GENERAL INFORMATION:

RBC Airframe (or Aircraft) Control Bearings and RBC Ball Bearing Rod Ends are manufactured in compliance to U.S. Government and Aerospace Industry Standards and Specifications.

Airframe Control Bearings and Ball Bearing Rod Ends are of lightweight design, corrosion protected, grease-lubricated, and typically sealed. Although designed and manufactured under demanding quality control requirements for airborne systems, these bearings have been successfully used in other fields of application, where motions are mainly oscillatory and/or with limited rotation.

PRECISION:

RBC supplies airframe control bearings both in "Standard" and "Precision" series. The prefix "M" in a bearing number indicates that it is of a precision series. RBC supplies Ball Bearing Rod Ends as a "Precision" series.

MATERIAL:

Rings and balls are made of hardened bearing alloy, AISI 52100, with all exposed surfaces except bearing bore cadmium or zinc nickel plated for corrosion protection.

For improved corrosion protection, RBC also supplies bearings made of hardened stainless steel alloy, AISI 440C. This alloy may, in addition, be passivated, cadmium plated or zinc nickel plated for enhanced corrosion protection.

On Ball Bearing Rod Ends the outer rod body is made of a selectively hardened AISI 8620 or RBC AeroCres© Fracture-Tough material. AeroCres Fracture-Tough Airframe Products use a specialized carburized stainless steel. RBC has developed and optimized the heat treatment process resulting in a homogeneous microstructure — delivering both corrosion protection and core fracture toughness.

PERFORMANCE:

Please refer to the Engineering Section for specific useful information on bearing performance characteristics as for load rating, installation and application.

Tabulated performance data provided in this catalog are guidelines only. Rotational load ratings listed are calculated assuming intermittent slow rotation. When selecting bearings, the loads, motion modes of oscillation or rotation, and speeds must be taken into account.

We strongly recommend that you consult RBC before finalizing your selection especially when considering a full complement airframe control or rod end bearing for continuous rotational application.

RBC Airframe Control and Rod End Bearings offer the following key design features

- Inch and Metric Sizes with final as-plated dimensions.
- Corrosion Resistance available with stainless steel and/or cadmium plated alloy steels on all exposed surfaces except bore and seals. RBC also offers other corrosion resistant plated materials, which include zinc nickel plated alloy steels and RBC AeroCres Fracture-Tough airframe products.
- High load capacities in a compact, lightweight design.
- Inert PTFE (Teflon®) seals standard on most sizes.
- Extended inner rings eliminate the need for spacers.
- Bearings with suffix FS428 are prepacked with lubricant conforming to specification MIL-G-23827 and BMS3-33 and are equipped with PTFE seals.
- Bearings with suffix FS464 are prepacked 80% to 100% with lubricant comforming to specification MIL-G-81322 and are equipped with PTFE seals.
- Most self-aligning designs permit up to 10° misalignment in either direction.
- RBC airframe control ball bearings conform to SAE-AS7949 (formerly MIL-B-7949) and all major OEM specifications.
- RBC ball bearing rod ends conform to SAE-AS6039 (formerly MIL-B-6039) and OEM specifications.
- NSA Ball Bearing Rod Ends.

AIRFRAME CONTROL & ROD END BEARINGS

Bearings listed herein are tabulated in two groups: (1) full-complement bearings, which have no ball separators (retainers or cages); and, (2) bearings with ball-separator (ball-retainers or ball-cages). As noted before, the full-complement bearings should be used in applications where the motion is mainly oscillatory; whereas, the bearings with ball-separators may be used in applications where the motion may be continuous rotation or oscillatory under relatively light loads.

Airframe Control Full-Compliment (No-Cage) Bearings

- KP, MKP, AMKP Series
- KP-A, MKP-A, AMKP-A Series
- KSP, MKSP, AMKSP Series
- KSP-A, MKSP-A, AMKSP-A Series
- KP-B, MKP-B, AMKP-B Series
- KP-BS, MKP-BS, AMKP-BS Series
- DPP Series
- DPP-W Series
- DSP, MDSP Series
- DSRP, GDSRP Series
- DW (except DWK, DWK2 and MDW-K), AMDWK Series
- GDW (except GDW4K and GDW4K2)
- B500DD, MB500DD, AMB500DD Series
- B500, MB500, AMB500 Series
- B5500WZZ Series
- P8 Pulley Bearing Series
- K Series, D Series

Rod End Full-Compliment (No-Cage) Bearings

- REP Series
- RAP Series
- RA Series (NAS659)
- RR Series (NAS660)

Airframe Control Bearings with Ball Separators

- AW-AK Series
- DW4K and DW4K2 Bearing Series
- GDW4K and GDW4K2 Bearing Series
- P Series (except P8)
- BCP Bell Crank Series

STANDARDS OF QUALITY

All RBC bearings are manufactured to the same high standards of quality and reliability. We strive to engineer and utilize the latest available manufacturing technologies for producing bearings which meet and exceed all existing customer standards and expectations. This is our assurance that RBC bearings will be available to fill the most demanding performance requirements in variety of applications.

BEARING SELECTION, KEY CONSIDERATIONS:

When selecting bearings, the primary focus should be on application requirements. Once the application requirements are clearly understood and specified, selecting bearing type and design is relatively straightforward. What are the main application requirements for bearings? Loads (radial, axial, moment, and magnitude), motion (oscillatory, rotating, or intermittent), speed (fast or slow), bearing life requirements (long or short), operating temperature (hot or cold) and operating medium (clean or contaminated air, water, vacuum, etc.) are among key application requirements. Depending on combination and severity of such factors, RBC Engineering can guide you in selecting bearings for optimum service in your application.

As an aid in the preliminary stages of bearing selection, but not as a substitute for the services of a skilled bearing engineer, the following points are listed for the guidance of designers and inspectors:

1. If the bearing is used for continuous rotation, or in a delicate instrument application, do not consider any of the control type series, such as KP, KP-A, KP-B, KSP, DPP, DSP, etc., but refer to standard radial bearings or other more specialized types listed in other RBC catalogs.
2. All control surface hinge bearings should be of the sealed type. The sealed type is recommended on installations exposed to salt water spray, aircraft cleaning solutions, and where subjected to severe dust or dirt. Bearings having no shields or seals should be completely enclosed by the housing in which they are mounted to provide protection against external contaminants from entering the bearing and prevent lubricant inside from migrating or escape out of the bearing.
3. Airframe control self-aligning bearings of the KSP series are intended to compensate for misalignment due to initial setup and deflection in structure. They should not be used as rod-end bearings in non-planar linkages. For such applications, the DSP or DSRP series should be considered.
4. Bearing design intent and installation guideline should be followed closely. Due consideration should be given to how a bearing would feel as installed and loaded in the next level assembly, as opposed to how it feels during free-state handling. Inspectors, therefore, should not reject KSP, DSP and DSRP series bearings because of

tightness and/or roughness when the bearing is spun in a misaligned position. A study of the internal design will show that in pure misalignment (not accompanied by rotation) the balls do not roll but skid across the ball raceway due to their wedging action. Any inspectors' insistence that bearings be loosely fitted to insure ease of misalignment would be unjustified and might cause flutter because of sloppy controls. A reasonable amount of tightness in self-aligning bearings (not excess binding) will insure the desired rigidity in the control linkage system. Please adhere to instructions on shaft and housing fits provided in this catalog.

5. On applications where a pair of bearings are assembled in a housing, such as on a bell crank pivot, for example, the following considerations are vital to satisfactory service:
   a. Bearings should not be preloaded when the nut is tightened up on the bolt or shaft supporting the two bearings.
   b. Insure concentricity of bearing seats in the housing to avoid binding of bearing with respect to each other, when the bolt is passed through. As rule of thumb, to prevent premature bearing failures, the size and form precision of supporting housing and shaft should be comparable to those of bearing itself.

Should you encounter questions in finding and selecting correct bearing types not covered in this catalog, please contact our Engineering Department for assistance or visit the RBC website.

LOAD RATINGS, LIMIT & STATIC RATINGS

The Limit Load Ratings published in this catalog for airframe control bearings are the product of a special study undertaken jointly in 1949 by the Bureau of Aeronautics, the United States Air Force, the National Aircraft Standards Committee (NASC) and the American Bearing Manufacturers Association (ABMA). The purpose of this study was to develop a system for rating airframe control bearings based on criteria which would simulate more closely conditions encountered in real flight.

The basic equation is:

Limit Load Rating = Knd^2

where K = Load Rating constant
n = Number of balls
d = Ball Diameter

Typical K factors for radial limit load ratings are about 10,000 for deep groove bearings, 4800 for single row self-aligning bearings, 3800 for double row self-aligning bearings and 3200 for rod end bearings. In no case does the limit load rating exceed two-thirds of the bearings minimum static fracture strength. That is, the minimum static-fracture strength is 1.5 times the limit load rating.

OSCILLATING LOAD RATINGS

For bearing life and load calculations under oscillating conditions, consult the RBC Engineering Department.

Full complement type bearings should not be used for rotating applications either intermittent or continuous. If it becomes necessary to consider these bearings in such applications, consult the RBC Engineering Department prior to making selections.

An oscillating load rating system was accepted by AFBMA as an unpublished standard in 1959.

This standard permits selection of the smallest bearing which will operate under the normal loading for the desired life. This data is presented as tables of Radial Load Ratings for 10,000 complete 90° oscillatory cycles. The 90° angle was selected as typical, a good value for test work, and conservative for bearing selection until more data is accumulated on the effect of various angles of oscillation. Rating are given for:

- Case I where the load is fixed with respect to the outer race (inner ring oscillation)
- Case II where the load is fixed with respect to the inner race. (outer ring oscillation)

Radial load ratings for any other number of oscillatory cycles may be readily obtained by multiplying the basic 10,000 cycle rating by a life factor obtained from a life-factor curve.

The formulas for the ratings and life factors were derived from data accumulated by testing many bearings of different sizes and types under several different radial loads.

Briefly then, in selecting a bearing there are two steps:

1. Select a bearing which has a radial limit load rating equal to or in excess of application limit load.
2. Check the oscillatory rating of this bearing to insure that the desired average life will be obtained under the normal loading.

In actual service, the load on any control position varies as the number of times the various loads are applied. Knowing the different loads and their duration, it is possible to calculate one equivalent load which would give the same number of cycles average life as the various loads. No one load may be greater than the limit load rating of the bearing. The equivalent load may be calculated from the formula:

$$P = [\sum K_i (P_i)^{3.6}]^{1/3.6}$$

where P = Equivalent load – Pounds or Newtons

P_i = Actual applied load – Pounds or Newtons

K_i = Proportion of service time that Pi is applied

For example, suppose a particular application carries a radial load of 500 lbs. for 15% of the total service time, 1000 lbs. for 75% and 2000 lbs. for 10%. Then the equivalent load on this bearing is:

$$P = [.15(500)^{3.6} + .75(1000)^{3.6} + .10(2000)^{3.6}]^{1/3.6} = 1208 \text{ lbs.}$$

The tabulated values shown in various load rating tables will give an average life of 10,000 complete oscillatory cycles for two conditions of operation. Case I values are bearing capacities with the load fixed with respect to the outer race. Case II values are for loads fixed with respect to the inner race.

A Life Factor Chart is provided to determine bearing capacity for an average life greater than 10,000 cycles and is used with the load rating tables. The life factor for the required average life is taken from the chart. The Case I or Case II rating of the bearing is then multiplied by this life factor. This product is the load which the bearing can carry to give the required average life. For life requirements of less than 10,000 cycles, we advise using the 10,000 cycle rating. Beyond this point the criteria which determined this graph do not remain constant.

The proportionate amount of time that the various service loads are carried by a bearing can best be determined by the designer, who is familiar with the type of aircraft under consideration. With accumulated experience it is expected that short-cuts in using this method of bearing selection will be developed for each type of airplane.

Following are typical examples of bearing selection based upon the procedure described above:

Example #1

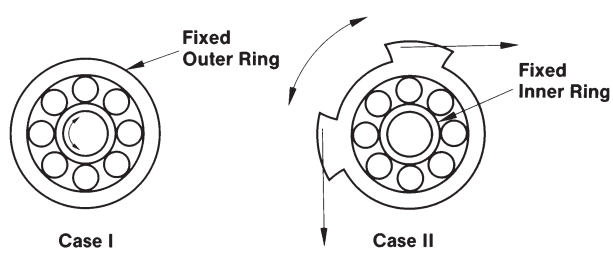
Taking the 1208 lb. Equivalent load (above) in an application where the heaviest of three radial loads is 2000 lbs., we can proceed through the KP and KP-A Series locating the smallest acceptable bearing as follows.

If there is no oscillatory life requirement stated and we are setting up an overhaul period acording to oscillatory life indicated, we proceed through the KP Series until we reach the KP4 which is the first size having a radial limit load rating exceeding 2000 lbs. (2680 lbs.) and Case II rating 2030 lbs. Both of which exceed the 1208 lb. Equivalent. The average oscillatory life for 1208 lbs. on a KP4 for Case I condition is 120,200 cycles for a Life Factor of 1208/240 = .501. The average oscillatory life for 1208 lbs. on a KP4 for Case II condition is 64,700 cycles for a Life Factor of 1208/3030 = .595. The overhaul schedule can be set up for these average lives or on the basis of one-fifth of these lives for minimum life (90% survival).

Similar procedure in the KP-A Series shows KP5A as the smallest acceptable size with an average life of 43,700 cycles for Case I and 27,500 cycles for Case II. Minimum life is again one-fifth of these average life values.

Example #2

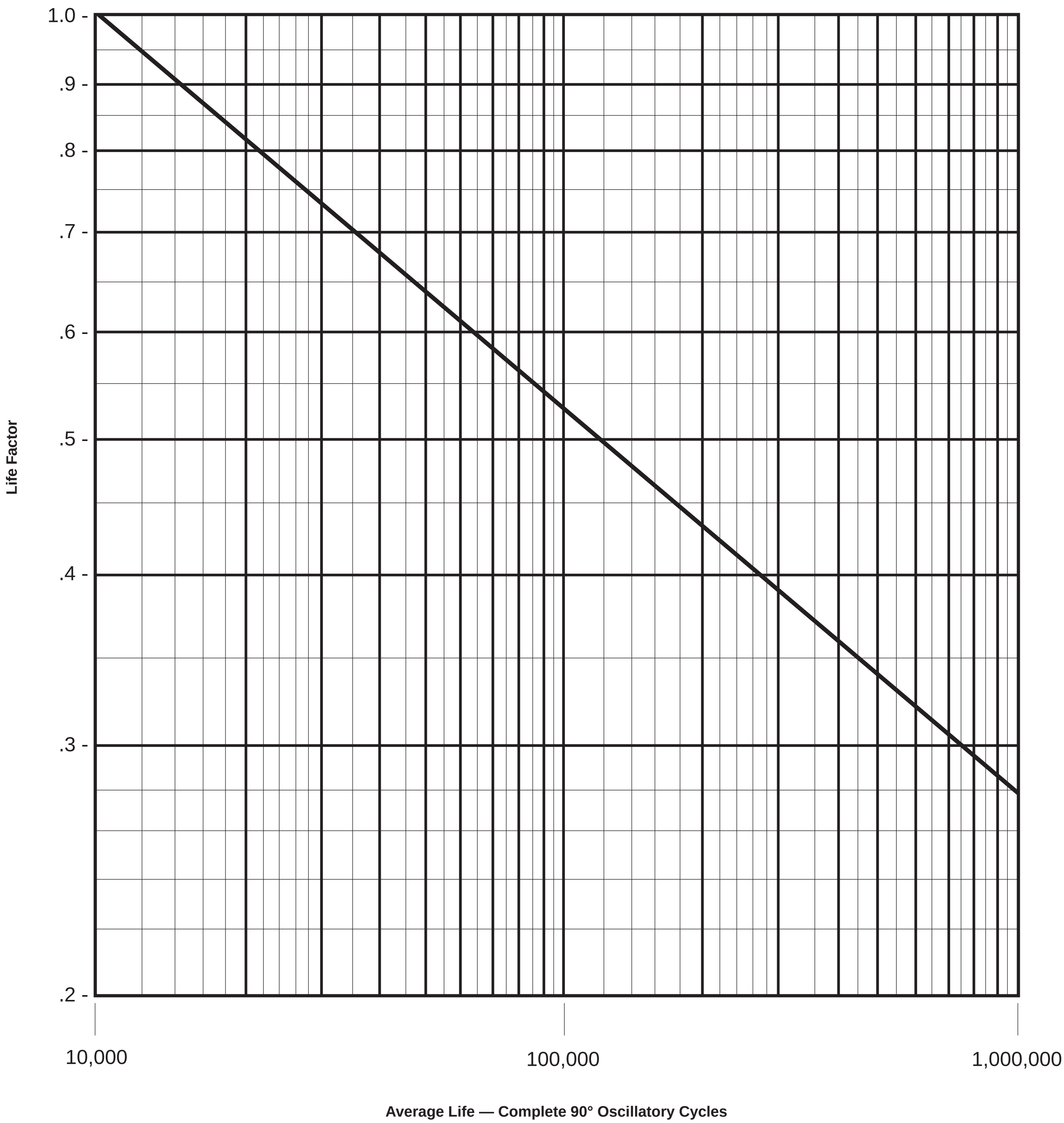
For another case let us keep this 1208 lb. Equivalent load and 2000 lb. Maximum load and select a bearing which would have a Case I average life requirement of 690,000 cycles. The Life Factor to give this life is .309 or the Case I raging must exceed 3910 (from 1208/.309). A KP5 or KP10A are the smallest bearing sizes in these series to satisfy this condition.



RATED RADIAL CAPACITIES

The rated radial capacities for complete rotation given in this catalog are based on AFBMA Standard Section 9, Method of Evaluating Load Ratings for Ball Bearings. The Life Basis is for 2500 hours average life at 100, 300 and 500 rpm. For other Life Basis and/or speed conditions, consult RBC.

LIFE FACTOR CHART



EXAMPLES OF BEARING SELECTION UNDER COMBINED LOADING CONDITIONS

Equivalent Limit Load – Combined Loading

When Radial Load, Thrust Load and Moment Load are encountered in combination (all three or any two) on a single bearing mounting, we obtain an equivalent thrust limit load and select an airframe bearing of a size having a thrust limit rating exceeding the equivalent thrust load. This is for static condition and disregards life requirements under oscillation.

The formula for an individual size of bearing follows here and footnotes under various series tables give approximations for sizes within a series with applicable approximate ratios of ratings given.

Equiv.

Thrust Load =

$$\frac{\text{Thrust Limit Load Rating}}{\text{Radial Limit Load Rating}} \text{ X Radial Load}$$

+ Thrust Load + Moment Constant

X Moment in Inch Pounds

As an example on a KP6A bearing

Equiv. Thrust Load = (1100/2500) X Radial Load

+ Thrust Load + 7.68 X Moment

Note that it is necessary to be dealing with a certain bearing size especially when moment is involved, and trial sizes are chosen having pure moment ratings larger than moment load involved to leave the capacity to be absorbed by radial and thrust components. If moment load is a big part of the loading, then it is necessary to select a bearing from a series having good moment ratings. When only radial and thrust loads are present, the problem is not so involved as any certain series has a fairly constant ratio of radial and thrust limit load ratings.

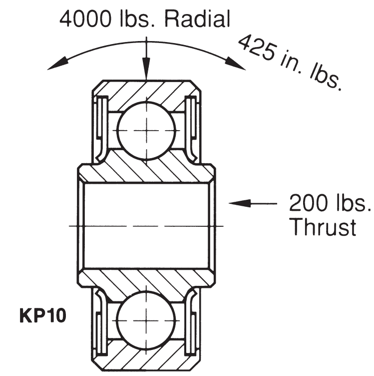
COMBINED LOADS INCLUDING MOMENT LOADS FOR SINGLE AND DOUBLE ROW BEARINGS

Note that the dynamic thrust load should not exceed 60% of the applied radial load for a full type bearing.

To Illustrate the use of the moment constants given in the load rating tables, here are two typical calculations.

Problem 1

We want to figure the Equivalent Thrust Load and the safety factor on a KP10 (Single Row) bearing in an application where the radial load imposed is 4000 lbs., the thrust load is 200 lbs., and the overturning moment load is 425 in. lbs.



Substituting in the formula:

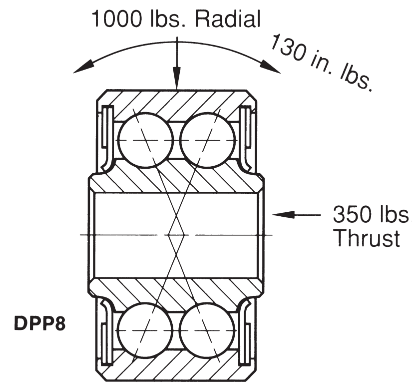
Equivalent Thrust Load = (.44 X 4000 lbs.) + 200 lbs.

+ (4.09 X 425 in. lbs.) = 3698 lbs.

Safety Factor =(6200 lbs./3698 lbs.) X 1.68

Problem 2

Consider a DPP8 (Double Row) bearing in an application where the loads imposed are as follow: 1000 lbs. Radial load, 350 lbs. Thrust load and an overturning moment load of 130 in. lbs.



Substituting in the formula:

Equivalent Thrust Load = (.3 X 1000 lbs.) + 350 lbs.

+ (13.2 X 130 in. lbs.) = 2366 lbs.

Safety Factor = (7800 lbs./2366 lbs.) X 3.30

TORQUE

Torque in ball bearings can be conveniently classified under two headings, Inherent Torque and Induced Torque.

Inherent Torque

The first, Inherent Torque, is the cumulative effect of the following factors:

Geometry: Surface finish of mating parts, deviations from roundness in the races, ball sphericity, and tolerances between functional surfaces.

Internal fit up: Race curvatures, contact angle, radial internal clearance, and number of balls.

Bearing type: Full complement, radial or angular contact, type of retainer, shields and seals, if any.

Lubricant: Type and quantity.

The term "Inherent Torque" is used to emphasize the nature of the torque due to the above causes. While the amount of torque in inch-ounces or gram-centimeters varies according to the degree of precision exercised in the manufacture of a bearing, a certain mean value is attained for each set of conditions, and that level of torque cannot practically be further reduced. The actual no-load, slow-speed Inherent Torque is very small compared with the torque induced by external causes during operation. At best, Inherent Torque is a comparative quality for bearing evaluation. Therefore, it is often measured with only a few drops of oil in the bearing. It is controlled almost entirely by the manufacturer rather than by the customer.

Induced Torque

The second category, Induced Torque, is the cumulative effect of the following factors, all of which are external in origin to the bearing:

Loads: Both the magnitude and direction of the loads.

Speeds: The variation of, and maximum rpm.

Fits: The shaft and housing fits, plus the alignment of shaft and housing.

Temperature: The effect on fits and lubricant properties.

Contamination: Both foreign matter which enters the bearing and by-products of lubricant breakdown within the bearing.

The term "Induced Torque" as used herein denotes torque resulting from the method of bearing operation and its environment. With the exception of very lightly loaded, slow-speed applications, Induced Torque far exceeds Inherent Torque in a ball bearing, by a factor of 50 or more. The customer, therefore, has the final control over how much torque the bearings he uses will exhibit. Reduction of Induced Torque is primarily the customer's responsibility.

Design Criteria

The designer or engineer who strives to achieve the lowest economical torque must begin his task before placing his order. The bearing manufacturer can furnish bearings with minimum Inherent Torque and the least potential for Induced Torque only if a complete description of the application is made available. Such description will include the following:

Speeds: Maximum; normal; acceleration if it is rapid.

Loads: Radial, axial or moment loading; magnitude; and relation to speed when possible.

Temperature: Minimum; maximum; normal operating; duration at extremes; shut-down conditions if soak-back is involved when the bearing is stationary; loads during high temperatures.

Lubrication: Whether grease or oil is required; if a circulating or splash-feed oil system is used, accurate determination of the quantity of oil available.

Materials: Specification of shaft and housing material and configurations; i.e., wall thickness, hollow, solid or splined shaft.

Environment: Specify if air, hot gases, fluids, dust, mud, etc. If a foreign substance, either a liquid or slurry, is present, indicate whether it is present continuously or only as a spray or occasional splashing.

Frequently an inquiry for a ball bearing application includes most of the above, but no drawing accompanies the data. Both a drawing and a complete description as outlined above are required to properly specify the bearing to be used.

Shaft and Housing Fits

Once the bearings are ordered, the designer must insure that the mating components are consistent with his requirements. Particularly, he must hold housing and shaft fits within specified limits and maintain close control on roundness of these two dimensions. Interference fits directly affect the internal clearance in ball bearings, as much as 50% to 80% of the interference translates into reduced radial internal clearance, depending on the size of the bearing involved. Paralleling this situation, unequal heating of the inner and outer rings can have the same effect. Frequently, both conditions exist simultaneously; a press fit on the shaft, and higher shaft temperatures than housing temperatures. The result can be an increase in bearing torque or even complete failure due to damage caused by internal interference. Heat soak-back can also damage bearings due to thermal expansion occurring while the bearing is not rotating.

Effect of Low Temperature

Very low temperature conditions can also cause torque to increase sharply. The increase results from a change in housing fits due to thermal contraction and is very pronounced with dissimilar metals such as aluminum housings and steel bearings. There is also a marked increase in lubricant viscosity, particularly with greases. An example is found in aircraft control bearings, which are frequently mounted in aluminum housings and sealed with a quantity of grease enclosed. During ground handling and take-off, there is no detrimental torque in the bearings. However, during extended cruise at altitudes where the air temperature drops to -65°F (-54°C) or lower, the bearing may be literally frozen, due to interference and/or stiffened lubricant. After returning to more normal temperatures, the bearing may operate satisfactorily if only the stiff grease caused it to freeze; however, if the housing interference was excessive, and the races are brinelled, subsequent operation will be rough and noisy.

Misalignment

Misalignment of the rotating member and the housing can cause high torque by applying a preload as the balls travel from one side of the race to the other during each revolution of the bearing. At sustained speeds, there is also a temperature rise, and the possibility of exceeding the load capacity of the lubricant. This condition, if self-sustaining, rapidly worsens to the point of bearing failure.

Loading

Torque in bearings increases directly as a function of load, either radial, axial, or a combination of the two. When loads are substantial, the designer should allow for the largest bearing possible, consistent with his overall requirements early in the design stage. High torque due to loading cannot be significantly reduced for a given size bearing.

Seals

In applications where low speeds or oscillation are involved and where seals are needed to protect the bearing and retain lubricant, it is essential that information relative to contaminants be included with the description of the application. A variety of materials are available for seals; however, each one is unique in its ability to resist chemical attack by lubricants, hydraulic fluids, etc., and in its physical characteristics such as flexibility. For a particular condition of temperature, lubricant, and outside contamination, there is usually only one specific seal material that will best satisfy all requirements. The standard seal material used in the RBC airframe control and rod end bearings is polytetrafluoroethelene (PTFE).

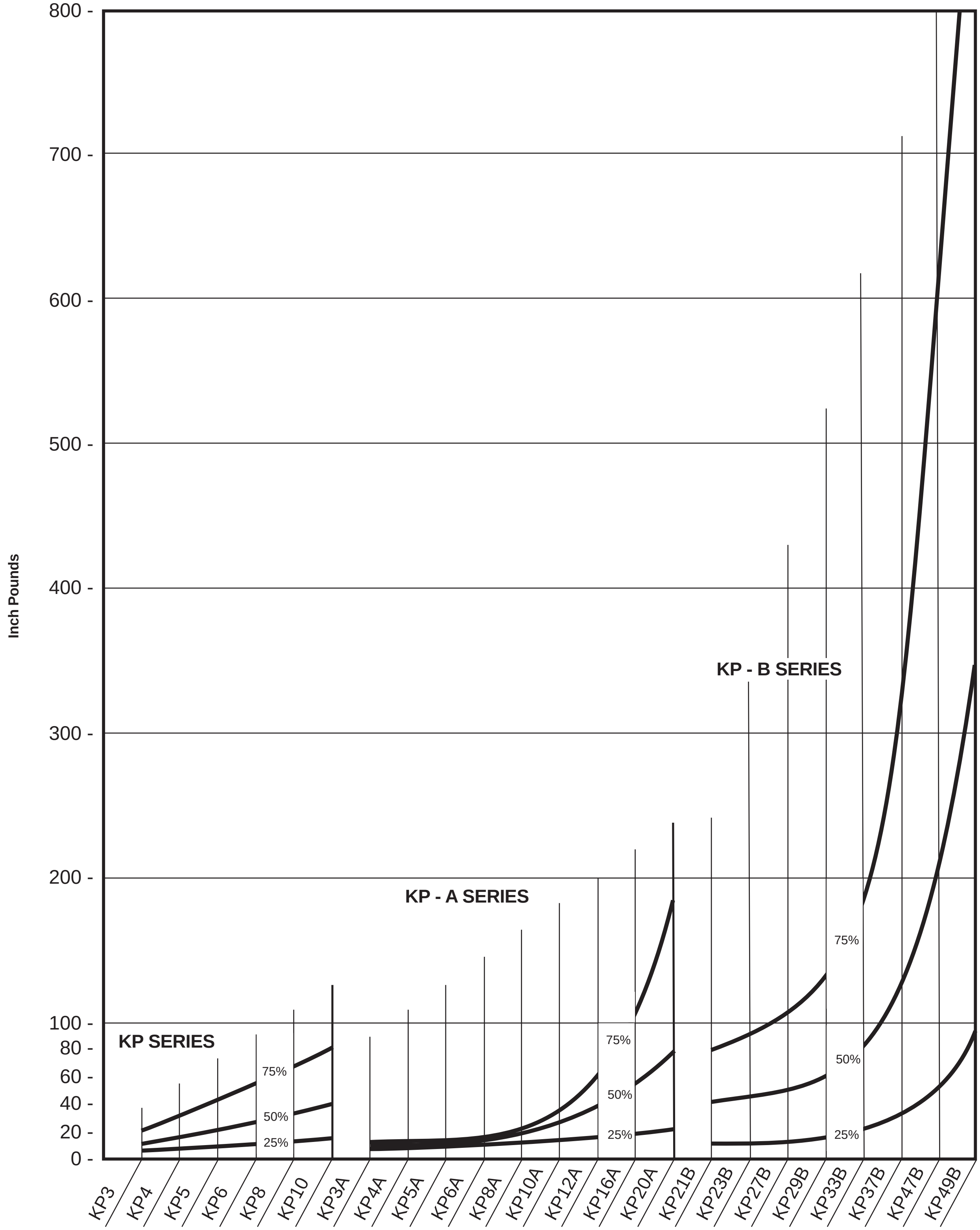
STARTING TORQUE LEVELS

Proper interpretation of the graph (page XX) on starting torque levels under radial loads requires that the user keep the following limitations in mind. The values were obtained under laboratory conditions with controlled fits, pure radial loading, and at room temperature. Therefore, the torque values are probably lower than what should be expected in airframe installations. The numerous other external factors which contribute to induced torque, as previously discussed, are not accounted for in the chart. For example, the effect of low temperature on starting torque due to grease stiffness varies widely. A KP3A bearing may show a 100% increase in starting torque at -65°F (-54°C), whereas a KP47B may show only about 10% greater torque, when both bearings are radially loaded to 75% of their rated capacity. Interference fits in housings, differential thermal expansion and contraction of steel bearings and aluminum housings, thrust loads, moment loads, etc., will all add significantly to the chart values for starting torque.

In applications where low torque is critical, consult RBC for recommendations, giving full particulars of the application.

STARTING TORQUE CHART

Note: This chart is intended only as a guide.



Representative Starting Torque Levels at 25%-50% and 75% of Radial Limit Load:
KP, KP-A, and KP-B Series

SAE-AS7949 SPECIFICATIONS

The airframe control bearings listed on the following pages are manufactured in accordance with the U.S. Government standards as set forth under the appropriate military specifications. The govern-ment specification covering the largest number of bearings is SAE-AS7949. Standards applicable under this specification and the bearing series to which they apply are shown below:

Table 1

RADIAL PLAY AND GREASE VARIATIONS FOR SAE-AS7949 BEARINGS

MS Series	Fafnir Series	Standard Radial Play MIL-G-81322 Grease		Reduced Radial Play MIL-G-81322 Grease		Standard Radial Play MIL-G-23827 Grease		Reduced Radial Play MIL-G-23827 Grease	
		MS Suffix	FAFNIR Suffix	MS Suffix	FAFNIR Prefix/Suffix	MS Suffix	FAFNIR Suffix	MS Suffix	FAFNIR Prefix/Suffix
27640 27641 27643 27645	KP KP-A DSP KSP	NONE	FS464	R	M/FS464	G	FS428	RG	M/FS428
27644 27646 27648 27649 21428	DPP B500DD KP-BS AW-AK MB500DD	NONE	FS464	N/A	N/A	G	FS428	N/A	N/A
27647 27642	DW KP-B(1)	NONE	FS464	R S(1)	M/FS464 FS464	L G	M/FS464	RL SG(1)	M/FS428 FS428

(1) MKP-B Series are used for MS27642 bearings with an S or SG suffix (MS27642-16S is Fafnir MKP-16B FS464)

COMPARISON OF INSPECTION LIMITS - STANDARD SERIES VERSUS PRECISION SERIES

Bearing Series		Standard KP, KP-A, KSP[4], KSP-A[4], DPP, DSP, DW, DSRP, GDSRP	Precision MKP, MKP-A, MKSP, MKSP-A, MDPP, MDSP, MDW, MDSRP	Standard KP-B and KP-BS	Precision MKP-B and MKP-BS	Standard B538(DD) thru B543(DD)	Precision MB538(DD) thru MB543(DD)	Standard B544(DD) and up	Precision MB544(DD) and up
		in. / mm	in. / mm	in. / mm	in. / mm	in. / mm	in. / mm	in. / mm	in. / mm
bore:	**ave. plus diam.**	0	0	.0000[1]	0	0.0007	0	0.001	0
	minus	0.0005	0.0003	.0010[1]	0.0005	0.0007	0.0005	0.001	0.0008
		0	0	0	0	0.018	0	0.025	0
		0.013	0.008	0.025	0.013	0.018	0.013	0.025	0.02
O.D.:	**ave. plus diam.**	0	0	0	0	0	0	0	0
	minus	0.0005	0.0004	0.001	0.001	0.001	0.0005	0.0015	0.0007
		0	0	0	0	0	0	0	0
		0.013	0.01	0.025	0.025	0.025	0.013	0.038	0.018
width:	**inner plus**	0	0	0	0	0	0	0	0
	minus	0.005	0.0025	0.005	0.0025	0.005	0.0025	0.005	0.0025
		0	0	0	0	0	0	0	0
		0.13	0.064	0.13	0.064	0.13	0.064	0.13	0.064
width:	**outer plus**	0	0	0	0	0	0	0	0
	minus	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
		0	0	0	0	0	0	0	0
		0.13	0.013	0.13	0.13	0.13	0.13	0.13	0.13
parallelism:	**inner**	0.0008	0.0005	0.0008	0.0004	0.0008	0.0004	0.0008	0.0004
	outer	0.0008	0.0005	0.0008	0.0004	0.0008	0.0004	0.0008	0.0004
		0.02	0.013	0.02	0.01	0.02	0.01	0.02	0.01
		0.02	0.013	0.02	0.01	0.02	0.01	0.02	0.01
squareness:	**inner**	0.001	0.0005	0.001	0.0005	0.001	0.0005	0.001	0.0005
	outer	0.001	0.0005	0.001	0.0005	0.001	0.0005	0.001	0.0005
		0.025	0.013	0.025	0.013	0.025	0.013	0.025	0.013
		0.025	0.013	0.025	0.013	0.025	0.013	0.025	0.013
radial eccent:	**inner**	0.001	0.0005	0.001	0.0008	0.002	0.0008	0.002	0.0008
	outer	0.0016	0.0008	0.0016	0.0008	0.0016	0.0008	0.0016	0.0008
		0.025	0.013	0.025	0.02	0.05	0.02	0.05	0.02
		0.04	0.02	0.04	0.02	0.04	0.02	0.04	0.02
face runout:	**inner**	0.001	0.0007	0.001	0.0008	0.002	0.0008	0.002	0.0008
	outer	0.0016	0.001	0.0016	0.001	0.0016	0.0008	0.0016	0.0008
		0.025	0.018	0.025	0.02	0.05	0.02	0.05	0.02
		0.04	0.025	0.04	0.025	0.04	0.02	0.04	0.02
internal fit:	**radial**	0.0004	0.0002	0.0003	0.0001	0.0008	0.0001	0.0008	0.0001
	Internal	.0010(2)	0.0005	.0010(3)(5)	0.0005	0.0018	0.0005	0.0018	0.0005
	clearance	0.01	0.005	0.01	0.003	0.02	0.003	0.1	0.003
		0.025	0.013	0.025	0.013	0.045	0.013	0.15	0.013

(1) All bore and O.D. tolerances including those for MKP-B are referred to the nominal fractional dimensions except the bores of the KP-B and KP-BS series whose "nominal" dimensions are .0005:, .013mm above the nominal fractional dimension.

(2) For reduced internal radial play of .0002" / .0005", .005mm / .013mm use FS464R after bearing number.

(3) For reduced internal radial play of .0001" / .005", .003mm / .013mm use FS464R after bearing number.

(4) Radial play for KSP and KSP-A series is .0000" / .0010".

(5) Radial play for KP52B and KP52BS thru KP96B and KP96BS is .0003" / .0015".

Note: Not all sizes are in production. We will make most sizes as demand justifies tooling.

SHAFT AND HOUSING FITS FOR AIRFRAME BEARINGS

It is essential for proper operation that small, heavily loaded bearings in oscillating service be mounted in housings with a light but positive interference (press) fit. Staking or spinning of the housing over the outer ring chamfer is recommended to secure the bearing axially. In some applications involving considerable thrust load a housing shoulder is desirable.

Minimum and Maximum Fits

The minimum and maximum press fits shown in the following tables represent a compromise condition. Actually, the optimum press fit is approximately .0005", .013mm for steel and approximately .0007", .018mm for aluminum or magnesium. However, since the bearing outside diameter tolerance is .0005", .013mm and a housing bore tolerance of .0005", 013mm is the least which can be maintained by usual manufacturing practice, a total possible range of fit of .0010", .025mm results. The average outside diameter pressed into the average housing bore results in a press fit range of approximately .0006", .015mm; viz., for steel .0002" - .0008", .005mm - .020mm and for aluminum or magnesium .0005" - .0010", .010mm - .025mm. Housing bores should not be allowed to run consistently to the low side of the tolerance, as this will obviously increase the average interference and raise the percentage of extreme fits.

SHAFT AND HOUSING FITS FOR OSCILLATORY SERVICE
AW-AK, KP, KP-A, KSP, KSP-A, DPP, DPP-W, DSP, DSRP, GDSRP, DW, GDW, P SERIES
Housing Fits — Standard Series

Bearing O.D.	Steel Housing Bore	Mean Fit Tight	Aluminum or Magnesium Housing Bore	Mean Fit Tight	Bearing O.D.	Steel Housing Bore	Mean Fit Tight	Aluminum or Magnesium Housing Bore	Mean Fit Tight
in. / mm	in. / mm	in. / mm	in. / mm	in. / mm	in. / mm	in. / mm	in. / mm	in. / mm	in. / mm
0.6250	0.6245	0.0005	0.6243	0.0007	1.2500	1.2495	0.0005	1.2493	0.0007
0.6245	0.6240		0.6238		1.2495	1.2490		1.2488	
15.875	15.862	0.013	15.857	0.018	31.750	31.737	0.013	31.732	0.018
15.862	15.849		15.844		31.737	31.724		31.719	
0.7500	0.7495	0.0005	0.7493	0.0007	1.3750	1.3740	0.0005	1.3743	0.0007
0.7495	0.7490		0.7488		1.3740	1.3745		1.3738	
19.050	19.037	0.013	19.032	0.018	34.925	34.912	0.013	34.907	0.018
19.037	19.024		19.019		34.912	34.899		34.894	
0.7774	0.7769	0.0005	0.7767	0.0007	1.4375	1.4370	0.0005	1.4368	0.0007
0.7769	0.7764		0.7762		1.4370	1.4365		1.4363	
19.746	19.733	0.013	19.728	0.018	36.512	36.499	0.013	36.495	0.018
19.733	19.720		19.715		36.499	36.486		36.482	
0.8125	0.8120	0.0005	0.8118	0.0007	1.6250	1.6245	0.0005	1.6243	0.0007
0.8120	0.8115		0.8113		1.6245	1.6240		1.6238	
20.638	20.625	0.013	20.620	0.018	41.275	41.262	0.013	41.257	0.018
20.625	20.612		20.607		41.262	41.249		41.244	
0.8750	0.8745	0.0005	0.8743	0.0007	1.6875	1.6870	0.0005	1.6868	0.0007
0.8754	0.8740		0.8738		1.6870	1.6865		1.6863	
22.225	22.212	0.013	22.207	0.018	42.862	42.849	0.013	42.845	0.018
22.212	22.199		22.194		42.849	42.836		42.832	
0.9014	0.9009	0.0005	0.9007	0.0007	1.9375	1.9370	0.0005	1.9368	0.0007
0.9009	0.9004		0.9002		1.9370	1.9365		1.9363	
22.896	22.883	0.013	22.878	0.018	49.212	49.199	0.013	49.195	0.018
22.883	22.870		22.865		49.199	42.186		49.182	
1.0625	1.0620	0.0005	1.0618	0.0007	2.0000	1.9995	0.0005	1.9999	0.0007
1.0620	1.0615		1.0613		1.9995	1.9990		1.9988	
26.988	26.975	0.013	26.970	0.018	50.800	50.787	0.013	50.782	0.018
26.975	26.962		26.957		50.787	50.774		50.769	
1.1250	1.1245	0.0005	1.1243	0.0007	2.2500	2.2495	0.0005	2.2493	0.0007
1.1245	1.1240		1.1238		2.2495	2.2490		2.2488	
28.575	28.562	0.013	28.557	0.018	57.150	50.137	0.013	57.132	0.018
28.562	28.546		28.544		57.137	57.124		57.119	
1.1875	1.1870	0.0005	1.1868	0.0007					
1.1870	1.1865		1.1863						
30.162	30.149	0.013	30.145	0.018					
30.149	30.136		30.132						

Shaft Fits – Standard Series

For oscillating service where bearings are not mounted on standard aircraft bolts, and are not clamped axially on shafts, it is recommended that shaft diameters from nominal bearing bore size -.0005" (-.013mm) to nominal bearing bore size -.0010" (.025mm) be used.

Radial Clearance

In all but specially assembled aircraft bearings, a small amount (less than .0010", .025mm) of radial clearance is provided between balls and races. When the outer ring is press-fitted into a housing, a portion of the interference is absorbed bycontraction of the outer ring, the balance by the expansion of the housing – the proportions depending on the relative sections and the modulus of elasticity of the material.

When the press fit becomes too heavy, the initial radial clearance in the bearing may be removed, resulting in a radially preloaded bearing. Such preloading lessens the capacity of the bearing for applied loads. Hence, excessive press fits should be carefully avoided.

Mean Fits (Tight or Loose)

The expected mean fits listed in the tables result when bearings are mounted on shafts and in housings having the recommended diameters. In the manufacture of ball bearings, most of the bores and outside diameters are near the mean diameter of the tolerance. Similarly, the majority of shafts and housings are held to diameters near the mean of the recommended tolerances. Experience has shown that when standard bearings are mounted on shafts and in housings, the diameters of which are held to recommended tolerances, 85% to 90% of the assemblies will be close to the mean expected fits, and less than 2% will be near the extremes for tightness and looseness.

Although selective assembly is not feasible in most aircraft plants, when extreme fits are encountered, as evidenced by pronounced drag in bearing rotation after mounting, it is recommended that the bearing be removed and fitted to a slightly larger housing bore. This is seldom necessary with rigid type bearings but may be desirable with self-aligning bearings.

MKP, MKP-A, MKSP, MKSP-A, MDPP, MDSP, MDW(K) SERIES
Housing Fits – Precision M Seriess

Bearing O.D.	Steel Housing Bore	Mean Fit Tight	Aluminum or Magnesium Housing Bore	Mean Fit Tight	Bearing O.D.	Steel Housing Bore	Mean Fit Tight	Aluminum or Magnesium Housing Bore	Mean Fit Tight
in. / mm	in. / mm	in. / mm	in. / mm	in. / mm	in. / mm	in. / mm	in. / mm	in. / mm	in. / mm
0.6250	0.6246	0.00045	0.6244	0.00065	1.2500	1.2496	0.00045	1.2494	0.00065
0.6246	0.6241		0.6239		1.2496	1.2491		1.2489	
15.875	15.865	0.0115	15.860	0.0165	31.750	31.740	0.0115	31.735	0.0165
15.865	15.852		15.847		31.740	31.727		31.722	
0.7500	0.7496	0.00045	0.7494	0.00065	1.3750	1.3746	0.00045	1.3744	0.00065
0.7496	0.7491		0.7489		1.3746	1.3741		1.3739	
19.050	19.040	0.0115	19.035	0.0165	34.925	34.915	0.0115	34.910	0.0165
19.040	19.027		19.072		34.915	34.902		34.897	
0.7774	0.7770	0.00045	0.7768	0.00065	1.4375	1.4371	0.00045	1.4369	0.00065
0.7770	0.7765		0.7763		1.4366	1.4366		1.4364	
19.746	19.736	0.0115	19.731	0.0165	36.512	36.502	0.0115	36.497	0.0165
19.736	19.723		19.718		36.502	36.489		36.484	
0.8125	0.8121	0.00045	0.8119	0.00065	1.6250	1.6246	0.00045	1.6244	0.00065
0.8121	0.8116		0.8114		1.6246	1.6241		1.6239	
20.638	20.628	0.0115	20.622	0.0165	41.275	41.265	0.0115	41.260	0.0165
20.628	20.615		20.609		41.265	41.252		41.247	
0.8750	0.8746	0.00045	0.8744	0.00065	1.6875	1.6871	0.00045	1.6869	0.00065
0.8746	0.8741		0.8739		1.6871	1.6866		1.6864	
22.225	22.215	0.0115	22.210	0.0165	42.862	42.852	0.0115	42.847	0.0165
22.215	22.202		22.197		42.852	42.839		42.834	
0.9014	0.9010	0.00045	0.9008	0.00065	1.9375	1.9371	0.00045	1.9369	0.00065
0.9010	0.9005		0.9003		1.9371	1.9366		1.9364	
22.896	22.886	0.0115	22.880	0.0165	49.212	49.202	0.0115	49.197	0.0165
22.886	22.873		22.867		49.202	49.189		49.184	
1.0625	1.0621	0.00045	1.0619	0.00065	2.0000	1.9996	0.00045	1.9994	0.00065
1.0621	1.0616		1.0614		1.9996	1.9991		1.9889	
26.988	26.978	0.0115	26.972	0.0165	50.800	50.790	0.0115	50.785	0.0165
26.978	26.965		26.959		50.790	50.777		50.782	
1.1250	1.1246	0.00045	1.1244	0.00065	2.2500	2.2496	0.00045	2.2494	0.00065
1.1246	1.1241		1.1239		2.2496	2.2491		2.2489	
28.575	28.565	0.0115	28.560	0.0165	57.150	57.140	0.0115	57.135	0.0165
28.565	28.552		28.547		57.140	57.127		57.122	
1.1875	1.1871	0.00045	1.1869	0.00065					
1.1871	1.1866		1.1864						
30.162	30.152	0.0115	30.147	0.0165					
30.152	30.139		30.134						

Shaft Fits – Precision M Series

For oscillating service where bearings are not mounted on standard aircraft bolts, and are not clamped axially on shafts, it is recommended that shaft diameters from nominal bearing bore size -.0003" (-.008mm) to nominal bearing bore size -.0008" (.020mm) be used.