BARDEN

Precision Ball Bearings
Catalog CD-30

The Barden Corporation
FAG Aerospace and Super Precision Bearings Division

INTRODUCTION

HOW THIS CATALOG IS ORGANIZED

Welcome to the world of Barden Precision Bearings.

This catalog contains the most complete list of Barden precision bearings currently available.

If you have a copy of an earlier Barden catalog, you'll notice that this version is organized differently. First of all, the catalog is divided into two primary sections:

1) product
2) engineering

The product section is now organized by bearing type:

- Instrument Bearings (Deep Groove and Angular Contact)
- Spindle Bearings (Angular Contact)
- Spindle Bearings (Deep Groove)
- Ball Screw Support Bearings

Bearings are also now listed by bore diameter – from the smallest to the largest.

Another key change to this catalog is that data on limiting speeds, ball complement, static capacity, basic dynamic load ratings and standard preloads has been moved to the appropriate product page, alongside bearing dimensions and nomenclature. This information was previously listed in the engineering section in the back of our older catalogs.

Additional relevant data (e.g. on seal and cage options, etc) can now be found in the appropriate product sections, instead of appearing in the general engineering reference section, as before.

The engineering section also has been reorganized. Much of the specific bearing operating data, as mentioned, can now be found in the appropriate product section. New material has also been added to the engineering section, particularly on handling and mounting procedures.

One significant new feature, this catalog now has four fold-out pages at the beginning of each product section. Each fold-out page contains detailed descriptions of appropriate bearing nomenclature by type of bearing.

We believe that all of these changes will improve the functionality –and usefulness– of our primary product catalog. Finding exactly the right Barden Precision Bearing should now be easier than ever.

Finally, we would welcome any comments or suggestions you may have regarding our new format. And, as always, thank you for choosing Barden.

Barden manufactures super precision spindle bearings and instrument bearings at plants located in Danbury, Connecticut (shown above) and the U.K.

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BARDEN PRECISION BEARINGS

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The data, specifications and characteristics in this catalog were developed using sound testing and engineering techniques and are believed to be accurate. Every attempt has been made to preclude errors. However, use of this information is the customer's responsibility. The Barden Corporation's sole responsibility or liability is contained in the Warranty statement at the end of this catalog.

Hybrid bearings utilizing ceramic balls help reduce vibration levels resulting in lower operating temperatures, longer life, greater accuracy and higher running speeds.

BARDEN'S COMMITMENT TO EXCELLENCE

The Barden Corporation was originally founded to make ball bearings of exceptional quality requiring rotational precision and tolerance control beyond the scope of technology then available. Today, over fifty years later, Barden continues to meet the challenge of manufacturing to super-precise/super-critical levels, and is recognized as an industry leader in this achievement. Excellence in manufacturing remains our guiding principle.

Barden produces thousands of bearing types, sizes and designs for a wide range of precision applications serving narrow – but highly demanding – market segments, like spindle and turbine bearings for industrial machinery and aircraft accessories, as well as instrument bearings for medical applications and gyroscopes.

Barden's goal remains not only to provide the highest quality, most precise bearings that can be made, but to enable our customers to compete more successfully in the markets they serve.

Regardless of design, all Barden bearings share one thing in common: they adhere to the highest standards possible, with tolerances measured in the millionths of an inch.

INTERNATIONAL RECOGNITION

The Barden name – long synonymous with quality, precision and excellence – is known and respected in virtually every industrialized nation, including the Far East.

The Barden Corporation is a world leader in the engineering, design and manufacture of precision ball bearings and bearing components.

In 1991, Barden became affiliated with the FAG Kugelfischer Group, and now forms the nucleus of its Aerospace and Super Precision Division along with Barden U.K., a manufacturer of precision ball and spindle bearings, based in Plymouth, England. Also included in this division are facilities in Stratford, Canada; Schweinfurt, Germany and subsidiary Winsted Precision Ball Company.

Aerospace and Super Precision Division customers are served primarily by a staff of Barden Sales Engineers. The replacement market is served by approximately 1,000 distributor outlets. Both are supplemented by a network of agents and distributors throughout the world.

With this global distribution system, Barden can provide bearings of identical quality at any point of need. Present customers include many multinational companies that buy Barden bearings in more than one country.

BARDEN PRODUCTS

The Barden product line encompasses predominantly radial, single row, super precision angular contact (separable and nonseparable) and deep groove ball bearings. Ball bearings are made to exacting ABEC-7 and ABEC-9 specifications, standards which Barden routinely exceeds.

Barden super precision bearings come in inch or metric dimensions with diameters ranging from 3/8" (9.5mm) O.D. up to 11½" (300mm) O.D. A variety of seals, shields and metallic/nonmetallic cage designs are available to satisfy most requirements. Many Barden bearings operate comfortably at speeds ranging to 2.0 million dN (bore in mm × RPM), or above.

PRECISION CLASSES

Precision ball bearings are manufactured to tolerance standards set by the Bearing Engineers Committee (BEC) of the American Bearing Manufacturers Association (ABMA). These standards have been accepted by the American National Standards Institute (ANSI) and conform essentially with equivalent standards of the International Organization for Standardization (ISO).

ABEC standards define tolerances for several major bearing dimensions and characteristics. They are divided into mounting dimensions (bore, O.D. and width) and bearing geometry. General-purpose, spindle size ball bearings are manufactured to precision classes ABEC 1, ABEC 3, ABEC 5, ABEC 7 and ABEC 9. The ascending numbers indicate increasingly stricter tolerances and additional requirements. All Barden angular contact machine tool spindle bearings meet or exceed ABEC 9 geometric standards. Bores and O.D.'s are calibrated for greater mounting flexibility. Barden deep groove spindle bearings meet or exceed ABEC 7.

Instrument bearings are produced in comparable classes, with added refinements designated by suffixes: ABEC 3P, ABEC 5P, ABEC 7P, ABEC 9P, ABEC 5T and ABEC 7T. Barden bearings in this category are made to ABEC 7P or better.

GOING BEYOND ABEC STANDARDS

While ABEC classes are very helpful in categorizing bearing precision, they are not all-inclusive. At Barden, we are concerned about total bearing quality and "fitness for use" in critical applications. We often maintain closer tolerances than specified and we address many factors affecting bearing performance and life that are not covered by ABEC standards.

ABEC criteria, for example, do not include functional testing of assembled bearings, yet this measure can be extremely important. Barden applies self-established standards, using a number of proprietary tests and instruments to ensure that we deliver quiet, smooth-running bearings that will perform exceptionally well.

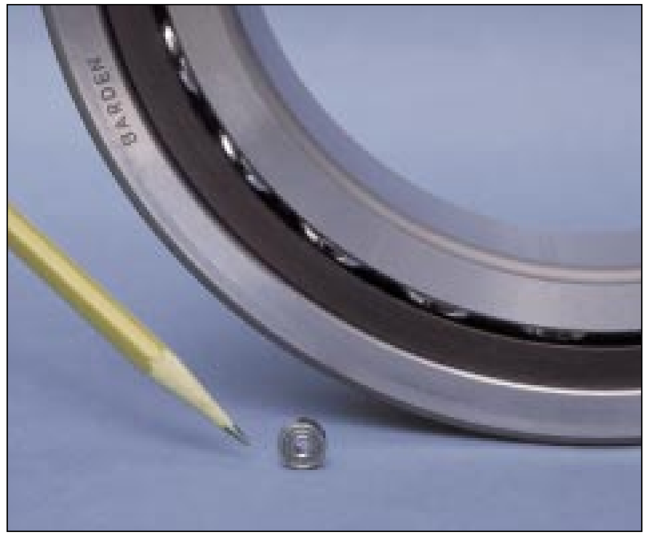
Bearing design is also not included in ABEC standards, but it too can make the difference between success and failure in bearing use. Barden design criteria are based on knowledge of all the factors which are significant for different applications.

Thus, a Barden bearing may have specific low torque characteristics for a gyro gimbal, extra stiffness for a machine tool spindle, or extremely high reliability for a jet engine application.

Because ball quality affects the ability of a bearing to run smoothly, Barden uses both steel and ceramic balls produced to its own exacting specifications for ball geometry, finish and size control.

SIZES

Barden bearings are sized in both inch and metric dimensions. They are categorized as either instrument or spindle types. This distinction is primarily size-related but is sometimes application-related.



Barden precision bearings are manufactured to ABEC 7 and ABEC 9 tolerances and are available in sizes ranging from 3/8" (9.5mm) O.D. to 11½" (300mm) O.D.

CONFIGURATIONS

Barden manufactures deep groove and angular contact (separable and nonseparable) bearings, some of which are available with flanged outer rings.

Flanged bearings are especially useful in through-bored housings. The inboard side of the flange provides an accurate positioning surface for bearing alignment, eliminating a need for housing shoulders or shoulder rings.

Extra wide, or cartridge width, deep groove bearings are available in Series 9000 for installations requiring lengthy operation without relubrication. Series 9000 bearings have more interior free volume and therefore hold more grease.

Innovative products include ZSB-series small ball angular contact machine tool spindle bearings, which feature integral shields – an industry first – and can be equipped with ceramic balls for increased speedability.

Series L and BSB ball screw support bearings consist of angular contact spindle bearings which are specially designed for – and restricted to – specific machine tool applications. Contact angle is unusually high (L=65°, BSB=60°) to provide axial rigidity and the very high thrust capacity needed in ball screw supports, tool frames, etc.

Most Barden bearings are available with a variety of cage and closure options.

APPLICATIONS

Many now-standard bearings featured in this catalog were once considered "special," since they offered users something new in precision, size or configuration. At any given time, Barden has dozens of such new designs and developments being used very successfully in limited quantities. Current examples of Barden bearing applications include:

- Turbo molecular pumps
- Jet engine starters
- Auxiliary aircraft equipment.
- Control moment gyroscopes in satellites
- X-Ray tube anode rotation devices.

Photo courtesy of HAAS Automation, Inc. U.S.A.

Barden spindle bearings used in machines like this multi-axis machining center offer the ultimate in precision, speed and accuracy to help optimize cutting tool performance.

The precision bearings found in CAT scanner X-ray tubes use a special Barden bearing design which must operate in a vacuum under boundary lubrication conditions.

Commercial aviation applications include a wide variety of aircraft accessories and critical components, and comprise a large percentage of Barden's core business.

Photo courtesy of Balzer's High Vacuum Products.

Vacuum pumps place severe demands on spindle bearings which must operate flawlessly under grueling conditions and meet long life requirements.

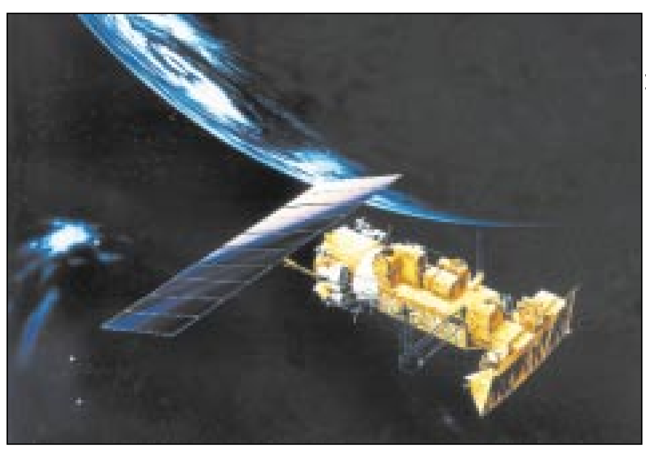


Photo courtesy of NASA.

The Barden super precision bearings used in NASA's TIROS weather satellite must meet stringent performance requirements with minimal lubrication.

QUALITY CONTROL

Barden is ISO 9001 certified. The quality controls systems used at Barden comply fully with MIL-I-45208, Inspection System Requirements; MIL-H-6875, Heat Treat Procedures and ISO 10012-1, Quality Assurance Requirements for Measuring Equipment (formerly MIL-STD-45662). Barden is also certified by The National Aerospace and Defense Contractors Accreditation Program (NADCAP) for our nondestructive testing processes and is an approved supplier for the Federal Aviation Administration. These controls are coupled with a planned flexibility which enables Barden to comply with specific requirements of individual customers through a system of quality levels, inspections levels and certification of our product.

Quality is built into all Barden products. This thinking is applied to every aspect of manufacturing, from raw materials through packaged assembled bearings.

Through the use of Statistical Process Control, the Quality Engineering staff determines and monitors process capabilities to assure that process tolerances can be maintained. In-process machine control is facilitated using pre-control. These statistical methods are employed as production tools to gain better and more consistent quality.

The inspection department is the operating arm of our quality control organization. Each lot of parts or assembled bearings must conform to quality requirements before it is allowed to move to the next operation. Rather than delay inspection until operations have been completed, Barden's operators are certified through rigorous training and auditing to perform inspection operations during the manufacturing process. Our "Certified Supplier" program ensures that our suppliers are top notch, consistently supplying us with acceptable product.

The Metrology Department of Barden's quality control organization provides basic standards of reference, using many advanced types of instrumentation. All linear measurements are certified to The National Institute of Standards and Technology.

Our Metallurgical and Chemical Laboratories are the surveillance unit for all incoming bearing steel, lubricants, cage material and other supplies. These laboratories work closely with other laboratories, universities and manufacturers to develop the highest quality parts, new bearing cleaning equipment, and the most advanced heat treating systems.

Barden's vibration test lab allows engineers to monitor and refine bearing performance in a spindle assembly under "real-world" operating conditions.

PRODUCT ENGINEERING

Barden Product Engineering services are available to all customers and prospective users of Barden precision bearings. Our engineers and technicians have capabilities in every area of bearing design, application, testing and development. When bearing performance involving torque, vibration or stiffness is an issue, they can perform computer analysis of characteristics and requirements in order to determine a suitable bearing design.

If standard cataloged bearings lack the necessary characteristics for a particular application, our Product Engineering Department can design a special bearing to satisfy your need.

With over 50 years of specialization in the field of precision ball bearings, Barden engineers can draw upon a wealth of technical information to aid in failure analysis or troubleshooting of performance problems. They can readily identify the contributing causes and recommend solutions to improve bearing performance or life.

Our Product Development Laboratory conducts special investigations into new materials, coatings, lubricants and bearing designs. This laboratory is the center for Barden work on unusual bearing problems, special environmental testing and vibration analysis. Endurance and reliability testing is also performed here.

If you have a particular problem that you would like Barden's engineers to review, please contact your Barden Sales or Application Engineer, or an Authorized Barden Distributor.

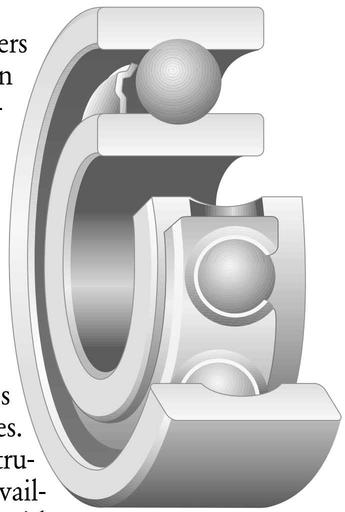
INSTRUMENT BEARINGS

Deep Groove and Angular Contact

ENGINEERING

DEEP GROOVE BEARING DESIGN

Deep groove instrument ball bearings have full shoulders on both sides of the raceways of the inner and outer rings. They can accept radial loads, thrust loads in either direction, or a combination of loads.



The full shoulders and the cages used in deep groove bearings make them suitable for the addition of closures. Besides single deep groove bearings with closures, Barden also offers duplex pairs with seals or shields on the outboard faces.

Deep groove instrument bearings are available in many sizes, with a variety of cage types. Their versatility makes deep groove bearings the most widely used type.

DEEP GROOVE BEARING CAGES

The principal cage designs for Barden deep groove instrument bearings are snap-in-types Q and TA; symmetrical types P, W and T. Type W is a low torque cage developed by Barden, available in many instrument sizes. This two-piece ribbon cage is loosely clinched to prevent cage windup (a torque-increasing drawback of some cage designs) in sensitive low torque applications.

Ribbon cages P and W are used at moderate speeds and are particularly suited for bearings with grease lubrication and seals or shields. For higher speeds, Barden offers the one-piece phenolic snap-in type TA cage in smaller bearing sizes and the two piece riveted phenolic, aluminum-reinforced T cage for larger sizes. The aluminum reinforcement, a Barden first, provides additional strength and permits use of this high-speed cage in most standard width sealed or shielded bearings.

BEARING NOMENCLATURE

BARDEN PRECISION BEARINGS

DEEP GROOVE

Example: SR4SSWX8K5VKC 0-11

CLOSURE

Absence of a symbol indicates an open bearing.

Shielded bearings
S – Single shield.
SS – Double shield.

Sealed Bearings
F – Single Flexeal™
FF – Double Flexeal.

MATERIAL (BALLS & RINGS)

Absence of a symbol indicates SAE 52100 (chrome) bearing steel.

S = AISI 440C stainless steel.

CAGE

Absence of a symbol indicates standard cage, which varies with series and size. For standard cages see Cage Options in the Engineering section, page 81.

W – loosely clinched steel 2-piece ribbon
TA – phenolic 1-piece snap-in
T – phenolic 2-piece riveted
JB – 1-piece bronze

RADIAL PLAY

Numeric code indicates range of radial play. See Radial Play discussion on pages 12 and/or 23.

Note: To avoid confusion, radial play code number is preceded by separating letter "K" when previous section of bearing number ends in a numeral.

FUNCTIONAL TEST

Most Series R inch deep groove bearings and Series 30 metric deep groove bearings are available with low torque characteristics. Variations in torque levels are designated as follows:

V – Guaranteed low maximum torque level.
VK – Very low starting torque.
VM – Very low running torque.
VT – Actual torque trace furnished with each VM level bearing. Consult Barden for specific levels.

LUBRICATION

Type of prelubrication is indicated on package.

O – indicates oil
G – indicates grease

Number code following letter denotes specific type of lubricant. A discussion of lubricants can be found in the Engineering section, page 97.

S	R4		SS	W	X8	K5	VK			C	O-11
	38	H						DB	R2		G-2

SERIES & SIZE

First character always denotes series.

R = inch series
3 = metric series

Remaining character denotes bore size.

TYPE

B – Separable angular contact bearing with cutaway inner ring shoulder.

H– Nonseparable angular contact bearing with cutaway outer ring shoulder.

Absence of a symbol indicates a deep groove bearing.

SPECIAL FEATURES

Letter "X" followed by number(s) indicates special features. Consult Barden Engineering for details.

DUPLEXING AND PRELOADS

D – Universal mounting. Angular contact duplex sets universally ground have inner and outer rings of the same width and can be installed DB, DF or DT.

DB – Back-to-back mounting.
DF – Face-to-face mounting.
DT – Tandem mounting.

CALIBRATION

Bores and O.D.s are divided into .0001" or .000050" increments within the tolerance range.

C – .0001" groups
C44 – .000050" groups

Refer to calibration discussion in the Engineering section, page 133.

RADIAL RUNOUT

A special value of radial runout may be indicated in bearing number by:

E – Special radial runout (tighter than standard tolerances). Consult Barden.

The following codes for high point markings may be used with letter "E" (to indicate high points of radial runout for bearings with special values) or separately (to indicate high points for bearings with standard tolerances).

R – Inner ring marked for high point of radial runout.

R1 – Outer ring marked for high point of radial runout.

R2 – Both inner and outer rings marked for high points of radial runout.

ANGULAR CONTACT

Example: 38HDBR2 G-2

ENGINEERING

RADIAL PLAY

Deep groove bearings are available from Barden in a range of radial play groups. Each group is expressed as a Radial Play Code, representing limits to the range of radial internal clearance. The code number is used in bearing identification as shown in the Nomenclature explanation on overleaf.

The available radial play groups listed in Table 1 give the designer wide latitude in the selection of proper radial internal clearance. Such ranges have nothing to do with ABEC tolerances or precision classes, hence a bearing with a high value of radial play does not necessarily have lower quality or less precision.

Specifying a radial code must take into account the installation practice. If a bearing is press-fitted onto a shaft or into a housing, its radial internal clearance is reduced by approximately 80% of the interference fit. Thus, an interference fit of .00025" would cause a .0002" decrease in internal clearance.

Table 2 is an initial guide for radial play selection. Deep groove bearings with Code 3 and Code 5 radial play are more readily available than those with other codes. When performance requirements exceed the standard radial play codes, consult the Barden Product Engineering Department. Special ranges of internal clearance can be supplied, but should be avoided unless there is a technical justification.

Table 1. Radial play code selection guide for deep groove instrument bearings.

Radial Play Code	Radial Play Values
2	.0001 to .0003
3	.0002 to .0004
4	.0003 to .0005
5	.0005 to .0008
6	.0008 to .0011

All dimensions in inches.

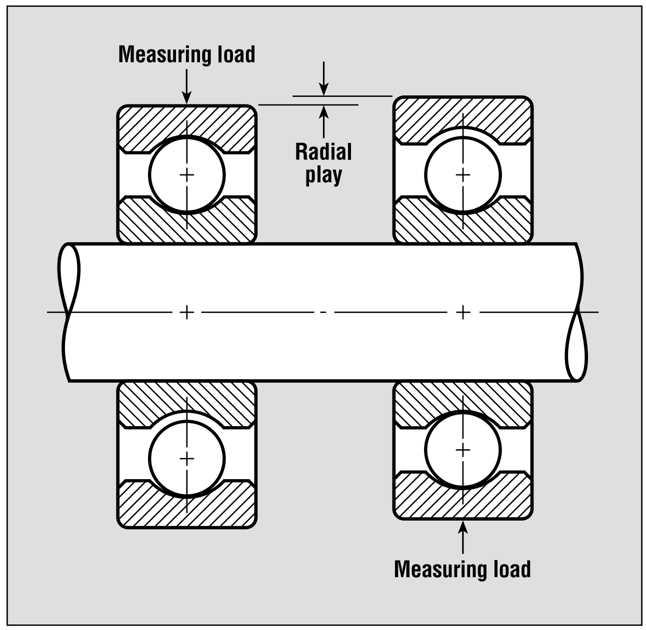


***Fig. 1.** Radial play is a measure of internal clearance and is influenced by measuring load and installation practices. A high radial play value is not an indication of lower quality or less precision.*

Table 2. Radial play code selection guide for deep groove instrument bearings.

Performance Requirements	Loads and Speeds	Recommended Radial Play Code	Limitations
Minimum radial clearance without axial adjustment.	Light loads, low speeds.	3	Lowest axial load capacity. Highest torque under thrust. Not suitable for hot or cold running applications. Must not be interference fitted to either shaft or housing.
Internal clearance not critical; moderate torque under thrust loading.	Moderate loads and speeds.	3	Axial adjustment for very low speed or axial spring loading for moderate speed may be necessary.
Minimum torque under thrust loading; endurance life under wide temperature range.	Moderate to heavy loads, very low to high speeds.	5	Axial adjustment, spring preloading or fixed preloads usually required; light interference fits permissible in some cases.
Specific requirements for axial and radial rigidity; high thrust capacity at extreme speeds and temperatures.	Moderate to heavy loads at high speeds.	Consult Barden.	Complete analysis of all performance and design factors is essential before radial play specification.

AXIAL PLAY

Axial play, also called end play, is the maximum possible movement, parallel to the bearing axis, of the inner ring in relation to the outer ring. It is measured under a light reversing axial load.

End play is a function of radial internal clearance, thus the nominal end play values given in Table 3 are expressed for various radial play codes of deep groove instrument bearings.

End play will increase when a thrust load is imposed, due to axial yield. If this is objectionable, the end play can be reduced by axial shimming or axial preloading.

End play is not a design specification; the Barden Product Engineering Department should be consulted if end play modifications are desired in deep groove instrument bearings.

Table 3. Nominal axial play values of deep groove instrument bearings for various radial play codes.

Basic Bearing Nomenclature	Radial Play Codes				
	2	3	4	5	6
	Axial Play Values				
R2, R2A	.0027	.0033	.0039	.0049	.0059
R3, R4	.0032	.0040	.0046	.0058	.0070
R4A	.0040	.0049	.0056	.0071	.0086
R6	.0042	.0051	.0059	.0075	.0091
R8	.0021	.0025	.0029	.0037	.0044
R10	.0021	.0026	.0030	.0038	.0045
34, 34-5	.0037	.0046	.0053	.0067	.0081
35, 36	.0040	.0049	.0056	.0071	.0086
37, 38	.0042	.0051	.0059	.0075	.0091
39	.0021	.0026	.0030	.0038	.0045

All dimensions in inches.

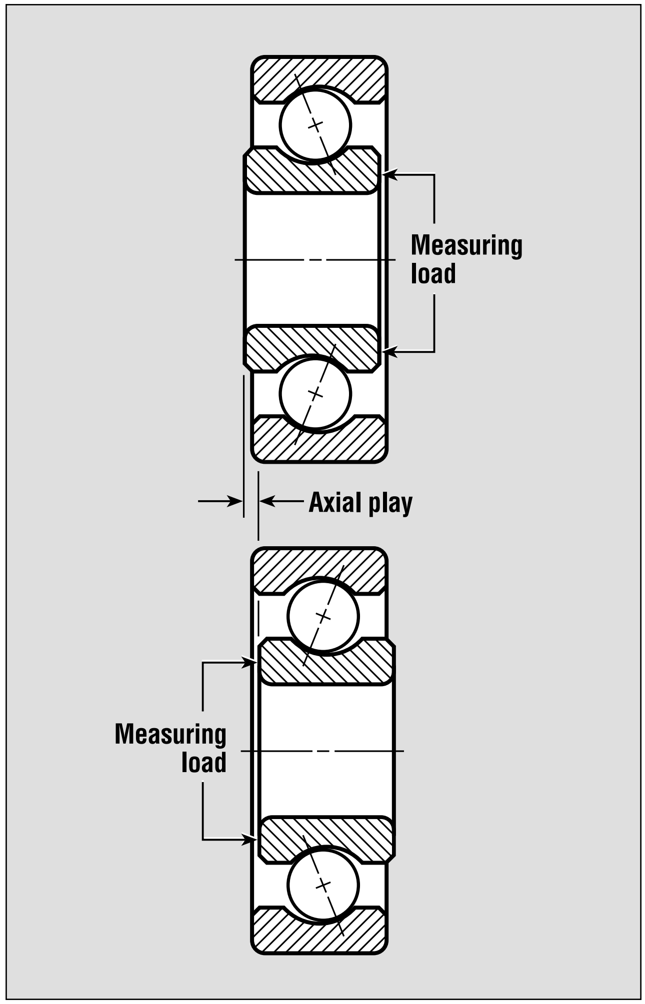


Fig. 2. Axial play, or end play, is defined as the maximum possible movement, parallel to the axis of the bearing, of the inner ring relative to the outer ring. Axial play, if objectionable, can be reduced by shimming or preloading.

ENGINEERING

TOLERANCES

Deep groove instrument bearings are manufactured to ABEC 7P tolerances as defined by ABMA Standard 12.

Table 4. Tolerances for Series R, FR and 30.

INNER RING	ABEC Class 7P
Bore	
Mean diameter [1]	+.0000 – .0002
Minimum diameter [2]	– .0002
Maximum diameter [2]	+.0000
Out of Round — maximum	.0001
Taper — maximum	.0001
Radial runout — maximum	.0001
Bore runout with side — maximum	.0001
Raceway runout with side — maximum	.0001
Width, single bearing — individual ring	+.0000 – .0010
Width, duplex pair — per pair	+.0000 – .0150
Width variation — maximum	.0001
OUTER RING (Outside cylindrical surface)	**ABEC Class 7P**
Open bearings	
Mean diameter [1]	+.0000 – .0002
Minimum diameter [2]	–.0002
Maximum diameter [2]	+.0000
Out of Round — maximum	.0001
Taper — maximum	.0001
Bearings with closures	
Mean diameter [1]	+.0000 – .0002
Minimum diameter [2]	–.00024
Maximum diameter [2]	+.000040
Out of round — maximum	.0002
Taper — maximum	.0002
Radial runout — maximum [3]	.00015
Outside cylindrical surface runout with side — max.	.00015
Raceway runout with side — maximum	.0002
Width, single bearing — individual ring	+.0000 – .0010
Width, duplex pair — per pair	+.0000 – .0150
Width variation — maximum	.0001

All tolerances in inches.

[1] Mean diameter = 1/2 (maximum diameter + minimum diameter).

[2] All diameter measurements are two point measurements.

[3] Radial runout of R10 outer ring is .0002".

PRODUCT SERIES DESCRIPTIONS

BARDEN PRECISION BEARINGS

SERIES R, FR AND 30

- Deep Groove
- Open, Shielded and Sealed
- Series R and FR Inch Instrument Series
- Series 30 Metric Instrument Series

Series R deep groove bearings have full shoulders on both sides of the raceways of the inner and outer rings. They can accept radial loads, thrust loads in either direction, or combinations of loads. They are manufactured to inch dimensions.

Series FR deep groove bearings have full shoulders on both sides of the raceways of the inner and outer rings. The outer rings of Series FR bearings are flanged to provide accurate positioning surfaces. These bearings are easily installed in through-bored holes, eliminating the need for housing shoulders or shoulder rings. They are manufactured to inch dimensions. They can accept radial loads, thrust loads in either direction, or combinations of loads.

Series 30 deep groove bearings have full shoulders on both sides of the raceways of the inner and outer rings. They can accept radial loads, thrust loads in either direction, or combinations of loads. They are manufactured to metric dimensions.

Bearing Data: Bearing data applicable to these bearings is shown in the following tables. Lubrication and mounting data can be found in the engineering section.

Cages: Series R and FR standard cage is a one-piece steel snap-in type (no symbol) up through R3. A two-piece ribbon cage is used for R4 and up. For other available cages, see following product tables or consult Barden. Series 30 standard cage is a two-piece steel ribbon type (no symbol). Some sizes are also available with a one-piece phenolic snap-in type (symbol TA) or a two-piece riveted phenolic, aluminum-reinforced type (symbol T); see Cages discussion on page 82. For other cage options, consult Barden.

Closures: In bearing nomenclature, symbol SS denotes double shield; FF denotes double seal (Flexeal). To specify single shield or seal, omit one S or F in bearing number.

Attainable Speeds: Limits given are for lightly loaded single bearings. See Engineering section, page 88, for qualifications. For flanged bearings, limiting speeds are the same as the equivalent size of unflanged bearings.

Materials: Series R and FR standard material is AISI 440C stainless steel; some sizes are available in SAE 52100 bearing steel. Series 30 standard material is SAE 52100 bearing steel. Most sizes are also available in AISI 440C stainless steel.

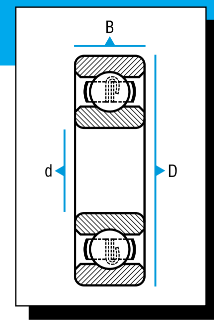
Duplexing: Most bearings on these pages are available in matched pairs for duplex DB or DF mounting. See details in the Engineering section.

Lubricant: Desired lubrication should be specified when ordering, based on torque, speed and temperature conditions of the application. See details in the Engineering section.

INSTRUMENT BEARINGS (DEEP GROOVE)

BORE DIAMETERS: 3mm TO 7mm

- Open, Shielded and Sealed
- Inch and Metric Series



SHAFT	Bore Diameter d		Outside Diameter D		Width B		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear		BASIC BEARING NOMENCLATURE* CONFIGURATION		
inch/mm	mm	inch	mm	inch	mm	inch	mm	inch	Open	Shielded (SS)	Flexeal (FF)
.1250in	3.175	.1250	9.525	.3750	3.967	.1562	.30	.012	SR2**	SR2SS**	SR2FF**
			9.525	.3750	3.967	.1562	.30	.012		SR2SSTA**	
			12.700	.5000	4.366	.1719	.30	.012	SR2A	SR2ASS	
4mm	4	.1575	16	.6299	5	.1969	.30	.012	34	34SS	
			16	.6299	5	.1969	.30	.012		34STA***	
.1875in	4.762	.1875	12.700	.5000	3.967	.1562	.30	.012	SR3		
			12.700	.5000	4.978	.1960	.30	.012		SR3SS**	SR3FF**
			12.700	.5000	4.978	.1960	.30	.012		SR3SSTA**	SR3FFTA**
			19.050	.7500	4.978	.1960	.30	.012		SR3SSX8	
			22.225	.8750	4.978	.1960	.30	.012		SR3SSTAX23	
5mm	5	.1969	16	.6299	5	.1969	.30	.012	34-5	34-5SS	
			19	.7480	6	.2362	.30	.012		35SS	
6mm	6	.2362	19	.7480	6	.2362	.30	.012	36	36SS	
			19	.7480	6	.2362	.30	.012	36TA		
			19	.7480	6	.2362	.30	.012	36T		
.2500in	6.350	.2500	15.875	.6250	4.978	.1960	.30	.012	SR4**	SR4SS**	SR4FF**
			15.875	.6250	4.978	.1960	.30	.012	SR4T		
			15.875	.6250	4.978	.1960	.30	.012		SR4SSTA**	
			19.050	.7500	5.558	.2188	.40	.016	SR4A		
			19.050	.7500	7.142	.2812	.40	.016		SR4ASS	SR4AFF
			19.050	.7500	7.142	.2812	.40	.016		SR4ASSTA	SR4AFFTA
7mm	7	.2756	22	.8661	7	.2756	.30	.012	37	37SS	
			22	.8661	10.31	.4060	.30	.012		37SSTAX2	
			22	.8661	10.31	.4060	.30	.012		37SSTX2	37FFTX2

*Certain sizes listed in these tables may not be in current production. Check for availability. **Flanged configurations also available. See page 20 for details.
***Available with single shield only.

BARDEN PRECISION BEARINGS

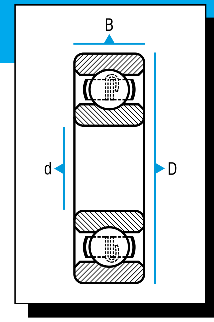
BASIC BEARING NOMENCLATURE*			CAGE OPTIONS				ATTAINABLE SPEEDS (RPM)		Ball Complement		Static Capacity		Basic Dynamic Load Rating
CONFIGURATION													
Open	Shielded (SS)	Flexeal (FF)	Ribbon Cage	Snap In Cage	T Cage	TMT Cage	Oil	Grease	No. n	Diam. d	Radial C_0 (lbs.)	Thrust T_0 (lbs.)	C (lbs.)
SR2**	SR2SS**	SR2FF**	X	X†			50,000	50,000	7	1/16"	10	23	86
	SR2SSTA**					X	120,000	120,000	7	1/16"	10	23	86
SR2A	SR2ASS		X	X†			50,000	50,000	7	1/16"	10	23	86
34	34SS		X†	X			34,000	34,000	6	1/8"	38	64	258
	34STA***					X	82,000	82,000	6	1/8"	38	64	258
SR3			X	X†			38,000	38,000	7	3/32"	27	49	179
	SR3SS**	SR3FF**	X	X†			38,000	38,000	7	3/32"	27	49	179
	SR3SSTA**	SR3FFTA**				X	91,000	91,000	7	3/32"	27	49	179
	SR3SSX8		X	X†			38,000	38,000	7	3/32"	27	49	179
	SR3SSTAX23					X	91,000	91,000	7	3/32"	27	49	179
34-5	34-5SS		X				34,000	34,000	6	1/8"	38	64	258
	35SS		X				27,000	27,000	6	9/64"	53	84	332
36	36SS		X				27,000	27,000	6	9/64"	53	84	332
36TA						X	65,000	65,000	6	9/64"	53	84	332
36T					X		108,000	70,000	6	9/64"	53	84	332
SR4**	SR4SS**	SR4FF**	X				28,000	28,000	8	3/32"	35	63	202
SR4T					X		114,000	74,000	8	3/32"	35	63	202
	SR4SSTA**					X	67,000	67,000	8	3/32"	35	63	202
SR4A			X				27,000	27,000	6	9/64"	53	84	332
	SR4ASS	SR4AFF	X				27,000	27,000	6	9/64"	53	84	332
	SR4ASSTA	SR4AFFTA				X	65,000	65,000	6	9/64"	53	84	332
37	37SS		X				22,000	22,000	7	5/32"	83	123	454
	37SSTAX2					X	53,000	53,000	7	5/32"	215	81	767
	37SSTX2	37FFTX2			X		88,000	57,000	7	5/32"	215	81	767

*Certain sizes listed in these tables may not be in current production. Check for availability. **Flanged configurations also available. See page 20 for details. **Continued on page 18**
***Available with single shield only. †Standard cage.

INSTRUMENT BEARINGS (DEEP GROOVE)

BORE DIAMETERS: 8mm TO 15mm

- Open, Shielded and Sealed
- Inch and Metric Series



SHAFT	Bore Diameter d		Outside Diameter D		Width B		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear		BASIC BEARING NOMENCLATURE* CONFIGURATION		
inch/mm	mm	inch	mm	inch	mm	inch	mm	inch	Open	Shielded (SS)	Flexeal (FF)
8mm	8	.3150	22	.8661	7	.2756	.30	.012	38	38SS	38FF
			22	.8661	7	.2756	.30	.012		38STA***	
			22	.8661	10.31	.4060	.30	.012		38SSTAX2	38FFTAX2
			22	.8661	10.31	.4060	.30	.012	38TX2	38SSTX2	38FFTX2
			24	.9449	10.31	.4060	.30	.012		38SSTX6	38FFTX6
9mm	9	.3543	26	1.0236	8	.3150	.40	.016	39	39SS	
			26	1.0236	8	.3150	.40	.016	39T		
.3750in	9.525	.3750	22.225	.8750	5.558	.2188	.40	.016	SR6		
			22.225	.8750	7.142	.2812	.40	.016		SR6SS**	SR6FF**
			22.225	.8750	7.142	.2812	.40	.016		SR6SSTA**	SR6FFTA**
.5000in	12.700	.5000	28.575	1.1250	6.350	.2500	.40	.016	SR8		
			28.575	1.1250	7.938	.3125	.40	.016		SR8SS	SR8FF
			28.575	1.1250	7.938	.3125	.40	.016		SR8SSTA	SR8FFTA
.6250in	15.875	.6250	34.925	1.3750	7.142	.2812	.79	.031	SR10		
			34.925	1.3750	7.142	.2812	.79	.031	SR10T		
			34.925	1.3750	8.733	.3438	.79	.031		SR10SS	SR10FF

*Certain sizes listed in these tables may not be in current production. Check for availability. **Flanged configurations also available. See page 20 for details.
***Available with single shield only.

BARDEN
PRECISION
BEARINGS

BASIC BEARING NOMENCLATURE*			CAGE OPTIONS				ATTAINABLE SPEEDS (RPM)		Ball Complement		Static Capacity		Basic Dynamic Load Rating
CONFIGURATION													
Open	Shielded (SS)	Flexeal (FF)	Ribbon Cage	Snap In Cage	T Cage	TMT Cage	Oil	Grease	No. n	Diam. d	Radial C_0 (lbs.)	Thrust T_0 (lbs.)	C (lbs.)
38	38SS	38FF	X				22,000	22,000	7	5/32"	83	123	454
	38STA***					X	53,000	53,000	7	5/32"	83	123	454
	38SSTAX2	38FFTAX2				X	53,000	53,000	7	5/32"	215	81	767
38TX2	38SSTX2	38FFTX2			X		88,000	57,000	7	5/32"	215	81	767
	38SSTX6	38FFTX6			X		88,000	57,000	7	5/32"	215	81	767
39	39SS		X				18,000	18,000	7	3/16"	495	311	1104
39T					X		72,000	47,000	7	3/16"	495	311	1104
SR6			X				20,000	20,000	7	5/32"	83	123	454
	SR6SS**	SR6FF**	X				20,000	20,000	7	5/32"	83	123	454
	SR6SSTA**	SR6FFTA**				X	48,000	48,000	7	5/32"	83	123	454
SR8			X				14,000	14,000	10	5/32"	347	230	994
	SR8SS	SR8FF	X				14,000	14,000	10	5/32"	347	230	994
	SR8SSTA	SR8FFTA				X	34,000	34,000	10	5/32"	347	230	994
SR10			X				12,000	12,000	10	3/16"	533	431	1455
SR10T					X		48,000	32,000	10	3/16"	533	431	1455
	SR10SS	SR10FF	X				12,000	12,000	10	3/16"	533	431	1455

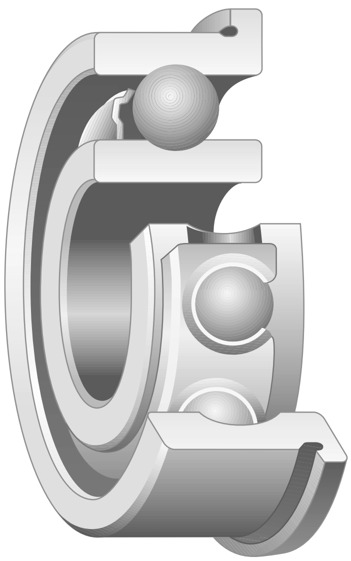
*Certain sizes listed in these tables may not be in current production. Check for availability. **Flanged configurations also available. See page 20 for details.
***Available with single shield only.

FLANGED BEARINGS

- Open, Shielded and Sealed
- Inch Series

FLANGED BEARINGS

Flanged bearings provide solid mounting for good axial control and eliminate a need for housing shoulders or shoulder rings. Housings can be through-bored to reduce manufacturing costs and simplify assembly. When flanged bearings are used, the housing mounting surfaces must be accurately machined to properly position and support the bearings.



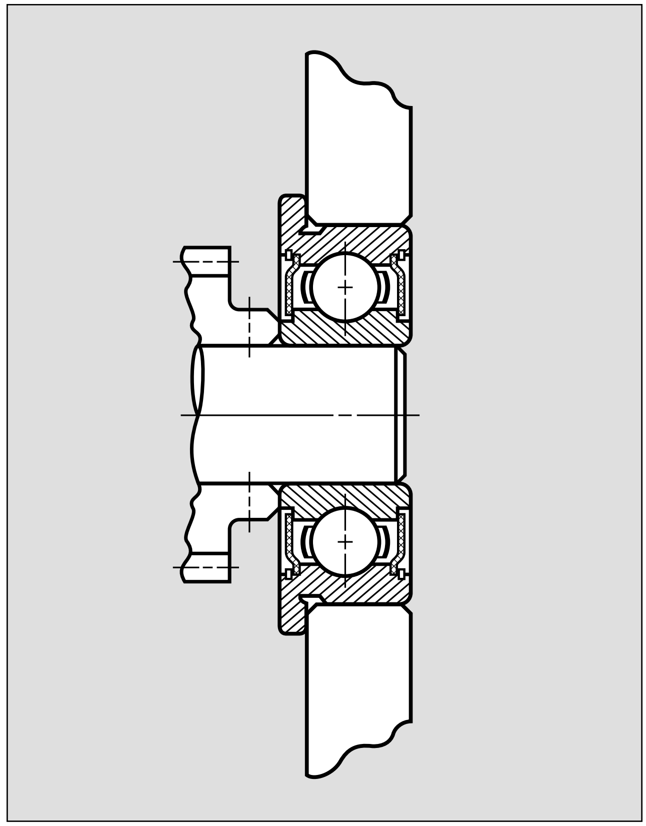


Fig. 3. Flanged bearings are recommended when housing designs cannot accommodate full bearing width or where the quality of housing bore is a concern.

Table 5. Flange dimensions.

Basic Bearing Nomenclature	Flange Diameter (A) mm	Flange Diameter (A) inches	Flange Width (C) mm	Flange Width (C) inches
SFR2	11.18	.440	.76	.030
SFR3	14.35	.565	1.07	.042
SFR4	17.53	.690	1.07	.042
SFR6	24.61	.969	1.57	.062

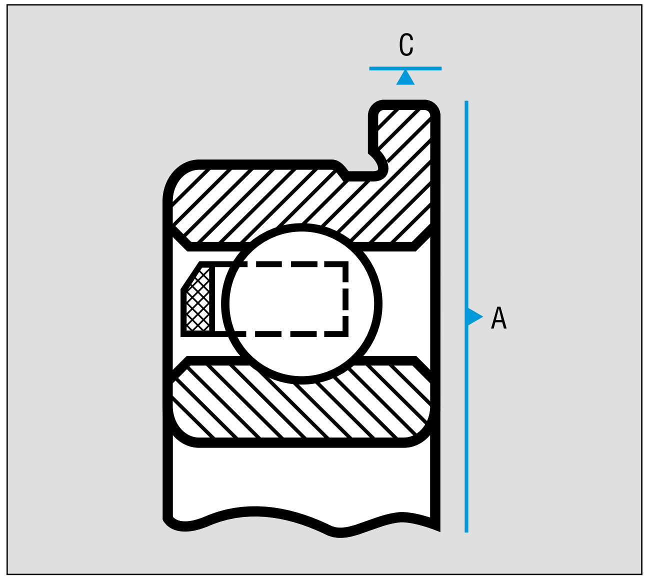
Bore, width and O.D. dimensions are the same as standard bearings.
Most of the above basic sizes are also available with shields (SS) or seals (FF).

Table 6. Flanged outer ring tolerances.

FLANGED OUTER RING	
Diameter, flange	+.0000 – .0010
Raceway runout with inside flange face — maximum	.0003
Width — flange	+.0000 – .0020
Width variation, flange — maximum	.0001

For technical data, see pages 16 and 18 for the same bearing without the flange.
Single closure is on flanged side, unless otherwise noted.
All tolerances shown in inches.

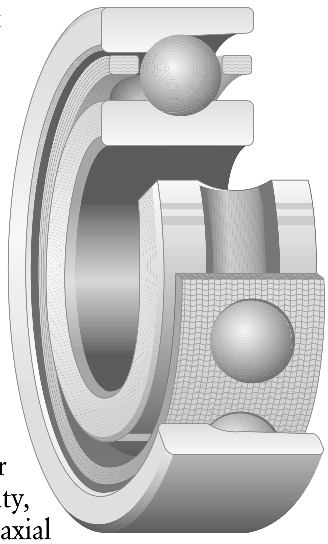
Fig. 4. Width and diameter of bearing flanges.



ANGULAR CONTACT BEARING DESIGN

Angular contact instrument bearings have one ring shoulder partially or totally removed. This allows a larger ball complement than found in comparable deep groove bearings, hence a greater load capacity. Speed capability is also greater.

Barden angular contact instrument bearings have nominal contact angles ranging from 10° to 15°. They can be used in preloaded duplex sets, either back-to-back (DB) or face-to-face (DF) so they can support thrust loads in both directions.



Contact angles are obtained by assembling the bearing to appropriate radial play values. The smaller angle delivers better radial capacity and rigidity, the larger angle is better for axial rigidity.

Angular contact bearings support thrust loads or combinations of radial and thrust loading. They cannot accept radial loads only – a thrust load of sufficient magnitude must be present. An individual angular contact bearing can be thrust-loaded in only one direction; this load may be a working load or a preload.

Separable and nonseparable types are available within the category of angular contact bearings. In a separable bearing (B type), the cage holds the balls in place so that the outer ring assembly (with cage and balls) can be separated from the inner ring.

Separable bearings are useful where bearings must be installed in blind holes or where press fits are required, both on the shaft and in the housing. The separable feature also permits dynamic balancing of a rotating component with inner ring in place, apart from the outer ring and housing.

ANGULAR CONTACT BEARING CAGES

In Barden angular contact bearings, (types B and H), machined phenolic cages with high-speed capability are standard. These cages are outer ring land guided, which allows lubricant access to the most desired point – the inner ring/ball contact area. Centrifugal force carries lubricant outward during operation to reach the other areas of need.

Consult Barden Engineering for questions regarding additional cage application considerations, or refer to Cages discussion in the Engineering section, page 84.

CONTACT ANGLE

Contact angle refers to the nominal angle between the ball-to-race contact line and a plane through the ball centers, perpendicular to the bearing axis. It may be expressed in terms of zero load or applied thrust load.

The unloaded (zero load) contact angle is established after axial takeup of the bearing but before imposition of the working thrust load. The loaded contact angle is greater, reflecting the influence of the applied thrust load.

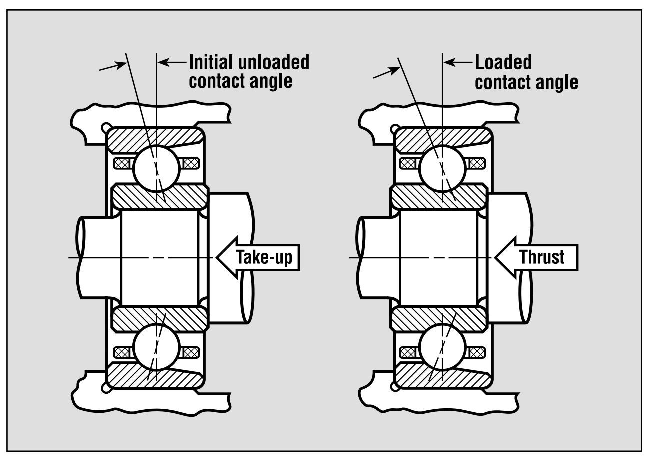


Fig. 5. Contact angle refers to the nominal angle between the ball-to-race contact line and a plane through the ball centers, perpendicular to the bearing axis.

RADIAL PLAY

Angular contact bearings make use of radial play, combined with thrust loading, to develop their primary characteristic – an angular line of contact between the balls and both races.

Barden instrument angular contact bearings are available in a selection of radial play codes – see Table 7.

Table 7. Available radial play codes for angular contact instrument bearings.

Basic Bearing Nomenclature	Radial Play Codes			
	Standard No Code	4	5	6
SR2B	.0003 – .0011	—	—	—
SR2H	.0003 – .0005	—	—	—
SR3B, SR4B	.0005 – .0014	—	—	—
SR3H, SR4H, SR4HX8	.0003 – .0006	—	.0005 – .0008	—
34BX4, 34 – 5B, 36BX1	.0006 – .0016	—	—	—
34 – 5H	.0005 – .0008	.0003 – .0005	.0005 – .0008	.0008 – .0011
36H, 38H, 39H	.0005 – .0008	—	.0005 – .0008	.0008 – .0011
38BX2	.0007 – .0017	—	—	—

All dimensions in inches.

TOLERANCES

Barden angular contact instrument bearings are manufactured to ABEC 7P geometric tolerances as defined by ABMA Standard 12. Sizes 38 and 39 are manufactured to ABEC 9 geometric tolerances as defined by ABMA Standard 20.

Table 8. Tolerances for Series R and 30 (34–36).

INNER RING	ABEC Class 7P
Bore	
Mean diameter [1]	+.0000 – .0002
Minimum diameter [2]	– .0002
Maximum diameter [2]	+.0000
Out of Round — maximum	.0001
Taper — maximum	.0001
Radial runout — maximum	.0001
Bore runout with side — maximum	.0001
Raceway runout with side — maximum	.0001
Width, single bearing — individual ring	+.0000 – .0010
Width, duplex pair — per pair	+.0000 – .0150
Width variation — maximum	.0001
OUTER RING (Outside cylindrical surface)	**ABEC Class 7P**
Mean diameter [1]	+.0000 – .0002
Minimum diameter [2]	–.0002
Maximum diameter [2]	+.0000
Out of Round — maximum	.0001
Taper — maximum	.0001
Radial runout — maximum	.00015
Outside cylindrical surface runout with side — max.	.00015
Raceway runout with side — maximum	.0002
Width, single bearing — individual ring	+.0000 – .0010
Width, duplex pair — per pair	+.0000 – .0150
Width variation — maximum	.0001

All dimensions in inches.

[1] Mean diameter = 1/2 (maximum diameter + minimum diameter).

[2] All diameter measurements are two point measurements.

Table 9. Tolerances for Series 30 (38–39).

INNER RING	
Bore	
Mean diameter [1]	+.0000 – .00015
Minimum diameter [2]	– .00015
Maximum diameter [2]	+.0000
Out of Round — maximum	.0001
Taper — maximum	.0001
Radial runout — maximum	.00005
Side runout with bore — maximum	.00005
Raceway runout with side — maximum	.00005
Width, single bearing — individual ring	+.0000 – .0016
Width, duplex pair — per pair	+.0000 – .0100
Width variation — maximum	.00005
OUTER RING (Outside cylindrical surface)	
Mean diameter [1]	+.0000 – .0002
Minimum diameter [2]	–.0002
Maximum diameter [2]	+.0000
Out of Round — maximum	.00015
Taper — maximum	.0001
Radial runout — maximum	.0001
Outside cylindrical surface runout with side — max.	.00005
Raceway runout with side — maximum	.0001
Width, single bearing — individual ring	+.0000 – .0016
Width, duplex pair — per pair	+.0000 – .0100
Width variation — maximum	.00005

All dimensions in inches.

[1] Mean diameter = 1/2 (maximum diameter + minimum diameter).

[2] All diameter measurements are two point measurements.

SERIES R AND 30

Series R and 30 angular contact bearings have one ring shoulder partially or totally removed. They can support thrust loads in one direction or combinations of radial and thrust loads, but not radial loading alone. Load and speed capacities are higher than for deep groove bearings. Bearings cataloged here include both separable and nonseparable types.

Separable Type: Outer ring has full shoulders, inner ring has one shoulder cut away. Inner ring is removable for mounting on shaft separately from outer ring assembly.

Nonseparable Type: Inner ring has full shoulders, outer ring has one shoulder cut away.

Bearing Data: Bearing data applicable to these bearings is shown in the following tables. Lubrication and mounting data can be found in the Engineering section.

Cages: Standard cage is a one-piece phenolic type (no symbol) with circular ball pockets. In separable bearings, ball pockets are designed to hold balls in place when inner ring is removed. For other available cages, refer to Cages discussion in Engineering section, page 84.

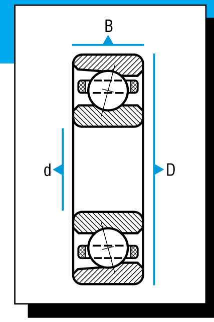
Attainable Speeds: Limits given are for lightly loaded single bearings. See Engineering section, page 88, for qualifications.

Materials: Series R standard material is AISI 440C stainless steel; some sizes are available in SAE 52100 bearing steel – consult Barden. Series 30 standard material is SAE 52100 bearing steel; some sizes are available in AISI 440C stainless steel.

Duplexing: Some bearings are available in matched pairs – consult Barden.

Lubricant: Desired lubrication should be specified when ordering, based on torque, speed and temperature conditions of the application. See details in the Engineering section.

INSTRUMENT BEARINGS (ANGULAR CONTACT)



BORE DIAMETERS: 3mm TO 9mm

- Standard
- Separable and Nonseparable
- Inch and Metric Series

SHAFT	Bore Diameter d		Outside Diameter D		Width B		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear (cutaway side)		Reference Contact Angle	BASIC BEARING NOMENCLATURE*
inch/mm	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch		
.1250in	3.175	.1250	9.525	.3750	3.967	.1562	.30	.012	.15	.006	15°	R2B
			9.525	.3750	3.967	.1562	.30	.012	.15	.006	15°	SR2H
4mm	4	.1575	16	.6299	5	.1969	.30	.012	.13	.005	15°	34BX4
.1875in	4.762	.1875	12.700	.5000	3.967	.1562	.30	.012	.13	.005	15°	R3B
			12.700	.5000	3.967	.1562	.30	.012	.13	.005	10°	SR3H
5mm	5	.1969	16	.6299	5	·1969	.30	.012	.13	.005	15°	34-5B
			16	.6299	5	·1969	.30	.012	.25	.010	15°	34-5H
6mm	6	.2362	19	.7480	6	.2362	.30	.012	.13	.005	10°	36BX1
			19	.7480	6	.2362	.30	.012	.25	.010	15°	36H
			19	.7480	6	.2362	.30	.012	.25	.010	15°	36HJB
.2500in	6.350	.2500	15.875	.6250	4.978	.1960	.30	.012	.25	.010	15°	R4B
			15.875	.6250	4.978	.1960	.30	.012	.25	.010	10°	SR4H
			15.875	.6250	4.978	.1960	.30	.012	.15	.006	15°	SR4HX8
8mm	8	.3150	22	.8661	7	.2756	.30	.012	.13	.005	15°	38BX2
			22	.8661	7	.2756	.30	.012	.25	.010	15°	38H
			22	.8661	7	.2756	.30	.012	.25	.010	15°	38HJB
9mm	9	.3543	26	1.0236	8	.3150	.30	.012	.25	.010	15°	39H

*Certain sizes listed in these tables may not be in current production. Check for availability.

BARDEN PRECISION BEARINGS

BASIC BEARING NOMENCLATURE*	ATTAINABLE SPEEDS (RPM)		Ball Complement		Static Capacity		Basic Dynamic Load Rating C (lbs.)	STANDARD PRELOADS (lbs.)
	Oil	Grease	No. n	Diam. d	Radial C_0 (lbs.)	Thrust T_0 (lbs.)		
R2B	202,000	162,000	7	1/16"	15	24	84	2
SR2H	202,000	162,000	8	1/16"	25	30	117	2
34BX4	136,000	88,000	6	1/8"	33	41	209	—
R3B	152,000	122,000	7	3/32"	34	54	176	2
SR3H	152,000	122,000	8	3/32"	34	52	198	2
34-5B	136,000	88,000	6	1/8"	47	72	256	6
34-5H	136,000	88,000	8	1/8"	107	116	424	6
36BX1	108,000	70,000	6	9/64"	44	53	270	—
36H	108,000	70,000	8	9/64"	145	173	545	6
36HJB	162,000	—	8	9/64"	145	173	545	—
R4B	116,000	93,000	8	3/32"	43	69	202	2
SR4H	116,000	93,000	9	3/32"	49	65	220	2
SR4HX8	130,000	100,000	8	9/64"	206	407	676	6
38BX2	88,000	57,000	7	5/32"	97	140	448	—
38H	88,000	57,000	9	5/32"	206	304	724	12
38HJB	132,000	—	9	5/32"	206	304	724	—
39H	72,000	47,000	9	3/16"	434	607	1006	15

*Certain sizes listed in these tables may not be in current production. Check for availability.

SPINDLE BEARINGS

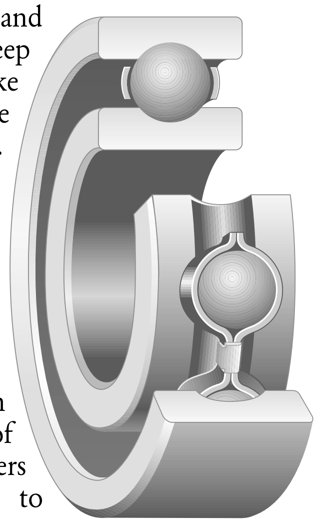
Deep Groove

ENGINEERING

DESIGN

Deep groove ball bearings have full shoulders on both sides of the raceways of the inner and outer rings. They can accept radial loads, thrust loads in either direction, or a combination of loads.

The full shoulders and the cages used in deep groove bearings make them suitable for the addition of closures. Besides single deep groove bearings with closures, Barden also offers duplex pairs with seals or shields on the outboard faces.



Deep groove bearings are available in many combinations of sizes – bore diameters range from 10mm to 160mm – and cage types.

Ceramic (silicon nitride) balls can be specified to increase bearing stiffness, reduce vibration levels and prolong bearing life.

CAGES

The principal cage designs for Barden deep-groove bearings are side entrance snap-in types (TAT, TMT) and symmetrical types (Ribbon, T, TST). Ribbon and TMT types are used at moderate speeds and are particularly suited for bearings with grease lubrication and seals or shields.

For higher speeds, Barden offers the two-piece riveted phenolic, aluminum-reinforced T cage. The aluminum reinforcement, a Barden first, provides additional strength, allowing this high-speed cage to be used in most standard width sealed or shielded bearings.

BEARING NOMENCLATURE

BARDEN PRECISION BEARINGS

DEEP GROOVE SPINDLE

Example: 204FTMT5VAR2C G-6

[ ] [204] [F] [TMT] [ ] [5] [VA] [ ] [R2] [C] [G-6]

MATERIAL (BALLS & RINGS)

Absence of a symbol indicates SAE 52100 (chrome) bearing steel.

S = AISI 440C stainless steel.
M = M50 tool steel.
C = Ceramic balls.

CAGE

Absence of a symbol indicates standard cage. For additional standard cages see Cage Options in the Engineering section, page 81.

T – 2-piece phenolic, aluminum reinforced.
TMT – Snap-in nylon.

SPECIAL FEATURES

Letter "X" followed by number(s) indicates special features. Because of frequent usage, certain features have permanently assigned X numbers. They include:

X200 – Oil-tight seal between outer-ring recess and shield.
X204 – Customer part number marked on bearing.
X216 – Shields and snap wires are shipped disassembled.

Consult Barden Engineering for details.

FUNCTIONAL TEST

Deep groove bearings are available with special low vibration limits. These are designated as follows:

VA – Special Barden anderometer functional test.
VB – Special Navy anderometer functional test per MIL-B-17931.

LUBRICATION

Type of prelubrication is indicated on package.

O – indicates oil
G – indicates grease

Number code following letter denotes specific type of lubricant. A discussion of lubricants can be found in the Engineering section, page 97.

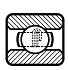
SERIES AND SIZE

First character always denotes series. Last two digits denote bore size.

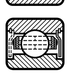
SERIES
1900 – Ultra light
100 – Extra light
200 – Light
9200 – Light, extra width
300 – Medium
9300 – Med., extra width

BORE SIZE
00 – 10mm
01 – 12mm
02 – 15mm
03 – 17mm
04 – 20mm
04 and up – Multiply last two digits by five to get bore in mm.

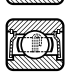
CLOSURE



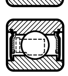
Absence of a symbol indicates an open bearing.



Shielded bearings
S – Single shield.
SS – Double shield.



Sealed Bearings
F – Single Flexeal.™
FF – Double Flexeal.



Y – Single Barseal.™
YY – Double Barseal.

RADIAL PLAY

Numeric code indicates range of radial play. See Radial Play discussion on page 32.

Note: To avoid confusion, radial play code number is preceded by separating letter "K" when previous section of bearing number ends in a numeral.

DUPLEXING AND PRELOADS

DB – Back-to-back mounting.
DF – Face-to-face mounting.
DT – Tandem mounting.

Standard preloads for Series 100, 200 and 300 are indicated by:

L – Light
M – Medium
H – Heavy

CALIBRATION

Bores and O.D.s are divided into .0001" or .000050" increments within the tolerance range.

C – .0001" groups
C44 – .000050" groups

Refer to calibration discussion in the Engineering section, page 133.

RADIAL RUNOUT

A special value of radial runout may be indicated in bearing number by:

E – Special radial runout (tighter than standard tolerances). Consult Barden.

The following codes for high point markings may be used with letter "E" (to indicate high points of radial runout for bearings with special values) or separately (to indicate high points for bearings with standard tolerances).

R – Inner ring marked for high point of radial runout.
R1 – Outer ring marked for high point of radial runout.
R2 – Both inner and outer rings marked for high points of radial runout.

ENGINEERING, *CONTINUED*

RADIAL PLAY

Deep groove bearings are available from Barden in a range of radial play groups. Each group is expressed as a Radial Play Code, representing limits to the range of radial internal clearance. The code number is used in bearing identification as shown in the Nomenclature explanation on overleaf.

The available radial play groups listed in Table 11 give the designer wide latitude in the selection of proper radial internal clearance. Such ranges have nothing to do with ABEC tolerances or precision classes, hence a bearing with a high value of radial play does not necessarily have lower quality or less precision.

Specifying a radial code must take into account the installation practice.

Fig. 6. Radial play is the amount of internal clearance between ball and raceway.

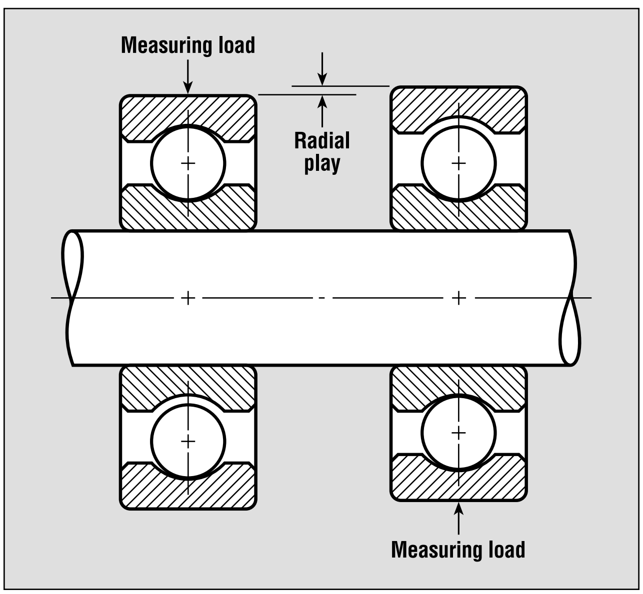


Table 10 is an initial guide for radial play selection. Deep groove bearings with Code 5 radial play are more readily available than those with other codes. When performance requirements exceed the standard radial play codes, consult Barden Engineering. Special ranges of internal clearance can be supplied, but should be avoided unless there is a technical justification.

Table 11. Radial play ranges of Barden deep groove bearings for various radial play codes.

Basic Bearing Nomenclature	Radial Play Codes		
	3	5	6
100 – 103	.0002 – .0004	.0005 – .0008	.0008 – .0011
104 – 107	.0002 – .0005	.0005 – .0009	.0009 – .0014
108	.0002 – .0005	.0007 – .0012	.0012 – .0017
109 – 110	.0004 – .0008	.0008 – .0013	.0013 – .0019
111	.0005 – .0010	.0010 – .0016	.0016 – .0023
200 – 205	.0002 – .0005	.0005 – .0009	.0009 – .0014
206 – 209	.0002 – .0005	.0007 – .0012	.0012 – .0017
210	.0004 – .0008	.0008 – .0013	.0013 – .0019
211 – 213	.0005 – .0010	.0010 – .0016	.0016 – .0023
214 – 216	.0005 – .0011	.0011 – .0019	.0019 – .0027
217 – 220	.0006 – .0013	.0013 – .0022	.0022 – .0032
221 – 224	.0007 – .0015	.0015 – .0025	.0025 – .0037
226 – 228	.0008 – .0018	.0018 – .0030	.0030 – .0043
230 – 232	.0008 – .0020	.0020 – .0034	.0034 – .0049
300 – 303	.0002 – .0004	.0005 – .0008	.0008 – .0011
304	.0003 – .0007	.0006 – .0010	.0009 – .0014
305 – 306	.0003 – .0007	.0006 – .0010	.0010 – .0015
307 – 308	.0003 – .0007	.0007 – .0012	.0012 – .0017
309 – 310	.0004 – .0008	.0008 – .0013	.0013 – .0019
311 – 313	.0005 – .0010	.0010 – .0016	.0016 – .0023
314 – 316	.0005 – .0011	.0011 – .0019	.0019 – .0027
317 – 320	.0006 – .0013	.0013 – .0022	.0022 – .0032
322 – 324	.0007 – .0015	.0015 – .0025	.0025 – .0037

All dimensions in inches.

Table 10. Radial play code selection guide for deep groove spindle bearings.

Performance Requirements	Loads and Speeds	Recommended Radial Play Code	Limitations
Axial and radial rigidity, minimum runout.	Light loads, high speeds.	Consult Barden.	Complete analysis of all performance and design factors is essential before radial play specification.
Axial and radial rigidity, low runout.	Heavy loads, low to moderate speeds.	5	Axial adjustment, spring preloading or fixed preloading is usually required; interference fits required on rotating rings.
Minimum torque, maximum life under wide temperature range.	Moderate.	5 or 6	May require spring preloading; usually interference fitted on rotating ring.

BARDEN PRECISION BEARINGS

AXIAL PLAY

Axial play, also called end play, is the maximum possible movement parallel to the bearing axis of the inner ring in relation to the outer ring. It is measured under a light reversing axial load.

End play is a function of radial internal clearance and raceway curvature, thus the end play values given in Table 12 are expressed for various radial play codes of deep groove bearings.

End play will increase when a thrust load is imposed, due to axial yield. If this is objectionable, the end play can be reduced by axial shimming or axial preloading.

End play is not a design specification; Barden Product Engineering should be consulted if end play modifications are desired in deep groove bearings.

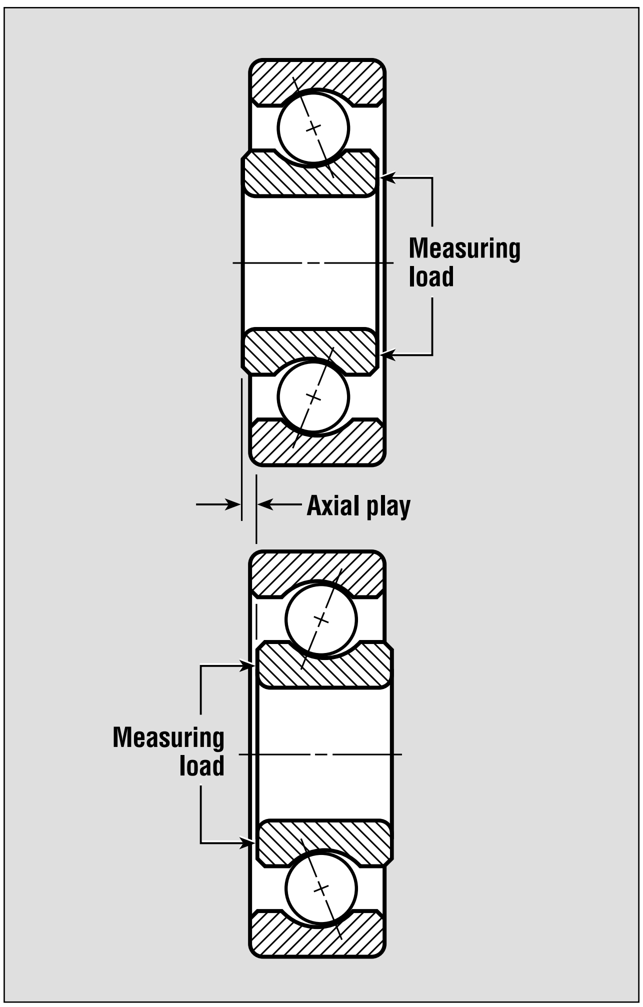


Fig. 7. Axial play, or end play, is defined as the maximum possible movement, parallel to the axis of the bearing, of the inner ring relative to the outer ring.

Table 12. Nominal axial play for the following radial play codes.

Basic Bearing Nomenclature	Radial Play Codes		
	3	5	6
100	.0026	.0038	.0045
100X1	.0040	.0058	.0070
101, 101X1	.0032	.0046	.0056
102	.0030	.0044	.0053
103	.0026	.0038	.0045
104	.0044	.0062	.0079
105	.0037	.0052	.0067
106	.0046	.0065	.0084
107	.0051	.0072	.0092
108	.0042	.0068	.0084
109, 110	.0060	.0079	.0097
111	.0072	.0095	.0115
200	.0035	.0049	.0062
201, 201X1	.0036	.0051	.0065
202, 202X1	.0037	.0052	.0067
203	.0038	.0054	.0069
204, 9204, 205, 9205	.0042	.0059	.0075
206, 9206	.0046	.0075	.0092
207, 9207	.0049	.0081	.0100
208, 9208, 209, 9209	.0051	.0084	.0103
210	.0069	.0091	.0112
211	.0082	.0107	.0131
213	.0091	.0119	.0145
222	.0140	.0189	.0234
232	.0175	.0242	.0299
303	.0041	.0059	.0072
305	.0059	.0074	.0093
306	.0061	.0077	.0096
307	.0071	.0097	.0120
308	.0071	.0097	.0120
309	.0081	.0107	.0132
310	.0085	.0112	.0138
311	.0099	.0129	.0158
312	.0102	.0134	.0164
313	.0106	.0139	.0170
316	.0116	.0159	.0196
317	.0130	.0177	.0219
318	.0134	.0182	.0225
322	.0152	.0204	.0253

All dimensions in inches.

ENGINEERING, *CONTINUED*

TOLERANCES

Deep groove bearings are manufactured to ABEC 7 tolerances as defined by ABMA Standards 4 and 20 and ISO Standard 15.

Table 13. Inner ring tolerances for Series 1900, 100, 200, 300, 9200 and 9300.

Bearing Bore Over mm	Bearing Bore Including mm	Average Bore Diameter (+.0000 to…)	Raceway Radial Runout	Face Runout with Bore (Squareness)	Raceway Axial Runout	Single Bearing Width Tolerance (+.000 to…)	Single Width Tolerance for Duplex (Preloaded) Bearing (+.000 to…)	Width Variation (Parallelism)
10*	18	–.00015	.0001	.0001	.0001	–.0032**	–.010	.0001
18	30	–.0002	.0001	.00015	.00015	–.005	–.010	.0001
30	50	–.00025	.00015	.00015	.00015	–.005	–.010	.0001
50	80	–.0003	.00015	.0002	.0002	–.006	–.010	.00015
80	120	–.0003	.0002	.0002	.0002	–.008	–.015	.00015
120	150	–.0004	.00025	.00025	.0003	–.010	–.015	.0002
150	180	–.0004	.00025	.00025	.0003	–.010	–.015	.0002

All tolerances in inches.

*This diameter is included in this group.

**Single bearing width of 10mm bore bearings is –.0016.

Table 14. Outer ring tolerances for Series 1900, 100, 200, 300, 9200 and 9300.

Bearing O.D. Over mm	Bearing O.D. Including mm	Average Outside Diameter (+.0000 to…)	Raceway Radial Runout	Outside Diameter Runout With Face (Squareness)	Raceway Axial Runout	Width	Width Variation (Parallelism)
18	30	–.0002	.00015	.00015	.0002	*	.0001
30	50	–.00025	.0002	.00015	.0002	*	.0001
50	80	–.0003	.0002	.00015	.0002	*	.0001
80	120	–.0003	.00025	.0002	.00025	*	.00015
120	150	–.00035	.0003	.0002	.0003	*	.0002
150	180	–.0004	.0003	.0002	.0003	*	.0002
180	250	–.00045	.0004	.0003	.0004	*	.0003
250	315	–.0005	.00045	.0003	.0004	*	.0003

All tolerances in inches.

*Identical to width tolerance of inner ring of same bearing.

BARDEN PRECISION BEARINGS

SERIES 100, 200, 300 AND 9000

Metric Extra Light, Light and Medium Series

Series 100, 200 and 300 deep groove bearings have full shoulders on both sides of the raceways of the inner and outer rings and are available in matched pairs for duplex mounting.

Series 9200 and 9300 deep groove bearings are cartridge width (extra wide) bearings with full shoulders on both sides of the raceways of the inner and outer rings. Extra width Series 9200 and 9300 bearings have more free volume in the bearing interior than Series 200 or 300, allowing a greater grease capacity for longer life. Series 9000 bearings are suitable for installations requiring lengthy operation without relubrication.

Bearing Data: Bearing data applicable to these bearings is shown in the following tables. Lubrication and mounting data can be found in the engineering section.

Cages: Standard cage is a two-piece steel ribbon type (no symbol). Most sizes are also available with a two-piece riveted phenolic, aluminum-reinforced type (symbol T). Some sizes are available with a one-piece filled nylon snap-in type (symbol TMT). For other cage options, see Engineering section, page 82.

Closures: Most are available in shielded and sealed versions. In bearing numbers that follow, symbol SS denotes double shield; FF denotes double seal (Flexeal). To specify single shield or seal, omit one S or F in bearing number.

Attainable Speeds: Limits given are for lightly loaded single bearings.

Material: Standard material is SAE 52100 steel.

Lubricant: Desired lubrication should be specified when ordering, based on torque, speed and temperature conditions of the application. See details in the Engineering section, page 97.

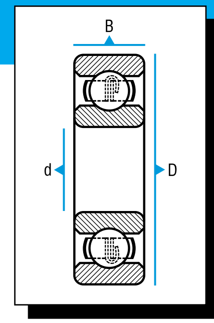
Loads: Can accept radial loads, thrust loads in either direction, or combinations of loads.

Duplexing: Deep groove bearings are available in matched pairs for duplex DB, DF or DT mounting. Consult Barden Engineering for details.

SPINDLE BEARINGS (DEEP GROOVE)

BORE DIAMETERS: 10mm TO 17mm

• Open, Shielded and Sealed



SHAFT	Bore Diameter d		Outside Diameter D		Width B		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear		BASIC BEARING NOMENCLATURE* CONFIGURATION			
mm	mm	inch	mm	inch	mm	inch	mm	inch	Open	Shielded (SS)	Flexeal (FF)	Bar Seal (YY, VV, PP)
10mm	10	.3937	26	1.0236	8	.3150	.30	.012	100	100SS	100FF	
			26	1.0236	11.51	.4531	.30	.012		100SSTX1	100FFTX1	
			30	1.1811	9	.3543	.64	.025	200	200SS	200FF	
			30	1.1811	9	.3543	.64	.025	200T			
12mm	12	.4724	28	1.1024	8	.3150	.30	.012	101T			
			28	1.1024	11.51	.4531	.30	.012		101SSTMTX1	101FFTMTX1	
			28	1.1024	11.51	.4531	.30	.012		101SSTX1	101FFTX1	
			32	1.2598	10	.3937	.64	.025	201	201SS	201FF	
			32	1.2598	10	.3937	.64	.025	201T			
13mm	13	.5118	32	1.2598	12.70	.5000	.64	.025		201SSTX1	201FFTX1	
15mm	15	.5906	32	1.2598	9	.3543	.30	.012	102T			
			32	1.2598	9	.3543	.30	.012		102SSTMT	102FFTMT	
			35	1.3780	11	.4331	.64	.025	202	202SS	202FF	
			35	1.3780	11	.4331	.64	.025		202SSTMT	202FFTMT	
			35	1.3780	11	.4331	.64	.025	202T	202SST	202FFT	
			35	1.3780	11	.4331	.64	.025				202YY
			35	1.3780	12.70	.5000	.64	.025		202SSX1	202FFX1	
			35	1.3780	12.70	.5000	.64	.025		202SSTX1	202FFTX1	
17mm	17	.6693	35	1.3780	10	.3937	.30	.012	103	103SS	103FF	
			35	1.3780	10	.3937	.30	.012	103T	103SST	103FFT	
			40	1.5748	12	.4724	.64	.025	203	203SS	203FF	
			40	1.5748	12	.4724	.64	.025		203SSTMT	203FFTMT	
			40	1.5748	12	.4724	.64	.025	203T	203SST	203FFT	
			40	1.5748	12	.4724	.64	.025				203YY

*Certain sizes listed in these tables may not be in current production. Check for availability.

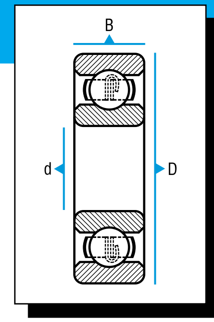
BARDEN PRECISION BEARINGS

BASIC BEARING NOMENCLATURE*				CAGE OPTIONS			ATTAINABLE SPEEDS (RPM)				Ball Complement		Static Capacity		Basic Dynamic Load Rating
CONFIGURATION							Oil Lubricated — Open			Grease Lubricated					
Open	Shielded (SS)	Flexeal (FF)	Bar Seal (YY, VV, PP)	Ribbon Cage	T Cage	TMT Cage	Ribbon Cage	T Cage	TMT Cage		No. n	Diam. d	Radial C_0 (lbs.)	Thrust T_0 (lbs.)	C (lbs.)
100	100SS	100FF		X			26,500			26,500	7	3/16"	627	340	1,001
	100SSTX1	100FFTX1			X			106,000		69,000	7	3/16"	384	472	1,018
200	200SS	200FF		X			25,000			25,000	7	7/32"	694	521	1,326
200T					X			100,000		65,000	7	7/32"	694	521	1,326
101T					X			89,000		58,000	8	3/16"	485	515	1,125
	101SSTMTX1	101FFTMTX1				X			26,500	26,500	8	3/16"	759	403	1,111
	101SSTX1	101FFTX1				X		89,000		58,000	8	3/16"	759	403	1,111
201	201SS	201FF		X			20,500			20,500	7	15/64"	806	566	1,511
201T					X			83,000		54,000	7	15/64"	806	566	1,511
	201SSTX1	201FFTX1			X			83,000		54,000	7	15/64"	806	566	1,511
102T					X			71,000		46,000	9	3/16"	740	658	1,222
	102SSTMT	102FFTMT				X			21,000	21,000	9	3/16"	740	658	1,222
202	202SS	202FF		X			16,800			16,800	7	1/4"	937	703	1,713
	202SSTMT	202FFTMT				X			20,000	20,000	7	1/4"	937	703	1,713
202T	202SST	202FFT			X			67,000		43,500	7	1/4"	937	703	1,713
			202YY	X†		X				12,000	7	1/4"	937	703	1,713
	202SSX1	202FFX1		X			16,800			16,800	7	1/4"	937	703	1,713
	202SSTX1	202FFTX1			X			67,000		43,500	7	1/4"	937	703	1,713
103	103SS	103FF		X			15,400			15,400	10	3/16"	1,026	476	1,291
103T	103SST	103FFT			X			62,000		40,500	10	3/16"	1,026	476	1,291
203	203SS	203FF		X			14,800			14,800	8	17/64"	1,258	1,090	2,112
	203SSTMT	203FFTMT				X			17,600	17,600	8	17/64"	1,258	1,090	2,112
203T	203SST	203FFT			X			59,000		38,000	8	17/64"	1,258	1,090	2,112
			203YY	X†	X	X				10,600	8	17/64"	1,258	1,090	2,112

*Certain sizes listed in these tables may not be in current production. Check for availability.
†Standard cage.

Continued on page 38

SPINDLE BEARINGS (DEEP GROOVE)



BORE DIAMETERS: 20mm TO 30mm

• Open, Shielded and Sealed

SHAFT	Bore Diameter d		Outside Diameter D		Width B		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear		BASIC BEARING NOMENCLATURE* CONFIGURATION			
mm	mm	inch	mm	inch	mm	inch	mm	inch	Open	Shielded (SS)	Flexeal (FF)	Bar Seal (YY, VV, PP)
20mm	20	.7874	42	1.6535	12	.4724	.64	.025	104T	104SST	104FFT	
			47	1.8504	14	.5512	1	.040	204	204SS	204FF	
			47	1.8504	14	.5512	1	.040		204SSTMT	204FFTMT	
			47	1.8504	14	.5512	1	.040	204T	204SST	204FFT	
			47	1.8504	14	.5512	1	.040				204YY
			47	1.8504	20.64	.8125	1	.040		9204SS	9204FF	
			47	1.8504	20.64	.8125	1	.040		9204SST	9204FFT	
			47	1.8504	20.64	.8125	1	.040		9204SSTMT	9204FFTMT	
25mm	25	.9843	47	1.8504	12	.4724	.64	.025	105T	105SST	105FFT	
			52	2.0472	15	.5906	1	.040	205	205SS	205FF	
			52	2.0472	15	.5906	1	.040		205SSTMT	205FFTMT	
			52	2.0472	15	.5906	1	.040	205T	205SST	205FFT	
			52	2.0472	15	.5906	1	.040				205YY
			52	2.0472	20.64	.8125	1	.040		9205SS	9205FF	
			52	2.0472	20.64	.8125	1	.040		9205SST	9205FFT	
			52	2.0472	20.64	.8125	1	.040		9205SSTMT	9205FFTMT	
			62	2.4409	17	.6693	1	.040	305TAT	305SSTAT	305FFTAT	
30mm	30	1.1811	55	2.1654	13	.5118	1	.040	106T	106SST	106FFT	
			62	2.4409	16	.6299	1	.040	206	206SS	206FF	
			62	2.4409	16	.6299	1	.040		206SSTMT	206FFTMT	
			62	2.4409	16	.6299	1	.040	206T	206SST	206FFT	
			62	2.4409	16	.6299	1	.040				206YY
			62	2.4409	23.81	.9375	1	.040		9206SS	9206FF	
			62	2.4409	23.81	.9375	1	.040		9206SST	9206FFT	
			62	2.4409	23.81	.9375	1	.040		9206SSTMT	9206FFTMT	
			72	2.8346	19	.7480	1	.040	306TAT	306SSTAT		

*Certain sizes listed in these tables may not be in current production. Check for availability.

BARDEN
PRECISION
BEARINGS

BASIC BEARING NOMENCLATURE*				CAGE OPTIONS			ATTAINABLE SPEEDS (RPM)				Ball Complement		Static Capacity		Basic Dynamic Load Rating
CONFIGURATION							Oil Lubricated — Open			Grease Lubricated					
Open	Shielded (SS)	Flexeal (FF)	Bar Seal (YY, VV, PP)	Ribbon Cage	T Cage	TMT Cage	Ribbon Cage	T Cage	TMT Cage		No. n	Diam. d	Radial C_0 (lbs.)	Thrust T_0 (lbs.)	C (lbs.)
104T	104SST	104FFT			X			53,000		34,500	9	1/4"	1,456	943	2,076
204	204SS	204FF		X			12,500			12,500	8	5/16"	1,747	1,512	2,840
	204SSTMT	204FFTMT				X			15,000	15,000	8	5/16"	1,747	1,512	2,840
204T	204SST	204FFT			X			50,000		32,500	8	5/16"	1,747	1,512	2,840
			204YY	X†	X	X				9,000	8	5/16"	1,747	1,512	2,840
	9204SS	9204FF		X			12,500			12,500	8	5/16"	1,747	1,512	2,840
	9204SST	9204FFT			X			50,000		32,500	8	5/16"	1,747	1,512	2,840
	9204SSTMT	9204FFTMT				X			15,000	15,000	8	5/16"	1,747	1,512	2,840
105T	105SST	105FFT			X			42,500		27,500	10	1/4"	1,522	2,069	2,203
205	205SS	205FF		X			10,000			10,000	9	5/16"	2,046	1,742	3,097
	205SSTMT	205FFTMT				X			12,000	12,000	9	5/16"	2,046	1,742	3,097
205T	205SST	205FFT			X			40,000		26,000	9	5/16"	2,046	1,742	3,097
			205YY	X†	X	X				7,200	9	5/16"	2,046	1,742	3,097
	9205SS	9205FF		X			10,000			10,000	9	5/16"	2,046	1,742	3,097
	9205SST	9205FFT			X			40,000		26,000	9	5/16"	2,046	1,742	3,097
	9205SSTMT	9205FFTMT				X			12,000	12,000	9	5/16"	2,046	1,742	3,097
305TAT	305SSTAT	305FFTAT		Available with TAT cage only.					12,800††	12,800††	7	7/16"	2,862	4,177	4,720
106T	106SST	106FFT			X			35,500		23,000	11	9/32"	2,151	1,804	2,918
206	206SS	206FF		X			8,400			8,400	9	3/8"	2,943	2,508	4,288
	206SSTMT	206FFTMT				X			10,000	10,000	9	3/8"	2,943	2,508	4,288
206T	206SST	206FFT			X			33,500		21,500	9	3/8"	2,943	2,508	4,288
		206YY		X†	X	X				6,000	9	3/8"	2,943	2,508	4,288
	9206SS	9206FF		X			8,400			8,400	9	3/8"	2,943	2,508	4,288
	9206SST	9206FFT			X			33,500		21,500	9	3/8"	2,943	2,508	4,288
	9206SSTMT	9206FFTMT				X			10,000	10,000	9	3/8"	2,943	2,508	4,288
306TAT	306SSTAT			Available with TAT cage only.					10,700††	10,700††	8	15/32"	3,941	5,566	5,875

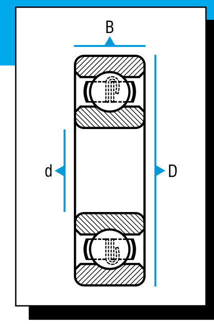
*Certain sizes listed in these tables may not be in current production. Check for availability.
†Standard cage. ††TAT cage.

Continued on page 40

SPINDLE BEARINGS (DEEP GROOVE)

BORE DIAMETERS: 35mm TO 45mm

• Open, Shielded and Sealed



SHAFT	Bore Diameter d		Outside Diameter D		Width B		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear		BASIC BEARING NOMENCLATURE* CONFIGURATION			
mm	mm	inch	mm	inch	mm	inch	mm	inch	Open	Shielded (SS)	Flexeal (FF)	Bar Seal (YY, VV, PP)
35mm	35	1.3780	62	2.4409	14	.5512	1	.040	107T	107SST	107FFT	
			72	2.8346	17	.6693	1	.040	207	207SS	207FF	
			72	2.8346	17	.6693	1	.040		207SSTMT	207FFTMT	
			72	2.8346	17	.6693	1	.040	207T	207SST	207FFT	
			72	2.8346	17	.6693	1	.040				207YY
			72	2.8346	26.99	1.0625	1	.040			9207FFT	
			72	2.8346	26.99	1.0625	1	.040			9207FFTMT	
			80	3.1496	21	.8268	1.5	.060	307TMT			
			80	3.1496	34.92	1.3750	1.5	.060			9307FFTMT	
40mm	40	1.5748	68	2.6772	15	.5906	1	.040		108SST		
			80	3.1496	18	.7087	1	.040	208T			
			80	3.1496	18	.7087	1	.040		208SSTMT	208FFTMT	
			80	3.1496	18	.7087	1	.040				208YYTMT
			80	3.1496	30.16	1.1875	1	.040		9208SST		
			90	3.5433	23	.9055	1.5	.060	308TMT			
			90	3.5433	36.51	1.4375	1.5	.060		9308SSTMT		
45mm	45	1.7717	75	2.9578	16	.6299	1	.040			109FFTMT	
			85	3.3465	19	.7480	1	.040	209T			
			85	3.3465	19	.7480	1	.040			209FFTMT	
			85	3.3465	30.16	1.1875	1	.040		9209SST		
			85	3.3465	30.16	1.1875	1	.040		9209SSTMT		
			100	3.9370	25	.9843	1.5	.060	309TMT			

*Certain sizes listed in these tables may not be in current production. Check for availability.

BARDEN
PRECISION
BEARINGS

BASIC BEARING NOMENCLATURE*				CAGE OPTIONS			ATTAINABLE SPEEDS (RPM)				Ball Complement		Static Capacity		Basic Dynamic Load Rating C (lbs.)
CONFIGURATION							Oil Lubricated — Open			Grease Lubricated					
Open	Shielded (SS)	Flexeal (FF)	Bar Seal (YY, VV, PP)	Ribbon Cage	T Cage	TMT Cage	Ribbon Cage	T Cage	TMT Cage		No. n	Diam. d	Radial C_0 (lbs.)	Thrust T_0 (lbs.)	
107T	107SST	107FFT			X			30,500		19,800	11	5/16"	2,629	3,420	3,534
207	207SS	207FF		X			7,100			7,100	9	7/16"	4,004	4,628	5,678
	207SSTMT	207FFTMT				X			8,500	8,500	9	7/16"	4,004	4,628	5,678
207T	207SST	207FFT			X			28,500		18,600	9	7/16"	4,004	4,628	5,678
			207YY	X†	X	X				5,100	9	7/16"	4,004	4,628	5,678
		9207FFT			X			28,500		18,600	9	7/16"	4,004	4,628	5,678
		9207FTMT				X			8,500	8,500	9	7/16"	4,004	4,628	5,678
307TMT						X			6,900	6,900	7	9/16"	4,792	6,961	7,458
		9307FFTMT				X			6,900	6,900	7	9/16"	4,792	6,961	7,458
	108SST				X			27,000		17,500	12	5/16"	3,015	2,858	3,676
208T					X			25,000		16,200	9	15/32"	4,659	6,041	6,439
	208SSTMT	208FFTMT				X			7,500	7,500	9	15/32"	4,659	6,041	6,439
			208YYTMT			X				4,500	9	15/32"	4,659	6,041	6,439
	9208SST				X			25,000		16,200	9	15/32"	4,659	6,041	6,439
308TMT						X			6,000	6,000	8	5/8"	6,912	9,866	9,911
	9308SSTMT					X			6,000	6,000	8	5/8"	6,912	9,866	9,911
		109FFTMT				X			7,000	7,000	11	3/8"	3,894	5,220	4,828
209T					X			23,000		14,800	10	15/32"	5,300	5,223	6,893
		209FFTMT				X			6,700	6,700	10	15/32"	5,300	5,223	6,893
	9209SST				X			23,000		14,800	10	15/32"	5,300	5,223	6,893
		9209SSTMT				X			6,700	6,700	10	15/32"	5,300	5,223	6,893
	309TMT					X			5,300	5,300	8	11/16"	8,367	11,895	11,665

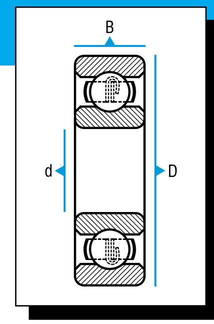
*Certain sizes listed in these tables may not be in current production. Check for availability.
†Standard cage.

Continued on page 42

SPINDLE BEARINGS (DEEP GROOVE)

BORE DIAMETERS: 50mm TO 160mm

• Open, Shielded and Sealed



SHAFT mm	Bore Diameter d mm	Bore Diameter d inch	Outside Diameter D mm	Outside Diameter D inch	Width B mm	Width B inch	Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear mm	Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear inch	BASIC BEARING NOMENCLATURE* CONFIGURATION Open	Shielded (SS)	Flexeal (FF)	Bar Seal (YY, VV, PP)
50mm	50	1.9685	80	3.1496	16	.6299	1	.040	110T	110SST		
			90	3.5433	20	.7874	1	.040	210T			
			110	4.3307	27	1.0630	2	.080	310TMT			
			110	4.3307	44.45	1.7500	2	.080			9310FFTMT	
55mm	55	2.1654	90	3.5433	18	.7087	1	.040	111T	111SST		
			100	3.9370	21	.8268	1.5	.060	211TMT			
			120	4.7244	29	1.1417	2.0	.080	311TMT			
60mm	60	2.3622	130	5.1181	31	1.2205	2.0	.080	312TMT			
65mm	65	2.5591	140	5.5118	33	1.2992	2.0	.080	313TMT			
80mm	80	3.1496	170	6.6929	39	1.5354	2.0	.080	316TMT			
85mm	85	3.3465	180	7.0866	29	1.6142	2.5	.100	317TMT			
90mm	90	3.5433	190	7.4803	43	1.6929	2.5	.100	318TMT			
110mm	110	4.3307	200	7.8740	38	1.4961	2.0	.080	222TMT			
			240	9.4488	50	1.9685	3.0	.120	322TMT			
160mm	160	6.2992	290	11.4173	48	1.8898	3.0	.120	232TMT			

*Certain sizes listed in these tables may not be in current production. Check for availability.

BARDEN PRECISION BEARINGS

BASIC BEARING NOMENCLATURE*				CAGE OPTIONS			ATTAINABLE SPEEDS (RPM)				Ball Complement		Static Capacity		Basic Dynamic Load Rating
CONFIGURATION							Oil Lubricated — Open			Grease Lubricated					
Open	Shielded (SS)	Flexeal (FF)	Bar Seal (YY, VV, PP)	Ribbon Cage	T Cage	TMT Cage	Ribbon Cage	T Cage	TMT Cage		No. n	Diam. d	Radial C_0 (lbs.)	Thrust T_0 (lbs.)	C (lbs.)
110T	110SST				X			22,500		14,600	13	3/8"	4,699	4,642	5,351
210T					X			20,000		13,000	10	1/2"	6,042	5,974	7,733
310TMT						X			4,800	4,800	8	3/4"	10,006	14,225	13,661
		9310FFTMT				X			4,800	4,800	8	3/4"	10,006	14,225	13,661
111T	111SST				X			20,000		13,200	12	7/16"	5,826	6,387	6,719
211TMT						X			5,500	5,500	10	9/16"	7,602	10,463	9,014
311TMT						X			4,400	4,400	8	13/16"	11,794	16,950	15,796
312TMT						X			4,000	4,000	8	7/8"	13,721	19,407	18,064
313TMT						X			3,700	3,700	8	15/16"	15,798	22,376	20,679
316TMT						X			3,000	3,000	8	1 1/16"	20,885	29,145	26,083
317TMT						X			2,800	2,800	8	1 1/8"	23,425	32,630	28,880
318TMT						X			2,700	2,700	8	1 3/16"	26,110	36,375	31,481
222TMT						X			2,700	2,700	10	1 1/8"	24,088	64,445	33,120
322TMT						X			2,200	2,200	8	1 1/2"	41,505	58,642	48,188
232TMT						X			1,500	1,500	11	1 3/8"	52,653	70,435	49,990

*Certain sizes listed in these tables may not be in current production. Check for availability.

SPINDLE BEARINGS

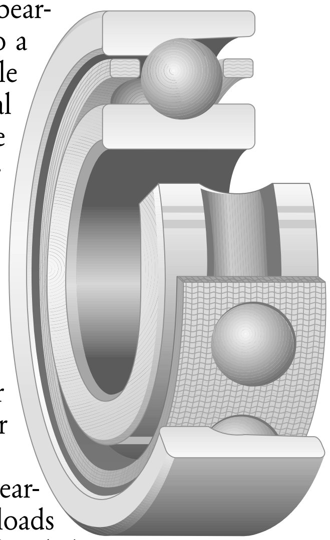
Angular Contact

ENGINEERING

DESIGN

Angular contact bearings have one ring shoulder partially or totally removed. This allows a larger ball complement than found in comparable deep groove bearings, hence a greater load capacity. Speed capability is also greater.

Angular contact bearings are assembled to a constant contact angle by varying the radial clearance. Spindle size Barden angular contact bearings have nominal contact angles of either 15° or 25°. The smaller angle delivers better radial capacity and rigidity, the larger angle is better for axial rigidity.



Angular contact bearings support thrust loads or combinations of radial and thrust loading. They cannot accept radial loads only – a thrust load of sufficient magnitude must be present. An individual angular contact bearing can be thrust-loaded in only one direction; this load may be a working load or a preload.

Separable and nonseparable types are available within the category of angular contact bearings. In a separable bearing (B type), the cage holds the balls in place so that the outer ring assembly (with cage and balls) can be separated from the inner ring.

Separable bearings are useful where bearings must be installed in blind holes or where press fits are required, both on the shaft and in the housing. The separable feature also permits dynamic balancing of a rotating component with inner ring mounted in place, apart from the outer ring and housing.

CAGES

In Barden angular contact bearings, (types B and H), machined phenolic cages with high-speed capability are standard. These cages are outer ring land guided, which allows lubricant access to the most desired point-the inner ring/ball contact area. Centrifugal force carries lubricant outward during operation to reach the other areas of need.

The H-type phenolic cage has a grooved inner surface to hold extra lubricant. From the grooves, lubricant can migrate to critical bearing contact surfaces. In separable bearings, the B-type cage has ball pockets which hold the balls in place when the inner ring is removed.

See Cages discussion in Engineering section, page 81 or consult Barden Engineering for questions regarding additional cage application considerations.

CONTACT ANGLE

Contact angle refers to the nominal angle between the ball-to-race contact line and a plane through the ball centers, perpendicular to the bearing axis. It may be expressed in terms of zero load or applied thrust load.

Barden angular contact bearings have a nominal contact angle of either 15° or 25°. They are most commonly used in preloaded duplex sets, either back-to-back (DB) or face-to-face (DF) so they can support thrust loads in both directions.

The unloaded contact angle is established after axial takeup of the bearing but before imposition of the working thrust load. The loaded contact angle is greater, reflecting the influence of the applied thrust load.

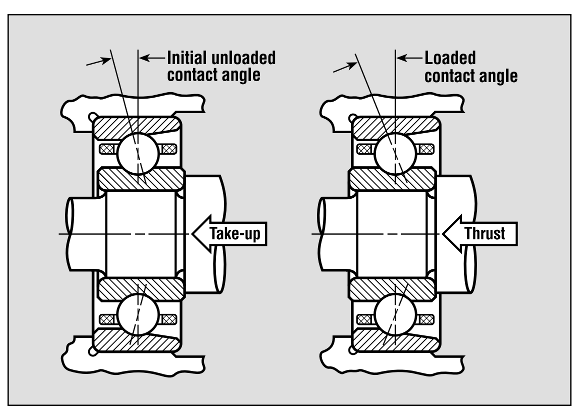


Fig. 8. Contact angle refers to the nominal angle between the ball-to-race contact line and a plane through the ball centers, perpendicular to the bearing axis.

BEARING NOMENCLATURE

BARDEN PRECISION BEARINGS

ANGULAR CONTACT SPINDLE

Example: C206HVADM G-46

C	206	H			VA	DM		G-46

MATERIAL (BALLS & RINGS)

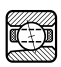
Absence of a symbol indicates SAE 52100 (chrome) bearing steel.

S = AISI 440C stainless steel.

M = M50 tool steel.

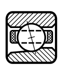
C = Ceramic balls.

TYPE



B – Separable angular contact bearing with cutaway inner ring shoulder.

H – Nonseparable angular contact bearing with cutaway outer ring shoulder.



J – Same as "B" type, except nonseparable.

SPECIAL FEATURES

Letter "X" followed by number(s) indicates special features. Because of frequent usage, certain features have permanently assigned X numbers. They include:

X204 – Customer part number marked on bearing.

X205 – Full ball complement.

Consult Barden Engineering for details.

FUNCTIONAL TEST

VA – Special Barden anderometer functional test.

VB – Special Navy anderometer functional test per MIL-B-17931.

CALIBRATION

Bores and O.D.s are divided into .0001" or .000050" increments within the tolerance range.

C – .0001" groups

C44 – .000050" groups

Refer to calibration discussion in the Engineering section, page 133.

SERIES, CONTACT ANGLE AND SIZE

First character always denotes series. Last two digits denote bore size.

SERIES

1900 – Ultra light 15°
100 – Extra light 15°
2100 – Extra light 25°
ZSB 100 – Extra light, small ball 15°
200 – Light 15°
2200 – Light 25°
ZSB 200 – Light, small ball 15°
300 – Medium 15°
2300 – Medium 25°

BORE SIZE

00 – 10mm
01 – 12mm
02 – 15mm
03 – 17mm
04 – 20mm
04 and up – Multiply last two digits by five to get bore in mm.

CAGE

Absence of a symbol indicates a standard phenolic 1-piece cage. For standard cages see Cage Options in the Engineering section, page 84.

JB or JH – 1-piece bronze cage.

DUPLEXING AND PRELOADS

For duplex sets, letter symbol indicates type of mounting. If followed by number, numerals indicate mean preload in pounds. Absence of number indicates standard preload.

D – Universal mounting. Angular contact duplex sets universally ground have inner and outer rings of the same width, and can be installed DB, DF or DT.

DB – Back-to-back mounting.
DF – Face-to-face mounting.
DT – Tandem mounting.
DD – Tandem triplex set.

Standard preloads are indicated by:
L – Light **M –** Medium **H –** Heavy

LUBRICATION

Type of prelubrication is indicated on package.

O – indicates oil
G – indicates grease

Number code following letter denotes specific type of lubricant. A discussion of lubricants can be found in the Engineering section, page 97.

ENGINEERING

RADIAL PLAY

Angular contact bearings combine radial play and thrust loading to develop their primary characteristic – an angular line of contact between the balls and both races.

Spindle size nonseparable Barden angular contact bearings are manufactured to standard radial play ranges (see tables, pages 48 and 49) resulting in nominal contact angles of either 15˚ or 25˚. Barden separable angular contact bearings have standard radial play ranges only (see Table 15).

Table 15. Radial play ranges of Barden B-Type separable 15° angular contact bearings.

Basic Bearing Nomenclature	Radial Play Range	Basic Bearing Nomenclature	Radial Play Range
101B, 102B, 103B	.0008 – .0012	108B	.0017 – .0021
104B, 105B	.0012 – .0016	110B	.0018 – .0023
106B	.0013 – .0017	113B	.0021 – .0027
107B	.0015 – .0019	117B	.0027 – .0035

All dimensions in inches.

Table 16. Radial play ranges of Barden ZSB nonseparable 15° angular contact bearings.

Basic Bearing Nomenclature	Radial Play Range	Basic Bearing Nomenclature	Radial Play Range
ZSB101J	.0004 – .0007	ZSB124J	.0016 – .0026
ZSB102J, ZSB103J	.0005 – .0009	ZSB202J	.0005 – .0009
ZSB104J, ZSB105J, ZSB106J	.0006 – .0010	ZSB204J	.0008 – .0012
		ZSB206J	.0009 – .0014
ZSB107J, ZSB108J	.0008 – .0012	ZSB207J	.0011 – .0017
ZSB111J, ZSB113J	.0009 – .0015	ZSB210J	.0015 – .0021
ZSB114J	.0011 – .0017	ZSB211J	.0013 – .0020
ZSB118J, ZSB120J	.0014 – .0022		

All dimensions in inches.

Table 17. Radial play ranges of Barden 1900H nonseparable 15° angular contact bearings.

Basic Bearing Nomenclature	Radial Play Range	Basic Bearing Nomenclature	Radial Play Range
1900H, 1901H, 1902H, 1903H	.0004 – .0008	1914H, 1915H, 1916H	.0010 – .0015
1904H, 1905H 1906H	.0006 – .0010	1917H, 1918H, 1919H	.0012 – .0018
1907H	.0007 – .0011	1920H, 1921H, 1922H	.0014 – .0020
1908H, 1909H, 1910H	.0008 – .0012	1924H	.0015 – .0023
1911H, 1912H 1913H	.0008 – .0013	1926H, 1928H	.0017 – .0025
		1930H	.0022 – .0030

All dimensions in inches.

Table 18. Radial play ranges of Barden 100H nonseparable 15° angular contact bearings.

Basic Bearing Nomenclature	Radial Play Range	Basic Bearing Nomenclature	Radial Play Range
100H, 101H, 103H, 106H	.0007 – .0011	111H, 112H, 113H	.0012 – .0018
		114H, 115H	.0014 – .0020
102H, 105H	.0006 – .0010	116H, 117H	.0015 – .0023
104H	.0010 – .0014	118H, 119H, 120H	.0017 – .0025
107H	.0008 – .0012	121H	.0020 – .0029
108H	.0008 – .0013	122H, 124H	.0022 – .0032
109H, 110H	.0010 – .0015	126H, 128H, 130H	.0026 – .0036

All dimensions in inches.

Table 19. Radial play ranges of Barden 200H nonseparable 15° angular contact bearings.

Basic Bearing Nomenclature	Radial Play Range	Basic Bearing Nomenclature	Radial Play Range
200H	.0007 – .0011	212H	.0017 – .0025
201H, 202H, 203H	.0008 – .0012	213H, 214H, 215H	.0020 – .0028
204H, 205H	.0011 – .0015	216H	.0022 – .0030
206H	.0011 – .0017	217H	.0023 – .0033
207H	.0012 – .0017	218H	.0026 – .0036
208H, 209H	.0013 – .0019	219H, 220H	.0030 – .0040
210H	.0014 – .0020	221H	.0031 – .0042
211H	.0015 – .0023	222H	.0033 – .0045

All dimensions in inches.

Table 20. Radial play ranges of Barden 300H nonseparable 15° angular contact bearings.

Basic Bearing Nomenclature	Radial Play Range	Basic Bearing Nomenclature	Radial Play Range
302H, 303H	.0009 – .0014	307H	.0015 – .0023
304H	.0011 – .0017	308H	.0017 – .0025
305H	.0013 – .0019	309H	.0020 – .0028
306H	.0014 – .0022	310H	.0021 – .0031

All dimensions in inches.

Table 21. Radial play ranges of Barden 2100H nonseparable 25° angular contact bearings.

Basic Bearing Nomenclature	Radial Play Range	Basic Bearing Nomenclature	Radial Play Range
2100H, 2101H	.0016 – .0020	2114H, 2115H	.0044 – .0050
2102H, 2103H	.0018 – .0022	2116H, 2117H	.0049 – .0057
2104H, 2105H	.0021 – .0025	2118H, 2119H, 2120H	.0054 – .0062
2106H	.0024 – .0028		
2107H, 2108H	.0027 – .0032	2121H	.0060 – .0070
2109H, 2110H	.0032 – .0038	2122H, 2124H	.0068 – .0078
2111H, 2112H, 2113H	.0038 – .0044	2126H	.0080 – .0092

All dimensions in inches.

Table 22. Radial play ranges of Barden 2200H nonseparable 25° angular contact bearings.

Basic Bearing Nomenclature	Radial Play Range	Basic Bearing Nomenclature	Radial Play Range
2200H	.0018 – .0022	2208H, 2209H	.0040 – .0046
2201H	.0020 – .0024	2210H	.0044 – .0050
2202H	.0021 – .0025	2211H	.0049 – .0057
2203H, 2204H, 2205H	.0027 – .0032	2212H	.0054 – .0062
2206H	.0034 – .0040	2213H, 2214H, 2215H	.0061 – .0069
2207H	.0038 – .0044	2216H	.0066 – .0074

All dimensions in inches.

Table 23. Radial play ranges of Barden 2300H nonseparable 25° angular contact bearings.

Basic Bearing Nomenclature	Radial Play Range	Basic Bearing Nomenclature	Radial Play Range
2301H	.0023 – .0027	2309H	.0061 – .0069
2302H, 2303H	.0029 – .0034	2310H	.0065 – .0075
2304H	.0035 – .0041	2312H	.0077 – .0087
2305H	.0040 – .0047	2319H	.0117 – .0129
2306H	.0049 – .0057	2322H	.0130 – .0150
2308H	.0054 – .0062		

All dimensions in inches.

TOLERANCES

Barden angular contact bearings are manufactured to ABEC-9 geometric tolerances. Mounting diameters (bore and O.D.) are measured and coded on all spindle size angular contact bearing boxes. The tolerances conform to ABMA Standard 4 and 20 and ISO Standard 15. (See tables below. See page 133 in the Engineering section for calibration codes.)

Table 24. Inner ring tolerances for Series 1900, 100, 200, 300 and ZSB.

Bearing Bore[1] Over mm	Bearing Bore[1] Including mm	Average Bore Diameter (+.0000 to…)	Raceway Radial Runout	Face Runout with Bore (Squareness)	Raceway Axial Runout	Single Bearing Width (+.000 to…)	Duplex Bearing Width (+.000 to…)	Width Variation (Parallelism)
10*	18	–.00015	.00005	.00005	.00005	–.0032**	–.010	.00005
18	30	–.0002	.0001	.00005	.0001	–.005	–.010	.00005
30	50	–.00025	.0001	.00005	.0001	–.005	–.010	.00005
50	80	–.0003	.0001	.00005	.0001	–.006	–.010	.00005
80	120	–.0003	.0001	.0001	.0001	–.008	–.015	.0001
120	150	–.0004	.0001	.0001	.0001	–.010	–.015	.0001
150	180	–.0004	.0002	.00015	.0002	–.010	–.015	.00015

All tolerances in inches. *This diameter is included in this group. **Single bearing width of 10mm bore bearings is –.0016.

Table 25. Outer ring tolerances for Series 1900, 100, 200, 300 and ZSB.

Bearing O.D. Over mm	Bearing O.D. Including mm	Average Outside Diameter (+.0000 to…)	Raceway Radial Runout	Outside Diameter Runout With Face (Squareness)	Raceway Axial Runout	Width	Width Variation (Parallelism)
18	30	–.0002	.0001	.00005	.0001	*	.00005
30	50	–.00025	.0001	.00005	.0001	*	.00005
50	80	–.0003	.00015	.00005	.00015	*	.00005
80	120	–.0003	.0002	.0001	.0002	*	.0001
120	150	–.00035	.0002	.0001	.0002	*	.0001
150	180	–.0004	.0002	.0001	.0002	*	.0001
180	250	–.00045	.0003	.00015	.0003	*	.00015
250	315	–.0005	.0003	.0002	.0003	*	.0002

All tolerances in inches. *Identical to width tolerance of inner ring of same bearing.

PRODUCT SERIES DESCRIPTIONS

SERIES 1900, 100, 200 AND 300

Metric Ultra Light, Extra Light, Light and Medium

Design: Series 1900, 100, 200, 300 Angular contact bearings have one ring shoulder partially or totally removed. They can support thrust loads in one direction or combinations of radial and thrust loads, but not radial loading alone. Load capacities are higher than for deep groove bearings. The bearings cataloged here include both separable and nonseparable types.

Separable Type (B): Outer ring has full shoulders, inner ring has one shoulder cut away. The inner ring is removable for mounting on the shaft separately from the outer ring assembly.

Nonseparable Type (H): Inner ring has full shoulders, outer ring has one shoulder cut away.

Contact Angles: Standard contact angles are 15° for separables and 15° or 25° for nonseparable. (Prefix "2" in bearing numbers denotes 25°contact angle.) The smaller angle delivers better radial rigidity and capacity, the larger angle is better for axial rigidity under thrust loading.

Bearing Data: Bearing data applicable to these bearings is shown in the following tables. Lubrication and mounting data can be found in the engineering section.

Cages: Standard cage is a one-piece phenolic type (no symbol) with circular ball pockets. Some sizes are also available with a one-piece bronze type (symbol JB or JH) of similar design. In separable bearings, ball pockets are designed to hold balls in place when inner ring is removed. For other cage options, see Cages discussion in Engineering section, page 81, or consult Barden.

Attainable Speeds: Limits given are for spring loaded single bearings.

Material: Standard material is SAE 52100 bearing steel for both rings and balls. With the option of using silicon nitride ceramic balls even higher speeds can be attained.

Duplexing: All bearings are available universally ground (D) for DB, DF, or DT mounting in sets of two or more. Bearings may also be ordered as specific DB or DF duplex pairs. Standard light, medium and heavy preloads are shown in the following tables (see details in the Engineering section).

Lubricant: Desired lubrication should be specified when ordering, based on torque, speed and temperature conditions of the application. (See details in the Engineering section, page 97.)

Calibration: For applications that cannot tolerate extreme fits, selective fitting with calibrated parts should be considered. Selective fitting utilizes a system of sizing bearings, shafts and housings within the diametral tolerance range and selectively assembling those parts which fall within the same respective area of the range. When Barden bearings are calibrated, they are sorted into groups and are specified by calibration code (see "Calibration" discussion in Engineering section, page 133). Angular contact spindle bearings are calibrated to the average bore and O.D.

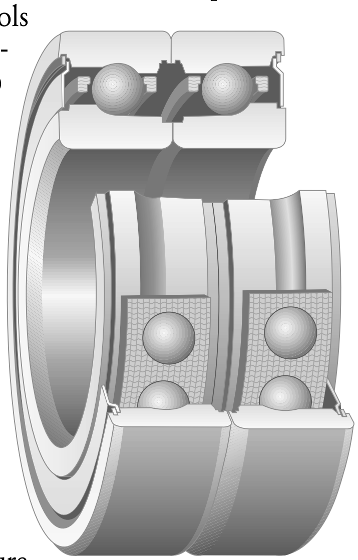
PRODUCT SERIES DESCRIPTIONS

BARDEN PRECISION BEARINGS

SERIES ZSB

Small Ball

Design: Barden engineers have developed the ZSB small ball angular contact shielded series spindle bearings to allow machine tools to operate at higher running speeds (up to 20% more) while maintaining optimum workpiece finish characteristics. The small ball feature of the ZSB series allows a greater number of balls to be used, increasing bearing stiffness, which leads to improved machining accuracy at higher speeds.



Barden's ZSB series offer optional integral shields which reduce the chances of bearing failure through contamination and prolong lubricant life when bearings are grease lubricated. Shields are available as an option on most sizes. Check for availability. To specify single or double shields add S or SS to the basic bearing number.

The inner ring outside diameter land is removed from one side and the outer ring bore diameter land is removed from the opposite side. This allows for 1) optimum exposure and flow through characteristics for air/oil lube systems, and 2) increased storage areas for shielded grease lubed bearings.

Contact Angles: Standard contact angle is 15°.

Bearing Data: Bearing data applicable to these bearings is shown in the following tables. Lubrication and mounting data can be found in the Engineering section.

Cages: Standard cage is a one-piece phenolic type (no symbol) with circular ball pockets.

Attainable Speeds: Limits given are for spring preloaded single bearings.

Material: Standard material is SAE 52100 bearing steel for both rings and balls. With the option of using silicon nitride ceramic balls even higher speeds can be attained.

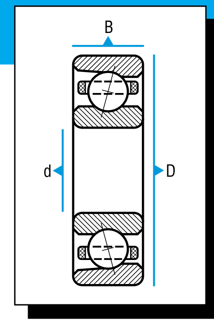
Duplexing: All bearings are available universally ground (D) for DB, DF, or DT mounting in sets of two or more. Bearings may also be ordered in specific DB or DF duplex pairs. Standard light, medium and heavy preloads are shown in the following product tables (see details in the Engineering section).

Lubricant: Desired lubrication should be specified when ordering, based on torque, speed and temperature conditions of the application. (See details in the Engineering section, page 97.)

Calibration: For applications that cannot tolerate extreme fits, selective fitting with calibrated parts should be considered. Selective fitting utilizes a system of sizing bearings, shafts and housings within the diametral tolerance range and selectively assembling those parts which fall within the same respective area of the range. When Barden bearings are calibrated, they are sorted into groups and are specified by calibration code (see "Calibration" discussion in Engineering section, page 133). Angular contact spindle bearings are calibrated to the average bore and O.D.

SPINDLE BEARINGS (ANGULAR CONTACT)

BORE DIAMETERS: 10mm TO 15mm



SHAFT	Bore Diameter d		Outside Diameter D		Width B		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear (cutaway side)		Standard Contact Angle	BASIC BEARING NOMENCLATURE*
mm	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch		
10mm	10	.3937	22	.8661	6	.2362	.30	.012	.15	.006	15°	1900H
			26	1.0236	8	.3150	.30	.012	.25	.010	15°	100H
			26	1.0236	8	.3150	.30	.012	.25	.010	15°	100HJH
			26	1.0236	8	.3150	.30	.012	.25	.010	25°	2100H
			30	1.1811	9	.3543	.64	.025	.38	.015	15°	200H
			30	1.1811	9	.3543	.64	.025	.38	.015	15°	200HJB
			30	1.1811	9	.3543	.64	.025	.38	.015	25°	2200H
12mm	12	.4724	24	.9449	6	.2362	.30	.012	.15	.006	15°	1901H
			28	1.1024	8	.3150	.30	.012	.25	.010	15°	101H
			28	1.1024	8	.3150	.30	.012	.25	.010	15°	101HJB
			28	1.1024	8	.3150	.30	.012	.25	.010	15°	101BX48
			28	1.1024	8	.3150	.30	.012	.25	.010	25°	2101H
			28	1.1024	8	.3150	.30	.012	.30	.012	15°	ZSB101J
			32	1.2598	10	.3937	.64	.025	.38	.015	15°	201H
			32	1.2598	10	.3937	.64	.025	.38	.015	15°	201HJB
			32	1.2598	10	.3937	.64	.025	.38	.015	25°	2201H
			37	1.4567	12	.4724	1.0	.040	.50	.020	25°	2301H
15mm	15	.5906	28	1.1024	7	.2756	.30	.012	.15	.006	15°	1902H
			32	1.2598	9	.3543	.30	.012	.25	.010	15°	102H
			32	1.2598	9	.3543	.30	.012	.25	.010	15°	102HJB
			32	1.2598	9	.3543	.30	.012	.25	.010	15°	102BX48
			32	1.2598	9	.3543	.30	.012	.25	.010	25°	2102H
			32	1.2598	9	.3543	.30	.012	.30	.012	15°	ZSB102J
			35	1.3780	11	.4331	.64	.025	.38	.015	15°	202H
			35	1.3780	11	.4331	.64	.025	.38	.015	15°	202HJB
			35	1.3780	11	.4331	.64	.025	.38	.015	25°	2202H
			35	1.3780	11	.4331	.64	.025	.64	.025	15°	ZSB202J
			42	1.6535	13	.5118	1.0	.040	.50	.020	15°	302H

*Certain sizes listed in these tables may not be in current production. Check for availability.

BARDEN PRECISION BEARINGS

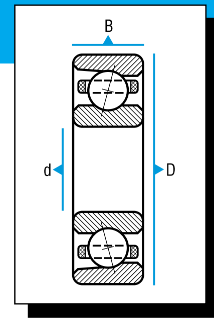
BASIC BEARING NOMENCLATURE*	ATTAINABLE SPEEDS (RPM) Oil	Grease	Ball Complement No. n	Diam. d	Static Capacity Radial C_0 (lbs.)	Thrust T_0 (lbs.)	Basic Dynamic Load Rating C (lbs.)	STANDARD PRELOADS (lbs.) L (Light)	M (Medium)	H (Heavy)
1900H	140,000	90,000	10	5/32"	541	794	934	4	8	16
100H	135,000	85,000	9	3/16"	532	607	1,199	4	10	20
100HJH	155,000	—	10	3/16"	592	675	1,286	—	—	—
2100H	122,000	76,500	9	3/16"	662	772	1,157	6	16	30
200H	130,000	80,000	9	7/32"	913	727	1,567	6	15	30
200HJB	150,000	—	9	7/32"	913	727	1,578	—	—	—
2200H	117,000	72,000	9	7/32"	880	1,240	1,519	8	20	40
1901H	116,700	75,000	11	5/32"	627	884	1,007	4	9	18
101H	112,500	70,800	10	3/16"	623	701	1,309	5	12	24
101HJB	129,000	—	11	3/16"	688	771	1,395	—	—	—
101BX48	129,000	70,800	10	3/16"	522	779	1,030	—	—	—
2101H	101,200	63,700	11	3/16"	850	1,153	1,338	7	18	40
ZSB101J	133,000	91,600	15	1/8"	528	748	823	5	10	20
201H	108,300	66,700	9	15/64"	1,061	792	1,788	7	17	35
201HJB	125,000	—	10	15/64"	1,180	880	1,918	—	—	—
2201H	7,500	60,000	10	15/64"	1,140	1,597	1,853	10	25	50
2301H	75,000	45,000	9	17/64"	1,304	1,806	2,155			
1902H	93,300	60,000	14	5/32"	851	1,167	1,181	4	10	20
102H	90,000	56,700	11	3/16"	929	967	1,404	5	13	26
102HJB	103,300	—	12	3/16"	1,013	1,055	1,488	—	—	—
102BX48	103,300	56,700	11	3/16"	608	880	1,115	—	—	—
2102H	81,000	51,000	11	7/32"	1,161	1,570	1,773	8	20	40
ZSB102J	106,700	73,300	15	5/32"	812	1,159	1,235	5	10	20
202H	86,700	53,300	10	1/4"	1,370	1,090	2,175	8	20	40
202HJB	100,000	—	10	1/4"	1,370	1,090	2,174	—	—	—
2202H	78,000	48,000	10	1/4"	1,333	1,835	2,101	14	35	70
ZSB202J	100,000	66,700	16	5/32"	889	1,269	1,279	8	17	35
302H	66,700	40,000	9	11/32"	2,129	3,260	3,439	12	30	60

*Certain sizes listed in these tables may not be in current production. Check for availability.

Continued on page 54

SPINDLE BEARINGS (ANGULAR CONTACT)

BORE DIAMETERS: 15mm TO 25mm



SHAFT	Bore Diameter d		Outside Diameter D		Width B		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear (cutaway side)		Standard Contact Angle	BASIC BEARING NOMENCLATURE*
mm	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch		
15mm	15	.5906	42	1.6535	13	.5118	1.0	.040	.50	.020	25°	2302H
16mm	16	.6299	38	1.4961	12	.4724	.64	.025	.38	.015	13°	203HX37
17mm	17	.6693	30	1.1811	7	.2756	.30	.012	.15	.006	15°	1903H
			35	1.3780	10	.3937	.30	.012	.25	.010	15°	103H
			35	1.3780	10	.3937	.30	.012	.25	.010	15°	103HJB
			35	1.3780	10	.3937	.30	.012	.25	.010	15°	103BX48
			35	1.3780	10	.3937	.30	.012	.25	.010	25°	2103H
			35	1.3780	10	.3937	.30	.012	.30	.012	15°	ZSB103J
			40	1.5748	12	.4724	.64	.025	.38	.015	15°	203H
			40	1.5748	12	.4724	.64	.025	.38	.015	15°	203HJB
			40	1.5748	12	.4724	.64	.025	.38	.015	25°	2203H
			47	1.8504	14	.5512	1.0	.040	.50	.020	15°	303H
			47	1.8504	14	.5512	1.0	.040	.50	.020	25°	2303H
20mm	20	.7874	37	1.4567	9	.3543	.30	.012	.15	.006	15°	1904H
			42	1.6535	12	.4724	.64	.025	.38	.015	15°	104H
			42	1.6535	12	.4724	.64	.025	.38	.015	15°	104HJB
			42	1.6535	12	.4724	.64	.025	.38	.015	15°	104BX48
			42	1.6535	12	.4724	.64	.025	.38	.015	25°	2104H
			42	1.6535	12	.4724	.64	.025	.64	.025	15°	ZSB104J
			47	1.8504	14	.5512	1.0	.040	.50	.020	15°	204H
			47	1.8504	14	.5512	1.0	.040	.50	.020	15°	204HJB
			47	1.8504	14	.5512	1.0	.040	.50	.020	25°	2204H
			47	1.8504	14	.5512	1.0	.040	1.0	.040	15°	ZSB204J
			52	2.0472	15	.5906	1.0	.040	.50	.020	15°	304H
			52	2.0472	15	.5906	1.0	.040	.50	.020	25°	2304H
25mm	25	.9843	42	1.6535	9	.3543	.30	.012	.25	.010	15°	1905H
			47	1.8504	12	.4724	.64	.025	.38	.015	15°	105H
			47	1.8504	12	.4724	.64	.025	.38	.015	15°	105HJB

*Certain sizes listed in these tables may not be in current production. Check for availability.

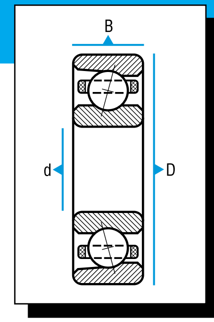
BASIC BEARING NOMENCLATURE*	ATTAINABLE SPEEDS (RPM)		Ball Complement		Static Capacity		Basic Dynamic Load Rating	STANDARD PRELOADS (lbs.)		
	Oil	Grease	No. n	Diam. d	Radial C_0 (lbs.)	Thrust T_0 (lbs.)	C (lbs.)	L (Light)	M (Medium)	H (Heavy)
2302H	60,000	36,000	9	11/32"	2,076	2,986	3,356	20	50	100
203HX37	76,500	47,000	10	17/64"	1,594	1,477	2,462	—	—	—
1903H	82,300	52,900	14	5/32"	867	1,176	1,176	5	12	24
103H	79,400	50,000	13	3/16"	885	870	1,567	6	15	30
103HJB	91,200	—	13	3/16"	885	870	1,565	—	—	—
103BX48	91,200	50,000	13	3/16"	741	1,299	1,250	—	—	—
2103H	71,500	45,000	12	7/32"	1,314	1,745	1,884	10	25	50
ZSB103J	94,100	64,700	16	5/32"	889	1,269	1,277	5	10	20
203H	76,500	47,000	10	17/64"	1,593	2,353	2,452	10	25	50
203HJB	88,200	—	11	17/64"	1,760	2,596	2,613	—	—	—
2203H	68,800	42,300	10	17/64"	1,544	2,141	2,356	16	40	80
303H	58,800	35,300	10	11/32"	2,506	3,731	3,801	20	45	90
2303H	52,900	31,800	10	11/32"	2,440	3,375	3,688	30	70	140
1904H	70,000	45,000	13	7/32"	1,513	2,104	2,069	8	20	40
104H	67,500	42,500	11	1/4"	1,287	1,413	2,358	10	25	50
104HJB	77,500	—	13	1/4"	1,517	1,670	2,663	—	—	—
104BX48	77,500	42,500	11	1/4"	1,078	1,976	1,870	—	—	—
2104H	60,700	38,200	13	1/4"	1,882	2,485	2,524	14	35	70
ZSB104J	80,000	55,000	16	3/16"	1,278	1,803	1,777	10	20	40
204H	65,000	40,000	10	5/16"	2,214	2,037	3,283	15	35	70
204HJB	75,000	—	11	5/16"	2,444	2,240	3,498	—	—	—
2204H	58,500	36,000	11	5/16"	2,375	3,169	3,362	22	55	110
ZSB204J	75,000	50,000	15	7/32"	1,599	2,301	2,259	15	30	60
304H	50,000	30,000	9	13/32"	3,069	4,614	4,726	20	55	110
2304H	45,000	27,000	9	13/32"	2,991	4,182	4,594	35	80	160
1905H	56,000	36,000	16	7/32"	1,954	2,664	2,356	8	20	40
105H	54,000	34,000	13	1/4"	2,035	1,967	2,630	12	30	60
105HJB	62,000	—	14	1/4"	2,192	2,119	2,772	—	—	—

*Certain sizes listed in these tables may not be in current production. Check for availability.

Continued on page 56

SPINDLE BEARINGS (ANGULAR CONTACT)

BORE DIAMETERS: 25mm TO 35mm



SHAFT	Bore Diameter d		Outside Diameter D		Width B		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear (cutaway side)		Standard Contact Angle	BASIC BEARING NOMENCLATURE*
mm	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch		
25mm	25	.9843	47	1.8504	12	.4724	.64	.025	.38	.015	15°	105BX48
			47	1.8504	12	.4724	.64	.025	.38	.015	25°	2105H
			47	1.8504	12	.4724	.64	.025	.64	.025	15°	ZSB105J
			52	2.0472	15	.5906	1.0	.040	.50	.020	15°	205H
			52	2.0472	15	.5906	1.0	.040	.50	.020	15°	205HJB
			52	2.0472	15	.5906	1.0	.040	.50	.020	25°	2205H
			62	2.4409	17	.6693	1.0	.040	.50	.020	15°	305H
			62	2.4409	17	.6693	1.0	.040	.50	.020	25°	2305H
30mm	30	1.1811	47	1.8504	9	.3543	.30	.012	.25	.010	15°	1906H
			55	2.1654	13	.5118	1.0	.040	.50	.020	15°	106H
			55	2.1654	13	.5118	1.0	.040	.50	.020	15°	106HJB
			55	2.1654	13	.5118	1.0	.040	.50	.020	15°	106BX48
			55	2.1654	13	.5118	1.0	.040	.50	.020	25°	2106H
			55	2.1654	13	.5118	1.0	.040	1.0	.040	15°	ZSB106J
			62	2.4409	16	.6299	1.0	.040	.50	.020	15°	206H
			62	2.4409	16	.6299	1.0	.040	.50	.020	15°	206HJB
			62	2.4409	16	.6299	1.0	.040	.50	.020	25°	2206H
			62	2.4409	16	.6299	1.0	.040	1.0	.040	15°	ZSB206J
			71.9	2.8310	19	.7480	1.0	.040	1.0	.040	27°	2306HX3
			72	2.8346	19	.7480	1.0	.040	1.0	.040	15°	306H
			72	2.8346	19	.7480	1.0	.040	1.0	.040	25°	2306H
35mm	35	1.3780	55	2.1654	10	.3937	.64	.025	.38	.015	15°	1907H
			62	2.4409	14	.5512	1.0	.040	.50	.020	15°	107H
			62	2.4409	14	.5512	1.0	.040	.50	.020	15°	107BX48
			62	2.4409	14	.5512	1.0	.040	.50	.020	25°	2107H
			62	2.4409	14	.5512	1.0	.040	1.0	.040	15°	ZSB107J
			72	2.8346	17	.6693	1.0	.040	.50	.020	15°	207H
			72	2.8346	17	.6693	1.0	.040	.50	.020	25°	2207H

*Certain sizes listed in these tables may not be in current production. Check for availability.

BARDEN PRECISION BEARINGS

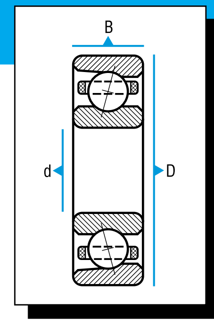
BASIC BEARING NOMENCLATURE*	ATTAINABLE SPEEDS (RPM) Oil	ATTAINABLE SPEEDS (RPM) Grease	Ball Complement No. n	Ball Complement Diam. d	Static Capacity Radial C_0 (lbs.)	Static Capacity Thrust T_0 (lbs.)	Basic Dynamic Load Rating C (lbs.)	STANDARD PRELOADS (lbs.) L (Light)	STANDARD PRELOADS (lbs.) M (Medium)	STANDARD PRELOADS (lbs.) H (Heavy)
105BX48	62,000	34,000	13	1/4"	1,331	2,801	2,090	—	—	—
2105H	48,600	30,600	13	1/4"	1,968	2,491	2,503	18	45	90
ZSB105J	64,000	44,000	19	3/16"	1,568	2,179	1,975	15	30	60
205H	52,000	32,000	11	5/16"	2,569	2,298	3,524	15	40	80
205HJB	60,000	—	13	5/16"	3,029	2,716	3,939	—	—	—
2205H	46,800	28,800	11	5/16"	2,491	3,245	3,368	25	60	120
305H	40,000	24,000	10	15/32"	4,170	6,740	6,635	30	80	160
2305H	36,000	21,600	10	15/32"	4,057	6,182	6,436	50	125	250
1906H	46,700	30,000	18	7/32"	2,272	3,050	2,512	10	25	50
106H	45,000	28,300	14	9/32"	3,369	2,216	3,392	15	40	80
106HJB	51,700	—	14	9/32"	3,369	2,216	3,413	—	—	—
106BX48	51,700	28,300	14	9/32"	1,843	3,103	2,715	—	—	—
2106H	40,500	25,500	16	9/32"	3,109	3,985	3,537	25	60	120
ZSB106J	53,300	36,700	21	3/16"	1,782	2,353	2,034	15	30	60
206H	43,300	26,700	11	13/32"	4,217	5,982	5,634	25	65	130
206HJB	50,000	—	11	13/32"	4,217	5,982	5,634	—	—	—
2206H	39,000	24,000	11	13/32"	4,091	5,387	5,415	40	100	200
ZSB206J	50,000	33,300	17	17/64"	2,756	3,864	3,443	25	50	100
2306HX3	30,000	18,500	10	17/32"	5,931	7,817	8,038	40	100	200
306H	33,300	20,000	10	17/32"	6,086	8,966	8,378	40	100	200
2306H	30,000	18,000	10	17/32"	5,910	8,481	8,038	65	160	320
1907H	40,000	25,700	19	1/4"	3,156	4,227	3,299	12	30	60
107H	38,600	24,300	15	5/16"	3,750	5,087	4,300	20	50	100
107BX48	44,300	24,300	15	5/16"	2,451	4,093	3,430	—	—	—
2107H	34,700	21,900	15	5/16"	3,623	4,562	4,077	30	80	160
ZSB107J	45,700	31,400	22	7/32"	2,537	3,367	2,778	20	40	80
207H	37,100	22,900	12	7/16"	5,490	5,543	6,849	30	80	160
2207H	33,400	20,600	12	7/16"	5,320	4,688	6,544	50	120	240

*Certain sizes listed in these tables may not be in current production. Check for availability.

Continued on page 58

SPINDLE BEARINGS (ANGULAR CONTACT)

BORE DIAMETERS: 35mm TO 50mm



SHAFT mm	Bore Diameter d mm	Bore Diameter d inch	Outside Diameter D mm	Outside Diameter D inch	Width B mm	Width B inch	Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear mm	Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear inch	Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear (cutaway side) mm	Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear (cutaway side) inch	Standard Contact Angle	BASIC BEARING NOMENCLATURE*
35mm	35	1.3780	72	2.8346	17	.6693	1.0	.040	1.0	.040	15°	ZSB207J
			80	3.1496	21	.8268	1.52	.060	.76	.030	15°	307H
40mm	40	1.5748	62	2.4409	12	.4724	.64	.025	.38	.015	15°	1908H
			68	2.6772	15	.5906	1.0	.040	.50	.020	15°	108H
			68	2.6772	15	.5906	1.0	.040	.50	.020	15°	108BX48
			68	2.6772	15	.5906	1.0	.040	.50	.020	25°	2108H
			68	2.6772	15	.5906	1.0	.040	1.0	.040	15°	ZSB108J
			80	3.1496	18	.7087	1.0	.040	.50	.020	15°	208H
			80	3.1496	18	.7087	1.0	.040	.50	.020	25°	2208H
			90	3.5433	23	.9055	1.52	.060	.76	.030	15°	308H
			90	3.5433	23	.9055	1.52	.060	.76	.030	25°	2308H
45mm	45	1.7717	68	2.6772	12	.4724	.64	.025	.38	.015	15°	1909H
			75	2.9528	16	.6299	1.0	.040	.50	.020	15°	109H
			75	2.9528	16	.6299	1.0	.040	.50	.020	25°	2109H
			85	3.3465	19	.7480	1.0	.040	.50	.020	15°	209H
			85	3.3465	19	.7480	1.0	.040	.50	.020	25°	2209H
			100	3.9370	25	.9843	1.52	.060	.76	.030	15°	309H
			100	3.9370	25	.9843	1.52	.060	.76	.030	25°	2309H
50mm	50	1.9685	72	2.8346	12	.4724	.64	.025	.38	.015	15°	1910H
			80	3.1496	16	.6299	1.0	.040	.50	.020	15°	110H
			80	3.1496	16	.6299	1.0	.040	.50	.020	15°	110BX48
			80	3.1496	16	.6299	1.0	.040	.50	.020	25°	2110H
			90	3.5433	20	.7874	1.0	.040	.50	.020	15°	210H
			90	3.5433	20	.7874	1.0	.040	.50	.020	25°	2210H
			90	3.5433	20	.7874	1.0	.040	1.0	.040	15°	ZSB210J
			110	4.3307	27	1.0630	2.0	.080	1.0	.040	15°	310H
			110	4.3307	27	1.0630	2.0	.080	1.0	.040	25°	2310H

*Certain sizes listed in these tables may not be in current production. Check for availability.

BARDEN PRECISION BEARINGS

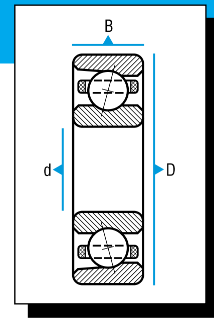
BASIC BEARING NOMENCLATURE*	ATTAINABLE SPEEDS (RPM) Oil	Grease	Ball Complement No. n	Diam. d	Static Capacity Radial C_0 (lbs.)	Thrust T_0 (lbs.)	Basic Dynamic Load Rating C (lbs.)	STANDARD PRELOADS (lbs.) L (Light)	M (Medium)	H (Heavy)
ZSB207J	42,800	28,600	18	5/16"	4,023	5,670	4,799	30	60	120
307H	28,600	17,100	11	9/16"	7,738	11,271	10,010	50	125	250
1908H	35,000	22,500	19	9/32"	3,991	5,322	4,081	15	40	80
108H	33,700	21,200	17	5/16"	4,360	4,221	4,614	25	60	120
108BX48	38,750	21,200	17	5/16"	2,848	6,047	3,685	—	—	—
2108H	30,300	19,100	17	5/16"	4,207	3,558	4,375	35	90	180
ZSB108J	40,000	27,500	25	7/32"	2,861	3,793	2,966	25	50	100
208H	32,500	20,000	12	15/32"	6,386	9,008	7,750	40	95	190
2208H	29,200	18,000	12	15/32"	6,184	8,115	7,413	60	150	300
308H	25,000	15,000	11	5/8"	9,679	13,981	12,152	65	160	320
2308H	22,500	13,500	11	5/8"	9,401	12,615	11,751	100	250	500
1909H	31,100	22,500	21	9/32"	4,504	5,977	4,302	20	50	100
109H	30,000	18,900	16	3/8"	5,805	7,841	6,209	30	80	160
2109H	27,000	17,000	16	3/8"	5,606	7,029	5,896	50	125	250
209H	28,900	17,800	13	15/32"	7,087	7,073	8,155	40	100	200
2209H	26,000	16,000	13	15/32"	6,856	5,979	7,782	65	160	320
309H	22,200	13,300	11	11/16"	11,714	16,940	14,416	75	190	380
2309H	20,000	12,000	11	11/16"	11,378	15,288	13,874	120	300	600
1910H	28,000	18,000	23	9/32"	5,005	6,594	4,514	20	55	110
110H	27,000	17,000	18	3/8"	6,653	8,917	6,658	35	85	170
110BX48	31,000	17,000	18	3/8"	4,346	9,227	5,325	—	—	—
2110H	24,300	15,300	18	3/8"	6,419	7,987	6,314	50	130	260
210H	26,000	16,000	14	1/2"	8,703	8,712	9,261	50	125	250
2210H	23,400	14,400	14	1/2"	8,418	7,371	9,162	80	200	400
ZSB210J	30,000	20,000	21	11/32"	4,404	6,995	6,118	45	90	180
310H	20,000	12,000	11	3/4"	14,008	20,132	16,886	90	230	460
2310H	18,000	10,800	11	3/4"	13,605	18,226	16,253	150	360	720

*Certain sizes listed in these tables may not be in current production. Check for availability.

Continued on page 60

SPINDLE BEARINGS (ANGULAR CONTACT)

BORE DIAMETERS: 55mm TO 75mm



SHAFT	Bore Diameter d		Outside Diameter D		Width B		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear (cutaway side)		Standard Contact Angle	BASIC BEARING NOMENCLATURE*
mm	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch		
55mm	55	2.1654	80	3.1496	13	.5118	1.0	.040	.50	.020	15°	1911H
			90	3.5433	18	.7087	1.0	.040	.50	.020	15°	111H
			90	3.5433	18	.7087	1.0	.040	.50	.020	25°	2111H
			90	3.5433	18	.7087	1.0	.040	1.0	.040	15°	ZSB111J
			100	3.9370	21	.8268	1.52	.060	.76	.030	15°	211H
			100	3.9370	21	.8268	1.52	.060	.76	.030	25°	2211H
			100	3.9370	21	.8268	1.52	.060	1.52	.060	15°	ZSB211J
60mm	60	2.3622	85	3.3465	13	.5118	1.0	.040	.50	.020	15°	1912H
			95	3.7402	18	.7087	1.0	.040	.50	.020	15°	112H
			95	3.7402	18	.7087	1.0	.040	.50	.020	25°	2112H
			110	4.3307	22	.8661	1.52	.060	.76	.030	15°	212H
			110	4.3307	22	.8661	1.52	.060	.76	.030	25°	2212H
			130	5.1181	31	1.2205	2.0	.080	1.0	.060	25°	2312H
65mm	65	2.5591	90	3.5433	13	.5118	1.0	.040	.50	.020	15°	1913H
			100	3.9370	18	.7087	1.0	.040	.50	.020	15°	113H
			100	3.9370	18	.7087	1.0	.040	.50	.020	15°	113BX48
			100	3.9370	18	.7087	1.0	.040	.50	.020	25°	2113H
			100	3.9370	18	.7087	1.0	.040	1.0	.040	15°	ZSB113J
			120	4.7244	23	.9055	1.52	.060	.76	.030	15°	213H
			120	4.7244	23	.9055	1.52	.060	.76	.030	25°	2213H
70mm	70	2.7559	100	3.9370	16	.6299	1.0	.040	.50	.020	15°	1914H
			110	4.3307	20	.7874	1.0	.040	.50	.020	15°	114H
			110	4.3307	20	.7874	1.0	.040	.50	.020	25°	2114H
			110	4.3307	20	.7874	1.0	.040	1.0	.040	15°	ZSB114J
			125	4.9213	24	.9449	1.52	.060	.76	.030	15°	214H
			125	4.9213	24	.9449	1.52	.060	.76	.030	25°	2214H
75mm	75	2.9528	105	4.1339	16	.6299	1.0	.040	.50	.020	15°	1915H
			115	4.5276	20	.7874	1.0	.040	.50	.020	15°	115H

*Certain sizes listed in these tables may not be in current production. Check for availability.

BARDEN PRECISION BEARINGS

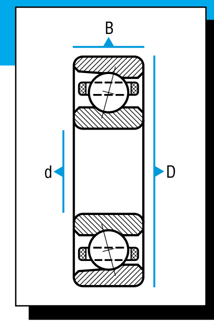
BASIC BEARING NOMENCLATURE*	ATTAINABLE SPEEDS (RPM) Oil	Grease	Ball Complement No. n	Diam. d	Static Capacity Radial C_0 (lbs.)	Thrust T_0 (lbs.)	Basic Dynamic Load Rating C (lbs.)	STANDARD PRELOADS (lbs.) L (Light)	M (Medium)	H (Heavy)
1911H	25,400	16,400	23	5/16"	6,173	8,130	5,470	30	70	140
111H	24,500	15,400	17	7/16"	8,458	9,456	8,493	50	120	240
2111H	22,000	13,900	17	7/16"	8,165	8,200	8,067	70	180	360
ZSB111J	29,100	20,000	25	9/32"	4,704	6,286	4,634	40	80	160
211H	23,600	14,500	14	9/16"	10,952	15,119	11,906	65	160	320
2211H	21,200	13,000	14	9/16"	10,596	13,579	11,338	100	250	500
ZSB211J	27,300	18,200	21	3/8"	7,029	9,496	7,194	60	120	240
1912H	23,300	15,000	25	5/16"	6,791	8,893	5,711	30	75	150
112H	22,500	14,200	18	7/16"	9,099	12,154	8,756	50	130	260
2112H	20,200	12,800	18	7/16"	8,777	10,881	8,306	75	190	380
212H	21,700	13,300	14	5/8"	13,498	13,565	14,400	80	200	400
2212H	19,500	12,000	14	5/8"	13,043	11,479	13,732	130	320	640
2312H	15,000	10,000	12	7/8"	20,341	27,050	22,749	200	490	980
1913H	21,500	13,800	26	5/16"	7,412	9,657	5,790	35	90	180
113H	20,800	13,100	19	7/16"	9,739	10,645	9,003	50	130	260
113BX48	23,800	13,100	18	7/16"	6,022	12,826	6,960	—	—	—
2113H	18,700	11,800	19	7/16"	9,390	9,206	8,533	80	200	400
ZSB113J	24,600	16,900	28	9/32"	3,078	6,084	4,863	50	100	200
213H	20,000	12,300	14	11/16"	16,248	22,483	17,086	100	250	500
2213H	18,000	11,100	14	11/16"	15,725	20,196	16,291	150	380	760
1914H	20,000	12,800	24	3/8"	9,353	11,254	7,751	45	110	220
114H	19,300	12,100	18	1/2"	11,923	13,216	11,117	65	160	320
2114H	17,400	10,900	18	1/2"	11,501	11,453	10,538	105	260	520
ZSB114J	22,800	15,700	29	5/16"	6,657	8,909	6,030	50	100	200
214H	18,600	11,400	15	11/16"	17,700	24,300	17,847	100	260	520
2214H	16,700	10,300	15	11/16"	17,125	21,815	16,994	160	410	820
1915H	18,700	12,000	26	3/8"	10,225	13,349	8,092	50	120	240
115H	18,000	11,300	20	1/2"	13,410	17,852	11,839	70	170	340

*Certain sizes listed in these tables may not be in current production. Check for availability.

Continued on page 62

SPINDLE BEARINGS (ANGULAR CONTACT)

BORE DIAMETERS: 75mm TO 100mm



SHAFT	Bore Diameter d		Outside Diameter D		Width B		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear (cutaway side)		Standard Contact Angle	BASIC BEARING NOMENCLATURE*
mm	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch		
75mm	75	2.9528	115	4.5276	20	.7874	1.0	.040	.50	.020	25°	2115H
			130	5.1181	25	.9843	1.52	.060	.76	.030	15°	215H
			130	5.1181	25	.9843	1.52	.060	.76	.030	25°	2215H
80mm	80	3.1496	110	4.3307	16	.6299	1.0	.040	.50	.020	15°	1916H
			125	4.9213	22	.8661	1.0	.040	.50	.020	15°	116H
			125	4.9213	22	.8661	1.0	.040	.50	.020	25°	2116H
			140	5.5118	26	1.0236	2.0	.080	1.0	.040	15°	216H
			140	5.5118	26	1.0236	2.0	.080	1.0	.040	25°	2216H
85mm	85	3.3465	120	4.7244	18	.7087	1.0	.040	.50	.020	15°	1917H
			130	5.1181	22	.8661	1.0	.040	.50	.020	15°	117H
			130	5.1181	22	.8661	1.0	.040	.50	.020	15°	117BX48
			130	5.1181	22	.8661	1.0	.040	.50	.020	25°	2117H
			150	5.9055	28	1.1024	2.0	.080	1.0	.040	15°	217H
90mm	90	3.5433	125	4.9213	18	.7087	1.0	.040	.50	.020	15°	1918H
			140	5.5118	24	.9449	1.52	.060	.76	.030	15°	118H
			140	5.5118	24	.9449	1.52	.060	.76	.030	25°	2118H
			140	5.5118	24	.9449	1.52	.060	1.52	.060	15°	ZSB118J
			160	6.2992	30	1.1811	2.0	.080	1.0	.040	15°	218H
95mm	95	3.7402	130	5.1181	18	.7807	1.0	.040	.50	.020	15°	1919H
			145	5.7087	24	.9449	1.52	.060	.76	.030	15°	119H
			145	5.7087	24	.9449	1.52	.060	.76	.030	25°	2119H
			170	6.6929	32	1.2598	2.1	.082	1.1	.041	15°	219H
			200	7.8740	45	1.7716	3.0	.120	1.5	.060	25°	2319H
100mm	100	3.9370	140	5.5118	20	.7874	1.0	.040	.50	.020	15°	1920H
			150	5.9055	24	.9449	1.52	.060	.76	.030	15°	120H
			150	5.9055	24	.9449	1.52	.060	.76	.030	25°	2120H
			150	5.9055	24	.9449	1.52	.060	1.52	.060	15°	ZSB120J
			180	7.0866	34	1.3386	2.0	.080	1.0	.040	15°	220H

*Certain sizes listed in these tables may not be in current production. Check for availability.

BARDEN PRECISION BEARINGS

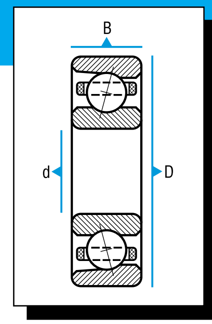
BASIC BEARING NOMENCLATURE*	ATTAINABLE SPEEDS (RPM) Oil	ATTAINABLE SPEEDS (RPM) Grease	Ball Complement No. n	Ball Complement Diam. d	Static Capacity Radial C_0 (lbs.)	Static Capacity Thrust T_0 (lbs.)	Basic Dynamic Load Rating C (lbs.)	STANDARD PRELOADS (lbs.) L (Light)	STANDARD PRELOADS (lbs.) M (Medium)	STANDARD PRELOADS (lbs.) H (Heavy)
2115H	16,200	10,200	20	1/2"	12,927	15,984	11,213	110	270	540
215H	17,300	10,700	17	11/16"	20,341	27,389	19,335	100	260	520
2215H	15,600	9,600	17	11/16"	19,660	24,520	18,391	160	410	820
1916H	17,500	11,200	27	3/8"	10,708	13,922	8,212	50	125	250
116H	16,900	10,600	20	9/16"	16,823	22,487	14,720	90	220	440
2116H	15,200	9,500	20	9/16"	16,224	20,141	13,945	140	350	700
216H	16,200	10,000	15	3/4"	21,273	29,088	20,834	120	310	620
2216H	14,600	9,000	15	3/4"	20,565	26,106	19,840	200	490	980
1917H	16,500	10,600	25	7/16"	13,330	17,442	10,441	65	160	320
117H	15,900	10,000	21	9/16"	17,835	23,638	15,109	90	230	460
117BX48	18,200	10,000	20	9/16"	11,095	23,643	11,710	—	—	—
2117H	14,300	9,000	21	9/16"	17,192	21,148	14,304	150	370	740
217H	15,300	9,400	16	25/32"	26,528	36,496	23,367	150	370	740
1918H	15,500	10,000	26	7/16"	13,969	18,210	10,623	70	170	340
118H	15,000	9,400	19	5/8"	19,773	26,484	17,176	110	280	560
2118H	13,500	8,500	19	5/8"	19,067	23,730	16,288	170	430	860
ZSB118J	17,800	12,200	28	13/32"	10,885	14,542	9,489	90	180	360
218H	14,400	8,900	15	7/8"	28,742	39,395	27,526	160	400	800
1919H	14,700	9,500	27	7/16"	14,607	18,977	10,796	70	175	350
119H	14,200	8,900	21	5/8"	22,039	29,351	18,255	120	290	580
2119H	12,800	8,000	21	5/8"	21,243	26,573	17,302	180	450	900
219H	13,700	8,400	15	31/32"	34,780	48,196	33,164	190	470	940
2319H	9,500	5,700	12	15/16"	46,372	61,255	47,266	320	800	1600
1920H	14,000	9,000	26	1/2"	18,178	27,732	13,573	90	220	440
120H	13,500	8,500	22	5/8"	23,277	30,892	18,718	130	310	620
2120H	12,100	7,600	22	5/8"	22,429	27,653	17,731	190	470	940
ZSB120J	16,000	11,000	31	13/32"	11,949	16,049	13,043	100	200	400
220H	13,000	8,000	15	1"	37,322	51,547	35,055	220	540	1080

*Certain sizes listed in these tables may not be in current production. Check for availability.

Continued on page 64

SPINDLE BEARINGS (ANGULAR CONTACT)

BORE DIAMETERS: 105mm TO 150mm



SHAFT mm	Bore Diameter d mm	Bore Diameter d inch	Outside Diameter D mm	Outside Diameter D inch	Width B mm	Width B inch	Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear mm	Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear inch	Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear (cutaway side) mm	Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear (cutaway side) inch	Standard Contact Angle	BASIC BEARING NOMENCLATURE*
105mm	105	4.1339	145	5.7087	20	.7874	1.0	.040	.60	.024	15°	1921H
			160	6.2992	26	1.0236	2.0	.080	1.0	.040	15°	121H
			160	6.2992	26	1.0236	2.0	.080	1.0	.040	25°	2121H
			190	7.4803	36	1.4173	2.0	.080	1.0	.040	15°	221H
110mm	110	4.3307	150	5.9055	20	.7874	1.0	.040	.50	.020	15°	1922H
			170	6.6929	28	1.1024	2.0	.080	1.0	.040	15°	122H
			170	6.6929	28	1.1024	2.0	.080	1.0	.040	25°	2122H
			200	7.8740	38	1.4961	2.0	.080	1.0	.040	15°	222H
			240	9.4488	50	1.9685	2.0	.080	1.0	.040	25°	2322H
120mm	120	4.7244	165	6.4961	22	.8661	1.0	.040	.60	.024	15°	1924H
			180	7.0866	28	1.1024	2.0	.080	1.0	.040	15°	124H
			180	7.0866	28	1.1024	2.0	.080	1.0	.040	25°	2124H
			180	7.0866	28	1.1024	2.0	.080	2.0	.080	15°	ZSB124J
130mm	130	5.1181	180	7.0866	24	.9449	1.5	.060	.60	.024	15°	1926H
			200	7.8740	33	1.2992	2.0	.080	1.0	.040	15°	126H
			200	7.8740	33	1.2992	2.0	.080	1.0	.040	25°	2126H
140mm	140	5.5118	190	7.4803	24	.9449	1.5	.060	1.0	.040	15°	1928H
			210	8.2677	33	1.2992	2.0	.080	1.0	.040	15°	128H
150mm	150	5.9055	210	8.2677	28	1.1024	2.0	.080	1.0	.040	15°	1930H
			225	8.8583	35	1.3780	2.2	.085	1.3	.050	15°	130H

*Certain sizes listed in these tables may not be in current production. Check for availability.

BASIC BEARING NOMENCLATURE*	ATTAINABLE SPEEDS (RPM)		Ball Complement		Static Capacity		Basic Dynamic Load Rating C (lbs.)	STANDARD PRELOADS (lbs.)		
	Oil	Grease	No. n	Diam. d	Radial C_0 (lbs.)	Thrust T_0 (lbs.)		L (Light)	M (Medium)	H (Heavy)
1921H	13,300	8,600	28	1/2"	19,703	25,641	14,150	90	230	460
121H	12,800	8,100	21	11/16"	26,652	38,175	21,635	150	360	720
2121H	11,600	7,300	21	11/16"	25,725	31,680	20,521	220	560	1,120
221H	12,400	7,600	15	1 1/16"	42,025	58,260	39,133	230	570	1,140
1922H	12,700	8,200	29	1/2"	20,523	26,636	14,372	95	240	480
122H	12,300	7,700	20	25/32"	32,338	43,319	26,629	150	390	780
2122H	11,100	6,900	20	25/32"	31,189	39,251	25,268	240	600	1,200
222H	11,800	7,300	16	1 1/16"	45,469	62,923	40,754	280	670	1,340
2322H	8,200	4,900	13	1 1/2"	66,386	88,631	63,466			
1924H	11,700	7,500	28	9/16"	24,786	32,213	17,444	120	290	580
124H	11,200	7,100	21	25/32"	34,436	45,828	27,255	170	420	840
2124H	10,100	6,400	21	25/32"	33,195	41,551	25,838	250	620	1,240
ZSB124J	13,300	9,200	32	15/32"	16,359	22,005	13,043	140	280	550
1926H	10,800	6,900	27	5/8"	29,723	38,657	20,644	150	370	740
126H	10,400	6,500	20	29/32"	43,659	58,450	34,723	230	560	1,120
2126H	9,400	5,800	20	29/32"	42,106	52,365	32,921	380	960	1,920
1928H	10,000	6,400	29	5/8"	32,138	41,571	21,408	160	390	780
128H	9,600	6,100	21	29/32"	46,391	61,763	35,584	250	620	1,240
1930H	9,300	6,000	26	3/4"	40,902	53,154	28,158	170	410	820
130H	9,000	5,700	23	29/32"	51,506	68,329	37,420	280	700	1,400

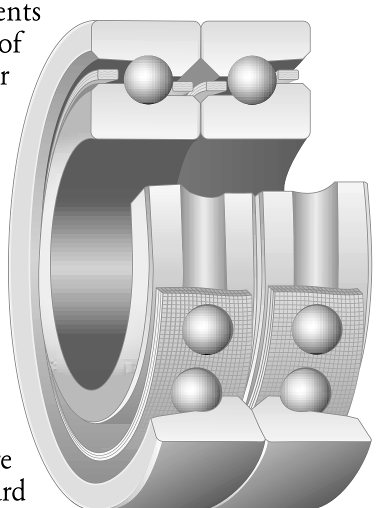
*Certain sizes listed in these tables may not be in current production. Check for availability.

BALL SCREW SUPPORT BEARINGS

ENGINEERING

DESIGN/APPLICATIONS

Series L and BSB Series ball screw support bearings are manufactured specifically for high performance ball screw applications, where extreme rigidity requirements preclude the use of standard angular contact bearings. The internal configuration has been designed to provide an optimum combination of high rigidity, low drag torque, exceptional control of lateral runout and long life.



These bearings are available in standard duplex or quadruplex sets. In addition, we will supply custom combination sets to meet specialized application needs.

LIMITING SPEEDS

Limiting speeds shown on page 70 are useful guidelines. Actual speed limits must be based on the application characteristics. Life requirements, heat transfer conditions, loading and lubrication methods are typical influential factors.

CAGES

The unique cage developed for Barden Series L ball screw support bearings is designed to enhance the speed capability and lubrication effectiveness of the bearing. Series L bearings have a land-piloted cage of reinforced phenolic, precision-machined, with evenly spaced ball pockets.

BSB Series bearings have a molded nylon, glass fiber reinforced polyamide cage with spherical ball pockets.

PRELOADS

Standard values shown on page 71 will be supplied unless otherwise specified. Barden recognizes that some applications do not require the full axial stiffness (compliance) of the standard preload and will supply bearings with custom-ground preloads if required.

MOUNTING AND FITTING

Because heavy preloads are built into Series L and BSB Series bearings, they should not be mounted using interference fits. Normal fitting practice is line-to-line to loose for both shaft and housing fits, as shown on page 71.

All bearing pairs and sets are match-marked on their outside cylindrical surfaces to indicate correct positioning of each bearing. Barden packaging also contains detailed instructions for proper installation.

Recommendations on page 71 for shaft and housing shoulder diameters are based on maximum support of duplex-mounted bearings. In circumstances with other mounting arrangements, consult Barden Product Engineering.

LIFE CALCULATIONS

Most ball screw support bearing applications are subject to duty-cycle loading with constantly changing feeds, speeds and operating loads. These factors, in combination with the heavy preloads built into the bearings, make life calculations difficult. Consult Barden Product Engineering for information which can be used in specific cases.

BEARING NOMENCLATURE

BARDEN PRECISION BEARINGS

Example: L150HX205DBTT1500 0-9

L	150	H	X205	DBTT	1500	0-9

SERIES TYPE (L)
Ball screw support bearing indicator.
L – Inch.
BSB – Metric.

BASIC SIZE (150)
Inch: Three digits indicate bore size.
Metric: Four digits show bore and O.D.

TYPE (H)
H – Angular contact bearing with counter-bored outer ring. Inch sizes only.

SPECIAL FEATURES (X205)
X205: Full ball complement.

MOUNTING (DBTT)
D – Duplex set.
U – Universal.
Q – Quad (metric).
B – Back-to-Back.
F – Face-to-Face.
FTT – Face-to-Face Quad.
BTT – Back-to-Back Quad.

PRELOAD (1500)
Expressed in pounds.
H – Heavy (metric).

LUBRICATION (0-9)
Type of prelubrication is indicated on package.
O – Indicates oil
G – Indicates grease
Number code following letter denotes specific type of lubricant. A discussion of lubricants can be found in the Engineering section, page 97.

ENGINEERING DATA SUMMARY

SERIES L AND BSB SERIES

Series L and BSB Series nonseparable angular contact bearings have cutaway shoulders on both the inner and outer rings. They can support very high thrust loads in one direction or combinations of radial and thrust loads, but not radial loading alone. Series L and BSB Series bearings are designed to provide machine tool drive systems with extreme axial rigidity, low drag torque and minimal lateral runout. They are intended for specific applications in NC machine tools, e.g., ball screw supports, tool frames, cross slides, X-Y table positioners and transfer tables. They should not be used in place of standard angular contact spindle bearings.

Configurations: Standard configuration includes a cage; some sizes are also available in a full complement version (X205 suffix). Please consult Barden.

Cages: Standard cage is a one-piece phenolic (Series L) and a nylon, glass fiber reinforced polyamide (BSB Series). Both types have circular ball pockets.

Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear: .040" (1.02 mm)

Attainable Speeds: Limits given are for DU mounted sets with standard heavy preload.

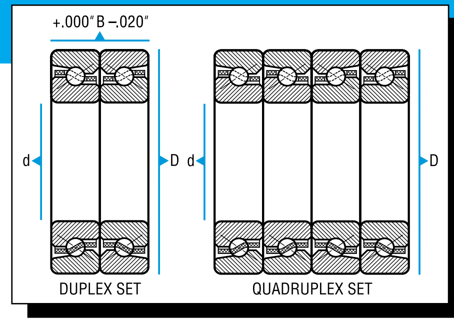
Material: SAE 52100 bearing steel is standard.

Duplexing: All bearings are universally ground D and can be mounted DU (Universal), DF (Face-to-Face), or DB (Back-to-Back), in pairs or in various combinations – three, four or more bearings as required. Standard preloads for pairs are shown on page 71. For quads, double the duplex preload.

Tolerances: Standard precision class for Series L and BSB Series is ABEC 7, except for a tighter maximum raceway runout with side (.0001").

Lubricant: Desired lubrication should be specified when ordering, based on torque, speed and temperature conditions of the application. Consult Barden. Barden strongly recommends a NLGI Class 2 grease with EP additives.

BALL SCREW SUPPORT BEARINGS



BORE DIAMETERS: 20mm TO 76.2mm

- Angular Contact, 60° and 65°
- Nonseparable
- Inch and Metric Series

	Bore Diameter d		Outside Diameter D		DUPLEX SET Width B		DUPLEX SET	ATTAINABLE SPEEDS (RPM)	
	mm	inch	mm	inch	mm	inch	Basic Bearing Nomenclature*	Oil	Grease
	20	.7874	47	1.8504	30	1.181	BSB2047DUH	6700	5000
	20	.7874	47	1.8504	31.75	1.2500	L078HDF	4000	2800
	23.838	.9385	62	2.4409	31.75	1.2500	L093HDF	2400	1680
	25	.9843	62	2.4409	30	1.181	BSB2562DUH	5000	3800
	30	1.1811	62	2.4409	30	1.181	BSB3062DUH	5000	3800
	35	1.3780	72	2.8346	30	1.181	BSB3572DUH	4300	3200
	38.1	1.5000	72	2.8346	31.75	1.2500	L150HDF	1600	1100
	38.1	1.5000	72	2.8346	31.75	1.2500	L150HX4DF	1600	1100
	40	1.5748	72	2.8346	30	1.181	BSB4072DUH	4000	3000
	44.475	1.7510	76.2	3.0000	31.75	1.2500	L175HDF	1400	1000
	57.150	2.2500	90	3.5433	31.75	1.2500	L225HDF	1200	850
	76.2	3.0000	110	4.3307	31.75	1.2500	L300HDF	800	600

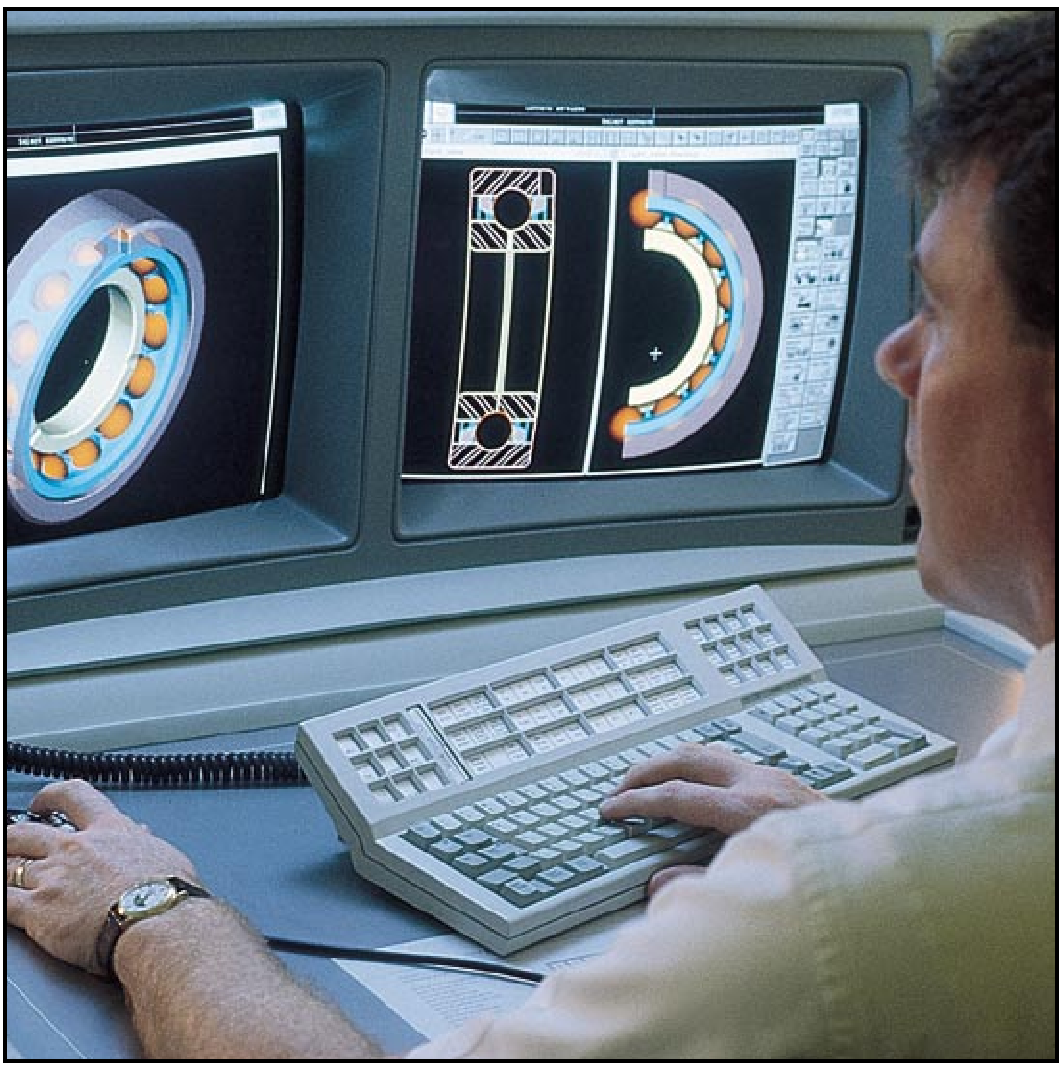
*Certain sizes listed in these tables may not be in current production. Check for availability.

BARDEN PRECISION BEARINGS

Basic Bearing Nomenclature*	Standard Preloads (lbs.)**	Shaft and Housing Shoulder Diameters (in.) ±.005"		Fitting Practice (in.) (Line-to-Line to Loose)		Axial Spring Constant (x10⁶ lbs./in.)	Drag Torque (in.– lbs.)	Dynamic Thrust Capacity (lbs.)	Static Thrust Capacity (lbs.)
		Shaft	Housing	Shaft	Housing	Duplex	Duplex	Duplex	Duplex
BSB2047DUH	500	1.065	1.520	.0004	.0005	4.28	0.44	4300	5600
L078HDF	750	1.065	1.520	.0004	.0005	5.0	2.00	3300	4700
L093HDF	1000	1.590	2.130	.0004	.0005	6.6	2.80	3850	6500
BSB2562DUH	750	1.590	2.130	.0004	.0005	5.42	0.75	6400	9300
BSB3062DUH	650	1.590	2.130	.0004	.0005	5.14	0.75	5800	8800
BSB3572DUH	750	1.880	2.430	.0004	.0005	6.0	1.02	6700	11,200
L150HDF	1500	1.880	2.430	.0004	.0005	8.4	4.00	4000	7500
L150HX4DF	1500	1.880	2.480	.0004	.0005	7.8	4.00	5500	10,000
BSB4072DUH	650	1.880	2.430	.0004	.0005	6.0	1.02	6300	11,000
L175HDF	1500	2.140	2.680	.0004	.0005	9.1	4.50	4100	8200
L225HDF	1750	2.610	3.145	.0004	.0005	11.6	6.00	4400	10,000
L300HDF	2250	3.385	3.915	.0005	.0007	14.3	8.00	4850	12,900

*Certain sizes listed in these tables may not be in current production. Check for availability.
**Duplex preloads shown. Quad set preloads are twice the value shown.

ENGINEERING



CONVERSION VALUES

MULTIPLY	BY	TO OBTAIN
Pounds	4.4488	Newtons
Newtons	.2248	Pounds
Pounds	.4536	Kilograms
Kilograms	2.2046	Pounds
Inches	25.40	Millimeters
Millimeters	.03937	Inches
Pounds/Inch^2	6894.76	Pascals
Pascals	.000145	Pounds/Inch^2
Inch Pounds	.1130	Newton Meters
Newton Meters	8.8507	Inch Pounds

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BARDEN PRECISION BEARINGS

ENGINEERING SECTION

BEARING SELECTION

SELECTING THE RIGHT BEARING

Selection of a suitable standard bearing – or the decision to utilize a special bearing – represents an effort to deal with performance requirements and operating limitations. Sometimes the task involves conflicts which must be resolved to reach a practical solution.

Making the right choice requires a careful review of all criteria in relation to available options in bearing design. Each performance requirement, such as a certain speed, torque or load rating, usually generates its own specifications which can be compared with available bearing characteristics.

When operating conditions and performance requirements have been formally established, each bearing considered should be reviewed in terms of its ability to satisfy these parameters. If a standard bearing does not meet the requirements, a design compromise will be necessary in either the assembly or the bearing.

At this point, the feasibility of a bearing design change (creation of a special bearing) should be explored with Barden's Product Engineering Department. Consideration of a special bearing should not be rejected out-of-hand, since it can pose an ideal solution to a difficult application problem.

OPERATING CONDITIONS

Operating conditions which must be considered in the selection process are listed in Table 26. This is a convenient checklist for the designer who must determine which items apply to a prospective application, their input values and often their relative importance. Performing this exercise is a useful preliminary step in determining what trade-offs are necessary to resolve the design conflicts.

Among the most important application considerations that must be evaluated are speed and load conditions.

Specific bearing design choices should be based on anticipated operating conditions. Design choices include:

- Materials (rings and balls)
- Bearing size and capacity
- Internal design parameters
- Preloading (duplexing)
- Tolerances & geometric accuracy
- Bearing type
- Closures
- Cages
- Lubrication

BEARING TYPES

Barden Precision Bearings are available in two basic design configurations: Deep groove and angular contact. Design selections between deep groove and angular contact bearings depend primarily upon application characteristics such as:

- Magnitude and direction of loading.
- Operating speed and conditions.
- Lubrication
- Requirements for accuracy and rigidity.
- Need for built-in sealing or shielding.

Some of the basic design differences are explored in the following discussion.

Table 26. Basic operating conditions which affect bearing selection.

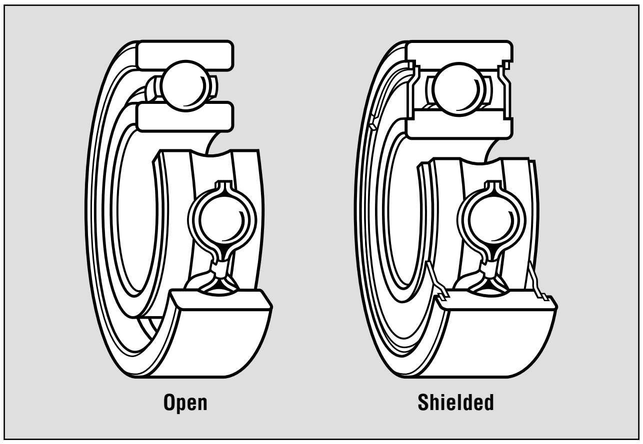
Load	Speed	Temperature	Environment	Shaft and Housing Factors
Direction • Radial • Thrust • Moment • Combined **Nature** • Acceleration (including gravity) • Elastic (belt, spring, etc.) • Vibratory Impact (shock) • Preload **Duty Cycle** • Continuous • Intermittent • Random	**Constant or Variable** **Continuous or Intermittent** **Ring Rotation** • Inner ring • Outer ring	**Average Operating** **Operating Range** **Differential between rotating and nonrotating elements** **Ambient**	**Air or other gas** **Vacuum** **Moisture (humidity)** **Contaminants**	**Metallic Material** • Ferrous • Nonferrous **Nonmetallic Material Stiffness** **Precision of Mating Parts** • Size tolerance • Roundness • Geometry • Surface finish

BARDEN PRECISION BEARINGS

Deep Groove

Deep groove ball bearings have full shoulders on both sides of the raceways of the inner and outer rings. They can accept radial loads, thrust loads in either direction, or a combination of loads.

Fig. 9. Deep groove bearing design.



The full shoulders and the cages used in deep groove bearings make them suitable for the addition of closures. Besides single deep groove bearings with closures, Barden also offers duplex pairs with seals or shields on the outboard faces.

Deep groove bearings are available in many sizes, with a variety of cage types. Because of their versatility, deep groove bearings are the most widely used type of bearing.

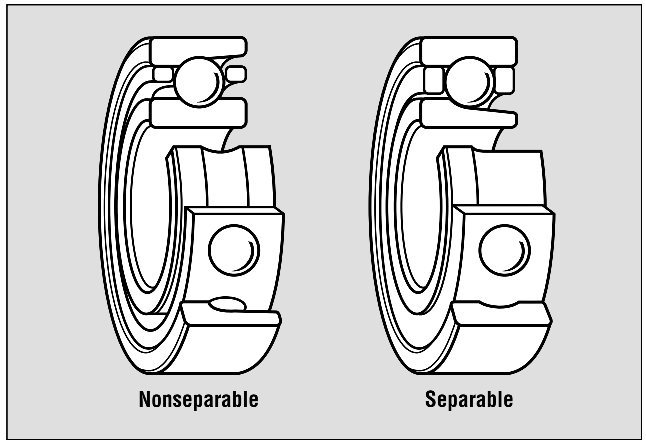
Angular Contact

Angular contact bearings have one ring shoulder partially or totally removed. This allows a larger ball complement than found in comparable deep groove bearings, hence a greater load capacity. Speed capability is also greater.

Angular contact bearings support thrust loads or combinations of radial and thrust loading. They cannot accept radial loads only –a thrust load of sufficient magnitude must be present. An individual angular contact bearing can be thrust-loaded in only one direction; this load may be a working load or a preload.

Barden spindle size angular contact bearings have a nominal contact angle of either 15° or 25°. They are most commonly used in preloaded duplex sets, either back-to-back (DB) or face-to-face (DF) so they can support thrust loads in both directions.

Fig. 10. Angular contact bearing design.



Separable and nonseparable types are available within the category of angular contact bearings. In a separable bearing (B type), the cage holds the balls in place so that the outer ring assembly (with cage and balls) can be separated from the inner ring.

Separable bearings are useful where bearings must be installed in blind holes or where press fits are required, both on the shaft and in the housing. The separable feature also permits dynamic balancing of a rotating component with inner ring in place, apart from the outer ring and housing.

BEARING SIZE

A variety of criteria will have an influence on bearing size selection for different installations, as follows:

Mating parts. One or more of the bearing dimensions may be governed by the size of a mating part (e.g. shaft, housing).

Capacity. Bearing loading, dynamic and static, will establish minimum capacity requirements and influence size selection because capacity generally increases with size.

Attainable Speeds. Smaller bearings can usually operate at higher speeds than larger bearings, hence the speed requirement of an application may affect size selection.

Stiffness. Large bearings yield less than small bearings and are the better choice where bearing stiffness is crucial.

Weight. In some cases, bearing weight may have to be considered and factored into the selection process.

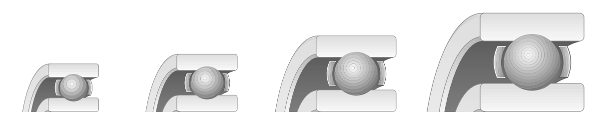
Torque. Reducing the ball size and using wider raceway curvatures are tactics which may be used to reduce torque.

BEARING SELECTION

Diameter Series

For spindle size bearings, most bore diameter sizes have a number of progressively increasing series of outside diameters, width and ball size. This allows further choice of bearing design and capacity. These series are termed Series 1900, 100, 200 and 300 and are shown in the product tables.

Fig. 11. Diameter series comparison.



BALL AND RING MATERIALS

Selection of a material for bearing rings and balls is strongly influenced by availability. Standard bearing materials have been established and are the most likely to be available without delay. For special materials, availability should be determined and these additional factors considered during the selection process:

- Hardness
- Fatigue resistance
- Dimensional stability
- Wear resistance
- Material cleanliness
- Workability
- Corrosion resistance
- Temperature resistance

For all of its ball and ring materials, Barden has established specifications which meet or exceed industry standards. Before any material is used in Barden production, mill samples are analyzed and approved. The three predominant ball and ring materials used by Barden are AISI 440C, SAE 52100 and AISI M50.

AISI 440C stainless steel is the standard material for instrument bearings. It is optional for spindle and turbine bearings. This is a hardenable, corrosion-resistant steel with adequate fatigue resistance, good load-carrying capacity, excellent stability and wear resistance. Operating temperature range is -400˚F to 300˚F for instrument bearings, -400˚F to 600˚F for spindle and turbine bearings. Applicable specifications include Federal Standard 66, QQ-S-763 and AMS 5630.

SAE 52100 chrome steel is the standard material for spindle and turbine bearings. It is also available in some instrument sizes, and may be preferable when fatigue life, static capacity and torque are critical. This material has excellent capacity, fatigue resistance and stability. Operating temperature limit is 400˚F when used in spindle and turbine bearings. Applicable specifications include Fed Std 66, QQ-S-624 and AMS 6440.

AISI M50 tool steel is suitable for operation up to 600˚F. Applicable specifications include AMS 6490 and AMS 6491.

Other nonstandard steels such as Rex 20 tool steel or Cronidur 30, a high nitrogen steel, may be specified, along with variations in heat treating and bearing processing, or special coatings. Please contact Barden Product Engineering to discuss any such special requirements.

CERAMIC HYBRIDS

Use of ceramic (silicon nitride) balls in place of steel balls can radically improve bearing performance several ways. Because ceramic balls are 60% lighter than steel balls, and because their surface finish is almost perfectly smooth, they exhibit vibration levels two to seven times lower than conventional steel ball bearings.

Ceramic hybrid bearings also run at significantly lower operating temperatures, and can allow running speeds to increase by as much as 40% to 50%. Bearings with ceramic balls have been proven to last up to five times longer than conventional steel ball bearings. Lower operating temperatures help extend lubricant life.

Spindles equipped with ceramic hybrids show higher rigidity and higher natural frequency making them less sensitive to vibration. Improved stability leads to greater accuracy, better workpiece finish characteristics, lower scrap rates and reduced downtime. Diamond cutting tool life can also be prolonged.

Because of the unique properties of silicon nitride, ceramic balls drastically reduce the predominant cause of surface wear in conventional bearings (metal rings/metal balls). In conventional bearings, microscopic surface asperities on balls and races will “cold weld” or stick together even under normal lubrication and load conditions. As the bearing rotates, the microscopic cold welds break, producing roughness and, eventually, worn contact surfaces. This “stickpull” characteristic is known as adhesive wear. Since ceramic balls will not cold weld to steel rings, wear is dramatically reduced. Because wear particles generated by adhesive wear are not present in ceramic hybrids, lubricant life is also prolonged. The savings in reduced maintenance costs alone can be significant.

Ceramic Ball Bearing Features

60% lighter than steel balls
- Centrifugal forces reduced
- Lower vibration levels
- Less heat build up
- Reduced ball skidding
- Fatigue life increased

50% higher modulus of elasticity
- Improved spindle rigidity
- Naturally fatigue resistant

Tribochemically inert
- Low adhesive wear
- Improved lubricant life
- Superior corrosion resistance

Benefits of Ceramic Ball Bearings

- Bearing service life is two to five times longer
- Running speeds up to 50% higher
- Overall accuracy and quality improves.
- Better workpiece finish characteristics
- Lower operating costs
- Boost productivity
- High temperature capability
- Cutting tool life is increased
- Electrically non-conductive

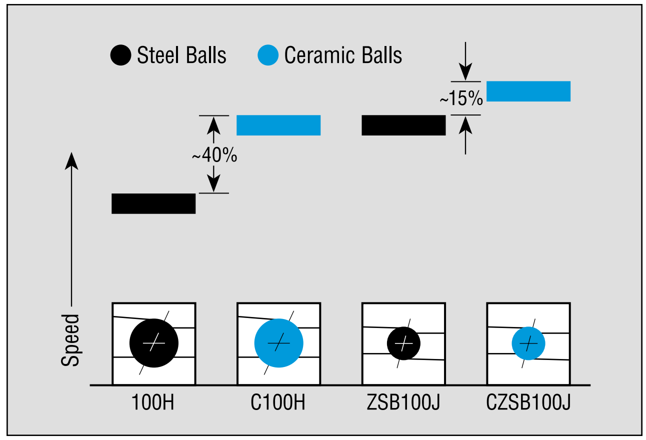


Fig. 12. *Running speed of large diameter ceramic ball exceed same-size steel ball by 40%. Converting to a small diameter ceramic ball will boost running speeds an additional 15%.*

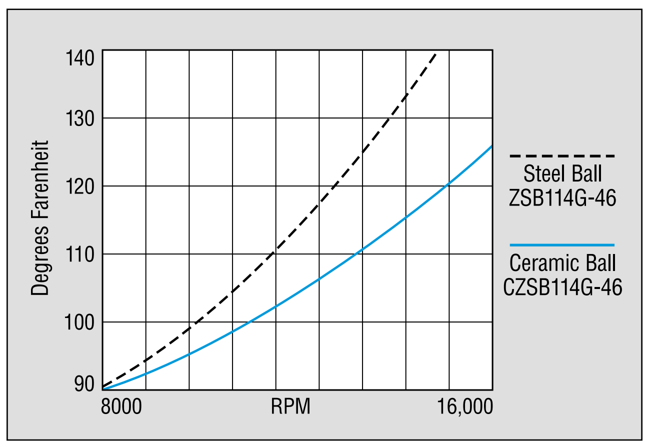


Fig. 13. *Lower operating temperature. As running speeds increase, ceramic balls always run cooler than conventional steel balls. With reduced heat build up, lubricant life is prolonged.*

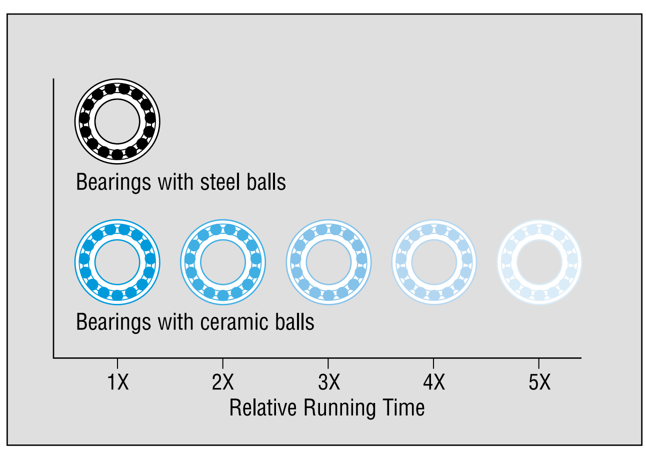


Fig. 14. *Service life (fatigue life) of ceramic hybrid bearings is two to five times that of conventional steel ball bearings, depending upon operating conditions.*

BEARING SELECTION

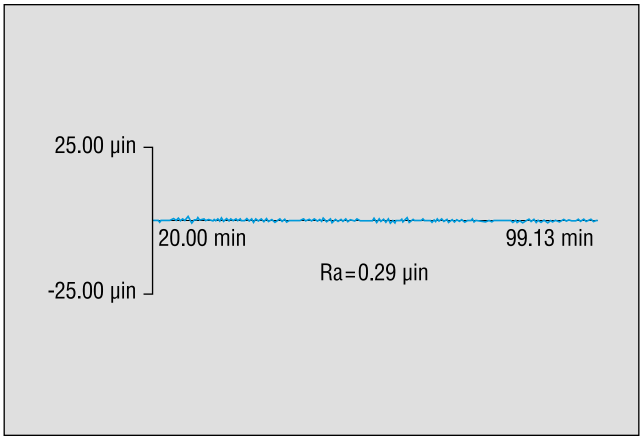


Fig. 15. *Surface finish of a silicon nitride ceramic ball, as expressed in this Form Talysurf trace, reveals a surface that is almost perfectly smooth.*

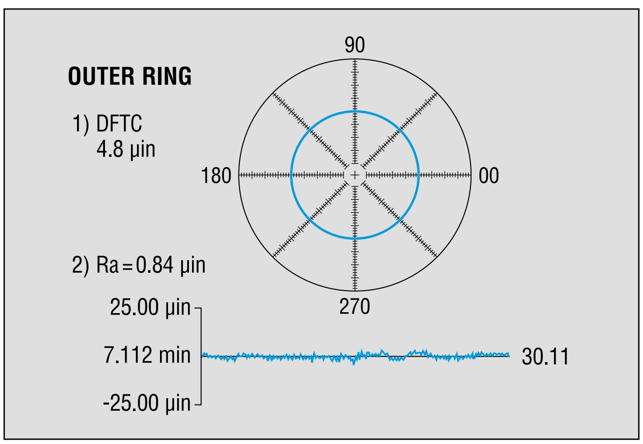


Fig. 16. *Workpiece surface finish/geometry. Ceramic hybrids improve spindle rigidity resulting in greater accuracy and enhanced workpiece finish characteristics. For Talysurf traces show high degree of precision in finished parts.*

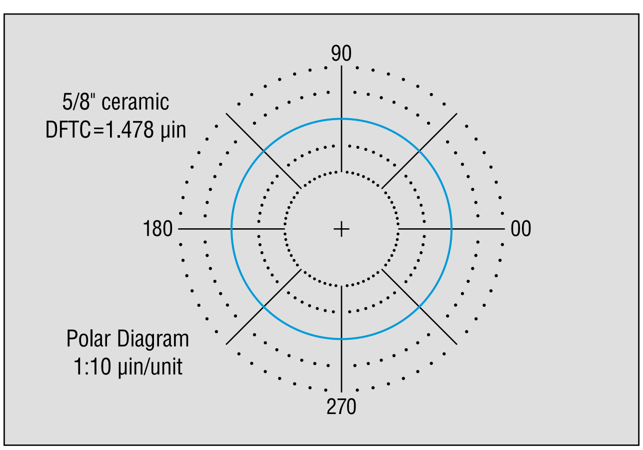


Fig. 17. *Deviation from true circularity (DFTC). Polar trace of a 5/8" silicon nitride ball indicates near perfect roundness, which results in dramatically lower vibration levels.*

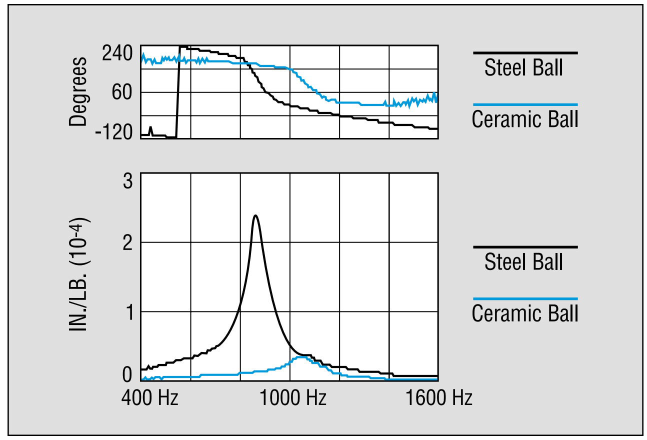


Fig. 18. *Dynamic stiffness analysis performed before/after grinding spindle rebuilding shows higher rigidity and higher natural frequency for hybrid bearings.*

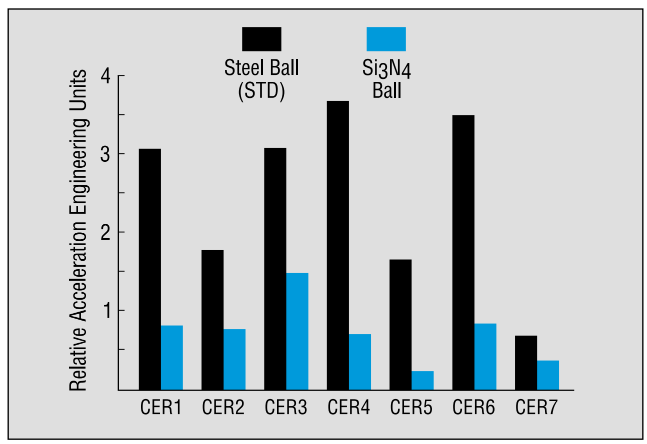


Fig. 19. *Vibration tests comparing spindles with steel ball bearings and the same spindle retrofit with ceramic hybrids. Vibration levels averaged two to seven times lower with silicon nitride balls.*

Comparison of Bearing Steel & Silicon Nitride Properties

Property	Steel	Ceramic
Density (g/cm³)	7.8	3.2
Elastic Modulus (10^6 psi)	30	45
Hardness	R_c60	R_c78
Coefficient of thermal expansion ($X10^{-6}$/°F)	6.7	1.7
Coefficient of friction	0.42 dry	0.17 dry
Poisson's ratio	0.3	0.26
Maximum use temperature (°F)	620	2,000
Chemically inert	No	Yes
Electrically non-conductive	No	Yes
Non-magnetic	No	Yes

Fig. 20. *Ceramic balls are lighter and harder than steel balls, characteristics which improve overall bearing performance.*

BEARING CAPACITY

Three different capacity values are listed in the product section for each ball bearing. They are:

- C – Basic dynamic load rating.
- C_O – Static radial capacity.
- T_O – Static thrust capacity.

All of these values are dependent upon the number and size of balls, contact angle, cross race curvature and material.

Basic dynamic load rating, C, is based on fatigue capacity of the bearing components. The word dynamic denotes rotation of the inner ring while a stationary radial load is applied. The C value is used to calculate bearing fatigue life in the equation:

$$L_{10} = \left(\frac{C}{P}\right)^3 \times 10^6 \text{ revolutions.}$$

L_{10} = Minimum fatigue life in revolutions for 90% of a typical group of apparently identical bearings.

P = Equivalent radial load.

Static radial capacity is based on ball-to-race contact stress developed by a radial load with both bearing races stationary. The static radial capacity, C_O of instrument bearings is the maximum radial load that can be imposed on a bearing without changing its performance characteristics, torque or vibration. It is based upon calculated stress values, assuming a maximum contact stress of 508,000 psi (3.5 GPa maximum stress). C_O values for spindle and turbine bearings are based on a maximum contact stress of 609,000 psi (4.2 GPa maximum stress).

Static thrust capacity, T_O, is rated similarly to C_O, with thrust loading developing the stress. The same mean and maximum stress levels apply.

In both radial and thrust loading, the stress developed between ball and raceway causes the point of contact to assume an elliptical shape. Theoretically, this contact ellipse should be contained within the solid raceway. Thus, thrust capacity is ordinarily a function of either the maximum allowable stress or the maximum force that generates a contact ellipse whose periphery just reaches the raceway edge. However, for lightly loaded, shallow raceway bearings, the maximum load may be reached at very low stress levels. Testing has shown that, for such bearings, a minor extension of the contact ellipse past the raceway edge may be allowed without a loss in bearing performance.

During the bearing selection process, there may be several candidate bearings which meet all design requirements but vary in capacity. As a general rule, the bearing with the highest capacity will have the longest service life.

BEARING CAGES

Proper selection of cage design and materials is essential to the successful performance of a precision ball bearing. The basic purpose of a cage is to maintain uniform ball spacing, but it can also be designed to reduce torque and minimize heat build-up.

In separable bearings, the cage is designed to retain the balls in the outer ring so the rings can be handled separately.

Cage loading is normally light but various acceleration and centrifugal forces may develop and impose cage loading. Also, it may be important for the cage to accommodate varying ball speeds that occur in certain applications.

Cages are piloted (guided) by the balls or one of the rings. Typically, low to moderate speed cages are ball-piloted. Most high-speed cages have machined surfaces and are piloted by the land of either the inner or outer ring.

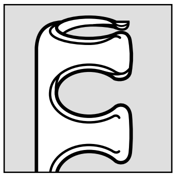
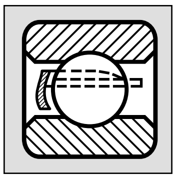
Barden deep groove and angular contact bearings are available with several different types of cages to suit a variety of applications. Many factors enter into cage design and cage selection, including:

- Low coefficient of friction with ball and race materials
- Compatible expansion rate with ball/ring materials
- Low tendency to gall or wear
- Ability to absorb lubricant
- Dimensional stability
- Thermal stability
- Suitable density
- Adequate tensile strength
- Creep resistance
- Cost

This list can be expanded to match the complexity of any bearing application. As a general guide, the information on pages 82–84 may be used by the designer to determine cage selection. It presents basic data in a tabulated format for review and comparison.

BEARING SELECTION
Deep Groove Bearing Cages

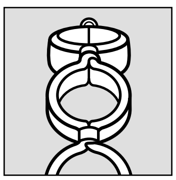
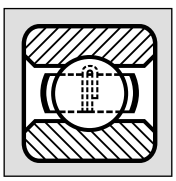
Maximum speed limits shown are for cage comparison purposes only.
See the product section for actual bearing speedability.

Type: Snap-In

Description: Material: Stainless Steel AISI 410. One-piece, stamped, with coined ball pockets and polished surfaces. Side entry snap-in assembly. Inner ring land controlled.

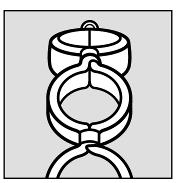
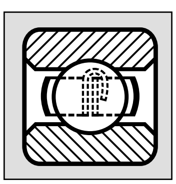
Application: A general purpose cage available only in instrument sizes. Maximum ball size: 3/32". Maximum operating temperature of cage material: 600˚F. Maximum speed with oil or grease: 250,000 dN.

Type: Two-Piece Ribbon

Description: Material: Stainless Steel AISI 430 or AISI 305. Two-piece, stamped ribbons to form ball pockets.

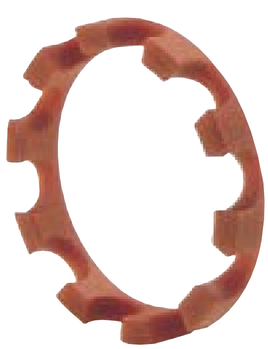
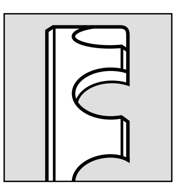
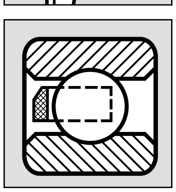
Application: A general purpose cage for bearings with 5mm or greater bores. Available for many instrument sizes and certain spindle and turbine sizes. Depending on the size, assembly of the cage halves is accomplished by tightly clinching tabs on one of the halves or by rivets. Maximum operating temperature of the cage material: 900˚. Maximum speed with oil or grease: 250,000 dN.

Type: W

Description: Material: Stainless Steel AISI 430 or AISI 305. Two-piece stamped ribbons to form ball pockets with loosely clinched tabs.

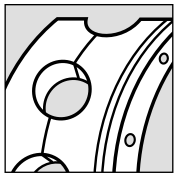
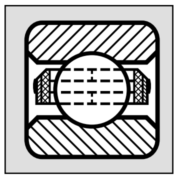
Application: The W cage is similar to the two-piece ribbon cage, but with one important difference: the cage halves are loosely clinched. The loose clinching prevents cage windup (a torque increasing drawback of some cage designs) in sensitive low torque applications. Available in instrument sizes up to R8. Maximum operating temperature of cage material: 900˚F. Maximum speed with oil or grease: 250,000 dN.

Type: TA

Description: A one-piece, side entry snap-in type machined from fiber reinforced phenolic.

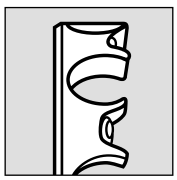
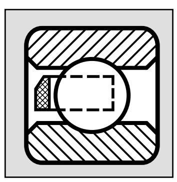
Application: A general purpose high-speed cage available in instrument sizes (1/32" ball minimum) and smaller spindle and turbine sizes. Maximum operating temperature of cage material: 300˚F. Maximum speed with oil or grease: 600,000 dN.

Type: T

Description: Machined from sheets of phenolic/aluminum laminate. Aluminum reinforcement bonded to the outboard faces – a Barden first – provides strength for high speed operation. Cage halves riveted at assembly.

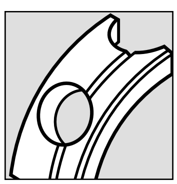
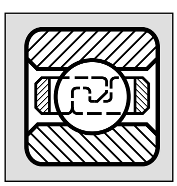
Application: General purpose, high-speed cage available in most deep groove sizes with ball size of ≥3/32". T cage has highest speed rating (dN) of any non-metallic deep groove cage. Aluminum reinforcement provides additional strength and allows cage to be used in most standard width sealed or shielded bearings. Max. speed with oil: 1,000,000 dN: with grease: 650,000 dN. Max. operating temp.: 300˚F.

Type: TMT

Description: A one-piece, snap-in design molded of Nylon 6/6 with spherical ball pockets.

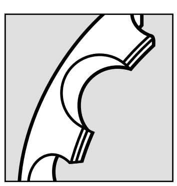
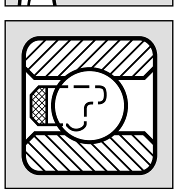
Application: A general purpose, moderate-speed cage available in a wide range of spindle and turbine sizes (100, 200, 300 series). Maximum operating temperature: 300˚F. Maximum speed with oil or grease: 300,000 dN.

Type: TST Two-piece, snap together

Description: A unique design utilizing two machined phenolic halves which lock together at assembly to form a symmetric cage.

Application: A general purpose, high-speed cage similar to the T cage but without the aluminum side plates and rivets. Available in spindle and turbine sizes (30, 100, 200, 300 series). Maximum speed 750,000 dN with oil, 600,000 dN with grease for larger sizes. Consult Barden for dN values on smaller sizes. Maximum operating temperature: 300˚F.

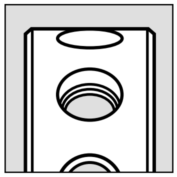
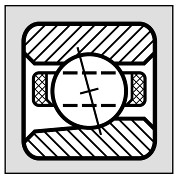
Type: TAT

Description: A one-piece, side entry snap-in type, machined from fiber reinforced phenolic. Inner ring controlled.

Application: A general purpose, moderate-to-high speed cage available in spindle and turbine sizes (100 & 200 series). Maximum operating temperature of cage material: 300˚F. Maximum speed with oil or grease: 400,000 dN.

BEARING SELECTION
Angular Contact Bearing Cages

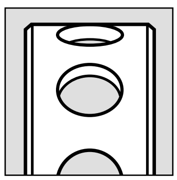
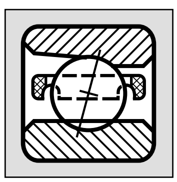
Maximum speed limits shown are for cage comparison purposes only.
See the product section for actual bearing speedability.

Type: B (Symbol for bearing type. No symbol is used in nomenclature for standard cage.)

Description: Material: Fiber reinforced phenolic. A one-piece machined cage whose ball pockets are designed to retain the balls with the outer ring if the separable inner ring is removed.

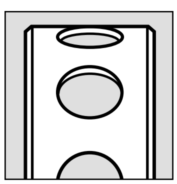
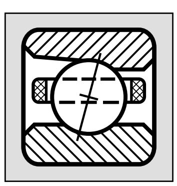
Application: High-speed, general purpose. Outer ring controlled except for R2B size. Available in instrument sizes and certain spindle and turbine sizes. Maximum operating temperature: 300˚F. Maximum speed: 1,200,000 dN with oil, 850,000 dN with grease.

Type: H (Symbol for bearing type. No symbol is used in nomenclature for standard cage.)

Description: Material: Fiber reinforced phenolic. A one-piece machined cage with cylindrical ball pockets.

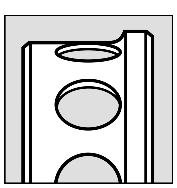
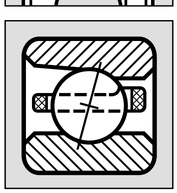
Application: High-speed, general purpose cage available in instrument sizes and in all spindle and turbine sizes. In spindle sizes above 104H and 204H, these cages have a unique feature which greatly improves cage stability. This patented design (U.S. Patent #3,685,877) features two grooves in the cage bore, each one parallel to the cage faces and intersecting the outer edge of the ball pockets. maximum operating temperature: 300˚F. Maximum speed: 1,200,000 dN with oil, 850,000 dN with grease.

Type: JB

Description: Material: 80-10-10 bronze. One piece, machined with cylindrical ball pockets. Outer ring controlled.

Application: For high-speed, high-temperature, thrust loaded applications where continuous oil lubrication is provided. Grease lubrication is not recommended. This design calls for minimum lubrication conditions such as oil mist. Synthetic oils will stain this material. Maximum temperature: 625˚F. Maximum velocity with oil lubrication: 1,500,000 dN. Usually allows more balls than JH type.

Type: JH

Description: Material: 80-10-10 bronze. One piece, machined with cylindrical ball pockets. Outer ring controlled. Can be used in H, B, and J type bearings.

Application: For high-speed, high-temperature, applications where continuous oil lubrication is provided. Grease lubrication is not recommended. This differs from the JB type, in that the cage, although outer ring controlled, rides at the ball pitch circle. Depending on the application, the sturdier JH type may be more durable than JB. Synthetic oils will stain this material. Maximum operating temperature: 625˚F. Maximum speed with oil lubrication: 1,500,000 dN.

When a standard cage does not meet the end use requirements, the Barden Product Engineering Department should be consulted. Barden has developed and manufactured many specialized cages for unusual applications. Some examples of conditions which merit engineering review are ultra-high-speed operation, a need for extra oil absorption, extreme environments and critical low torque situations. Materials as diverse as silver-plated steel, bronze alloys and porous plastics have been used by Barden to create custom cage specifications for such conditions.

Deep Groove Bearing Cages

The principal cage designs for Barden deep-groove bearings are side entrance snap-in types (TA, TAT, TMT) and symmetrical types (Ribbon, W, T, TST). Ribbon and W types are used at moderate speeds and are particularly suited for bearings with grease lubrication and seals or shields. W-type is a low-torque pressed metal cage developed by Barden, and is available in many instrument sizes. This two-piece ribbon cage is loosely clinched to prevent cage windup (a torque increasing drawback of some cage designs) in sensitive low-torque applications.

For higher speeds, Barden offers the one-piece phenolic snap-in TA-type cage in smaller bearing sizes and the two-piece riveted phenolic, aluminum-reinforced T cage for larger sizes. The aluminum reinforcement, another Barden first, provides additional strength, allowing this high-speed cage to be used in most standard width sealed or shielded bearings.

Angular Contact Bearing Cages

In Barden angular contact bearings, (types B and H), machined phenolic cages with high-speed capability are standard. These cages are outer ring land guided, which allows lubricant access to the most desired point-the inner ring/ball contact area. Centrifugal force carries lubricant outward during operation to reach the other areas of need.

The larger H-type phenolic cage has a grooved bore to enhance dynamic cage stability. The B-type cage used in separable bearings has ball pockets which hold the balls in place when the inner ring is removed.

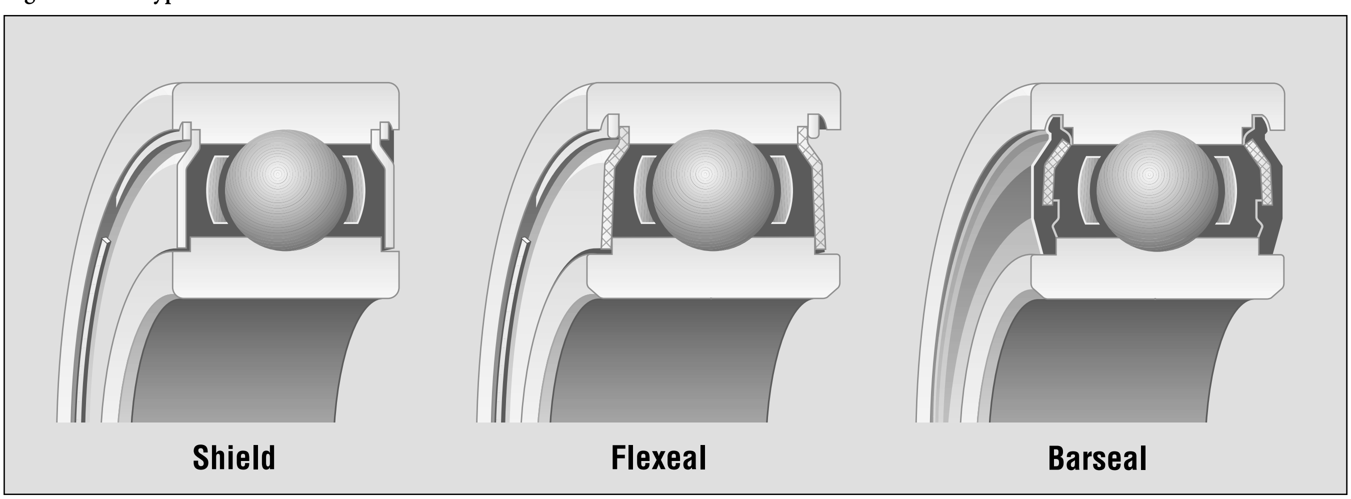
BEARING CLOSURES

The two basic types of bearing closures are shields and seals, both of which may be ordered as integral components of deep groove bearings. The standard angular contact bearing design is not easily adaptable to integral closures. The small-ball angular contact series (ZSB) is available with shields in several sizes.

All closures serve the same purposes with varying effectiveness. They exclude contamination, contain lubricants and protect the bearing from internal damage during handling.

Closures are attached to the outer ring. If they contact the inner ring, they are seals. If they clear the inner ring, they are shields. Seals and shields in Barden bearings are designed so that the stringent precision tolerances are not affected by the closures. They are available in large precision spindle and turbine bearings as well as in Barden instrument bearings.

Fig. 21. Three types of Barden closures.



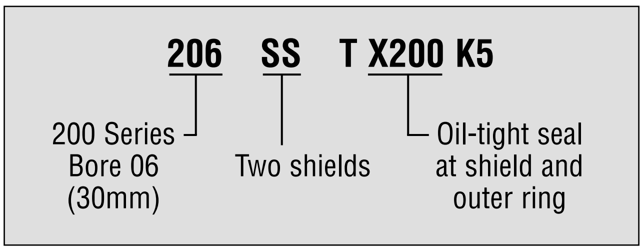
Closures Nomenclature

In the Barden nomenclature, closures are designated by suffix letters:

- F – (Flexeal™)
- A – (Barshield™)
- U – (Synchroseal™)
- S – (Shield)
- Y, V, P – (Barseal™)

Usually two closures are used in a bearing, so the callout is a double letter e.g. "FF", "SS" etc. The closure callout follows the series-size and bearing type.

Example:



Selection of Closures

Determining the proper closure for an application involves a tradeoff, usually balancing sealing efficiency against speed capability and bearing torque.

Shields do not raise bearing torque or limit speeds, but they have low sealing efficiency. Seals are more efficient, but they may restrict operating speed and increase torque and temperature.

Another consideration in closure selection is air flow through the bearing which is detrimental because it carries contamination into the bearing and dries out the lubricant. Seals should be used if air flow is present.

Shields are precision-stamped 302 stainless steel in a dished shape to provide rigidity, resistance to resonant vibration and maximum lubricant space within the bearing.

- Designated by SS or S suffix in nomenclature
- Bearing torque/performance not affected since shield does not contact inner ring
- Good contamination protection/lubricant retention
- Speed not limited by shields
- Temperature limit of shield material is 600° F
- Available with oil tight seal between outer ring and shield where there is outer ring rotation. Specify X200.
- Available in practically all sizes of deep groove bearings and certain ZSB series angular contact bearings.

Inner ring notches are provided where space permits, to present a difficult entry path for contaminants. Where the face width is insufficient for notching, the shield extends nearly to the inner ring maintaining a closely controlled clearance above the inner ring land.

Barshield™ (not shown) is a composite shield made of molded rubber with a metal stiffener. It is positioned closer to the inner ring than conventional shields, thus offering increased protection from contaminants while inhibiting lubricant migration.

- Designated by AA or A suffix in nomenclature.
- Temperature range is -30°F to 225°F.
- Speed not limited by Barshield.
- Also provides a seal against lube migration at outer ring where there is outer ring rotation

Flexeal™ is a Barden-developed seal with a layer of fiber bonded to a precision aluminum stamping. The fiber is prelubricated to produce extremely low friction at the ground sealing notch.

Flexeal seals are recommended for applications where contamination is generated near the bearing (e.g. commutators or similar mechanisms which produce minute dirt particles) or in instruments which must operate in a contaminated environment.

- Designated by FF or F suffix in nomenclature
- Light rubbing contact on inner ring precision ground notch
- Design provides excellent exclusion of contaminants with minimum torque but does not provide a positive seal to the flow of air or liquids
- Precision stamped from an aluminum/fiber laminate
- Resistant to aircraft hydraulic fluids
- Recommended limiting speed 650,000 dN*
- Temperature limit 300° F continuous, 350° F for short periods
- Wide availability in deep groove sizes

*dN = Bearing bore in mm × rpm.

BARDEN PRECISION BEARINGS

Barseal™ is a composite seal consisting of molded rubber with metal stiffener. It offers optimum sealing and is designed to contact the inner ring intimately under all loading conditions. The inner ring seal riding surfaces are ground for better sealing, lower torque and longer life.

Barseal seals are recommended where applications require the most positive type of integral contact sealing. They are also best-suited for situations with air flow problems because external air pressure increases the seal/ring contact pressure. Barseal running torque is slightly higher than that of Flexeal seals.

- Molded rubber seal with metal stiffener
- Available in three different compounds providing a range of high temperature limits
- Provides best sealing from contamination – more positive than Flexeal
- Sealing remains positive on both inner ring precision ground sealing notches even with high thrust loads
- Also provides a seal to prevent lube migration at outer ring where there is outer ring rotation
- Recommended limiting speed 180,000 dN*
- Available in most 200 & 9200 series.

Buna-N-Barseal™

- Designated by YY or Y suffix in nomenclature
- Temperature limit: 225˚F

Polyacrylic Barseal™

- Designated by PP or P suffix in nomenclature
- Temperature limit: 265˚F

Viton™ Barseal™

- Designated by VV or V suffix in nomenclature
- Temperature limit: 400˚ F

Synchroseal™ is a specialized seal suitable for low torque applications.

- Designated by suffix UU or U in nomenclature
- Light rubbing contact on inner ring seal notch provides good contamination protection but not a positive seal to flow of air or liquids
- Material is Teflon filled fiber glass
- Very low torque – lower than Flexeal or Barseal
- Speed limit 100,000 dN*
- Temperature limit 600˚ F
- Contact Barden for availability

*dN = Bearing bore in mm × rpm.

ATTAINABLE SPEEDS

Attainable speed is defined as the speed at which the internally generated temperature in a mounted bearing reaches the lowest of the maximum temperatures permissible for any one of its components, including the lubricant.

Attainable speeds shown in the Product Tables are values influenced by bearing design and size; cage design and material; lubricant type, quantity and characteristics; type of lubrication system; load; alignment and mounting. With so many interactive factors, it is difficult to establish a definitive speed limit. The listed values in this catalog represent informed judgments based on Barden experience.

Each listed attainable speed limit assumes the existence of proper mounting, preloading and lubrication. For an oil-lubricated bearing, an adequate oil jet or air/oil mist lubrication system should be used. For a grease-lubricated bearing, the proper type and quantity of grease should be used (see pages 97–100). When the actual operating speed approaches the calculated limiting speed, Barden Product Engineering should be contacted for a thorough application review.

Mounting and operating conditions which are less than ideal will reduce the published speed limits. Limiting speed factors for spindle and turbine bearings with phenolic cages are shown in Tables 27 and 28. They may be used to modify listed values to reflect various application conditions. For example, changing the lubricant from oil to grease increases bearing temperature due to lubricant "shear" and reduces the maximum speed. Increasing spindle stiffness by replacing a spring preload with a rigid preload such as axial adjustment also reduces the speed potential.

LIMITING SPEED FACTORS

Tables 27 and 28 apply only to spindle and turbine bearings with phenolic cages. Applicable series: 1900, 100, 200, 300, 9000, and ZSB, deep groove and angular contact. These factors are applied to limiting speeds shown in the Product Section.

Example: An existing application has a spindle running at 6000 RPM using 111HDM angular contact bearings, grease lubricated. Mounting arrangement is two DB mounted sets with medium preload, one end fixed, the other end floating. Can speed be increased and still maintain grease lubrication? And if so, to what value?

Step 1: Obtain grease-lubricated base attainable speed from product table, page 61..........15,400 RPM

Step 2: Multiply by factor for medium DB preload from Table 27 ....0.60

Answer: Modified speed................................9,240 RPM
Therefore, spindle speed can be increased to approximately 9,240 RPM.

Example: Find limiting speed for a duplex pair of 206 deep groove bearings with Flexeals, grease lubrication and medium DB preload (Bearing Set #206FT5DBM G-6).

Step 1: Obtain grease-lubricated base limiting speed from product table, page 39: . . . . .21,500 rpm

Step 2: Multiply by factor for medium DB preload from Table 28: 0.66

Answer: Modified limiting speed: . . . . . . .14,190 rpm

Speedability Factor dN

In addition to rpm ratings, ball bearings may also have their speed limitations or capabilities expressed in dN values, with dN being:

dN = bearing bore in mm multiplied by speed in rpm.

This term is a simple means of indicating the speed limit for a bearing equipped with a particular cage and lubricant. For instance, angular contact bearings which are grease-lubricated and spring-loaded should be limited to approximately 850,000 dN. Deep groove bearings with metal cages should not exceed approximately 250,000 dN, regardless of lubricant.

Table 27. Speed factors for use with *angular contact* bearings.

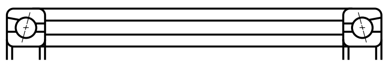
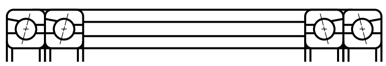
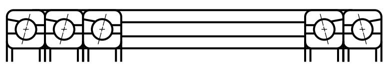
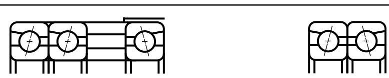
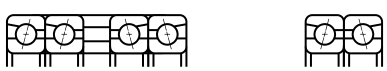
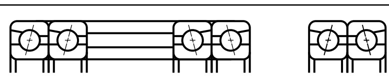
Speed Factor Bearing Arrangement	Bearing Preload		
Solid Preload	**Light**	**Med.**	**Heavy**
	0.85	0.75	0.50
	0.80	0.70	0.50
	0.75	0.65	0.45
Fixed End **Floating End**			
	0.75	0.60	0.35
	0.65	0.50	0.30
	0.65	0.50	0.30
	0.68	0.53	0.33
	0.65	0.50	0.30
	0.72	0.57	0.37

Table 28. Speed factors for use with *deep groove* bearings with T cage and shields or Flexeals.

Lubrication	**Grease**		
Spring Load or Preload*	**L (Light)**	**M (Medium)**	**H (Heavy)**
Single Bearings (Spring Loaded)	**	1.0	—
Duplex Pairs			
DB	0.75	0.60	0.35
DF	0.65	0.50	0.30
Tandem Pairs (Spring Loaded)	**	0.90	—

*For L, M and H values, see Table 29, page 96.

**Spring-loaded bearings require preloads heavier than L at limiting speeds.

INTERNAL DESIGN PARAMETERS

The principal internal design parameters for a ball bearing are the ball complement (number and size of balls), internal clearances (radial play, axial play and contact angle), and raceway curvature.

Ball Complement

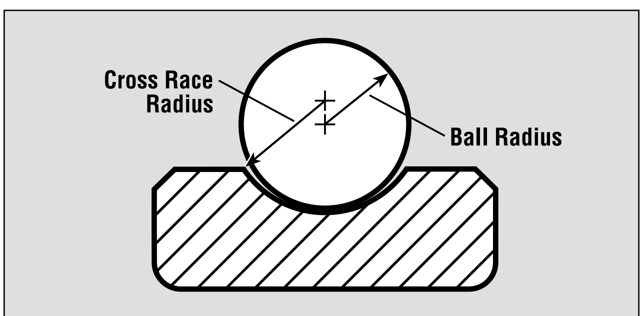
The number and size of balls are generally selected to give maximum capacity in the available space. In some specialized cases, the ball complement may be chosen on a basis of minimum torque, speed considerations or rigidity.

With some applications, you may have a choice of ball complement. The small ball feature of ZSB Series bearings results in bearings with a greater number of balls, thus increasing bearing stiffness. Outer ring and inner ring mounting diameters and width do not change from the equivalent standard ball bearing.

Raceway Curvature

The raceway groove in the inner and outer rings has a cross race radius which is slightly greater than the ball radius (see Fig. 22). This is a deliberate design feature which provides optimum contact area between balls and raceway, to achieve the desired combination of high load capacity and low torque.

Fig. 22. Raceway curvature.

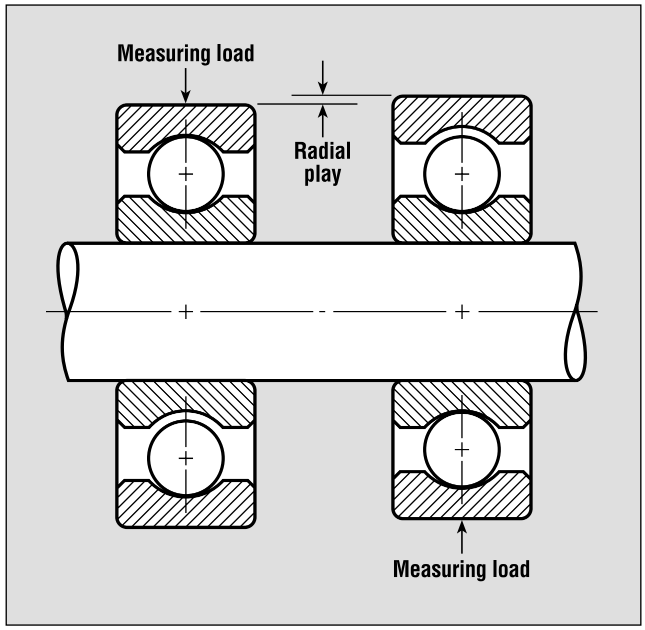


Radial Internal Clearance

Commonly referred to as radial play, this is the maximum possible movement, perpendicular to the bearing axis, of the inner ring in relation to the outer ring (see Fig. 23).

Radial internal clearance is measured under a light reversing radial load and corrected to zero load, to establish radial play values. Although often overlooked by designers, radial play is one of the most important basic bearing specifications. The presence and magnitude of radial play are vital factors in bearing performance.

Fig. 23. Radial internal clearance.



Without sufficient radial play, interference fits (press fits) and normal expansion of components cannot be accommodated, causing binding and early failure.

Radial internal clearance of the mounted bearing has a profound effect on the contact angle, which in turn influence bearing capacity, life and other performance characteristics. Proper internal clearance will provide a suitable contact angle to support thrust loads or to meet exacting requirements of elastic yield.

High operating speeds create heat through friction and require greater than usual radial play. Higher values of radial play are also beneficial where thrust loads predominate, to increase load capacity, life and axial rigidity. Low values of radial play are better suited for predominantly radial support.

Deep groove bearings are available from Barden in a range of radial play groups. Each group is expressed as a Radial Play Code, representing limits to the range of radial internal clearance. The code number is used in bearing identification as shown in the Nomenclature explanations (see overleaf pages in each bearing product section).

The available radial play groups are listed in the appropriate tables in each product section. Radial play values give the designer wide latitude in the selection of proper radial internal clearance. Such ranges have nothing to do with ABEC tolerances or precision classes, hence a bearing with a high value of radial play does not necessarily have lower quality or less precision.

Specifying a radial code must take into account the installation practice. If a bearing is press-fitted onto a shaft or into a housing, its radial internal clearance is reduced by approximately 80% of the interference fit. Thus, an interference fit of .00025" would cause a .0002" decrease in internal clearance.

Deep groove bearings with Code 3 and Code 5 radial play are more readily available than those with other codes. When performance requirements exceed the standard radial play codes, consult the Barden Product Engineering Department. Special ranges of internal clearance can be supplied, but should be avoided unless there is a technical justification.

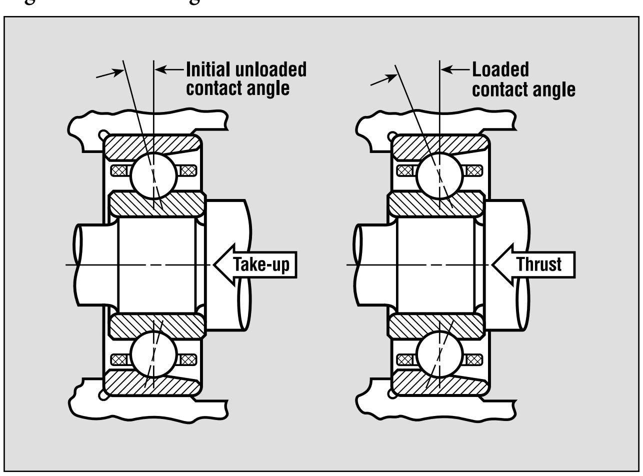
Angular contact bearings make use of radial play, combined with thrust loading, to develop their primary characteristic –an angular line of contact between the balls and both races.

Contact Angle

Contact angle is the nominal angle between the ball-to race contact line and a plane through the ball centers, perpendicular to the bearing axis (see Fig. 24). It may be expressed in terms of zero load or applied thrust load. The unloaded contact angle is established after axial takeup of the bearing but before imposition of the working thrust load. The loaded contact angle is greater, reflecting the influence of the applied thrust load. Each radial play code for Barden deep groove bearings has a calculable corresponding contact angle value.

Angular contact bearings, on the other hand, are

Fig. 24. Contact angle.



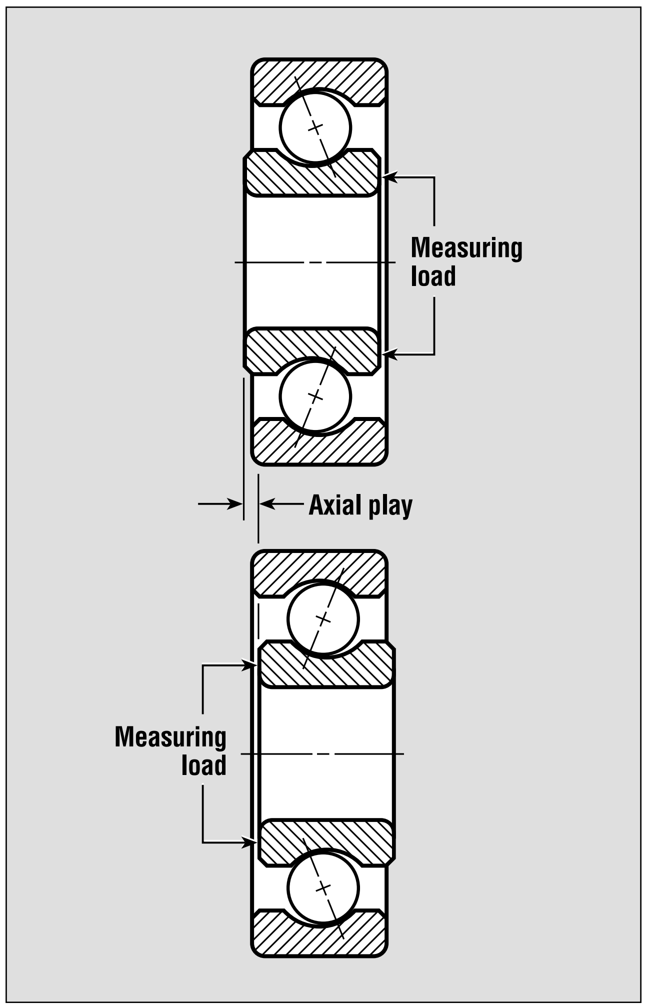
assembled to a constant contact angle by varying the radial clearance. Spindle size Barden angular contact bearings have nominal contact angles of either 15° or 25°. The smaller angle delivers better radial capacity and rigidity, the larger angle is better for axial rigidity.

Axial Play

Axial play, commonly called end play, is the maximum possible movement, parallel to the bearing axis, of the inner ring in relation to the outer ring (see Fig. 25). It is measured under a light reversing axial load.

End play is a function of radial internal clearance, thus the end play values given in the product section are expressed for various radial play codes of deep groove bearings.

Fig. 25. Axial play.



PRELOADING

Preloading is the removal of internal clearance in a bearing by applying a permanent thrust load to it. Preloading:

- Eliminates radial and axial play.
- Increases system rigidity.
- Reduces nonrepetitive runout.
- Lessens the difference in contact angles between the balls and both inner and outer rings at very high speeds
- Prevents ball skidding under very high acceleration.

Bearing Yield

Axial yield is the axial deflection between inner and outer rings after end play is removed and a working load or preload is applied. It results from elastic deformation of balls and raceways under thrust loading.

Radial yield, similarly, is the radial deflection caused by radial loading. Both types of yield are governed by the internal design of the bearing, the contact angle and load characteristics (magnitude and direction).

When a thrust load is applied to a bearing, the unloaded point-to-point contacts of balls and raceways broaden into elliptical contact areas as balls and raceways are stressed. All balls share this thrust load equally.

The radial yield of a loaded angular contact bearing is considerably less than the axial yield, as shown by the graphs on page 93. Radial loading tends to force the balls on the loaded side of the bearing toward the bottom of both inner and outer raceways – a relatively small displacement. Thrust loading tends to make the balls climb the sides of both raceways with a wedging action. Combined with the contact angle, this causes greater displacement than under radial loading.

Zero load is the point at which only sufficient takeup has been applied to remove radial and axial play. The nonlinear yield curves indicate diminishing yield rates as loads increase. This is because larger contact areas are developed between the balls and raceways. If the high initial deflections are eliminated, further yield under applied external loads is reduced. This can be achieved by axial preloading of bearing pairs.

Not only are yields of preloaded pairs lower, but their yield rates are essentially constant over a substantial range of external loading, up to approximately three times the rigid preload, at which point one of the bearings unloads completely.

Specific yield characteristics may be achieved by specifying matched preloaded pairs or by opposed mounting of two bearings. Consult Barden Product Engineering for yield rate information for individual cases.

Preloading Techniques

Bearings should be preloaded as lightly as is necessary to achieve the desired results. This avoids excessive heat generation, which reduces speed capability and bearing life. There are three basic methods of preloading: springs, axial adjustment and duplex bearings.

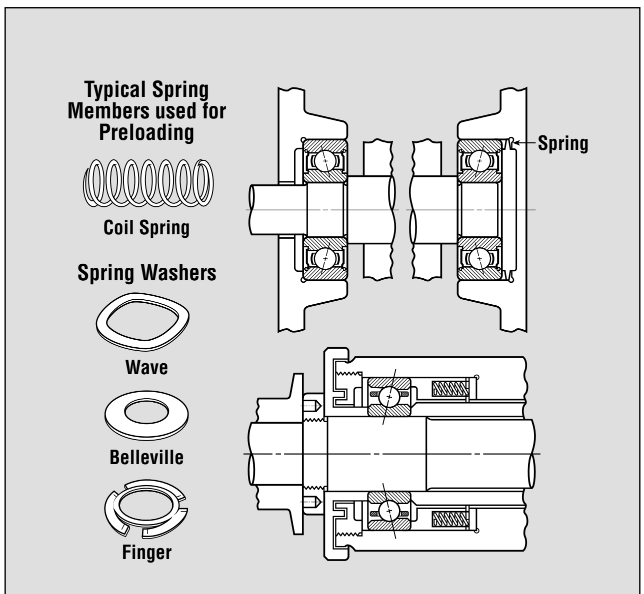
Spring Preloading

This is often the simplest method and should be considered first. Spring preloading provides a relatively constant preload because it is less sensitive to differential thermal expansion than rigid preloading and accommodates minor misalignment better. Also, it is possible to use bearings which have not been preload ground.

Many types of springs may be used (see Fig. 26), among them coil springs and belleville, wave or finger spring washers. Usually the spring is applied to the non-rotating part of the bearing-typically the outer ring. This ring must have a slip fit in the housing at all temperatures.

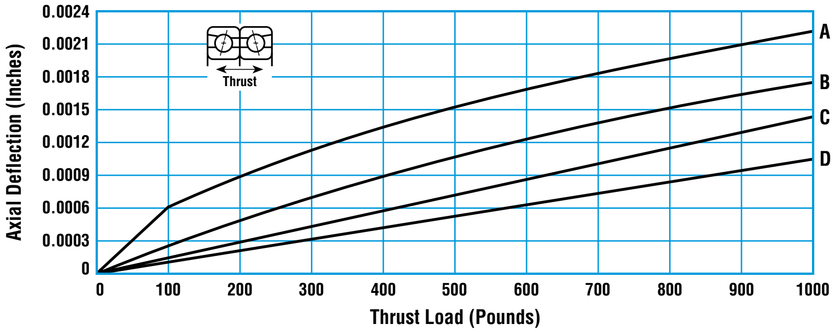
A disadvantage of this method is that spring preloading cannot accept reversing thrust loads. Space must also be provided to accommodate both the springs and spring travel, and springs may tend to misalign the ring being loaded.

Fig. 26. Different types of spring preloading.

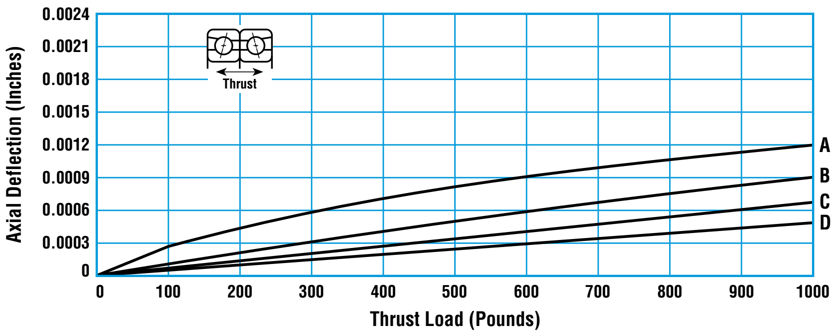


BARDEN PRECISION BEARINGS

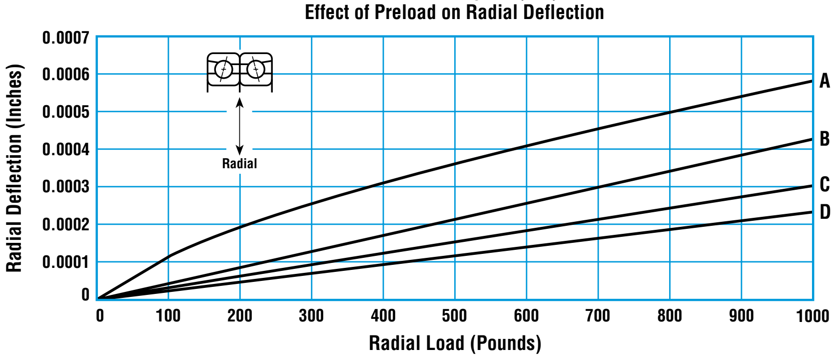
114HDB Bearing Set (15°)
Effect of Preload on Axial Deflection



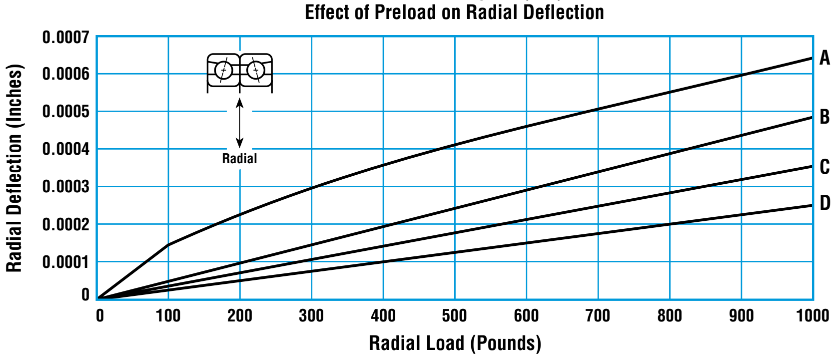
2114HDB Bearing Set (25°)
Effect of Preload on Axial Deflection



114HDB Bearing Set (15°)
Effect of Preload on Radial Deflection



2114HDB Bearing Set (25°)
Effect of Preload on Radial Deflection



114HDB
15° Contact Angle

A = No preload
B = Light preload (65 lbs.)
C = Medium preload (160 lbs.)
D = Heavy preload (320 lbs.)

2114HDB
25° Contact Angle

A = No preload
B = Light preload (105 lbs.)
C = Medium preload (260 lbs.)
D = Heavy preload (520 lbs.)

A higher contact angle will result in a stiffer system axially, i.e. less axial deflection.

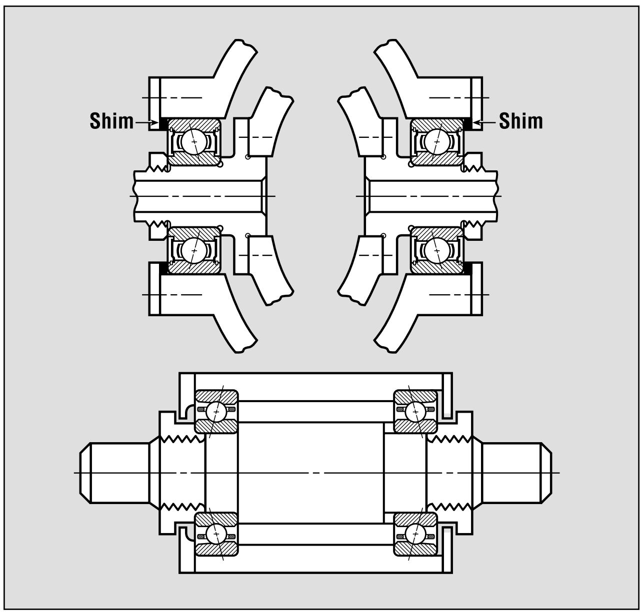
A lower contact angle will result in a stiffer system radially, i.e. less radial deflection.

BEARING SELECTION

Axial Adjustment

Axial adjustment calls for mounting at least two bearings in opposition so that the inner and outer rings of each bearing are offset axially (see Fig. 27). Threaded members, shims and spacers are typical means of providing rigid preloads through axial adjustment.

Fig. 27. Axial adjustment.



This technique requires great care and accuracy to avoid excessive preloading, which might occur during setup by overloading the bearings, or during operation due to thermal expansion. Precision lapped shims are usually preferable to threaded members, because helical threads can lead to misalignment.

For low torque applications such as gyro gimbals, an ideal axial adjustment removes all play, both radial and axial, but puts no preload on either bearing under any operating condition.

The shims should be manufactured to parallelism tolerances equal to those of the bearings, because they must be capable of spacing the bearings to accuracies of one ten-thousandth of an inch or better. Bearing ring faces must be well aligned and solidly seated, and there must be extreme cleanliness during assembly.

Duplex Bearings

Duplex bearings are matched pairs of bearings with built-in means of preloading. The inner or outer ring faces of these bearings have been selectively relieved a precise amount called the preload offset.

When the bearings are clamped together during installation, the offset faces meet, establishing a permanent preload in the bearing set. Duplex bearings are usually speed-limited due to heat generated by this rigid preload.

Most Barden angular contact duplex bearings in spindle and turbine sizes are universally ground for mounting either DB, DF or DT. They are available with light, medium and heavy preloads; values for each change with the bearing size as shown in the Product Section tables.

Duplexing is used to greatly increase radial and axial rigidity. Duplex bearings can withstand bidirectional thrust loads (DB and DF mounting) or heavy unidirectional thrust loads (DT mounting). Other advantages include their ease of assembly and minimum runout.

Some drawbacks of duplex bearings include:

- Increased torque.
- Reduced speed capacity.
- Sensitivity to differential thermal expansion.
- Susceptibility to gross torque variations due to misalignment.
- Poor adaptability to interference fitting.

For a given Barden duplex pair, bore and O.D. are matched within 0.0001", therefore, duplex sets should not be separated or intermixed. High points of eccentricity are marked on both inner and outer rings. The high points should be aligned during assembly (inner to inner, outer to outer) to get a smoother, cooler and more accurate running spindle.

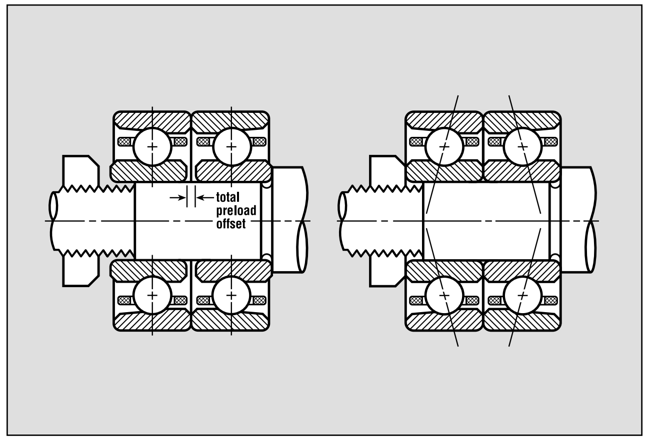
Barden deep groove bearings are also available in duplex sets. They are not universally ground, but are furnished in specific DB, DF or DT configurations. Spindle and turbine sizes (Series 100 and 200) are available with light, medium and heavy preloads.

DB mounting (back-to-back)

This configuration is suited for most applications having good alignment of bearing housings and shafts. It is also preferable where high moment rigidity is required, and where the shaft runs warmer than the housing.

Inner ring abutting faces of DB duplex bearings are relieved. When they are mounted and the inner rings clamped together, the load lines (lines through points of ball contact) converge outside the bearings, resulting in increased moment rigidity.

Fig. 28. DB mounting.

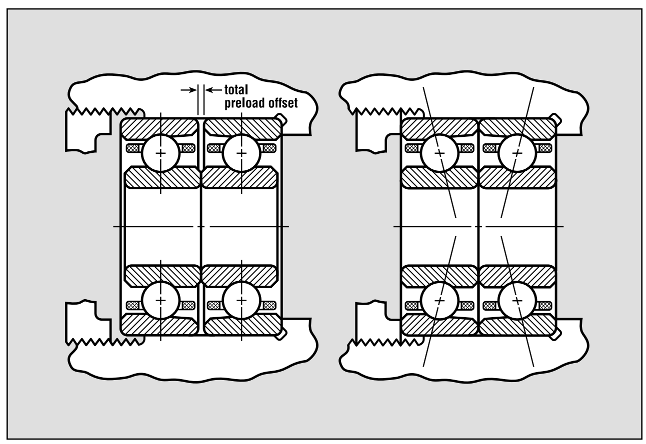


DF mounting (face-to-face)

DF mounting is used in few applications - mainly where misalignment must be accommodated. Speed capability is usually lower than a DB pair of identical preload.

Outer ring abutting faces of DF duplex bearings are relieved. When the bearings are mounted and the outer rings clamped together, the load lines converge toward the bore.

Fig. 29. DF mounting.

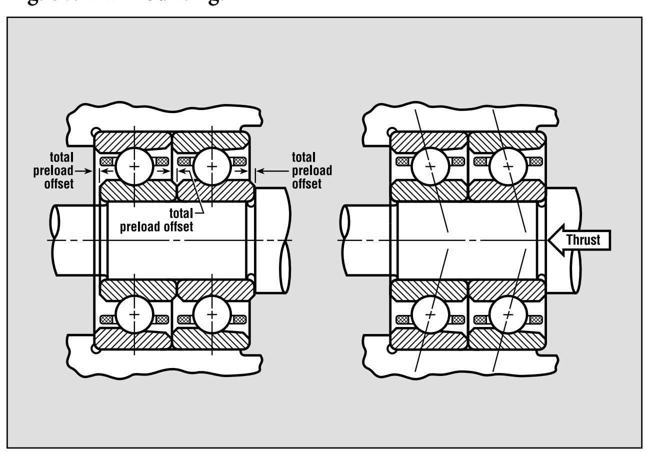


DT mounting (tandem)

DT pairs offer greater capacity without increasing bearing size, through load sharing. They can counter heavy thrust loads from one direction, but they cannot take reversing loads as DB and DF pairs can. However, DT pairs are usually opposed by another DT pair or a single bearing.

Abutting faces of DT pairs have equal offsets, creating parallel load lines. When mounted and preloaded by thrust forces, both bearings share the load equally.

Fig. 30. DT mounting.



BEARING SELECTION

Duplex Bearing Spacers

All duplex pairs can be separated by equal width spacers to increase moment rigidity. Inner and outer ring spacer widths (axial length) must be matched to within .0001"; their faces must be square with the bore and outside cylindrical surface, flat and parallel within .0001" to preserve preload and alignment. Custom designed spacers can be supplied with bearings as a matched set.

Fig. 31. Duplex bearing pairs with equal width spacers.

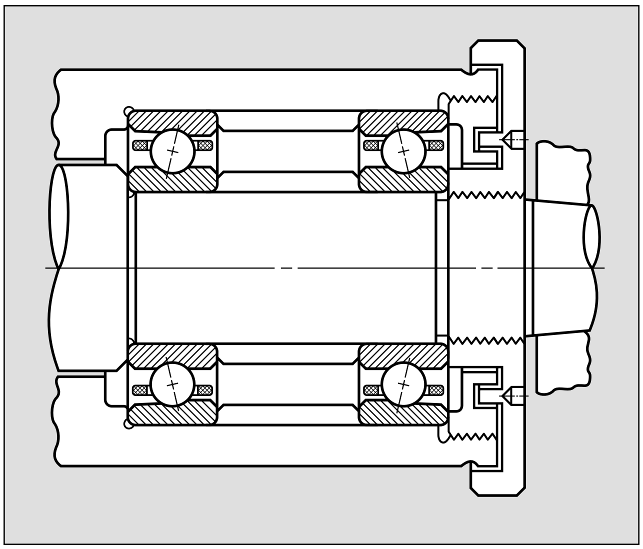


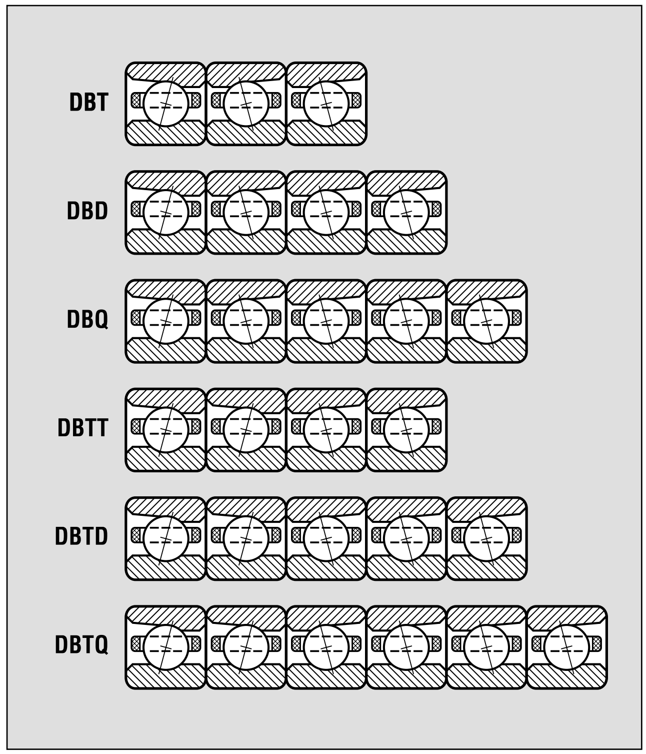
Table 29. Standard preloads (lbs.) for Barden deep groove bearings: Series 100 and 200.

Bore Size	Series 100			Series 200		
	L (Light)	M (Medium)	H (Heavy)	L (Light)	M (Medium)	H (Heavy)
00	5	10	20	5	12	22
01	6	10	25	6	14	27
02	6	13	25	7	17	30
03	8	18	30	9	22	40
04	8	20	40	13	30	55
05	10	25	45	15	35	65
06	14	35	65	22	50	100
07	20	40	80	30	70	130
08	30	45	90	35	85	160
09	30	70	130	40	90	170
10	40	75	140	45	110	200
11	40	90	175	50	145	265

Specialized Preloads

Sets of three or more bearings are sometimes used in special cases having requirements for increased stiffness or capacity, where the shaft or housing size cannot be changed to accommodate larger bearings. Consult Barden Product Engineering for details.

Fig. 32. Increased stiffness can be achieved by mounting bearings in sets.



LUBRICATION

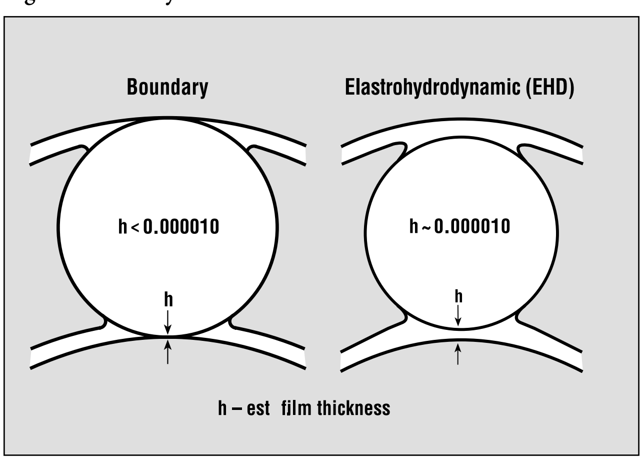
Adequate lubrication is essential to the successful performance of anti-friction bearings. Increased speeds, higher temperatures, improved accuracy and reliability requirements result in the need for closer attention to lubricant selection. Lubricant type and quantity have a marked effect on functional properties and service life of each application. Properly selected lubricants:

- Reduce friction by providing a viscous hydrodynamic film of sufficient strength to support the load and separate the balls from the raceways, preventing metal-to-metal contact.
- Minimize cage wear by reducing sliding friction in cage pockets and land surfaces.
- Prevent oxidation/corrosion of rolling elements.
- Act as a barrier to contaminants.
- Serve as a heat transfer agent in some cases, conducting heat away from the bearing.

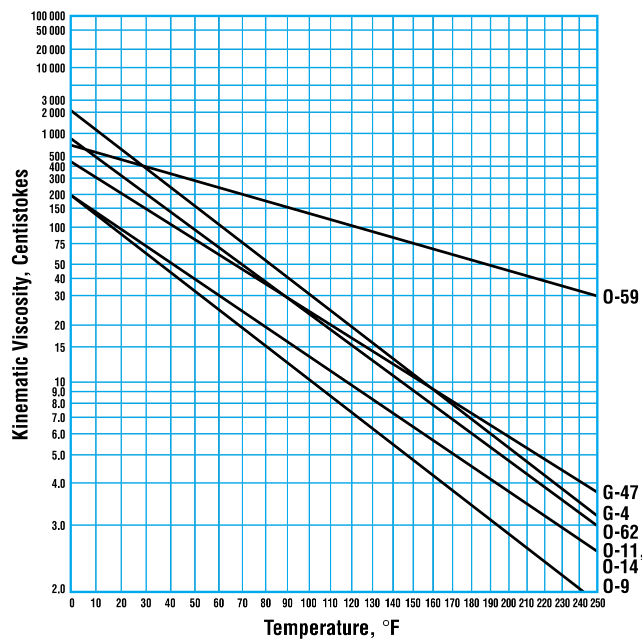
Lubricants are available in three basic forms:

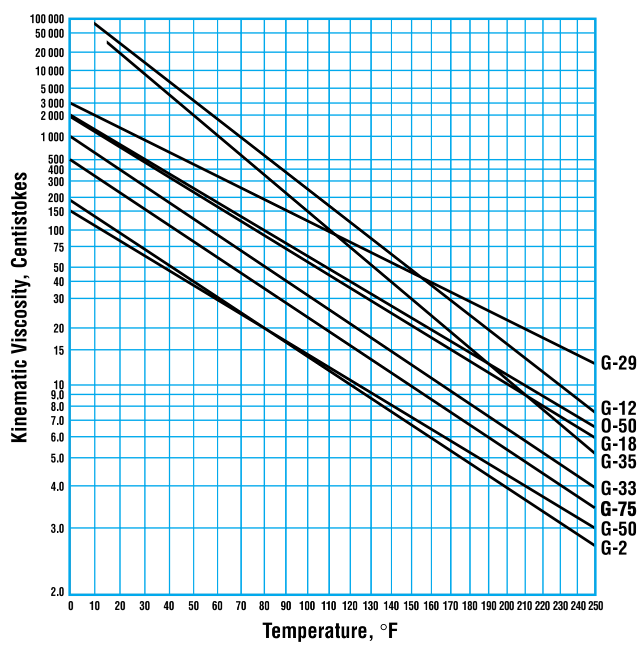
- Fluid lubricants (oils)
- Greases – solid to semisolid products consisting of an oil and a thickening agent.
- Dry lubricants, including films. Dry film lubrication is usually limited to moderate speed and very light loading conditions. Consult Barden Product Engineering for additional information.

Fig. 33. Boundary lubrication.



Viscosity graphs for several typical lubricants.





Barden Lubrication Practices

Factory prelubrication of bearings is highly recommended, since the correct quantity of applied lubricant can be as important as the correct type of lubricant. This is especially true of greases, where an excess can cause high torque, overheating and – if the speed is high enough – rapid bearing failure.

Based on its lengthy experience in this field, Barden has established standard quantities of lubricants that are suitable for most applications. When grease is specified, Barden applies a predetermined amount of filtered grease to the appropriate bearing surfaces.

Barden bearings normally available from stock are furnished with the following standard lubricants:

Deep groove open bearings
Instrument sizes..O-11
Spindle and turbine sizes......................................O-9

Deep groove shielded or sealed
Instrument sizes...G-2
Spindle and turbine sizes......................................G-6

Angular contact bearings
Instrument sizes..O-11
Spindle and turbine sizes......................................O-9

Lubricant Selection

Selection of lubricant and method of lubrication are generally governed by the operating conditions and limitations of the system. Three of the most significant factors in selecting a lubricant are:

- Viscosity of the lubricant at operating temperature.
- Maximum and minimum allowable operating temperatures.
- Operating speed.

Tables 30 and 31 (see page 99) provides comparative reference data, including temperature ranges and speed limits, for several of the lubricants used by Barden.

Hydrodynamic films are generated with both oils and greases, but do not exist in a true sense with dry films. The formation of an elastohydrodynamic film depends mainly on bearing speed and lubricant viscosity at operating temperature. Computational methods for determining the effect of elastohydrodynamic films on bearing life are given on page 107 (calculating fatigue life).

The minimum viscosity required at operating temperature to achieve a full elastohydrodynamic film may be obtained from the following formula:

Instrument bearings (Series R, 30,)

$$V = \frac{400 \times 10^6}{nCNC_p}$$

Spindle and turbine bearings (Series 1900, 100, 200, 300, 9000, ZSB, L)

$$V = \frac{1500 \times 10^6}{nCNC_p}$$

where
V = Viscosity in centistokes at operating temperature.
C = Basic load rating in pounds
N = Speed in rpm.
n = Number of balls.
Cp= Load factor

Grease Considerations

The primary advantage of grease over oil is that bearings can be prelubricated with grease, eliminating the need for an external lubrication system. This grease is often adequate for the service life of the application, especially in extra-wide Series 9000 bearings which have greater than usual grease capacity.

Besides simplicity, grease lubrication also requires less maintenance and has less stringent sealing requirements than oil systems. Grease tends to remain in proximity to bearing components, metering its oil content to operating surfaces as needed.

On the other hand, grease can be expected to increase the initial bearing torque and may exhibit a slightly higher running torque. Other considerations:

Speedability. This is expressed as a dN value, with dN being the bearing bore in mm multiplied by RPM. The greatest dN that greases can normally tolerate for continuous operation is approximately 850,000. Speed limits for greases are lower than for oils due to the plastic nature of grease that tends to cause overheating at high speed. Compared to circulating oil, grease has less ability to remove heat from bearings. Following are general limits for grease-lubricated bearings, according to the type of lubricant base oils and thickeners. These values are influenced by loads, temperature and cage designs.

Temperature. Most greases are limited to a maximum temperature of 300°F, some only to 250°F or 200°F. Specially formulated high temperature greases can operate at 450°F or 500°F for short periods. For all greases, life is severely shortened by operation near their temperature limits.

BARDEN PRECISION BEARINGS

Lubricants recommended for use in Barden Precision Bearings

Table 30. Typical oil lubricants.

Barden Code	Designation	Base Oil	Operating Temperature Range °F	Maximum dN	Comments
0–9	Exxon instrument oil	Petroleum	–65 to 150	1,000,000*	Anti-oxidation, anti-corrosion E.P. additives.
0–11	Winsorlube L-245X	Diester	–65 to 175	1,000,000*	Attacks paint, neoprene, anti-corrosion additives. MIL-L-6085.
0–14	Exxon Turbo Oil #2389	Diester	–65 to 400**	1,000,000*	Anti-oxidation, additives, MIL-L-7808.
0–17	Nyosil M-20	Silicone	–100 to 350	200,000	Low surface tension, tends to migrate, MIL-S-81087 Type 1.
0–28	SHF-61	Synthetic hydrocarbon	–65 to 350	1,000,000*	Good heat stability, low volatility.
0–49	Exxon Turbo Oil #2380	Diester	–65 to 400**	1,000,000*	Anti-oxidation additives, MIL-L-23699. Improved base lubricant for jet engines.

* Max dN for continuous oil supply. Max for prelubricated 2000,000 dN.
** Requires circulation system.

Table 31. Typical grease lubricants.

Barden Code	Designation	Base Oil	Thickener	Operating Temperature Range °F	Maximum dN	Comments
G–2	Exxon Beacon 325	Diester	Lithium	–65 to 250	400,000	Good anti-corrosion, low torque.
G–4	NYE Rheolube 757SSG	Petroleum	Sodium	–20 to 200	650,000	Anti-oxidation additives, machine tool spindle grease.
G–18	NYE Rheotemp 500	Ester and petroleum	Sodium	–50 to 350	500,000	For high temperature, high speed.
G–33	Mobil 28	Synthetic hydrocarbon	Clay	–65 to 350	400,000	MIL-G-81322, DOD-G-24508, wide temperature range.
G–42	NYE Rheolube 350-SBG-2	Petroleum	Sodium/Calcium	–30 to 250+	650,000	Spindle bearing grease for normal temperatures and maximum life at high speed.
G-44	Braycote 601	Perfluorinated Polyether	Tetrafluoro-ethylene Telomer	–100 to 500+	400,000	Excellent thermal and oxidative stability, does not creep water resistant.
G–46	Isoflex NBU-15	Ester	Barium Complex	–40 to 250+	1,000,000	Spindle bearing grease for maximum speeds, moderate loads.
G–75	Arcanol L-75	PAO/Ester	Polyurea	–60 to 250	1,500,000	Spindle bearing grease for maximum speeds, moderate bonds. Requires shorter run-in time than G-46.

BEARING SELECTION

Table 32. Max dN based on grease thickener and base oil type.

Grease Base Oil	Thickener	Maximum dN
Ester	Barium complex	850,000
Petroleum	Sodium	650,000
Diester	Any	400,000
Fluorocarbon	Any	400,000
Silicone	Any	200,000

Consistency (stiffness). Stiffer consistency greases are beneficial for applications with outer ring rotation where centrifugal force tends to sling grease out of the bearing, and those vertical axis applications (bearings installed horizontally) where gravity pulls grease away from its intended position.

Channeling type greases have the property of being displaced during initial running and maintaining a relatively fixed position during life. Other things being equal, high-speed torques with channeling greases will be lower. Non-channeling greases will tend to give high torque at low temperatures and high pumping losses at high temperatures.

"Bleeding". Every grease has a tendency to "bleed" - that is, the oil component separates from its thickener. The amount of bleeding varies with the type of grease, its oil viscosity and thickener characteristics. This phenomenon requires consideration if there is a lengthy time before initial bearing usage or between periods of operation. If bearings are installed in mechanisms which are used soon after assembly and are not subject to extended shutdowns, no problem is created.

Combination of factors. To maintain a normal grease life expectancy, adverse operating conditions must not be present in combination. Thus, at temperatures near the upper limit for a given grease, speed and load should be low. Or, at maximum speeds, temperature and load should be low.

In certain applications, such combinations are unavoidable and tradeoffs are necessary. For example, if speed and temperature are both high, loads must be low and life will be short.

Grease thickeners. There are several types of thickeners, each with its own special characteristics and advantages for specific applications. The most common types used in precision bearing applications are:

- **Barium complex:** non-channeling; rated to 850,000 dN; water resistant.
- **Sodium thickeners:** channeling type; good for high speeds to 650,000 dN; are water soluble.
- **Lithium thickener:** non-channeling; rated to 400,000 dN; offers good water resistance; generally soft.
- **Polyurea thickener:** non-channeling; rated to 400,000 dN; water resistant.
- **Clay thickener:** non-channeling; rated to 400,000 dN; water resistant.
- **Teflon thickener:** non-channeling; rated to 400,000 dN; water resistant; chemical inertness; non-flammable, excellent oxidative and thermal stability.

Grease Quantity. "If a little is good, more is better!" Not always true! Too much grease can cause ball skid, localized over-heating in the ball contact area, cage pocket wear, and rapid bearing failure under certain conditions of operation. Generally, for precision high speed applications, grease quantity in a bearing should be about 20% to 30% full based on the free internal space in a specific bearing. This quantity may be modified to meet the requirements of the application regarding torque, life, and other specifics.

Grease Filtering. Greases for precision bearings are factory filtered to preclude loss of precision, noise generation, high torque, and premature failure in the application. There is no intermediate grease container following the filtering operation since the in-line filter injects the grease into the bearings immediately prior to bearing packaging.

Grease filter sizes range from about 10 to 40 microns depending on grease variables such as thickener and additive particle size.

BARDEN PRECISION BEARINGS

Oil Considerations

While grease lubrication is inherently simpler than lubrication with oil, there are applications where oil is the better choice.

Instrument bearings with extremely low values of starting and running torque need only a minimal, one-time lubrication. Each bearing receives just a few milligrams of oil – a single drop or less.

In machine tool spindles and other high-speed applications, oil is continuously supplied and provides cooling as well as lubrication.

Speedability. Limiting speeds shown in the product tables (front of catalog) for oil-lubricated bearings assume the use of petroleum or diester-based oils. These limits are imposed by bearing size and cage design rather than by the lubricant. The lubricant by itself can accommodate 1,500,000 dN or higher

In the case of silicone-based oils, the maximum speed rating drops to 200,000 dN. Similarly, when computing life for bearings lubricated with silicone-based oils, the Basic Load Rating (C) should be reduced by two-thirds (C/3).

For long life at high speeds, the lubrication system should provide for retention, circulation, filtration and possibly cooling of the oil. On all applications where speeds approach the upper limits, Barden Product Engineering should be consulted for application review and recommendations.

Oil Properties

Some of the key properties of oils include:

- **Viscosity.** Resistance to flow.
- **Viscosity Index.** Rating of viscosity changes at varying temperatures.
- **Lubricity.** Rating of sliding friction at boundary conditions* of lubrication.
- **Pour Point.** Lowest temperature at which oil will flow.
- **Oxidation Resistance.** Rating an oil's resistance to oxidation caused by high temperatures, presence of oxygen and catalytic metals (especially copper).
- **Corrosion Resistance.** Rating an oil's ability to protect bearing from corrosion.
- **Flash Point.** Temperature at which an oil gives off flammable vapors.
- **Fire Point.** Temperature at which an oil burns if ignited.

Oil Types

Oils used in bearings are of two general types – petroleums and synthetics – which are usually supplemented by additives to compensate for deficiencies or to provide special characteristics.

PETROLEUM OILS

Classified as naphthenic or parraffnic, depending on the crude oil source. Excellent general-purpose oils at normal temperatures (-40°F to 250°F). Additives are typically required to inhibit oxidation, corrosion, foaming and polymerization; and to improve viscosity index.

SYNTHETIC OILS

Synthetic oils include the following:

Diesters. Synthetic oils developed for applications requiring low torque at subzero starting temperatures and higher operating temperatures. General temperature range: -75°F to 350°F.

Silicones. Synthetic compounds with a relatively constant viscosity over their temperature range. Used for very cold starting and low torque applications. Generally undesirable for high loads and speeds. General temperature range: -100°F to 450°F. Maximum dN rating of 200,000.

Fluorocarbons. Synthetic oils for corrosive, reactive or high temperature (up to 550°F) environments. Nonsoluble in most solvents. Excellent oxidative stability, low volatility. They provide poor protection against bearing corrosion. Designed for specific temperature ranges with several products used to cover from -70˚F to 550°F.

Synthetic Hydrocarbons. These are fluids which are chemically reacted to provide performance areas superior to petroleum and other synthetic oils. These oils are useable over a wider temperature range than petroleum oils. They are less volatile, more heat resistant and oxidation-stable at high temperatures and are more fluid at low temperatures. General temperature range: -80°F to 350°F.

*Boundary lubrication exists when less than a full elastohydrodynamic film is formed with resulting metal to metal contact – ball to raceway wear.

Oil Lubrication Systems

An oil-lubricated bearing usually requires a systems approach. The most common types of lubrication systems are:

Bath or Wick. Oil is fed to the bearing from a built-in reservoir by wicking, dripping or submerging the bearing partially in oil.

Splash. From a built-in reservoir, oil is distributed by a high-speed rotating component partially submerged in oil.

Air/oil mist. Mixture of air and oil is sprayed into and through the bearing from an external source. Excellent system for lubricating and cooling bearings operating at very high speeds under light loads.

Jet. Oil is squirted into and through the bearing from an external source. Excellent where loads are heavy, speeds and temperatures are high. Efficiently applied flow of oil both lubricates and cools. Provision must be made to remove the oil after it passes through the bearing to prevent overheating.

Pulsed Air/Oil. Similar to air/oil mist configuration, but with intermittent pulse and higher ratio of air to oil.

For more information on lubrication windows/nozzle placement see page 130.

Fig. 34. Pulsed air/oil lubrication system.

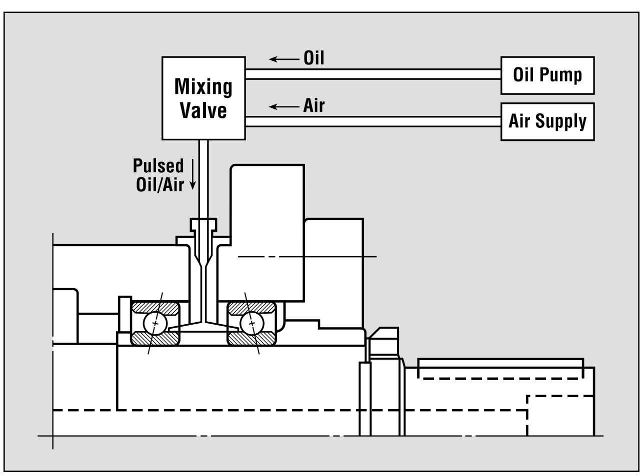


Fig. 35. Wick lubrication system.

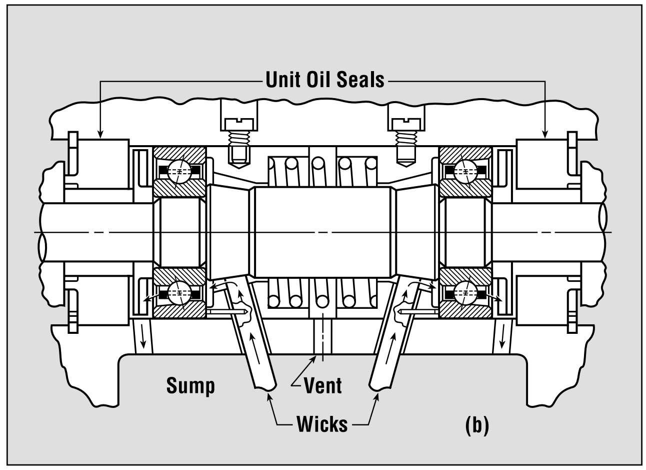


Fig. 36. Air/oil mist lubrication system.

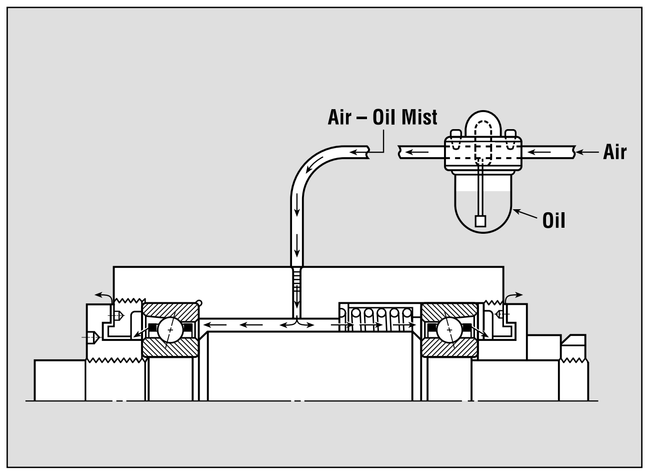
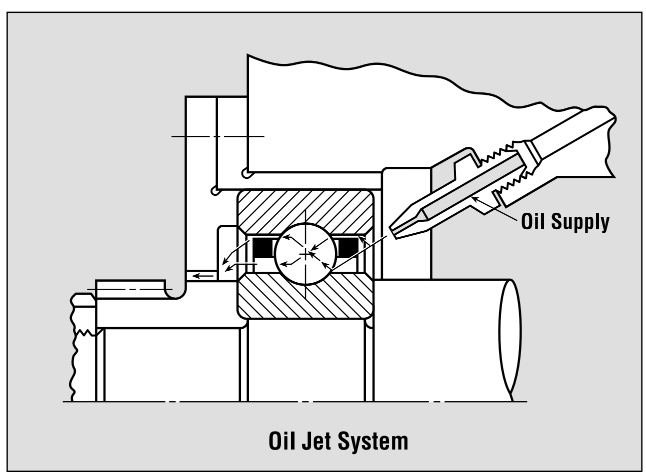


Fig. 37. Oil jet lubrication system.



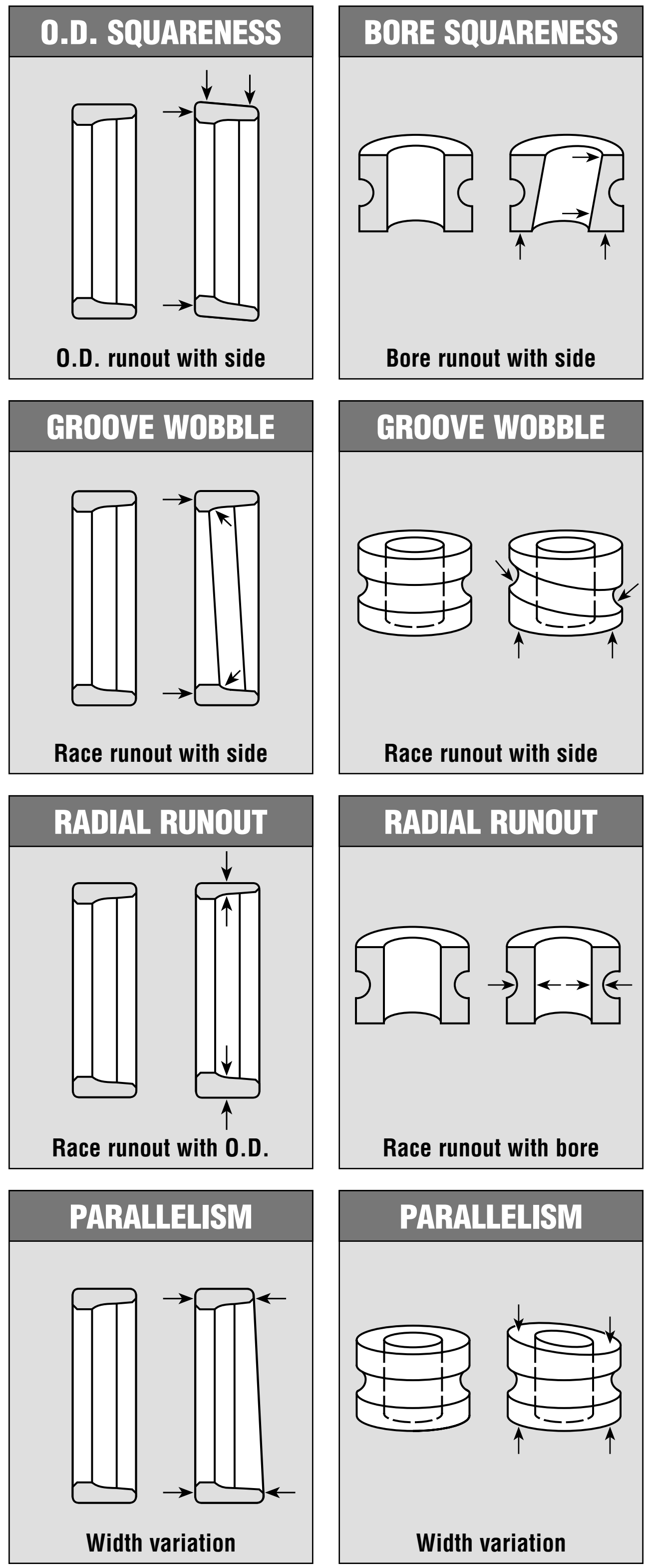
TOLERANCES & GEOMETRIC ACCURACY

The ABEC classes for precision ball bearings define tolerances for major bearing dimensions and characteristics divided into mounting dimensions and bearing geometry. The bearing geometry characteristics are illustrated below.

In selecting a class of precision for a bearing application, the designer should consider three basic areas involving bearing installation and performance of the total mechanism:

1. How bearing bore and outside diameter variations affect:
   a. Bearing fit with mating parts.
   b. Installation methods, tools and fixtures necessary to install bearings without damage.
   c. Radial internal clearance of mounted bearing.
   d. Means of creating or adjusting preload.
   e. Problems due to thermal changes during operation.
2. Allowable errors (runout) of bearing surfaces and:
   a. Their relationship to similar errors in mating parts.
   b. Their combined effect on torque or vibration.
3. Normally unspecified tolerances for the design, form or surface finish of both bearing parts and mating surfaces, which interact to affect bearing torque, bearing vibration and overall rigidity of the rotating mass.

Standard tolerances for all Barden bearings are given in each product section.



BEARING SELECTION

Exclusions From ABEC Standards

As useful as ABEC classes are for defining the levels of bearing precision, they are not all-inclusive. ABEC standards do not address many factors which affect performance and life, including:

- Materials
- Ball complement – number, size and precision
- Raceway curvature, roundness and finish
- Radial play or contact angle
- Cage design
- Cleanliness of manufacturing and assembly
- Lubricant

Barden Internal Standards

Deep groove and angular contact instrument bearings are manufactured to ABEC 7P tolerances as defined by ABMA Standard 12.

Deep groove spindle size bearings are manufactured to ABEC 7 tolerances as defined by ABMA Standards 4 and 20 and ISO Standard 492.

Angular contact spindle size bearings are manufactured to ABEC-9 geometric tolerances. Mounting diameters (bore and O.D.) are measured and coded on every box. The tolerances conform to ABMA Standard 4 and 20 and ISO Standard 492.

To maintain a consistent level of precision in all aspects of its bearings, Barden applies internally developed standards to the important factors not controlled by ABEC.

Ball complement, shoulder heights, cage design and material quality are studied as part of the overall bearing design. Specialized component tolerances are used to check several aspects of inner and outer rings, including raceway roundness, cross race radius form and raceway finish.

The ABMA has generated grades of balls for bearings, but these are not specified in ABEC tolerance classes. Barden uses balls produced to its specifications by Winsted Precision Ball Company, a wholly owned division of The Barden Corporation.

After its self-established criteria have been applied to bearing design and component manufacturing, Barden performs functional testing of assembled bearings to be sure they exhibit uniform, predictable performance characteristics.

Special Tolerance Ranges

Barden can meet users' requirements for even tighter control of dimensions or functional characteristics than are specified in ABEC classifications. Working with customers, the Barden Product Engineering Department will set tolerances and performance levels to meet specific application needs.

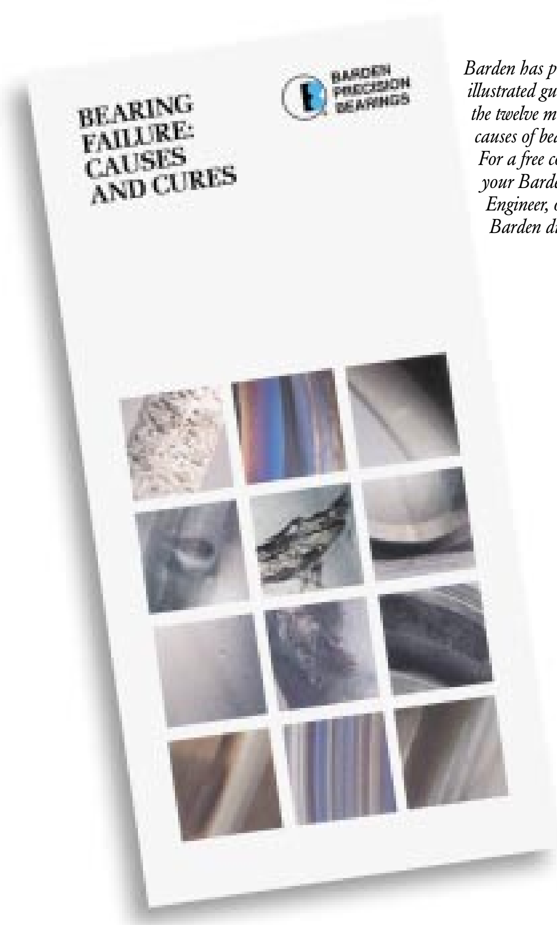
Low Radial Runout Bearings

Especially for high-precision spindles, Barden can provide bearings with a very tight specification on radial runout. This condition is designated by use of suffix "E" in the bearing number. Consult Barden Product Engineering for details.

BEARING LIFE

The useful life of a ball bearing has historically been considered to be limited by the onset of fatigue or spalling of the raceways and balls, assuming that the bearing was properly selected and mounted, effectively lubricated and protected against contaminants.

This basic concept is still valid, but refinements have been introduced as a result of intensive study of bearing failure modes. Useful bearing life may be limited by reasons other than the onset of fatigue.



Barden has published an illustrated guide describing the twelve most common causes of bearing failure. For a free copy, contact your Barden Sales Engineer, or call Barden directly.

Service Life

When a bearing no longer fulfills minimum performance requirements in such categories as torque, vibration or elastic yield, its service life may be effectively ended.

If the bearing remains in operation, its performance is likely to decline for some time before fatigue spalling takes place. In such circumstances, bearing performance is properly used as the governing factor in determining bearing life.

Lubrication can be an important factor influencing service life. Many bearings are prelubricated by the bearing manufacturer with an appropriate quantity of lubricant. They will reach the end of their useful life when the lubricant either migrates away from the bearing parts, oxidizes or suffers some other degradation. At that point, the lubricant is no longer effective and surface distress of the operating surfaces, rather than fatigue, is the cause of failure. Bearing life is thus very dependent upon characteristics of specific lubricants, operating temperature and atmospheric environment.

Specific determination of bearing life under unfavorable conditions can be difficult, but experience offers the following guidelines to achieve better life.

1. Reduce load. Particularly minimize applied axial preload.
2. Decrease speed to reduce the duty upon the lubricant and reduce churning.
3. Lower the temperature. This is important if lubricants are adversely affected by oxidation, which is accelerated at high temperatures.
4. Increase lubricant supply by improving reservoir provisions.
5. Increase viscosity of the lubricant, but not to the point where the bearing torque is adversely affected.
6. To reduce introduction of contaminants, substitute sealed or shielded bearings for open bearings and use extra care in installation.
7. Improve alignment and fitting practice, both of which will reduce duty on the lubricant and tend to minimize wear of bearing cages.

The most reliable bearing service life predictions are those based on field experience under comparable operating and environmental conditions.

Fatigue Life

The traditional concept that bearing life is limited by the onset of fatigue is generally accurate for bearings operating under high stress levels. The latest evidence suggests that if Hertzian stress levels are kept below a certain point and there are no unaccounted stresses, the rolling contact fatigue life of the bearing will exceed the calculated life. The traditional basic relationship between bearing capacity imposed loading and fatigue life is presented here.

$$L_{10} = \left(\frac{C}{P}\right)^3 \times 10^6 \text{ revolutions.*} \qquad \text{(Formula 1)}$$

In the above expression:

L_{10} = Minimum life in revolutions for 90% of a typical group of apparently identical bearings.

C = Basic Dynamic Load Rating.

P = Equivalent Radial Load, computed as follows:

$$P = XR + YT \qquad \text{(Formula 2)}$$

or

$$P = R \qquad \text{(Formula 2)}$$

whichever is greater.

In the preceding equation:

R = Radial load.
T = Thrust load.
X = Radial load factor relating to contact angle.
Y = Axial load factor depending upon contact angle, T and ball complement.

For Basic Load Ratings, see product section tables. For X and Y factors, see Tables 33 and 34.

*See ABMA Standard 9 for more complete discussion of bearing life in terms of usual industry concepts.

Table 33. Load factors for instrument bearings.

T/nd^2	Contact Angle, degrees			
	5	10	15	20
	Values of Axial Load Factor Y			
25	3.23	2.23	1.60	1.18
50	2.77	2.09	1.56	1.18
100	2.41	1.93	1.51	1.18
150	2.22	1.83	1.46	1.18
200	2.10	1.76	1.43	1.18
300	1.92	1.66	1.38	1.18
500	1.71	1.53	1.31	1.18
750	1.55	1.43	1.25	1.18
1000	1.43	1.35	1.21	1.18
	Values of Radial Load Factor X			
	0.56	0.46	0.44	0.43

Table 34. Load factors for spindle and turbine bearings.

T/nd^2	Contact Angle, degrees				
	5	10	15	20	25
	Values of Axial Load Factor Y				
10	—	2.13	1.57	1.00	0.87
20	2.40	1.94	1.50	1.00	0.87
30	2.22	1.83	1.46	1.00	0.87
40	2.09	1.76	1.42	1.00	0.87
50	1.99	1.70	1.40	1.00	0.87
60	1.91	1.65	1.37	1.00	0.87
70	1.85	1.61	1.35	1.00	0.87
80	1.79	1.58	1.33	1.00	0.87
90	1.75	1.55	1.31	1.00	0.87
100	1.71	1.52	1.30	1.00	0.87
150	1.55	1.41	1.23	1.00	0.87
200	1.45	1.34	1.19	1.00	0.87
300	1.31	1.23	1.12	1.00	0.87
400	1.22	1.16	1.07	1.00	0.87
500	1.15	1.10	1.02	1.00	0.87
600	1.10	1.05	1.00	1.00	0.87
700	1.06	1.01	1.00	1.00	0.87
800	1.03	1.00	1.00	1.00	0.87
900	1.00	1.00	1.00	1.00	0.87
1000	1.00	1.00	1.00	1.00	0.87
Values of Radial Load Factor X					
	0.56	0.46	0.44	0.43	0.41

Note: Number of balls and diameters are found in the product section.

Modifications to Formula 1 have been made, based on a better understanding of the causes of fatigue. Influencing factors include:

- An increased interest in reliability factors for survival rates greater than 90%.
- Improved raw materials and manufacturing processes for ball bearing rings and balls.
- The beneficial effects of elastohydrodynamic lubricant films.

Formula 1 can be rewritten to reflect these influencing factors as:

$$L_{10} \text{ Modified} = (A_1)(A_2)(A_3)\,\frac{16{,}666}{N}\left(\frac{C}{P}\right)^3 \text{ hours.}$$

(Formula 3)

wherein:

L_{10} = Number of hours which 90% of a typical group of apparently identical bearings will survive.

N = Speed in rpm.

A_1 = Statistical life reliability factor for a chosen survival rate, from Table 35.

A_2 = Life modifying factor reflecting bearing material type and condition, from Table 36.

A_3 = Application factor, commonly limited to the elastohydrodynamic lubricant film factor calculated from formula 4 or 5. If good lubrication is assumed, $A_3 = 3$.

Factor A_1. Reliability factors listed in Table 35 represent a statistical approach. In addition, there are published analyses that suggest fatigue failures do not occur prior to the life obtained using an A_1 factor of .05.

Table 35. Reliability factor A_1 for various survival rates.

Survival Rate (Percentage)	Bearing Life Notation	Reliability Factor A_1
90	L_{10}	1.00
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

Factor A_2. While not formally recognized by the ABMA, estimated A_2 factors are commonly used as represented by the values in Table 36. The main considerations in establishing A_2 values are the material type, melting procedure, mechanical working and grain orientation, and hardness.

Note: SAE 52100 material in Barden bearings is vacuum processed, AISI 440C is air melted or vacuum melted - contact Barden Product Engineering for details.

Table 36. Life modifying factor A_2.

Process \ Material	440C	52100	M50
Air melt	.25X	NA	NA
Vacuum processed	NA	1.0	NA
VAR (CEVM)	1.25X	1.5X	NA
VIM – VAR	1.5X	1.75X	2.0X

Factor A_3. This factor for lubricant film effects is separately calculated for instrument (I) bearings and spindle and turbine (S&T) bearings as:

(I) $\mathbf{A_3} = 17.8 \times 10^{-10} n\ C\ N\ U\ C_p$ (Formula 4)

(S&T) $\mathbf{A_3} = 3.68 \times 10^{-10} n\ C\ N\ U\ C_p$ (Formula 5)

(The difference in constants is primarily due to the different surface finishes of the two bearing types.)

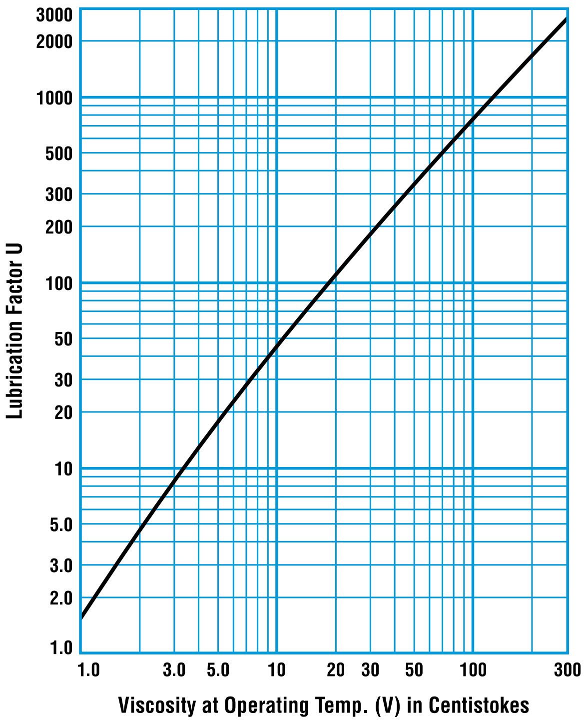
U = Lubrication Factor (from Fig. 38).
n = Number of balls (from appropriate product section table).
C_p = Load Factor (from Fig. 39)

In calculating factor A_3, do not use a value greater than 3 or less than 1. (Outside these limits, the calculated life predictions, are unreliable.) A value less than 1 presumes poor lubrication conditions. If A_3 is greater than 3, use 3.

Note: Silicone-based oils are generally unsuitable for speeds above 200,000 dN and require a 2/3 reduction in Basic Load Rating C.

BEARING PERFORMANCE

Fig. 38. Lubrication factor U.

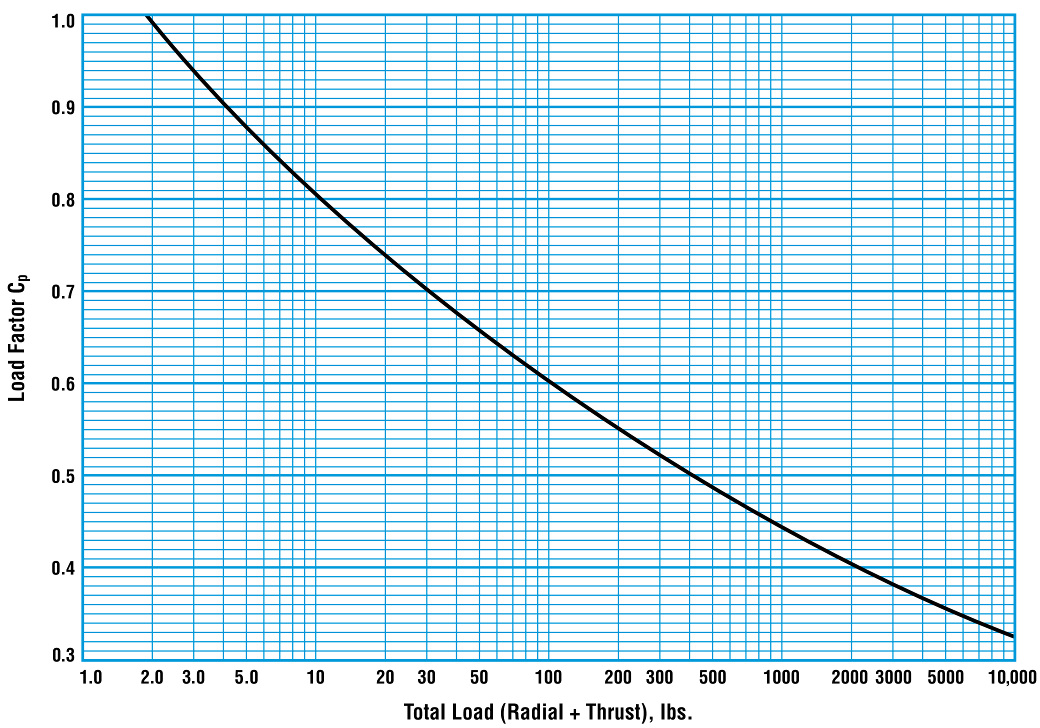


Sample Fatigue Life Calculation

Application Conditions

Application	High-speed turbine
Operating speed	40,000 RPM
Rotating members	Shaft, Inner Ring
Lubrication	Oil Mist, Winsor Lube L-245X (MIL-L-6085, Barden Code 0-11)
Dead weight radial load	10 lbs. (spaced equally on two bearings)
Turbine thrust	20 lbs.
Thrust from preload spring	15 lbs.
Ambient temperature	160 F
Tentative bearing choice	102H (vacuum processed SAE 52100 steel)

Fig. 39. Load factor C_p.



BARDEN PRECISION BEARINGS

Step 1. Calculation of basic fatigue life in hours

Data for 102H (see product data section, pages 52–53):
C = 1404
$nd^2 = 0.3867$
Contact angle = 15°
Total Thrust Load = 20 + 15 = 35 lbs.

$$T/nd^2 = \frac{35}{.3867} = 90.51$$

Radial Load Per Bearing = 5 lbs.

From Table 34, page 106: X = 0.44
Y = 1.31

P = XR + YT = (.44) (5) + (1.31) (35) = 48.05

$$L_{10} = \frac{16{,}666}{40{,}000} \times \left(\frac{1404}{48.05}\right)^3 = 10{,}394 \text{ hours}$$

Answer: Basic fatigue life . . . . .10,394 hours

Step 2. Calculation of life modifying factors A_1–A_3
$A_1 = 1$ for L_{10} from Table 35
$A_2 = 1$ for vacuum processed SAE 52100 from Table 36
$A_3 = 3.68 \times 10^{-10}$ n C N U Cp for spindle and turbine bearings

From product data table: n = 11
C = 1404
N = 40,000

From graph on page 97, viscosity of Barden Code 0-11, 160 F = 5.7Cs

From Fig. 38, U = 20
Determine Cp, Load Factor, from Fig. 39:
Total Load (Radial + Thrust) = 5 + 35 = 40, Cp = 0.68

$A_3 = 3.68 \times 10^{-10} \times 11 \times 1404 \times 40{,}000 \times 20 \times 0.68 = 3.092$

Use maximum value of 3.0 for A_3.

Step 3. Calculation of modified fatigue life
L_{10} Modified = $A_1\, A_2\, A_3\, L_{10}$ =
(1) (1) (3.00) 10,394 = 31,182 hours

Answer: Modified fatigue life ....31,182 hours

Miscellaneous Life Considerations

Other application factors usually considered separately from A_3 include high-speed centrifugal ball loading effects, varying operating conditions and installations of more than one bearing.

High-speed centrifugal ball effects. Fatigue life calculations discussed previously do not allow for centrifugal ball loading which starts to become significant at 750,000 dN. These effects require computerized analysis, which can be obtained by consulting Barden Product Engineering.

Varying operating conditions. If loads, speeds and modifying factors are not constant, bearing life can be determined by the following relationship:

$$L = \frac{1}{\frac{F_1}{L_1} + \frac{F_2}{L_2} + \frac{F_3}{L_3} + \frac{F_n}{L_n}}$$

in which
F_n = Fraction of the total life under conditions 1, 2, 3, etc.

$(F_1 + F_2 + F_3 + F_n = 1.0)$.

L_n = The bearing life calculated for conditions 1, 2, 3, etc.

Bearing sets. When the life of tandem pairs (DT) or tandem triplex sets (DD) is being evaluated, the basic load rating should be taken as:

1.62 C for pairs
2.16 C for triplex sets

and the pair or triplex set treated as a single bearing. When determining Y values from Tables 33 or 34, the table should be entered with the following modifications for values of T/nd^2:

$0.50\ T/nd^2$ for pairs
$0.33\ T/nd^2$ for triplex sets

and again, the pair or set should be treated as a single bearing.

The life of bearings mounted as DB or DF pairs and subjected to thrust loads is dependent on the preload, the thrust load and the axial yield properties of the pair. Consult Barden Product Engineering for assistance with this type of application.

BEARING PERFORMANCE

EQUIPMENT LIFE

If the life of a piece of equipment is dependent on the life of more than one ball bearing, the equipment life for a given survival rate will be less than the comparable life of the bearing. The equipment life may be determined from the following expression:

$$L = \left[\frac{1}{\frac{1}{(L_1)^{1.4}} + \frac{1}{(L_2)^{1.4}} + \frac{1}{(L_3)^{1.4}} + \frac{1}{(L_n)^{1.4}}} \right]^{0.71}$$

in which Ln is the calculated life for a given survival rate for each of the n bearings. If the bearings have been selected to give approximately the same life, the equipment life can be determined from:

$$L = \frac{L_m}{(n')^{0.71}}$$

n' = Number of bearings
L_m = Average life of n individual bearings.

VIBRATION

Performance of a bearing may be affected by vibration arising from exposure to external vibration or from self-generated frequencies.

Effect of Imposed Vibration

Bearings that are subject to external vibration along with other adverse conditions can fail or degrade in modes known as false brinelling, wear oxidation or corrosion fretting. Such problems arise when loaded bearings operate without sufficient lubrication at very low speeds, oscillating or even stationary. When vibration is added, surface oxidation and selective wear result from minute vibratory movement and limited rolling action in the ball-to-raceway contact areas. The condition can be relieved by properly designed isolation supports and adequate lubrication.

Vibration sources

All bearings have minute variations of circular form in their balls and raceways. At operating speed, low level cyclic displacement can occur as a function of these variations, in combination with the speed of rotation and the internal bearing design. The magnitude of this cyclic displacement is usually less than the residual unbalance of the supported rotating member, and can be identified with vibration measuring equipment.

The presence of a pitched frequency in the bearings can excite a resonance in the supporting structure. The principal frequencies of ball bearing vibration can be identified from the bearing design and knowledge of variation-caused frequencies. Frequency analysis of the supporting structure is usually more difficult, but can be accomplished experimentally.

Vibration problems in bearing applications are usually resolved by changes in bearing design, system modifications, damping or by using higher precision bearings with specially controlled vibration levels. The problem must first be clearly identified, which can be done in cooperation with the Barden Product Engineering Department.

Bearing Frequency Coefficients

Monitoring vibration levels is an important tool in any preventive maintenance program. Vibration monitoring can detect abnormalities in components and indicate their replacement well before failure occurs. Knowledge of vibration levels helps reduce downtime and loss of production. The tables that follow include frequency coefficients for our most popular angular contact bearings with inner ring rotation.

Example: 209H bearing at 8,000 RPM (I.R. rotation)

- **Generated frequency from unbalance**
  (8,000) (1.00)/60 = 133.3 Hertz
- **Generated frequency from retainer speed (FTF)**
  (8,000) (.412)/60 = 54.9 Hertz
- **Generated frequency from a single defect on a ball (BSF)**
  (8,000) (2.657)/60 = 354.3 Hertz
- **Generated frequency from a single defect on the outer ring (BPFO)**
  (8,000) (5.355)/60 = 714.0 Hertz
- **Generated frequency from a single defect on the inner ring (BPFI)**
  (8,000) (7.645)/60 = 1,019.3 Hertz

Table 37. Frequency coefficient factors.

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.

Bearing	Imbalance	FTF	BSF	BPFO	BPFI
SERIES 100H					
100H	1.00	.372	1.771	3.352	5.648
101H	1.00	.386	2.016	3.864	6.136
102H	1.00	.402	2.371	4.423	6.577
103H	1.00	.412	2.648	5.352	7.648
104H	1.00	.401	2.344	4.411	6.589
105H	1.00	.415	2.751	5.392	7.608
106H	1.00	.420	2.927	5.875	8.125
107H	1.00	.421	2.979	6.314	8.686
108H	1.00	.429	3.334	7.293	9.707
109H	1.00	.423	3.075	6.773	9.227
110H	1.00	.429	3.344	7.726	10.274
111H	1.00	.426	3.185	7.240	9.76
112H	1.00	.431	3.420	7.753	10.247
113H	1.00	.435	3.651	8.265	10.735
114H	1.00	.432	3.474	7.772	10.228
115H	1.00	.435	3.678	8.709	11.291
116H	1.00	.433	3.522	8.654	11.346
117H	1.00	.436	3.700	9.152	11.848
118H	1.00	.433	3.559	8.234	10.766
119H	1.00	.436	3.718	9.158	11.842
120H	1.00	.439	3.878	9.651	12.349
121H	1.00	.436	3.732	9.163	11.837
122H	1.00	.432	3.461	8.631	11.369
124H	1.00	.436	3.718	9.158	11.842
126H	1.00	.433	3.519	8.652	11.348
128H	1.00	.436	3.740	9.166	11.834
130H	1.00	.441	4.016	10.136	12.864
101BX48	1.00	.386	2.015	3.863	6.137
102BX48	1.00	.402	2.371	4.423	6.577
103BX48	1.00	.412	2.648	5.352	7.648
104BX48	1.00	.401	2.342	4.410	6.590
105BX48	1.00	.415	2.750	5.392	7.608
106BX48	1.00	.420	2.926	5.874	8.126
107BX48	1.00	.421	2.978	6.314	8.686
108BX48	1.00	.429	3.333	7.293	9.707
110BX48	1.00	.429	3.344	7.726	10.274
113BX48	1.00	.435	3.651	7.829	10.171
117BX48	1.00	.436	3.699	8.716	11.284

Continued on next page

BEARING PERFORMANCE

Table 37, *continued.* Frequency coefficient factors.

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.

Bearing	Imbalance	FTF	BSF	BPFO	BPFI
SERIES ZSB100					
ZSB101J	1.00	.423	3.078	6.351	8.649
ZSB102J	1.00	.418	2.880	6.276	8.724
ZSB103J	1.00	.426	3.209	6.822	9.178
ZSB104J	1.00	.426	3.184	6.813	9.187
ZSB105J	1.00	.436	3.718	8.286	10.714
ZSB106J	1.00	.446	4.455	9.375	11.625
ZSB107J	1.00	.445	4.312	9.783	12.217
ZSB108J	1.00	.450	4.811	11.258	13.742
ZSB111J	1.00	.452	5.028	11.310	13.690
ZSB113J	1.00	.458	5.734	12.829	15.171
ZSB114J	1.00	.457	5.639	13.267	15.733
ZSB118J	1.00	.457	5.531	12.787	15.213
ZSB120J	1.00	.460	6.019	14.264	16.736
ZSB124J	1.00	.462	6.263	14.773	17.227
SERIES 200H					
200H	1.00	.369	1.713	3.319	5.681
201H	1.00	.372	1.760	3.347	5.653
202H	1.00	.377	1.850	3.773	6.227
203H	1.00	.385	1.996	3.854	6.146
204H	1.00	.387	2.019	3.865	6.135
205H	1.00	.401	2.337	4.408	6.592
206H	1.00	.392	2.136	4.314	6.686
207H	1.00	.400	2.327	4.804	7.196
208H	1.00	.404	2.427	4.850	7.150
209H	1.00	.412	2.656	5.355	7.645
210H	1.00	.412	2.675	5.775	8.225
211H	1.00	.411	2.621	5.751	8.249
212H	1.00	.410	2.593	5.738	8.262
213H	1.00	.409	2.559	5.723	8.277
214H	1.00	.414	2.709	6.203	8.797
215H	1.00	.418	2.858	7.103	9.897
216H	1.00	.416	2.806	6.245	8.755
217H	1.00	.415	2.765	6.643	9.357
218H	1.00	.414	2.729	6.212	8.788
219H	1.00	.410	2.661	6.155	8.845
220H	1.00	.412	2.671	6.186	8.814
221H	1.00	.412	2.647	6.175	8.825
222H	1.00	.416	2.790	6.655	9.345

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BARDEN PRECISION BEARINGS

Table 37, *continued.* Frequency coefficient factors.

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.

Bearing	Imbalance	FTF	BSF	BPFO	BPFI
SERIES ZSB200					
ZSB202J	1.00	.462	3.209	6.822	9.178
ZSB204J	1.00	.420	2.937	6.299	8.701
ZSB206J	1.00	.430	3.358	7.302	9.698
ZSB207J	1.00	.428	3.300	7.710	10.290
ZSB210J	1.00	.441	4.016	9.261	11.739
ZSB211J	1.00	.441	4.011	9.253	11.747
SERIES 1900H					
1900H	1.00	.381	1.901	3.807	6.193
1901H	1.00	.394	2.166	4.334	6.666
1902H	1.00	.411	2.623	5.757	8.243
1903H	1.00	.419	2.883	5.863	8.137
1904H	1.00	.406	2.474	5.276	7.724
1905H	1.00	.420	2.937	6.718	9.282
1906H	1.00	.430	3.397	7.745	10.255
1907H	1.00	.433	3.515	8.218	10.782
1908H	1.00	.432	3.504	8.215	10.785
1909H	1.00	.439	3.896	9.218	11.782
1910H	1.00	.443	4.215	10.199	12.801
1911H	1.00	.443	4.197	10.194	12.806
1912H	1.00	.447	4.516	11.178	13.822
1913H	1.00	.451	4.834	11.714	14.286
1914H	1.00	.446	4.410	10.701	13.229
1915H	1.00	.449	4.675	11.671	14.329
1916H	1.00	.452	4.940	12.193	14.807
1917H	1.00	.448	4.561	11.191	13.809
1918H	1.00	.450	4.780	11.702	14.298
1919H	1.00	.452	5.016	12.212	14.788
1920H	1.00	.449	4.675	11.671	14.329
1921H	1.00	.451	4.874	12.626	15.374
1922H	1.00	.453	5.073	13.132	15.868
1924H	1.00	.452	4.940	12.644	15.356
1926H	1.00	.451	4.834	12.164	14.836
1928H	1.00	.454	5.152	13.152	15.848
1930H	1.00	.449	4.675	11.671	14.329

BEARING PERFORMANCE

YIELD/STIFFNESS

A ball bearing may be considered elastic in that when either radial, axial or moment loading is applied, it will yield in a predictable manner. Due to its inherent design, the yield rate of a bearing decreases as the applied load is increased.

As previously discussed under Preloading, the yield characteristics of bearings are employed in preloaded duplex pairs to provide essentially linear yield rates. Yield must also be considered in figuring loads for duplex pairs and the effects of interference fits on established preloads.

The deflection and resonance of bearing support systems are affected by bearing yield; questions or problems that arise in these areas should be referred to the Barden Product Engineering Department.

TORQUE

Starting torque, running torque and variations in torque levels can all be important to a bearing application. Starting torque - the moment required to start rotation - affects the power requirement of the system and may be crucial in such applications as gyro gimbals

Running torque – the moment required to maintain rotation – is a factor in the system power loss during operation. Variations in running torque can cause errors in sensitive gyros and other instruments.

To minimize bearing torque, it is important to consider internal bearing geometry and to have no contaminants present, minimal raceway and ball roundness variation, good finishes on rolling and sliding surfaces, and a lightweight, free-running cage.

The type and amount of lubricant must also be considered in determining bearing torque, but lubricant-related effects are often difficult to predict. This is particularly true as speeds increase, when an elastohydrodynamic film builds up between balls and races, decreasing the running torque significantly. Also influential are the viscosity/pressure coefficients of lubricants, which are affected by temperature.

Several aspects of bearing applications should be evaluated for their torque implications. For example, loading is relevant because torque generally increases in proportion to applied loads. Precision mounting surfaces, controlled fitting practices and careful axial adjustment should be employed to minimize torque.

As an engineering service, the Barden Engineering Department can provide computer-assisted estimates of bearing torque.

MEASUREMENT & TESTING TECHNIQUES

Barden's ability to manufacture reliable high precision bearings results from a strong commitment to quality control. All facets of bearing manufacture and all bearing components are subjected to a battery of tests using highly sophisticated instruments and techniques, some of our own design.

Examples of the types of test regularly performed by Barden include metallurgical testing of bar stock; torque and vibration analysis; roundness, smoothness and raceway curvature measurement; preload offset gauging; and lubricant chemistry evaluation.

Nondestructive Testing

Nondestructive tests, i.e. those that evaluate without requiring that the test sample be damaged or destroyed, are among the most important that can be performed. Nondestructive tests can identify flaws and imperfections in bearing components that otherwise might not be detected.

Barden conducts many types of nondestructive tests, each designed to reveal potentially undesirable characteristics caused by manufacturing or material process flaws. Five of the most useful general purpose nondestructive tests are 1) liquid penetrant, 2) etch inspection, 3) magnetic particle, 4) eddy current, and 5) Barkhausen.

Liquid Penetrant Testing

This method utilizes a penetrating liquid which seeps into surface discontinuities and provides a visual indication of flaws. It is commonly used on metals, glass or ceramics. Parts are vapor degreased, cooled, then dipped into a series of solutions including a fluorescent penetrant bath and an emulsifier water rinse. Parts are then carefully dried and treated with a dry powder developer. The powder acts as blotter and pulls the liquid penetrant up out of surface imperfections. The liquid tends to spread in the developer, thereby enlarging the indication. Parts are then inspected under black light, where hairline cracks and other imperfections are revealed.

Etch Inspection

Heat caused by abusive grinding can alter, beyond specification, the molecular structure of steel. Etch inspection is the process of using acids to detect the type of flaws –such as small cracks, stress fractures and burns– that are often found in improperly ground surfaces.

A hot acid bath attacks weaknesses in the surface structure so they become visible to the naked eye.

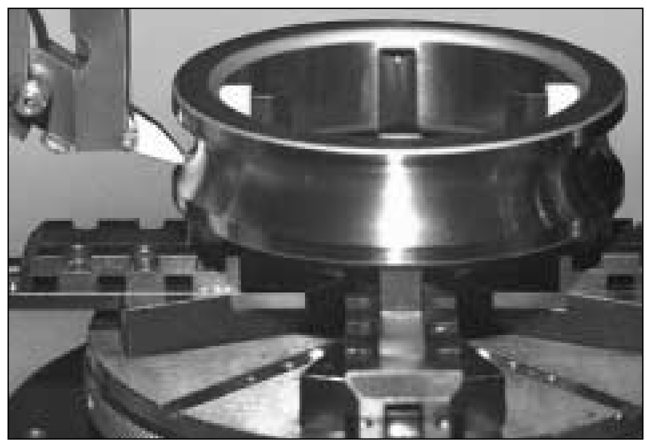
Surface discrepancies revealed through acid immersion are then inspected under microscope so the flaw can be properly diagnosed.

Magnetic Particle Testing
Ferromagnetic materials can be inspected using this method. The part being tested is first cleaned and then exposed to a directional magnetic field which magnetizes the part. A light-sensitive solution of high permeability particles is then applied to the part. An instrument is configured to produce a current which generates a magnetic field in the workpiece. Accumulations of particles align themselves to any stray magnetic fields that may result. These fields can be caused by cracks and/or internal nonmagnetic inclusions. The particle alignment can be easily inspected under ultraviolet (black) light.

Eddy Current Testing
Only materials which are conductors can be tested using this method. The field from the test coil is induced into the workpiece which generates a circular (eddy) current in the workpiece. The eddy currents generate a field which is opposite to that of the test core and therefore can be detected as an impedance change in the test coil. Discontinuities in the workpiece are then detected as a result of a change in eddy current path length and/or field variations generated by the eddy current. This method detects surface cracks, subsurface discontinuities, hardness and coating thickness variations due to their effect on the conductivity, permeability, or dimensional characteristics of the material.

Barkhausen Test
Measurement of stresses and stress related defects can be measured based on the principle of magnetoelastic interaction. Shortly described, this is the relationship between magnetostrictive and elastic lattice strains and appears as follows: If a piece of ferromagnetic steel is magnetized, it will elongate in the direction of applied magnetic field; and, conversely, if the same piece is stretched by an external load, it will be magnetized in the direction of load. The same occurs with compressions, except that the piece is now magnetized at 90 degrees to the direction of compression. Barkhausen noise is used to detect the magnetoelastic interaction which is caused by abusive grinding.

Results of a magnetic particle test showing how particles have aligned themselves along stray magnetic fields caused by cracks in the material.



Eddy current test fixture showing probe addressing the part to be tested. Current is induced and discontinuities in field, indicating flaws, are detected as an impedance change in the test coil.

Barkenhausen test equipment.

BEARING PERFORMANCE

Functional Testing

Because functional testing of assembled bearings can be extremely important, Barden has developed several proprietary testing instruments for this purpose.

Bearing-generated vibration is checked by using either the Barden SmoothRator,® the Bendix Anderometer,® the FAG functional tester or the Barden Quiet Bearing Analyzer. The function of these instruments is to detect any defective surfaces, parts and contamination present in a bearing. They are used as quality control devices by Barden, to ensure that we deliver quiet, smooth-running bearings, and also as a troubleshooting aid to trace the causes of bearing malfunction.

Bearing running torque is measured by various instruments such as the Barden Torkintegrator. Starting torque can also be measured on special gages.

Nonrepetitive runout of a bearing – a function of race lobing, ball diameter variation and cleanliness – is gaged on proprietary Barden instruments.

The Barden Quiet Bearing Analyzer

When the Navy contracted with Barden to provide large, high capacity precision bearings for the "Navy Quiet running" submarine program, a method for analyzing them was needed. Proper testing of these bearings required thrust loads beyond the capability of any commercially available bearing tester. The Barden Quality Engineering Department decided to pioneer the development of a new tester. The unique Quiet Bearing Analyzer was the result.

The "QBA's" principal uses include functional testing of lot samples and evaluating bearing vibration vs. raceway surface finish, ball quality, cage design, lubricant quantity, speed, thrust load and grease type.

The QBA's versatility allows Barden engineers, through the adjustment of speed and load application, to simulate "real world" operating conditions. For example, thrust loads can be applied ranging from 20 lbs. up to 1,500 lbs. while running speeds can start as low as 0 RPM and go as high as 4,400 RPM.

The critical spindle assembly is an oil hydrostatic unit with 10 millionths inch accuracy. The measuring system electronics were built around standard components assembled by Barden's Quality Engineering Department.

Because of the designed-in flexibility of the QBA, existing Anderometer databases can be correlated with new QBA measurements. Historical comparisons of vibration characteristics are now possible.

Many other unique features –including thrust load servo force control and a displacement transducer for reading low frequency radial motion, for example– give Barden the means to even more accurately analyze bearing performance.

Barden's Quiet Bearing Analyzer controls speed and load application to simulate "real world" operating conditions.

BARDEN PRECISION BEARINGS

Component Tolerances

There are several aspects of inner and outer rings not covered by ABEC standards, including raceway roundness, cross race radius form and raceway finish. Barden has imposed its own exacting criteria and uses several means to check roundness and cross race radius for compliance.

DFTC (deviation from true circularity) measurements are made and graphically depicted by concentric circles enclosing the low and high points of raceway deviation.

dr/dθ (change in radius with a change in circumferential location) measurements are made to define lobing or waviness that could generate noise and vibration in an operating bearing.

Cross race characteristics. Radius form, waviness and surface finish are closely monitored, using laser and computer technology. With equipment unique in the industry, cross race traces are made for comparison with Barden standards.

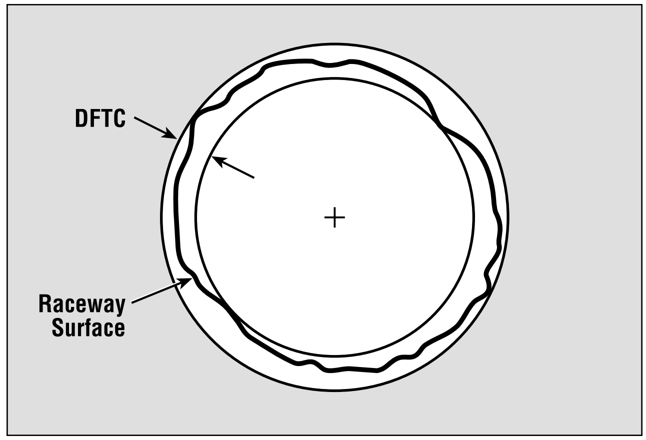


Fig. 40. *DFTC (deviation from true circularity).*

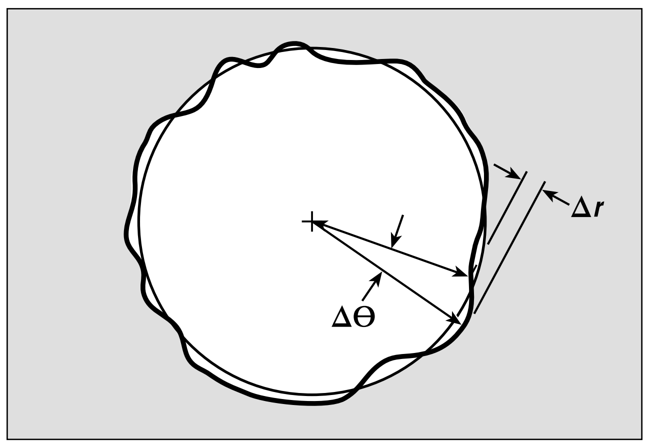


Fig. 41. *dr/dθ (change in radius with a change in circumferential location).*

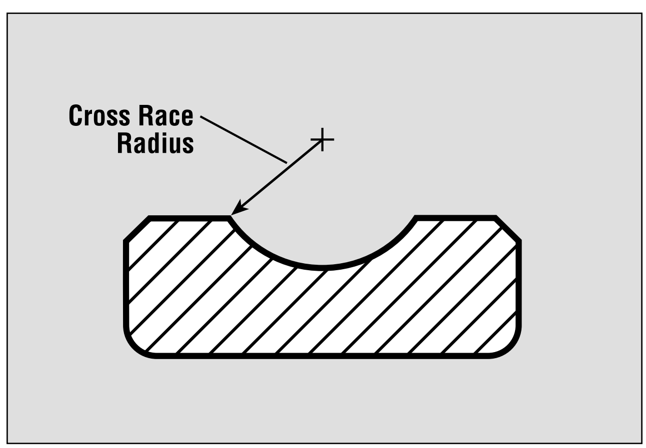


Fig. 42. *Cross race curvature.*

BEARING APPLICATION

MOUNTING & FITTING

After a bearing selection has been made, the product or system designer should pay careful attention to details of bearing mounting and fitting.

Bearing seats on shafts and housings must be accurately machined, and should match the bearing ring width to provide maximum seating surface.

Recommendations for geometry and surface finish of bearing seats and shoulders are shown in Table 40. Dimensional accuracy recommendations for shafts and housings can be found in Tables 38 and 39.

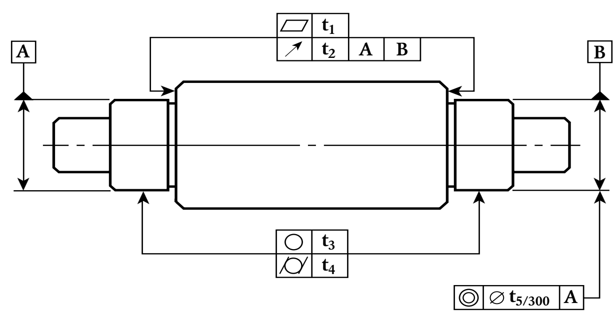


Table 38. Dimensional accuracy recommendations for shafts.

Characteristic	Outside Diameter of Shaft Bearing Seat, mm						
	6-10	11-18	19-30	31-50	51-80	81-120	121-180
▱ Flatness, t_1	60	80	100	100	120	150	200
↗ Runout, t_2	100	120	150	150	200	250	300
○ Roundness, t_3	50	60	75	75	100	125	150
⌭ Taper, t_4	50	60	75	75	100	125	150
◎ Concentricity, t_5	100	120	150	150	200	250	300

Values in microinches.

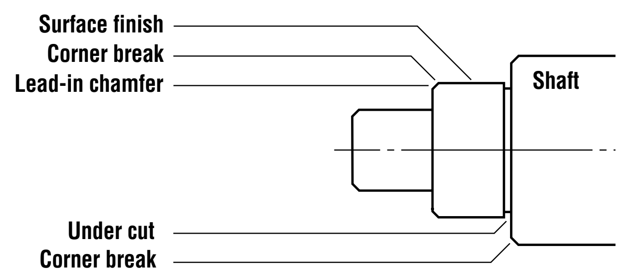


Table 40. Recommended finish of bearing seats and shoulders.

Detail or characteristic	Specification
Lead-in chamfer	Required
Under-cut	Preferred
All corners	Burr-free at 5x magnification
Surface finish	16 micro inch AA max
Bearing seats	Clean at 5x magnification

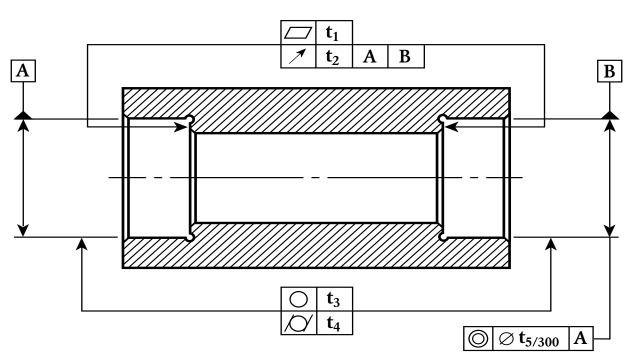


Table 39. Dimensional accuracy recommendations for housings.

Characteristic	Bore Diameter of Bearing Housing, mm						
	10-18	19-30	31-50	51-80	81-120	121-180	181-250
▱ Flatness, t_1	80	100	100	120	150	200	300
↗ Runout, t_2	120	150	150	200	520	300	400
○ Roundness, t_3	75	100	125	150	150	200	250
⌭ Taper, t_4	60	75	75	100	125	150	200
◎ Concentricity, t_5	120	150	150	200	250	300	400

Values in microinches.

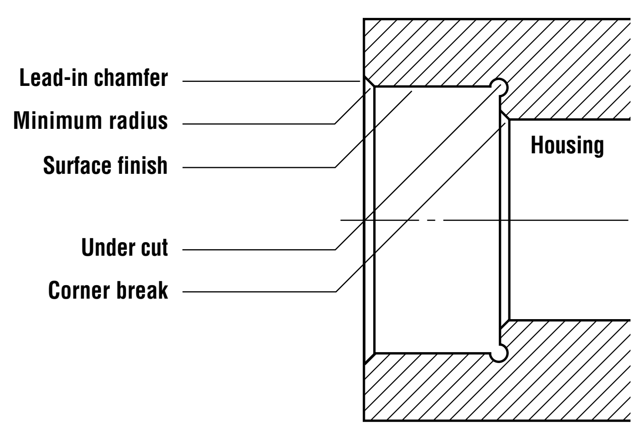


Table 41. Recommended geometry of corners.

Detail \ Bearing	Instrument size bearings	Nominal Bore Diameter, mm		
		6-50	51-120	121-180
Corner break, min.	.001"	.002"	.003"	.004"
Minimum radius	.003"	.003"	.003"	.004"

BARDEN PRECISION BEARINGS

Shaft & Housing Fits

The ideal mounting for a precision bearing has a line-to-line fit, both on the shaft and in the housing. Such an idealized fit has no interference or looseness.

As a practical matter, many influencing factors have to be considered:

- Operating conditions such as load, speed, temperature.
- Provision for axial expansion.
- Ease of assembly and disassembly.
- Requirements for rigidity and rotational accuracy.
- Machining tolerances.

Thus, the appropriate fit may have moderate interference, moderate looseness or even a transitional nature, as governed by operating requirements and the mounting design. Tables 42 and 43 provide general guidelines for typical applications, according to dominant requirements.

Fitting Practice

Interference fits (press fits) may be required when there is:

- A need to avoid mass center shifts.
- Heavy radial loading.
- Vibration that could cause fretting and wear.
- A need for heat transfer.
- A lack of axial clamping.

Interference fits should be used cautiously, as they can distort the raceway and reduce radial play. In preloaded pairs, reduction of radial play increases the preload. If excessive, this can result in markedly reduced speed capability, higher operating temperature and premature failure.

Loose fits may be advisable when:

- There are axial clamping forces
- Ease of assembly is important
- There must be axial movement to accommodate spring loading or thermal movements

Table 42. Shaft and housing fits for instrument bearings.

	Dominant Requirements*		Fit Extremes, inches** Random Fitting	Fit Extremes, inches** Selective Fitting
Shaft Fits	Inner ring clamped	Normal accuracy	.0000	– .0001
			– .0004	– .0003
		Very low runout, high radial rigidity.	+ .0001	.0000
			– .0003	– .0002
	Inner ring not clamped	Normal accuracy	+ .0001	.0000
			– .0003	– .0002
		Very low runout, high radial rigidity.	+ .0003	+ .0002
			– .0001	.0000
		Very high speed service	+ .0002	+ .0001
			– .0002	– .0001
		Inner ring must float to allow for expansion	.0000	– .0001
			– .0004	– .0003
		Inner ring must hold fast to rotating shaft	+ .0003	+ .0002
			– .0001	.0000
Housing Fits	Normal accuracy, low to high speeds. Outer ring can move readily in housing for expansion.		.0000	– .0001
			– .0004	– .0003
	Very low runout, high radial rigidity. Outer ring need not move readily to allow for expansion.		+ .0001	.0000
			– .0003	– .0002
	Heavy radial load. Outer ring rotates.		+ .0001	.0000
			– .0003	– .0002
	Outer ring must hold fast to rotating housing. Outer ring not clamped.		+ .0004	+ .0003
			.0000	+ .0001

*Radial loads are assumed to be stationary with respect to rotating ring.
**Interference fits are positive (+) and loose fits negative (–) for use in shaft and housing size determination, page 121.

BEARING APPLICATION

Loose fits for stationary rings can be a problem if there is a dominant rotating radial load (usually unbalanced). While axial clamping, tighter fits and antirotation devices can help, a better solution is good dynamic balancing of rotating mass.

The appropriate fit may also vary, as governed by operating requirements and mounting design. To ensure a proper fit, assemble only clean, burr-free parts. Even small amounts of dirt on the shaft or housing can cause severe bearing misalignment problems.

When press fitting bearings onto a shaft, force should be applied evenly and only to the ring being fitted or internal damage to the bearing – such as brinelling – could result. If mounting of bearings remains difficult, selective fitting practices should be considered. Selective fitting – utilizing a system of bearing calibration – allows better matching of bearing, shaft and housing tolerances, and can provide more control over assembly.

Fitting Notes:

1. Before establishing tight interference fits, consider their effect on radial internal clearance and bearing preloads (if present). Also realize that inaccuracies in shaft or housing geometry may be transferred to the bearings through interference fits.

2. Radial internal clearance is reduced by approximately 80% of an interference fit. Thus, an interference of .00025" would cause an estimated .0002" decrease in internal clearance. Bearings with

Table 43. Shaft and housing fits for spindle and turbine bearings.

	Dominant Requirements*			Fit Extremes, inches**		
				Nominal Bore Diameter, mm		
				7–30	31–80	81–180
Shaft Fits	Inner ring clamped	Very low runout, high radial rigidity.		+ .0002	+ .0003	+ .0004
				– .0001	– .0001	– .0002
		Low to high speeds, low to moderate radial loads.		+ .00015	+ .0002	+ .0003
				– .00015	– .0002	– .0003
		Heavy radial load	Inner ring rotates	+ .0003	+ .0004	+ .0006
				+ .0000	+ .0000	+ .0000
			Outer ring rotates	+ .0000	+ .0001	.0001
				+ .0003	+ .0003	+ .0005
	Inner ring not clamped	Very low runout, high radial rigidity, light to moderate radial loads.		+ .0003	+ .0004	– .0006
				+ .0000	.0000	.0000
		Heavy radial load	Inner ring rotates	+ .0004	+ .0005	+ .0007
				+ .0001	+ .0001	+ .0001
			Outer ring rotates	+ .0000	+ .0001	+ .0001
				+ .0003	+ .0003	– .0005
		Inner ring must float to allow for expansion, low speed only.		.0000	– .0001	– .0008
				– .0003	– .0005	– .0002
				Nominal Outside Diameter, mm		
				18–80	81–120	121–250
Housing Fits	Normal accuracy, low to high speeds, moderate temperature.			.0000	+ .0001	+ .0002
				– .0004	– .0005	– .0006
	Very low runout, high radial rigidity. Outer ring need not move readily to allow for expansion.			+ .0001	+ .0002	+ .0002
				– .0003	– .0004	– .0006
	High temperature, moderate to high speed. Outer ring can move readily to allow for expansion.			– .0001	– .0001	– .0002
				– .0005	– .0007	– .0010
	Heavy radial load, outer ring rotates.			+ .0004	+ .0006	+ .0008
				+ .0000	.0000	.0005

*Radial loads are assumed to be stationary with respect to rotating ring.
**Interference fits are positive (+) and loose fits negative (–) for use in shaft and housing size determination, page 121.

Code 3 radial play or less should have little or no interference fitting.

3. Keep in mind that mounting fits may be substantially altered at operating temperatures due to differential expansion of components. Excessive thermal expansion can quickly cause bearing failure if the radial play is reduced to zero or less, creating a radial preload.
4. An axially floating loose fit for one bearing of two-bearing system is usually needed to avoid preloading caused by thermal expansion during operation.
5. When an interference fit is used, it is generally applied to the rotating ring. The stationary ring is fitted loose for ease of assembly.
6. Spring-loaded bearings require a loose fit to ensure that the spring loading remains operational.
7. In the case of loose fits, inner and outer rings should be clamped against shoulders to minimize the possibility of nonrepetitive runout.
8. Diameter and squareness tolerances for shaft and housing mounting surfaces and shoulders should be similar to those for the bearing bore and O.D. The surface finish and hardness of mating components should be suitable for prolonged use, to avoid deterioration of fits during operation.
9. Proper press-fitting techniques must be used to prevent damage during assembly. Mounting forces must never be transmitted through the balls from one ring to the other. Thus, if the inner ring is being press fitted, force must be applied directly to the inner ring.
10. When a more precise fit is desired, bearings can be obtained that are calibrated into narrower bore and O.D. tolerance groups. These can be matched to similarly calibrated shafts and housings to cut the fit tolerance range by 50% or more.

Shaft and Housing Size Determination

The fits listed in Tables 42 and 43 (pages 119 and 120) apply to normal operating temperatures and are based on average O.D. and bore sizes. The size and tolerance of the shaft or housing for a particular application can be readily computed by working back from the resulting fit, as shown in the example. Note that the total fit tolerance is always the sum of the bearing bore or O.D. tolerance plus the mating shaft or housing tolerance.

Example: Determination of shaft and housing size for a 204H bearing installation in a grinding spindle.

	Bore	**O.D.**
204H nominal diameter	20mm (.7874")	47mm (1.8504")
204H tolerance from Tables 24 and 25 (page 49)	+.000" −.0002"	+.000" −.00025"
Actual diameter range	.78740"/.7872"	1.8504"/1.85015"

Desired fit chosen for this application
(data from Table 43, page 120)

On shaft: +.0002" (tight) / −.0001" (loose)

In housing: .0000" (line-to-line) / −.0004" (loose)

DETERMINING SHAFT O.D.

Tightest fit is with maximum shaft O.D. and minimum bearing bore diameter:

Minimum bearing bore diameter .... .7872"
Add: tightest fit extreme .... .0002"
Maximum Shaft O.D. .... .7874"

Loosest fit is with minimum shaft O.D. and maximum bearing bore diameter:

Maximum bearing bore diameter .... .7874"
Subtract: loosest fit extreme .... .0001"
Minimum Shaft O.D..................................... .7873"

DETERMINING HOUSING I.D.

Tightest fit is with maximum bearing O.D. and minimum housing I.D.:

Maximum bearing O.D. .... 1.8504"
Subtract: tightest fit extreme.......................... .0000"
Minimum housing I.D. .... 1.8504"

Loosest fit is with minimum bearing O.D. and maximum housing I.D.:

Minimum bearing O.D.............................. 1.85015"
Add: loosest fit extreme .... .0004"
Maximum housing I.D............................. 1.85055"

Shaft and Housing Shoulder Diameters

Shaft and housing shoulders must be high enough to provide accurate, solid seating with good alignment and support under maximum thrust loading. At the same time, the shoulders should not interfere with bearing cages, shields or seals. This caution is particularly important when bearings have high values of radial play and are subject to heavy thrust loads.

Besides being high enough for good seating, shoulders should be low enough to allow use of bearing tools against appropriate ring faces when bearings are dismounted, to avoid damage from forces transmitted through the balls. This caution applies especially to interference-fitted bearings that are going to be used again after dismounting.

Spacers, sleeves or other parts may be used to provide shoulders as long as recommended dimensional limits are observed. When possible, the rotating ring of a bearing should be located against an accurately machined surface on at least one face.

In high-speed applications where oil spray or mist lubrication systems are used, shoulder design may be extremely important because it is essential that lubricant flow be effective and unimpeded.

Fig. 43. ZSB shaft and housing shoulder diameters.

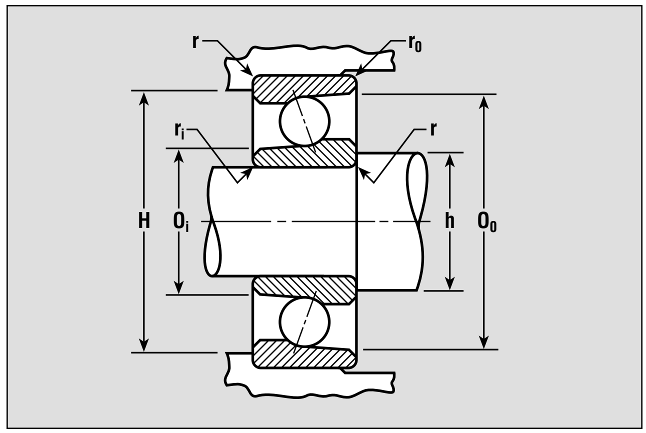


Table 44. Shaft and housing shoulder diameters.

Bearing Number	Bearing Dimensions		Relieved Face Diameter		Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear			Shaft Shoulder Diameters				Housing Shoulder Diameters			
	Bore Dia.	Outside Dia.	O_i	O_o	r	r_i	r_o	Open h min.	Open h max	Shielded or Sealed h min.	Shielded or Sealed h max	Open H min.	Open H max	Shielded or Sealed H min.	Shielded or Sealed H max
Series ZSB															
ZSB101JSS	.4724	1.1024	.612	.956	.012	.012	.012			.620	.668			.924	.956
ZSB102JSS	.5906	1.2598	.714	1.121	.012	.012	.012			.738	.798			1.081	1.113
ZSB103JSS	.6693	1.3780	.800	1.227	.012	.012	.012			.818	.878			1.187	1.230
ZSB104JSS	.7874	1.6535	.963	1.458	.025	.025	.025			.947	1.042			1.409	1.467
ZSB105JSS	.9843	1.8504	1.164	1.655	.025	.025	.025			1.144	1.245			1.606	1.664
ZSB106JSS	1.1811	2.1654	1.437	1.928	.040	.040	.040			1.441	1.517			1.879	1.905
ZSB107JSS	1.3780	2.4409	1.585	2.185	.040	.040	.040			1.638	1.700			2.130	2.181
ZSB108JSS	1.5748	2.6772	1.801	2.403	.040	.040	.040			1.835	1.916			2.346	2.417
ZSB111JSS	2.1654	3.5433	2.5731	3.304	.040	.040	.040			2.485	2.602			3.375	3.420
ZSB113JSS	2.5591	3.9370	2.855	3.644	.040	.040	.040			2.879	3.000			3.572	3.617
ZSB114JSS	2.7559	4.3307	3.110	3.975	.040	.040	.040			3.076	3.295			3.894	4.011
ZSB118JSS	3.5433	5.5118	3.920	5.145	.060	.060	.060			3.943	4.145			5.037	5.112
ZSB120JSS	3.9370	5.9055	4.315	5.535	.060	.060	.060			4.337	4.540			5.432	5.506
ZSB124JSS	4.7244	7.0866	5.235	6.577	.080	.080	.080			5.284	5.490			6.455	6.527
ZSB202JSS	.5906	1.3780	.800	1.227	.025	.025	.025			.764	.878			1.187	1.205
ZSB204JSS	.7874	1.8504	1.028	1.595	.040	.040	.040			1.027	1.127			1.539	1.610
ZSB206JSS	1.1811	2.4409	1.459	2.200	.040	.040	.040			1.431	1.591			2.130	2.191
ZSB207JSS	1.3780	2.8346	1.693	2.523	.040	.040	.040			1.628	1.841			2.450	2.585
ZSB210JSS	1.9685	3.5433	2.335	3.250	.040	.040	.040			2.238	2.515			3.161	3.273

All dimensions in inches.

Continued on next page.

Fig. 44. Non-ZSB bearing shaft and housing diameters. When planned applications involve bearing removal and remounting, shoulder dimensions should be selected to facilitate dismounting. Minimum shaft shoulders and maximum housing shoulders are preferred, particularly with interference fits.

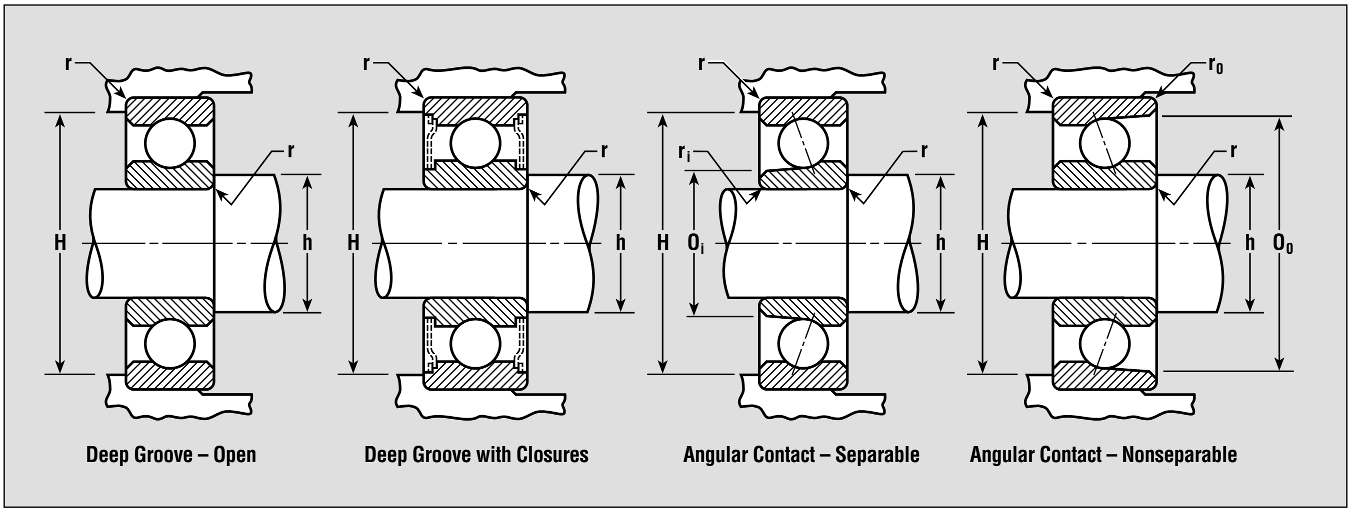


Table 44, *continued.* Shaft and housing shoulder diameters.

Bearing Number	Bearing Dimensions				Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear			Shaft Shoulder Diameters				Housing Shoulder Diameters			
			Relieved Face Diameter					Open		Shielded or Sealed		Open		Shielded or Sealed	
	Bore Dia.	Outside Dia.	O_i	O_o	r	r_i	r_o	h min.	h max	h min.	h max	H min.	H max	H min.	H max
Series R and FR															
SR2, SFR2	.1250	.3750			.012			.179	.200	.079	.200	.300	.325	.320	.325
SR2B	.1250	.3750	.184		.012			.179	.200			.292	.325		
SR2H	.1250	.3750		.311	.012		.006	.179	.200			.300	.325		
SR2A	.1250	.5000			.012			.179	.182	.179	.182	.320	.446	.320	.446
SR3, SFR3	.1875	.5000			.012			.244	.276	.244	.252	.412	.446	.430	.446
SR3B	.1875	.5000	.247		.012	.005		.244	.276			.412	.446		
SR3H	.1875	.5000		.436	.012		.005	.244	.276			.412	.446		
SR3SSX8	.1875	.7500			.012					.244	.252			.430	.678
SR3SSX23	.1875	.8750			.012					.244	.252			.430	.799
SR4, SFR4	.2500	.6250			.012			.310	.365	.310	.322	.512	.565	.547	.565
SR4B	.2500	.6250	.333		.012	.010		.310	.365			.503	.565		
SR4H	.2500	.6250		.530	.012		.010	.310	.365			.503	.565		
SR4HX8	.2500	.6250		.578	.012		.006	.310	.365			.512	.565		
SR4A	.2500	.7500			.016			.322	.386	.322	.342	.596	.678	.648	.678
SR6, SFR6	.3750	.8750			.016			.451	.520	.451	.472	.744	.799	.784	.799
SR8	.5000	1.1250			.016			.625	.736	.625	.682	.972	1.025	1.013	1.025
SR8H	.5000	1.1250		1.011	.016		.008	.625	.736			.972	1.025		
SR10	.6250	1.3750			.031			.750	.895	.750	.835	1.153	1.250	1.215	1.250

All dimensions in inches.

Continued on next page.

BEARING APPLICATION

Table 44, *continued.* Shaft and housing shoulder diameters.

Bearing Number	Bearing Dimensions				Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear			Shaft Shoulder Diameters				Housing Shoulder Diameters			
	Bore Dia.	Outside Dia.	Relieved Face Diameter					Open		Shielded or Sealed		Open		Shielded or Sealed	
			O_i	O_o	r	r_i	r_o	h min.	h max	h min.	h max	H min.	H max	H min.	H max
Series 30															
34	.1575	.6299			.012			.222	.295	.222	.256	.492	.556	.547	.556
34BX4	.1575	.6299	.234		.012		.005	.222	.300			.492	.556		
34-5	.1969	.6299			.012			.222	.295	.222	.256	.492	.556	.547	.556
34-5B	.1969	.6299	.263		.012		.005	.222	.300			.492	.556		
34-5H	.1969	.6299		.522	.012			.222	.295			.492	.556		
35	.1969	.7480			.012	.005		.261	.383	.261	.342	.596	.674	.646	.674
36	.2362	.7480			.012			.300	.383	.300	.342	.596	.674	.646	.674
36BX1	.2362	.7480	.310		.012		.005	.300	.383			.596	.674		
36H	.2362	.7480		.636	.012			.300	.383			.596	.674		
37	.2756	.8661			.012			.340	.463	.340	.415	.692	.792	.744	.792
37H	.2756	.8661		.739	.012	.010		.340	.463			.692	.792		
37SSTX2	.2756	.8661			.012					.340	.415			.744	.792
38	.2756	.8661			.012			.340	.463			.692	.792		
38SSX2	.3150	.8661			.012			.379	.463	.379	.415	.692	.792	.744	.792
38SSX6	.3150	.9449			.012					.379	.415			.744	.870
38BX2	.3150	.8661	.413		.012		.005	.379	.463			.692	.792		
38H	.3150	.8661		.739	.012			.379	.463			.692	.792		
39	.3543	1.0236			.016			.450	.583	.450	.547	.837	.924	.893	.924
39H	.3543	1.0236		.898	.012			.450	.583			.837	.924		
Series 1900															
1900H	.3937	.8661		.788	.012		.006	.489	.552			.716	.770		
1901H	.4724	.9449		.870	.012			.570	.630			.795	.850		
1902H	.5906	1.1024		1.022	.012		.006	.708	.785			.951	1.006		
1903H	.6693	1.1811		1.082	.016		.006	.773	.847			1.019	1.077		
1904H	.7874	1.4567		1.341	.012		.006	.903	1.013			1.242	1.360		
1905H	.9843	1.6535		.1538	.012		.010	1.092	1.210			1.439	1.539		
1906H	1.1811	1.8504		1.736	.012		.010	1.296	1.407			1.636	1.742		
1907H	1.3780	2.1654		2.041	.025		.015	1.540	1.655			1.928	2.050		
1908H	1.5748	2.4409		2.290	.025		.015	1.726	1.867			2.163	2.300		
1909H	1.7717	2.6772		2.510	.025		.015	1.932	2.084			2.380	2.517		
1910H	1.9685	2.8346		2.683	.025		.015	2.150	2.261			2.556	2.655		
1911H	2.1654	3.1496		2.971	.040		.015	2.400	2.500			2.830	2.910		
1912H	2.6322	3.3465		3.170	.040		.020	2.600	2.700			3.027	3.110		
1913H	2.5591	3.5433		3.365	.040		.020	2.795	2.895			3.223	3.326		
1914H	2.7559	3.9310		3.730	.040		.020	3.035	3.155			3.555	3.655		
1915H	2.9528	4.1339		3.920	.040		.020	3.270	3.337			3.731	3.815		
1916H	3.1496	4.3307		4.116	.040		.020	3.430	3.555			3.945	4.050		
1917H	3.3465	4.7244		4.480	.040		.020	3.670	3.815			4.276	4.400		
1918H	3.5433	4.9213		4.672	.040		.020	3.865	4.010			4.475	4.600		
1919H	3.7402	5.1181		4.870	.040		.020	4.060	4.210			4.670	4.800		
1920H	3.9370	5.5118		5.226	.040		.020	4.250	4.475			5.000	5.195		
1921H	4.1339	5.7087		5.430	.040		.020	4.380	4.795			5.200	5.470		
1922H	4.3307	5.9055		5.625	.040		.020	4.580	4.865			5.395	5.660		

All dimensions in inches.

Continued on next page.

BARDEN PRECISION BEARINGS

Fig. 44, *continued.* **Non-ZSB bearing shaft and housing diameters. When planned applications involve bearing removal and remounting, shoulder dimensions should be selected to facilitate dismounting. Minimum shaft shoulders and maximum housing shoulders are preferred, particularly with interference fits.**

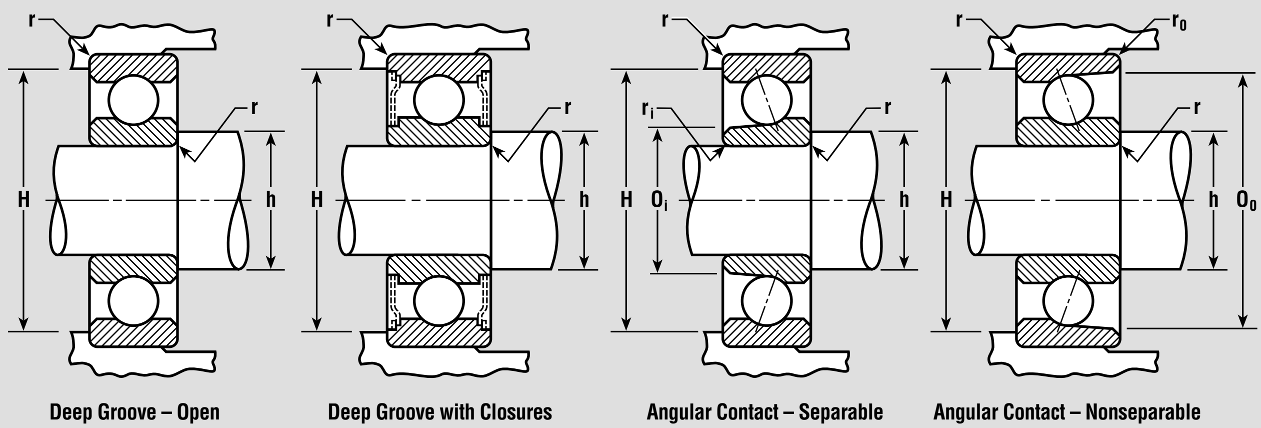


Table 44, *continued.* **Shaft and housing shoulder diameters.**

Bearing Number	Bearing Dimensions				Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear			Shaft Shoulder Diameters				Housing Shoulder Diameters			
	Bore Dia.	Outside Dia.	Relieved Face Diameter					Open		Shielded or Sealed		Open		Shielded or Sealed	
			O_i	O_o	r	r_i	r_o	h min.	h max	h min.	h max	H min.	H max	H min.	H max
Series 1900, *continued*															
1924H	4.7244	6.4961		6.174	.040		.020	4.965	5.328			5.920	6.205		
1926H	5.1181	7.0867		6.730	.060		.030	5.520	5.790			6.445	6.685		
1928H	5.5118	7.4803		7.130	.060		.030	5.950	6.184			6.840	7.040		
1930H	5.9055	8.2677		7.870	.080		.040	6.465	6.695			7.516	7.710		
Series 100															
100	.3937	1.0236			.012			.465	.547	.465	.547	.893	.953	.893	.953
100SSX1	.3937	1.0236			.012					.465	.547			.893	.953
100H	.3937	1.0236		.898	.012		.010	.465	.583			.837	.953		
2100H	.3937	1.0236		.898	.012		.010	.465	.615			.812	.953		
101	.4724	1.1024			.012			.543	.670			.924	1.031		
101SSX1	.4724	1.1024			.012					.543	.630			.980	1.031
101BX48	.4724	1.1024	.599		.012	.010		.543	.670			.924	1.031		
101H	.4724	1.1024		.985	.012		.010	.543	.670			.924	1.031		
2101H	.4724	1.1024		.985	.012		.010	.580	.703			.900	.994		
102	.5906	1.2598			.012			.662	.798	.662	.772	1.053	1.189	1.101	1.189
102BX48	.5906	1.2598	.725		.012	.010		.662	.798			1.053	1.189		
102H	.5906	1.2598		1.112	.012		.010	.662	.798			1.053	1.189		
2102H	.5906	1.2598		1.145	.012		.010	.662	.816			1.046	1.189		
103	.6693	1.3780			.012			.740	.835	.740	.835	1.215	1.307	1.215	1.307
103BX48	.6693	1.3780	.786		.012	.010		.740	.930			1.153	1.307		
103H	.6693	1.3780		1.213	.012		.010	.740	.835			1.153	1.307		
2103H	.6693	1.3780		1.245	.012		.010	.740	.914			1.145	1.307		

All dimensions in inches.

Continued on next page.

BEARING APPLICATION

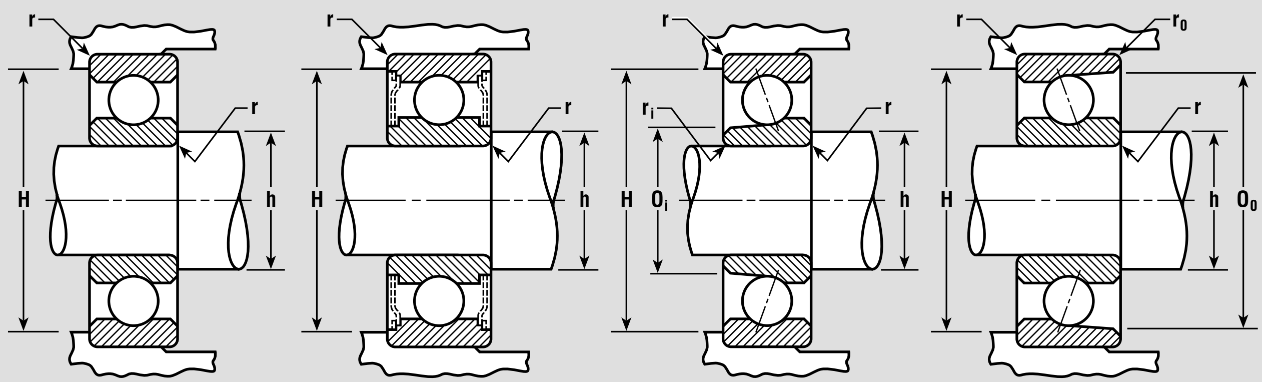
Table 44, *continued.* Shaft and housing shoulder diameters.

Bearing Number	Bearing Dimensions				Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear			Shaft Shoulder Diameters				Housing Shoulder Diameters			
			Relieved Face Diameter					Open		Shielded or Sealed		Open		Shielded or Sealed	
	Bore Dia.	Outside Dia.	O_i	O_o	r	r_i	r_o	h min.	h max	h min.	h max	H min.	H max	H min.	H max
Series 100, ***continued***															
104	.7874	1.6535			.025			.898	1.050	.898	.981	1.390	1.543	1.458	1.543
104BX48	.7874	1.6535	.922		.025	.015		.898	1.093			1.390	1.543		
104H	.7874	1.6535		1.470	.025		.015	.898	1.050			1.390	1.543		
2104H	.7874	1.6535		1.470	.025		.015	.898	1.095			1.358	1.543		
105	.9843	1.8504			.025			1.095	1.291	1.095	1.176	1.554	1.740	1.655	1.740
105BX48	.9843	1.8504	1.119		.025	.015		1.095	1.291			1.554	1.740		
105H	.9843	1.8504		1.668	.025		.015	1.095	1.291			1.587	1.740		
2105H	.9843	1.8504		1.668	.025		.015	1.103	1.291			1.556	1.740		
106	1.1811	2.1654			.040			1.331	1.451	1.331	1.451	1.949	2.015	1.949	2.015
106BX48	1.1811	2.1654	1.367		.040	.020		1.331	1.511			1.869	2.015		
106H, 2106H	1.1811	2.1654		1.972	.040		.020	1.331	1.511			1.869	2.015	2.190	2.283
107	1.3780	2.4409			.040			1.536	1.620	1.536	1.620	2.190	2.283		
107BX48	1.3780	2.4409	1.542		.040	.020		1.615	1.710			2.190	2.283		
107H, 2107H	1.3780	2.4409		2.225	.040		.020	1.536	1.753			2.081	2.283	2.395	2.503
108	1.5748	2.6772			.040					1.749	1.848				
108BX48	1.5748	2.6772	1.755		.040	.020		1.835	1.970			2.298	2.503		
108H, 2108H	1.5748	2.6772		2.442	.040		.020	1.749	1.939			2.315	2.503		
109	1.7717	2.9528			.040			1.945	2.174			2.714	2.779		
109H, 2109H	1.7717	2.9528		2.739	.040		.020	1.945	2.174			2.569	2.779	2.908	2.976
110	1.9685	3.1496			.040			2.142	2.238	2.142	2.238	2.908	2.976		
110BX48	1.9685	3.1496	2.142		.040	.020		2.183	2.372			2.768	2.937		
110H, 2110H	1.9685	3.1496		2.937	.040		.020	2.142	2.372			2.768	2.976	3.254	3.354
111	2.1654	3.5433			.040					2.355	2.524				
111H, 2111H	2.1654	3.5433		3.290	.040		.020	2.355	2.604			3.113	3.354		
112H, 2112H	2.3622	3.7402		3.490	.040		.020	2.552	2.832			3.292	3.551		
113BX48	2.5591	3.9370	2.759		.040	.020		2.811	3.003			3.513	3.688		
113H, 2113H	2.5591	3.9370		3.688	.040		.020	2.748	3.003			3.513	3.748		
114H, 2114H	2.7559	4.3307		4.043	.040		.020	2.961	3.259			3.815	4.126		
115H, 2115H	2.9528	4.5276		4.243	.040		.020	3.158	3.490			4.015	4.323		
116H, 2116H	3.1496	4.9213		4.601	.040		.020	3.370	3.754			4.344	4.701		
117BX48	3.3465	5.1181	3.625		.040	.020		3.668	3.950			4.542	4.795		
117H, 2117H	3.3465	5.1181		4.797	.040		.020	3.567	3.950			4.542	4.897		
118H, 2118H	3.5433	5.5118		5.156	.060		.030	3.820	4.217			4.874	5.236		
119H, 2119H	3.7402	5.7087		5.353	.060		.030	4.016	4.412			5.068	5.432		
120H, 2120H	3.9370	5.9055		5.549	.060		.030	4.213	4.609			5.265	5.629		
121H, 2121H	4.1339	6.2992		5.910	.080		.040	4.695	4.872			5.596	5.740		
122H, 2122H	4.3307	6.6929		6.296	.080		.040	4.686	5.121			5.942	6.338		
124H, 2124H	4.7244	7.0866		6.691	.080		.040	5.080	5.515			6.335	6.731		
126H, 2126H	5.1181	7.8740		7.404	.080		.040	5.505	6.043			6.994	7.487		
128H	5.5118	8.2677		7.798	.080		.040	5.982	6.437			5.982	7.880		
130H	5.9055	8.8583		8.290	.085		.050	6.474	6.930			7.880	8.370		

All dimensions in inches.

Continued on next page.

Fig. 44, *continued.* Non-ZSB bearing shaft and housing diameters. When planned applications involve bearing removal and remounting, shoulder dimensions should be selected to facilitate dismounting. Minimum shaft shoulders and maximum housing shoulders are preferred, particularly with interference fits.



Deep Groove – Open | Deep Groove with Closures | Angular Contact – Separable | Angular Contact – Nonseparable

Table 44, *continued.* Shaft and housing shoulder diameters.

Bearing Number	Bearing Dimensions				Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear			Shaft Shoulder Diameters				Housing Shoulder Diameters			
	Bore Dia.	Outside Dia.	Relieved Face Diameter O_i	O_0	r	r_i	r_0	Open h min.	Open h max	Shielded or Sealed h min.	Shielded or Sealed h max	Open H min.	Open H max	Shielded or Sealed H min.	Shielded or Sealed H max
Series 200															
200	.3937	1.1811			.025			.518	.656	.518	.596	.953	1.057	1.014	1.057
200H	.3937	1.1811		1.024	.025		.015	.518	.656			.953	1.057		
2200H	.3937	1.1811		1.010	.025		.015	.518	.687			.908	1.057		
201	.4724	1.2598			.025			.602	.675	.602	.675	1.100	1.130	1.100	1.130
201SSX1	.5118	1.2598			.025					.642	.675			1.100	1.130
201H	.4724	1.2598		1.118	.025		.015	.602	.721			1.040	1.130		
2201H	.4724	1.2598		1.118	.025		.015	.602	.749			.995	1.130		
202	.5906	1.3780			.025			.726	.755	.726	.755	1.223	1.243	1.223	1.243
202SSX1	.5906	1.3780			.025					.726	.755			1.223	1.243
202H	.5906	1.3780		1.235	.025		.015	.726	.815			1.153	1.243		
2202H	.5906	1.3780		1.010	.025		.015	.726	.678			.908	1.243		
203HX37	.6299	1.4961		1.388	.025		.015	.771	.952			1.292	1.354		
203	.6693	1.5748			.025			.810	.952	.810	.890	1.292	1.433	1.372	1.433
203H, 2203H	.6693	1.5748		1.388	.025		.015	.810	.986			1.267	1.433		
204	.7874	1.8504			.040			.977	1.060	.977	1.060	1.610	1.661	1.610	1.661
204H	.7874	1.8504		1.645	.040		.020	.977	1.130			1.530	1.661		
2204H	.7874	1.8504		1.645	.040		.020	.977	1.174			1.502	1.661		
205	.9843	2.0472			.040			1.174	1.320	1.174	1.245	1.720	1.858	1.610	1.661
205H	.9843	2.0472		1.835	.040		.020	1.174	1.320			1.720	1.858		
2205H	.9843	2.0472		1.835	.040		.020	1.174	1.364			1.693	1.858	1.800	1.858
206	1.1811	2.4409			.040			1.392	1.500	1.392	1.500	2.200	2.230		
206H, 2206H	1.1811	2.4409		2.228	.040		.020	1.392	1.616			2.044	2.230	2.200	2.230

All dimensions in inches.

Continued on next page.

BEARING APPLICATION

Table 44, *continued.* Shaft and housing shoulder diameters.

Bearing Number	Bearing Dimensions: Bore Dia.	Outside Dia.	Relieved Face Diameter O_i	O_o	Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear: r	r_i	r_o	Shaft Shoulder Diameters: Open h min.	Open h max	Shielded or Sealed h min.	Shielded or Sealed h max	Housing Shoulder Diameters: Open H min.	Open H max	Shielded or Sealed H min.	Shielded or Sealed H max
Series 200, ***continued***															
207	1.3780	2.8346			.040			1.611	1.777	1.611	1.777	2.523	2.601	2.523	2.601
207H, 2207H	1.3780	2.8346		2.562	.040		.020	1.611	1.857			2.382	2.601		
208	1.5748	3.1496			.040			1.819	2.130	1.819	2.050	2.643	2.906	2.788	2.906
208H, 2208H	1.5748	3.1496		2.834	.040		.020	1.819	2.130			2.620	2.906		
209	1.7717	3.3465			.040			2.016	2.289	2.016		2.850	3.102	2.995	3.102
209H, 2209H	1.7717	3.3465		3.042	.040		.020	2.016	2.289			2.850	3.102		
210H, 2210H	1.9685	3.5433		3.263	.040		.020	2.224	2.460			3.060	3.288		
210	1.9685	3.5433			.040			2.224	2.460			3.060	3.288		
211	2.1654	3.9370			.060			2.482	2.764			3.362	3.620		
211H, 2211H	2.1654	3.9370		3.612	.060		.030	2.482	2.764			3.362	3.620		
212H, 2212H	2.3622	4.3307		3.978	.060		.030	2.701	2.975			3.725	3.993		
213H, 2213H	2.5591	4.7244		4.331	.060		.030	2.920	3.295			4.013	4.364		
214H, 2214H	2.7559	4.9213		4.531	.060		.030	3.117	3.495			4.220	4.561		
215H, 2215H	2.9528	5.1181		4.731	.060		.030	3.313	3.692			4.420	4.757		
216H, 2216H	3.1496	5.5118		5.084	.080		.040	3.572	3.954			4.743	5.089		
217H, 2217H	3.3465	5.9055		5.457	.080		.040	3.812	4.235			5.056	5.435		
218H, 2218H	3.5433	6.2992		5.798	.080		.040	4.020	4.483			5.405	5.822		
219H, 2219H	3.7402	6.6929		6.220	.080		.040	4.380	4.750			5.736	6.053		
220H, 2220H	3.9370	7.0866		6.514	.080		.040	4.447	5.012			6.062	6.576		
221H, 2221H	4.1339	7.4803		6.875	.080		.040	4.770	5.270			6.396	6.840		
222H, 2222H	4.3307	7.8740		7.240	.080		.040	4.970	5.539			6.722	7.234		
222	4.3307	7.8740			.080			4.970	5.539			6.722	7.234		
232	6.2992	11.4173			.120			7.090	8.172			9.616	10.610		
Series 300															
2301H, 301H	.4724	1.4567		1.235	.040		.020	.712	.832			1.111	1.220		
302H	.5906	1.6535		1.481	.040		.020	.830	.963			1.324	1.413		
2302H	.5906	1.6535		1.489	.040		.020	.830	.963			1.324	1.413		
303	.6693	1.8504			.040			.900	1.000			1.450	1.610		
303H	.6693	1.8504		1.610	.040		.020	.900	1.000			1.450	1.610		
2303H	.6693	1.8504		1.610	.040		.020	.900	1.000			1.450	1.610		
304H, 2304H	.7874	2.0472		1.837	.040		.020	1.013	1.216			1.665	1.780		
305	.9843	2.4409			.040			1.224	1.425			2.094	2.200		
305H, 2305H	.9843	2.4409		2.192	.040		.020	1.230	1.476			1.968	2.180		
306	1.1811	2.8346			.040			1.460	1.693			2.410	2.550		
306H	1.1811	2.8346		2.552	.040		.040	1.460	1.742			2.300	2.550		
2306H	1.1811	2.8346		2.552	.040		.040	1.460	1.742			2.300	2.550		
2306HX3	1.1811	2.8310		2.556	.040		.040	1.460	1.742			2.304	2.550		
307	1.3780	3.1496			.060			1.738	1.905			2.720	2.800		
307H	1.3780	3.1496		2.842	.060		.030	1.738	1.983			2.573	2.800		
308	1.5748	3.5433			.060			1.935	2.200			3.080	3.185		
308H	1.5748	3.5433		3.220	.060		.030	1.935	2.280			2.937	3.185		
2308H	1.5748	3.5433		3.220	.060		.030	1.935	2.280			2.937	3.185		
309	1.7117	3.9370			.080			2.252	2.510			3.232	3.580		

All dimensions in inches.

Continued on next page.

BARDEN PRECISION BEARINGS

Fig. 44, *continued.* Non-ZSB bearing shaft and housing diameters. When planned applications involve bearing removal and remounting, shoulder dimensions should be selected to facilitate dismounting. Minimum shaft shoulders and maximum housing shoulders are preferred, particularly with interference fits.

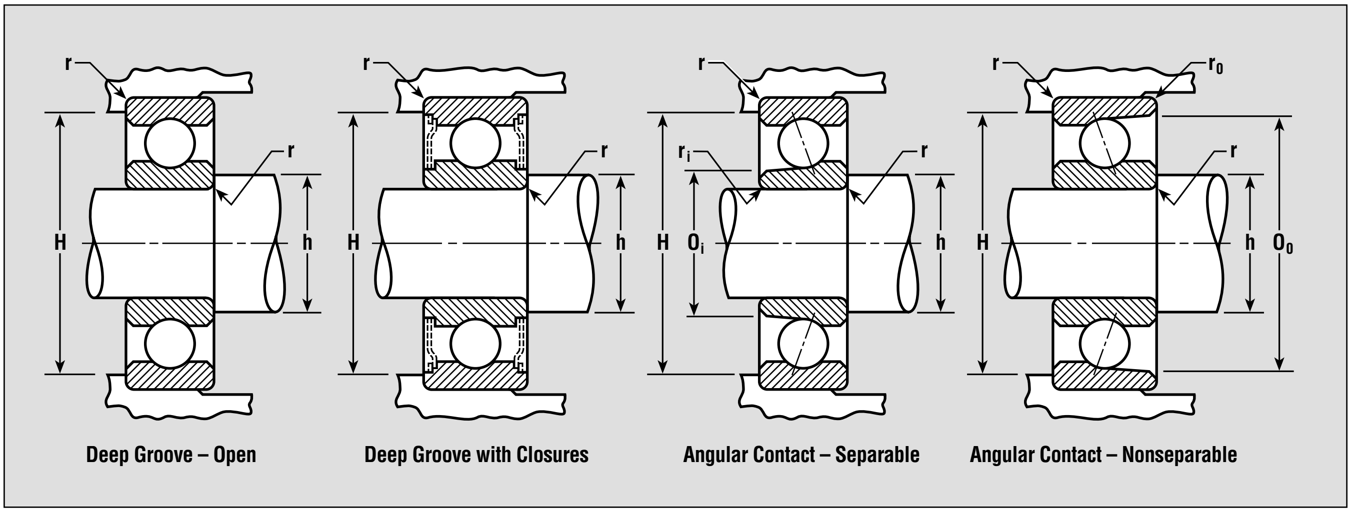


Table 44, *continued.* Shaft and housing shoulder diameters.

Bearing Number	Bearing Dimensions: Bore Dia.	Outside Dia.	Relieved Face Diameter O_i	O_o	Maximum Shaft/Housing Fillet Radius Which Bearing Corner Will Clear: r	r_i	r_o	Shaft Shoulder Diameters, Open: h min.	h max	Shielded or Sealed: h min.	h max	Housing Shoulder Diameters, Open: H min.	H max	Shielded or Sealed: H min.	H max
Series 300, *continued*															
309H	1.7717	3.9370		3.545	.060		.030	2.130	2.510			3.232	3.580		
2309H	1.7717	3.9370		3.545	.060		.030	2.130	2.510			3.232	3.580		
310	1.9685	4.3307			.080			2.589	2.700			3.600	3.712		
310H, 2310H	1.9685	4.3307		3.9017	.080		.040	2.589	2.700			3.502	3.851		
311	2.1654	4.7244			.080			2.645	3.044			3.897	4.244		
312	2.3622	5.1181			.080			2.842	3.155			4.222	4.638		
316	3.1496	6.6924			.080			3.630	4.390			5.505	6.213		
317	3.3465	7.0866			.100			3.947	4.654			5.836	6.487		
318	3.5433	7.4803			.100			4.193	4.918			6.165	6.880		
322	4.3307	9.4488			.120			5.131	6.150			7.725	8.649		
Series 9000															
9204	.7874	1.8504			.040					.977	1.060			1.610	1.6610
9205	.9483	2.0472			.040					1.174	1.245			1.800	1.8580
9206	1.1811	2.4409			.040					1.392	1.500			2.200	2.2300
9207	1.3780	2.8346			.040					1.618	1.786			2.523	2.5950
9208	1.5748	3.1496			.040					1.819	2.050			2.788	2.9060
9209	1.7717	3.3465			.040					2.012	2.209			2.995	3.1070
9307	1.3780	3.1496			.060					1.738	1.902			2.720	2.7896
9308	1.5748	3.5433			.060					1.935	2.200			3.083	3.1833
9310	1.9685	4.3307			.080					2.449	2.650			3.762	3.8507

All dimensions in inches.

ENGINEERING

BEARING APPLICATION

LUBRICATION WINDOWS

For those angular contact spindle bearings being lubricated by an air/oil or jet system the following tables will guide the placement of the spray or jet.

Fig. 45. Lubrication window for H-type bearing.

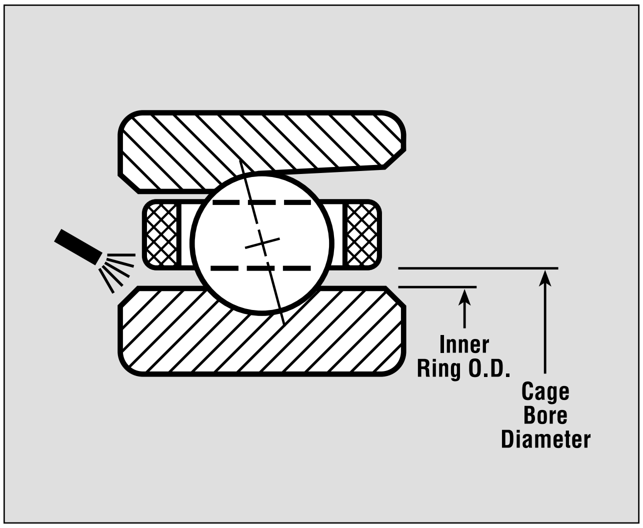


Fig. 46. Lubrication window for B and ZSB-type bearings.

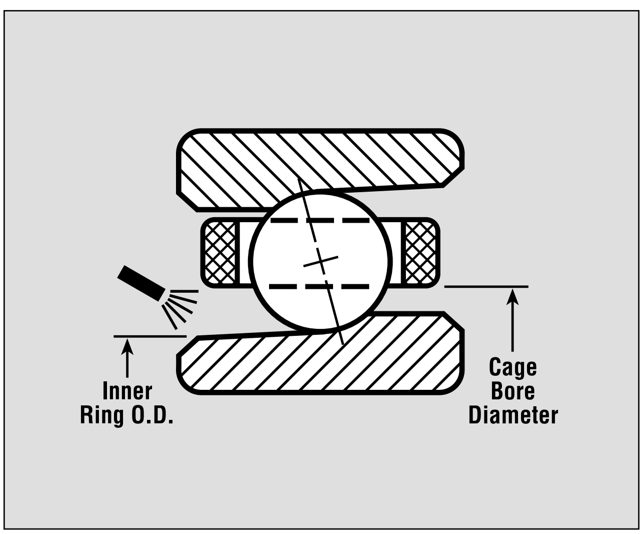


Table 45. Bearing lubrication window – 1900H Series.

Bearing Size	Cage Bore Diameter (Inches)	Inner Ring O.D. (Inches)
1900H	.623	.552
1901H	.688	.631
1902H	.846	.787
1903H	.910	.847
1904H	1.116	1.013
1905H	1.289	1.210
1906H	1.473	1.407
1907H	1.736	1.665
1908H	1.953	1.867
1910H	2.327	2.261
1911H	2.620	2.501
1913H	3.012	2.895
1918H	4.180	4.013

Table 46. Bearing lubrication window – 100H Series.

Bearing Size	Cage Bore Diameter (Inches)	Inner Ring O.D. (Inches)
100H	.731	.583
101H	.805	.670
102H	.902	.798
103H	1.022	.895
104H	1.236	1.050
105H	1.390	1.291
106H	1.652	1.511
107H	1.867	1.753
108H	2.073	1.939
109H	2.310	2.174
110H	2.487	2.372
111H	2.779	2.604
112H	2.970	2.832
113H	3.157	3.003
114H	3.534	3.259
115H	3.667	3.490
116H	3.922	3.754
117H	4.104	3.950
118H	4.396	4.217
119H	4.580	4.412
120H	4.777	4.609
121H	5.057	4.872
122H	5.355	5.121
124H	5.726	5.515
126H	6.314	6.043
128H	6.680	6.437
130H	7.145	6.930

Table 47. Bearing lubrication window – 200H Series.

Bearing Size	Cage Bore Diameter (Inches)	Inner Ring O.D. (Inches)
200H	.831	.656
201H	.917	.721
202H	1.023	.815
203H	1.121	.986
204H	1.328	1.130
205H	1.516	1.320
206H	1.816	1.616
207H	2.116	1.857
208H	2.288	2.130
209H	2.539	2.289
210H	2.730	2.460
211H	3.008	2.764
212H	3.314	2.975
213H	3.583	3.295
214H	3.791	3.495
215H	3.970	3.692
216H	4.247	3.954
217H	4.540	4.235
218H	4.826	4.483
220H	5.401	5.012

Table 48. Bearing lubrication window – 300H Series.

Bearing Size	Cage Bore Diameter (Inches)	Inner Ring O.D. (Inches)
304H	1.415	1.217
305H	1.704	1.476
306H	1.994	1.742
307H	2.255	1.983
308H	2.583	2.280
309H	2.845	2.510
310H	3.142	2.775

Table 49. Bearing lubrication window – ZSB100/200 Series.

Bearing Size	Cage Bore Diameter (Inches)	Inner Ring O.D. (Inches)
ZSB101J	.770	.663
ZSB102J	.906	.768
ZSB103J	.997	.868
ZSB104J	1.186	1.033
ZSB105J	1.387	1.230
ZSB106J	1.636	1.502
ZSB107J	1.850	1.691
ZSB108J	2.066	1.907
ZSB111J	2.761	2.573
ZSB113J	3.195	2.966
ZSB114J	3.525	3.237
ZSB118J	4.520	4.121
ZSB120J	4.850	4.515
ZSB124J	5.940	5.436
ZSB202J	.997	.869
ZSB204J	1.290	1.100
ZSB206J	1.776	1.554
ZSB207J	2.041	1.793
ZSB210J	2.725	2.455
ZSB211J	3.025	2.676

Table 50. Bearing lubrication window – B Series.

Bearing Size	Cage Bore Diameter (Inches)	Inner Ring O.D. (Inches)
101BX48	.700	.609
102BX48	.825	.737
103BX48	.915	.837
104BX48	1.095	.969
105BX48	1.281	1.166
106BX48	1.590	1.408
107BX48	1.750	1.596
108BX48	1.945	1.813
110BX48	2.390	2.183
113BX48	2.995	2.811
117BX48	3.954	3.668

BEARING APPLICATION

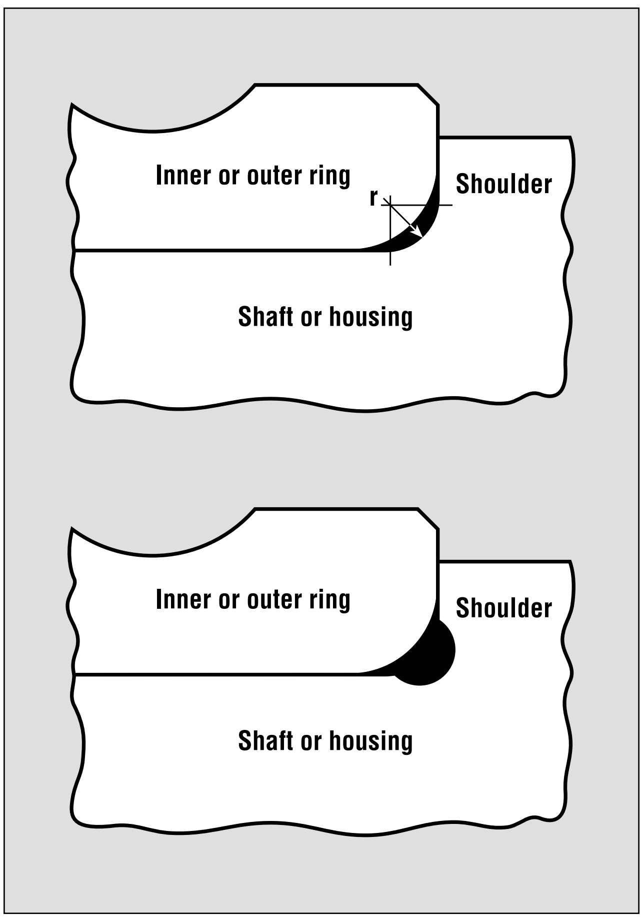
MAXIMUM FILLET RADII

When a shaft or housing has integral shoulders for bearing retention, fillet radii of the shoulders must clear the corners of inner and outer rings to allow accurate seating of the bearing.

All product listings in the front of this catalog and the shoulder diameter tables include values for maximum fillet radii. In the case of angular contact bearings, the smaller value r_i or r_o should be used when the cutaway side (nonthrust face) of the inner or outer ring is mounted against a solid shoulder.

Fig. 47 illustrates two methods of providing clearance for the bearing corner. In the upper view, fillet radius r is the maximum that the bearing will clear. The undercut fillet shown at bottom is preferred because it allows more accurate machining of the shoulder and seat, and permits more accurate bearing mounting.

Fig. 47. Two methods of providing clearance for bearing corner.



NONFERROUS BEARING HOUSINGS

Mounting bearings directly in soft nonferrous alloy housings is considered poor practice unless loads are very light and temperatures are normal and steady - not subject to wide extremes. When temperatures vary drastically as in aircraft applications, where aluminum is a common structural material, steel housing liners should be used to resist the effects of excessive thermal contraction or expansion upon bearing fits. Such liners should be carefully machined to the required size and tolerance while in place in the housing, to minimize possibility of runout errors.

Other problems associated with nonferrous alloys are galling during assembly and “pounding out” of bearing seats. Any questions that arise in unusual mounting situations should be discussed with the Barden Product Engineering Department.

RANDOM AND SELECTIVE FITTING

Random fitting of precision bearings entails installation of any standard bearing of a given lot on any shaft or in any housing. In order to retain the performance advantages of precision bearings, the shaft and housing should have the same diametral tolerance as the bearing being used. This procedure will result in some extreme fits due to statistical variations of the dimensions involved.

For applications that cannot tolerate extreme fits, it is usually more economical to use selective fitting with calibrated parts rather than reducing the component tolerances.

Selective fitting utilizes a system of sizing bearings, shafts and housings within the diametral tolerance range and selectively assembling those parts which fall in the same respective area of the range. This practice has the advantage of reducing the fit range from twice the size tolerance to +/- 0.0001" without affecting the average fit.

Calibration

Bearing calibration can influence the installation and performance characteristics of ball bearings, and should be considered an important selection criteria.

When bearings are calibrated they are sorted into groups whose bores and/or outside diameters (O.D.) fall within a specific increment of the bore and O.D. tolerance. Knowing the calibration of a bearing and the size of the shaft or housing gives users better control of bearing fits.

Barden bearings are typically sorted in increments of either .00005" (fifty millionths) or .0001" (one ten-thousandths). The number of calibration groups for a given bearing size depends on its diametral tolerance and the size of the calibration increment.

Calibration is standard with angular contact spindle bearings. If it is required for other bearing types, it must be called for in the last part of the bearing nomenclature using a combination of letters and numbers, as shown in Table 51 and Table 52.

On calibrated duplex pairs, both bearings in the pair have the bore and O.D. matched to within 0.0001".

Most instrument bearings are calibrated using the minimum bore and maximum O.D., while spindle bearings are calibrated using the average bore and O.D.

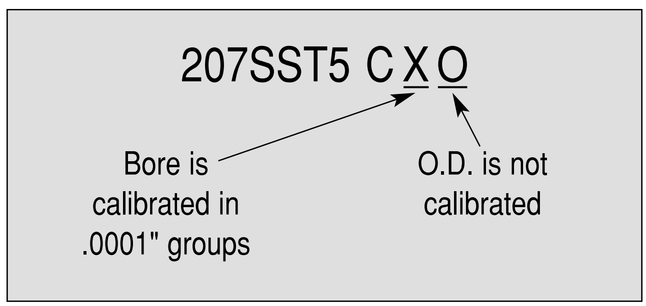
Random vs. Specific Calibration

Random calibration means the bearing bores and/or O.D.s are measured and the specific increment that the bore or O.D. falls into is marked on the package. With random calibration there is no guarantee of which calibration you will receive. Table 51 shows the callouts for various types of random calibration.

Table 51. Random calibrated bearings are ordered by adding the appropriate code to the bearing number according to this table.

Code	Type of Random Calibration
C	Bore and O.D. calibrated in groups of .0001".
CXO	Bore only calibrated in groups of .0001".
COX	O.D. only calibrated in groups of .0001".
C44	Bore and O.D. calibrated in groups of .00005".
C40	Bore only calibrated in groups of .00005".
C04	O.D. only calibrated in groups of .00005".

Fig. 48. Example of random calibration nomenclature.



BEARING APPLICATION

Specific calibration means the bore and/or O.D.s are manufactured or selected to a specific calibration increment. Barden uses letters (A, B, C, etc.) to designate specific .00005" groups, and numbers (1, 2, 3, etc.) to designate specific .0001" groups. Table 52 shows the letters and numbers which correspond to the various tolerances increments.

Fig. 49 is exaggerated to help you visualize calibration. The bands around the O.D. and in the bore show bearing tolerances divided into both .00005" groups, shown as A, B, C, D and .0001" groups, shown as 1, 2, etc.

Availability of specific calibrations is usually limited to what parts on hand actually measure. Therefore, if specific calibrations are required and cannot be supplied from existing inner or outer ring inventories, new parts would have to be manufactured, usually requiring a minimum quantity. Please check for availability before ordering specific calibrations.

Selective fitting utilizing a system of sizing bearings (calibration), shafts and housings and selectively assembling those parts which fall in the same respective area of the range effectively allows users to obtain the desired fit.

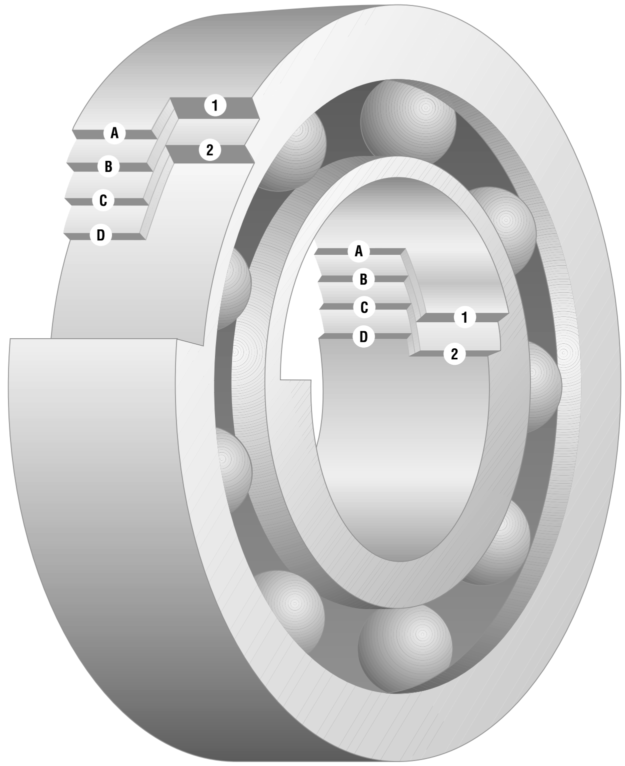


Fig. 49. This drawing, grossly exaggerated for clarity, illustrates specific calibration options for bore and O.D. Letters are used to indicate increments in fifty millionths, numbers to designate increments of one ten thousandth.

Table 52. Barden calibration codes for all bearings. Letters are used to designate calibrations in increments of fifty millionths, numbers for calibrations in increments of ten thousandths.

Bore and O.D. Specific Calibration Codes		
Size Tolerance (from nominal)	All Series Except A500 .00005" Calib.	All Series Except A500 .0001" Calib.
Nominal to –.00005"	A	1
–.00005" to –.0001"	B	
–.0001" to –.00015"	C	2
–.00015" to –.0002"	D	
–.0002" to –.00025"	E	3
–.00025" to –.0003"	F	
–.0003" to –.00035"	G	4
–.00035" to –.0004"	H	

Fig. 50. A typical example of specific calibration.

SR4SS5 C _ _

Specific Bore Specific O.D.

1, 2 (.0001" groups) 1, 2

A, B, C (.00005" groups) A, B, C, etc.

AXIAL LOCATION AND CONTROL OF END PLAY

Proper location of a rotating mass in relation to its supporting structure requires some type of shouldering for the bearings.

Snap rings can be used in place of integral shoulders, but since these devices provide less accurate location they are more frequently used on the stationary member, usually in the housing. When snap rings are used in precision applications, they should be ground flat and parallel to prevent misalignment. In some cases, flat and parallel washers should be used between bearing and snap ring.

The simplest technique is an opposed mounting, with one bearing supporting thrust loads in one direction and the other supporting thrust in the opposite direction. Typical application examples are small motors and generators, some types of which have through-bored housings using snap rings for shoulders outboard of each bearing in the housing and integral shaft shoulders inboard of each bearing on the shaft.

End play, which includes bearing end play but is also influenced by tolerance variations of shaft and housing members, may be controlled by insertion of shims or spacers of varying thickness between shoulders or snap rings and bearing ring faces. In such applications, loose housing fits are usually employed.

PRELOAD ADJUSTING SPRINGS

The simplest method of locating masses and removing unwanted clearances from bearings is by means of adjusting springs. In an opposed mounting of two bearings, a preload spring may be used to impose a light thrust load on the bearings, instead of shims or spacers.

Such springs should have a yield rate at least ten times greater than that of the bearings so that slight variations in bearing spacing due to thermal changes will have little effect on bearing loading. The thrust load of the spring should be kept quite low in comparison with the bearing load rating, and must be considered in life computations. Springs should be accurately formed to prevent accidental misalignment of the bearings. For additional information, see section on Preloading, page 92.

Problems involving bearing location and end play control can be difficult. If questions arise, consult the Barden Product Engineering Department for recommendations.

CLAMPING PLATES AND NUTS

For a more secure mounting of a bearing on a shaft or in a housing, clamping plates are considered superior to threaded nuts or collars. Plates are easily secured with separate screws.

When used with shafts and housings that are not shouldered, threaded nuts or collars can misalign bearings. Care must be taken to assure that threaded members are machined square to clamping surfaces. For high-speed precision applications, it may be necessary to custom scrape the contact faces of clamping nuts. In all cases, the clamping forces developed should not be capable of distorting the mating parts.

MAINTAINING BEARING CLEANLINESS

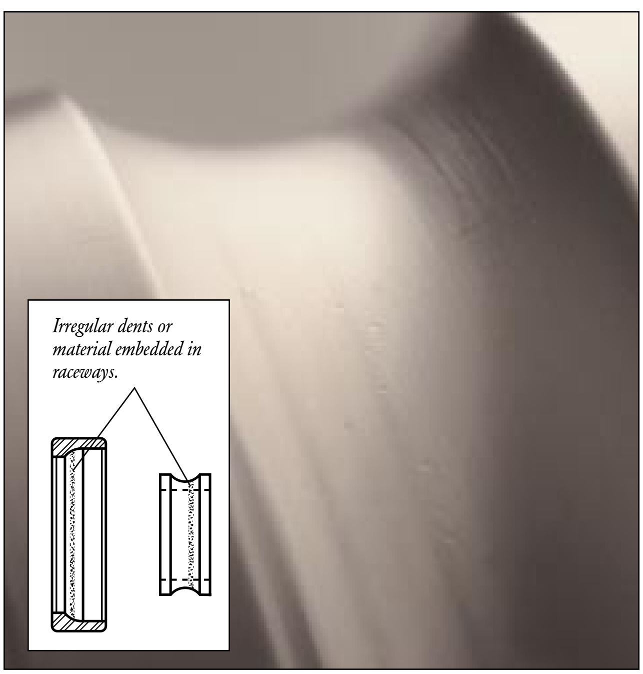
It is vital to maintain a high degree of cleanliness inside precision bearings. Small particles of foreign matter can ruin smooth running qualities and low torque values.

Dirt and contaminants that can impede a bearing's performance are of three varieties:

1) Airborne contaminants – lint, metal fines, abrasive fines, smoke, dust.
2) Transferred contaminants – dirt picked up from one source and passed along to the bearing from hands, work surfaces, packaging, tools and fixtures.
3) Introduced dirt – typically from dirty solvents or lubricants.

Contaminants that are often overlooked are humidity and moisture, fingerprints (transferred through handling), dirty greases and oils, and cigarette smoke. All of the above sources should be considered abrasive, corrosive or leading causes of degradation of bearing performance. It should be noted that cleanliness extends not just to the bearings themselves, but to all work and storage areas, benches, transport equipment, tools, fixtures shafts, housings and other bearing components.

When using air/oil mist or jet lubricating systems, continuously filter the oil and air to avoid the introduction of contaminants.



Sometimes, the effects on contamination are barely visible, as this magnified image shows.

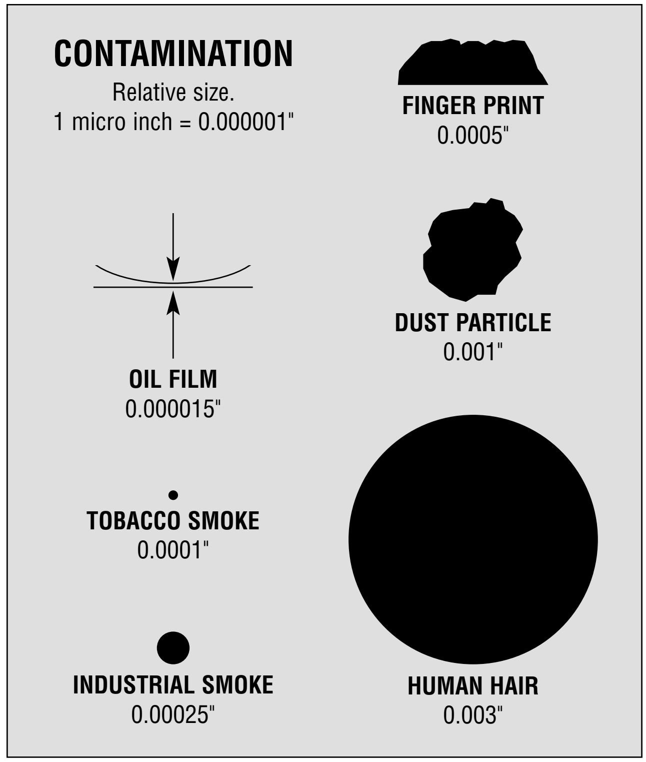


Chart compares relative sizes of typical contaminants. Oil film under boundary lubrication conditions is only 15 micro inches thick, and can be easily penetrated by even a single particle of tobacco smoke.

Use of Shields and Seals

As a rule, it is unwise to mount bearings exposed to the environment. Wherever possible, shielded or sealed bearings should be used, even when enclosed in a protective casing. In situations where inboard sides of bearings are exposed in a closed-in unit, all internal surfaces of parts between the bearings must be kept clean of foreign matter.

If it is impossible to use shielded or sealed bearings or in cases where these are not available (for example, most sizes of angular contact bearings), protective enclosures such as end bells, caps or labyrinth seals may be used to prevent ambient dust from entering the bearings.

Handling Precision Bearings

All too often bearing problems can be traced back to improper handling. Even microscopic particles of dirt can affect bearing performance.

Precision bearing users should observe proper installation techniques to prevent dirt and contamination.

Foreign particles entering a bearing will do severe damage by causing minute denting of the raceways and balls. The outward signs that contamination may be present include increased vibration, accelerated wear, the inability to hold tolerances and elevated running temperatures. All of these conditions could eventually lead to bearing failure.

Close examination of inner or outer ring races will show irregular dents, scratches or a pock-marked appearance. Balls will be similarly dented, dulled or scratched. The effects of some types of contamination may be hard to see at first because of their microscopic nature.

Work Area

Good bearing installation habits begin with a clean work area. Work bench surface materials include wood, rubber, metal and plastic. Generally, painted metal is not desirable as a work surface because it can chip, flake or rust. Plastic laminates may be acceptable and are easy to keep clean, but are also more fragile than steel or wood and are prone towards static electricity build-up. Stainless steel, splinter-free hardwoods such as maple, or dense rubber mats that won't shred or granulate and have no oily residue are all suitable work surfaces.

A clutter-free work area, with good lighting, organized tool storage, handy parts bins and appropriate work holding devices constitute an ideal working environment.

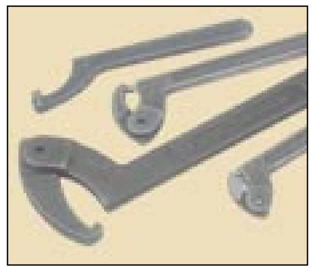
Under no circumstances should food or drink be consumed on or near work surfaces. Smoking should not be allowed in the room where bearings are being replaced. Locate bearing installation operations away from other machining operations (grinding, drilling, etc.) to help minimize contamination problems.

Static electricity – or any operation that may cause steel rings and balls to become magnetized – could result in dust or fine metallic particles being introduced into bearings. Since all Barden precision bearings are demagnetized before being shipped, if you suspect bearings have become magnetized, pass them through a demagnetizer while still in their original sealed pouches.

Proper Tools

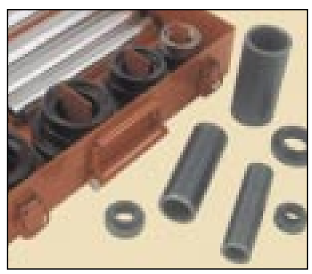
Every workbench should have a well-stocked compliment of proper tools to facilitate bearing removal and replacement. Tools required include wrenches and spanners (unplated and unpainted only), drifts, gages, gage blocks and bearing pullers.

Bearing installers will also want to have access to a variety of diagnostic tools. These may include a run-in stand for spindle testing, a bearing balancer and a portable vibration analyzer. Most spindle bearings are installed with an induction heater (using the principle of thermal expansion) which enlarges the inner ring slightly so the bearing can be slipped over the shaft. An arbor press can be used for installing small shaft/small bore instrument bearings.



Hook Spanners

Induction Heater

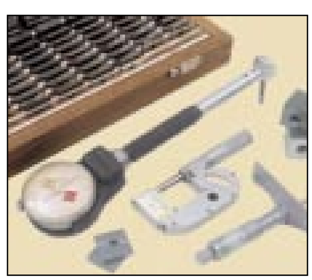


Drifts

Vibration Analyzer

Open End Wrenches

Run In Stand



Gages and Gage Blocks

Balancer

Handling Guidelines

All Barden bearings are manufactured, assembled and packaged in strictly controlled environments. If the full potential of precision bearings is to be realized the same degree of care and cleanliness must be used in handling and installing them.

The first rule for handling bearings is to keep them clean. Consider every kind of foreign material – dust, moisture, fingerprints, solvents, lint, dirty grease – to be abrasive, corrosive or otherwise potentially destructive.

Bearing installers should follow these guidelines:

1. Clean the work area and keep it clean.
2. Use clean, burr-free tools that are designed for the job. They should not be painted or chrome plated.
3. Handle bearings with clean, talc-free gloves. Use tweezers for instrument bearings.
4. Keep bearings in original packaging until ready for use. Nomenclature for each Barden bearing is printed on its box, so there is no need to refer to the bearing itself for identification. And, since the full bearing number appears only on the box, it should stay with the bearing until installation
5. Protect unwrapped bearings by keeping them covered at all times.
6. Assemble only clean, burr-free parts. Clean the interior of housings.
7. For interference fits, use heat assembly (differential expansion) or an arbor press. Never use a hammer, screwdriver or drift; never apply sharp blows.
8. Make sure bearing rings are started evenly on shafts or in housings, to prevent cocking and distortion.
9. Apply force only to the ring being press-fitted. Never strike the outer ring, for example, to force the inner ring onto a shaft, or brinelling could result and cause high torque or noisy operation.
10. Use bearing-quality lubricants; keep them clean during application and covered between uses. For greased bearings, apply only the proper quantity of grease with a clean applicator.
11. Do not wash or treat new bearings. Barden takes great care in cleaning its bearings and properly pre-lubricating them before packaging.
12. When removing bearings, clean all surrounding surfaces first. Isolate used bearings and inspect them carefully before reuse.
13. Keep records of bearing nomenclature and mounting arrangements for future reference and reordering.
14. All Barden bearings are demagnetized before shipment. If there is any indication that they have become magnetized, which would attract metallic contaminants, pass the wrapped bearings through a demagnetizer.

Barden has published an illustrated guide to "Handling and Mounting Precision Ball Bearings." Contact your Barden Sales Engineer, or call Barden directly for your free copy.

BARDEN PRECISION BEARINGS

BARDEN WARRANTY

The Barden Corporation warrants its bearings to be free from defects in workmanship and materials and agrees to furnish a new bearing free of cost or, at its option, to issue a credit for any defective bearing provided such defect shall occur within one year after delivery, the defective bearing returned immediately, charges prepaid, to Barden and upon inspection appears to Barden to have been properly mounted, lubricated and protected and not subjected to abuse. Barden shall not be responsible for any other or contingent charges. This warranty is in lieu of all other warranties, either expressed or implied.

The information contained in this catalog is intended for use by persons having technical skill, at their own discretion and risk. The data, specifications and characteristics set forth were developed using sound testing and engineering techniques and are believed to be accurate. Every attempt has been made to preclude errors. However, use of this information is the customer's responsibility; The Barden Corporation's sole responsibility or liability is contained in the Warranty statement above.

Due to its continual product improvement programs, The Barden Corporation reserves the right to make changes in products or specifications at any time.

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Exxon – Exxon Company
ISOFLEX – Kluber Lubrication Corp.
Mobil – Mobil Oil Corp.
Rheolube – William F. Nye, Inc.
Teflon – Du Pont Company
Viton – Du Pont Company
Winsor Lube – Anderson Oil & Chemical Co.

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