	9.806650
kilogram-force/millirneter^2	pascal	Pa	9806650
pound-force/foot^2	pascal	Pa	47.88026
pound-force/inch^2 (psi)	megapascal	MPa	0.006894757
Temperature			
degree Celsius	degree Kelvin	°K	$t_k = t_c + 273.15$
degree Fahrenheit	degree Kelvin	°K	$k = 5/9\ (t_f + 459.67)$
degree Fahrenheit	degree Celsius	°C	$t_c = 5/9\ (t_f - 32)$
Velocity			
foot/minute	meter/second	m/s	0.00508
foot/second	meter/second	m/s	0.3048
inch/second	meter/second	m/s	0.0254
kilometer/hour	meter/second	m/s	0.27778
mile/hour (U.S. statute)	meter/second	m/s	0.44704
mile/hour (U.S. statute)	kilometer/hour	km/h	1.609344
Volume			
foot^3	meter^3	m^3	0.02831685
gallon (U.S. liquid)	liter	**l**	3.785412
liter	meter^3	m^3	0.001
inch^3	meter^3	m^3	0.00001638706
inch^3	centimeter^3	cm^3	16.38706
inch^3	millimeter^3	mm^3	16387.06
ounce (U.S. fluid)	centimeter^3	cm^3	29.57353
yard^3	meter^3	m^3	0.7645549

VISCOSITY CONVERSION TABLE

SUS Saybolt (sec.)	R' Redwood (sec.)	E Engler (deg.)	cSt Centistokes
35	32.2	1.18	2.7
40	36.2	1.32	4.3
45	40.6	1.46	5.9
50	44.9	1.60	7.4
55	49.1	1.75	8.9
60	53.5	1.88	10.4
65	57.9	2.02	11.8
70	62.3	2.15	13.1
75	67.6	2.31	14.5
80	71.0	2.42	15.8
85	75.1	2.55	17.0
90	79.6	2.68	18.2
95	84.2	2.81	19.4
100	88.4	2.95	20.6
110	97.1	3.21	23.0
120	105.9	3.49	25.0
130	114.8	3.77	27.5
140	123.6	4.04	29.8
150	132.4	4.32	32.1
160	141.1	4.59	34.3
170	150.0	4.88	36.5
180	158.8	5.15	38.8
190	167.5	5.44	41.0
200	176.4	5.72	43.2
220	194.0	6.28	47.5
240	212	6.85	51.9
260	229	7.38	56.5
280	247	7.95	60.5
300	265	8.51	64.9
325	287	9.24	70.3
350	309	9.95	75.8
375	331	10.7	81.2
400	353	11.4	86.8
425	375	12.1	92.0
450	397	12.8	97.4
475	419	13.5	103
500	441	14.2	108
550	485	15.6	119
600	529	17.0	130
650	573	18.5	141
700	617	19.9	152
750	661	21.3	163
800	705	22.7	173
850	749	24.2	184
900	793	25.6	195
950	837	27.0	206
1000	882	28.4	217
1200	1058	34.1	260
1400	1234	39.8	302
1600	1411	45.5	347
1800	1587	51	390
2000	1763	57	433
2500	2204	71	542
3000	2646	85	650
3500	3087	99	758
4000	3526	114	867
4500	3967	128	974
5000	4408	142	1082
5500	4849	156	1150
6000	5290	170	1300
6500	5730	185	1400
7000	6171	199	1510
7500	6612	213	1630
8000	7053	227	1740
8500	7494	242	1850
9000	7934	256	1960
9500	8375	270	2070
10000	8816	284	2200

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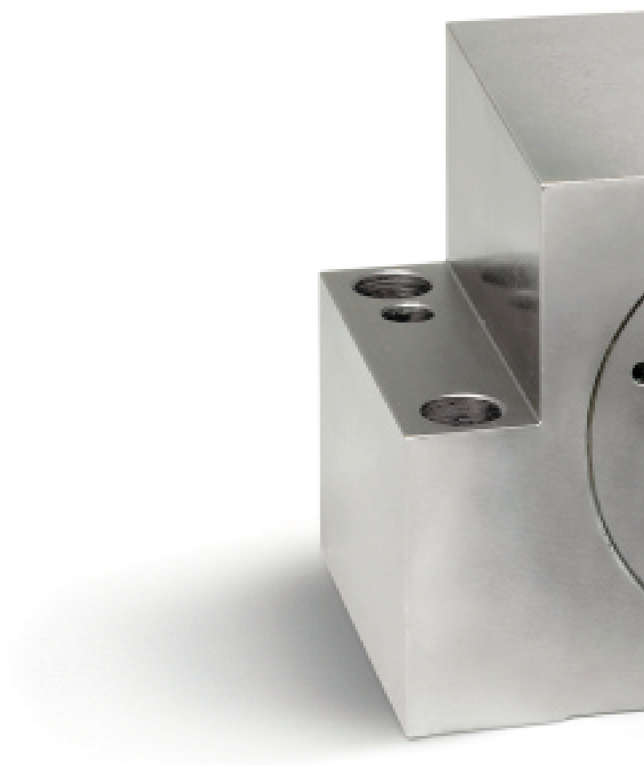

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