

TIMKEN®

Super Precision Bearings
and Bearing Products



Timken Super Precision (MPB)

ISO 9001 Registered
AS9000 Certified
D1-9000 AQS Certified

QUALITY *YOU CAN BUILD ON*

In 1936, an ingenious New England inventor produced a tiny ball bearing to replace a jewel in a family heirloom. Winslow Pierce not only repaired his father's watch, he founded an entire industry. His industry made possible instrumentation that travels millions of miles into space and settles softly and accurately on a distant planet; dental handpieces that operate painlessly at half a million revolutions per minute; aircraft that navigate precisely through darkness and adverse weather. Literally hundreds of various devices employ the millions of ball bearings produced every year.

Some three years after his invention, Winslow Pierce led a group who founded Miniature Precision Bearings, Inc. In 1941 the group established their headquarters in Keene, New Hampshire and the industry was born.

The fledgling company began to prosper, stimulated by instrumentation requirements for World War II aircraft. Most notable among those instruments was the Norden bomb sight, credited by many as one of the major technological developments of that era and one that greatly enhanced the effectiveness of the U.S. Army Air Corps.

During and after World War II, Miniature Precision Bearings pioneered the effort to produce precision ball bearings on a mass production basis while maintaining a high standard of



Plant I Keene, NH. 130,000 sq ft.: Bearing Operations

quality. This ingenuity and dedication produced many innovations in miniature and instrument ball bearings:

- First integrally flanged bearings.
- First shielded bearing.
- First thrust and pivot bearings.
- First molded retainers.
- First modular cartridge assemblies.
- First full complement bearing.
- Extended inner ring bearing.
- First angular contact bearing.
- First integral assemblies.
- First manufacturing plant devoted to production of miniature bearings.



Plant II Keene, NH. 56,000 sq ft.: Gyro and Rotary Assemblies

Today, Timken Super Precision is a wholly owned subsidiary of the Timken Company. This relationship further strengthens our abilities to fulfill application requirements with quality products, produced in the most efficient manner possible.

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WARNING

Proper bearing installation, maintenance, and handling practices are critical: * ALWAYS follow proper bearing installation, maintenance, and handling practices. * NEVER remove the rolling elements or any part of a bearing assembly * NEVER substitute an unauthorized or unproved bearing in any installation * NEVER remove a bearing from its package until ready to use. Store in a clean dry area. Failure to follow equipment manufacturers instructions, maintain proper lubrication and/or follow any of these directives can cause equipment failure, creating the risk of serious bodily injury.

Background and Capabilities

MPB promotes a continuing commitment, backed by the necessary investments, to produce the highest quality bearing products available anywhere in the world. Those investments may take many forms; the purchase or construction of specialty manufacturing and measuring equipment; the development of critical human skills; the analysis of new materials; testing products in application, often in conjunction with our customers. All of this is done with one goal in mind: To assure that our products as well as our customers' products meet or exceed performance levels for which they were designed.

APPLICATION ENGINEERING

Supported by a Product Development Laboratory, MPB's skilled Product Engineers are ready to provide design assistance whenever a customer's application requires specialized knowledge of ball bearing technology. Meeting with customers' engineers, either at their plant or at MPB's facilities, MPB engineers can often identify time, space or cost savings, as well as performance improvements, in developing bearing specifications.

In addition, MPB engineers frequently present seminars or group technical sessions on bearing design, technology, handling and installation procedures for customers' engineers, purchasing, quality control, or manufacturing personnel.

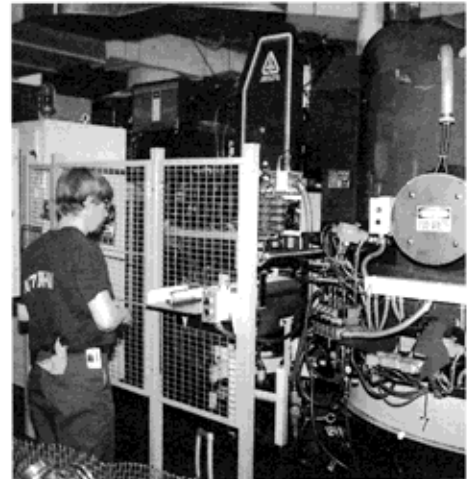
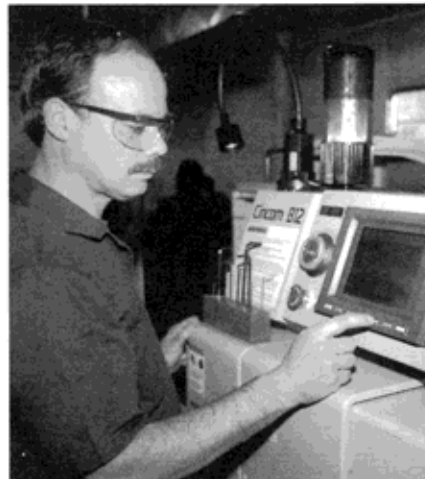
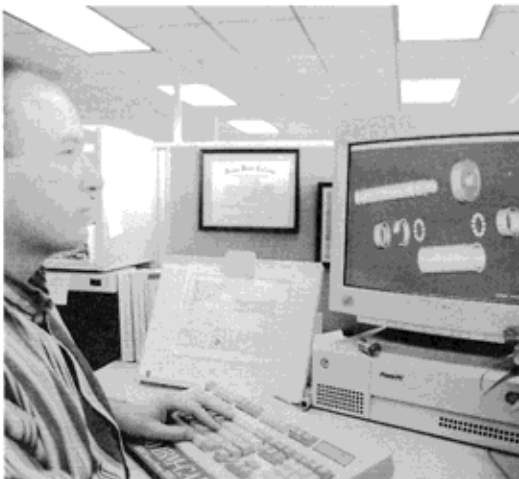
As product designers, MPB engineers combine their own wealth of experience with that of other departments, coordinating the ideas of manufacturing, processing and quality control personnel assuring optimum design. The entire effort is supported by the latest available design and testing technology.

MANUFACTURING

MPB's manufacturing operations are carried out in a facility that is continually monitored, improved and upgraded, and staffed by specialists in precision metalworking. Each product line has dedicated space and equipment to maximize attention to detail. Manufacturing engineers work with machine tool builders and gage producers to develop new equipment or introduce improvements to existing equipment. Much of the manufacturing and inspection equipment is designed and, in some cases, built at MPB to assure total control and product compliance.

Continual unit gaging and inspection is an integral part of the manufacturing process, handled by both the machine operators, who have the ultimate responsibility for quality, and by Quality Control stations throughout the line.

The precision and performance demanded of MPB products requires final assembly under "clean room" conditions. In the clean room areas, stringent environmental controls are maintained to assure contamination-free products, free from dimensional distortion. It is in these clean rooms that final performance tests are made and the products documented to specification.



QUALITY CONTROL

MPB is certified to the ISO 9001 standards of quality, which assures that high standards for quality and performance are met consistently by monitoring systems, standards, procedures, tooling, gaging and equipment. The primary objective is prevention rather than detection of defects, where the goal is consistency of finished product each and every time. Controls are established, not only in product areas, but among the support groups as well.

MPB's Quality Control System complies with the requirements of MIL-Q-9858A, inspection sampling methods are based upon MIL-STD-105 and gaging and inspection equipment conforms to MIL-I-45208. When required, several levels of traceability can be provided in accordance with various military and NASA specifications or to the customer's own specification. In addition, MPB complies with and certifies to a wide variety of Government, commercial and customer specifications.

MPB Quality Control personnel welcome discussions on instrumentation and programs, gaging techniques, gage correlation, and quality control procedures in order to speed and simplify receiving inspection and to assure product conformance.

SERVICE

MPB sales personnel are trained to provide a variety of services to customers. A highly qualified staff of Field Sales Engineers are prepared to offer support in solving technical problems as well as problems of a general business nature. They can provide on-the-spot application recommendations and, when necessary, call on additional support from our Product Engineering staff.

The Customer Services Department is staffed with experienced personnel, trained to handle all manner of requests to meet customer requirements and provide solutions to problems. They provide timely responses to quotation requests, process orders and associated paperwork, expedite internal requirements, and call up technical support when necessary.

PEOPLE

MPB relies on the dedication and support of its people to design, produce, sell and service the highest quality bearing products available. These people, with their spirit, pride and dedication to servicing customers are our greatest asset.



Numbering Systems

CODE POSITION →	1	2	3	4
FEATURE →	Material	Size	Flange	Type
EXAMPLE A →	S	418	F	C
EXAMPLE B →	S	1014	—	MC

1. Material:

- S = AISI 440C Stainless Steel
- C = SAE 52100 Chrome Steel
- N = Beryllium Copper (Consult factory for availability)

2. Bearing Size:

This number designates the basic envelope dimensions of the bearing.

3. Flange:

F = flanged bearing

4. Type:

- No Symbol = Full ball complement
- A = Alternate undersize ball
- B = Fractured outer ring
- C = Crown-type stainless steel retainer
- M = Non-separable, phenolic retainer
- MB = Separable inner ring, phenolic retainer
- MP = Non-separable, porous polyimide retainer
- MBORA = Outer ring—retainer and ball sub-assembly
- MBR = Separable inner—full ball complement
- MC = One-piece snap-type phenolic retainer
- MCD = One-piece snap-type acetal resin retainer
- MCJ = One-piece snap-type self-lubricating retainer
- MCP = One-piece snap-type porous polyimide retainer
- MCX = One-piece snap-type self-lubricating retainer
- MCK = One-piece molded snap-type Minapar II[®] retainer
- MR = Non-separable, full ball complement
- R = Ribbon-type stainless steel retainer
- RT = Ribbon-type stainless steel retainer, PTFE-coated
- S = Thru-hole stainless steel retainer
- SO = Toroid ball separators
- ST = PTFE slug separators

5. Features:

- H = Single shield
- HH = Double shield
- I = Integral shield
- Z = Single seal
- ZZ = Double seal
- OH = Single shield on side opposite flange
- OZ = Single seal on side opposite flange
- E = Extended inner ring*
- N = Narrower than standard width*
- W = Wider than standard width*

*These symbols, indicating variations in dimensions, may appear following other feature codes above.

6. Tolerance:

- 1 = Class 1
- 3 = Class 3
- 5 = ABEC 5P or 5T
- 7 = ABEC 7P or 7T

7. Radial Play:

P followed by numbers indicates radial play range in ten-thousandths of an inch. Examples:
P28 indicates radial play of .0002" to .0008".
P58 indicates radial play of .0005" to .0008".
P515 indicates radial play of .0005" to .0015".

8. Lubrication:

- LD** no lubrication or dry bearings.
- LO** followed by a number indicates specified oil lubrication.
- LG** followed by a number indicates specified grease lubrication.
- LY** followed by a number indicates other MPB-approved lubricants.
- LOV or LYV** followed by a number indicates specified oil to be vacuum impregnated into the retainer.
- LOC or LYC** followed by a number indicates specified oil to be used and the bearing centrifuged.
- LGF** followed by a number indicates film of a specific grease.

MPB code numbers for the most frequently specified lubricants are listed on page 52.

5	6	7	8	9	10	11
Features	Tolerance	Radial Play	Lubrication	Torque	Dimensional Code	Duplexed Pair
H	7	—	—	Q13	—	—
—	5	P38	LYC5	—	ZDM	DB10

9. Torque:

Q followed by a number indicates peak starting torque limit in hundreds of mg.mm. For example, **Q14** indicates a bearing with less than 1400 mg.mm. peak starting torque.

V followed by a number indicates peak running torque limit in hundreds of mg.mm. For example, **V13** indicates a bearing with less than 1300 mg.mm. peak running torque.

Torque is measured under a 75 gram thrust load for bearings having an OD of $\frac{3}{8}$ " or less. Larger cataloged bearings are measured under a test load of 400 grams.

10. Dimensional Coding:

ZO = graded OD's only

ZB = graded bores only

ZD = graded OD's and bores

ZDM = graded for preloaded pairs having matched OD's and bores

Standard dimensional grading is in increments of .0001".

"X" prefix for .000050 increments.

11. Preloaded Pairs:

DB = back-to-back mounting

DF = face-to-face mounting

DT = tandem mounting

Numbers following letter code indicate nominal preload in pounds.

SPECIAL DESIGN BALL BEARINGS AND ASSEMBLIES:

Bearings with modified dimensions, special designs and assemblies are designated by a sequential drawing number consisting of letters and numerical digits.

PIVOT AND THRUST BALL BEARINGS:

The numbering system used by MPB for pivot and thrust bearings consists of code designations for material, size, type and lubricant.

Material and lubrication codes are the same as those describing radial retainer bearings. Type designations are as follows:

PR = pivot bearing with closed end

A = pivot bearing with open end

T = thrust bearing

Examples:

S418FCH7 Q13: Flanged-Radial Retainer Bearing with one shield. Material of rings and balls is AISI 440C stainless steel, size 418 ($\frac{1}{4}$ " OD and $\frac{1}{8}$ " bore) with a crown-type retainer to ABEC 7P tolerances. Since no radial play or lubrication is given, it will be supplied with a standard radial play of .0002" to .0008" and its lubrication will be Anderol 401D per MIL-L-6085A. The starting torque of the bearing should not exceed 1300 mg/mm (Q13).

S1014MC5 P38 LYC5 ZDM DB10: Duplexed pair of a Radial Retainer Bearing of AISI 440C stainless steel, size 1014 ($\frac{3}{8}$ " bore and $\frac{7}{8}$ " OD) with a snap-type phenolic retainer to ABEC 5T tolerances. Radial play is .0003" to .0008", with G.E. F50 lubricant, centrifuged to remove excess oil. Both bearings have matched bores and OD's to within .0001" and are duplexed back to back (DB) to 10 lbs.

CR4MB7 P811 LYV161 ZDM DB3: Radial retainer bearing, of SAE 52100 steel, size R4 ($\frac{5}{8}$ " OD and $\frac{1}{4}$ " bore), angular contact type with separable inner ring and phenolic retainer, ABEC 7P tolerances. Radial play is .0008" to .0011", lubrication is KRYTOX 143 AC, vacuum impregnated into the retainer. Bearings are to be supplied in preloaded pairs, back to back, with a preload of 3 lbs. dimensionally coded and matched OD's and bores.

S6TL02: Thrust bearing, of AISI 440C stainless steel, size $\frac{3}{8}$ " OD and $\frac{3}{16}$ " bore, with Anderol L-401D oil.

Size Code:

The procedure to determine the bore and OD of most miniature and instrument bearings is as follows. The first digit of the size code (position 2 above) represents the OD of the bearing in $\frac{1}{16}$ inches. The remaining digits represent the bore size.

Example: 418—This bearing has an OD of $\frac{4}{16}$ " and a bore of $\frac{18}{16}$ " (.250 × .125)

On thin section bearings, the first two digits represent the bore in $\frac{1}{16}$ inches and the remaining two digits represent the OD in $\frac{1}{16}$ inches.

Example: 1014—This bearing has a bore of $\frac{10}{16}$ " and an OD of $\frac{14}{16}$ " (.625 × .875).



RADIAL RETAINER



ANGULAR CONTACT



FRACTURED RACE
RETAINER



FULL COMPLEMENT
INTEGRAL SHIELD

Product Selection

MPB manufactures the industry's most complete line of bearings and bearing products. Bearings range in size from .059" to 2" outside diameter. Specially designed assemblies measure from fractions of an inch to several inches in diameter and length. Listed below are the various product types and their design features and characteristics.

MINIATURE AND INSTRUMENT BEARINGS

A wide variety of bearing types and design variations are available to meet the requirements of virtually all precision instrument applications. Bearing types include:

- Radial Retainer
- High Speed Radial
- Pivot
- Angular Contact
- Thrust
- Full Ball Complement

Many of the selections are available in both inch and metric dimensions.

Design features include:

- Extended inner rings and flanged outer rings to facilitate mounting.
- Shields and seals for contamination protection.
- Radial play and contact angle variations to suit application loading and deflection requirements.
- Ring and ball material choices from among AISI 440C stainless steel, SAE 52100 "chrome" steel and beryllium copper.
- Various ball retainer styles and materials for optimum bearing performance.
- Factory lubrication from a stock of several hundred lubricants.
- Performance testing to noise and frictional torque specifications.
- Tolerance levels to exact applications requirements.

Miniature and Instrument bearings are used in a large number of applications including gyros, synchros, servos, motors, dental, medical and industrial handpieces, fuel controls, carriage assemblies, recorders, flow meters and many more.

THIN SECTION BEARINGS

As with miniature and instrument bearings, Thin Section Bearings are available with various features in several configurations so they can be selected to meet specific application requirements.

Included in the types available are:

- Radial Retainer
- Angular Contact
- Fractured Outer Ring
- Full Ball Complement

Design features include:

- Extended inner rings to facilitate mounting.
- Integral shields and removable shields and seals for contamination protection.
- Radial play and contact angle variations to meet application loading and deflection requirements.
- Ring and ball material choices between AISI 440C stainless steel and SAE 52100 bearing steel.
- Various ball retainer configurations and materials for optimum bearing performance.
- Factory lubrication from a stock of several hundred lubricants.
- Performance testing to noise and frictional torque specifications.
- Tolerance levels to meet precise applications requirements.

Thin Section Bearings were originally designed for specific aircraft applications but have since been designed into such applications as radar and microwave equipment, read/write assemblies, dental and medical equipment, motors and other applications where thin bearing cross-sections are important.

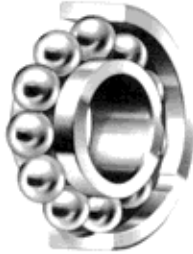
*This page and the facing page represent a variety of products offered by MPB. Additional catalogs dedicated to **Thin Section Bearing** products and **Airframe Bearings** are available. MPB also produces many **Specialized Bearing** and bearing related products for particular applications where a standard bearing will not do. It is suggested that the user contact the factory directly for specifications and information on special applications.*



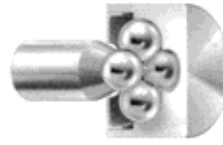
RADIAL RETAINER



ANGULAR CONTACT



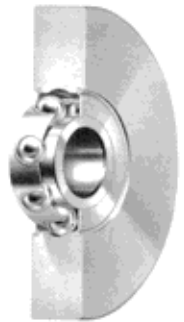
FULL COMPLEMENT



PIVOT



THRUST



SPECIAL

SPECIAL PRODUCTS

MPB is dedicated to and, indeed, has developed a reputation for solving customers' problems. When conventional products won't do the job, special products are developed to fill the need. This philosophy, combined with an understanding of the applications, has generated a number of special products which resolve specific problems and contribute to enhanced end-product performance.

Gyro Spin and Gimbal Bearings

Produced from AISI 440C or SAE 52100 materials, many gyro spin and gimbal bearings are produced to ABEC 9 tolerances or better. They are designed to give precise gyro performance in even the most critical applications.

Duplexed Bearings

Duplexing of bearings is accomplished by matching two bearings so that, when clamped together, a predetermined preload results. For more precise tolerance control, duplexing may also be achieved by grinding two races in a common outer ring and precisely matching two inner rings. For ultimate control of deflection and bearing stability, a single inner ring and single outer ring, each with two races, may be employed, with preload achieved by ball selection.

Gyro Optics Assemblies

A series of "seeker-type" gyros has been developed over the years which command highly accurate manufacturing capabilities, the latest in bearing technology and precise assembly techniques. Participation in design, prototype and production efforts has enabled MPB to supply hardware at all levels including bearings, component parts, sub-assemblies and assemblies.

Integral Assemblies

Many applications require precise dynamic control of both radial and axial runouts as well as noise free operation. Reducing the number of components and controlling raceway finish and geometry results in highly accurate, low noise assemblies. Such assemblies are termed integral assemblies because the bearing raceways are integrated into the shafts and/or housings. Integral designs have the added benefits of mounting ease, stability and deflection control.

Cartridge Bearings

Cartridge Bearings are double row outer ring bearings designed for mounting in relatively unprecise holes without losing bearing-to-bearing alignments. They feature ease of assembly resulting in lower assembly costs and fewer bearings lost through damage during the assembly process.

Carriage Bearings

Precise dynamic positional control of read/write carriage and way devices is the function of carriage bearings. Such control is achieved by careful attention to bearing design and functional parameters. Design choices include single or double row rings, integral or separate pin, grooved or straight outer ring configuration and retainer selection. Functional parameters are outer ring runout and finish, internal clearance and end play control and control of noise generating surfaces.

Tape Control Assemblies

Tape guides, idlers, capstans and pulleys are designed to control tape in voice and data recording devices. Tape control components vary in material choices, precision level and design as dictated by application requirements. Designs may include one or two bearings, integrally or separately installed. Housing, shaft and pulley material selections may be made from various metal and plastic options.

Bearing Test Equipment




In response to an industry-wide demand to replace antiquated test equipment, MPB developed Starting and Running Torque Testers. These devices, first used within MPB as production testers, are now in use around the world as monitors of production quality and as analytical tools. With direct readout of torque measurements, these testers provide information on the suitability of a bearing or group of bearings for use in a particular application. They also offer information on bearing geometry and cleanliness.

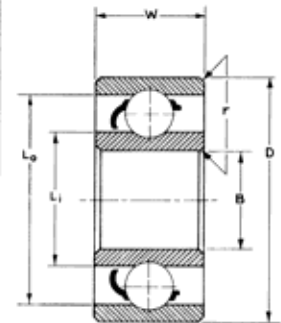
Lubricants

In addition to the several hundred lubricants available off-the-shelf, MPB has developed a line of specialty lubricants for use in specific critical applications. Minapure Grease, which is qualified under MIL-G-81937, is an ultra-clean grease manufactured under stringent controls. Also available in several viscosities are Minapure Oils, a series of ultra-clean synthetic hydrocarbon lubricants.

ABEC 5P and 7P

Radial Retainer Open Bearings

Bore	O.D.	Width	Bearing Numbers			Land Diameter		Radius*	Ball Complement		Load Ratings (lbs.)		
						L ₁	L ₂		n	d	C	R _s	T _s
B + .0010 - .0002	D + .0010 - .0002	W + .000 - .001	Open Crown Retainer	Open Ribbon Retainer	Open Minapar II Retainer			r	number	diameter	Dynamic	Static Radial	Static Thrust
.0250	.1000												
.0400	.1250	.0469	S2C			.064	.102	.003	5	.025	13	3	7
.0469	.1562	.0625	S25C	S25R		.077	.122	.003	6	1/32	22	4	11
.0550	.1875	.0781	S3C			.093	.159	.003	5	3/64	36	8	16
.0550	.1875	.0781		S3R		.092	.155	.003	6	1mm	35	7	17
.0781	.2500	.0937	S4C			.125	.215	.003	5	1/16	61	13	27
.0781	.2500	.0937		S4R	S4MCK	.163	.222	.003	8	1mm	46	11	29
.0937	.1875	.0625	S3332C		S3332MCK	.120	.165	.003	7	1/32	26	5	15
.0937	.1875	.0625		S3332R		.117	.162	.003	8	1/32	29	6	17
.0937	.3125	.1094	S5C	S5R	S5MCK	.173	.271	.005	6	1/16	81	19	40
.1250	.2500	.0937	S418C			.166	.220	.003	7	1mm	42	10	26
.1250	.2500	.0937		S418R	S418MCK	.166	.220	.003	8	1mm	46	11	29
.1250	.3125	.1094	S518C	S518R	S518MCK	.173	.271	.003	6	1/16	81	19	40
.1250	.3750	.1094	S618C	S618R	S618MCK	.202	.298	.005	7	1/16	94	23	49
.1250	.3750	.1562	SR2C	SR2R	SR2MCK	.202	.298	.012	7	1/16	94	23	49
.1250	.5000	.1719	SR2AC	SR2AR	SR2AMCK	.202	.298	.012	7	1/16	94	23	49
.1562	.3125	.1094	S5532C	S5532R	S5532MCK	.226	.285	.003	7	3/64	56	14	32
.1575	.6299	.1969		S34R		.295	.493	.012	6	1/8	268	68	108
.1875	.3125	.1094	S5632C	S5632R	S5632MCK	.226	.285	.003	7	3/64	56	14	32
.1875	.3750	.1250	S6316C	S6316R	S6316MCK	.236	.329	.003	8	1/16	103	28	59
.1875	.5000	.1562	SR3C	SR3R	SR3MCK	.272	.415	.012	7	3/32	181	50	89
.1969	.6299	.1969		S345R		.295	.493	.012	6	1/8	268	68	108
.2187	.3125												
.2362	.7480	.2362		S36R		.386	.596	.012	6	9/64	332	95	139
.2500	.3750	.1250	S614C		S614MCK	.290	.342	.003	11	1mm	53	18	45
.2500	.5000	.1250	S814C		S814MCK	.336	.429	.010	10	1/16	120	39	81
.2500	.5000	.1250		S814R		.336	.429	.010	11	1/16	127	43	89
.2500	.6250	.1960	SR4C	SR4R	SR4MCK	.366	.509	.012	8	3/32	209	63	114
.2500	.7500	.2188		SR4AR		.386	.596	.016	6	9/64	332	95	139
.3125	.5000	.1562	S8516C	S8516R	S8516MCK	.362	.450	.005	11	1/16	121	43	91
.3150	.8661	.2756		S38R		.463	.692	.012	7	5/32	443	139	213
.3750	.8750	.2188		SR6R	SR6MCK	.520	.745	.016	7	5/32	577	209	267
.5000	1.1250	.2500		SR8R		.739	.974	.016	10	5/32	904	489	205



STANDARD SPECIFICATIONS

Tolerances—All precision standard radial retainer bearings are available in ABEC 5P (add suffix 5 to bearing number) or ABEC 7P (add suffix 7 to bearing number) tolerances. For information on ABEC tolerances see page 47.

Radial Play— .0002/.0008". Other ranges are available (see page 48).

Lubrication—MI L-L-6085A. Other lubricants are available (see page 52).

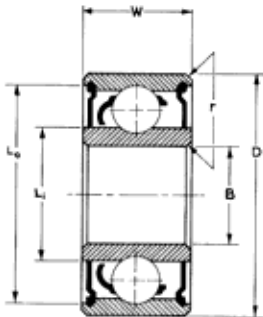
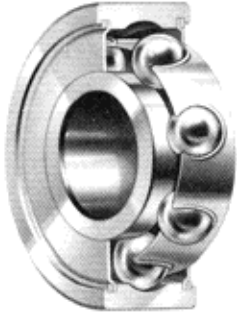
Packaging—Individual pill pack strips or vial pack.

Dimensions—All dimensions are in inches.

*r is maximum radius of shaft or housing fillet that bearing corner will clear.

ABEC 5P and 7P

Radial Retainer Shielded Bearings



Bore B + .000 - .002	O.D. D + .000 - .002	Width W + .000 - .001	Bearing Numbers			Land Diameter		Radius* r	Ball Complement		Load Ratings (lbs.)		
						L ₁	L ₂		number	diameter	C Dynamic	R _s Static Radial	T _s Static Thrust
.0250	.1000												
.0400	.1250												
.0469	.1562	.0937	S25CHH	S25RHH		.077	.134	.003	6	1/32	22	4	11
.0550	.1875	.1094	S3CHH			.093	.167	.003	5	3/64	36	8	16
.0550	.1875	.1094		S3RHH		.092	.167	.003	6	1mm	35	7	17
.0781	.2500	.1406	S4CHH			.125	.222	.003	5	1/16	61	13	27
.0781	.2500	.1406		S4RHH	S4MCKHH	.163	.230	.003	8	1mm	46	11	29
.0937	.1875	.0937	S3332CHH			.120	.169	.003	8	.025	20	4	13
.0937	.1875	.0937		S3332RHH		.117	.169	.003	8	1/32	29	6	17
.0937	.3125	.1406	S5CHH	S5RHH	S5MCKHH	.173	.283	.005	6	1/16	81	19	40
.1250	.2500	.1094	S418CHH			.166	.230	.003	7	1mm	42	10	26
.1250	.2500	.1094		S418RHH	S418MCKHH	.166	.230	.003	8	1mm	46	11	29
.1250	.3125	.1406	S518CHH	S518RHH	S518MCKHH	.173	.283	.003	6	1/16	81	19	40
.1250	.3750	.1406	S618CHH	S618RHH	S618MCKHH	.202	.324	.005	7	1/16	94	23	49
.1250	.3750	.1562	SR2CHH	SR2RHH	SR2MCKHH	.202	.324	.012	7	1/16	94	23	49
.1250	.5000	.1719	SR2ACHH	SR2ARHH	SR2AMCKHH	.202	.324	.012	7	1/16	94	23	49
.1562	.3125	.1250	S5532CHH	S5532RHH	S5532MCKHH	.226	.293	.003	7	3/64	56	14	32
.1575	.6299	.1969		S34RHH		.256	.547	.012	6	1/8	268	68	108
.1875	.3125	.1250	S5632CHH	S5632RHH	S5632MCKHH	.226	.293	.003	7	3/64	56	14	32
.1875	.3750	.1250	S6316CHH	S6316RHH	S6316MCKHH†	.236	.343	.003	8	1/16	103	28	59
.1875	.5000	.1960	SR3CHH	SR3RHH	SR3MCKHH	.272	.440	.012	7	3/32	181	50	89
.1969	.6299	.1969		S345RHH		.256	.547	.012	6	1/8	268	69	108
.2187	.3125												
.2362	.7480	.2362		S36RHH		.342	.649	.012	6	9/64	332	95	139
.2500	.3750	.1250	S614CHH		S614MCKHH	.290	.352	.003	11	1mm	53	18	45
.2500	.5000	.1875	S814CHH		S814MCKHH	.336	.443	.010	10	1/16	120	39	81
.2500	.5000	.1875		S814RHH		.336	.443	.010	11	1/16	127	43	89
.2500	.6250	.1960	SR4CHH	SR4RHH	SR4MCKHH	.366	.535	.012	8	3/32	209	63	114
.2500	.7500	.2812		SR4ARHH		.386	.649	.016	6	9/64	332	95	139
.3125	.5000	.1562	S8516CHH	S8516RHH	S8516MCKHH	.362	.461	.005	11	1/16	121	43	91
.3150	.8661	.2756		S38RHH		.415	.747	.012	7	5/32	443	139	213
.3750	.8750	.2812		SR6RHH	SR6MCKHH	.520	.787	.016	7	5/32	577	209	267
.5000	1.1250	.3125		SR8RHH		.678	.998	.016	10	5/32	904	489	205

AVAILABILITY

Sizes listed above are normally available from stock in AISI 440C stainless steel material. For SAE 52100 and beryllium copper material, please check with MPB for latest availability information.

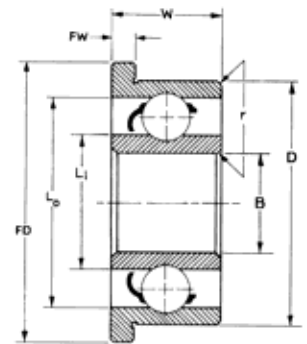
See page 18 for additional radial retainer bearing sizes.

Shielded versions may be specified with single shield (use one H in bearing number). Items marked with † are available as standard only with single shield. For double shield consult MPB engineering.

ABEC 5P and 7P

Radial Retainer Flanged Open Bearings

Bore	O.D.	Width	Bearing Numbers			Flange Dia. FD + .000 - .001	Flange Width FW + .000 - .001	Land Dia. L ₁	Land Dia. L ₀	Radius* r	Ball Complement		Load Ratings (lbs.)		
			Flanged Open Crown Retainer	Flanged Open Ribbon Retainer	Flanged Open Minapar II Retainer						number	diameter	C Dynamic	R _s Static Radial	T _s Static Thrust
.0250	.1000														
.0400	.1250	.0469	S2FC			.171	.013	.064	.102	.003	5	.025	13	3	7
.0469	.1562	.0625	S25FC	S25FR		.203	.013	.077	.122	.003	6	1/32	22	4	11
.0550	.1875	.0781	S3FC			.234	.023	.093	.159	.003	5	3/64	36	8	16
.0550	.1875	.0781		S3FR		.234	.023	.092	.155	.003	6	1mm	35	7	17
.0781	.2500	.0937	S4FC			.296	.023	.125	.215	.003	5	1/16	61	13	27
.0781	.2500	.0937		S4FR		.296	.023	.163	.222	.003	8	1mm	46	11	29
.0937	.1875	.0625	S3332FC		S3332FMCK	.234	.018	.120	.165	.003	7	1/32	26	5	15
.0937	.1875	.0625		S3332FR		.234	.018	.117	.162	.003	8	1/32	29	6	17
.0937	.3125	.1094	S5FC	S5FR	S5FMCK	.359	.023	.173	.271	.005	6	1/16	81	19	40
.1250	.2500	.0937	S418FC			.296	.023	.166	.220	.003	7	1mm	42	10	26
.1250	.2500	.0937		S418FR	S418FMCK	.296	.023	.166	.220	.003	8	1mm	46	11	29
.1250	.3125	.1094	S518FC	S518FR	S518FMCK	.359	.023	.173	.271	.003	6	1/16	81	19	40
.1250	.3750	.1094	S618FC	S618FR	S618FMCK	.422	.023	.202	.298	.005	7	1/16	94	23	49
.1250	.3750	.1562	SR2FC	SR2FR	SR2FMCK	.440	.030	.202	.298	.012	7	1/16	94	23	49
.1250	.5000														
.1562	.3125	.1094	S5532FC	S5532FR	S5532FMCK	.359	.023	.226	.285	.003	7	3/64	56	14	32
.1575	.6299														
.1875	.3125	.1094	S5632FC	S5632FR	S5632FMCK	.359	.023	.226	.285	.003	7	3/64	56	14	32
.1875	.3750	.1250	S6316FC	S6316FR	S6316FMCK	.422	.023	.236	.329	.003	8	1/16	103	28	59
.1875	.5000	.1562	SR3FC	SR3FR	SR3FMCK	.565	.042	.272	.415	.012	7	3/32	181	50	89
.1969	.6299														
.2187	.3125														
.2362	.7480														
.2500	.3750	.1250	S614FC		S614FMCK	.422	.023	.290	.342	.003	11	1mm	53	18	45
.2500	.5000	.1250	S814FC		S814FMCK	.547	.023	.336	.429	.010	10	1/16	120	39	81
.2500	.5000	.1250		S814FR		.547	.023	.336	.429	.010	11	1/16	127	43	89
.2500	.6250	.1960	SR4FC	SR4FR	SR4FMCK	.690	.042	.366	.509	.012	8	3/32	209	63	114
.2500	.7500														
.3125	.5000	.1562	S8516FC	S8516FR	S8516FMCK	.547	.031	.362	.450	.005	11	1/16	121	43	91
.3150	.8661														
.3750	.8750	.2812		SR6FR	SR6FMCK	.969	.062	.520	.787	.016	7	5/32	577	209	267



STANDARD SPECIFICATIONS

Tolerances—All precision standard radial retainer bearings are available in ABEC 5P (add suffix 5 to bearing number) or ABEC 7P (add suffix 7 to bearing number) tolerances. For information on ABEC tolerances see page 47.

Radial Play— .0002/.0008". Other ranges are available (see page 48).

Lubrication—MI L-L-6085A. Other lubricants are available (see page 52).

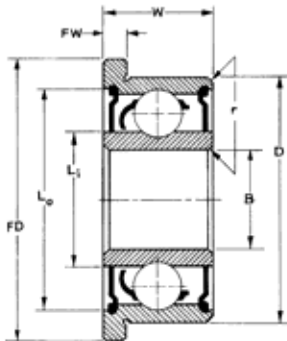
Packaging—Individual pill pack strips or vial pack.

Dimensions—All dimensions are in inches.

*r is maximum radius of shaft or housing fillet that bearing corner will clear.

ABEC 5P AND 7P

Radial Retainer Flanged Shielded Bearings



Bore B +.0000 -.0002	O.D. D +.0000 -.0002	Width W +.000 -.001	Bearing Numbers			Flange Dia. FD +.000 -.001	Flange Width FW +.000 -.001	Land Dia. L ₁ L ₂	Radius r	Ball Complement		Lead Ratings (lbs.)			
			Flanged Double Shielded Crown Retainer	Flanged Double Shielded Ribbon Retainer	Flanged Double Shielded Minapar II Retainer					number	diameter	Dynamic C	Static Radial R _s	Static Thrust T _s	
.0250	.1000														
.0400	.1250														
.0469	.1562	.0937	S25FCHH	S25FRHH		.203	.031	.077	.134	.003	6	1/32	22	4	11
.0550	.1875	.1094	S3FCHH			.234	.031	.093	.167	.003	5	3/64	36	8	16
.0550	.1875	.1094		S3FRHH		.234	.031	.092	.167	.003	6	1mm	35	7	17
.0781	.2500	.1406	S4FCHH			.296	.031	.125	.222	.003	5	1/16	61	13	27
.0781	.2500	.1406		S4FRHH	S4FMCKHH	.296	.031	.163	.230	.003	8	1mm	46	11	29
.0937	.1875	.0937	S3332FCHH			.234	.031	.120	.169	.003	8	.025	20	4	13
.0937	.1875	.0937		S3332FRHH		.234	.031	.117	.169	.003	8	1/32	29	6	17
.0937	.3125	.1406	S5FCHH	S5FRHH	S5FMCKHH	.359	.031	.173	.283	.005	6	1/16	81	19	40
.1250	.2500	.1094	S418FCHH			.296	.031	.166	.230	.003	7	1mm	42	10	26
.1250	.2500	.1094		S418FRHH	S418FMCKHH	.296	.031	.166	.230	.003	8	1mm	46	11	29
.1250	.3125	.1406	S518FCHH	S518FRHH	S518FMCKHH	.359	.031	.173	.283	.003	6	1/16	81	19	40
.1250	.3750	.1406	S618FCHH	S618FRHH	S618FMCKHH	.422	.031	.202	.324	.005	7	1/16	94	23	49
.1250	.3750	.1562	SR2FCHH	SR2FRHH	SR2FMCKHH	.440	.030	.202	.324	.012	7	1/16	94	23	49
.1250	.5000														
.1562	.3125	.1250	S5532FCHH	S5532FRHH	S5532FMCKHH	.359	.036	.226	.293	.003	7	3/64	56	14	32
.1575	.6299												0		
.1875	.3125	.1250	S5632FCHH	S5632FRHH	S5632FMCKHH	.359	.036	.226	.293	.003	7	3/64	56	14	32
.1875	.3750	.1250	S6316FCHH	S6316FRHH	S6316FMCKHH†	.422	.031	.236	.343	.003	8	1/16	103	28	59
.1875	.5000	.1960	SR3FCHH	SR3FRHH	SR3FMCKHH	.565	.042	.272	.440	.012	7	3/32	181	50	89
.1969	.6299														
.2187	.3125														
.2362	.7480														
.2500	.3750	.1250	S614FCHH		S614FMCKHH	.422	.036	.290	.352	.003	11	1mm	53	18	45
.2500	.5000	.1875	S814FCHH		S814FMCKHH	.547	.045	.336	.443	.010	10	1/16	120	39	81
.2500	.5000	.1875		S814FRHH		.547	.045	.336	.443	.010	11	1/16	127	43	89
.2500	.6250	.1960	SR4FCHH	SR4FRHH	SR4FMCKHH	.690	.042	.366	.535	.012	8	3/32	209	63	114
.2500	.7500														
.3125	.5000	.1562	S8516FCHH	S8516FRHH	S8516FMCKHH	.547	.031	.362	.461	.005	11	1/16	121	43	91
.3150	.8661														
.3750	.8750	.2812		SR6FRHH	SR6FMCKHH	.969	.062	.520	.787	.016	7	5/32	577	209	267

AVAILABILITY




Sizes listed above are normally available from stock in AISI 440C stainless steel material. For SAE 52100 and beryllium copper material, please check with MPB for latest availability information. See page 18 for additional radial retainer bearing sizes.

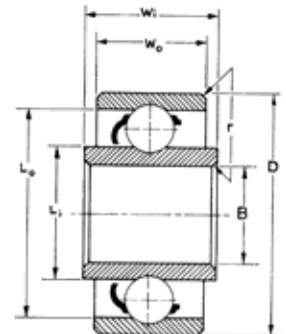
Shielded versions may be specified with single shield (use one H in bearing number). Items marked with † are available as standard only with single shield. For double shield consult MPB engineering.

MPB PRECISION STANDARD MINIATURE AND INSTRUMENT BEARINGS

ABEC 5P and 7P

Radial Retainer Extended Inner Ring Open Bearings

Bore	O.D.	Width		Bearing Numbers			Land Diameter		Radius*	Ball Complement		Load Ratings (lbs.)		
		D	W _i	W _o				L _i		L _o	number	diameter	C	R _s
B + .0000 - .0002	D + .0000 - .0002	W _i + .000 - .001	W _o + .000 - .001	Extended Inner Ring Open Crown Retainer	Extended Inner Ring Open Ribbon Retainer	Extended Inner Ring Open Minapar II Retainer	L _i	L _o	r			C	R _s	T _s
.0250	.1000													
.0400	.1250	.0781	.0469	S2CE			.064	.102	.003	5	.025	13	3	7
.0469	.1562	.0937	.0625	S25CE	S25RE		.077	.122	.003	6	1/32	22	4	11
.0550	.1875	.1094	.0781	S3CE			.093	.159	.003	5	3/64	36	8	16
.0550	.1875	.1094	.0781		S3RE		.092	.155	.003	6	1mm	35	7	17
.0781	.2500	.1250	.0937	S4CE			.125	.215	.003	5	1/16	61	13	27
.0781	.2500	.1250	.0937		S4RE		.163	.222	.003	8	1mm	46	11	29
.0937	.1875	.0937	.0625	S3332CE		S3332MCKE	.120	.165	.003	7	1/32	26	5	15
.0937	.1875	.0937	.0625		S3332RE		.117	.162	.003	8	1/32	29	6	17
.0937	.3125	.1406	.1094	S5CE	S5RE	S5MCKE	.173	.271	.005	6	1/16	81	19	40
.1250	.2500	.1250	.0937	S418CE			.166	.220	.003	7	1mm	42	10	26
.1250	.2500	.1250	.0937		S418RE	S418MCKE	.166	.220	.003	8	1mm	46	11	29
.1250	.3125	.1406	.1094	S518CE	S518RE	S518MCKE	.173	.271	.003	6	1/16	81	19	40
.1250	.3750	.1406	.1094	S618CE	S618RE	S618MCKE	.202	.298	.005	7	1/16	94	23	49
.1250	.3750	.1875	.1562	SR2CE	SR2RE	SR2MCKE	.202	.298	.012	7	1/16	94	23	49
.1250	.5000													
.1562	.3125	.1406	.1094	S5532CE	S5532RE	S5532MCKE	.226	.285	.003	7	3/64	56	14	32
.1575	.6299													
.1875	.3125	.1406	.1094	S5632CE	S5632RE	S5632MCKE	.226	.285	.003	7	3/64	56	14	32
.1875	.3750	.1562	.1250	S6316CE	S6316RE	S6316MCKE	.236	.329	.003	8	1/16	103	28	59
.1875	.5000	.1875	.1562	SR3CE	SR3RE	SR3MCKE	.272	.415	.012	7	3/32	181	50	89
.1969	.6299													
.2187	.3125													
.2362	.7480													
.2500	.3750	.1562	.1250	S614CE		S614MCKE	.290	.342	.003	11	1mm	53	18	45
.2500	.5000	.1562	.1250	S814CE		S814MCKE	.336	.429	.010	10	1/16	120	39	81
.2500	.5000	.1562	.1250		S814RE		.336	.429	.010	11	1/16	127	43	89
.2500	.6250	.2272	.1960	SR4CE	SR4RE	SR4MCKE	.366	.509	.012	8	3/32	209	63	114
.2500	.7500													
.3125	.5000	.1875	.1562	S8516CE	S8516RE	S8516MCKE	.362	.450	.005	11	1/16	121	43	91
.3150	.8661													
.3750	.8750													



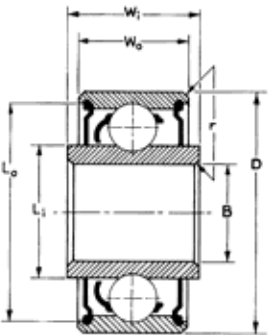
STANDARD SPECIFICATIONS

Tolerances—All precision standard radial retainer bearings are available in ABEC 5P (add suffix 5 to bearing number) or ABEC 7P (add suffix 7 to bearing number) tolerances. For information on ABEC tolerances see page 47.
Radial Play— .0002/.0008*. Other ranges are available (see page 48).
Lubrication—MI L-L-6085A. Other lubricants are available (see page 52).
Packaging—Individual pill pack strips or vial pack.

Dimensions—All dimensions are in inches.

*r is maximum radius of shaft or housing fillet that bearing corner will clear.

Radial Retainer Extended Inner Ring Shielded Bearings



Bore B + .0000 - .0002	O.D. D + .0000 - .0002	Width		Bearing Numbers			Land Diameter		Radius* r	Ball Complement		Load Ratings (lbs.)		
		W_i + .000 - .001	W_o + .000 - .001				L_i	L_o		n number	d diameter	C Dynamic	R_s Static Radial	T_s Static Thrust
.0250	.1000													
.0400	.1250													
.0469	.1562	.1250	.0937	S25CHHE	S25RHHE		.077	.134	.003	6	1/32	22	4	11
.0550	.1875	.1406	.1094	S3CHHE			.093	.167	.003	5	3/64	36	8	16
.0550	.1875	.1406	.1094		S3RHHE		.092	.167	.003	6	1mm	35	7	17
.0781	.2500	.1718	.1406	S4CHHE			.125	.222	.003	5	1/16	61	13	27
.0781	.2500	.1718	.1406		S4RHHE	S4MCKHHE	.163	.230	.003	8	1mm	46	11	29
.0937	.1875	.1250	.0937	S3332CHHE			.120	.169	.003	8	.025	20	4	13
.0937	.1875	.1250	.0937		S3332RHHE		.117	.169	.003	8	1/32	29	6	17
.0937	.3125	.1718	.1406	S5CHHE	S5RHHE	S5MCKHHE	.173	.283	.005	6	1/16	81	19	40
.1250	.2500	.1406	.1094	S418CHHE			.166	.230	.003	7	1mm	42	10	26
.1250	.2500	.1406	.1094		S418RHHE	S418MCKHHE	.166	.230	.003	8	1mm	46	11	29
.1250	.3125	.1718	.1406	S518CHHE	S518RHHE	S518MCKHHE	.173	.283	.003	6	1/16	81	19	40
.1250	.3750	.1718	.1406	S618CHHE	S618RHHE	S618MCKHHE	.202	.324	.005	7	1/16	94	23	49
.1250	.3750	.1875	.1562	SR2CHHE	SR2RHHE	SR2MCKHHE	.202	.324	.012	7	1/16	94	23	49
.1250	.5000													
.1562	.3125	.1562	.1250	S5532CHHE	S5532RHHE	S5532MCKHHE	.226	.293	.003	7	3/64	56	14	32
.1575	.6299													
.1875	.3125	.1562	.1250	S5632CHHE	S5632RHHE	S5632MCKHHE	.226	.293	.003	7	3/64	56	14	32
.1875	.3750	.1562	.1250	S6316CHHE	S6316RHHE	S6316MCKHHE†	.236	.343	.003	8	1/16	103	28	59
.1875	.5000	.2272	.1960	SR3CHHE	SR3RHHE	SR3MCKHHE	.272	.440	.012	7	3/32	181	50	89
.1969	.6299													
.2187	.3125													
.2362	.7480													
.2500	.3750	.1562	.1250	S614CHHE		S614MCKHHE	.290	.352	.003	11	1mm	53	18	45
.2500	.5000	.2187	.1875	S814CHHE		S814MCKHHE	.336	.443	.010	10	1/16	120	39	81
.2500	.5000	.2187	.1875		S814RHHE		.336	.443	.010	11	1/16	127	43	89
.2500	.6250	.2272	.1960	SR4CHHE	SR4RHHE	SR4MCKHHE	.366	.535	.012	8	3/32	209	63	114
.2500	.7500													
.3125	.5000	.1875	.1562	S8516CHHE	S8516RHHE	S8516MCKHHE	.362	.461	.005	11	1/16	121	43	91
.3150	.8661													
.3750	.8750													

AVAILABILITY

Sizes listed above are normally available from stock in AISI 440C stainless steel material. For SAE 52100 and beryllium copper material, please check with MPB for latest availability information.




See page 18 for additional radial retainer bearing sizes.

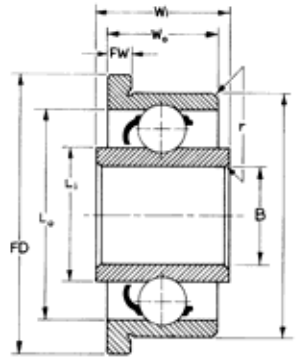
Shielded versions may be specified with single shield (use one H in bearing number). Items marked with † are available as standard only with single shield. For double shield consult MPB engineering.

MPB PRECISION STANDARD MINIATURE AND INSTRUMENT BEARINGS

ABEC 5P and 7P

Radial Retainer Flanged Extended Inner Ring Open Bearings

Bore	O.D.	Width		Bearing Numbers			Flange Dia. FD	Flange Width FW	Land Diameter		Radius* r	Ball Complement		Load Ratings (lbs.)		
		W _i	W _o	Flanged Extended Inner Ring Open Crown Retainer	Flanged Extended Inner Ring Open Ribbon Retainer	Flanged Extended Inner Ring Open Minapar II Retainer			L _i	L _o		number	diameter	C	R _s	T _s
B + .0000 - .0002	D + .0000 - .0002	W_i + .000 - .001	W_o + .000 - .001				FD + .000 - .001	FW + .000 - .001	L_i	L_o	r			C	R_s	T_s
.0250	.1000															
.0400	.1250	.0781	.0469	S2FCE			.171	.013	.064	.102	.003	5	.025	13	3	7
.0469	.1562	.0937	.0625	S25FCE	S25FRE		.203	.013	.077	.122	.003	6	1/32	22	4	11
.0550	.1875	.1094	.0781	S3FCE			.234	.023	.093	.159	.003	5	3/64	36	8	16
.0550	.1875	.1094	.0781		S3FRE		.234	.023	.092	.155	.003	6	1mm	35	7	17
.0781	.2500	.1250	.0937	S4FCE			.296	.023	.125	.215	.003	5	1/16	61	13	27
.0781	.2500	.1250	.0937		S4FRE		.296	.023	.163	.222	.003	8	1mm	46	11	29
.0937	.1875	.0937	.0625	S3332FCE		S3332FMCKE	.234	.018	.120	.165	.003	7	1/32	26	5	15
.0937	.1875	.0937	.0625		S3332FRE		.234	.018	.117	.162	.003	8	1/32	29	6	17
.0937	.3125	.1406	.1094	S5FCE	S5FRE	S5FMCKE	.359	.023	.173	.271	.005	6	1/16	81	19	40
.1250	.2500	.1250	.0937	S418FCE			.296	.023	.166	.220	.003	7	1mm	42	10	26
.1250	.2500	.1250	.0937		S418FRE	S418FMCKE	.296	.023	.166	.220	.003	8	1mm	46	11	29
.1250	.3125	.1406	.1094	S518FCE	S518FRE	S518FMCKE	.359	.023	.173	.271	.003	6	1/16	81	19	40
.1250	.3750	.1406	.1094	S618FCE	S618FRE	S618FMCKE	.422	.023	.202	.298	.005	7	1/16	94	23	49
.1250	.3750	.1875	.1562	SR2FCE	SR2FRE	SR2FMCKE	.440	.030	.202	.298	.012	7	1/16	94	23	49
.1250	.5000															
.1562	.3125	.1406	.1094	S5532FCE	S5532FRE	S5532FMCKE	.359	.023	.226	.285	.003	7	3/64	56	14	32
.1575	.6299															
.1875	.3125	.1406	.1094	S5632FCE	S5632FRE	S5632FMCKE	.359	.023	.226	.285	.003	7	3/64	56	14	32
.1875	.3750	.1562	.1250	S6316FCE	S6316FRE	S6316FMCKE	.422	.023	.236	.329	.003	8	1/16	103	28	59
.1875	.5000	.1875	.1562	SR3FCE	SR3FRE	SR3FMCKE	.565	.042	.272	.415	.012	7	3/32	181	50	89
.1969	.6299															
.2187	.3125															
.2362	.7480															
.2500	.3750	.1562	.1250	S614FCE		S614FMCKE	.422	.023	.290	.342	.003	11	1mm	53	18	45
.2500	.5000	.1562	.1250	S814FCE		S814FMCKE	.547	.023	.336	.429	.010	10	1/16	120	39	81
.2500	.5000	.1562	.1250		S814FRE		.547	.023	.336	.429	.010	11	1/16	127	43	89
.2500	.6250	.2272	.1960	SR4FCE	SR4FRE	SR4FMCKE	.690	.042	.366	.509	.012	8	3/32	209	63	114
.2500	.7500															
.3125	.5000	.1875	.1562	S8516FCE	S8516FRE	S8516FMCKE	.547	.031	.362	.450	.005	11	1/16	121	43	91
.3150	.8661															
.3750	.8750															



STANDARD SPECIFICATIONS

Tolerances—All precision standard radial retainer bearings are available in ABEC 5P (add suffix 5 to bearing number) or ABEC 7P (add suffix 7 to bearing number) tolerances. For information on ABEC tolerances see page 47.

Radial Play—.0002/.0008". Other ranges are available (see page 48).

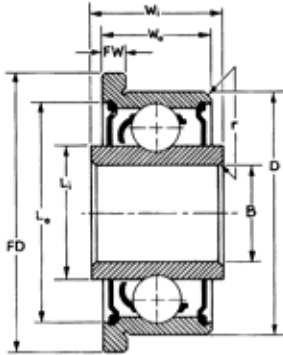
Lubrication—MI L-L-6085A. Other lubricants are available (see page 52).

Packaging—Individual pill pack strips or vial pack.

Dimensions—All dimensions are in inches.

*r is maximum radius of shaft or housing fillet that bearing corner will clear.

Radial Retainer Flanged Extended Inner Ring Shielded Bearings



Bore	O.D.	Width		Bearing Numbers			Flange Dia.	Flange Width	Land Diameter		Radius*	Ball Complement		Load Ratings (lbs.)			
		W_1	W_2	Flanged Extended Inner Ring Double Shielded Crown Retainer	Flanged Extended Inner Ring Double Shielded Ribbon Retainer	Flanged Extended Inner Ring Double Shielded Minapar II Retainer			L_1	L_2		number	diameter	C	R-	T-	
.0250	.1000																
.0400	.1250																
.0469	.1562	.1250	.0937	S25FCHHE	S25FRHHE		.203	.031	.077	.134	.003	6	1/32	22	4	11	
.0550	.1875	.1406	.1094	S3FCHHE			.234	.031	.093	.167	.003	5	3/64	36	8	16	
.0550	.1875	.1406	.1094		S3FRHHE		.234	.031	.092	.167	.003	6	1mm	35	7	17	
.0781	.2500	.1718	.1406	S4FCHHE			.296	.031	.125	.222	.003	5	1/16	61	13	27	
.0781	.2500	.1718	.1406		S4FRHHE	S4FMCKHHE	.296	.031	.163	.230	.003	8	1mm	46	11	29	
.0937	.1875	.1250	.0937	S3332FCHHE			.234	.031	.120	.169	.003	8	.025	20	4	13	
.0937	.1875	.1250	.0937		S3332FRHHE		.234	.031	.117	.169	.003	8	1/32	29	6	17	
.0937	.3125	.1718	.1406	S5FCHHE	S5FRHHE	S5FMCKHHE	.359	.031	.173	.283	.005	6	1/16	81	19	40	
.1250	.2500	.1406	.1094	S418FCHHE			.296	.031	.166	.230	.003	7	1mm	42	10	26	
.1250	.2500	.1406	.1094		S418FRHHE	S418FMCKHHE	.296	.031	.166	.230	.003	8	1mm	46	11	29	
.1250	.3125	.1718	.1406	S518FCHHE	S518FRHHE	S518FMCKHHE	.359	.031	.173	.283	.003	6	1/16	81	19	40	
.1250	.3750	.1718	.1406	S618FCHHE	S618FRHHE	S618FMCKHHE	.422	.031	.202	.324	.005	7	1/16	94	23	49	
.1250	.3750	.1875	.1562	SR2FCHHE	SR2FRHHE	SR2FMCKHHE	.440	.030	.202	.324	.012	7	1/16	94	23	49	
.1250	.5000																
.1562	.3125	.1562	.1250	S5532FCHHE	S5532FRHHE	S5532FMCKHHE	.359	.036	.226	.293	.003	7	3/64	56	14	32	
.1575	.6299																
.1875	.3125	.1562	.1250	S5632FCHHE	S5632FRHHE	S5632FMCKHHE	.359	.036	.226	.293	.003	7	3/64	56	14	32	
.1875	.3750	.1562	.1250	S6316FCHHE	S6316FRHHE	S6316FMCKHHE†	.422	.031	.236	.343	.003	8	1/16	103	28	59	
.1875	.5000	.2272	.1960	SR3FCHHE	SR3FRHHE	SR3FMCKHHE	.565	.042	.272	.440	.012	7	3/32	181	50	89	
.1969	.6299																
.2187	.3125																
.2362	.7480																
.2500	.3750	.1562	.1250	S614FCHHE		S614FMCKHHE	.422	.036	.290	.352	.003	11	1mm	53	18	45	
.2500	.5000	.2187	.1875	S814FCHHE		S814FMCKHHE	.547	.045	.336	.443	.010	10	1/16	120	39	81	
.2500	.5000	.2187	.1875		S814FRHHE		.547	.045	.336	.443	.010	11	1/16	127	43	89	
.2500	.6250	.2272	.1960	SR4FCHHE	SR4FRHHE	SR4FMCKHHE	.690	.042	.366	.535	.012	8	3/32	209	63	114	
.2500	.7500																
.3125	.5000	.1875	.1562	S8516FCHHE	S8516FRHHE	S8516FMCKHHE	.547	.031	.362	.461	.005	11	1/16	121	43	91	
.3150	.8661																
.3750	.8750																

AVAILABILITY




Sizes listed above are normally available from stock in AISI 440C stainless steel material. For SAE 52100 and beryllium copper material, please check with MPB for latest availability information.

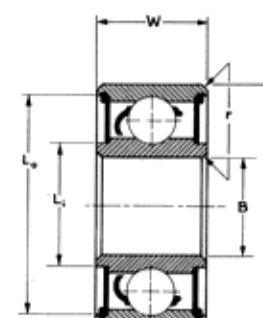
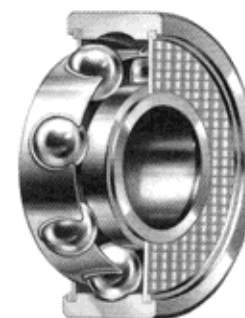
See page 18 for additional radial retainer bearing sizes.

Shielded versions may be specified with single shield (use one H in bearing number). Items marked with † are available as standard only with single shield. For double shield consult MPB engineering.

ABEC 5P and 7P

Radial Retainer Sealed Bearings

Bore	O.D.	Width	Bearing Numbers			Land Diameter		Radius*	Ball Complement		Load Ratings (lbs.)		
						L ₁	L ₂	r	number	diameter	C Dynamic	R _s Static Radial	T _s Static Thrust
.0250	.1000												
.0400	.1250												
.0469	.1562												
.0550	.1875												
.0550	.1875												
.0781	.2500												
.0781	.2500												
.0937	.1875												
.0937	.1875												
.0937	.3125	.1406	S5CZZ	S5RZZ	S5MCKZZ	.160	.283	.005	6	1/16	81	19	40
.1250	.2500	.1094	S418CZZ			.148	.230	.003	7	1mm	42	10	26
.1250	.2500	.1094		S418RZZ	S418MCKZZ	.148	.230	.003	8	1mm	46	11	29
.1250	.3125	.1406	S518CZZ	S518RZZ	S518MCKZZ	.160	.283	.003	6	1/16	81	19	40
.1250	.3750	.1406	S618CZZ	S618RZZ	S618MCKZZ	.181	.324	.005	7	1/16	94	23	49
.1250	.3750	.1562	SR2CZZ	SR2RZZ	SR2MCKZZ	.181	.324	.012	7	1/16	94	23	49
.1250	.5000	.1719	SR2ACZZ	SR2ARZZ	SR2AMCKZZ	.181	.324	.012	7	1/16	94	23	49
.1562	.3125	.1250	S5532CZZ	S5532RZZ	S5532MCKZZ	.210	.293	.003	7	3/64	56	14	32
.1575	.6299												
.1875	.3125	.1250	S5632CZZ	S5632RZZ	S5632MCKZZ	.210	.293	.003	7	3/64	56	14	32
.1875	.3750												
.1875	.5000	.1960	SR3CZZ	SR3RZZ	SR3MCKZZ	.252	.440	.012	7	3/32	181	50	89
.1969	.6299												
.2187	.3125												
.2362	.7480												
.2500	.3750												
.2500	.5000	.1875	S814CZZ		S814MCKZZ	.315	.443	.010	10	1/16	120	39	81
.2500	.5000	.1875		S814RZZ		.315	.443	.010	11	1/16	127	43	89
.2500	.6250	.1960	SR4CZZ‡	SR4RZZ‡	SR4MCKZZ‡	.346	.535	.012	8	3/32	209	63	114
.2500	.7500	.2812		SR4ARZZ		.338	.649	.016	6	9/64	332	95	139
.3125	.5000	.1562	S8516CZZ	S8516RZZ	S8516MCKZZ	.351	.461	.005	11	1/16	121	43	91
.3150	.8661												
.3750	.8750	.2812		SR6RZZ△	SR6MCKZZ△	.450	.787	.016	7	5/32	444	209	267
.5000	1.1250	.3125		SR8RZZ		.678	.998	.016	10	5/32	904	489	205



STANDARD SPECIFICATIONS

Tolerances—All precision standard radial retainer bearings are available in ABEC 5P (add suffix 5 to bearing number) or ABEC 7P (add suffix 7 to bearing number) tolerances. For information on ABEC tolerances see page 47.

Radial Play—.0002/.0008". Other ranges are available (see page 48).

Lubrication—MI L-L-6085A. Other lubricants are available (see page 52).

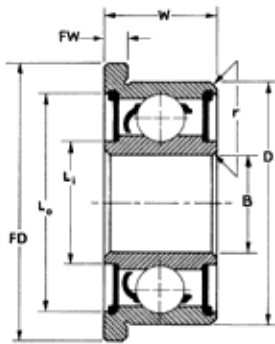
Packaging—Individual pill pack strips or vial pack.

Dimensions—All dimensions are in inches.

*r is maximum radius of shaft or housing fillet that bearing corner will clear.
 ‡ Also available with Buna N seal.
 △ Buna N seal only.

ABEC 5P AND 7P

Radial Retainer Flanged Sealed Bearings



Bore B + .0010 - .0002	O.D. D + .0010 - .0002	Width W + .000 - .001	Bearing Numbers			Flange Dia. FD + .000 - .001	Flange Width FW + .000 - .001	Land Diameter		Radius* r	Ball Complement		Load Ratings (lbs.)		
			Flanged Double Seal Crown Retainer	Flanged Double Seal Ribbon Retainer	Flanged Double Seal Minapar II Retainer			L ₁	L ₂		number	diameter	C	R _s Static Radial	T _s Static Thrust
.0250	.1000														
.0400	.1250														
.0469	.1562														
.0550	.1875														
.0550	.1875														
.0781	.2500														
.0781	.2500														
.0937	.1875														
.0937	.1875														
.0937	.3125	.1406	S5FCZZ	S5FRZZ	S5FMCKZZ	.359	.031	.160	.283	.005	6	1/16	81	19	40
.1250	.2500	.1094	S418FCZZ			.296	.031	.148	.230	.003	7	1mm	42	10	26
.1250	.2500	.1094		S418FRZZ	S418FMCKZZ	.296	.031	.148	.230	.003	8	1mm	46	11	29
.1250	.3125	.1406	S518FCZZ	S518FRZZ	S518FMCKZZ	.359	.031	.160	.283	.003	6	1/16	81	19	40
.1250	.3750	.1406	S618FCZZ	S618FRZZ	S618FMCKZZ	.422	.031	.181	.324	.005	7	1/16	94	23	49
.1250	.3750	.1562	SR2FCZZ	SR2FRZZ	SR2FMCKZZ	.440	.030	.181	.324	.012	7	1/16	94	23	49
.1250	.5000														
.1562	.3125	.1250	S5532FCZZ	S5532FRZZ	S5532FMCKZZ	.359	.036	.210	.293	.003	7	3/64	56	14	32
.1575	.6299														
.1875	.3125	.1250	S5632FCZZ	S5632FRZZ	S5632FMCKZZ	.359	.036	.210	.293	.003	7	3/64	56	14	32
.1875	.3750														
.1875	.5000	.1960	SR3FCZZ	SR3FRZZ	SR3FMCKZZ	.565	.042	.252	.440	.012	7	3/32	181	50	89
.1969	.6299														
.2187	.3125														
.2362	.7480														
.2500	.3750														
.2500	.5000	.1875	S814FCZZ		S814FMCKZZ	.547	.045	.315	.443	.010	10	1/16	120	39	81
.2500	.5000	.1875		S814FRZZ		.547	.045	.315	.443	.010	11	1/16	127	43	89
.2500	.6250	.1960	SR4FCZZ‡	SR4FRZZ‡	SR4FMCKZZ‡	.690	.042	.346	.535	.012	8	3/32	209	63	114
.2500	.7500														
.3125	.5000	.1562	S8516FCZZ	S8516FRZZ	S8516FMCKZZ	.547	.031	.351	.461	.005	11	1/16	121	43	91
.3150	.8661														
.3750	.8750	.2812		SR6FRZZ△	SR6FMCKZZ△	.969	.062	.450	.787	.016	7	5/32	414	209	267

AVAILABILITY

Sizes listed above are normally available from stock in AISI 440C stainless steel material. For SAE 52100 and beryllium copper material please check with MPB for latest availability information. Sealed versions may be specified with a single seal (use one Z in bearing part number).




Note: All dimensions are in inches.

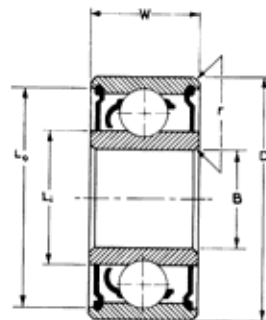
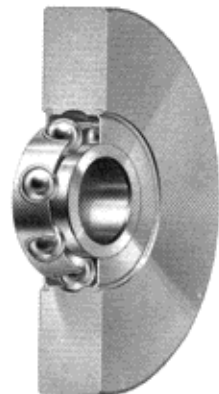
‡ Also available with Buna N seal.

△ Buna N seal only.

ABEC 5P

Modified Dimension Radial Retainer Bearings

Bore	O.D.	Width	Bearing Numbers			Land Diameter		Radius*	Ball Complement		Load Ratings (lbs.)		
			Open	Single Shield	Double Shield	L _i	L _o		number	diameter	C Dynamic	R _s Static Radial	T _s Static Thrust
B +.0000 -.0002	D +.0000 -.0002	W +.000 -.001						r					
.0469	.1875	.0937			A158	.077	.134	.005	6	1/32	22	4	11
.0550	.1875	.0937		S3CHN		.093	.167	.003	5	3/64	36	8	14
.0781	.2500	.1094		S4CHN		.125	.222	.003	5	1/16	61	13	27
.0937	.2500	.0937			A833†	.166	.230	.005	8	1mm	46	11	29
.0937	.2750	.0625		A280		.120	.190	.005	8	.025	20	4	13
.0937	.3125	.1094	■	S5CHN		.173	.283	.005	6	1/16	81	19	40
.1250	.2500	.0937	■	S418CHN		.166	.230	.003	7	1mm	42	10	25
.1250	.2500	.0937			A891†	.166	.230	.005	8	1mm	46	11	29
.1250	.3125	.1094	■	S518CHN		.173	.283	.003	6	1/16	81	19	40
.1250	.3750	.0937			A834†	.166	.230	.005	8	1mm	46	11	29
.1250	.3750	.1094	■	S618CHN		.202	.324	.005	7	1/16	94	23	49
.1250	.3750	.1094	■		A281	.166	.230	.005	7	1mm	42	10	25
.1250	.4100	.0937		A521		.226	.293	.005	11	1mm	53	17	43
.1250	.4100	.0937			B70†	.166	.230	.005	8	1mm	46	11	29
.1250	.4250	.1094		A282		.202	.324	.005	7	1/16	94	23	49
.1250	.5000	.1094		A430	A431	.166	.230	.005	7	1mm	42	10	25
.1562	.3125	.1094	■	S5532CHN		.226	.293	.003	7	3/64	56	14	32
.1875	.3125	.1094	■	S5632CHN		.226	.293	.003	7	3/64	56	13	33
.1875	.3750	.1562	B50			.226	.285	.005	7	3/64	56	14	32
.1875	.5000	.1094	A245			.290	.342	.008	11	1mm	53	17	43
.1875	.5000	.1094		B44†		.226	.293	.005	7	3/64	56	14	32
.1875	.5000	.1562			D893, A872†	.236	.343	.005	8	1/16	103	28	59
.2499	.7500	.2812			A615†	.366	.535	.012	8	3/32	209	63	114
.2500	.5000	.1250	■	S814CHN		.336	.443	.010	10	1/16	120	39	81
.2500	.7500	.1960			B698†	.366	.535	.012	8	3/32	209	63	114
.2500	.8685	.1960			B234†	.366	.535	.012	8	3/32	209	63	114
.2500	1.0480	.1960			B285†	.366	.535	.012	8	3/32	209	63	114
.3125	.5000	.1094	E685†△			.362	.450	.010	11	1/16	121	43	91
.3750	.8750	.2188			F469‡, G224‡	.510	.787	.016	17	1/16	161	74	155



STANDARD SPECIFICATIONS

Material—AISI 440C stainless steel rings and balls.

Tolerances—Modified dimension bearings are available in ABEC 7P and ABEC 5P tolerances. Specify when ordering or consult with MPB.

Retainer—One-piece stainless steel crown retainer is standard. Bearings indicated by a † have a two-piece ribbon retainer. Bearings indicated by ‡ have PTFE slug separators.

Radial Play—.0002 to .0008". Other ranges are available. See Page 48.

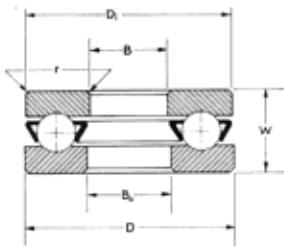
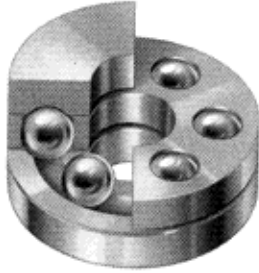
Lubrication—MI L-L-6085A. Other lubricants are available. See Page 52.

*r is maximum radius of shaft or housing fillet that bearing corner will clear.

■ Open bearings in these sizes are standard bearings. See page 8.

△ Flanged outer ring.

Thrust Bearings



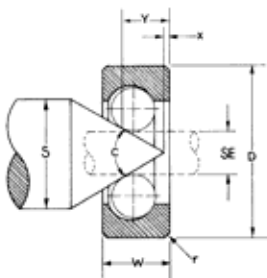
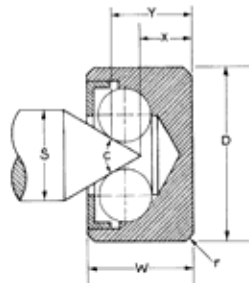
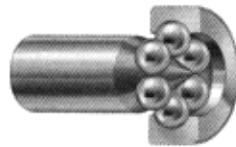
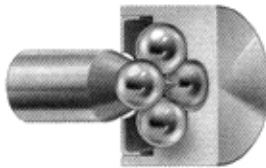
AVAILABILITY

Thrust bearings are normally available from stock in AISI 440C stainless steel.

Note: All dimensions are in inches.

Bore	O.D.	Width	Bearing Numbers		D _i +.000 -.002	B _o +.002 -.000	Radius* r	Ball Complement		Load Ratings	
			Stamped Stainless Steel Retainers	Machined Stainless Steel Retainers				number	diameter	C Dynamic	T _s Static Thrust
.0937	.2500	.0937	S4T		.2480	.0957	.005	8	3/64	159	89
.1250	.3125	.1250	S5T		.3105	.1270	.008	8	1/16	272	156
.1250	.3125	.1250		A722	.3105	.1270	.008	8	1/16	272	156
.1875	.3750	.1500	S6T		.3730	.1895	.008	8	1/16	250	173
.1875	.3750	.1500		A721	.3730	.1895	.008	8	1/16	250	173
.1250	.4375	.1500	S7T		.4355	.1270	.008	10	1/16	289	232
.1250	.4375	.1875		A680	.4355	.1270	.008	6	3/32	484	238

*r is maximum radius of shaft or housing fillet that bearing corner will clear.



AVAILABILITY

Pivot bearings are normally available from stock in AISI 440C stainless steel.

Note: All dimensions are in inches.



O.D.	Width	Bearing Numbers		S	SE	X	Y	Pivot Angle Degrees C	Radius* r	Ball Complement		Load Rating T _s Static Thrust
		Type PR	Type A							number	diameter	
.0590	.0472	S15PR		.020		.026	.034	60	.003	4	1/64	0.2
.1181	.0709	S3PR		.030		.037	.054	60	.004	4	1/32	1
.1250	.0469		S2A	.042	.032	.001	.034	60	.003	6	1/32	2
.1575	.0945	S4PR		.040		.049	.074	60	.005	4	3/64	2
.1875	.0700		S3A	.062	.048	.003	.051	60	.005	6	3/64	4
.1968	.1181	S5PR		.050		.059	.091	60	.006	4	1/16	3.5
.2500	.0937		S4A	.085	.065	.002	.066	60	.008	6	1/16	7
.2953	.1772	S75PR		.075		.090	.138	60	.008	4	3/32	8
.3750	.1406		S6A	.124	.094	.006	.098	60	.010	6	3/32	16
.3750	.1406		S6A7B	.150	.125	-.014	.104	60	.010	7	3/32	20
.3937	.2362	S10PR		.100		.118	.182	60	.008	4	1/8	14

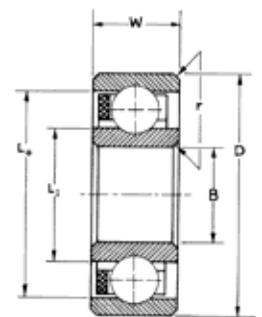
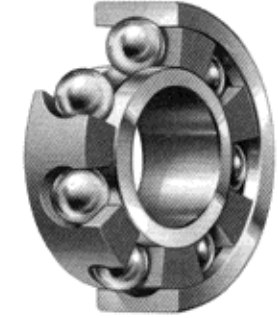
*r is maximum radius of housing fillet that bearing corner will clear.

MPB PRECISION STANDARD MINIATURE AND INSTRUMENT BEARINGS

ABEC 5P and 7P

Radial Retainer High Speed Open and Shielded Bearings

			OPEN				SHIELDED				OPEN & SHIELDED				
Bore	O. D.	Width	Bearing Numbers	Lead Diameter		Width	Bearing Numbers	Lead Diameter		Radius*	Ball Complement		Load Ratings (lbs.)		
B +.0000 -.0002	D +.0030 -.0002	W +.000 -.001		L ₁	L ₂	W +.000 -.001		L ₁	L ₂	r	number	diameter	C Dynamic	R _s Static Radial	T _s Static Thrust
			Open				Double Shielded								
.0250	.1000														
.0400	.1250														
.0469	.1562														
.0550	.1875														
.0550	.1875														
.0781	.2500	.0937	S4MC	.163	.222	.1406	S4MCHH	.163	.230	.003	7	1mm	42	10	26
.0781	.2500														
.0937	.1875	.0625	S3332MCD#	.120	.165					.003	7	1/32	26	5	15
.0937	.1875														
.0937	.3125	.1094	S5MC	.173	.271	.1406	S5MCHH	.173	.283	.005	6	1/16	81	19	40
.1250	.2500	.0937	S418MC	.166	.220	.1094	S418MCH†	.166	.230	.003	7	1mm	42	10	26
.1250	.2500														
.1250	.3125	.1094	S518MC	.173	.271	.1406	S518MCHH	.173	.283	.003	6	1/16	81	19	40
.1250	.3750	.1094	S618MC	.202	.298	.1406	S618MCHH	.202	.324	.005	7	1/16	94	23	49
.1250	.3750	.1562	SR2MC	.202	.298	.1562	SR2MCHH	.202	.324	.012	7	1/16	94	23	49
.1250	.5000	.1719	SR2AMC	.202	.324	.1719	SR2AMCHH	.202	.324	.012	7	1/16	94	23	49
.1562	.3125	.1094	S5532MC	.226	.285	.1250	S5532MCH†	.226	.293	.003	7	3/64	56	14	32
.1575	.6299														
.1875	.3125	.1094	S5632MC	.226	.285	.1250	S5632MCH†	.226	.293	.003	7	3/64	56	14	32
.1875	.3750	.1250	S6316MC	.236	.329	.1250	S6316MCH†	.236	.343	.003	8	1/16	103	28	59
.1875	.5000	.1562	SR3MC	.272	.415	.1960	SR3MCHH	.272	.440	.012	7	3/32	181	50	89
.1969	.6299														
.2187	.3125														
.2362	.7480	.2362	S36MC	.386	.596	.2362	S36MCH†	.342	.649	.012	6	9/64	332	95	139
.2500	.3750														
.2500	.5000	.1250	S814MC	.336	.429	.1875	S814MCHH	.336	.443	.010	10	1/16	120	39	81
.2500	.5000														
.2500	.6250	.1960	SR4MC	.366	.509	.1960	SR4MCHH	.366	.535	.012	8	3/32	209	63	114
.2500	.7500	.2188	SR4AMC	.386	.596	.2812	SR4AMCHH	.386	.649	.016	6	9/64	332	95	139
.3125	.5000	.1562	S8516MC	.362	.450	.1562	S8516MCHH	.362	.461	.005	11	1/16	121	43	91
.3150	.8661	.2756	S38MC	.463	.692	.2756	S38MCH†	.415	.747	.012	7	5/32	443	139	213
.3750	.8750	.2812	SR6MCW	.520	.787	.2812	SR6MCHH	.520	.787	.016	7	5/32	444	209	267



STANDARD SPECIFICATIONS

Tolerances—All precision standard radial retainer bearings are available in ABEC 5P (add suffix 5 to bearing number) or ABEC 7P (add suffix 7 to bearing number) tolerances. For information on ABEC tolerances see page 47.

Radial Play—.0002/.0008". Other ranges are available (see page 48).

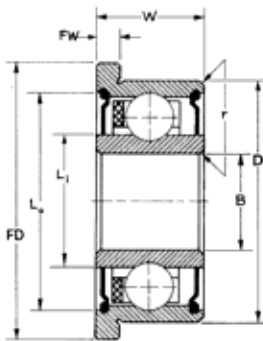
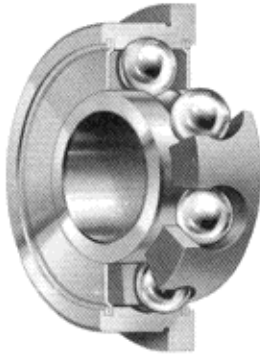
Lubrication—MI L-L-6085A. Other lubricants are available (see page 52).



Packaging—Individual pill pack strips or vial pack.

Dimensions—All dimensions are in inches.

*r is maximum radius of shaft or housing fillet that bearing corner will clear.
 # Acetal Resin Retainer
 † Available with single shield only.

Radial Retainer High Speed Flanged Open and Shielded Bearings



OPEN							SHIELDED					OPEN & SHIELDED								
Bore	O.D.	Width	Bearing Numbers	Flange Dia.	Flange Width	Land Diameter		Width	Bearing Numbers	Flange Dia.	Flange Width	Land Diameter		Radius*	Ball Complement		Load Ratings (lbs.)			
B + .0000 - .0002	D + .0000 - .0002	W + .000 - .001	 Open	FD + .000 - .001	FW + .000 - .001	L ₁	L ₂	W + .000 - .001	 Double Shielded	FD + .000 - .001	FW + .000 - .001	L ₁	L ₂	r	number	diameter	C	R _s	T _s	
.0250	.1000																			
.0400	.1250																			
.0469	.1562																			
.0550	.1875																			
.0550	.1875																			
.0781	.2500	.0937	S4FMC	.296	.023	.163	.222	.1406	S4FMCHH	.296	.031	.163	.230	.003	7	1mm	42	10	26	
.0781	.2500																			
.0937	.1875	.0625	S3332FMC [#]	.234	.018	.120	.165							.003	7	1/32	26	5	15	
.0937	.1875																			
.0937	.3125	.1094	S5FMC	.359	.023	.173	.271	.1406	S5FMCHH	.359	.031	.173	.283	.005	6	1/16	81	19	40	
.1250	.2500	.0937	S418FMC	.296	.023	.166	.220	.1094	S418FMCHH	.296	.031	.166	.230	.003	7	1mm	42	10	26	
.1250	.2500																			
.1250	.3125	.1094	S518FMC	.359	.023	.173	.271	.1406	S518FMCHH	.359	.031	.173	.283	.003	6	1/16	81	19	40	
.1250	.3750	.1094	S618FMC	.422	.023	.202	.298	.1406	S618FMCHH	.422	.031	.202	.324	.005	7	1/16	94	23	49	
.1250	.3750	.1562	SR2FMC	.440	.030	.202	.298	.1562	SR2FMCHH	.440	.030	.202	.324	.012	7	1/16	94	23	49	
.1250	.5000																			
.1562	.3125	.1094	S5532FMC	.359	.023	.226	.285	.1250	S5532FMCHH	.359	.036	.226	.293	.003	7	3/64	56	14	32	
.1575	.6299																			
.1875	.3125	.1094	S5632FMC	.359	.023	.226	.285	.1250	S5632FMCHH	.359	.036	.226	.293	.003	7	3/64	56	14	32	
.1875	.3750	.1250	S6316FMC	.422	.023	.236	.329	.1250	S6316FMCHH	.422	.031	.236	.343	.003	8	1/16	103	28	59	
.1875	.5000	.1562	SR3FMC	.565	.042	.272	.415	.1960	SR3FMCHH	.565	.042	.272	.440	.012	7	3/32	181	50	89	
.1969	.6299																			
.2187	.3125																			
.2362	.7480																			
.2500	.3750																			
.2500	.5000	.1250	S814FMC	.547	.023	.336	.429	.1875	S814FMCHH	.547	.045	.336	.443	.010	10	1/16	120	39	81	
.2500	.5000																			
.2500	.6250	.1960	SR4FMC	.690	.042	.366	.509	.1960	SR4FMCHH	.690	.042	.366	.535	.012	8	3/32	209	63	114	
.2500	.7500																			
.3125	.5000	.1562	S8516FMC	.547	.031	.362	.450	.1562	S8516FMCHH	.547	.031	.362	.461	.005	11	1/16	121	43	91	
.3150	.8661																			
.3750	.8750	.2812	SR6FMC	.969	.062	.520	.787	.2812	SR6FMCHH	.969	.062	.520	.787	.016	7	5/32	444	209	267	

AVAILABILITY

Sizes listed above are normally available from stock in AISI 440C stainless steel rings and balls with paper base phenolic resin retainer material as denoted by MC. These MC retainers can be impregnated with oil lubricant if desired. Consult MPB Engineering for other retainer materials.

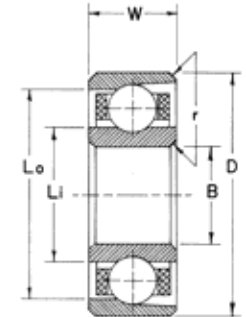
For SAE 52100 and beryllium copper material please check with MPB for latest availability information.

Note: All dimensions are in inches.

ABEC 7P

High Speed Angular Contact Non-Separable Bearings

Bore	O.D.	Width	Bearing Numbers		Flange Dia. FD +.000 -.001	Flange Width FW +.000 -.001	Land Diameter		Radius* r	Ball Complement		Contact Angle degrees	Radial Play	Load Ratings (lbs.)		
			Non-Separable	Flanged Non-Separable			L ₁	L ₂		n number	d diameter			C Dynamic	R _s Static Radial	T _s Static Thrust
.0250	.1000															
.0400	.1250															
.0469	.1562															
.0550	.1875															
.0550	.1875															
.0781	.2500															
.0781	.2500															
.0937	.1875															
.0937	.1875															
.0937	.3125	.1094	C5M	C5FM	.359	.023	.160	.248	.005	7	1/16	12	.0003	88	21	44
.1250	.2500															
.1250	.2500	.0937	C418M				.166	.220	.003	8	1mm	15	.0003	47	12	26
.1250	.3125	.1094	C518M	C518FM	.359	.023	.179	.267	.003	7	1/16	12	.0003	88	22	46
.1250	.3750	.1094	C618M	C618FM	.422	.023	.202	.298	.005	7	1/16	12	.0003	94	23	49
.1250	.3750	.1562	CR2M	CR2FM	.440	.030	.204	.293	.012	8	1/16	16	.0004	103	27	56
.1250	.5000															
.1562	.3125															
.1575	.6299	.1969	C34M				.300	.488	.012	8	1/8	16	.0006	320	82	170
.1875	.3125															
.1875	.3750															
.1875	.5000	.1562	CR3M	CR3FM	.565	.042	.278	.410	.012	8	3/32	10	.0003	195	54	112
.1969	.6299	.1969	C345M				.300	.488	.012	8	1/8	16	.0006	320	82	170
.2187	.3125															
.2362	.7480	.2362	C36M				.386	.596	.012	8	9/64	15	.0004	395	111	228
.2500	.3750															
.2500	.5000	.1250	C814M	C814FM	.547	.023	.336	.430	.010	10	1/16	12	.0003	120	39	81
.2500	.5000															
.2500	.6250	.1960	CR4M	CR4FM	.690	.042	.372	.504	.012	9	3/32	10	.0003	224	67	140
.2500	.7500															
.3125	.5000	.1562	C8516M	C8516FM	.547	.031	.363	.449	.005	11	1/16	12	.0003	121	43	91
.3150	.8661	.2756	C38M				.463	.692	.012	9	5/32	14	.0006	414	169	263
.3750	.8750	.2188	CR6M				.520	.745	.016	9	5/32	10	.0004	421	165	339



STANDARD SPECIFICATIONS

Tolerances—These angular contact bearings are manufactured to ABEC 7P tolerances.

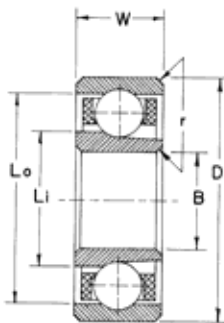
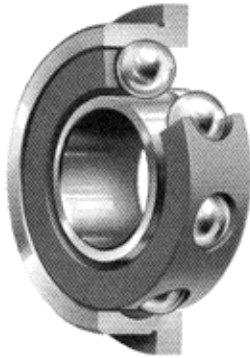
Contact angle/radial play—These bearings are assembled to a radial play range to yield the nominal contact angle shown. The standard tolerance is $\pm 3^\circ$. Other contact angles or tolerances available upon request.



Lubrication—Standard lubrication is vacuum impregnation of the phenolic retainer with MIL-L-6085A oil. Other lubricant options available.

*r is maximum radius of shaft or housing fillet that bearing corner will clear.

ABEC 7P

High Speed Angular Contact Separable Bearings



Bore	O.D.	Width	Bearing Numbers		Flange Dia.	Flange Width	Land Diameter		Radius*	Ball Complement		Contact Angle	Radial Play	Load Ratings (lbs.)		
B +.0000 -.0002	D +.0030 -.0032	W +.000 -.001	 Separable	 Flanged Separable	FD +.000 -.001	FW +.000 -.001	L ₁	L ₂	r	n	d	degrees		C	R _s	T _s
											number	diameter			Dynamic	Static Radial
.0250	.1000															
.0400	.1250															
.0469	.1562															
.0550	.1875															
.0550	.1875															
.0781	.2500															
.0781	.2500															
.0937	.1875															
.0937	.1875															
.0937	.3125	.1094	C5MB	C5FMB	.359	.023	.160	.248	.005	6	1/16	16	.0006	81	18	38
.1250	.2500															
.1250	.2500															
.1250	.3125	.1094	C518MB	C518FMB	.359	.023	.179	.267	.003	7	1/16	16	.0006	88	23	47
.1250	.3750	.1094	C618MB	C618FMB	.422	.023	.202	.298	.005	7	1/16	17	.0007	94	23	49
.1250	.3750	.1562	CR2MB	CR2FMB	.440	.030	.204	.293	.012	7	1/16	16	.0006	94	23	49
.1250	.5000															
.1562	.3125															
.1575	.6299	.1969	C34MB				.300	.488	.012	6	1/8	12	.0009	264	61	127
.1875	.3125															
.1875	.3750															
.1875	.5000	.1562	CR3MB	CR3FMB	.565	.042	.278	.410	.012	7	3/32	16	.0008	179	47	98
.1969	.6299	.1969	C345MB				.300	.488	.012	6	1/8	14	.0010	264	61	127
.2187	.3125															
.2362	.7480	.2362	C36MB				.386	.596	.012	6	9/64	11	.0009	326	83	171
.2500	.3750															
.2500	.5000	.1250	C814MB	C814FMB	.547	.023	.336	.430	.010	10	1/16	17	.0007	120	39	81
.2500	.5000															
.2500	.6250	.1960	CR4MB	CR4FMB	.690	.042	.372	.504	.012	8	3/32	16	.0008	207	60	124
.2500	.7500															
.3125	.5000															
.3150	.8661	.2756	C38MB				.463	.692	.012	7	5/32	14	.0012	437	123	254
.3750	.8750															

AVAILABILITY

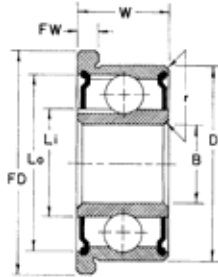
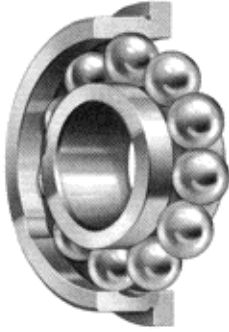
—The above bearings are shown with prefix C (SAE 52100), but this series is also available in AISI 440C (prefix S). Consult factory for availability.

*r is maximum radius of shaft or housing fillet that bearing corner will clear.

MPB PRECISION STANDARD MINIATURE AND INSTRUMENT BEARINGS

ABEC 5P AND 7P

Radial Open and Shielded Flanged Full Complement Bearings



OPEN							SHIELDED					OPEN & SHIELDED			
Bore	O.D.	Width	Bearing Numbers	Flange Dia.	Flange Width	Land Diameter	Width	Bearing Numbers	Flange Dia.	Flange Width	Land Diameter	Radius*	Ball Complement	Load Ratings (lbs.)	
B + .000 - .002	D + .000 - .002	W + .000 - .001	 Open	FD + .000 - .001	FW + .000 - .001	L ₁ L ₂	W + .000 - .001	 Double Shielded	FD + .000 - .001	FW + .000 - .001	L ₁ L ₂	r	number diameter	C Dynamic	R _s Static Radial
.0250	.1000														
.0400	.1250	.0469	S2F	.171	.013	.065 .102						.003	10 .025	21	4
.0469	.1562	.0625	S25F	.203	.013	.082 .129						.003	10 1/32	31	7
.0550	.1875	.0781	S3F	.234	.023	.093 .159	.1094	S3FHH	.234	.031	.093 .167	.003	8 3/64	49	11
.0550	.1875														
.0781	.2500	.0937	S4F	.296	.023	.125 .215	.1406	S4FHH	.296	.031	.125 .222	.003	8 1/16	83	20
.0781	.2500														
.0937	.1875	.0625	S3332F	.234	.018	.120 .165	.0937	S3332FHH	.234	.031	.120 .168	.003	14 1/32	42	11
.0937	.1875														
.0937	.3125	.1094	S5F	.359	.023	.173 .271	.1406	S5FHH	.359	.031	.173 .283	.005	11 1/16	120	34
.1250	.2500	.0937	S418F	.296	.023	.166 .220	.1094	S418FHH	.296	.031	.166 .230	.003	15 1mm	69	21
.1250	.2500														
.1250	.3125	.1094	S518F	.359	.023	.173 .271	.1406	S518FHH	.359	.031	.173 .283	.003	11 1/16	120	34
.1250	.3750	.1094	S618F	.422	.023	.202 .298	.1406	S618FHH	.422	.031	.202 .324	.005	12 1/16	127	39
.1250	.3750	.1562	SR2F	.440	.030	.202 .298	.1562	SR2FHH	.440	.030	.202 .324	.012	12 1/16	127	39
.1250	.5000														
.1562	.3125	.1094	S5532F	.359	.023	.226 .285	.1250	S5532FHH	.359	.036	.226 .293	.003	16 3/64	96	32
.1575	.6299														
.1875	.3125	.1094	S5632F	.359	.023	.226 .285	.1250	S5632FHH	.359	.036	.226 .293	.003	16 3/64	96	32
.1875	.3750	.1250	S6316F	.422	.023	.236 .329	.1250	S6316FHH	.422	.031	.236 .343	.003	13 1/16	142	45
.1875	.5000	.1562	SR3F	.565	.042	.272 .415	.1960	SR3FHH	.565	.042	.272 .440	.012	11 3/32	244	74
.1969	.6299														
.2187	.3125														
.2362	.7480														
.2500	.3750	.1250	S614F	.422	.023	.290 .342	.1250	S614FHH	.422	.036	.290 .352	.003	25 1mm	92	41
.2500	.5000	.1250	S814F	.547	.023	.336 .429	.1875	S814FHH	.547	.045	.336 .443	.010	19 1/16	183	74
.2500	.5000														
.2500	.6250	.1960	SR4F	.690	.042	.366 .509	.1960	SR4FHH	.690	.042	.366 .535	.012	14 3/32	303	111
.2500	.7500														
.3125	.5000	.1562	S8516F	.547	.031	.362 .450	.1562	S8516FHH	.547	.031	.362 .461	.005	20 1/16	183	78
.3150	.8661														
.3750	.8750														

AVAILABILITY

Sizes listed above are normally available from stock in AISI 440C stainless steel material. Please check with MPB for latest availability information.



Shielded versions may be specified with single shield (use one H in bearing number).

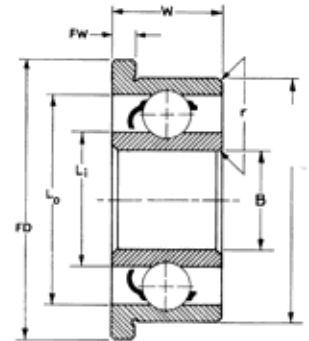
Note: This series is designed for predominantly radial load applications.

METRIC

ABEC 5P and 7P

Radial Retainer Flanged Open Bearings

Bore		O.D.		Width		Bearing Numbers		Flange Dia.	Flange Width	Land Dia.		Radius*	Ball Complement		Load Ratings (lbs.)		
B + .000 - .005mm		D + .000 - .005mm		W + .000 - .025mm				FD mm + .000 - .025	FW mm + .000 - .025	L₁ mm	L₂ mm	r mm	n number	d inch diameter	C Dynamic	R_s Static Radial	T_s Static Thrust
mm	in	mm	in	mm	in	Flanged Open Crown Retainer	Flanged Open Ribbon Retainer										
1	.0394	4	.1575	1.6	.0630	SEL1FC		5.00	0.50	1.96	3.10	.05	6	1/32	22	4	11
1.5	.0591	4	.1575	1.2	.0472												
1.5	.0591	5	.1969	2	.0787	SEL15FC		6.50	0.60	3.05	4.19	.08	7	1/32	26	5	15
1.5	.0591	5	.1969	2	.0787		SEL15FR●	6.50	0.60			.08	8	1/32	29	5	14
2	.0787	5	.1969	1.5	.0591	SUL20FC		6.10	0.50	3.05	4.19	.08	7	1/32	26	5	15
2	.0787	6	.2362	2.3	.0906	SEL2FC●		7.50	.060			.10	7	1/32	26	5	15
2	.0787	6	.2362	2.5	.0984												
2.5	.0984	6	.2362	1.8	.0709												
2.5	.0984	7	.2756	2.5	.0984												
3	.1181	7	.2756	2	.0787	SUL30FC		8.10	.050	4.14	5.64	.10	9	1mm	49	13	33
3	.1181	8	.3150	3	.1181												
3	.1181	10	.3937	4	.1575		SEL3FR●	11.50	1.00			.15	7	1/16	94	23	47
4	.1575	9	.3543	2.5	.0984	SUL40FC		10.30	0.60	5.13	7.57	.10	7	1/16	94	23	49
4	.1575	13	.5118	5	.1969												
4	.1575	16	.6299	5	.1969												
5	.1969	11	.4331	3	.1181	SUL50FC		12.50	0.80	6.71	9.30	.15	8	1/16	103	29	61
5	.1969	16	.6299	5	.1969												
5	.1969	16	.6299	5	.1969												
5	.1969	19	.7480	6	.2362												
6	.2362	13	.5118	3.5	.1378	SUL60FC		15.00	1.00	7.95	10.80	.15	8	5/64	155	46	87
6	.2362	15	.5906	5	.1969												
6	.2362	19	.7480	6	.2362												
6	.2362	19	.7480	6	.2362												
7	.2756	14	.5512	3.5	.1378	SUL70FC		16.00	1.00	8.53	10.90	.15	10	1/16	120	39	81
7	.2756	17	.6693	5	.1969												
7	.2756	19	.7480	6	.2362												
7	.2756	22	.8661	7	.2756												
8	.3150	19	.7480	6	.2362												
8	.3150	22	.8661	7	.2756												
8	.3150	22	.8661	7	.2756												
8	.3150	24	.9449	8	.3150												
9	.3543	20	.7874	6	.2362												
9	.3543	26	1.0236	8	.3150												



STANDARD SPECIFICATIONS

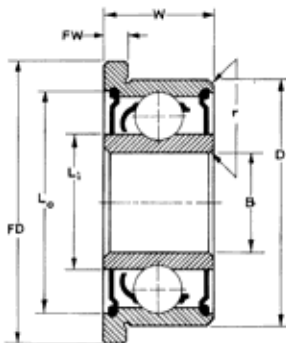
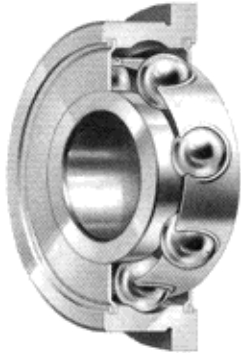
Tolerances—All precision standard radial retainer bearings are available in ABEC 5P (add suffix 5 to bearing number) or ABEC 7P (add suffix 7 to bearing number) tolerances. For information on ABEC tolerances see page 47.

Radial Play—.0002/.0008". Other ranges are available (see page 48).

Lubrication—MI L-L-6085A. Other lubricants are available (see page 52).

Packaging—Individual pill pack strips or vial pack.

Radial Retainer Flanged Shielded Bearings



Bore		O.D.		Width		Bearing Numbers		Flange Dia.	Flange Width	Lead Dia.	Radius*	Ball Complement		Load Ratings (lbs.)			
B	D	W						FD	FW	L ₁	L ₂	r	n	d	C	R _s	T _s
+ .030 - .005	+ .030 - .005	+ .000 - .025						mm + .000 - .025	mm + .000 - .025	mm	mm	mm	number	inch	Dynamic	Static Radial	Static Thrust
mm	In	mm	In	mm	In												
1	.0394	4	.1575														
1.5	.0591	4	.1575	2	.0787												
1.5	.0591	5	.1969	2.6	.1024	SEL15FCHH●		6.50	0.80			.08	7	1/32	26	5	15
1.5	.0591	5	.1969	2	.0787			6.50	0.80			.08	8	1/32	29	6	14
2	.0787	5	.1969	2.3	.0906	SUL20FCHH		6.10	0.60	2.67	4.39	.08	7	1/32	26	5	15
2	.0787	6	.2362	3	.1181	SEL2FCHH●		7.50	.080			.10	7	1/32	26	5	15
2	.0787	6	.2362	2.3	.0906												
2.5	.0984	6	.2362	2.6	.1024												
2.5	.0984	7	.2756	3.5	.1378												
3	.1181	7	.2756	3	.1181	SUL30FCHH		8.10	0.80	3.76	5.84	.10	9	1mm	49	13	33
3	.1181	8	.3150	4	.1575												
3	.1181	10	.3937	4	.1575			11.50	1.00			.15	7	1/16	94	23	47
4	.1575	9	.3543	4	.1575	SUL40FCHH		10.30	1.00	4.72	8.23	.10	7	1/16	94	23	49
4	.1575	13	.5118	5	.1969												
4	.1575	16	.6299	5	.1969												
5	.1969	11	.4331	5	.1969	SUL50FCHH		12.50	1.00	6.71	9.98	.15	8	1/16	103	29	61
5	.1969	16	.6299	5	.1969												
5	.1969	16	.6299	5	.1969												
5	.1969	19	.7480	6	.2362												
6	.2362	13	.5118	5	.1969	SUL60FCHH		15.00	1.10	7.70	11.30	.15	8	5/64	155	46	87
6	.2362	15	.5906	5	.1969												
6	.2362	19	.7480	6	.2362												
6	.2362	19	.7480	6	.2362												
7	.2756	14	.5512	5	.1969	SUL70FCHH		16.00	1.10	8.53	11.30	.15	10	1/16	120	39	81
7	.2756	17	.6693	5	.1969												
7	.2756	19	.7480	6	.2362												
7	.2756	22	.8661	7	.2756												
8	.3150	19	.7480	6	.2362												
8	.3150	22	.8661	7	.2756												
8	.3150	22	.8661	7	.2756												
8	.3150	24	.9449	8	.3150												
9	.3543	20	.7874	6	.2362												
9	.3543	26	1.0236	8	.3150												

AVAILABILITY

Sizes listed above are normally available from stock in AISI 440C stainless steel material. For SAE 52100 and items indicated with a ●, please check with MPB for latest availability information.

Shielded versions may be specified with single shield (use one H in bearing number.)

Special Products

A precision bearing product may be any component, sub-assembly, or assembly which can be produced utilizing the unique technological and problem-solving capabilities of MPB. Pages 30 to 41 depict a few of the many special products manufactured by MPB. We would welcome the opportunity to discuss your special requirements.

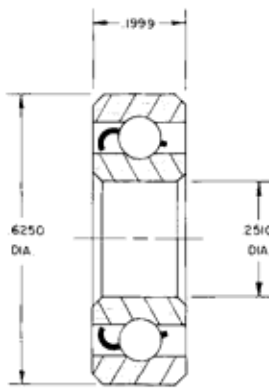


Figure 30-1—An AISI 316 stainless steel bearing used in highly corrosive environment processes.

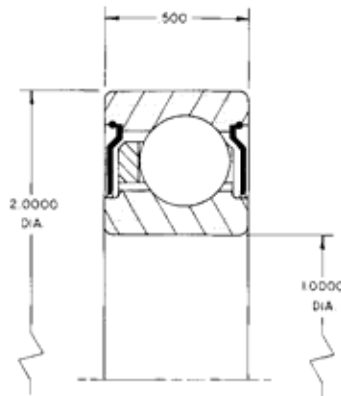


Figure 30-2—An inch series phenolic retainer bearing built to R16 dimensions.

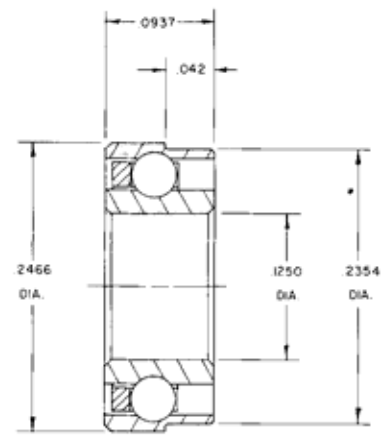


Figure 30-3—Special OD configuration high speed dental handpiece bearing. S418MC chassis.

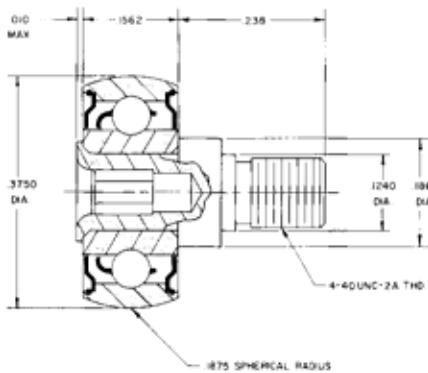


Figure 30-4—Spherical radius OD and threaded pin form this follower bearing. S618CHH chassis.

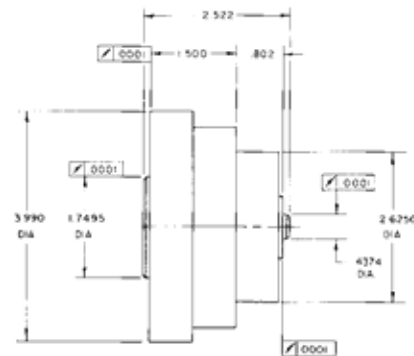


Figure 30-5—A video disk drive spindle assembly.

Gyro Spin Axis Bearings

Gyro spin axis bearings are designed and manufactured to provide long life at high speed under critical torque and stability requirements.

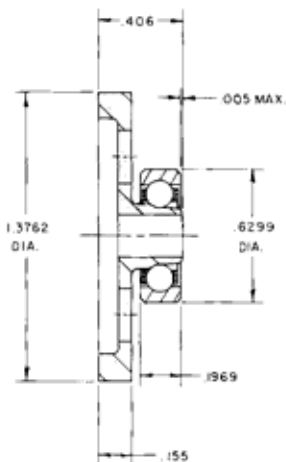


Figure 31-1—This bearing has an unusual inner race end bell design which helps to accurately locate the spinning mass while providing for inner ring rotation. Inner ring rotation avoids lubricant throwout at high speeds.

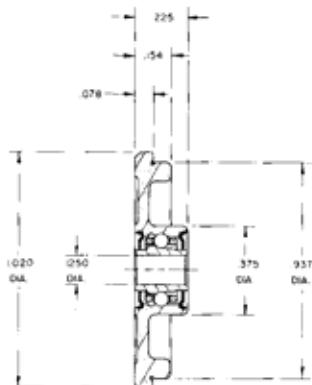


Figure 31-2—An end cap bearing with a rugged outer ring for heavier gyro wheel designs and for maximum rigidity.

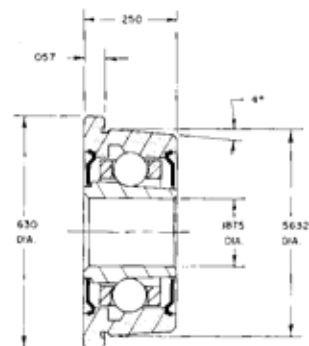


Figure 31-3—This bearing provides ease of assembly with the tapered OD. The extra width provides for shields and ample grease capacity.

Figure 31-4—This end cap bearing is typical of a large number of similar bearings used in small rate gyros. The end cap style outer ring forms the entire end bell of the motor. An oil-impregnated retainer, plus a controlled quantity of additional grease, are commonly specified.

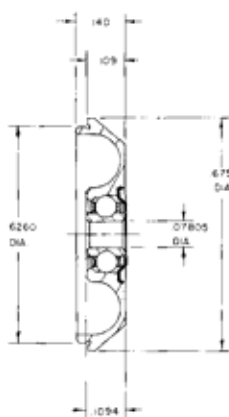


Figure 31-5—Called a gyro stop bearing, this bearing is used to support an air bearing gyro during shutdown and startup to prevent scuffing of air bearing surfaces. High speed and acceleration are its primary operating conditions.

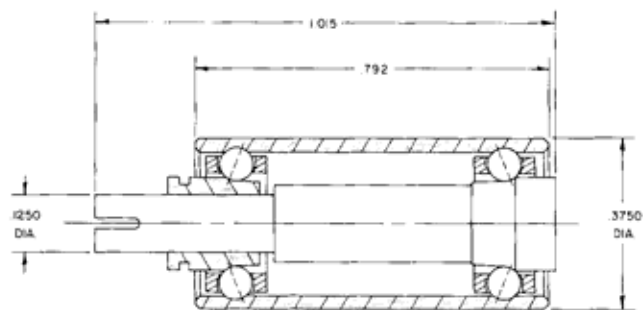
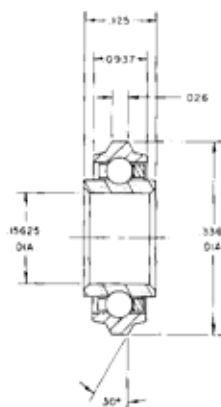


Figure 31-6—This integral cartridge-type bearing provides or preloading through the one moveable inner ring. The double row outer ring helps assure good alignment and concentricity. The raceway on the shaft insures adequate concentricity and geometry control for tuned gyro applications.

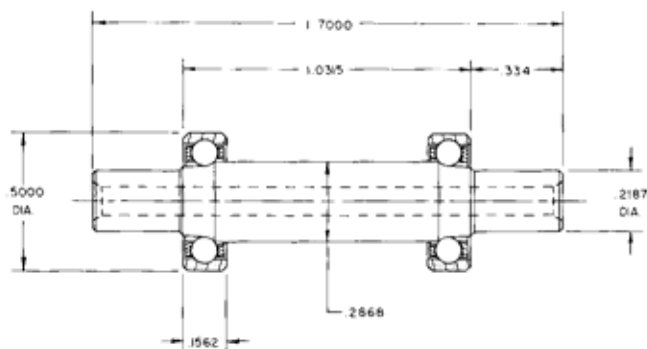


Figure 31-7—An integral raceway shaft characterizes this high precision gyro bearing. The integral approach helps reduce the tolerance buildup of discrete bearings.

Gimbal Bearings

Gyro gimbal bearings are designed and manufactured to provide minimum starting frictional torque with a minimum of free radial and end play.

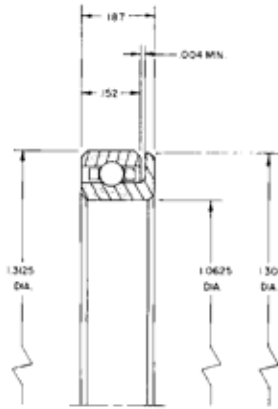


Figure 32-1—A thin section, toroid retainer, platform gimbal bearing with an external shield integral with the inner ring.

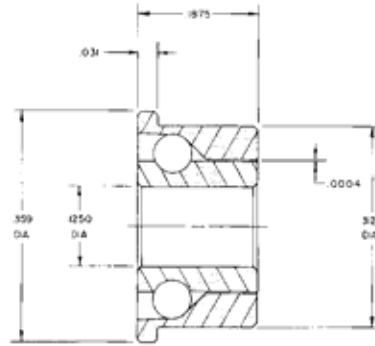


Figure 32-2—This unique, close-land clearance design provides bearing survivability under extremely high shock loads. The lands instantaneously "bottom out" under high G launch loads before the balls and races become overloaded.

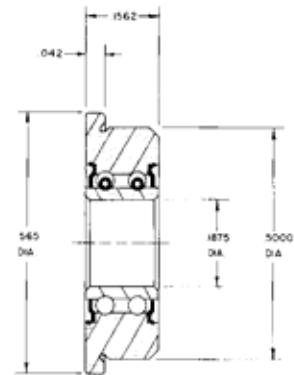


Figure 32-3—Double row, Teflon slug bearing with controlled end play for low starting torque and moment support.

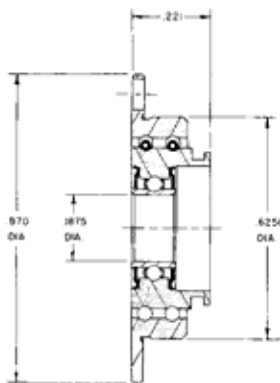


Figure 32-4—A typical "Piggyback" bearing with a motor driven, rotatable middle ring for reduction of inner ring starting torque.

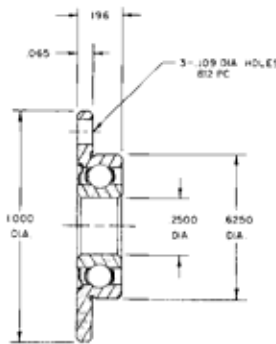


Figure 32-5—The large flange provides holes for bolt on mounting of this otherwise conventional low torque ribbon retainer gimbal bearing.

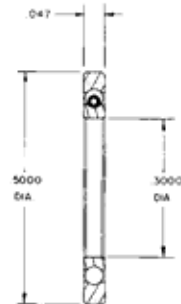


Figure 32-6—The extremely thin width made possible by use of Teflon slugs saves space and offers low torque.

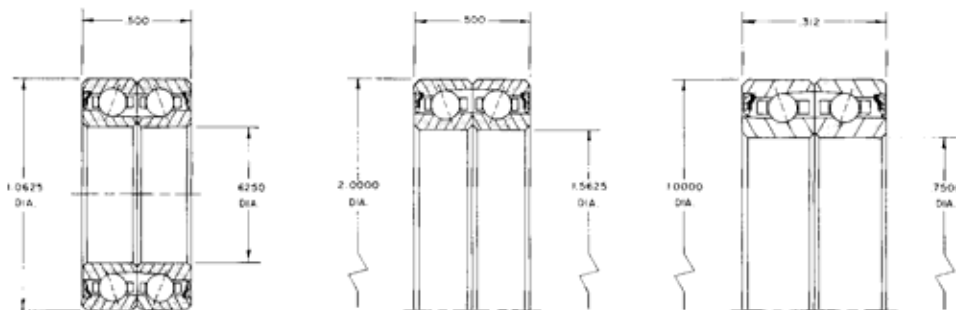


Figure 32-7, 32-8, 32-9—This group of preloaded pair, angular contact gimbal bearings is equipped with outboard shields.

Integral Duplex Bearings

A level of operating performance and compliance control not possible with discrete bearings, is achieved by integrating dual races in a single outer ring to produce integral duplex bearings.

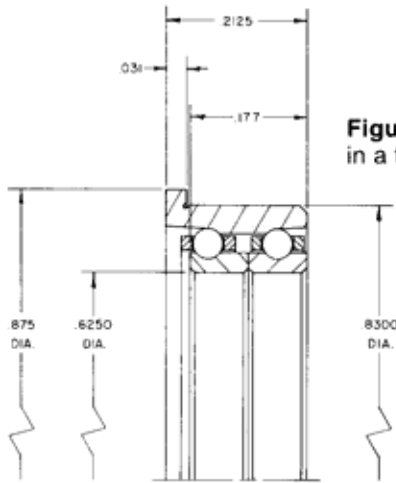


Figure 33-1—A gyro spin axis bearing in a tactical missile guidance system.

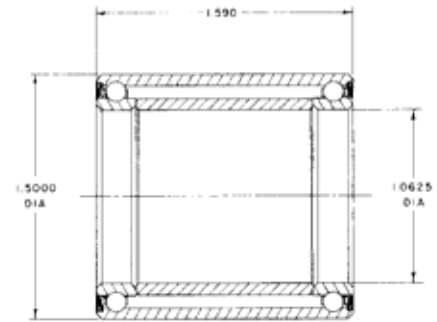


Figure 33-2—An articulated arm joint bearing used in precision laser surgery equipment.

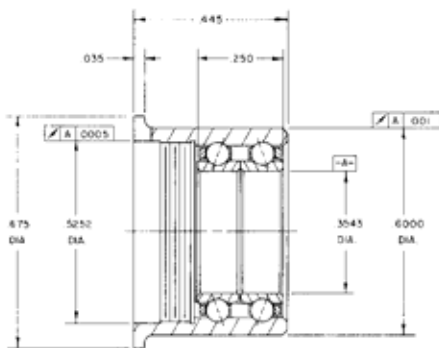


Figure 33-3—A gyro gimbal torquer motor bearing used in a tactical missile guidance system.

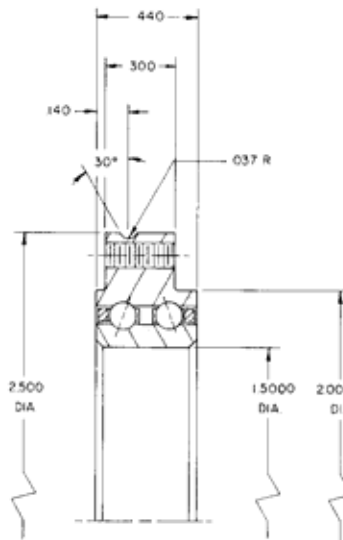


Figure 33-4—A support bearing for the optics in a laser scanning mechanism.

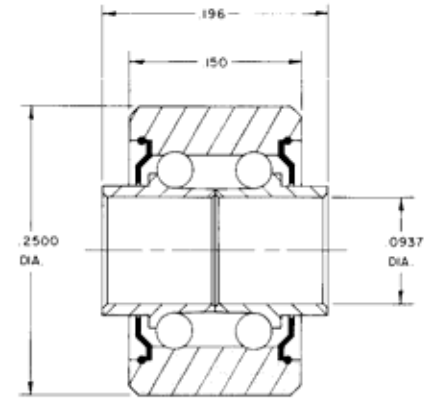


Figure 33-5—A precision double row full ball complement cam follower bearing.

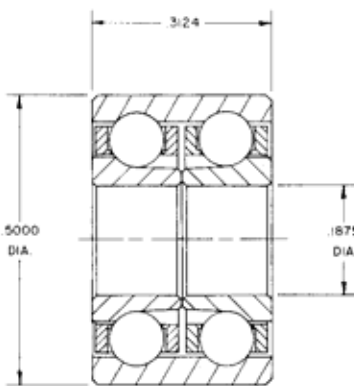


Figure 33-6—A high speed turbo molecular pump bearing used for hard vacuum work.

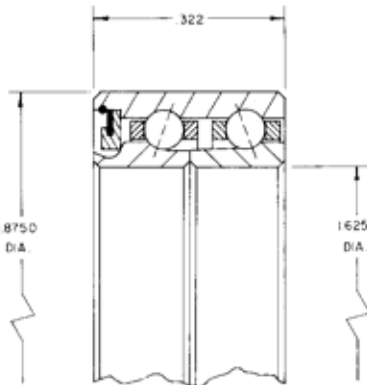


Figure 33-7—A single sealed airborne radar system bearing.

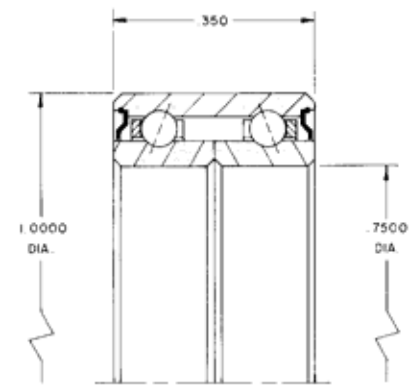


Figure 33-8—A gyro gimbal torquer motor bearing used in a tactical missile guidance system.

Carriage Bearings Guide Bearings

Close control of carriage bearing radial play and run-out results in accurate positional control of carriage and way assemblies. Smooth operation is assured by careful control of OD finish and roundness. Greater accuracy, stability and load capacity may be achieved by integrating components or incorporating the double row feature.

Guide bearings provide an economical alternative to machining and assembling individual components in applications such as wire guides, plotters, printers and cable or belt drive systems.

Carriage Bearings

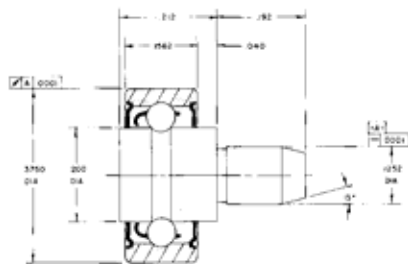


Figure 34-1—Integral pin design, SR2CHH chassis.

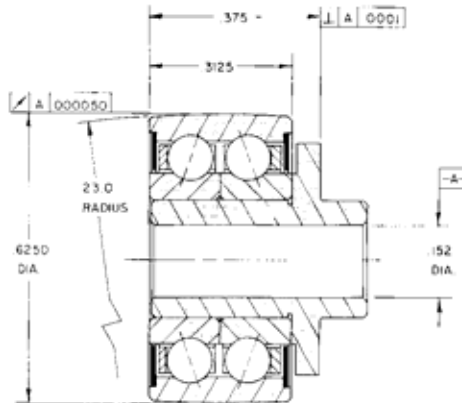


Figure 34-2—Double row, crowned OD, end play controlled carriage bearing assembly.

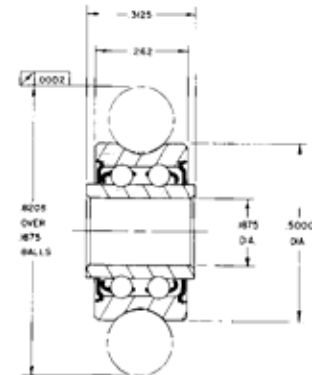


Figure 34-3—Double row, gothic outer groove construction with controlled end play.

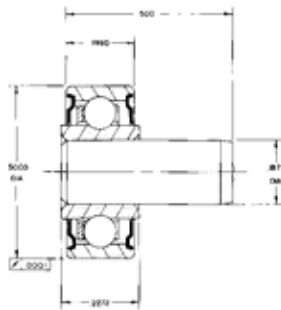


Figure 34-4—Discrete pin mounted in the bore of the bearing. SR3MCKHHE chassis.

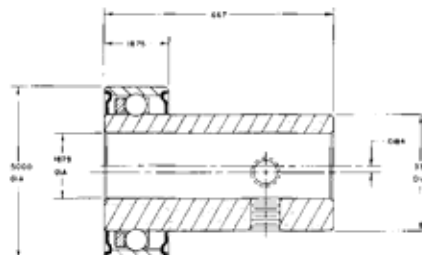


Figure 34-5—Integral pin design with built-in eccentric feature for radial position adjustability. S814MCKHH chassis.

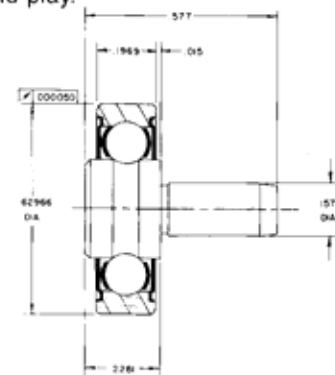


Figure 34-6—Integral pin design, S34RHH chassis with close radial runout control.

Guide Bearings

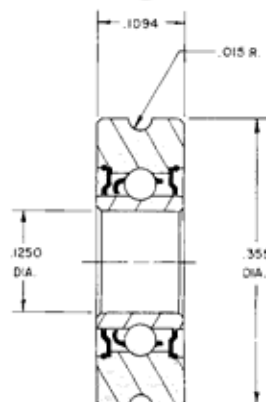


Figure 34-7—Wire guide bearing with a full radius groove integral with the M50 tool steel outer ring. S418CHH chassis.

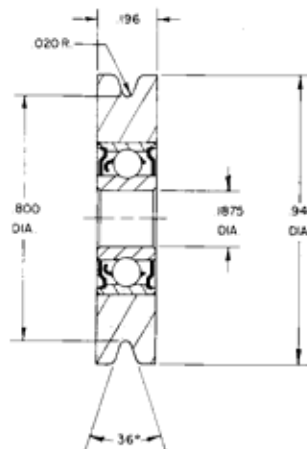


Figure 34-8—Wire guide bearing with a blended "V" groove in a discrete aluminum housing. SR3CHH chassis.

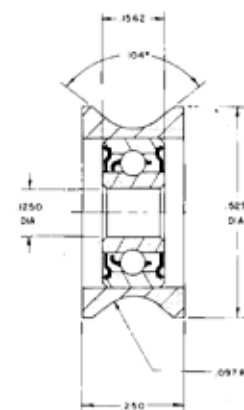


Figure 34-9—A radiused "V" groove, acetresin guide housing with an SR2CHH bearing.

High Temperature Bearings

High temperature applications present unique problems, many of which can be solved by selection of specially alloyed materials and designs which compensate for significant temperature variations.

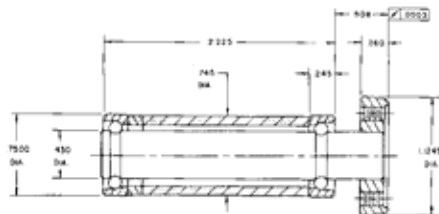


Figure 35-1—This bearing assembly supports the rotating anode in an x-ray generating vacuum tube. To meet the severe operating conditions of 10^{-8} TORR vacuum, 400° - 500° C and 10,000 RPM, super high speed steel alloys are required for bearing rings and balls. The integral shaft raceway design offers cost and performance advantages.

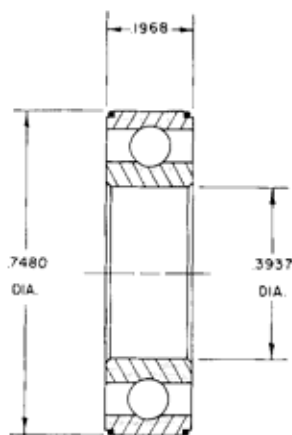


Figure 35-2—This fractured outer ring, full complement bearing is used in a magnetron application which is a radio frequency generator for an airborne radar unit. The high speed, high temperature and high vacuum requires super high speed alloy steels similar to x-ray tube bearings.



Figure 35-3—A discrete bearing version of an x-ray tube bearing similar to the F730 requirements. The spacers are preselected to control the axial play of the assembly.

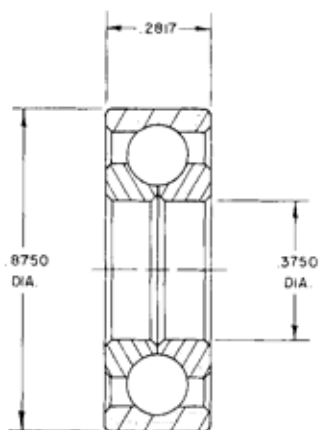


Figure 35-4—A two-piece, Gothic arch inner raceway design. This x-ray tube bearing employs the Gothic design to control the axial play of the assembly.

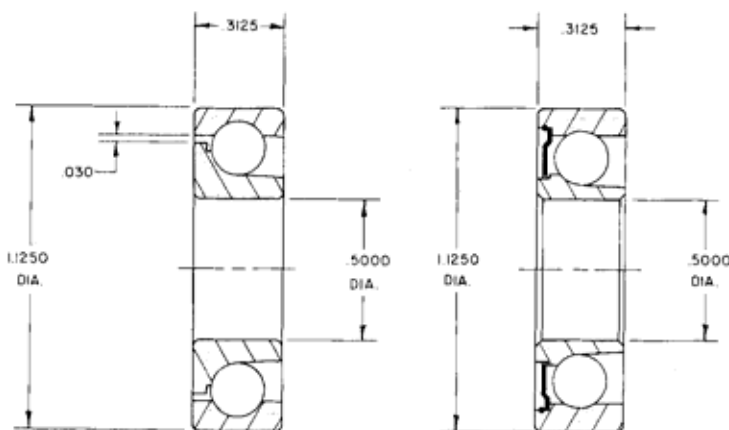


Figure 35-5, 35-6—These bearings are used in actuator motors which are driven by bleed air from gas turbine engines. Temperatures are typically 500° C coupled with high speed rotation.

Tape Control Assemblies

Precise control of tape speed and position in voice and data recording devices is featured in this specially designed series of assemblies.

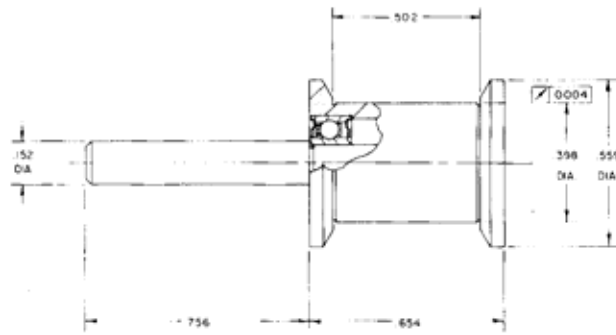


Figure 36-1—Computer tape drive flanged tape tension idler.

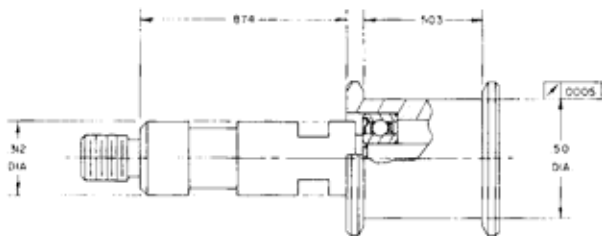


Figure 36-2—Computer tape drive guide roller.

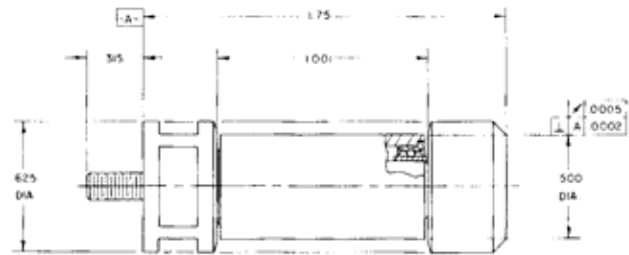


Figure 36-3—Naval audio recording system, stationary-flange tape guide.

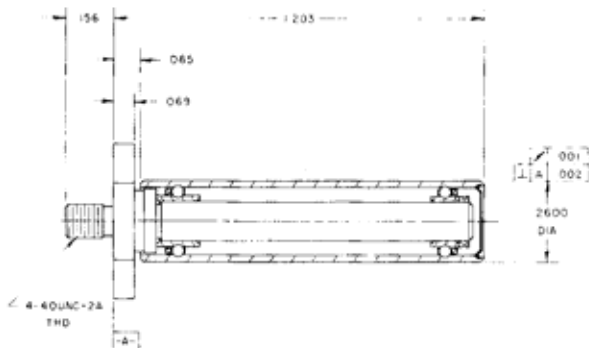


Figure 36-4—Computer tape drive tension idler.

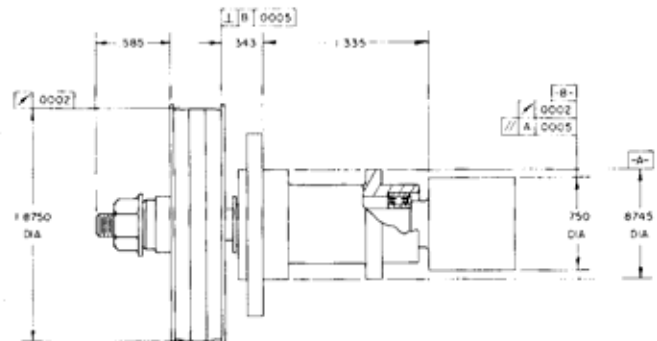


Figure 36-5—Aircraft flight recorder tape drive capstan.

Integral Assemblies

Integral assemblies offer the ultimate in stiffness and runout control, by reducing the number of components involved. This type of design often results in reduced costs at subsequent assembly operations.

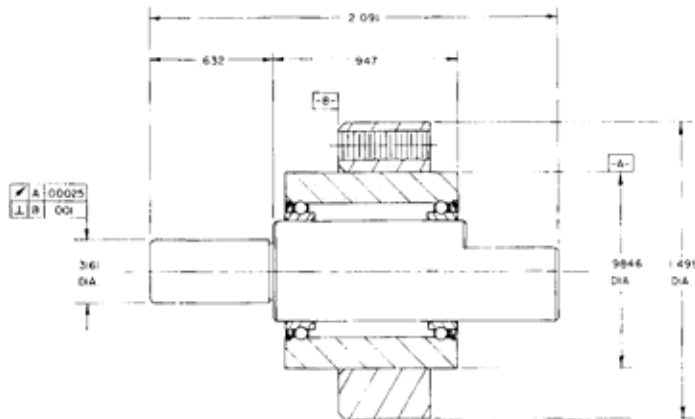


Figure 37-1—Rotary arm actuator pivot assembly used in a computer memory disk drive.

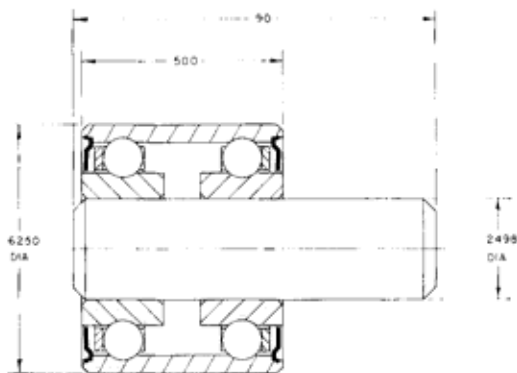


Figure 37-2—Integral idler assembly.

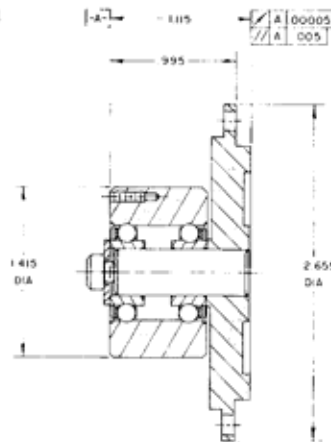


Figure 37-3—Support spindle for the rotating optics in a laser transit device.

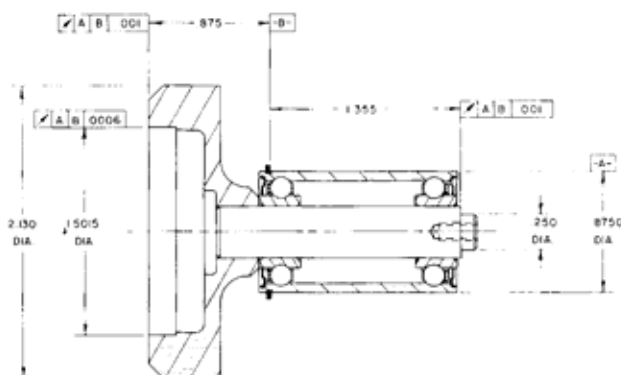


Figure 37-4—Cartridge-type spindle used in double-sided, double-density floppy disk drive.

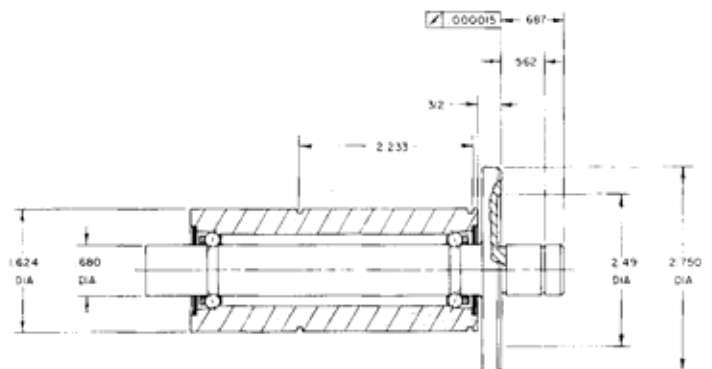


Figure 37-5—A precision high speed spindle for use in computer memory disk drive or laser scanner applications.

Gyro Optics Assemblies

Extensive experience working with metallic and non-metallic materials are combined with precision grinding, machining and assembly skills to produce Gyro Optics assemblies, sub-assemblies and components. These optical/mechanical assemblies are routinely built with gimbal axis and spin axis intersection tolerances of less than .0002 inches. Basic precision bearing technology is applied to select and match bearings to each other and the mating hardware.

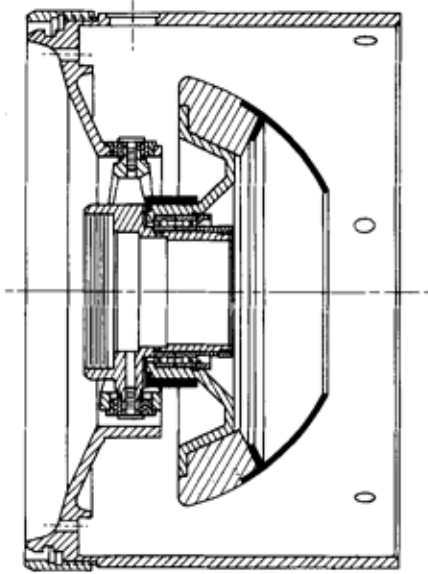


Figure 38-1—Gyro, Gimbal Assembly

This unit provides stabilization and look angle for a videotype detector on a "fire and forget" anti-armor missile. Large free gyro ID allows space for mounting of video detector/ optics.

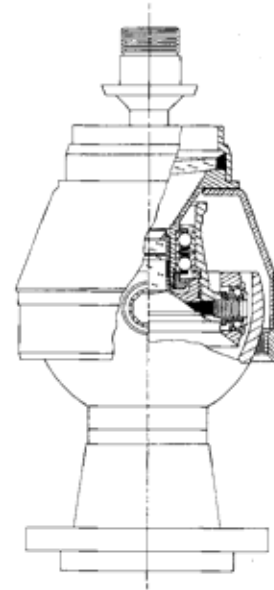


Figure 38-2—Infrared Gyro Optics Sub-Assembly

This unit integrates gimbal, gyro, and Cassegrain optics for a heat-seeking missile application.

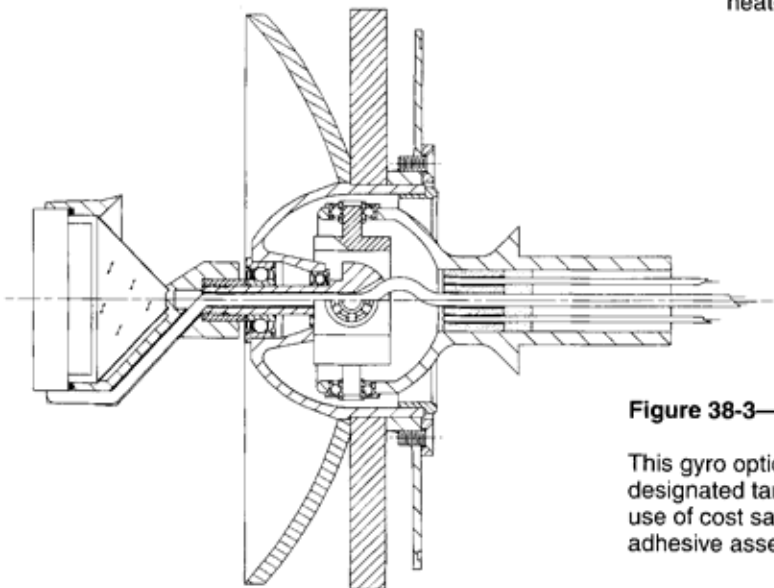
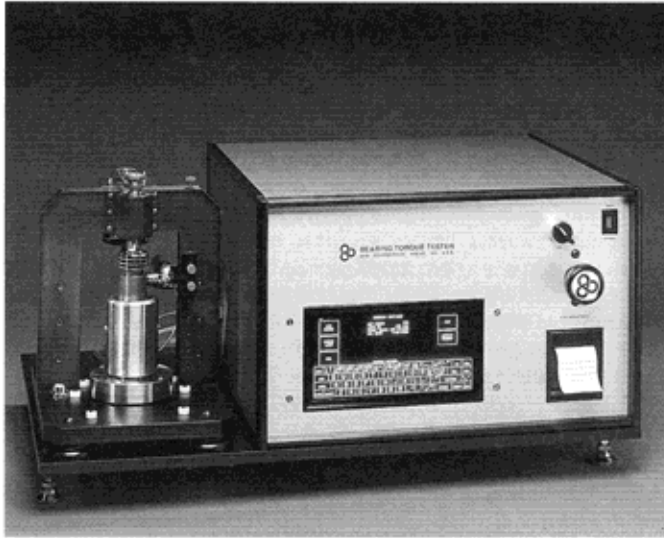


Figure 38-3—Laser Seeker Gyro Assembly

This gyro optics package for a missile that homes on a laser designated target is an integrated unit that makes extensive use of cost saving concepts such as molded components and adhesive assembly techniques.

MPB Bearing Test Equipment



RT2C Running Torque Tester

INTRODUCTION

The RT2C running torque tester is a diagnostic instrument used to measure the running torque values of miniature and instrument ball bearings. Through the interpretation of running torque data, the user of the RT2C is able to identify many common bearing problems such as retainer hangup, ball or race surface problems, contamination, problems with internal geometry or other structural defects. Almost any problem affecting the performance of a bearing can be identified through analysis of the RT2C torque data output. Torque data may be used to assess the quality of a single bearing, or using sampling methods, the quality of a group of bearings. The RT2C may also be used to analyze a bearing's quality prior to its use, or to provide post service analysis of a bearing failure.

The RT2C meets or exceeds the guidelines established by MIL-STD-206, the most comprehensive running torque specification in the industry.

RT2C OPERATION

The RT2C is easy to operate, with training usually accomplished in an hour or less. Micro-processor based CRT commands lead the operator through most gage functions, including the calibration, setup, and test procedures. The average cycle time is under (2) two minutes. The system features validity checking of operator key inputs, rejecting incorrect entries. Typical inputs require only a few key punches. The typical operations sequence is outlined in the sample CRT instruction screen to the right.

RT2C DESIGN

The RT2C has standard tooling to accept 26 industry standard Miniature and Instrument bearing sizes from $\frac{1}{8}$ " OD to $\frac{7}{8}$ " OD. Torque tests are completed at the low rotational speed of 2 RPM and usually under axial loads of either 75 or 400 grams, which are accepted standards.



ST2 Starting Torque Tester

INTRODUCTION

The ST2 Starting Torque Tester is a GO/NO GO diagnostic gaging system used to determine if the starting torque of a given miniature or instrument bearing is within the maximum torque level established by the operator. Starting or "breakaway" torque is often a critical consideration for bearings used in sensitive instrumentation. The ST2 provides an easy means of identifying starting torque problems in single bearings or using sampling methods, in groups of bearings, prior to their use in your applications.

The ST2 meets or exceeds the guidelines established by MIL-STD-206, the most comprehensive starting torque specifications in the industry. Micro-processor based, the ST2 automatically performs bearing torque measurement, analysis and test cycle sequencing.

ST2 DESIGN

The Universal tooling concept developed for the RT2C was adapted for the ST2. Twenty-six miniature and instrument bearing sizes in a range from $\frac{1}{8}$ " OD to $\frac{7}{8}$ " OD may be tested on the ST2. Optional tooling will accept bearing sizes up to 1.250" O.D.

Tests are performed under standard axial loads of either 75 grams or 400 grams with maximum measurable torque beyond the requirements anticipated for most miniature and instrument bearing sizes.

INFORMATION

For more details about the operation or availability of the ST2 starting torque tester or the RT2C running torque tester, please contact MPB Corporation, Keene, N.H.

MPB Bearing Lubricants



Minapure™ Grease is supplied in 100 gram tubes or (1) one pound glass jars. Minapure Oil is available in 1 oz., 4 oz. and 16 oz. containers.

Minapure™ Grease was first introduced by MPB in 1960 after an extended development period. Its introduction was in response to an industry need for a pure, ultra-clean grease, suitable for use in miniature and instrument bearings and related components.

Originally qualified under MIL-G-3278 and MIL-G-15793, Minapure™ Grease is QPL approved by MIL-G-81937. It is a Lithium soap thickened diester oil.

Upgraded continually over the years, Minapure™ exceeds the requirements of MIL-G-81937 for purity and performance. It has virtually no particulate contamination. Cleanliness is assured by blending contamination-free base materials to form a grease of consistently high purity and quality. This process sets Minapure™ above other commercially available greases. The manufacture and packaging are carefully controlled by technicians used to working in a white room environment and sensitive to the need to supply ultra-clean bearing products.

Oxidation stability of Minapure™ is excellent, with outstanding evaporation, separation and water resistance characteristics. Operating temperature range is -65°F to +250°F.

Minapure™ Grease is clean-room packaged in sterile 100 gram polyethylene tubes or in (1) one pound glass jars. This type of packaging eliminates cracking or chipping and minimizes waste.

Minapure™ may be applied by syringe (20-22 gauge needle) or other suitable metering device, depending on the quantity tolerance required.

For most applications, a quantity of one third to one half of the free void space within the bearing is satisfactory. For more torque-sensitive applications, more specific weight limitations may be required. When grease weight becomes very small it is sometimes advantageous to employ a grease plating or grease filming process. This involves applying a grease solvent mixture to the bearing and evaporating the solvent. MPB engineers can help establish the greasing method most applicable to the requirements.

To assure contamination-free use, it is recommended that the clean-packed tubes be used under clean room conditions, opened only as needed, and kept tightly sealed when not in use. Minapure™ should be stored in a dark area at room temperature. Do not exceed 120°F.

TYPICAL PROPERTIES OF MINAPURE™ GREASE COMPARED WITH MIL-G-81937		
TEST	MINAPURE™ TYPICAL VALUES	MIL-G-81937 SPECIFICATION
Grease Properties		
Color	Light Tan	—
Texture	Smooth	—
Specific Gravity @ 60°F	0.95	—
Dropping Point (ASTM D2265)	377°F	350°F Min
Penetration (ASTM D217)		
Unworked	229	200 Min
Worked—60 Strokes	278	265 to 300
Worked—100,000 Strokes	371	375 Max
Bomb Oxidation (ASTM D942)		
100 Hours	0 Psi	3 Psi Max
500 Hours	3 Psi	10 Psi Max
Evaporation (ASTM D972)		
22 Hours at 250°F	0.21%	2.5% Max
Oil Separation (FSTM 791-321)		
30 Hours at 250°F	2.5% (24 hours)	5% Max
Water Resistance (ASTM D1264)		
Test Temperature 105°F	8.7%	20% Max
Particulate Contamination		
10 Microns or Larger	0	1000 Maximum
35 Microns or Larger	0	0
BASE OIL PROPERTIES		
Pour Point (ASTM D92)	-80°F	
Flash Point (ASTM D97)	+420°F	
Viscosity (ASTM D88)		
@ 210°F	3.3 cs	
@ 100°F	12.7 cs	
@ -65°F	8100 cs	

The information contained herein is believed to be accurate, but all recommendations, stated or implied are made without guarantee.

Other lubricants available on request from factory.

Minapure Special Precision Bearing Lubricating Oils are synthetic-hydrocarbon-based, developed to assure manufacturers and users of instrument bearings of a long term availability for specialized oils qualified for immediate use in instrument bearings.

Three viscosity oils are available for a choice of optimum EHD film over a wide temperature range. Low volatility and oxidation stability enhance Minapure's properties in "lubed-for-life" bearings. An anti-wear additive is featured for longer bearing life. Minapure™ oils are ultra-clean and designed for clean room environments.

Viscosity and EHD Film:

Elastohydrodynamic (EHD) lubrication theory has been shown in recent years to apply to ball bearing operation. Applications of EHD theory to a specific set of bearing operating conditions result in a determination of optimum lubricant viscosity; i.e., for known speeds, loads, and configuration one may calculate the lubricant viscosity necessary to provide complete film separation of balls and races at operating temperature.

MPB Corporation's Minapure™ lubricant family allows a choice of viscosity to result in optimum EHD film.

Viscosity Index and Temperature:

Instrument bearing applications often must function over a wide temperature range. Lubricants limit bearing performance by increasing viscous drag at low temperatures and limit bearing life as they thin out at high temperatures. Viscosity Index (VI) is a relative measure of the rate of viscosity change with temperature. Higher VI indicates a preferred lower rate of viscosity change.

Minapure™ lubricants have high VI's in comparison to petroleum products: (e.g., KG-8U oil, a well-known gyro bearing lubricant has a VI of 100 compared to the MO119 VI value of 128).

Stability and Bearing Life:

Instrument ball bearings are typically lubricated by their manufacturer, with a "one-shot lubrication" providing for their entire service life.

Oxidation products formed during the bearing's service can significantly deter smooth rotation and cause failure.

Evaporative losses over a period of time deplete the available quantity of lubricant as well, affecting viscosity changes ultimately causing failure.

Both oxidation and evaporation rates are accelerated by the high surface area to bulk mass ratios afforded by typical instrument bearing application.

The low volatility synthesized hydrocarbon base oils have their already superior oxidation stability enhanced by the addition of a low volatility oxidation inhibitor.

MPB Corporation's Minapure™ lubricants are compounded for maximum property retention over long time periods in "lubed-for-life" instrument bearing applications.

Anti-Wear Additive:

Tricresyl Phosphate (TCP) has for years been associated with bearing lubrication as an inhibitor of surface wear under oil starved or boundary lubrication conditions.

In gyro spin axis bearing applications, TCP's use in metal pretreatment and as a lubricant additive has resulted in enhanced performance and longer bearing life.

MPB Corporation's Minapure™ lubricants contain a controlled amount of Tricresyl Phosphate (TCP).

Cleanness:

The presence of particulate contamination in lubricants is of particular concern to instrument bearing users. The extremely small ball-race contacts coupled with the need for low frictional torques and long life make instrument bearing application susceptible to contamination levels considered normal in industrial lubricants. Although oil may be filtered to acceptable levels, the filtration process becomes time consuming with the higher viscosity fluids.

MPB Corporation's Minapure™ lubricants are supplied with particulate contaminant levels suitably low for immediate use in instrument ball bearings.

MINAPURE OILS™ TYPICAL PHYSICAL PROPERTIES

	MO18	MO75	MO119
Viscosity:			
@ 100°F (CS)	18.5	75.0	119.0
@ 210°F (CS)	3.7	10.9	15.4
@ 210°F (SUS)	36	63	80
Viscosity Index:	91	130	128
Flash Point (°F)	430	480	485
Pour Point (°F)	-75	-65	-55
Trace Sediment (% Vol)	—	—	Less Than 0.001
Wettability (MIL-L-0083176A)			
	OK	OK	OK
Oxidation Stability: Loss of Weight of Metals			
Steel (mg/cm ²)	0.00	0.00	0.00
Copper (mg/cm ²)	-0.001	-0.01	-0.01
Oxidation Resistance:			
Change in Viscosity (%)	-0.5	-0.5	+2.7
Change in Neutralization number (mg KOH/g)	-0.01	0.00	-0.01
Evaporation Loss:			
48 hrs. @ 300°F (%)	0.1	0.3	0.7
Cleanness:	Product is filtered thru 0.45 micron filter		

The information contained herein is believed to be accurate, but all recommendations, stated or implied, are made without guarantee.

Materials

SPECIFICATIONS

MPB's extensive experience in the development and manufacture of ball bearings and bearing assemblies has led to a system of detailed material specifications. These specifications are continuously reviewed and updated as new applications place increasing demands on bearing components and as new materials manufacturing techniques allow improved quality standards. In addition, MPB works closely with materials suppliers to develop new materials which improve bearing capabilities. Only the cleanest and most uniform materials are used. Our requirements include chemical analysis, micro-cleanliness, micro-structure, carbide distribution, grain size, and hardenability. These specifications generally exceed industry, government, and customer specifications. Such quality results in improved surface finish, dimensional stability, resistance to rolling contact fatigue, dimensional tolerance control, and operating characteristics.

QUALITY CONTROL

Each lot of material is inspected by MPB inspectors for conformance to the engineering specifications before it is accepted for use. Furthermore bearing rings and balls are inspected during the manufacturing process for hardness, dimensional stability, and where applicable, corrosion resistance.

RING AND BALL MATERIALS

440C Stainless Steel remains the predominant alloy for standard instrument bearing rings and balls. It is a high carbon, 18% chromium steel which provides both the high hardness needed for bearing applications and corrosion resistance. With the standard heat treatment, bearings of 440C have a minimum hardness of Rockwell C 58 and can be operated at temperatures of 350°F. With special heat treatment, operating temperatures of 500°F may be tolerated.

MPB uses primarily consumable electrode vacuum arc remelted 440C made to the strictest limits of cleanliness and uniformity of structure. These requirements, especially of micro-cleanliness and carbide structure, have resulted in improved raceway finishes and, hence, improved bearing performance. MPB 440C bearings are identified with an "S" prefix in the part number.

52100 high carbon, 1½% chromium steel is used for a variety of bearing applications such as gyroscope spin-axis bearings which operate in inert environment, making corrosion resistance a minor consideration. It has a slightly higher minimum hardness than 440C at Rockwell C 60 and

greater wear resistance. It is sometimes chosen in instrument bearing applications because of its extraordinarily uniform micro-structure. The standard heat treatment will be suitable for service at temperatures as high as 350°F. Special heat treatments are available which provide higher rockwell hardness or extraordinary stability.

The 52100 used at MPB is primarily made by double vacuum melting (vacuum induction melting followed by consumable electrode vacuum arc remelting) to provide material of the highest micro-cleanliness and carbide structure standards. MPB bearings made of 52100 steel are identified with a "C" prefix in the part number.

M-50 High Speed Steel contains 4½% molybdenum, 4% chromium, and 1% vanadium. This material has proven particularly suited to main shaft bearings in gas turbine engines, however, it solves many other application problems as well.

It has better wear resistance than 52100 and 440C as well as operating temperature capabilities as high as 600°F. All M-50 used at MPB is made by the double vacuum melting process (vacuum induction melting plus consumable electrode vacuum arc remelting) to achieve to highest degree of cleanliness and uniformity of structure.

Beryllium Copper is a precipitation hardening alloy of 2% beryllium in copper. This material is frequently specified where non-magnetic properties and electrical conductivity are critical. Since the hardness is well below that of other bearing materials, bearings made of this material are load rated at lower values. Beryllium copper bearings are identified with an "N" in the prefix of the bearings part number. (Consult factory for availability.)

Super High Speed Tool Steels, highly alloyed steels with high hardness (Rockwell C 64 minimum), excellent wear resistance, and superior hot hardness, are used for severe service applications. This family of steels can be used at temperatures of 1000°F.

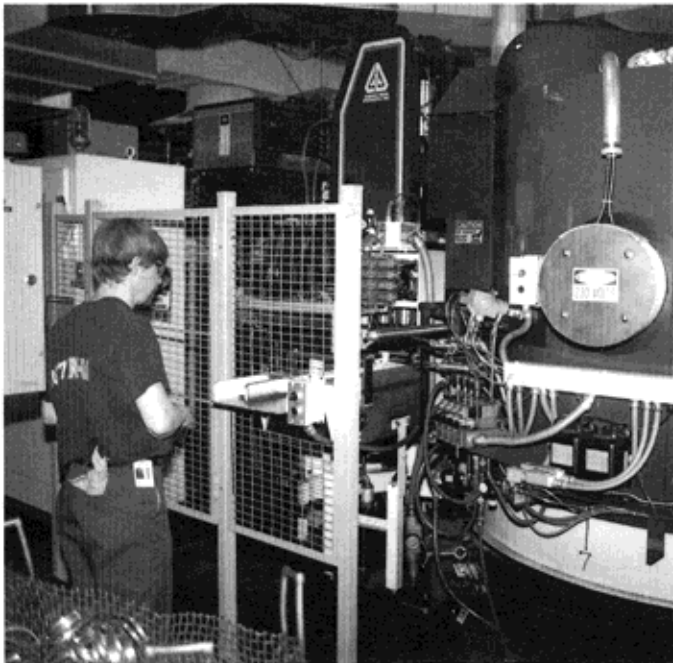
Other Materials. MPB is continually investigating new materials to solve special bearing problems. Our laboratory facilities enable us to do extensive metallurgical evaluations and allow us to simulate many actual applications for bearing performance tests. Although some of the testing is performed to determine characteristics of new or differently processed materials, a substantial portion of testing is directed toward solving specific applications problems. For example, some materials may be tested for high temperature applications where hot hardness is a problem, while others are investigated to improve torque or noise characteristics.

HEAT TREATMENT

MPB maintains a highly sophisticated heat treat department with special capabilities suitable to our product. Heat treating specifications are closely correlated with material specifications and end-use requirements.

In many cases a unique heat treatment is developed for a particular customer need. Special heat treating techniques involving low temperature tempering and sub zero treatment have been developed at MPB for both 440C and 52100 steels.

These proprietary techniques produce maximum hardness and stability, and in the case of 440C, maintain maximum corrosion resistance.



MPB's modern vacuum furnaces allow us to meet the strictest heat treating requirements of a wide variety of materials.

RETAINER, SHIELD & SEAL MATERIALS

One-piece, pressed steel retainers (type C) are made of AISI 410 stainless steel, heat treated to provide optimum resistance to distortion. Beryllium copper is used for C-type retainers in nonmagnetic bearings.

Two-piece ribbon retainers (type R) are made of AISI 430 or AISI 300 series stainless steel. Hardening is unnecessary due to design and assembly methods.

One-piece Minapar II retainers (type MCK) are molded plastic snap-type retainers. They have torque characteristics comparable to metallic retainers with lower noise and vibration levels, and the high speed performance characteristics of non-metallic retainers.

Standard retainers for angular contact and high speed bearings (M, MB, and MC types) are made of wound cotton or paper base phenolic laminates.

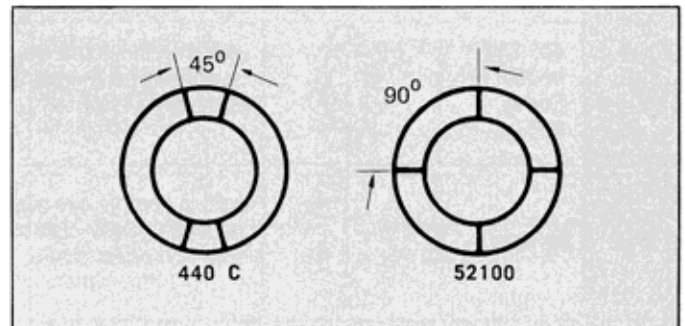
Certain high speed applications where retainer porosity is not required use machined or precision molded retainers of acetal resins. Other special machined retainer materials include glass-filled fluoro-polymers, porous polyimides, and poly amide-imides, for special applications or severe environments such as high radiation levels or cryogenic temperatures.

Shields and shield retaining wires are made of AISI 300 series stainless steel for maximum corrosion resistance. In nonmagnetic bearings, beryllium copper is used.

Standard miniature bearings have seals made of fluoro-polymer impregnated glass cloth, combining high abrasion resistance with resistance to oils, greases and solvents. Standard thin section bearings have Buna N molded rubber seals which can be used to 225°F. Viton is specified for higher temperature applications to 400°F.

RING MARKING

Certain radial lines on one bearing face indicate that the bearing was made by MPB, and identifies the material. These identifying marks are shown below.



Retainers

The ball retainer or ball cage is the element of a ball bearing assembly functioning to separate the balls and maintain their symmetrical radial spacing. Its rubbing contact, inherent in this function, produces frictional forces adding to the overall friction torque of the bearing assembly. Variations of retainer material and configuration have been developed to "trade-off" these two diverging design characteristics in relation to specific bearing application requirements. Other functions performed by a ball retainer include its use as a lubricant reservoir for fluid lubricants or sacrificial solid lubricants and as a means of maintaining outer race assembly of separable, angular contact bearings.

Proper selection of retainer design is essential to successful application of instrument bearings. For this purpose, tabulation of bearing size and configuration data has been grouped around retainer type. Certain retainer designs are limited by bearing size and configuration as some types are suitable only for miniature sizes while others are best utilized in the larger thin section bearings. If a




retainer type is not listed in the appropriate table, MPB Sales Engineering should be contacted for availability.









Many of the retainers shown can be made from a variety of special materials which can be fabricated on a special basis for specific application needs. Some of these materials are bronze, silver-plated steel, aluminum, polyimide plastics, etc.

Ribbon retainers may be coated with PTFE, providing self-lubrication in their contact with ball and ring surfaces. Although compatible with most oils and greases, the PTFE coated retainer is designed for lightly loaded, low speed use where conventional lubricants cannot be used. These include applications such as units functioning in a vacuum and bearings operating in close proximity to optics, as well as special requirements for long term shelf life capability.

The following table describes some of the more widely used MPB retainer designs and their application and limitations.

MPB RETAINER OPTIONS

Bearing Type Code	Material	Design	Description	Useful Features	Limitation
C	410 SST Hardened		Balls in deep groove bearing separated by a one-piece snap-in pressed steel retainer.	Low frictional torque at speeds up to 10,000 RPM.	Not to be used under high acceleration.
R	430 SST or 300 Series SST		Balls in deep groove bearing separated by a two-piece, pressed steel retainer.	Low breakaway friction at speeds to 10,000 RPM.	High speeds may result in excessive wear.
MCK	Minapar II		Balls in deep groove bearing separated by a one-piece snap-in molded retainer.	Low friction torque, speeds to 200,000 RPM. Low wear rate.	Ambient temperature to 275°F.

Bearing Type Code	Material	Design	Description	Useful Features	Limitation
M	Phenolic Laminate		Angular contact, outer race relieved, non-separable bearing with one-piece machined retainer.	Can be vacuum impregnated with oil for long life. Assembly has maximum ball complement. Operates at speeds to 400,000 RPM.	Ambient temperature to 275°F. Unidirectional thrust load.
MB	Phenolic Laminate		Angular contact, inner race relieved, separable bearing with one-piece, step-pocketed machined retainer.	Retains balls in outer race allowing removal of inner race. Can be vacuum impregnated. Speeds to 200,000 RPM.	Ambient temperature to 275°F. Unidirectional thrust load.
MC	Phenolic Laminate		Balls in deep groove bearing separated by a one-piece snap-in machined retainer.	Can be vacuum impregnated with oil. Speeds to 200,000 RPM. Accepts thrust loads in both directions.	Ambient temperature to 275°F.
MCJ	Glass Reinforced Teflon with MOS₂		Balls in deep groove. Bearing separated by a one-piece snap-in machined retainer.	Self lubricated. Compatible with high vacuum and cryogenic environments. Temperature to 550°F.	Long life is dependent on low speeds and light loads.
MCP	Minapore Meldin 8100 Porous Polyimide		Balls in deep groove. Bearing separated by a one-piece snap-in machined retainer.	High oil retention when vacuum impregnated (8% by weight.) speeds up to 200,000 RPM.	Temperature range -400°F to 600°F
MCX	Bronze Reinforced Teflon		Balls in deep groove. Bearing separated by a one-piece snap-in machined retainer.	Self lubricated. Compatible with high vacuum and cryogenic environments. Temperature to 550°F.	Long life is dependent on low speeds and light loads.
MP	Minapore Meldin 8100 Porous Polyimide		Angular contact outer race relieved "non-separable bearing," with one piece machined retainer.	High oil retention when vacuum impregnated (8% by weight.) speeds up to 200,000 RPM.	Temperature range -400°F to 600°F
—	Full Ball Complement		Bearing has full ball complement utilizing filling notch construction. No ball separation.	High radial load capacity and radial stiffness available in fractured design.	Little thrust load capacity. High torque due to ball rubbing.

Shields and Seals

SHIELDS

MPB Miniature size bearings use precision stainless steel stampings held to the outer ring by snap wires. These shields are accurately positioned in the outer ring to maintain a close clearance with the OD of the inner ring. The snap wires are precision formed to minimize distortion of the outer ring, while at the same time retaining the shield in the outer ring under external vibration and shock loads. (See Figure 1)

MPB Thin Section bearings incorporate a stainless steel insert which has a rubber bonded to it. The shield is held securely in place by the compression of the rubber around the OD of the insert while the bore of the shield is precision trimmed to provide a close clearance with the OD of the inner ring. (See Figure 2)

Both of these shield designs provide contamination protection with a minimum effect on frictional torque levels. Since the shield does not come into direct contact with the rotating ring, certain very fine contaminants could possibly enter the bearing. The same environmental controls are recommended for the handling of shielded bearings as for open bearings. (See page 64)

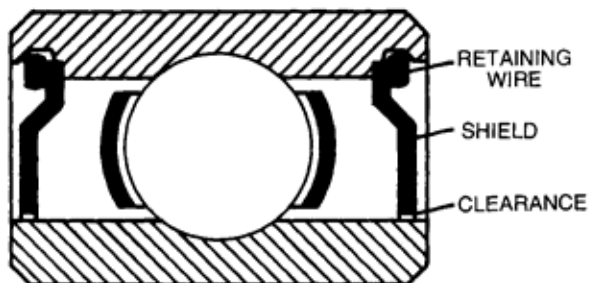


FIGURE 1

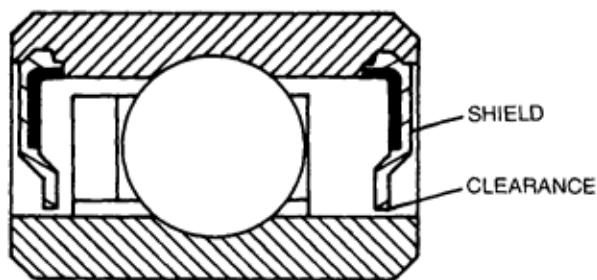


FIGURE 2

SEALS

In extremely dirty application environments, seals provide extra contamination protection at a sacrifice of the lowest possible frictional torque levels.

MPB's standard seal design for miniature size bearings features a thin fluoro-polymer-coated glass cloth washer fixed to the outer ring by a snap ring and maintaining a rubbing contact with a polished shoulder on the inner ring. (See Figure 3)

MPB's Thin Section bearings use a stainless steel insert and molded rubber design similar to the shields, except that the ID of the seal is carefully controlled to provide a positive contact against the sealing surface on the inner ring. Buna N (nitrile) rubber is the standard seal material for these sizes. Other materials, such as Viton, can be supplied, if necessary. (See Figure 4)

Because of the rubbing contact, the frictional level of a sealed bearing can be as much as ten times higher than in a shielded or open bearing.

Special seal designs have been developed by MPB for extremely contaminated applications or for cases where significant pressure differentials exist. Consult MPB for more information.

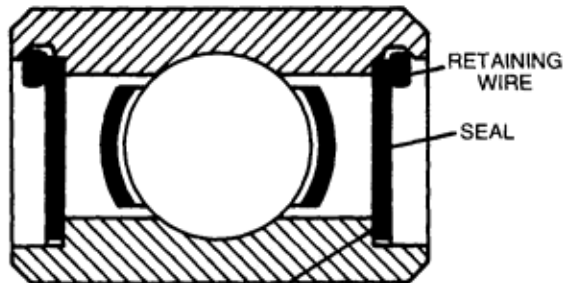


FIGURE 3

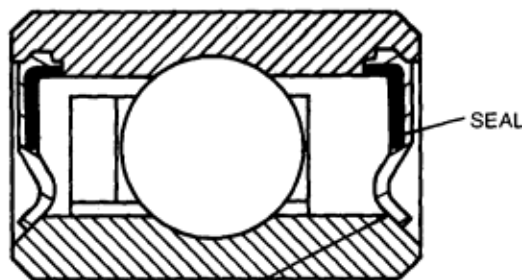


FIGURE 4

Tolerances

Miniature and Instrument Bearings

MPB bearing tolerances comply with those specified by the Anti-Friction Bearing Manufacturers' Association (AFBMA). "AFBMA Standards for Instrument Ball Bearings—Section 12" describes various tolerance classes including ABEC 3, 5P, 7P and 9P. AFBMA Section 12 has been approved by the American National Standards Institute, Inc. under number B3.10-1970. These classes reflect instrument bearing usage in various degrees of precision, ABEC 3 being the lowest and ABEC 9P the highest.

This table compares the toleranced features of the various ABEC classes. These tolerances relate to external dimensions as well as the geometric relationship of the ball groove with bearing mounting surfaces. These individual

tolerance values provide a guide to the bearing user in designing his shaft and housings, since surfaces to which bearings are mounted should have tolerance levels equivalent to those on the corresponding bearing surface.

Tolerances on features not yet defined by AFBMA Standard are under constant review and development by MPB to achieve optimum performance under typical application of each ABEC class. MPB recommendations of specific ABEC classes or special tolerances insure that bearing users' goals are met—both in performance and cost. MPB radial bearings are normally manufactured to ABEC 5P or 7P tolerances.

ABEC 3 THRU ABEC 9P TOLERANCES LISTED BELOW ARE FOR COMPARISON

All Tolerances are in .0001 Inches Limits: Bores to 0.7087; OD's to 1.1811	ABEC 3	ABEC 5P	ABEC 7P	ABEC 9P
INNER RING				
Mean Bore—High Tolerance Limit (1)	+0	—	—	—
Mean Bore—Low Tolerance Limit (1)	-2	—	—	—
Bore Maximum Tolerance Limit	+1	+0	+0	+0
Bore Minimum Tolerance Limit	-3	-2	-2	-1
Radial Runout	2	1.5	1	0.5
Face Parallelism	—	2	1	0.5
Reference Side Runout Width Bore	—	3	1	0.5
Groove Runout with Reference Side	—	3	1	0.5
OUTER RING				
Mean OD—High Tolerance Limit (2)	+0	+0	+0	—
Mean OD—Low Tolerance Limit (2)	-3	-2	-2	—
OD Max. Tolerance Limit—Open Bearing	+1(3)	+0	+0	+0*
OD Min. Tolerance Limit—Open Bearing	-4(3)	-2	-2	-1*
OD Max. Tolerance Limit—Seal/Shield Bearing	+2(3)	+0.4(3)	+0.4(3)	+0*
OD Min. Tolerance Limit—Seal/Shield Bearing	-5(3)	-2.4(3)	-2.4(3)	-1*
Radial Runout	4	2	1.5	0.5*
Face Parallelism	—	2	1	0.5
OD Runout with Reference Side	—	3	1.5	0.5
Groove Runout with Reference Side	—	3	2	0.5*
Inner and Outer Width Tolerance, Bearings, other than Duplexed, Width of Individual Inner and Outer Rings	+0 -50	+0 -10	+0 -10	+0 -10
Duplexed Bearings, Total Width of a Pair of Inner or Outer Rings	+0 -200	+0 -150	+0 -150	+0 -150

NOTES: 1—Mean Bore = $\frac{\text{Bore Max.} + \text{Bore Min.}}{2}$

2—Mean OD = $\frac{\text{OD Max.} - \text{OD Min.}}{2}$

3— $\frac{\text{OD Max.} + \text{OD Min.}}{2}$ Must be within OD mean

*—For OD's from 0.7087 + 1.1811: OD Tolerance Limits (Open or Shielded) = +0, -1.5
Radial Runout = 1, Groove Runout with Ref Side = 1

Radial Play, End Play and Contact Angle

RADIAL PLAY

Radial play or free internal clearance in a radial ball bearing is defined as the difference between the inner ball groove diameter and the outer ball groove diameter minus twice the actual ball diameter. It is measured directly on MPB bearings under precisely located and controlled reversing loads chosen to minimize erroneous readings due to outer ring distortion.

The radial play value in a specific ball bearing application is an important design consideration. Contrary to a common misconception, radial play is completely independent of quality or the ABEC tolerance class. It directly affects and controls operating contact angle and free end play.

Radial Play Selection: The selection of radial play is as important as basic bore and OD sizes. The value of radial play in the bearing as "mounted" is the basic consideration. When MPB bearings are mounted with interference fits on shafts or in housings, the "free" radial play is reduced by approximately 80% of the diametral interference. Allowances for bearing ring fits must be considered in establishing the "free" radial play of the bearing. Standard clearances for all bearings are shown in the table below. These values are considered optimum for most miniature, instrument or airframe applications. All other clearances are special and the actual value must be shown in our part number by a "P" followed by two or more digits which indicate the radial play range in ten-thousandths of an inch.

BEARING TYPE	STANDARD RADIAL PLAY RANGE (INCH)
MINIATURE & INSTRUMENT	.0002/.0008

Reasons for Radial Play Selection

Looser Fits—Specify to:

1. Allow for a press fit on one or both races.
2. Provide higher contact angles under thrust loads to reduce stress levels and torque.
3. Provide greater axial stability in preloaded pairs.
4. Allow greater misalignment.

Tighter Fits—Specify to:

1. Control cocking or end play when a preloaded pair is impractical.
2. Control radial movement.

END PLAY OR AXIAL PLAY

End play or axial play of a radial ballbearing is the total amount of axial shift of the inner ring in relation to the outer ring under a reversing axial gage load.

End play is proportional to radial play, ball size and race curvature, such that:

$$P_E = \sqrt{4 B d P_R - P_R^2}$$

where P_E = end play
 B = total raceway curvature
 d = ball diameter
 P_R = radial play

The total raceway curvature (B) is a constant for each series of MPB bearings. Therefore, the end play versus radial play relationship may be plotted for each ball size (See Figure 5). When using this curve to determine end play in an application, the "mounted" radial play value must be used.

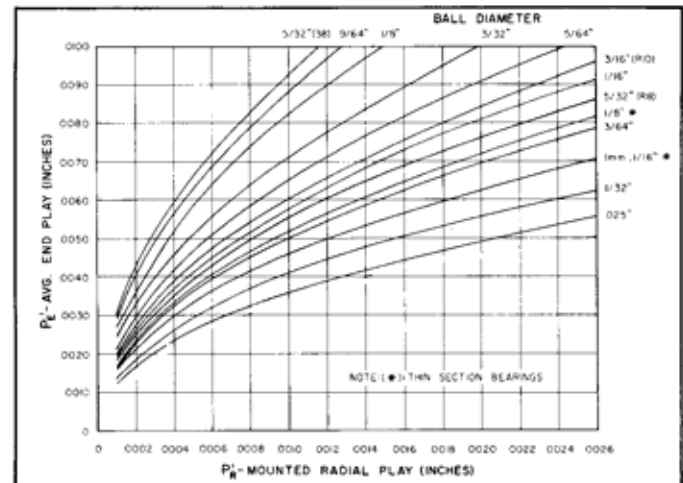


Figure 5

Normally, end play is not directly measured on MPB bearings, since radial play is the controlling parameter.

In applications where end play must be controlled to values approaching zero, it is advisable to shim out or otherwise remove end play in application assembly rather than specify extremely low radial play values. This assures minimum frictional torque and maximum operating life.

Radial Play, End Play and Contact Angle (cont.)

CONTACT ANGLE

When bearing end play is removed by shimming or axial preloading, a line through the ball-to-race contact points forms an angle with a line perpendicular to the bearing axis. This angle is the bearing contact angle (Figure 6).

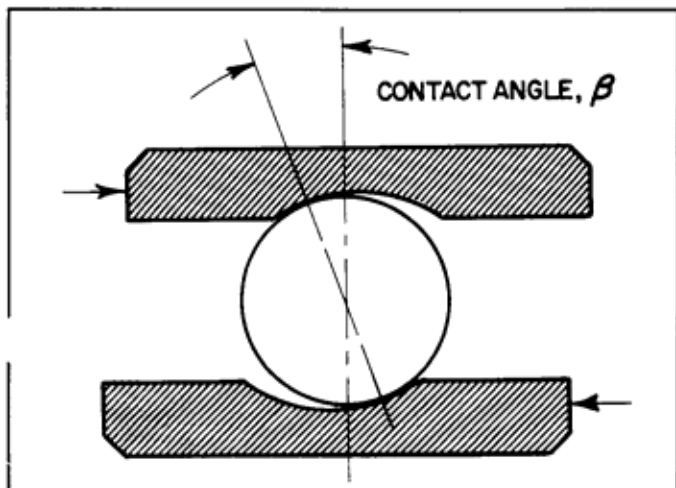


FIGURE 6

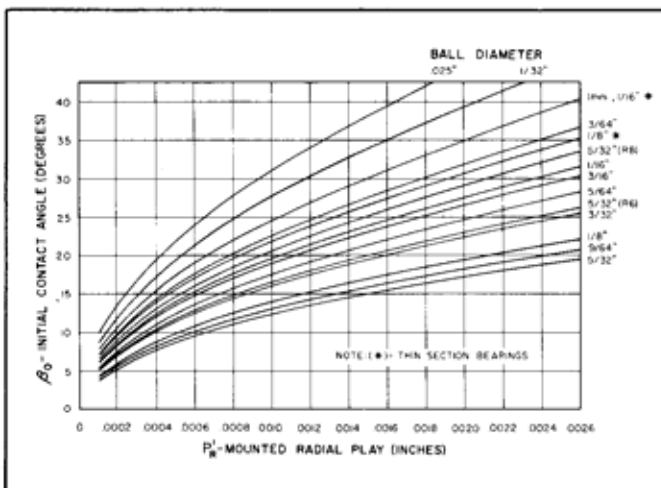


FIGURE 7

Contact angle determination is necessary to control deflection of axially loaded bearings and to assess stress levels due to bearing loading.

The contact angle is related to radial play, ball size, race-curvature and applied load. This relationship may be depressed for bearings under zero load as:

$$\cos \beta_0 = 1 - \frac{P_r}{2 Bd}$$

where β_0 = Initial Contact Angle (no load)

P_r = Radial Play

B = Total Raceway Curvature

d = Ball Diameter

Assuming no load, the initial contact angle versus radial play relationship may be plotted for each ball size using standard MPB total curvatures (Figure 7).

The contact angle is normally controlled indirectly by radial play specification and measurement. However, when extremely close control of contact angle is necessary (usually because of a need for closely controlled bearing deflection rates), contact angle may be specified and measured directly.

Lubrication

The function and operational life of instrument ballbearings depend heavily on their lubrication. A lubricant may be visualized as a separating layer between two sliding surfaces, the purpose of which is to inhibit surface wear while maintaining the lowest possible friction torque level. The ball and raceway surfaces, although finished to levels expressed in less than 3 microinch CLA, appear microscopically as a pattern of "hills and valleys." When rubbed together under the high unit loadings inherent in point contacts, these asperities are thought to weld together, then break off, initiating an adhesive wear process which ultimately fails the bearing by increasing friction torque and changing dimension.

Adhesive wear is inhibited by:

- elastohydrodynamic (EHD) film
- boundary lubrication
- mixed film lubrication

EHD films are generated dynamically in the rotating bearing, depending on the lubricating fluid's property of increasing viscosity with increasing pressure. Ball-to-race contacts can be effectively separated by the high viscosities generated under typical pressures expressed in hundreds of thousands of pounds per square inch.

Once separated by a distance greater than asperity height, the surfaces will not contact and adhesive wear will be eliminated.

In practical terms, EHD film depends primarily on:

- fluid viscosity at operating temperature
- bearing speed

Boundary lubricating films are formed on machined steel surfaces as complex chemical adsorbed layers resulting from the surface's interaction with its environment. Preferred layers may be formed by chemical treatment of the surface as it is processed and by additives in the lubricating fluid.

Mixed film lubrication, a combination of EHD film and boundary conditions, describes the regime in which most instrument ball bearing contacting surfaces operate.

LUBRICANT SELECTION

Fluids used as bearing lubricants are effective as they reflect these film generating properties:

- high pressure-viscosity coefficient
- viscosity (at operating temp.) compatible with adequate EHD film generation
- additives providing preferred adsorbed films

Further consideration must be given to the fluid properties relating to other application parameters:

- temperature capability
- volatility
- viscosity-temperature
- surface tension (migration)
- oxidation stability
- corrosion inhibition

Fluids used as lubricants are generally mineral or synthetic oils, formulated with anti-oxidation and anti-wear additives, and offered commercially.

Greases are oils, thickened with metallic soaps, clay, urea or other material, to maintain their position within the bearing cavity, assuring a supply of fluid over an extended time.

Oils are used where low bearing friction torque is a primary consideration, although grease may provide longer operating life and better resist lubricant loss due to "spin-out" at higher speeds. EHD film criteria should be applied to grease base-oils in the same manner as applied to oils. However, the vast difference in properties of various grease thickeners makes their selection somewhat more complex than oils.

Military specifications in effect describe various classes of lubricants, both oils and greases, and usually relate to specific bulk properties rather than to specific formulation. For this reason, and the large number of proprietary formulations on the market, care should be taken to fully evaluate specific trade-name lubricant products in application.

MPB catalogs over 300 lubricants which have been applied to specific applications of instrument ball bearings. A number of these, typical of current applications, are tabulated in Table 8, page 52.

Lubrication (cont.)

LUBRICATING METHODS

Instrument ball bearings, with few exceptions, are prelubricated and receive no further lubrication during their operating life. Applications often depend on the maintenance of very low bearing friction torque for proper function which, in turn, is influenced by lubricant quantity and placement. MPB has developed a number of techniques for control of lubricant quantity and placement to allow use of the bearing directly out of the package with the pre-lubrication fully compatible with application requirements.

Vacuum Impregnate: Bearings with porous ball retainers are immersed in oil under vacuum, followed by soak at room pressure, thereby forcing oil into retainer pores. Specify as LOV or LYV.

Film Oiling: Dip bearing into oil-solvent mixture, leaving a thin film on all surfaces. Specify as LOF or LYF, with oil-to-solvent ratio.

OILING METHODS

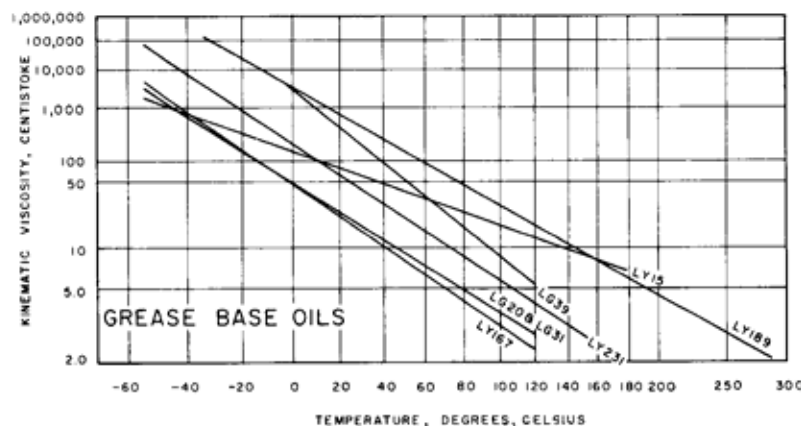
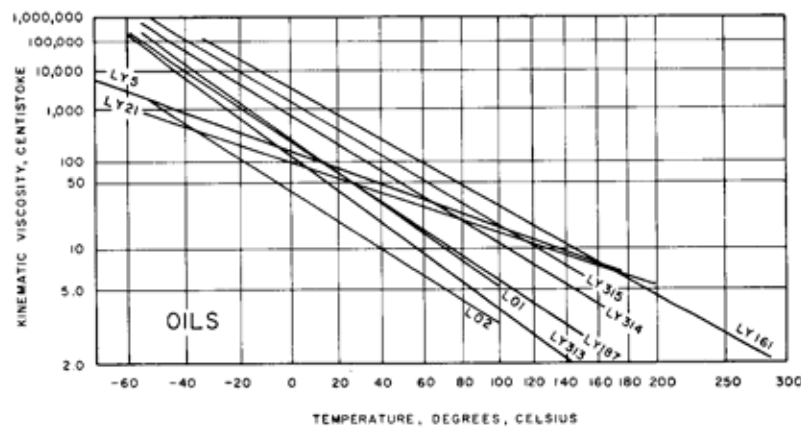
Dip and Drain: Slight excess of oil on all bearing surfaces, providing corrosion protection as well as final lubrication; specify as LO or LY.

Dip and Centrifuge: Oil on all surfaces with quantity controlled by specified centrifuge level. Specify as LOC or LYC plus "G" level.

GREASING METHODS

Standard Greasing: Meter controlled quantity of grease directly into bearing cavity. Specify as LG or LY, plus quantity in % fill or milligrams.

Film Greasing. Apply grease-solvent mixture to bearing cavity to achieve controlled quantity. Specify as LGF or LYF, plus quantity in % fill or milligrams.



Lubrication (cont.)

SPECIAL LUBRICATION

The vast majority of instrument ballbearing applications are adequately lubricated by conventional oils and greases. In certain environments this is not possible, usually because of high or low temperatures, high vacuums or other limitations on use of fluids. Various types of solid film coatings may be considered for these applications, although, in general, bearing performance and life expectancy must be down-rated severely.

Proprietary solid film lubricating systems are available commercially. Their consideration for instrument ballbearing application should be discussed with MPB engineers to assure compatibility with bearing materials, processing and function.

MPB LUBRICANTS

MPB Minapure lubricants are available both in prelubricated instrument ballbearings and in bulk. MPB markets Minapure to assure its customers a source for clean, instrument-quality grease and oils.

Minapure grease is a lithium soap thickened diester oil, qualified under MIL-G-81937, with a cleanliness level exceeded by no other commercial product.

Minapure oils are formulated synthetic hydrocarbon oils offered in three viscosity grades for matching with bearing application EHD film needs. See pages 40-41.

Commonly-Used Bearing Lubricants TABLE 8

MPB Code	Lubricant	Oil Type	Thickener	Oil Viscosity (Centistokes)		Temp. Range (°F)	Mil-Spec
				100°F	210°F		
L01	Winsor Lube L-245X	Diester	—	31.0	5.3	-65 to 200	MIL-L-6085A
L02	Anderol 401D	Diester	—	11.5	3.2	-65 to 200	MIL-L-6085A
LY5	Versilube F50	Silicone	—	50.0	16.0	-100 to 350	MIL-S-81087 (Type 1)
LY21	DC510 (50 CS)	Silicone	—	38.0	14.0	-65 to 400	—
LY161	Krytox 143AC	Fluorocarbon	—	260.0	26.0	-30 to 550	—
LY187	SHC2224 (formerly RL714)	Synthetic Hydrocarbon	—	31.1	5.6	-80 to 300	—
LY313	M018	Synthetic Hydrocarbon	—	18.0	3.7	-80 to 300	—
LY314	M075	Synthetic Hydrocarbon	—	75.0	10.9	-65 to 300	—
LY315	M0119	Synthetic Hydrocarbon	—	119.0	15.4	-60 to 300	—
LG20	Beacon 325	Diester	Lithium Soap	13.0	3.6	-65 to 250	—
LG31	Minapure Grease	Diester	Lithium Soap	12.0	3.3	-65 to 250	MIL-G-81937
LG39	Andok C	Mineral	Sodium Soap	110.0	8.5	+20 to 250	—
LY15	Versilube G300	Silicone	Lithium Soap	50.0	16.0	-65 to 350	—
LY196	Aeroshell 7	Diester	Microgel	10	3.1	-100 to 300	MIL-G-23827
LY231	Mobil 28	Synthetic Hydrocarbon	Clay	30.0	5.7	-65 to 300	MIL-G-81322
LY189	Krytox 240AC	Fluorocarbon	Telomer	260.0	26.0	-30 to 550	MIL-G-27617

Other lubricants available on request from factory.

Shoulder Diameters

SHOULDER DIAMETERS

Shaft and housing shoulders should be of adequate height properly support the face of the bearing. Shoulders should be carefully machined to prevent misalignment, with squareness held to a tolerance comparable to the "groove runout to reference side" values specified in the tolerance charts. Housing and shaft fillet radii for the shoulders should not exceed the radius (r) dimension listed in the tabular sections.

Table 12 shows minimum shaft and maximum housing shoulder diameters for MPB standard miniature, instrument bearings.

Sleeves, spacers, snap rings and similar devices can be used to provide shoulders, provided the above recommendations for precision and size are considered. The rotating ring should preferably be provided with as precise a shoulder as possible.

TABLE NO. 12

Basic Bearing Size	A Minimum Shaft Shoulder Diameter (Inches)	B Maximum Housing Shoulder Diameter (Inches)
100	.043	.082
2	.060	.105
2½	.071	.135
3	.079	.168
4	.102	.226
3332	.118	.168
5	.114	.284
418	.148	.231
518	.153	.284
618	.153	.347
R2	.179	.325
R2A	.179	.446
5532	.180	.294
34	.223	.548
5632	.210	.294
6316	.216	.347
R3	.244	.446
34.5	.265	.548
35	.285	.651
5732	.242	.286
36	.329	.651
614	.272	.352
814	.284	.466
R4	.310	.565
R4A	.322	.678
37	.361	.749
8516	.347	.466
38	.381	.749
R6	.463	.788
R8	.609	1.000
R10	.805	1.250

Shaft and Housing Fits

SHAFT AND HOUSING FITS

Since MPB miniature and instrument bearings are precision mechanical components, it is important that the size and tolerances of the shaft OD, housing bore and adjacent shoulders be carefully chosen and consistent with the tolerances of the bearings.

The inner and outer rings of these bearings are relatively thin in cross section. These bearing rings will be distorted when interference fitted on shafts or in housings which are not of true geometric form. The roundness of the shaft or housing should, therefore, be held within .0001" and the surface finish should be 12 AA or better.

Generally shaft and housing diameters should be held to tolerances equivalent to the bore and OD tolerances of

the bearing to be used. Use of larger tolerances negates the advantages of precision positional control built into the bearing itself. Tables No. 9 and 10 below which assume ground steel housing and shaft mounting surfaces, indicate general recommended fits for various operating conditions.

(Examples are shown for bearings with +.0000, -.0002 tolerances on both bore and OD.) Extreme fits are, of course, possible from random assembly, but occur only in a small percentage of cases due to statistical variation in the related diameter dimensions.

Keep in mind that 50-80% of an interference fit is reflected in loss of radial play. Interference fits are even more significant in their effect on increasing preload in factory duplex preloaded pairs.

TABLE 9

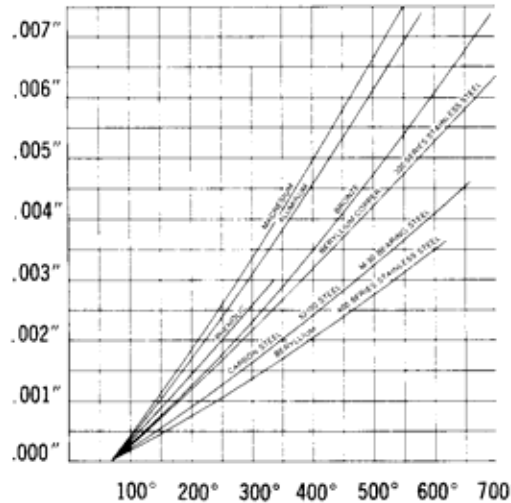
SHAFT FITS

Operating Conditions	Recommended Fit	Average Fit	Bearing Bore	Shaft Diameter	Extreme Fits
STATIONARY SHAFT					
Light load, low to high speed	Clearance	.0001" loose	B + .0000" to B - .0002"	B - .0001" to B - .0003"	.0001" tight to .0003" loose
Medium load, low to high speed, or high cycle oscillation	Line-to-Line	.0000"	B + .0000" to B - .0002"	B + .0000" to B - .0002"	.0002" tight to .0002" loose
Heavy load, high speed or high cycle oscillation	Interference	.0001" tight	B + .0000" to B - .0002"	B + .0001" to B - .0001"	.0003" tight to .0001" loose
ROTATING SHAFT					
Light load, low to high speed	Clearance	.0001" loose	B + .0000" to B - .0002"	B - .0001" to B - .0003"	.0001" tight to .0003" loose
Light load, low cycle oscillation	Line-to-Line	.0000"	B + .0000" to B - .0002"	B + .0000" to B - .0002"	.0002" tight to .0002" loose
Medium to heavy load, high speed or high cycle oscillation	Interference	.0001" tight	B + .0000" to B - .0002"	B + .0001" to B - .0001"	.0003" tight to .0001" loose

Note: B = nominal bearing bore

If extreme fits are unacceptable in certain applications, selective assembly of coded bearings matched with similarly graded shaft and housing diameters may be utilized. This approach is usually more economical than a reduction in diameter tolerances. See Page 56 for coding of bores and OD's.

It is always preferable to use shaft and housing materials having compatible coefficients of expansion with the bearing. Whenever this is impractical, due to weight or other material considerations, use Table 11 to determine the possible degree of looseness or interferences at temperature extremes. This additional looseness or tightness can be partially compensated for by adjusting fits and radial play. Contact your MPB Field Sales Engineer for specific application assistance.



To determine expansion or potential fit variation for dissimilar materials: Multiply bore or OD diameter times the expansion for each material @ the maximum temperature required. Contraction @ temperatures below 70°F is equal to the expansion for a comparable temperature differential above 70°F.

TABLE NO. 11

Linear or diametral expansion from 70°F shown in inches/ inch of diameter.

TABLE 10

HOUSING FITS

Operating Conditions	Recommended Fit	Average Fit	Bearing O D	Housing Bore	Extreme Fits
STATIONARY HOUSING					
Light load, low to high speed	Clearance	.0002" loose	D + .0000" to D - .0002"	D + .0002" to D - .0000"	.0000" tight to .0004" loose
Medium load, low to high speed, or high cycle oscillation	Line-to-Line	.0000"	D + .0000" to D - .0002"	D + .0000" to D - .0002"	.0002" tight to .0002" loose
Heavy load, high speed or high cycle oscillation	Interference	.0001" tight	D + .0000" to D - .0002"	D - .0001" to D - .0003"	.0003" tight to .0001" loose
ROTATING HOUSING					
Light load, low to high speed	Clearance	.0002" loose	D + .0000" to D - .0002"	D + .0002" to D - .0000"	.0000" tight to .0004" loose
Light load, low cycle oscillation	Line-to-Line	.0000"	D + .0000" to D - .0002"	D + .0000" to D - .0002"	.0002" tight to .0002" loose
Medium to heavy load, high speed or high cycle oscillation	Interference	.0001" tight	D + .0000" to D - .0002"	D - .0001" to D - .0003"	.0003" tight to .0001" loose

Note: D = nominal housing OD

Coding of Bores and O.D.'S

Where closer fits than those listed in Tables 9 and 10 are desired, the bore and/or OD dimensions can be coded to the nearest .0001" or, if necessary, to the nearest .000050". Bearings so coded are packaged in groups and labeled with their specific code. Coded bearings can be selectively assembled with components which have been similarly coded so the actual fits are closer to the average fit specified. While random bore and OD coding does not reduce the tolerance spread shipped in any one order, it does reduce extreme conditions of fit.

Bearing codes for the various tolerances are listed in the following table.

For miniature and instrument bearings the codes are determined on the basis of the minimum bore and the maximum OD size.

Tolerance	.0001" Increment Coding (Standard)	.000050" Increment Coding	Half Tolerance Coding
Nominal to - .000050"	1	A	H
- .000050" to - .000100"		B	
- .000100" to - .000150"	2	C	L
- .000150" to - .000200"		D	
- .000200" to - .000250"	3	E	L
- .000250" to - .000300"		F	
GRADE SYMBOLS			
Graded Bore and OD	ZD	XZD	HZD
Graded Bore Only	ZB	XZB	HZB
Graded OD Only	ZO	XZO	HZO
Graded Bore and OD Matched for Preloaded Pairs	ZDM	XZDM	HZDM

The basic symbol ZDM is used to define or specify a condition where both bores and both OD's of a preload pair are selected to be the same size within the increment indicated. It is not necessary that they be of the same code symbol. The code symbol of the pair will be that of the smaller bore and the larger OD of the pair.

Also available on metric bearings is coding to 1 micron increments rounded off to .000040". Use prefix M, as in MZD, etc. to specify.

To avoid confusion between digits or letters and symbols hyphens are used before bore and/or OD symbols. The bore code is the first digit.

EXAMPLES

ZD-1-2 = Bore Nominal to - .000100"
OD - .000100" to - .000200"

XZD-D-A = Bore - .000150" to - .000200"
OD Nominal to - .000050"

ZO-1 = OD Nominal to - .000100"

HZB-L = Bore size in lower half of bore tolerance

ZDM-2-1 = Both bores of pair are equal size within .000100".
The smaller bore is from - .000100" to .000200".

Both OD's of pair are equal size within .000100".
The larger OD is from Nominal to - .000100".



MPB Air Gaging Equipment avoids the distortions of mechanical gaging and assures accurate grading of Bores and OD's.

Preloading

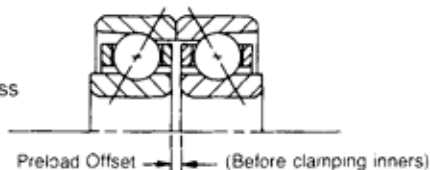
There are several basic reasons for preloading a ball bearing set:

1. To remove radial and axial play for more precise shaft positioning.
2. To control the axial and radial stiffness (compliance) of the system.
3. To maintain ball-race contact to prevent skidding and reduce noise.
4. To improve load sharing between bearings.

MPB supplies preloaded bearings that are flush-ground or have matched stick-out stick-in as a pair to achieve a specified preload range. The bearings are marked for proper orientation and preloaded as illustrated below:

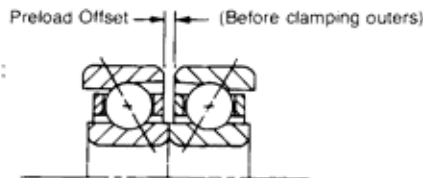
DB (Back to Back) Preferred for

- a. high moment stiffness
- b. higher speeds where shaft may run hotter than housing (without preload build-up)



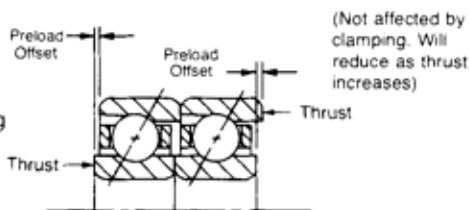
DF (Face to Face) Preferred for

- a. low moment stiffness; allows for slight misalignment at low speeds
- b. use where housing may be hotter than shaft



DT (Tandem) Preferred for

- a. unidirectional axial load sharing
- b. greater axial stiffness



Note (Tandem sets must be opposed by another bearing or set)

Bearings can also be preloaded using solid equal length spacers between them and axially clamping the stack together. Springs are also used to achieve preload: the bearing rings may be allowed to "float" axially or can be secured in place with an adhesive.

PRELOADING THIN SECTION BEARINGS

Thin section bearings have relatively low compliance levels when preloaded—they are very stiff. Because of this characteristic, the preload range should be as open as the application will permit. It is recommended that the minimum preload for an extra thin section bearing be equivalent to about 1/8 lb./ball. The preload tolerance should be at least 0.5× the minimum preload level specified or 2 lbs., whichever is greater. For a torque tube bearing, the minimum preload should be equivalent to about 1/3 lb./ball. The preload tolerance should be at least 0.5× the minimum preload level specified or 4 lbs., whichever is greater.

EXAMPLES

S1014M (24 balls)—Minimum preload = $24 \times \frac{1}{8} = 3$ lbs.
Tolerance = $0.5 \times 3 = 1.5$ lb.
(Use 2 lbs.)
Recommended preload specification 3-5 lbs.

S1421M (20 balls)—Minimum preload = $20 \times \frac{1}{3} = 6.66$
Tolerance = $0.5 \times 6.66 = 3.33$
(use 4 lbs.)
Recommended preload specification 7-11 lbs.

Preloads below the recommended minimums do not permit consistent, accurate measurement during preload operation. Too narrow a preload range cannot be achieved consistently because the deflection difference between min. and max. preload is less than the repeatability of the measuring equipment.

PRELOADING MINIATURE AND INSTRUMENT BEARINGS

Miniature and instrument bearings, with their more open curvature and low capacities, have relatively high compliance when preloaded—they are less stiff. Accordingly, the levels of preload and the min.-max. spread can be more closely controlled than with thin section bearings. Preloads in the pound range are practical for the miniature size, with a tolerance of 1 lb. as a recommended minimum.

For specific applications, requiring preloaded bearings, contact your MPB Sales Engineer or Product Engineering at MPB.

Preloading (cont.)

PRELOADED PAIR MARKING

These bearing pairs are marked with two axial lines forming a 30° included angle "V" etched across their OD's. As shown in Fig. 14 for DT pairs, the "V" points in the direction of thrust load to the outer ring face per Figure 15.

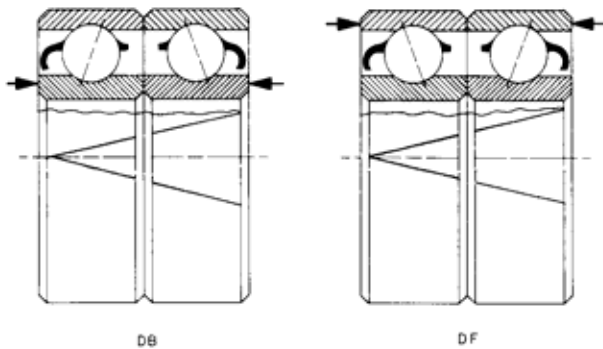


FIGURE NO. 14

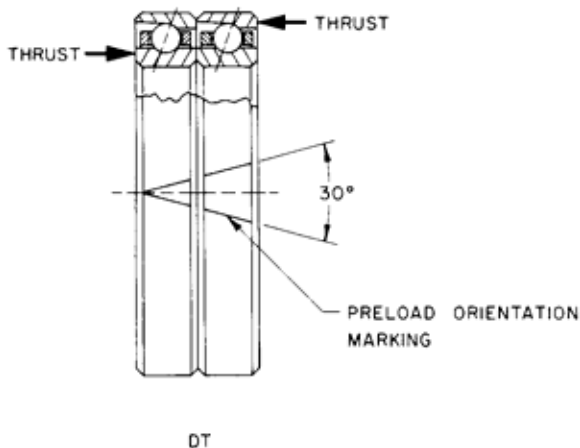
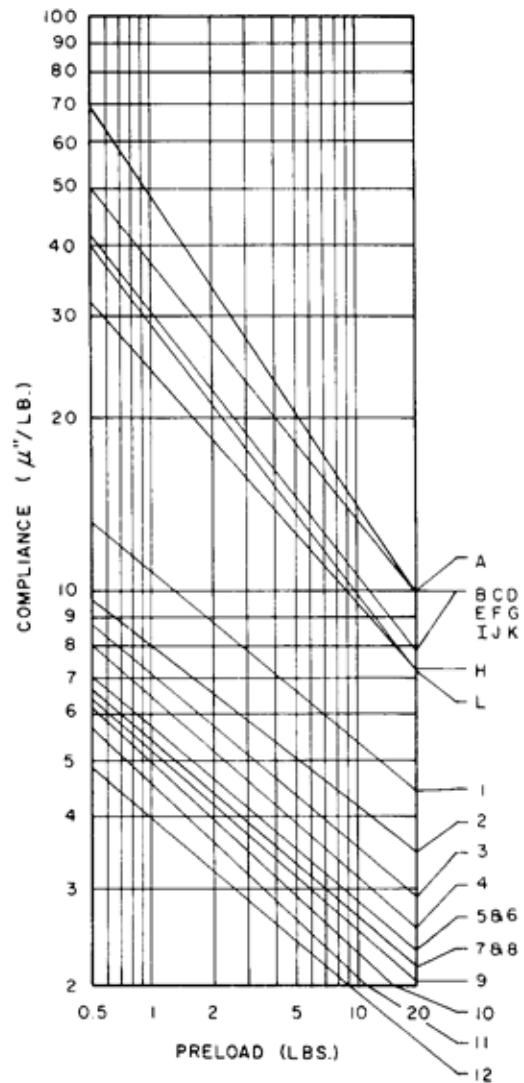


FIGURE NO. 15



BEARING SIZE KEY

A,1	3	G,7	R4
B,2	418	H,8	8516
C,3	5	I,9	34
D,4	R2	J,10	36
E,5	R3	K,H	38
F,6	814	L,12	R6

All data is based on 15° initial contact angle and standard race curvature. All bearings are angular contact construction and ball complement. These curves represent axial (upper set) and radial (lower set) compliance or preloaded pairs vs. preload. This data is presented only as a guide. For more detailed data, contact Product Engineering at MPB.

Load Ratings

Tabular data within this catalog includes load rating values termed "dynamic", "static radial" and "static thrust". It is important for the bearing user to understand the bases for determining these values, so that invalid comparison with other manufacturers' data may be avoided. Load ratings are calculated to provide a guide for bearing selection against application requirements. They are not absolute and variations in calculation methods existing within the industry make direct comparison between manufacturers' catalog values impractical. Load ratings in this catalog are calculated for bearing steels using the mean of the standard radial play range or in the case of angular contact bearings, the nominal contact angle tabulated.

DYNAMIC LOAD RATING

Bearing life may be defined as the length of time a bearing will operate satisfactorily in the application at its operating speed under an applied load. Life predictions depend on careful definition of failure criteria and consideration of operating environment, mounting practice, lubrication, possible contamination, geometry control, operating speed, and, of course, loading.

The expected fatigue life under operating loads is seldom the most important design consideration in the selection of miniature and instrument ball bearings. The dynamic load rating figures are presented primarily to permit a comparison of the load carrying potential for bearings of similar material but differing in size, internal design and ball complement.

Life predictions are necessarily nonprecise because of the interaction of these many parameters. The AFBMA (Anti-Friction Bearing Manufacturers' Association) has established an accepted method of calculating fatigue life, outlined in AFBMA Standards. The AFBMA Rating Life (L) is the number of revolutions, or hours at constant speed, that 90% of a group of apparently identical bearings will attain, or exceed, before the first evidence of fatigue develops. The dynamic load rating (C) is the constant radial load, stationary with respect to the outer ring, that a bearing can endure for a rating life of one million revolutions of the inner ring, or 500 hours at 33 $\frac{1}{3}$ rpm. The dynamic load rating is determined by bearing geometry, number and size of balls, bearing pitch diameter, and ring and ball material. The dynamic load rating (C) for each bearing is shown in the tabulations in the body of the catalog.

This load rating is used in conjunction with the actual applied radial load (R) to calculate bearing fatigue life as follows:

$$L_h = \frac{16667}{N} \left(\frac{C}{R} \right)^3$$

where: L_h = Rating Life in Hours
 N = Speed of Inner Ring Rotation, in RPM
 C = Dynamic Load Rating
 R = Applied Pure Radial Load, in Lbs.

The rating life as defined above relates solely to metal fatigue and assumes perfect bearing configuration, alignment, lubrication and cleanliness. In addition, these load ratings and life calculations are based on the application of a pure radial load. Note that the dynamic load rating value is used only in life calculations and, for instrument bearing applications, should not be approached in actual applied load. MPB can assist in establishing fatigue life calculations for combination thrust and radial loads, pure thrust loads, outer ring rotation, preloaded bearing pairs, or probabilities other than 90%.

STATIC LOAD RATINGS

As load is applied to a nonrotating bearing a value will be reached beyond which permanent deformation of raceways and balls occurs. The resulting indentations, or "brinells", become defects interfering with smooth operation and shortening bearing life. Static load ratings relate to limiting loads applied to nonrotating bearings, as in bearing mounting, or to shock loads applied to rotating bearings. Operating loads should not approach the rated value except in isolated cases.

AFBMA standards state that static load ratings depend on the maximum contact stress between the balls and either of the two raceways. It is affected by material, number and size of balls, raceway curvatures, raceway depths and contact angle.

A maximum contact stress level of 580,000 PSI has been established as a satisfactory limit for most applications and is the basis for static load ratings tabulated herein.

Where low vibration and frictional torque levels are of primary concern, applied loads should result in no more than 508,000 PSI maximum contact stress, representing an approximate 40% reduction in tabulated static load ratings.

STATIC RADIAL LOAD RATINGS

The static radial load ratings (R_s) is that pure, radial load which, when applied to a non-rotating ball bearing, will result in a maximum stress level of 580,000 PSI at the most heavily loaded ball contact.

STATIC THRUST LOAD RATINGS

The static thrust load rating (T_s) is that pure axial load which, when applied to a ball bearing, will result in:

- (a) a maximum stress level of 580,000 PSI and or
- (b) a ball-raceway contact area which lies completely within the raceway (i.e., the contact area is not truncated by the raceway shoulder on either ring).

Bearing Testing

Instrument ball bearing applications typically require precise positioning of a rotating member, low frictional torque, and smooth operation—all remaining within limits for the desired operating life.

Positioning can be controlled by selecting the proper tolerance classification and by holding certain dimensions to special tolerances. These tolerances can be accurately gaged and related directly to the control required.

Frictional torque and smoothness of operation are much more difficult to deal with. Many dimensional and physical parameters affect them, both in the bearing itself and the bearing as mounted and operated in an application.

To insure optimum bearing performance, MPB uses several types of test instrumentation suitable for production checks and used in the analysis of process improvements or actual customer application simulation. Production-oriented test gear involves standardized test conditions and a relatively high rate of test cycling. Instrumentation for bearing analysis is constantly being developed and modified as ball bearing technology progresses and applications become more demanding.

MINIATURE AND INSTRUMENT BEARING TORQUE TESTING

Ball bearing frictional torque measurement is dependent upon bearing speed, load and alignment. Since applications and bearings involve an infinite variation of these parameters, MPB has standardized production tests into either starting or running torque testing. These tests compare bearing performance levels under standardized test conditions but do not necessarily simulate actual application levels.

Starting Torque

Starting Torque, defined as the torque necessary to start bearing rotation, is measured under a 75 gm thrust load on bearings with an OD of $\frac{3}{8}$ " or less, 400 gm on larger instrument sizes, and expressed in milligram-millimeters. As both instruments are widely utilized by bearing users, test data correlation between the manufacturer and customer can be maintained.

The development of the ST2 Starting Torque Tester by MPB, shown in Figure 17, provides miniature and instrument bearing producers and users with a gage to monitor and analyze bearing performance. The ST2 may be used as an inspection device on a bearing or group of bearings or as an analytical tool to aid in bearing design.

The ST2 features solid state design, automatic test sequencing, repeatability, and low maintenance. It is easily calibrated and easy to operate. Under normal conditions, a novice operator can become proficient with training time of an hour or less. These features combine to produce the most reliable device of its kind ever available and at a lower unit cost per test.

Virtually all of the industry standard miniature and instrument bearing series can be tested on the ST2. The universal tooling concept developed for the RT2 Running Torque Tester was adapted to the ST2 making it a versatile test instrument. If necessary, non-standard sizes can be tooled by special order.

STANDARD STARTING TORQUE LEVELS

Basic Bearing Size	Test Load (Grams)	Maximum Starting Torque (Milligram-Millimeter)		
		Radial Play Range		
		P13	P25	P58
2	75	1800	1500	1400
2½	75	1800	1500	1400
3	75	1800	1500	1400
3332	75	1800	1500	1400
4	75	1800	1500	1400
418	75	1800	1500	1400
5	75	1800	1500	1400
518	75	1800	1500	1400
5532	75	1800	1500	1400
5632	75	1800	1500	1400
618	75	2000	1600	1500
6632	75	2000	1600	1500
6316	75	2000	1600	1500
614	75	1800	1500	1400
814	400	6000	5200	4800
8516	400	6000	5200	4800
R 2	400	5000	4500	4200
R 2A	400	5000	4500	4200
R 3	400	6500	5500	5000
R 4	400	7000	6000	5500
R 4A	400	8000	7000	6500
R 6	400	11000	9500	9000

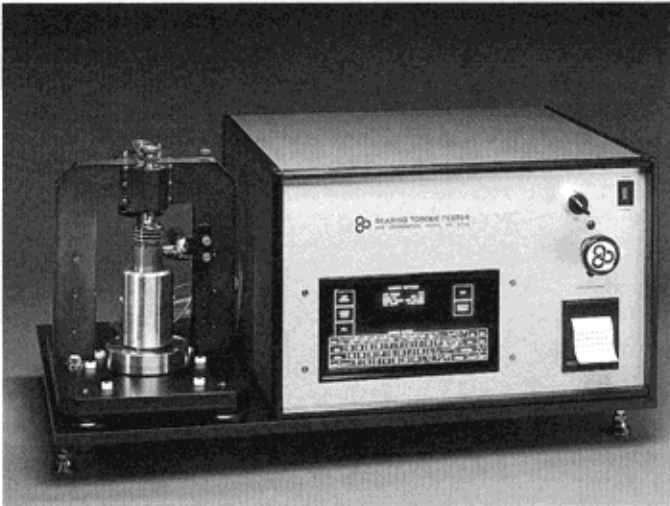
GENERAL CONDITIONS

These maximum starting torque values are subject to specific definitions and test conditions covered in Paragraph 9 of Section No. 12, AFBMA Standard for Instrument Ball Bearings. These standard torque values are valid for bearings that are:

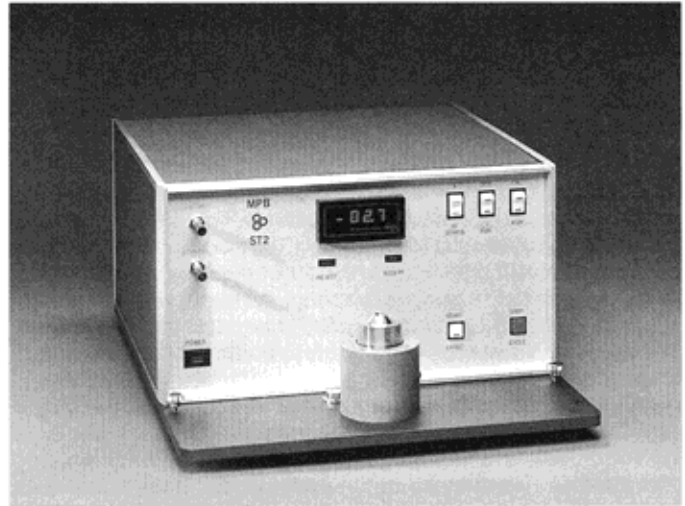
- 1) ABEC 7P tolerances.
- 2) open or shielded bearings.
- 3) Stainless 440C or SAE 52100 material.
- 4) Crown or Ribbon Retainers, and
- 5) lubricated with MIL-L-6085A oil.

MPB interprets the test conditions such that prior to testing, the bearings are to be cleaned with a filtered solvent, lubricated with one drop of filtered MIL-L-6085A oil (or an equivalent viscosity lube) and demagnetized. Testing is to be done in a nominally clean room environment.

The bearings are to be tested a minimum of 10 starts (5 per side) with the test load applied axially in a vertical position. MPB uses the industry accepted MPB ST2 Starting Torque Tester to determine torque levels.



RT2C Running Torque Tester



ST2 Starting Torque Tester

Running Torque

Bearing running torque, tested at a speed of 2 rpm, is measured under either a 75 gm or a 400 gm thrust load on the MPB RT2C Torque Tester, shown above. Designed and built by MPB, this tester is used per MIL-STD-206. A strip chart recording indicates instantaneous torque peaks as well as average torque values over two complete revolutions. This tester has a two-fold purpose—it may be used in production to test bearings against maximum torque limits or as an analysis tool to evaluate geometric perfection, surface finish, cleanliness and internal damage in the bearing tested.

The RT2C is basically a diagnostic instrument featuring high reliability and repeatability with minimal maintenance requirements. Perhaps its most important feature is its ease of operation, enhanced by automatic cycling.

Bearing Testing

NOISE AND VIBRATION

Bearing noise is a performance characteristic under constant examination to define and eliminate its causes.

Although it is accepted that all bearings generate vibrations or noise, there is no recognized definition or test method for noise available as a standard.

Each application may define a different acceptable noise level in the assembled bearing system. These definitions range from subjective audible levels to readouts from specialized electronic test equipment. Since either extreme of method relates to a unique bearing system consisting of mounted bearings, specific loads, speeds, environments and a specific frequency range, the problem of designing a meaningful free bearing test becomes even more complex.

Although no bearing noise tester yet devised can relate to all application noise specifications, there is one in use at MPB which can provide relative noise readings from bearing to bearing. The Smoothrator is one such noise measuring instrument. It reads out dimensionless numbers for noise comparison under standardized speed and thrust load. This instrument is used by many bearing users, allowing them to establish noise levels consistent with their own application requirements.

Other specialized vibration analysis equipment and fixturing has been developed for investigation and analysis of bearing noise as related to specific application conditions. MPB engineers are available for discussion of your noise and vibration problems.



MPB's test facilities feature a wide variety of equipment.

TORQUE CONVERSION CHART

1 MG. MM.	equals	.098 DYNE CM.	equals	.0001 GM. CM.	equals	.0000139 IN. OZ.
500		50		.05		.00070
600		60		.06		.00080
700		70		.07		.00090
800		80		.08		.00100
900		90		.09		.00120
1000		100		.10		.00130
1100		110		.11		.00140
1200		120		.12		.00150
1300		130		.13		.00160
1400		140		.14		.00170
1500		150		.15		.00180
1600		160		.16		.00190
1700		170		.17		.00200
1800		180		.18		.00210
1900		190		.19		.00220
2000		200		.20		.00230
2100		210		.21		.00240
2200		220		.22		.00250
2300		230		.23		.00260
2400		240		.24		.00270
2500		240		.25		.00280
						.00290
						.00300
						.00310
						.00320
						.00330
						.00340

LIFE TESTING

Just as there is no universal bearing performance test which will guarantee specific performance levels in application, there is no standardized life test to prove the ability of a bearing to function properly over a given period of time in its application. Many life tests have been, and are being, performed at MPB, comparing bearing designs, materials and lubrications under varying loads and speeds.

Although these life test results seldom apply directly to a specific application, they do allow MPB engineers to recommend the most satisfactory bearing system.

Life testing of unmounted bearings under specified loads and speeds, cannot substitute for testing of the entire bearing system in application. Handling and mounting techniques, fits and operating environment are as significant in determining unit life as bearing quality.

MPB engineers are available to help design bearing system life tests as well as recommend bearing designs consistent with application life requirements.

Packaging

The packaging of MPB bearings is designed to deliver them clean and undamaged. The containers used provide easy identification, complete protection in transit and storage and best meet the use and handling requirements of the customer. To prevent contamination, packaging operations are performed in the clean room. The same rigid cleanliness standards are observed in the packaging section as are specified for the inspection, lubricating and testing sections of the clean room.

Four standard packages are available:

- Pill pack
- Vial pack
- Box pack
- Kraft foil pouch

The type or method of packaging desired should always be specified on drawings or purchase orders. If no specific packaging is requested, bearings will be packed in vials or pill pack strips.

To reduce the possibility of bearing contamination at the user's facility, all outer packaging such as boxes, cartons, or Kraft pouches, should be removed and the inner wrap (vial or polyester pouch) cleaned of all dust particles before being taken into white or clean areas.

PILL PACK

Pill packs are formed from strips of transparent, heat sealable polyester backed polyethylene film or preformed polyethylene bags. Both materials are impervious to most lubricants and offer low vapor permeability and gas penetration. The strips of static-free and clean film are heat sealed into a strip of five pouches with one bearing in each pouch. The pouch size is 2" x 2". The preformed bags are sealed into a strip of four pouches with one bearing in each pouch. The pouch size is 2½" x 2½" to accommodate the thin section bearing size range. The strip pack material thickness is 2.5 mils and the preformed bag material is 4 mils thick.

A pressure sensitive label is applied to each pouch of the strip pack whereas the preformed bag is direct printed on each pouch. The printed information includes the customer purchase order number, customer part number, MPB order number, date packaged, MPB part number, quantity, lubrication and radial play.

To prevent damage during shipment, the boxes containing the pill pack strips are enclosed in sturdy corrugated shipping cartons. Filler material is used to prevent shifting and to strengthen the package.

VIAL PACK

For high production requirements, packaging in transparent cellulose acetate butyrate reclosable vials is preferred. Each vial contains a quantity of 50 bearings of the miniature size range and 25 bearings of the instrument size range. When specified by the customer the bearings may be shipped in an excess of lubricant in which case the vial is hermetically sealed to prevent leakage. When bearings are lubricated with the dip and centrifuge method, the caps are secured in place with a transparent vinyl tape. A pressure sensitive label is applied to each vial imprinted with the customer purchase order number, customer part number, MPB order number, date of packaging, MPB part number, quantity, the MPB lubrication code and radial play.

Several vials are normally packed in a polyethylene bag and each bag is labeled with the same information as is printed on the individual vial label. Depending on the number of vials to be shipped, the external shipping carton is a chip board mailer or a 275-lb test corrugated carton.

BOX PACK

The intimate wrap for the box pack is a 2" x 2" x 6 mil polyethylene clean bag for the miniature and instrument bearing sizes and a 2½" x 5" x 3 mil poly bag for the thin section bearings over 1" OD. The air is pressed from the poly bag, sealed and placed in a reverse tuck folding box of appropriate size. A pressure sensitive label is applied to one face of the box printed with the customer purchase order number, customer part number, MPB order number and part number, date packed, MPB lube code, quantity and radial play. The bag and box is MPB's standard method of packaging bearings, one inch OD and larger, for distributors and is used for OEM accounts when specified.

For the necessary protection in shipment, the boxes are arranged in a corrugated carton with the necessary dunnage to prevent damage in transit.

KRAFT FOIL POUCH

Each Kraft foil pouch is labeled per MIL-STD-129 with the Federal Stock Number, the item description, the quantity and unit of issue, the contract number, the level packaging and the month and year of shipment. Following and below the MIL-STD-129 marking format is the MPB order number and part number. When required by the customer and/or contract, each Kraft foil pouch will be packed in an individual paperboard box conforming to military specification PPP-B-566, a, Style II, Type D, Class a. When required, each box will be labeled with a duplication of the information that appears on the face of the Kraft foil pouch.

Pouches or pouches boxed to the required level are shipped in sturdy corrugated cartons. Rigid styrofoam blocks or a cushioning filler is used to prevent shifting and strengthen the package.

Upon request, MPB can provide Bar Code package marking per MIL-STD-1189.

Bearing Handling

Instrument ball bearings are precision devices which will provide long service life when properly specified and applied. However, unskilled or careless handling will inevitably result in poor performance and life. Unfortunately, many problems encountered by instrument bearing users are self-imposed through improper handling.

Introduction of particulate contamination into instrument ball bearings is probably the most universal problem, and one of the more elusive and difficult to control.

Almost by definition, most instrument ball bearings are used in torque and noise-sensitive applications. Even very small particles of foreign matter (on the order of a few tens of micro-inches) can degrade the quiet running qualities and low torque values of the bearing.

The control of particulate contamination must be a conscious endeavor throughout the entire life of an instrument bearing. MPB bearings are manufactured, assembled, inspected, tested and packaged under rigidly controlled conditions. It is imperative that the bearing user extends good handling practices on his end so that the full performance potential of MPB bearings may be realized.

Some fundamentals to preserve bearing cleanliness are:

- Clean work areas.
- Properly garbed personnel.
- Clean and maintained bearing handling instruments and related equipment.
- Proper handling techniques.
- Maintenance of demagnetized bearing condition.

MPB bearings should be kept in the original, unopened packages until ready for installation. Only the actual required number of bearings should be removed from the package at any one time. Bearings should be removed from the protective intimate package only in a clean, dry and dust-free atmosphere. Any unused, opened bearings should be stored and properly identified in clean, dry, covered containers.

It is preferable to handle bearings with specifically-designed, handheld instruments, such as tweezers with special work ends.

In many cases, instruments of this sort are commercially available. It goes without saying that these instruments must be maintained in a state as clean as the bearings themselves.

In some cases, it is necessary to handle bearings by hand, without the benefit of tools. In this event, fingers or any other bare skin must not touch the bearing. Microscopic skin particles shed easily from hands and will inevitably find a way into the bearing. Furthermore, most bearing steel, other than AISI 440C, will corrode rapidly from the moisture and other residue left after skin contact. Clean, dry, undusted finger cots or lint-free gloves should be worn.

All MPB bearings are thoroughly demagnetized prior to shipment to the customer. If it happens that the bearings become magnetized during shipment, the unopened bearings must be demagnetized before further use because of the obvious danger of attracting metallic particles into the bearing.

BEARING CLEANING

MPB bearings are thoroughly inspected, washed and lubricated to individual customer specification prior to final packaging. They are, therefore, ready for immediate installation into the bearing user's equipment.

If any bearings become accidentally contaminated, it is recommended they be returned to MPB for cleaning and relubrication.

If, however, the bearing user must wash and relubricate the bearings, then the following advice is offered:

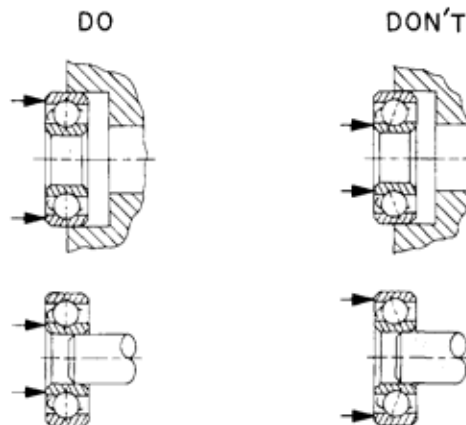
Bearings should be cleaned with a filtered, high-purity solvent, such as trichlorotrifluoroethane. Solvents which leave any film on the metal surface must be avoided. Solvents should be filtered through a 0.5 micron filter before use.

Bearings may be individually spray-washed or bulk-processed in an ultrasonically-agitated wash tank. If the spray-wash method is used, an end-of-line filter just ahead of the spray nozzle is recommended to trap contamination traveling through the air line. Also, care must be exercised to prevent fast bearing rotation due to the spray-blast. If the ultrasonic method is used, care must be taken here as well to ensure that bearing damage does not result from over-exposure to the ultrasonic energy.

Bearings should be dried either under an infrared heat-lamp or by a flow of filtered, dry air. Here again, if air-flow is used, the bearing must be prevented from spinning.

Lubricating oil applied to the bearing after wash should be filtered through a 0.8-1.2 micron filter and then injected directly into the bearing through a clean hypodermic syringe. The syringe itself should also be fitted with a 0.8-1.2 micron filter between the barrel and the needle.

After cleaning and lubrication, the bearings should be stored in clean, dry, covered containers that are properly identified.



Correct and Incorrect Bearing Mounting Practices

BEARING INSTALLATION

To repeat, only the actual number of bearings needed should be removed from the bearing package.

- The mounting components, shafts/housings/related hardware, should be fully complete and thoroughly clean prior to any contact with the bearing.
- The performance and life of a ball bearing are significantly affected by the geometry of the components that contain the bearing. Hence, shaft/housing diameter tolerances and geometry must be carefully determined and maintained before any attempt is made to install the bearings (see Shaft and Housing Fits, Page 64-65).
- Interference fits with shaft and housing provide positive retention and location. Potential drawbacks are: Bearing radial play, or internal clearance, is reduced by about 50%-80% of the diametral interference fit. This fact must be considered in the initial bearing selection.
- Geometric errors of the fit diameters, out-of-roundness for example, will be transferred to the mating bearing ring. In other words, a round bearing can be greatly distorted by an out-of-round shaft or housing.

Clearance fits do not affect bearing geometry, but also do not provide for the same degree of positive positioning, unless special provision is taken in the hardware design. Clearance fits are also prone to fretting corrosion at the mounting interfaces, which can occur during normal operation or during exposure to external vibration sources.

Installation tooling must be thoughtfully designed and carefully made. Important points to remember here are:

- Tooling should be designed and made to be easily-cleaned and to remain burr-free.
- Tooling should mount the bearings squarely onto the shaft or into the housing. Misalignment during installation can severely distort a bearing.
- Tooling must be designed and used in a manner which will not damage a bearing. **AT NO TIME CAN ANY INSTALLATION FORCES BE TRANSMITTED FROM ONE BEARING RING TO THE OTHER THROUGH THE BALLS.** This will "brinell" the bearing, resulting in high torque and noise. As a general statement, any force should be applied only to the ring that is being mounted.
- Shock or impact techniques should never be used to seat the bearing.

ENVIRONMENTAL CONTROL

A controlled work environment for handling bearings will help to reduce contamination and corrosion problems. Ideally, an entire "clean room" should be available. Alternatively, individual, hooded work-stations or "clean" benches may be used.

CLEAN ROOMS

A clean room, or white room, is an area in which temperature, humidity and cleanliness, particularly in terms of airborne contamination, are rigidly and continuously controlled.

Clean rooms are generally of two types: Laminar flow and non-Laminar flow. In Laminar flow rooms the filtered, conditioned air moves with uniform velocity along parallel flow lines. Air flow may be vertical, that is ceiling-to-floor, or horizontal, wall-to-wall. In non-Laminar rooms, there are no specified airflow patterns nor any requirements for uniform velocity.

Clean rooms should be maintained at a constant temperature of 68°F-72°F with relative humidity in the 30%-45% range. Rooms should also be pressurized to a level higher than the surrounding external areas, so that contaminated, external air cannot flow into the room. Usually, a system of interlocking doors or an air-lock entrance is employed to insure that the clean internal atmosphere is not directly exposed to the outside atmosphere during personnel entrance.

Personnel traffic in and out of the clean room should be kept to a minimum. Where feasible, pass-through windows should be used to deliver material and supplies.

Part of the control of airborne contamination is the requirement that personnel in the clean room be properly garbed. This normally means external garb made of lint-free, synthetic yarn over street clothes. The external garb should be laundered frequently and treated so as to be kept lint and dust free. All exposed hair should likewise be covered with a suitable cap or face-mask. Wearing of cosmetics, such as face powders, needs to be prohibited. Naturally, any food, drink or smoking materials must be excluded from the area.

INDIVIDUAL WORK STATIONS

Where a clean room is unavailable, pressurized "clean-benches" are recommended for bearing handling. These clean-benches are commercially available.

Naturally, many of the same prudent practices recommended for the clean-room environment are appropriate in the clean bench as well. For example, fingers and hands should be covered, clean instruments for bearing handling should be used, bearings should not be removed unprotected, from the controlled atmosphere of the clean bench.

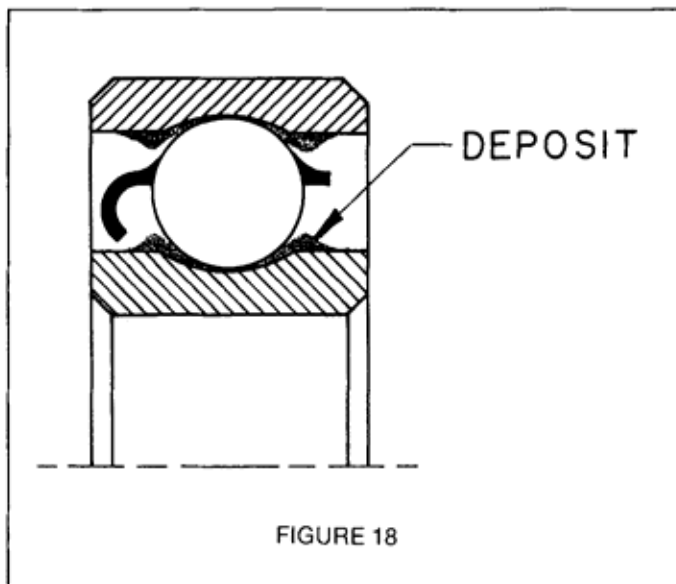
Post-Service Analysis

MPB engineers welcome the opportunity to aid our customers in post-service analysis.

Much can be learned from careful examination and analysis of bearings that have been in service. Although most post-service examinations are made after bearing failure, it is often helpful to examine bearings before failure occurs to determine incipient failure modes or conditions. Often such visual examinations yield estimates of applied loads, misalignment, geometry errors, contamination levels and lubricant effectiveness. Further analytical investigation can then be made as indicated before the evidence is obliterated by catastrophic failure.

VISUAL ANALYSIS

It is of utmost importance that bearings returned for analysis are accompanied by application history, including loads, speeds, operating environment and failure criteria, as well as a detailed description of the handling involved subsequent to failure. For maximum information, bearings should be left just as they were at the termination operation. If possible, they should still be mounted in the unit.



The basic equipment necessary for visual post-service analysis of instrument bearings is a 10X to 40X microscope with adequate lighting. The following discussion points out some pertinent visual conditions and their meanings, in the order in which they would be determined in a typical examination.

LUBRICANT

The assembled bearing should first be examined for the appearance of the lubricant or for any residue in its place. Fig. 18 shows the areas within the bearing to be examined. The initial type and quantity of lubricant should be known in order to analyze properly the post-service condition.

1. Oil Lubricant

- Dry surfaces with little evidence of residue, or perhaps only a slight brownish haze on ball and raceway surfaces indicate too little lubricant, either in initial application or because of oil migration.
- Free oil mixed with red or brown particles indicates partial lubrication failure. Look for high temperatures, high loading or contamination.
- Dry surfaces accompanied by dry, particulate residue, red to black in color, both free and attached to metal surfaces. This is an extreme progression of condition "a" above.

2. Grease Lubricant

- Grease darkened but still oily suggests high loads or contamination.
- Grease darkened and dry indicates an extreme progression of the above condition or loss of oily constituents through migration or evaporation.
- Grease surface darkened and hard, with soft interior, is probably caused by exposure to high external heat.

3. Oil or Grease Lubricant

- Reddish deposit at ball contact indicates fretting corrosion. Look for oscillatory or vibratory motion in operation.
- Metallic particles, if accompanied by indication of wear on bearing components, suggest that the lubrication failed first. Otherwise, the particles may be from a contaminant source external to the bearing.

RINGS

The bearing inner ring will generally yield more information from a visual analysis than the outer, since its raceway is more exposed to view and ball contact stresses are generally higher than on the outer raceway.

The most significant feature is the "track" formed by the balls during service. This track may present the following appearances:

1. **Matte Finish.** This is usually apparent after short running time and does not indicate incipient failure.
2. **Pitted or Etched Finish.** This is usually associated with a pattern of "dirt brinells"—minute impingements of microscopic contaminants in the ball path.

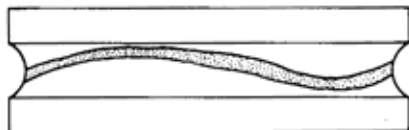


FIGURE 19

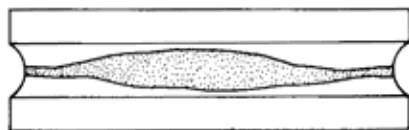


FIGURE 20

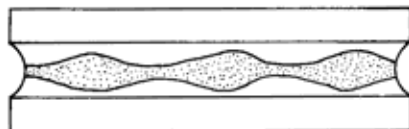


FIGURE 21

3. **Spalling.** This is a pattern of "craters" left when a piece of the contact surface is lost due to metal fatigue. Spalling is seldom a failure mode in miniature instrument bearings since loads are typically low. Larger more heavily-loaded bearings are more apt to exhibit fatigue failure.
4. **Brown, Circumferential Bands.** Usually these brown bands follow the path of rolling contact, with burnished areas between the bands scrubbed by sliding between balls and raceway. The brown color is the result of localized high heat, typically a result of inadequate lubrication or conditions working to break the lubricant film.

The position and shape of the ball track is also significant:

1. Track in bottom of raceway indicates a radial load.
2. Track away from bottom of raceway indicates a thrust load and the direction of load. Visual estimate of contact angle compared with theoretical contact angle may point up a mounting problem.
3. Track width is indirectly an indication of applied load. The wider the track, the heavier the load.
4. Wavy track (Fig. 19) is caused by misalignment of the bearing race rotating in respect to the load.
5. A single wide section in the track (Fig. 20) suggests dynamic unbalance in a rotating member or a point of constant radial load in a stationary member.
6. Multiple wide sections in track (Fig. 21) indicates out-of-round raceway as mounted.

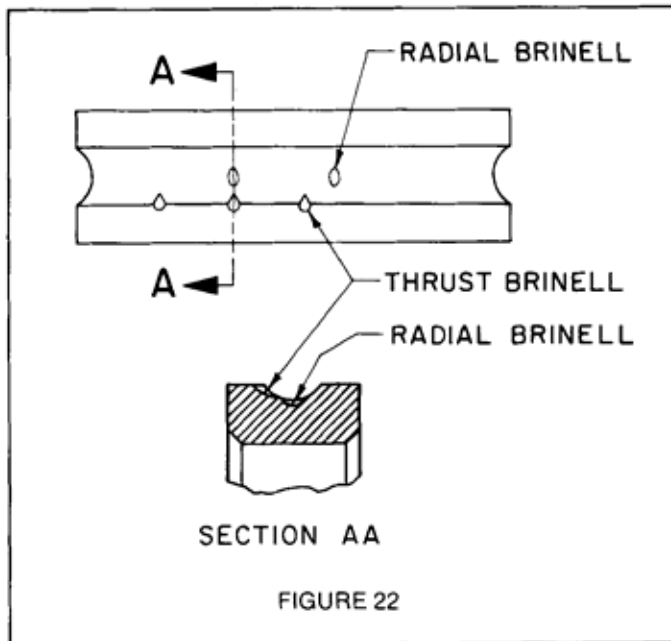
The raceway should be examined for brinell marks. These are indentations caused by overloading the bearing under radial, axial or moment loads. They may be difficult to see and careful manipulation of the ring under the microscope is necessary. Several types of brinells are shown in Fig. 22.

1. Evenly spaced shoulder brinells indicate excessive thrust load. These often occur in mounting or dismounting a bearing or by dropping a mounted bearing assembly.
2. Irregularly spaced shoulder brinells, in groups approximately 180 degrees apart, may result from cocking the bearing during installation. Any two opposing groups of brinells would be on opposite race shoulders.

Post-Service Analysis (cont.)

3. Radial brinells, appearing in the bottom of the race, are the result of high static radial loading or shock loading.

Outer races should be examined for track irregularities and brinell marks in the same way as the inner races. Outer race markings are usually less well defined than those on inner races. However, correlations will exist between visual characteristics of the inner and the outer races.

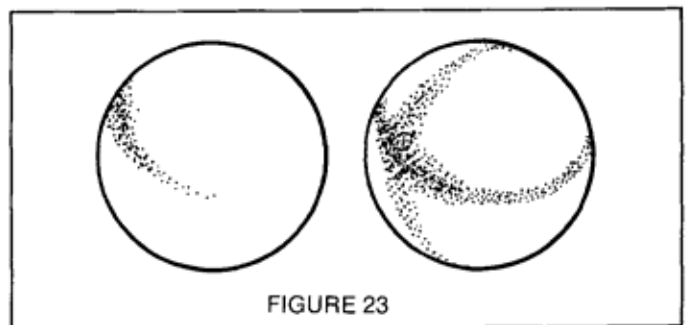


EXTERNAL SURFACES

An examination of inner ring bore, outer ring OD and both ring face surfaces can also provide significant information. Axial scratches on bore and OD surfaces indicate a press fit on shaft or in housing. Tapered mating surfaces are indicated by axial lines not extending across the entire ring width. Unmarked sections indicate out-of-round shaft or housing. Slippage of a race on the shaft or in the housing will be apparent from circumferential scratches on the corresponding ring surface, sometimes accompanied by wear debris. Ring faces also may show similar indications of slipping, as well as damage occurring from improper mounting or dismounting.

BALLS

Figure 23 shows several markings that occur on balls. Matte finish wear bands indicate operation under continual high thrust loads. A light, uniform, matte finish is a result of bearing operation in a lightly contaminated condition. Protuberances or depressions may be caused by low potential electric currents passing through the bearing. Where this characteristic is observed, evidence of arcing may also exist on bearing bore and OD surfaces.

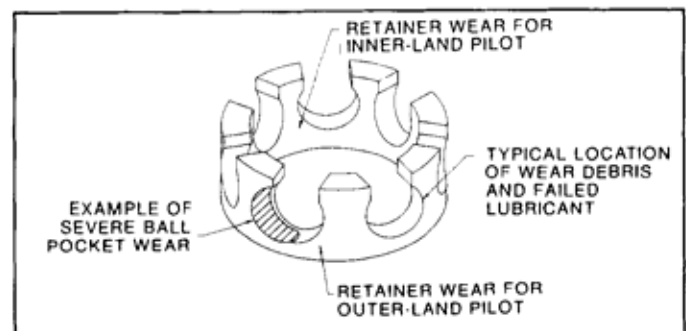


RETAINERS

The normal progression of events leading to bearing failure ultimately cause retainer wear and distortion sufficient to stop rotation completely. Seldom is the retainer itself responsible for failure. However, where incipient failure modes are at work in the bearing under examination, the retainer condition frequently can lead the analyst to the source of the problem.

Partial lubricant failure or lack of sufficient lubricant will result in retainer wear on the land-locating surfaces. Wear patterns on non-metallic retainers often indicate dynamic out-of-balance or the presence of forces acting on the retainer from outside the bearing.

The ball pockets tend to trap enough lubricant residue and wear debris to be visible before they are apparent in other parts of the bearing. These accumulations of debris can provide evidence of incipient failure.



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Our manufacturing facilities are modern, clean and equipped with the latest equipment designed to ensure manufacturing quality. Final inspection, assembly and packaging of bearing products are done in a "clean room" environment, where stringent controls are maintained to assure contamination-free products. It is in these clean rooms that final performance tests are made and the products are documented to specification.

The chart below provides a general guide to miniature and instrument bearing selection beyond basic size considerations.

While a variety of typical situations are listed, many specific bearing applications are not covered directly. The chart is intended only to suggest reasonable parameters for bearing specification. It also provides data from which nonlisted application requirements may be interpolated.

If you have any question as to proper bearing selection for your application, MPB bearing engineers are readily available to assist you. See inside back cover for the location of the nearest MPB Sales Engineering Office.

Applications

Application	Typical Bearing Type	Material Rings and Balls	Radial Play
Synchro Motor	Radial Retainer Miniature	AISI 440C	.0002" to .0005" is typical. .0005" to .0008" if end play is reduced by shimming or preloading.
Servo Motor	Radial Retainer Miniature	AISI 440C	.0002" to .0005" is typical. .0005" to .0008" if end play is reduced by shimming or preloading.
Gear Train	Radial Retainer Miniature	AISI 440C	.0001" to .0003" for low speed. .0003" to .0006" for high speed.
Gyro Spin Axis	Angular Contact Miniature or Thin Section	SAE 52100 or AISI 440C	Radial play value corresponding to specific contact angle within 15° to 35° range.
Gyro Gimbal + Platforms	Radial Retainer Miniature or Thin Section	AISI 440C or SAE 52100	.0005" to .0008" with end play reduced by shimming. .0001" to .0003" if shimming is impractical. Standard radial play for thin section bearings.
Tape Guide Rollers	Radial Retainer Miniature	AISI 440C	.0005" to .0008"
Dental Handpiece Air Turbines	Radial Retainer High Speed Miniature	AISI 440C	.0003" to .0006"
Fuel Control Governor	Thrust Bearing	AISI 440C	N/A
Disk Drive Carriage Bearings	Radial Retainer Miniature	AISI 440C	.0002" to .0005" after press fit on pin is typical. .0005" to .0008" also common.
Disk Drive Rotary Actuator Bearings	Radial Retainer Thin Section	SAE 52100	Standard of .0003" to .0008" or .0005" to .0011" depending on size.
Antenna-Wave Guide Bearings	Radial Retainer Thin Section	AISI 440C	.0005" to .0011" is typical.

Lubrication	Application Comments
Minimum amount of MIL-L-6085A instrument oil typical (LOC-2), light silicone fluid for wide temperature range (LYC-5).	Shields desirable to protect against brush wear debris. Low starting torque and low radial runout requirements typically require ABEC 5P or ABEC 7P bearings. "Thin width" special bearing designs allow precise assembly of unit without removing end bells and allow space for longer rotors in same external envelope.
Instrument grease typical (LG-31), high temperature grease for high temperature operation (LY-198).	Shields desirable. Consistent torque and low radial runout typically require ABEC 5P or 7P. "Thin width" special bearing designs useful. Machined "MC" or "MCJ" type retainers desirable for severe operating environments (e.g. vacuum, high temperature, or cryogenic).
MIL-L-6085A instrument oil for light loads and low speeds (LO-2), instrument grease for greater loads and speeds (LG-31).	Shields desirable for protection from gear wear debris. Extended inner rings allow assembly without use of bosses or separate spacers. Flanges allow through-bored housings without snap rings. Degree of allowable radial runout and driving torque in unit determine ABEC class.
Synthetic hydrocarbon oil impregnated into porous ball retainer and excess oil removed.	Gyro wheel deflection rate requirements and available driving torque dictate preload and contact angle specifications. Better than ABEC 7P tolerances often necessary for bearing performance and life. Bearing design should relate to overall gyro wheel design. Contact MPB engineers for bearing design service.
Minimum amount of MIL-L-6085A instrument oil (LOC-2).	Low starting torque critical. Loose clinch ribbon retainers or toroids preferred. ABEC 7P, ABEC 5T or better tolerances.
MIL-L-6085A instrument oil (LO-2)	Shields desirable. Flanged and extended inner rings may facilitate roller design. End play shimmed out or light preload spring used to maintain position and reduce noise. Unit runout and noise requirements determine ABEC class.
Air oil mist via turbine air supply or daily aerosol spray lubrication.	Machined phenolic or molded plastic retainer allows speeds in excess of 400,000 rpm. Partial shimming out of end play or light preload desirable. Geometry control of shaft and housings critical. ABEC 7P or better tolerances. Porous retainers preferred with aerosol lube.
Bearings immersed in fuel as only lubricant.	High thrust load capacity. Bearing life determined by maximum allowable wear of balls and races.
A channeling type grease such as LG-39.	Shields desirable as bearings are exposed. The bearings operate in a frequent random oscillatory mode. Torque uniformity is important to the accurate and fast positioning of the carriage. Radial outer ring runout is controlled by ABEC class or by use of a tighter controlled special outer ring. The bearings are often press fitted on a pin or employ an integral inner race and shaft.
A channeling type grease such as LG-39.	Thin-section-type bearings are the most commonly used. At least one shield is desirable. The bearing operation is small angle random oscillation. High hardness to combat adhesive wear is recommended. In some cases, special heat treatment may be beneficial. ABEC 5T precision levels are recommended.
Instrument bearing grease often applied as a grease film.	Shielded or sealed bearings are most often used. The operation is normally moderate speed continuous rotation. Sealed bearings are often required to act as air pressure seals in addition to excluding contaminants.



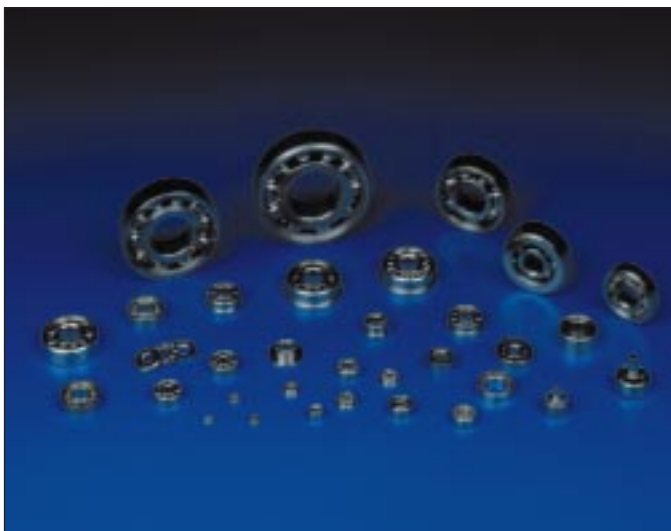
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