Fafnir®

Superprecision Ball Bearings

ABOUT THE COVER

The Torrington Company is committed to develop, produce and deliver products and services that consistently meet or exceed customer expectations.

Helping The Torrington Company achieve the goals stated above are our corps of highly trained sales engineers, the latest analytical and manufacturing systems, a commitment to research and development for new ideas and products, our devotion to the principles of Total Quality and a history steeped in technological firsts in the antifriction industry.

This catalog will help you to design the technology, quality and service of The Torrington Company into your products.

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INTRODUCTION

The Torrington Company (hereinafter referred to as "Torrington"), part of worldwide Ingersoll-Rand, is a bearing and automotive component supplier of international stature. Its global presence in North America, Europe, Australia, South America and the Far East, plus joint ventures in Japan, The People's Republic of China, and Europe, support customer operations around the world.

Torrington began manufacturing bearings in the early 1900s and now produces every basic type of precision ground anti-friction bearing, as well as many precision components for other mechanisms. Torrington's wholly owned subsidiary, Kilian Manufacturing Corporation, produces lighter duty machined bearings. Torrington's merger with Fafnir Bearing, founded in 1911 and recognized as one of the world's major suppliers of precision bearings and housed units, has further strengthened Torrington's leadership position as a broad line supplier to the world's industries.

Torrington's world leadership position in an automotive component technology is based on its complete technical ability. This extends from the initial design stages through application analysis, to optimizing the entire manufacturing process. The experience gained from broad design and manufacturing activities is available to our customers through Torrington's resident engineers and field sales engineers in all parts of the world.

As Torrington enters the 21st century, it has dedicated its capabilities and resources — its people, facilities, systems and technologies — to two goals:

- producing world-class products.
- assuring total customer satisfaction.

TORRINGTON IS AT HOME AROUND THE WORLD

To support its sales and service activities, Torrington has:

- Over 20 manufacturing plants on five continents.
- Over 40 district sales engineering offices throughout the world.
- Warehouses throughout the U.S.A., Canada and Germany, with interlinking computerized inventory control.
- Extensive capabilities in metric and inch bearings.
- Technical resources for customer assistance.

For new concepts of the future, for the challenges faced by industry, Torrington offers in-depth design assistance and multinational supply capability for products that are made to identical standards worldwide.

USING THIS CATALOG

We are committed to providing our customers with maximum service and quality. Included in this commitment is a concern for the suitability of the bearing selected for any application. Only those with sufficient engineering training and technical competence to interpret and apply the data and principles involved should make the final selection of a bearing. The part number in this catalog describes only the dimensions. The part number of the product supplied may differ than those listed in these pages.

This catalog contains dimensions, tolerances and load ratings, as well as an engineering section describing fitting practices for shafts and housings, internal clearances, materials and other features of superprecision bearings. It is not to be considered as containing sufficient data for reliable bearing design and selection for all applications. It can, however, provide valuable assistance in the initial consideration of the type and characteristics of the bearing which may be most suitable for particular needs.

Although all data in this catalog has been carefully compiled to make the information as complete as possible, Torrington assumes no liability to any company or person for any damages, direct or indirect, to property or person, based on information contained in this publication.

CATALOG FEATURES

Dimension and load rating data for the various types and styles of bearings is organized by size. There is also a numeric/alpha listing of product designation codes in the front of the catalog.

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.

FAFNIR SUPERPRECISION BEARINGS

Fafnir introduced its superprecision bearings, developed specifically for machine tool applications, in 1935. Since that time our engineers, designers, metallurgists and skilled machinists, utilizing state-of-the-art process technology have made improvements in their design, material, lubrication, and manufacturing processes. The result is a line of Fafnir superprecision bearings capable of higher speeds, greater reliability, and wider versatility.

As part of our on-going research, development and testing program, our engineers analyze their client's application problems using sophisticated computers and software which enable them to:

- recommend the precise type and size of bearing that will give optimum performance under a variety of conditions.
- predict the probable service life of all bearings with considerable accuracy.

All of the superprecision bearings listed in this catalog embody the same high standards of precision and quality which have made the FAFNIR name synonymous with bearing excellence throughout the world.

* Formerly the AFBMA – Anti-Friction Bearing Manufacturers Association.

HYBRID CERAMIC BEARINGS

Any of the bearings offered by the Torrington Company are also available with ceramic, silicon nitride, rolling elements.

Designed with increased speed capabilities, the hybrid ceramic bearing features a higher elastic modulus for grater stiffness. Its lower friction characteristics result in less skidding than the all-steel bearings are discussed in greater detail on pages 38 and 39.

The Torrington Company Sales Engineer in your area can assist you in determining if the hybrid ceramic bearing is suitable for your application. They will help you to determine if hybrid ceramics are the answer, or if another Torrington Company product is a better solution. For the location of the Torrington Company Sales Office in your area refer to the last page in this catalog.

SALES ENGINEERING SERVICES

Since no catalog can include or disclose all the factors necessary for proper bearing selection in every type of application, we highly recommend consulting with us on any application where property damage or injury to persons from misapplication should be of special concern in the selection of the bearing.

Part of the Torrington world-wide service system is a corps of highly trained sales engineers who are available to work toward solving new or unusual problems. Torrington may have already solved a similar problem and can offer a speedy, cost-effective solution. The last page of this catalog lists the phone number and address of the Torrington office nearest you.

Torrington reserves the right to change the design and/or specifications of its products without notice.

TERMS AND CONDITIONS OF SALE

All products described in this catalog are subject to Torrington's Terms and Conditions of Sale, copies of which are available from Torrington's district offices as listed in the back of this catalog. It is understood that the buyer, in selecting and ordering from this catalog which supersedes all previous editions, accepts all Terms and Conditions of Sale including the following:

WARRANTY

Torrington warrants that parts manufactured by it will be as specified and will be free from defects in material and workmanship. Torrington's liability under this warranty shall be limited to the repair or replacement or the repayment of the purchase price, or the granting of a reasonable allowance (as Torrington may elect) of any part which upon return to Torrington is found to be defective at the time of shipment, providing the buyer notifies Torrington of any such defect within 10 days of its discovery, but in no event later than 90 days from the date of shipment of such part by Torrington. Repair or replacement shall be made by Torrington F.O.B. point of shipment.

Seller makes no other warranty or representation of any kind whatsoever, expressed, or implied, except that of title and all implied warranties, including any warranty of merchantability or fitness for a particular purpose, are hereby disclaimed.

LIABILITY

Total liability of Torrington with respect to any order, whether based on contract, warranty, negligence, indemnity, strict liability or otherwise, shall not exceed the purchase price of the part upon which such liability is based.

Torrington shall in no event be liable to the buyer, any successors in interest or any beneficiary of any order, for any consequential, incidental, indirect, special or punitive damages arising out of such order or any breach thereof, whether or not such loss or damage is based on contract, warranty, negligence, indemnity, strict liability or otherwise.

NUCLEAR APPLICATION

The bearings described within this catalog are not intended for nuclear application. Should any such application be considered, it is urged that you consult with Torrington.

For use within any nuclear facility, Owner/Licensee of the nuclear facility and/or buyer shall indemnify and hold Torrington harmless from any liability occurring on or off-site, at any time, including loss of use, whether based in contract or tort, including negligence attributable in whole or in part to Torrington, resulting directly or indirectly from a nuclear incident.

HELICOPTER APPLICATION

Torrington has discontinued offering it's products to the helicopter industry. This includes bearings previously sold to the helicopter industry under the Torrington, Fafnir and Kilian trade names. As a result of this decision, Torrington will no longer provide engineering support nor recommend that Torrington bearings be used in helicopter applications.

With regard to aircraft bearings manufactured to military standards, only the aircraft/helicopter manufacturer can determine if the aircraft mil spec bearings are suitable for use in its aircraft.

SAFETY RECOMMENDATIONS

- Product should be stored in a dry and clean area.
- Package should not be opened until ready to use.
- Prior to installation, Torrington should be consulted for recommendations. Proper installation and maintenance must be adhered to for ultimate performance.
- Failure to adhere to recommendations may result in premature product failure, and/or in extreme cases, personal injury.

SHELF LIFE AND STORAGE OF GREASE LUBRICATED BEARINGS AND COMPONENTS

SHELF LIFE POLICY:

The Torrington Policy for the Shelf Life of Grease Lubricated Rolling Element Bearings, Components and assemblies is set forth below. The Shelf Life values are based on test data and experience.

Shelf Life should be distinguished from lubricated bearing/component Service Life as follows:

Shelf Life

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

Service Life

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

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

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

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

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

THE BEARING/COMPONENT SHOULD NOT BE PUT INTO SERVICE IF THIS SHELF LIFE IS EXCEEDED.

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

STORAGE POLICY:

The Torrington policy recommends the following storage guidelines for its finished products (bearings, components, and assemblies, hereinafter the “Products”):

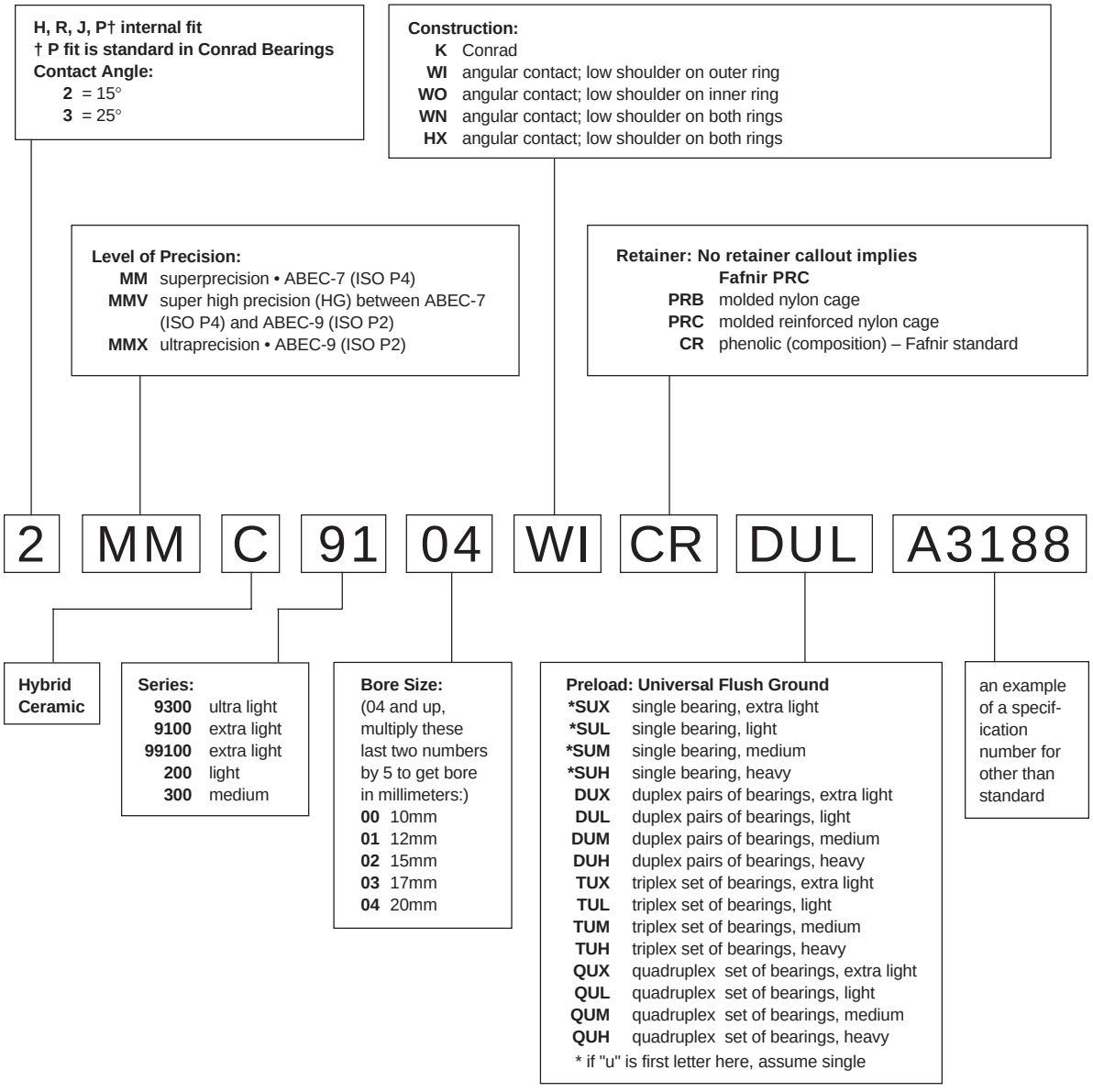
- Unless directed otherwise by The Torrington Company, Products should be kept in their original packaging until they are ready to be placed into service.
- Do not remove or alter any labels or stencil markings on the packaging.
- Products should be stored in such a way that the packaging is not pierced, 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 Torrington’s Shelf Life Policy Statement.
- The storage area temperature should be maintained between 0° C (32° F) and 40° C (104° F); temperature fluctuations should be minimized.
- The relative humidity should be maintained below 60%.
- The storage area should be kept free from airborne contaminants such as, but not limited to: dust, dirt, harmful vapors, etc.
- The storage area should be isolated from undue vibration.
- Extreme conditions of any kind should be avoided.

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

FAILURE TO FOLLOW THESE GUIDELINES MAY RESULT IN REDUCED PRODUCT SHELF LIFE AND/OR ADVERSELY AFFECT PRODUCT PERFORMANCE.

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

Superprecision Ball Bearings



Superprecision MM (ABEC-7, ISO P4)

Superprecision bearings of the K or non-filling slot construction are generally used on woodworking spindles, aircraft accessory units and machine tool applications where duplex bearings are not a definite requirement. By virtue of the single row radial deep groove construction and superprecision tolerances, they are capable of carrying thrust loads in either direction and have relatively high-speed ability.

More popular on precision machine tool spindle applications are the WI angular-contact type bearing variations, namely 2MM-WI and 3MM-WI. Since this bearing type has a low shoulder on outer ring, it carries thrust in one direction.

Fafnir's MM Superprecision bearings are finished to MMV tolerances – as standard procedure.

Super High Precision MMV (HG)

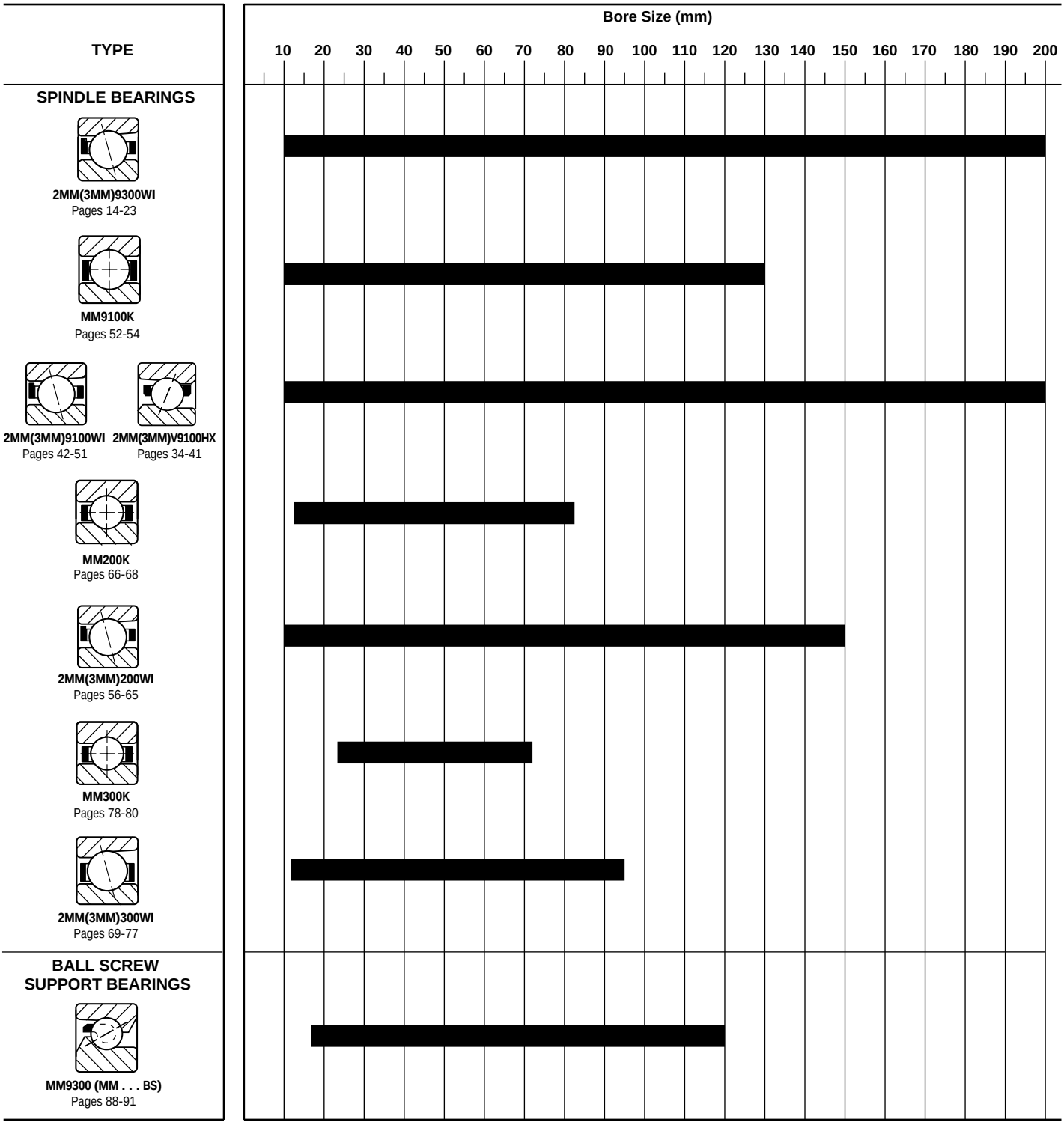
Superprecision bearings are manufactured to our new HG tolerance class, with running accuracy and performance meeting ABEC-9 (ISO P2) while maintaining noncritical features at ABEC-7 (ISO P4) level for cost-effectiveness. Bore and O.D. surfaces are coded in micron units for the convenience of the discriminating machine tool builder who is striving for optimum fitting of all spindle components.

The recent development of ceramic rolling elements in high performance bearings offers the customer the ultimate of speed capability, high stiffness, long life, low heat generation, and overall system reliability. The 99100 series is available with the option of ceramic ball selection.

Ultraprecision MMX (ABEC-9, ISO P2)

Superprecision 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 made as WO and WN construction, and are use on ultra-high speed grinding spindles designed for tight dimensional tolerances and super-fine surface finishes. Consult our Engineering Department for availability.

MACHINE TOOL BEARING PRODUCT RANGE*



*Current product offering range. For sizes not found within this listing, check with the Torrington Engineering Department for design possibilities.

Bearing Types

Angular-Contact Bearings

2MM -WI type, with 15° initial contact angle is designed to meet the needs of machine builders for precision bearings which will operate at as low a temperature as possible for a wide range of speeds and operating loads. In order for machines to produce more accurate work at a higher production rate, the bearings must provide a high degree of rigidity in both axial and radial directions while operating at minimum temperatures. For example, precision machining or cutting tools impose heavier loads on bearings than those encountered in precision grinding. In the former, speeds are slower and loads heavier than the latter, where speeds are high and loads light. The 2MM-WI type gives the machine builder the flexibility required to meet such variations in applications.
3MM -WI type, manufactured with 25° contact angle, is for use on applications where the loading on the bearings is predominately thrust — and a high degree of axial rigidity is a definite requirement. Typical applications for these are large vertical rotary surface grinders, horizontal and vertical disc grinders, and thrust bearing applications for heavy duty lathes where the bearings must directly carry extremely high tail stock or chucking pressure.

2MM-WI Type

3MM-WI Type

2MM -WO type, with 15° initial contact angle is designed for extremely high-speed applications where centrifugal force of the balls is the principal load on the bearing. Unlike the MM-WI type which has a low shoulder outer ring, the 2MM-WO type has full shoulders on both sides of the outer race and a low shoulder on one side of the inner ring. This design permits assembly with a maximum complement of balls and a one-piece cage which pilots against the precision-ground lands of the outer ring. Generally this bearing series is supplied with a separable inner ring and ball retaining cage along with special race geometry for extremely high speed operation.

2MM-WO Type

2MMV and 3MMV99100WN types are available with 15° or 25° contact angle variations and have been developed to operate under the demanding requirements of high speed machine tools. They incorporate design features which permit operation at higher speed than standard angular contact ball bearings. The bore, outside diameter, and width are the same as the MM9100 series.

This series is designed to operate at rotational speeds 20% greater than the MM9100 series, with no increase in operating temperature. The greatest advantage of these series is at speeds greater than 500,000 DN (Bore in mm x RPM). Silicon nitride balls (ceramic) and precision machined ball separators are available and, when used, the ultimate performance will be achieved.

2MMV and 3MMV99100WN Types

2MMV - HX type, with 15° initial contact angle is designed to meet the needs of machine manufacturers who require optimum oil flow through the bearings. This design incorporates a low shoulder on the non-thrust side of both the inner and outer rings. The maximum complement of balls is separated by a one-piece cage which pilots against the ground land of the outer ring.

Fafnir has developed an ISO Series – 10 bearing designed 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 turn around of finished product. These improvements are imparted by subtle changes to ball complements and internal geometries concluded by Fafnir design engineers as being a reliable path toward better machining efficiencies.

The Fafnir HX Series is dimensionally interchangeable with our present 9100 and 99100 series spindle bearings along with competitive ISO Series-10 designs.

2MMV-HX Type

Ballscrew Support Bearings

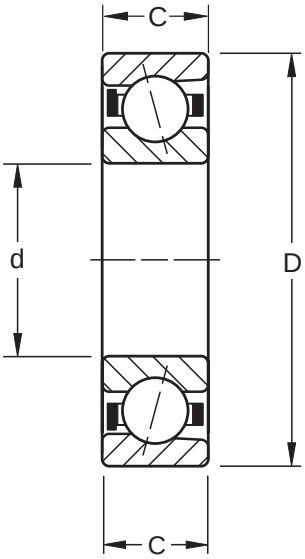
To meet the requirements of the servo-controlled machinery field, Torrington has developed a new series of ball bearings specially designed for ballscrew applications. Design criteria for these bearings are maximum axial rigidity, low drag torque, and extreme control of lateral eccentricity.

These bearings are manufactured to ABEC-7 tolerances and are of the nonseparable angular-contact type design with a 60° contact angle and maximum complement of balls.These bearings are supplied prelubricated with heavy duty grease NLGI #2 . Bearings are supplied packaged in DB arrangement. However, they can be mounted in duplexed pairs and in multiplexed sets in either Back-to-Back (DB), Face-to-Face (DF) or Tandem (DT) arrangements.

Standard sizes are available and are stocked and packaged as duplex pairs, triplex sets or quadruplex sets. These bearings are designed primarily for ballscrew applications and should not be considered in other areas such as spindles or gear-box shafting without approval by our Engineering Department. These bearings are offered in both standard inch and metric envelope dimensions.

MM9300WI DUH (Inch)
MM…BS…DUH (Metric)

Ultra-Light 2MM9300WI & 3MM9300WI Series



Superprecision MM:
Superprecision bearings are manufactured to a ABEC-7 (ISO P4) tolerance class.

WI Construction:
This design incorporates a low shoulder on the non-thrust side of the outer rings. The maximum complement of balls is separated by a one-piece cage which is piloted against the ground thrust shoulder land of the outer ring.

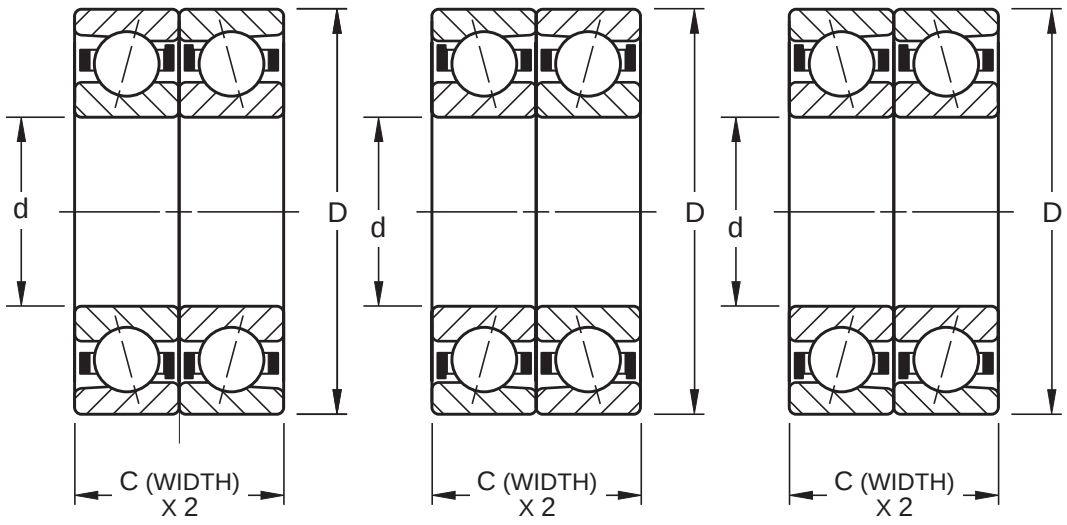
TO ORDER: Specify bearing number with prefix 2MM for 15° contact angle and 3MM for 25° contact angle.

Example 2MM9300WI CR

DIMENSIONS – TOLERANCES ALL INCH TOLERANCE IN .0001 UNITS

Bearing Number 2MM & 3MM	Bore		Tolerance +.0000" +.0 µm to minus		Outside Diameter		Tolerance +.0000" +.0 µm to minus		Width *		Tolerance +.0000" +.0 µm to minus		Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement	
	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	Qty.	(Dia.) in.
9300WI	0.3937	10	1.5	4	0.8661	22	2.0	5	0.2362	6	16	40	0.012	0.3	12	1/8
9301WI	0.4724	12	1.5	4	0.9449	24	2.0	5	0.2362	6	31	80	0.012	0.3	13	1/8
9302WI	0.5906	15	1.5	4	1.1024	28	2.0	5	0.2756	7	31	80	0.012	0.3	13	9/64
9303WI	0.6693	17	1.5	4	1.1811	30	2.0	5	0.2756	7	31	80	0.012	0.3	14	9/64
9304WI	0.7874	20	2.0	5	1.4567	37	2.5	6	0.3543	9	47	120	0.012	0.3	14	3/16
9305WI	0.9843	25	2.0	5	1.6535	42	2.5	6	0.3543	9	47	120	0.012	0.3	17	3/16
9306WI	1.1811	30	2.0	5	1.8504	47	2.5	6	0.3543	9	47	120	0.012	0.3	19	3/16
9307WI	1.3780	35	2.5	6	2.1654	55	3.0	7	0.3937	10	47	120	0.024	0.6	19	7/32
9308WI	1.5748	40	2.5	6	2.4409	62	3.0	7	0.4724	12	47	120	0.024	0.6	19	1/4
9309WI	1.7717	45	2.5	6	2.6772	68	3.0	7	0.4724	12	47	120	0.024	0.6	21	1/4
9310WI	1.9685	50	2.5	6	2.8346	72	3.0	7	0.4724	12	47	120	0.024	0.6	23	1/4
9311WI	2.1654	55	3.0	7	3.1496	80	3.0	7	0.5118	13	59	150	0.039	1.0	23	9/32
9312WI	2.3622	60	3.0	7	3.3465	85	3.0	8	0.5118	13	59	150	0.039	1.0	25	9/32
9313WI	2.5591	65	3.0	7	3.5433	90	3.0	8	0.5118	13	59	150	0.039	1.0	27	9/32
9314WI	2.7559	70	3.0	7	3.9370	100	3.0	8	0.6299	16	59	150	0.039	1.0	24	11/32

* Refer to page E4 for width tolerance of preloaded bearings.
** ABMA std. 20 ($r_{as\ max}$).



Back-to-Back
DB

Face-to-Face
DF

Tandem
DT

WI Type Duplex Mounting Arrangements

DIMENSIONS – TOLERANCES ALL INCH TOLERANCE IN .0001 UNITS

Bearing Number 2MM & 3MM	Bore		Tolerance +.0000" +.0 µm to minus		Outside Diameter		Tolerance +.0000" +.0 µm to minus		Width *		Tolerance +.0000" +.0 µm to minus		Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement	
	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	Qty.	(Dia.) in.
9315WI	2.9528	75	3.0	7	4.1339	105	3.0	8	0.6299	16	59	150	0.039	1.0	25	11/32
9316WI	3.1496	80	3.0	7	4.3307	110	3.0	8	0.6299	16	59	150	0.039	1.0	27	11/32
9317WI	3.3465	85	3.0	8	4.7244	120	3.0	8	0.7087	18	79	200	0.039	1.0	26	3/8
9318WI	3.5433	90	3.0	8	4.9213	125	3.5	9	0.7087	18	79	200	0.039	1.0	26	13/32
9319WI	3.7402	95	3.0	8	5.1181	130	3.5	9	0.7087	18	79	200	0.039	1.0	28	13/32
9320WI	3.9370	100	3.0	8	5.5118	140	3.5	9	0.7874	20	79	200	0.039	1.0	29	13/32
9322WI	4.3307	110	3.0	8	5.9055	150	3.5	9	0.7874	20	79	200	0.039	1.0	31	13/32
9324WI	4.7244	120	3.0	8	6.4961	165	4.0	10	0.8661	22	79	200	0.039	1.0	30	15/32
9326WI	5.1181	130	4.0	10	7.0866	180	4.0	10	0.9449	24	98	250	0.059	1.5	30	17/32
9328WI	5.5118	140	4.0	10	7.4803	190	4.5	11	0.9449	24	98	250	0.059	1.5	32	17/32
9330WI	5.9055	150	4.0	10	8.2677	210	4.5	11	1.1024	28	98	250	0.079	2.0	27	11/16
9332WI	6.2992	160	4.0	10	8.6614	220	4.5	11	1.1024	28	98	250	0.079	2.0	27	23/32
9334WI	6.6929	170	4.0	10	9.0551	230	4.5	11	1.1024	28	98	250	0.079	2.0	29	23/32
9340WI	7.8740	200	4.5	12	11.0236	280	5.0	13	1.4961	38	118	300	0.083	2.1	27	15/16

* Refer to page E4 for width tolerance of preloaded bearings.
** ABMA std. 20 ($r_{as\ max}$).

Ultra-Light
2MM9300WI Series

PHYSICAL CHARACTERISTICS – LOAD RATINGS

RADIAL LOAD RATING AT 33 1/3 RPM
Based on 1500 hours L_{10} Life and Permissible Speed

Bearing Number	Weight Per Bearing		Static Load Rating C_o		Extended Dynamic Load Ratings C_e		Permissible Speed Ng *	Preload Levels							
								Extralight (1) (DUX)		Light (DUL)		Medium (DUM)		Heavy (DUH)	
	lbs	kg	lbs	N	lbs	N	RPM	lbs	N	lbs	N	lbs	N	lbs	N
2MM9300WI	0.02	0.010	285	1,300	735	3,300	77,500	—	—	3	15	6	25	12	55
2MM9301WI	0.03	0.011	320	1,400	765	3,400	67,200	—	—	3	15	6	25	12	55
2MM9302WI	0.04	0.016	415	1,800	950	4,200	55,600	—	—	5	20	10	45	20	90
2MM9303WI	0.04	0.018	490	2,200	1,040	4,600	50,100	—	—	5	20	15	65	30	130
2MM9304WI	0.08	0.037	780	3,500	1,700	7,600	42,100	—	—	10	45	20	90	35	160
2MM9305WI	0.10	0.043	1,000	4,400	1,900	8,500	34,800	—	—	10	45	25	110	40	180
2MM9306WI	0.11	0.050	1,140	5,100	2,000	8,900	29,700	—	—	10	45	25	110	40	180
2MM9307WI	0.17	0.077	1,560	6,900	2,600	11,600	25,400	—	—	10	45	25	110	55	240
2MM9308WI	0.25	0.112	2,040	9,100	3,350	14,900	22,400	5	30	15	65	35	160	70	310
2MM9309WI	0.29	0.133	2,280	10,100	3,450	15,300	20,000	10	30	20	90	40	180	80	360
2MM9310WI	0.30	0.135	2,550	11,300	3,650	16,200	18,300	10	40	20	90	45	200	90	400
2MM9311WI	0.41	0.187	3,200	14,200	4,550	20,200	16,600	10	40	25	110	55	240	110	490
2MM9312WI	0.44	0.200	3,450	15,300	4,750	21,100	15,300	10	40	25	110	55	240	115	510
2MM9313WI	0.47	0.215	3,750	16,700	4,900	21,800	14,200	15	70	30	130	60	270	120	530
2MM9314WI	0.76	0.344	5,000	22,200	6,700	29,800	13,100	15	70	40	180	80	360	160	710
2MM9315WI	0.80	0.363	5,200	23,100	6,800	30,200	12,300	20	90	40	180	85	380	170	760
2MM9316WI	0.85	0.385	5,600	24,900	7,100	31,600	11,600	20	90	45	200	90	400	180	800
2MM9317WI	1.23	0.556	6,550	29,100	8,150	36,300	10,800	25	110	60	270	120	530	240	1070
2MM9318WI	1.26	0.573	7,650	34,000	9,500	42,300	10,300	25	110	60	270	120	530	240	1070
2MM9319WI	1.33	0.601	8,150	36,300	9,800	43,600	9,800	30	130	65	290	130	580	260	1160
2MM9320WI	1.87	0.846	8,300	36,900	9,800	43,600	9,100	30	130	80	360	160	710	330	1470
2MM9322WI	2.02	0.918	8,800	39,100	10,200	45,400	8,400	40	180	90	400	180	800	360	1600
2MM9324WI	2.74	1.243	11,600	51,600	12,900	57,400	7,700	45	200	110	490	220	980	440	1960
2MM9326WI	3.63	1.648	15,000	66,700	16,300	72,500	7,100	50	220	140	620	275	1220	550	2450
2MM9328WI	3.85	1.746	15,600	69,400	17,000	75,600	6,600	60	270	140	620	280	1250	575	2560
2MM9330WI	5.75	2.609	22,000	97,400	25,000	111,200	6,200	65	290	190	850	380	1690	775	3450
2MM9332WI	6.06	2.749	32,200	143,100	29,000	128,900	5,800	110	489	220	980	445	1980	890	3960
2MM9334WI	6.34	2.875	26,000	115,600	28,000	124,500	5,500	80	360	230	1020	460	2050	900	4000
2MM9340WI	13.87	6.291	54,700	243,300	47,100	209,500	4,600	175	778	350	1560	700	3110	1400	6230

* Limits shown for grease lubricated, single bearing, spring preloaded.
(1) Call for availability.

Ultra-Light
2MM9300WI Series

Superprecision Bearings

FTF **Fundamental Train Frequency:** The frequency at which the retainer will operate.

BSF **Ball Spin Frequency:** The frequency at which a single defect on a rolling element will be detected.

BPFO **Ball Pass Frequency Outer:** The frequency at which a single defect in the outer race will be detected.

BPFI **Ball Pass Frequency Inner:** The frequency at which a single defect in the inner race will be detected.

FREQUENCY COEFFICIENTS

Bearing Number	FTF Fundamental Train Frequency (Inner Rotation)	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner	FTF Fundamental Train Frequency (Outer Rotation)
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

Ultra-Light
3MM9300WI Series

PHYSICAL CHARACTERISTICS – LOAD RATINGS

RADIAL LOAD RATING AT 33 ⅓ RPM
Based on 1500 hours L_{10} Life and Permissible Speed

Bearing Number	Weight Per Bearing		Static Load Rating C_o		Extended Dynamic Load Ratings C_e		Permissible Speed Ng *	Preload Levels							
								Extralight (DUX)		Light (DUL)		Medium (DUM)		Heavy (DUH)	
	lbs	kg	lbs	N	lbs	N	RPM	lbs	N	lbs	N	lbs	N	lbs	N
3MM9300WI	0.02	0.010	360	1,580	760	3,380	69,800	—	—	5	20	10	45	20	90
3MM9302WI	0.04	0.016	510	2,280	980	4,360	50,000	—	—	10	45	20	90	35	160
3MM9303WI	0.04	0.018	600	2,680	1,070	4,740	45,100	—	—	10	45	30	130	55	240
3MM9305WI	0.10	0.043	1,230	5,500	1,930	8,600	31,300	—	—	15	65	40	180	70	310
3MM9306WI	0.11	0.050	1,080	4,800	1,900	8,500	26,700	—	—	15	70	40	180	70	310
3MM9307WI	0.17	0.077	1,460	6,500	2,500	11,100	22,900	—	—	20	90	55	240	95	420
3MM9308WI	0.25	0.112	1,930	8,600	3,150	14,000	20,200	—	—	30	130	70	310	125	560
3MM9309WI	0.29	0.133	2,160	9,600	3,350	14,900	18,000	—	—	35	160	80	360	150	670
3MM9310WI	0.30	0.135	2,400	10,700	3,450	15,300	16,500	—	—	35	160	90	400	150	670
3MM9311WI	0.41	0.187	3,000	13,300	4,300	19,100	14,900	—	—	45	200	110	490	190	850
3MM9312WI	0.44	0.200	3,250	14,500	4,500	20,000	13,800	—	—	45	200	115	510	200	890
3MM9313WI	0.47	0.214	3,550	15,800	4,650	20,700	12,800	—	—	50	220	120	530	240	1070
3MM9314WI	0.76	0.344	4,750	21,100	6,300	28,000	11,800	—	—	65	290	160	710	290	1290
3MM9315WI	0.80	0.363	4,900	21,800	6,400	28,500	11,100	—	—	70	310	170	760	300	1330
3MM9316WI	0.85	0.385	5,200	23,100	6,700	29,800	10,400	—	—	75	330	180	800	310	1380
3MM9317WI	1.22	0.555	6,000	26,700	7,650	34,000	9,700	—	—	100	440	240	1070	420	1870
3MM9318WI	1.26	0.572	7,100	31,600	8,800	39,100	9,300	—	—	90	400	210	930	375	1670
3MM9319WI	1.32	0.601	7,650	34,000	9,300	41,400	8,800	—	—	105	470	260	1160	450	2000
3MM9320WI	1.86	0.846	7,800	34,700	9,300	41,400	8,200	—	—	135	600	330	1470	575	2560
3MM9322WI	2.02	0.917	8,300	36,900	9,500	42,300	7,600	—	—	150	670	360	1600	625	2780
3MM9324WI	2.74	1.242	10,800	48,000	12,200	54,300	6,900	—	—	180	800	440	1960	775	3450
3MM9326WI	3.63	1.647	14,000	62,300	15,600	69,400	6,400	—	—	230	1020	550	2450	975	4340
3MM9328WI	3.85	1.744	14,600	64,900	16,000	71,200	5,900	—	—	240	1070	575	2560	1000	4450
3MM9330WI	5.75	2.607	21,200	94,300	23,600	105,000	5,600	—	—	325	1450	775	3450	1350	6000
3MM9334WI	6.33	2.871	24,500	109,000	26,000	115,600	5,000	—	—	—	—	—	—	—	—
3MM9340WI	13.87	6.291	51,400	228,500	44,400	197,500	4,100	—	—	700	3110	1400	6230	2800	12460

* Limits shown for a single row, spring preloaded and grease lubricated bearing.

Ultra-Light
3MM9300WI Series

Superprecision Bearings

FTF Fundamental Train Frequency: The frequency at which the retainer will operate.

BSF Ball Spin Frequency: The frequency at which a single defect on a rolling element will be detected.

BPFO Ball Pass Frequency Outer: The frequency at which a single defect in the outer race will be detected.

BPFI Ball Pass Frequency Inner: The frequency at which a single defect in the inner race will be detected.

FREQUENCY COEFFICIENTS

Bearing Number	FTF Fundamental Train Frequency (Inner Rotation)	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner	FTF Fundamental Train Frequency (Outer Rotation)
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

Ultra-Light
9300WI Series

PERMISSIBLE OPERATING SPEEDS – RPM
2MM & 3MM Superprecision Angular Contact Spindle Bearings

	GREASE							OIL		
	"DB" Mounting			Grease Capacity		Kluber Isoflex NBU 15		"DB" Mounting		
15 Degree Contact Angle	(DUL) Light	(DUM) Medium	(DUH) Heavy	25 % (grams)	40 % (grams)	15 % (grams)	20 % (grams)	(DUL) Light	(DUM) Medium	(DUH) Heavy
2MM9300WI	62,000	46,500	31,000	0.09	0.15	0.06	0.08	105,400	79,100	52,700
2MM9301WI	53,800	40,300	26,900	0.11	0.17	0.07	0.10	91,500	68,500	45,700
2MM9302WI	44,500	33,400	22,200	0.17	0.28	0.12	0.15	75,700	56,800	37,700
2MM9303WI	40,100	30,100	20,000	0.19	0.30	0.12	0.16	68,200	51,200	34,000
2MM9304WI	33,700	25,300	16,800	0.4	0.6	0.25	0.34	57,300	43,000	28,600
2MM9305WI	27,800	20,900	13,900	0.4	0.7	0.29	0.39	47,300	35,500	23,600
2MM9306WI	23,800	17,800	11,900	0.5	0.8	0.34	0.45	40,500	30,300	20,200
2MM9307WI	20,300	15,200	10,200	0.8	1.2	0.51	0.68	34,500	25,800	17,300
2MM9308WI	17,900	13,400	9,000	1.2	1.9	0.80	1.07	30,400	22,800	15,300
2MM9309WI	16,000	12,000	8,000	1.3	2.1	0.88	1.18	27,200	20,400	13,600
2MM9310WI	14,600	11,000	7,300	1.4	2.3	0.95	1.27	24,800	18,700	12,400
2MM9311WI	13,300	10,000	6,600	1.9	3.0	1.3	1.7	22,600	17,000	11,200
2MM9312WI	12,200	9,200	6,100	2.0	3.2	1.4	1.8	20,700	15,600	10,400
2MM9313WI	11,400	8,500	5,700	2.1	3.4	1.4	1.9	19,400	14,500	9,700
2MM9314WI	10,500	7,900	5,200	3.6	5.7	2.4	3.2	17,900	13,400	8,800
2MM9315WI	9,800	7,400	4,900	3.8	6.1	2.5	3.4	16,700	12,600	8,300
2MM9316WI	9,300	7,000	4,600	4.0	6.4	2.7	3.5	15,800	11,900	7,800
2MM9317WI	8,600	6,500	4,300	5.3	8.6	3.6	4.8	14,600	11,100	7,300
2MM9318WI	8,200	6,200	4,100	5.9	9.4	3.9	5.2	13,900	10,500	7,000
2MM9319WI	7,800	5,900	3,900	6.1	9.7	4.1	5.4	13,300	10,000	6,600
2MM9320WI	7,300	5,500	3,600	7.5	12.0	5.0	6.7	12,400	9,400	6,100
2MM9322WI	6,700	5,000	3,400	8.1	13.0	5.4	7.3	11,400	8,500	5,800
2MM9324WI	6,200	4,600	3,100	11.1	17.8	7.4	9.9	10,500	7,800	5,300
2MM9326WI	5,700	4,300	2,800	14.6	23.3	9.7	13.0	9,700	7,300	4,800
2MM9328WI	5,300	4,000	2,600	15.5	24.8	10.4	13.8	9,000	6,800	4,400
2MM9330WI	5,000	3,700	2,500	24.8	39.7	16.6	22.1	8,500	6,300	4,300
2MM9332WI	4,600	3,500	2,300	26.2	41.9	17.5	23.3	7,900	5,900	3,900
2MM9334WI	4,400	3,300	2,200	28.2	45.2	18.9	25.1	7,500	5,600	3,700
2MM9340WI	3,700	2,800	1,800	56.8	90.9	37.9	50.6	6,300	4,700	3,100

Notes: For 3MM (25 Degree Contact Angle) Spindle Bearings, use 90% of the Permissible Operating Speeds above.
* For 2MMC and 3MMC Spindle Bearings, use 120% of the Permissible Operating Speeds.
For other bearing configurations beside a back-to-back mounted duplex set, please refer to page E36 to calculate the permissible operating speed (Sp.).

Axial Stiffness
9300WI Series
(For Duplex Set*)

2MM9300WI SERIES					3MM9300WI SERIES			
Bore #	X-Light (10^6 lb/in.)	Light (10^6 lb/in.)	Medium (10^6 lb/in.)	Heavy (10^6 lb/in.)	Bore #	Light (10^6 lb/in.)	Medium (10^6 lb/in.)	Heavy (10^6 lb/in.)
00	0.081	0.094	0.124	0.167	00	0.187	0.242	0.316
01	0.085	0.099	0.130	0.175	01	—	—	—
02	0.094	0.115	0.153	0.209	02	0.265	0.344	0.430
03	0.102	0.125	0.198	0.273	03	0.290	0.440	0.564
04	0.104	0.151	0.204	0.264	04	—	—	—
05	0.118	0.169	0.251	0.312	05	0.388	0.560	0.700
06	0.126	0.180	0.266	0.331	06	0.417	0.602	0.747
07	0.145	0.189	0.276	0.393	07	0.484	0.705	0.872
08	0.156	0.223	0.317	0.435	08	0.582	0.797	1.000
09	0.176	0.265	0.356	0.488	09	0.656	0.893	1.142
10	0.196	0.280	0.394	0.542	10	0.695	0.998	1.206
11	0.222	0.316	0.440	0.603	11	0.793	1.108	1.371
12	0.250	0.333	0.461	0.644	12	0.839	1.187	1.472
13	0.286	0.375	0.501	0.684	13	0.913	1.265	1.658
14	0.284	0.397	0.532	0.729	14	0.981	1.369	1.725
15	0.304	0.407	0.559	0.767	15	1.034	1.437	1.792
16	0.331	0.447	0.598	0.821	16	1.114	1.540	1.902
17	0.351	0.491	0.662	0.915	17	1.229	1.705	2.126
18	0.372	0.516	0.689	0.943	18	1.216	1.661	2.076
19	0.401	0.557	0.744	1.018	19	1.348	1.886	2.333
20	0.431	0.619	0.832	1.162	20	1.511	2.111	2.629
22	0.504	0.719	0.969	1.339	22	1.638	2.275	2.829
24	0.559	0.826	1.102	1.518	24	1.782	2.409	3.110
26	0.610	0.858	1.152	1.603	26	2.016	2.792	3.496
28	0.601	0.913	1.226	1.700	28	2.133	2.955	3.671
30	0.686	1.039	1.395	1.899	30	2.293	3.151	3.935
—	—	—	—	—	—	—	—	—
34	0.934	1.230	1.651	2.270	34	—	—	—
40	0.943	1.241	1.664	2.286	40	3.317	4.294	5.632

* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Radial Stiffness 9300WI Series (For Duplex Set*)

2MM9300WI SERIES				3MM9300WI SERIES			
Bore #	Light (10^6 lb/in)	Medium (10^6 lb/in)	Heavy (10^6 lb/in)	Bore #	Light (10^6 lb/in)	Medium (10^6 lb/in)	Heavy (10^6 lb/in)
00	0.418	0.527	0.660	00	0.403	0.507	0.634
01	0.440	0.557	0.697	01	—	—	—
02	0.561	0.705	0.880	02	0.554	0.695	0.830
03	0.617	0.886	1.102	03	0.609	0.872	1.055
04	0.848	1.064	1.272	04	—	—	—
05	0.965	1.305	1.516	05	0.839	1.160	1.388
06	1.038	1.407	1.636	06	0.902	1.251	1.498
07	1.083	1.479	1.907	07	1.045	1.462	1.743
08	1.310	1.742	2.177	08	1.251	1.657	1.997
09	1.545	1.945	2.433	09	1.408	1.852	2.266
10	1.640	2.151	2.687	10	1.495	2.046	2.399
11	1.831	2.384	2.979	11	1.684	2.266	2.702
12	1.933	2.522	3.199	12	1.779	2.432	2.907
13	2.166	2.733	3.417	13	1.940	2.598	3.426
14	2.382	3.004	3.755	14	2.095	2.829	3.426
15	2.446	3.150	3.937	15	2.205	2.966	3.561
16	2.680	3.380	4.225	16	2.377	3.183	3.793
17	2.980	3.745	4.674	17	2.642	3.528	4.221
18	3.021	3.812	4.767	18	2.603	3.460	4.175
19	3.260	4.113	5.143	19	2.882	3.900	4.655
20	3.582	4.507	5.680	20	3.213	4.315	5.154
22	3.896	4.899	6.111	22	3.480	4.643	5.538
24	4.305	5.415	6.758	24	3.795	5.099	6.113
26	4.840	6.054	7.559	26	4.295	5.730	6.855
28	5.052	6.361	8.012	28	4.548	6.073	7.253
30	5.460	6.880	8.649	30	4.886	6.541	7.793
34	6.209	7.820	9.699	—	—	—	—
40	7.414	9.344	11.680	40	6.987	8.788	10.980

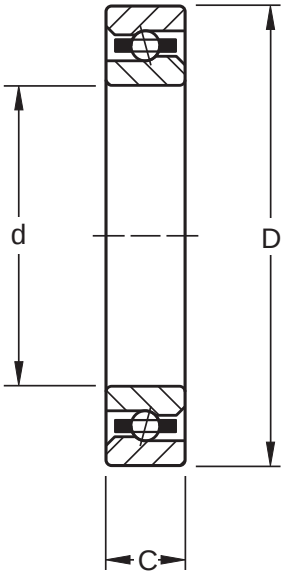
* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Spacer Offsets
9300WI Series
(For Duplex Set*)

2MM9300WI Series				3MM9300WI Series		
Bore #	X-Light to Light	Light to Medium	Medium to Heavy	Bore #	Light Medium	Medium Heavy
00	0.00005	0.00011	0.00016	00	0.00010	0.00015
01	0.00004	0.00010	0.00016	01	—	—
02	0.00008	0.00015	0.00022	02	0.00013	0.00016
03	0.00007	0.00025	0.00025	03	0.00022	0.00020
04	0.00019	0.00023	0.00026	04	—	—
05	0.00017	0.00029	0.00021	05	0.00021	0.00019
06	0.00016	0.00027	0.00020	06	0.00020	0.00018
07	0.00012	0.00026	0.00036	07	0.00023	0.00020
08	0.00019	0.00030	0.00037	08	0.00023	0.00024
09	0.00023	0.00026	0.00038	09	0.00023	0.00027
10	0.00020	0.00030	0.00038	10	0.00026	0.00022
11	0.00022	0.00032	0.00042	11	0.00027	0.00026
12	0.00018	0.00030	0.00043	12	0.00027	0.00026
13	0.00018	0.00027	0.00041	13	0.00026	0.00033
14	0.00027	0.00034	0.00051	14	0.00032	0.00034
15	0.00024	0.00037	0.00051	15	0.00032	0.00032
16	0.00025	0.00034	0.00051	16	0.00031	0.00030
17	0.00032	0.00042	0.00061	17	0.00038	0.00038
18	0.00031	0.00040	0.00059	18	0.00033	0.00035
19	0.00031	0.00040	0.00059	19	0.00038	0.00036
20	0.00036	0.00044	0.00068	20	0.00043	0.00041
22	0.00036	0.00045	0.00067	22	0.00043	0.00041
24	0.00042	0.00052	0.00076	24	0.00048	0.00048
26	0.00051	0.00056	0.00084	26	0.00053	0.00054
28	0.00044	0.00056	0.00086	28	—	—
30	0.00066	0.00071	0.00108	30	—	—
34	0.00069	0.00076	0.00107	34	—	—
40	0.00064	0.00096	0.00142	40	0.00074	0.00113

* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Extra-Light High Speed 2MMV99100WN & 3MMV99100WN Series



Super High Precision MMV (HG):
Superprecision bearings are manufactured to a HG tolerance class, with running accuracy and performance meeting ABEC-9 (ISO P2) while maintaining noncritical features at ABEC-7 (ISO P4) ie. Bore, OD and width.

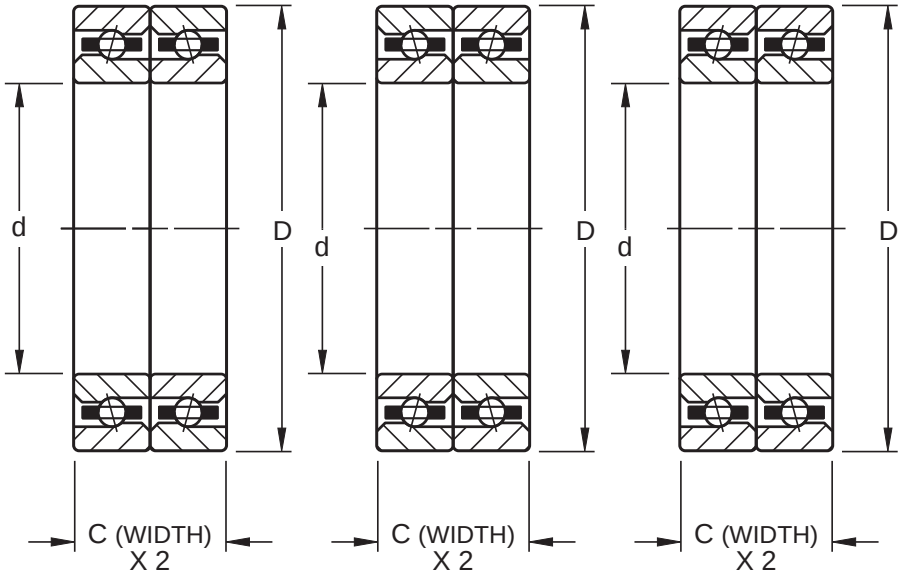
WN Construction:
This design incorporates a low shoulder on the non-thrust side of both the inner and outer rings. The maximum complement of balls is separated by a one-piece cage which is piloted against the ground thrust shoulder land of the outer ring.

To specify a ceramic hybrid bearing, add “C” to the part number, after the prefix that specifies precision type.

DIMENSIONS – TOLERANCES
All Inch tolerance in .0001 units

Bearing Number	Bore		Tolerance +.0000" +.0mm to minus		Outside Diameter		Tolerance +.0000" +.0mm to minus		Width *		Tolerance +.0000" +.0mm to minus		Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement Bearing Corner	
2MMV & 3MMV	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	Qty.	(Dia.) in.
99101WN	0.4724	12	1.5	4	1.1024	28	2.0	5	0.3150	8	31	80	0.012	0.3	9	3/16
99102WN	0.5906	15	1.5	4	1.2598	32	2.5	6	0.3543	9	31	80	0.012	0.3	11	3/16
99103WN	0.6693	17	1.5	4	1.3780	35	2.5	6	0.3937	10	31	80	0.012	0.3	13	3/16
99104WN	0.7874	20	2.0	5	1.6535	42	2.5	6	0.4724	12	47	120	0.024	0.6	11	1/4
99105WN	0.9843	25	2.0	5	1.8504	47	2.5	6	0.4724	12	47	120	0.024	0.6	13	1/4
99106WN	1.1811	30	2.0	5	2.1654	55	3.0	7	0.5118	13	47	120	0.039	1.0	16	1/4
99107WN	1.3780	35	2.5	6	2.4409	62	3.0	7	0.5512	14	47	120	0.039	1.0	21	7/32
99108WN	1.5748	40	2.5	6	2.6772	68	3.0	7	0.5906	15	47	120	0.039	1.0	24	7/32
99109WN	1.7717	45	2.5	6	2.9528	75	3.0	7	0.6299	16	47	120	0.039	1.0	23	1/4
99110WN	1.9685	50	2.5	6	3.1496	80	3.0	7	0.6299	16	47	120	0.039	1.0	25	1/4
99111WN	2.1654	55	3.0	7	3.5433	90	3.0	8	0.7087	18	59	150	0.039	1.0	25	9/32
99112WN	2.3622	60	3.0	7	3.7402	95	3.0	8	0.7087	18	59	150	0.039	1.0	26	9/32
99113WN	2.5591	65	3.0	7	3.9370	100	3.0	8	0.7087	18	59	150	0.039	1.0	28	9/32
99114WN	2.7559	70	3.0	7	4.3307	110	3.0	8	0.7874	20	59	150	0.039	1.0	28	5/16
99115WN	2.9528	75	3.0	7	4.5276	115	3.0	8	0.7874	20	59	150	0.039	1.0	30	5/16

* Refer to page E4 for width tolerance of preloaded bearings.
** ABMA std. 20 ($r_{as\ max}$).



WN Type Duplex Mounting Arrangement

DIMENSIONS – TOLERANCES
All Inch tolerance in .0001 units

Bearing Number	Bore				Outside Diameter				Width *				Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement	
			Tolerance +.0000" +.0mm to minus				Tolerance +.0000" +.0mm to minus				Tolerance +.0000" +.0mm to minus					
2MMV & 3MMV	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	Qty.	(Dia.) in.
99116WN	3.1496	80	3.0	7	4.9213	125	3.5	9	0.8661	22	59	150	0.039	1.0	29	11/32
99117WN	3.3465	85	3.0	8	5.1181	130	3.5	9	0.8661	22	79	200	0.039	1.0	31	11/32
99118WN	3.5433	90	3.0	8	5.5118	140	3.5	9	0.9449	24	79	200	0.059	1.5	28	13/32
99119WN	3.7402	95	3.0	8	5.7087	145	3.5	9	0.9449	24	79	200	0.059	1.5	29	13/32
99120WN	3.9370	100	3.0	8	5.9055	150	3.5	9	0.9449	24	79	200	0.059	1.5	31	13/32
99121WN	4.1339	105	3.0	8	6.2992	160	4.0	10	1.0236	26	79	200	0.079	2.0	30	7/16
99122WN	4.3307	110	3.0	8	6.6929	170	4.0	10	1.1024	28	79	200	0.079	2.0	30	15/32
99124WN	4.7244	120	3.0	8	7.0866	180	4.0	10	1.1024	28	79	200	0.079	2.0	32	15/32
99126WN	5.1181	130	4.0	10	7.8740	200	4.5	11	1.2992	33	98	250	0.079	2.0	32	17/32
99128WN	5.5118	140	4.0	10	8.2677	210	4.5	11	1.2992	33	98	250	0.079	2.0	34	17/32
99130WN	5.9055	150	4.0	10	8.8583	225	4.5	11	1.3780	35	98	250	0.079	2.0	34	19/32

* Refer to page E4 for width tolerance of preloaded bearings.
** ABMA std. 20 ($r_{as\ max}$).

Extra-Light High Speed
2MMV99100WN Series

PHYSICAL CHARACTERISTICS – LOAD RATINGS

RADIAL LOAD RATING AT 33 1/3 RPM
Based on 1500 hours L_{10} Life and Permissible Speed

Bearing Number	Weight Per Bearing		Static Load Rating C_o		Extended Dynamic Load Ratings C_e		Permissible Speed Ng *	Preload Levels **							
								Extralight (DUX)		Light (DUL)		Medium (DUM)		Heavy (DUH)	
	lbs	kg	lbs	N	lbs	N	RPM	lbs	N	lbs	N	lbs	N	lbs	N
2MMV99101WN	0.04	0.019	380	1,700	1,160	5,200	75,800	—	—	5	20	10	40	20	90
2MMV99102WN	0.06	0.028	490	2,200	1,320	5,900	64,300	—	—	5	20	10	40	20	90
2MMV99103WN	0.08	0.038	600	2,700	1,500	6,700	56,900	—	—	5	20	10	40	20	90
2MMV99104WN	0.14	0.064	1,040	4,600	2,450	10,900	43,800	5	20	10	40	20	90	40	180
2MMV99105WN	0.16	0.074	1,290	5,700	2,700	12,000	36,500	5	20	15	70	30	130	60	270
2MMV99106WN	0.25	0.116	1,660	7,400	3,050	13,600	29,500	5	20	15	70	30	130	60	270
2MMV99107WN	0.37	0.167	1,730	7,700	2,800	12,500	25,300	10	40	20	90	40	180	80	360
2MMV99108WN	0.46	0.207	2,040	9,100	3,000	13,300	22,000	15	70	25	110	50	220	100	440
2MMV99109WN	0.57	0.259	2,550	11,300	3,650	16,200	20,200	15	70	30	130	60	270	120	530
2MMV99110WN	0.62	0.281	2,750	12,200	3,800	16,900	18,500	15	70	30	130	60	270	120	530
2MMV99111WN	0.92	0.417	3,450	15,300	4,750	21,100	16,600	20	90	40	180	80	360	160	710
2MMV99112WN	0.98	0.445	3,650	16,200	4,800	21,400	15,400	20	90	40	180	80	360	160	710
2MMV99113WN	1.05	0.474	3,900	17,300	5,000	22,200	14,400	25	110	50	220	100	440	200	890
2MMV99114WN	1.47	0.665	4,800	21,400	6,000	26,700	13,200	25	110	50	220	100	440	200	890
2MMV99115WN	1.54	0.699	5,100	22,700	6,200	27,600	12,300	30	130	60	270	120	530	240	1070
2MMV99116WN	2.08	0.944	6,000	26,700	7,350	32,700	11,600	35	160	70	310	140	620	280	1250
2MMV99117WN	2.18	0.991	6,400	28,500	7,500	33,400	11,000	40	180	80	360	160	710	320	1420
2MMV99118WN	2.79	1.266	8,150	36,300	9,300	41,400	10,400	45	200	90	400	180	800	360	1600
2MMV99119WN	2.87	1.303	8,300	36,900	9,300	41,400	9,900	45	200	90	400	180	800	360	1600
2MMV99120WN	3.03	1.374	9,000	40,000	10,200	45,400	9,400	50	220	100	440	200	890	400	1780
2MMV99121WN	3.81	1.729	10,000	44,500	11,400	50,700	8,900	55	240	110	490	220	980	440	1960
2MMV99122WN	4.82	2.188	11,400	50,700	12,900	57,400	8,500	60	270	120	530	240	1070	480	2140
2MMV99124WN	5.17	2.343	12,200	54,300	13,400	59,600	7,900	70	310	140	620	280	1250	560	2490
2MMV99126WN	7.85	3.563	15,600	69,400	17,000	75,600	7,100	90	400	180	800	360	1600	720	3200
2MMV99128WN	8.32	3.776	16,600	73,800	17,300	77,000	6,600	95	420	190	850	380	1690	760	3380
2MMV99130WN	9.94	4.509	20,000	89,000	20,800	92,500	6,200	100	440	200	890	400	1780	800	3560

* Limits shown for a single row, spring preloaded and grease lubricated bearing.
** All ceramic hybrid bearing preloads are equivalent to the table above.

Extra-Light High Speed 2MMV99100WN Series

Superprecision Bearings

FTF Fundamental Train Frequency: The frequency at which the retainer will operate.

BSF Ball Spin Frequency: The frequency at which a single defect on a rolling element will be detected.

BPFO Ball Pass Frequency Outer: The frequency at which a single defect in the outer race will be detected.

BPFI Ball Pass Frequency Inner: The frequency at which a single defect in the inner race will be detected.

FREQUENCY COEFFICIENTS

Bearing Number	FTF Fundamental Train Frequency (Inner Rotation)	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner	FTF Fundamental Train Frequency (Outer Rotation)
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

Extra-Light High Speed
3MMV99100WN Series

PHYSICAL CHARACTERISTICS – LOAD RATINGS

RADIAL LOAD RATING AT 33 1/3 RPM
Based on 1500 hours L_{10} Life and Permissible Speed

Bearing Number	Weight Per Bearing		Static Load Rating C_o		Extended Dynamic Load Ratings C_e		Permissible Speed Ng *	Preload Levels **							
								Extralight (DUX)		Light (DUL)		Medium (DUM)		Heavy (DUH)	
	lbs	kg	lbs	N	lbs	N	RPM	lbs	N	lbs	N	lbs	N	lbs	N
3MMV99101WN	0.04	0.019	365	1,600	1,100	4,900	68,200	—	—	10	40	20	90	40	180
3MMV99102WN	0.06	0.028	465	2,100	1,270	5,600	57,900	—	—	10	40	20	90	40	180
3MMV99103WN	0.08	0.038	570	2,500	1,400	6,200	51,200	—	—	10	40	20	90	40	180
3MMV99104WN	0.14	0.064	930	4,100	2,320	10,300	39,400	10	40	20	90	40	180	80	360
3MMV99105WN	0.16	0.074	1,220	5,400	2,600	11,600	32,900	15	70	30	130	60	270	120	530
3MMV99106WN	0.25	0.116	1,560	6,900	2,900	12,900	26,600	15	70	30	130	60	270	120	530
3MMV99107WN	0.37	0.167	1,660	7,400	2,600	11,600	22,800	20	90	40	180	80	360	160	710
3MMV99108WN	0.46	0.207	1,900	8,500	2,800	12,500	19,800	25	110	50	220	100	440	200	890
3MMV99109WN	0.57	0.259	2,360	10,500	3,450	15,300	18,200	30	130	60	270	120	530	240	1070
3MMV99110WN	0.62	0.281	2,600	11,600	3,600	16,000	16,700	30	130	60	270	120	530	240	1070
3MMV99111WN	0.92	0.417	3,250	14,500	4,500	20,000	14,900	40	180	80	360	160	710	320	1420
3MMV99112WN	0.98	0.445	3,400	15,100	4,550	20,200	13,900	40	180	80	360	160	710	320	1420
3MMV99113WN	1.05	0.474	3,600	16,000	4,650	20,700	13,000	50	220	100	440	200	890	400	1780
3MMV99114WN	1.46	0.664	4,500	20,000	5,700	25,400	11,900	50	220	100	440	200	890	400	1780
3MMV99115WN	1.54	0.699	4,750	21,100	5,850	26,000	11,100	60	270	120	530	240	1070	500	2220
3MMV99116WN	2.08	0.943	5,600	24,900	6,800	30,200	10,400	70	310	140	620	280	1250	550	2450
3MMV99117WN	2.18	0.990	6,000	26,700	7,100	31,600	9,900	80	360	160	710	320	1420	600	2670
3MMV99118WN	2.79	1.266	7,650	34,000	9,150	40,700	9,400	90	400	180	800	360	1600	700	3110
3MMV99119WN	2.87	1.303	7,800	34,700	9,300	41,400	8,900	90	400	180	800	360	1600	700	3110
3MMV99120WN	3.03	1.373	8,300	36,900	9,300	41,400	8,500	100	440	200	890	400	1780	800	3560
3MMV99121WN	3.81	1.728	9,300	41,400	10,800	48,000	8,000	110	490	220	980	450	2000	900	4000
3MMV99122WN	4.82	2.187	10,800	48,000	12,200	54,300	7,700	120	530	240	1070	500	2220	1000	4450
3MMV99124WN	5.16	2.342	11,400	50,700	12,500	55,600	7,100	140	620	280	1250	550	2450	1100	4890
3MMV99126WN	7.85	3.561	14,600	64,900	16,000	71,200	6,400	180	800	360	1600	700	3110	1400	6230
3MMV99128WN	8.32	3.774	15,600	69,400	16,300	72,500	5,900	190	850	380	1690	750	3340	1500	6670
3MMV99130WN	9.94	4.507	19,000	84,500	19,600	87,200	5,600	200	890	400	1780	800	3560	1600	7120

* Limits shown for a single row, spring preloaded and grease lubricated bearing.
** All ceramic hybrid bearing preloads are equivalent to the table above.

Extra-Light High Speed 3MMV99100WN Series

Superprecision Bearings

FTF Fundamental Train Frequency: The frequency at which the retainer will operate.

BSF Ball Spin Frequency: The frequency at which a single defect on a rolling element will be detected.

BPFO Ball Pass Frequency Outer: The frequency at which a single defect in the outer race will be detected.

BPFI Ball Pass Frequency Inner: The frequency at which a single defect in the inner race will be detected.

FREQUENCY COEFFICIENTS

Bearing Number	FTF Fundamental Train Frequency (Inner Rotation)	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner	FTF Fundamental Train Frequency (Outer Rotation)
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

Extra-Light High Speed 99100WN Series

PERMISSIBLE OPERATING SPEEDS – RPM
2MMV & 3MMV Superprecision Angular Contact Spindle Bearings

	GREASE							OIL		
	"DB" Mounting			Grease Capacity		Kluber Isoflex NBU 15		"DB" Mounting		
15 Degree Contact Angle	(DUX) X-Light	(DUL) Light	(DUM) Medium	25 % (grams)	40 % (grams)	15 % (grams)	20 % (grams)	(DUX) X-Light	(DUL) Light	(DUM) Medium
2MMV99101WN	68,200	60,600	45,500	0.3	0.5	0.20	0.27	116,000	103,000	77,400
2MMV99102WN	57,900	51,400	38,600	0.4	0.6	0.24	0.32	98,400	98,400	65,600
2MMV99103WN	51,200	45,500	34,100	0.5	0.7	0.31	0.41	87,100	87,100	58,000
2MMV99104WN	39,400	35,000	26,300	0.9	1.4	0.58	0.77	67,000	67,000	44,700
2MMV99105WN	32,900	29,200	21,900	1.0	1.6	0.67	0.90	55,800	55,800	37,200
2MMV99106WN	26,600	23,600	17,700	1.3	2.1	0.87	1.17	45,100	45,100	30,100
2MMV99107WN	22,800	20,200	15,200	1.4	2.2	0.91	1.22	38,700	38,700	25,800
2MMV99108WN	19,800	17,600	13,200	1.7	2.7	1.14	1.52	33,700	33,700	22,400
2MMV99109WN	18,200	16,200	12,100	2.2	3.5	1.47	1.96	30,900	30,900	20,600
2MMV99110WN	16,700	14,800	11,100	2.4	3.8	1.58	2.11	28,300	28,300	18,900
2MMV99111WN	14,900	13,300	10,000	3.4	5.4	2.2	3.0	25,400	25,400	17,000
2MMV99112WN	13,900	12,300	9,200	3.6	5.8	2.4	3.2	23,600	23,600	15,600
2MMV99113WN	13,000	11,500	8,600	3.8	6.1	2.6	3.4	22,000	22,000	14,600
2MMV99114WN	11,900	10,600	7,900	5.1	8.2	3.4	4.6	20,200	20,200	13,400
2MMV99115WN	11,100	9,800	7,400	5.5	8.8	3.7	4.9	18,800	18,800	12,600
2MMV99116WN	10,400	9,300	7,000	7.1	11.3	4.7	6.3	17,700	17,700	11,900
2MMV99117WN	9,900	8,800	6,600	7.4	11.8	4.9	6.6	16,800	16,800	11,200
2MMV99118WN	9,400	8,300	6,200	9.7	15.6	6.5	8.7	15,900	15,900	10,500
2MMV99119WN	8,900	7,900	5,900	13.3	21.3	7.1	9.5	15,100	15,100	10,000
2MMV99120WN	8,500	7,500	5,600	10.6	17.0	7.4	9.9	14,400	14,400	9,500
2MMV99121WN	8,000	7,100	5,300	17.1	27.4	9.1	12.2	13,600	13,600	9,000
2MMV99122WN	7,700	6,800	5,100	16.0	25.6	10.7	14.2	13,000	13,000	8,700
2MMV99124WN	7,100	6,300	4,700	17.1	27.4	11.4	15.3	12,100	12,100	8,000
2MMV99126WN	6,400	5,700	4,300	25.8	41.3	17.2	23.0	10,900	10,900	7,300
2MMV99128WN	5,900	5,300	4,000	27.5	43.9	18.3	24.4	10,100	10,100	6,800
2MMV99130WN	5,600	5,000	3,700	43.9	70.3	29.3	39.1	9,500	9,500	6,300

Notes:
For 3MM (25 Degree Contact Angle) Spindle Bearings, use 90% of the Permissible Operating Speeds above.
For 2MMVC and 3MMVC Spindle Bearings, use 120% of Permissible Operating Speeds.
For other bearing configurations beside a back-to-back mounted duplex set, please refer to page E36 to calculate the permissible operating speed (Sp.).

Axial Stiffness 99100WN Series (For Duplex Set*)

2MM99100WN SERIES					3MM99100WN SERIES				
Bore #	X-Light (10^6 LB/IN.)	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6LB/IN.)	Bore #	X-Light (10^6 LB/IN.)	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)
01	0.055	0.077	0.102	0.138	01	0.160	0.205	0.263	0.343
02	0.062	0.087	0.115	0.155	02	0.182	0.233	0.299	0.388
03	0.069	0.097	0.127	0.170	03	0.203	0.259	0.332	0.430
04	0.098	0.128	0.171	0.233	04	0.274	0.351	0.453	0.591
05	0.123	0.167	0.224	0.308	05	0.353	0.452	0.586	0.768
06	0.140	0.189	0.252	0.344	06	0.403	0.516	0.667	0.870
07	0.191	0.252	0.338	0.464	07	0.515	0.661	0.857	1.125
08	0.223	0.298	0.401	0.553	08	0.608	0.781	1.013	1.333
09	0.237	0.313	0.422	0.582	09	0.652	0.837	1.086	1.428
10	0.249	0.329	0.442	0.608	10	0.688	0.883	1.144	1.501
11	0.292	0.384	0.516	0.711	11	0.784	1.007	1.306	1.716
12	0.299	0.393	0.528	0.725	12	0.804	1.032	1.338	1.757
13	0.341	0.450	0.607	0.839	13	0.913	1.174	1.525	2.010
14	0.356	0.467	0.624	0.854	14	0.935	1.201	1.555	2.040
15	0.398	0.524	0.703	0.966	15	1.043	1.341	1.740	2.327
16	0.001	0.547	0.735	1.012	16	1.109	1.425	1.848	2.413
17	0.455	0.601	0.810	1.117	17	1.214	1.561	2.027	2.601
18	0.461	0.607	0.815	1.121	18	1.236	1.588	2.060	2.677
19	0.471	0.620	0.831	1.142	19	1.265	1.624	2.105	2.733
20	0.511	0.673	0.904	1.244	20	1.371	1.761	2.284	3.002
21	0.538	0.708	0.948	1.315	21	1.410	1.811	2.369	3.116
22	0.571	0.749	1.001	1.397	22	1.484	1.905	2.507	3.295
24	0.630	0.829	1.111	1.512	24	1.634	2.100	2.706	3.559
26	0.695	0.916	1.231	1.672	26	1.852	2.381	3.056	4.018
28	0.736	0.970	1.304	1.783	28	1.963	2.523	3.258	4.284
30	0.773	1.014	1.355	1.851	30	2.014	2.584	3.347	4.390

* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Radial Stiffness 99100WN Series (For Duplex Set*)

2MMV99100WN SERIES				3MMV99100WN SERIES			
Bore #	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)	Bore #	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)
01	0.347	0.450	0.569	01	0.336	0.429	0.529
02	0.513	0.651	0.800	02	0.490	0.606	0.760
03	0.570	0.727	0.896	03	0.546	0.677	0.851
04	0.719	0.891	1.118	04	0.659	0.832	1.044
05	0.801	0.996	1.252	05	0.735	0.931	1.169
06	0.992	1.259	1.581	06	0.930	1.177	1.476
07	1.199	1.538	1.927	07	1.148	1.448	1.813
08	1.413	1.786	2.237	08	1.334	1.681	2.105
09	1.599	2.018	2.526	09	1.498	1.886	2.360
10	1.689	2.134	2.673	10	1.582	1.994	2.497
11	1.998	2.518	3.150	11	1.890	2.378	2.973
12	2.050	2.586	3.235	12	1.940	2.441	3.053
13	2.152	2.718	3.403	13	2.037	2.566	3.211
14	2.439	3.077	3.580	14	2.328	2.930	3.664
15	2.552	3.223	4.036	15	2.437	3.069	3.840
16	2.799	3.531	4.417	16	2.654	3.340	3.176
17	2.924	3.692	4.623	17	2.773	3.493	4.370
18	3.071	3.880	4.860	18	2.918	3.677	4.603
19	3.142	3.972	4.978	19	2.987	3.765	4.714
20	3.462	4.371	5.472	20	3.289	4.142	5.152
21	3.613	4.561	4.709	21	3.452	4.346	5.463
22	3.674	4.649	5.829	22	3.532	4.454	5.606
24	4.141	5.226	6.542	24	3.976	5.004	6.259
26	4.634	5.852	7.328	26	4.410	5.554	6.928
28	5.084	6.412	7.976	28	4.836	6.049	7.566
30	5.363	6.771	8.520	30	5.148	6.515	8.150

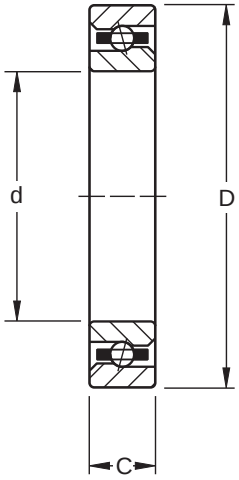
* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Spacer Offsets 99100WN Series (For Duplex Set*)

2MM99100WN SERIES				3MM99100WN SERIES			
Bore #	X-Light to Light (IN.)	Light to Medium (IN.)	Medium to Heavy (IN.)	Bore #	X-Light to Light (IN.)	Light to Medium (IN.)	Medium to Heavy (IN.)
01	0.00018	0.00022	0.00033	01	0.00011	0.00017	0.00026
02	0.00016	0.00020	0.00030	02	0.00010	0.00015	0.00023
03	0.00014	0.00018	0.00027	03	0.00009	0.00013	0.00021
04	0.00018	0.00027	0.00040	04	0.00013	0.00020	0.00031
05	0.00022	0.00031	0.00045	05	0.00015	0.00023	0.00035
06	0.00019	0.00027	0.00040	06	0.00013	0.00020	0.00031
07	0.00018	0.00027	0.00040	07	0.00014	0.00021	0.00032
08	0.00020	0.00029	0.00042	08	0.00014	0.00022	0.00034
09	0.00022	0.00033	0.00048	09	0.00016	0.00025	0.00038
10	0.00021	0.00031	0.00046	10	0.00015	0.00024	0.00036
11	0.00024	0.00036	0.00052	11	0.00018	0.00028	0.00042
12	0.00023	0.00035	0.00051	12	0.00017	0.00027	0.00041
13	0.00025	0.00038	0.00055	13	0.00019	0.00030	0.00045
14	0.00024	0.00037	0.00054	14	0.00019	0.00029	0.00044
15	0.00026	0.00039	0.00058	15	0.00020	0.00031	0.00051
16	0.00029	0.00044	0.00044	16	0.00022	0.00034	0.00051
17	0.00030	0.00045	0.00066	17	0.00023	0.00036	0.00048
18	0.00034	0.00051	0.00074	18	0.00025	0.00039	0.00057
19	0.00033	0.00050	0.00050	19	0.00025	0.00039	0.00056
20	0.00034	0.00051	0.00075	20	0.00025	0.00039	0.00060
21	0.00035	0.00053	0.00081	21	0.00027	0.00044	0.00065
22	0.00036	0.00055	0.00087	22	0.00028	0.00047	0.00069
24	0.00038	0.00058	0.00082	24	0.00030	0.00045	0.00070
26	0.00045	0.00067	0.00094	26	0.00034	0.00050	0.00079
28	0.00044	0.00067	0.00096	28	0.00034	0.00051	0.00079
30	0.00045	0.00067	0.00100	30	0.00035	0.00054	0.00083

* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Extra-Light 2MMV9100HX Series



Super High Precision MMV (HG):
Superprecision bearings are manufactured to a HG tolerance class, with running accuracy and performance meeting ABEC-9 (ISO P2) while maintaining noncritical features at ABEC-7 (ISO P4) ie. Bore, OD and width.

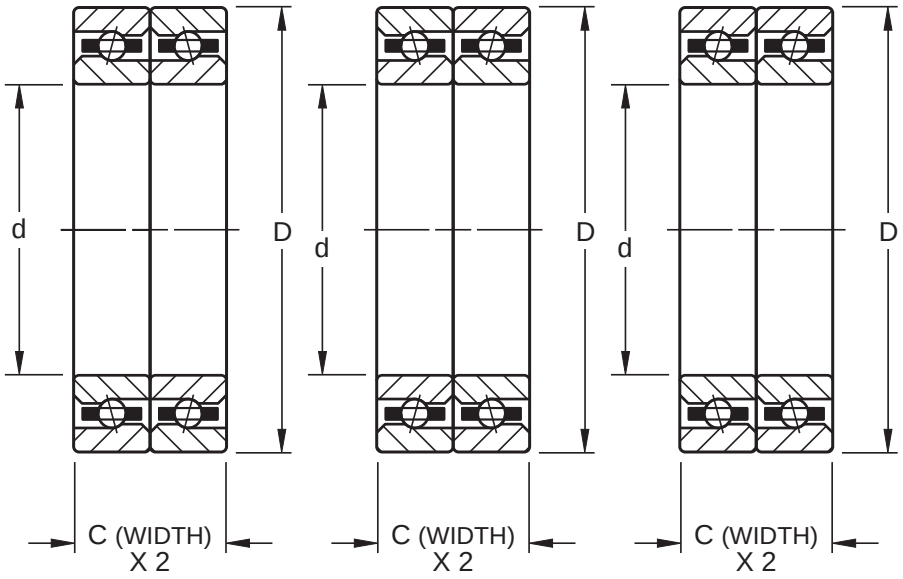
WN Construction:
This design incorporates a low shoulder on the non-thrust side of both the inner and outer rings. The maximum complement of balls is separated by a one-piece cage which is piloted against the ground thrust shoulder land of the outer ring.

To specify a ceramic hybrid bearing, add “C” to the part number, after the prefix that specifies precision type.

DIMENSIONS – TOLERANCES
All inch tolerance in .0001 units

Bearing Number	Bore				Outside Diameter				Width *				Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement	
	Nominal Dimension		Tolerance +.0000" +.0µm to minus		Nominal Dimension		Tolerance +.0000" +.0µm to minus		Nominal Dimension		Tolerance +.0000" +.0µm to minus					
2MM	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	Qty.	(Dia.) in.
9100HX	0.3937	10	1.5	4	1.0236	26	2.0	5	0.3150	8	16	40	0.012	0.3	10	11/64
9101HX	0.4724	12	1.5	4	1.1024	28	2.0	5	0.3150	8	31	80	0.012	0.3	10	3/16
9102HX	0.5906	15	1.5	4	1.2598	32	2.5	6	0.3543	9	31	80	0.012	0.3	12	3/16
9103HX	0.6693	17	1.5	4	1.3780	35	2.5	6	0.3937	10	31	80	0.012	0.3	12	7/32
9104HX	0.7874	20	2.0	5	1.6535	42	2.5	6	0.4724	12	47	130	0.024	0.6	12	1/4
9105HX	0.9843	25	2.0	5	1.8504	47	2.5	6	0.4724	12	47	130	0.024	0.6	13	9/32
9106HX	1.1811	30	2.0	5	2.1654	55	3.0	7	0.5118	13	47	130	0.039	1.0	13	5/16
9107HX	1.3780	35	2.5	6	2.4409	62	3.0	7	0.5512	14	47	130	0.039	1.0	15	5/16
9108HX	1.5748	40	2.5	6	2.6772	68	3.0	7	0.5906	15	47	130	0.039	1.0	16	5/16
9109HX	1.7717	45	2.5	6	2.9528	75	3.0	7	0.6299	16	47	130	0.039	1.0	15	3/8

* Refer to page E4 for width tolerance of preloaded bearings.
** ABMA std. 20 ($r_{as\ max}$).



WN Type Duplex Mounting Arrangement

DIMENSIONS – TOLERANCES
All inch tolerance in .0001 units

Bearing Number	Bore				Outside Diameter				Width *				Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement	
	Nominal Dimension		Tolerance +.0000" +.0μm to minus		Nominal Dimension		Tolerance +.0000" +.0μm to minus		Nominal Dimension		Tolerance +.0000" +.0μm to minus					
2MM	in.	mm	in.	μm	in.	mm	in.	μm	in.	mm	in.	μm	in.	mm	Qty.	(Dia.) in.
9110HX	1.9685	50	2.5	6	3.1496	80	3.0	7	0.6299	16	47	130	0.039	1.0	16	3/8
9111HX	2.1654	55	3.0	7	3.5433	90	3.0	8	0.7087	18	59	150	0.039	1.0	24	5/16
9112HX	2.3622	60	3.0	7	3.7402	95	3.0	8	0.7087	18	59	150	0.039	1.0	25	5/16
9113HX	2.5591	65	3.0	7	3.9370	100	3.0	8	0.7087	18	59	150	0.039	1.0	25	11/32
9114HX	2.7559	70	3.0	7	4.3307	110	3.0	8	0.7874	20	59	150	0.039	1.0	25	3/8
9115HX	2.9528	75	3.0	7	4.5276	115	3.0	8	0.7874	20	59	150	0.039	1.0	26	3/8
9116HX	3.1496	80	3.0	7	4.9213	125	3.5	9	0.8661	22	59	150	0.039	1.0	25	7/16
9117HX	3.3465	85	3.0	8	5.1181	130	3.5	9	0.8610	22	79	210	0.039	1.0	26	7/16
9118HX	3.5433	90	3.0	8	5.5118	140	3.5	9	0.9449	24	79	210	0.059	1.5	28	7/16
9119HX	3.7402	95	3.0	8	5.7087	145	3.5	9	0.9449	24	79	210	0.059	1.5	26	1/2
9120HX	3.9370	100	3.0	8	5.9055	150	3.5	9	0.9449	24	79	210	0.059	1.5	27	1/2
9121HX	4.1339	105	3.0	8	6.2992	160	4.0	10	1.0236	26	79	210	0.079	2.0	28	1/2
9122HX	4.3307	110	3.0	8	6.6929	170	4.0	10	1.1024	28	79	210	0.079	2.0	30	1/2
9124HX	4.7244	120	3.0	8	7.0866	180	4.0	10	1.1024	28	79	210	0.079	2.0	29	9/16

* Refer to page E4 for width tolerance of preloaded bearings.
** ABMA std. 20 ($r_{as\ max}$).

Extra-Light
2MMV9100HX Series

PHYSICAL CHARACTERISTICS – LOAD RATINGS

RADIAL LOAD RATING AT 33 1/3 RPM
Based on 1500 hours L_{10} Life and Permissible Speed

Bearing Number	Weight Per Bearing		Static Load Rating C_o		Extended Dynamic Load Rating C_e		Permissible Speed Ng *	Preload Levels **					
								Light (DUL)		Medium (DUM)		Heavy (DUH)	
	lbs	kg	lbs	N	lbs	N	RPM	lbs	N	lbs	N	lbs	N
2MMV9100HX	0.04	0.018	305	1,400	965	4,300	88,000	5	20	15	70	30	130
2MMV9101HX	0.04	0.020	365	1,600	1,140	5,100	78,900	5	20	15	70	30	130
2MMV9102HX	0.06	0.027	465	2,100	1,290	5,700	64,300	5	20	15	70	30	130
2MMV9103HX	0.08	0.038	620	2,800	1,700	7,600	58,900	5	20	15	70	30	130
2MMV9104HX	0.14	0.064	830	3,700	2,160	9,600	48,900	10	40	30	90	60	270
2MMV9105HX	0.16	0.073	1,140	5,100	2,850	12,700	41,800	10	40	30	130	60	270
2MMV9106HX	0.23	0.104	1,430	6,400	3,450	15,300	34,900	15	70	45	200	90	400
2MMV9107HX	0.32	0.145	1,730	7,700	3,750	16,700	29,800	15	70	45	200	90	400
2MMV9108HX	0.40	0.181	1,900	8,500	3,900	17,300	26,200	15	70	45	200	90	400
2MMV9109HX	0.48	0.218	2,500	11,100	5,200	23,100	23,900	20	90	60	270	120	530
2MMV9110HX	0.52	0.236	2,700	12,000	5,400	24,000	21,800	20	90	60	270	120	530
2MMV9111HX	0.88	0.399	3,000	13,300	4,800	21,400	18,700	25	110	75	330	150	670
2MMV9112HX	0.94	0.426	3,150	14,000	4,900	21,800	17,400	25	110	75	330	150	670
2MMV9113HX	0.98	0.445	3,800	16,900	5,850	26,000	16,400	30	130	90	400	180	800
2MMV9114HX	1.38	0.626	4,500	20,000	6,800	30,200	15,000	35	160	105	470	210	930
2MMV9115HX	1.45	0.658	4,650	20,700	6,950	30,900	14,200	35	160	105	470	210	930
2MMV9116HX	1.93	0.875	6,100	27,100	9,150	40,700	13,200	45	200	135	600	270	1200
2MMV9117HX	2.02	0.916	6,400	28,500	9,300	41,400	12,600	50	220	150	670	300	1330
2MMV9118HX	2.71	1.229	6,950	30,900	9,500	42,300	11,700	50	220	150	670	300	1330
2MMV9119HX	2.73	1.238	8,300	36,900	11,800	52,500	11,300	60	270	180	800	360	1600
2MMV9120HX	2.84	1.288	8,650	38,500	12,000	53,000	10,800	60	270	180	800	360	1600
2MMV9121HX	3.69	1.674	9,000	40,000	12,200	54,300	10,100	60	270	180	800	360	1600
2MMV9122HX	4.70	2.132	9,650	42,900	12,500	55,600	9,500	65	290	195	870	390	1730
2MMV9124HX	4.89	2.218	11,800	52,500	15,300	68,100	8,900	80	360	240	1070	480	2140

* Limits shown for a single row, spring preloaded and grease lubricated bearing.
** All ceramic hybrid bearing preloads are equivalent to the table above.

Extra-Light
2MMV9100HX Series

Frequency Coefficients Superprecision Bearings

FTF **Fundamental Train Frequency:** The frequency at which the retainer will operate.

BSF **Ball Spin Frequency:** The frequency at which a single defect on a rolling element will be detected.

BPFO **Ball Pass Frequency Outer:** The frequency at which a single defect in the outer race will be detected.

BPFI **Ball Pass Frequency Inner:** The frequency at which a single defect in the inner race will be detected.

EXTRA-LIGHT – 2MMV9100HX SERIES

Bearing Number	FTF Fundamental Train Frequency (Inner Rotation)	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner	FTF Fundamental Train Frequency (Outer Rotation)
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

Extra-Light
2MMV9100HX Series

PERMISSIBLE OPERATING SPEEDS – RPM
2MMV9100HX Series

	GREASE							OIL		
	"DB" Mounting			Grease Capacity		Kluber Isoflex NBU 15		"DB" Mounting		
15 Degree Contact Angle	(DUL) Light	(DUM) Medium	(DUH) Heavy	25% (grams)	40% (grams)	15% (grams)	20% (grams)	(DUL) Light	(DUM) Medium	(DUH) Heavy
2MMV9100HX	70,400	52,800	35,200	0.3	0.4	0.16	0.21	119,700	89,800	59,800
2MMV9101HX	63,100	47,300	31,600	0.3	0.5	0.18	0.24	107,300	80,400	53,700
2MMV9102HX	51,400	38,600	25,700	0.4	0.7	0.25	0.33	87,400	65,600	43,700
2MMV9103HX	47,100	35,300	23,600	0.6	0.9	0.33	0.44	80,100	60,000	40,100
2MMV9104HX	39,100	29,300	19,600	1.0	1.6	0.57	0.77	66,500	49,800	33,300
2MMV9105HX	33,400	25,100	16,700	1.2	1.9	0.70	0.93	56,800	42,700	28,400
2MMV9106HX	27,900	20,900	14,000	1.7	2.7	1.01	1.34	47,400	35,500	23,800
2MMV9107HX	23,800	17,900	11,900	2.1	3.4	1.25	1.67	40,500	30,400	20,200
2MMV9108HX	21,000	15,700	10,500	2.7	4.3	1.54	2.06	35,700	26,700	17,900
2MMV9109HX	19,100	14,300	9,600	3.5	5.6	2.12	2.83	32,500	24,300	16,300
2MMV9110HX	17,400	13,100	8,700	3.9	6.2	2.3	3.1	29,600	22,300	14,800
2MMV9111HX	15,000	11,200	7,500	4.6	7.3	2.5	3.3	25,500	19,000	12,800
2MMV9112HX	13,900	10,400	7,000	4.9	7.9	2.7	3.6	23,600	17,700	11,900
2MMV9113HX	13,100	9,800	6,600	5.5	8.8	3.1	4.1	22,300	16,700	11,200
2MMV9114HX	12,000	9,000	6,000	7.3	11.7	4.1	5.4	20,400	15,300	10,200
2MMV9115HX	11,400	8,500	5,700	7.7	12.4	4.3	5.7	19,400	14,500	9,700
2MMV9116HX	10,600	7,900	5,300	10.3	16.5	5.8	7.7	18,000	13,400	9,000
2MMV9117HX	10,100	7,600	5,000	10.8	17.3	6.1	8.1	17,200	12,900	8,500
2MMV9118HX	9,400	7,000	4,700	13.2	21.0	7.2	9.7	16,000	11,900	8,000
2MMV9119HX	9,000	6,800	4,500	14.6	23.4	8.3	11.1	15,300	11,600	7,700
2MMV9120HX	8,600	6,500	4,300	15.2	24.4	8.6	11.5	14,600	11,100	7,300
2MMV9121HX	8,100	6,100	4,000	18.3	29.3	10.2	13.6	13,800	10,400	6,800
2MMV9122HX	7,600	5,700	3,800	21.5	34.3	11.8	15.7	12,900	9,700	6,500
2MMV9124HX	7,100	5,300	3,600	24.4	39.1	13.7	18.3	12,100	9,000	6,100

Note: For 2MMVC and 3MMVC Spindle bearings, use 120% of Permissible Operating Speeds.
For other bearing configurations beside a back-to-back mounted duplex set, please refer to page E36 to calculate the permissible operating speed (Sp.).

Axial Stiffness
2MMV9100HX Series
(For Duplex Set*)

2MMV9100HX SERIES

Bore Number	Light (10^6 lb/in.)	Medium (10^6 lb/in.)	Heavy (10^6 lb/in.)
00	0.0860	0.1345	0.1834
01	0.0824	0.1290	0.1760
02	0.0923	0.1434	0.1943
03	0.0958	0.1471	0.1974
04	0.1287	0.2010	0.2735
05	0.1399	0.2154	0.2896
06	0.1665	0.2586	0.3504
07	0.1820	0.2811	0.3792
08	0.1895	0.2920	0.3930
09	0.2122	0.3268	0.4396
10	0.2209	0.3395	0.4558
11	0.2960	0.4578	0.6183
12	0.3036	0.4689	0.6324
13	0.3329	0.5140	0.6930
14	0.3604	0.5561	0.7493
15	0.3694	0.5691	0.7658
16	0.4011	0.6192	0.8349
17	0.4388	0.6773	0.9130
18	0.4596	0.7075	0.9513
19	0.4857	0.7474	1.0047
20	0.4974	0.7643	1.0261
21	0.5088	0.7809	1.0473
22	0.5475	0.8405	1.1276
24	0.6213	0.9503	1.2707

* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Radial Stiffness
2MMV9100HX Series
(For Duplex Set*)

2MMV9100HX SERIES

Bore Number	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)
00	0.4690	0.6743	0.8414
01	0.4924	0.7094	0.8860
02	0.5552	0.8029	1.0042
03	0.5803	0.8462	1.0610
04	0.7711	1.1124	1.3900
05	0.8471	1.2328	1.5450
06	1.0017	1.4486	1.8119
07	1.0995	1.5956	1.9980
08	1.1464	1.6666	2.0882
09	1.2837	1.8669	2.3394
10	1.3380	1.9498	2.4445
11	1.7862	2.5895	3.2417
12	1.8341	2.6618	3.3332
13	2.0115	2.9198	3.6566
14	2.1789	3.1645	3.9637
15	2.2347	3.2491	4.0710
16	2.5122	3.6526	4.5762
17	2.6524	3.8513	4.8236
18	2.7819	4.0479	5.0729
19	2.9406	4.2802	5.3645
20	3.0125	4.3899	5.5038
21	3.0831	4.4984	5.6416
22	3.3169	4.8377	6.0665
24	3.5654	5.2038	6.5275

* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

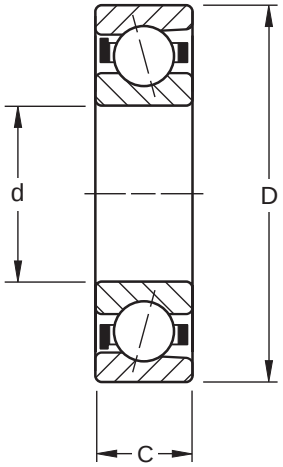
Spacer Offsets
2MMV9100HX Series
(For Duplex Set*)

2MMV9100HX – SERIES

Bore Number	X-Light to Light (in.)	Light to Medium (in.)	Medium to Heavy (in.)
04	0.00018	0.00034	0.00051
05	0.00016	0.00046	0.00048
06	0.00019	0.00056	0.00059
07	0.00017	0.00052	0.00055
08	0.00017	0.00056	0.00052
09	0.00021	0.00059	0.00063
10	0.00020	0.00056	0.00060
11	0.00018	0.00053	0.00056
12	0.00018	0.00052	0.00055
13	0.00020	0.00056	0.00060
14	0.00021	0.00061	0.00064
15	0.00021	0.00059	0.00063
16	0.00025	0.00070	0.00074
17	0.00026	0.00071	0.00075
18	0.00025	0.00068	0.00072
19	0.00028	0.00077	0.00082
20	0.00027	0.00076	0.00080
21	0.00026	0.00074	0.00079
22	0.00027	0.00075	0.00079
24	0.00029	0.00081	0.00086

* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Extra-Light 2MM9100WI & 3MM9100WI Series



Superprecision MM:
Superprecision bearings are manufactured to a ABEC-7 (ISO P4) tolerance class.

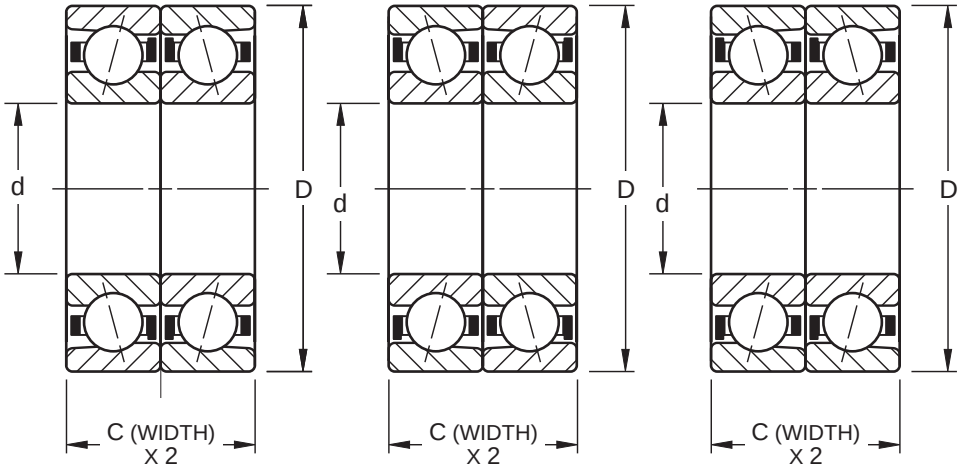
WI Construction:
This design incorporates a low shoulder on the non-thrust side of the outer rings. The maximum complement of balls is separated by a one-piece cage which is piloted against the ground land of the outer ring.

To specify a ceramic hybrid bearing, add “C” to the part number, after the prefix that specifies precision type.

DIMENSIONS – TOLERANCES
All inch tolerance in .0001 units

Bearing Number	Bore				Outside Diameter				Width *				Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement	
	Nominal Dimension		Tolerance +.0000" +.0μm to minus		Nominal Dimension		Tolerance +.0000" +.0μm to minus		Nominal Dimension		Tolerance +.0000" +.0μm to minus					
2MM & 3MM	in.	mm	in.	μm	in.	mm	in.	μm	in.	mm	in.	μm	in.	mm	Qty.	(Dia.) in.
9100WI	0.3937	10	1.5	4	1.0236	26	2.0	5	0.3150	8	16	40	0.012	0.3	8	3/16
9101WI	0.4724	12	1.5	4	1.1024	28	2.0	5	0.3150	8	31	80	0.012	0.3	10	3/16
9102WI	0.5906	15	1.5	4	1.2598	32	2.5	6	0.3543	9	31	80	0.012	0.3	12	3/16
9103WI	0.6693	17	1.5	4	1.3780	35	2.5	6	0.3937	10	31	80	0.012	0.3	11	3/16
9104WI	0.7874	20	2.0	5	1.6535	42	2.5	6	0.4724	12	47	120	0.024	0.6	11	1/4
9105WI	0.9843	25	2.0	5	1.8504	47	2.5	6	0.4724	12	47	120	0.024	0.6	13	1/4
9106WI	1.1811	30	2.0	5	2.1654	55	3.0	7	0.5118	13	47	120	0.039	1.0	14	9/32
9107WI	1.3780	35	2.5	6	2.4409	62	3.0	7	0.5512	14	47	120	0.039	1.0	15	5/16
9108WI	1.5748	40	2.5	6	2.6772	68	3.0	7	0.5906	15	47	120	0.039	1.0	16	5/16
9109WI	1.7717	45	2.5	6	2.9528	75	3.0	7	0.6299	16	47	120	0.039	1.0	17	11/32
9110WI	1.9685	50	2.5	6	3.1496	80	3.0	7	0.6299	16	47	120	0.039	1.0	18	11/32
9111WI	2.1654	55	3.0	7	3.5433	90	3.0	8	0.7087	18	59	150	0.039	1.0	18	13/32
9112WI	2.3622	60	3.0	7	3.7402	95	3.0	8	0.7087	18	59	150	0.039	1.0	19	13/32
9113WI	2.5591	65	3.0	7	3.9370	100	3.0	8	0.7087	18	59	150	0.039	1.0	20	13/32
9114WI	2.7559	70	3.0	7	4.3307	110	3.0	8	0.7874	20	59	150	0.039	1.0	19	15/32

* Refer to page E4 for width tolerance of preloaded bearings.
** ABMA std. 20 ($r_{as\ max}$).



Back-to-Back
DB

Face-to-Face
DF

Tandem
DT

WI Type Duplex Mounting Arrangements

DIMENSIONS – TOLERANCES
All inch tolerance in .0001 units

Bearing Number	Bore				Outside Diameter				Width *				Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement	
	Nominal Dimension		Tolerance +.0000" +.0μm to minus		Nominal Dimension		Tolerance +.0000" +.0μm to minus		Nominal Dimension		Tolerance +.0000" +.0μm to minus					
2MM & 3MM	in.	mm	in.	μm	in.	mm	in.	μm	in.	mm	in.	μm	in.	mm	Qty.	(Dia.) in.
9115WI	2.9528	75	3.0	7	4.5276	115	3.0	8	0.7874	20	59	150	0.039	1.0	20	15/32
9116WI	3.1496	80	3.0	7	4.9213	125	3.5	9	0.8661	22	59	150	0.039	1.0	20	17/32
9117WI	3.3465	85	3.0	8	5.1181	130	3.5	9	0.8661	22	79	200	0.039	1.0	21	17/32
9118WI	3.5433	90	3.0	8	5.5118	140	3.5	9	0.9449	24	79	200	0.059	1.5	20	19/32
9119WI	3.7402	95	3.0	8	5.7087	145	3.5	9	0.9449	24	79	200	0.059	1.5	21	19/32
9120WI	3.9370	100	3.0	8	5.9055	150	3.5	9	0.9449	24	79	200	0.059	1.5	22	19/32
9121WI	4.1339	105	3.0	8	6.2992	160	4.0	10	1.0236	26	79	200	0.079	2.0	21	21/32
9122WI	4.3307	110	3.0	8	6.6929	170	4.0	10	1.1024	28	79	200	0.079	2.0	22	11/16
9124WI	4.7244	120	3.0	8	7.0866	180	4.0	10	1.1024	28	79	200	0.079	2.0	23	11/16
9126WI	5.1181	130	4.0	10	7.8740	200	4.5	11	1.2992	33	98	250	0.079	2.0	21	13/16
9128WI	5.5118	140	4.0	10	8.2677	210	4.5	11	1.2992	33	98	250	0.079	2.0	22	13/16
9130WI	5.9055	150	4.0	10	8.8583	225	4.5	11	1.3780	35	98	250	0.079	2.0	22	7/8
9132WI	6.2992	160	4.0	10	9.4488	240	4.5	11	1.4961	38	98	250	0.079	2.0	22	15/16
9134WI	6.6929	170	4.0	10	10.2362	260	5.0	13	1.6535	42	98	250	0.079	2.0	22	1 1/16
9136WI	7.0866	180	4.0	10	11.0236	280	5.0	13	1.8110	46	98	250	0.079	2.0	20	1 3/16
9140WI	7.8740	200	4.5	12	12.2047	310	5.0	13	2.0079	51	118	300	0.079	2.0	20	1 5/16

* Refer to page E4 for width tolerance of preloaded bearings.
** ABMA std. 20 ($r_{as\ max}$).

Extra-Light
2MM9100WI Series

PHYSICAL CHARACTERISTICS – LOAD RATINGS

RADIAL LOAD RATING AT 33 1/3 RPM
Based on 1500 hours L_{10} Life and Permissible Speed

Bearing Number	Weight Per Bearing		Static Load Rating C_o		Extended Dynamic Load Ratings C_e		Permissible Speed Ng *	Preload Levels **							
								Extralight (DUX)		Light (DUL)		Medium (DUM)		Heavy (DUH)	
	lbs	kg	lbs	N	lbs	N	RPM	lbs	N	lbs	N	lbs	N	lbs	N
2MM9100WI	0.04	0.018	490	2,200	1,210	5,400	68,500	—	—	3	13	6	25	12	55
2MM9101WI	0.04	0.020	650	2,900	1,430	6,400	57,300	—	—	5	20	10	45	20	90
2MM9102WI	0.07	0.030	820	3,600	1,630	7,300	48,600	—	—	5	20	15	65	30	130
2MM9103WI	0.08	0.038	770	3,400	1,530	6,800	43,100	—	—	5	20	20	90	35	160
2MM9104WI	0.15	0.067	1,350	6,000	2,600	11,600	37,100	—	—	10	45	20	90	40	180
2MM9105WI	0.17	0.077	1,660	7,400	2,900	12,900	30,900	—	—	10	45	25	110	60	270
2MM9106WI	0.25	0.113	2,310	10,300	3,770	16,800	25,500	—	—	15	65	30	130	75	330
2MM9107WI	0.33	0.151	3,070	13,700	4,760	21,200	22,600	—	—	20	90	50	220	90	400
2MM9108WI	0.41	0.187	3,360	14,900	4,920	21,900	19,900	—	—	20	90	50	220	100	440
2MM9109WI	0.53	0.240	4,330	19,300	6,080	27,000	17,900	—	—	30	130	60	270	125	560
2MM9110WI	0.57	0.258	4,670	20,800	6,270	27,900	16,300	20	89	30	130	60	270	150	670
2MM9111WI	0.84	0.383	6,420	28,600	8,500	37,800	14,700	25	110	35	160	75	330	150	670
2MM9112WI	0.90	0.409	6,860	30,500	8,730	38,800	13,600	25	110	40	180	75	330	200	890
2MM9113WI	0.96	0.435	7,330	32,600	8,950	39,800	12,700	25	110	50	220	100	440	200	890
2MM9114WI	1.33	0.604	9,150	40,700	11,300	50,300	11,700	30	130	60	270	125	560	250	1110
2MM9115WI	1.41	0.638	9,790	43,500	11,600	51,600	11,000	30	130	60	270	125	560	275	1220
2MM9116WI	1.89	0.859	12,400	55,200	14,600	64,900	10,300	35	160	70	310	150	670	350	1560
2MM9117WI	1.99	0.901	13,200	58,700	15,000	66,700	9,700	40	180	80	360	175	780	375	1670
2MM9118WI	2.58	1.170	15,500	68,900	17,900	79,600	9,200	40	180	100	440	200	890	400	1780
2MM9119WI	2.69	1.222	16,500	73,400	18,300	81,400	8,700	45	200	110	490	220	980	445	1980
2MM9120WI	2.86	1.299	17,400	77,400	18,800	83,600	8,300	50	220	125	560	250	1110	450	2000
2MM9121WI	3.57	1.617	20,100	89,400	22,000	97,900	7,900	55	240	135	600	275	1220	550	2450
2MM9122WI	4.50	2.043	23,100	102,700	24,600	109,400	7,500	60	270	150	670	300	1330	600	2670
2MM9124WI	4.81	2.180	24,400	108,500	25,000	111,200	6,900	65	290	175	780	350	1560	650	2890
2MM9126WI	7.21	3.273	30,800	137,000	32,200	143,200	6,400	75	330	200	890	400	1780	825	3670
2MM9128WI	7.62	3.454	32,600	145,000	32,900	146,300	5,900	85	380	225	1000	450	2000	875	3890
2MM9130WI	9.26	4.200	37,800	168,100	37,600	167,200	5,600	100	440	250	1110	550	2450	1000	4450
2MM9132WI	11.44	5.188	43,300	192,600	42,600	189,500	5,200	110	490	300	1330	600	2670	1200	5340
2MM9134WI	15.43	6.999	55,200	245,500	52,600	234,000	4,900	130	580	375	1670	750	3340	1500	6670
2MM9136WI	20.40	9.250	62,100	276,200	58,100	258,400	4,600	150	670	390	1730	780	3470	1560	6940
2MM9140WI	26.78	12.148	75,800	337,200	66,700	296,700	4,100	210	930	500	2220	1000	4450	2000	8900

* Limits shown for a single row, spring preloaded and grease lubricated bearing.
** All ceramic hybrid bearing preloads are equivalent to the table above.

Extra-Light
2MM9100WI Series

Superprecision Bearings

FTF Fundamental Train Frequency: The frequency at which the retainer will operate.

BSF Ball Spin Frequency: The frequency at which a single defect on a rolling element will be detected.

BPFO Ball Pass Frequency Outer: The frequency at which a single defect in the outer race will be detected.

BPFI Ball Pass Frequency Inner: The frequency at which a single defect in the inner race will be detected.

FREQUENCY COEFFICIENTS

Bearing Number	FTF Fundamental Train Frequency (Inner Rotation)	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner	FTF Fundamental Train Frequency (Outer Rotation)
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
2MM9140WI	0.4369	3.7645	8.7378	11.2622	0.5631

Extra-Light
3MM9100WI Series

PHYSICAL CHARACTERISTICS – LOAD RATINGS

RADIAL LOAD RATING AT 33 1/3 RPM
Based on 1500 hours L_{10} Life and Permissible Speed

Bearing Number	Weight Per Bearing		Static Load Rating C_o		Extended Dynamic Load Ratings C_e		Permissible Speed Ng *	Preload Levels **							
								Extralight (DUX)		Light (DUL)		Medium (DUM)		Heavy (DUH)	
	lbs	kg	lbs	N	lbs	N	RPM	lbs	N	lbs	N	lbs	N	lbs	N
3MM9100WI	0.04	0.018	480	2,100	1,190	5,300	61,700	—	—	5	20	10	45	20	90
3MM9101WI	0.04	0.020	630	2,800	1,390	6,200	51,600	—	—	10	45	20	90	40	180
3MM9102WI	0.07	0.030	790	3,530	1,580	7,020	43,700	—	—	10	45	20	90	40	180
3MM9103WI	0.08	0.038	750	3,300	1,480	6,600	38,800	—	—	15	65	35	160	50	220
3MM9104WI	0.15	0.067	1,290	5,700	2,500	11,100	33,400	—	—	20	90	40	180	75	330
3MM9105WI	0.17	0.077	1,590	7,100	2,770	12,300	27,800	—	—	20	90	50	220	90	400
3MM9106WI	0.25	0.113	2,200	9,900	3,600	16,000	23,000	—	—	30	130	65	290	120	530
3MM9107WI	0.33	0.151	2,930	13,000	4,540	20,200	20,300	—	—	35	160	80	360	160	710
3MM9108WI	0.41	0.187	3,190	14,200	4,670	20,800	17,900	—	—	40	180	100	440	170	760
3MM9109WI	0.53	0.240	4,110	18,300	5,760	25,600	16,100	—	—	50	220	125	560	220	980
3MM9110WI	0.57	0.258	4,430	19,700	5,910	26,300	14,700	25	110	55	240	150	670	240	1070
3MM9111WI	0.84	0.383	6,110	27,200	8,080	35,900	13,200	30	130	75	330	175	780	300	1330
3MM9112WI	0.90	0.409	7,470	33,200	8,290	36,900	12,200	35	160	80	360	200	890	325	1450
3MM9113WI	0.96	0.435	6,970	31,000	8,480	37,700	11,400	40	180	80	360	200	890	350	1560
3MM9114WI	1.33	0.604	8,730	38,800	10,700	47,600	10,500	45	200	100	440	250	1110	450	2000
3MM9115WI	1.41	0.638	9,260	41,200	11,000	48,900	9,900	50	220	110	490	275	1220	475	2110
3MM9116WI	1.89	0.859	11,800	52,500	13,800	61,400	9,300	55	240	140	620	350	1560	600	2670
3MM9117WI	1.99	0.901	12,500	55,600	14,200	63,200	8,700	60	270	150	670	375	1670	650	2890
3MM9118WI	2.58	1.170	14,800	65,800	16,900	75,200	8,300	65	270	170	760	400	1780	750	3340
3MM9119WI	2.69	1.222	15,600	69,400	17,400	77,400	7,800	65	290	185	820	445	1980	775	3450
3MM9120WI	2.86	1.299	16,500	73,400	17,800	79,200	7,500	75	330	190	850	450	2000	800	3560
3MM9121WI	3.57	1.617	19,000	84,500	20,700	92,100	7,100	80	360	215	960	460	2050	920	4090
3MM9122WI	4.50	2.043	21,900	97,400	23,200	103,200	6,800	90	400	250	1110	600	2670	1100	4890
3MM9124WI	4.81	2.180	23,200	103,200	23,600	105,000	6,200	100	440	275	1220	650	2890	1150	5120
3MM9126WI	7.21	3.273	29,200	129,900	30,500	135,700	5,800	115	510	340	1510	825	3670	1500	6670
3MM9128WI	7.62	3.454	30,900	137,400	31,100	138,300	5,300	130	580	350	1560	875	3890	1550	6890
3MM9130WI	9.26	4.200	35,800	159,200	35,500	157,900	5,000	145	640	400	1780	1000	4450	1800	8010
3MM9132WI	11.44	5.188	41,100	182,800	40,300	179,300	4,700	170	760	500	2220	1200	5340	2000	8900
3MM9134WI	15.43	6.999	52,300	232,600	49,700	221,100	4,400	210	930	625	2780	1300	5780	2600	11560
3MM9136WI	20.40	9.250	59,000	262,400	55,000	244,400	4,200	230	1020	700	3110	1400	6230	2800	12460
3MM9140WI	26.78	12.148	72,200	321,100	63,200	281,100	3,700	280	1250	850	3780	2000	8900	3600	16010

* Limits shown for a single row, spring preloaded and grease lubricated bearing.
** All ceramic hybrid bearing preloads are equivalent to the table above.

Extra-Light
3MM9100WI Series

Superprecision Bearings

FTF Fundamental Train Frequency: The frequency at which the retainer will operate.

BSF Ball Spin Frequency: The frequency at which a single defect on a rolling element will be detected.

BPFO Ball Pass Frequency Outer: The frequency at which a single defect in the outer race will be detected.

BPFI Ball Pass Frequency Inner: The frequency at which a single defect in the inner race will be detected.

FREQUENCY COEFFICIENTS

Bearing Number	FTF Fundamental Train Frequency (Inner Rotation)	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner	FTF Fundamental Train Frequency (Outer Rotation)
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

Extra-Light
9100WI Series

PERMISSIBLE OPERATING SPEEDS – RPM
2MM & 3MM Superprecision Angular Contact Spindle Bearings

	GREASE							OIL		
	"DB" Mounting			Grease Capacity		High Speed Grease		"DB" Mounting		
15 Degree Contact Angle	(DUL) Light	(DUM) Medium	(DUH) Heavy	25 % (grams)	40 % (grams)	15 % (grams)	20 % (grams)	(DUL) Light	(DUM) Medium	(DUH) Heavy
2MM9100WI	54,800	41,100	27,400	0.2	0.4	0.15	0.20	93,200	69,900	46,600
2MM9101WI	45,800	34,400	22,900	0.3	0.4	0.17	0.22	77,900	58,500	38,900
2MM9102WI	38,900	29,200	19,400	0.3	0.5	0.22	0.29	66,100	49,600	33,000
2MM9103WI	34,500	25,900	17,200	0.4	0.7	0.28	0.37	58,700	44,000	29,200
2MM9104WI	29,700	22,300	14,800	0.7	1.2	0.50	0.66	50,500	37,900	25,200
2MM9105WI	24,700	18,500	12,400	0.9	1.4	0.59	0.78	42,000	31,500	21,100
2MM9106WI	20,400	15,300	10,200	1.3	2.0	0.84	1.12	34,700	26,000	17,300
2MM9107WI	18,100	13,600	9,000	1.6	2.6	1.09	1.46	30,800	23,100	15,300
2MM9108WI	15,900	11,900	8,000	2.0	3.2	1.35	1.80	27,000	20,200	13,600
2MM9109WI	14,300	10,000	7,200	2.5	4.0	1.68	2.24	24,300	18,200	12,200
2MM9110WI	13,000	9,800	6,500	2.8	4.4	1.9	2.5	22,100	16,700	11,100
2MM9111WI	11,800	8,800	5,900	4.0	6.4	2.7	3.5	20,100	15,000	10,000
2MM9112WI	10,900	8,200	5,400	4.2	6.8	2.8	3.8	18,500	13,900	9,200
2MM9113WI	10,200	7,600	5,100	4.5	7.2	3.0	4.0	17,300	12,900	8,700
2MM9114WI	9,400	7,000	4,700	6.3	10.0	4.2	5.6	16,000	11,900	8,000
2MM9115WI	8,800	6,600	4,400	6.6	10.6	4.4	5.9	15,000	11,200	7,500
2MM9116WI	8,200	6,200	4,100	8.6	13.8	5.8	7.7	13,900	10,500	7,000
2MM9117WI	7,800	5,800	3,900	9.1	14.5	6.0	8.1	13,300	9,900	6,600
2MM9118WI	7,400	5,500	3,700	11.7	18.8	7.8	10.4	12,600	9,400	6,300
2MM9119WI	7,000	5,200	3,500	12.2	19.5	8.1	10.9	11,900	8,800	6,000
2MM9120WI	6,600	5,000	3,300	12.1	19.4	8.1	10.8	11,200	8,500	5,600
2MM9121WI	6,300	4,700	3,200	15.9	25.4	10.6	14.1	10,700	8,000	5,400
2MM9122WI	6,000	4,500	3,000	18.9	30.2	12.6	16.8	10,200	7,700	5,100
2MM9124WI	5,500	4,100	2,800	20.5	32.8	13.7	18.2	9,400	7,000	4,800
2MM9126WI	5,100	3,800	2,600	31.7	50.7	21.1	28.2	8,700	6,500	4,400
2MM9128WI	4,700	3,500	2,400	33.8	54.0	22.5	30.1	8,000	6,000	4,100
2MM9130WI	4,500	3,400	2,200	41.1	65.7	27.4	36.5	7,700	5,800	3,700
2MM9132WI	4,200	3,100	2,100	51.0	81.6	34.1	45.4	7,100	5,300	3,600
2MM9134WI	3,900	2,900	2,000	66.3	106.0	44.2	59.0	6,600	4,900	3,400
2MM9136WI	3,700	2,800	1,800	88.4	141.5	59.0	78.7	6,200	4,700	3,100
2MM9140WI	3,300	2,500	1,600	121.0	193.5	80.7	107.6	5,600	4,300	2,700

Notes: For 3MM (25 Degree Contact Angle) Spindle Bearings, use 90% of the Permissible Operating Speeds above.

* For 2MMC and 3MMC Spindle Bearings, use 120% of the Permissible Operating Speeds.

For other bearing configurations beside a back-to-back mounted duplex set, please refer to page E36 to calculate the permissible operating speed (Sp.).

Axial Stiffness
9100WI Series
(For Duplex Set*)

2MM9100WI SERIES					3MM9100WI SERIES				
Bore #	X-Light (10^6 LB/IN.)	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)	Bore #	X-Light (10^6 LB/IN.)	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)
00	0.808	0.939	0.123	0.163	00	0.123	0.142	0.182	0.236
01	0.108	0.131	0.172	0.230	01	0.164	0.197	0.253	0.329
02	0.115	0.139	0.215	0.290	02	0.175	0.209	0.313	0.409
03	0.115	0.139	0.243	0.311	03	0.175	0.210	0.349	0.435
04	0.012	0.159	0.213	0.290	04	0.231	0.295	0.379	0.492
05	0.161	0.176	0.258	0.384	05	0.303	0.328	0.457	0.638
06	0.173	0.204	0.274	0.420	06	0.346	0.400	0.514	0.728
07	0.194	0.246	0.364	0.479	07	0.393	0.485	0.678	0.848
08	0.221	0.255	0.377	0.521	08	0.446	0.506	0.706	0.919
09	0.240	0.310	0.418	0.590	09	0.503	0.629	0.809	1.068
10	0.261	0.320	0.431	0.664	10	0.628	0.812	1.187	1.433
11	0.303	0.358	0.493	0.676	11	0.688	0.935	1.287	1.595
12	0.323	0.390	0.508	0.799	12	0.743	0.991	1.402	1.702
13	0.344	0.441	0.594	0.820	13	0.804	1.023	1.446	1.808
14	0.357	0.477	0.652	0.899	14	0.848	1.130	1.595	2.015
15	0.382	0.491	0.671	0.967	15	0.910	1.209	1.708	2.123
16	0.408	0.531	0.732	1.084	16	0.975	1.373	1.939	2.402
17	0.429	0.577	0.806	1.150	17	1.039	1.452	2.052	2.554
18	0.424	0.606	0.817	1.130	18	1.052	1.502	2.071	2.659
19	0.453	0.648	0.876	1.221	19	1.109	1.597	2.224	2.774
20	0.485	0.703	0.952	1.257	20	1.184	1.661	2.298	2.888
21	0.510	0.730	0.993	1.375	21	1.243	1.763	2.342	3.075
22	0.545	0.790	1.065	1.471	22	1.330	1.932	2.684	3.412
24	0.588	0.865	1.170	1.565	24	1.437	2.058	2.845	3.568
26	0.601	0.884	1.192	1.674	26	1.481	2.183	3.048	3.866
28	0.646	0.954	1.290	1.764	28	1.585	2.273	3.208	4.028
30	0.703	1.017	1.433	1.898	30	1.699	2.448	3.454	4.361
32	0.744	1.111	1.500	2.078	32	1.827	2.691	3.745	4.588
34	0.809	1.234	1.667	2.309	34	2.055	3.036	3.995	5.251
36	0.819	1.198	1.616	2.233	36	2.050	3.052	3.956	5.196
40	0.972	1.375	1.853	2.561	40	2.262	3.366	4.644	5.864

* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Radial Stiffness 9100WI Series (For Duplex Set*)

2MM9100WI SERIES				3MM9100WI SERIES			
Bore #	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)	Bore #	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)
00	0.3754	0.4790	0.6020	00	0.3626	0.4597	0.5767
01	0.5209	0.6592	0.8255	01	0.5333	0.6709	0.8374
02	0.5539	0.8028	1.0017	02	0.5680	0.7154	0.8939
03	0.5540	0.8809	1.0512	03	0.6509	0.8569	0.9589
04	0.8278	1.0441	1.3041	04	0.7882	0.9912	1.2121
05	0.9229	1.2568	1.6608	05	0.8801	1.1930	1.4395
06	1.1599	1.4649	1.9641	06	1.1170	1.4427	1.7551
07	1.3877	1.8841	2.2724	07	1.2722	1.6754	2.0918
08	1.4473	1.9681	2.4551	08	1.3894	1.8814	2.2285
09	1.7883	2.2539	2.8499	09	1.6065	2.1765	2.6070
10	1.8566	2.3423	3.1380	10	1.7232	2.3994	2.7864
11	2.0492	2.6558	3.3225	11	2.0264	2.6839	3.1895
12	2.2246	2.7537	3.7753	12	2.1466	2.9068	3.3944
13	2.4856	3.1325	3.9105	13	2.2203	3.0095	3.5989
14	2.6839	3.4307	4.2828	14	2.4192	3.2798	3.9577
15	2.7754	3.5512	4.5710	15	2.5851	3.5019	4.1696
16	3.0301	3.9221	5.1481	16	2.9056	3.9372	4.6774
17	3.2774	4.2628	5.4399	17	3.0720	4.1611	4.9599
18	3.5589	4.4902	5.6092	18	3.2347	4.2995	5.2579
19	3.7973	4.7869	5.9979	19	3.4382	4.5999	5.4929
20	4.0905	5.1492	6.2139	20	3.5775	4.7639	5.7276
21	4.2128	5.3415	6.6668	21	3.7315	4.8099	6.0097
22	4.5288	5.7138	7.1380	22	4.1088	5.4970	6.6740
24	4.9166	6.1909	7.5465	24	4.3708	5.8135	6.9773
26	5.1327	6.4744	8.1656	26	4.6588	6.2531	7.5702
28	5.5106	6.9421	8.5876	28	4.8513	6.5769	7.8963
30	5.8567	7.6158	9.2186	30	5.1953	7.0453	8.5025
32	6.3811	8.0375	10.0299	32	5.7275	7.6534	9.0115
34	7.2290	9.1064	11.3637	34	6.4240	8.1980	10.2407
36	7.0951	8.9538	11.1864	36	6.4927	8.1819	10.2263
40	7.9862	10.0685	12.5714	40	7.1552	9.5082	11.4776

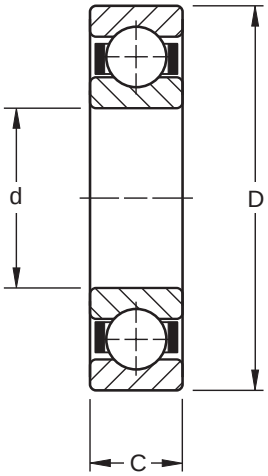
* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Spacer Offsets
9100WI Series
(For Duplex Set*)

2MM9100WI SERIES				3MM9100WI SERIES			
Bore #	X-Light to Light	Light to Medium	Medium to Heavy	Bore #	X-Light to Light	Light to Medium	Medium to Heavy
	(IN.)	(IN.)	(IN.)		(IN.)	(IN.)	(IN.)
00	0.00005	0.00011	0.00017	00	0.00003	0.00007	0.00011
01	0.00007	0.00013	0.00020	01	0.00004	0.00009	0.00014
02	0.00006	0.00023	0.00024	02	0.00004	0.00015	0.00017
03	0.00006	0.00031	0.00022	03	0.00004	0.00021	0.00015
04	0.00014	0.00021	0.00032	04	0.00008	0.00012	0.00018
05	0.00005	0.00028	0.00044	05	0.00003	0.00015	0.00025
06	0.00011	0.00025	0.00052	06	0.00005	0.00013	0.00029
07	0.00016	0.00039	0.00038	07	0.00008	0.00021	0.00021
08	0.00010	0.00038	0.00045	08	0.00005	0.00020	0.00025
09	0.00020	0.00033	0.00052	09	0.00010	0.00017	0.00028
10	0.00017	0.00032	0.00066	10	0.00015	0.00038	0.00027
11	0.00015	0.00038	0.00051	11	0.00021	0.00036	0.00035
12	0.00017	0.00031	0.00077	12	0.00021	0.00040	0.00032
13	0.00023	0.00039	0.00057	13	0.00017	0.00039	0.00037
14	0.00030	0.00046	0.00065	14	0.00022	0.00044	0.00044
15	0.00026	0.00045	0.00073	15	0.00023	0.00045	0.00042
16	0.00029	0.00051	0.00088	16	0.00029	0.00050	0.00046
17	0.00033	0.00055	0.00082	17	0.00029	0.00051	0.00048
18	0.00046	0.00056	0.00082	18	0.00033	0.00051	0.00059
19	0.00047	0.00058	0.00086	19	0.00035	0.00054	0.00053
20	0.00050	0.00060	0.00072	20	0.00032	0.00052	0.00054
21	0.00051	0.00065	0.00093	21	0.00035	0.00048	0.00068
22	0.00054	0.00065	0.00095	22	0.00039	0.00060	0.00066
24	0.00059	0.00069	0.00088	24	0.00040	0.00061	0.00062
26	0.00067	0.00077	0.00119	26	0.00049	0.00074	0.00078
28	0.00070	0.00080	0.00111	28	0.00046	0.00076	0.00075
30	0.00070	0.00098	0.00108	30	0.00049	0.00081	0.00082
32	0.00082	0.00092	0.00134	32	0.00058	0.00087	0.00077
34	0.00096	0.00103	0.00151	34	0.00065	0.00077	0.00112
36	0.00095	0.00111	0.00162	36	0.00073	0.00080	0.00122
40	0.00099	0.00124	0.00181	40	0.00080	0.00114	0.00122

* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Extra-Light
MM9100K Series
Deep Groove Conrad



Superprecision MM:
Superprecision bearings are manufactured to a ABEC-7 (ISO P4) tolerance class.

K Construction:
This design incorporates two full shoulders on both the inner and outer rings. The complement of balls are separated by a two-piece cage.

To specify a ceramic hybrid bearing, add “C” to the part number, after the prefix that specifies precision type.

DIMENSIONS – TOLERANCES
All inch tolerance in .0001 units

Bearing Number	Bore		Tolerance +.0000" +.0µm to minus		Outside Diameter		Tolerance +.0000" +.0µm to minus		Width		Tolerance +.0000" +.0µm to minus		Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement	
	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	Qty.	(Dia.)in.
MM9101K	0.4724	12	1.5	4	1.1024	28	2.0	5	0.3150	8	31	80	0.012	0.3	8	3/16
MM9103K	0.6693	17	1.5	4	1.3780	35	2.5	6	0.3937	10	31	80	0.012	0.3	10	3/16
MM9104K	0.7874	20	2.0	5	1.6535	42	2.5	6	0.4724	12	47	120	0.024	0.6	8	1/4
MM9105K	0.9843	25	2.0	5	1.8504	47	2.5	6	0.4724	12	47	120	0.024	0.6	10	1/4
MM9106K	1.1811	30	2.0	5	2.1654	55	3.0	7	0.5118	13	47	120	0.039	1.0	11	9/32
MM9107K	1.3780	35	2.5	6	2.4409	62	3.0	7	0.5512	14	47	120	0.039	1.0	11	5/16
MM9108K	1.5748	40	2.5	6	2.6772	68	3.0	7	0.5906	15	47	120	0.039	1.0	12	5/16
MM9109K	1.7717	45	2.5	6	2.9528	75	3.0	7	0.6299	16	47	120	0.039	1.0	13	11/32
MM9110K	1.9685	50	2.5	6	3.1496	80	3.0	7	0.6299	16	47	120	0.039	1.0	14	11/32
MM9111K	2.1654	55	3.0	7	3.5433	90	3.0	8	0.7087	18	59	150	0.039	1.0	13	13/32
MM9112K	2.3622	60	3.0	7	3.7402	95	3.0	8	0.7087	18	59	150	0.039	1.0	14	13/32
MM9113K	2.5591	65	3.0	7	3.9370	100	3.0	8	0.7087	18	59	150	0.039	1.0	15	13/32
MM9114K	2.7559	70	3.0	7	4.3307	110	3.0	8	0.7874	20	59	150	0.039	1.0	14	15/32
MM9115K	2.9528	75	3.0	7	4.5276	115	3.0	8	0.7874	20	59	150	0.039	1.0	15	15/32
MM9116K	3.1496	80	3.0	7	4.9213	125	3.5	9	0.8661	22	59	150	0.039	1.0	14	17/32
MM9117K	3.3465	85	3.0	8	5.1181	130	3.5	9	0.8661	22	79	200	0.039	1.0	15	17/32
MM9118K	3.5433	90	3.0	8	5.5118	140	3.5	9	0.9449	24	79	200	0.059	1.5	14	19/32
MM9120K	3.9370	100	3.0	8	5.9055	150	3.5	9	0.9449	24	79	200	0.059	1.5	15	19/32
MM9122K	4.3307	110	3.0	8	6.6929	170	4.0	10	1.1024	28	79	200	0.079	2.0	14	11/16
MM9124K	4.7244	120	3.0	8	7.0866	180	4.0	10	1.1024	28	79	200	0.079	2.0	15	11/16
MM9126K	5.1181	130	4.0	10	7.8740	200	4.5	11	1.2992	33	98	250	0.079	2.0	14	13/16

For standard, non-preloaded applications, do not exceed 350,000 dN.
** ABMA std. 20 ($r_{as\ max}$).

Extra-Light
MM9100K Series
Deep Groove Conrad

RADIAL LOAD RATING AT 33 1/3 RPM
Based on 1500 hours L_{10} Life and Permissible Speed

PHYSICAL CHARACTERISTICS – LOAD RATINGS

Bearing Number	Weight Per Bearing		Static Load Rating C_o		Extended Dynamic Load Ratings C_e		Permissible Speed Ng *
	lbs	kg	lbs	N	lbs	N	RPM
MM9101K	0.04	0.020	540	2,400	1,320	5,900	52,800
MM9103K	0.08	0.038	735	3,300	1,530	6,800	39,600
MM9104K	0.14	0.064	1,000	4,400	2,200	9,800	34,000
MM9105K	0.16	0.074	1,320	5,900	2,550	11,300	28,300
MM9106K	0.24	0.109	1,860	8,300	3,350	14,900	23,300
MM9107K	0.32	0.144	2,320	10,300	4,050	18,000	20,700
MM9108K	0.40	0.180	2,600	11,600	4,300	19,100	18,200
MM9109K	0.51	0.230	3,400	15,100	5,400	24,000	16,300
MM9110K	0.55	0.248	3,750	16,700	5,600	24,900	14,900
MM9111K	0.80	0.362	4,800	21,400	7,200	32,000	13,500
MM9112K	0.95	0.430	5,210	23,200	7,340	32,600	12,500
MM9113K	0.99	0.450	5,650	25,200	7,610	33,900	11,500
MM9114K	1.37	0.620	6,940	30,900	9,490	42,200	10,700
MM9115K	1.34	0.606	7,500	33,400	10,000	44,500	10,100
MM9116K	1.77	0.804	9,000	40,000	12,200	54,300	9,400
MM9117K	1.86	0.845	9,650	42,900	12,700	56,500	8,900
MM9118K	2.41	1.092	11,200	49,800	15,000	66,700	8,400
MM9120K	2.66	1.208	12,200	54,300	15,300	68,100	7,600
MM9122K	4.15	1.882	15,000	66,700	19,300	85,800	6,800
MM9124K	4.45	2.019	16,300	72,500	20,000	89,000	6,300
MM9126K	6.70	3.041	21,200	94,300	26,000	115,600	5,800

* Limits shown for a single row, spring preloaded and grease lubricated bearing.
For standard, non-preloaded applications, do not exceed 350,000 dN.

Extra-Light
MM9100K Series
Deep Groove Conrad

Superprecision Bearings

FTF Fundamental Train Frequency: The frequency at which the retainer will operate.

BSF Ball Spin Frequency: The frequency at which a single defect on a rolling element will be detected.

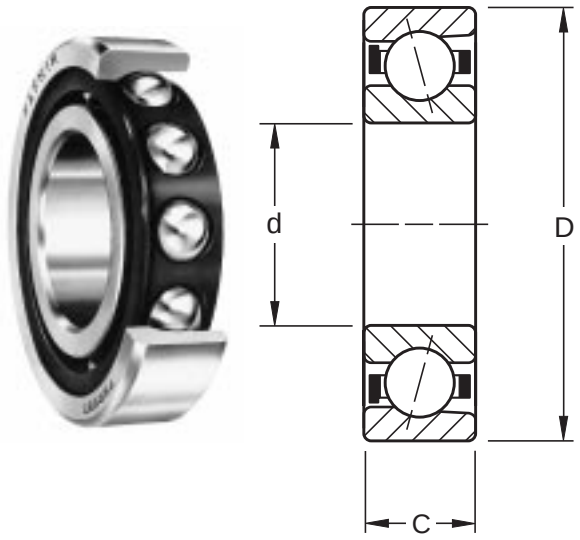
BPFO Ball Pass Frequency Outer: The frequency at which a single defect in the outer race will be detected.

BPFI Ball Pass Frequency Inner: The frequency at which a single defect in the inner race will be detected.

FREQUENCY COEFFICIENTS

Bearing Number	FTF Fundamental Train Frequency (Inner Rotation)	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner	FTF Fundamental Train Frequency (Outer Rotation)
MM9101K	0.3846	2.0513	3.0769	4.9231	0.6154
MM9103K	0.4082	2.6325	4.0823	5.9177	0.5918
MM9104K	0.3976	2.3386	3.1807	4.8193	0.6024
MM9105K	0.4118	2.7464	4.1180	5.8820	0.5882
MM9106K	0.4171	2.9329	4.5881	6.4119	0.5829
MM9107K	0.4182	2.9732	4.5998	6.4002	0.5818
MM9108K	0.4265	3.3281	5.1181	6.8819	0.5735
MM9109K	0.4272	3.3632	5.5541	7.4459	0.5728
MM9110K	0.4328	3.6550	6.0597	7.9403	0.5672
MM9111K	0.4288	3.4419	5.5749	7.4251	0.5712
MM9112K	0.4334	3.6888	6.0680	7.9320	0.5666
MM9113K	0.4375	3.9351	6.5619	8.4381	0.5625
MM9114K	0.4339	3.7134	6.0740	7.9260	0.5661
MM9115K	0.4373	3.9268	6.5600	8.4400	0.5627
MM9116K	0.4342	3.7322	6.0785	7.9215	0.5658
MM9117K	0.4374	3.9288	6.5605	8.4395	0.5626
MM9118K	0.4344	3.7471	6.0820	7.9180	0.5656
MM9120K	0.4397	4.0839	6.5951	8.4049	0.5603
MM9122K	0.4376	3.9462	6.1269	7.8731	0.5624
MM9124K	0.4418	4.2376	6.6271	8.3729	0.5582
MM9126K	0.4375	3.9351	6.1245	7.8755	0.5625

Light
2MM200WI Series
3MM200WI Series



Superprecision MM:
Superprecision bearings are manufactured to a ABEC-7 (ISO P4) tolerance class.

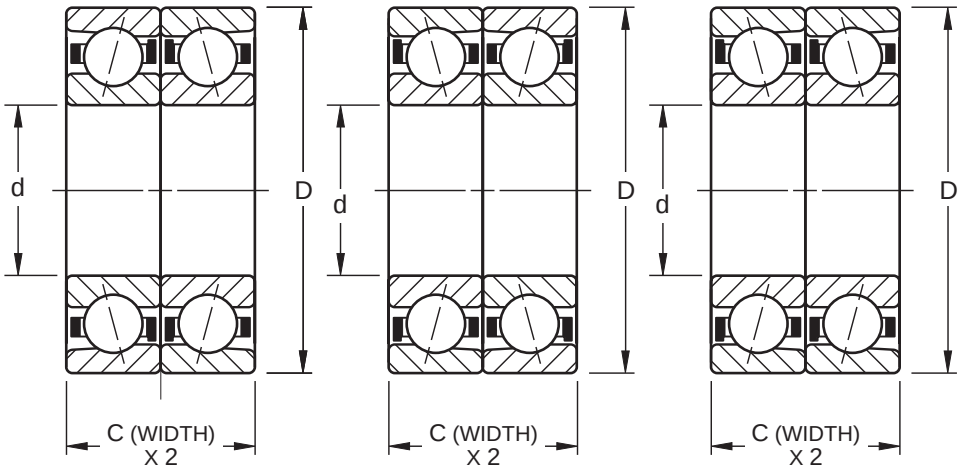
WI Construction:
This design incorporates a low shoulder on the non-thrust side of the outer rings. The maximum complement of balls is separated by a one-piece cage which is piloted against the ground land of the outer ring.

To specify a ceramic hybrid bearing, add “C” to the part number, after the prefix that specifies precision type.

DIMENSIONS – TOLERANCES
All inch tolerance in .0001 Units

Bearing Number	Bore				Outside Diameter				Width*				Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement	
	Nominal Dimension		Tolerance +.0000" +.0µm to minus		Nominal Dimension		Tolerance +.0000" +.0µm to minus		Nominal Dimension		Tolerance +.0000" +.0µm to minus					
2MM &3MM	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	Qty.	(Dia.)in.
200WI	0.3937	10	1.5	3.8	1.1811	30	2.0	5.1	0.3543	9	16	40	0.024	0.6	8	7/32
201WI	0.4724	12	1.5	3.8	1.2598	32	2.5	6.4	0.3937	10	31	80	0.024	0.6	9	15/64
202WI	0.5906	15	1.5	3.8	1.3780	35	2.5	6.4	0.4331	11	31	80	0.024	0.6	10	15/64
203WI	0.6693	17	1.5	3.8	1.5748	40	2.5	6.4	0.4724	12	31	80	0.024	0.6	10	17/64
204WI	0.7874	20	2.0	5.1	1.8504	47	2.5	6.4	0.5512	14	47	130	0.039	1.0	10	5/16
205WI	0.9843	25	2.0	5.1	2.0472	52	3.0	7.7	0.5906	15	47	130	0.039	1.0	12	5/16
206WI	1.1811	30	2.0	5.1	2.4409	62	3.0	7.7	0.6299	16	47	130	0.039	1.0	12	3/8
207WI	1.3780	35	2.5	6.4	2.8346	72	3.0	7.7	0.6693	17	47	130	0.039	1.0	12	7/16
208WI	1.5748	40	2.5	6.4	3.1496	80	3.0	7.7	0.7087	18	47	130	0.039	1.0	11	1/2
209WI	1.7717	45	2.5	6.4	3.3465	85	3.0	7.7	0.7480	19	47	130	0.039	1.0	13	1/2

* Refer to page E4 for width tolerance of preloaded bearings.
** ABMA std. 20 ($r_{as\ max}$).



Back-to-Back
DB

Face-to-Face
DF

Tandem
DT

WI Type Duplex Mounting Arrangements

DIMENSIONS – TOLERANCES
All inch tolerance in .0001 Units

Bearing Number	Bore				Outside Diameter				Width*				Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement	
	Nominal Dimension		Tolerance +.0000" +.0μm to minus		Nominal Dimension		Tolerance +.0000" +.0μm to minus		Nominal Dimension		Tolerance +.0000" +.0μm to minus					
2MM &3MM	in.	mm	in.	μm	in.	mm	in.	μm	in.	mm	in.	μm	in.	mm	Qty.	(Dia.)in.
210WI	1.9685	50	2.5	6.4	3.5433	90	3.0	7.7	0.7874	20	47	130	0.039	1.0	14	1/2
211WI	2.1654	55	3.0	7.7	3.9370	100	3.0	7.7	0.8268	21	59	150	0.059	1.5	14	9/16
212WI	2.3622	60	3.0	7.7	4.3307	110	3.0	7.7	0.8661	22	59	150	0.059	1.5	14	5/8
213WI	2.5591	65	3.0	7.7	4.7244	120	3.0	7.7	0.9055	23	59	150	0.059	1.5	14	21/32
214WI	2.7559	70	3.0	7.7	4.9213	125	3.5	9.0	0.9449	24	59	150	0.059	1.5	14	11/16
215WI	2.9528	75	3.0	7.7	5.1181	130	3.5	9.0	0.9843	25	59	150	0.059	1.5	15	11/16
216WI	3.1496	80	3.0	7.7	5.5118	140	3.5	9.0	1.0236	26	59	150	0.079	2.0	15	3/4
217WI	3.3465	85	3.0	7.7	5.9055	150	3.5	9.0	1.1024	28	79	200	0.079	2.0	15	13/16
218WI	3.5433	90	3.0	7.7	6.2992	160	4.0	10.3	1.1811	30	79	200	0.079	2.0	14	7/8
219WI	3.7402	95	3.0	7.7	6.6929	170	4.0	10.3	1.2598	32	79	200	0.079	2.1	14	15/16
220WI	3.9370	100	3.0	7.7	7.0866	180	4.0	10.3	1.3386	34	79	200	0.079	2.1	14	1
222WI	4.3307	110	3.0	7.7	7.8740	200	4.5	11.5	1.4961	38	79	200	0.079	2.1	14	1 1/8
224WI	4.7244	120	3.0	7.7	8.4646	215	4.5	11.5	1.5748	40	79	200	0.079	2.1	14	1 3/16
226WI	5.1181	130	4.0	10.3	9.0551	230	4.5	11.5	1.5748	40	98	250	0.098	2.5	17	1 3/16
230WI	5.9055	150	4.0	10.3	10.6299	270	5.0	12.8	1.7717	45	98	250	0.098	2.5	15	1 1/2

* Refer to page E4 for width tolerance of preloaded bearings.
** ABMA std. 20 ($r_{as\ max}$).

Light
2MM200WI Series

PHYSICAL CHARACTERISTICS – LOAD RATINGS

RADIAL LOAD RATING AT 33 1/3 RPM
Based on 1500 hours L_{10} Life and Permissible Speed

Bearing Number	Weight Per Bearing		Static Load Rating C_o		Extended Dynamic Load Ratings C_e		Permissible Speed Ng *	Preload Levels **							
								Extralight (DUX)		Light (DUL)		Medium (DUM)		Heavy (DUH)	
	lbs	kg	lbs	N	lbs	N	RPM	lbs	N	lbs	N	lbs	N	lbs	N
2MM200WI	0.07	0.030	660	2,900	1,630	7,300	62,800	—	—	5	20	20	90	35	160
2MM201WI	0.08	0.036	860	3,800	2,000	8,900	56,700	—	—	5	20	20	90	35	160
2MM202WI	0.10	0.044	1,010	4,500	2,200	9,800	47,800	—	—	5	20	20	90	40	180
2MM203WI	0.14	0.064	1,320	5,900	2,750	12,200	41,900	—	—	10	40	30	130	75	330
2MM204WI	0.23	0.103	1,810	8,100	3,750	16,700	35,700	—	—	15	70	40	180	80	360
2MM205WI	0.28	0.127	2,320	10,200	4,250	18,900	29,800	—	—	20	90	50	220	90	400
2MM206WI	0.43	0.195	3,310	14,700	5,850	26,000	25,100	—	—	20	90	50	220	125	560
2MM207WI	0.62	0.282	4,490	20,000	7,800	34,700	21,600	—	—	30	130	90	400	175	780
2MM208WI	0.78	0.352	5,340	23,800	9,300	41,400	19,300	—	—	30	130	100	440	200	890
2MM209WI	0.90	0.408	6,470	28,800	10,400	46,300	17,500	25	110	40	180	125	560	250	1110
2MM210WI	1.01	0.457	7,130	31,700	11,000	48,900	16,000	30	130	50	220	125	560	275	1220
2MM211WI	1.34	0.608	9,000	40,000	13,400	59,600	14,500	35	160	50	220	175	780	350	1560
2MM212WI	1.74	0.787	11,000	48,900	16,300	72,500	13,200	40	180	75	330	200	890	425	1890
2MM213WI	2.20	0.998	12,300	54,700	18,000	80,100	12,100	45	200	100	440	225	1000	475	2110
2MM214WI	2.37	1.074	13,400	60,000	19,300	85,800	11,400	50	220	100	440	250	1110	500	2220
2MM215WI	2.59	1.174	14,600	64,900	20,400	90,700	10,800	55	240	125	560	275	1220	550	2450
2MM216WI	3.19	1.448	17,300	77,000	23,600	105,000	10,100	60	270	150	670	325	1450	625	2780
2MM217WI	4.01	1.817	20,400	90,700	27,500	122,300	9,400	65	290	175	780	375	1670	750	3340
2MM218WI	4.84	2.196	22,000	97,900	30,000	133,400	8,900	75	330	175	780	400	1780	800	3560
2MM219WI	5.88	2.669	25,000	111,200	34,000	151,200	8,400	80	360	200	890	450	2000	900	4000
2MM220WI	7.07	3.209	28,500	126,800	38,000	169,000	8,000	85	380	250	1110	500	2220	1000	4450
2MM222WI	9.89	4.486	36,000	160,100	45,000	200,200	7,200	100	440	300	1330	600	2670	1200	5340
2MM224WI	11.81	5.358	40,500	180,100	48,000	213,500	6,700	110	490	330	1470	660	2940	1320	5870
2MM226WI	14.26	6.468	50,000	222,400	55,000	244,600	6,100	125	560	370	1650	740	3290	1480	6580
2MM230WI	22.00	9.980	68,000	302,500	69,500	309,100	5,300	155	690	425	1890	850	3780	1700	7560

* Limits shown for a single row, spring preloaded and grease lubricated bearing.
** All ceramic hybrid bearing preloads are equivalent to the table above.

Light
2MM200WI Series

Superprecision Bearings

FTF Fundamental Train Frequency: The frequency at which the retainer will operate.

BSF Ball Spin Frequency: The frequency at which a single defect on a rolling element will be detected.

BPFO Ball Pass Frequency Outer: The frequency at which a single defect in the outer race will be detected.

BPFI Ball Pass Frequency Inner: The frequency at which a single defect in the inner race will be detected.

FREQUENCY COEFFICIENTS

Bearing Number	FTF Fundamental Train Frequency (Inner Rotation)	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner	FTF Fundamental Train Frequency (Outer Rotation)
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

Light
3MM200WI Series

PHYSICAL CHARACTERISTICS – LOAD RATINGS

RADIAL LOAD RATING AT 33 1/3 RPM
Based on 1500 hours L_{10} Life and Permissible Speed

Bearing Number	Weight Per Bearing		Static Load Rating C_o		Extended Dynamic Load Ratings C_e		Permissible Speed Ng *	Preload Levels **							
								Extralight (DUX)		Light (DUL)		Medium (DUM)		Heavy (DUH)	
	lbs	kg	lbs	N	lbs	N	RPM	lbs	N	lbs	N	lbs	N	lbs	N
3MM200WI	0.07	0.030	640	2,800	1,600	7,100	56,500	—	—	10	40	30	130	60	270
3MM201WI	0.08	0.036	830	3,700	1,960	8,700	51,000	—	—	10	40	30	130	60	270
3MM202WI	0.10	0.044	980	4,400	2,120	9,400	43,000	—	—	15	70	40	180	80	360
3MM203WI	0.14	0.064	1,270	5,600	2,600	11,600	37,700	—	—	20	90	75	330	100	440
3MM204WI	0.23	0.103	1,730	7,700	3,550	15,800	32,100	—	—	30	130	80	360	125	560
3MM205WI	0.28	0.127	2,200	9,800	4,050	18,000	26,800	—	—	35	160	90	400	150	670
3MM206WI	0.43	0.195	3,150	14,000	5,600	24,900	22,600	—	—	50	220	125	560	200	890
3MM207WI	0.62	0.282	4,300	19,100	7,350	32,700	19,400	30	130	70	310	175	780	300	1330
3MM208WI	0.78	0.352	5,100	22,700	9,000	40,000	17,400	35	160	80	360	200	890	300	1330
3MM209WI	0.90	0.408	6,200	27,600	10,000	44,500	15,800	40	180	100	440	250	1110	400	1780
3MM210WI	1.01	0.457	6,800	30,200	10,400	46,300	14,400	45	200	110	490	275	1220	450	2000
3MM211WI	1.34	0.608	8,650	38,500	12,900	57,400	13,100	50	220	140	620	350	1560	550	2450
3MM212WI	1.74	0.787	10,600	47,100	15,600	69,400	11,900	55	240	170	760	425	1890	650	2890
3MM213WI	2.20	0.998	11,800	52,500	17,000	75,600	10,900	60	270	190	850	475	2110	750	3340
3MM214WI	2.37	1.074	12,900	57,400	18,600	82,700	10,300	65	290	200	890	500	2220	800	3560
3MM215WI	2.59	1.174	14,000	62,300	19,300	85,800	9,700	80	360	220	980	550	2450	850	3780
3MM216WI	3.19	1.448	16,600	73,800	22,000	97,900	9,100	90	400	250	1110	625	2780	1000	4450
3MM217WI	4.01	1.817	19,300	85,800	26,000	115,600	8,500	100	440	270	1200	675	3000	1100	4890
3MM218WI	4.84	2.196	20,800	92,500	28,500	126,800	8,000	110	490	300	1330	700	3110	1250	5560
3MM219WI	5.88	2.669	24,000	106,800	32,000	142,300	7,600	125	560	350	1560	700	3110	1400	6230
3MM220WI	7.07	3.209	27,000	120,100	36,000	160,100	7,200	135	600	390	1730	780	3470	1560	6940
3MM222WI	9.89	4.486	34,500	153,500	42,500	189,000	6,500	155	690	460	2050	920	4082	1840	8180
3MM224WI	11.81	5.358	39,000	173,500	46,500	206,800	6,000	185	820	505	2250	1010	4480	2020	8980
3MM226WI	14.26	6.468	47,500	211,300	52,000	231,300	5,500	220	980	575	2560	1150	5120	2300	10230
3MM230WI	22.00	9.980	65,500	291,300	67,000	298,000	4,800	290	1290	700	3110	1400	6230	2800	12450

* Limits shown for a single row, spring preloaded and grease lubricated bearing.
** All ceramic hybrid bearing preloads are equivalent to the table above.

Light
3MM200WI Series

Superprecision Bearings

FTF Fundamental Train Frequency: The frequency at which the retainer will operate.

BSF Ball Spin Frequency: The frequency at which a single defect on a rolling element will be detected.

BPFO Ball Pass Frequency Outer: The frequency at which a single defect in the outer race will be detected.

BPFI Ball Pass Frequency Inner: The frequency at which a single defect in the inner race will be detected.

FREQUENCY COEFFICIENTS

Bearing Number	FTF Fundamental Train Frequency (Inner Rotation)	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner	FTF Fundamental Train Frequency (Outer Rotation)
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	0.4205	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

Light
200WI Series

PERMISSIBLE OPERATING SPEEDS – RPM
2MM & 3MM Superprecision Angular Contact Spindle Bearings

	GREASE							OIL		
	"DB" Mounting			Grease Capacity		Kluber Isoflex NBU 15		"DB" Mounting		
15 Degree Contact Angle	(DUL) Light	(DUM) Medium	(DUH) Heavy	25 % (grams)	40 % (grams)	15 % (grams)	20 % (grams)	(DUL) Light	(DUM) Medium	(DUH) Heavy
2MM200WI	50,200	37,700	25,100	0.3	0.5	0.20	0.27	85,300	64,100	42,700
2MM201WI	45,400	34,000	22,200	0.4	0.6	0.25	0.33	79,100	57,800	39,400
2MM202WI	38,200	28,700	19,100	0.5	0.8	0.32	0.43	66,300	48,800	33,200
2MM203WI	33,500	25,100	16,500	0.7	1.1	0.45	0.59	58,100	42,700	29,100
2MM204WI	28,600	21,400	14,300	1.1	1.7	0.72	0.96	48,600	36,400	24,300
2MM205WI	23,800	17,900	11,900	1.3	2.1	0.88	1.18	40,500	30,400	20,200
2MM206WI	20,000	15,100	10,000	2.0	3.1	1.31	1.74	34,200	25,600	17,000
2MM207WI	17,300	13,000	8,600	2.7	4.4	1.82	2.43	29,400	22,000	14,600
2MM208WI	15,400	11,600	7,700	3.7	6.0	2.49	3.32	26,200	19,700	13,100
2MM209WI	14,000	10,500	7,000	4.2	6.6	2.77	3.70	22,800	17,900	11,900
2MM210WI	12,500	9,600	6,400	4.8	7.6	3.2	4.3	21,800	16,300	10,900
2MM211WI	11,600	8,700	5,800	6.1	9.7	4.1	5.4	19,700	14,800	9,900
2MM212WI	10,600	7,920	5,300	7.5	12.0	5.0	6.7	18,000	13,500	9,000
2MM213WI	9,700	7,260	4,800	9.2	14.6	6.1	8.1	16,500	12,300	8,200
2MM214WI	9,100	6,840	4,600	10.6	16.9	7.0	9.4	15,500	11,600	7,800
2MM215WI	8,600	6,480	4,300	11.6	18.6	7.8	10.3	14,600	11,020	7,300
2MM216WI	8,100	6,060	4,000	13.7	22.0	9.2	12.2	13,800	10,300	6,800
2MM217WI	7,500	5,640	3,800	16.9	27.1	11.3	15.1	12,800	9,590	6,500
2MM218WI	7,100	5,340	3,600	21.5	34.4	14.4	19.1	12,100	9,080	6,100
2MM219WI	6,700	5,040	3,400	25.8	41.4	17.3	23.0	11,400	8,570	5,800
2MM220WI	6,400	4,800	3,200	30.7	49.1	20.5	27.3	10,900	8,160	5,400
2MM222WI	5,800	4,320	2,900	42.3	67.6	28.2	37.6	9,900	7,340	4,900
2MM224WI	5,400	4,020	2,700	51.4	82.3	34.3	45.8	9,200	6,830	4,600
2MM226WI	4,900	3,660	2,400	50.8	81.3	33.9	45.2	8,300	6,220	4,100
2MM230WI	4,200	3,180	2,160	82.4	131.9	55.0	73.4	7,100	5,410	3,600

Notes: For 3MM (25 Degree Contact Angle) Spindle Bearings, use 90% of the Permissible Operating Speeds above.
* For 2MMC and 3MMC Spindle Bearings, use 120% of the Permissible Operating Speeds.
For other bearing configurations beside a back-to-back mounted duplex set, please refer to page E36 to calculate the permissible operating speed (Sp.).

Axial Stiffness
200WI Series
(For Duplex Set*)

2MM200WI SERIES

Bore #	X-Light (10^6 LB/IN.)	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)
00	0.009	0.106	0.189	0.245
01	0.091	0.110	0.195	0.252
02	0.097	0.118	0.207	0.284
03	0.127	0.146	0.235	0.365
04	0.140	0.172	0.264	0.368
05	0.169	0.215	0.323	0.428
06	0.190	0.219	0.323	0.498
07	0.220	0.270	0.434	0.597
08	0.233	0.259	0.433	0.603
09	0.266	0.321	0.525	0.733
10	0.295	0.367	0.547	0.798
11	0.310	0.362	0.626	0.879
12	0.338	0.444	0.681	0.980
13	0.358	0.505	0.722	1.036
14	0.388	0.513	0.766	1.069
15	0.417	0.586	0.831	1.161
16	0.444	0.647	0.910	1.245
17	0.461	0.682	0.957	1.339
18	0.472	0.668	0.962	1.344
19	0.496	0.721	1.029	1.435
20	0.508	0.787	1.070	1.494
22	0.564	0.880	1.192	1.657
24	0.588	0.908	1.233	1.716
26	0.693	1.066	1.443	2.003
30	0.745	1.102	1.480	2.036

3MM200WI SERIES

Bore #	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)
00	0.225	0.343	0.456
01	0.256	0.386	0.508
02	0.317	0.460	0.609
03	0.365	0.606	0.682
04	0.430	0.627	0.751
05	0.510	0.733	0.902
06	0.607	0.862	1.043
07	0.723	1.027	1.278
08	0.758	1.074	1.263
09	0.914	1.297	1.568
10	0.993	1.409	1.719
11	1.107	1.572	1.888
12	1.222	1.736	2.061
13	1.290	1.832	2.205
14	1.323	1.878	2.272
15	1.431	2.034	2.425
16	1.543	2.190	2.646
17	1.603	2.272	2.764
18	1.636	2.257	2.848
19	1.774	2.304	3.036
20	1.877	2.438	3.211
22	2.058	2.669	3.510
24	2.160	2.802	3.682
26	2.562	3.319	4.356
30	2.708	3.501	4.580

* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Radial Stiffness
200WI Series
(For Duplex Set*)

2MM200WI SERIES				3MM200WI SERIES			
Bore #	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)	Bore #	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)
00	0.491	0.778	0.927	00	0.484	0.694	0.863
01	0.549	0.878	1.048	01	0.538	0.777	0.969
02	0.587	0.943	1.175	02	0.663	0.916	1.140
03	0.784	1.129	1.504	03	0.760	1.169	1.280
04	0.963	1.332	1.657	04	0.912	1.258	1.448
05	1.198	1.619	1.949	05	1.084	1.478	1.738
06	1.272	1.733	2.320	06	1.298	1.754	2.036
07	1.540	2.219	2.737	07	1.529	2.064	2.449
08	1.496	2.245	2.797	08	1.576	2.131	2.424
09	1.846	2.702	3.364	09	1.899	2.564	2.976
10	2.094	2.841	3.647	10	2.059	2.780	3.249
11	2.189	3.330	4.143	11	2.329	3.143	3.627
12	2.609	3.615	4.588	12	2.573	3.473	3.974
13	2.926	3.823	4.840	13	2.713	3.662	4.232
14	2.972	4.024	5.010	14	2.818	3.806	4.417
15	3.356	4.349	5.411	15	3.046	4.112	4.720
16	3.659	4.718	5.801	16	3.261	4.406	5.115
17	3.961	5.089	6.336	17	3.433	4.645	5.427
18	3.880	5.097	6.346	18	3.481	4.603	5.537
19	4.156	5.333	6.764	19	3.749	4.715	5.885
20	4.550	5.718	7.124	20	3.969	4.994	6.235
22	5.039	6.336	7.898	22	4.359	5.489	6.858
24	5.300	6.667	8.311	24	4.607	5.802	7.249
26	6.229	7.847	9.793	26	5.455	6.808	8.599
30	6.500	8.218	10.280	30	5.774	7.297	9.138

* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Spacer Offsets
200WI Series
(For Duplex Set*)

2MM200WI SERIES				3MM200WI SERIES			
Bore #	X-Light to Light (in.)	Light to Medium (in.)	Medium to Heavy (in.)	Bore #	X-Light to Light (in.)	Light to Medium (in.)	Medium to Heavy (in.)
00	0.00008	0.00041	0.00028	00	0.00010	0.00028	0.00030
01	0.00008	0.00039	0.00027	01	0.00009	0.00025	0.00027
02	0.00007	0.00037	0.00033	02	0.00005	0.00026	0.00026
03	0.00009	0.00042	0.00060	03	0.00011	0.00045	0.00016
04	0.00015	0.00046	0.00051	04	0.00013	0.00038	0.00026
05	0.00019	0.00045	0.00043	05	0.00016	0.00035	0.00029
06	0.00012	0.00044	0.00073	06	0.00020	0.00041	0.00031
07	0.00020	0.00068	0.00066	07	0.00027	0.00048	0.00048
08	0.00011	0.00081	0.00077	08	0.00028	0.00052	0.00034
09	0.00020	0.00080	0.00080	09	0.00031	0.00054	0.00042
10	0.00025	0.00066	0.00089	10	0.00030	0.00055	0.00045
11	0.00019	0.00101	0.00093	11	0.00038	0.00062	0.00046
12	0.00038	0.00089	0.00109	12	0.00044	0.00069	0.00047
13	0.00053	0.00082	0.00114	13	0.00047	0.00073	0.00054
14	0.00044	0.00094	0.00109	14	0.00048	0.00075	0.00058
15	0.00057	0.00085	0.00111	15	0.00046	0.00076	0.00054
16	0.00067	0.00090	0.00112	16	0.00049	0.00080	0.00062
17	0.00075	0.00098	0.00131	17	0.00049	0.00083	0.00067
18	0.00071	0.00110	0.00139	18	0.00054	0.00082	0.00086
19	0.00079	0.00114	0.00146	19	0.00060	0.00068	0.00105
20	0.00102	0.00108	0.00156	20	0.00064	0.00072	0.00110
22	0.00111	0.00116	0.00169	22	0.00070	0.00078	0.00119
24	0.00116	0.00123	0.00179	24	0.00069	0.00081	0.00124
26	0.00110	0.00118	0.00172	26	0.00065	0.00078	0.00120
30	0.00116	0.00132	0.00194	30	0.00069	0.00090	0.00138

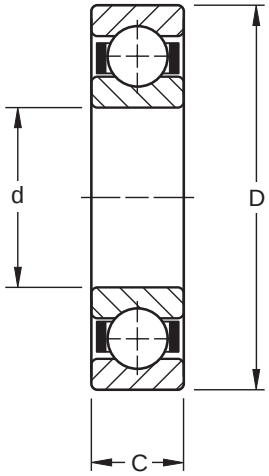
* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Light
MM200K Series
Deep Groove Conrad

Superprecision MM:
Superprecision bearings are manufactured to a ABEC-7 (ISO P4) tolerance class.

K Construction:
This design incorporates two full shoulders on both the inner and outer rings. The complement of balls are separated by a two-piece cage.

To specify a ceramic hybrid bearing, add “C” to the part number, after the prefix that specifies precision type.



DIMENSIONS – TOLERANCES
All inch tolerance in .0001 units

Bearing Number	Bore				Outside Diameter				Width				Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement	
	Nominal Dimension		Tolerance +.0000" +.0μm to minus		Nominal Dimension		Tolerance +.0000" +.0μm to minus		Nominal Dimension		Tolerance +.0000" +.0μm to minus					
	in.	mm	in.	μm	in.	mm	in.	μm	in.	mm	in.	μm	in.	mm	Qty.	(Dia.)in.
MM201K	0.4724	12	1.5	4	1.2598	32	2.5	6	0.0394	10	31	80	0.024	0.6	7	15/64
MM202K	0.5906	15	1.5	4	1.3780	35	2.5	6	0.4331	11	31	80	0.024	0.6	8	15/64
MM203K	0.6693	17	1.5	4	1.5748	40	2.5	6	0.4724	12	31	80	0.024	0.6	8	17/64
MM204K	0.7874	20	2.0	5	1.8504	47	2.5	6	0.5512	14	47	130	0.039	1.0	8	5/16
MM205K	0.9843	25	2.0	5	2.0472	52	3.0	7	0.5906	15	47	130	0.039	1.0	9	5/16
MM206K	1.1811	30	2.0	5	2.4409	62	3.0	7	0.6299	16	47	130	0.039	1.0	9	3/8
MM207K	1.3780	35	2.5	6	2.8346	72	3.0	7	0.6693	17	47	130	0.039	1.0	9	7/16
MM208K	1.5748	40	2.5	6	3.1496	80	3.0	7	0.7087	18	47	130	0.039	1.0	9	1/2
MM209K	1.7717	45	2.5	6	3.3465	85	3.0	8	0.7480	19	47	130	0.039	1.0	9	1/2
MM210K	1.9685	50	2.5	6	3.5433	90	3.0	8	0.7874	20	47	130	0.039	1.0	10	1/2
MM211K	2.1654	55	3.0	7	3.9370	100	3.0	8	0.8268	21	59	150	0.059	1.5	10	9/16
MM212K	2.3622	60	3.0	7	4.3307	110	3.0	8	0.8661	22	59	150	0.059	1.5	10	5/8
MM213K	2.5591	65	3.0	7	4.7244	120	3.0	8	0.9055	23	59	150	0.059	1.5	10	21/32
MM214K	2.7559	70	3.0	7	4.9213	125	3.5	9	0.9449	24	59	150	0.059	1.5	10	11/16
MM215K	2.9528	75	3.0	7	5.1181	130	3.5	9	0.9843	25	59	150	0.059	1.5	10	11/16
MM216K	3.1496	80	3.0	7	5.5118	140	3.5	9	1.0236	26	59	150	0.079	2.0	10	3/4

** ABMA std. 20 ($r_{as\ max}$).

Light
MM200K Series
Deep Groove Conrad

PHYSICAL CHARACTERISTICS – LOAD RATINGS

Bearing Number	Weight Per Bearing		Static Load Rating C_o		Extended Dynamic Load Ratings C_e		Permissible Speed Ng *
	lbs	kg	lbs	N	lbs	N	RPM
MM201K	0.08	0.035	680	3,000	1,730	7,700	52,200
MM202K	0.09	0.043	830	3,700	1,930	8,600	44,000
MM203K	0.14	0.062	1,060	4,700	2,450	10,900	38,500
MM204K	0.22	0.100	1,460	6,500	3,250	14,500	32,800
MM205K	0.27	0.122	1,760	7,800	3,600	16,000	27,400
MM206K	0.41	0.185	2,550	11,300	5,000	22,200	23,000
MM207K	0.59	0.267	3,450	15,300	6,550	29,100	19,800
MM208K	0.74	0.337	4,500	20,000	8,300	36,900	17,700
MM209K	0.83	0.377	4,550	20,200	8,300	36,900	16,000
MM210K	0.94	0.425	5,200	23,100	9,000	40,000	14,600
MM211K	1.24	0.564	6,550	29,100	11,000	48,900	13,300
MM212K	1.60	0.727	8,150	36,300	13,400	59,600	12,100
MM213K	2.05	0.928	9,000	40,000	14,600	64,900	11,100
MM214K	2.19	0.994	9,800	43,600	16,000	71,200	10,500
MM215K	2.37	1.074	10,000	44,500	16,000	71,200	9,900
MM216K	2.90	1.317	12,000	53,400	18,600	82,700	9,200

* Limits shown for a single row, spring preloaded and grease lubricated bearing.
For standard, non-preloaded applications, do not exceed 350,000 dN.

Light
MM200K Series
Deep Groove Conrad

Superprecision Bearings

FTF Fundamental Train Frequency: The frequency at which the retainer will operate.

BSF Ball Spin Frequency: The frequency at which a single defect on a rolling element will be detected.

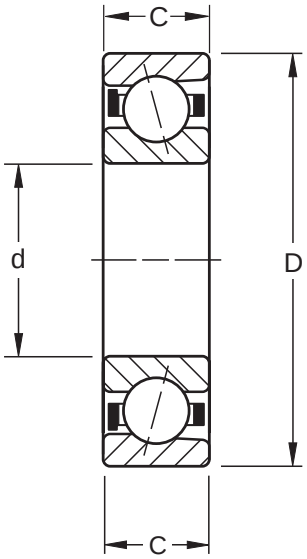
BPFO Ball Pass Frequency Outer: The frequency at which a single defect in the outer race will be detected.

BPFI Ball Pass Frequency Inner: The frequency at which a single defect in the inner race will be detected.

FREQUENCY COEFFICIENTS

Bearing Number	FTF Fundamental Train Frequency (Inner Rotation)	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner	FTF Fundamental Train Frequency (Outer Rotation)
MM201K	0.3647	1.7124	2.5529	4.4471	0.6353
MM202K	0.3809	1.9808	3.0475	4.9525	0.6191
MM203K	0.3816	1.9937	3.0531	4.9469	0.6184
MM204K	0.3815	1.9918	3.0522	4.9478	0.6185
MM205K	0.3971	2.3275	3.5742	5.4258	0.6029
MM206K	0.3965	2.3111	3.5682	5.4318	0.6035
MM207K	0.3961	2.3034	3.5653	5.4347	0.6039
MM208K	0.3942	2.2564	3.5475	5.4525	0.6058
MM209K	0.4023	2.4614	3.6208	5.3792	0.5977
MM210K	0.4093	2.6652	4.0929	5.9071	0.5907
MM211K	0.4078	2.6200	4.0782	5.9218	0.5922
MM212K	0.4066	2.5837	4.0662	5.9338	0.5934
MM213K	0.4099	2.6846	4.0990	5.9010	0.5901
MM214K	0.4104	2.7022	4.1045	5.8955	0.5896
MM215K	0.4148	2.8497	4.1482	5.8518	0.5852
MM216K	0.4134	2.8005	4.1341	5.8659	0.5866

Medium
2MM300WI Series
3MM300WI Series



Superprecision MM:
Superprecision bearings are manufactured to a ABEC-7 (ISO P4) tolerance class.

WI Construction:
This design incorporates a low shoulder on the non-thrust side of the outer rings. The maximum complement of balls is separated by a one-piece cage which is piloted against the ground land of the outer ring.

To specify a ceramic hybrid bearing, add “C” to the part number, after the prefix that specifies precision type.

DIMENSIONS – TOLERANCES
All inch tolerance in .0001 units

Bearing Number	Bore				Outside Diameter				Width *				Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement	
	Nominal Dimension		Tolerance +.0000" +.0µm to minus		Nominal Dimension		Tolerance +.0000" +.0µm to minus		Nominal Dimension		Tolerance +.0000" +.0µm to minus					
2MM & 3MM	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	Qty.	(Dia.)in.
301WI	0.4724	12	1.5	4	1.4567	37	2.5	6	0.4724	12	31	80	0.039	1.0	8	9/32
302WI	0.5906	15	1.5	4	1.6535	42	2.5	6	0.5118	13	31	80	0.039	1.0	10	17/64
303WI	0.6693	17	1.5	4	1.8504	47	2.5	6	0.5512	14	31	80	0.039	1.0	7	3/8
304WI	0.7874	20	2.0	5	2.0472	52	3.0	7	0.5906	15	47	120	0.039	1.0	8	13/32
305WI	0.9843	25	2.0	5	2.4409	62	3.0	7	0.6693	17	47	120	0.039	1.0	9	15/32
306WI	1.1811	30	2.0	5	2.8346	72	3.0	7	0.7480	19	47	120	0.039	1.0	9	17/32
307WI	1.3780	35	2.5	6	3.1496	80	3.0	7	0.8268	21	47	120	0.059	1.5	10	9/16
308WI	1.5748	40	2.5	6	3.5433	90	3.0	8	0.9055	23	47	120	0.059	1.5	10	5/8
309WI	1.7717	45	2.5	6	3.9370	100	3.0	8	0.9843	25	47	120	0.059	1.5	10	11/16
310WI	1.9685	50	2.5	6	4.3307	110	3.0	8	1.0630	27	47	120	0.079	2.0	10	3/4
311WI	2.1654	55	3.0	7	4.7244	120	3.0	8	1.1417	29	59	150	0.079	2.0	10	13/16
312WI	2.3622	60	3.0	7	5.1181	130	3.5	9	1.2205	31	59	150	0.079	2.0	10	7/8
313WI	2.5591	65	3.0	7	5.5118	140	3.5	9	1.2992	33	59	150	0.079	2.0	11	15/16
314WI	2.7559	70	3.0	7	5.9055	150	3.5	9	1.3780	35	59	150	0.079	2.0	11	1
319WI	3.7402	95	3.0	7	7.8740	200	4.0	10	1.7717	45	79	200	0.118	3.0	10	1 3/8

* Refer to page E4 for width tolerance of preloaded bearings.
** ABMA std. 20 ($r_{as\ max}$).

Medium
2MM300WI Series

PHYSICAL CHARACTERISTICS – LOAD RATINGS

RADIAL LOAD RATING AT 33 1/3 RPM
Based on 1500 hours L_{10} Life and Permissible Speed

Bearing Number	Weight Per Bearing		Static Load Rating C_o		Extended Dynamic Load Ratings C_e		Permissible Speed Ng *	Preload Levels **							
								Extralight (DUX)		Light (DUL)		Medium (DUM)		Heavy (DUH)	
	lbs	kg	lbs	N	lbs	N	RPM	lbs	N	lbs	N	lbs	N	lbs	N
2MM301WI	0.13	0.061	1,060	4,700	2,550	11,300	47,600	—	—	5	20	15	70	40	180
2MM302WI	0.19	0.087	1,320	5,900	2,750	12,200	38,100	—	—	10	40	25	110	50	220
2MM303WI	0.23	0.104	1,630	7,300	3,900	17,300	36,800	—	—	15	70	35	160	70	310
2MM304WI	0.30	0.137	2,200	9,800	5,000	22,200	32,200	—	—	20	90	50	220	90	400
2MM305WI	0.49	0.221	3,450	15,300	6,950	30,900	26,200	—	—	35	160	75	330	140	620
2MM306WI	0.72	0.328	4,500	20,000	8,800	39,100	22,100	—	—	40	180	100	440	175	780
2MM307WI	0.98	0.443	5,700	25,400	10,600	47,100	19,200	—	—	50	220	125	560	225	1000
2MM308WI	1.34	0.608	7,200	32,000	12,900	57,400	16,900	—	—	65	290	150	670	275	1220
2MM309WI	1.78	0.809	8,650	38,500	15,300	68,100	15,100	—	—	75	330	175	780	350	1560
2MM310WI	2.31	1.046	10,400	46,300	18,000	80,100	13,600	—	—	100	440	225	1000	400	1780
2MM311WI	2.94	1.332	12,200	54,300	20,800	92,500	12,400	—	—	125	560	250	1110	475	2110
2MM312WI	3.67	1.665	14,300	63,600	23,600	105,000	11,400	—	—	125	560	300	1330	550	2450
2MM313WI	4.63	2.101	18,000	80,100	28,500	126,800	10,500	—	—	150	670	375	1670	675	3000
2MM314WI	5.62	2.548	20,800	92,500	32,000	142,300	9,800	—	—	175	780	425	1890	775	3450
2MM319WI	12.32	5.587	35,500	157,900	47,500	211,300	7,400	—	—	300	1330	700	3110	1400	6230

* Limits shown for a single row, spring preloaded and grease lubricated bearing.
** All ceramic hybrid bearing preloads are equivalent to the table above.

Medium
2MM300WI Series

Superprecision Bearings

FTF Fundamental Train Frequency: The frequency at which the retainer will operate.

BSF Ball Spin Frequency: The frequency at which a single defect on a rolling element will be detected.

BPFO Ball Pass Frequency Outer: The frequency at which a single defect in the outer race will be detected.

BPFI Ball Pass Frequency Inner: The frequency at which a single defect in the inner race will be detected.

FREQUENCY COEFFICIENTS

Bearing Number	FTF Fundamental Train Frequency (Inner Rotation)	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner	FTF Fundamental Train Frequency (Outer Rotation)
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	0.3724	1.7666	3.3514	5.6486	0.6276
2MM307WI	0.3799	1.8962	3.7990	6.2010	0.6201
2MM308WI	0.3820	1.9332	3.8203	6.1797	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

Medium
3MM300WI Series

PHYSICAL CHARACTERISTICS - LOAD RATINGS

RADIAL LOAD RATING AT 33 1/3 RPM
Based on 1500 hours L_{10} Life and Permissible Speed

Bearing Number	Weight Per Bearing		Static Load Rating C_o		Extended Dynamic Load Ratings C_e		Permissible Speed Ng *	Preload Levels **							
								Extralight (DUX)		Light (DUL)		Medium (DUM)		Heavy (DUH)	
	lbs	kg	lbs	N	lbs	N	RPM	lbs	N	lbs	N	lbs	N	lbs	N
3MM301WI	0.13	0.061	1,040	4,600	2,450	10,900	42,800	—	—	20	90	40	180	70	310
3MM302WI	0.19	0.087	1,270	5,600	2,600	11,600	34,300	—	—	20	90	40	180	80	360
3MM303WI	0.23	0.104	1,600	7,100	3,800	16,900	33,100	—	—	25	110	60	270	100	440
3MM304WI	0.30	0.137	2,160	9,600	4,800	21,400	29,000	—	—	35	160	80	360	140	620
3MM305WI	0.49	0.221	3,350	14,900	6,800	30,200	23,600	—	—	50	220	120	530	200	890
3MM306WI	0.72	0.328	4,300	19,100	8,500	37,800	19,900	—	—	60	270	150	670	250	1110
3MM307WI	0.98	0.443	5,600	24,900	10,200	45,400	17,300	—	—	80	360	190	850	350	1560
3MM308WI	1.34	0.608	6,950	30,900	12,500	55,600	15,200	—	—	100	440	250	1110	400	1780
3MM309WI	1.78	0.808	8,500	37,800	14,600	64,900	13,600	—	—	120	530	300	1330	500	2220
3MM310WI	2.30	1.045	10,000	44,500	17,300	77,000	12,200	—	—	140	620	350	1560	600	2670
3MM311WI	2.93	1.331	11,800	52,500	20,000	89,000	11,200	—	—	175	780	400	1780	700	3110
3MM312WI	3.67	1.663	13,700	60,900	22,800	101,400	10,300	—	—	200	890	450	2000	800	3560
3MM313WI	4.63	2.099	17,300	77,000	27,500	122,300	9,500	—	—	250	1110	600	2670	1000	4450
3MM314WI	5.61	2.546	20,000	89,000	31,000	137,900	8,800	—	—	275	1220	650	2890	1150	5120
3MM319WI	12.30	5.581	34,000	151,200	45,500	202,400	6,700	—	—	475	2110	1100	4890	2000	8900

* Limits shown for a single row, spring preloaded and grease lubricated bearing.
** All ceramic hybrid bearing preloads are equivalent to the table above.

Medium
3MM300WI Series

Superprecision Bearings

FTF Fundamental Train Frequency: The frequency at which the retainer will operate.

BSF Ball Spin Frequency: The frequency at which a single defect on a rolling element will be detected.

BPFO Ball Pass Frequency Outer: The frequency at which a single defect in the outer race will be detected.

BPFI Ball Pass Frequency Inner: The frequency at which a single defect in the inner race will be detected.

FREQUENCY COEFFICIENTS

Bearing Number	FTF Fundamental Train Frequency (Inner Rotation)	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner	FTF Fundamental Train Frequency (Outer Rotation)
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	0.3802	1.7812	3.4214	5.5786	0.6198
3MM307WI	0.3874	1.9101	3.8736	6.1264	0.6126
3MM308WI	0.3894	1.9470	3.8936	6.1064	0.6106
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

Medium
300WI Series

PERMISSIBLE OPERATING SPEEDS – RPM
2MM & 3MM Superprecision Angular Contact Spindle Bearings

	GREASE							OIL		
	"DB" Mounting			Grease Capacity		Kluber Isoflex NBU 15		"DB" Mounting		
15 Degree Contact Angle	(DUL) Light	(DUM) Medium	(DUH) Heavy	25 % (grams)	40 % (grams)	15 % (grams)	20 % (grams)	(DUL) Light	(DUM) Medium	(DUH) Heavy
2MM301WI	35,700	28,600	19,000	0.6	1.0	0.40	0.53	60,700	48,600	32,400
2MM302WI	28,600	22,900	15,200	0.7	1.2	0.49	0.65	48,600	38,900	25,900
2MM303WI	27,600	22,100	14,700	1.2	2.0	0.83	1.10	46,900	37,500	25,000
2MM304WI	24,200	19,300	12,900	1.5	2.5	1.03	1.38	41,100	32,800	21,900
2MM305WI	19,700	15,700	10,500	2.3	3.8	1.57	2.09	33,400	26,700	17,800
2MM306WI	16,600	13,300	8,800	3.5	5.6	2.35	3.14	28,200	22,500	15,000
2MM307WI	14,400	11,500	7,700	4.6	7.4	3.07	4.10	24,500	19,600	13,100
2MM308WI	12,700	10,100	6,800	6.4	10.2	4.25	5.66	21,500	17,200	11,500
2MM309WI	11,300	9,100	6,000	8.5	13.6	5.68	7.58	19,300	15,400	10,300
2MM310WI	10,200	8,200	5,400	11.1	17.8	7.4	9.9	17,300	13,900	9,200
2MM311WI	9,300	7,400	5,000	14.2	22.7	9.5	12.6	15,800	12,600	8,400
2MM312WI	8,600	6,800	4,600	17.7	28.3	11.8	15.8	14,500	11,600	7,800
2MM313WI	7,900	6,300	4,200	20.7	33.2	13.8	18.5	13,400	10,700	7,100
2MM314WI	7,400	5,900	3,900	25.2	40.3	16.8	22.4	12,500	10,000	6,700
2MM319WI	5,600	4,400	3,000	60.9	97.4	40.6	54.1	9,400	7,500	5,000

Notes: For 3MM (25 Degree Contact Angle) Spindle Bearings, use 90% of the Permissible Operating Speeds above.
* For 2MMC and 3MMC Spindle Bearings, use 120% of the Permissible Operating Speeds.
For other bearing configurations beside a back-to-back mounted duplex set, please refer to page E36 to calculate the permissible operating speed (Sp.).

Axial Stiffness
300WI Series
(For Duplex Set*)

2MM300WI SERIES

Bore #	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)
00	—	—	—
01	0.100	0.159	0.253
02	0.157	0.234	0.327
03	0.152	0.222	0.312
04	0.189	0.285	0.380
05	0.264	0.373	0.506
06	0.283	0.427	0.563
07	0.320	0.487	0.654
08	0.370	0.541	0.731
09	0.401	0.589	0.830
10	0.464	0.671	0.892
11	0.504	0.694	0.956
12	0.513	0.765	1.034
13	0.596	0.903	1.208
14	0.634	0.951	1.282
15	—	—	—
16	—	—	—
17	—	—	—
18	—	—	—
19	0.803	1.178	1.660

* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

3MM300WI SERIES

Bore #	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)
00	—	—	—
01	0.335	0.438	0.551
02	0.380	0.496	0.658
03	0.364	0.509	0.626
04	0.453	0.623	0.782
05	0.581	0.813	1.000
06	0.642	0.911	1.121
07	0.771	1.074	1.378
08	0.860	1.224	1.482
09	0.949	1.349	1.661
10	1.022	1.453	1.810
11	1.133	1.557	1.956
12	1.220	1.665	2.103
13	1.425	1.995	2.456
14	1.501	2.087	2.632
15	—	—	—
16	—	—	—
17	—	—	—
18	—	—	—
19	1.880	2.593	3.306

Radial Stiffness 300WI Series (For Duplex Set*)

2MM300WI SERIES

Bore #	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)
01	0.565	0.878	1.048
02	0.819	0.943	1.175
03	0.843	1.129	1.504
04	1.039	1.332	1.657
05	1.417	1.619	1.949
06	1.551	1.733	2.320
07	1.852	2.219	2.737
08	2.085	2.245	2.797
09	2.248	2.702	3.364
10	2.094	2.841	3.647
11	2.189	3.330	4.143
12	2.609	3.615	4.588
13	2.926	3.823	4.840
14	2.972	4.024	5.010
15	3.356	4.349	5.411
16	3.659	4.718	5.801
17	3.961	5.089	6.336
18	3.880	5.097	6.346
19	4.156	5.333	6.764

* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

3MM300WI SERIES

Bore #	Light (10^6 LB/IN.)	Medium (10^6 LB/IN.)	Heavy (10^6 LB/IN.)
01	0.538	0.777	0.969
02	0.663	0.916	1.140
03	0.760	1.169	1.280
04	0.912	1.258	1.448
05	1.084	1.478	1.738
06	1.298	1.754	2.036
07	1.529	2.064	2.449
08	1.576	2.131	2.424
09	1.899	2.564	2.976
10	2.059	2.780	3.249
11	2.329	3.143	3.627
12	2.573	3.473	3.974
13	2.713	3.662	4.232
14	2.818	3.806	4.417
15	3.046	4.112	4.720
16	3.262	4.406	5.115
17	3.433	4.645	5.427
18	3.481	4.603	5.537
19	3.749	4.715	5.885

Spacer Offsets 300WI Series (For Duplex Set*)

2MM300WI SERIES

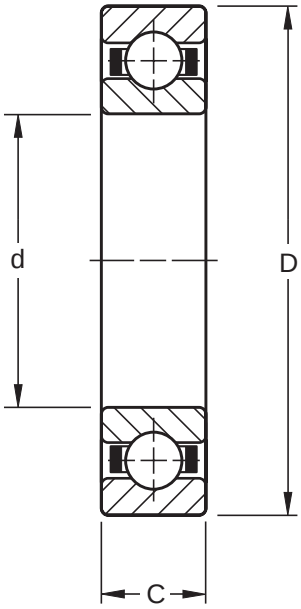
Bore #	Light to Medium	Medium to Heavy
	(in.)	(in.)
00	—	—
01	0.00031	0.00049
02	0.00031	0.00036
03	0.00043	0.00053
04	0.00051	0.00480
05	0.00050	0.00059
06	0.00068	0.00061
07	0.00074	0.00070
08	0.00075	0.00079
09	0.00081	0.00099
10	0.00088	0.00090
11	0.00084	0.00109
12	0.00110	0.00111
13	0.00120	0.00114
14	0.00127	0.00126
15	—	—
16	—	—
17	—	—
18	—	—
19	0.00040	0.00059

3MM300WI SERIES

Bore #	Light to Medium	Medium to Heavy
	(in.)	(in.)
00	—	—
01	0.00021	0.00024
02	0.00018	0.00028
03	0.00032	0.00028
04	0.00033	0.00034
05	0.00040	0.00035
06	0.00046	0.00039
07	0.00048	0.00052
08	0.00057	0.00044
09	0.00062	0.00053
10	0.00068	0.00061
11	0.00067	0.00068
12	0.00069	0.00074
13	0.00082	0.00072
14	0.00083	0.00085
15	—	—
16	—	—
17	—	—
18	—	—
19	0.00111	0.00122

* DB (back-to-back) or DF (face-to-face) arrangement only; For other mounting arrangements, contact the Torrington Engineering Department.

Medium
MM300K Series
Deep Groove Conrad



Superprecision MM:
Superprecision bearings are manufactured to a ABEC-7 (ISO P4) tolerance class.

K Construction:
This design incorporates two full shoulders on both the inner and outer rings. The complement of balls are separated by a two-piece cage.

To specify a ceramic hybrid bearing, add “C” to the part number, after the prefix that specifies precision type.

DIMENSIONS – TOLERANCES
All inch tolerance in .0001 units

Bearing Number	Bore		Tolerance +.0000" +.0µm to minus		Outside Diameter		Tolerance +.0000" +.0µm to minus		Width		Tolerance +.0000" +.0µm to minus		Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement	
	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	in.	µm	in.	mm	Qty.	(Dia.)in.
MM305K-CR	0.9843	25	2.0	5	2.4409	62	3.0	7	0.6693	17	47	130	0.039	1	7	15/32
MM306K-CR	1.1811	30	2.0	5	2.8346	72	3.0	7	0.7480	19	47	130	0.039	1	7	17/32
MM307K-CR	1.378	35	2.5	6	3.1496	80	3.0	7	0.8268	21	47	130	0.059	1.5	7	9/16
MM308K-CR	1.5748	40	2.5	6	3.5433	90	3.0	8	0.9055	23	47	130	0.059	1.5	8	5/8
MM309K-CR	1.7717	45	2.5	6	3.9370	100	3.0	8	0.9843	25	47	130	0.059	1.5	8	11/16
MM310K-CR	1.9685	50	2.5	6	4.3307	110	3.0	8	1.0630	27	47	130	0.059	1.5	8	3/4
MM311K-CR	2.1654	55	3.0	7	4.7244	120	3.0	8	1.1417	29	59	150	0.079	2	8	13/16
MM312K-CR	2.3622	60	3.0	7	5.1181	130	3.5	9	1.2205	31	59	150	0.079	2	8	7/8
MM313K-CR	2.5591	65	3.0	7	5.5118	140	3.5	9	1.2992	33	59	150	0.079	2	8	15/16
MM314K-CR	2.7559	70	3.0	7	5.9055	150	3.5	9	1.3780	35	59	150	0.079	2	8	1

Two piece inner ring-piloted composition cage is standard. Check for availability.
** ABMA std. 20 ($r_{as\ max}$).

Medium
MM300K Series
Deep Groove Conrad

RADIAL LOAD RATING AT 33 1/3 RPM
Based on 1500 Hours L_{10} Life and Permissible Speed

Bearing Number	Weight Per Bearing		Static Load Rating C_o		Extended Dynamic Load Ratings [1] C_e		Permissible Speed [2] (grease)
	lbs	kg	lbs	N	lbs	N	RPM
MM305K-CR	0.49	0.222	2,750	12,200	6000	26,700	26,500
MM306K-CR	0.72	0.327	3,550	15,800	7,650	34,000	22,300
MM307K-CR	0.95	0.431	4,150	18,500	8,500	37,800	19,400
MM308K-CR	1.31	0.594	5,100	22,700	10,400	46,300	17,100
MM309K-CR	1.78	0.807	7,100	31,600	13,400	59,600	15,200
MM310K-CR	2.32	1.052	8,500	37,800	15,600	69,400	13,800
MM311K-CR	2.93	1.329	10,000	44,500	18,300	81,400	12,500
MM312K-CR	3.67	1.665	11,600	51,600	20,800	92,500	11,500
MM313K-CR	4.51	2.046	13,400	59,600	23,600	105,000	10,700
MM314K-CR	5.48	2.486	15,300	68,100	26,000	115,600	9,900

[1] C_e should be used for calculating bearing life only, and should not be confused with C_0 which is the maximum radial load a bearing can safely support.

[2] Limits shown for a single row, spring preloaded and grease lubricated bearing.

For standard, non-preloaded applications, do not exceed 350,000 dN.

Medium
MM300K Series
Deep Groove Conrad

Superprecision Bearings

FTF Fundamental Train Frequency: The frequency at which the retainer will operate.

BSF Ball Spin Frequency: The frequency at which a single defect on a rolling element will be detected.

BPFO Ball Pass Frequency Outer: The frequency at which a single defect in the outer race will be detected.

BPFI Ball Pass Frequency Inner: The frequency at which a single defect in the inner race will be detected.

FREQUENCY COEFFICIENTS

Bearing Number	FTF Fundamental Train Frequency	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner
MM301K	0.354	1.569	2.125	3.875
MM302K	0.382	1.994	3.053	4.947
MM303K	0.351	1.531	2.107	3.893
MM304K	0.357	1.601	2.140	3.860
MM305K	0.363	1.690	2.542	4.458
MM306K	0.368	1.757	2.574	4.426
MM307K	0.376	1.888	2.630	4.370
MM308K	0.378	1.925	2.645	4.355
MM309K	0.380	1.955	3.037	4.963
MM310K	0.381	1.981	3.047	4.953
MM311K	0.382	2.002	3.057	4.943
MM312K	0.383	2.020	3.064	4.936
MM313K	0.384	2.036	3.071	4.929
MM314K	0.385	2.050	3.076	4.924

Ex-Cell-O Spindle Bearings

The original bearing design developed by Ex-Cell-O for use in their spindles incorporated inch dimensions and had bore and O.D. tolerances which were nominal to plus. The “EX” series of bearings are designed to meet Ex-Cell-O replacement requirements. These bearings are Fafnir WI construction.

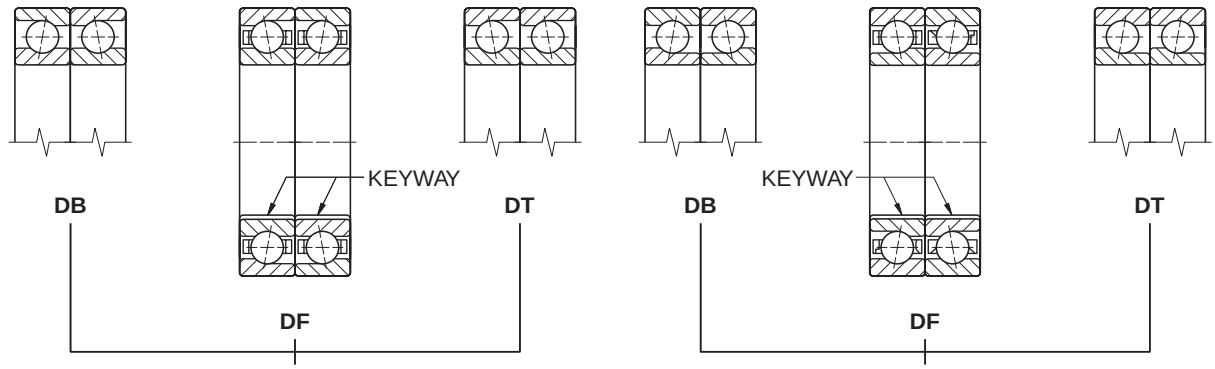
More recently, Ex-Cell-O established a bearing design with the same inch boundary dimensions, but with bore and O.D. tolerances nominal to minus. These bearings are the Fafnir WO separable construction and the series is designated “XWO.”

Spindle shaft and housing diameters were toleranced by Ex-Cell-O to properly fit each of their bearing series.

Repairing older spindles with the new style bearing, or newer spindles with the old style bearing without reworking of shafts and housings can result in improper shaft and housing fits. Measurement of shafts and housings, or reconditioning of parts should determine what style bearing is proper replacement.

The charts which follow show the physical dimensions and part number interchange of Ex-Cell-O bearings. The preload section should be based on the operating speed and the lubrication system of the spindle.

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



Old design, MM-EX
Bore and O.D. Tolerance
Nominal + Tolerance
“WI” Construction

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

Note: These bearings not intended for new design applications. Consult your local Torrington Company Engineering Sales office

MM-EX Replacement Bearings For Ex-Cell-O Spindles

Fafnir Bearing Number	Ex-Cell-O Part No.	Preload lbs.	Bore (in.)	O.D. (in.)	Width of Pair (in.)	Maximum Speed (RPM)
MM20EXCR DU FS223	20	0	0.3752/.3750	1.1252/1.1250	0.6875/.6775	65000
MM30EXCR DU FS223	30	0	0.6252/.6250	1.5002/1.5000	1.0000/9900	35000
MM30EXCR DU 5 #	30	5	0.6252/.6250	1.5002/1.5000	1.0000/9900	25000
MM50EXCR DU FS223	50	0	0.8127/.8125	2.0002/2.0000	1.0000/9900	30000
MM50EXCR DU 10 #	50	10	0.8127/.8125	2.0002/2.0000	1.0000/9900	18000
MM50EXCR DU 50 #	50	50	0.8127/.8125	2.0002/2.0000	1.0000/9900	5000
***MM55EXCR DU 10 #**	55	10	0.8127/.8125	2.0002/2.0000	1.0000/9900	22000
MM57EXCR DU FS223	57	0	1.0627/1.0625	2.2502/2.2500	1.0000/9900	30000
MM57EXCR DU 10 #	57	10	1.0627/1.0625	2.2502/2.2500	1.0000/9900	15000
MM57EXCR DU 50 #	57	50	1.0627/1.0625	2.2502/2.2500	1.0000/9900	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
****MM92EXCR DU 20 #**	92	20	1.7502/1.7500	3.4377/3.4375	1.6250/1.6150	12000
****MM92EXCR DU 100 #**	92	100	1.7502/1.7500	3.4377/3.4375	1.6250/1.6150	4500
****MM92EXCR DU 150 #**	92	150	1.7502/1.7500	3.4377/3.4375	1.6250/1.6150	2700
****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

* Four slots in outer ring faces.

** No keyway in bore.

FS-223 Zero to negative preload.

Do not interchange with MM-XWO.

MM-XWO produced to nominal minus tolerance.

MM-EX produced to nominal plus tolerance.

MM-XWO Replacement Bearings For Ex-Cell-O Spindles

Fafnir Bearing Number	Ex-Cell-O Part No.	Preload lbs.	Bore (in.)	O.D. (in.)	Width of Pair (in.)	Maximum Speed		
						Grease	Oil	Mist
MM20XWOCRDU E9103A	XLO 20-107	0	0.37500/.37485	1.1250/1.1248	0.6875/.6675	40000	65000	80000
MM30XWOCRDU E9103C	XLO 30-57	10	0.62500/.62485	1.5000/1.4998	1.000/.980	27000	30000	35000
MM30XWOCRDU E9103A	XLO 30-107	0	0.62500/.62485	1.5000/1.4998	1.000/.980	35000	40000	60000
MM55XWOCRDU E9103E	XLO 55-27	50	0.81250/.81235	2.0000/1.9998	1.000/.980	5000	8000	12000
MM55XWOCRDU E9103C	XLO 55-57	20	0.81250/.81235	2.0000/1.9998	1.000/.980	20000	22000	24000
MM55XWOCRDU E9103A	XLO 55-107	0	0.81250/.81235	2.0000/1.9998	1.000/.980	24000	27000	45000
MM57XWOCRDU E9103F	XLO 57-17	100	1.06250/1.06235	2.2500/2.2498	1.000/.980	2000	4000	6000
MM57XWOCRDU E9103C	XLO 57-57	20	1.06250/1.06235	2.2500/2.2498	1.000/.980	18000	20000	22000
MM57XWOCRDU E9103A	XLO 57-107	0	1.06250/1.06235	2.2500/2.2498	1.000/.980	22000	25000	35000
MM67XWOCRDU E9103F	XLO 67-17	90	1.2500/1.2498	2.4375/2.4373	1.250/1.230	36000	4500	6000
MM67XWOCRDU E9103C	XLO 67-57	20	1.2500/1.2498	2.4375/2.4373	1.250/1.230	12500	15000	20000
MM67XWOCRDU E9103A	XLO 67-107	0	1.2500/1.2498	2.4375/2.4373	1.250/1.230	16000	20000	30000
MM90XWOCRDU E9103F	XLO 90-17	250	1.6250/1.6248	3.4375/3.4372	1.625/1.605	1000	2000	4000
MM90XWOCRDU E9103D	XLO 90-47	175	1.6250/1.6248	3.4375/3.4372	1.625/1.605	3000	5000	8000
MM90XWOCRDU E9103C	XLO 90-57	100	1.6250/1.6248	3.4375/3.4372	1.625/1.605	5000	7000	11000
MM90XWOCRDU E9103A	XLO 90-77	20	1.6250/1.6248	3.4375/3.4372	1.625/1.605	10000	14000	20000
MM115XWOCRDU E9103E	XLO 115-27	300	2.2500/2.2498	4.7500/4.7496	2.250/2.230	1000	2000	3000
MM115XWOCRDU E9103C	XLO 115-47	150	2.2500/2.2498	4.7500/4.7496	2.250/2.230	3000	4500	7000
MM115XWOCRDU E9103A	XLO 115-77	30	2.2500/2.2498	4.7500/4.7496	2.250/2.230	6000	8000	15000
MM135XWOCRDU E9103C	XLO 135-67	50	1.2500/1.2498	2.6875/2.6873	1.250/1.230	6000	7000	12000
MM135XWOCRDU E9103A	XLO 135-107	0	1.2500/1.2498	2.6875/2.6873	1.250/1.230	15000	19000	28000
MM155XWOCRDU E9103D	XLO 155-37	300	2.7500/2.7498	4.7500/4.7496	2.250/2.230	1000	2000	3000
MM155XWOCRDU E9103B	XLO 155-67	150	2.7500/2.7498	4.7500/4.7496	2.250/2.230	4000	5000	6500
MM155XWOCRDU E9103A	XLO 155-87	50	2.7500/2.7498	4.7500/4.7496	2.250/2.230	6000	7000	10000
MM165XWOCRDU E9103E	XLO 165-27	800	3.50000/3.49975	6.3125/6.3121	3.000/2.980	500	1000	2000
MM165XWOCRDU E9103C	XLO 165-57	250	3.50000/3.49975	6.3125/6.3121	3.000/2.980	2000	3000	5000
MM165XWOCRDU E9103A	XLO 165-87	50	3.50000/3.49975	6.3125/6.3121	3.000/2.980	5000	6500	9000

Do not interchange with MM-EX.

MM-XWO produced to nominal minus tolerance.

MM-EX produced to nominal plus tolerance.

* Standard preload levels are shown. Other preload variations are attainable by spacer adjustment.

Ceramic Hybrid Bearings

A ceramic hybrid bearing is a combination of ceramic balls with standard steel rings and retainer material appropriate for the application.

Ceramic Bearing Benefits

- **High Speed**
  Up to three million DN with reduced skidding, wear and heat generation; grease-lubricated hybrids up to one million DN.
- **Extended Fatigue Life**
  Three to five times greater than steel when properly applied.
- **Marginal Lubrication**
  Unique tribological features enhance operation under low lubrication conditions and extend life and speed capabilities of lubricants.
- **Corrosion resistance**
  Virtually inert silicone nitride resists corrosion and galling while thin-dense-chrome (TDC) coating may be used to enhance hybrid results.
- **High Stiffness**
  Modulus of elasticity 50 percent greater than steel increases bearing rigidity.
- **Low Torque**
  Low friction, even under marginal lubrication, with extremely fine surface finishes of .1 to .2 micro-inch AA.
- **Long Wear Life**
  High hardness of Rc78 greatly extends bearing wear characteristics.
- **Light Weight**
  60 percent lighter than steel, reducing centrifugal forces and overall system weight.
- **Special Properties**
  All silicon nitride components are:
  – non-magnetic
  – electrically insulative
- **Increased Speed**
  Provides over a 20% increased speed factor over steel balls.

Applications

- **Aerospace**
  – gas and air turbines
  – gearboxes
  – auxiliary power units/generators
  – valves and nozzles
- **Machine Tools**
  – ultra and high-speed milling spindles
  – ultra and high-speed grinding spindles
  – extended life units
- **Instruments**
  – gyro, gimbal and platform
  – spectroscopy
- **Biotechnology**
  – rotating anode
  – medical centrifuge
- **Defense**
  – space
  – radar
  – missiles
- **Automotive**
  – turbochargers
- **General Industry**
  – pumps and compressors
  – reactors and mixers
  – chemical processing
  – cryogenic

Industry's present day applications place demands on machinery that could not be imagined as little as a decade ago.

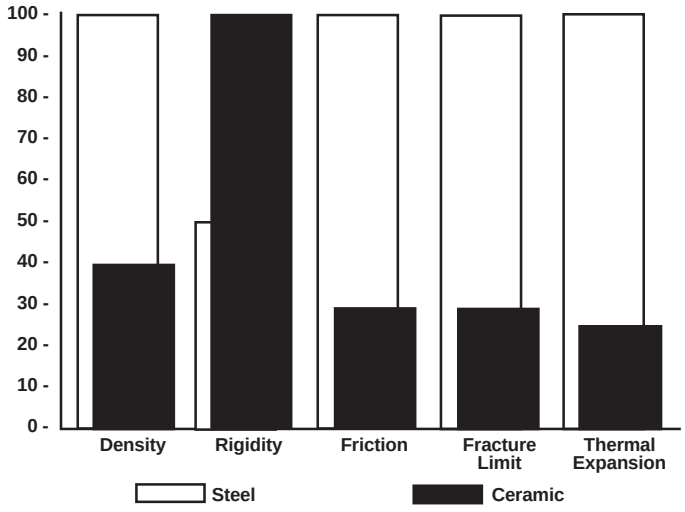
Machinery is expected to be more efficient, reliable, faster and last longer with less maintenance. In the future, even the great reliability and wide versatility of the standard Torrington steel bearing may be challenged.

By incorporating ceramic and state-of-the-art bearing technology, The Torrington Company has developed the hybrid ceramic bearing. Designed with increased speed capabilities, the hybrid ceramic bearing features a higher elastic modulus for greater stiffness. Its lower friction characteristics result in less skidding than the all-steel bearing.

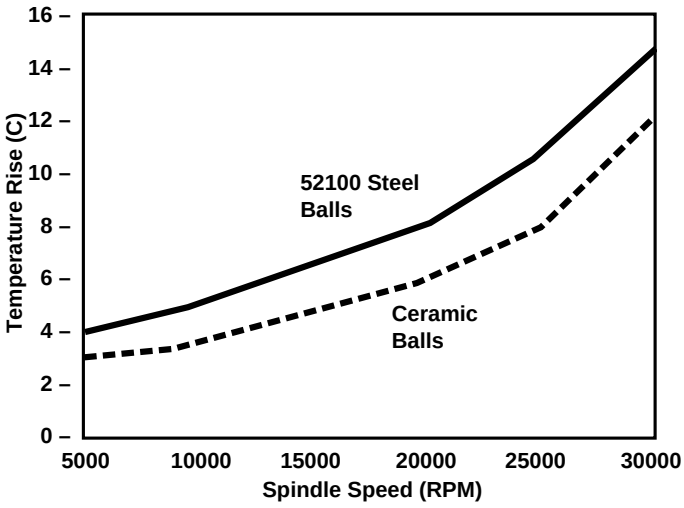
The Torrington Company Sales Engineering professional in your area can assist you in determining if the hybrid ceramic bearing is suitable for your application.

When ordering a ceramic hybrid bearing add "C" to the part number after the prefix that specifies precision type, i.e. 2MMVC9110HX or 2MMVC99110WN.

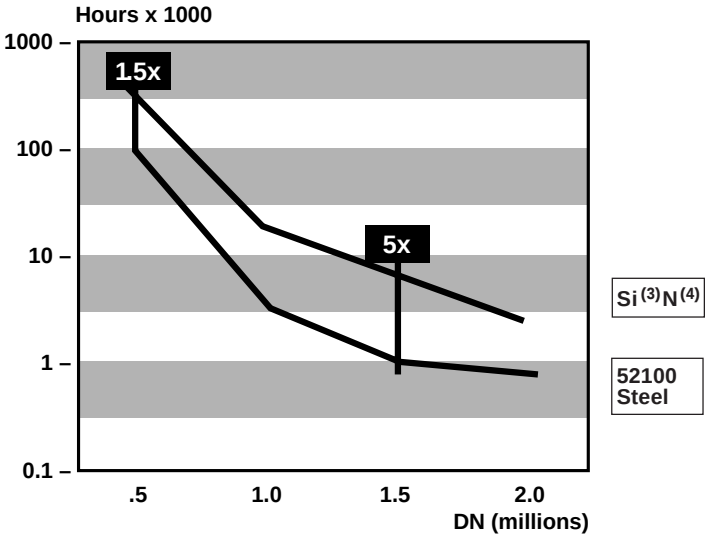
Material Properties



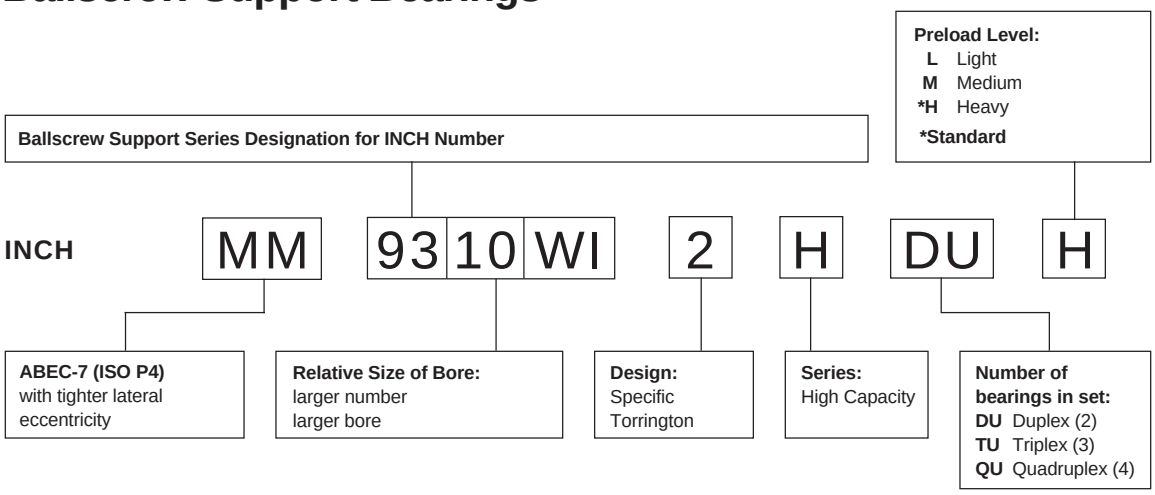
Temperature vs Speed
2MMV99110WN (50 mm bore). Grease lubrication.

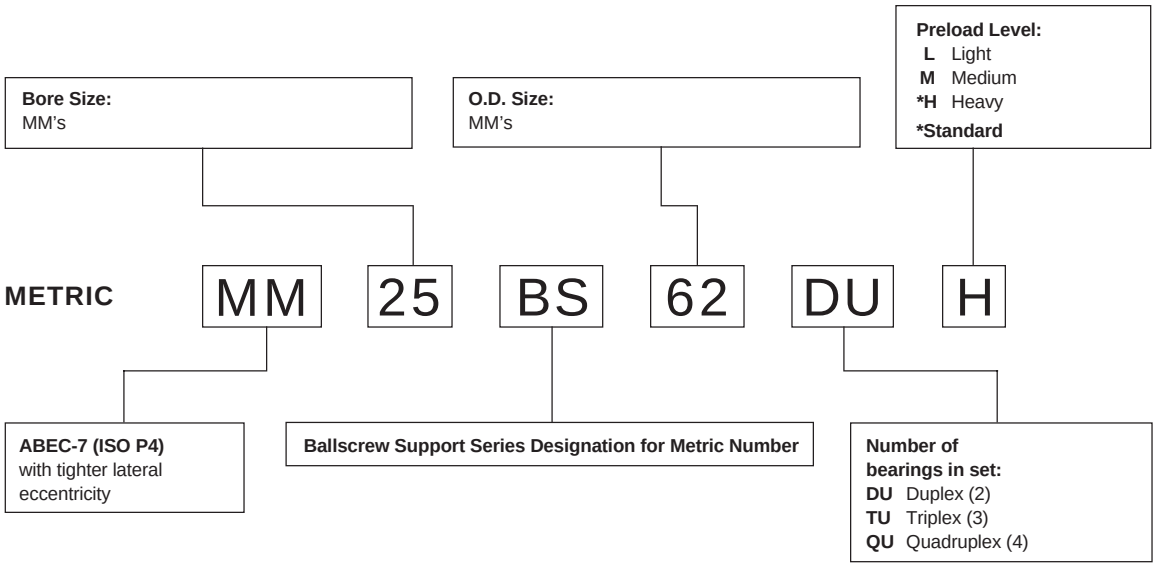


Life vs Ball Material
2MMV99110WN DUL (DB Mounting)



Ballscrew Support Bearings





Ballscrew Support Bearings

To meet the requirements of the servo-controlled machinery field, Torrington has developed a new series of ball bearings specially designed for ballscrew applications. Design criteria for these bearings with maximum axial rigidity, low drag torque, and extreme control of lateral eccentricity.

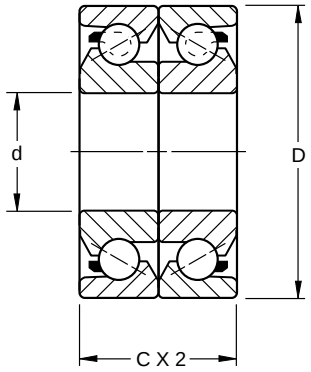
These bearings are manufactured to ABEC-7 tolerances and are of the nonseparable angular-contact type design with a 60° contact angle and maximum complement of balls.These bearings are supplied prelubricated with heavy duty grease NLGI #2 . Bearings are supplied packaged in DB arrangement. However, they can be mounted in duplexed pairs and in multiplexed sets in either Back-to-Back (DB), Face-to-Face (DF) or Tandem (DT) arrangements.

Standard sizes are available and are stocked and packaged as duplex pairs, triplex sets or quadruplex sets. These bearings are designed primarily for ballscrew applications and should not be considered in other areas such as spindles or gear-box shafting without approval by our Engineering Department. These bearings are offered in both standard inch and metric envelope dimensions.

DIMENSIONS – TOLERANCES
All inch tolerance in .0001 units

Bearing Number	Bore				Outside Diameter				(Single) Width *				Maximum Fillet Radius Bearing Corner will Clear **		Ball Complement	
	Nominal Dimension d		Tolerance +.0000" +.0μm to minus		Nominal Dimension D		Tolerance +.0000" +.0μm to minus		Nominal Dimension C		Tolerance +.0000" +.0μm to minus					Dia.
	in.	mm	in.	μm	in.	mm	in.	μm	in.	mm	in.	μm	in.	mm	Qty.	in.
MM9306WI2H	0.7874	20	2.0	5	1.8504	47	2.5	6	0.6250	15.9	50	130	0.031	0.8	12	5/16
MM17BS47	0.6693	17	1.5	4	1.8504	47	2.5	6	0.5906	15	32	80	0.031	0.8	12	5/16
MM20BS47	0.7874	20	2.0	5	1.8504	47	2.5	6	0.5906	15	50	130	0.031	0.8	12	5/16
MM25BS52	0.0983	25	2.0	5	2.0472	52	3.0	7	0.5906	15	50	130	0.031	0.8	13	5/16
MM9308WI2H	0.9385	23.8	2.0	5	2.4409	62	3.0	7	0.6250	15.9	50	130	0.031	0.8	17	5/16
MM25BS62	0.9843	25	2.0	5	2.4409	62	3.0	7	0.5906	15	50	130	0.031	0.8	17	5/16
MM30BS62	1.1811	30	2.0	5	2.4409	62	3.0	7	0.5906	15	50	130	0.031	0.8	17	5/16
MM9310WI2H	1.5000	38.1	2.5	6	2.8346	72	3.0	7	0.6250	15.9	50	130	0.031	0.8	18	11/32
MM30BS72	1.1811	30	2.0	5	2.8346	72	3.0	7	0.5906	15	50	130	0.031	0.8	18	11/32
MM35BS72	1.3780	35	2.5	6	2.8346	72	3.0	7	0.5906	15	50	130	0.031	0.8	18	11/32
MM40BS72	1.5748	40	2.5	6	2.8346	72	3.0	7	0.5906	15	50	130	0.031	0.8	18	11/32
MM9311WI3H	1.7510	44.5	2.5	6	3.0000	76.2	3.0	7	0.6250	15.9	50	130	0.031	0.8	20	11/32
MM45BS75	1.7717	45	2.5	6	2.9528	75	3.0	7	0.5906	15	50	130	0.031	0.8	20	11/32
MM9313WI5H	2.2500	57.2	3.0	7	3.5433	90	3.0	8	0.6250	15.9	60	150	0.031	0.8	24	11/32
MM40BS90	1.5748	40	2.5	6	3.5433	90	3.0	8	0.5906	15	50	130	0.031	0.8	24	11/32
MM50BS90	1.9685	50	2.5	6	3.5433	90	3.0	8	0.5906	15	50	130	0.031	0.8	24	11/32
MM55BS90	2.1654	55	3.0	7	3.5433	90	3.0	8	0.5906	15	60	150	0.031	0.8	24	11/32
MM35BS100	1.3780	35	2.5	6	3.9370	100	3.0	8	0.7874	20	50	130	0.031	0.8	18	1/2
MM40BS100	1.5748	40	2.5	6	3.9370	100	3.0	8	0.7874	20	50	130	0.031	0.8	18	1/2
MM45BS100	1.7717	45	2.5	6	3.9370	100	3.0	8	0.7874	20	50	130	0.031	0.8	18	1/2
MM50BS100	1.9685	50	2.5	6	3.9370	100	3.0	8	0.7874	20	50	130	0.031	0.8	18	1/2
MM9316WI3H	3.0000	76.2	3.0	7	4.3307	110	3.0	8	0.6250	15.9	60	150	0.031	0.8	30	11/32
MM75BS110	2.9528	75	3.0	7	4.3307	110	3.0	8	0.5906	15	60	150	0.031	0.8	30	11/32
MM55BS120	2.1654	55	3.0	7	4.7244	120	3.0	8	0.7874	20	60	150	0.039	1.0	21	1/2
MM60BS120	2.3622	60	3.0	7	4.7244	120	3.0	8	0.7874	20	60	150	0.039	1.0	21	1/2
MM9321WI3	4.0000	101.6	3.0	8	5.7087	145	3.5	9	0.8750	22.2	80	210	0.039	1.0	37	3/8
MM100BS150	3.9370	100	3.0	8	5.9055	150	3.5	9	0.7874	20	60	150	0.039	1.0	26	1/2
MM9326WI6H	5.0000	127	3.0	8	7.0866	180	4.0	10	0.8750	22.2	100	260	0.039	1.0	35	1/2

* Refer to E4 page for width tolerance of preloaded bearings.
** ABMA std. 20 ($r_{as\ max}$).



Duplex Mounting

PHYSICAL CHARACTERISTICS – LOAD RATINGS

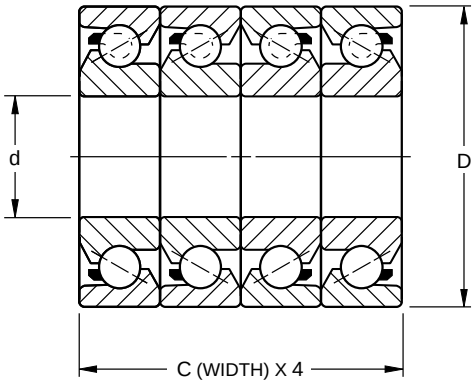
RADIAL LOAD RATING AT 33 1/3 RPM
Based on 1500 hours L_{10} Life and Permissible Speed

Bearing Number	Weight Per Bearing		Static Limiting Thrust Capacity TI		Extended Thrust Dynamic Axial Load Ratings C_{ae}		Maximum Speed	Axial Spring Constant		Drag Torque of Preloaded Set		Preload * Heavy (DUH)	
DUPLEX	lbs	kg	lbs	N	lbs	N	RPM	10^6 lbs/in	10^6 N/m	in-lbs	N-m	lbs(per set)	N
MM9306WI2HDUH	0.28	0.129	5,600	24,900	5,600	24,900	4,400	4.3	750	2.83	0.320	700	3110
MM17BS47DUH	0.29	0.132	5,600	24,900	5,600	24,900	4,400	4.3	750	2.83	0.320	700	3110
MM20BS47DUH	0.27	0.122	5,600	24,900	5,600	24,900	4,400	4.3	750	2.83	0.320	700	3110
MM25BS52DUH	0.31	0.140	6,100	27,100	5,850	26,000	4,400	4.4	780	2.17	0.245	600	2700
MM9308WI2HDUH	0.56	0.252	8,000	35,600	6,700	29,800	3,200	6.0	1050	3.89	0.439	1000	4450
MM25BS62DUH	0.51	0.233	8,000	35,600	6,700	29,800	3,200	6.0	1050	3.89	0.439	1000	4450
MM30BS62DUH	0.46	0.208	8,000	35,600	6,700	29,800	3,200	6.0	1050	3.89	0.439	1000	4450
MM9310WI2HDUH	0.62	0.281	10,200	45,400	8,150	36,300	2,500	7.2	1260	3.89	0.439	1400	6230
MM30BS72DUH	0.70	0.317	10,200	45,400	8,150	36,300	2,500	7.2	1260	3.89	0.439	1400	6230
MM35BS72DUH	0.63	0.287	10,200	45,400	8,150	36,300	2,500	7.2	1260	3.89	0.439	1400	6230
MM40BS72DUH	0.56	0.252	10,200	45,400	8,150	36,300	2,500	7.2	1260	3.89	0.439	1400	6230
MM9311WI3HDUH	0.63	0.284	11,400	50,700	8,650	38,500	2,100	7.9	1380	4.96	0.560	1500	6670
MM45BS75DUH	0.55	0.248	11,400	50,700	8,650	38,500	2,100	7.9	1380	4.96	0.560	1500	6670
MM9313WI5HDUH	0.80	0.361	13,700	60,900	9,300	41,400	2,000	9.5	1660	7.26	0.820	1800	8010
MM40BS90DUH	1.09	0.496	13,700	60,900	9,300	41,400	2,000	9.5	1660	7.26	0.820	1800	8010
MM50BS90DUH	0.91	0.413	13,700	60,900	9,300	41,400	2,000	9.5	1660	7.26	0.820	1800	8010
MM55BS90DUH	0.80	0.364	13,700	60,900	9,300	41,400	2,000	9.5	1660	7.26	0.820	1800	8010
MM35BS100DUH	1.90	0.862	21,000	93,400	16,000	71,200	1,700	10.0	1750	9.03	1.020	2900	12900
MM40BS100DUH	1.80	0.816	21,000	93,400	16,000	71,200	1,700	10.0	1750	9.03	1.020	2900	12900
MM45BS100DUH	1.68	0.763	21,000	93,400	16,000	71,200	1,700	10.0	1750	9.03	1.020	2900	12900
MM50BS100DUH	1.55	0.705	21,000	93,400	16,000	71,200	1,700	10.0	1750	9.03	1.020	2900	12900
MM9316WI3HDUH	1.04	0.472	17,300	77,000	10,000	44,500	1,400	11.9	2080	8.85	1.000	2200	9790
MM75BS110DUH	1.02	0.463	17,300	77,000	10,000	44,500	1,400	11.9	2080	8.85	1.000	2200	9790
MM55BS120DUH	2.49	1.128	30,000	133,400	17,000	75,600	1,400	12.3	2150	12.04	1.360	3500	15570
MM60BS120DUH	2.33	1.058	30,000	133,400	17,000	75,600	1,400	12.3	2150	12.04	1.360	3500	15570
MM9321WI3DUH	2.60	1.178	26,000	115,600	12,900	57,400	1,000	19.4	3400	19.30	2.180	4800	21350
MM100BS150DUH	2.83	1.282	26,000	115,600	12,900	57,400	1,000	19.4	3400	19.30	2.180	4800	21350
MM9326WI6HDUH	3.85	1.748	42,000	186,800	21,200	94,300	750	20.7	3620	35.10	3.966	6000	26690

* Heavy preload is the standard.

Ball Screw Support Series

The recommended maximum limitations on ballscrew bearing speed limits are based on 50% active duty cycle and a ten minute total cycle period. Speed limitations may be increased somewhat with lighter duty cycles. Please consult our Engineering Department regarding bearing speeds and duty cycles.



Quadruplex Mounting

PHYSICAL CHARACTERISTICS – LOAD RATINGS

RADIAL LOAD RATING AT 33 1/3 RPM
Based on 1500 hours L_{10} Life and Permissible Speed

Bearing Number	Weight Per Bearing		Static Limiting Thrust Capacity TI		Extended Thrust Dynamic Axial Load Ratings C_{ae}		Maximum Speed	Axial Spring Constant		Drag Torque of Preloaded Set		Preload * Heavy (QUH)	
Quadruplex	lbs	kg	lbs	N	lbs	N	RPM	10^6 lbs/in	10^6 N/m	in-lbs	N-m	lbs(per set)	N
MM9306WI2HQUH	0.28	0.129	11,200	49,800	9,100	40,500	3,700	8.6	1510	5.66	0.639	1400	6230
MM17BS47QUH	0.29	0.132	11,200	49,800	9,100	40,500	3,700	8.6	1510	5.66	0.639	1400	6230
MM20BS47QUH	0.27	0.122	11,200	49,800	9,100	40,500	3,700	8.6	1510	5.66	0.639	1400	6230
MM25BS52QUH	0.31	0.140	12,200	54,300	9,500	42,300	3,700	8.9	1560	4.34	0.490	1200	5400
MM9308WI2HQUH	0.56	0.252	16,000	71,200	10,900	48,500	2,700	12.0	2100	7.78	0.879	2000	8900
MM25BS62QUH	0.51	0.233	16,000	71,200	10,900	48,500	2,700	12.0	2100	7.78	0.879	2000	8900
MM30BS62QUH	0.46	0.208	16,000	71,200	10,900	48,500	2,700	12.0	2100	7.78	0.879	2000	8900
MM9310WI2HQUH	0.62	0.281	20,400	90,700	13,200	58,700	2,100	14.4	2520	7.78	0.879	2800	12450
MM30BS72QUH	0.70	0.317	20,400	90,700	13,200	58,700	2,100	14.4	2520	7.78	0.879	2800	12450
MM35BS72QUH	0.63	0.287	20,400	90,700	13,200	58,700	2,100	14.4	2520	7.78	0.879	2800	12450
MM40BS72QUH	0.56	0.252	20,400	90,700	13,200	58,700	2,100	14.4	2520	7.78	0.879	2800	12450
MM9311WI3HQUH	0.63	0.284	22,800	101,400	14,100	62,700	1,800	15.8	2770	9.92	1.121	3000	13340
MM45BS75QUH	0.55	0.248	22,800	101,400	14,100	62,700	1,800	15.8	2770	9.92	1.121	3000	13340
MM9313WI5HQUH	0.80	0.361	27,400	121,900	15,100	67,200	1,700	19.0	3330	14.52	1.640	3600	16010
MM40BS90QUH	1.09	0.496	27,400	121,900	15,100	67,200	1,700	19.0	3330	14.52	1.640	3600	16010
MM50BS90QUH	0.91	0.413	27,400	121,900	15,100	67,200	1,700	19.0	3330	14.52	1.640	3600	16010
MM55BS90QUH	0.80	0.364	27,400	121,900	15,100	67,200	1,700	19.0	3330	14.52	1.640	3600	16010
MM35BS100QUH	1.90	0.862	42,000	186,800	26,000	115,600	1,400	20.0	3500	18.06	2.040	5800	25800
MM40BS100QUH	1.80	0.816	42,000	186,800	26,000	115,600	1,400	20.0	3500	18.06	2.040	5800	25800
MM45BS100QUH	1.68	0.763	42,000	186,800	26,000	115,600	1,400	20.0	3500	18.06	2.040	5800	25800
MM50BS100QUH	1.55	0.705	42,000	186,800	26,000	115,600	1,400	20.0	3500	18.06	2.040	5800	25800
MM9316WI3HQUH	1.04	0.472	34,600	153,900	16,200	72,100	1,200	23.8	4170	17.70	2.000	4400	19570
MM75BS110QUH	1.02	0.463	34,600	153,900	16,200	72,100	1,200	23.8	4170	17.70	2.000	4400	19570
MM55BS120QUH	2.49	1.128	60,000	266,900	27,600	122,800	1,200	24.6	4310	24.08	2.721	7000	31140
MM60BS120QUH	2.33	1.058	60,000	266,900	27,600	122,800	1,200	24.6	4310	24.08	2.721	7000	31140
MM9321WI3QUH	2.60	1.178	52,000	231,300	21,000	93,400	900	38.8	6790	38.60	4.361	9600	42700
MM100BS150QUH	2.83	1.284	52,000	231,300	21,000	93,400	900	38.8	6790	38.60	4.361	9600	42700
MM9326WI6HQUH	3.85	1.748	84,000	373,600	34,400	153,000	600	41.4	7250	70.20	7.931	12000	53380

* Heavy preload is the standard.

Ball Screw Support Series

Superprecision Bearings

FTF Fundamental Train Frequency: The frequency at which the retainer will operate.

BSF Ball Spin Frequency: The frequency at which a single defect on a rolling element will be detected.

BPFO Ball Pass Frequency Outer: The frequency at which a single defect in the outer race will be detected.

BPFI Ball Pass Frequency Inner: The frequency at which a single defect in the inner race will be detected.

FREQUENCY COEFFICIENTS

Bearing Number	FTF Fundamental Train Frequency (Inner Rotation)	BSF Ball Spin Frequency	BPFO Ball Pass Frequency Outer	BPFI Ball Pass Frequency Inner	FTF Fundamental Train Frequency (Outer Rotation)
MM9306WI2H	0.4362	2.1044	5.2349	6.7651	0.5638
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
MM9308WI2H	0.4554	3.0307	7.7410	9.2590	0.5446
MM25BS62	0.4554	3.0307	7.7410	9.2590	0.5446
MM30BS62	0.4554	3.0307	7.7410	9.2590	0.5446
MM9310WI2H	0.4569	3.1286	8.2244	9.7756	0.5431
MM30BS72	0.4569	3.1286	8.2244	9.7756	0.5431
MM35BS72	0.4569	3.1286	8.2244	9.7756	0.5431
MM40BS72	0.4569	3.1286	8.2244	9.7756	0.5431
MM9311WI3H	0.4605	3.4145	9.2094	10.7906	0.5395
MM45BS75	0.4605	3.4145	9.2094	10.7906	0.5395
MM9313WI5H	0.4676	4.1773	11.2230	12.7770	0.5324
MM40BS90	0.4676	4.1773	11.2230	12.7770	0.5324
MM50BS90	0.4676	4.1773	11.2230	12.7770	0.5324
MM55BS90	0.4676	4.1773	11.2230	12.7770	0.5324
MM35BS100	0.4564	3.0983	8.2159	9.7841	0.5436
MM40BS100	0.4564	3.0983	8.2159	9.7841	0.5436
MM45BS100	0.4564	3.0983	8.2159	9.7841	0.5436
MM50BS100	0.4564	3.0983	8.2159	9.7841	0.5436
MM9316WI3H	0.4747	5.3492	14.2402	15.7598	0.5253
MM75BS110	0.4747	5.3492	14.2402	15.7598	0.5253
MM55BS120	0.4644	3.7967	9.7516	11.2484	0.5356
MM60BS120	0.4644	3.7967	9.7516	11.2484	0.5356
MM9321WI3	0.4794	6.4615	17.7378	19.2622	0.5206
MM100BS150	0.4790	6.4611	17.7226	19.2774	0.5210
MM9326WI6H	0.4778	6.1209	16.7239	18.2761	0.5222

BSBU D
Standard and Heavy Duty Bearings

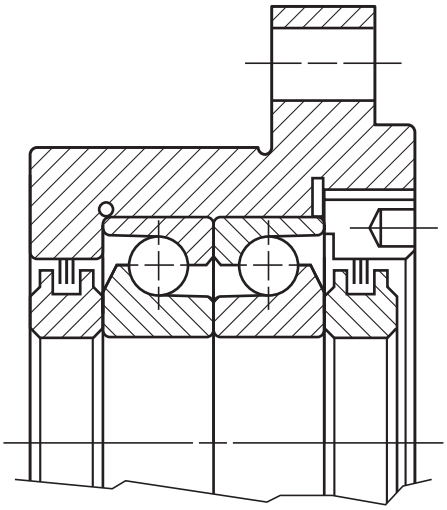
The BSBU D series of bearing cartridge units were designed and developed to give the machine manufacturer a ready made unit providing excellent stiffness and accuracy in ballscrew applications. The unit incorporates a flange enabling it to be bolted to a flat surface perpendicular to the ballscrew axis.

These units combine the features of MM-BS-DU (Duplex) ballscrew 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.

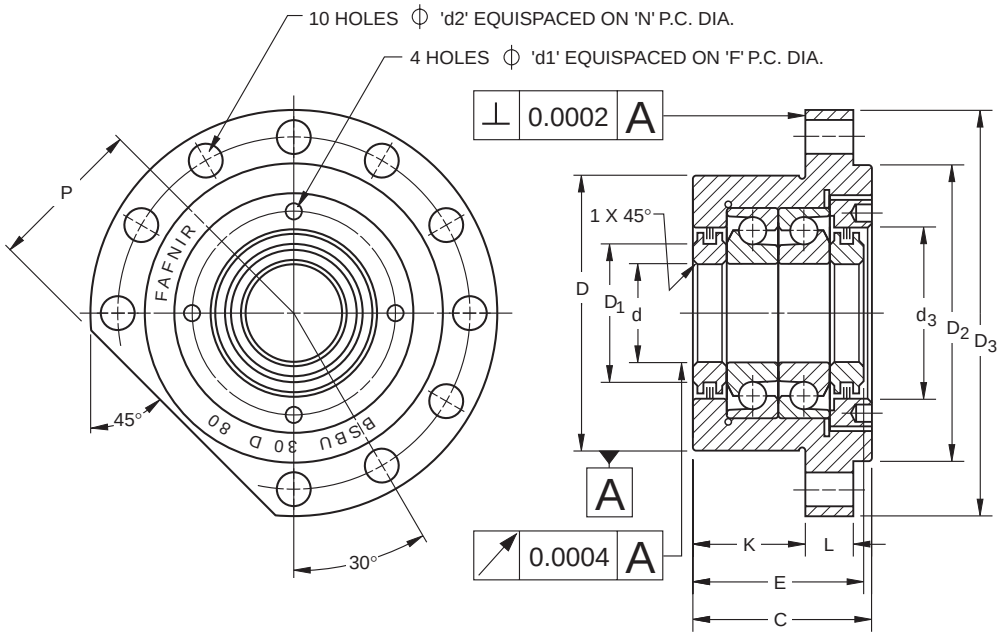
Units are supplied with the bearings in pairs or quad sets mounted in the “DB” (“O”) arrangement. Other bearing arrangements can be accommodated if required and in these cases please contact us with details of your requirements.

Consult our Engineering Department for recommended shaft and housing fits.



STANDARD SERIES – DIMENSIONAL TOLERANCES ± 0.005" (±.13 MM) UNLESS OTHERWISE STATED.

Shaft Diam.	Unit Number	C	d	d_1	d_2	d_3	D	D_1	D_2	D_3	E	F	K	L	N	P	Wt.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	lbs.
mm		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	kg
17	**BSBU17D60**	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						
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	32.0	1.1
			16.996				59.987				43.24						
20	**BSBU20D60**	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						
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	32.0	1.1
			19.996				59.987				43.24						
25	**BSBU25D80**	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						
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	44.0	2.3
			24.996				79.987				49.24						
30	**BSBU30D80**	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						
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	44.0	2.2
			29.996				79.987				49.24						
35	**BSBU35D90**	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						
52.0			35.000	4.3	9.2	60	90.000	46	98	130	50.26	66.5	32.0	15.0	113.0	49	3.2
			34.995				89.985				49.24						
40	**BSBU40D90**	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						
52.0			40.000	4.3	9.2	60.0	90.000	46.0	98	130.0	50.26	66.5	32.0	15.0	113.0	49	3.1
			39.995				89.985				49.24						



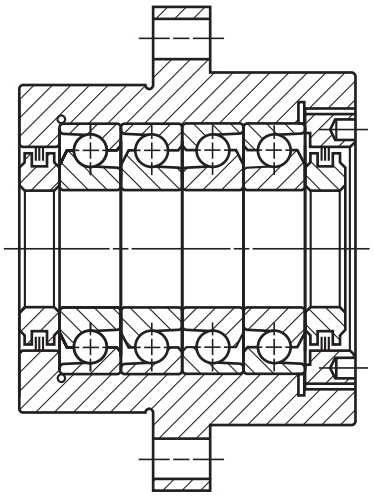
HEAVY DUTY SERIES – DIMENSIONAL TOLERANCES ± 0.005" (±.13 MM) UNLESS OTHERWISE STATED.

Shaft Diam.	Unit Number	C	d	d_1	d_2	d_3	D	D_1	D_2	D_3	E	F	K	L	N	P	Wt.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	lbs.
mm		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	kg
35	**BSBU35D124**	2.6	1.3780	0.21	0.45	2.99	4.8819	2.6	5.04	6.5	2.530	3.54	1.71	0.67	5.75	2.52	13.86
			1.3778				4.8812				2.490						
		66.0	35.000	5.3	11.4	76.0	124.000	66.0	128	165.0	64.26	90.0	43.5	17.0	146.0	64.0	6.3
			34.995				123.982				63.24						
40	**BSBU40D124**	2.6	1.5748	0.21	0.45	2.99	4.8819	2.6	5.04	6.5	2.530	3.54	1.71	0.67	5.75	2.52	13.42
			1.5746				4.8812				2.490						
		66.0	40.000	5.3	11.4	76.0	124.000	66.0	128	165.0	64.26	90.0	43.5	17.0	146.0	64.0	6.1
			39.995				123.982				63.24						
45	**BSBU45D124**	2.6	1.7716	0.21	0.45	2.99	4.8819	2.6	5.04	6.5	2.530	3.54	1.71	0.67	5.75	2.52	13.2
			1.7714				4.8812				2.490						
		66.0	45.000	5.3	11.4	76.0	124.000	66.0	128	165.0	64.26	90.0	43.5	17.0	146.0	64.0	6.0
			44.995				123.982				63.24						
50	**BSBU50D124**	2.6	1.9685	0.21	0.45	2.99	4.8819	2.6	5.04	6.5	2.530	3.54	1.71	0.67	5.75	2.52	12.898
			1.9683				4.8812				2.490						
		66.0	50.000	5.3	11.4	76.0	124.000	66.0	128	165.0	64.26	90.0	43.5	17.0	146.0	64.0	5.9
			49.995				123.982				63.24						

BSBU Q Standard and Heavy Duty Bearings

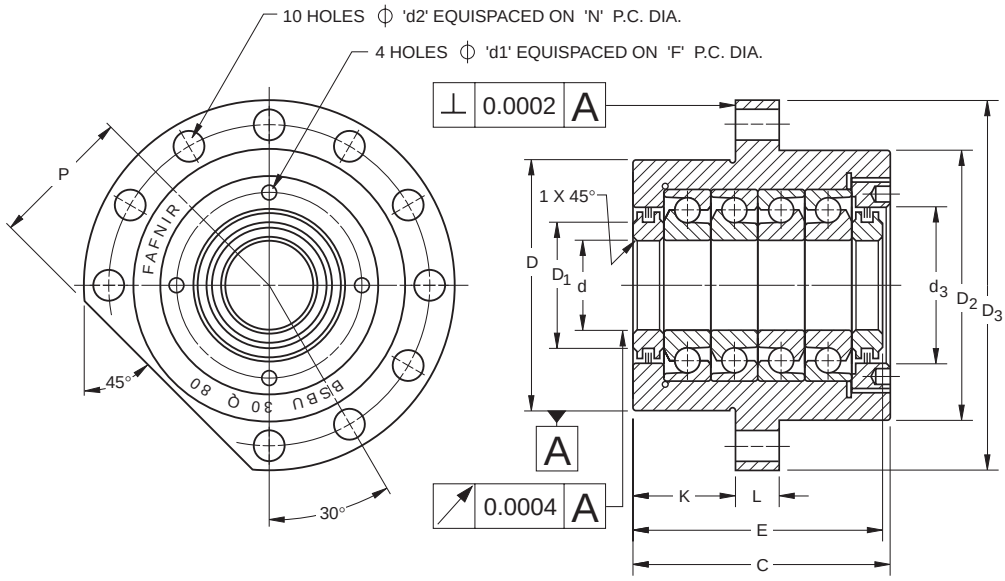
The BSBU Q series are similar in design and features to the BSBU D series except MM-BS-QU Quadruplex bearings are used.

Consult our Engineering Department for recommended shaft and housing fits.



STANDARD SERIES – DIMENSIONAL TOLERANCES ±.005" (±.13 mm) UNLESS OTHERWISE STATED

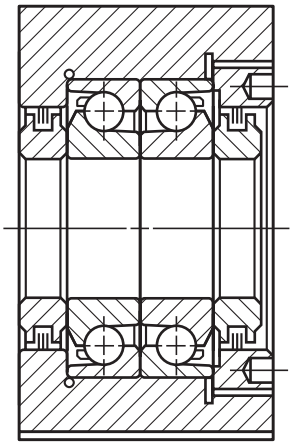
Shaft Diam.	Unit Number	C	d	d_1	d_2	d_3	D	D_1	D_2	D_3	E	F	K	L	N	P	Wt.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	lbs.
mm		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	kg
17	**BSBU17Q60**	3.03	0.6693	0.17	0.26	1.42	2.3622	1.02	2.52	3.54	2.924	1.67	1.26	0.51	2.99	1.26	3.74
			0.6690				2.3617				2.864						
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
			16.993				59.987				72.74						
20	**BSBU20Q60**	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						
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						
25	**BSBU25Q80**	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	7.7
			0.9841				3.1491				3.100						
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						
30	**BSBU30Q80**	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						
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
			29.995				79.987				78.74						
35	**BSBU35Q90**	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						
82.0			40.000	4.3	9.2	60	90.000	46	98	130	80.26	66.5	32.0	15.0	113.0	49	4.6
			39.000				89.985				78.74						
40	**BSBU40Q90**	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	9.9
			1.5746				3.5427				3.100						
82.0			40.000	4.3	9.2	60.0	90.000	46.0	98	130.0	80.26	66.5	32.0	15.0	113.0	49	4.5
			39.995				89.985				78.74						



HEAVY DUTY SERIES – DIMENSIONAL TOLERANCES ±.005" (±.13 mm) UNLESS OTHERWISE STATED

Shaft Diam.	Unit Number	C	d	d_1	d_2	d_3	D	D_1	D_2	D_3	E	F	K	L	N	P	Wt.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	lbs.
mm		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	kg
35	**BSBU35Q124**	4.17	1.3780	0.21	0.45	2.99	4.8819	2.6	5.04	6.5	4.105	3.54	1.71	0.67	5.75	2.52	22.22
			1.3778				4.8812				4.045						
106.0			35.000	5.3	11.4	76.0	124.000	66.0	128	165.0	104.26	90.0	43.5	17.0	146.0	64.0	10.1
			34.995				123.982				102.74						
40	**BSBU40Q124**	4.17	1.5748	0.21	0.45	2.99	4.8819	2.6	5.04	6.5	4.105	3.54	1.71	0.67	5.75	2.52	21.34
			1.5746				4.8812				4.045						
106.0			40.000	5.3	11.4	76.0	124.000	66.0	128	165.0	104.26	90.0	43.5	17.0	146.0	64.0	9.7
			39.995				123.982				102.74						
45	**BSBU45Q124**	4.17	1.7716	0.21	0.45	2.99	4.8819	2.6	5.04	6.5	4.105	3.54	1.71	0.67	5.75	2.52	20.9
			1.7714				4.8812				4.045						
106.0			45.000	5.3	11.4	76.0	124.000	66.0	128	165.0	104.26	90.0	43.5	17.0	146.0	64.0	9.5
			44.995				123.982				102.74						
50	**BSBU50Q124**	4.17	1.9685	0.21	0.45	2.99	4.8819	2.6	5.04	6.5	4.105	3.54	1.71	0.67	5.75	2.52	20.46
			1.9683				4.8812				4.045						
106.0			50.000	5.3	11.4	76.0	124.000	66.0	128	165.0	104.26	90.0	43.5	17.0	146.0	64.0	9.3
			49.995				123.982				102.74						

BSPB D
Standard and
Heavy Duty Bearings



The BSPB D series is a design of bearing pillow block unit for ballscrew applications.

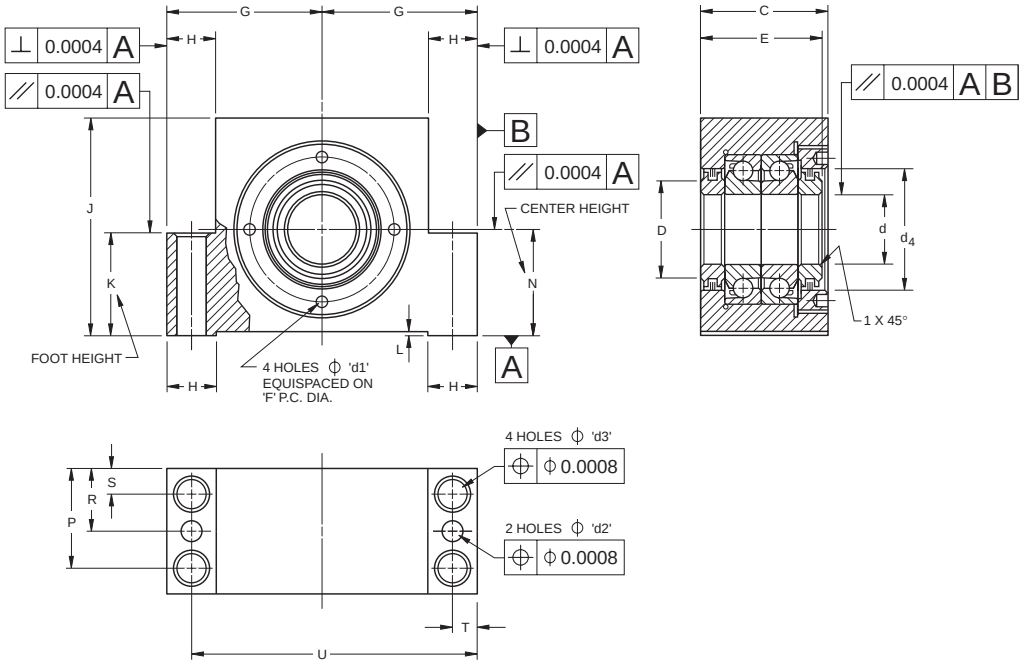
The unit incorporates similar features to the BSBU D series but is designed to bolt down onto a flat surface, parallel to the ballscrew axis.

In the standard unit, pilot holes for dowels are provided. Units with finished holes for dowels can be supplied by special order if required.

Consult our Engineering Department for recommended shaft and housing fits.

STANDARD SERIES – DIMENSIONAL TOLERANCES ±.005" (±.13mm) UNLESS OTHERWISE STATED.

Shaft Diam.	Unit Number	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.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	lbs.
mm		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	kg
17	**BSPB17D32**	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	3.3
		1.848	0.6691						1.702		1.8499					1.2593						
		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						
20	**BSPB20D32**	1.850	0.7874	0.17	0.31	0.35	1.42	1.02	1.742	1.67	1.8504	0.67	2.44	1.65	0.04	1.2598	1.50	0.87	0.35	0.33	3.37	3.3
		1.848	0.7872						1.702		1.8499					1.2593						
		47.000	20.000	4.3	7.8	9.0	36.0	26.0	44.26	42.5	47.000	17	62	42.0	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						
25	**BSPB25D42**	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						
		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						
30	**BSPB30D42**	2.047	1.1811	0.17	0.39	0.43	1.97	1.57	1.979	2.34	2.4606	0.79	3.35	1.97	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						
		52.000	30.000	4.3	9.8	11.0	50.0	40.0	50.26	59.5	62.500	20	85	50.0	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						
35	**BSPB35D50**	2.047	1.378	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						
		52.000	35.000	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	3.8
		51.950	34.995						49.24		67.987					49.987						
40	**BSPB40D50**	2.047	1.5748	0.17	0.51	0.51	2.36	1.81	1.979	2.62	2.6772	0.81	3.74	1.26	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						
		52.000	40.000	4.3	13.0	13.0	60.0	46.0	50.26	66.5	68.000	20.5	95	32.0	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						



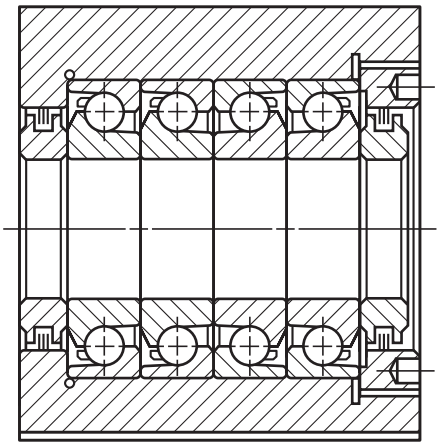
HEAVY DUTY SERIES – DIMENSIONAL TOLERANCES ±.005" (±.13mm) UNLESS OTHERWISE STATED.

Shaft Diam.	Unit Number	C	d	d1	d2	d3	d4	D	E	F	G	H	J	K	L	N	P	R	S	T	U	Wt.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	lbs.
mm		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	kg
35	**BSPB35D65**	2.598	1.3780	0.21	0.46	0.71	2.99	2.6	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						
		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	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						
40	**BSPB40D65**	2.598	1.5748	0.21	0.46	0.71	2.99	2.6	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	20.9
		2.596	1.5746						2.490		3.7396					2.5585						
		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	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						
45	**BSPB45D65**	2.598	1.7716	0.21	0.46	0.71	2.99	2.6	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						
		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	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						
50	**BSPB50D65**	2.598	1.9685	0.21	0.46	0.71	2.99	2.6	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						
		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	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						

BSPB Q Standard and Heavy Duty Bearings

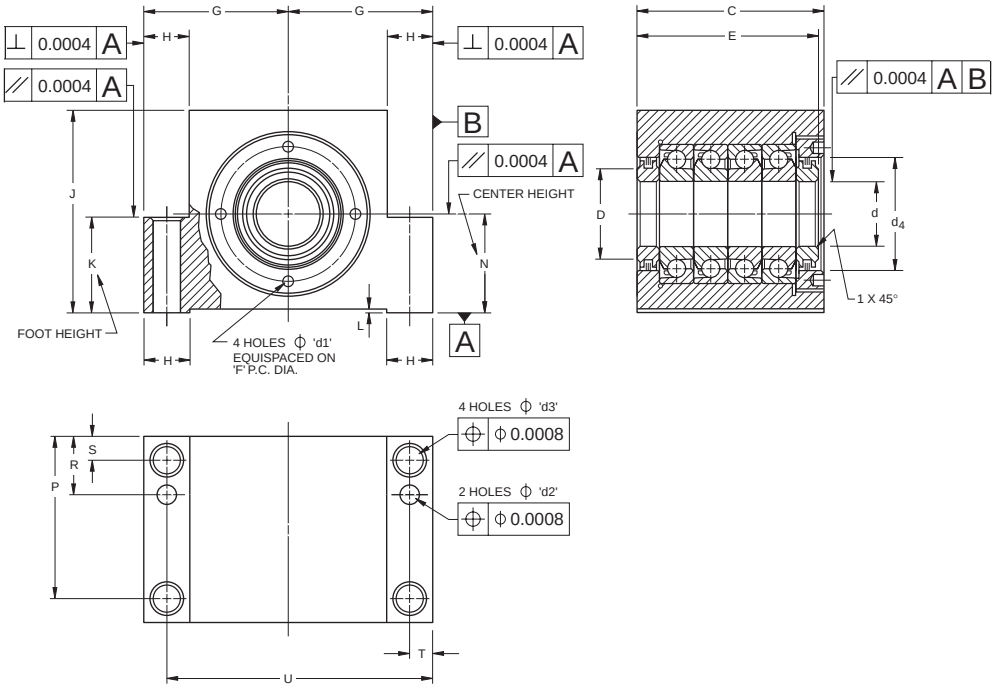
The BSPB Q series is similar in design and features to the BSPB D series except MM-BS-QU Quadruplex bearings are used.

Consult our Engineering Department for recommended shaft and housing fits.



STANDARD SERIES – DIMENSIONAL TOLERANCES ±.005" (±.13 MM) UNLESS OTHERWISE STATED

Shaft Diam.	Unit Number	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.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	lbs.
mm		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	kg
17	**BSPB17Q32**	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
		3.030	0.6691						2.864		1.8499					1.2593						
		77.000	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
		76.950	16.996						72.74		46.987					31.987						
20	**BSPB20Q32**	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	5.5
		3.030	0.7872						2.864		1.8499					1.2593						
		77.000	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
		76.950	19.996						72.74		46.987					31.987						
25	**BSPB25Q42**	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						
		82.000	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
		81.950	24.995						78.74		62.487					41.987						
30	**BSPB30Q42**	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	9.9
		3.226	1.1809						3.100		2.4601					1.6530						
		82.000	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
		81.950	29.996						78.74		62.487					41.987						
35	**BSPB35Q50**	3.228	1.378	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						
		82.000	35.000	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	6.2
		81.950	34.995						78.74		67.987					49.987						
40	**BSPB40Q50**	3.228	1.5748	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	13.2
		3.226	1.5746						3.100		2.6767					1.9680						
		82.000	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
		81.950	39.995						78.74		67.987					49.987						



HEAVY DUTY SERIES – DIMENSIONAL TOLERANCES ±.005" (±.13 MM) UNLESS OTHERWISE STATED

Shaft Diam.	Unit Number	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.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	lbs.
mm		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	kg
35	**BSPB35Q65**	4.173	1.3780	0.21	0.46	0.71	2.99	2.6	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	34.98
		4.171	1.3778						4.045		3.7396					2.5585						
		106.000	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
		105.950	34.995						102.74		94.987					65.987						
40	**BSPB40Q65**	4.173	1.5748	0.21	0.46	0.71	2.99	2.6	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						
		106.000	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
		105.950	39.995						102.74		94.987					65.987						
45	**BSPB45Q65**	4.173	1.7716	0.21	0.46	0.71	2.99	2.6	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						
		106.000	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
		105.950	44.995						102.74		94.987					65.987						
50	**BSPB50Q65**	4.173	1.9685	0.21	0.46	0.71	2.99	2.6	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						
		106.000	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
		105.950	49.995						102.74		94.987					65.987						

FAFNIR BALLSCREW SUPPORT BEARING HOUSED UNITS

Unit Ref.	Bearing Set Ref.	Unit Ref.	Bearing Set Ref.
BSBU17D60	MM17BS47DUH	BSBU17Q60	MM17BS47QUH
BSBU20D60	MM20BS47DUH	BSBU20Q60	MM20BS47QUH
BSBU25D80	MM25BS62DUH	BSBU25Q80	MM25BS62QUH
BSBU30D80	MM30BS62DUH	BSBU30Q80	MM30BS62QUH
BSBU35D90	MM35BS72DUH	BSBU35Q90	MM35BS72QUH
BSBU40D90	MM40BS72DUH	BSBU40Q90	MM40BS72QUH
BSBU35D124	MM35BS100DUH	BSBU35Q124	MM35BS100QUH
BSBU40D124	MM40BS100DUH	BSBU40Q124	MM40BS100QUH
BSBU45D124	MM45BS100DUH	BSBU45Q124	MM45BS100QUH
BSBU50D124	MM50BS100DUH	BSBU50Q124	MM50BS100QUH

Unit Ref.	Bearing Set Ref.	Unit Ref.	Bearing Set Ref.
BSPB17D32	MM17BS47DUH	BSPB17Q32	MM17BS47QUH
BSPB20D32	MM20BS47DUH	BSPB20Q32	MM20BS47QUH
BSPB25D42	MM25BS62DUH	BSPB25Q42	MM25BS62QUH
BSPB30D42	MM30BS62DUH	BSPB30Q42	MM30BS62QUH
BSPB35D50	MM35BS72DUH	BSPB35Q50	MM35BS72QUH
BSPB40D50	MM40BS72DUH	BSPB40Q50	MM40BS72QUH
BSPB35D65	MM35BS100DUH	BSPB35Q65	MM35BS100QUH
BSPB40D65	MM40BS100DUH	BSPB40Q65	MM40BS100QUH
BSPB45D65	MM45BS100DUH	BSPB45Q65	MM45BS100QUH
BSPB50D65	MM50BS100DUH	BSPB50Q65	MM50BS100QUH

Foreword

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

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

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

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

Tolerances

The Annular Bearing Engineers' Committee has established four classes of tolerances for ball bearings, known as ABEC-1, ABEC-5, ABEC-7, and ABEC-9. The highest number indicates the class with the most exacting tolerances.

Every ball bearing manufactured by The Torrington Company is made to close tolerances, adhering to the established ABEC standards. Even the most liberal classification of ABEC -1 assures a precision product. Many applications in numerous types of machines can be satisfactorily operated with ABEC-1 tolerance bearings.

However, for applications involving high speeds, extreme accuracy and rigidity in such equipment as high-grade machine tools, precision wheelheads and workheads, woodworking machines, superchargers, jet engines, sensitive precision instruments and digital computers, Torrington manufactures a complete line of superprecision ball bearings made to ABEC-9 tolerances.

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

In Figure 1, the chart shows the various classes of tolerances for 35-millimeter bore size, light series bearings (207). To meet the requirements of the machine tool industry, even ABEC-9 tolerances do not represent the ultimate, since some special applications require even higher precision.

ABEC Tolerances (Figure 1)

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

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

Values of standard tolerances ABEC-7 and ABEC-9, for superprecision ball bearings used in machine tool applications are shown on pages E4 and E5.

ABEC TOLERANCES
35 MM Bore Light Series Bearing

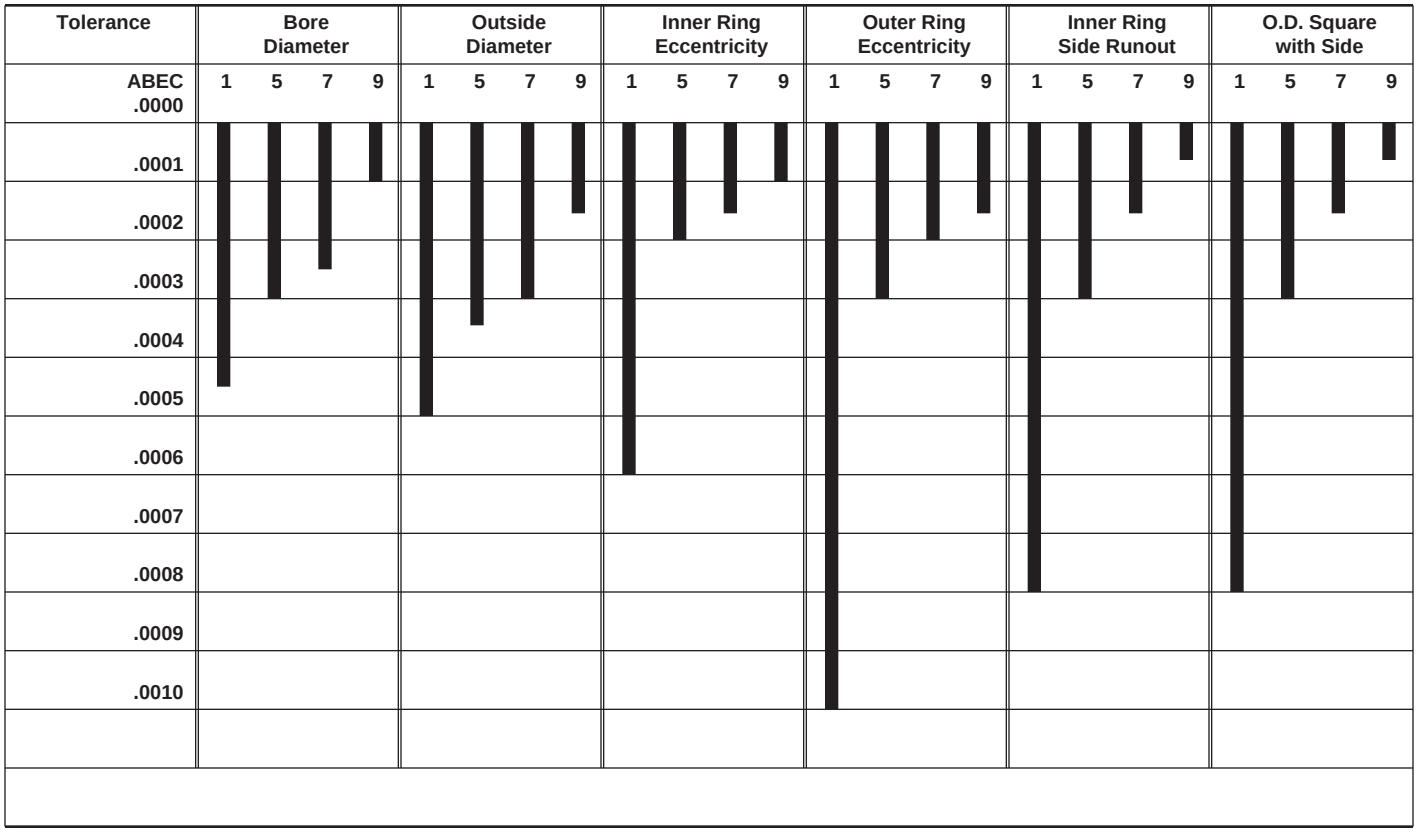


Figure 1 — ABEC Tolerances

Standard Tolerances

Inner Ring ABEC – 7,9—ISO P4, P2

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

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

Values of tolerances ABEC-7 and ABEC-9 for superprecision ball bearings are shown below.

ABMA/ISO Symbols – Inner Ring

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

K_{ia} Radial runout of assembled bearing inner ring, i.e., radial runout of raceway.

V_{Bs} Inner ring width variation, i.e. parallelism.

S_d Inner ring reference face runout with bore, i.e., squareness – bore to face.

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

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

STANDARD ABEC TOLERANCES – INNER RING

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

d Bearing Bore		Δdmp Bore Diameter(1) +.0000",+.000mm to minus		V_{Bs} Width Variation (Parallelism)		K_{ia} Raceway Radial Runout		S_d Face Runout With Bore (Squareness)		S_{ia} Raceway Axial Runout		Δ_{Bs} & Δ_{Cs} Width Inner & Outer Rings +.0000",+.000mm to minus
		MMV ABEC 7	ABEC 9	ABEC 7	*MMV* ABEC 9	ABEC 7	*MMV* ABEC 9	ABEC 7	*MMV* ABEC 9	ABEC 7	*MMV* ABEC 9	ABEC 7,9
Over mm	Incl. mm	inch μm	inch μm	inch μm	inch μm	inch μm	inch μm	inch μm	inch μm	inch μm	inch μm	inch μm
0	10	-1 ½ -4	-1 -2 ½	1 2.5	½ 1 ½	1 2 ½	½ 1 ½	1 3	½ 1 ½	1 3	½ 1 ½	0.0016 0.04
10	18	-1 ½ -4	-1 -2 ½	1 2.5	½ 1 ½	1 2 ½	½ 1 ½	1 3	½ 1 ½	1 3	½ 1 ½	0.0031 0.08
18	30	-2 -5	-1 -2 ½	1 2.5	½ 1 ½	1 3	1 2 ½	1 ½ 4	½ 1 ½	1 ½ 4	1 2 ½	0.0047 0.12
30	50	-2 ½ -6	-1 -2 ½	1 3	½ 1 ½	1 ½ 4	1 2 ½	1 ½ 4	½ 1 ½	1 ½ 4	1 2 ½	0.0047 0.12
50	80	-3 -7	-1 ½ -4	1 ½ 4	½ 1 ½	1 ½ 4	1 2 ½	2 5	½ 1 ½	2 5	1 2 ½	0.0059 0.15
80	120	-3 -8	-2 -5	1 ½ 4	1 2 ½	2 5	1 2 ½	2 5	1 2 ½	2 5	1 2 ½	0.0079 0.20
120	150	-4 -10	-3 -7	2 5	1 2 ½	2 5	1 2 ½	2 ½ 6	1 2 ½	3 7	1 2 ½	0.0098 0.25
150	180	-4 -10	-3 -7	2 5	1 ½ 4	2 ½ 6	2 5	2 ½ 6	1 ½ 4	3 7	2 5	0.0098 0.25
180	250	-4 ½ -12	-3 -8	2 ½ 6	2 5	3 8	2 5	3 7	2 5	3 8	2 5	0.0118 0.30

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

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

Width Tolerances:

The width tolerances for individual inner and outer rings are shown in the above table but, to allow for the face grinding on two bearings for various preloads, the total width tolerances of duplex pairs of bearings are as shown.

Preloaded Duplex Set Width Tolerance

Nominal bore Millimeters		Width Tolerance	
Over	Inclusive	Maximum	Minimum
0	200	.000" .00mm	.010" .25mm

Standard Tolerances

Outer Ring ABEC – 7,9—ISO P4, P2

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

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

Values of tolerances ABEC-7 and ABEC-9 for superprecision ball bearings are shown below.

ABMA/ISO Symbols – Outer Ring

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

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

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

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

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

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

STANDARD ABEC TOLERANCES – OUTER RING

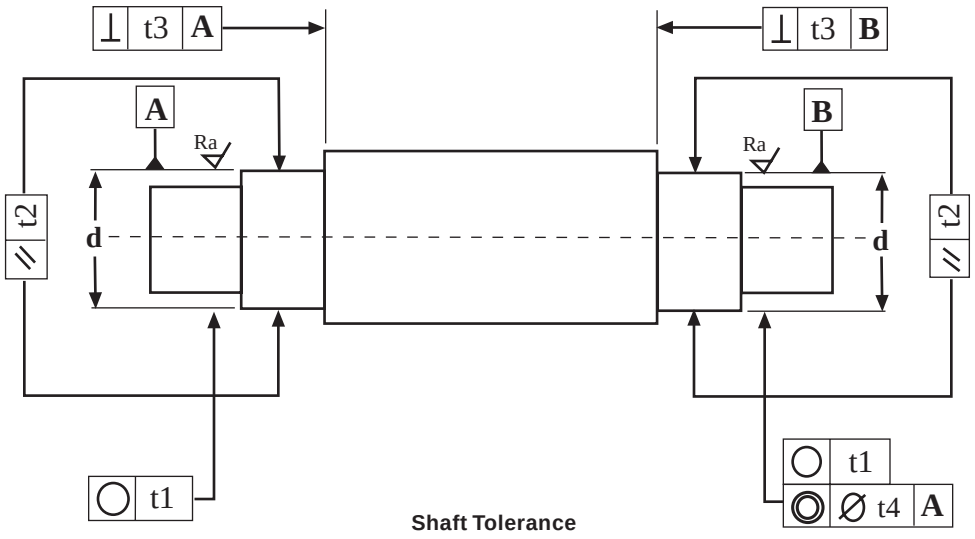
All tolerances in number of ten-thousandths inches (.0001") and **micrometers (μm)**

D Bearing O.D.		ΔDmp Outside Diameter(1) +.0000",+.000mm to minus		V_{Cs} Width Variation (Parallelism)		K_{ea} Raceway Radial Runout		S_{ea} Raceway Axial Runout		S_D Outside Diameter Runout With Face (Squareness)	
		MMV ABEC 7	ABEC 9	ABEC 7	*MMV* ABEC 9	ABEC 7	*MMV* ABEC 9	ABEC 7	*MMV* ABEC 9	ABEC 7	*MMV* ABEC 9
Over mm	Incl. mm	inch μm	inch μm	inch μm	inch μm	inch μm	inch μm	inch μm	inch μm	inch μm	inch μm
0	18	-1 1/2 -4	-1 -2 ½	1 2 ½	1/2 1 ½	1 3	1/2 1 ½	2 5	1/2 1 ½	1 1/2 4	1/2 1 ½
18	30	-2 -5	-1 1/2 -4	1 2 ½	1/2 1 ½	1 1/2 4	1 2 ½	2 5	1 2 ½	1 1/2 4	1/2 1 ½
30	50	-2 1/2 -6	-1 1/2 -4	1 2 ½	1/2 1 ½	2 5	1 2 ½	2 5	1 2 ½	1 1/2 4	1/2 1 ½
50	80	-3 -7	-1 1/2 -4	1 3	1/2 1 ½	2 5	1 1/2 4	2 5	1 1/2 4	1 1/2 4	1/2 1 ½
80	120	-3 -8	-2 -5	1 1/2 4	1 2 ½	2 1/2 6	2 5	2 1/2 6	2 5	2 5	1 2 ½
120	150	-3 1/2 -9	-2 -5	2 5	1 2 ½	3 7	2 5	3 7	2 5	2 5	1 2 ½
150	180	-4 -10	-3 -7	2 5	1 2 ½	3 8	2 5	3 8	2 5	2 5	1 2 ½
180	250	-4 1/2 -11	-3 -8	3 7	1 1/2 4	4 10	3 7	4 10	3 7	3 7	1 1/2 4
250	315	-5 -13	-3 -8	3 7	2 5	4 1/2 11	3 7	4 10	3 7	3 8	2 5
315	400	-6 -15	-4 -10	3 8	3 7	5 13	3 8	5 13	3 8	4 10	3 7

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

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

Shaft Geometry Requirements



Shaft Tolerance

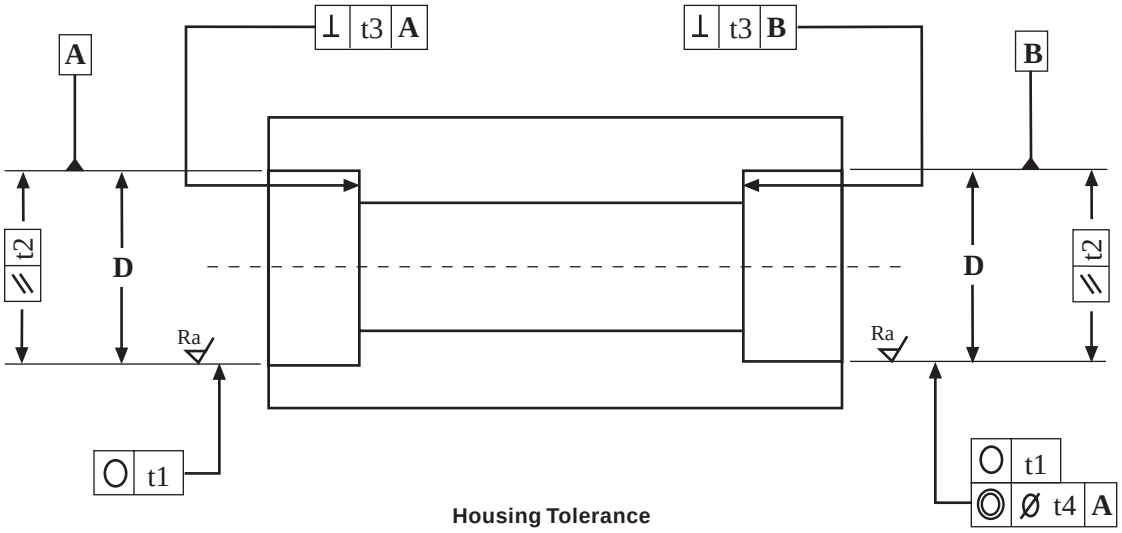
Description	Symbol	Tolerance Value	MM ABEC 7	MMV HG	MMX ABEC 9
Roundness	○	t1	IT2	IT1	IT0
Parallelism	\\	t2	IT2	IT1	IT0
Squareness	⊥	t3	IT2	IT1	IT0
Concentricity	◎	t4	IT3	IT2	IT2
Surface Finish	Ra		16 µ"	or	0.4 µm

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

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

Reference ISO 286.

Housing Geometry Requirements



Housing Tolerance

Description	Symbol	Tolerance Value	MM ABEC 7	MMV HG	MMX ABEC 9
Roundness	○	t1	IT2	IT1	IT0
Parallelism	\\	t2	IT2	IT1	IT0
Squareness	⊥	t3	IT2	IT1	IT0
Concentricity	◎	t4	IT3	IT2	IT2
Surface Finish	Ra		16 μ"	or	0.4 μm

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

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

Reference ISO 286.

Recommended Spindle Shaft Tolerances

* SHAFT MOUNTING FITS – ABEC – 7 (ISO P4)

Bearing Bore Number	Bearing Bore Diameter				Rotating Shaft							
					Shaft Diameter				Mounting Fits			
	max. inch	min. inch	max. mm	min. mm	min. inch	max. inch	min. mm	max. mm	loose inch	tight inch	loose mm	tight mm
00	0.3937	0.39355	10	9.996	0.3935	0.3937	9.995	10.000	0.0002	0.00015	0.005	0.004
01	0.4724	0.47225	12	11.996	0.4722	0.4724	11.995	12.000	0.0002	0.00015	0.005	0.004
02	0.5906	0.59045	15	14.996	0.5904	0.5906	14.995	15.000	0.0002	0.00015	0.005	0.004
03	0.6693	0.66915	17	16.996	0.6691	0.6693	16.995	17.000	0.0002	0.00015	0.005	0.004
04	0.7874	0.78720	20	19.995	0.7872	0.7874	19.995	20.000	0.0002	0.00020	0.005	0.005
05	0.9843	0.98410	25	24.995	0.9841	0.9843	24.995	25.000	0.0002	0.00020	0.005	0.005
06	1.1811	1.18090	30	29.995	1.1809	1.1811	29.995	30.000	0.0002	0.00020	0.005	0.005
07	1.3780	1.37775	35	34.994	1.3778	1.3780	34.995	35.000	0.0002	0.00025	0.005	0.006
08	1.5748	1.57455	40	39.994	1.5746	1.5748	39.995	40.000	0.0002	0.00025	0.005	0.006
09	1.7717	1.77145	45	44.994	1.7715	1.7717	44.995	45.000	0.0002	0.00025	0.005	0.006
10	1.9685	1.96825	50	49.994	1.9683	1.9685	49.995	50.000	0.0002	0.00025	0.005	0.006
11	2.1654	2.16510	55	54.993	2.1652	2.1654	54.995	55.000	0.0002	0.00030	0.005	0.007
12	2.3622	2.36190	60	59.993	2.3620	2.3622	59.995	60.000	0.0002	0.00030	0.005	0.007
13	2.5591	2.55880	65	64.993	2.5589	2.5591	64.995	65.000	0.0002	0.00030	0.005	0.007
14	2.7559	2.75560	70	69.993	2.7557	2.7559	69.995	70.000	0.0002	0.00030	0.005	0.007
15	2.9528	2.95250	75	74.993	2.9526	2.9530	74.995	75.005	0.0002	0.00050	0.005	0.012
16	3.1496	3.14930	80	79.993	3.1494	3.1498	79.995	80.005	0.0002	0.00050	0.005	0.012
17	3.3465	3.34620	85	84.992	3.3463	3.3467	84.995	85.005	0.0002	0.00050	0.005	0.012
18	3.5433	3.5430	90	89.992	3.5431	3.5435	89.995	90.005	0.0002	0.00050	0.005	0.013
19	3.7402	3.73990	95	94.992	3.7400	3.7404	94.995	95.005	0.0002	0.00050	0.005	0.013

* Over 750,000 dN, consult with Torrington Engineering Department.

* SHAFT MOUNTING FITS – ABEC – 7 (ISO P4)

Bearing Bore Number	Bearing Bore Diameter				Rotating Shaft							
					Shaft Diameter				Mounting Fits			
	max. inch	min. inch	max. mm	min. mm	min. inch	max. inch	min. mm	max. mm	loose inch	tight inch	loose mm	tight mm
20	3.9370	3.93670	100	99.992	3.9368	3.9372	99.995	100.005	0.0002	0.0005	0.005	0.013
21	4.1339	4.13360	105	104.992	4.1337	4.1341	104.995	105.005	0.0002	0.0005	0.005	0.013
22	4.3307	4.33040	110	109.992	4.3305	4.3309	109.995	110.005	0.0002	0.0005	0.005	0.013
24	4.7244	4.72410	120	119.992	4.7242	4.7246	119.995	120.005	0.0002	0.0005	0.005	0.013
26	5.1181	5.11770	130	129.990	5.1179	5.1183	129.995	130.005	0.0002	0.0006	0.005	0.015
28	5.5118	5.51140	140	139.990	5.5116	5.5120	139.995	140.005	0.0002	0.0006	0.005	0.015
30	5.9055	5.90510	150	149.990	5.9053	5.9057	149.995	150.005	0.0002	0.0006	0.005	0.015
32	6.2992	6.29880	160	159.990	6.2990	6.2994	159.995	160.005	0.0002	0.0006	0.005	0.015
34	6.6929	6.69250	170	169.990	6.6927	6.6931	169.995	170.005	0.0002	0.0006	0.005	0.015
36	7.0866	7.08620	180	179.990	7.0863	7.0869	179.993	180.008	0.0003	0.0007	0.007	0.018
38	7.4803	7.47985	190	189.990	7.4800	7.4806	189.993	190.008	0.0003	0.0008	0.007	0.019
40	7.8740	7.87355	200	199.990	7.8737	7.8743	199.993	200.008	0.0003	0.0008	0.007	0.019

* Over 750,000 dN, consult with Torrington Engineering Department.

Recommended Spindle Housing Tolerances

HOUSING MOUNTING FITS (FIXED) – ABEC – 7 (ISO P4)

Bearing O.D. Diameter		Stationary Housing			
		Housing Bore		Mounting Fits	
max.	min.	min.	max.	tight	loose
inch mm	inch mm	inch mm	inch mm	inch mm	inch mm
0.8661 22	0.8659 21.995	0.8661 22	0.8663 22.005	0.0000 0.000	0.0004 0.010
0.9449 24	0.9447 23.995	0.9449 24	0.9451 24.005	0.0000 0.000	0.0004 0.010
1.0236 26	1.0234 25.995	1.0236 26	1.0238 26.005	0.0000 0.000	0.0004 0.010
1.1024 28	1.1022 27.995	1.1024 28	1.1026 28.005	0.0000 0.000	0.0004 0.010
1.1811 30	1.1809 29.995	1.1811 30	1.1813 30.005	0.0000 0.000	0.0004 0.010
1.2598 32	1.25955 31.994	1.2598 32	1.2600 32.005	0.0000 0.000	0.00045 0.011
1.3780 35	1.37775 34.994	1.3780 35	1.3783 35.006	0.0000 0.000	0.0005 0.012
1.4567 37	1.45645 36.994	1.4567 37	1.4570 37.006	0.0000 0.000	0.0005 0.012
1.5748 40	1.57455 39.994	1.5748 40	1.5751 40.006	0.0000 0.000	0.0005 0.012
1.6535 42	1.65325 41.994	1.6535 42	1.6538 42.006	0.0000 0.000	0.0005 0.012
1.8504 47	1.85015 46.994	1.8504 47	1.8507 47.006	0.0000 0.000	0.0005 0.012
2.0472 52	2.0469 51.993	2.0472 52	2.0475 52.006	0.0000 0.000	0.00055 0.013
2.1654 55	2.1651 54.993	2.1654 55	2.1657 55.008	0.0000 0.000	0.0006 0.015
2.4409 62	2.4406 61.993	2.4409 62	2.4412 62.008	0.0000 0.000	0.0006 0.015
2.6772 68	2.6769 67.993	2.6772 68	2.6775 68.008	0.0000 0.000	0.0006 0.015
2.8346 72	2.8343 71.993	2.8346 72	2.8349 72.008	0.0000 0.000	0.0006 0.015

HOUSING MOUNTING FITS (FIXED) – ABEC – 7 (ISO P4)

Bearing O.D. Diameter		Stationary Housing			
		Housing Bore		Mounting Fits	
max.	min.	min.	max.	tight	loose
inch mm	inch mm	inch mm	inch mm	inch mm	inch mm
2.9528 75	2.9525 74.993	2.9528 75	2.9531 75.008	0.0000 0.000	0.0006 0.015
3.1496 80	3.1493 79.993	3.1496 80	3.1499 80.008	0.0000 0.000	0.0006 0.015
3.3465 85	3.3462 84.992	3.3465 85	3.3468 85.008	0.0000 0.000	0.0006 0.016
3.5433 90	3.543 89.992	3.5433 90	3.5436 90.008	0.0000 0.000	0.0006 0.016
3.7402 95	3.7399 94.992	3.7402 95	3.7405 95.008	0.0000 0.000	0.0006 0.016
3.9370 100	3.9367 99.992	3.9370 100	3.9373 100.008	0.0000 0.000	0.0006 0.016
4.1339 105	4.1336 104.992	4.1339 105	4.1342 105.008	0.0000 0.000	0.0006 0.016
4.3307 110	4.3304 109.992	4.3307 110	4.3310 110.008	0.0000 0.000	0.0006 0.016
4.5276 115	4.5273 114.992	4.5276 115	4.5279 115.008	0.0000 0.000	0.0006 0.016
4.7244 120	4.7241 119.992	4.7244 120	4.7247 120.008	0.0000 0.000	0.0006 0.016
4.9213 125	4.92095 124.991	4.9213 125	4.9216 125.008	0.0000 0.000	0.0007 0.017
5.1181 130	5.11775 129.991	5.1181 130	5.1185 130.009	0.0000 0.000	0.0007 0.018
5.5118 140	5.51145 139.991	5.5118 140	5.5122 140.009	0.0000 0.000	0.0007 0.018
5.7087 145	5.70835 144.991	5.7087 145	5.7091 145.009	0.0000 0.000	0.0007 0.018
5.9055 150	5.90515 149.991	5.9055 150	5.9059 150.009	0.0000 0.000	0.0007 0.018
6.2992 160	6.2988 159.990	6.2992 160	6.2996 160.009	0.0000 0.000	0.0008 0.0219

Recommended Spindle Housing Tolerances

HOUSING MOUNTING FITS (FIXED) – ABEC – 7 (ISO P4)

Bearing O.D. Diameter		Stationary Housing			
		Housing Bore		Mounting Fits	
max.	min.	min.	max.	tight	loose
inch mm	inch mm	inch mm	inch mm	inch mm	inch mm
6.4961 165	6.4957 164.990	6.4961 165	6.4965 165.010	0.0000 0.000	0.0008 0.020
6.6929 170	6.6925 169.990	6.6929 170	6.6933 170.010	0.0000 0.000	0.0008 0.020
7.0866 180	7.0862 179.990	7.0866 180	7.0870 180.010	0.0000 0.000	0.0008 0.020
7.4803 190	7.47985 189.989	7.4803 190	7.4807 190.010	0.0000 0.000	0.0008 0.021
7.8740 200	7.87355 199.989	7.8740 200	7.8745 200.011	0.0000 0.000	0.0009 0.022
8.2677 210	8.26725 209.989	8.2677 210	8.2682 210.011	0.0000 0.000	0.0009 0.022
8.4646 215	8.46415 214.989	8.4646 215	8.4651 215.011	0.0000 0.000	0.0009 0.022
8.8583 225	8.85785 224.989	8.8583 225	8.8588 225.011	0.0000 0.000	0.0009 0.022
9.0551 230	9.05465 229.989	9.0551 230	9.0556 230.011	0.0000 0.000	0.0009 0.022
9.4488 240	9.44835 239.989	9.4488 240	9.4493 240.011	0.0000 0.000	0.0009 0.022
10.2362 260	10.2357 259.987	10.2362 260	10.2367 260.011	0.0000 0.000	0.0010 0.024
10.6299 270	10.6294 269.987	10.6299 270	10.6304 270.013	0.0000 0.000	0.0010 0.026
11.0236 280	11.0231 279.987	11.0236 280	11.0241 280.013	0.0000 0.000	0.0010 0.026
12.2047 310	12.2042 309.987	12.2047 310	12.2052 310.013	0.0000 0.000	0.0010 0.026

HOUSING MOUNTING FITS (FLOAT) – ABEC – 7 (ISO P4)

Bearing O.D. Diameter		Stationary Housing			
		Housing Bore		Housing Clearance	
max.	min.	max.	min.	max.	min.
inch mm	inch mm	inch mm	inch mm	inch mm	inch mm
0.8661 22	0.8659 21.995	0.8665 22.010	0.8663 22.005	0.0006 0.015	0.0002 0.005
0.9449 24	0.9447 23.995	0.9453 24.010	0.9451 24.005	0.0006 0.015	0.0002 0.005
1.0236 26	1.0234 25.995	1.0240 26.010	1.0238 26.005	0.0006 0.015	0.0002 0.005
1.1024 28	1.1022 27.995	1.1028 28.010	1.1026 28.005	0.0006 0.015	0.0002 0.005
1.1811 30	1.1809 29.995	1.1815 30.010	1.1813 30.005	0.0006 0.015	0.0002 0.005
1.2598 32	1.2596 31.994	1.2602 32.010	1.2600 32.005	0.0007 0.016	0.0002 0.005
1.3780 35	1.3778 34.994	1.3784 35.010	1.3782 35.005	0.0007 0.016	0.0002 0.005
1.4567 37	1.4565 36.994	1.4571 37.010	1.4569 37.005	0.0007 0.016	0.0002 0.005
1.5748 40	1.5746 39.994	1.5752 40.010	1.5750 40.005	0.0007 0.016	0.0002 0.005
1.6535 42	1.6533 41.994	1.6539 42.010	1.6537 42.005	0.0007 0.016	0.0002 0.005
1.8504 47	1.8502 46.994	1.8509 47.012	1.8507 47.007	0.0008 0.018	0.0003 0.007
2.0472 52	2.0469 51.993	2.0477 52.012	2.0475 52.007	0.0008 0.019	0.0003 0.007
2.1654 55	2.1651 54.993	2.1659 55.012	2.1657 55.007	0.0008 0.019	0.0003 0.007
2.4409 62	2.4406 61.993	2.4414 62.012	2.4412 62.007	0.0008 0.019	0.0003 0.007
2.6772 68	2.6769 67.993	2.6777 68.012	2.6775 68.007	0.0008 0.019	0.0003 0.007
2.8346 72	2.8343 71.993	2.8351 72.0112	2.8349 72.007	0.0008 0.019	0.0003 0.007

Recommended Spindle Housing Tolerances

HOUSING MOUNTING FITS (FLOAT) – ABEC – 7 (ISO P4)

Bearing O.D. Diameter		Stationary Housing			
		Housing Bore		Housing Clearance	
max.	min.	max.	min.	max.	min.
inch mm	inch mm	inch mm	inch mm	inch mm	inch mm
2.9528	2.9525	2.9533	2.9531	0.0008	0.0003
75	74.992	75.014	75.009	0.022	0.009
3.1496	3.1493	3.1501	3.1499	0.0008	0.0003
80	79.992	80.012	80.008	0.020	0.008
3.3465	3.3462	3.3471	3.3468	0.0009	0.0003
85	84.992	85.016	85.009	0.024	0.009
3.5433	3.5430	3.5439	3.5436	0.0009	0.0003
90	89.992	90.015	90.007	0.023	0.007
3.7402	3.7399	3.7408	3.7405	0.0009	0.0003
95	94.992	95.016	95.009	0.024	0.009
3.9370	3.9367	3.9377	3.9374	0.001	0.0004
100	99.992	100.018	100.010	0.025	0.010
4.1339	4.1336	4.1346	4.1343	0.001	0.0004
105	104.992	105.019	105.011	0.026	0.011
4.3307	4.3304	4.3314	4.3311	0.001	0.0004
110	109.992	110.018	110.010	0.025	0.010
4.5276	4.5273	4.5283	4.5280	0.001	0.0004
115	114.992	115.019	115.011	0.026	0.010
4.7244	4.7241	4.7251	4.7248	0.001	0.0004
120	119.992	120.018	120.010	0.025	0.010
4.9213	4.9210	4.9221	4.9217	0.0012	0.0004
125	124.991	125.021	125.011	0.030	0.011
5.1181	5.1177	5.1189	5.1185	0.0011	0.0004
130	129.991	130.020	130.010	0.029	0.010
5.5118	5.5115	5.5126	5.5122	0.0011	0.0004
140	139.991	140.020	140.010	0.029	0.010
5.9055	5.9051	5.7095	5.7091	0.0011	0.0004
145	144.991	145.021	145.011	0.030	0.011
6.2992	6.2988	5.9064	5.9060	0.0012	0.0005
150	149.991	150.023	150.012	0.032	0.012
6.6929	6.6925	6.3001	6.2997	0.0013	0.0005
160	159.989	160.022	160.012	0.033	0.012

HOUSING MOUNTING FITS (FLOAT) – ABEC – 7 (ISO P4)

Bearing O.D. Diameter		Stationary Housing			
		Housing Bore		Housing Clearance	
max.	min.	max.	min.	max.	min.
inch mm	inch mm	inch mm	inch mm	inch mm	inch mm
6.4961 165	6.4957 164.990	6.4970 165.022	6.4966 165.012	0.0013 0.032	0.0005 0.012
6.6929 170	6.6925 169.990	6.6938 170.022	6.6934 170.012	0.0013 0.032	0.0005 0.012
7.0866 180	7.0862 179.990	7.0875 180.022	7.0871 180.012	0.0013 0.032	0.0005 0.012
7.4803 190	7.4799 189.989	7.4812 190.022	7.4808 190.012	0.0014 0.033	0.0005 0.012
7.8740 200	7.8736 199.989	7.8750 200.025	7.8746 200.015	0.0015 0.036	0.0006 0.015
8.2677 210	8.2673 209.989	8.2687 210.025	8.2683 210.015	0.0015 0.036	0.0006 0.015
8.4646 215	8.4642 214.989	8.4656 215.025	8.4652 215.015	0.0015 0.036	0.0006 0.015
8.8583 225	8.8579 224.989	8.8593 225.025	8.8589 225.015	0.0015 0.036	0.0006 0.015
9.0551 230	9.0547 229.989	9.0561 230.025	9.0557 230.015	0.0015 0.036	0.0006 0.015
9.4488 240	9.4484 239.989	9.4500 240.025	9.4494 240.015	0.0016 0.041	0.0006 0.015
10.2362 260	10.2357 259.987	10.2375 260.030	10.2370 260.015	0.0018 0.044	0.0008 0.018
10.6299 270	10.6294 269.987	10.6312 270.031	10.6307 270.018	0.0018 0.044	0.0008 0.018
11.0236 280	11.0231 279.987	11.0249 280.031	11.0244 280.018	0.0018 0.044	0.0008 0.018
11.4173 290	11.4168 289.987	11.4186 290.031	11.4181 290.018	0.0018 0.044	0.0008 0.018
12.2047 310	12.2042 309.987	12.2060 310.031	12.2055 310.018	0.0018 0.044	0.0008 0.018

Ball Screw Support Series Shaft and Housing Shoulder Dimensions

SHAFT AND HOUSING SHOULDER DIMENSIONS (INCH SERIES)

Bearing Number	Shaft		Housing		Fillet Radius (max.)	
	±.005"	±.13mm	±.005"	±.13mm		
	in.	mm	in.	mm	in.	mm
MM9306WI2H	1.078	27.4	1.636	41.6	0.031	0.8
MM9308WI2H	1.316	33.4	2.174	55.2	0.031	0.8
MM9310WI2H	1.860	47.2	2.474	62.8	0.031	0.8
MM9311WI3H	2.052	52.1	2.667	67.7	0.031	0.8
MM9313WI5H	2.572	65.3	3.191	81.1	0.031	0.8
MM9316WI3H	3.375	85.7	3.995	101.5	0.031	0.8
MM9321WI3	4.413	112.1	5.296	134.5	0.039	1.0
MM9326WI6H	5.664	143.9	6.606	167.8	0.039	1.0

SHAFT AND HOUSING SHOULDER DIMENSIONS (METRIC SERIES)

Bearing Number	Shaft		Housing		Fillet Radius (max.)		Bearing Size	Shaft		Housing		Fillet Radius (max.)	
	±.005"	±.13mm	±.005"	±.13mm				±.005"	±.13mm	±.005"	±.13mm		
	in.	mm	in.	mm	in.	mm		in.	mm	in.	mm	in.	mm
MM17BS 47	0.905	23.00	1.634	41.50	0.031	0.8	**MM45BS 75**	2.047	52.00	2.717	69.00	0.039	1.0
MM20BS 47	1.024	26.00	1.634	41.50	0.031	0.8	**MM45BS 100**	2.126	54.00	3.543	90.00	0.039	1.0
MM25BS 62	1.378	35.00	2.205	56.00	0.031	0.8	**MM50BS 90**	2.323	59.00	3.228	82.00	0.039	1.0
MM30BS 62	1.575	40.00	2.205	56.00	0.031	0.8	**MM50BS 100**	2.323	59.00	3.543	90.00	0.039	1.0
MM30BS 72	1.575	40.00	2.205	56.00	0.031	0.8	**MM55BS 90**	2.48	63.00	3.228	82.00	0.039	1.0
MM35BS 72	1.653	42.00	2.520	64.00	0.031	0.8	**MM55BS 120**	2.559	65.00	4.331	110.00	0.039	1.0
MM35BS 100	1.653	42.00	3.543	90.00	0.031	0.8	**MM60BS 120**	2.756	70.00	4.331	110.00	0.039	1.0
MM40BS 72	1.850	47.00	2.520	64.00	0.031	0.8	**MM75BS 110**	3.307	84.00	4.016	102.00	0.039	1.0
MM40BS 90	1.850	47.00	3.228	82.00	0.031	0.8	**MM100BS 150**	4.331	110.00	5.433	138.00	0.039	1.0
MM40BS 100	1.850	47.00	3.543	90.00	0.031	0.8							

Shaft and Housing Shoulder Diameters

ULTRA-LIGHT 9300 SERIES

Basic Bearing Number	Shoulder Diameters			
	Shaft		Housing	
	max.	min.	max.	min.
	inch mm	inch mm	inch mm	inch mm
9300	0.52 13.2	0.51 13.0	0.77 19.6	0.76 19.3
9301	0.60 15.2	0.59 14.9	0.85 21.6	0.84 21.3
9302	0.72 18.3	0.71 18.1	1.00 25.5	0.99 25.2
9303	0.80 20.3	0.79 20.0	1.08 27.5	1.07 27.2
9304	0.95 24.1	0.94 23.9	1.33 33.7	1.32 33.4
9305	1.15 29.1	1.14 28.9	1.52 38.7	1.51 38.4
9306	1.34 34.1	1.33 33.9	1.72 43.7	1.71 43.4
9307	1.57 40.0	1.55 39.5	2.01 51.1	1.99 50.6
9308	1.78 45.1	1.76 44.6	2.28 57.9	2.26 57.4
9309	1.99 50.7	1.97 50.1	2.50 63.4	2.48 62.9
9310	2.17 55.1	2.15 54.6	2.67 67.9	2.65 67.4
9311	2.40 60.9	2.38 60.4	2.96 75.2	2.94 74.7
9312	2.59 65.8	2.57 65.3	3.16 80.2	3.14 79.7
9313	2.79 70.8	2.77 70.3	3.35 85.2	3.33 84.7
9314	3.02 76.8	3.00 76.3	3.71 94.3	3.69 93.8

EXTRA LIGHT 9100 SERIES

Basic Bearing Number	Shoulder Diameters			
	Shaft		Housing	
	max.	min.	max.	min.
	inch mm	inch mm	inch mm	inch mm
9100	0.54 13.6	0.53 13.3	0.92 23.2	0.91 23.0
9101	0.64 16.1	0.63 15.9	1.01 25.5	1.00 25.3
9102	0.76 19.2	0.75 18.9	1.13 28.6	1.12 28.3
9103	0.86 21.7	0.85 21.5	1.23 31.1	1.22 30.9
9104	0.99 25.0	0.98 24.8	1.49 37.7	1.48 37.5
9105	1.19 30.1	1.18 29.9	1.68 42.6	1.67 42.3
9106	1.43 36.2	1.42 35.9	2.00 50.7	1.99 50.4
9107	1.62 41.2	1.60 40.6	2.23 56.6	2.21 56.1
9108	1.82 46.2	1.80 45.7	2.45 62.2	2.43 61.7
9109	2.04 51.8	2.02 51.3	2.73 69.3	2.71 68.8
9110	2.23 56.6	2.21 56.1	2.92 74.2	2.90 73.7
9111	2.47 62.7	2.45 62.2	3.28 83.3	3.26 82.8
9112	2.67 67.8	2.65 67.3	3.47 88.1	3.45 87.6
9113	2.86 72.6	2.84 72.1	3.67 93.2	3.65 92.7
9114	3.08 78.2	3.06 77.7	4.03 102.4	4.01 101.9

Shaft and Housing Shoulder Diameters

ULTRA-LIGHT 9300 SERIES

Basic Bearing Number	Shoulder Diameters			
	Shaft		Housing	
	max.	min.	max.	min.
	inch mm	inch mm	inch mm	inch mm
9315	3.22 81.9	3.19 81.1	3.91 99.4	3.88 98.6
9316	3.42 86.9	3.39 86.1	4.11 104.4	4.08 103.6
9317	3.69 93.6	3.66 92.8	4.44 112.7	4.41 111.9
9318	3.85 97.8	3.82 97.0	4.66 118.5	4.63 117.7
9319	4.05 102.8	4.02 102.0	4.86 123.5	4.83 122.7
9320	4.34 110.3	4.31 109.5	5.16 131.0	5.13 130.2
9322	4.74 120.3	4.71 119.5	5.55 141.0	5.52 140.2
9324	5.16 131.2	5.13 130.4	6.10 155.0	6.07 154.3
9326	5.60 142.1	5.57 141.4	6.66 169.2	6.63 168.4
9328	5.99 152.1	5.96 151.4	7.05 179.2	7.02 178.4
9330	6.42 163.1	6.39 162.4	7.80 198.2	7.77 197.4
9332	6.82 173.2	6.79 172.4	8.20 208.2	8.17 207.4
9334	7.30 185.4	7.27 184.7	8.51 216.1	8.48 215.4
9336	7.68 195.0	7.65 194.2	9.31 236.4	9.28 235.6
9338	8.07 205.0	8.04 204.2	9.70 246.4	9.67 245.6
9340	8.54 216.8	8.51 216.0	10.41 264.5	10.38 263.7

EXTRA LIGHT 9100 SERIES

Basic Bearing Number	Shoulder Diameters			
	Shaft		Housing	
	max.	min.	max.	min.
	inch mm	inch mm	inch mm	inch mm
9115	3.29 83.4	3.26 82.7	4.23 107.3	4.20 106.6
9116	3.52 89.3	3.49 88.5	4.59 116.5	4.56 115.7
9117	3.74 94.9	3.71 94.1	4.81 122.1	4.78 121.3
9118	3.96 100.5	3.93 99.7	5.16 130.9	5.13 130.2
9119	4.16 105.5	4.13 104.8	5.35 135.8	5.32 135.0
9120	4.36 110.6	4.33 109.9	5.55 140.8	5.52 140.1
9121	4.59 116.5	4.56 115.7	5.91 150.0	5.88 149.2
9122	4.85 123.1	4.82 122.3	6.24 158.4	6.21 157.6
9124	5.25 133.2	5.22 132.5	6.63 168.3	6.60 167.5
9126	5.71 144.9	5.68 144.2	7.35 186.6	7.32 185.8
9128	6.11 155.1	6.08 154.3	7.74 196.5	7.71 195.7
9130	6.54 166.0	6.51 165.2	8.30 210.7	8.27 209.9
9132	6.97 176.9	6.94 176.2	8.85 224.7	8.82 223.9
9134	7.43 188.6	7.40 187.8	9.56 242.7	9.53 241.9
9136	7.90 200.5	7.87 199.8	10.28 261.0	10.25 260.2
9140	8.76 222.4	8.73 221.6	11.39 289.2	11.36 288.4

Shaft and Housing Shoulder Diameters

EXTRA LIGHT 9100HX SERIES

Basic Bearing Number	Shoulder Diameters				Basic Bearing Number	Shoulder Diameters			
	Shaft		Housing			Shaft		Housing	
	max.	min.	max.	min.		max.	min.	max.	min.
	inch mm	inch mm	inch mm	inch mm		inch mm	inch mm	inch mm	inch mm
9104	0.98 24.8	0.97 24.5	1.48 37.5	1.47 37.2	**9114**	3.18 80.8	3.16 80.3	3.93 99.8	3.91 99.3
9105	1.15 29.1	1.14 28.8	1.71 43.3	1.70 43.1	**9115**	3.38 85.7	3.35 85.0	4.14 105.0	4.11 104.3
9106	1.37 34.7	1.36 34.4	2.00 50.7	1.99 50.4	**9116**	3.62 91.8	3.59 91.1	4.49 113.9	4.46 113.2
9107	1.61 40.9	1.59 40.4	2.23 56.6	2.21 56.1	**9117**	3.81 96.7	3.78 95.9	4.69 119.0	4.66 118.2
9108	1.82 46.2	1.80 45.7	2.45 62.2	2.43 61.7	**9118**	4.11 104.3	4.08 103.5	4.99 126.6	4.96 125.9
9109	2.00 50.8	1.98 50.3	2.75 69.9	2.73 69.3	**9119**	4.24 107.6	4.21 106.8	5.25 133.2	5.22 132.5
9110	2.19 55.6	2.17 55.1	2.95 74.9	2.93 74.4	**9120**	4.44 112.7	4.41 111.9	5.44 138.1	5.41 137.3
9111	2.55 64.8	2.53 64.3	3.18 80.8	3.16 80.3	**9121**	4.73 120.0	4.70 119.3	5.74 145.7	5.71 144.9
9112	2.75 69.9	2.73 69.3	3.37 85.6	3.35 85.1	**9122**	5.03 127.6	5.00 126.9	6.03 153.0	6.00 152.3
9113	2.91 73.9	2.89 73.4	3.60 91.4	3.58 90.9	**9124**	5.36 136.0	5.33 135.3	6.49 164.7	6.46 164.0

Shaft and Housing Shoulder Diameters

LIGHT 200 SERIES

Basic Bearing Number	Shoulder Diameters				Basic Bearing Number	Shoulder Diameters			
	Shaft		Housing			Shaft		Housing	
	max.	min.	max.	min.		max.	min.	max.	min.
	inch mm	inch mm	inch mm	inch mm		inch mm	inch mm	inch mm	inch mm
200	0.60 15.1	0.59 14.9	1.03 26.0	1.02 25.8	**213**	3.00 76.2	2.98 75.7	4.32 109.7	4.30 109.2
201	0.66 16.6	0.65 16.4	1.11 28.1	1.10 27.8	**214**	3.18 80.8	3.16 80.3	4.56 115.8	4.54 115.3
202	0.76 19.2	0.75 18.9	1.23 31.1	1.22 30.9	**215**	3.39 86.0	3.36 85.2	4.76 120.8	4.73 120.0
203	0.86 21.7	0.85 21.5	1.41 35.7	1.40 35.4	**216**	3.60 91.3	3.57 90.6	5.12 129.9	5.09 129.2
204	1.03 26.0	1.02 25.8	1.64 41.5	1.63 41.3	**217**	3.84 97.4	3.81 96.7	5.47 138.8	5.44 138.1
205	1.23 31.1	1.22 30.9	1.86 47.1	1.85 46.9	**218**	4.08 103.5	4.05 102.7	5.83 148.0	5.8 147.2
206	1.45 36.7	1.44 36.5	2.21 56.0	2.20 55.8	**219**	4.31 109.4	4.28 108.6	6.19 157.1	6.16 153.3
207	1.68 42.7	1.66 42.2	2.57 65.3	2.55 64.8	**220**	4.54 115.2	4.51 114.4	6.54 166.0	6.51 165.2
208	1.88 47.8	1.86 47.2	2.88 73.2	2.86 72.6	**222**	5.01 127.1	4.98 126.4	7.26 184.3	7.23 183.5
209	2.08 52.8	2.06 52.3	3.08 78.2	3.06 77.7	**224**	5.44 138.1	5.41 137.3	7.82 198.5	7.79 197.7
210	2.28 57.9	2.26 57.4	3.28 83.3	3.26 82.8	**226**	5.93 150.5	5.90 149.7	8.31 211.0	8.28 210.2
211	2.51 63.8	2.49 63.3	3.63 92.2	3.61 91.7	**230**	6.80 172.6	6.77 171.8	9.80 248.8	9.77 248.0
212	2.75 69.9	2.73 69.3	3.99 101.4	3.97 100.8					

Shaft and Housing Shoulder Diameters

MEDIUM 300 SERIES

Basic Bearing Number	Shoulder Diameters				Basic Bearing Number	Shoulder Diameters			
	Shaft		Housing			Shaft		Housing	
	max.	min.	max.	min.		max.	min.	max.	min.
	inch mm	inch mm	inch mm	inch mm		inch mm	inch mm	inch mm	inch mm
301	0.70 17.7	0.69 17.4	1.27 32.1	1.26 31.9	**311**	2.65 67.3	2.63 66.8	4.28 108.7	4.26 108.2
302	0.88 22.2	0.87 22.0	1.41 35.7	1.40 35.4	**312**	2.88 43.2	2.86 72.6	4.64 117.9	4.62 117.3
303	0.90 22.7	0.89 22.5	1.66 42.0	1.65 41.8	**313**	3.16 80.3	3.14 79.8	4.99 126.8	4.97 126.2
304	1.19 30.1	1.18 29.9	1.84 46.6	1.83 46.4	**314**	3.36 85.3	3.34 84.8	5.34 135.6	5.32 135.1
305	1.27 32.1	1.26 31.9	2.20 55.8	2.19 55.5	**315**	— —	— —	— —	— —
306	1.49 37.7	1.48 37.5	2.57 65.2	2.56 64.9	**316**	— —	— —	— —	— —
307	1.72 43.7	1.70 43.2	2.84 72.1	2.82 71.6	**317**	— —	— —	— —	— —
308	1.96 49.8	1.94 49.3	3.20 81.3	3.18 80.8	**318**	— —	— —	— —	— —
309	2.20 55.9	2.18 55.4	3.55 90.2	3.53 89.7	**319**	4.46 113.2	4.43 112.4	7.22 183.3	7.19 182.5
310	2.41 61.2	2.39 60.7	3.93 99.8	3.91 99.3					

Locknut Torque

Locknut torques are standardized regardless of the type of locknut used. Acceptable locknut torques for dry thread engagement are shown in the following table. Bearing locknuts shall be tightened using a torque wrench and a two-point locknut wrench or other suitable torque wrench adapter.

Reference MIL-B-17931F

Bearing Bore (mm)	Locknut Torque (ft-lb)	Approximate Clamping Force (lb)
10	10-20	1,620-3,240
12	10-20	1,340-2,680
15	10-20	1,070-2,140
17	10-20	940-1,880
20	12-35	950-2,770
25	23-50	1,450-3,170
30	32-60	1,690-3,170
35	39-70	1,750-3,140
40	50-80	1,970-3,140
45	64-90	2,220-3,120
50	67-100	2,090-3,120
55	82-125	2,330-3,540
60	99-150	2,560-3,880
65	131-175	3,130-4,190
70	152-200	3,360-4,430
75	173-250	3,610-5,220
80	197-275	3,840-5,350
85	222-325	4,060-5,940
90	248-375	4,280-6,480
95	277-425	4,520-6,950
100	345-475	5,360-7,380
105	380-550	5,620-8,120
110	380-550	5,340-7,740
120	380-550	4,900-7,080
130	380-550	4,510-6,540
140	380-550	4,190-6,070
150	380-550	3,910-5,660
160	380-550	3,680-5,330

Micron Bore & O.D. coding

To better match machine tool bearings to spindles, Torrington offers micron coding. Micron coding is standard on all products except ball screw support bearings and Ex-Cell-O bearings.

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

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

DEVIATION FROM NOMINAL

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

Recommended Ballscrew (inch series) Shaft and Housing Tolerances

Shaft and Housing Diameters (Inch Series)

Bearing Number	Bearing Bore Diameter		Shaft Diameter		Bearing O.D. Diameter		Housing Diameter	
	max.	min.	max.	min.	max.	min.	max.	min.
	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm
MM9306WI2H	0.7874 20.000	0.7872 19.995	0.7872 19.995	0.7870 19.990	1.8504 47.000	1.8501 46.994	1.8507 47.006	1.8504 47.000
MM9308WI2H	0.9385 23.838	0.9383 23.833	0.9383 23.833	0.9381 23.828	2.4409 62.000	2.4406 61.993	2.4412 62.007	2.4409 62.000
MM9310WI2H	1.5000 38.100	1.4997 38.094	1.4997 38.094	1.4994 38.088	2.8346 72.000	2.8343 71.993	2.8349 72.007	2.8346 72.000
MM9311WI3H	1.7510 44.475	1.7507 44.469	1.7507 44.469	1.7504 44.463	3.0000 76.200	2.9997 76.193	3.0003 76.207	3.0000 76.200
MM9313WI5H	2.2500 57.150	2.2497 57.143	2.2497 57.143	2.2494 57.136	3.5433 90.000	3.5430 89.992	3.5436 90.008	3.5433 90.000
MM9316WI3H	3.0000 76.200	2.9997 76.193	2.9997 76.193	2.9994 76.186	4.3307 110.000	4.3304 109.992	4.3310 110.008	4.3307 110.000
MM9321WI3	4.0000 101.600	3.9997 101.592	3.9997 101.592	3.9994 101.584	5.7087 145.000	5.7083 144.991	5.7091 145.009	5.7087 145.000
MM9326WI6H	5.0000 127.000	4.9997 126.992	4.9997 126.992	4.9994 126.984	7.0866 180.000	7.0862 179.990	7.0870 180.010	7.0866 180.000

Recommended Ballscrew (metric series) Shaft and Housing Tolerances

Shaft and Housing Diameters (Metric Series)

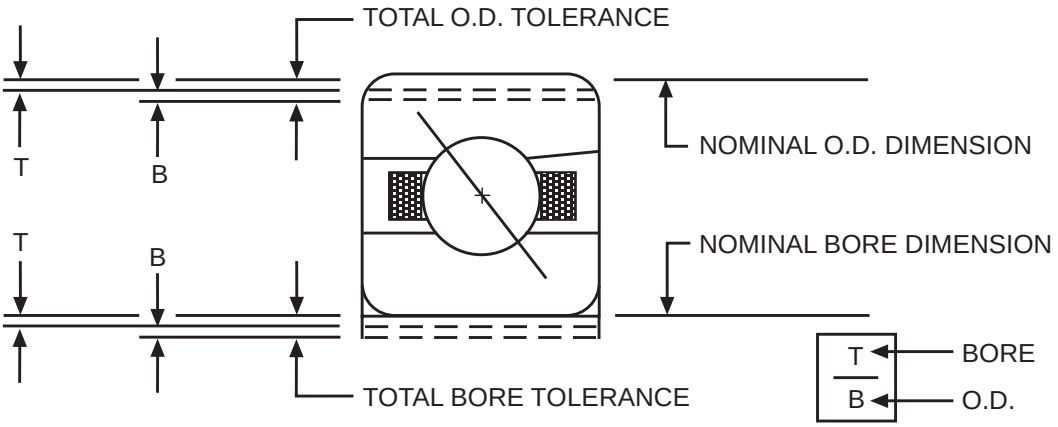
Bearing Number	Bearing Bore Diameter		Shaft Diameter		Bearing O.D. Diameter		Housing Diameter	
	max.	min.	max.	min.	max.	min.	max.	min.
	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm	inch mm
MM17BS47	0.6693 17.000	0.6691 16.996	0.6691 16.996	0.6689 16.992	1.8504 47.000	1.8501 46.994	1.8507 47.006	1.8504 47.000
MM20BS47	0.7874 20.000	0.7872 19.995	0.7872 19.995	0.7870 19.990	1.8504 47.000	1.8501 46.994	1.8507 47.006	1.8504 47.000
MM25BS52	0.9843 25.000	0.9841 24.995	0.9841 24.995	0.9839 24.990	2.0472 52.000	2.0469 51.993	2.0475 52.007	2.0472 52.000
MM25BS62	0.9843 25.000	0.9841 24.995	0.9841 24.995	0.9839 24.990	2.4409 62.000	2.4406 61.993	2.4412 62.007	2.4409 62.000
MM30BS62	1.1811 30.000	1.1809 29.995	1.1809 29.995	1.1807 29.990	2.4409 62.000	2.4406 61.993	2.4412 62.007	2.4409 62.000
MM30BS72	1.1811 30.000	1.1809 29.995	1.1809 29.995	1.1807 29.990	2.8346 72.000	2.8343 71.993	2.8349 72.007	2.8346 72.000
MM35BS72	1.3780 35.000	1.3777 34.994	1.3777 34.994	1.3774 34.988	2.8346 72.000	2.8343 71.993	2.8349 72.007	2.8346 72.000
MM40BS72	1.5748 40.000	1.5745 39.994	1.5745 39.994	1.5742 39.988	2.8346 72.000	2.8343 71.993	2.8349 72.007	2.8346 72.000
MM45BS75	1.7717 45.000	1.7714 44.994	1.7714 44.994	1.7711 44.988	2.9528 75.000	2.9525 74.993	2.9531 75.007	2.9528 75.000
MM40BS90	1.5748 40.000	1.5745 39.994	1.5745 39.994	1.5742 39.988	3.5433 90.000	3.5430 89.992	3.5436 90.008	3.5433 90.000
MM50BS90	1.9685 50.000	1.9682 49.994	1.9682 49.994	1.9679 49.988	3.5433 90.000	3.5430 89.992	3.5436 90.008	3.5433 90.000
MM55BS90	2.1654 55.000	2.1651 54.993	2.1651 54.993	2.1648 54.986	3.5433 90.000	3.5430 89.992	3.5436 90.008	3.5433 90.000
MM35BS100	1.3780 35.000	1.3777 34.994	1.3777 34.994	1.3774 34.988	3.9370 100.000	3.9367 99.992	3.9373 100.008	3.9370 100.000
MM40BS100	1.5748 40.000	1.5745 39.994	1.5745 39.994	1.5742 39.988	3.9370 100.000	3.9367 99.992	3.9373 100.008	3.9370 100.000
MM45BS100	1.7717 45.000	1.7714 44.994	1.7714 44.994	1.7711 44.988	3.9370 100.000	3.9367 99.992	3.9373 100.008	3.9370 100.000
MM50BS100	1.9685 50.000	1.9683 49.994	1.9683 49.994	1.9680 49.988	3.9370 100.000	3.9367 99.992	3.9373 100.008	3.9370 100.000
MM75BS110	2.9528 75.000	2.9525 74.993	2.9525 74.993	2.9522 74.986	4.3307 110.000	4.3304 109.992	4.3310 110.008	4.3307 110.000
MM55BS120	2.1654 55.000	2.1651 54.993	2.1651 54.993	2.1648 54.986	4.7244 120.000	4.7241 119.992	4.7247 120.008	4.7244 120.000
MM60BS120	2.3622 60.000	2.3619 59.993	2.3619 59.993	2.3616 59.986	4.7244 120.000	4.7241 119.992	4.7247 120.008	4.7244 120.000
MM100BS150	3.9370 100.000	3.9367 99.992	3.9367 99.992	3.9364 99.984	5.9055 150.000	5.9052 149.991	5.9059 150.009	5.9055 150.000

Bore and O.D. Coding

To better match machine tool bearings to spindles, Torrington currently offers Bottom/Top bore and O.D. coding as standard for angular contact superprecision bearings.

The code is a mark on the box label with the bore code shown above the O.D. code. The tolerances are split in half as shown in the figure below. If the bore and O.D. sizes fall in the half closest to nominal, this is considered the top half and the set will be marked with a T/T. With a T/T code, the bore and O.D. tolerances would meet ABEC 9 requirements. If the bore and O.D sizes fall in the half farthest from the nominal, this is considered the bottom half and the set will be marked with a B/B. If the bore is in the top half and O.D. is in the bottom half, the set will be marked T/B and vice versa B/T.

BOTTOM/TOP BORE & O.D. CODING



Offering bore and O.D. coding makes it easier to obtain the optimum recommended fits for spindles. Each bearing in a set is matched to within half the bore and O.D. tolerance to insure equal load sharing. It also enables our customers to use pairs of bearings with same bore and O.D. codes to make triplex and quadruplex sets.

Lube Inlet Diameters

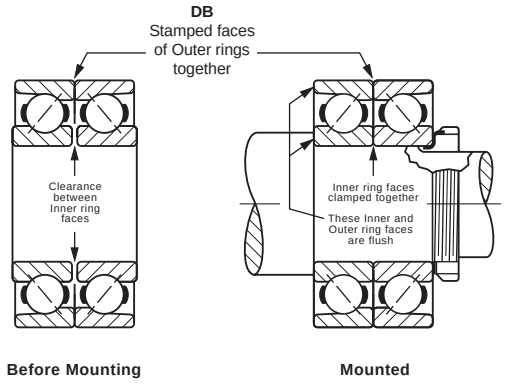
200 Series		9100 Series		99100 Series	
Bore Number	Lube Inlet Diameter (inches)	Bore Number	Lube Inlet Diameter (inches)	Bore Number	Lube Inlet Diameter (inches)
00	0.6950	00	0.6290	00	—
01	0.7660	01	0.7200	01	—
02	0.8850	02	0.8490	02	—
03	1.1015	03	0.9420	03	0.9370
04	1.1893	04	1.1200	04	1.1080
05	1.3938	05	1.3120	05	1.3050
06	1.6608	06	1.5690	06	1.5955
07	1.9313	07	1.7840	07	1.8108
08	2.1623	08	1.9953	08	2.0635
09	2.3593	09	2.2248	09	2.2495
10	2.5558	10	2.4218	10	2.4465
11	2.8263	11	2.6918	11	2.7283
12	3.0963	12	2.8888	12	2.9258
13	3.3793	13	3.0858	13	3.1218
14	3.5638	14	3.3558	14	3.4033
15	3.7608	15	3.5533	15	3.6413
16	4.0308	16	3.8233	16	3.8810
17	4.3010	17	4.0285	17	4.0868
18	4.5705	18	4.2900	18	4.3453
19	4.8410	19	4.4870	19	4.5403
20	5.1115	20	4.7135	20	4.7813
21	5.4061	21	4.9610	22	5.3008
22	5.6540	22	5.2360	24	5.6948
24	6.1190	24	5.6325	26	6.3210
26	6.3850	26	6.1710		
30	7.8160	28	6.5750		
		30	7.0320		
		32	7.5000		
		34	7.8460		
		40	9.5150		

300 SERIES		9300 SERIES		9100 HX SERIES	
Bore Number	Lube Inlet Diameter (inches)	Bore Number	Lube Inlet Diameter (inches)	Bore Number	Lube Inlet Diameter (inches)
00	—	00	—	00	—
01	0.8520	01	—	01	—
02	1.0120	02	0.7840	02	—
03	1.0910	03	0.8630	03	—
04	1.2328	04	1.0458	04	1.114
05	1.5238	05	1.2093	05	1.306
06	1.7908	06	1.4393	06	1.549
07	2.0363	07	1.6828	07	1.785
08	2.3043	08	1.9063	08	2.001
09	2.5768	09	2.0308	09	2.212
10	2.8473	10	2.2998	10	2.408
11	3.1173	11	2.5418	11	2.730
12	3.3848	12	2.7383	12	2.926
13	3.6573	13	2.9363	13	3.111
14	3.9268	14	3.2068	14	3.393
		15	3.4033	15	3.590
		16	3.5993	16	3.861
		17	3.8828	18	4.355
		18	4.0683	20	4.745
		28	6.1985	22	5.335
				24	5.708

TYPICAL MOUNTINGS OF DUPLEX BEARINGS

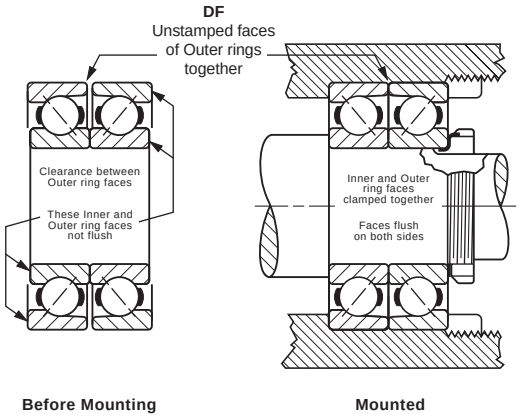
Back-to-Back Mounting, DB or (“O”) (Contact angles diverging toward shaft centerline)

Before mounting, there is clearance between the two adjacent inner ring faces the bearings. After mounting, these faces are clamped together to provide an internal preload on each bearing. This arrangement is well suited for pulleys, sheaves, and in other applications where there are overturning loads, and also in all floating positions where thermal expansion of shaft occurs. It also provides axial and radial rigidity and equal thrust capacity in either direction when used in a fixed location. Back-to-back is the most commonly used of all duplex arrangements. Specify bearing number followed by suffix DU. Examples: 7207W-DU, 2MM207WI-DU. Also available as two single flush-ground bearings, i.e., 7207W SU (2 bearings).



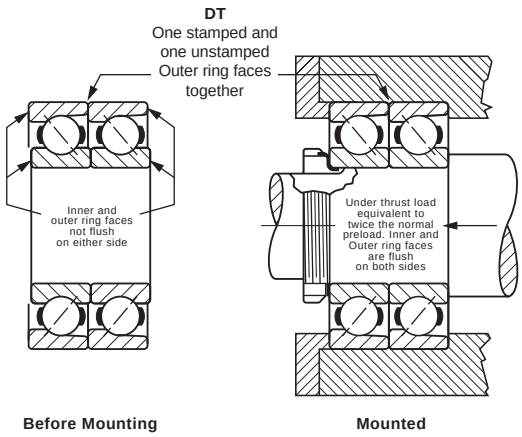
Face-to-Face Mounting, DF or (“X”) (Contact angles converging toward shaft centerline)

Before mounting, there is clearance between the two adjacent outer ring faces. After mounting, these faces are clamped together between the housing shoulder and cover plate shoulder, providing an internal preload on each bearing. This arrangement provides equal thrust capacity in either direction as well as radial and axial rigidity. Since the face-to-face mounting has inherent disadvantages of low resistance to moment loading and thermal instability, it should not be considered unless a significantly more convenient method of assembly or disassembly occurs from its use. Fafnir pairs for face-to-face mounting should be ordered as DU. Examples: 7212W-DU, 2M212WI-DU. Also available as two single flush-ground bearings, i.e., 7212W SU (2 bearings).



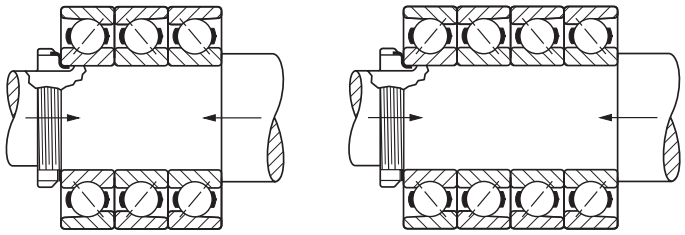
Tandem Mounting, DT

Before mounting, the inner ring faces of each bearing are offset from the outer ring faces. After mounting, when a thrust load is applied equal to that of twice the normal preload, the inner and outer ring faces are brought into alignment on both sides. This arrangement provides double thrust capacity in one direction only. More than two bearings can be used in tandem if additional thrust capacity is required. Fafnir pairs for tandem mounting should be specified as DU. Examples: 7205W-DU, 2M205WI-DU. Also available as two single flush-ground bearings with suffix SU, i.e., 7210W SU (2 bearings).



Other Mountings

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



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

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

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

In a face-to-face mounting, Figure 5, the shaft expands radially and longitudinally and the inner-ring spacer lengthens, but at a faster rate than the outer-ring spacer. This thermal expansion causes an additional thrust to be imposed on both inner rings, increasing the preload of the bearings. Conversely, in back-to-back mounting, Figure 6, the longitudinal expansion of the inner-ring spacer tends to relieve, rather than build up, the bearing preload.

The two back-to back pairs, shown in Figure 7, are mounted so that the two middle bearings are face-to-face. As previously observed, temperature differentials cause the preload of these inside bearings to increase during operation. This mounting operation is **not** recommended. In bearing mountings of the type seen in Figure 8, undue thrust loads are put on the two outside bearings as the temperature along the shaft becomes higher than at the housing. The two inside bearings unload, starting a vicious cycle of increasing temperature, preload build-up, and lubricant depletion. This is also an unacceptable mounting arrangement, and is **not** recommended. The same bearings are shown correctly mounted in tandem and arranged back-to-back in Figure 9. Lateral expansion of the shaft and inner-ring spacer of such mountings increase neither thrust loading nor bearing preload.

Therefore, in order to prevent increases in preload due to the thermal expansion, back-to-back mountings are preferred for bearings on machine tool spindles. When two pairs are used, each pair should be mounted in tandom but the combination should be arranged back-to-back as in Figure 9.

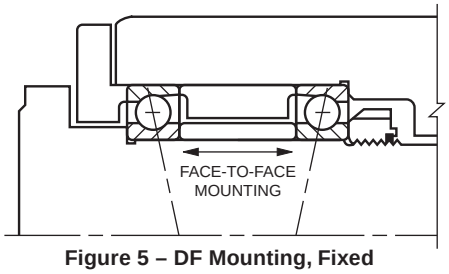


Figure 5 – DF Mounting, Fixed

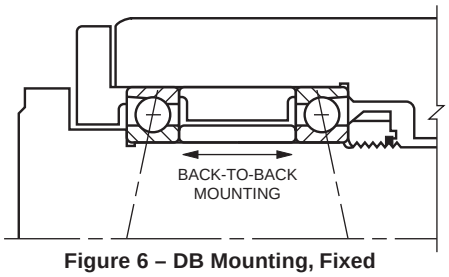


Figure 6 – DB Mounting, Fixed

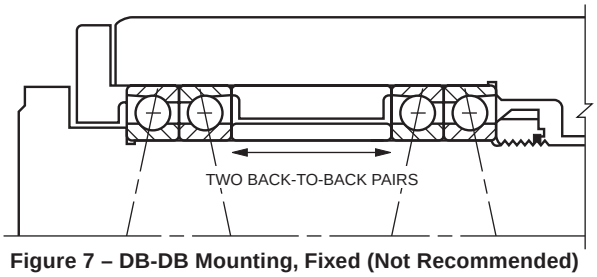


Figure 7 – DB-DB Mounting, Fixed (Not Recommended)

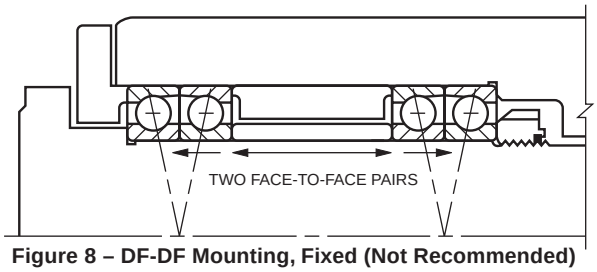


Figure 8 – DF-DF Mounting, Fixed (Not Recommended)

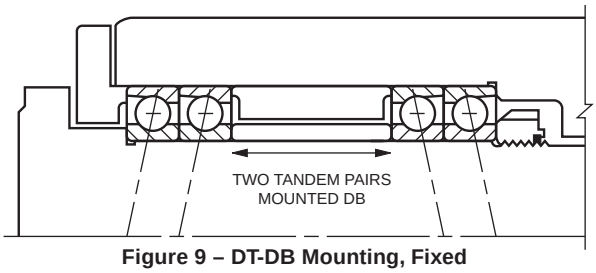


Figure 9 – DT-DB Mounting, Fixed

Spring Loaded Mountings

For high speed applications, radial and axial rigidity and smooth spindle performance may be obtained by spring loading the ball bearings with a predetermined thrust load. Spring loading allows the spindle to float laterally during temperature changes without appreciably increasing or decreasing the original spring thrust load.

As the inner ring heats up during operation it expands radially. This radial expansion applies an increasing load through the ball and outer ring and finally to the preload springs. The preload springs deflect slightly to compensate for the loads due to thermal expansion and maintain a consistent load on the spindle system.

In some applications, single, spring-loaded bearings are employed at the front and rear locations, mounted in back-to-back arrangement. Other mountings, similarly spring loaded, have a pair of bearings installed in tandem at each end of the spindle in back-to-back arrangement (DT-DB). In either case, the spring pressure is applied to the pulley-end or rear bearing position, placing the shaft in tension between the two bearing locations.

High Contact Angle
- High Axial Rigidity
- Moderate Radial Rigidity

Low Contact Angle
- High Radial Rigidity
- Moderate Axial Rigidity

Preloading

Preloading of precision ball bearings to a predetermined thrust load for universal mounting is accomplished by grinding off a certain amount of stock off faces of the inner and outer rings so that before mounting the bearing on faces on the abutting side are offset an amount equal to the deflection under “preload”. When mounted, these faces are clamped together, the opposite bearing faces become flush and the bearing parts are subjected to compressive forces, bringing the balls into contact with their respective raceways, to take up the initial clearances of the bearings. Thus, the preload built into the bearings is automatically obtained. The condition of a preloaded ball bearing is similar to that of one in operation under thrust load. This initial thrust load serves to decrease markedly the axial and radial deflections when subsequent operational loads are imposed on the bearing assembly.

Bearings are preloaded no more than necessary. Excessive preload adds little to the rigidity of the spindle but appreciably reduces the range of operating speeds by causing bearings to run hot at higher speeds. To meet conditions of speed, mounting arrangement and maximum rigidity consistent with low operating temperatures, Fafnir precision ball bearings are designed and produced with preloads varying from heavy to zero and, in some instances, with negative preload.

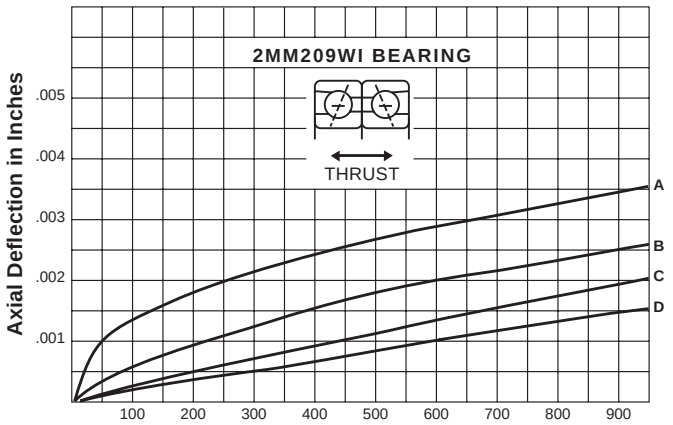
In many cases, the amount of bearing preload is a trade-off between having the desired degree of rigidity and reducing any adverse effect preloading has on the equipment. If the operating speed is high, a heavy preload can lead to excessively high operating temperatures, resulting in early bearing failure. For these reasons, three classes of ball bearing preloads are used – Light, Medium and Heavy.

In certain applications, such as high-speed motorized router spindles, specially preloaded, superprecision ball bearings are required. Such bearings are “zero” preloaded – that is, the faces of the inner and outer rings are ground flush under negligible load.

The Light, Medium and Heavy standard preload values for Fafnir superprecision angular-contact ball bearings and for both high and low contact angles in “Physical Characteristics”.

Axial deflection curves of various preload conditions for duplex pairs of 2MM209WI superprecision ball bearings are shown in figure 10 and the radial deflection curves for the same bearings are shown in Figure 11.

Effect of Preload on Axial Deflection

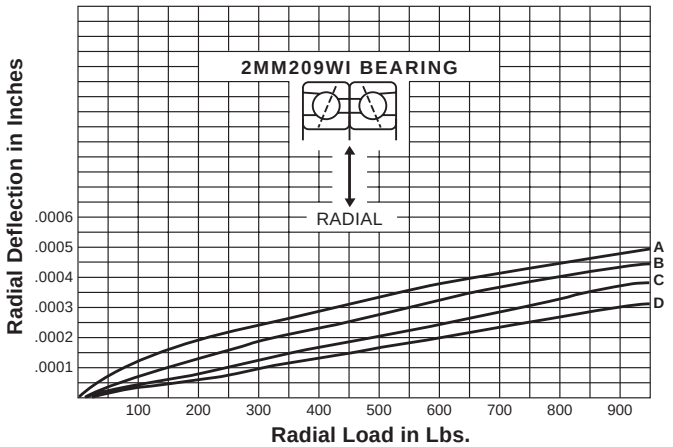


Thrust Load in Lbs.

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

Figure 10 – Axial Deflection Curves

Effect of Preload on Radial Deflection



Radial Load in Lbs.

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

Figure 11 – Radial Deflection Curves

Bearing Selection

Fafnir angular-contact precision ball bearings are available with high (25°) and low (15° – 18°) contact angles. Each type has inherent characteristics that are desirable for machine tool spindles. Low contact angle bearings are more rigid radially and less rigid axially than high contact angle bearings. A bearing having a low contact angle allows more axial yield and less radial deflection than one having a high contact angle.

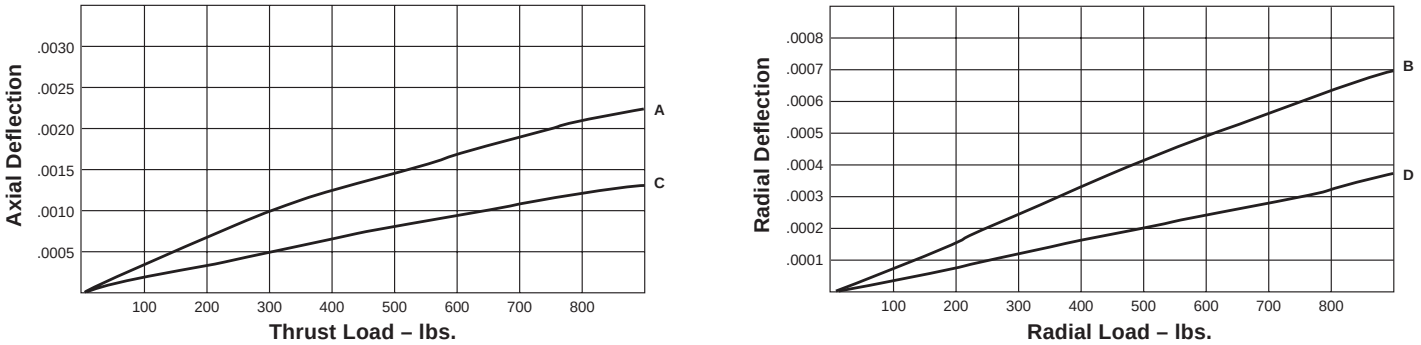
In selecting the proper size and type of bearing, consideration is given to the size and construction of the spindle and the kind of mounting, since the latter relates directly to the spindle rigidity and the deflection characteristics. In general, where the operating load is principally radial, low contact angle type bearings are selected, but where the loading is chiefly in thrust and a high degree of axial rigidity is required, higher contact angle type bearings are recommended. Therefore, for the majority of applications, superprecision ball bearings with low contact angles are used. However, when maximum axial rigidity is required in combination with heavy thrust loads or when high ambient temperatures are involved, bearings having the higher contact angles are preferred. The three established preload values are necessarily higher for high contact angle bearings than for those having low contact angles. The axial and radial deflection characteristics of low angular-contact, light series, preloaded ball bearings of a standard size are shown in figure 12. Curves C and D, which are for a preloded tandem pair of such bearings, indicate the greatly reduced axial and radial deflections as compared to those for a preloded single bearing of the same size (Curves A and B). For example, a tandem pair of bearings under a thrust load of 600 pounds would have an axial defection of 0.0010 inch, while that for a single bearing would be about 0.0017 inch. Similarly, the radial deflections for these bearings operated under 600 pounds radial loads would be 0.00024 inch and 0.00049 inch.

Axial deflection curves for the standard preload levels for both the 2MM (15° contact angle) and the 3MM (25° contact angle) are shown in Figure 13. Please note the force for the equivalent preload level for a 2MM bearing is about one-half that of the preload level for a 3MM bearing. Preload values for all Fafnir machine toll grade angular-contact bearings have been calculated to give optimum performance by machine designers.

A comparison of the curves in Figure 13 shows the 25° contact angle bearing to be more rigid under axial loads than the 15° contact angle bearing. Note that the axial deflection for the 2MM 15° contact angle preloaded pair of bearings with a medium preload (60 pounds) is 0.0013" under a 300 pound thrust load. The 3MM 25° contact angle preloaded pair with a light preload (60 pounds) deflects 0.0008" under the same 300 pound thrust load.

	2MM 15° Contact Angle Preload Force in Pounds	3MM 25° Contact Angle Preload Force in Pounds
Light	30	60
Medium	60	120
Heavy	120	240

EFFECT OF SINGLE AND TANDEM MOUNTING ON AXIAL AND RADIAL RIGIDITY

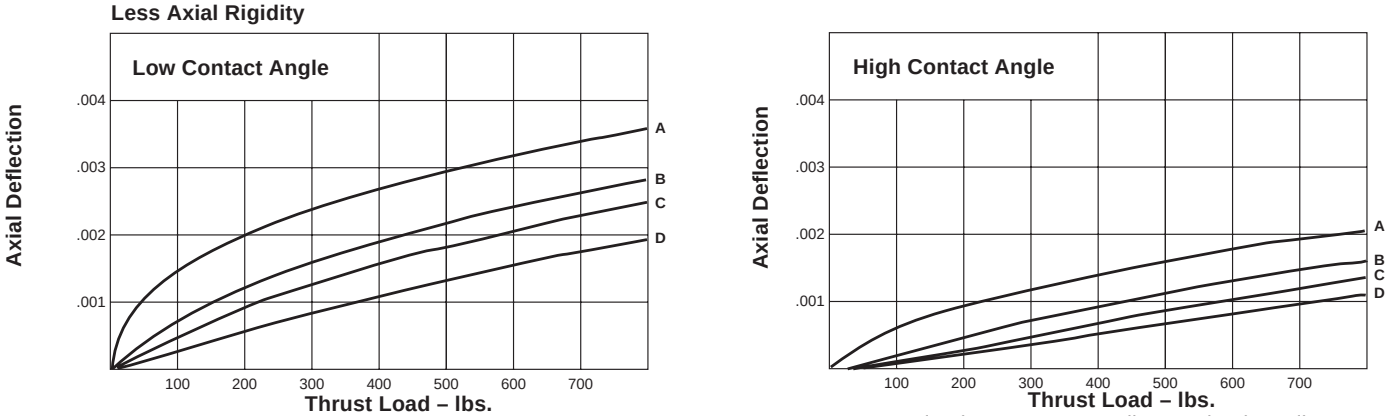


A Preloaded DB
C Preloaded Tandem

B Preloaded DB
D Preloaded Tandem

Figure 12 – Axial vs Radial Deflections

EFFECTS OF CONTACT ANGLE ON AXIAL DEFLECTION



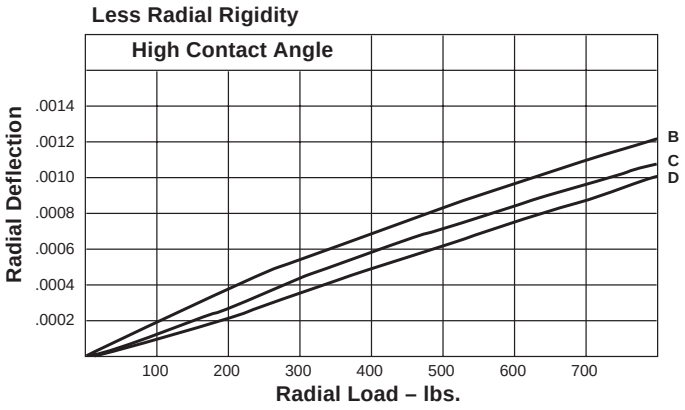
A No Preload
B Light Preload 40lbs.
C Medium Preload 125lbs.
D Heavy Preload 250lbs.

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

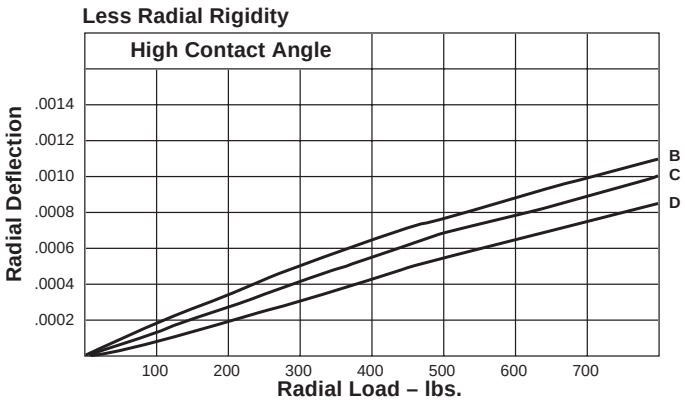
Figure 13 – Axial Deflections

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 14. These curves show that increased radial deflections result when bearings having the higher contact angle are used. The indicated radial deflections are for one bearing. **When employing duplex pairs of bearings under equal, applied loads, the radial deflections would be approximately one-half of the values shown.**

EFFECT OF CONTACT ANGLE ON RADIAL DEFLECTION



B LIGHT PRELOAD 40 LBS.
C MEDIUM PRELOAD 125 LBS.
D HEAVY PRELOAD 250 LBS.



B LIGHT PRELOAD 40 LBS.
C MEDIUM PRELOAD 125 LBS.
D HEAVY PRELOAD 250 LBS.

Figure 14 – Radial Deflections

Width Tolerances

The width tolerance for individual inner and outer rings is shown on pages E4, E5 but, to allow for the face grinding on two bearings for various preloads, the total width tolerances of duplex pairs of bearings are as follows:

Nominal bore Millimeters		Width Tolerance	
Over	Inclusive	Maximum	Minimum
0	200	.000"	.010"
		.00mm	.25mm

If other than a pair of bearings is involved, the total width tolerance is in proportion to the number of bearings. If closer than standard width tolerances are required specify by adding FS732 as a suffix to the part number.

Recommended Shaft and Housing Tolerances

Shaft Fits

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

As a general rule, it is recommended that the shaft size and tolerance for seating superprecision bearings (ABEC-7 and 9) be the same as the bearing bore. In the case of preloaded bearings, the ideal shaft fit to strive for is line-to-line fit, since an excessively tight fit expands the bearing inner ring and increases the bearing preload which can lead to over-heating. For example, a duplex pair of 2MM9111WI-DUL bearings, with 35 pounds built-in preload, when mounted on a shaft that provides an interference fit of .0004 inch, will increase the preload to approximately 180 pounds which could result in elevated operating temperatures.

EXAMPLE: ABEC 7

Bore size Inches	Shaft Diameter Inches	Resulting Mounting Fit, Inches	Average Fit
max. 2.1654	min. 2.1652	.0002 loose	line-to-line
min. 2.1652	max. 2.1654	.0002 tight	

EXAMPLE: ABEC 9

Bore size Inches	Shaft Diameter Inches	Resulting Mounting Fit, Inches	Average Fit
max. 2.16540	min. 2.16525	.00015 loose	line-to-line
min. 2.16525	max. 2.16540	.00015 tight	

Housing Fits

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

As a general rule, the minimum housing bore dimension for superprecision bearings (ABEC-7 and 9) may be established as the same as the maximum bearing outside diameter. If the bearing O.D. tolerance is .0003 inch (.0008mm), the maximum housing bore should be established as .0003 inch (.0008mm) larger than the minimum housing bore dimensions.

EXAMPLE: ABEC 7

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

EXAMPLE: ABEC 9

Outside Diameter Inches	Housing Bore Inches	Resulting Mounting Fit Inches	Average Fit Inches
max. 3.54330 min. 3.54310	min. 3.54330 max. 3.54350	.0000 tight .0004 loose	.0002 loose

Tables covering recommended shaft and housing seat dimensions for superprecision (ABEC-7) ball bearings are shown on pages E8 through E15.

The “average” mounting fit is usually considered the ideal mounting condition and should be obtained.

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

On high-speed applications where nearby heat input is along the shaft, it is extremely important that the floating bearings can move axially to compensate for thermal changes. Ball bearings cannot float longitudinally if they are restricted by tight housing bores or by the radial expansion of the bearing itself due to temperature differentials. Therefore, in such cases, the housing mounting fit for the floating bearings is slightly looser than the tabulated average fit. Likewise, in spring-loaded ball bearing applications the housing mounting fit must be free enough to permit axial movement of the bearings under the spring pressure, during all conditions of operation. The recommended housing dimensions to ensure proper “float” of the bearings under average conditions are tabulated on pages E13 and E15.

Shafts

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

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 rounded 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 add clearance of not more than .0010 inch (.025mm) over the maximum shaft diameter has been found generally acceptable. For long spacers and low speeds, this clearance may be increased to prevent the shaft from disturbing the face parallelism of the spacer. The spacer outside diameter should not be less than the outside diameter of the inner ring of the bearing.

The outside diameter of the outer-ring spacers should be about .0010 inch (.025mm) smaller than the minimum bore of the housing. These should have lubricant holes and grooves where necessary and are usually centrally located. Spacer end parallelism should be the same as the parallelism tolerance for the adjacent bearing.

Selective Assembly

Under certain conditions it may be desirable to control fits more accurately without the added expense of using closer tolerance bearings and assembly parts. This can be accomplished by selective assembly of the bearings, shafts and housings after they have been sized and sorted according to bores and outside diameters. At the customer’s request, we can provide bearings with bore’s and O.D.’s coded in inch or metric dimensions from nominal size. A nominal charge is required for this additional inspection. This improved fit-up at assembly provides a higher degree of precision in the spindle. Generally, however, it is quite satisfactory for production and field servicing to use closer shaft and housing tolerances with bearings having a higher degree of precision.

Housing Design

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

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

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

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

Shaft shoulders and housing shoulders should be square and true, and should be of such diameters as to meet the recommendations given on page E17 through E21. The choice between fillets and undercut reliefs rests with the individual shaft design and conditions surrounding its normal use.

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

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

Housing Seals

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

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

The axial clearances of the internal faces between slinger and end cover should be about $^{1}/_{16}$ inch (1.6mm). The first radial clearance opening on any design through which liquid may pass should be made very close, about .007 inch (.18mm) on the diameter .0035 inch (.089mm) on a side. The inner radial clearances should be between 0.15 inch (.38mm) and .0075 inch (.190mm). These are figures actually used in successful practice.

Bearing Locknuts

To position precision ball bearings on spindle shafts, precision manufactured self locking bearing locknuts are recommended rather than the conventional locknuts and lockwashers used for bearings made to ABEC-1 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 ball bearings.

Successful Applications

Detailed assembly drawings on pages E45 to E48, are representative of successful applications of Fafnir precision bearings on such equipment as gear drive assemblies; automatic screw machines; high-cycle wheel heads; high-speed internal grinding spindles; superprecision work heads; and high-speed router spindles. It is hoped that these arrangements will stimulate questions regarding your particular application problems. They will gladly be examined by our Engineering Department.

Special Requirements

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

Lubrication

Even though ball bearings have the least amount of friction of any of the so-called anti-friction bearings, lubrication is required to minimize rolling resistance due to deformation or kneading action of the balls in the raceways under load, and to minimize any sliding friction that occurs between the balls, the raceway and the retainer. Lubrication also serves to protect the accurately ground and polished surfaces from corrosion. In addition, lubrication, in general, dissipates generated heat and helps protect the bearing moving parts from the entry of foreign matter.

Only enough lubrication to accomplish these purposes should be used since another source of heat may become present, namely friction between the lubricant and the moving parts, in the form of churning or internal shear of the lubricant itself.

Regardless of the method of lubrication or type of lubricant, it is important that quality lubricants be used to minimize oxidation, gumming or sludging and that the lubricant be clean and free of moisture to minimize wear.

In the lubrication of ball bearings, it is important to realize that a small quantity of oil or grease will, if constantly present in the bearing, suffice for its requirements. More trouble can result from excessive lubrication than from too little, although either condition should be avoided. Excessive oil or grease will result in high temperature and possibly failure. When grease is used, it is especially necessary to take into consideration the maximum operating temperature. Also particular attention must be given the housing design relating to the proximity of the grease to the bearing, in order to assure adequate purge room and grease retention.

Depending upon operating speeds, loads and temperatures, machine-tool ball bearings are lubricated with grease, oil or oil mist. In general, oils are required when bearings operate at high speeds and to provide greater cooling than is possible with grease.

Heat Generation

When ball bearing spindles are grease lubricated, the heat generated is removed only by conduction through the surrounding parts. With jet or circulating oil lubrication, generated heat is dissipated by the oil passing through the bearings as well as by conduction through the shaft and housing. Both means of removing heat from the bearings are important but, generally, dissipation through conduction is less obvious.

As an example, in an oil mist lubricated grinding spindle the nose or wheel-end bearings are fixed and close to the grinding coolant. The pulley-end or rear bearings are secured axially on the shaft but permitted to float laterally in the housing to compensate for size variations due to thermal changes. Heat is conducted away from the front bearings at a faster rate because of the mass of the spindle nose and the intimate contact of the outer rings with the housing shoulder, the end cover, and the housing bore. This condition, coupled with oil mist lubrication and the proximity of the grinding coolant, takes away generated heat efficiently.

The rear or floating pair of bearings are not so favored. Usually, the mass of the shaft at the pulley-end is not so great. The pulley possesses some heat-conduction ability but also receives heat generated by belt friction. The absence of grinding coolant and the reduced area of conduction usually results in a slightly higher operating temperature.

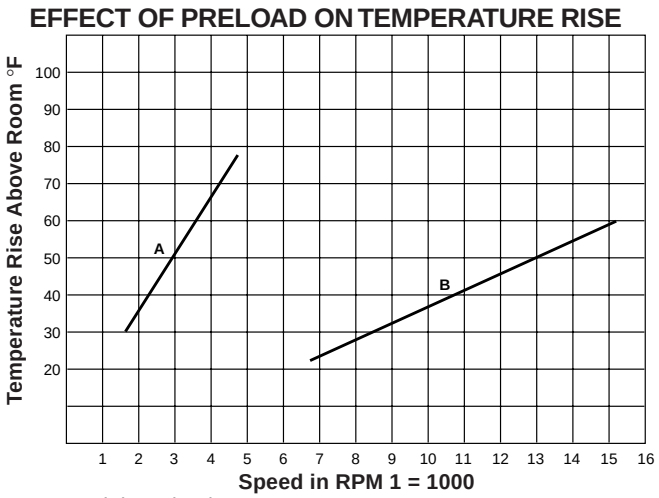
Low operating temperatures, combined with adequate spindle rigidity, are important and highly desirable for precision machine tools. This is particularly true for high-speed grinding spindles where the preload of the bearings is the principle load imposed upon them. Some of the benefits derived from low operating temperatures and better dimensional stability of the processed work, less need for bearing lubrication, prevention of objectionable heat at the external surfaces of the spindle housing, and elimination of troubles due to thermal effects on mounting fits and preloads.

The heat developed at the ball bearings under load is a function of the operating speed and the bearing preload. Preloading is necessary for maximum axial and radial rigidity. Unfortunately, if speeds are increased, the bearing preload may have to be lessened to maintain proper operating temperatures at the bearing.

For high-speed operation, the bearing preload should be sufficient to maintain proper rolling friction for the balls but not so high as to generate excessive heat. In cases where lower operating speeds are desired, bearing preloads may be increased to obtain additional bearing rigidity, provided the proper operating temperatures are maintained. Thus, a balance between heat generation and spindle rigidity dictates the amount of bearing preload that is used, commensurate with the operational speed and the bearing life required.

How bearing preload affects the operating temperature is illustrated in Figure 15. This graph applies to 207 size, angular-contact, duplexed superprecision ball bearings, mounted back-to-back. Curve **A** is a plot of operating temperature at the bearing outside diameter for the speeds indicated, using bearings with a 150 pound built-in preload. Curve **B** is for bearings having a 30 pound preload. The slope of Curve **A** is much steeper than that of Curve **B**. Using bearings with a 150 pound preload, the temperature rise at the bearing outside diameter is 60° F when operating at 3600 rpm. For the same temperature rise, using bearings with 30 pounds preload, an operating speed of 15,300 rpm is indicated. Therefore it is evident that for higher-speed operation the bearing preload should be kept to the minimum necessary to assure sufficient bearing rigidity.

For workhead spindles, the operating speeds are generally low and the loading conditions heavy. Maximum radial and axial spindle rigidity is required under these loads, making increased bearing preload mandatory.



A High Preload
B Low Preload

Figure 15 — Temperature vs Speed

Permissible Operating Speed

When determining the permissible operating speeds corresponding to the bearing preloads used in machine tool spindles, many influencing factors are involved. Among those considered are spindle mass and construction; type of mounting; spindle rigidity and accuracy requirements; spindle loads' service life; type of service, (intermittent or continuous); and method of lubrication.

Bearing temperatures, generally, **vary directly with both speed and load.** However, high speed applications must have sufficient thrust loading on the bearings to prevent heat generation from ball skidding. The amount of bearing preload is determined primarily from these operating conditions. At lower speeds, the operating loads are heavier and the bearing deflections are greater. Therefore, the bearing preload must be high enough to provide adequate bearing rigidity under the heaviest loads and still maintain reasonable temperatures when the spindle is operated at high speeds.

The following relationship may be used to estimate the effect of preload and lubrication method on the Permissible Operating Speed. (S_P)

$$S_P = F_L \times F_P \times F_B \times N_G$$

Where

F_L is Lubrication Factor

F_P is Preload Factor

F_B is Ball Material Factor

N_G is Permissible Speed for single grease lubricated bearing with inner ring rotation. This value is found in the **Physical Characteristics** sections.

Factors are as follows:

LUBRICATION FACTOR (F_L)

Grease	F_L = 1.00
Oil Bath	F_L = 1.50
Oil Mist	F_L = 1.70
Oil Jet	F_L = 2.00

BEARING PRELOAD FACTORS = (F_P)

Bearing Mounting 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

BALL MATERIAL FACTOR = (F_B)

Steel Balls	F_B = 1.00
*Ceramic Balls	F_B = 1.20

If a cage other than one shown in this catalog is used, contact the Engineering Department for recommendations.

** Ceramic balls allow 20% increase to speed factor.*

LUBRICATION

Grease

The use of grease as a lubricant for our precision bearings on various spindle applications is becoming more popular due to the development of better ball bearing greases, simplification of design and elimination of the “human maintenance factor” which is frequently responsible for too much lubrication, not enough lubrication, or the wrong kind of lubrication. Prelubricating the bearings at assembly with the correct amount of the right grease and thus eliminating all grease fittings has increased precision production 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 heavier, have proved to be suitable lubricants for machine tool spindle bearings. The “soft” greases have a worked penetration factor of about 300. The heavier grease has a worked penetration factor of about 200 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 heavier grease is of the channeling type, the amount used is not critical.

Below a 400,000 DN value, which is equivalent to a 40mm bore bearing rotating at 10,000 rpm, either a light consistency grease or the channeling grease may be used. When using grease of a channeling type **at low speeds**, the bearing may be packed full and will operate at no appreciable rise in temperature. Bearings may also be packed full of the lighter grease, but a greater rise in temperature will be noticeable until the excess lubricant is expelled from the bearings.

At continuous speeds above a DN value of 400,000, the operating temperature is generally lower when the bearings are lubricated with a lower consistency grease. However, the grease quantity in each bearing must be limited. At these high speeds, an excessive amount of grease in the bearing may result in greatly increased operating temperatures, due to churning action. This condition, if uncontrolled, may lead to premature bearing failure.

The top graph in Figure 16 shows bearing temperature increase due to break-in procedure. The peaking temperature followed by the leveling off is a result of the new grease being worked and then stabilized for a particular condition of load and speed.

It is important that the peak temperature not exceed 100°F above room temperature since the chemical consistency and characteristics of the grease can be permanently altered. Thus, the proper break-in procedure is to run the machine until the spindle temperature rises to 150° F and then turn it off to allow the grease to cool. Repeat until the spindle temperature stabilizes at a temperature below 130°F.

The bottom graph in Figure 16 shows the typical temperature rise of the bearing once the grease has been worked in for the specific speed and load.

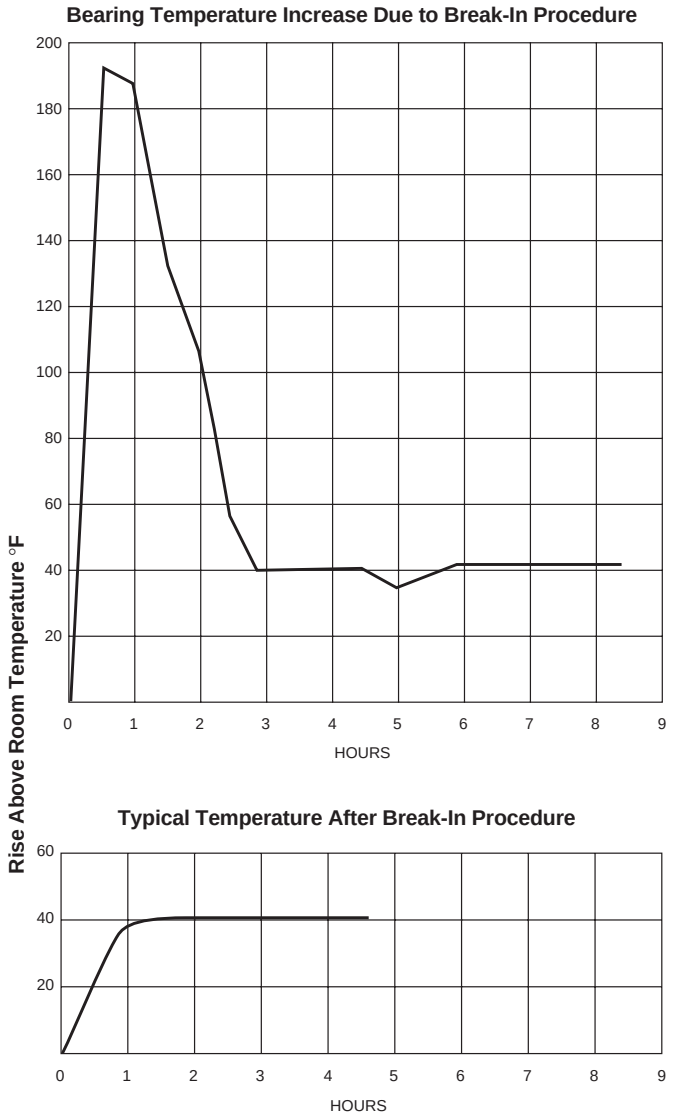


Figure 16 – Temperature vs Time

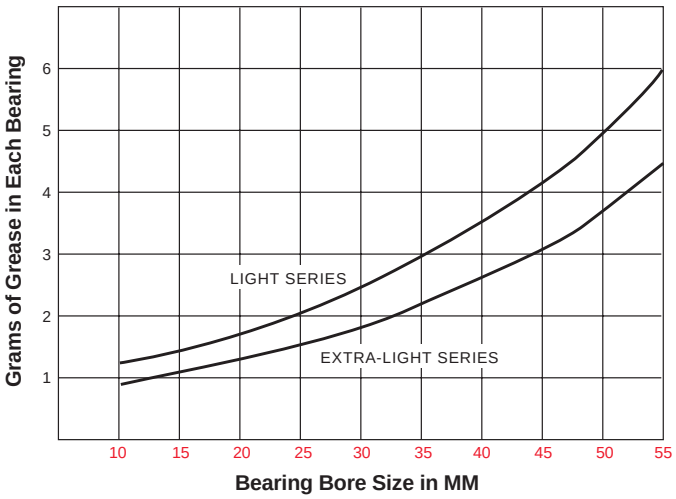


Figure 17 – Grease Quantity Chart

It is generally recognized that only the grease which is immediately adjacent to and in contact with the bearing contributes to its lubrication. In most applications, unless the speed is exceptionally low, a large quantity of grease can be objectionable. An excessive amount increases churning action, which may lead to overheating and possible breakdown of the grease.The tendency to churn depends upon the consistency of the grease, the bearing design, the housing construction and the quantity of grease that is used.

Ordinarily, bearings need to be packed only about 25% to 30% full of grease. As a guide, the chart shown in Figure 17 may be used to determine the approximate amount of grease which should be used in each bearing. The chart covers the extra-light series bearings for bore sizes of 10 to 55 mm's inclusive.

Prior to mounting, each bearing is carefully packed with the required quantity of clean, suitable grease using a flat steel scale for inserting the grease into the bearing and around the balls. Grease voids within the bearing are eliminated and even distribution of the grease is accomplished by revolving the bearing slowly in the hands until the torque throughout the bearing becomes noticeably constant.

Oil

Although several grease products have been successful at DN values as high as one million, oils are generally required for bearings operating at high speeds or to provide more cooling and dissipation of heat than is possible with grease. High-grade spindle oil having a viscosity of 100 seconds Saybolt at 100°F is recommended for use in drip-feed oilers, oil bath lubrication arrangements and oil mist systems. In heavily-loaded applications, oil in relatively large quantities must be supplied, and where temperatures run higher than normal, oil coolers will be required. Churning of a large pool of oil is to be avoided if speed is appreciable.

Oil Bath

The conventional oil-bath system for lubricating the bearings is satisfactory for low and moderate speeds. The static oil level must never be higher than the center of the lowermost ball. When the shaft is rotating, the running level may drop considerably below the standstill level, depending on the speed of the revolving parts. A sight gauge or other suitable means should be provided to permit an easy check.

Drip-Feed Oil

Where the speeds are considered high for oil bath and the bearings are moderately loaded, oil, introduced through a filter-type, sight-feed oiler, is recommended. This assures a constant supply of lubricant. The feed in drops per minute is determined by closely observing the operating temperatures.

Oil Jet

In applications where the ball bearing is heavily loaded and operating at high speed and high temperatures or where the operating conditions are severe with high ambient temperatures encountered, oil jet lubrication may be required. In such cases it is necessary to lubricate each bearing location individually, and to provide adequately large drain openings to prevent excessive accumulation of oil after it has passed through the bearings.

Oil Mist

Oil mist lubrication is recommended for spindles running continuously at high speeds. With this method of lubrication, oil of the proper viscosity is atomized into finely divided particles, mixed with clean, filtered, dry compressed air and directed to pass through the bearings in a constant stream. This oil is metered into the air under pressure. Thus, the system not only lubricates the bearings but it affords some cooling due to the air flow. This continuous passage of air and oil through the bearings and the labyrinth seals also serves to prevent the entrance of contaminants into the bearings.

To insure the "wetting" of the bearings and to prevent possible damage to the balls and raceways, it is imperative that the oil mist system be turned on for several minutes before the spindle is started. The importance of wetting the bearings before starting cannot be over stressed and has particular significance for spindles that have been idle for extended periods of time. To avoid such effects, most oil mist systems have interlocks which make it impossible to start the spindle until the lubricating system is working properly and the bearings are thoroughly wetted.

Metered Oil

This method is similar to the oil mist; however, the oil is fed by periodic pulses to the lubrication line providing a higher air to oil ratio. Therefore, this method lowers the operating bearing temperature and lubricant shear effects, enabling higher operating speeds.

LUBE SYSTEM COMPARISON

	System Cost	Typical * Speed (DN)
Grease	Low	500,000
Oil Bath	Low	400,000
Oil Drip	Low	600,000
Oil Mist	Medium	1,000,000
Metered Oil	High	>1,000,000
Oil Jet	High	>1,000,000

* Speed value is an approximation and assumes proper mounting and preload techniques along with average loading conditions. For more specific guidance contact your local sales engineer.

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

Grease and Speed Capability

Before selecting a grease, it is important to define a relative speed capability of the application. There is no precise method that can be applied to determine the operating speed of a bearing. Over the years, designers of machine tool systems have been guided by their own experiences from which many basic “rules of thumb” have been established. One such rule is the “DN” speed value.

DN = Bore in millimeters * RPM

The four most common spindle greases that Torrington recommends are:

Exxon Andok C – Vertical applications < 500,000 DN

Mobil 28 – Light loads < 600,000 DN

Chevron SRI – Medium to heavy loads < 350,000 DN

Kluber Isoflex NBU 15 – Light loads, vertical or

Kluber Isoflex NCA 15 horizontal applications > 500,000 DN

These are the greases that Torrington would recommend, equivalents to the above greases could be substituted.

Quantity of Grease:

25% to 40% pack for **Normal Speed (< 500,000 DN)**

15% to 20% pack for **High Speed (> 500,000 DN)**

LUBE SPECS

LUBE CODE	LUBE	FS SPEC
160	AEROSHELL 22	FS381B-P
044	ANDOK 260	FS167E
049	ANDOK B	FS104A
023	ANDOK C	FS118
436	ANTICORIT L-245XBF	FS890
078	CHEVRON SRI	FS545
037	DOW CORNING 44	FS137A
004	DRY	—
125	FERROCOTE 5856 BF	FS639
162	ISOFLEX NBU 15	FS637
443	ISOFLEX NCA 15	FS905
422	ISOFLEX SUPERLDS18	FS735
115	ISOFLEX TOPAS NB52	FS737
149	ISOFLEX TOPAS NCA15	FS883
076	KRYTOX 240AB	FS452
161	KRYTOX 240AC	FS433
—	LUBCON L252	FS915
086	MOBIL 28	FS381A
456	MOBILITH SHC15	FS919
095	MOBILTEMP SHC 32	FS612
169	PQ CORROSION PREV.	FS216
067	RHEOTEMP 500	FS208
012	WINSOR LUBE L-245X	FS171A
167	WINSOR LUBE L1018	FS179A

RUN-IN PROCEDURE FOR GREASED BEARINGS

A proper run-in procedure will provide the following results:

- Expel the excess grease found in the system
- Orient the lubricating film on each contact surface
- Establish a low equilibrium operating temperature
- Achieve a sealed-for-life lubrication condition

Run-In Procedure

1. Start at a reasonable low speed, typically 10% of the maximum operating speed.
2. Increase speed incrementally when a stable temperature is reached.
3. Continue incremental increase in speed as described. If a rapid temperature increase occurs, stop the run-in process. This temperature spike indicates a preload due to thermal expansion.

Maximum bearing temperatures should not exceed 70°C (158°F). Temperatures in excess of 70°C will cause excessive bearing preloads and possible permanent grease bearing damage.

4. Allow the system to cool to room temperature.
5. Restart procedure at the last speed prior to the temperature spike.
6. 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 40°C (95°F to 105°F).

Alternative Run-In Procedure

Run-in at constant speed is also possible. In this operation, the bearing should run at full speed for about 30 seconds. After stopping, the heat in the bearing dissipates. In this way, a dangerous temperature rise is prevented. The non-running time depends on the various design factors, but it should be at least 5 times greater than the running time. This process is repeated until the bearing temperature becomes constant.

Life Calculations

Load Ratings – Radial Ball Bearings

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

Fatigue Life

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

The basic equation for radial ball bearings is:

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

Calculate EQUIVALENT RADIAL LOAD (P) by using Table 1 and required Y factors from Table 2.

Notations Used in this Section:

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

* Bearings with **TDC** plated races may use an a_2 factor of 3 for calculating life.

Table 1

Bearing Description	Single Row Bearings and Tandem Mountings	Double Row Bearings and Preload Pair Mountings
Bearing Type and/or Series	$K_T = \frac{T}{i_B C_o}$	$K_T = \frac{T}{C_o}$
RADIAL TYPE BALL BEARINGS	**Use larger of Resulting "P" Value**	
MM9300K MM9100K MM200K MM300K	P = R or $P = 0.56R + Y_1T$	$P = R + 1.20Y_1T$ or $P = 0.78R + 1.625Y_1T$
ANGULAR CONTACT BALL BEARINGS		
2MM9100WI 2MMV99100WN 2MM9300WI 2MM200WI 2MM300WI	P = R or $P = 0.44R + Y_2T$	$P = R + 1.124Y_2T$ or $P = 0.72R + 1.625Y_2T$
2MM9100WO	P = R or $P = 0.44R + Y_3T$	$P = R + 1.124Y_3T$ or $P = 0.72R + 1.625Y_3T$
3MM9100WI 3MMV99100WN 3MM200WI 3MM300WI	P = R or P = 0.41R + 0.87T	P = R + 0.92T or P = 0.67R + 1.41T

Table 2

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

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

$f_B = (i_B)^{0.7}$

Table 3

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

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

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

Life Calculations

Determine the Life Adjustment Factors a_1, a_2, a_3:

a_1, Life Adjustment Factor for Reliability

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

Table 4

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

a_2, Life Adjustment Factor for Bearing Material

In previous catalogs Fafnir used a Factor of 3 for material and processing for Fafnir Superior Steel. This factor has now been incorporated in the C_E value and accordingly, the a_2 factor for Fafnir superior steel now is 1. Factors for other materials are given in Table 5.

Table 5

Bearing Steel	Life Adjustment Factor For Material: a_2
Fafnir Superior Steel (standard material)	1
Vacuum Melted (VIM-VAR) 52100	4*

*In certain applications this factor can exceed 4. Consult our Engineering Department.

a_3, Life Adjustment Factor for Application Conditions

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

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

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

Determine the Reference Viscosity from Figure 1 (page E44) by entering the bearing pitch diameter, which is equal to the outer diameter plus the bore divided by 2 and the bearing speed.

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

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

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

Bearing Life Under Varying Loads and Speeds

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

$$L_r = \frac{1}{\frac{p_1}{L_{n1}} + \frac{p_2}{L_{n2}} + \frac{p_3}{L_{n3}} + \ldots + \frac{p_n}{L_{nn}}}$$

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

Figure 1

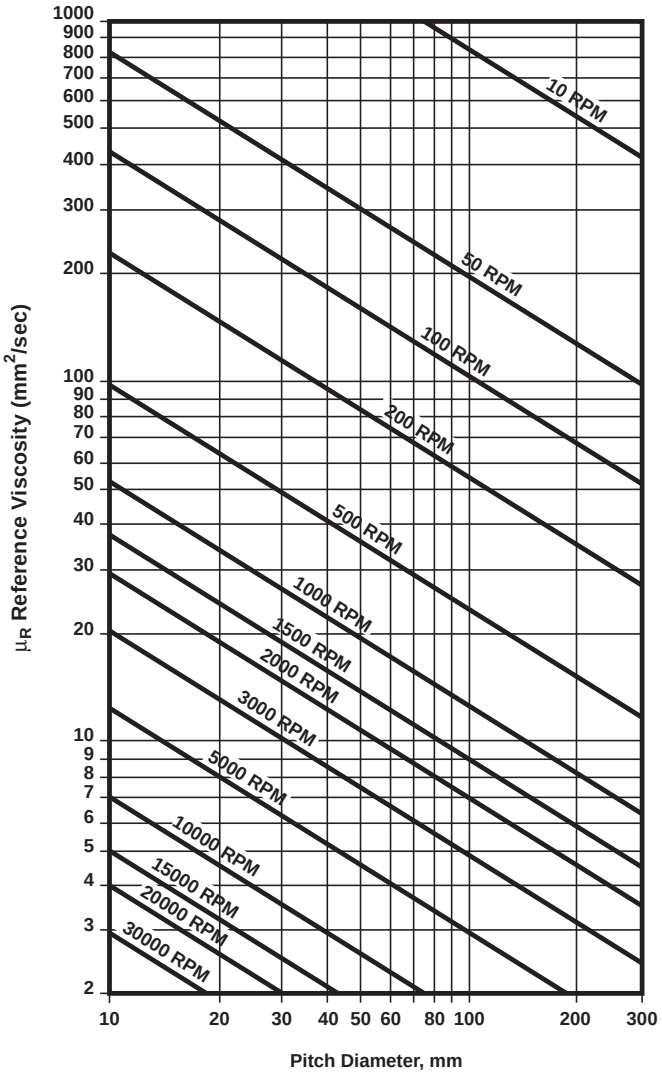


Figure 1 – Determining the Reference Viscosity

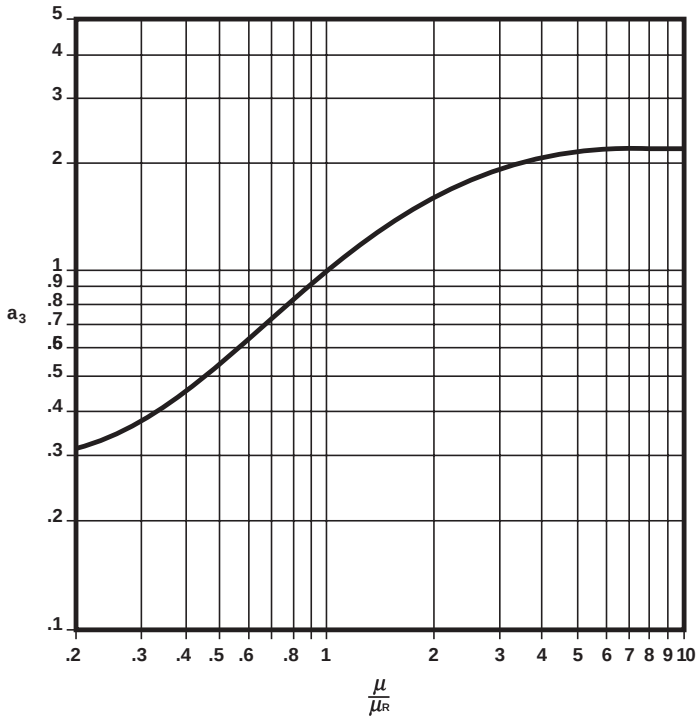
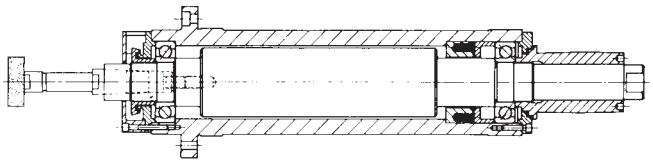


Figure 2 – Determining the Value of a_3 the Life adjustment Factor for Lubrication.

Applications

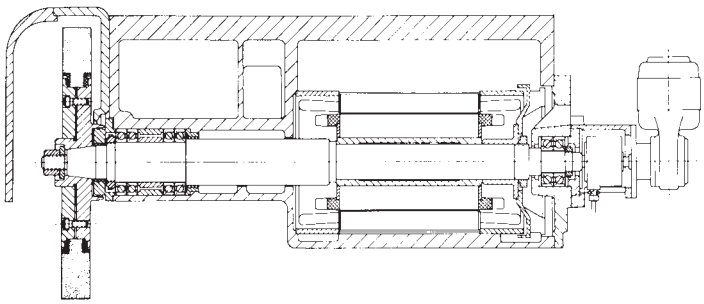
High-Speed Internal Grinding Spindle

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



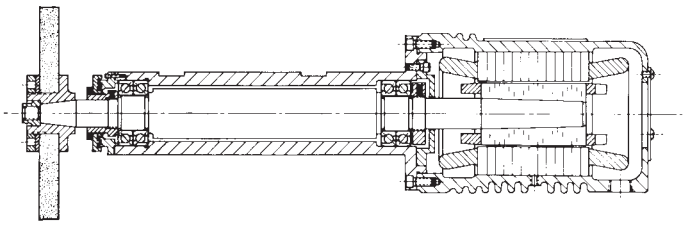
Ultra-Precision Surface Grinding Spindle

2MMX9122WI-DUM superprecision bearings, produced to ABEC-9 tolerances, are employed in this horizontal surface grinding spindle for maximum rigidity and accuracy. A back-to-back pair of 2MM312WI-CR-DUL superprecision bearings are used as the floating location. This spindle grinds surfaces that are accurate within .000025 inch, flat, parallel and square within .000010 inch, and to a surface finish of 5 rms, or better. The spindle, driven by a 30 hp motor, operates at 900 rpm. Bearings are packed with grease prior to assembly.



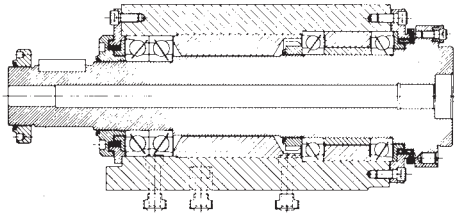
Precision Surface Grinding Spindle

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



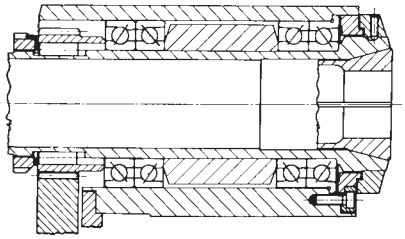
Heavy-Duty Precision Boring Spindle

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



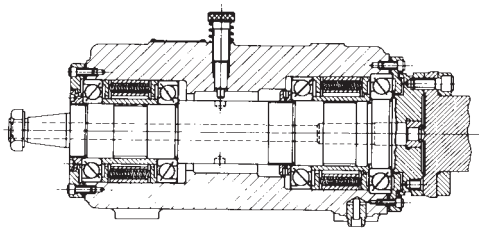
Six-Spindle Automatic Screw Machine

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



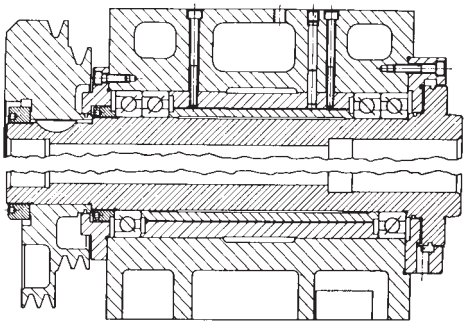
High-Speed Precision Boring Head

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



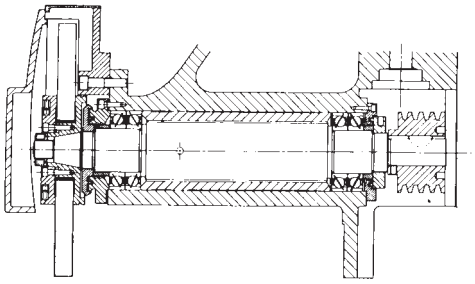
Ultra-Precision Grinding Workhead

This workhead must maintain straightness and roundness accuracy within ten millionths (.000010) of an inch. To meet such rigid requirements for extremely close dimensional control, ultra-precision ball bearings and a shaft of extra stiffness are used. The bearings for such applications are manufactured to tolerances closer than those for ABEC-9 specifications. Equally important is the high degree of workmanship and accuracy with which the shaft, housing and component parts of the workhead must be made. Upper section shows a four-bearing arrangement for heavy work. Lower half shows a two-bearing mounting for lighter work. In either case, the bearings are packed with grease, prior to mounting.



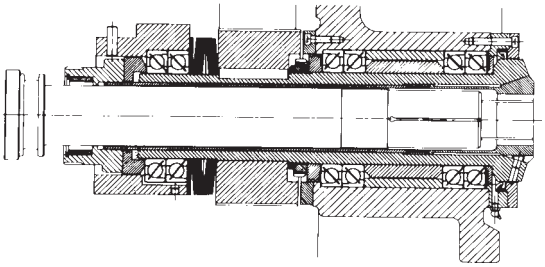
Precision Toolroom Surface Grinder Spindle

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



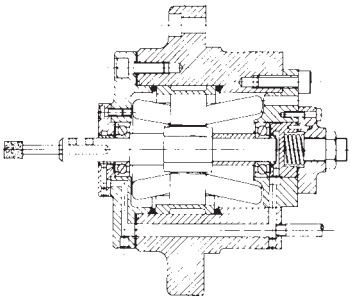
Single Bar Machine

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



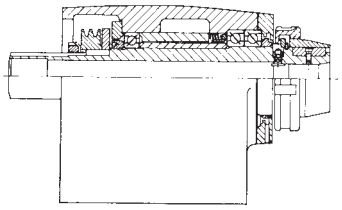
100,000 RPM High-Cycle Wheelhead

Superprecision 2MMX9101WO-CR bearings produced to ABEC-9 tolerances are spring-loaded in this wheelhead which operates at 100,000 rpm at 1660 cycles. Oil mist lubrication is employed and the motor is water cooled.



Superprecision Lathe Headstock

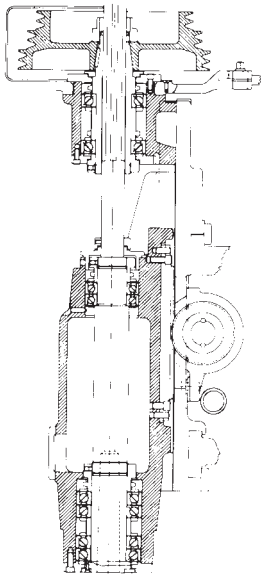
This lathe spindle produces work held to a roundness of 35 millionths (.000035) of an inch. Maximum operating speed is 4800 rpm. Tandem pair of 3MM9114WI-DUL bearings is opposed by a spring-loaded 3MM9113WI bearing, resulting in excellent spindle rigidity. Bearings are prelubricated with grease.



Precision Vertical Milling Spindle

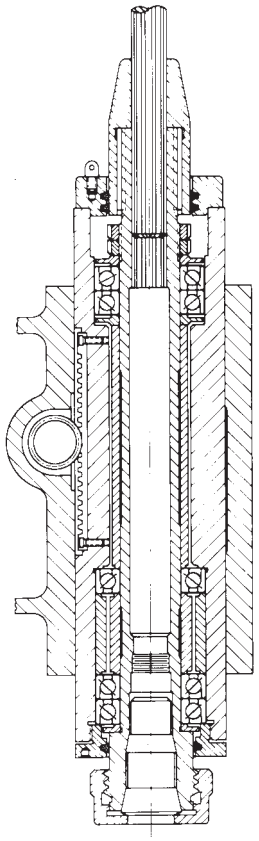
This spindle operates at 12 different speeds ranging from 260 to 6200 rpm under a wide variety of conditions. At the work end, two duplex pairs of Fafnir 2MM212WI-DUL preloaded bearings are mounted in tandem pairs in a back-to-back arrangement, separated by spacers of equal length. This affords extremely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

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



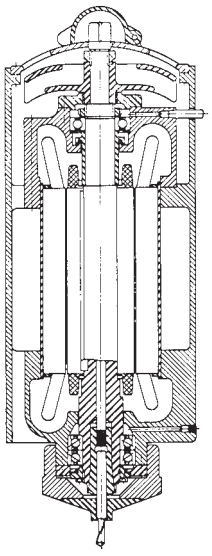
Precision Jig-Boring Spindle

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



High Speed Motorized Router

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



Radial Internal Clearance

Deep groove radial type bearings may be matched to various radial internal clearances to meet specific design and performance requirements. The following chart lists the clearances options available.

Conrad bearings ordered without a prefix for clearance specification will be supplied with a "P" fit as standard.

VALUES SHOWN IN TEN-THOUSANDTHS INCHES (.0001") AND MICROMETERS (μm)

Bearing Size	H" Fit Snug (C2)		R" Fit regular (C0)		P" Fit Loose (C3)		J" Fit Extra-loose (C4)	
	0.0000"	μm	0.0000"	μm	0.0000"	μm	0.0000"	μm
00	1-3	3-8	2-5	5-13	4-8	10-20	7-10	18-25
01	1-4	3-10	2-6	5-15	5-9	13-23	8-12	20-30
02	1-4	3-10	2-6	5-15	5-9	13-23	8-12	20-30
03	1-4	3-10	2-6	5-15	5-9	13-23	8-12	20-30
04	1-4	3-10	3-7	8-18	6-10	15-25	9-13	23-33
05	1-4	3-10	3-7	8-18	6-10	15-25	10-15	25-38
06	1-4	3-10	3-7	8-18	6-10	15-25	10-15	25-38
07	1-4	3-10	3-7	8-18	7-12	18-30	12-17	30-43
08	1-4	3-10	3-7	8-18	7-12	18-30	12-17	30-43
09	1-4	3-10	3-8	8-20	8-13	20-33	13-19	33-48
10	1-4	3-10	3-8	8-20	8-13	20-33	13-19	33-48
11	1-5	3-13	4-10	10-25	10-16	25-40	16-23	40-58
12	1-5	3-13	4-10	10-25	10-16	25-40	16-23	40-58
13	1-5	3-13	4-10	10-25	10-16	25-40	16-23	40-58
14	1-5	3-13	5-11	13-28	11-19	28-48	19-27	48-68
15	1-5	3-13	5-11	13-28	11-19	28-48	19-27	48-68
16	1-5	3-13	5-11	13-28	11-19	28-48	19-27	48-68
17-20	1-6	3-15	5-13	13-33	13-22	33-55	22-32	55-80
21-24	1-6	3-15	7-15	18-38	15-25	38-63	25-37	63-93
25-28	2-8	5-20	8-18	20-45	17-31	43-79	29-50	74-127

The "R" fit is standard for M and V series bearings.

Forward

Machine tools must meet the ever-increasing demands of modern industry for faster speeds, greater accuracy, smoother finishes and higher production rates at minimum costs. Such considerations are primarily influenced by the machine tool spindle with its superprecision ball bearings; and the machine tool builder, the spindle maker, and the ball bearing manufacturer are all making great advances in the achievement of these goals.

The machine tool spindle is expertly designed. It is fabricated from the best materials with the utmost care. Quality and accuracy of machining and the rate of production depend greatly on the ball bearings that support the spindle. Spindle maintenance and servicing have become a matter of prime importance and be done only by expert assemblers in meticulously clean, well-lighted and constant temperature surroundings.

Procedure

In this section the basic principles involved in the proper maintenance of machine tool spindles are outlined. Although the servicing of a permanently grease-lubricated belt-driven internal grinding wheelhead, Figure 1, is described, the mounting techniques and installation procedures are typical for almost all types of ball bearing spindles.

Enclosed Dust-Free Working Area

The desired results in the maintenance of machine tool spindles are achieved by an experienced mechanic working in a well organized, clean, and enclosed area set apart from the manufacturing processes or machines that propagate dust-laden air. His work bench and tools are clean and maintained in good working order. His surface plate is equipped with bench centers or parallel V-blocks and weighted end block, and test gage-blocks with 0.0001 inch dial indicators. He is equipped with outside and inside micrometers, a hole gage with 0.0001 inch indicator, a comparator gage with 0.0001 inch indicator and master discs and rings or precision blocks.

To insure dimensional accuracy and proper fitting of the spindle parts and ball bearings, all checking and assembly operations should be performed with gages, parts, and bearings that have attained a constant temperature. The equipment and all the parts to be assembled should be held in the working area long enough for them to assume thermal equilibrium before any measurements are taken.

Inspection of Parts before Assembly

The ideal shaft bearing seat is accurately and smoothly ground and absolutely free from burrs, tool marks and rust. An indicator gage that reads 0.0001 inch is used to check the bearing seat. This gage is set to the basic diameter with a master disc or with precision blocks. Deviations from the standard dimension are indicated by rolling the shaft backward and forward in several positions, and an axial movement of the bearing seat under the indicator gage registers any taper.

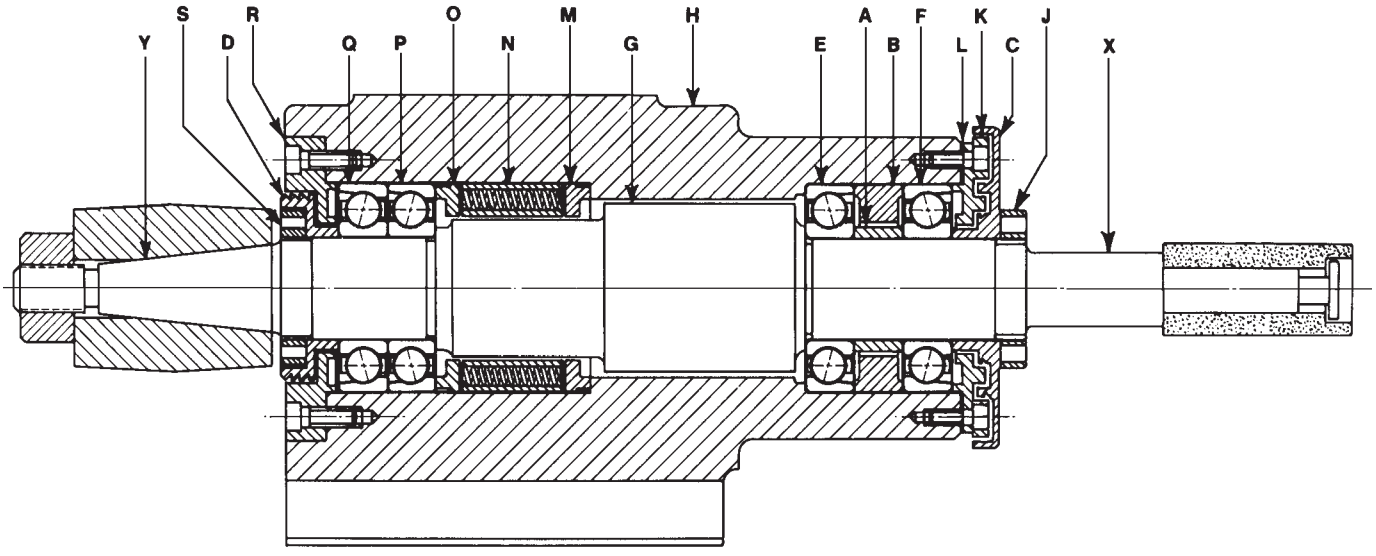


Figure 1 – Internal Grinding Wheelhead

The spindle shaft, with a steel ball located in one of its centers, is then mounted on parallel V-blocks and held against a weighted end block, Figure 2. Bench centers may be used, provided the shaft centers are free of damage and true. With the dial indicator seen at the left set at zero and contacting the bearing seat, the shaft is revolved slowly to determine runout and straightness. Both seats should be true with each other within 0.0002 inch total indicator reading (TIR), and within 0.0001 inch for very high-speed spindles. The wheel-end and pulley taper of the shaft are checked, and if the runouts do not coincide with the respective bearing seats, the high points of eccentricities are marked for identification. With the dial indicator seen at the right in Figure 2, the squareness of the bearing shoulders on the shaft is ascertained. This runout should not exceed 0.0002 inch total indicator reading.

The housing bore is checked with a two- or three- point hole gage which is set to the basic diameter with a master ring, or with precision blocks and a micrometer. By rocking the gage in several positions in the housing bore, any out-of-roundness and deviation of diameter is indicated. To discover any existing taper, the gage is moved axially. Housing bores are held within specified limits and checked for finish and freedom from burrs and tool marks.

Spacers, locknuts, and slingers carefully inspected, and all burrs are removed to insure proper seating of the ball bearings. Faces of spacers **A** and **B**, Figure 1, and slingers **C** and **D** must be flat and parallel within 0.0002 inch and square with their bores. The inner-ring and outer-ring spacers should be equal in length within 0.0002 inch.

Prior to assembly, all parts of the wheelhead, Figure 3, including housing bores are cleaned thoroughly with a solvent such as Varsol and then carefully wiped with a clean, lint-free cloth. All dirt must be removed from threads, keyways, grooves, and splines. To prevent corrosion, all parts, including shaft bearing seats and shoulders as well as the housing bores, are wiped with grease, leaving only a thin, protective film.

Each Bearing Packed with Three Grams of Grease

For this particular installation two pairs of 35mm bore, light series, angular -contact, duplexed superprecision ball bearings are used. In unpackaging, care is taken to prevent the entry of dirt or moisture into the bearings. The light protective oil put in the bearing by the manufacturer is removed with Varsol. Each bearing is carefully packed with about three grams of clean, suitable, ball bearing grease, using a flat steel scale for inserting the grease in to the bearing and around the balls. Grease voids within the bearing are eliminated, and even distribution of the grease is accomplished by revolving the bearing slowly in the hands until the torque throughout the bearing becomes noticeably constant.

Bearings Assembled in Spindle Mounting

Proper shaft and housing mounting fits must be established and maintained in the application of ball bearings. Generally, for machine tool spindles, the ball bearing should have a line-to-line fit with the shaft bearing seat and a sliding push fit in the housing bore. Before the actual assembly operations begin, the ball bearings may be used for trial purposes to insure the desired mounting fits at final assembly. Damage to the ball bearings is avoided by taking care to mount bearings without cocking and to apply a firm hand pressure to the inner-ring face when placing the bearing on the shaft. Only thumb pressure is applied to the face of the outer ring when the bearing is pushed into the housing. Each bearing should be earmarked for its eventual position in the spindle assembly, making certain that the floating or spring-loaded bearings are slightly looser in the housing than the front or fixed bearings.

At the wheel-end or nose of the spindle, the minimum housing bore dimension for the fixed superprecision ball bearings may be established as 0.0001 inch less than the maximum outside diameter of the bearing. If the bearing outside diameter tolerance is 0.0002 inch, the maximum housing bore dimension is established at 0.0004 inch larger than the minimum housing bore.

Figure 2 – Inspection of Shaft

Figure 3 – Wheelhead Parts

Bearings O.D.	Housing Bore	Mounting Fit
inches	inches	inches
max. 2.8346	min.2.8345	.0001 tight
min. 2.8344	max.2.8349	.0005 loose

Thus, the average mounted resultant fit is .0002 inch loose. If possible these clearances should be obtained, since it produces the ideal fit of the bearing in the housing bore.

At the drive-end of the spindle where the floating bearing is located, it is highly desirable to strive for an average fit of about 0.0001 inch looser than for the wheel-end ball bearings. For the drive-end, therefore, this ideal housing fit is 0.0003 inch loose. In operation, the bearing is itself a heat source and the housing functions as a heat sink and radiator. The equilibrium housing temperature is at some level between room temperature and the bearing. Obviously, the bearing will expand at a higher rate than the housing bore. For example: if we assume that the temperature gradient between the bearing and the housing is 10° F, the bearing will expand in diameter approximately 0.0002 inch more than the housing.

In the case of superprecision, preloaded pairs of ball bearings for high-speed wheelheads, the ideal shaft fit is a line-to-line fit to one with a looseness of 0.0001 inch. This mounted fit is attained if the bearing is assembled on the shaft under a firm thumb pressure applied to the face of the inner ring. Likewise, a good fit is indicated when the bearing can be assembled by applying gentle tapping blows on the face of a suitable mounting sleeve held against the bearing inner ring face. For these wheelhead bearings it is generally recommended that the shaft-seat diameter be the same as the bearing bore. The ideal mounting fit may be obtained by cross-matching the shafts and the bearings. The bearing bore is matched with the shaft seat that will result in a mounted fit of 0.0001 inch loose to one of line-to-line. Where single superprecision ball bearings are employed in high-speed wheelheads, and preloading is accomplished by the application of spring pressure, it is good practice to use the shaft-fitting procedure.

Bearing and Shaft Assembled with Eccentricities Opposed

With the asteric markings (*) – denoting the high points of eccentricity – on the faces of the inner and outer rings of the bearings positioned in line, the front pair of ball bearings **E** and **F**, Figure 1, with their outer ring thrust faces toward the drive end of the shaft, are mounted in tandem on the shaft **G**. Inner-ring spacer **A** and outer ring spacer **B** are placed between them. The mounting is done in such a way that the location of the high points of eccentricity of the shaft seat and of the bearing inner rings are diametrically opposed. This practice is intended to minimize, and not compound the effects of eccentricity of the shaft and inner rings. This sub-assembly is placed in the housing **H**, as shown in Figure 4.

The ball bearings are then properly seated against the shaft seat shoulder by placing front slinger **C** against the bearing inner-ring face, and locknut **J**, having a right-hand thread, is tightened with a spanner wrench. With the outer ring face of the inboard bearing seated against the internal housing shoulder, locknut **J** and front slinger **C** are removed. Next, outer-ring cap **K** and gasket **L** are assembled and secured in place, this cap being locked evenly, parallel, and firmly against the outer-ring face of the outside bearing. Front slinger **C** and locknut **J** are then replaced, temporarily securing the bearings with a spanner wrench.

After the shaft is in the housing and assembled with the front pair of bearings, thrust collar **M** is mounted on the shaft from the drive end, as illustrated in Figure 1. This collar is placed with its wide face outward in order to support the preloaded springs. The springs, in turn, are inserted in cage unit **N**, which is then mounted in position on the shaft. Spring washer **O** with its greased packed cavity outward, is placed against the springs.

With the burnished spots in line, ball bearings **P** and **Q** are similarly assembled in tandem but with the thrust faces of the outer rings inward and toward the wheel-end of the shaft. Again, the bearings are mounted in such a way that the high points of eccentricity of the shaft seat and of the bearing inner rings are diametrically opposed. Assembly of these bearings is shown in Figure 5.

FIGURE 4 – SUB-ASSEMBLY

FIGURE 5 – MOUNTING DRIVE-END BEARINGS

After closure cap **R** is securely fastened to the housing, rear slinger **D** is placed in position against the inner-ring face of the ball bearing, and locknut **S**, having a left-hand thread, is screwed on the shaft with a spanner wrench handle with two sharp raps of a light hammer. The procedure is repeated from the opposite side by relocating the spanner wrench on the locknut 180° from the first position. The clearance between the closure cap **R** and the rear slinger **D** is checked with a feeler gage to make sure that no interference exists between the two parts.

Front locknut **J** is loosened counterclockwise about four turns and indicator readings taken at the wheel-end of the shaft, Figure 6,. If these readings correspond to the nose runout or eccentricity previously obtained when the shaft was inspected on parallel V-blocks before assembly, no inaccuracies have been introduced through installation of the bearing. Following the check, the front locknut **J** is screwed on the shaft until the face of the front slinger **C** comes to bear on the inner ring face of the ball bearing. This locknut is set with a spanner wrench to tighten the bearing inner rings together and against the shaft shoulder, Figure 7. Tightening is done evenly and securely by striking the wrench handle with two sharp raps of a light hammer and repeating this operation on the other side of the locknut, 180° from the first position. Approximately the same force should be used in tightening the locknut every time it is tightened. This is important, especially during the trial and error scraping process.

Once these bearings are locked by the locknut, they become a preloaded pair in a fixed position, and the spindle is checked for possible runout. Should runout now exist in the assembly, it can be attributed directly to the relation between the threads and the locking face of the locknut. If the shaft shows a runout of 0.0001 inch or more, it can be assumed that the trouble lies in the locknut contact with the outward face of the front slinger. If the locknut face is tightened against the bearing inner face without the locknut face being square with the threaded bore of the shaft, the shaft may be forced to bend. This shaft bending will cause a radial eccentricity (runout) as measured on the shaft. Scraping of the high points on the locknut face will eliminate this out-of-squareness condition and provide optimum running accuracy.

Scraping Locknut to Eliminate Runout

To determine where to scrape, first check with an indicator over the front end of the shaft at point **X**, Figure 1, until the highest reading is noted. This shows that the tip of the indicator point is directly over the vertical diameter of the shaft. Stopping at the highest reading on the indicator, the shaft is slowly rotated from the opposite end of the spindle which, in this case, would be the drive or rear end. Stop at the lowest reading on the indicator dial and with a red pencil or metal-marking pencil scribe a line longitudinally along the shaft and on the outside diameter of the locknut **J** directly in line with the low reading.

Figure 6 – Checking Nose-End Runout

Figure 7 – Tightening with Spanner Wrench

The locknut is removed from the assembly and the line transferred to its front face. This procedure locates the area to be scraped or lapped.

Scraping may be done with a scraping tool on the high surface and approximately 90° on both sides. Care should be taken to scrape evenly and uniformly. The depth of scraping (which will always be slight) can be judged only by the amount of runout shown on the indicator dial.

When the estimated amount of metal has been removed by scraping, the locknut is washed and blown clean. It is then placed against the face of the front slinger and tightened. New readings are taken, and if the runout persists, the locknut is removed and scraped in the same manner. If scraping on the same surface area is necessary, it is obvious that not enough metal was removed the first time. If the high surface is diagonally opposite, too much metal was removed. Scraping is continued until the face shows a very close reading on the indicator. To determine and correct any inaccuracies that might exist at the drive-end of the spindle, indicator readings are taken at point **Y**, Figure 1. After locknut **S** is loosened clockwise and removed, the same basic procedures used for the wheel end of the spindle are followed. The wheelhead assembly is then ready for the run-in test and final inspection.

Checking Temperature, Vibration and Roughness

Before starting the test run for final inspection, the spindle is started and stopped a few times to make sure the wheelhead and testing equipment are in good working order. The spindle is then brought up to operational speed, which should not exceed the maximum speed indicated on the nameplate.

Temperature readings are taken as close to the bearings as possible, every five minutes at first, for each bearing on the housing. If the wheelhead heats up rapidly, it is stopped, allowed to cool to room temperature, and then re-started. Readings are then taken about every fifteen minutes until the temperature levels off, The wheelhead should not be permitted to run hotter than 50° above room temperature or to run so that the heat becomes unbearable to the touch. Generally, temperature readings of more than 120°F are not encountered. Three to four hours should be reasonable time for running-in the wheelhead and checking for temperatures, unusual sounds, vibration, and roughness. Following the successful completion of this test, the precision-built wheelhead is ready for use in the manufacturing area.

Cleanliness

Elaborate precautions are taken to insure that superprecision ball bearings are dirt-free and thoroughly protected when packaged. Extreme care should be exercised to keep them clean and away from moisture and contamination from the time they are unpackaged until they are mounted in spindles and running.

In servicing machine tool spindles, cleanliness cannot be overemphasized. THe work area, bench and tools should be clean and well organized. Clean hands are necessary, too. Plenty of clean lint-free rags should be available to keep the hands free of moisture, grime and dust-gathering oil. The spindle parts should be washed thoroughly in cleaning solution and dried with a filtered air under pressure.In addition to the spindle parts, the inside of the housing and all oil holes and threads should be solvent cleaned and air dried. Any corrosion on the shaft should be carefully removed. This is done by stoning or with crocus cloth while rotating the shaft and must be done carefully to avoid polishing the shaft undersize. These operations are followed with solvent cleaning and air drying.

Varsol with a 10% oil mixture is a good grade of non-flammable cleaning solution and an excellent cleansing agent. Chlorinated solvents such as tetrachloride are definitely not recommended for this purpose.

Freshly unpackaged bearings that are to be in oil or oil mist lubricated in spindles need not be cleaned of their protective oil. Bearings that are grease packed at our factories should be used as received.

Often times, the user packs bearings with grease prior to mounting. In such cases, the original protective oil slush is removed from the bearings with Varsol, and the bearings are dried with air under pressure by holding the bearing firmly so that spinning is avoided. Clean grease of the correct type should be packed carefully into the bearings in recommended quantities.

In servicing machine tool spindles it is essential to analyze the operating troubles and probable causes of the improper performance or malfunctions of the spindle, especially if the ball bearings have failed prematurely.

Causes and conditions that indicate or lead to ball bearing replacement are:

Out-of-roundness of work;

Impossibility of maintaining tolerances;

Existence of noise and chatter;

Production of rough or poor finishes;

Accidental damage to machine spindle;

“Brinelling” of bearings;

Entry of coolant and contamination into bearings;

Faulty lubrication of bearings.

Before the spindle is removed from the machine, a check should be made to ascertain whether the trouble is with the spindle and the bearings or the result of improper tooling, roughness in the machine slides, irregular feeds or some other such cause.

When the cause of damage or failure of ball bearings is not immediately apparent, there is a tendency to suspect faulty bearing materials or defective workmanship in the product; but the materials and the manufacturing methods in the production of ball bearings, through many years of research, have reached such a state of refinement that defects in bearings are extremely remote. In most cases, ball bearings fail from preventable causes, such as faulty mounting practice, incorrect shaft and housing mounting fits, improper or unsuitable lubrication and intrusion of foreign matter.

Bearing replacements without corrective measures often result in the repetition of the trouble. It becomes very important, therefore, to determine accurately and completely, the cause of the improper functioning of the ball bearings.

Ball bearings should be pressed onto a shaft with the mounting force applied only to the inner ring. Similarly, when bearings are mounted in a housing, the mounting force should be applied solely to the outer ring. Mounting dents or ‘brinells’ high on the raceway are caused when the mounting force is applied to a ring which is not being mounted. They should be seated solidly against the shoulders by means of an arbor press and a tubular drift. It is important that both ends of the tube are faced square and that all corners are broken to avoid flaking. The tubes must be clean and free from scale, both inside and out, to avoid the possibility of dirt falling into the bearings.

In mounting ball bearings, particular attention should be given to the mounting fits. If the bearing seat is of the correct diameter and without serious taper, the bearing can be pressed to the shoulder with a uniform pressure. However, if the bearing sticks and requires excessive force at any point, it may have been cocked . Continued pressure on the bearing ring that was not squarely is likely to scrape and seriously damage the bearing seat. The source of trouble, which can be a burred or tapered seat, should be determined and corrected before proceeding.

Fretting corrosion in the bearing bore can be the result of loose shaft fits. This action produces iron oxide causing free iron to be removed from the shaft. This material gets into the bearing and being abrasive causes wear in the bearing, produces noise and engenders premature bearing failure.

Misaligned bearings can be the cause of early fatigue failures. Bearing misalignment can be caused by housing bores that are not in line with each other or when the bearing seats on the shaft are not concentric. Bearings may also become misaligned if the shaft or housing shoulder is out-of-square. When considerable misalignment is present, the load track veers from one side of the raceway to the other. Highly misaligned loads could force the balls over the edge of the raceway shoulder, causing the ball surfaces to be creased and resulting in premature fatigue failures.

Foreign matter – coolant, dust, dirt or other contaminants – pressed to ball bearings is the most common cause of bearing failure. Such a condition may be caused either by the entry of dirt or moisture, by the improper handling of the bearing during the mounting procedure or from inadequate sealing of the shaft and housing. Severe cases may cause abrasion and wear of the revolving parts, generally resulting in excessive axial looseness in the bearing. Visual evidence of this would be dull, gray discoloration of the raceways and the balls. Under such conditions ball bearings become noisy and inevitably fail to perform satisfactorily.

Lubrication is essential for the proper operation of ball bearings. Greases and oils are both used over a considerable range of speeds and operating temperatures. The choice of lubrication should be made after the careful consideration of the factors involved.

Generally, ball bearings operating at moderate speeds require relatively small amounts of lubrication. Too much lubrication, accompanied by churning and excessive torque, is manifested by temperature rise and intense over-heating. Lack of lubrication causes a rise in operating temperature, coupled with a whistling sound when running. Unless such conditions are corrected, the rings, balls and cage may be seriously damaged. Discoloration of the bearing parts is evidence of excessive operating temperatures.

In taking corrective measures it is important to know the operating history of the spindle and to study a cross-sectional drawing of the mounting arrangement. This information should include the following:

Operational speed

Operating temperature

Type of lubrication

Estimate of working loads

Type of drive and horsepower

Material processed

Reason for spindle failure

In addition and before the spindle is disassembled, the runout of the spindle nose should be determined with a 0.0001 inch indicator and recorded. The bearings should be removed carefully, without further damage, and tagged 1, 2, 3, 4, etc. starting from the work-end of the spindle. Pairs of bearings should be marked DB, DF or DT to denote whether the bearings had been mounted back-to-back, face-to-face, or in tandem. The conditions of the bearings should be noted for the entry of foreign matter, lack of lubrication, excessive temperatures and the extent of damage.

Before bearing replacement is made, the spindle parts should be thoroughly cleaned with Varsol and measured carefully for wear in the housing bores and shaft seats. Housing and shaft shoulders should be checked for equal lengths and parallelism of faces. All mating parts should be free of nicks and burrs.

Typical applications of precision ball bearings to machine tool spindles, showing bearing bore sizes, speed range, type of lubrication and approximate operating temperature, are tabulated at the bottom of this page.

In their efforts to attain even smoother and finer surface finishes, many users of high-speed wheelheads, especially of the belt driven type, operate their spindles at higher speeds than those for which they were designed. Spindle failure often occurs due to the rise in operating temperature caused by the breakdown of the lubricant, and because the original spring preload on the bearings was not reduced to correspond with that recommended for the increased speed. In such cases, the induced heat expands the internal parts of the spindle, thereby tightening the mounting fits and preventing the floating of spring loaded bearings from moving axially. Thus, additional heat is generated and failure results. Wheelhead users are cautioned to consult the original equipment manufacturer when increased speeds for their spindles are contemplated.

Many factors are involved in the design, fabrication and use of high speed spindles. Among them are the selection of the ball bearings, the amount of applied preloading, the mounting fits, the accuracy of the parts and the skill with which they are assembled, the operating temperature and speed involved, and lastly, the type of lubricant - grease, oil, or oil mist. Adequate lubrication, low operating temperatures, accurate and smooth operation, low friction, and a high degree of axial and radial rigidity are all extremely important qualities for successful machine tool spindle performance. The attainment of these qualities will continue to require the cooperation of the ball bearing manufacturer and the machine tool builder, as well as the machine tool user.

TYPICAL APPLICATIONS OF BALL BEARINGS TO MACHINE TOOL SPINDLES

Application	Bearing Bore, mm	Speed Range, rpm	Lubrication	Approximate Operating Degrees F.
Cylindrical and Internal Grinders				
Wheelheads				
Belt Drive	17-50	Up to 100,000	Oil mist- grease-oil	100-120
High-Frequency motor Drive	8-50	10,000-150,000	Oil mist- grease	95-120
Workheads	Wide Range	Up to 5,000	Grease	95-110
Surface Grinders	Wide Range	1,800-6,000	Grease	110
Tool and Cutter Grinders	20-35	5,000-10,000	Grease	100-115
Gear and Thread Grinders	60-80	3,000 - 5,000	Grease	100-115
Boring Heads	Wide Range	Up to 10,000	Oil mist-grease-oil	105-120
Jig Bores	25-75	Up to 3,000	Grease	85-100
Lathes	Wide Range	Up to 10,000	Oil-grease	100-120
Drilling Machines	15-40	Up to 30,000	Oil-grease	100-115
Milling Machines	Wide Range	Up to 12,500	Oil mist-grease-oil	100-115
Routers	20-60	12,000-30,000	Oil mist-grease	110-125

Fractional/Decimal/Metric Equivalents

To convert inches to millimeters, multiply the inches by 25.4.
To convert millimeters to inches, divide the millimeters by 25.4.
(As established by the American Standards Association.)

fractional	decimal inches	mm	fractional	decimal inches	mm	decimal inches	mm	decimal inches	mm
1/64	0.0156		33/64	0.5156		1.0236	26	2.7953	71
1/32	0.0312		17/32	0.5312		1.0630	27	2.8346	72
	0.0394	1	35/64	0.5469		1.1024	28	2.8740	73
				0.5512	14	1.1417	29	2.9134	74
3/64	0.0469					1.1811	30	2.9528	75
1/16	0.0625		9/16	0.5625					
5/64	0.0781		37/64	0.5781		1.2205	31	2.9921	76
	0.0787	2		**0.5906**	15	1.2598	32	3.0315	77
						1.2992	33	3.0709	78
3/32	0.0938		19/32	0.5938		1.3386	34	3.1102	79
7/64	0.1094		39/64	0.6094		1.3780	35	3.1496	80
	0.1181	3	5/8	0.6250					
1/8	0.1250			**0.6299**	16	1.4173	36	3.1890	81
9/64	0.1406					1.4567	37	3.2283	82
5/32	0.1562		41/64	0.6406		1.4961	38	3.2677	83
	0.1575	4	21/32	0.6562		1.5354	39	3.3071	84
				0.6693	17	1.5748	40	3.3465	85
11/64	0.1719								
3/16	0.1875		43/64	0.6719		1.6142	41	3.3858	86
	0.1969	5	11/16	0.6875		1.6535	42	3.4252	87
			45/64	0.7031		1.6929	43	3.4646	88
13/64	0.2031			**0.7087**	18	1.7323	44	3.5039	89
7/32	0.2188		23/32	0.7188		1.7717	45	3.5433	90
15/64	0.2344		47/64	0.7344					
	0.2362	6		**0.7480**	19	1.8110	46	3.5827	91
						1.8504	47	3.6220	92
1/4	0.2500		3/4	0.7500		1.8898	48	3.6614	93
17/64	0.2656		49/64	0.7656		1.9291	49	3.7008	94
	0.2756	7	25/32	0.7812		1.9685	50	3.7402	95
				0.7874	20				
9/32	0.2812					2.0079	51	3.7795	96
19/64	0.2969		51/64	0.7969		2.0472	52	3.8189	97
5/16	0.3125		13/16	0.8125		2.0866	53	3.8583	98
	0.3150	8		**0.8268**	21	2.1260	54	3.8976	99
						2.1654	55	3.9370	100
21/64	0.3281		53/64	0.8281					
11/32	0.3438		27/32	0.8438		2.2047	56	4.1339	105
	0.3543	9	55/64	0.8594		2.2441	57	4.3307	110
				0.8661	22	2.2835	58	4.5276	115
23/64	0.3594					2.3228	59	4.7244	120
3/8	0.3750		7/8	0.8750		2.3622	60	4.9213	125
25/64	0.3906		57/64	0.8906					
	0.3937	10		**0.9055**	23	2.4016	61	5.1181	130
						2.4409	62	5.3150	135
13/32	0.4062		29/32	0.9062		2.4803	63	5.5118	140
27/64	0.4219		59/64	0.9219		2.5197	64	5.7087	145
	0.4331	11	15/16	0.9375		2.5591	65	5.9055	150
				0.9449	24				
7/16	0.4375					2.5984	66	6.1024	155
29/64	0.4531		61/64	0.9531		2.6378	67	6.2992	160
15/32	0.4688		31/32	0.9688		2.6772	68	6.4691	165
	0.4724	12		**0.9843**	25	2.7165	69	6.6929	170
31/64	0.4844					2.7559	70	6.8898	175
1/2	0.5000		63/64	0.9844					
	0.5118	13	1	1.0000				7.0866	180
								7.2835	185
								7.4803	190
								7.6772	195
								7.8740	200

Quick Reference Data Sheets

For Ball Screw Support Bearings Only:

***Procedure for making a **Quad Set** from two sets of **Duplex Bearings.**

1. Physically remove the bearings from their boxes

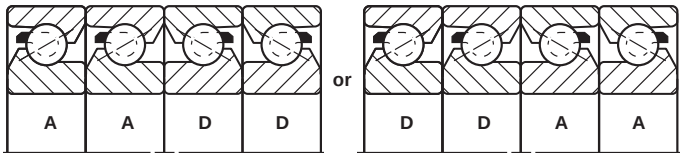
2. Without removing the bearings from their plastic bags, locate the laser marked code on the outer ring (O.D.). The marking will be a single letter. There are four possible letters, either “A, B, C, or D”.

Note: There are two possible combinations of marking that can be on the outer rings of a **DUPLEX** set of bearings. One combination is having one bearing marked with an “A” and the other with a “D”. The second combination is having one bearing marked with a “B” and the other with a “C”.

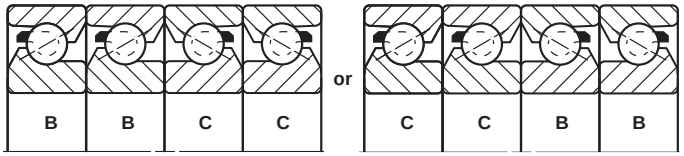
3. Locate two sets of **DUPLEX** bearings (four bearings total) marked with “A” and “D” or two sets of bearings marked with “B” and “C”.

4. **Quad Sets** should be matched according to one of the following configurations.

I. Having two sets of bearings that are marked “A”, “D”. Match as shown below.



II. Having two sets of bearings that are marked “B”, “C”. Match as shown below.



Quick Reference Data Sheets

For Ball Screw Support Bearings Only:

*Procedure for making a **Triplex Set** from two sets of **Duplex Bearings.**

1. Physically remove the bearings from their boxes

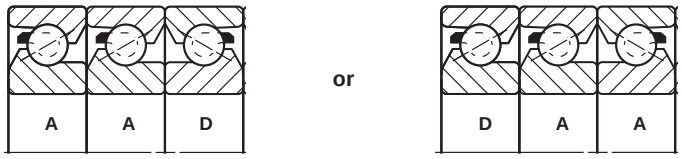
2. Without removing the bearings from their plastic bags, locate the laser marked code on the outer ring (O.D.). The marking will be a single letter. There are four possible letters, either “A, B, C, or D”.

Note: There are two possible combinations of marking that can be on the outer rings of a **DUPLEX** set of bearings. One combination is having one bearing marked with an “A” and the other with a “D”. The second combination is having one bearing marked with a “B” and the other with a “C”.

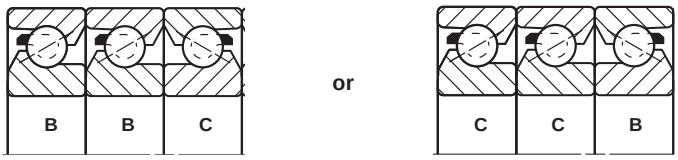
3. Locate two sets of **DUPLEX** bearings (four bearings total) marked with “A” and “D” or two sets of bearings marked with “B” and “C”.

4. **Triplex Sets** should be matched according to one of the following configurations.

I. Having two sets of bearings that are marked “A”, “D”. Match as shown below.



II. Having two sets of bearings that are marked “B”, “C”. Match as shown below.



Quick Reference Data Sheets

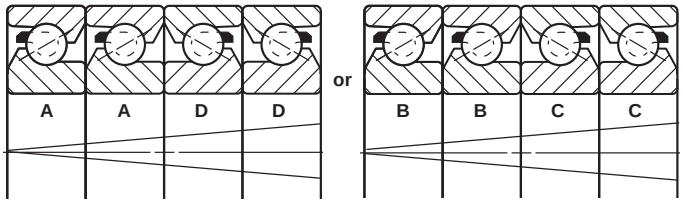
For Ball Screw Support Bearings Only:

*Procedure for making a **Duplex Set** from one **Quad set of bearings.**

1. Physically remove the bearings from their box(es).

2. Without removing the bearing from the plastic bags, locate the laser “V,, mark and the laser marked code on the outer ring (O.D.). The laser “V” mark on the O.D. of the quad set is used to orient the bearings in a back-to-back configuration. The laser mark code will be a single letter. There are four possible letters, either “A, B, C, or D”.

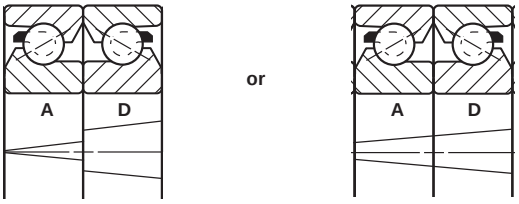
Note: There are two possible combinations of markings that can be on the outer rings of a QUAD set of bearings. One combination is having the two bearings in tandem marked with an “A” opposed by two bearings in tandem marked with a **“D”**. The second combination is having two bearings in tandem marked with a “B” opposed by two bearings in tandem marked with a “C”. Refer to possible combinations below.

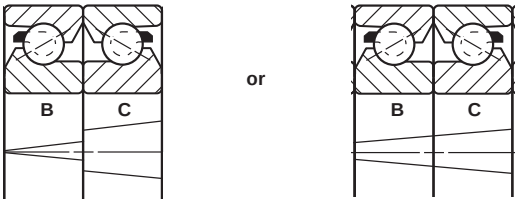


3. **Duplex Sets** should be matched according to the following procedure.

   The two outer bearings should be paired together to form one set of duplex bearings and the two inner bearings will form the other pair.

(example)





FAFNIR ENGINEERING DAMAGED BEARING ANALYSIS SHEET

GENERAL INFORMATION

CUSTOMER: _____ CCR/RGA #: _____

BEARING USER: _____ QTY: _____ DATE REQ'D: _____

SALES ENGINEER: _____ DISTRICT OFFICE: _____

REASON FOR ANALYSIS REQUEST: _____

REPAIRABILITY AND COST TO REPAIR REQUIRED: ☐ YES ☐ NO

☐ HOLD BEARING UNTIL FURTHER NOTICE ☐ SCRAP 30 DAYS AFTER ANALYSIS ☐ RETURN TO D.O.

BEARING INFORMATION

BRG. NO: _____ TYPE: _____ DATE CODE: _____ S. N.: _____

☐ NEW BEARING ☐ REPAIRED BEARING DATE INSTALLED: _____ SERVICE LIFE: _____

APPLICATION INFORMATION

EQUIPMENT/MODEL NO.: _____ JOB NO.: _____

LOADS: RADIAL _____ (lb) AXIAL _____ (lb) MOMENT _____ (ft-lb) ROTATION ☐ I.R. ☐ O.R.

SPEED: _____ (rpm) OSCILLATION ANGLE: _____ (Total Degrees) FREQ.: _____ (opm)

LUBRICATION METHOD: _____ BRAND: _____

TEMP: AMBIENT _____ (°F) HOUSING _____ (°F) BEARING _____ (°F) LUBRICANT _____ (°F)

SHAFT FIT/SIZE: _____ HOUSING FIT/SIZE: _____

INSTALLATION METHOD: ☐ HYDRAULIC ☐ MECHANICAL ☐ THERMAL OTHER _____

REMOVAL METHOD: ☐ HYDRAULIC ☐ MECHANICAL ☐ THERMAL OTHER _____

OPERATING EQUIPMENT CONDITION

INITIAL INDICATION OF BEARING DAMAGE: ☐ VIBRATION ☐ NOISE ☐ HEAT OTHER _____

SHAFT CONDITION: _____

HOUSING CONDITION: _____

LUBRICANT CONDITION: _____

INNER RING CONDITION: _____

OUTER RING CONDITION: _____

CAGE CONDITION: _____

ROLLING ELEMENTS CONDITION: _____

GENERAL COMMENTS: _____

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