TIMKEN

Where You Turn

Timken® Super Precision Bearings for Machine Tool Applications

TIMKEN
Where You Turn

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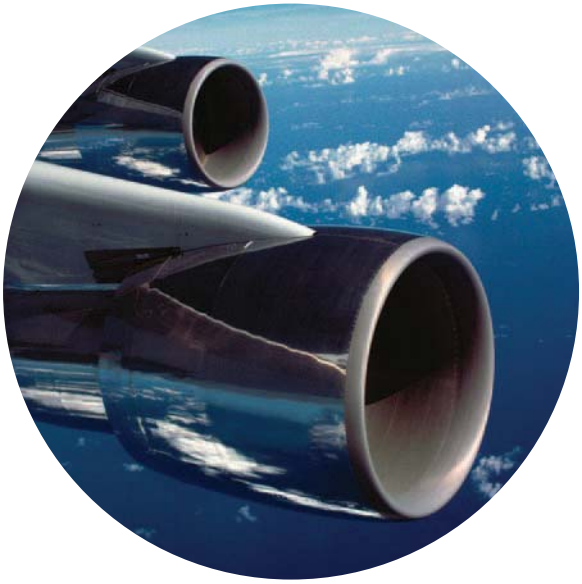


TIMKEN. WHERE YOU TURN.

The world turns to Timken for innovation to move ahead of the competition. Our contributions to advancing work and living standards – through innovations surrounding friction management and power transmission – are invaluable. We have played a role in virtually all major technologies that have shaped our age, from automobile travel to artificial hearts. You'll find our products wherever you turn – on land, sea and in space.

When customers turn to us, they are turning to a worldwide team of highly trained and experienced associates. Because of our ability to help their products perform better, customers honor us with more than 300 awards each year. Whether it is a wheel assembly for a family vehicle, bearings for a roller coaster, repair services for rail bearings or steel for an aircraft engine shaft, we supply the products and services that help keep the world turning.

FRICTION MANAGEMENT SOLUTIONS – A TOTAL SYSTEM APPROACH

As needs change and advanced motion control systems evolve, Timken is leveraging its knowledge of friction management to offer a broader array of bearings, related products and integrated services to the marketplace. We supply quality products and services that extend beyond bearings to help all systems run smoothly.

We are committed to providing a wide array of friction management solutions. Customers can benefit by having Timken, a trusted name for more than 100 years, evaluate entire systems, not just individual components. This approach provides cost-effective solutions, while also helping to achieve application-specific objectives.

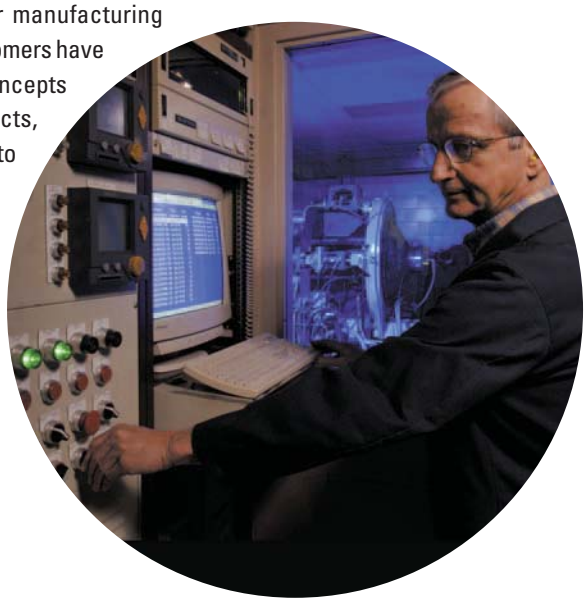
TECHNOLOGY THAT MOVES YOU

Today, major industries turn to Timken for our ability to influence the fundamentals of motion through the creation, transfer, and control of power. We invest in people, attracting scholars, engineers and specialists from around the world. We invest in tools – computers, manufacturing equipment and state-of-the-art laboratories. We invest in the future by identifying new concepts that will help Timken and its customers make their mark for years to come. Innovation is one of our core values.

The return on our technology investment has grown exponentially. Our associates increase the reliability of Timken® products and create designs that can set new performance standards. We help customers solve their immediate system issues, while developing the systems of tomorrow.

Our teams of engineers and scientists are dedicated to using everything they know about friction management and power transmission. They translate the scientific aspects of metallurgy, bearing operating characteristics, lubrication, torque, noise, heat treatment, advanced processing concepts and application development into friction management solutions.

Because our teams are located at technology centers in North America, Europe and Asia – as well as in our manufacturing facilities and field offices on six continents – customers have access to ideas and resources to transform concepts into reality. Our technology focuses on products, materials, processes and emerging technology to create new solutions.



BRANDS YOU CAN TRUST

Timken has built a strong tradition of quality, technology and innovation. A long list of customer certifications provides solid evidence that our products have earned customer trust. As our founder, Henry Timken, said, "Don't set your name to anything you will ever have cause to be ashamed of."

From design to distribution, Timken gives customers expanded options and the security of knowing that each box contains an industry-trusted product.

ABOUT THE TIMKEN COMPANY

The Timken Company is a diversified industrial manufacturer of innovative, highly engineered materials, products and power transmission systems. Timken's proprietary technologies reduce friction and enable machinery to operate more efficiently, powerfully and reliably, using less energy. With operations throughout the world, the company serves a wide range of mobile, industrial and aerospace customers

Timken has technical centers in North America, Europe and Asia and more than 100 years of engineering experience. Recognized by Forbes magazine in 2009 as one of the "100 Most Trustworthy Companies in America," Timken has been listed on the New York Stock Exchange since 1922.

TIMKEN MACHINE TOOL SOLUTIONS

When it comes to improving machine tool performance, Timken leads the industry with an unmatched offering of friction management solutions. Our roller bearings and related products and services set the standard in high-speed spindles, ball screws, rotary tables and other demanding applications. This wide variety means that we can offer the right bearing for almost any machine position.

Backed by global Timken innovation and a long machine tool heritage, we focus on enhancing customer performance and productivity through our product technology and application experience. With renowned Timken quality and a commitment to precision that exceeds industry standards, we continue to develop bearings that support the drive for higher speeds, maximum resolution, accuracy and repeatability. Longer bearing service life translates to more machine uptime and production throughput.

PRODUCT BREADTH

Timken offers a broad range of rolling bearings and related products and services to meet worldwide machine tool needs. Our portfolio includes specialized tapered roller and ball bearings, produced to the precision classes that deliver the operating characteristics necessary for the highest performance. Timken® bearings meet or exceed application needs for rotational accuracy, consistency and rigidity. Our total friction management approach also includes lubrication, condition monitors and other products “around the bearing.”

Timken® tapered roller bearing types available in precision classes include the single-row TS and TSF styles, as well as the variable-preload Hydra-Rib™ bearing, the high-speed TSMA bearing and the compact TXR crossed roller bearing. Timken® precision tapered roller bearings range from less than 20.000 mm (0.7874 in.) bore to more than 2000.000 mm (78.7402 in.) outside diameter, depending upon bearing type.

Timken® Fafnir® angular contact ball bearings are manufactured to ABEC 7 (ISO P4) and ABEC 9 (ISO P2) precision classes. They are available in 15 degree and 25 degree contact angles, as well as custom configurations. Different ring designs (WI, WO, WN and K) meet specific application requirements with either steel or ceramic balls. The HX and sealed HXVV bearings deliver high-speed benefits with unique ball complements and raceway geometries. Sizes range from 10.000 mm (0.3937 in.) bore to 400.000 mm (15.7480 in.) outside diameter.

Ball screw support bearings with steep contact angles, available singly, or in housed units, provide high levels of stiffness for the demands of servo-controlled machinery. Sealed double-row flanged (or cartridge) units simplify installation.

The Quick Change Program can perform cost-effective modifications and minor rework procedures to your machine tool bearings to extend operational and application flexibility.

Engineered Surfaces improve wear and fatigue resistance for bearings and other components through a variety of applied treatments and finishes.

Condition Monitoring Products and Services are available in an expanding offering that enables you to stay on top of machine performance, and quickly detect potential problems.

As a Timken customer, you receive an uncompromising standard of quality across the broadest range of bearings and related products. Brands like Timken and Fafnir reflect an extensive line of tapered, spherical, cylindrical, ball bearings and mounted units ideal for virtually every machine tool and industrial application. Our core products are complemented by an ever-growing line of friction management solutions including lubricants, single-point lubricators, maintenance tools, safety equipment, condition monitoring systems and repair services that help keep operations running smoothly.

Ultra-High Speed Spindle Grease, part of Timken's broad lubricant line, is specifically designed for the precision and high-speed bearings typically used in machine tools.

ABOUT THIS CATALOG

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

USING THIS CATALOG

We are committed to providing our customers with maximum service and quality. 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 bearing features. It can provide valuable assistance in the initial consideration of the type and characteristics of the bearing that may best suit your particular needs.

CATALOG FEATURES

Dimension and load rating data within the various types and styles of bearings is organized by size.

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.

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.

NOTE

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

LIMITED WARRANTY

We warrant for a period of one year (unless a shorter period applies to a particular product) from the date of shipment 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 our quotation or this 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.

TERMS AND CONDITIONS OF SALE

All products described in this catalog are sold subject to Timken's Terms and Conditions of Sale.

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, a copy of which may be obtained from your Timken sales office. Timken objects to any additional or different terms.

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

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

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

NOTE

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

SHELF LIFE AND STORAGE OF GREASE-LUBRICATED BEARINGS AND COMPONENTS

Timken guidelines for the shelf life of grease-lubricated rolling bearings, components and assemblies are set forth below. Shelf life information is based on test data and experience. Shelf life should be distinguished from lubricated bearing/component service life as follows:

SHELF LIFE

Shelf life of the grease-lubricated bearing/component represents the period of time prior to use or installation. The shelf life is a portion of the anticipated aggregate service life.

It is impossible to accurately predict service life due to variations in lubricant bleed rates, oil migration, operating conditions, installation conditions, temperature, humidity and extended storage. Timken cannot anticipate the performance of the grease lubricant after the bearing or component is installed or placed in service.

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.

Shelf life values, available from Timken, represent a maximum limit and assume adherence to the Timken suggested storage and handling guidelines. Deviations from Timken's storage and handling guidelines 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

Timken suggests the following storage guidelines for its 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 guidelines 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 percent.
- 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.

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

Most bearing types are typically shipped protected with a corrosion-preventive compound that is not a lubricant. Such bearings may be used in oil-lubricated applications without removal of the corrosion-preventive compound. When using some specialized grease lubrication it is advisable to remove the corrosion-preventive compound before packing the bearings with suitable grease.

Some bearing types in this catalog are pre-packed with general-purpose grease suitable for their normal application. Frequent replenishment of the grease may be necessary for optimum performance. Care must be exercised in lubricant selection, however, since different lubricants are often incompatible.

When specified by the customer, bearings may be ordered pre-lubricated with suitable greases and oils.

Upon receipt of a bearing shipment, it should be ensured that the bearings are not removed from their packaging until they are ready for mounting so that they do not become corroded or contaminated. Bearings should be stored in an appropriate atmosphere in order that they remain protected for the intended period.

Any questions concerning the shelf life or storage policy should be directed to your local sales office.

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ENGINEERING

A

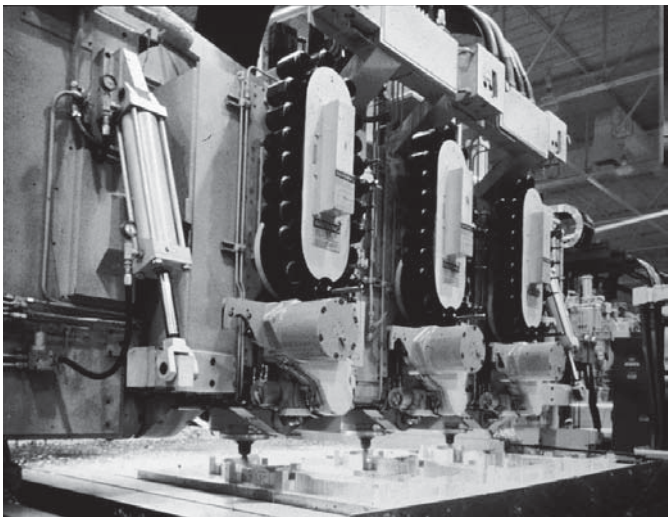
THE BEARING SELECTION PROCESS

TIMKEN® BEARINGS

Timken provides an extensive variety of rolling bearing types and sizes – to the extent that customers need not look elsewhere. Knowing that the bearing is often the most critical component within a moving assembly, Timken engineers take great care to ensure the customer is receiving maximum value when a Timken® bearing is selected to perform a given function. With the acquisition of the Fafnir® brand, Timken can provide the proper bearing for virtually any motion-control application. With more than 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 powerful resource for customers to turn to for assistance in the appropriate selection of bearings to meet any of the following considerations:

- Higher technical demands or higher levels of application requirements.
- Higher levels of machine complexity.
- Critical applications where system damage must be avoided for all modes of operation.
- Potential exposure to personal injury.
- Costly damage or downtime resulting from the use of an inappropriate bearing for a given task.



Because Timken offers so many bearing configurations to serve a wide variety of situations, a suggested starting point in the selection process should focus on the assessment of two basic categories: the first being boundary (or fixed) conditions and the second being performance expectations (or desired results). Depending on your application, the boundary conditions and performance expectations will vary. Trade-offs or compromises must often be addressed so that the final bearing type and size selected are a reasonable balance of all factors. It is a wise practice to examine factors critical to the success of the device and prioritize them.

Boundary (or fixed) conditions that should be taken into consideration include:

- External loads, including radial, thrust, moment, shock and combination loads.
- Acceleration and deceleration levels.
- Operating temperature range (including extreme limits and thermal cycling).
- Other environmental factors, such as humidity, fluids, vibration, debris, magnetic fields.
- Spatial constraints.

Performance expectations (or desired results) to consider include:

- Rotational accuracy and repeatability (e.g., service precision level).
- System rigidity (axial or radial stiffness).
- Application service life.
- Speed.

Since the rolling bearing is an integral part of the machine, looking at the key operating parameters of the system also will help focus on the most viable bearing solution.

Typical considerations in machine design also include optimization of controllable variables affecting application performance:

- Bearing design.
- Bearing shaft and housing arrangement; shaft and housing material.
- Installation and handling requirements of the bearing, as well as shaft and housing preparation.
- Presence of adequate sealing for the exclusion of contaminants; types of foreign materials possible.
- Lubricating method (lubrication type and delivery system).
- Maintenance procedures and intervals.

Once these conditions and expectations have been identified and prioritized, the most appropriate bearing type(s), size(s), and part number(s) that meet the basic application requirements can be selected.

BEARING PERFORMANCE CHARACTERISTICS

The following matrix should be viewed only as a general overview of bearings available from Timken and their general performance characteristics. Bearing selection is not a clear-cut, simplistic procedure, but rather a sequence of interdependent tasks that must take into consideration customer goals, manufacturing economics, design expectations and, above all, human safety.

Most machine tool applications require bearings with extreme precision, designed specifically to meet the boundary conditions and performance requirements. Timken® super precision bearings offer quality and precision tolerances to help customers achieve target job requirements and production throughput. It is always prudent to enlist the assistance of your Timken representative to achieve optimum results.

Tapered roller bearing

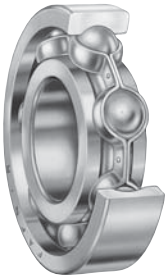
Thrust tapered roller bearing

Cylindrical roller bearing

Thrust cylindrical roller bearing

Spherical roller bearing

Thrust spherical roller bearing



Ball bearing

Thrust ball bearing

Needle roller bearing

Thrust needle roller bearing

Characteristic	Tapered roller bearing	Thrust tapered roller bearing	Cylindrical roller bearing	Thrust cylindrical roller bearing	Spherical roller bearing	Thrust spherical roller bearing	Ball bearing	Thrust ball bearing	Needle roller bearing	Thrust needle roller bearing
Pure radial load	Excellent	Unsuitable	Excellent	Unsuitable	Excellent	Unsuitable	Good	Poor	Excellent	Unsuitable
Pure axial load	Good	Excellent	Unsuitable	Good	Fair	Excellent	Fair	Excellent	Unsuitable	Excellent
Combined load	Excellent	Fair	Fair	Unsuitable	Excellent	Fair	Good	Poor	Unsuitable	Unsuitable
Moment load	Fair	Poor	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Good	Poor	Fair	Unsuitable
High stiffness	Excellent	Excellent	Good	Excellent	Good	Good	Fair	Good	Good	Excellent
Quiet running	Fair	Fair	Good	Poor	Fair	Poor	Excellent	Good	Good	Fair
Low friction	Fair	Fair	Good	Poor	Fair	Fair	Excellent	Excellent	Good	Good
Misalignment	Poor	Poor	Poor	Unsuitable	Excellent	Excellent	Good	Poor	Poor	Poor
Locating position (fixed)	Excellent	Good	Fair	Fair	Good	Good	Good	Excellent	Unsuitable	Excellent
Non-locating position (floating)	Good	Unsuitable	Excellent	Unsuitable	Fair	Unsuitable	Good	Unsuitable	Good	Unsuitable
Speed	Good	Good	Good	Poor	Fair	Fair	Excellent	Excellent	Good	Poor

Table 1. Relative operating characteristics of various bearing types.

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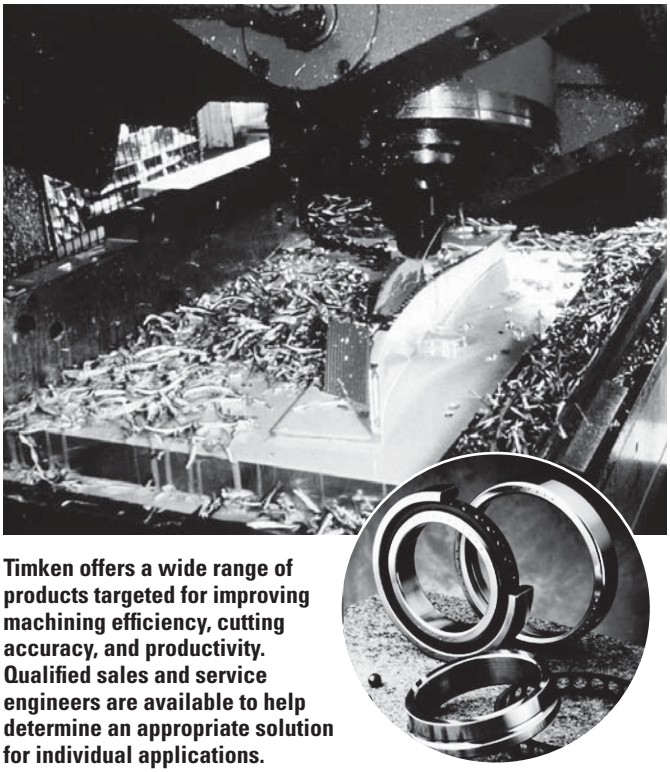
TIMKEN® SUPER PRECISION BEARINGS

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 rolling bearings used to support the spindles, rotating tables, ball screws and other critical precision positions. A manufactured bearing's precision level has a major influence on the ability to perform in high-speed applications commonly seen in factory machining environments.

WHICH TYPE OF TIMKEN BEARING IS MOST APPROPRIATE FOR YOUR MACHINE TOOL APPLICATION?

To achieve the highest possible performance precision level, the majority of machine tool-related bearing applications must address four primary requirements: speed, stiffness, accuracy and load capacity.



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 an appropriate solution for individual applications.

Speed

Today's industrial machining environments stress maximum production rates. To reach these high metal-removal goals, machines are operating at maximum speeds with working spindles tuned to provide premium running accuracy.

Achievable spindle rotating speeds require management of 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, especially where higher speeds are desired.

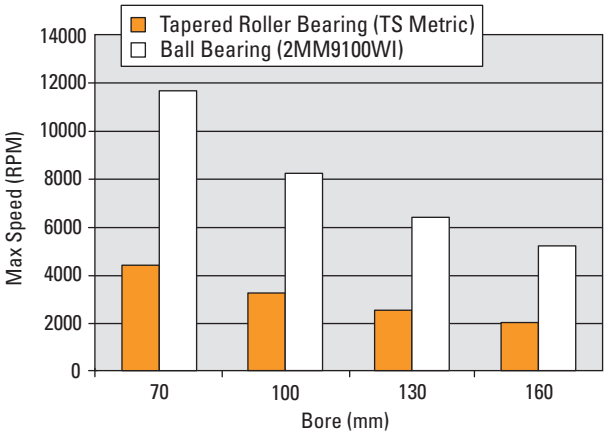


Fig. 1. Tapered roller bearing vs. ball bearing maximum permissible speed (with synthetic high-speed grease).

Figure 1 compares the relative maximum speed of similar cross section ball and tapered roller bearings (both using synthetic grease as a baseline lubricant). Therefore, in applications where higher RPM levels are the primary concern, ball bearings have a distinct advantage.

Bearings must be carefully designed to minimize heat generation and vibration to enable high speeds. Specific strategies include overall bearing configuration, precision internal geometry and material selection. Optimizing bearing ring and shoulder construction with the ball complement supports higher speed performance. Engineering raceway and ball geometry helps to minimize friction, while ceramic rolling elements generate less heat with reduced skidding.

To prevent vibration at high speeds, close bearing tolerances are required. Timken® machine tool bearings are designed to meet or exceed industry tolerance standards and deliver smooth running performance.

In addition to the use of hybrid ceramic technology, further enhancements in speed, as well as control of bearing noise and temperature, can be achieved through cage design or material, and choice of lubrication.

Many of the factors that allow for maximum speed have been designed into Timken's HX series of super precision ball bearings. Engineered for the reduction of friction and minimum heat buildup, this series features unique ball complements and precision-engineered surface geometries. Options for further enhancing speed include the use of low weight ceramic rolling elements, lubrication designed for high speed, and lighter preload levels. These are discussed in further detail later in this catalog.

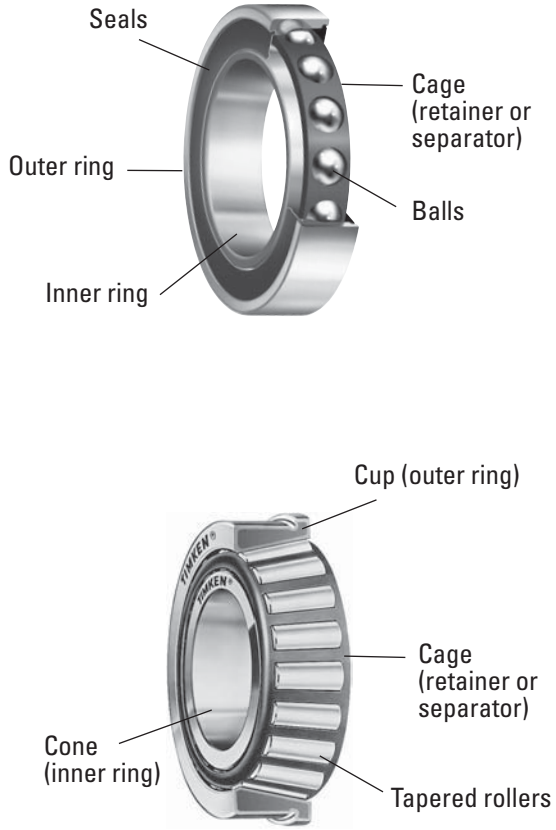


Fig. 2. Bearing components.

Stiffness

The ability to minimize tool deflection experienced under cutting loads is vital to achieving the accuracy needed to produce finished parts within specified tolerances. Less variance produces better quality and helps keep product scrap levels at a minimum. Bearings have a significant effect on spindle stiffness, due to their deflection under applied load. Because of their internal geometry and rolling element type, tapered roller bearings provide considerably higher stiffness levels as shown in Figure 3 and 4.

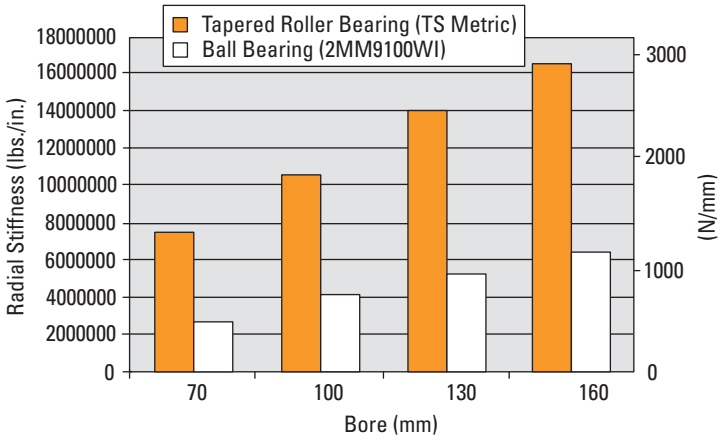


Fig. 3. Tapered roller bearing vs. ball bearing radial stiffness.

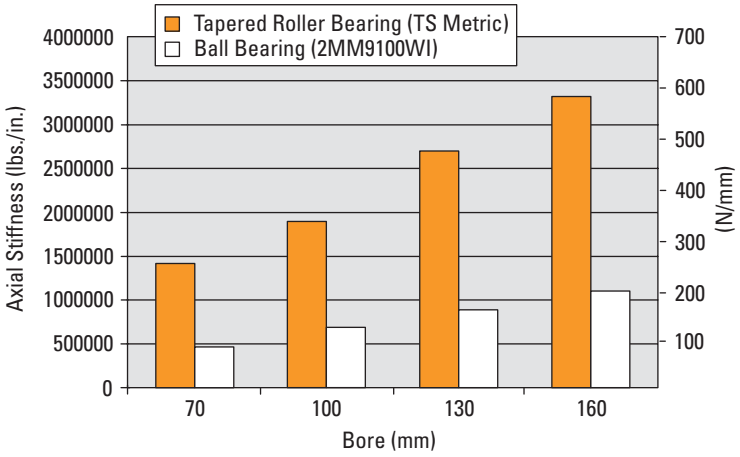


Fig. 4. Tapered roller bearing vs. ball bearing axial stiffness.

Bearing stiffness also depends on design load zone, which is directly related to bearing setting, clearances and applied loads. (Setting is defined as a specific amount of either end play or preload.)[1] A bearing under radial load with zero end play/zero preload has a load zone close to 180 degrees, while a bearing with preload can reach 360 degrees load zone. Figure 5 shows the effect of load zone on tapered roller bearing stiffness. The curves demonstrate that while the effect of external loads on stiffness is important, the impact from setting is more significant.

[1]For additional information, see guidelines on page 101.

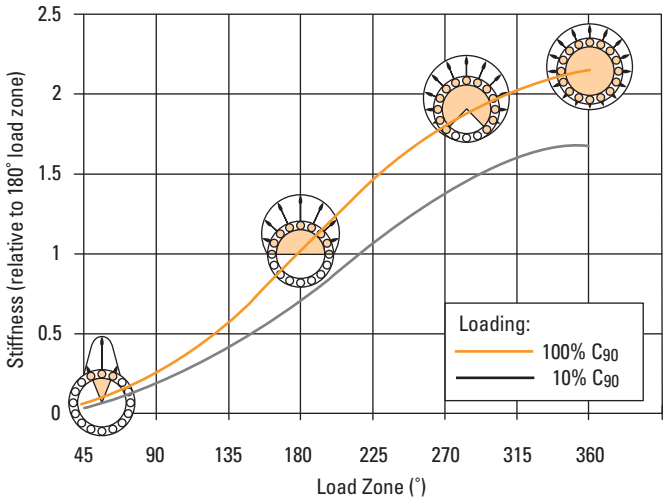


Fig. 5. Effect of load zone on bearing stiffness.

Since thermal expansion can dramatically affect preload or setting, it can also play a very important role in the resulting static and dynamic stiffness of a spindle system. This applies to ball bearings as well.

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, or during running by the use of a "variable preload" bearing design such as Timken® Hydra-Rib™ and Spring-Rib™ bearings.

To better manage the load sharing of the set of rolling elements, Timken offers a variety of designed-in preload levels for ball bearings. Be conservative with the addition of preloading as these forces will contribute to heat generation, reducing the maximum permissible speed of either ball or tapered roller bearing designs.

Accuracy

Another key factor in the machine's precision is the runout (rotational accuracy) of the bearing. This affects the geometry and surface finish of the target workpiece. For the ultimate accuracy and repeatability of machine tool motion, Timken® super precision ball bearings offer the best control, with quietness of operation and reduced vibration. To achieve the highest level of precision with increased stiffness and load capacity, multiple ball bearings may be used in sets specifically designed for this purpose.

The most widely recognized definition of quality is contained within the ABEC/ISO classes; however some factors affecting performance of a bearing are not completely defined within these standards. This allows for a significant range of variability in product performance among bearing manufacturers. To provide premium performance, all Timken ball bearing MM, MMV and MMX precision grades comply with strict controls over these non-specified parameters – all of which can have a direct impact on the service life and performance of a bearing.

System bearing type			Precision bearing class			
Metric	Timken	Tapered roller bearings	C	B	A	AA
		Crossed roller bearings	S	P	–	–
	ISO/DIN	All bearing types	P5	P4	P2	–
	ABMA	Non-tapered roller bearings	RBEC 5	RBEC 7	RBEC 9	–
		Ball bearings	ABEC 5	ABEC 7	ABEC 9	–
		Tapered roller bearings	C	B	A	–
Inch	Timken	Tapered roller bearings	3	0	00	000
		Crossed roller bearings	3	0	–	–
	ABMA	Ball bearings	ABEC 5	ABEC 7	ABEC 9	–
		Tapered roller bearings	3	0	00	–

Table 2. Precision bearing classes.

Super Precision Ball Bearings, Super High Precision (ABEC 7/9; ISO P4/P2)

Timken super precision ball bearings manufactured to the MM/MMV tolerance class operate with running accuracy and performance levels meeting ABEC 9 (ISO P2) standards yet maintain other features at ABEC 7 (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.

Ultra-Precision Ball Bearings (ABEC 9, ISO P2)

Timken MMX super precision ball bearings, with closer tolerances and running accuracies than ABEC 7 (ISO P4) bearings, are made to ABEC 9 (ISO P2) tolerances. Bearings produced to these tolerances are generally used on ultra-high-speed grinding spindles designed for tight dimensional tolerances and superfine surface finishes. Contact your Timken representative for availability of product range.

Precision Tapered Roller Bearings (Class C/S/3, B/P/0 and A/00)

The more demanding the precision objective, the more accurate the bearing must be. Timken provides three tapered roller bearing classes, in both metric and inch systems, that cover the full range of precision application requirements. In ascending order of accuracy, they are identified in the metric system as Class C/S, B/P, and A, while in the inch system as Class 3, 0, and 00.

Precision Plus™ Tapered Roller Bearings (Class 000/AA)

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

• High-speed motorized routers. • Precision milling/boring machines. • Super precision lathes. • Precision surface grinding machines.	Class MM/MMV
• Ultra-precision grinding machines. • Ball screws.	Class MMX
• Low precision machines. • Drilling machines. • Conventional lathes. • Milling machines. • Precision gear drives.	Class C or 3
• Grinding machines. • Jig boring machines. • Workpiece 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

Timken engineers 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 for common machine tool bearing applications.

Table 3. Typical precision classes for common machine tool bearing applications.

A

Load Capacity

Some machining centers, such as rough grinding operations, are strategically designed for higher material removal rates. The need for aggressive feed rates requires higher load-carrying capacities. These loads can be properly distributed among the rolling elements by providing a permanent force called "preload" or "setting." Preload is the strategic removal of radial play within the bearing to ensure proper rolling element contact on both the inner and outer race. 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 decreasing the importance of bearing capacity.

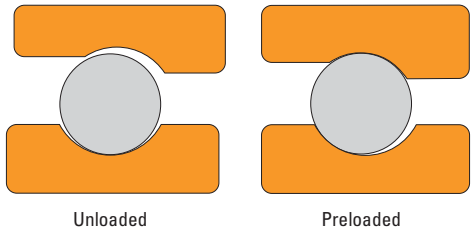


Fig. 6. Effect of preloading on ball bearing raceway contact.

Figure 7 compares the levels of static capacity of ball vs. tapered roller bearings for the benefit of contrasting basic load capability of both bearing types.

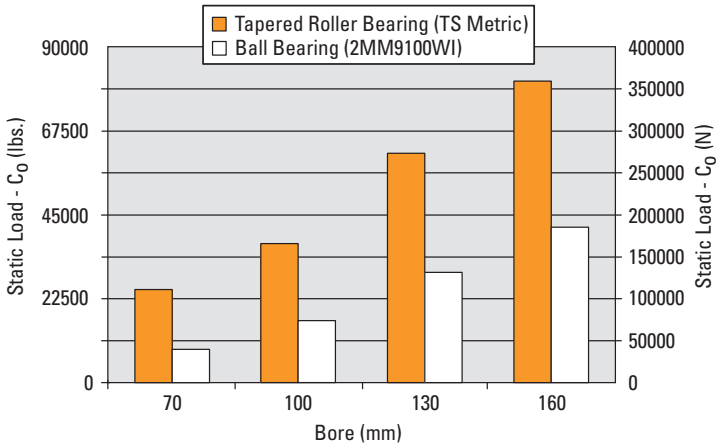


Fig. 7. Tapered roller bearing vs. ball bearing static capacities.

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

Timken can assist in the final bearing selection to help you achieve your precision machining production goals. Timken's staff of application engineers is ready to put its vast experience to any test for assisting our customers with the challenging bearing applications commonly found in the machine tool industry. To refine your search, please turn to the sections covering tapered roller bearings (Sec. B) or ball bearings (Sec. C) for more information needed to obtain a complete Timken part number specification.

TIMKEN® MACHINE TOOL BEARING DESIGN

From this introductory discussion and the additional technical content within this catalog, one can obtain an indication of which rolling bearing type should be further investigated to meet the given set of boundary conditions and performance expectations.

TIMKEN® PRECISION TAPERED ROLLER BEARINGS

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

True Rolling Motion

The angled raceways of a tapered roller bearing enable it to carry combinations of radial and axial loads. True rolling motion of the rollers and line contact on the race allow the bearing to run cooler and improve spindle stiffness and accuracy as compared to 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 so extensions of the lines along the roller body converge toward the centerline of the bearing and meet at an apex on this centerline (Figure 8). As a result, there is no relative slip between the rollers and races.

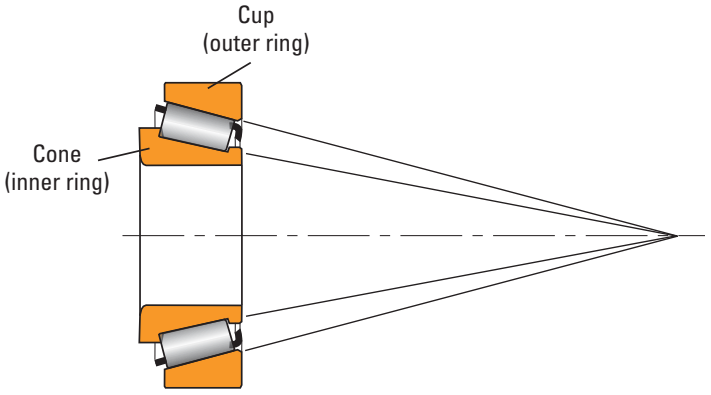


Fig. 8. On-apex design results in true rolling motion at all points along the roller body.

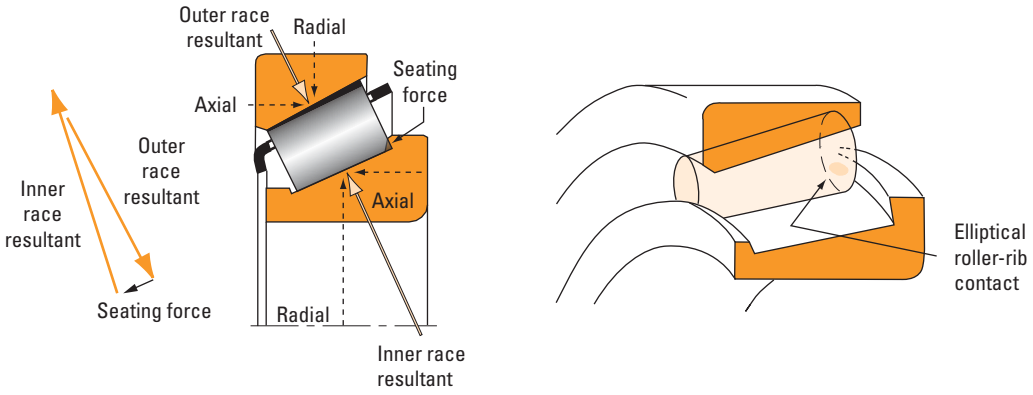


Fig. 9. Small seating force from the inner race rib keeps rollers aligned on the raceway.

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 that 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 (Figure 9) and prevents rollers from skewing off apex. No skew means positive roller alignment, thereby enhancing bearing life, stiffness and accuracy.

Some applications require a level of precision that cannot be achieved 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.

PRECISION CLASSES

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

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

To better serve the global machine tool market, Timken has manufacturing resources around the world focused exclusively on premium precision bearings. With these dedicated resources, precision quality is built into the bearing during manufacturing. To further increase service reliability, Timken precision tapered roller bearings are manufactured from high-quality steel alloys.

A

Precision Tapered Roller Bearing Types

The size range of Timken precision tapered roller bearings starts from less than 20.000 mm (0.7874 in.) bore and extends to more than 2000.000 mm (78.7402 in.) O.D., depending on bearing type. The most popular types made in precision classes are the single-row TS and flanged TSF as shown in Sec. B. Comprised of two main separable parts, they are usually fitted as one of an opposing pair. 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 is available only in precision classes. Timken also offers a selection of two-row precision tapered roller bearings types such as the double outer ring type TDO.

Crossed Roller Bearings

A crossed roller (TXR) bearing is comprised of 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-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. This bearing also is well-suited for 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 common form of the bearing is type TXRDO, which has a double outer race and two inner races, with rollers spaced by separators.

Other mounting configurations and sizes of crossed roller bearings can be supplied to meet particular assembly or setting requirements. Please contact your Timken representative for further information. Also, refer to Section B for more details.

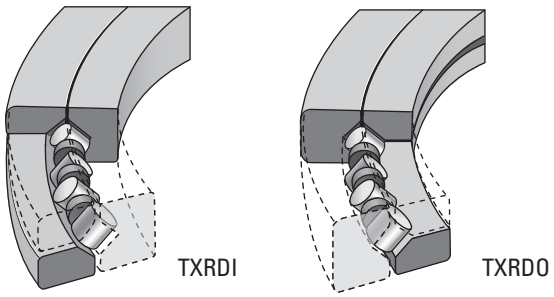


Fig. 10. TXRDI and TXRDO.

Hydra-Rib™ Bearings

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 provides good results over a range of speeds and power. However, for very wide variations of speed and load, the variable preload Timken Hydra-Rib bearing concept is an excellent solution.

The Hydra-Rib bearing (Figure 11) has a floating outer ring rib in contact with the large roller ends instead of the usual fixed inner ring 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.

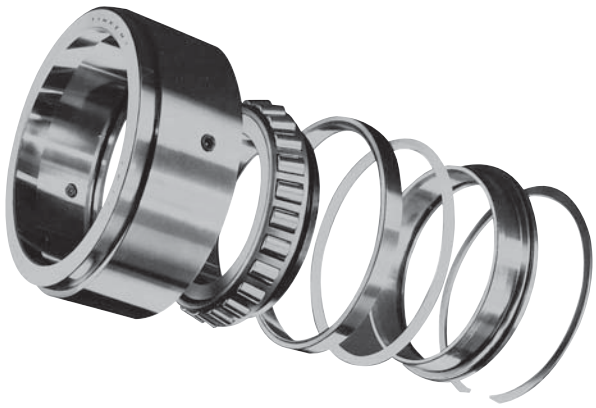


Fig. 11. Exploded view of a typical Hydra-Rib™ bearing.

The controlled pressure enables the floating rib to maintain constant spindle preload even though 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.

Your Timken representative should be consulted to determine the optimum bearing selection as well as the pressure figures, as a function of the given running conditions.

TIMKEN® SUPER PRECISION BALL BEARINGS

The Timken line of super precision machine tool ball bearings is designed to meet ABEC 7/9 (ISO P4/P2) tolerance levels. However, Timken manufactures all super precision ball bearings to surpass ISO/ABMA criteria to ensure that the end users receive only the highest quality product to maximize machine performance.

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

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

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

Most of the bearing types are available in either 15 degree (2MM) or 25 degree (3MM) contact angles. In addition, Timken now stocks more ceramic ball sizes than ever for the highest speed requirements.

The K-type deep-groove (Conrad) super precision radial bearing is generally used in applications where capacity and stiffness do not require sets containing multiple bearings. By virtue of the single-row, radial deep-groove construction, and super precision level tolerances, these are capable of carrying thrust loads in either direction, and have a relatively high-speed capability – especially if a light axial preload is applied. Timken offers deep-groove 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, Timken® ball screw support bearings are specially designed with steep contact angles and provide high levels of stiffness for ball screw application requirements. Timken's series of double-row, sealed, flanged (or cartridge) units use an 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).

A

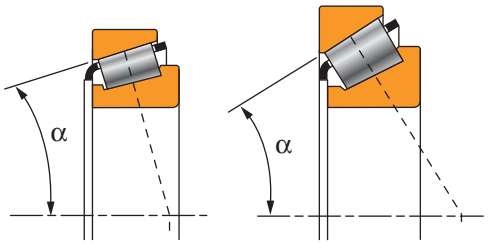
SELECTING THE APPROPRIATE MACHINE TOOL BEARING

PRECISION TAPERED ROLLER BEARINGS

Angularity (K-factor)

The angled raceways allow the tapered roller bearing to carry combinations of radial and axial loads. Since load capacities are intrinsically linked to the bearing stiffness, the selection of the most appropriate tapered roller bearing cup angle can help optimize the bearing selection for a given application.

The angularity of the bearing is often described by a factor called "K." This factor is the ratio of basic dynamic radial load rating (C_{90}) to basic dynamic axial 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 geometry factors in the catalog appendix. The smaller the K factor, the steeper the bearing angle. (See Figure 12).



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

Fig. 12. Designs to support radial and axial loads in any combination.

Size

Optimizing stiffness is often a customer's primary design goal when choosing a tapered roller bearing. This usually results in the determination of a desired spindle diameter. Therefore, meeting a given envelope narrows the choices for the tapered roller bearing size selection.

Speed

The next most common criteria are the speed capability/limitations of the remaining potential candidates. This can be challenging, since the speed rating 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. There is a speed guideline matrix on page 54 that will aid in determining the speed rating and suggested lubricant/delivery method for your tapered roller bearing application. Included in the appendix is a table listing the G_1 and G_2 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 topics on permissible operating speeds and heat generation for further discussion.

Construction

Tapered bearings are uniquely designed to manage both axial and radial loads on rotating shafts and in housings. The steeper the cup angle, the greater the ability of the bearing to handle axial loads. Customized geometries and engineered surfaces can be applied to these bearings to further enhance performance in demanding applications.

Timken has designed a variety of tapered roller bearing types to specifically address various machine tool requirements. Each of these designs is best suited to a specific set of application needs. The key features of each type are highlighted below:

TS or TSF Bearing

- Most widely used type of tapered roller bearing.
- Minimum precision grade Level 3 or C (ISO P5).
- TSF has a flanged outer ring to facilitate axial location.
- Available in most bearing series.
- Used in rotating shaft applications.

TSMA Bearing

- Axial oil manifold with axial holes through rib.
- Suitable with circulating oil or oil mist lubrication.
- Centrifugal force distributes oil to critical rib/roller end contact.
- Available in most precision grades.
- Available in most bearing series.
- Used in rotating shaft applications.

Hydra-Rib Bearing

- Designed to maintain optimum spindle system preload.
- Floating outer ring rib is positioned by a "pressure" system.
- Rib in contact with the large roller ends instead of the usual fixed inner ring rib.
- Variable preload setting adaptable to manual, tape, or computer control.
- Wide speed range with optimum preload setting.
- Improved spindle accuracy.
- Improved static and dynamic stiffness.
- Lower operating temperatures.
- Heavier cuts with better tool life.

Spring-Rib Bearing

- Designed to maintain optimum spindle system preload.
- Floating outer ring rib is positioned by a "spring" system – pressurizing system not required.
- Rib in contact with the large roller ends instead of the usual fixed inner ring rib.
- Improved spindle accuracy.
- Improved static and dynamic stiffness.
- Heavier cuts with better tool life.

Crossed Roller Bearing

- Designed to resist overturning loads.
- Steep-angled geometry provides wider effective spread.
- High tilting stiffness.
- Adjustable design for optimum preload.
- Compact design reduces space requirement.
- Reduced application machining costs.

End Play (Preload)

The end play of a tapered roller bearing during installation affects:

- Load zone control, impacting bearing life.
- System rigidity, impacting deflection.
- Housing and shaft diameter tolerances.

End play/preload setting is determined based on desired stiffness, reduction in heat generation, and optimal rated life. For information on setting, please see page 101.

Precision Class

Typically, once the most appropriate bearing part number is identified for a particular application, the final parameter is the desired precision level. Standard class tapered roller bearings have crowned or enhanced profiles for races and rollers. Timken precision tapered roller bearings have straight profiles with running accuracy and performance meeting ABEC 5/ISO P5, ABEC 7/ISO P4, and ABEC 9/ISO P2 levels. The Precision Plus series offers total radial runout of less than a single micron, exceeding the ABEC 9/ISO P2 precision level and allowing for improved accuracy. The suggested assembly and/or inspection code (precision class and performance code) can be applied to the chosen part number to obtain the necessary precision level.

Other

Consult Timken for suggestions related to appropriate bearing enhancements that can 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.

A

SUPER PRECISION BALL BEARINGS

As previously noted, optimizing speed, stiffness, accuracy and load capacity is often a customer's primary design goal. This usually results in the identification of several characteristics that will determine the final bearing selection. The following design variables influence bearing performance as noted.

Contact Angle

A contact angle is created between the rolling element and raceway to support a combination of radial and axial (thrust) loads. Deep-groove (Conrad) bearings designed with 0-degree contact angle are best for supporting radial loads or small axial loads in two directions. To support high axial or combination loads, angular contact bearings are often preferred. For additional support of radial and axial load in either direction, sets of bearings in opposing directions are utilized.

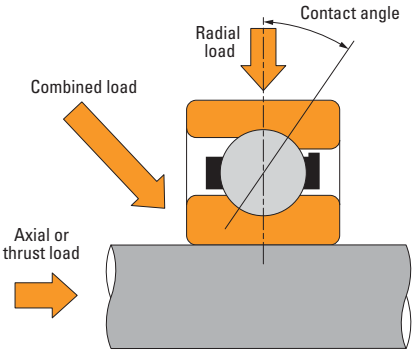


Fig 13. Example of ball bearing loading.

The majority of Timken angular contact super precision ball bearings are available with standard high (25 degree) and low (15 degree) contact angles, with additional options upon request. Each type has inherent characteristics that are desirable for machine tool spindles. Contact angle is chosen primarily based on the predominant load direction.

- 15º - used when loading is primarily radial; for very high speed applications.
- 25º - used when loading is primarily axial.
- 60º - highest axial stiffness; used in ball screw support bearings.

High speeds cause centrifugal forces on the ball. A lower contact angle handles the centrifugal force more favorably as higher speeds lead to higher internal radial loads.

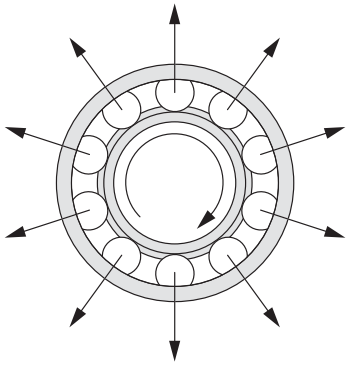


Fig 14. Centrifugal forces of a rotating ball bearing.

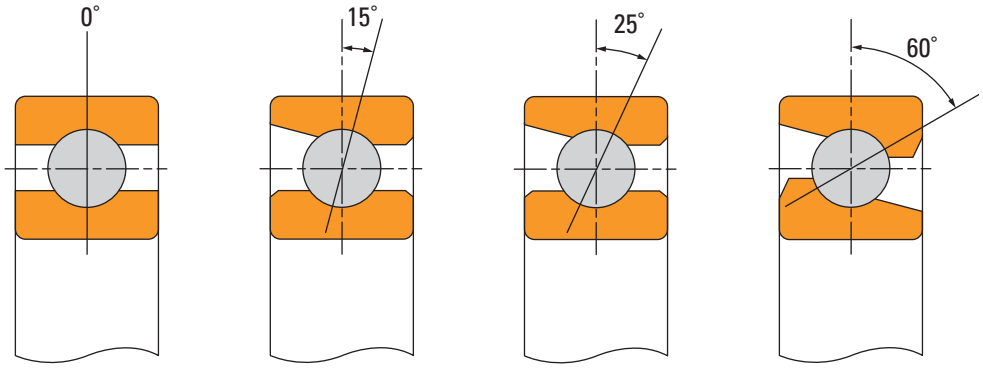


Fig 15. Examples of common machine tool ball bearing contact angles.

Spindle rotating speeds are limited by heat generated within the bearing assembly. As viewed in Figure 16, a lower contact angle minimizes heat buildup yielding lower operating temperatures at higher speeds.

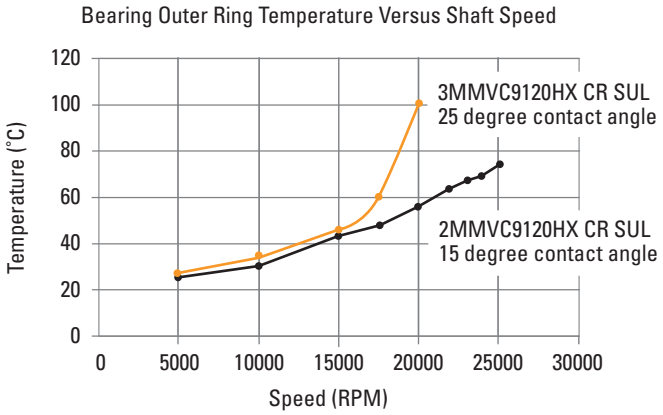


Fig 16. Effect of contact angle on temperature.

Axial deflection curves for two like-series, equal bore-sized bearings with standard preloads and contact angles are shown below.

A comparison of the curves in Figure 17 shows the 25-degree contact angle bearing to be more rigid axially under axial loads than the 15-degree contact angle bearing. 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 18. These curves show that decreased radial deflections result when bearings having a lower, 15-degree angle are used.

Generally, the force for the equivalent preload level for a 15-degree contact angle bearing is about one-half that of the preload level for a 25-degree contact angle bearing. Preload values for all Timken machine tool grade angular contact bearings are calculated to give optimum performance over a wide range of applications.

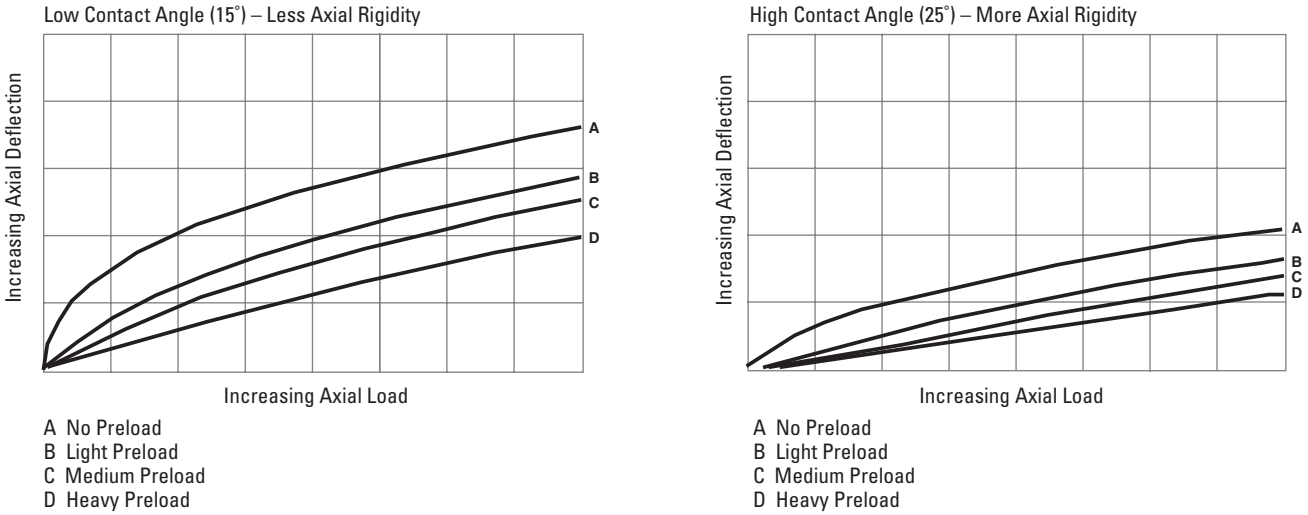


Fig. 17. Effect of contact angle on axial deflection.

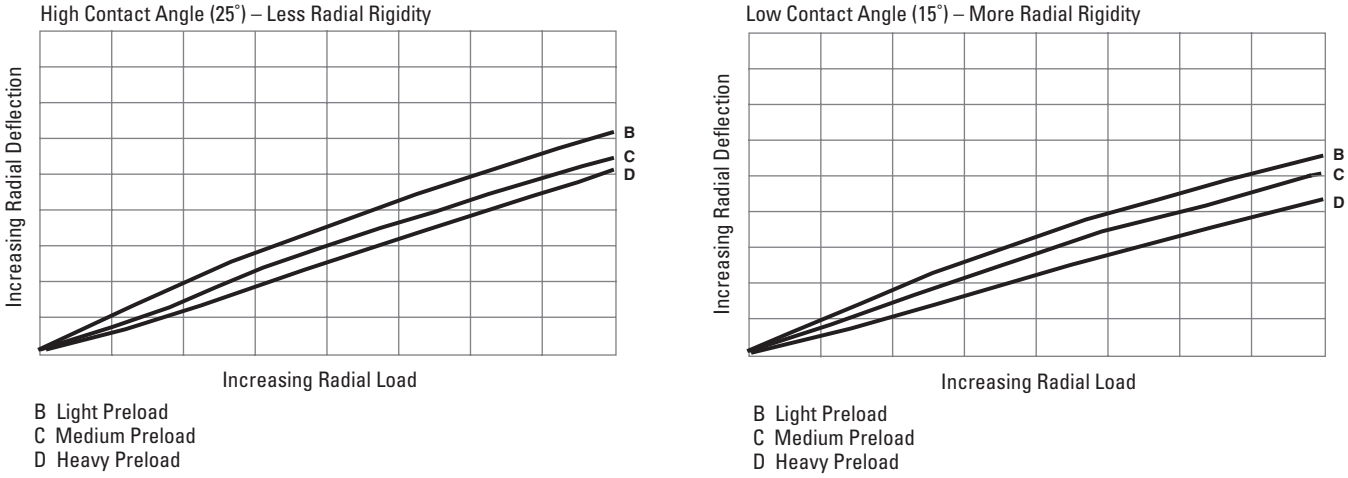


Fig. 18. Effect of contact angle on radial deflection.

Timken ball screw support bearings are designed with a 60-degree contact angle. They are used for low-speed operations and offer the highest axial stiffness in the standard super precision ball bearing machine tool line. As contact angle increases, axial stiffness increases, radial stiffness decreases, and maximum operating speed decreases.

Precision Class

Super high precision MM/MMV bearings are manufactured with running accuracy and performance meeting ABEC 9/ISO P2 while maintaining other features at ABEC 7/ISO P4 levels for cost-effectiveness.

Ultraprecision MMX ABEC 9/ISO P2 have closer tolerances on bore and O.D. Bearings produced to these tolerances are used on ultra-high-speed grinding spindles designed for tight dimensional tolerances and superfine surface finishes.

Hybrid Ceramic

Timken has designed an advanced bearing that combines ceramic rolling elements with premium steel rings and state-of-the-art bearing technology to achieve maximum speed capability and greater stiffness. Compared with an all-steel bearing, the hybrid ceramic bearing's lower friction characteristics, even under marginal lubrication, result in less ball skidding, lower heat generation, higher speeds and greater overall system reliability.

Ceramic balls are 60 percent lighter than steel with extremely fine surface finishes equal to or less than 0.5 micro-inch Ra. This helps to reduce centrifugal forces and allows for a 20 percent higher speed factor than steel balls. Oil-lubricated ceramic hybrid bearings can operate up to three million dN, while grease-lubricated ceramic hybrids can run up to one million dN.

dN = bore size (mm) x speed (RPM)

The ceramic material has a modulus of elasticity 50 percent greater than steel, increasing bearing rigidity. This higher stiffness may result in higher contact stress levels in the bearings. Ceramics are generally not appropriate for higher loads and/or low speeds. As seen in Figure 19, below 750,000 dN, ceramic balls experience a reduction in overall rated bearing life.

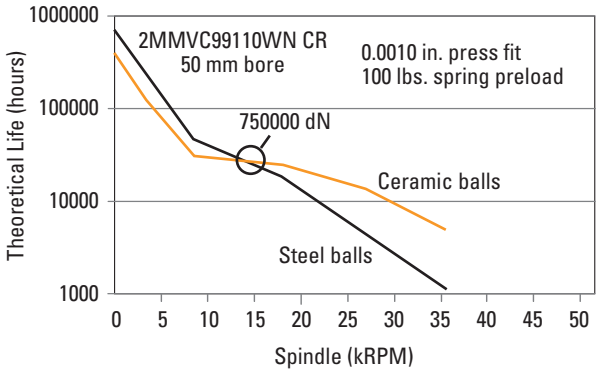


Fig. 19. L_{10} life vs. speed comparison of steel and ceramic balls.

Size/Series

Increasing bearing size causes an increase in centrifugal forces which, as discussed earlier, reduces the speedability of the bearing. An increase in ISO cross-section series improves the ability of a bearing to carry higher loads as shown in Figure 20.

- 9300 series: ultra-light loads, high speed.
- 9100 series: extra-light loads, high speed.
- 200 series: light loads.
- 300 series: medium loads.

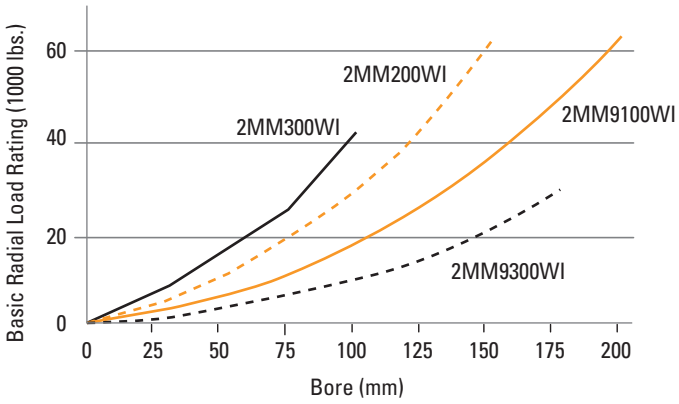


Fig 20. Angular contact ball bearing load ratings.

When stiffness is a factor of the design, this usually results in the determination of a desired spindle diameter and corresponding bearing bore size. Speedability and load capacity then determine the series selected.

Construction

WI is the standard construction for an angular contact ball bearing. The WI-type has full shoulders on both sides of the inner ring and a low shoulder on the outer ring. This simplifies bearing assembly during manufacturing.

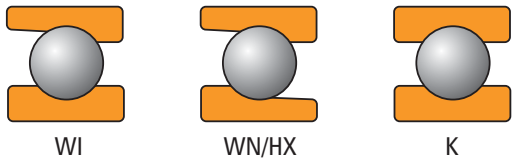


Fig. 21. Angular contact spindle bearing types.

Timken has developed an HX bearing design to enhance two key factors contributing to metalworking throughput: spindle speed and radial stiffness. This design enables spindle heads to remove more material in less time while maintaining superior finished product tolerances by minimizing tool "wander." This efficient combination translates into faster turnaround of finished product. These improvements are imparted by subtle changes to ball complements and internal geometries. The Timken HX Series is dimensionally interchangeable with the 9300 and 9100 series ball bearings.

The HX and WN-types also are designed to meet the needs of machine manufacturers who require optimum lubrication through the bearings. These designs incorporate a low shoulder on the non-thrust side of both the inner and outer rings to facilitate oil flow.

K-type, deep groove (Conrad), 0-degree radial ball bearings are generally chosen in applications where capacity and stiffness do not require a duplex set of bearings. Axial load applied to the bearing will increase the contact angle.

Cage (Retainer or Separator)

A cage's function is to separate the rolling elements within the bearing. It first affects bearing performance by adding weight, which will increase the centrifugal forces and resulting radial load at high speeds. This limits the ability of the bearing to perform at high temperatures. Timken's range of cage types includes:

CR	Phenolic (composition) - standard
PRC	Molded reinforced nylon - former standard
MBR	Machined bronze
PRJ	High-performance polymer
SR	Silver-plated machined steel

Timken's phenolic composition cage is standard for high-speed applications up to 93°C (200°F). For high-heat applications, machined bronze is often used. However, the increase in weight reduces the speedability of the bearing assembly.

Seals

Seals are used to exclude contaminants and retain lubricant for reliable bearing operation and extended service life. The HX bearing has an optional non-contacting seal, available as single or pair (V, VV). The WI 9100 and 9300 series have an optional light-drag contacting seal (P, PP). Ball screw support bearing cartridges (MMN/MMF) include integral, low-torque contact seals.

Bearing Set Quantity

Timken super precision ball bearings are available as single, duplex, triplex, and quadruplex matched sets:

SU	(X, L, M, H) - single bearing/preload level
DU	(X, L, M, H) - duplex pairs/preload level
TU	(X, L, M, H) - triplex set/preload level
QU	(X, L, M, H) - quadruplex set/preload level

Each additional bearing increases system rigidity and load-carrying capabilities. The quantity of bearings in a set is specified in the part number as shown.

A

Timken super precision ball bearings are universal flush ground, which allows for DB (back-to-back), DF (face-to-face), or DT (tandem) mounting of all matched duplex sets. This does not need to be specified during order.

Preload Level

The internal condition of a preloaded ball bearing is similar to that of one in operation under axial load. This initial axial load serves to decrease markedly the axial and radial deflections when subsequent operational loads are imposed on the bearing assembly. Preload levels limit change in contact angle at very high speeds, and prevent ball skidding under very high acceleration and speed.

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, which may result in bearing damage. To match general performance requirements, four classes of ball bearing preloads are used – extra-light, light, medium and heavy. To maximize performance, Timken can design specially preloaded super precision ball bearings.

Sealed Ball Screw Support Bearings

Available in flanged (MMF) and non-flanged (MMN) series, these designs simplify installation for both standard and rotating nut mountings. The flanged version eliminates the need for external clamping of the outer ring. The standard version is the sealed duplex configuration, but both series may be ordered with seals or shields in either a duplex or quad set arrangement.

Wear/Debris-Resistant Material

Advanced bearings can resist debris wear for improved machine tool performance and service life. Timken super precision bearings with WearEver technology combine a special high-alloy steel with ceramic balls to provide superior performance and cutting quality for high-speed applications. Extended capabilities help improve machine efficiency and utilization while reducing secondary finishing operations and downtime.

This unique, wear/debris-resistant steel was specifically incorporated into the bearing design to withstand damage from hard contaminants, a primary cause for shortened bearing life. Studies have shown that bearings with this advanced material can deliver up to ten times the standard service life in the presence of hard contamination. This represents a significant advancement in high-speed machining productivity and improved product quality. Consult your Timken representative for availability.

Other

Bearings may be customized to specify lubrication type, special coding, special part marking, etc. Contact your Timken representative for more information.

2 MM C 91 04 WI CR DUL **A4437**
FS637

A4437 = Special coding requirement
FS637 = Kluber isoflex NBU 15 Grease

Fig. 22. Examples of non-standard specification numbers.

SPINDLE SYSTEM CHARACTERISTICS

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.

Due to increasing cutting speeds and 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 rolling bearing used.

SPINDLE SYSTEM 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 (lbs./in.).

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

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

- Bare spindle stiffness.
- Bearing stiffness.
- Housing stiffness.

Bare Spindle Stiffness

Figure 23 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.

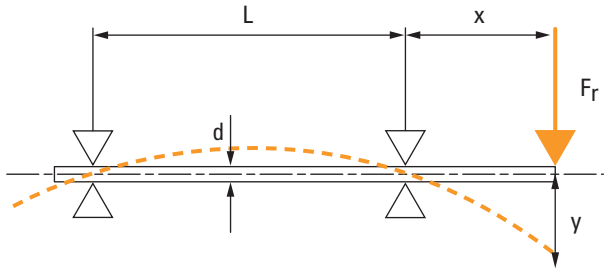


Fig. 23. Deflection of the bare spindle on two supports.

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

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

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:

$$K = \frac{F_r}{y} = \frac{3EI}{x^2(x + L)} = \frac{3E\pi d^4}{64x^2(x + L)}$$

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. From a design standpoint, this means that the selected bearings should have as large a bore diameter as practical for a given outside diameter (Figure 24).

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 (Figure 25).

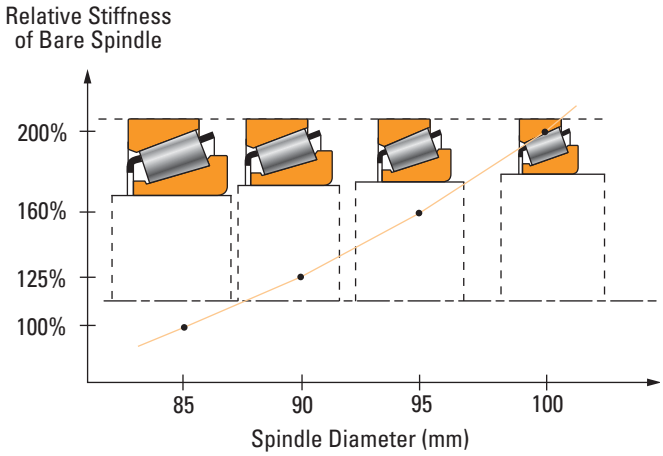


Fig. 24. Influence of spindle diameter on its stiffness for different tapered roller bearings sections within same envelope (85 mm bore taken as reference).

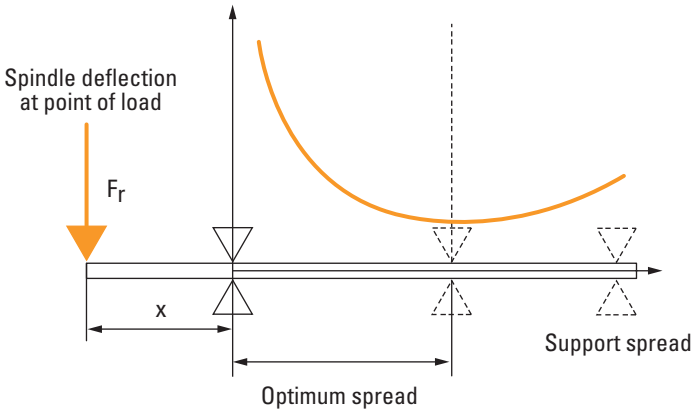


Fig. 25. Influence of spread on bare spindle deflection at point of load.

Bearing Stiffness

Stiffness is significant in precision machining applications. This impacts machine repeatability and running accuracy. Bearing stiffness is determined by movement or microscopic deflection under load within the bearing assembly.

Because of the contribution of bearing stiffness to the global system, it is of prime importance to consider the effect of the selection of the bearing and its geometrical characteristics. 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.

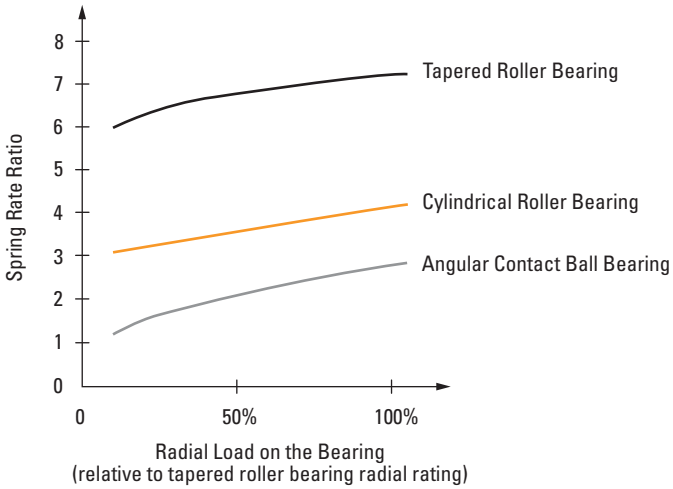


Fig. 26. Radial spring rate comparison between popular machine tool bearings of a comparable size under zero internal clearance.

Comparisons (Figure 26) show that a tapered roller bearing has as much as six 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.

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 stiffness should be verified.

SPINDLE SYSTEM DYNAMIC STIFFNESS

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

Figure 27 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.

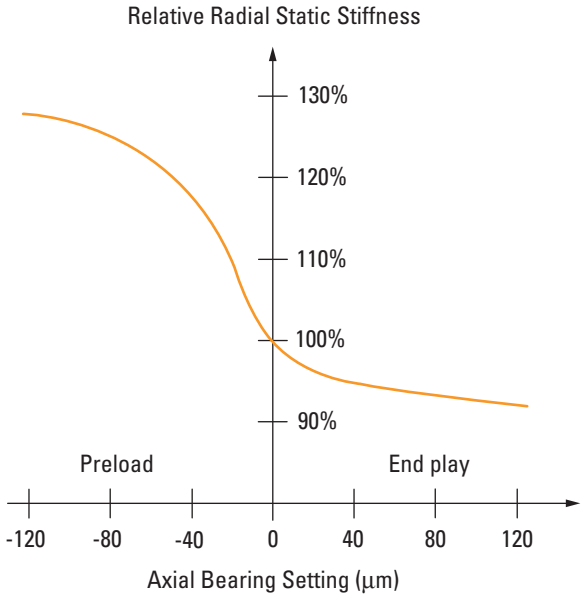


Fig. 27. Effect of bearing setting on spindle system static stiffness.

A load that would cause very little static deflection can cause very high dynamic 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 in Figure 28 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.

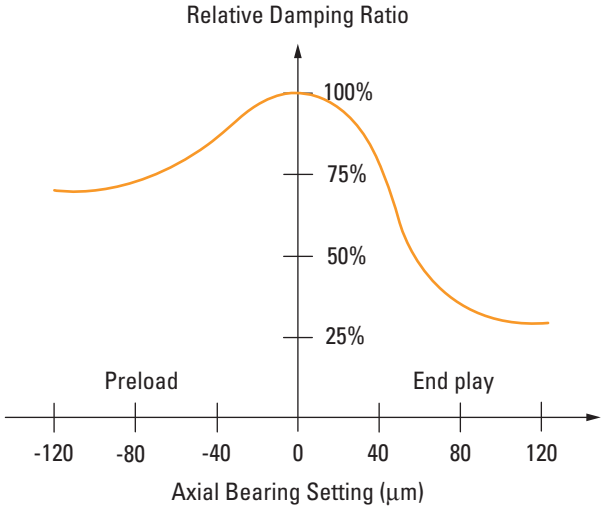


Fig. 28. Effect of bearing setting on spindle system damping ratio.

Finally, the resulting dynamic stiffness characteristics of a spindle system are directly affected by the bearing setting. The curve plotted in Figure 29 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 Timken has resulted in a better knowledge of machine tool spindle behavior. It was identified that higher accuracy and improved surface finish can be achieved at an optimum preload setting (Figure 30).

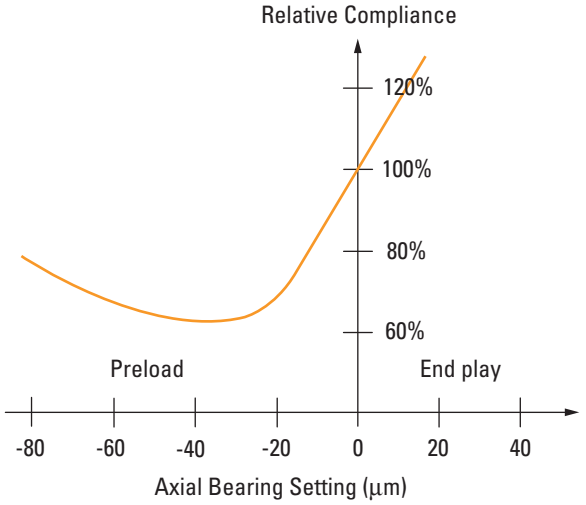


Fig. 29. Effect of bearing setting on spindle system dynamic stiffness.

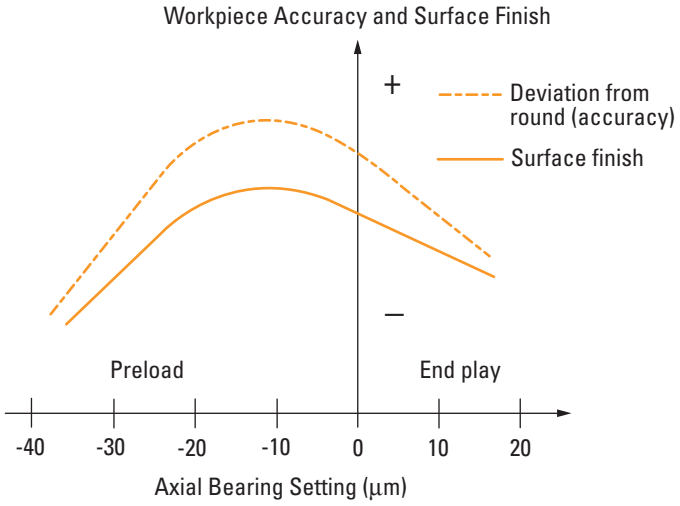


Fig. 30. Effect of bearing setting on surface finish and accuracy of the workpieces.

The unique design of a tapered roller bearing with its line contact produces a damping characteristic that is not necessarily inherent to other bearing designs (Figure 31). This is due to the bending mode of the spindle and bearing centerline caused by dynamic deflection which 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 that results in improved damping characteristics.

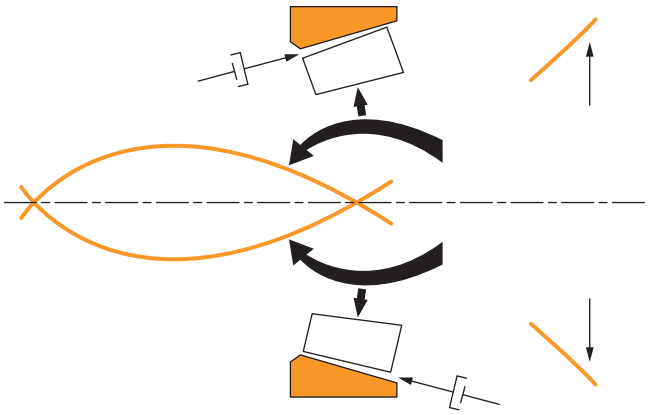


Fig. 31. Damping in a tapered roller bearing.

An extension of this insight culminated in the development of a bearing system called the Hydra-Rib. It is, 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. Also, 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.

OTHER FACTORS AFFECTING BEARING SELECTION

Some additional 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.

THERMAL EXPANSION

Issues such as axial displacement must be addressed where shaft length differentials must be tolerated when thermal expansion occurs. For these 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 motion and thereby maintain workpiece accuracy. Installation considerations for the typical fixed bearing positions should note the fitting suggestions 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 design must allow for axial displacement of the shaft. This can be accomplished by allowing the bearing to “slide” laterally along the shaft or housing respectively. A looser fit during the machining of the shaft or housing cavity is required. This not only alleviates the axial stresses on this end of the assembly, but will also facilitate bearing and shaft installation.

MISALIGNMENT

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 mounting (DF, face-to-face).

This can help compensate for machining variations and assist in managing dynamic forces by featuring a spherical outside diameter or thrust face.

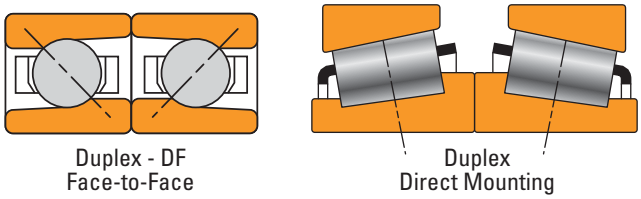
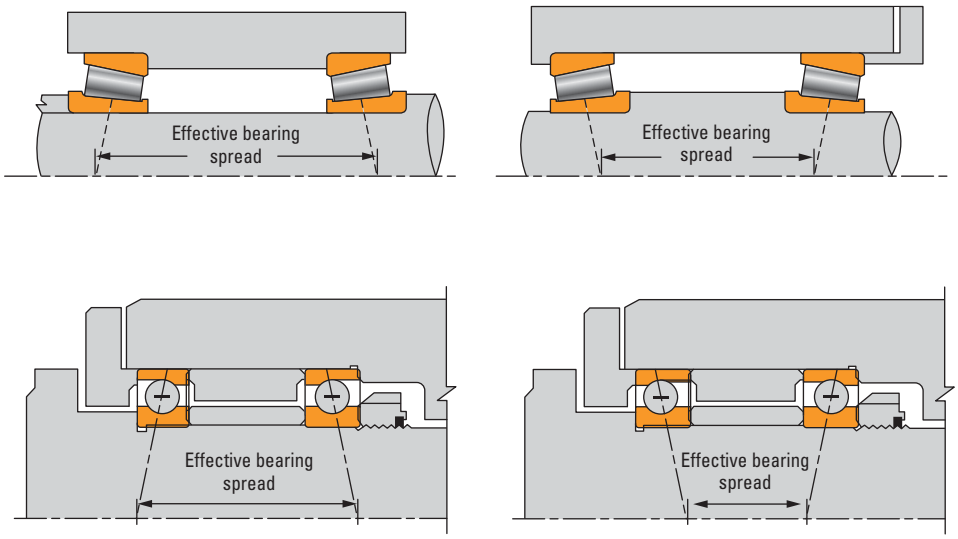


Fig. 32. Self-aligning bearing mountings.



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

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

Fig. 33. Choice of mounting configuration for single-row bearings, showing position of effective load-carrying centers.

EFFECTIVE SPREAD

When a load is applied to a tapered roller or angular contact ball bearing, the internal forces at each rolling element-to-outer raceway contact act normal to the raceway. These forces have radial and axial components. With the exception of the special case of pure axial loads, the inner ring and the shaft will experience moments imposed by the asymmetrical axial components of the forces on the rolling elements.

It can be demonstrated mathematically that, if the shaft is modeled as being supported at its effective bearing center rather than at its geometric bearing center, the bearing moment may be ignored when calculating radial loads on the bearing. Only externally applied loads need to be considered, and moments are taken about the effective centers of the bearings to determine loads or reactions. Figure 33 shows single-row bearings in a direct and indirect mounting configuration. The choice of whether to use direct or indirect mounting depends upon the application.

With so many factors to consider for the successful operation of any device incorporating rolling bearings, Timken brings to its customers more than 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 not be considered the final word. Timken bearing expertise is only a phone call away.

A

DETERMINATION OF APPLIED LOADS AND BEARING ANALYSIS

This key is not intended to be comprehensive, but serves as a useful reference for symbols found in this catalog.

SUMMARY OF SYMBOLS USED IN THIS CATALOG

Symbol	Description	Units
a_1	Reliability Life Factor	
a_2	Material Life Factor	
a_3	Operating Condition Life Factor	
a_{3d}	Debris Life Factor	
a_{3h}	Hardness Life Factor	
a_{3k}	Load Zone Life Factor	
a_{3l}	Lubrication Life Factor	
a_{3m}	Misalignment Life Factor	
a_{3p}	Low Load Life Factor	
a_e	Effective Bearing Spread	mm, in.
b	Tooth Length	mm, in.
c_1, c_2	Linear Distance (positive or negative)	mm, in.
C	Dynamic Radial Load Rating	N, lbf
C_0	Static Load Rating	N, lbf
C_{90}	Single-Row Basic Dynamic Load Rating	N, lbf
C_e	Extended Dynamic Capacity	N, lbf
C_p	Specific Heat of Lubricant	J/(kg -˚C), BTU/(lb x ˚F)
d	Bearing Bore Diameter	mm, in.
d_c	Distance Between Gear Centers	mm, in.
d_m	Mean Bearing Diameter	mm, in.
dN	Bore in mm • RPM	
D	Bearing Outside Diameter	mm, in.
D_m	Mean Diameter or Effective Working Diameter of a Sprocket, Pulley, Wheel or Tire Also, Tapered Roller Bearing Mean Large Rib Diameter	mm, in.
D_{mG}	Mean or Effective Working Diameter of the Gear	mm, in.
D_{mP}	Effective Working Diameter of the Pinion	mm, in.
D_{mW}	Effective Working Diameter of the Worm	mm, in.
D_{pG}	Pitch Diameter of the Gear	mm, in.
D_{pP}	Pitch Diameter of the Pinion	mm, in.
D_{pW}	Pitch Diameter of the Worm	mm, in.
e	Life Exponent	
f	Lubricant Flow Rate	L/min, U.S. pt/min
f_B	Belt or Chain Pull Factor	
F	General Term for Force	N, lbf
F_a	Applied Axial Load	N, lbf
F_{ae}	External Axial Load	N, lbf
F_{aG}	Axial Force on Gear	N, lbf
F_{aP}	Axial Force on Pinion	N, lbf
F_{aW}	Axial Force on Worm	N, lbf
F_c	Centrifugal Force	N, lbf
F_r	Applied Radial Load	N, lbf
F_{sG}	Separating Force on Gear	N, lbf
F_{sP}	Separating Force on Pinion	N, lbf
F_{sW}	Separating Force on Worm	N, lbf
F_{tG}	Tangential Force on Gear	N, lbf
F_{tP}	Tangential Force on Pinion	N, lbf
F_{tW}	Tangential Force on Worm	N, lbf
F_W	Force of Unbalance	N, lbf
$F_{\Phi P}$	Axial Force on Pinion	N, lbf
H	Power	kW, HP
HF_s	Static Load Rating Adjustment Factor for Raceway Hardness	
k	Centrifugal Force Constant	lbf/RPM^2
k_1	Bearing Torque Constant	N-m, lbf-in.
k_4, k_5, k_6	Dimensional Factor to Calculate Heat Generation	

Symbol	Description	Units
K	Tapered Roller Bearing Radial-to-Axial Dynamic Load Rating Factor	
K_T	Relative Axial Load Factor (Ball Bearings)	
L_H	Lead Axial Advance of a Helix for One Complete Revolution	mm, in.
L	Distance Between Bearing Geometric Center Lines	mm, in.
m	Gearing Ratio	
M	Bearing Operating Torque or Moment	N-m, N-mm, lbf-in.
n	Bearing Operating Speed or General Term for Speed	rot/min, RPM
n_G	Gear Operating Speed (RPM)	rot/min, RPM
n_P	Pinion Operating Speed (RPM)	rot/min, RPM
n_W	Worm Operating Speed (RPM)	rot/min, RPM
N_G	Number of Teeth in the Gear	
N_P	Number of Teeth in the Pinion	
N_S	Number of Teeth in the Sprocket	
P_a	Dynamic Equivalent Axial Load	N, lbf
P_0	Static Equivalent Load	N, lbf
P_{0a}	Static Equivalent Axial Load	N, lbf
P_{0r}	Static Equivalent Radial Load	N, lbf
P_r	Dynamic Equivalent Radial Load	N, lbf
Q	Generated Heat or Heat Dissipation Rate	W, BTU/min
r	Radius	
R	Percent Reliability Used in the Calculation of the a_1 Factor	
T	Torque	N-m, lbf-in.
v	Vertical (used as subscript)	
V	Linear Velocity or Speed	km/h, mph
V_r	Rubbing, Surface or Tapered Roller Bearing Rib Velocity	m/s, fpm
X	Dynamic Radial Load Factor	
Y	Dynamic Axial Load Factor	
Y_1, Y_2, Y_3	Axial Load Factors	
Υ_G	Bevel Gearing – Gear Pitch Angle	deg.
	Hypoid Gearing – Gear Root Angle	deg.
Υ_P	Bevel Gearing – Pinion Pitch Angle	deg.
	Hypoid Gearing – Pinion Face Angle	deg.
α	Half Included Cup Angle	deg.
A, B...	Bearing Position (used as a subscript)	cSt
η	Efficiency, Decimal Fraction	
θ_{ambt}	Ambient Temperature	˚C, ˚F
θ_1, θ_2, θ_3	Gear Mesh Angles Relative to the Reference Plane	deg.
θi, θo	Oil Inlet or Outlet Temperature	˚C, ˚F
λ	Worm Gear Lead Angle	deg.
μ	Coefficient of Friction	
v	Lubricant Kinematic Viscosity	cSt
σ_0	Approximate Maximum Contact Stress	MPa, psi
Φ	Normal Tooth Pressure for the Worm (Gearing)	deg.
Φ_G	Normal Tooth Pressure Angle for the Gear	deg.
Φ_P	Normal Tooth Pressure Angle for the Pinion	deg.
Ψ_G	Helix (Helical) or Spiral Angle for the Gear	deg.
Ψ_P	Helix (Helical) or Spiral Angle for the Pinion	deg.
ρ	Lubricant Density	kg/m^3, lb/ft^3
1, 2, ...n	Conditions (used as subscript)	

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

Spur Gearing

Tangential force

$$F_{tG} = \frac{(1.91 \times 10^7)\, H}{D_{pG}\, n_G} \quad \text{(newtons)}$$

$$= \frac{(1.26 \times 10^5)\, H}{D_{pG}\, n_G} \quad \text{(pounds-force)}$$

Separating force

$F_{sG} = F_{tG} \tan \phi_G$

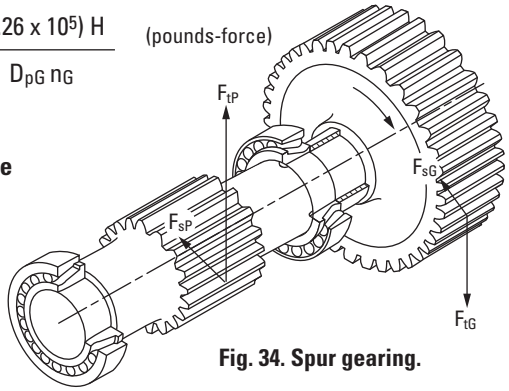


Fig. 34. Spur gearing.

Single Helical Gearing

Tangential force

$$F_{tG} = \frac{(1.91 \times 10^7)\, H}{D_{pG}\, n_G} \quad \text{(newtons)}$$

$$= \frac{(1.26 \times 10^5)\, H}{D_{pG}\, n_G} \quad \text{(pounds-force)}$$

Thrust force

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

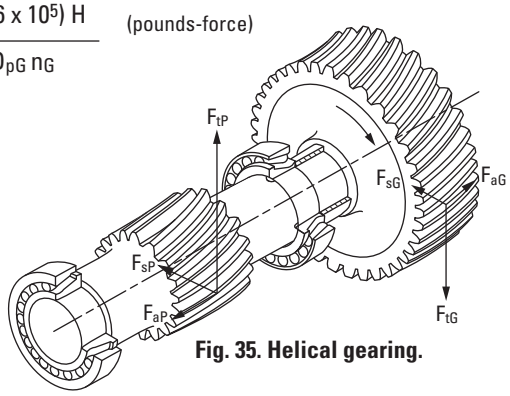


Fig. 35. Helical gearing.

Separating force

$$F_{sG} = \frac{F_{tG} \tan \phi_G}{\cos \psi_G}$$

Straight Bevel and Zerol Gearing with Zero Degrees Spiral

In straight bevel and zerol gearing, the gear forces tend to push the pinion and gear out of mesh, such that the direction of the thrust and separating forces is always the same regardless of direction of rotation (Figure 36). In calculating the tangential force (F_{tP} or F_{tG}) for bevel gearing, the pinion or gear mean diameter (D_{mP} or D_{mG}) is used instead of the pitch diameter (D_{pP} or D_{pG}). The mean diameter is calculated as follows:

$D_{mG} = D_{pG} - b \sin \Upsilon_G$ or $D_{mP} = D_{pP} - b \sin \Upsilon_P$

In straight bevel and zerol gearing:

$F_{tP} = F_{tG}$

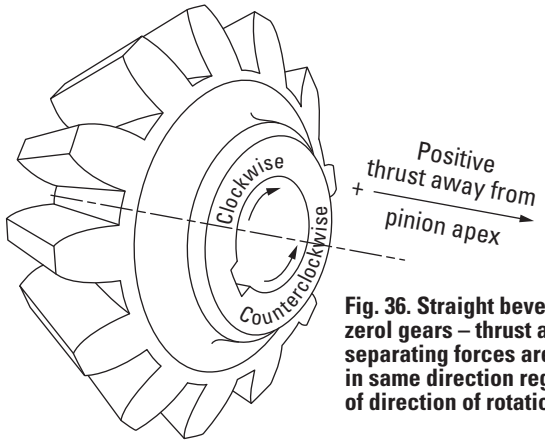


Fig. 36. Straight bevel and zerol gears – thrust and separating forces are always in same direction regardless of direction of rotation.

Pinion

Tangential force

$$F_{tP} = \frac{(1.91 \times 10^7)\, H}{D_{mP}\, n_P} \quad \text{(newtons)}$$

$$= \frac{(1.26 \times 10^5)\, H}{D_{mP}\, n_P} \quad \text{(pounds-force)}$$

Thrust force

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

Separating force

$F_{sP} = F_{tP} \tan \phi_P \cos \Upsilon_P$

A

Straight Bevel Gear

Tangential force

$$F_{tG} = \frac{(1.91 \times 10^7)\, H}{D_{mG}\, n_G} \quad \text{(newtons)}$$

$$= \frac{(1.26 \times 10^5)\, H}{D_{mG}\, n_G} \quad \text{(pounds-force)}$$

Thrust force

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

Separating force

$$F_{sG} = F_{tG} \tan \phi_G \cos \Upsilon_G$$

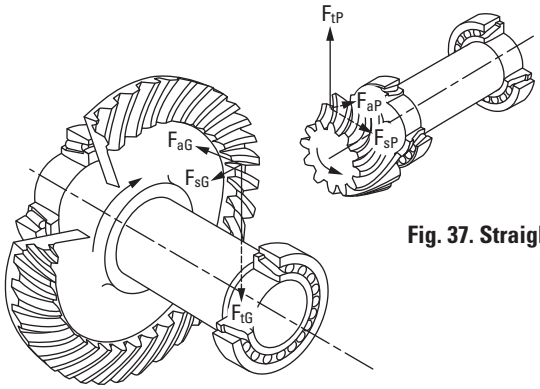


Fig. 37. Straight bevel gearing.

Spiral Bevel and Hypoid Gearing

In spiral bevel and hypoid gearing, the direction of the thrust and separating forces depends upon spiral angle, hand of spiral, direction of rotation, and whether the gear is driving or driven (see 4). The hand of the spiral is determined by noting whether the tooth curvature on the near face of the gear (Figure 38) inclines to the left or right from the shaft axis. Direction of rotation is determined by viewing toward the gear or pinion apex.

In spiral bevel gearing:

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

In hypoid gearing:

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

Hypoid pinion effective working diameter:

$$D_{mP} = D_{mG} \left(\frac{N_p}{N_G} \right) \left(\frac{\cos \Psi_G}{\cos \Psi_P} \right)$$

Tangential force

$$F_{tG} = \frac{(1.91 \times 10^7)\, H}{D_{mG}\, n_G} \quad \text{(newtons)}$$

$$= \frac{(1.26 \times 10^5)\, H}{D_{mG}\, n_G} \quad \text{(pounds-force)}$$

Hypoid gear effective working diameter:

$$D_{mG} = D_{pG} - b \sin \Upsilon_G$$

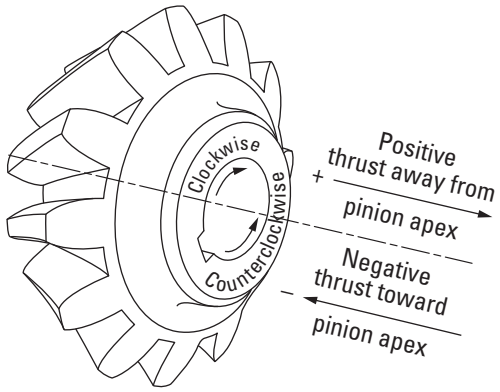


Fig. 38. Spiral bevel and hypoid gears – the direction of thrust and separating forces depends upon spiral angle, hand of spiral, direction of rotation, and whether the gear is driving or driven.

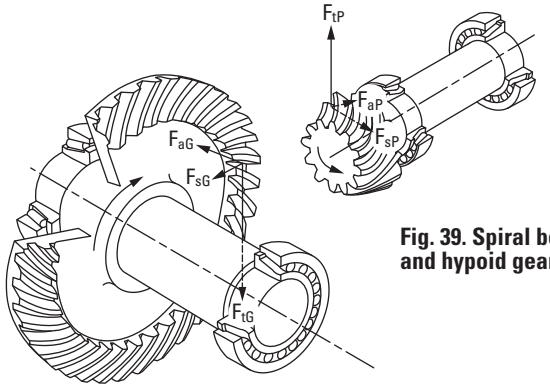
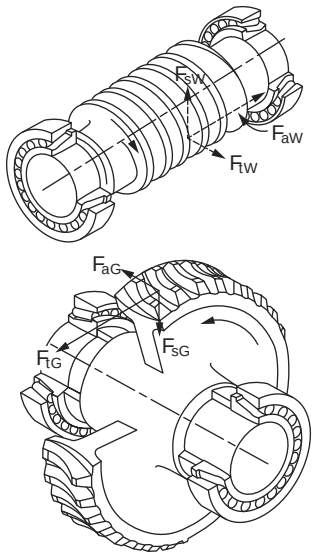


Fig. 39. Spiral bevel and hypoid gearing.

Driving member rotation	Thrust force	Separating force
Right hand spiral counterclockwise or Left hand spiral clockwise	Driving member $F_{aP} = \frac{F_{tP}}{\cos \gamma_P} (\tan \gamma_P \sin \gamma_P + \sin \gamma_P \cos \gamma_P)$	Driving member $F_{sP} = \frac{F_{tP}}{\cos \gamma_P} (\tan \gamma_P \cos \gamma_P .. \sin \gamma_P \sin \gamma_P)$
	Driven member $F_{aG} = \frac{F_{tG}}{\cos \gamma_G} (\tan \gamma_G \sin \gamma_G .. \sin \gamma_G \cos \gamma_G)$	Driven member $F_{sG} = \frac{F_{tG}}{\cos \gamma_G} (\tan \gamma_G \cos \gamma_G + \sin \gamma_G \sin \gamma_G)$



A

BALL BEARINGS

Even though ball bearings have the least amount of friction of any of the common rolling 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 cage. 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.

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.

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.

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 too much lubrication just as it can from too little. Both conditions should be avoided. Excessive oil or grease will result in high temperature and possible damage. When grease is used, it is necessary to take into consideration the maximum operating temperature. Particular attention must be given to the housing design relating to the proximity of the grease to the bearing, 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.

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 = lubrication factor
F_P = preload factor
F_B = ball material factor

N_G is Permissible Speed for a 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 or metered oil	F_L = 2.00

Table 11. Lubrication factor = (F_L).

Bearing mounting arrangement	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

Table 12. Bearing preload factor = (F_p).

Ball material factor (F_B)	
Steel balls	F_B = 1.00
Ceramic balls[1]	F_B = 1.20

[1]Ceramic balls allow 20 percent increase to speed factor.

Table 13. Ball material factor (F_B).

GREASE

The use of grease as a lubricant for Timken 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 correct grease, 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 two or less. The firmer grease has a worked penetration factor of three 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 500000 dN value, which is equivalent to a 50.000 mm (1.9685 in.) bore bearing rotating at 10000 RPM, either a light-consistency grease or the channeling grease may be used.

At continuous speeds above a dN value of 500000, the operating temperature is generally lower when the bearings are lubricated with a lower-consistency grease and after sufficient break-in.

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 damage.

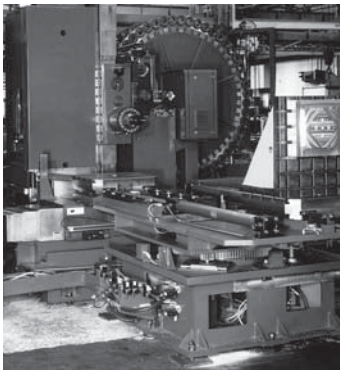
Grease and Speed Capability

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 x RPM

The most common spindle greases that Timken suggests for Timken spindle ball bearings are:

Unirex N3	Vertical applications < 500000 dN
Mobil 28	Light loads < 600000 dN
Chevron SRI	Medium to heavy loads < 350000 dN
Kluber Isoflex NBU 15/ NCA 15	Light loads, vertical or horizontal applications > 500000 dN
Timken Ultra-High Speed Spindle Grease/ Kluber BF-7222	Light loads, vertical or horizontal applications at higher speeds > 750000 dN



A

OIL

Although several grease products have been successful at dN values as high as one million, oils are generally suggested 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 37° C (100° F) is suggested 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 suggested. 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 method 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 suggested. 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, 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.[1]

Oil Mist

Oil mist lubrication is often used 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. This system not only lubricates the bearings, 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 ensure 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 overstated 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 that make it impossible to start the spindle until the lubricating system is working properly and the bearings are thoroughly wetted.[1]

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. [1]

	System cost	Typical speed (dN)[2]
Grease	Low	500000
High-speed grease	Low	750000
Oil bath	Low	400000
Oil drip	Low	600000
Oil mist	Medium	1000000
Metered air/oil	High	>1000000
Oil jet	High	>1000000

[2]Speed value is an approximation and assumes proper mounting and preload techniques along with average loading conditions. For more specific guidance contact your Timken representative.

The speed, "dN," value is obtained by multiplying the bearing bore size in millimeters by the shaft RPM.

Table 14. Lubrication system comparison.

[1]For further information, refer to the lubrication specification tables found on pages 243-244.

RUN-IN PROCEDURES

TAPERED ROLLER BEARINGS WITH SYNTHETIC GREASE

The aim of run-in cycles is to correctly spread the grease inside the bearing, 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 run-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.

Time	Action
10 sec	Run
1 min	Stop
20 sec	Run
1 min	Stop
30 sec	Run
1 min	Stop
40 sec	Run
1 min	Stop
50 sec	Run
1 min	Stop
1 min	Run
1 min	Stop
90 sec	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 percent of max. speed until the temperature stabilizes again. Then restart the cycle from the beginning at max. speed.

Table 15. Run-in suggestions for synthetic grease-lubricated tapered roller bearings with single-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 minutes and run again at same speed.		⟹ Then run until temperature stabilizes. At this step of the cycle, closely watch the curve's shape. If it tends to be vertical, stop 15 minutes and run again at 75 percent of max. speed until the temperature stabilizes again. Then restart the cycle from the beginning at max. speed.	

Table 16. Run-in suggestions for synthetic grease-lubricated tapered roller bearings with multi-speed spindles.

A

BALL BEARINGS WITH GREASE LUBRICATION

Figure 63 shows bearing temperature increase due to run-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 55° C (100° F) above room temperature since the chemical consistency and characteristics of the grease can be permanently altered. Thus, the proper run-in procedure is to run the machine until the spindle temperature rises to 65° C (150° F) and then turn it off to allow the grease to cool. Repeat until the spindle temperature stabilizes at a temperature below 54° C (130° F).

Figure 64 shows the typical temperature rise of the bearing once the grease has been worked in for the specific speed and load.

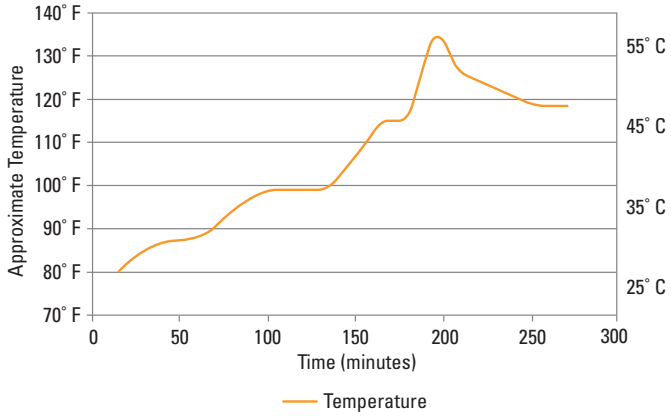


Fig. 63. Typical temperature profile during break-in (4 speed increments from 200000 dN start to 800000 dN finish).

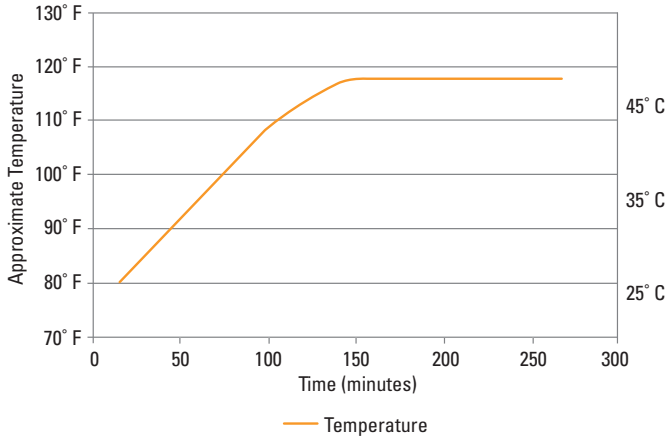


Fig. 64. Typical temperature after break-in procedure.

BALL BEARINGS WITH GREASE (FOR SPEEDS > 500000 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.

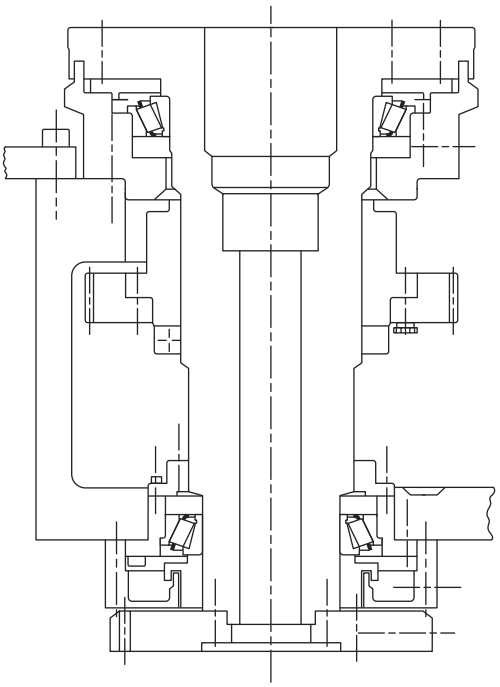
Run-In Procedure

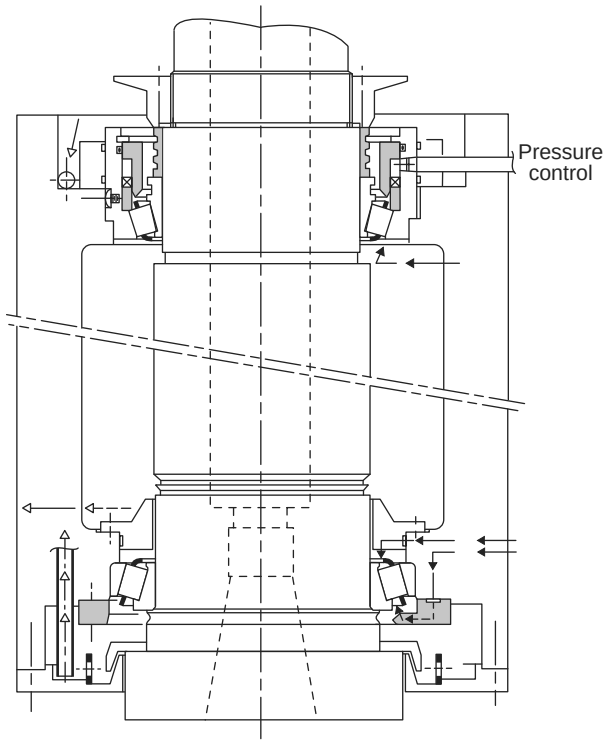
1) Install proper quantity of grease.
2) Start at a reasonable low speed, typically 10 percent of the maximum operating speed.
3) Increase speed with small, reasonable increments when a stable temperature is reached.
4) Continue incremental increase in speed as described. If a rapid temperature increase 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 (170° F) may 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 also is 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 five times greater than the running time. This process is repeated until the bearing temperature becomes constant.

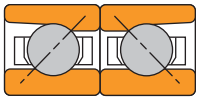



Pressure
control

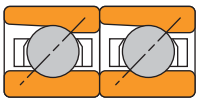
LIGHT 3MM200WI ISO 02 SERIES

DUPLEX PERFORMANCE DATA

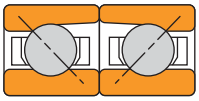
MOUNTING ARRANGEMENTS



Back-to-Back
DB



Tandem
DT



Face-to-Face
DF

Bearing Number	Preload				Axial Stiffness[1]			Radial Stiffness[1]			Spacer Offsets[1]		
	DUX X-light	DUL Light	DUM Med.	DUH Heavy	Light	Med.	Heavy	Light	Med.	Heavy	X-light to Light	Light to Med.	Med. to Heavy
	N lbs.				N/µm 10^6 lbs./in.			N/µm 10^6 lbs./in.			µm in.		
3MM200WI	—	**40**	**130**	**270**	**39.35**	**59.99**	**79.75**	**84.65**	**121.38**	**150.94**	—	**7.11**	**7.62**
	—	10	30	60	0.225	0.343	0.456	0.484	0.694	0.863	—	0.00028	0.00030
3MM201WI	—	**40**	**130**	**270**	**44.77**	**67.51**	**88.85**	**94.10**	**135.90**	**169.48**	—	**6.35**	**6.86**
	—	10	30	60	0.256	0.386	0.508	0.538	0.777	0.969	—	0.00025	0.00027
3MM202WI	—	**70**	**180**	**360**	**55.44**	**80.45**	**106.51**	**115.96**	**160.21**	**199.39**	—	**6.60**	**6.60**
	—	15	40	80	0.317	0.460	0.609	0.663	0.916	1.140	—	0.00026	0.00026
3MM203WI	—	**90**	**330**	**440**	**63.84**	**105.99**	**119.28**	**132.92**	**204.46**	**223.87**	—	**11.43**	**4.06**
	—	20	75	100	0.365	0.606	0.682	0.760	1.169	1.280	—	0.00045	0.00016
3MM204WI	—	**130**	**360**	**560**	**75.21**	**109.66**	**131.35**	**159.51**	**220.02**	**253.26**	—	**9.65**	**6.60**
	—	30	80	125	0.430	0.627	0.751	0.912	1.258	1.448	—	0.00038	0.00026
3MM205WI	—	**160**	**400**	**670**	**89.20**	**128.20**	**157.76**	**189.59**	**258.50**	**303.98**	—	**8.89**	**7.37**
	—	35	90	150	0.510	0.733	0.902	1.084	1.478	1.738	—	0.00035	0.00029
3MM206WI	—	**220**	**560**	**890**	**106.16**	**150.76**	**182.42**	**227.02**	**306.77**	**356.10**	—	**10.41**	**7.87**
	—	50	125	200	0.607	0.862	1.043	1.298	1.754	2.036	—	0.00041	0.00031
3MM207WI	**130**	**310**	**780**	**1330**	**126.45**	**179.62**	**223.52**	**267.42**	**360.99**	**428.33**	**6.86**	**12.19**	**12.19**
	30	70	175	300	0.723	1.027	1.278	1.529	2.064	2.449	0.00027	0.00048	0.00048
3MM208WI	**160**	**360**	**890**	**1330**	**132.57**	**187.84**	**220.90**	**275.64**	**372.71**	**423.96**	**7.11**	**13.21**	**8.64**
	35	80	200	300	0.758	1.074	1.263	1.576	2.131	2.424	0.00028	0.00052	0.00034
3MM209WI	**180**	**440**	**1110**	**1780**	**159.86**	**226.85**	**274.24**	**332.14**	**448.44**	**520.50**	**7.87**	**13.72**	**10.67**
	40	100	250	400	0.914	1.297	1.568	1.899	2.564	2.976	0.00031	0.00054	0.00042
3MM210WI	**200**	**490**	**1220**	**2000**	**173.68**	**246.43**	**300.65**	**360.12**	**486.22**	**568.25**	**7.62**	**13.97**	**11.43**
	45	110	275	450	0.993	1.409	1.719	2.059	2.780	3.249	0.00030	0.00055	0.00045
3MM211WI	**220**	**620**	**1560**	**2450**	**193.61**	**274.94**	**330.21**	**407.34**	**549.71**	**634.36**	**9.65**	**15.75**	**11.68**
	50	140	350	550	1.107	1.572	1.888	2.329	3.143	3.627	0.00038	0.00062	0.00046
3MM212WI	**240**	**760**	**1890**	**2890**	**213.73**	**303.63**	**360.47**	**450.02**	**607.43**	**695.05**	**11.18**	**17.53**	**11.94**
	55	170	425	650	1.222	1.736	2.061	2.573	3.473	3.974	0.00044	0.00069	0.00047
3MM213WI	**270**	**850**	**2110**	**3340**	**225.62**	**320.42**	**385.65**	**474.50**	**640.48**	**740.18**	**11.94**	**18.54**	**13.72**
	60	190	475	750	1.290	1.832	2.205	2.713	3.662	4.232	0.00047	0.00073	0.00054
3MM214WI	**290**	**890**	**2220**	**3560**	**231.39**	**328.46**	**397.37**	**492.87**	**665.67**	**772.53**	**12.19**	**19.05**	**14.73**
	65	200	500	800	1.323	1.878	2.272	2.818	3.806	4.417	0.00048	0.00075	0.00058
3MM215WI	**360**	**980**	**2450**	**3780**	**250.28**	**355.75**	**424.13**	**532.75**	**719.19**	**825.53**	**11.68**	**19.30**	**13.72**
	80	220	550	850	1.431	2.034	2.425	3.046	4.112	4.720	0.00046	0.00076	0.00054
3MM216WI	**400**	**1110**	**2780**	**4450**	**269.87**	**383.03**	**462.79**	**570.35**	**770.61**	**894.61**	**12.45**	**20.32**	**15.75**
	90	250	625	1000	1.543	2.190	2.646	3.261	4.406	5.115	0.00049	0.00080	0.00062
3MM217WI	**440**	**1200**	**3000**	**4890**	**280.36**	**397.37**	**483.42**	**600.43**	**812.41**	**949.18**	**12.45**	**21.08**	**17.02**
	100	270	675	1100	1.603	2.272	2.764	3.433	4.645	5.427	0.00049	0.00083	0.00067
3MM218WI	**490**	**1330**	**3110**	**5560**	**286.14**	**394.75**	**498.12**	**608.83**	**805.06**	**968.42**	**13.72**	**20.83**	**21.84**
	110	300	700	1250	1.636	2.257	2.848	3.481	4.603	5.537	0.00054	0.00082	0.00086
3MM219WI	**560**	**1560**	**3110**	**6230**	**310.27**	**402.97**	**531.00**	**655.70**	**824.65**	**1029.29**	**15.24**	**17.27**	**26.67**
	125	350	700	1400	1.774	2.304	3.036	3.749	4.715	5.885	0.00060	0.00068	0.00105
3MM220WI	**600**	**1730**	**3470**	**6940**	**328.29**	**426.41**	**561.60**	**694.18**	**873.45**	**1090.50**	**16.26**	**18.29**	**27.94**
	135	390	780	1560	1.877	2.438	3.211	3.969	4.994	6.235	0.00064	0.00072	0.00110
3MM222WI	**690**	**2050**	**4082**	**8180**	**359.94**	**466.81**	**613.90**	**762.39**	**960.03**	**1199.46**	**17.78**	**19.81**	**30.23**
	155	460	920	1840	2.058	2.669	3.510	4.359	5.489	6.858	0.00070	0.00078	0.00119
3MM224WI	**820**	**2250**	**4480**	**8980**	**377.78**	**490.07**	**643.98**	**805.76**	**1014.77**	**1267.85**	**17.53**	**20.57**	**31.50**
	185	505	1010	2020	2.160	2.802	3.682	4.607	5.802	7.249	0.00069	0.00081	0.00124
3MM226WI	**980**	**2560**	**5120**	**10230**	**448.09**	**580.49**	**761.86**	**954.08**	**1190.72**	**1503.97**	**16.51**	**19.81**	**30.48**
	220	575	1150	2300	2.562	3.319	4.356	5.455	6.808	8.599	0.00065	0.00078	0.00120
3MM230WI	**1290**	**3110**	**6230**	**12450**	**473.63**	**612.32**	**801.04**	**1009.87**	**1276.25**	**1598.24**	**17.53**	**22.86**	**35.05**
	290	700	1400	2800	2.708	3.501	4.580	5.774	7.297	9.138	0.00069	0.0009	0.00138

[1] For DB or DF arrangements only. For other mounting arrangements, contact your Timken representative.

LIGHT 2MM200WI
ISO 02 SERIES

SPEED CAPABILITY DATA

Bearing Number	Grease Capacity[1]				Operating Speeds[4] (DB Mounting)[5]					
	Low Speed[2]		High Speed[3]		Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams		grams		RPM			RPM		
2MM200WI	0.30	0.50	0.20	0.27	50200	37700	25100	85300	64100	42700
2MM201WI	0.40	0.60	0.25	0.33	45400	34000	22200	79100	57800	39400
2MM202WI	0.50	0.80	0.32	0.43	38200	28700	19100	66300	48800	33200
2MM203WI	0.70	1.10	0.45	0.59	33500	25100	16500	58100	42700	29100
2MM204WI	1.10	1.70	0.72	0.96	28600	21400	14300	48600	36400	24300
2MM205WI	1.30	2.10	0.88	1.18	23800	17900	11900	40500	30400	20200
2MM206WI	2.00	3.10	1.31	1.74	20000	15100	10000	34200	25600	17000
2MM207WI	2.70	4.40	1.82	2.43	17300	13,000	8600	29400	22000	14600
2MM208WI	3.70	6.00	2.49	3.32	15400	11600	7700	26200	19700	13100
2MM209WI	4.20	6.60	2.77	3.70	14000	10500	7000	22800	17900	11900
2MM210WI	4.80	7.60	3.20	4.30	12500	9600	6400	21800	16300	10900
2MM211WI	6.10	9.70	4.10	5.40	11600	8700	5800	19700	14800	9900
2MM212WI	7.50	12.00	5.00	6.70	10600	7920	5300	18000	13500	9000
2MM213WI	9.20	14.60	6.10	8.10	9700	7260	4800	16500	12300	8200
2MM214WI	10.60	16.90	7.00	9.40	9100	6840	4600	15500	11600	7800
2MM215WI	11.60	18.60	7.80	10.30	8600	6480	4300	14600	11020	7300
2MM216WI	13.70	22.00	9.20	12.20	8100	6060	4000	13800	10300	6800
2MM217WI	16.90	27.10	11.30	15.10	7500	5640	3800	12800	9590	6500
2MM218WI	21.50	34.40	14.40	19.10	7100	5340	3600	12100	9080	6100
2MM219WI	25.80	41.40	17.30	23.00	6700	5040	3400	11400	8570	5800
2MM220WI	30.70	49.10	20.50	27.30	6400	4800	3200	10900	8160	5400
2MM222WI	42.30	67.60	28.20	37.60	5800	4320	2900	9900	7340	4900
2MM224WI	51.40	82.30	34.30	45.80	5400	4020	2700	9200	6830	4600
2MM226WI	50.80	81.30	33.90	45.20	4900	3660	2400	8300	6220	4100
2MM230WI	82.40	131.90	55.00	73.40	4200	3180	2160	7100	5410	3600

[1] Fill weights based on specific gravity of 0.99.
[2] Low speed <500000 dN.
[3] High speed ≥ 500000 dN.
[4] For ceramic ball complements, use 120 percent of speeds shown.
[5] For other mounting arrangement configurations, refer to the engineering section on permissible speed calculation methods.

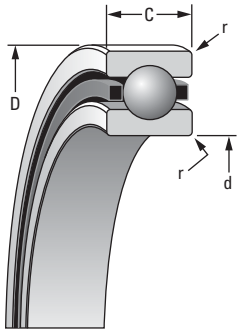
LIGHT 3MM200WI ISO 02 SERIES

SPEED CAPABILITY DATA

Bearing Number	Grease Capacity[1]				Operating Speeds[4] (DB Mounting)[5]					
	Low Speed[2]		High Speed[3]		Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams		grams		RPM			RPM		
3MM200WI	0.30	0.50	0.20	0.27	45180	33930	22590	76770	57690	38430
3MM201WI	0.40	0.60	0.25	0.33	40860	30600	19980	71190	52020	35460
3MM202WI	0.50	0.80	0.32	0.43	34380	25830	17190	59670	43920	29880
3MM203WI	0.70	1.10	0.45	0.59	30150	22590	14850	52290	38430	26190
3MM204WI	1.10	1.70	0.72	0.96	25740	19260	12870	43740	32760	21870
3MM205WI	1.30	2.10	0.88	1.18	21420	16110	10710	36450	27360	18180
3MM206WI	2.00	3.10	1.31	1.74	18000	13590	9000	30780	23040	15300
3MM207WI	2.70	4.40	1.82	2.43	15570	11700	7740	26460	19800	13140
3MM208WI	3.70	6.00	2.49	3.32	13860	10440	6930	23580	17730	11790
3MM209WI	4.20	6.60	2.77	3.70	12600	9450	6300	20520	16110	10710
3MM210WI	4.80	7.60	3.20	4.30	11250	8640	5760	19620	14670	9810
3MM211WI	6.10	9.70	4.10	5.40	10440	7830	5220	17730	13320	8910
3MM212WI	7.50	12.00	5.00	6.70	9540	7128	4770	16200	12150	8100
3MM213WI	9.20	14.60	6.10	8.10	8730	6534	4320	14850	11070	7380
3MM214WI	10.60	16.90	7.00	9.40	8190	6156	4140	13950	10440	7020
3MM215WI	11.60	18.60	7.80	10.30	7740	5832	3870	13140	9918	6570
3MM216WI	13.70	22.00	9.20	12.20	7290	5454	3600	12420	9270	6120
3MM217WI	16.90	27.10	11.30	15.10	6750	5076	3420	11520	8631	5850
3MM218WI	21.50	34.40	14.40	19.10	6390	4806	3240	10890	8172	5490
3MM219WI	25.80	41.40	17.30	23.00	6030	4536	3060	10260	7713	5220
3MM220WI	30.70	49.10	20.50	27.30	5760	4320	2880	9810	7344	4860
3MM222WI	42.30	67.60	28.20	37.60	5220	3888	2610	8910	6606	4410
3MM224WI	51.40	82.30	34.30	45.80	4860	3618	2430	8280	6147	4140
3MM226WI	50.80	81.30	33.90	45.20	4410	3294	2160	7470	5598	3690
3MM230WI	82.40	131.90	55.00	73.40	3780	2862	1944	6390	4869	3240

[1] Fill weights based on specific gravity of 0.99.
[2] Low speed <500000 dN.
[3] High speed ≥ 500000 dN.
[4] For ceramic ball complements, use 120 percent of speeds shown.
[5] For other mounting arrangement configurations, refer to the engineering section on permissible speed calculation methods.

LIGHT ISO 02 SERIES
MM200K



SUPER PRECISION MM

Running accuracy and performance meet ABEC 9 (ISO P2) levels.
Other features conform to ABEC 7 (ISO P4) requirements.

C

Bearing Number	d Bore	D O.D.	C Width(1)	Ball Qty. x Dia.	Bearing Wt.	LOAD RATINGS						r Rad.(2)
						Steel Ball			Ceramic Ball			
						C_o Static	C_e Dynamic	Speed Rating(Ng)	C_o Static	C_e Dynamic	Speed Rating(Ng)	
	mm/in.			mm/in.	kg/lbs.	N/lbs.		RPM	N/lbs.		RPM	mm/in.
MM201K	**12**	**32**	**10**	**7 x 5.95**	**0.035**	**3000**	**7550**	**52200**	**2710**	**7550**	**62600**	**0.6**
	0.4724	1.2598	0.3940	7 x 15/64	0.08	680	1700	52200	610	1700	62600	0.024
MM202K	**15**	**35**	**11**	**8 x 5.95**	**0.043**	**3700**	**8450**	**44000**	**3290**	**8450**	**52800**	**0.6**
	0.5906	1.3780	0.4331	8 x 15/64	0.09	830	1900	44000	740	1900	52800	0.024
MM203K	**17**	**40**	**12**	**8 x 6.75**	**0.062**	**4700**	**10600**	**38500**	**4230**	**10600**	**46200**	**0.6**
	0.6693	1.5748	0.4724	8 x 17/64	0.14	1060	2380	38500	950	2380	46200	0.024
MM204K	**20**	**47**	**14**	**8 x 7.94**	**0.100**	**6500**	**14200**	**32800**	**5860**	**14200**	**39400**	**1.0**
	0.7874	1.8504	0.5512	8 x 5/16	0.22	1460	3190	32800	1320	3190	39400	0.039
MM205K	**25**	**52**	**15**	**9 x 7.94**	**0.122**	**7800**	**15500**	**27400**	**6980**	**15500**	**32900**	**1.0**
	0.9843	2.0472	0.5906	9 x 5/16	0.27	1760	3490	27400	1570	3490	32900	0.039
MM206K	**30**	**62**	**16**	**9 x 9.53**	**0.185**	**11300**	**21600**	**23000**	**10000**	**21600**	**27600**	**1.0**
	1.1811	2.4409	0.6299	9 x 3/8	0.41	2550	4850	23000	2.25	4850	27600	0.039
MM207K	**35**	**72**	**17**	**9 x 11.11**	**0.267**	**15300**	**28500**	**19800**	**13600**	**28500**	**23800**	**1.0**
	1.3780	2.8346	0.6693	9 x 7/16	0.59	3450	6400	19800	3060	6400	23800	0.039
MM208K	**40**	**80**	**18**	**9 x 12.70**	**0.337**	**20000**	**36200**	**17700**	**17700**	**36200**	**21200**	**1.0**
	1.5748	3.1496	0.7087	9 x 1/2	0.74	4500	8130	17700	3970	8130	21200	0.039
MM209K	**45**	**85**	**19**	**9 x 12.70**	**0.377**	**20200**	**36300**	**16000**	**18200**	**36300**	**19200**	**1.0**
	1.7717	3.3465	0.7480	9 x 1/2	0.83	4550	8160	16000	4090	8160	19200	0.039
MM210K	**50**	**90**	**20**	**10 x 12.70**	**0.425**	**23100**	**38900**	**14600**	**20600**	**38900**	**17500**	**1.0**
	1.9685	3.5433	0.7874	10 x 1/2	0.94	5200	8740	14600	4640	8740	17500	0.039
MM211K	**55**	**100**	**21**	**10 x 14.29**	**0.564**	**29100**	**48100**	**13300**	**26000**	**48100**	**16000**	**1.5**
	2.1654	3.9370	0.8268	10 x 9/16	1.24	6550	10800	13300	5850	10800	16000	0.059
MM212K	**60**	**110**	**22**	**10 x 15.88**	**0.727**	**36300**	**58200**	**12100**	**32000**	**58200**	**14500**	**1.5**
	2.3622	4.3307	0.8661	10 x 5/8	1.60	8150	13100	12100	7190	13100	14500	0.059
MM213K	**65**	**120**	**23**	**10 x 16.67**	**0.928**	**40000**	**63400**	**11100**	**35600**	**63400**	**13300**	**1.5**
	2.5591	4.7244	0.9055	10 x 21/32	2.05	9000	14300	11100	8000	14300	13300	0.059
MM214K	**70**	**125**	**24**	**10 x 17.46**	**0.994**	**43600**	**69000**	**10500**	**39200**	**69000**	**12600**	**1.5**
	2.7559	4.9213	0.9449	10 x 11/16	2.19	9800	15500	10500	8800	15500	12600	0.059
MM215K	**75**	**130**	**25**	**10 x 17.46**	**1.074**	**44500**	**68900**	**9900**	**39900**	**68900**	**11900**	**1.5**
	2.9528	5.1181	0.9843	10 x 11/16	2.37	10000	15500	9900	8960	15500	11900	0.059
MM216K	**80**	**140**	**26**	**10 x 19.05**	**1.317**	**53400**	**80600**	**9200**	**47200**	**80600**	**11000**	**2.0**
	3.1496	5.5118	1.0236	10 x 3/4	2.90	12000	18100	9200	10600	18100	11000	0.079

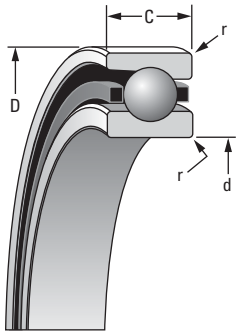
(Ng) For a single, grease-lubricated, spring-preloaded bearing. This value to be used in permissible operating speed (Sp) calculation.
(1) Width tolerance of preloaded bearing set +0.000/-0.254 mm (+0.0000/-0.0100 in.).
(2) ABMA STD 20 (r_{as} max).

DEEP-GROOVE (CONRAD) CONSTRUCTION

- Incorporates high shoulder on both inner and outer rings.
- Balls separated by two-piece and piloted cage.

Suggested Shoulder Diameters				Shaft Diameter		Mounting Fits		FIXED				FLOATING			
Shaft		Housing						Housing Bore (Stationary)		Mounting Fits		Housing Bore (Stationary)		Mounting Fits	
Max.	Min.	Max.	Min.	Max.	Min.	Loose	Tight	Max.	Min.	Tight	Loose	Max.	Min.	Loose	Loose
mm/in.		**mm**/in.		**mm**/in.		**mm**/in.		**mm**/in.		**mm**/in.		**mm**/in.		**mm**/in.	
16.6	**16.4**	**28.1**	**27.8**	**12.000**	**11.995**	**0.005**	**0.004**	**32.005**	**32.000**	**0.000**	**0.011**	**32.010**	**32.005**	**0.016**	**0.005**
0.66	0.65	1.11	1.10	0.47240	0.47220	0.00020	0.00015	1.26000	1.25980	0.00000	0.00045	1.26020	1.26000	0.00070	0.00020
19.2	**18.9**	**31.1**	**30.9**	**15.000**	**14.995**	**0.005**	**0.004**	**35.006**	**35.000**	**0.000**	**0.012**	**35.010**	**35.005**	**0.016**	**0.005**
0.76	0.75	1.23	1.22	0.59060	0.59040	0.00020	0.00015	1.37830	1.37800	0.00000	0.00050	1.37840	1.37820	0.00070	0.00020
21.7	**21.5**	**35.7**	**35.4**	**17.000**	**16.995**	**0.005**	**0.004**	**40.006**	**40.000**	**0.000**	**0.012**	**40.010**	**40.005**	**0.016**	**0.005**
0.86	0.85	1.41	1.40	0.66930	0.66910	0.00020	0.00015	1.57510	1.57480	0.00000	0.00050	1.57520	1.57500	0.00070	0.00020
26.0	**25.8**	**41.5**	**41.3**	**20.000**	**19.995**	**0.005**	**0.005**	**47.006**	**47.000**	**0.000**	**0.012**	**47.012**	**47.007**	**0.018**	**0.007**
1.03	1.02	1.64	1.63	0.78740	0.78720	0.00020	0.00020	1.85070	1.85040	0.00000	0.00050	1.85090	1.85070	0.00080	0.00030
31.1	**30.9**	**47.1**	**46.9**	**25.000**	**24.995**	**0.005**	**0.005**	**52.006**	**52.000**	**0.000**	**0.013**	**52.012**	**52.007**	**0.019**	**0.007**
1.23	1.22	1.86	1.85	0.98430	0.98410	0.00020	0.00020	2.04750	2.04720	0.00000	0.00055	2.04770	2.04750	0.00080	0.00030
36.7	**36.5**	**56.0**	**55.8**	**30.000**	**29.995**	**0.005**	**0.005**	**62.008**	**62.000**	**0.000**	**0.015**	**62.012**	**62.007**	**0.019**	**0.007**
1.45	1.44	2.21	2.20	1.18110	1.18090	0.00020	0.00020	2.44120	2.44090	0.00000	0.00060	2.44140	2.44120	0.00080	0.00030
42.7	**42.2**	**65.3**	**64.8**	**35.000**	**34.995**	**0.005**	**0.006**	**72.008**	**72.000**	**0.000**	**0.015**	**72.011**	**72.007**	**0.019**	**0.007**
1.68	1.66	2.57	2.55	1.37800	1.37780	0.00020	0.00025	2.83490	2.83460	0.00000	0.00060	2.83510	2.83490	0.00080	0.00030
47.8	**47.2**	**73.2**	**72.6**	**40.000**	**39.995**	**0.005**	**0.006**	**80.008**	**80.000**	**0.000**	**0.015**	**80.012**	**80.008**	**0.020**	**0.008**
1.88	1.86	2.88	2.86	1.57480	1.57460	0.00020	0.00025	3.14990	3.14960	0.00000	0.00060	3.15010	3.14990	0.00080	0.00030
52.8	**52.3**	**78.2**	**77.7**	**45.000**	**44.995**	**0.005**	**0.006**	**85.008**	**85.000**	**0.000**	**0.016**	**85.016**	**85.009**	**0.024**	**0.009**
2.08	2.06	3.08	3.06	1.77170	1.77150	0.00020	0.00025	3.34680	3.34650	0.00000	0.00060	3.34710	3.34680	0.00090	0.00030
57.9	**57.4**	**83.3**	**82.8**	**50.000**	**49.995**	**0.005**	**0.006**	**90.008**	**90.000**	**0.000**	**0.016**	**90.015**	**90.007**	**0.023**	**0.007**
2.28	2.26	3.28	3.26	1.96850	1.96830	0.00020	0.00025	3.54360	3.54330	0.00000	0.00060	3.54390	3.54360	0.00090	0.00030
63.8	**63.3**	**92.2**	**91.7**	**55.000**	**54.995**	**0.005**	**0.007**	**100.008**	**100.000**	**0.000**	**0.016**	**100.018**	**100.010**	**0.025**	**0.010**
2.51	2.49	3.63	3.61	2.16540	2.16520	0.00020	0.00030	3.93730	3.93700	0.00000	0.00060	3.93770	3.93740	0.00100	0.00040
69.9	**69.3**	**101.4**	**100.8**	**60.000**	**59.995**	**0.005**	**0.007**	**110.008**	**110.000**	**0.000**	**0.016**	**110.018**	**110.010**	**0.025**	**0.010**
2.75	2.73	3.99	3.97	2.36220	2.36200	0.00020	0.00030	4.33100	4.33070	0.00000	0.00060	4.33140	4.33110	0.00100	0.00040
76.2	**75.7**	**109.7**	**109.2**	**65.000**	**64.995**	**0.005**	**0.007**	**120.008**	**120.000**	**0.000**	**0.016**	**120.018**	**120.010**	**0.025**	**0.010**
3.00	2.98	4.32	4.30	2.55910	2.55890	0.00020	0.00030	4.72470	4.72440	0.00000	0.00060	4.72510	4.72480	0.00100	0.00040
80.8	**80.3**	**115.8**	**115.3**	**70.000**	**69.995**	**0.005**	**0.007**	**125.008**	**125.000**	**0.000**	**0.017**	**125.021**	**125.011**	**0.030**	**0.011**
3.18	3.16	4.56	4.54	2.75590	2.75570	0.00020	0.00030	4.92160	4.92130	0.00000	0.00070	4.92210	4.92170	0.00120	0.00040
86.0	**85.2**	**120.8**	**120.0**	**75.005**	**74.995**	**0.005**	**0.012**	**130.009**	**130.000**	**0.000**	**0.018**	**130.020**	**130.010**	**0.029**	**0.010**
3.39	3.36	4.76	4.73	2.95300	2.95260	0.00020	0.00050	5.11850	5.11810	0.00000	0.00070	5.11890	5.11850	0.00110	0.00040
91.3	**90.6**	**129.9**	**129.2**	**80.005**	**79.995**	**0.005**	**0.012**	**140.009**	**140.000**	**0.000**	**0.018**	**140.020**	**140.010**	**0.029**	**0.010**
3.60	3.57	5.12	5.09	3.14980	3.14940	0.00020	0.00050	5.51220	5.51180	0.00000	0.00070	5.51260	5.51220	0.00110	0.00040

MEDIUM ISO 03 SERIES
2(3)MM300WI



SUPER PRECISION MM

Running accuracy and performance meet ABEC 9 (ISO P2) levels.
Other features conform to ABEC 7 (ISO P4) requirements.

Bearing Number 2MM or 3MM	d Bore	D O.D.	C Width(1)	Ball Qty. x Dia.	Bearing Wt.	(2MM) LOAD RATINGS						(3MM) LOAD RATINGS					
						Steel Ball			Ceramic Ball			Steel Ball			Ceramic Ball		
						C_o Static	C_e Dynamic	Speed Rating(Ng)	C_o Static	C_e Dynamic	Speed Rating(Ng)	C_o Static	C_e Dynamic	Speed Rating(Ng)	C_o Static	C_e Dynamic	Speed Rating(Ng)
	mm/in.			**mm**/in.	**kg**/lbs.	**N**/lbs.		RPM	**N**/lbs.		RPM	**N**/lbs.		RPM	**N**/lbs.		RPM
301WI	**12**	**37**	**12**	**8 x 7.14**	**0.061**	**4700**	**11000**	**47600**	**4230**	**11000**	**57100**	**4600**	**10900**	**42800**	**4060**	**10900**	**51400**
	0.4724	1.4567	0.4724	8 x 9/32	0.13	1060	2450	47600	950	2450	57100	1040	2450	42800	920	2450	51400
302WI	**15**	**42**	**13**	**10 x 6.75**	**0.087**	**5810**	**12000**	**38100**	**5170**	**12900**	**45700**	**5600**	**11600**	**34300**	**5000**	**11600**	**41200**
	0.5906	1.6535	0.5118	10 x 17/64	0.19	1320	2700	38100	1160	2700	45700	1270	2600	34300	1120	2600	41200
303WI	**17**	**47**	**14**	**7 x 9.53**	**0.104**	**7280**	**16900**	**36800**	**6480**	**16900**	**44200**	**7100**	**16400**	**33100**	**6300**	**16400**	**39700**
	0.6693	1.8504	0.5512	7 x 3/8	0.23	1630	3790	36800	1460	3790	44100	1600	3690	33100	1420	3690	39700
304WI	**20**	**52**	**15**	**8 x 10.32**	**0.137**	**10000**	**21500**	**32200**	**8900**	**21500**	**38600**	**9650**	**20900**	**29000**	**8590**	**20900**	**34800**
	0.7874	2.0472	0.5906	8 x 13/32	0.30	2200	4840	32200	2000	4840	38600	2160	4700	29000	1930	4700	34800
305WI	**25**	**62**	**17**	**9 x 11.91**	**0.221**	**15300**	**30500**	**26200**	**13600**	**30500**	**31400**	**14800**	**29500**	**23600**	**13200**	**29500**	**28300**
	0.9843	2.4409	0.6693	9 x 15/32	0.49	3450	6850	26200	3060	6850	31400	3350	6630	23600	2970	6630	28300
306WI	**30**	**72**	**19**	**10 x 13.49**	**0.328**	**22200**	**34120**	**22100**	**19800**	**34120**	**26500**	**21500**	**39900**	**19900**	**19100**	**39900**	**23900**
	1.1811	2.8346	0.7480	10 x 17/32	0.72	4990	9270	22100	4440	9270	26500	4820	8960	19900	4290	8960	23900
307WI	**35**	**80**	**21**	**10 x 14.29**	**0.443**	**25600**	**46200**	**19200**	**22800**	**46200**	**23000**	**24700**	**44500**	**17300**	**22000**	**44500**	**20800**
	1.3780	3.1496	0.8268	10 x 9/16	0.98	5700	10400	19200	5130	10400	23000	5600	10000	17300	4940	10000	20800
308WI	**40**	**90**	**23**	**11 x 15.88**	**0.608**	**35000**	**59700**	**16900**	**31200**	**59700**	**20300**	**33800**	**57500**	**15200**	**30100**	**57500**	**18200**
	1.5748	3.5433	0.9055	11 x 5/8	1.34	7800	13400	16900	7010	13400	20300	7600	12900	15200	6770	12900	18200
309WI	**45**	**100**	**25**	**10 x 17.46**	**0.809**	**38700**	**66500**	**15100**	**34500**	**66500**	**18100**	**37400**	**64100**	**13600**	**33300**	**64100**	**16300**
	1.7717	3.9370	0.9843	10 x 11/16	1.78	8650	15000	15100	7750	15000	18100	8500	14400	13600	7480	14400	16300
310WI	**50**	**110**	**27**	**10 x 19.05**	**1.046**	**46200**	**77900**	**13600**	**41200**	**77900**	**16300**	**44700**	**75100**	**12200**	**39800**	**75100**	**14600**
	1.9685	4.3307	1.0630	10 x 3/4	2.31	10400	17500	13600	9250	17500	16300	10000	16900	12200	8940	16900	14600
311WI	**55**	**120**	**29**	**10 x 20.64**	**1.332**	**54600**	**90200**	**12400**	**48600**	**90200**	**14900**	**52600**	**86700**	**11200**	**46800**	**86700**	**13400**
	2.1654	4.7244	1.1417	10 x 13/16	2.94	12200	20300	12400	10900	20300	14900	11800	19500	11200	10500	19500	13400
312WI	**60**	**130**	**31**	**10 x 22.23**	**1.665**	**63500**	**103100**	**11400**	**56600**	**103100**	**13700**	**61000**	**99100**	**10300**	**54400**	**99100**	**12400**
	2.3622	5.1181	1.2205	10 x 7/8	3.67	14300	23200	11400	12700	23200	13700	13700	22300	10300	12200	22300	12400
313WI	**65**	**140**	**33**	**11 x 23.81**	**2.101**	**80500**	**124400**	**10500**	**71700**	**124400**	**12600**	**77400**	**119700**	**9500**	**68900**	**119700**	**11400**
	2.5591	5.5118	1.2992	11 x 15/16	4.63	18000	28000	10500	16100	28000	12600	17300	26900	9500	15500	26900	11400
314WI	**70**	**150**	**35**	**11 x 25.40**	**2.548**	**91900**	**139900**	**9800**	**81800**	**139900**	**11800**	**88300**	**134500**	**8800**	**78500**	**134500**	**10600**
	2.7559	5.9055	1.3780	11 x 1	5.62	20800	31500	9800	18400	31500	11800	20000	30200	8800	17700	30200	10600
319WI	**95**	**200**	**45**	**10 x 34.93**	**5.587**	**155900**	**204400**	**7400**	**138800**	**204400**	**8900**	**150400**	**196800**	**6700**	**133900**	**196800**	**8000**
	3.7402	7.8740	1.7717	10 x 1 3/8	12.32	35100	46000	7400	31200	46000	8900	33800	44200	6700	30100	44200	8000

(Ng) For a single, grease-lubricated, spring-preloaded bearing. This value to be used in permissible operating speed (Sp) calculation.
(1) Width tolerance of preloaded bearing set +0.000/-0.254 mm (+0.0000/-0.0100 in.).
(2) ABMA STD 20 (r_{as} max).

WI CONSTRUCTION

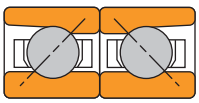
- Incorporates low shoulder on non-thrust side of outer rings.
- Balls separated by one-piece cage piloted against a ground thrust shoulder land of the outer ring.

r Rad.(2)	Suggested Shoulder Diameters				Shaft Diameter		Mounting Fits		FIXED				FLOATING			
	Shaft		Housing						Housing Bore (Stationary)		Mounting Fits		Housing Bore (Stationary)		Mounting Fits	
	Max.	Min.	Max.	Min.	Max.	Min.	Loose	Tight	Max.	Min.	Tight	Loose	Max.	Min.	Loose	Loose
mm/in.	**mm**/in.		**mm**/in.		**mm**/in.		**mm**/in.		**mm**/in.		**mm**/in.		**mm**/in.		**mm**/in.	
1.0	**17.7**	**17.4**	**32.1**	**31.9**	**12.000**	**11.995**	**0.005**	**0.004**	**37.006**	**37.000**	**0.000**	**0.012**	**37.010**	**37.005**	**0.016**	**0.005**
0.039	0.70	0.69	1.27	1.26	0.47240	0.47220	0.00020	0.00015	1.45700	1.45670	0.00000	0.00050	1.45710	1.45690	0.00070	0.00020
1.0	**22.2**	**22.0**	**35.7**	**35.4**	**15.000**	**14.995**	**0.005**	**0.004**	**42.006**	**42.000**	**0.000**	**0.012**	**42.010**	**42.005**	**0.016**	**0.005**
0.039	0.88	0.87	1.41	1.40	0.59060	0.59040	0.00020	0.00015	1.65380	1.65350	0.00000	0.00050	1.65390	1.65370	0.00070	0.00020
1.0	**22.7**	**22.5**	**42.0**	**41.8**	**17.000**	**16.995**	**0.005**	**0.004**	**47.006**	**47.000**	**0.000**	**0.012**	**47.012**	**47.007**	**0.018**	**0.007**
0.039	0.90	0.89	1.66	1.65	0.66930	0.66910	0.00020	0.00015	1.85070	1.85040	0.00000	0.00050	1.85090	1.85070	0.00080	0.00030
1.0	**30.1**	**29.9**	**46.6**	**46.4**	**20.000**	**19.995**	**0.005**	**0.005**	**52.006**	**52.000**	**0.000**	**0.013**	**52.012**	**52.007**	**0.019**	**0.007**
0.039	1.19	1.18	1.84	1.83	0.78740	0.78720	0.00020	0.00020	2.04750	2.04720	0.00000	0.00055	2.04770	2.04750	0.00080	0.00030
1.0	**32.1**	**31.9**	**55.8**	**55.5**	**25.000**	**24.995**	**0.005**	**0.005**	**62.008**	**62.000**	**0.000**	**0.015**	**62.012**	**62.007**	**0.019**	**0.007**
0.039	1.27	1.26	2.20	2.19	0.98430	0.98410	0.00020	0.00020	2.44120	2.44090	0.00000	0.00060	2.44140	2.44120	0.00080	0.00030
1.0	**37.7**	**37.5**	**65.2**	**64.9**	**30.000**	**29.995**	**0.005**	**0.005**	**72.008**	**72.000**	**0.000**	**0.015**	**72.011**	**72.007**	**0.019**	**0.007**
0.039	1.49	1.48	2.57	2.56	1.18110	1.18090	0.00020	0.00020	2.83490	2.83460	0.00000	0.00060	2.83510	2.83490	0.00080	0.00030
1.5	**43.7**	**43.2**	**72.1**	**71.6**	**35.000**	**34.995**	**0.005**	**0.006**	**80.008**	**80.000**	**0.000**	**0.015**	**80.012**	**80.008**	**0.020**	**0.008**
0.059	1.72	1.70	2.84	2.82	1.37800	1.37780	0.00020	0.00025	3.14990	3.14960	0.00000	0.00060	3.15010	3.14990	0.00080	0.00030
1.5	**49.8**	**49.3**	**81.3**	**80.8**	**40.000**	**39.995**	**0.005**	**0.006**	**90.008**	**90.000**	**0.000**	**0.016**	**90.015**	**90.007**	**0.023**	**0.007**
0.059	1.96	1.94	3.20	3.18	1.57480	1.57460	0.00020	0.00025	3.54360	3.54330	0.00000	0.00060	3.54390	3.54360	0.00090	0.00030
1.5	**55.9**	**55.4**	**90.2**	**89.7**	**45.000**	**44.995**	**0.005**	**0.006**	**100.008**	**100.000**	**0.000**	**0.016**	**100.018**	**100.010**	**0.025**	**0.010**
0.059	2.20	2.18	3.55	3.53	1.77170	1.77150	0.00020	0.00025	3.93730	3.93700	0.00000	0.00060	3.93770	3.93740	0.00100	0.00040
2.0	**61.2**	**60.7**	**99.8**	**99.3**	**50.000**	**49.995**	**0.005**	**0.006**	**110.008**	**110.000**	**0.000**	**0.016**	**110.018**	**110.010**	**0.025**	**0.010**
0.079	2.41	2.39	3.93	3.91	1.96850	1.96830	0.00020	0.00025	4.33100	4.33070	0.00000	0.00060	4.33140	4.33110	0.00100	0.00040
2.0	**67.3**	**66.8**	**108.7**	**108.2**	**55.000**	**54.995**	**0.005**	**0.007**	**120.008**	**120.000**	**0.000**	**0.016**	**120.018**	**120.010**	**0.025**	**0.010**
0.079	2.65	2.63	4.28	4.26	2.16540	2.16520	0.00020	0.00030	4.72470	4.72440	0.00000	0.00060	4.72510	4.72480	0.00100	0.00040
2.0	**73.1**	**72.6**	**117.9**	**117.3**	**60.000**	**59.995**	**0.005**	**0.007**	**130.009**	**130.000**	**0.000**	**0.018**	**130.020**	**130.010**	**0.029**	**0.010**
0.079	2.88	2.86	4.64	4.62	2.36220	2.36200	0.00020	0.00030	5.11850	5.11810	0.00000	0.00070	5.11890	5.11850	0.00110	0.00040
2.0	**80.3**	**79.8**	**126.8**	**126.2**	**65.000**	**64.995**	**0.005**	**0.007**	**140.009**	**140.000**	**0.000**	**0.018**	**140.020**	**140.010**	**0.029**	**0.010**
0.079	3.16	3.14	4.99	4.97	2.55910	2.55890	0.00020	0.00030	5.51220	5.51180	0.00000	0.00070	5.51260	5.51220	0.00110	0.00040
2.0	**85.3**	**84.8**	**135.6**	**135.1**	**70.000**	**69.995**	**0.005**	**0.007**	**150.009**	**150.000**	**0.000**	**0.018**	**150.023**	**150.012**	**0.032**	**0.012**
0.079	3.36	3.34	5.34	5.32	2.75590	2.75570	0.00020	0.00030	5.90590	5.90550	0.000	0.00070	5.90640	5.90600	0.00120	0.00050
3.0	**113.2**	**112.4**	**183.3**	**182.5**	**95.000**	**94.995**	**0.005**	**0.013**	**200.011**	**200.000**	**0.000**	**0.022**	**200.025**	**200.015**	**0.036**	**0.015**
0.118	4.46	4.43	7.22	7.19	3.74016	3.73996	0.00020	0.00051	7.87402	7.87445	0.00000	0.00087	7.87500	7.87461	0.00142	0.00059

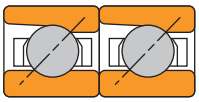
MEDIUM 2(3)MM300WI ISO 03 SERIES

DUPLEX PERFORMANCE DATA

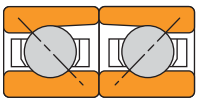
MOUNTING ARRANGEMENTS



Back-to-Back
DB



Tandem
DT



Face-to-Face
DF

Bearing Number	Preload				Axial Stiffness[1]				Radial Stiffness[1]				Spacer Offsets[1]		
	DUX X-light	DUL Light	DUM Med.	DUH Heavy	X-light	Light	Med.	Heavy	X-light	Light	Med.	Heavy	X-light to Light	Light to Med.	Med. to Heavy
	N lbs.				N/µm 10^6 lbs./in.				N/µm 10^6 lbs./in.				µm in.		
2MM301WI	—	20	70	180	—	17.49	27.81	44.25	—	98.82	153.56	183.30	—	7.87	12.45
	—	5	15	40	—	0.100	0.159	0.253	—	0.565	0.878	1.048	—	0.00031	0.00049
2MM302WI	20	40	110	220	—	27.46	40.93	57.19	109.97	143.24	164.93	205.51	3.70	7.87	9.14
	5	10	25	50	—	0.157	0.234	0.327	0.628	0.819	0.943	1.175	0.00015	0.00031	0.00036
2MM303WI	40	70	160	310	—	26.58	38.83	54.57	127.92	147.44	197.46	263.05	3.63	10.92	13.46
	10	15	35	70	—	0.152	0.222	0.312	0.730	0.843	1.129	1.504	0.00014	0.00043	0.00053
2MM304WI	40	90	220	400	—	33.06	49.85	66.46	140.53	181.72	232.97	289.81	6.14	12.95	12.92
	10	20	50	90	—	0.189	0.285	0.380	0.803	1.039	1.332	1.657	0.00024	0.00051	0.00051
2MM305WI	90	160	330	620	—	46.17	65.24	88.50	203.85	247.83	318.78	387.86	6.42	12.70	14.99
	20	35	75	140	—	0.264	0.373	0.506	1.164	1.417	1.820	2.215	0.00025	0.00050	0.00059
2MM306WI	90	180	440	780	—	49.50	74.68	98.47	223.77	271.27	394.56	470.83	7.73	17.27	15.49
	20	40	100	175	—	0.283	0.427	0.563	1.278	1.551	2.253	2.689	0.00030	0.00068	0.00061
2MM307WI	110	220	560	1000	—	55.97	85.18	114.38	251.87	323.91	438.09	526.52	9.05	18.80	17.78
	25	50	125	225	—	0.320	0.487	0.654	1.438	1.852	2.502	3.007	0.00036	0.00074	0.00070
2MM308WI	130	290	670	1220	—	64.71	94.62	127.85	290.33	364.67	512.52	620.41	10.56	19.05	20.07
	30	65	150	275	—	0.370	0.541	0.731	1.658	2.085	2.927	3.543	0.00042	0.00075	0.00079
2MM309WI	180	330	780	1560	—	70.13	103.02	145.17	313.69	393.18	520.48	646.82	10.00	20.57	25.15
	40	75	175	350	—	0.401	0.589	0.830	1.791	2.248	2.972	3.694	0.00039	0.00081	0.00099
2MM310WI	220	440	1000	1780	—	81.15	117.36	156.01	347.72	445.06	580.34	694.99	12.52	22.35	22.86
	50	100	225	400	—	0.464	0.671	0.892	1.986	2.541	3.314	3.969	0.00049	0.00088	0.00090
2MM311WI	270	560	1110	2110	—	88.15	121.38	167.20	383.15	496.30	622.37	761.00	15.05	21.34	27.69
	60	125	250	475	—	0.504	0.694	0.956	2.188	2.834	3.554	4.346	0.00059	0.00084	0.00109
2MM312WI	270	560	1330	2450	—	89.72	133.80	180.85	387.61	506.89	675.70	816.95	14.75	27.94	28.19
	60	125	300	550	—	0.513	0.765	1.034	2.213	2.895	3.859	4.665	0.00058	0.00110	0.00111
2MM313WI	330	670	1670	3000	—	104.24	157.93	211.28	453.84	585.60	791.90	952.23	14.55	30.48	28.96
	75	150	375	675	—	0.596	0.903	1.208	2.592	3.344	4.522	5.438	0.00057	0.00120	0.00114
2MM314WI	400	780	1890	3450	—	110.89	166.33	224.22	498.33	633.95	848.58	1024.31	15.49	32.26	32.00
	90	175	425	775	—	0.634	0.951	1.282	2.846	3.620	4.846	5.849	0.00061	0.00127	0.00126
2MM319WI	670	1330	3110	6230	—	140.44	206.03	290.33	611.00	787.43	1041.02	1293.71	21.67	41.05	50.24
	150	300	700	1400	—	0.803	1.178	1.660	3.489	4.497	5.945	7.388	0.00085	0.00162	0.00198
3MM301WI	40	90	180	310	—	58.59	76.61	96.37	96.32	122.54	153.78	183.56	3.42	5.33	6.10
	10	20	40	70	—	0.335	0.438	0.551	0.550	0.700	0.878	1.048	0.00013	0.00021	0.00024
3MM302WI	40	90	180	360	—	66.46	86.75	115.08	108.95	139.15	174.90	217.90	2.99	4.57	7.11
	10	20	40	80	—	0.380	0.496	0.658	0.622	0.795	0.999	1.244	0.00012	0.00018	0.00028
3MM303WI	40	110	270	440	—	63.66	89.02	109.49	93.69	132.92	176.19	207.22	4.85	8.13	7.11
	10	25	60	100	—	0.364	0.509	0.626	0.535	0.760	1.006	1.183	0.00019	0.00032	0.00028
3MM304WI	90	160	360	620	—	79.23	108.96	136.77	136.71	159.51	220.02	261.18	3.70	8.38	8.64
	20	35	80	140	—	0.453	0.623	0.782	0.781	0.912	1.258	1.491	0.00015	0.00033	0.00034
3MM305WI	110	220	530	890	—	101.62	142.19	174.90	165.18	212.03	283.21	333.10	4.90	10.16	8.89
	25	50	120	200	—	0.581	0.813	1.000	0.943	1.211	1.617	1.902	0.00019	0.00040	0.00035
3MM306WI	135	270	670	1110	—	112.29	159.33	196.06	193.95	252.07	342.44	403.21	4.99	11.68	9.91
	30	60	150	250	—	0.642	0.911	1.121	1.108	1.439	1.955	2.303	0.00020	0.00046	0.00039
3MM307WI	180	360	850	1560	—	134.85	187.84	241.01	221.46	284.26	378.37	459.17	5.93	12.19	13.21
	40	80	190	350	—	0.771	1.074	1.378	1.265	1.623	2.161	2.622	0.00023	0.00048	0.00052
3MM308WI	220	440	1110	1780	—	150.41	214.08	259.20	261.11	336.84	456.64	530.40	6.22	14.48	11.18
	50	100	250	400	—	0.860	1.224	1.482	1.491	1.923	2.608	3.029	0.00025	0.00057	0.00044
3MM309WI	270	530	1330	2220	—	165.98	235.94	290.51	269.80	332.14	468.66	551.00	7.20	15.75	13.46
	60	120	300	500	—	0.949	1.349	1.661	1.541	1.899	2.676	3.146	0.00028	0.00062	0.00053
3MM310WI	310	620	1560	2670	—	178.75	254.13	316.57	293.47	360.12	510.36	605.40	7.83	17.27	15.49
	70	140	350	600	—	1.022	1.453	1.810	1.676	2.059	2.914	3.457	0.00031	0.00068	0.00061
3MM311WI	400	780	1780	3110	—	198.16	272.32	342.10	328.74	407.34	547.14	653.40	8.51	17.02	17.27
	90	175	400	700	—	1.133	1.557	1.956	1.877	2.329	3.124	3.731	0.00034	0.00067	0.00068
3MM312WI	450	890	2000	3560	—	213.38	291.21	367.81	347.62	450.02	582.53	699.31	9.35	17.53	18.80
	100	200	450	800	—	1.220	1.665	2.103	1.985	2.573	3.326	3.993	0.00037	0.00069	0.00074
3MM313WI	560	1110	2670	4450	—	249.23	348.93	429.55	409.70	525.26	701.21	824.51	10.03	20.83	18.29
	125	250	600	1000	—	1.425	1.995	2.456	2.340	2.999	4.004	4.708	0.00039	0.00082	0.00072
3MM314WI	620	1220	2890	5120	—	262.52	365.02	460.34	433.61	552.97	735.10	881.07	10.22	21.08	21.59
	140	275	650	1150	—	1.501	2.087	2.632	2.476	3.158	4.198	5.031	0.00040	0.00083	0.00085
3MM319WI	1070	2110	4890	8900	—	328.81	453.52	578.22	541.62	692.64	914.62	1105.79	14.24	28.19	30.99
	240	475	1100	2000	—	1.880	2.593	3.306	3.093	3.955	5.223	6.315	0.00056	0.00111	0.00122

[1] For DB or DF arrangements only. For other mounting arrangements, contact your Timken representative.

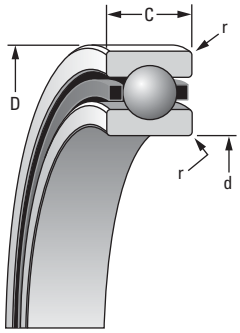
MEDIUM 2(3)MM300WI
ISO 03 SERIES

SPEED CAPABILITY DATA

Bearing Number	Grease Capacity[1]				Operating Speeds[4] (DB Mounting)[5]					
	Low Speed[2]		High Speed[3]		Grease			Oil		
	25%	40%	15%	20%	DUL	DUM	DUH	DUL	DUM	DUH
	grams		grams		RPM			RPM		
2MM301WI	0.60	1.00	0.40	0.53	35700	28600	19000	60700	48600	32400
2MM302WI	0.70	1.20	0.49	0.65	28600	22900	15200	48600	38900	25900
2MM303WI	1.20	2.00	0.83	1.10	27600	22100	14700	46900	37500	25000
2MM304WI	1.50	2.50	1.03	1.38	24200	19300	12900	41100	32800	21900
2MM305WI	2.30	3.80	1.57	2.09	19700	15700	10500	33400	26700	17800
2MM306WI	3.50	5.60	2.35	3.14	16600	13300	8800	28200	22500	15000
2MM307WI	4.60	7.40	3.07	4.10	14400	11500	7700	24500	19600	13100
2MM308WI	6.40	10.20	4.25	5.66	12700	10100	6800	21500	17200	11500
2MM309WI	8.50	13.60	5.68	7.58	11300	9100	6000	19300	15400	10300
2MM310WI	11.10	17.80	7.40	9.90	10200	8200	5400	17300	13900	9200
2MM311WI	14.20	22.70	9.50	12.60	9300	7400	5000	15800	12600	8400
2MM312WI	17.70	28.30	11.80	15.80	8600	6800	4600	14500	11600	7800
2MM313WI	20.70	33.20	13.80	18.50	7900	6300	4200	13400	10700	7100
2MM314WI	25.20	40.30	16.80	22.40	7400	5900	3900	12500	10000	6700
2MM319WI	60.90	97.40	40.60	54.10	5600	4400	3000	9400	7500	5000
3MM301WI	0.60	1.00	0.40	0.53	32130	25740	17100	54630	43740	29160
3MM302WI	0.70	1.20	0.49	0.65	25740	20610	13680	43740	35010	23310
3MM303WI	1.20	2.00	0.83	1.10	24840	19890	13230	42210	33750	22500
3MM304WI	1.50	2.50	1.03	1.38	21780	17370	11610	36990	29520	19710
3MM305WI	2.30	3.80	1.57	2.09	17730	14130	9450	30060	24030	16020
3MM306WI	3.50	5.60	2.35	3.14	14940	11970	7920	25380	20250	13500
3MM307WI	4.60	7.40	3.07	4.10	12960	10350	6930	22050	17640	11790
3MM308WI	6.40	10.20	4.25	5.66	11430	9090	6120	19350	15480	10350
3MM309WI	8.50	13.60	5.68	7.58	10170	8190	5400	17370	13860	9270
3MM310WI	11.10	17.80	7.40	9.90	9180	7380	4860	15570	12510	8280
3MM311WI	14.20	22.70	9.50	12.60	8370	6660	4500	14220	11340	7560
3MM312WI	17.70	28.30	11.80	15.80	7740	6120	4140	13050	10440	7020
3MM313WI	20.70	33.20	13.80	18.50	7110	5670	3780	12060	9630	6390
3MM314WI	25.20	40.30	16.80	22.40	6660	5310	3510	11250	9000	6030
3MM319WI	60.90	97.40	40.60	54.10	5040	3960	2700	8460	6750	4500

[1] Fill weights based on specific gravity of 0.99.
[2] Low speed <500000 dN.
[3] High speed ≥ 500000 dN.
[4] For ceramic ball complements, use 120 percent of speeds shown.
[5] For other mounting arrangement configurations, refer to the engineering section on permissible speed calculation methods.

MEDIUM ISO 03 SERIES
MM300K



SUPER PRECISION MM

Running accuracy and performance meet ABEC 9 (ISO P2) levels.
Other features conform to ABEC 7 (ISO P4) requirements.

Bearing Number	d Bore	D O.D.	C Width(1)	Ball Qty. x Dia.	Bearing Wt.	LOAD RATINGS Steel Ball C_o Static	Steel Ball C_e Dynamic	Steel Ball Speed Rating(Ng)	Ceramic Ball C_o Static	Ceramic Ball C_e Dynamic	Ceramic Ball Speed Rating(Ng)	r Rad.(2)
	mm/in.			**mm**/in.	**kg**/lbs.	**N**/lbs.		RPM	**N**/lbs.		RPM	**mm**/in.
MM305K	**25**	**62**	**17**	**7 x 11.9**	**0.222**	**12100**	**26200**	**26500**	**10800**	**26200**	**31800**	**1.0**
	0.9843	2.4409	0.6693	7 x 15/32	0.49	2730	5890	26500	2430	5890	31800	0.039
MM306K	**30**	**72**	**19**	**7 x 13.5**	**0.327**	**15800**	**33100**	**22300**	**14100**	**33100**	**26760**	**1.0**
	1.1811	2.8346	0.7480	7 x 17/32	0.72	3560	7440	22300	3160	7440	26760	0.039
MM307K	**35**	**80**	**21**	**7 x 14.3**	**0.431**	**18300**	**37100**	**19400**	**16300**	**37100**	**23280**	**1.5**
	1.3780	3.1496	0.8268	7 x 9/16	0.95	4120	8340	19400	3670	8340	23280	0.059
MM308K	**40**	**90**	**23**	**7 x 15.9**	**0.594**	**22800**	**45000**	**17100**	**20300**	**45000**	**20520**	**1.5**
	1.5748	3.5433	0.9055	7 x 5/8	1.31	5120	10100	17100	4560	10100	20520	0.059
MM309K	**45**	**100**	**25**	**8 x 17.5**	**0.807**	**31700**	**58500**	**15200**	**28200**	**58500**	**18240**	**1.5**
	1.7717	3.9370	0.9843	8 x 11/16	1.78	7120	13200	15200	6340	13200	18240	0.059
MM310K	**50**	**110**	**27**	**8 x 19.1**	**1.052**	**37900**	**68600**	**13800**	**33700**	**68600**	**16560**	**1.5**
	1.9685	4.3307	1.0630	8 x 3/4	2.32	8510	15400	13800	7570	15400	16560	0.059
MM311K	**55**	**120**	**29**	**8 x 20.6**	**1.329**	**44600**	**79300**	**12500**	**39700**	**79300**	**15000**	**2.0**
	2.1654	4.7244	1.1417	8 x 13/16	2.93	10000	17800	12500	8920	17800	15000	0.079
MM312K	**60**	**130**	**31**	**8 x 22.2**	**1.665**	**51800**	**90700**	**11500**	**46100**	**90700**	**13800**	**2.0**
	2.3622	5.1181	1.2205	8 x 7/8	3.67	11700	20400	11500	10400	20400	13800	0.079
MM313K	**65**	**140**	**33**	**8 x 23.8**	**2.046**	**59700**	**102700**	**10700**	**53100**	**102700**	**12840**	**2.0**
	2.5591	5.5118	1.2992	8 x 15/16	4.51	13400	23100	10700	11900	23100	12840	0.079
MM314K	**70**	**150**	**35**	**8 x 25.4**	**2.486**	**68000**	**115500**	**9900**	**60600**	**115500**	**11880**	**2.0**
	2.7559	5.9055	1.3780	8 x 1	5.48	15300	26000	9900	13600	26000	11880	0.079

(Ng) For a single, grease-lubricated, spring-preloaded bearing. This value to be used in permissible operating speed (Sp) calculation.
(1) Width tolerance of preloaded bearing set +0.000/-0.254 mm (+0.0000/-0.0100 in.).
(2) ABMA STD 20 (r_{as} max).

DEEP-GROOVE (CONRAD) CONSTRUCTION

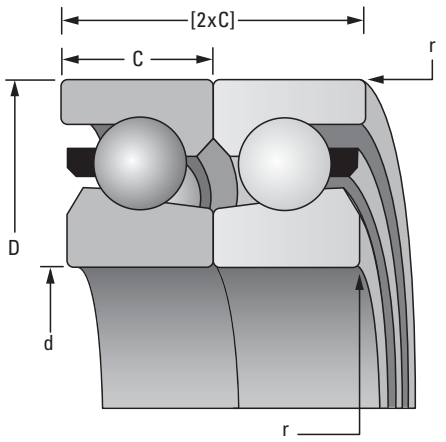
- Incorporates high shoulder on both inner and outer rings.
- Balls separated by two-piece and piloted cage.

Suggested Shoulder Diameters				Shaft Diameter		Mounting Fits		FIXED				FLOATING			
Shaft		Housing						Housing Bore (Stationary)		Mounting Fits		Housing Bore (Stationary)		Mounting Fits	
Max.	Min.	Max.	Min.	Max.	Min.	Loose	Tight	Max.	Min.	Tight	Loose	Max.	Min.	Loose	Loose
mm/in.		**mm**/in.		**mm**/in.		**mm**/in.		**mm**/in.		**mm**/in.		**mm**/in.		**mm**/in.	
32.1	**31.9**	**55.8**	**55.5**	**25.000**	**24.995**	**0.005**	**0.005**	**62.008**	**62.000**	**0.000**	**0.015**	**62.012**	**62.007**	**0.019**	**0.007**
1.27	1.26	2.20	2.19	0.98430	0.98410	0.00020	0.00020	2.44120	2.44090	0.00000	0.00060	2.44140	2.44120	0.00080	0.00030
37.7	**37.5**	**65.2**	**64.9**	**30.000**	**29.995**	**0.005**	**0.005**	**72.008**	**72.000**	**0.000**	**0.015**	**72.011**	**72.007**	**0.019**	**0.007**
1.49	1.48	2.57	2.56	1.18110	1.18090	0.00020	0.00020	2.83490	2.83460	0.00000	0.00060	2.83510	2.83490	0.00080	0.00030
43.7	**43.2**	**72.1**	**71.6**	**35.000**	**34.995**	**0.005**	**0.006**	**80.008**	**80.000**	**0.000**	**0.015**	**80.012**	**80.008**	**0.020**	**0.008**
1.72	1.70	2.84	2.82	1.37800	1.37780	0.00020	0.00025	3.14990	3.14960	0.00000	0.00060	3.15010	3.14990	0.00080	0.00030
49.8	**49.3**	**81.3**	**80.8**	**40.000**	**39.995**	**0.005**	**0.006**	**90.008**	**90.000**	**0.000**	**0.016**	**90.015**	**90.007**	**0.023**	**0.007**
1.96	1.94	3.20	3.18	1.57480	1.57460	0.00020	0.00025	3.54360	3.54330	0.00000	0.00060	3.54390	3.54360	0.00090	0.00030
55.9	**55.4**	**90.2**	**89.7**	**45.000**	**44.995**	**0.005**	**0.006**	**100.008**	**100.000**	**0.000**	**0.016**	**100.018**	**100.010**	**0.025**	**0.010**
2.20	2.18	3.55	3.53	1.77170	1.77150	0.00020	0.00025	3.93730	3.93700	0.00000	0.00060	3.93770	3.93740	0.00100	0.00040
61.2	**60.7**	**99.8**	**99.3**	**50.000**	**49.995**	**0.005**	**0.006**	**110.008**	**110.000**	**0.000**	**0.016**	**110.018**	**110.010**	**0.025**	**0.010**
2.41	2.39	3.93	3.91	1.96850	1.96830	0.00020	0.00025	4.33100	4.33070	0.00000	0.00060	4.33140	4.33110	0.00100	0.00040
67.3	**66.8**	**108.7**	**108.2**	**55.000**	**54.995**	**0.005**	**0.007**	**120.008**	**120.000**	**0.000**	**0.016**	**120.018**	**120.010**	**0.025**	**0.010**
2.65	2.63	4.28	4.26	2.16540	2.16520	0.00020	0.00030	4.72470	4.72440	0.00000	0.00060	4.72510	4.72480	0.00100	0.00040
43.2	**72.6**	**117.9**	**117.3**	**60.000**	**59.995**	**0.005**	**0.007**	**130.009**	**130.000**	**0.000**	**0.018**	**130.020**	**130.010**	**0.029**	**0.010**
2.88	2.86	4.64	4.62	2.36220	2.36200	0.00020	0.00030	5.11850	5.11810	0.00000	0.00070	5.11890	5.11850	0.00110	0.00040
80.3	**79.8**	**126.8**	**126.2**	**65.000**	**64.995**	**0.005**	**0.007**	**140.009**	**140.000**	**0.000**	**0.018**	**140.020**	**140.010**	**0.029**	**0.010**
3.16	3.14	4.99	4.97	2.55910	2.55890	0.00020	0.00030	5.51220	5.51180	0.00000	0.00070	5.51260	5.51220	0.00110	0.00040
85.3	**84.8**	**135.6**	**135.1**	**70.000**	**69.995**	**0.005**	**0.007**	**150.009**	**150.000**	**0.000**	**0.018**	**150.023**	**150.012**	**0.032**	**0.012**
3.36	3.34	5.34	5.32	2.75590	2.75570	0.00020	0.00030	5.90590	5.90550	0.00000	0.00070	5.90640	5.90600	0.00120	0.00050

BALL SCREW SUPPORT SERIES

METRIC SERIES

- Designed for maximum axial rigidity, low drag torque and extreme control of lateral eccentricity.
- Manufactured to ABEC 9/ISO P2 axial tolerances.
- Non-separable angular-contact type design (60 degree contact angle).
- Manufactured to ABEC 7/ISO P4 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].



Bearing Number	d Bore	D O.D.	C Width(1)	Ball Qty. x Dia.	Wt.(2)	r Rad.(3)	Suggested Shoulder Diameters				Shaft Dia.		Housing Dia.	
							Shaft		Housing					
							Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm/in.			mm/in.	kg/lbs	mm/in.	mm/in.		mm/in.		mm/in.		mm/in.	
MM12BS32	**12**	**32**	**10**	**11 x 4.8**	**0.040**	**0.8**	**17.630**	**17.370**	**26.630**	**26.370**	**11.996**	**11.992**	**32.006**	**32.000**
	0.4724	1.2598	0.3937	11 x 3/16	0.09	0.031	0.6941	0.6839	1.0484	1.0382	0.4723	0.4721	1.2601	1.2598
MM15BS35	**15**	**35**	**11**	**13 x 4.8**	**0.050**	**0.8**	**20.630**	**20.370**	**29.630**	**29.370**	**14.996**	**14.992**	**35.006**	**35.000**
	0.5906	1.3780	0.4331	13 x 3/16	0.11	0.031	0.8122	0.8020	1.1665	1.1563	0.5904	0.5902	1.3782	1.3780
MM17BS47	**17**	**47**	**15**	**12 x 7.9**	**0.130**	**0.8**	**23.130**	**22.870**	**41.630**	**41.370**	**16.996**	**16.992**	**47.006**	**47.000**
	0.6693	1.8504	0.5906	12 x 5/32	0.29	0.031	0.9106	0.9004	1.6390	1.6287	0.6691	0.6690	1.8506	1.8504
MM20BS47	**20**	**47**	**15**	**12 x 7.9**	**0.120**	**0.8**	**26.130**	**25.870**	**41.630**	**41.370**	**19.995**	**19.990**	**47.006**	**47.000**
	0.7874	1.8504	0.5906	12 x 5/32	0.26	0.031	1.0287	1.0185	1.6390	1.6287	0.7872	0.7870	1.8506	1.8504
MM25BS52	**25**	**52**	**15**	**13 x 7.9**	**0.140**	**0.8**	**31.630**	**31.370**	**43.630**	**43.370**	**24.995**	**24.990**	**52.007**	**52.000**
	0.9843	2.0472	0.5906	13 x 5/32	0.37	0.031	1.2453	1.2350	1.7177	1.7075	0.9841	0.9839	2.0475	2.0472
MM25BS62	**25**	**62**	**15**	**17 x 7.9**	**0.230**	**0.8**	**35.130**	**34.870**	**56.130**	**55.870**	**24.995**	**24.990**	**62.007**	**62.000**
	0.9843	2.4409	0.5906	17 x 5/32	0.51	0.031	1.3831	1.3728	2.2098	2.1996	0.9841	0.9839	2.4412	2.4409
MM30BS62	**30**	**62**	**15**	**17 x 7.9**	**0.210**	**0.8**	**40.130**	**39.870**	**56.130**	**55.870**	**29.995**	**29.990**	**62.007**	**62.000**
	1.1811	2.4409	0.5906	17 x 5/32	0.46	0.031	1.5799	1.5697	2.2098	2.1996	1.1809	1.1807	2.4412	2.4409
MM30BS72	**30**	**72**	**15**	**18 x 8.7**	**0.320**	**0.8**	**40.130**	**39.870**	**56.130**	**55.870**	**29.995**	**29.990**	**72.007**	**72.000**
	1.1811	2.8346	0.5906	18 x 11/32	0.71	0.031	1.5799	1.5697	2.2098	2.1996	1.1809	1.1807	2.8349	2.8346
MM35BS72	**35**	**72**	**15**	**18 x 8.7**	**0.290**	**0.8**	**42.130**	**41.870**	**64.130**	**63.870**	**34.994**	**34.988**	**72.007**	**72.000**
	1.3780	2.8346	0.5906	18 x 11/32	0.64	0.031	1.6587	1.6484	2.5248	2.5146	1.3777	1.3775	2.8349	2.8346
MM35BS100	**35**	**100**	**20**	**18 x 12.7**	**0.860**	**0.8**	**42.130**	**41.870**	**90.130**	**89.870**	**34.994**	**34.998**	**100.007**	**100.000**
	1.3780	3.9370	0.7874	18 x 1/2	1.90	0.031	1.6587	1.6484	3.5484	3.5382	1.3777	1.3775	3.9373	3.9370
MM40BS72	**40**	**72**	**15**	**18 x 8.7**	**0.250**	**0.8**	**47.130**	**46.870**	**64.130**	**63.870**	**39.994**	**39.998**	**72.007**	**72.000**
	1.5748	2.8346	0.5906	18 x 11/32	0.55	0.031	1.8555	1.8453	2.5248	2.5146	1.5746	1.5743	2.8349	2.8346
MM40BS90	**40**	**90**	**15**	**24 x 8.7**	**0.490**	**0.8**	**47.130**	**46.870**	**82.130**	**81.870**	**39.994**	**39.988**	**90.008**	**90.000**
	1.5748	3.5433	0.5906	24 x 11/32	1.08	0.031	1.8555	1.8453	3.2335	3.2232	1.5746	1.5743	3.5436	3.5433
MM40BS90-20	**40**	**90**	**20**	**24 x 8.7**	**0.660**	**0.8**	**47.130**	**46.870**	**82.130**	**81.870**	**39.994**	**39.998**	**90.008**	**90.000**
	1.5748	3.5433	0.7874	24 x 11/32	1.46	0.031	1.8555	1.8453	3.2335	3.2232	1.5746	1.5743	3.5436	3.5433
MM40BS90-23	**40**	**90**	**23**	**24 x 8.7**	**0.750**	**0.8**	**47.130**	**46.870**	**82.130**	**81.870**	**39.994**	**39.988**	**90.008**	**90.000**
	1.5748	3.5433	0.9055	24 x 11/32	1.65	0.031	1.8555	1.8453	3.2335	3.2232	1.5746	1.5743	3.5436	3.5433

(1) Width tolerance of preloaded bearing set +0.000/-0.254 mm (+0.0000/-0.0100 in.).
(2) Single bearing.
(3) ABMA STD 20 (r_{as} max).

Continued on next page.

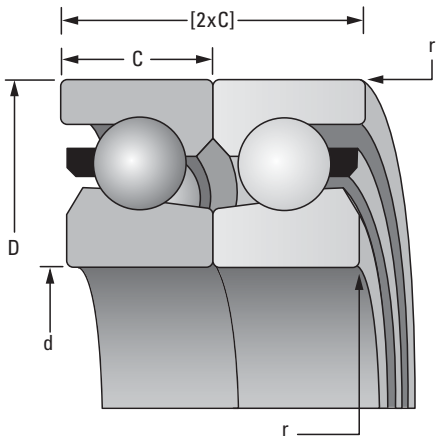
Bearing Number	d Bore	D O.D.	C Width[1]	Ball Qty. x Dia.	Wt.[2]	r Rad.[3]	Suggested Shoulder Diameters				Shaft Dia.		Housing Dia.	
							Shaft		Housing					
							Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm/in.			**mm**/in.	**kg**/lbs	**mm**/in.	**mm**/in.		**mm**/in.		**mm**/in.		**mm**/in.	
MM40BS100	**40**	**100**	**20**	**18 x 12.7**	**0.820**	**0.8**	**47.130**	**46.870**	**90.130**	**89.870**	**39.994**	**39.988**	**100.007**	**100.000**
	1.5748	3.9370	0.7874	18 x 1/2	1.81	0.031	1.8555	1.8453	3.5484	3.5382	1.5746	1.5743	3.9373	3.9370
MM45BS75	**45**	**75**	**15**	**20 x 8.7**	**0.250**	**0.8**	**52.130**	**51.870**	**69.130**	**68.870**	**44.994**	**44.988**	**75.007**	**75.000**
	1.7717	2.9528	0.5906	20 x 11/32	0.55	0.031	2.0524	2.0421	2.7217	2.7114	1.7714	1.7712	2.9530	2.9528
MM45BS100	**45**	**100**	**20**	**18 x 12.7**	**0.760**	**0.8**	**54.130**	**53.870**	**90.130**	**89.870**	**44.994**	**44.988**	**100.008**	**100.000**
	1.7717	3.9370	0.7874	18 x1/2	1.68	0.031	2.1311	2.1209	3.5484	3.5382	1.7714	1.7712	3.9373	3.9370
MM50BS90	**50**	**90**	**15**	**24 x 8.7**	**0.410**	**0.8**	**59.130**	**58.870**	**82.130**	**81.870**	**49.994**	**49.988**	**90.008**	**90.000**
	1.9685	3.5433	0.5906	24 x 11/32	0.90	0.031	2.3280	2.3177	3.2335	3.2232	1.9683	1.9680	3.5436	3.5433
MM50BS100	**50**	**100**	**20**	**18 x 12.7**	**0.710**	**0.8**	**59.130**	**58.870**	**90.130**	**89.870**	**49.994**	**49.988**	**100.008**	**100.000**
	1.9685	3.9370	0.7874	18 x1/2	1.57	0.031	2.3280	2.3177	3.5484	3.5382	1.9683	1.9680	3.9373	3.9370
MM55BS90	**55**	**90**	**15**	**24 x 8.7**	**0.360**	**0.8**	**63.130**	**62.870**	**82.130**	**81.870**	**54.993**	**54.986**	**90.008**	**90.000**
	2.1654	3.5433	0.5906	24 x 11/32	0.79	0.031	2.4854	2.4752	3.2335	3.2232	2.1651	2.1648	3.5436	3.5433
MM55BS120	**55**	**120**	**20**	**21 x 12.7**	**1.140**	**1.0**	**65.130**	**64.870**	**110.130**	**109.870**	**54.993**	**54.986**	**120.008**	**120.000**
	2.1654	4.7244	0.7874	21 x 1/2	2.51	0.039	2.5642	2.5539	4.3358	4.3256	2.1651	2.1648	4.7247	4.7244
MM60BS120	**60**	**120**	**20**	**21 x 12.7**	**1.060**	**1.0**	**70.130**	**69.870**	**110.130**	**109.870**	**59.993**	**59.986**	**120.008**	**120.000**
	2.3622	4.7244	0.7874	21 x 1/2	2.34	0.039	2.7610	2.7508	4.3358	4.3256	2.3619	2.3617	4.7247	4.7244
MM75BS110	**75**	**110**	**15**	**30 x 8.7**	**0.460**	**0.8**	**84.130**	**83.870**	**102.130**	**101.870**	**74.993**	**74.986**	**110.008**	**110.000**
	2.9528	4.3307	0.5906	30 x 11/32	1.01	0.031	3.3122	3.3020	4.0209	4.0106	2.9525	2.9522	4.3310	4.3307
MM100BS150	**100**	**150**	**20**	**26 x 12.7**	**1.280**	**1.0**	**110.130**	**109.870**	**138.130**	**137.870**	**99.992**	**99.984**	**150.009**	**150.000**
	3.9370	5.9055	0.7874	26 x 1/2	2.82	0.039	4.3358	4.3256	5.4382	5.4280	3.9367	3.9364	5.9059	5.9055

[1] Width tolerance of preloaded bearing set +0.000/-0.254 mm (+0.0000/-0.0100 in.).
[2] Single bearing.
[3] ABMA STD 20 (r_{as} max).

BALL SCREW SUPPORT SERIES

INCH SERIES

- Designed for maximum axial rigidity, low drag torque, and extreme control of lateral eccentricity.
- Manufactured to ABEC 9/ISO P2 axial tolerances.
- Nonseparable angular-contact type design (60˚ contact angle).
- Manufactured to ABEC 7/ISO P4 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].



C

Bearing Number	d Bore	D O.D.	C Width(1)	Ball Qty. x Dia.	Wt.(2)	r Rad.(3)	Suggested Shoulder Diameters				Shaft Dia.		Housing Dia.	
							Shaft		Housing					
							Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	mm/in.			mm/in.	kg/lbs	mm/in.	mm/in.		mm/in.		mm/in.		mm/in.	
MM9306WI2H	**20**	**47**	**15.88**	**12 x 7.9**	**0.130**	**0.8**	**27.508**	**27.254**	**41.681**	**41.427**	**19.995**	**19.990**	**47.008**	**47.000**
	0.7874	1.8504	0.6250	12 x 5/16	0.28	0.031	1.0830	1.0730	1.6410	1.6310	0.7872	0.7870	1.8507	1.8504
MM9308WI2H	**23.8**	**62**	**15.88**	**17 x 7.9**	**0.250**	**0.8**	**33.553**	**33.299**	**55.347**	**55.093**	**23.833**	**23.828**	**62.006**	**61.999**
	0.9385	2.4409	0.6250	17 x 5/16	0.56	0.031	1.3210	1.3110	2.1790	2.1690	0.9383	0.9381	2.4412	2.4409
MM9310WI2H	**38.1**	**72**	**15.88**	**18 x 8.7**	**0.280**	**0.8**	**47.371**	**47.117**	**62.967**	**62.713**	**38.092**	**38.085**	**72.006**	**71.999**
	1.5000	2.8346	0.6250	18 x 11/32	0.62	0.031	1.8650	1.8550	2.4790	2.4690	1.4997	1.4994	2.8349	2.8346
MM9311WI3H	**44.5**	**76.2**	**15.88**	**20 x 8.7**	**0.290**	**0.8**	**52.248**	**51.994**	**67.869**	**67.615**	**44.468**	**44.460**	**76.208**	**76.200**
	1.7510	3.0000	0.6250	20 x 11/32	0.63	0.031	2.0570	2.0470	2.6720	2.6620	1.7507	1.7504	3.0003	3.0000
MM9313WI5H	**57.2**	**90**	**15.88**	**24 x 8.7**	**0.360**	**0.8**	**65.456**	**65.202**	**81.178**	**80.924**	**57.142**	**57.135**	**90.007**	**90.000**
	2.2500	3.5433	0.6250	24 x 11/32	0.80	0.031	2.5770	2.5670	3.1960	3.1860	2.2497	2.2494	3.5436	3.5433
MM9316WI3H	**76.2**	**110**	**15.88**	**30 x 8.7**	**0.470**	**0.8**	**85.852**	**85.598**	**101.600**	**101.346**	**76.192**	**76.185**	**110.007**	**110.000**
	3.0000	4.3307	0.6250	30 x 11/32	1.04	0.031	3.3800	3.3700	4.0000	3.9900	2.9997	2.9994	4.3310	4.3307
MM9321WI3H	**101.6**	**145**	**22.23**	**37 x 9.5**	**1.180**	**1.0**	**112.217**	**111.963**	**134.645**	**134.391**	**101.592**	**101.585**	**145.011**	**145.001**
	4.0000	5.7087	0.8750	37 x 3/8	2.60	0.039	4.4180	4.4080	5.3010	5.2910	3.9997	3.9994	5.7091	5.7087
MM9326WI6H	**127**	**180**	**22.23**	**35 x 12.7**	**1.750**	**1.0**	**143.993**	**143.739**	**167.919**	**167.665**	**126.992**	**126.985**	**180.010**	**180.000**
	5.0000	7.0866	0.8750	35 x 1/2	3.85	0.039	5.6690	5.6590	6.6110	6.6010	4.9997	4.9994	7.0870	7.0866

(1) Width tolerance of preloaded bearing set +0.000/-0.254 mm (+0.0000/-0.0100 in.).
(2) Single bearing.
(3) ABMA STD 20 (r_{as} max).

BALL SCREW SUPPORT SERIES

PERFORMANCE DATA
METRIC SERIES
DUH

Bearing Number	T_L Static Limiting Thrust Capacity[3]	C_{ae} Dynamic Axial Load Rating[1][3]	Speed Rating	Axial Spring Constant[3]	Drag Torque (Preloaded Set)	Preload[2][3] (Heavy)
	N lbs.	**N** lbs.	RPM	**N/µm** 10^6 lbs./in	**N-m** lbs.-in.	**N** lbs.
MM12BS32DUH	**11400** 2600	**9500** 2140	**7300** 7300	**425** 2.4	**0.28** 2.48	**1000** 200
MM15BS35DUH	**13700** 3100	**10400** 2340	**6400** 6400	**490** 2.8	**0.30** 2.65	**1200** 300
MM17BS47DUH	**24900** 5600	**24900** 5600	**4700** 4700	**750** 4.3	**0.32** 2.83	**3110** 700
MM20BS47DUH	**24900** 5600	**24900** 5600	**4700** 4700	**750** 4.3	**0.32** 2.83	**3110** 700
MM25BS52DUH	**27100** 6100	**26000** 5850	**4300** 4300	**780** 4.5	**0.39** 3.45	**2700** 600
MM25BS62DUH	**35600** 8000	**29800** 6700	**3300** 3300	**1050** 6.0	**0.44** 3.88	**4450** 1000
MM30BS62DUH	**35600** 8000	**29800** 6700	**3300** 3300	**1050** 6.0	**0.44** 3.88	**4450** 1000
MM30BS72DUH	**45400** 10200	**36300** 8160	**2900** 2900	**1260** 7.2	**0.44** 3.88	**6230** 1400
MM35BS72DUH	**45400** 10200	**36300** 8160	**2900** 2900	**1260** 7.2	**0.44** 3.88	**6230** 1400
MM40BS72DUH	**45400** 10200	**36300** 8160	**2900** 2900	**1260** 7.2	**0.44** 3.88	**6230** 1400
MM45BS75DUH	**50700** 11400	**38500** 8660	**2700** 2700	**1380** 7.9	**0.56** 4.96	**6670** 1500
MM40BS90DUH	**60900** 13700	**41400** 9310	**2200** 2200	**1660** 9.5	**0.82** 7.26	**8010** 1800
MM40BS90-20DUH	**60900** 13700	**41400** 9310	**2200** 2200	**1660** 9.5	**0.82** 7.26	**8010** 1800
MM40BS90-23DUH	**60900** 13700	**41400** 9310	**2200** 2200	**1660** 9.5	**0.82** 7.26	**8010** 1800
MM50BS90DUH	**60900** 13700	**41400** 9310	**2200** 2200	**1660** 9.5	**0.82** 7.26	**8010** 1800
MM55BS90DUH	**60900** 13700	**41400** 9310	**2200** 2200	**1660** 9.5	**0.82** 7.26	**8010** 1800
MM35BS100DUH	**93400** 21000	**71200** 16010	**2000** 2000	**1750** 10.0	**1.02** 9.03	**12900** 2900
MM40BS100DUH	**93400** 21000	**71200** 16010	**2000** 2000	**1750** 10.0	**1.02** 9.03	**12900** 2900
MM45BS100DUH	**93400** 21000	**71200** 16010	**2000** 2000	**1750** 10.0	**1.02** 9.03	**12900** 2900
MM50BS100DUH	**93400** 21000	**71200** 16010	**2000** 2000	**1750** 10.0	**1.02** 9.03	**12900** 2900
MM75BS110DUH	**77000** 17300	**44500** 10000	**1700** 1700	**2080** 11.9	**1.00** 8.85	**9790** 2200
MM55BS120DUH	**133400** 30000	**75600** 17000	**1700** 1700	**2150** 12.3	**1.36** 12.04	**15570** 3500
MM60BS120DUH	**133400** 30000	**75600** 17000	**1700** 1700	**2150** 12.3	**1.36** 12.04	**15570** 3500
MM100BS150DUH	**200500** 45100	**80900** 18200	**1300** 1300	**3400** 19.4	**2.18** 19.29	**21350** 4800

(1) Based on 1500 hours L_{10} life and permissible speed.
(2) Heavy preload is standard.
(3) Data presented is for a single bearing in a DUH set.

BALL SCREW SUPPORT SERIES

PERFORMANCE DATA
METRIC SERIES
QUH

Bearing Number	T_L Static Limiting Thrust Capacity[3]	C_{ae} Dynamic Axial Load Rating[1][3]	Speed Rating	Axial Spring Constant[3]	Drag Torque (Preloaded Set)	Preload[2][3] (Heavy)
	N lbs.	**N** lbs.	RPM	**N/µm** 10^6 lbs./in	**N-m** lbs.-in.	**N** lbs.
MM12BS32QUH	**22800**	**15400**	**5100**	**850**	**0.56**	**2000**
	5100	3500	5100	4.9	4.96	400
MM15BS35QUH	**27400**	**16850**	**4500**	**980**	**0.60**	**2400**
	6200	3800	4500	5.6	5.31	500
MM17BS47QUH	**49800**	**40500**	**3700**	**1510**	**0.64**	**6230**
	11200	9100	3700	8.6	5.65	1400
MM20BS47QUH	**49800**	**40500**	**3700**	**1510**	**0.64**	**6230**
	11200	9100	3700	8.6	5.65	1400
MM25BS52QUH	**54300**	**42300**	**3700**	**1560**	**0.49**	**5400**
	12200	9500	3700	8.9	6.90	1200
MM25BS62QUH	**71200**	**48500**	**2700**	**2100**	**0.88**	**8900**
	16000	10900	2700	12.0	7.78	2000
MM30BS62QUH	**71200**	**48500**	**2700**	**2100**	**0.88**	**8900**
	16000	10900	2700	12.0	7.78	2000
MM30BS72QUH	**90700**	**58700**	**2100**	**2520**	**0.88**	**12450**
	20400	13200	2100	14.4	7.78	2800
MM35BS72QUH	**90700**	**58700**	**2100**	**2520**	**0.88**	**12450**
	20400	13200	2100	14.4	7.78	2800
MM40BS72QUH	**90700**	**58700**	**2100**	**2520**	**0.88**	**12450**
	20400	13200	2100	14.4	7.78	2800
MM45BS75QUH	**101400**	**62700**	**1800**	**2770**	**1.12**	**13340**
	22800	14100	1800	15.8	9.92	3000
MM40BS90QUH	**121900**	**67200**	**1700**	**3330**	**1.64**	**16010**
	27400	15100	1700	19.0	14.51	3600
MM50BS90QUH	**121900**	**67200**	**1700**	**3330**	**1.64**	**16010**
	27400	15100	1700	19.0	14.51	3600
MM55BS90QUH	**121900**	**67200**	**1700**	**3330**	**1.64**	**16010**
	27400	15100	1700	19.0	14.51	3600
MM35BS100QUH	**186800**	**115600**	**1400**	**3500**	**2.04**	**25800**
	42000	26000	1400	20.0	18.05	5800
MM40BS100QUH	**186800**	**115600**	**1400**	**3500**	**2.04**	**25800**
	42000	26000	1400	20.0	18.05	5800
MM45BS100QUH	**186800**	**115600**	**1400**	**3500**	**2.04**	**25800**
	42000	26000	1400	20.0	18.05	5800
MM50BS100QUH	**186800**	**115600**	**1400**	**3500**	**2.04**	**25800**
	42000	26000	1400	20.0	18.05	5800
MM75BS110QUH	**153900**	**72100**	**1200**	**4170**	**2.00**	**19570**
	34600	16200	1200	23.8	17.70	4400
MM55BS120QUH	**266900**	**122800**	**1200**	**4310**	**2.72**	**31140**
	60000	27600	1200	24.6	24.08	7000
MM60BS120QUH	**266900**	**122800**	**1200**	**4310**	**2.72**	**31140**
	60000	27600	1200	24.6	24.08	7000
MM100BS150QUH	**401000**	**131500**	**900**	**6790**	**4.36**	**42700**
	90100	29500	900	38.8	38.59	9600

(1) Based on 1500 hours L_{10} life and permissible speed.
(2) Heavy preload is standard.
(3) Data presented is for two bearings in a QUH set mounted DB or DF.

BALL SCREW SUPPORT SERIES

PERFORMANCE DATA
INCH SERIES
DUH/QUH

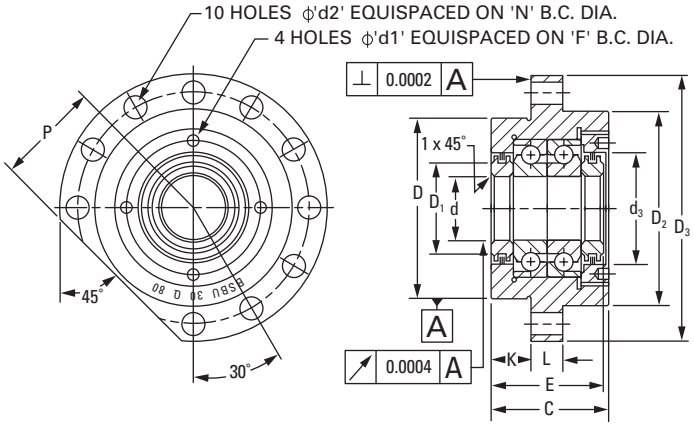
Bearing Number	T_L Static Limiting Thrust Capacity[3]	C_{ae} Dynamic Axial Load Rating[1][3]	Speed Rating	Axial Spring Constant[3]	Drag Torque (Preloaded Set)	Preload[2][3] (Heavy)
	N lbs.	**N** lbs.	RPM	**N/µm** 10 lbs./in	**N-m** lbs.-in.	**N** **lbs.**
MM9306WI2HDUH	**24900**	**24900**	**4400**	**750**	**0.32**	**3110**
	5600	5600	4400	4.3	2.83	700
MM9308WI2HDUH	**35600**	**29800**	**3200**	**1050**	**0.44**	**4450**
	8000	6700	3200	6.0	3.89	1000
MM9310WI2HDUH	**45400**	**36300**	**2500**	**1260**	**0.44**	**6230**
	10200	8150	2500	7.2	3.89	1400
MM9311WI3HDUH	**50700**	**38500**	**2100**	**1380**	**0.56**	**6670**
	11400	8650	2100	7.9	4.96	1500
MM9313WI5HDUH	**60900**	**41400**	**2000**	**1660**	**0.82**	**8010**
	13700	9300	2000	9.5	7.26	1800
MM9316WI3HDUH	**77000**	**44500**	**1400**	**2080**	**1.00**	**9790**
	17300	10000	1400	11.9	8.85	2200
MM9321WI3DUH	**115700**	**57400**	**1000**	**3400**	**1.02**	**21350**
	26000	12900	1000	19.4	9.01	4800
MM9326WI6HDUH	**186800**	**94300**	**750**	**3630**	**1.26**	**26690**
	42000	21200	750	20.7	11.10	6000
MM9306WI2HQUH	**49800**	**40500**	**3700**	**1510**	**0.64**	**6230**
	11200	9100	3700	8.6	5.66	1400
MM9308WI2HQUH	**71200**	**48500**	**2700**	**2100**	**0.88**	**8900**
	16000	10900	2700	12.0	7.78	2000
MM9310WI2HQUH	**90700**	**58700**	**2100**	**2520**	**0.88**	**12450**
	20400	13200	2100	14.4	7.78	2800
MM9311WI3HQUH	**101400**	**62700**	**1800**	**2770**	**1.12**	**13340**
	22800	14100	1800	15.8	9.92	3000
MM9313WI5HQUH	**121900**	**67200**	**1700**	**3330**	**1.64**	**16010**
	27400	15100	1700	19.0	14.52	3600
MM9316WI3HQUH	**153900**	**72100**	**1200**	**4170**	**2.00**	**19570**
	34600	16200	1200	23.8	17.70	4400
MM9321WI3QUH	**231300**	**93400**	**900**	**6800**	**2.04**	**42700**
	52000	21000	900	38.8	18.02	9600
MM9326WI6HQUH	**373600**	**153000**	**600**	**7250**	**2.51**	**53380**
	84000	34400	600	41.4	22.22	12000

[1] Based on 1500 hours L_{10} life and permissible speed.
[2] Heavy preload is standard.
[3] Data presented is for a single bearing in a DUH set and for two bearings in a QUH set mounted DB or DF.

BALL SCREW SUPPORT BEARING CARTRIDGE UNITS

BSBU D – STANDARD AND HEAVY-DUTY BEARINGS

- Designed and developed to give the machine manufacturer a ready-made unit providing excellent stiffness and accuracy in ball screw applications.
- Units combine the features of MM-BS-DU (Duplex) ball screw support bearings with an accurately manufactured housing and laminar ring seals.
- Each unit is prepacked with a measured quantity of high quality bearing grease and requires no further lubrication.
- Units are supplied with the bearings in pairs mounted in the "DB" ("O") arrangement.
- Other bearing arrangements can be accommodated if required. Please consult your Timken representative with details of your requirements or for suggested shaft and housing fits.
- For load and speed ratings, refer to bearing data on page 203.



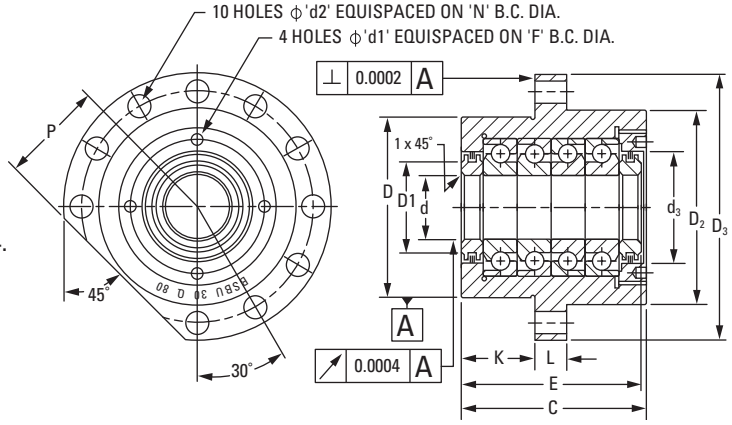
STANDARD SERIES – DIMENSIONAL TOLERANCES ±0.13 mm (± 0.005 in.) UNLESS OTHERWISE STATED.

Shaft Dia.	Unit Number (Bearing Set)	C	d	d_1	d_2	d_3	D	D_1	D_2	D_3	E	F	K	L	N	P	Wt.
mm		**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**kg** lbs.
17	BSBU17D60	**47.0**	**17.000**	**4.3**	**6.6**	**36.0**	**60.000**	**26.0**	**64.0**	**90.0**	**44.26**	**42.5**	**32.0**	**13.0**	**76.0**	**32**	**1.1**
			16.996				**59.987**				**43.24**						
	(MM17BS47DUH)	1.85	0.6693	0.17	0.26	1.42	2.3622	1.02	2.52	3.54	1.742	1.67	1.26	0.51	2.99	1.26	2.42
			0.6691				2.3617				1.702						
20	BSBU20D60	**47.0**	**20.000**	**4.3**	**6.6**	**36.0**	**60.000**	**26.0**	**64.0**	**90.0**	**44.26**	**42.5**	**32.0**	**13.0**	**76.0**	**32**	**1.1**
			19.996				**59.987**				**43.24**						
	(MM20BS47DUH)	1.85	0.7874	0.17	0.26	1.42	2.3622	1.02	2.52	3.54	1.742	1.67	1.26	0.51	2.99	1.26	2.42
			0.7872				2.3617				1.702						
25	BSBU25D80	**52.0**	**25.000**	**4.3**	**9.2**	**50.0**	**80.000**	**40.0**	**88.0**	**120.0**	**50.26**	**59.5**	**32.0**	**15.0**	**102.0**	**44**	**2.3**
			24.996				**79.987**				**49.24**						
	(MM25BS62DUH)	2.05	0.9842	0.17	0.36	1.97	3.1496	1.57	3.46	4.72	1.979	2.34	1.26	0.59	4.02	1.73	5.06
			0.9841				3.1491				1.938						
30	BSBU30D80	**52.0**	**30.000**	**4.3**	**9.2**	**50.0**	**80.000**	**40.0**	**88.0**	**120.0**	**50.26**	**59.5**	**32.0**	**15.0**	**102.0**	**44**	**2.2**
			29.996				**79.987**				**49.24**						
	(MM30BS62DUH)	2.05	1.1811	0.17	0.36	1.97	3.1496	1.57	3.46	4.72	1.979	2.34	1.26	0.59	4.02	1.73	4.84
			1.1809				3.1491				1.938						
35	BSBU35D90	**52.0**	**35.000**	**4.3**	**9.2**	**60.0**	**90.000**	**46.0**	**98.0**	**130.0**	**50.26**	**66.5**	**32.0**	**15.0**	**113.0**	**49**	**3.2**
			34.995				**89.985**				**49.24**						
	(MM35BS72DUH)	2.05	1.378	0.17	0.36	2.36	3.5433	1.81	3.86	5.12	1.979	2.62	1.26	0.59	4.45	1.93	7.04
			1.3778				3.5427				1.938						
40	BSBU40D90	**52.0**	**40.000**	**4.3**	**9.2**	**60.0**	**90.000**	**46.0**	**98.0**	**130.0**	**50.26**	**66.5**	**32.0**	**15.0**	**113.0**	**49**	**3.1**
			39.995				**89.985**				**49.24**						
	(MM40BS72DUH)	2.05	1.5748	0.17	0.36	2.36	3.5433	1.81	3.86	5.12	1.979	2.62	1.26	0.59	4.45	1.93	6.82
			1.5746				3.5427				1.938						
HEAVY-DUTY SERIES																	
35	BSBU35D124	**66.0**	**35.000**	**5.3**	**11.4**	**76.0**	**124.000**	**66.0**	**128.0**	**165.0**	**64.26**	**90.0**	**43.5**	**17.0**	**146.0**	**64**	**6.3**
			34.995				**123.982**				**63.24**						
	(MM35BS100DUH)	2.60	1.3780	0.21	0.45	2.99	4.8819	2.60	5.04	6.50	2.530	3.54	1.71	0.67	5.75	2.52	13.86
			1.3778				4.8812				2.490						
40	BSBU40D124	**66.0**	**40.000**	**5.3**	**11.4**	**76.0**	**124.000**	**66.0**	**128.0**	**165.0**	**64.26**	**90.0**	**43.5**	**17.0**	**146.0**	**64**	**6.1**
			39.995				**123.982**				**63.24**						
	(MM40BS100DUH)	2.60	1.5748	0.21	0.45	2.99	4.8819	2.60	5.04	6.50	2.530	3.54	1.71	0.67	5.75	2.52	13.42
			1.5746				4.8812				2.490						
45	BSBU45D124	**66.0**	**45.000**	**5.3**	**11.4**	**76.0**	**124.000**	**66.0**	**128.0**	**165.0**	**64.26**	**90.0**	**43.5**	**17.0**	**146.0**	**64**	**6.0**
			44.995				**123.982**				**63.24**						
	(MM45BS100DUH)	2.60	1.7716	0.21	0.45	2.99	4.8819	2.60	5.04	6.50	2.530	3.54	1.71	0.67	5.75	2.52	13.20
			1.7714				4.8812				2.490						
50	BSBU50D124	**66.0**	**50.000**	**5.3**	**11.4**	**76.0**	**124.000**	**66.0**	**128.0**	**165.0**	**64.26**	**90.0**	**43.5**	**17.0**	**146.0**	**64**	**5.9**
			49.995				**123.982**				**63.24**						
	(MM50BS100DUH)	2.60	1.9685	0.21	0.45	2.99	4.8819	2.60	5.04	6.50	2.530	3.54	1.71	0.67	5.75	2.52	12.89
			1.9683				4.8812				2.490						

BALL SCREW SUPPORT BEARING CARTRIDGE UNITS

BSBU Q – STANDARD AND HEAVY-DUTY BEARINGS

- Similar in design and features to the series BSBU D except MM-BS-QU Quadruplex bearings are used.
- Units are supplied with the bearings in quad sets mounted in the "DB" ("O") arrangement.
- Consult your Timken representative for suggested shaft fits.
- For load and speed ratings, refer to bearing data on page 204.



C

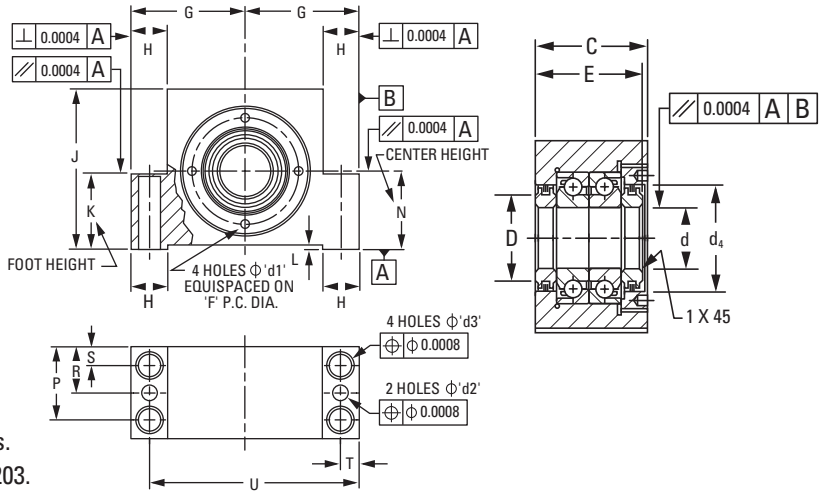
STANDARD SERIES – DIMENSIONAL TOLERANCES ±0.13 mm (± 0.005 in.) UNLESS OTHERWISE STATED.

Shaft Dia.	Unit Number (Bearing Set)	C	d	d_1	d_2	d_3	D	D_1	D_2	D_3	E	F	K	L	N	P	Wt.
mm		**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**kg** lbs.
17	BSBU17Q60	**77.0**	**17.000**	**4.3**	**6.6**	**36.0**	**60.000**	**26.0**	**64.0**	**90.0**	**74.26**	**42.5**	**32.0**	**13.0**	**76.0**	**32.0**	**1.7**
			16.996				**59.987**				**72.74**						
	(MM17BS47QUH)	3.03	0.6693	0.17	0.26	1.42	2.3622	1.02	2.52	3.54	2.924	1.67	1.26	0.51	2.99	1.26	3.74
			0.6690				2.3617				2.864						
20	BSBU20Q60	**77.0**	**20.000**	**4.3**	**6.6**	**36.0**	**60.000**	**26.0**	**64.0**	**90.0**	**74.26**	**42.5**	**32.0**	**13.0**	**76.0**	**32.0**	**1.7**
			19.996				**59.987**				**72.74**						
	(MM20BS47QUH)	3.03	0.7874	0.17	0.26	1.42	2.3622	1.02	2.52	3.54	2.924	1.67	1.26	0.51	2.99	1.26	3.74
			0.7872				2.3617				2.864						
25	BSBU25Q80	**82.0**	**25.000**	**4.3**	**9.2**	**50.0**	**80.000**	**40.0**	**88.0**	**120.0**	**80.26**	**59.5**	**32.0**	**15.0**	**102.0**	**44.0**	**3.5**
			24.996				**79.987**				**78.74**						
	(MM25BS62QUH)	3.23	0.9842	0.17	0.36	1.97	3.1496	1.57	3.46	4.72	3.160	2.34	1.26	0.59	4.02	1.73	7.70
			0.9841				3.1491				3.100						
30	BSBU30Q80	**82.0**	**30.000**	**4.3**	**9.2**	**50.0**	**80.000**	**40.0**	**88.0**	**120.0**	**80.26**	**59.5**	**32.0**	**15.0**	**102.0**	**44.0**	**3.4**
			29.996				**79.987**				**78.74**						
	(MM30BS62QUH)	3.23	1.1811	0.17	0.36	1.97	3.1496	1.57	3.46	4.72	3.160	2.34	1.26	0.59	4.02	1.73	7.48
			1.1809				3.1491				3.100						
35	BSBU35Q90	**82.0**	**35.000**	**4.3**	**9.2**	**60.0**	**90.000**	**46.0**	**98.0**	**130.0**	**80.26**	**66.5**	**32.0**	**15.0**	**113.0**	**49.0**	**4.6**
			34.995				**89.985**				**78.74**						
	(MM35BS72QUH	3.23	1.3780	0.17	0.36	2.36	3.5433	1.81	3.86	5.12	3.160	2.62	1.26	0.59	4.45	1.93	10.12
			1.3778				3.5427				3.100						
40	BSBU40Q90	**82.0**	**40.000**	**4.3**	**9.2**	**60.0**	**90.000**	**46.0**	**98.0**	**130.0**	**80.26**	**66.5**	**32.0**	**15.0**	**113.0**	**49.0**	**4.5**
			39.995				**89.985**				**78.74**						
	(MM40BS72QUH)	3.23	1.5748	0.17	0.36	2.36	3.5433	1.81	3.86	5.12	3.160	2.62	1.26	0.59	4.45	1.93	9.90
			1.5746				3.5427				3.100						
HEAVY-DUTY SERIES																	
35	BSBU35Q124	**106.0**	**35.000**	**5.3**	**11.4**	**76.0**	**124.000**	**66.0**	**128.0**	**165.0**	**104.26**	**90.0**	**43.5**	**17.0**	**146.0**	**64.0**	**10.1**
			34.995				**123.982**				**102.74**						
	(MM35BS100QUH)	4.17	1.3780	0.21	0.45	2.99	4.8819	2.60	5.04	6.50	4.105	3.54	1.71	0.67	5.75	2.52	22.22
			1.3778				4.8812				4.045						
40	BSBU40Q124	**106.0**	**40.000**	**5.3**	**11.4**	**76.0**	**124.000**	**66.0**	**128.0**	**165.0**	**104.26**	**90.0**	**43.5**	**17.0**	**146.0**	**64.0**	**9.7**
			39.995				**123.982**				**102.74**						
	(MM40BS100QUH)	4.17	1.5748	0.21	0.45	2.99	4.8819	2.60	5.04	6.50	4.105	3.54	1.71	0.67	5.75	2.52	21.34
			1.5746				4.8812				4.045						
45	BSBU45Q124	**106.0**	**45.000**	**5.3**	**11.4**	**76.0**	**124.000**	**66.0**	**128.0**	**165.0**	**104.26**	**90.0**	**43.5**	**17.0**	**146.0**	**64.0**	**9.5**
			44.995				**123.982**				**102.74**						
	(MM45BS100QUH)	4.17	1.7716	0.21	0.45	2.99	4.8819	2.60	5.04	6.50	4.105	3.54	1.71	0.67	5.75	2.52	20.90
			1.7714				4.8812				4.045						
50	BSBU50Q124	**106.0**	**50.000**	**5.3**	**11.4**	**76.0**	**124.000**	**66.0**	**128.0**	**165.0**	**104.26**	**90.0**	**43.5**	**17.0**	**146.0**	**64.0**	**9.3**
			49.995				**123.982**				**102.74**						
	(MM50BS100QUH)	4.17	1.9685	0.21	0.45	2.99	4.8819	2.60	5.04	6.50	4.105	3.54	1.71	0.67	5.75	2.52	20.46
			1.9683				4.8812				4.045						

BALL SCREW SUPPORT BEARING PILLOW BLOCK UNITS

BSPB D – STANDARD AND HEAVY-DUTY BEARINGS

- Designed for ball screw applications.
- Incorporates similar features to the series BSBU D but is designed to bolt down onto a flat surface, parallel to the ball screw axis.
- In the standard unit, pilot holes for dowels are provided.
- Units are supplied with the bearings in duplex sets mounted in the "DB" ("O") arrangement.
- Units with finished holes for dowels can be supplied by special order if required.
- Consult your Timken representative for suggested shaft fits.
- For load and speed ratings, refer to bearing data on page 203.



C

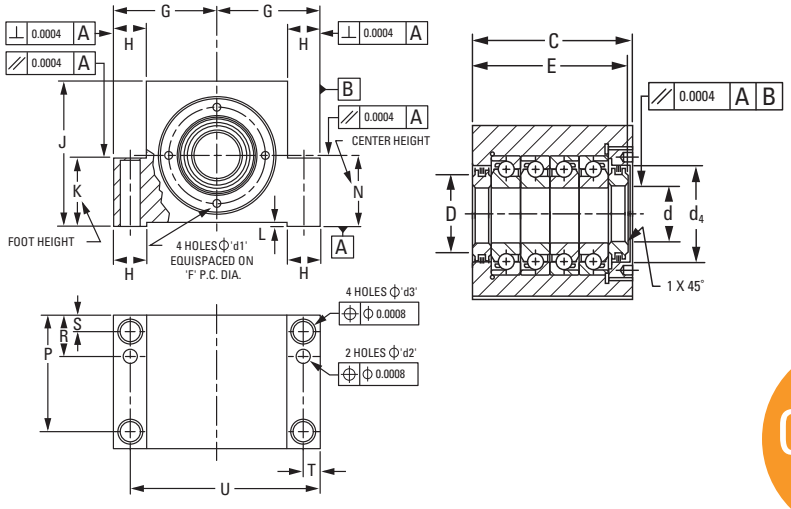
STANDARD SERIES – DIMENSIONAL TOLERANCES ±0.13 mm (± 0.005 in.) UNLESS OTHERWISE STATED.

Shaft Dia.	Unit Number (Bearing Set)	C	d	d_1	d_2	d_3	d_4	D	E	F	G	H	J	K	L	N	P	R	S	T	U	Wt.
mm		**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**kg** lbs.
17	BSPB17D32	**47.000**	**17.000**	**4.3**	**7.8**	**9.0**	**36.0**	**26.0**	**44.26**	**42.5**	**47.000**	**17**	**62**	**32.0**	**1.0**	**32.000**	**38.0**	**22.0**	**9.0**	**8.5**	**85.5**	**1.5**
		46.950	**16.996**						**43.24**		**46.987**					**31.987**						
	(MM17BS47DUH)	1.850	0.6693	0.17	0.31	0.35	1.42	1.02	1.742	1.67	1.8504	0.67	2.44	1.26	0.04	1.2598	1.50	0.87	0.35	0.33	3.37	3.30
		1.848	0.6691						1.702		1.8499					1.2593						
20	BSPB20D32	**47.000**	**20.000**	**4.3**	**7.8**	**9.0**	**36.0**	**26.0**	**44.26**	**42.5**	**47.000**	**17**	**62**	**32.0**	**1.0**	**32.000**	**38.0**	**22.0**	**9.0**	**8.5**	**85.5**	**1.5**
		46.950	**19.996**						**43.24**		**46.987**					**31.987**						
	(MM20BS47DUH)	1.850	0.7874	0.17	0.31	0.35	1.42	1.02	1.742	1.67	1.8504	0.67	2.44	1.26	0.04	1.2598	1.50	0.87	0.35	0.33	3.37	3.30
		1.848	0.7872						1.702		1.8499					1.2593						
25	BSPB25D42	**52.000**	**25.000**	**4.3**	**9.8**	**11.0**	**50.0**	**40.0**	**50.26**	**59.5**	**62.500**	**20**	**85**	**42.0**	**1.0**	**42.000**	**42.0**	**25.0**	**10.0**	**10.0**	**115.0**	**2.8**
		51.950	**24.996**						**49.24**		**62.487**					**41.987**						
	(MM25BS62DUH)	2.047	0.9842	0.17	0.39	0.43	1.97	1.57	1.979	2.34	2.4606	0.79	3.35	1.65	0.04	1.6535	1.65	0.98	0.39	0.39	4.53	6.16
		2.045	0.9841						1.938		2.4601					1.6530						
30	BSPB30D42	**52.000**	**30.000**	**4.3**	**9.8**	**11.0**	**50.0**	**40.0**	**50.26**	**59.5**	**62.500**	**20**	**85**	**42.0**	**1.0**	**42.000**	**42.0**	**25.0**	**10.0**	**10.0**	**115.0**	**2.7**
		51.920	**29.996**						**49.24**		**62.487**					**41.987**						
	(MM30BS62DUH)	2.047	1.1811	0.17	0.39	0.43	1.97	1.57	1.979	2.34	2.4606	0.79	3.35	1.65	0.04	1.6535	1.65	0.98	0.39	0.39	4.53	5.94
		2.045	1.1809						1.938		2.4601					1.6530						
35	BSPB35D50	**52.000**	**35.000**	**4.3**	**13.0**	**13.0**	**60.0**	**46.0**	**50.26**	**66.5**	**68.000**	**20.5**	**95**	**50**	**1.0**	**50.000**	**42.0**	**25.0**	**10.0**	**10.0**	**126.0**	**3.8**
		51.950	**34.995**						**49.24**		**67.987**					**49.987**						
	(MM35BS72DUH)	2.047	1.3780	0.17	0.51	0.51	2.36	1.81	1.979	2.62	2.6772	0.81	3.74	1.97	0.04	1.9685	1.65	0.98	0.39	0.39	4.96	8.36
		2.045	1.3778						1.938		2.6767					1.9680						
40	BSPB40D50	**52.000**	**40.000**	**4.3**	**13.0**	**13.0**	**60.0**	**46.0**	**50.26**	**66.5**	**68.000**	**20.5**	**95**	**50.0**	**1.0**	**50.000**	**42.0**	**25.0**	**10.0**	**10.0**	**126.0**	**3.7**
		51.950	**39.995**						**49.24**		**67.987**					**49.987**						
	(MM40BS72DUH)	2.047	1.5748	0.17	0.51	0.51	2.36	1.81	1.979	2.62	2.6772	0.81	3.74	1.97	0.04	1.9685	1.65	0.98	0.39	0.39	4.96	8.14
		2.045	1.5746						1.938		2.6767					1.9680						
HEAVY-DUTY SERIES																						
35	BSPB35D65	**66.000**	**35.000**	**5.3**	**11.8**	**18.0**	**76.0**	**66.0**	**64.26**	**90.0**	**95.000**	**30.0**	**130.0**	**65.0**	**1.0**	**65.000**	**53.0**	**32.0**	**13.0**	**15.0**	**175.0**	**9.7**
		65.950	**34.995**						**63.24**		**94.987**					**64.987**						
	(MM35BS100DUH)	2.598	1.3780	0.21	0.46	0.71	2.99	2.60	2.530	3.54	3.7402	1.18	5.12	2.56	0.04	2.5590	2.09	1.26	0.51	0.59	6.89	21.34
		2.596	1.3778						2.490		3.7396					2.5585						
40	BSPB40D65	**66.000**	**40.000**	**5.3**	**11.8**	**18.0**	**76.0**	**66.0**	**64.26**	**90.0**	**95.000**	**30.0**	**130.0**	**65.0**	**1.0**	**65.000**	**53.0**	**32.0**	**13.0**	**15.0**	**175.0**	**9.5**
		65.950	**39.995**						**63.24**		**94.987**					**64.987**						
	(MM40BS100DUH)	2.598	1.5748	0.21	0.46	0.71	2.99	2.60	2.530	3.54	3.7402	1.18	5.12	2.56	0.04	2.5590	2.09	1.26	0.51	0.59	6.89	20.90
		2.596	1.5746						2.490		3.7396					2.5585						
45	BSPB45D65	**66.000**	**45.000**	**5.3**	**11.8**	**18.0**	**76.0**	**66.0**	**64.26**	**90.0**	**95.000**	**30.0**	**130.0**	**65.0**	**1.0**	**65.000**	**53.0**	**32.0**	**13.0**	**15.0**	**175.0**	**9.3**
		65.950	**44.995**						**63.24**		**94.987**					**64.987**						
	(MM45BS100DUH)	2.598	1.7716	0.21	0.46	0.71	2.99	2.60	2.530	3.54	3.7402	1.18	5.12	2.56	0.04	2.5590	2.09	1.26	0.51	0.59	6.89	20.46
		2.596	1.7714						2.490		3.7396					2.5585						
50	BSPB50D65	**66.000**	**50.000**	**5.3**	**11.8**	**18.0**	**76.0**	**66.0**	**64.26**	**90.0**	**95.000**	**30.0**	**130.0**	**65.0**	**1.0**	**65.000**	**53.0**	**32.0**	**13.0**	**15.0**	**175.0**	**9.1**
		65.950	**49.995**						**63.24**		**94.987**					**64.987**						
	(MM50BS100DUH)	2.598	1.9685	0.21	0.46	0.71	2.99	2.60	2.530	3.54	3.7402	1.18	5.12	2.56	0.04	2.5590	2.09	1.26	0.51	0.59	6.89	20.02
		2.596	1.9683						2.490		3.7396					2.5585						

BALL SCREW SUPPORT BEARING PILLOW BLOCK UNITS

BSPB Q – STANDARD AND HEAVY-DUTY BEARINGS

- Similar in design and features to the Series BSPB D, except MM-BS-QU Quadruplex bearings are used.
- Units are supplied with the bearings in quad sets mounted in the "DB" ("O") arrangement.
- Consult your Timken representative for suggested shaft fits.
- For load and speed ratings, refer to bearing data on page 204.



C

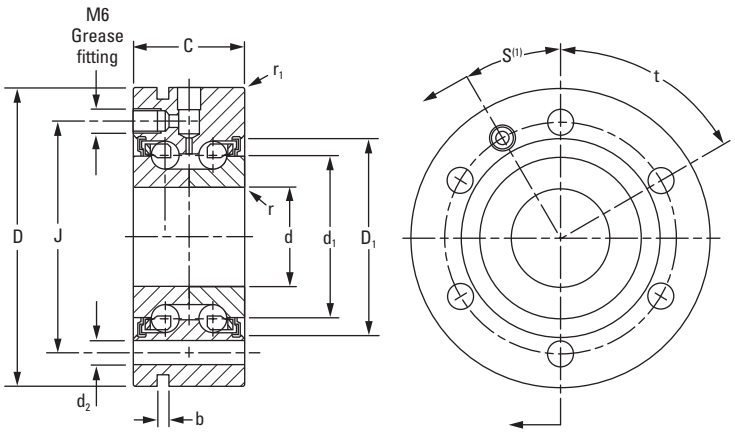
STANDARD SERIES – DIMENSIONAL TOLERANCES ±0.13 mm (± 0.005 in.) UNLESS OTHERWISE STATED.

Shaft Dia.	Unit Number (Bearing Set)	C	d	d_1	d_2	d_3	d_4	D	E	F	G	H	J	K	L	N	P	R	S	T	U	Wt.
mm		**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**kg** lbs.
17	BSPB17Q32	**77.00**	**17.000**	**4.3**	**7.8**	**9.0**	**36.0**	**26.0**	**74.26**	**42.5**	**47.000**	**17**	**62**	**32.0**	**1.0**	**32.000**	**68.0**	**22.0**	**9.0**	**8.5**	**85.5**	**2.6**
		76.95	**16.996**						**72.74**		**46.987**					**31.987**						
	(MM17BS47QUH)	3.031	0.6693	0.17	0.31	0.35	1.42	1.02	2.924	1.67	1.8504	0.67	2.44	1.26	0.04	1.2598	2.68	0.87	0.35	0.33	3.37	5.72
		3.03	0.6691						2.864		1.8499					1.2593						
20	BSPB20Q32	**77.00**	**20.000**	**4.3**	**7.8**	**9.0**	**36.0**	**26.0**	**74.26**	**42.5**	**47.000**	**17**	**62**	**32.0**	**1.0**	**32.000**	**68.0**	**22.0**	**9.0**	**8.5**	**85.5**	**2.5**
		76.95	**19.996**						**72.74**		**46.987**					**31.987**						
	(MM20BS47QUH)	3.031	0.7874	0.17	0.31	0.35	1.42	1.02	2.924	1.67	1.8504	0.67	2.44	1.26	0.04	1.2598	2.68	0.87	0.35	0.33	3.37	5.50
		3.03	0.7872						2.864		1.8499					1.2593						
25	BSPB25Q42	**82.00**	**25.000**	**4.3**	**9.8**	**11.0**	**50.0**	**40.0**	**80.26**	**59.5**	**62.500**	**20**	**85**	**42.0**	**1.0**	**42.000**	**72.0**	**25.0**	**10.0**	**10.0**	**115.0**	**4.6**
		81.95	**24.996**						**78.74**		**62.487**					**41.987**						
	(MM25BS62QUH)	3.228	0.9842	0.17	0.39	0.43	1.97	1.57	3.160	2.34	2.4606	0.79	3.35	1.65	0.04	1.6535	2.83	0.98	0.39	0.39	4.53	10.12
		3.226	0.9841						3.100		2.4601					1.6530						
30	BSPB30Q42	**82.00**	**30.000**	**4.3**	**9.8**	**11.0**	**50.0**	**40.0**	**80.26**	**59.5**	**62.500**	**20**	**85**	**42.0**	**1.0**	**42.000**	**72.0**	**25.0**	**10.0**	**10.0**	**115.0**	**4.5**
		81.95	**29.996**						**78.74**		**62.487**					**41.987**						
	(MM30BS62QUH)	3.228	1.1811	0.17	0.39	0.43	1.97	1.57	3.160	2.34	2.4606	0.79	3.35	1.65	0.04	1.6535	2.83	0.98	0.39	0.39	4.53	9.90
		3.226	1.1809						3.100		2.4601					1.6530						
35	BSPB35Q50	**82.00**	**35.000**	**4.3**	**13.0**	**13.0**	**60.0**	**46.0**	**80.26**	**66.5**	**68.000**	**20.5**	**95**	**50**	**1.0**	**50.000**	**72.0**	**25.0**	**10.0**	**10.0**	**126.0**	**6.2**
		81.95	**34.995**						**78.74**		**67.987**					**49.987**						
	(MM35BS72QUH)	3.228	1.3780	0.17	0.51	0.51	2.36	1.81	3.160	2.62	2.6772	0.81	3.74	1.97	0.04	1.9685	2.83	0.98	0.39	0.39	4.96	13.64
		3.226	1.3778						3.100		2.6767					1.9680						
40	BSPB40Q50	**82.00**	**40.000**	**4.3**	**13.0**	**13.0**	**60.0**	**46.0**	**80.26**	**66.5**	**68.000**	**20.5**	**95**	**50.0**	**1.0**	**50.000**	**72.0**	**25.0**	**10.0**	**10.0**	**126.0**	**6.0**
		81.95	**39.995**						**78.74**		**67.987**					**49.987**						
	(MM40BS72QUH)	3.228	1.5748	0.17	0.51	0.51	2.36	1.81	4.105	2.62	2.6772	0.81	3.74	1.97	0.04	1.9685	2.83	0.98	0.39	0.39	4.96	13.20
		3.226	1.5746						4.045		2.6767					1.9680						
HEAVY-DUTY SERIES																						
35	BSPB35D65	**106.00**	**35.000**	**5.3**	**11.8**	**18.0**	**76.0**	**66.0**	**104.26**	**90.0**	**95.000**	**30.0**	**130.0**	**65.0**	**1.0**	**65.000**	**93.0**	**32.0**	**13.0**	**15.0**	**175.0**	**15.9**
		105.95	**34.995**						**102.74**		**94.987**					**64.987**						
	(MM35BS100QUH)	4.173	1.3780	0.21	0.46	0.71	2.99	2.60	3.160	3.54	3.7402	1.18	5.12	2.56	0.04	2.5590	3.66	1.26	0.51	0.59	6.89	34.98
		4.171	1.3778						3.100		3.7396					2.5585						
40	BSPB40Q65	**106.00**	**40.000**	**5.3**	**11.8**	**18.0**	**76.0**	**66.0**	**104.26**	**90.0**	**95.000**	**30.0**	**130.0**	**65.0**	**1.0**	**65.000**	**93.0**	**32.0**	**13.0**	**15.0**	**175.0**	**15.7**
		105.95	**39.995**						**102.74**		**94.987**					**64.987**						
	(MM40BS100QUH)	4.173	1.5748	0.21	0.46	0.71	2.99	2.60	4.105	3.54	3.7402	1.18	5.12	2.56	0.04	2.5590	3.66	1.26	0.51	0.59	6.89	34.54
		4.171	1.5746						4.045		3.7396					2.5585						
45	BSPB45Q65	**106.00**	**45.000**	**5.3**	**11.8**	**18.0**	**76.0**	**66.0**	**104.26**	**90.0**	**95.000**	**30.0**	**130.0**	**65.0**	**1.0**	**65.000**	**93.0**	**32.0**	**13.0**	**15.0**	**175.0**	**15.4**
		105.95	**44.995**						**102.74**		**94.987**					**64.987**						
	(MM45BS100QUH)	4.173	1.7716	0.21	0.46	0.71	2.99	2.60	4.105	3.54	3.7402	1.18	5.12	2.56	0.04	2.5590	3.66	1.26	0.51	0.59	6.89	33.88
		4.171	1.7714						4.045		3.7396					2.5585						
50	BSPB50Q65	**106.00**	**50.000**	**5.3**	**11.8**	**18.0**	**76.0**	**66.0**	**104.26**	**90.0**	**95.000**	**30.0**	**130.0**	**65.0**	**1.0**	**65.000**	**93.0**	**32.0**	**13.0**	**15.0**	**175.0**	**15.1**
		105.95	**49.995**						**102.74**		**94.987**					**64.987**						
	(MM50BS100QUH)	4.173	1.9685	0.21	0.46	0.71	2.99	2.60	4.105	3.54	3.7402	1.18	5.12	2.56	0.04	2.5590	3.66	1.26	0.51	0.59	6.89	33.22
		4.171	1.9683						4.045		3.7396					2.5585						

BALL SCREW SUPPORT BEARINGS SEALED, DOUBLE-ROW FLANGED STYLE

MMF SERIES

- Specifically designed for ball screw applications.
- Integral double-row design supports axial and combined loads.
- Nominal contact angle 60 degrees for superior axial rigidity and accuracy.
- Low torque, integral contact seals.
- Easy and flexible installation without external clamping.
- Sealed duplex configuration standard with optional seals, shields, ceramic balls and quadruplex sets available.



MMF Series Flanged

Bearing Number	d Bore	D O.D.	C Width	Wt.	Capacity C Dynamic	Capacity C0a Static	Speed Rating	Radius r1 Outer	Radius r Inner	D1 Min.	d1 Max.
METRIC	mm +0/ -(µm)			kg	mm		mm	mm	mm	mm	mm
MMF512BS55PP DM	12 (3.8)	55 (7.6)	25 (254)	0.40	15300	18000	4700	0.6	0.3	33.1	25.0
MMF515BS60PP DM	15 (3.8)	60 (7.6)	25 (254)	0.47	16100	20200	4290	0.6	0.3	37.0	27.6
MMF517BS62PP DM	17 (3.8)	62 (7.6)	25 (254)	0.49	16800	22200	4000	0.6	0.3	37.8	28.4
MMF520BS68PP DM	20 (5.1)	68 (7.6)	28 (254)	0.64	21800	30600	3400	0.6	0.3	43.2	34.5
MMF525BS75PP DM	25 (5.1)	75 (7.6)	28 (254)	0.76	23200	36200	2900	0.6	0.3	49.5	40.6
MMF530BS80PP DM	30 (5.1)	80 (7.6)	28 (254)	0.84	24500	41500	2600	0.6	0.3	54.3	45.6
MMF540BS100PP DM	40 (6.4)	100 (7.6)	34 (254)	1.50	36300	65800	2070	0.6	0.3	68.7	57.5
MMF550BS115PP DM	50 (6.4)	115 (7.6)	34 (254)	1.37	40500	85900	1670	0.6	0.3	82.6	71.5
MMF550BS140PP DM	50 (6.4)	140 (8.9)	54 (254)	4.89	95400	164300	1460	0.6	0.6	99.6	81.1
MMF560BS145PP DM	60 (7.6)	145 (8.9)	45 (254)	4.28	71200	139700	1400	0.6	0.6	100.0	89.0

INCH	in. +0/-(x)			lbs.	in.		in.	in.	in.	in.	in.
MMF512BS55PP DM	0.4724 (0.00015)	2.1654 (0.0003)	0.9843 (0.0100)	0.88	3450	4050	4700	0.024	0.012	1.304	0.905
MMF515BS60PP DM	0.5906 (0.00015)	2.3622 (0.0003)	0.9843 (0.0100)	1.04	3600	4550	4290	0.024	0.012	1.456	1.088
MMF517BS62PP DM	0.6693 (0.00015)	2.4409 (0.0003)	0.9843 (0.0100)	1.08	3775	5000	4000	0.024	0.012	1.49	1.117
MMF520BS68PP DM	0.7874 (0.0002)	2.6772 (0.0003)	1.1024 (0.0100)	1.42	4900	6875	3400	0.024	0.012	1.700	1.357
MMF525BS75PP DM	0.9843 (0.0002)	2.9528 (0.0003)	1.1024 (0.0100)	1.68	5200	8150	2900	0.024	0.012	1.943	1.599
MMF530BS80PP DM	1.1811 (0.0002)	3.1496 (0.0003)	1.1024 (0.0100)	1.86	5500	9350	2600	0.024	0.012	2.138	1.795
MMF540BS100PP DM	1.5748 (0.00025)	3.937 (0.0003)	1.3386 (0.0100)	3.41	8150	14800	2070	0.024	0.012	2.704	2.264
MMF550BS115PP DM	1.9685 (0.00025)	4.5276 (0.0003)	1.3386 (0.0100)	4.37	9100	19300	1670	0.024	0.012	3.25	2.815
MMF550BS140PP DM	1.9685 (0.00025)	5.5118 (0.00035)	2.126 (0.0100)	10.78	21500	36900	1460	0.024	0.024	3.919	3.192
MMF560BS145PP DM	2.3622 (0.0003)	5.7087 (0.00035)	1.7717 (0.0100)	9.43	16000	31400	1400	0.024	0.024	3.938	3.308

(1) Grease fitting spacing (S) is conditional to the quantity of bolt holes: 3 holes, S = 60˚; 4 holes, S = 45˚; 6 holes, S = 30˚; 8 holes, S = 22.5˚; 12 holes, S = 15˚.

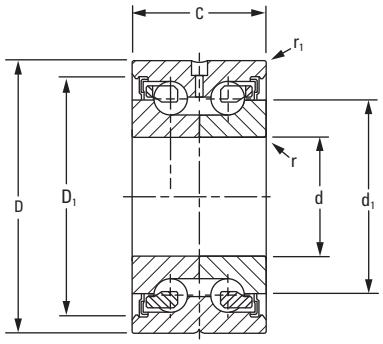
Suggested Shoulder Dia.		d_2 Bolt Dia.	Holes	b Groove Width	J Bolt Circle Diameter	t Hole Spacing	Stiffness		Inertia Moment	Preload
Housing	Shaft						Axial	Radial		
mm	**mm**	**mm**	Qty.	**mm**	**mm**	Degrees	**N/µm**	**N/µm**	**kg cm²**	**N**
32.0	**19.0**	**6.5**	3	**3**	**42**	120	**380**	**60**	**0.062**	**645**
34.5	**21.5**	**6.5**	3	**3**	**46**	120	**400**	**65**	**0.076**	**670**
36.5	**23.5**	**6.5**	3	**3**	**48**	120	**450**	**72**	**0.097**	**780**
42.5	**27.5**	**6.5**	4	**3**	**53**	90	**650**	**103**	**0.212**	**1780**
48.0	**33.5**	**6.5**	4	**3**	**58**	90	**750**	**118**	**0.415**	**2000**
53.5	**38.5**	**6.5**	6	**3**	**63**	60	**860**	**135**	**0.6**	**2335**
67.0	**49.0**	**8.5**	4	**3**	**80**	90	**1000**	**160**	**1.728**	**2780**
81.0	**63.0**	**8.5**	6	**3**	**94**	60	**1250**	**200**	**4.288**	**3335**
98.5	**66.0**	**10.5**	12	**3**	**113**	30	**1400**	**220**	**20.94**	**6784**
98.0	**72.0**	**8.5**	8	**3**	**120**	45	**1300**	**210**	**10.184**	**4225**

in.	in.	in.	Qty.	in.	in.	Degrees	10^6 lb/in.	10^6 lb/in.	lb in.²	lbs.
1.26	0.748	0.256	3	0.118	1.654	120	2.17132	0.34284	0.021186466	145
1.358	0.846	0.256	3	0.118	1.811	120	2.2856	0.37141	0.025970506	150
1.437	0.925	0.256	3	0.118	1.89	120	2.5713	0.411408	0.033146567	175
1.673	1.083	0.256	4	0.118	2.087	90	3.7141	0.588542	0.072444044	400
1.890	1.319	0.256	4	0.118	2.283	90	4.2855	0.674252	0.141812634	450
2.106	1.516	0.256	6	0.118	2.48	60	4.91404	0.77139	0.205030314	525
2.638	1.929	0.335	4	0.118	3.15	90	5.714	0.91424	0.590487304	625
3.189	2.408	0.335	6	0.118	3.701	60	7.1425	1.1428	1.465283311	750
3.878	2.598	0.413	12	0.118	4.449	30	7.9996	1.25708	7.155557959	1525
3.858	2.835	0.335	8	0.118	4.724	45	7.4282	1.19994	3.480047863	950

BALL SCREW SUPPORT BEARINGS SEALED, DOUBLE-ROW CARTRIDGE STYLE

MMN SERIES

- Specifically designed for ball screw applications.
- Integral double-row design supports axial and combined loads.
- Nominal contact angle 60 degrees for superior axial rigidity and accuracy.
- Low torque, integral contact seals.
- Easy and flexible installation for both fixed and rotating nut designs.
- Sealed duplex configuration standard with optional seals, shields, ceramic balls and quadruplex sets available.



MMN Series

C

Bearing Number	d Bore	D O.D.	C Width	Wt.	Capacity C Dynamic	Capacity C0a Static	Speed Rating	Radius r1 Outer	Radius r Inner	D1 Max.	d1 Min.	Suggested Shoulder Dia. Housing	Suggested Shoulder Dia. Shaft	Stiffness Axial	Stiffness Radial	Inertia Moment	Preload
METRIC	mm +0/ -(µm)			kg	N		RPM	mm		mm	mm	mm	mm	N/µm	N/µm	kg cm²	N
MMN512BS42PP DM	12 (3.8)	42 (6.4)	25 (254)	0.20	15300	18000	4700	0.6	0.3	25.0	33.1	32.0	19.0	380	60	0.062	645
MMN515BS45PP DM	15 (3.8)	45 (6.4)	25 (254)	0.23	16100	20200	4290	0.6	0.3	27.6	37.0	34.5	21.5	400	65	0.076	670
MMN517BS47PP DM	17 (3.8)	47 (6.4)	25 (254)	0.24	16800	22200	4000	0.6	0.3	28.4	37.8	36.5	23.5	450	72	0.097	780
MMN520BS52PP DM	20 (5.1)	52 (7.6)	28 (254)	0.32	21800	30600	3400	0.6	0.3	34.5	43.2	42.5	27.5	650	103	0.212	1780
MMN525BS57PP DM	25 (5.1)	57 (7.6)	28 (254)	0.35	23200	36200	2900	0.6	0.3	40.6	49.3	48.0	33.5	750	118	0.415	2000
MMN530BS62PP DM	30 (5.1)	62 (7.6)	28 (254)	0.40	24500	41500	2600	0.6	0.3	45.6	54.3	53.5	38.5	860	135	0.6	2335
MMN540BS75PPDM	40 (6.4)	75 (7.6)	34 (254)	0.64	36300	65800	2070	0.6	0.3	57.5	68.7	67.0	49.0	1000	160	1.728	2780
MMN550BS90PP DM	50 (6.4)	90 (7.6)	34 (254)	0.91	40500	85900	1670	0.6	0.3	71.5	82.6	81.0	63.0	1250	200	4.288	3335
MMN550BS110PP DM	50 (6.4)	110 (8.9)	54 (254)	2.42	95400	164300	1460	0.6	0.6	81.1	99.6	98.5	66.0	1400	220	20.94	6784
MMN560BS110PP DM	60 (7.6)	110 (8.9)	45 (254)	1.82	71200	139700	1400	0.6	0.6	84.0	100.0	98.0	72.0	1300	210	10.184	4225

Bearing Number	d Bore	D O.D.	C Width	Wt.	Capacity C Dynamic	Capacity C_{0a} Static	Speed Rating	Radius r_1 Outer	Radius r Inner	D_1 Min.	d_1 Max.	Suggested Shoulder Dia. Housing	Suggested Shoulder Dia. Shaft	Stiffness Axial	Stiffness Radial	Inertia Moment	Preload
INCH	in. +0/-(x)			lbs.	lbs.		RPM	in.	in.	in.	in.	in.	in.	10^6 lb/in.	10^6 lb/in.	lb in.^{2}	lbs.
MMN512BS42PP DM	0.4724 (0.00015)	1.6535 (0.00025)	0.9843 (0.0100)	0.44	3450	4050	4700	0.024	0.012	1.304	0.985	1.259	0.748	2.17132	0.34284	0.021186466	145
MMN515BS45PP DM	0.5906 (0.00015)	1.7717 (0.00025)	0.9843 (0.0100)	0.5	3600	4550	4290	0.024	0.012	1.456	1.088	1.358	0.846	2.2856	0.37141	0.025970506	150
MMN517BS47PP DM	0.6693 (0.00015)	1.8504 (0.00025)	0.9843 (0.0100)	0.54	3775	5000	4000	0.024	0.012	1.49	1.117	1.437	0.925	2.5713	0.411408	0.033146567	175
MMN520BS52PP DM	0.7874 (0.0002)	2.0472 (0.0003)	1.1024 (0.0100)	0.70	4900	6875	3400	0.024	0.012	1.700	1.357	1.673	1.083	3.7141	0.588542	0.072444044	400
MMN525BS57PP DM	0.9843 (0.0002)	2.2441 (0.0003)	1.1024 (0.0100)	0.78	5200	8150	2900	0.024	0.012	1.943	1.599	1.890	1.319	4.2855	0.674252	0.141812634	450
MMN530BS62PP DM	1.1811 (0.0002)	2.4409 (0.0003)	1.1024 (0.0100)	0.88	5500	9350	2600	0.024	0.012	2.138	1.795	2.106	1.516	4.91404	0.77139	0.205030314	525
MMN540BS75PPDM	1.5748 (0.00025)	2.9528 (0.0003)	1.3386 (0.0100)	1.42	8150	14800	2070	0.024	0.012	2.704	2.264	2.638	1.929	5.714	0.91424	0.590487304	625
MMN550BS90PP DM	1.9685 (0.00025)	3.5433 (0.0003)	1.3386 (0.0100)	2.02	9100	19300	1670	0.024	0.012	3.250	2.815	3.189	2.408	7.1425	1.1428	1.465283311	750
MMN550BS110PP DM	1.9685 (0.00025)	4.3307 (0.00035)	2.126 (0.0100)	5.34	21500	36900	1460	0.024	0.024	3.919	3.192	3.878	2.598	7.9996	1.25708	7.155557959	1525
MMN560BS110PP DM	2.3622 (0.0003)	4.3307 (0.00035)	1.7717 (0.0100)	4.02	16000	31400	1400	0.024	0.024	3.938	3.308	3.858	2.835	7.4282	1.19994	3.480047863	950

EX-CELL-O SPINDLE BEARINGS

- "EX" Series (Timken 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 (Timken 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.

MM-EX

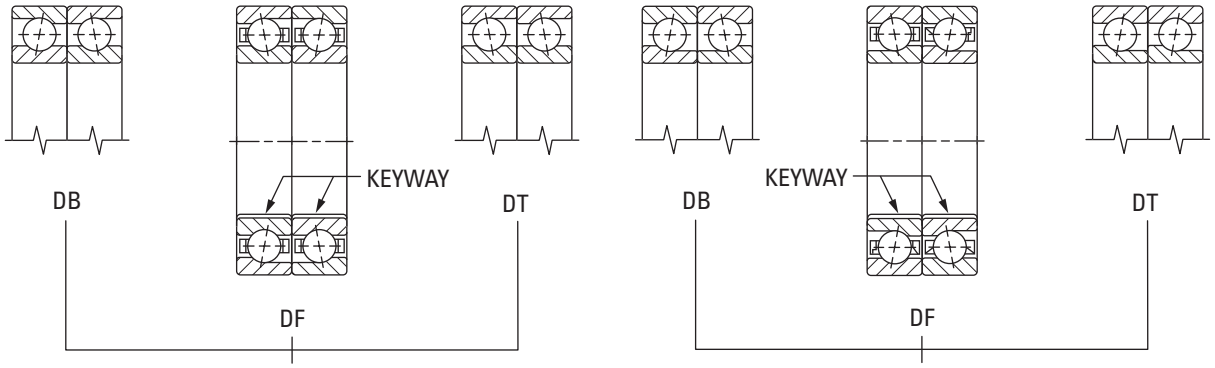
REPLACEMENT BEARINGS FOR EX-CELL-O SPINDLES

Bearing Number	Ex-Cell-O Part No.	Preload	Bore		O.D.		Width - Pair		Speed Rating Grease
			Max.	Min.	Max.	Min.	Max.	Min.	
		lbs.	in.		in.		in.		RPM
MM20EXCR DU FS223	20	0	0.3752	0.3750	1.1252	1.1250	0.6875	0.6775	65000
MM30EXCR DU FS223	30	0	0.6252	0.6250	1.5002	1.5000	1.0000	0.9900	35000
MM30EXCR DU 5	30	5	0.6252	0.6250	1.5002	1.5000	1.0000	0.9900	25000
MM50EXCR DU FS223	50	0	0.8127	0.8125	2.0002	2.0000	1.0000	0.9900	30000
[1] MM50EXCR DU 10	50	10	0.8127	0.8125	2.0002	2.0000	1.0000	0.9900	18000
MM50EXCR DU 50	50	50	0.8127	0.8125	2.0002	2.0000	1.0000	0.9900	5000
MM55EXCR DU 10	55	10	0.8127	0.8125	2.0002	2.0000	1.0000	0.9900	22000
MM57EXCR DU FS223	57	0	1.0627	1.0625	2.2502	2.2500	1.0000	0.9900	30000
MM57EXCR DU 10	57	10	1.0627	1.0625	2.2502	2.2500	1.0000	0.9900	15000
MM57EXCR DU 50	57	50	1.0627	1.0625	2.2502	2.2500	1.0000	0.9900	5000
MM67EXCR DU FS223	67	0	1.2502	1.2500	2.4377	2.4375	1.2500	1.2400	30000
MM67EXCR DU 10	67	10	1.2502	1.2500	2.4377	2.4375	1.2500	1.2400	12500
MM67EXCR DU 30	67	30	1.2502	1.2500	2.4377	2.4375	1.2500	1.2400	7500
MM67EXCR DU 75	67	75	1.2502	1.2500	2.4377	2.4375	1.2500	1.2400	4500
MM90EXCR DU 20	90	20	1.6252	1.6250	3.4377	3.4375	1.6250	1.6150	10000
MM90EXCR DU 100	90	100	1.6252	1.6250	3.4377	3.4375	1.6250	1.6150	4500
MM90EXCR DU 150	90	150	1.6252	1.6250	3.4377	3.4375	1.6250	1.6150	2700
MM90EXCR DU 250	90	250	1.6252	1.6250	3.4377	3.4375	1.6250	1.6150	900
[2] MM92EXCR DU 20	92	20	1.7502	1.7500	3.4377	3.4375	1.6250	1.6150	12000
[2] MM92EXCR DU 100	92	100	1.7502	1.7500	3.4377	3.4375	1.6250	1.6150	4500
[2] MM92EXCR DU 150	92	150	1.7502	1.7500	3.4377	3.4375	1.6250	1.6150	2700
[2] 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	5000
MM115EXCR DU 250	115	250	2.2502	2.2500	4.7502	4.7500	2.2500	2.2400	3600
MM115EXCR DU 350	115	350	2.2502	2.2500	4.7502	4.7500	2.2500	2.2400	1800
MM135EXCR DU 20	135	20	1.2502	1.2500	2.6877	2.6875	1.2500	1.2400	8000
MM135EXCR DU 75	135	75	1.2502	1.2500	2.6877	2.6875	1.2500	1.2400	4000
MM155EXCR DU 150	155	150	2.7502	2.7500	4.7502	4.7500	2.2500	2.2400	4000
MM155EXCR DU 300	155	300	2.7502	2.7500	4.7502	4.7500	2.2500	2.2400	1800
MM165EXCR DU 200	165	200	3.5002	3.5000	6.3127	6.3125	3.0000	2.9900	2800
MM165EXCR DU 400	165	400	3.5002	3.5000	6.3127	6.3125	3.0000	2.9900	1200

Do not interchange with MM-XWO.
MM-EX produced to nominal plus tolerance.

[1] Four slots in outer ring faces.
[2] No keyway in bore.

TIMKEN MM-EX AND MM-XWO BEARINGS FOR REPLACEMENT ON EX-CELL-O SPINDLES



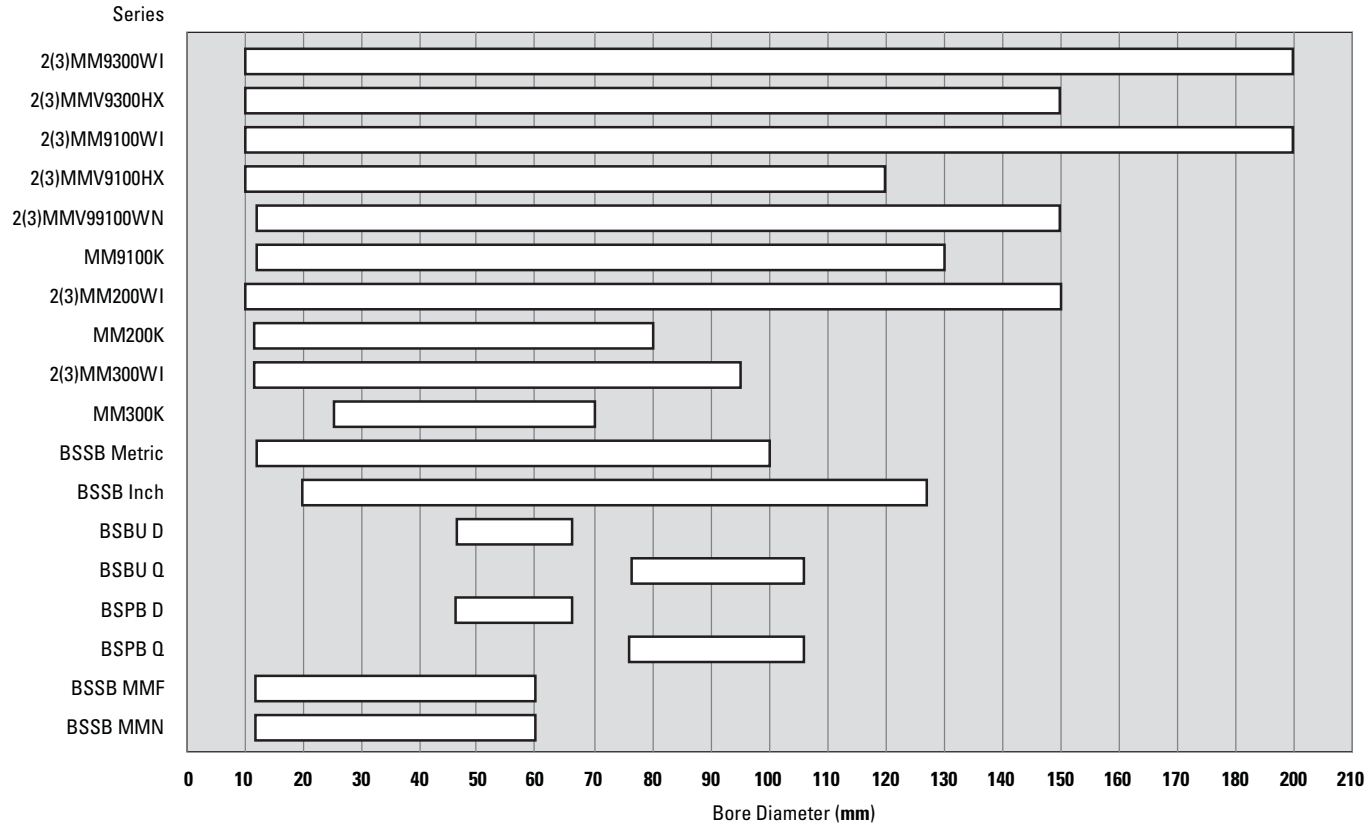
MM-XWO

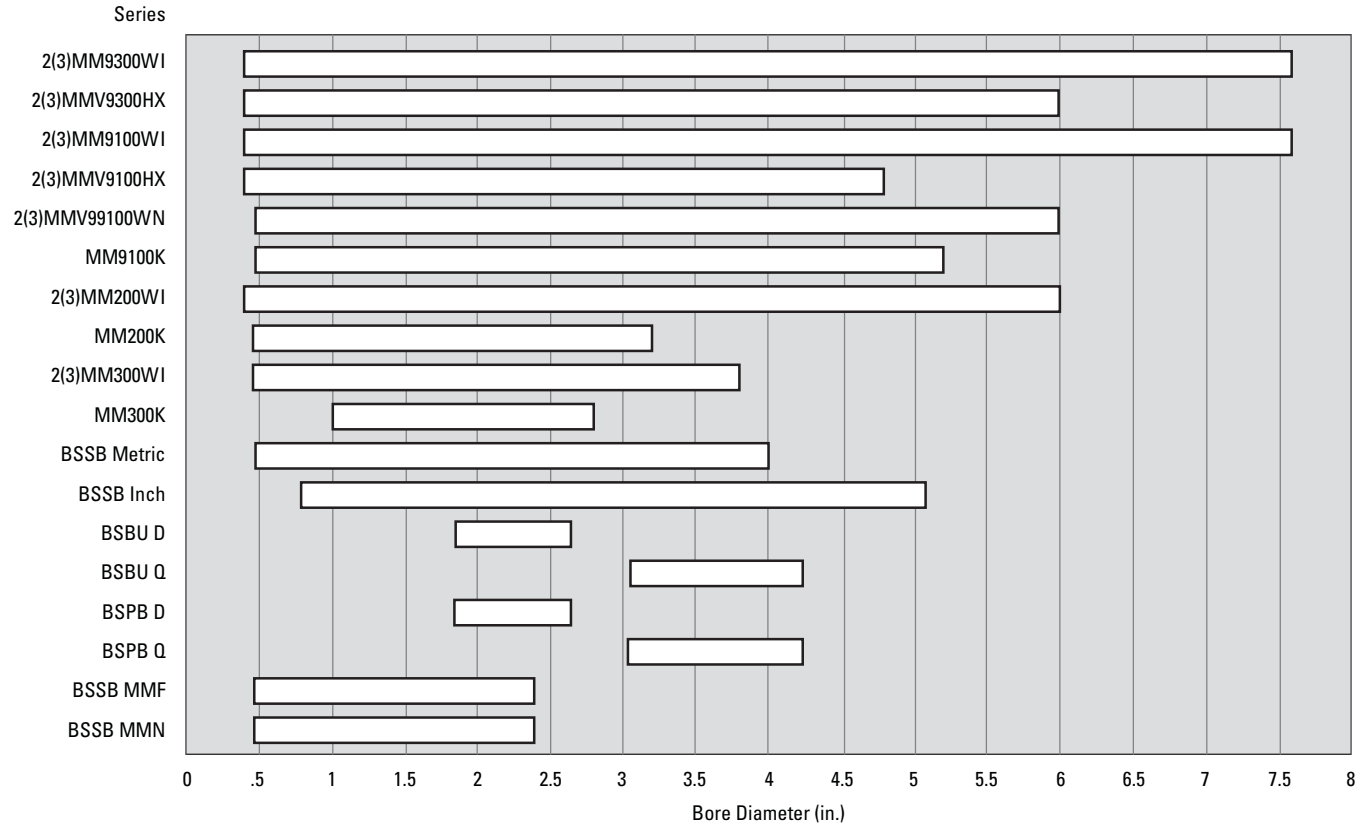
REPLACEMENT BEARINGS FOR EX-CELL-O SPINDLES

Bearing Number	Ex-Cell-O Part No.	Preload	Bore		O.D.		Width - Pair		Speed Rating		
			Max.	Min.	Max.	Min.	Max.	Min.	Grease	Oil	Mist
		lbs.	in.		in.		in.		RPM		
MM20XWOCRDU E9103A	XLO 20-107	0	0.37500	0.37485	1.1250	1.1248	0.6875	0.6675	40000	65000	80000
MM30XWOCRDU E9103C	XLO 30-57	10	0.62500	0.62485	1.5000	1.4998	1.0000	0.9800	27000	30000	35000
MM30XWOCRDU E9103A	XLO 30-107	0	0.62500	0.62485	1.5000	1.4998	1.0000	0.9800	35000	40000	60000
MM55XWOCRDU E9103E	XLO 55-27	50	0.81250	0.81235	2.0000	1.9998	1.0000	0.9800	5000	8000	12000
MM55XWOCRDU E9103C	XLO 55-57	20	0.81250	0.81235	2.0000	1.9998	1.0000	0.9800	20000	22000	24000
MM55XWOCRDU E9103A	XLO 55-107	0	0.81250	0.81235	2.0000	1.9998	1.0000	0.9800	24000	27000	45000
MM57XWOCRDU E9103F	XLO 57-17	100	1.06250	1.06235	2.2500	2.2498	1.0000	0.9800	2000	4000	6000
MM57XWOCRDU E9103C	XLO 57-57	20	1.06250	1.06235	2.2500	2.2498	1.0000	0.9800	18000	20000	22000
MM57XWOCRDU E9103A	XLO 57-107	0	1.06250	1.06235	2.2500	2.2498	1.0000	0.9800	22000	25000	35000
MM67XWOCRDU E9103F	XLO 67-17	90	1.25000	1.24980	2.4375	2.4373	1.2500	1.2300	36000	4500	6000
MM67XWOCRDU E9103C	XLO 67-57	20	1.25000	1.24980	2.4375	2.4373	1.2500	1.2300	12500	15000	20000
MM67XWOCRDU E9103A	XLO 67-107	0	1.25000	1.24980	2.4375	2.4373	1.2500	1.2300	16000	20000	30000
MM90XWOCRDU E9103F	XLO 90-17	250	1.62500	1.62480	3.4375	3.4372	1.6250	1.6050	1000	2000	4000
MM90XWOCRDU E9103D	XLO 90-47	175	1.62500	1.62480	3.4375	3.4372	1.6250	1.6050	3000	5000	8000
MM90XWOCRDU E9103C	XLO 90-57	100	1.62500	1.62480	3.4375	3.4372	1.6250	1.6050	5000	7000	11000
MM90XWOCRDU E9103A	XLO 90-77	20	1.62500	1.62480	3.4375	3.4372	1.6250	1.6050	10000	14000	20000
MM115XWOCRDU E9103E	XLO 115-27	300	2.25000	2.24980	4.7500	4.7496	2.2500	2.2300	1000	2000	3000
MM115XWOCRDU E9103C	XLO 115-47	150	2.25000	2.24980	4.7500	4.7496	2.2500	2.2300	3000	4500	7000
MM115XWOCRDU E9103A	XLO 115-77	30	2.25000	2.24980	4.7500	4.7496	2.2500	2.2300	6000	8000	15000
MM135XWOCRDU E9103C	XLO 135-67	50	1.25000	1.24980	2.6875	2.6873	1.2500	1.2300	6000	7000	12000
MM135XWOCRDU E9103A	XLO 135-10	70	1.25000	1.24980	2.6875	2.6873	1.2500	1.2300	15000	19000	28000
MM155XWOCRDU E9103D	XLO 155-37	300	2.75000	2.74980	4.7500	4.7496	2.2500	2.2300	1000	2000	3000
MM155XWOCRDU E9103B	XLO 155-67	150	2.75000	2.74980	4.7500	4.7496	2.2500	2.2300	4000	5000	6500
MM155XWOCRDU E9103A	XLO 155-87	50	2.75000	2.74980	4.7500	4.7496	2.2500	2.2300	6000	7000	10000
MM165XWOCRDU E9103E	XLO 165-27	800	3.50000	3.49975	6.3125	6.3121	3.0000	2.9800	500	1000	2000
MM165XWOCRDU E9103C	XLO 165-57	250	3.50000	3.49975	6.3125	6.3121	3.0000	2.9800	2000	3000	5000
MM165XWOCRDU E9103A	XLO 165-87	50	3.50000	3.49975	6.3125	6.3121	3.0000	2.9800	5000	6500	9000

Do not interchange with MM-EX.
MM-XWO produced to nominal minus tolerance.

BALL BEARING BORE DIAMETERS FOUND IN THIS CATALOG





APPENDIX

D

D APPENDIX

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FREQUENCY COEFFICIENTS

TAPERED ROLLER BEARINGS

Predictive maintenance of applications requires knowledge of the frequencies that a bearing can emit, which are based on its specific design. The tables that follow provide the most commonly used coefficients for this purpose. The frequencies are expressed as "Orders." To obtain bearing defect frequencies in Hz, multiply bearing coefficient by rotating speed in revolutions per second.

Tapered roller bearing example:

(FTF of JP6049-JP6010-B)
1200 RPM x 1min/60 sec x 0.436 = 8.72 Hz

Ball bearing example:

(FTF of 2MM9300WI)
1200 RPM x 1 min/60 sec x 0.4054 = 8.108 Hz

D

TS Metric Style

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Part Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
JP6049-JP6010	0.436	3.676	8.275	10.725	0.564
JLM710949C-JLM710910	0.441	4.070	9.271	11.729	0.559
JP7049-JP7010	0.443	4.160	9.299	11.701	0.557
JP8049-JP8010	0.444	4.255	9.323	11.677	0.556
JM716649-JM716610	0.452	5.019	11.761	14.239	0.548
JP9049-JP9010	0.449	4.669	10.331	12.669	0.551
JP10044-JP10010	0.453	5.093	11.331	13.669	0.547
JM719149-JM719113	0.448	4.580	10.748	13.252	0.552
JP10049-JP10010	0.453	5.093	11.331	13.669	0.547
JM822049-JM822010	0.454	5.169	12.260	14.740	0.546
JLM722948-JLM722912	0.459	5.761	13.297	15.703	0.541
JL724348-JL724314	0.462	6.367	15.260	17.740	0.538
JL725346-JL725316	0.464	6.606	16.236	18.764	0.536
JP13049-JP13010	0.455	5.252	11.820	14.180	0.545
JP14049-JP14010	0.458	5.587	12.811	15.189	0.542
JL730646-JL730612	0.467	7.219	17.273	19.727	0.533
JP16049-JP16010	0.459	5.791	13.308	15.692	0.541
JP17049-JP17010	0.461	6.132	14.292	16.708	0.539
JP18049-JP18010	0.463	6.437	14.816	17.184	0.537
JM736149-JM736110	0.462	6.290	14.787	17.213	0.538

[1] For inner ring rotation.
[2] For outer ring rotation.

TS Inch Style

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Part Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
29585-29520	0.452	4.935	11.742	14.258	0.548
399A-394A	0.443	4.191	9.740	12.260	0.557
29685-29620	0.455	5.251	12.277	14.723	0.545
34301-34478	0.450	4.734	10.789	13.211	0.550
497-493	0.448	4.606	10.307	12.693	0.552
LM718947-LM718910	0.452	4.970	11.303	13.697	0.548
52400-52618	0.452	4.935	11.745	14.255	0.548
68462-68712	0.450	4.749	11.251	13.749	0.550
36690-36620	0.472	8.597	20.286	22.714	0.528
36990-36920	0.477	10.260	23.829	26.171	0.523
87750-87111	0.457	5.592	13.253	15.747	0.543
67985-67920	0.470	7.996	19.283	21.717	0.530
543085-543114	0.473	8.987	19.868	22.132	0.527

[1] For inner ring rotation.
[2] For outer ring rotation.

TSF Metric Style

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Part Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
JP6049-JP6010-B	0.436	3.676	8.275	10.725	0.564
JP7049-JP7010-B	0.443	4.160	9.299	11.701	0.557
JP8049-JP8010-B	0.444	4.255	9.323	11.677	0.556
JP9049-JP9010-B	0.449	4.669	10.331	12.669	0.551
JP10044-JP10010-B	0.453	5.093	11.331	13.669	0.547
JP10049-JP10010-B	0.453	5.093	11.331	13.669	0.547
JP13049-JP13010-B	0.455	5.252	11.820	14.180	0.545
JP14049-JP14010-B	0.458	5.587	12.811	15.189	0.542
JL730646-JL730612-B	0.467	7.219	17.273	19.727	0.533

[1] For inner ring rotation.
[2] For outer ring rotation.

TSF Inch Style

Part Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
2984-2924-B	0.434	3.643	8.244	10.755	0.566
3984-3920-B	0.443	4.191	9.740	12.260	0.557
482-472-B	0.439	3.948	8.783	11.217	0.561
566-563-B	0.435	3.713	8.705	11.295	0.565
33287-33462-B	0.448	4.568	10.295	12.705	0.552
27690-27620-B	0.457	5.599	12.340	14.660	0.543
42350-42587-B	0.454	5.118	11.793	14.207	0.546
683-672-B	0.446	4.367	10.247	12.753	0.555
687-672-B	0.446	4.367	10.247	12.753	0.555
71450-71750-B	0.444	4.296	10.217	12.783	0.556

[1] For inner ring rotation.
[2] For outer ring rotation.

TSHR Style

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Part Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
JP5049P-JP5019HR	0.426	3.178	6.815	9.185	0.574
JP5049P-JP5020HR	0.426	3.178	6.815	9.185	0.574
JP5049PH-JP5017HR	0.426	3.178	6.815	9.185	0.574
JP5049PH-JP5020HR	0.426	3.178	6.815	9.185	0.574
JP7548P-JP7520HR	0.446	4.387	8.918	11.082	0.554
JP7549P-JP7519HR	0.446	4.387	8.918	11.082	0.554
JP8548-JP8518HR	0.447	4.462	9.827	12.173	0.553
JP8549P-JP8519HR	0.447	4.462	9.827	12.173	0.553
JP10048-JP10019HR	0.453	5.093	9.971	12.029	0.547
JP10048-JP10019HRA	0.453	5.093	9.971	12.029	0.547
JP11035-JP11019HR	0.452	4.955	9.937	12.063	0.548
JP11048-JP11019HR	0.452	4.955	9.937	12.063	0.548
JP12043P-JP12019HR	0.455	5.317	11.835	14.165	0.545
JP12049P-JP12019HR	0.455	5.317	11.835	14.165	0.545
JP13043P-JP13016HR	0.455	5.252	11.820	14.180	0.545
JP13049P-JP13016HR	0.455	5.252	11.820	14.180	0.545
JP14043P-JP14019HR	0.458	5.587	12.353	14.647	0.542
JP14049P-JP14019HR	0.458	5.587	12.353	14.647	0.542
JP16043P-JP16019HR	0.459	5.791	12.849	15.151	0.541
JP16049P-JP16019HR	0.459	5.791	12.849	15.151	0.541
JP17049P-JP17019HR	0.461	6.132	13.831	16.169	0.539
JP18049P-JP18019HR	0.463	6.437	14.353	16.647	0.537
JP20049P-JP20019HR	0.462	6.240	12.006	13.994	0.538
JP22049E-JP22019HR	0.465	6.769	13.949	16.051	0.535
JL555235-JL55512HR	0.472	8.567	16.041	17.959	0.528
JL555239-JL55512HR	0.472	8.567	16.041	17.959	0.528

[1] For inner ring rotation.
[2] For outer ring rotation.

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FREQUENCY COEFFICIENTS

BALL BEARINGS

2MM9300WI Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Bearing Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
2MM9300WI	0.4054	2.4294	4.8649	7.1351	0.5946
2MM9301WI	0.4159	2.7546	5.4070	7.5930	0.5841
2MM9302WI	0.4204	2.9335	5.4650	7.5350	0.5796
2MM9303WI	0.4272	3.2198	6.4074	8.5926	0.5728
2MM9304WI	0.4194	2.9144	5.8719	8.1281	0.5806
2MM9305WI	0.4314	3.4509	7.3346	9.6654	0.5686
2MM9306WI	0.4404	3.9846	8.3667	10.6333	0.5596
2MM9307WI	0.4405	3.9924	8.3695	10.6305	0.5595
2MM9308WI	0.4399	3.9578	8.3586	10.6414	0.5601
2MM9309WI	0.4458	4.3966	9.3612	11.6388	0.5542
2MM9310WI	0.4498	4.7547	10.3448	12.6552	0.5502
2MM9311WI	0.4490	4.6752	10.3262	12.6738	0.5510
2MM9312WI	0.4525	5.0286	11.3121	13.6879	0.5475
2MM9313WI	0.4556	5.3816	12.2999	14.7001	0.5444
2MM9314WI	0.4504	4.8196	10.8092	13.1908	0.5496
2MM9315WI	0.4531	5.1086	11.3285	13.6715	0.5469
2MM9316WI	0.4556	5.3974	12.3014	14.6986	0.5444
2MM9317WI	0.4557	5.3371	11.8322	14.1678	0.5449
2MM9318WI	0.4537	5.1643	11.7957	14.2043	0.5463
2MM9319WI	0.4557	5.4085	12.7607	15.2393	0.5443
2MM9320WI	0.4585	5.7746	13.2966	15.7034	0.5415
2MM9322WI	0.4617	6.2622	14.3126	16.6874	0.5383
2MM9324WI	0.4596	5.9438	13.7888	16.2112	0.5404
2MM9326WI	0.4580	5.7028	13.7392	16.2608	0.5420
2MM9328WI	0.4605	6.0759	14.7367	17.2633	0.5395
2MM9330WI	0.4531	5.1086	12.2348	14.7652	0.5469
2MM9332WI	0.4536	5.1589	12.2480	14.7520	0.5464
2MM9334WI	0.4559	5.4349	13.2209	15.7791	0.5441
2MM9340WI	0.4521	4.9931	12.2062	14.7938	0.5479

[1] For inner ring rotation.
[2] For outer ring rotation.

3MM9300WI Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Bearing Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
3MM9300WI	0.4100	2.4380	4.9204	7.0796	0.5900
3MM9302WI	0.4248	2.9417	5.5225	7.4775	0.5752
3MM9303WI	0.4312	3.2273	6.4681	8.5319	0.5688
3MM9305WI	0.4356	3.4586	7.4044	9.5956	0.5644
3MM9306WI	0.4439	3.9913	8.4346	10.5654	0.5561
3MM9307WI	0.4440	3.9990	8.4366	10.5634	0.5560
3MM9308WI	0.4437	3.9648	8.4295	10.5705	0.5563
3MM9309WI	0.4491	4.4029	9.4320	11.5680	0.5509
3MM9310WI	0.4529	4.7606	10.4166	12.5834	0.5471
3MM9311WI	0.4521	4.6811	10.3983	12.6017	0.5479
3MM9312WI	0.4554	5.0340	11.3851	13.6149	0.5446
3MM9313WI	0.4583	5.3867	12.3736	14.6264	0.5417
3MM9314WI	0.4535	4.8255	10.8839	13.1161	0.5465
3MM9315WI	0.4561	5.1141	11.4020	13.5980	0.5439
3MM9316WI	0.4584	5.4026	12.3766	14.6234	0.5416
3MM9317WI	0.4579	5.3423	11.9047	14.0953	0.5421
3MM9318WI	0.4565	5.1696	11.8699	14.1301	0.5435
3MM9319WI	0.4585	5.4136	12.8371	15.1629	0.5415
3MM9320WI	0.4611	5.7794	13.3708	15.6292	0.5389
3MM9322WI	0.4641	6.2666	14.3858	16.6142	0.5359
3MM9324WI	0.4622	5.9485	13.8645	16.1355	0.5378
3MM9326WI	0.4606	5.7077	13.8171	16.1829	0.5394
3MM9328WI	0.4630	6.0804	14.8147	17.1853	0.5370
3MM9330WI	0.4561	5.1141	12.3141	14.6859	0.5439
3MM9334WI	0.4586	5.4401	13.3007	15.6993	0.5414
3MM9340WI	0.4551	4.9987	12.2879	14.7121	0.5449

[1] For inner ring rotation.
[2] For outer ring rotation.

2MMV9300HX Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Part Number	FTF-inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
2MMV9300HX	0.4283	3.2887	5.5682	7.4318	0.5717
2MMV9302HX	0.4363	3.7164	6.1081	7.8919	0.5637
2MMV9302HX	0.4378	3.8096	7.0041	8.9959	0.5622
2MMV9303HX	0.4431	4.1747	7.5319	9.4681	0.5569
2MMV9304HX	0.4396	3.9312	7.4726	9.5274	0.5604
2MMV9305HX	0.4486	4.6398	8.9717	11.0283	0.5514
2MMV9306HX	0.4553	5.3464	10.4710	12.5290	0.5447
2MMV9307HX	0.4575	5.6286	11.4364	13.5636	0.5425
2MMV9308HX	0.4400	3.9579	8.3598	10.6402	0.5600
2MMV9309HX	0.4458	4.3967	9.3624	11.6376	0.5542
2MMV9310HX	0.4498	4.7548	10.3460	12.6540	0.5502
2MMV9311HX	0.4490	4.6752	10.3262	12.6738	0.5510
2MMV9312HX	0.4525	5.0286	11.3121	13.6879	0.5475
2MMV9313HX	0.4556	5.3816	12.2999	14.7001	0.5444
2MMV9314HX	0.4504	4.8197	10.8104	13.1896	0.5496
2MMV9315HX	0.4532	5.1087	11.3297	13.6703	0.5468
2MMV9316HX	0.4557	5.3975	12.3026	14.6974	0.5443
2MMV9317HX	0.4551	5.3372	11.8338	14.1662	0.5449
2MMV9318HX	0.4537	5.1642	11.7952	14.2048	0.5463
2MMV9319HX	0.4557	5.4085	12.7601	15.2399	0.5443
2MMV9320HX	0.4585	5.7746	13.2961	15.7039	0.5415
2MMV9322HX	0.4617	6.2622	14.3121	16.6879	0.5383
2MMV9324HX	0.4596	5.9438	13.7892	16.2108	0.5404
2MMV9326HX	0.4580	5.7028	13.7386	16.2614	0.5422
2MMV9328HX	0.4605	6.0759	14.7371	17.2629	0.5395
2MMV9330HX	0.4532	5.1086	12.2351	14.7649	0.5468

[1] For inner ring rotation.
[2] For outer ring rotation.

3MMV9300HX Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Part Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
3MMV9300HX	0.4327	3.2987	5.6255	7.3745	0.5673
3MMV9301HX	0.4402	3.7257	6.1629	7.8371	0.5598
3MMV9302HX	0.4416	3.8167	7.0655	8.9345	0.5584
3MMV9303HX	0.4466	4.1812	7.5916	9.4084	0.5534
3MMV9304HX	0.4434	3.9383	7.5370	9.4630	0.5566
3MMV9305HX	0.4518	4.6459	9.0361	10.9639	0.5482
3MMV9306HX	0.4581	5.3516	10.5355	12.4645	0.5419
3MMV9307HX	0.4601	5.6336	11.5035	13.4965	0.5399
3MMV9308HX	0.4436	3.9647	8.4284	10.5716	0.5564
3MMV9309HX	0.4491	4.4028	9.4309	11.5691	0.5509
3MMV9310HX	0.4528	4.7605	10.4154	12.5846	0.5472
3MMV9311HX	0.4521	4.6810	10.3976	12.6024	0.5479
3MMV9312HX	0.4554	5.0340	11.3844	13.6156	0.5446
3MMV9313HX	0.4583	5.3866	12.3729	14.6271	0.5417
3MMV9314HX	0.4535	4.8255	10.8839	13.1161	0.5465
3MMV9315HX	0.4561	5.1141	11.4020	13.5980	0.5439
3MMV9316HX	0.4584	5.4026	12.3766	14.6234	0.5416
3MMV9317HX	0.4579	5.3425	11.9063	14.0937	0.5421
3MMV9318HX	0.4566	5.1697	11.8704	14.1296	0.5434
3MMV9319HX	0.4585	5.4137	12.8376	15.1624	0.5415
3MMV9320HX	0.4611	5.7794	13.3713	15.6287	0.5389
3MMV9322HX	0.4641	6.2667	14.3863	16.6137	0.5359
3MMV9324HX	0.4622	5.9486	13.8654	16.1346	0.5378
3MMV9326HX	0.4606	5.7077	13.8183	16.1817	0.5394
3MMV9328HX	0.4630	6.0805	14.8159	17.1841	0.5370
3MMV9330HX	0.4560	5.1141	12.3132	14.6868	0.5440

[1] For inner ring rotation.
[2] For outer ring rotation.

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2MM9100WI Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Bearing Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
2MM9100WI	0.3740	1.7697	2.9924	5.0076	0.6260
2MM9101WI	0.3902	2.0621	3.9015	6.0985	0.6098
2MM9102WI	0.4035	2.3754	4.8424	7.1576	0.5965
2MM9103WI	0.4126	2.6411	4.5390	6.4610	0.5874
2MM9104WI	0.4013	2.3458	4.4140	6.5860	0.5987
2MM9105WI	0.4150	2.7526	5.3947	7.6053	0.5850
2MM9106WI	0.4201	2.9387	5.8807	8.1193	0.5799
2MM9107WI	0.4210	2.9789	6.3157	8.6843	0.5790
2MM9108WI	0.4291	3.3332	6.8655	9.1345	0.5709
2MM9109WI	0.4298	3.3682	7.3063	9.6937	0.5702
2MM9110WI	0.4352	3.6596	7.8332	10.1668	0.5648
2MM9111WI	0.4314	3.4469	7.7648	10.2352	0.5686
2MM9112WI	0.4358	3.6934	8.2803	10.7197	0.5642
2MM9113WI	0.4397	3.9394	8.7939	11.2061	0.5603
2MM9114WI	0.4362	3.7179	8.2875	10.7125	0.5638
2MM9115WI	0.4395	3.9312	8.7908	11.2092	0.5605
2MM9116WI	0.4365	3.7369	8.7306	11.2694	0.5635
2MM9117WI	0.4396	3.9332	9.2317	11.7683	0.5604
2MM9118WI	0.4367	3.7517	8.7350	11.2650	0.5633
2MM9119WI	0.4394	3.9200	9.2271	11.7729	0.5606
2MM9120WI	0.4418	4.0881	9.7198	12.2802	0.5582
2MM9121WI	0.4393	3.9167	9.2256	11.7744	0.5607
2MM9122WI	0.4399	3.9507	9.6778	12.3222	0.5601
2MM9124WI	0.4439	4.2417	10.2102	12.7898	0.5561
2MM9126WI	0.4397	3.9394	9.2336	11.7664	0.5603
2MM9128WI	0.4431	4.1850	9.7491	12.2509	0.5569
2MM9130WI	0.4428	4.1640	9.7426	12.2574	0.5572
2MM9132WI	0.4426	4.1450	9.7367	12.2633	0.5574
2MM9134WI	0.4394	3.9247	9.6660	12.3340	0.5606
2MM9136WI	0.4367	3.7516	8.7339	11.2661	0.5633
2MM9140WI	0.4369	3.7645	8.7378	11.2622	0.5631

[1] For inner ring rotation.
[2] For outer ring rotation.

3MM9100WI Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Bearing Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
3MM9100WI	0.3740	1.7697	2.9924	5.0076	0.6260
3MM9101WI	0.3957	2.0724	3.9569	6.0431	0.6043
3MM9102WI	0.4084	2.3844	4.4924	6.5076	0.5916
3MM9103WI	0.4170	2.6493	4.5875	6.4125	0.5830
3MM9104WI	0.4074	2.3573	4.4816	6.5184	0.5926
3MM9105WI	0.4203	2.7625	5.4635	7.5365	0.5797
3MM9106WI	0.4243	2.9475	5.9467	8.0533	0.5752
3MM9107WI	0.4258	2.9877	6.3864	8.6136	0.5742
3MM9108WI	0.4333	3.3411	6.9332	9.0668	0.5667
3MM9109WI	0.4340	3.3761	7.3782	9.6218	0.5660
3MM9110WI	0.4391	3.6669	7.9036	10.0964	0.5609
3MM9111WI	0.4354	3.4544	7.8373	10.1627	0.5646
3MM9112WI	0.4396	3.7005	8.3519	10.6481	0.5604
3MM9113WI	0.4432	3.9461	8.8647	11.1353	0.5568
3MM9114WI	0.4400	3.7251	8.3599	10.6401	0.5600
3MM9115WI	0.4432	3.9379	8.8630	11.1370	0.5568
3MM9116WI	0.4404	3.7441	8.8074	11.1926	0.5596
3MM9117WI	0.4433	3.9400	9.3085	11.6915	0.5567
3MM9118WI	0.4405	3.7587	8.8101	11.1899	0.5595
3MM9119WI	0.4430	3.9267	9.3026	11.6974	0.5570
3MM9120WI	0.4453	4.0945	9.7958	12.2042	0.5547
3MM9121WI	0.4430	3.9235	9.3021	11.6979	0.5570
3MM9122WI	0.4434	3.9573	9.7557	12.2443	0.5566
3MM9124WI	0.4472	4.2479	10.2861	12.7139	0.5528
3MM9126WI	0.4433	3.9462	9.3096	11.6904	0.5567
3MM9128WI	0.4466	4.1914	9.8241	12.1759	0.5534
3MM9130WI	0.4463	4.1705	9.8186	12.1814	0.5537
3MM9132WI	0.4461	4.1515	9.8135	12.1865	0.5539
3MM9134WI	0.4431	3.9318	9.7492	12.2508	0.5569
3MM9136WI	0.4406	3.7588	8.8114	11.1886	0.5594
3MM9140WI	0.4408	3.7719	8.8164	11.1836	0.5592

[1] For inner ring rotation.
[2] For outer ring rotation.

2MMV9100HX Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Bearing Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
2MMV9100HX	0.3834	1.9496	3.8344	6.1656	0.6166
2MMV9101HX	0.3852	1.9890	3.8517	6.1483	0.6148
2MMV9102HX	0.4023	2.3729	4.8273	7.1727	0.5977
2MMV9103HX	0.3969	2.2403	4.7634	7.2366	0.6031
2MMV9104HX	0.4012	2.3457	4.8147	7.1853	0.5988
2MMV9105HX	0.4043	2.4274	5.2560	7.7440	0.5957
2MMV9106HX	0.4099	2.5903	5.3292	7.6708	0.5901
2MMV9107HX	0.4211	2.9789	6.3162	8.6838	0.5789
2MMV9108HX	0.4291	3.3332	6.8659	9.1341	0.5709
2MMV9109HX	0.4234	3.0758	6.3517	8.6483	0.5766
2MMV9110HX	0.4293	3.3440	6.8694	9.1306	0.5707
2MMV9111HX	0.4472	4.5160	10.7329	13.2671	0.5528
2MMV9112HX	0.4506	4.8343	11.2653	13.7347	0.5494
2MMV9113HX	0.4490	4.6751	11.2241	13.7759	0.5510
2MMV9114HX	0.4490	4.6752	11.2241	13.7759	0.5510
2MMV9115HX	0.4517	4.9403	11.7429	14.2571	0.5483
2MMV9116HX	0.4477	4.5613	11.1913	13.8087	0.5523
2MMV9117HX	0.4502	4.7888	11.7039	14.2961	0.5498
2MMV9118HX	0.4534	5.1295	12.6953	15.3047	0.5466
2MMV9119HX	0.4490	4.6752	11.6731	14.3269	0.5510
2MMV9120HX	0.4510	4.8740	12.1772	14.8228	0.5490
2MMV9121HX	0.4538	5.1719	12.7058	15.2942	0.5462
2MMV9122HX	0.4563	5.4696	13.6877	16.3123	0.5437
2MMV9124HX	0.4542	5.2052	13.1707	15.8293	0.5458

[1] For inner ring rotation.
[2] For outer ring rotation.

3MMV9100HX Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Part Number	FTF-inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
3MMV9100HX	0.4003	2.1778	4.0035	5.9965	0.5997
3MMV9101HX	0.3922	2.0022	3.9223	6.0777	0.6078
3MMV9102HX	0.4083	2.3842	4.8993	7.1007	0.5917
3MMV9103HX	0.4032	2.2519	4.8383	7.1617	0.5968
3MMV9104HX	0.4071	2.3568	4.8857	7.1143	0.5929
3MMV9105HX	0.4202	2.7625	5.4630	7.5370	0.5798
3MMV9106HX	0.4250	2.9479	5.9495	8.0505	0.5750
3MMV9107HX	0.4259	2.9879	6.3882	8.6118	0.5741
3MMV9108HX	0.4334	3.3413	6.9349	9.0651	0.5666
3MMV9109HX	0.4280	3.0844	6.4205	8.5795	0.5720
3MMV9110HX	0.4336	3.3519	6.9371	9.0629	0.5664
3MMV9111HX	0.4504	4.5220	10.8100	13.1900	0.5496
3MMV9112HX	0.4536	4.8399	11.3404	13.6596	0.5464
3MMV9113HX	0.4520	4.6809	11.3011	13.6989	0.5480
3MMV9114HX	0.4521	4.6810	11.3025	13.6975	0.5479
3MMV9115HX	0.4545	4.9457	11.8182	14.1818	0.5455
3MMV9116HX	0.4509	4.5674	11.2722	13.7278	0.5491
3MMV9117HX	0.4532	4.7945	11.7824	14.2176	0.5468
3MMV9118HX	0.4562	5.1347	12.7743	15.2257	0.5438
3MMV9119HX	0.4521	4.6810	11.7541	14.2459	0.5479
3MMV9120HX	0.4540	4.8796	12.2580	14.7420	0.5460
3MMV9121HX	0.4566	5.1772	12.7848	15.2152	0.5434
3MMV9122HX	0.4589	5.4746	13.7678	16.2322	0.5411
3MMV9124HX	0.4568	5.2102	13.2485	15.7515	0.5432

[1] For inner ring rotation.
[2] For outer ring rotation.

2MMV99100WN Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Bearing Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
2MMV99101WN	0.3887	2.0593	3.4985	5.5015	0.6113
2MMV99102WN	0.4023	2.3729	4.4250	6.5750	0.5977
2MMV99103WN	0.4115	2.6389	5.3494	7.6506	0.5885
2MMV99104WN	0.4011	2.3455	4.4120	6.5880	0.5989
2MMV99105WN	0.4148	2.7523	5.3928	7.6072	0.5852
2MMV99106WN	0.4288	3.3241	6.8615	9.1385	0.5712
2MMV99107WN	0.4448	4.3111	9.3403	11.6597	0.5552
2MMV99108WN	0.4512	4.8947	10.8295	13.1705	0.5488
2MMV99109WN	0.4489	4.6750	10.3246	12.6754	0.5511
2MMV99110WN	0.4528	5.0724	11.3207	13.6793	0.5472
2MMV99111WN	0.4525	5.0285	11.3121	13.6879	0.5475
2MMV99112WN	0.4556	5.3815	11.8443	14.1557	0.5444
2MMV99113WN	0.4582	5.7340	12.8308	15.1692	0.5418
2MMV99114WN	0.4575	5.6283	12.8104	15.1896	0.5425
2MMV99115WN	0.4602	6.0120	13.8057	16.1943	0.5398
2MMV99116WN	0.4589	5.8300	13.3085	15.6915	0.5411
2MMV99117WN	0.4610	6.1310	14.2906	16.7094	0.5390
2MMV99118WN	0.4568	5.5308	12.7902	15.2098	0.5432
2MMV99119WN	0.4586	5.7748	13.2992	15.7008	0.5414
2MMV99120WN	0.4606	6.0708	14.2782	16.7218	0.5394
2MMV99121WN	0.4596	5.9229	13.7892	16.2108	0.5404
2MMV99122WN	0.4591	5.8399	13.7729	16.2271	0.5409
2MMV99124WN	0.4618	6.2625	14.7784	17.2216	0.5382
2MMV99126WN	0.4610	6.1362	14.7512	17.2488	0.5390
2MMV99128WN	0.4633	6.5243	15.7513	18.2487	0.5367
2MMV99130WN	0.4616	6.2346	15.2336	17.7664	0.5384

[1] For inner ring rotation.
[2] For outer ring rotation.

3MMV99100WN Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Bearing Number	FTF-inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
3MMV99101WN	0.3956	2.0721	3.5600	5.4400	0.6044
3MMV99102WN	0.4083	2.3842	4.4911	6.5089	0.5917
3MMV99103WN	0.4169	2.6491	5.4201	7.5799	0.5831
3MMV99104WN	0.4075	2.3575	4.4829	6.5171	0.5925
3MMV99105WN	0.4204	2.7627	5.4648	7.5352	0.5796
3MMV99106WN	0.4335	3.3327	6.9356	9.0644	0.5665
3MMV99107WN	0.4483	4.3177	9.4149	11.5851	0.5517
3MMV99108WN	0.4544	4.9006	10.9048	13.0952	0.5456
3MMV99109WN	0.4522	4.6813	10.4011	12.5989	0.5478
3MMV99110WN	0.4559	5.0782	11.3974	13.6026	0.5441
3MMV99111WN	0.4555	5.0341	11.3872	13.6128	0.5445
3MMV99112WN	0.4584	5.3867	11.9173	14.0827	0.5416
3MMV99113WN	0.4609	5.7389	12.9047	15.0953	0.5391
3MMV99114WN	0.4601	5.6332	12.8838	15.1162	0.5399
3MMV99115WN	0.4626	6.0166	13.8794	16.1206	0.5374
3MMV99116WN	0.4615	5.8348	13.3829	15.6171	0.5385
3MMV99117WN	0.4634	6.1356	14.3663	16.6337	0.5366
3MMV99118WN	0.4594	5.5357	12.8631	15.1369	0.5406
3MMV99119WN	0.4611	5.7794	13.3715	15.6285	0.5389
3MMV99120WN	0.4630	6.0753	14.3518	16.6482	0.5370
3MMV99121WN	0.4620	5.9273	13.8611	16.1389	0.5380
3MMV99122WN	0.4615	5.8444	13.8448	16.1552	0.5385
3MMV99124WN	0.4641	6.2667	14.8500	17.1500	0.5359
3MMV99126WN	0.4633	6.1406	14.8262	17.1738	0.5367
3MMV99128WN	0.4655	6.5284	15.8262	18.1738	0.5345
3MMV99130WN	0.4639	6.2388	15.3080	17.6920	0.5361

[1] For inner ring rotation.
[2] For outer ring rotation.

2MM200WI Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Bearing Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
2MM200WI	0.3668	1.6722	2.9345	5.0655	0.6332
2MM201WI	0.3699	1.7226	3.3290	5.6710	0.6301
2MM202WI	0.3855	1.9898	3.8552	6.1448	0.6145
2MM203WI	0.3861	2.0025	3.8609	6.1391	0.6139
2MM204WI	0.3857	2.0000	3.8570	6.1430	0.6143
2MM205WI	0.4008	2.3347	4.8091	7.1909	0.5992
2MM206WI	0.4001	2.3182	4.8007	7.1993	0.5999
2MM207WI	0.3997	2.3104	4.7965	7.2035	0.6003
2MM208WI	0.3980	2.2638	4.3777	6.6223	0.6020
2MM209WI	0.4058	2.4683	5.2757	7.7243	0.5942
2MM210WI	0.4126	2.6716	5.7757	8.2243	0.5874
2MM211WI	0.4110	2.6263	5.7543	8.2457	0.5890
2MM212WI	0.4098	2.5901	5.7376	8.2624	0.5902
2MM213WI	0.4130	2.6906	5.7818	8.2182	0.5870
2MM214WI	0.4135	2.7082	5.7891	8.2109	0.5865
2MM215WI	0.4177	2.8554	6.2659	8.7341	0.5823
2MM216WI	0.4164	2.8064	6.2462	8.7538	0.5836
2MM217WI	0.4152	2.7649	6.2281	8.7719	0.5848
2MM218WI	0.4142	2.7301	5.7984	8.2016	0.5858
2MM219WI	0.4132	2.6992	5.7853	8.2147	0.5868
2MM220WI	0.4125	2.6714	5.7744	8.2256	0.5875
2MM222WI	0.4110	2.6263	5.7543	8.2457	0.5890
2MM224WI	0.4131	2.6927	5.7830	8.2170	0.5869
2MM226WI	0.4192	2.9059	7.1260	9.8740	0.5808
2MM230WI	0.4124	2.6714	6.1865	8.8135	0.5876

[1] For inner ring rotation.
[2] For outer ring rotation.

3MM200WI Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Bearing Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
3MM200WI	0.3668	1.6722	2.9345	5.0655	0.6332
3MM201WI	0.3774	1.7366	3.3966	5.6034	0.6226
3MM202WI	0.3921	2.0021	3.9212	6.0788	0.6079
3MM203WI	0.3928	2.0150	3.9277	6.0723	0.6072
3MM204WI	0.3929	2.0134	3.9290	6.0710	0.6071
3MM205WI	0.4070	2.3463	4.8841	7.1159	0.5930
3MM206WI	0.4064	2.3301	4.8769	7.1231	0.5936
3MM207WI	0.4061	2.3224	4.8734	7.1266	0.5939
3MM208WI	0.4043	2.2757	4.4476	6.5524	0.5957
3MM209WI	0.4117	2.4793	5.3519	7.6481	0.5883
3MM210WI	0.4180	2.6818	5.8519	8.1481	0.5820
3MM211WI	0.4166	2.6367	5.8323	8.1677	0.5834
3MM212WI	0.4155	2.6007	5.8171	8.1829	0.5845
3MM213WI	0.4185	2.7009	5.8587	8.1413	0.5815
3MM214WI	0.4189	2.7182	5.8639	8.1361	0.5811
3MM215WI	0.4228	2.8649	6.3421	8.6579	0.5772
3MM216WI	0.4216	2.8162	6.3241	8.6759	0.5784
3MM217WI	.4205	2.7748	6.3076	8.6924	0.5795
3MM218WI	0.4196	2.7402	5.8738	8.1262	0.5804
3MM219WI	0.4187	2.7094	5.8618	8.1382	0.5813
3MM220WI	0.4179	2.6816	5.8506	8.1494	0.5821
3MM222WI	0.4166	2.6367	5.8323	8.1677	0.5834
3MM224WI	0.4184	2.7026	5.8573	8.1427	0.5816
3MM226WI	0.4241	2.9151	7.2100	9.7900	0.5759
3MM230WI	0.4179	2.6815	6.2681	8.7319	0.5821

[1] For inner ring rotation.
[2] For outer ring rotation.

2MM300WI Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Bearing Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
2MM301WI	0.3594	1.5791	2.8751	5.1249	0.6406
2MM302WI	0.3861	2.0024	3.8609	6.1391	0.6139
2MM303WI	0.3564	1.5411	2.4946	4.5054	0.6436
2MM304WI	0.3618	1.6111	2.8941	5.1059	0.6382
2MM305WI	0.3681	1.6997	3.3127	5.6873	0.6319
2MM306WI	0.3722	1.7663	3.7221	6.2779	0.6278
2MM307WI	0.3799	1.8962	3.7990	6.2010	0.6201
2MM308WI	0.3801	1.9333	4.2025	6.7975	0.6180
2MM309WI	0.3837	1.9636	3.8373	6.1627	0.6163
2MM310WI	0.3851	1.9889	3.8510	6.1490	0.6149
2MM311WI	0.3861	2.0099	3.8606	6.1394	0.6139
2MM312WI	0.3870	2.0281	3.8704	6.1296	0.6130
2MM313WI	0.3879	2.0440	4.2665	6.7335	0.6121
2MM314WI	0.3884	2.0576	4.2729	6.7271	0.6116
2MM319WI	0.3857	2.0013	3.8570	6.1430	0.6143

[1] For inner ring rotation.
[2] For outer ring rotation.

3MM300WI Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Bearing Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
3MM301WI	0.3678	1.5949	2.9425	5.0575	0.6322
3MM302WI	0.3928	2.0149	3.9277	6.0723	0.6072
3MM303WI	0.3653	1.5578	2.5571	4.4429	0.6347
3MM304WI	0.3701	1.6268	2.9611	5.0389	0.6299
3MM305WI	0.3761	1.7147	3.3850	5.6150	0.6239
3MM306WI	0.3801	1.7811	3.8010	6.1990	0.6199
3MM307WI	0.3874	1.9101	3.8736	6.1264	0.6126
3MM308WI	0.3893	1.9469	4.2826	6.7174	0.6107
3MM309WI	0.3910	1.9772	3.9096	6.0904	0.6090
3MM310WI	0.3920	2.0019	3.9205	6.0795	0.6080
3MM311WI	0.3931	2.0231	3.9314	6.0686	0.6069
3MM312WI	0.3941	2.0412	3.9405	6.0595	0.6059
3MM313WI	0.3947	2.0567	4.3415	6.6585	0.6053
3MM314WI	0.3954	2.0705	4.3491	6.6509	0.6046
3MM319WI	0.3927	2.0144	3.9270	6.0730	0.6073

[1] For inner ring rotation.
[2] For outer ring rotation.

FREQUENCY COEFFICIENTS

BALL SCREW SUPPORT SERIES

Metric Series

FTF: Fundamental Train Frequency: the frequency at which the cage 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.

Bearing Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
MM12BS32	0.4460	2.2827	4.9063	6.0937	0.5540
MM15BS35	0.4525	2.6008	5.8825	7.1175	0.5475
MM17BS47	0.4362	2.1044	5.2349	6.7651	0.5638
MM20BS47	0.4362	2.1044	5.2349	6.7651	0.5638
MM25BS52	0.4423	2.3307	5.7494	7.2506	0.5577
MM25BS62	0.4554	3.0307	7.7410	9.2590	0.5446
MM30BS62	0.4554	3.0307	7.7410	9.2590	0.5446
MM30BS72	0.4569	3.1286	8.2244	9.7756	0.5431
MM35BS72	0.4569	3.1286	8.2244	9.7756	0.5431
MM35BS100	0.4564	3.0983	8.2159	9.7841	0.5436
MM40BS72	0.4569	3.1286	8.2244	9.7756	0.5431
MM40BS90	0.4676	4.1773	11.2230	12.7770	0.5324
MM40BS90-20	0.4676	4.1767	11.2228	12.7772	0.5324
MM40BS90-23	0.4676	4.1767	11.2200	12.7772	0.5324
MM40BS100	0.4564	3.0983	8.2159	9.7841	0.5436
MM45BS75	0.4605	3.4145	9.2094	10.7906	0.5395
MM45BS100	0.4564	3.0983	8.2159	9.7841	0.5436
MM50BS90	0.4676	4.1773	11.2230	12.7770	0.5324
MM50BS100	0.4564	3.0983	8.2159	9.7841	0.5436
MM55BS90	0.4676	4.1773	11.2230	12.7770	0.5324
MM55BS120	0.4644	3.7967	9.7516	11.2484	0.5356
MM60BS120	0.4644	3.7967	9.7516	11.2484	0.5356
MM75BS110	0.4747	5.3492	14.2402	15.7598	0.5253
MM100BS150	0.4790	6.4611	17.7226	19.2774	0.5210

Inch Series

Bearing Number	FTF-Inner[1]	BSF	BPFO	BPFI	FTF-Outer[2]
MM9306WI2H	0.4362	2.1044	5.2349	6.7651	0.5638
MM9308WI2H	0.4554	3.0307	7.7410	9.2590	0.5446
MM9310WI2H	0.4569	3.1286	8.2244	9.7756	0.5431
MM9311WI3H	0.4605	3.4145	9.2094	10.7906	0.5395
MM9313WI5H	0.4676	4.1773	11.2230	12.7770	0.5324
MM9316WI3H	0.4747	5.3492	14.2402	15.7598	0.5253
MM9321WI3	0.4794	6.4615	17.7378	19.2622	0.5206
MM9326WI6H	0.4778	6.1209	16.7239	18.2761	0.5222

[1] For inner ring rotation.
[2] For outer ring rotation.

PRECISION TAG DEVIATION AND RUNOUT CHARTS

TAPERED ROLLER BEARINGS

Bearing tag markings include indication of bearing accuracy, which can assist with selective assembly and installation. Refer to diagrams on page 107.

METRIC SYSTEM

Class	Designation 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

Class	Designation 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

Class	Designation no.	Deviation	
		mm Over Incl.	in. Over Incl.
All	+1	**0.000 to 0.003**	0.0000 to 0.0001
	+2	**0.003 to 0.005**	0.0001 to 0.0002
	+3	**0.005 to 0.008**	0.0002 to 0.0003
	+4	**0.008 to 0.010**	0.0003 to 0.0004
	+5	**0.010 to 0.013**	0.0004 to 0.0005
	+6	**0.013 to 0.015**	0.0005 to 0.0006
	+7	**0.015 to 0.018**	0.0006 to 0.0007
	+8	**0.018 to 0.020**	0.0007 to 0.0008
	+9	**0.020 to 0.023**	0.0008 to 0.0009
	+10	**0.023 to 0.025**	0.0009 to 0.0010
	+11	**0.025 to 0.028**	0.0010 to 0.0011
	+12	**0.028 to 0.030**	0.0011 to 0.0012
	+13	**0.030 to 0.033**	0.0012 to 0.0013
	+14	**0.033 to 0.036**	0.0013 to 0.0014
	+15	**0.036 to 0.038**	0.0014 to 0.0015
	+16	**0.038 to 0.041**	0.0015 to 0.0016
	+17	**0.041 to 0.043**	0.0016 to 0.0017
	+18	**0.043 to 0.046**	0.0017 to 0.0018
	+19	**0.046 to 0.048**	0.0018 to 0.0019
	+20	**0.048 to 0.051**	0.0019 to 0.0020
	+21	**0.051 to 0.053**	0.0020 to 0.0021
	+22	**0.053 to 0.056**	0.0021 to 0.0022
	+23	**0.056 to 0.058**	0.0022 to 0.0023
	+24	**0.058 to 0.061**	0.0023 to 0.0024
	+25	**0.061 to 0.064**	0.0024 to 0.0025
	+26	**0.064 to 0.066**	0.0025 to 0.0026
	+27	**0.066 to 0.069**	0.0026 to 0.0027
	+28	**0.069 to 0.071**	0.0027 to 0.0028
	+29	**0.071 to 0.074**	0.0028 to 0.0029
	+30	**0.074 to 0.076**	0.0029 to 0.0030

Class	Designation no.	Deviation	
		mm Over Incl.	in. Over Incl.
3 & 0	+1	**0.000 to 0.003**	0.0000 to 0.0001
	+2	**0.003 to 0.005**	0.0001 to 0.0002
	+3	**0.005 to 0.008**	0.0002 to 0.0003
	+4	**0.008 to 0.010**	0.0003 to 0.0004
	+5	**0.010 to 0.013**	0.0004 to 0.0005
	+6	**0.013 to 0.015**	0.0005 to 0.0006
	+7	**0.015 to 0.018**	0.0006 to 0.0007
	+8	**0.018 to 0.020**	0.0007 to 0.0008
	+9	**0.020 to 0.023**	0.0008 to 0.0009
	+10	**0.023 to 0.025**	0.0009 to 0.0010
	+11	**0.025 to 0.028**	0.0010 to 0.0011
	+12	**0.028 to 0.030**	0.0011 to 0.0012
	+13	**0.030 to 0.033**	0.0012 to 0.0013
	+14	**0.033 to 0.036**	0.0013 to 0.0014
	+15	**0.036 to 0.038**	0.0014 to 0.0015
	+16	**0.038 to 0.041**	0.0015 to 0.0016
	+17	**0.041 to 0.043**	0.0016 to 0.0017
	+18	**0.043 to 0.046**	0.0017 to 0.0018
	+19	**0.046 to 0.048**	0.0018 to 0.0019
	+20	**0.048 to 0.051**	0.0019 to 0.0020
	+21	**0.051 to 0.053**	0.0020 to 0.0021
	+22	**0.053 to 0.056**	0.0021 to 0.0022
	+23	**0.056 to 0.058**	0.0022 to 0.0023
	+24	**0.058 to 0.061**	0.0023 to 0.0024
	+25	**0.061 to 0.064**	0.0024 to 0.0025
	+26	**0.064 to 0.066**	0.0025 to 0.0026
	+27	**0.066 to 0.069**	0.0026 to 0.0027
	+28	**0.069 to 0.071**	0.0027 to 0.0028
	+29	**0.071 to 0.074**	0.0028 to 0.0029
	+30	**0.074 to 0.076**	0.0029 to 0.0030
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

TAPERED ROLLER BEARINGS

The tables below list the C_g, G_1, G_2 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.

Part number	C_g	G_1	G_2	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

Table 23. TS style.

Part Number	C_g	G_1	G_2	K
2984-2924-B	0.0832	38.2	15.7	1.69
JP6049-JP6010-B	0.0240	39.5	22.5	1.24
3984-3920-B	0.1092	75.2	21.3	1.45
482-472-B	0.1083	77.2	23.0	1.61
566-563-B	0.1167	101.0	24.0	1.61
JP7049-JP7010-B	0.0264	51.1	31.0	1.27
33287-33462-B	0.1162	84.2	24.4	1.34
27690-27620-B	0.1198	98.2	41.8	1.40
42350-42587-B	0.1386	130.0	37.2	1.19
JP8049-JP8010-B	0.0297	69.7	37.4	1.29
JP9049-JB9010-B	(Call)	83.8	46.1	1.18
JP10044-JP10010-B	0.0357	104.0	40.9	1.24
683-672-B	0.1056	182.0	37.2	1.24
JP10049-JP10010-B	0.0357	104.0	40.9	1.24
687-672-B	0.1056	182.0	37.2	1.24
71450-71750-B	0.1156	269.0	45.7	1.40
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

Table 24. TSF style.

D

GEOMETRY FACTORS – *continued*

Part number	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

Table 25. Crossed roller style.

Part number	G_1	G_2	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

Table 26. Hydra-Rib style.

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 clearance options available.

Deep groove bearings ordered without a prefix for clearance specification will be supplied with a “P” fit (ISO C3) as standard.

Values shown in micrometers (µm) and ten-thousandths inches (0.0001 in.).

Bore no.	"H" fit snug (C2)		"R" fit regular (C0)		"P" fit loose (C3)-standard		"J" fit extra-loose (C4)	
	µm	0.0000 in.	µm	0.0000 in.	µm	0.0000 in.	µm	0.0000 in.
00	**3-8**	1-3	**5-13**	2-5	**10-20**	4-8	**18-25**	7-10
01	**3-10**	1-4	**5-15**	2-6	**13-23**	5-9	**20-30**	8-12
02	**3-10**	1-4	**5-15**	2-6	**13-23**	5-9	**20-30**	8-12
03	**3-10**	1-4	**5-15**	2-6	**13-23**	5-9	**20-30**	8-12
04	**3-10**	1-4	**8-18**	3-7	**15-25**	6-10	**23-33**	9-13
05	**3-10**	1-4	**8-18**	3-7	**15-25**	6-10	**25-38**	10-15
06	**3-10**	1-4	**8-18**	3-7	**15-25**	6-10	**25-38**	10-15
07	**3-10**	1-4	**8-18**	3-7	**18-30**	7-12	**30-43**	12-17
08	**3-10**	1-4	**8-18**	3-7	**18-30**	7-12	**30-43**	12-17
09	**3-10**	1-4	**8-20**	3-8	**20-33**	8-13	**33-48**	13-19
10	**3-10**	1-4	**8-20**	3-8	**20-33**	8-13	**33-48**	13-19
11	**3-13**	1-5	**10-25**	4-10	**25-40**	10-16	**40-58**	16-23
12	**3-13**	1-5	**10-25**	4-10	**25-40**	10-16	**40-58**	16-23
13	**3-13**	1-5	**10-25**	4-10	**25-40**	10-16	**40-58**	16-23
14	**3-13**	1-5	**10-25**	5-11	**28-48**	11-19	**48-68**	19-27
15	**3-13**	1-5	**13-28**	5-11	**28-48**	11-19	**48-68**	19-27
16	**3-13**	1-5	**13-28**	5-11	**28-48**	11-19	**48-68**	19-27
17-20	**3-15**	1-6	**13-28**	5-13	**33-55**	13-22	**55-80**	22-32
21-24	**3-15**	1-6	**18-38**	7-15	**38-63**	15-25	**63-93**	25-37
25-28	**5-20**	2-8	**20-45**	8-18	**43-79**	17-31	**74-127**	29-50

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 0.025 mm (0.0010 in.) 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 0.025 mm (0.0010 in.) 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 suggested rather than the conventional locknuts and lockwashers used for bearings made to ABEC 1/ISO P0 standard class tolerances.

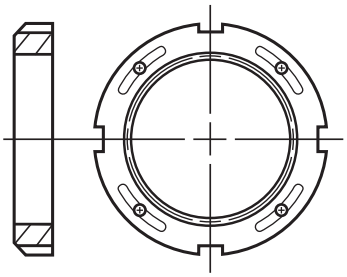
This precision bearing nut incorporates a locking feature in its design. The nut threads deform slightly as the locking setscrews are tightened. This slight deformation creates an interference with the shaft threads which prevents further rotation of the locknut. The precision threads of this locknut are cut square with the face to provide the necessary true-running clamping surface against the inner-ring face of the bearings.

LOCKNUT TORQUE(1)

BALL BEARINGS

General guidelines for locknut torques are shown in the table below for dry thread engagement. Bearing locknuts are to be tightened using a torque wrench and a two-point locknut wrench or other suitable torque wrench adapter.

Reference MIL-B-17931



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Bearing bore	Locknut torque(1)		Approximate clamping force	
mm	N/m	ft-lb.	kN	lb.
10	14-27	10-20	7.2-14.4	1620-3240
12	14-27	10-20	5.9-11.9	1340-2680
15	14-27	10-20	4.8-9.5	1070-2140
17	14-27	10-20	4.1-8.3	940-1880
20	16-47	12-35	4.2-12.3	950-2770
25	31-68	23-50	6.4-14.1	1450-3170
30	43-81	32-60	7.5-14.1	1690-3710
35	53-95	39-70	7.8-14.0	1750-3140
40	68-108	50-80	8.7-14.0	1970-3140
45	87-122	64-90	9.9-13.9	2220-3120
50	91-136	67-100	9.3-13.9	2090-3120
55	111-169	82-125	10.4-15.7	2330-3540
60	134-203	99-150	11.4-17.3	2560-3880
65	178-237	131-175	13.9-18.6	3130-4190
70	206-271	152-200	14.9-19.7	3360-4430
75	235-339	173-250	16.0-23.2	3610-5220
80	267-373	197-275	17.0-23.8	3840-5350
85	301-441	222-325	18.0-26.4	4060-5940
90	336-508	248-375	19.0-28.8	4280-6480
95	376-576	277-425	20.1-30.9	4520-6950
100	468-644	345-475	23.8-32.8	5360-7380
105	515-746	380-550	25.0-36.1	5620-8120
110	515-746	380-550	23.7-34.4	5340-7740
120	515-746	380-550	21.8-31.5	4900-7080
130	515-746	380-550	20.0-29.1	4510-6540
140	515-746	380-550	18.6-27.0	4190-6070
150	515-746	380-550	17.4-25.2	3910-5660
160	515-746	380-550	16.4-23.7	3680-5330

(1) Spindle bearings only. Contact Timken Engineering for use with tapered roller bearings. Valid in all preloaded bearing mounting arrangements.

LUBRICATION SPECIFICATIONS

BALL BEARINGS

Timken suggests 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 percent to 40 percent pack for low to moderate speed (< 500000 dN).
- 15 percent to 20 percent pack for high speed (≥ 500000 dN).

Lubrication code	Lubrication	FS specification
160	Aeroshell 22	FS381B-P
436	Anticorit L-245XBF	FS890
078[1]	Chevron SRI	FS545
037	Dow Corning 44	FS137A
125	Ferrocote 5856 BF	FS639
162[1]	Isoflex NBU 15	FS637
443[1]	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[1]	Mobil 28	FS381A
456	Mobilith SHC15	FS919
095	Mobiltemp SHC 32	FS612
167	Windsow Lube L101	FS179A
052	Unirex N3	FS118 or FS743
457	Thermoplex 2MTL	FS920
477	Kluberspeed BF72-22	FS934
176	Polyrex EM	FS615
150	Asonic GLY32	FS889
801	Petamo GHY133N	—

[1] Common suggestions for spindle grease.

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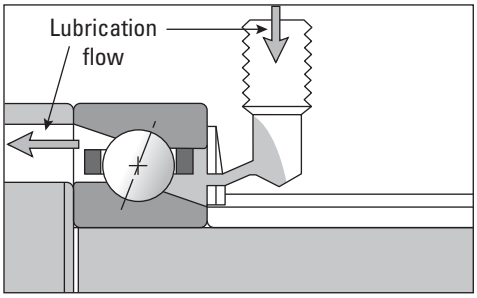
LUBRICATION SPECIFICATIONS – *continued*



Example of lubrication inlet location and direction of lubrication flow.

D

Bore No.	9300	9300HX	9100	9100HX	99100	200	300
	mm in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.	**mm** in.
0	—	**15.037**	**15.977**	—	—	**17.653**	—
	—	0.592	0.6290	—	—	0.6950	—
1	—	**17.043**	**18.288**	—	—	**19.456**	**21.641**
	—	0.6710	0.7200	—	—	0.7660	0.8520
2	**19.910**	**20.391**	**21.565**	—	—	**22.479**	**25.705**
	0.7839	0.8028	0.8490	—	—	0.8850	1.0120
3	**21.920**	**22.377**	**23.927**	—	**23.800**	**27.991**	**27.711**
	0.8629	0.8810	0.9420	—	0.9370	1.1020	1.0910
4	**26.563**	**27.254**	**28.448**	**28.296**	**28.143**	**30.201**	**31.313**
	1.0458	1.0730	1.1200	1.1140	1.1080	1.1890	1.2328
5	**30.716**	**32.233**	**33.325**	**33.172**	**33.147**	**35.408**	**38.705**
	1.2093	1.2690	1.3120	1.3060	1.3050	1.3940	1.5238
6	**36.558**	**37.246**	**39.853**	**39.345**	**40.526**	**42.189**	**45.486**
	1.4393	1.4660	1.5690	1.5490	1.5955	1.6610	1.7908
7	**42.743**	**43.599**	**45.314**	**45.339**	**46.177**	**49.047**	**51.722**
	1.6828	1.7165	1.7840	1.7850	1.8180	1.9310	2.0363
8	**48.420**	**48.763**	**50.681**	**50.825**	**52.413**	**54.915**	**58.592**
	1.9063	1.9198	1.9953	2.0010	2.0635	2.1620	2.3043
9	**51.582**	**54.267**	**56.510**	**56.185**	**57.137**	**59.920**	**65.451**
	2.0308	2.1365	2.2248	2.2120	2.2495	2.3590	2.5768
10	**58.415**	**58.783**	**61.514**	**61.163**	**62.141**	**64.897**	**72.321**
	2.2998	2.3143	2.4218	2.4080	2.4465	2.5550	2.8473
11	**64.562**	**64.981**	**68.372**	**69.342**	**69.300**	**71.780**	**79.179**
	2.5418	2.5583	2.6918	2.7300	2.7283	2.8260	3.1173
12	**69.553**	**70.010**	**73.376**	**74.320**	**74.315**	**78.638**	**85.974**
	2.7383	2.7563	2.8888	2.9260	2.9258	3.0960	3.3848
13	**74.582**	**75.001**	**78.379**	**79.019**	**79.294**	**85.827**	**92.895**
	2.9363	2.9528	3.0858	3.1110	3.1218	3.3790	3.6573
14	**81.453**	**81.496**	**85.237**	**86.182**	**86.444**	**90.530**	**99.741**
	3.2068	3.2085	3.3558	3.3930	3.4033	3.5640	3.9268
15	**86.444**	**86.939**	**97.112**	**91.186**	**92.489**	**95.529**	—
	3.4033	3.4228	3.8233	3.5900	3.6413	3.7610	—
16	**91.422**	**91.930**	**102.324**	**98.069**	**98.577**	**102.387**	—
	3.5993	3.6193	4.0285	3.8610	3.8810	4.0310	—
17	**98.623**	**99.162**	**102.324**	—	**103.805**	**109.245**	—
	3.8828	3.9040	4.0285	—	4.0868	4.3010	—
18	**103.335**	**103.894**	**108.966**	**110.617**	**110.371**	**116.078**	—
	4.0683	4.0903	4.2900	4.3550	4.3453	4.5700	—
19	—	**108.351**	**113.970**	—	**115.324**	**122.961**	—
	—	4.2658	4.4870	—	4.5403	4.8410	—
20	—	**116.383**	**119.723**	**120.523**	**121.445**	**129.845**	—
	—	4.5820	4.7135	4.7450	4.7813	5.1120	—
21	—	—	**124.866**	—	**134.640**	**137.312**	—
	—	—	4.9610	—	5.3008	5.4060	—
22	—	**125.882**	**132.994**	**135.509**	**144.648**	**143.612**	—
	—	4.9560	5.2360	5.3350	5.6948	5.6540	—
24	—	**138.298**	**143.066**	**144.983**	—	**155.423**	—
	—	5.4448	5.6325	5.7080	—	6.1190	—
26	—	—	**156.743**	—	**160.553**	**162.179**	—
	—	—	6.1710	—	6.3210	6.3850	—
28	**157.442**	**160.256**	**167.005**	—	—	—	—
	6.1985	6.3093	6.5750	—	—	—	—
30	—	**1173.87**	**178.613**	—	—	**198.526**	—
	—	6.8453	7.0320	—	—	7.8160	—
32	—	—	**190.500**	—	—	—	—
	—	—	7.5000	—	—	—	—
34	—	—	**199.746**	—	—	—	—
	—	—	7.8640	—	—	—	—
40	—	—	**241.681**	—	—	—	—
	—	—	9.5150	—	—	—	—

Table 27. Lubrication inlet location diameters.

OPERATING TEMPERATURES FOR BEARING COMPONENT MATERIALS

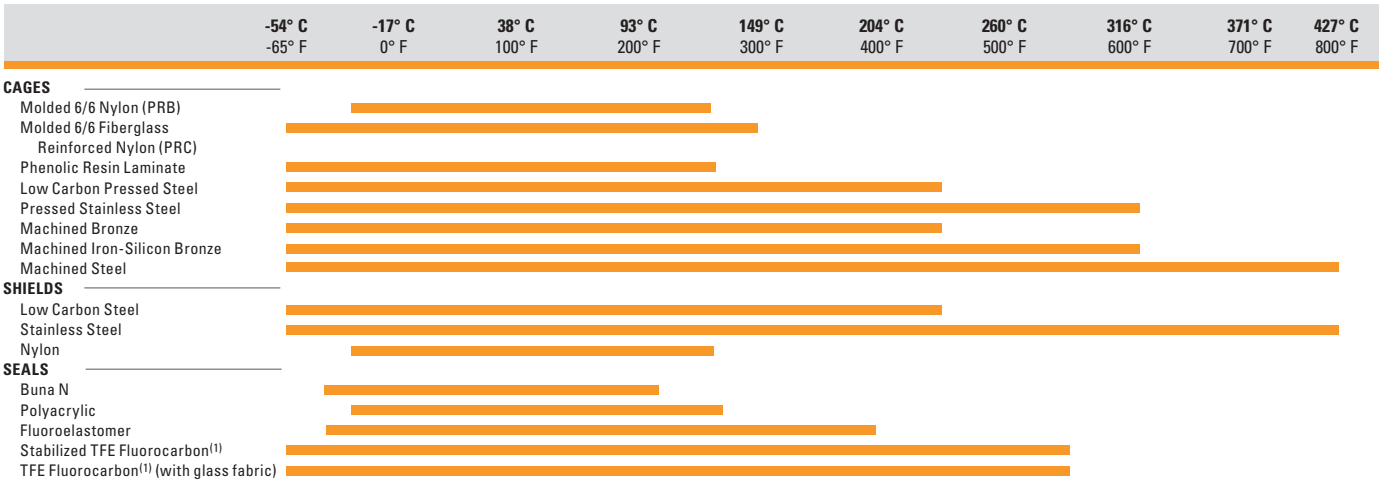
These tables provide standard operating temperatures for common bearing component materials. They should be used for reference purposes only. Other bearing component materials are available on request. Contact your Timken representative for further information.

Material	Approximate Chemical Analysis %	Temp. °F	Hardness HRC	-73° C -100° F	-54° C -65° F	-17° C 0° F	38° C 100° F	93° C 200° F	121° C 250° F	149° C 300° F	204° C 400° F	260° C 500° F	316° C 600° F	371° C 700° F	427° C 800° F
Low alloy carbon-chromium bearing steels. 52100 and others per ASTM A295	1C 0.5–1.5Cr 0.35Mn	70	60		STANDARD DIMENSIONAL STABILIZATION <0.0001 in./in dimensional change in 2500 hours at 100° C (212° F). Good oxidation resistance.										
Low alloy carbon-chromium bearing steels. 52100 and others per ASTM A295	1C 0.5–1.5Cr 0.35Mn	70 350 450	58 56 54	Heat stabilized per FS136. When given a stabilizing heat treatment, A295 steel is suitable for many applications in the 177°-232° C (350-450° F) range; however, it is not as stable dimensionally as it is at temperatures below 177° C (350°)F. If utmost stability is required, use materials in the 316° C (600° F) group below.											
Deep hardening steels for heavy sections per ASTM A485	1C 1–1.8Cr 1–1.5Mn .06Si	70 450 600	58 55 52	As heat-treated and tempered, it is stabilized.											
Carburizing steels per ASTM A534 a) low alloy 4118, 8X19, 5019, 8620 (Ni-Moly grades) b) high nickel 3311	Ni-Moly: 0.2C, 0.4-2.0Mn, 0.3-0.8Cr, 0-2.0Ni, 0-0.3Mo .0.1C, 1.5Cr, 0.4Mn, 3.5Ni	70	58		Nickel-Moly grades of steel frequently used to achieve extra ductility in inner rings for locking device bearings. 3311 and others used for extra-thick-section rings.										
Corrosion resistant 440C stainless steel per ASTM A756	1C 18Cr	70	58		Excellent corrosion resistance.										
Corrosion resistant 440C stainless steel per ASTM A756	1C 18Cr	70 450 600	58 55 52	As heat stabilized for maximum hardness at high temperatures (FS238). Good oxidation resistance at higher temperatures. Note load capacity drops off more rapidly at higher temperatures than M50 shown below, which should be considered if loads are high.											
M-50 medium high speed	4Cr 4Mo 1V 0.8C	70 450 600	60 59 57	Suggested where stable high hardness at elevated temperature is required.											

Bearings have been made of special material for operation at temperatures above 427° C (800° F). Consult your Timken representative regarding the application.

Note: ASTM A295 bearing steels are suitable for many applications up to 212° C (413° F) but are not as dimensionally stable as they are at the temperatures below 100° C (212° F).

Table 28. Rings, balls and rollers, single row.



(1) Limited life above these temperatures.

Table 29. Cages, shields and seals.

CONVERSION TABLES

VISCOSITY CONVERSION TABLE

SUS Saybolt (sec.)	R" Redwood (sec.)	E Engler (deg.)	cSt Centistokes (mm^2/s)
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

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		
BTU (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
kilopound-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	µm 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 (lbm avoirdupois)	kilogram	kg 0.4535924
ton (long, 2240 lbm)	kilogram	kg 1016.047
ton (short, 2000 lbm)	kilogram	kg 907.1847
tonn	kilogram	kg 1000.000
Power		
BTU (International Table)/hour	watt	W 0.293071
BTU (International Table)/minute	watt	W 17.58427
horsepower (550 ft lbf/s)	kilowatt	kW 0.745700
BTU (thermochemical)/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/millimeter^2	pascal	Pa 9806650
pound-force/foot^2	pascal	Pa 47.88026
pound-force/inch^2 (psi)	megapascal	MPa 0.006894757
Temperature		
degree Celsius	kelvin	k $t_k = t_c + 273.15$
degree Fahrenheit	kelvin	k $k = 5/9 (t_f + 459.67)$
degree Fahrenheit	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

SUPER PRECISION BEARING MODEL REQUEST FORM

When requesting assistance, use of this form provides your Timken sales representative with a better understanding of your specific needs.

General Information

Requester: _____ Customer: _____

Country: _____ Customer country: _____

Application/type of machine:_____

Bearing Information

Type of bearings (check all that apply):

☐ Angular contact ☐ Radial ball ☐ Tapered roller bearing ☐ To be determined

Quantity of bearings in system: _____ (if applicable)

Bearing mounting (check all that apply):

Only/front:	Rear (optional):
☐	☐
☐	☐
☐	☐
☐	☐
☐	☐
☐	☐
☐	☐
☐	☐
☐	☐
☐	☐

Bearing part number(s)/location (i.e. work end or drive end):

_____

_____

_____

or

New bearing:

Shaft size(s): _____

Housing size(s): _____

Width size(s): _____

(specific size(s) or range)

Bearing mounting configuration: *(please attach drawing or sketch with bearing positions and load positions OR with tool as position "0," provide distance to each bearing, including which bearing is fixed and which is float, if applicable – also, describe contact angle orientation.)*

Application Information

Speed: _____(rpm)

☐ All fixed or ☐ with rear floating

Temperature: ☐ Ambient temperature or

Lubrication method/name: _____

Rotation: ☐ Inner ring ☐ Outer ring

Shaft _____

Housing _____

Bearing _____

Sump (if applicable) _____

Application Information

Speed:_____ (RPM)

Lubrication method/name:_____

☐ All fixed or ☐ with rear floating

Rotation: ☐ Inner ring ☐ Outer ring

Temperature: ☐ Ambient temperature or

Shaft_____

Housing_____

Bearing_____

Sump (if applicable)_____

External Load Information

☐ Internal drive (i.e. motorized spindle)

☐ External drive loads

☐ Direct drive

☐ Belt drive or chain drive

$F_{belt\ or\ chain}$:_____ or HP:_____

D_m (pitch diameter):_____

☐ Single chain ☐ Double chain ☐ V belt

☐ Gear drive

	Spur	Helical	Herringbone	Straight bevel	Spiral bevel
Torque or HP					
Gear mesh point					
Drive or driven					
Location					
Pitch diameter				(1)	(1)
Pressure angle					
Hand (L/R)	N/A		N/A	N/A	
Mean working diameter	N/A	N/A	N/A		
Helix angle	N/A			N/A	N/A
Apex (L/R)	N/A	N/A	N/A		
Pitch angle	N/A	N/A	N/A		
Spiral angle	N/A	N/A	N/A	N/A	
Number of teeth	(1)	(1)	(1)	(1)	(1)
Gear thickness	(1)	(1)	(1)	(1)	(1)
Tooth length	N/A	N/A	N/A	(1)	(1)
Do not invert sense of rotation	N/A	N/A	N/A	☐	☐
Internal meshing	☐	☐	☐	N/A	N/A

(1)Optional fields.

External loads Radial:_____ Axial location:_____

Axial:_____ ☐ Reversing?

Moment:_____

Customer requirements (i.e. L_{10} life, stiffness, accuracy, etc.):_____

_____

SUPER PRECISION DAMAGE ANALYSIS REQUEST FORM

When requesting assistance, use of this form provides your Timken sales representative with a better understanding of your specific needs.

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 (Circle appropriate measurements)

Equipment/model no.: _____ Job no.: _____

Loads: Radial: _____(kg/lb.) Axial: _____(kg/lb.)

Moment: _____(ft-lb.) Rotation : ___I.R. ___O.R.

Speed: _____(RPM) Oscillation angle: _____(Total degrees) Freq.: _____(opm)

Lubrication Method: _____ Brand: _____

Temp.: Ambient _____(°C/°F) Housing: _____(°C/°F) Bearing: _____(°C/°F) Lubricant: _____(°C/°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: _____

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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

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