PLAIN BEARINGS ENGINEERING

RBC offers many types and sizes of plain bearings to the aerospace industry. Both metal-to-metal and self-lubricating bearings are featured in this catalog. These bearings have been qualified to stringent SAE, Military, NAS, AECMA, and customer design and performance standards in RBC test laboratories.

For information on special plain bearings or the many standard series of commercial plain bearings, that are available from RBC, consult the appropriate RBC Aerospace Bearings sales engineer.

The RBC bearing series, which apply to various standards are shown below:

SAE/MS/EN

Specification	Description
M81934/1	Journals, Plain, Self-lubricating
M81934/2	Journals, Flanged, Self-lubricating
M81935/1	Rod End, Male threads, Wide, Self-lubricating
M81935/2	Rod End, Female threads, Wide, Self-lubricating
M81935/4	Rod End, Male threads, Narrow, Self-lubricating
M81935/5	Rod End, Female threads, Narrow, Self-lubricating
MS14101	Spherical bearings, Self-lubricating, Narrow, Grooved
MS14102	Spherical bearings, Self-lubricating, Wide, Chamfered
MS14103	Spherical bearings, Self-lubricating, Wide, Grooved
MS14104	Spherical bearings, Self-lubricating, Narrow, Chamfered
MS21230	Spherical bearing, Self-lubricated, Wide, Grooved
MS21231	Spherical bearing, Self-Lubricated, Wide, Chamfered
MS12132	Spherical bearing, Self-Lubricated, Narrow, Grooved
MS21233	Spherical bearing, Self-Lubricated, Narrow, Chamfered
M81820/1	Spherical bearing, Self-lubricating, Narrow, Grooved, Lined bore
M81820/2	Spherical bearing, Self-lubricating, Wide, Chamfered, Lined bore
M81820/3	Spherical bearing, Self-lubricating, Wide, Grooved, Lined bore

SAE/MS/EN

Specification	Description
M81820/4	Spherical bearing, Self-lubricating, Narrow, Chamfered, Lined bore
M81936/1	Spherical bearing, BeCu ball grooved outer ring
M81936/2	Spherical bearing, BeCu ball chamfered outer ring
EN2285	Journals, Plains, Self-lubricating aluminum alloy
EN2286	Journals, Flanged, Self-lubricating aluminum alloy
EN2287	Journals, Plain, Self-lubricating corrosion resistant steel
EN2288	Journals, Flanged, Self-lubricating corrosion resistant steel
EN6056	Rod End, Self-lubricating, Threaded shank
EN2022	Spherical bearing, Self-lubricated, Light series, Chamfered and grooved
EN2023	Spherical bearing, Self-lubricated, Standard series, Chamfered and grooved outer ring
EN2335	Spherical bearing, Metal-to-metal, Chamfered and grooved outer ring
EN2501	Spherical bearing, Self-Lubricated, High Misalignment
EN4613	Spherical bearing, Self-lubricating, Narrow inch sizes
EN4614	Spherical bearing Self-lubricated, Wide inch sizes

PLAIN BEARINGS

CONFIGURATIONS

Spherical bearings, shown in this catalog, are assembled by forming the outer ring (race) over the inner ring (ball). The processes used by RBC assure excellent conformity of the spherical surfaces of the outer ring bore to the spherical inner ring O.D.

Rod Ends in this catalog have several different designs and options. Rod ends are manufactured by inserting an MS or EN self-lubricating bearing into the rod end body. Rod ends are available with right or left-handed, male-threaded or female-threaded shanks. Male-threaded shanks are also available with keyway slots and female threads are available with end slots for locking devices.

Journal Bearings are offered in both flanged and non-flanged versions. In this catalog the journal bearings are all self-lubricating.

Loader Slot Bearings are spherical metal-to-metal bearings for specific applications. In this design, loading slots are machined into the outer ring so that the inner ring may be inserted. See Figure 1 for the configuration of slot loader bearings.

FIGURE 1: Loader Slot Bearing

Split Ball Spherical Bearings are another special type of spherical bearing. See Figure 2 for the configuration of the spit ball spherical bearing.

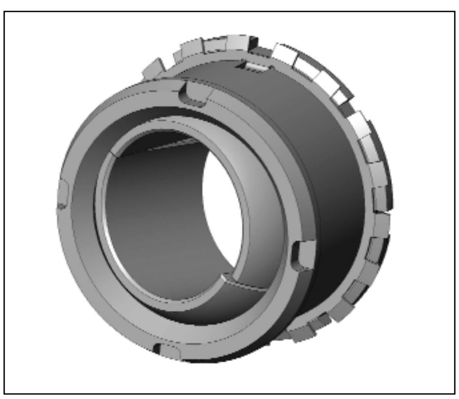


FIGURE 2: Split Ball Spherical Bearing

Links are available in many configurations for special customer applications. Since each link design is unique, many design options are possible, including high temperature liners and light weight materials such as aluminum and titanium. See Figure 3 for a typical aircraft link design.

FIGURE 3: Typical Aircraft Link

METAL-TO-METAL BEARINGS

Metal-to-metal bearings are primarily used where grease maintenance is practical or where temperatures exceed the limits for self-lubricating bearings. In this aerospace catalog, metal-to-metal bearings are shown for the spherical bearing configuration only. These bearings are available with grooves and holes so that they may be re-lubricated.

Metal-to-metal, spherical bearings have 17-4PH outer rings and beryllium copper inner rings (balls). The properties of 17-4PH, which make it an excellent choice for bearing outer rings (races), are its ability to resist wear, abrasion, and galling. Also, the corrosion resistance of 17-4PH is excellent when compared to other hardenable CRES steels. Beryllium copper is used for the inner rings (balls) because of its high strength and hardness, and because it is highly resistant to stress relaxation, fatigue, abrasion, and corrosion. Dry-film lubricants, which are bonded to the outer ring, are used for high temperatures, and greases such as MIL-PRF-81322 are used for temperatures up to 350°F (177°C).

The mean coefficient of thermal expansion for beryllium copper in the +70°F to +400°F (+21°C to +204°C) temperature range is 9.4 x 10-6 inches per inch per °F (16.9 x 10-6 mm per mm per °C). This is approximately 33% higher than that of 17-4PH. Therefore, care must be taken to review clearances between the bearing bore and shaft and also between the inner and outer rings, so that bearing lock up will not occur at elevated temperatures.

For some MS rod end bodies, PH13-8Mo is an option. This material offers better fatigue life and corrosion resistance than 17-4PH. Other series of metal-to-metal bearings are available with outer rings manufactured from cadmium plated 4340 steel, aluminum bronze, cadmium plated aluminum bronze and 17-4PH CRES steel. Inner rings are available in CRES 440C steel, chrome plated 440C, and chrome plated 52100 steel. Consult the appropriate RBC Aerospace Bearings engineering department for the best materials for your special applications.

SELF-LUBRICATING BEARINGS

Self-lubricating bearings are available in spherical, journal, flanged journal, and rod end bearing configurations. They were originally developed to eliminate the need for relubrication, to provide lower torque, and to solve application problems where conventional metal-to-metal bearings would not perform satisfactorily; such as with high frequency vibration.

The liner systems for self-lubricating bearings do not require supplemental lubrication. The polytetrafluoroethylene (PTFE) fibers in the liner act as the lubricant. When a bearing is operated, the pressure and movement of the inner ring shears PTFE from the liner system. As the bearing operates, the PTFE is burnished into the metal and also into the liner surfaces, thereby reducing the coefficient of friction. After the coefficient of friction becomes sufficiently low, no further PTFE is sheared from the liner. Through continued use, some PTFE on the surfaces may exit the bearing. When this occurs, friction increases and more PTFE is sheared from the liner and deposited on the ring and liner surfaces.

Self-lubricating spherical bearings are available in many combinations of ring and liner materials. Typically, inner rings (balls) used in SAE/Military Standards are 440C or PH13-8Mo, and outer rings (races) are 17-4PH. High temperature materials are also available.

Self-lubricating journal bearings are available with a variety of backing materials. Standard materials for SAE/Military standards include 17-4PH CRES steel and 7075-T6 and 2024-T851 aluminum alloys.

Rod ends have the bodies manufactured from 17-4PH or PH13-8Mo CRES steel or cadmium plated 4340 steel.

Light weight rod ends and spherical bearings are now being offered by RBC with titanium components to meet demanding aerospace application requirements.

LINER SYSTEMS

RBC provides five standard liner systems, that are qualified to SAE and AECMA performance standards. These are shown in Table 1 below:

Bearing Configuration	Standard Liner Systems
Spherical	Uniflon® E
	Fabroid® IIG2
	Fibriloid®
Journal	Uniflon® E
	Fiberglide® V
	Fabroid® IIG2
	Fibriloid®
	Uniflon® HP
Rod end	Uniflon® E
	Fabroid® IIG2
	Fibriloid®

TABLE 1: Standard RBC liner systems

RBC Bearings manufactures four different self-lubricating liner materials that are qualified to AS81820. In addition, over 60 other self-lubricating materials are available for specific characteristics; such as high temperature for turbine engine applications or machinability for airframe, helicopter, and landing gear applications.

The construction of most RBC liner systems revolves around a woven fabric where PTFE fibers are woven with other supporting and bondable fibers. The process used to produce the PTFE fibers results in a fiber, which has 25 times the tensile strength of that of the base resin. The weave of the fabric exposes the PTFE fibers on the working surface. The supporting fibers are interwoven with the PTFE fibers and are predominantly exposed on the surface that is bonded. This construction provides a positive locking of the PTFE fibers for strength and resistance to cold flow. It also provides a high strength bond to the backing material of the bearing.

Figure 4 depicts the basic liner system used for Fiberglide® and Fabroid® liners. In this system the entire fabric structure is flooded with resin, which locks the fibers in place. Then the liner is bonded to the outer ring, or backing material, with an adhesive resin. This type of liner system is referred to as a flooded liner, since the working surface of the fabric is flooded with binding resin. It provides a positive locking of the PTFE fibers for strength and resistance to cold flow; a bearing surface, that is almost entirely PTFE; and a high strength surface, that is bonded to the backing material of the bearing.

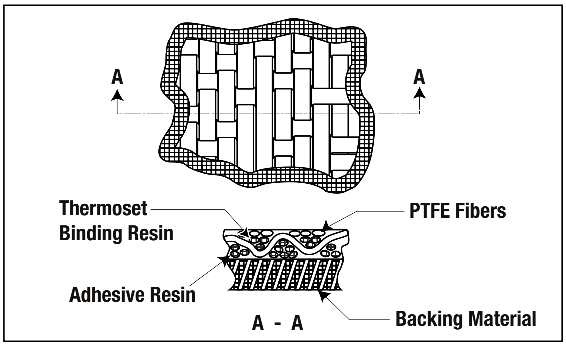


FIGURE 4: Fiberglide® and Fabroid® liner systems

Figure 5 depicts the construction of the Uniflon® E and Fibriloid® liner systems. This system is a flooded type of composite material with a thermoset resin binding the fibers in position. A thermoset adhesive resin is used to bond the liner to the outer ring or to the backing material. The interwoven fibers in this case are mainly to provide structural strength. Additives to the thermoset resin provide the lubrication. This construction provides exceptional strength and wear resistance.

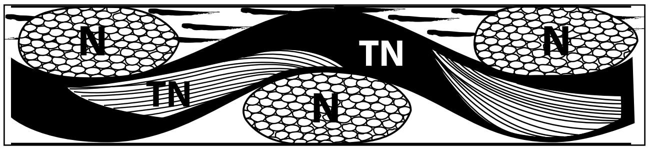


FIGURE 5: Uniflon® E and Fibriloid® liner systems

There are eight liner systems presented in this catalog (and many others for special application).

Uniflon® E liner system. The Uniflon® E liner system comprises of a heat stabilized nylon polyamide fabric that is coated with a high temperature resin containing PTFE particles. The fabric provides high compressive strength while the resin/PTFE wear coating provides the low coefficient of sliding friction. The bond side of the liner is coated with a high temperature resin only. This liner system was developed for airframe control applications and to meet the low wear requirements and high bearing pressures of the SAE AS81820 bearing specification (formerly MIL-B-81820).

Fiberglide® V liner system is a flooded liner system constructed of PTFE fibers interwoven with polyester fibers. The fabric is flooded with a phenolic thermoset resin. This system is ideally suited for demanding helicopter applications, where high oscillating speeds are encountered along with moderate impact or reverse loading. This system is highly fatigue resistant and able to absorb vibration.

Fabroid® IIG2 liner system is a flooded liner system. The fabric is a satin weave of PTFE fibers interwoven with glass fibers. The fabric is flooded with a modified thermoset resin. This system is the most widely accepted self-lubricating liner system in the aerospace industry, and is used on a wide variety of fixed wing aircraft applications. This system provides high speed oscillation capability under moderate loads with low wear rates.

Uniflon® HP is an advanced polymer resin system that is combined with a structural and self-lubricating additive to yield a high strength, low wear, and low friction bearing material. Since the material is homogeneous from bearing surface to substrate, it can be machined by the customer to their own demanding requirements. Uniflon® HP is also specially suited for coating unique part geometries and for other special applications. (At the time of catalog printing, the Uniflon® HP liner system is pending approval to the AS81934 specification.)

Fibriloid® liner system is constructed of interwoven compound fiber bundles of PTFE and polyamide fibers. The fabric is flooded with a thermoset resin. Fibriloid® is recognized as the strongest and most fatigue resistant bearing liner system in the aerospace industry. This proprietary system is covered by US Patent numbers 3,037,893 and 3,582,166. Characteristics of this liner system include very low wear rates at high psi loads, excellent temperature capability, and fatigue resistance in pounding or reverse load conditions.

Fabroid® X is a special liner system, that is engineered for very high temperature and high frequency vibration applications. Gas turbine engines and nacelles are examples of applications where Fabroid® X excels in performance.

Fiberglide® VI is a special liner system that is fine tuned to support reversing loads with low friction; Because of its low coefficient of friction, Fiberglide® VI is used in manual control linkages and in helicopter pitch link applications. The **Dyflon®** liner material is machinable and resistant to water/salt water/grease environments.

Special liner materials are also available and are engineered to provide optimum life in specific applications. For more technical data on these special liner systems, consult the appropriate RBC Aerospace Bearings engineering department.

PERFORMANCE CHARACTERISTICS

Radial Static Limit loads shown in this catalog are the ratings based on the requirements of SAE and Military specifications, such as SAE AS81820 (formerly MIL-B-81820). They are the maximum static radial loads that can be applied to the bearings, which will result in a maximum permanent set of 0.003 in. (0.076 mm) after three minutes of loading. It should be noted that for -3 and -4 size spherical bearings the static load rating is limited due to deflection/bending of the mounting pin. The Static Radial Limit loads that can be supported by the RBC liner systems in aerospace bearings are shown in Table 2 below.

RADIAL STATIC LIMIT LOAD RATINGS		
Liner System	**Load, psi**	**Load, MPa**
Fiberglide® V	60,000	410
Fabroid® IIG2	60,000	410
Uniflon® E	80,000	550
Fibriloid®	80,000	550
Uniflon® HP	160,000*	1100

*.0015 in. permanent set

TABLE 2: Static Limit Load Ratings in pounds per square inch (Megapascals) for RBC liner systems

The radial static limit load of a spherical bearing may be calculated using the following formula:

Radial static limit load = 0.85 x d x H x ML

Where: d = Ball spherical diameter
H = Outer ring width
ML = Max. load, psi (MPa)

The radial static limit load for journal bearings may be calculated using the following formula:

Radial Static Limit Load = B x (L- .100 in.) x ML

Where: B = Inner Diameter
L = Length
ML = Max. Load, psi (MPa)

For rod ends, the radial static limit load is based on the strength of the rod end body.

Radial static ultimate load ratings are 1.5 times the radial static limit load rating.

Axial Static Limit loads (spherical bearings) shown in this catalog are the maximum static axial loads that will result in a maximum permanent axial deformation of 0.005 in. (0.127 mm) after three minutes of loading. It may be calculated using the following formula:

$$\text{Axial static limit load} = \pi \times H^2 \div 4 \times ML$$

Where: H = Outer ring width
ML = Max. load, psi (MPa)

Oscillating load ratings given in the tables of this catalog are also based on the requirements of SAE, Military, and EN specifications. To meet this standard, bearings must have less than 0.0045 in. (.127 mm) wear when tested for 25,000 cycles at +/-25° of oscillation and 10 cycles per minute.

Radial oscillating load ratings may be calculated using the same radial projected area formula as used to calculate the radial limit load. The maximum load in psi for the oscillating load rating is shown in the Table 3 below.

RADIAL OSCILLATING LOAD RATINGS		
Liner System	**Load, Psi**	**Load, MPa**
Fiberglide® V	30,000	207
Fabroid® IIG2	30,000	207
Uniflon® E	37,500	258.5
Fibriloid®	37,500	258.5
Uniflon® HP	37,500	258.5

TABLE 3: Oscillating Load Ratings

Wear rate or bearing life is the most difficult area to define for lined bearings because of the variety of operating conditions in which these bearings operate. Life under controlled laboratory test conditions can be predicted fairly accurately. In actual applications, variations in load, speed, angle of oscillation, temperature, contamination, and other environmental conditions all affect wear. The air frame control liner systems shown herein are generally intended for high load, low speed aircraft applications as specified in the SAE, Military, and EN specifications. RBC has other liner systems for special applications, such as high speed and high temperature. Wear/life and PV data can be used to determine if a particular liner system should meet the requirements of a particular application. These curves are based on laboratory data and, therefore, specific operational and environmental conditions should be analyzed for each application.

Pressure (P) times velocity (V) or PV values are shown in Table 4 for the RBC liner systems. Many factors can affect PV, such as load, speed, surface finish, and material, and much of the test data is for slow speed, high load aerospace applications. Therefore, RBC has shown conservative PV values for the liner systems in Table 4. Short PV excursions up to 150% of the values shown can usually be applied without a detrimental effect on the bearing.

RADIAL OSCILLATING LOAD RATINGS			
Liner System System	**Typ. Dynamic P(lbs./Sq. in.)**	**Maximum V (ft/min)**	**Continuous PV**
Fibriloid®	15,000-40,000	10	75,000
Fabroid® IIG2	5,000-25,000	15	60,000
Fiberglide® V	2,000-20,000	18	35,000
Uniflon® E	5,000-40,000	12	80,000
Uniflon® HP	5,000-40,000	10	75,000

TABLE 4: PV values for RBC liner systems

To determine the actual PV for a specific spherical bearing application P (psi or MPa) and V (feet per minute or meters per minute) may be determined as follows:

$$P = \text{Radial load} / 0.85 \times d \times H$$

and

$$V = (4 \times A \times CPM / 360)(d \times \pi / 12)$$

Where: d = Ball spherical diameter
H = Outer ring width
A = Angle of oscillation
CPM = Frequency of oscillation in cycles per minute

Please note that for journal bearings the same formulae may be used except that the 0.85 (% factor) is eliminated and that "L" replaces "H". The angle of oscillation is the angular movement of a bearing inner ring from its neutral or start position. If the angle of oscillation is 25°, a complete cycle will be 100°, because the inner ring moves from the neutral position to +25°, back to neutral, to -25° and back to neutral again. In the above formula for V, the angle of oscillation has been multiplied by 4 to account for the complete travel of the inner ring in 1 full cycle.

Surface velocity of self-lubricated bearings is limited to moderate speeds because the liner systems are not thermally conductive, and the generated heat must be allowed to dissipate. Applications with intermittent high speed are acceptable, if the duty cycle or fluid environments allows for adequate heat dissipation.

Wear rates for the RBC liner systems are shown in Figures 6 and 7 below.

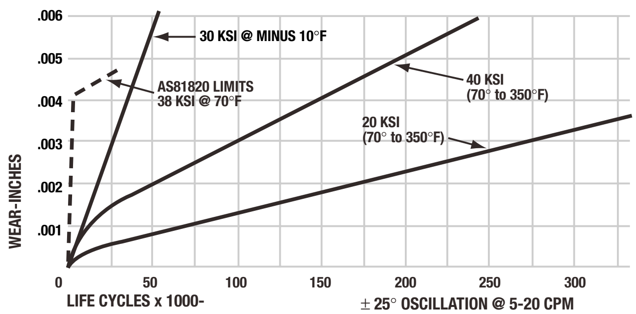


FIGURE 6: Typical wear rate for Uniflon® E and Fibriloid® liner

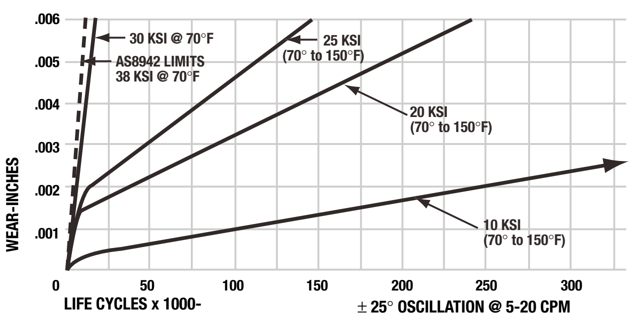


FIGURE 7: Typical wear rate for Fiberglide® V, Fabroid® IIG2

Surface Texture and Hardness of Mating Surfaces — For maximum life on journal bearings, the shaft on which the bearing runs should have a minimum hardness of Rockwell C 40 and a maximum surface texture of 8 RMS. Tables 5 and 6 show the average reductions in life for surface texture and material hardness.

Surface Texture (RMS)	Life Factor
4-10	1.00
16	0.75
32	0.40

TABLE 5: Life factor reduction due to surface texture

Hardness Rc	Life Factor
50	1.00
40	0.60
30	0.40

TABLE 6: Life factor reduction due to hardness

Table 7 gives maximum surface velocities for the standard RBC liner systems operating in dry environments.

	Max. Surface Velocity, ft/min	
Liner System	**@5000 psi**	**@100 psi**
Fiberglide® V	15	600
Fabroid® IIG2	12	500
Uniflon® E	8	200
Fibriloid®	5	150

	Max. Surface Velocity, m/min	
Liner System	**@34,500 kPa**	**@690 kPa**
Fiberglide® V	4.6	182.9
Fabroid® IIG2	3.7	152.4
Uniflon® E	2.5	75
Fibriloid®	1.5	45

TABLE 7: Surface velocity limits for dry bearings

Operating temperature capabilities vary among liner systems and are affected by environmental conditions. Extremely low temperatures cause the coefficient of friction to rise and wear rates to increase. High speed operation or high loads will increase the bearing temperature above the ambient temperature. Fluids may lower operating temperature, but they may also be more aggressive at high temperatures. The metal component material of the bearing must also be considered when operating at extreme temperature. For example, an aluminum backed bearing should not be used in applications above 250°F (121°C). Table 8 lists the continuous operating temperature ranges for RBC liner systems in an air environment and under moderate load (5000 psi or 34,500 kPa). Load ratings of bearings should be derated for applications operating at elevated temperatures.

OPERATING TEMPERATURE RANGES		
Liner System	**°F**	**°C**
Fiberglide® V	-320 to +300	-195 to +150
Fabroid® IIG2	-320 to +450	-195 to +230
Uniflon® E	-320 to +450	-195 to +230
Fibriloid®	-320 to +450	-195 to +230
Fabroid® X	-320 to +600	-195 to +300
Uniflon® HP	-65 to +325	-55 to +165

TABLE 8: Operating temperature ranges under 5000 psi (34.5 MPa) radial load

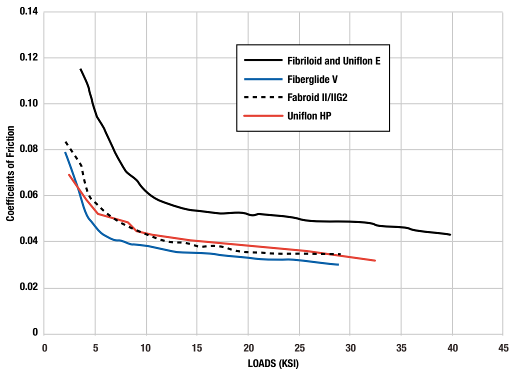


FIGURE 8: Effect of load on the coefficient of friction

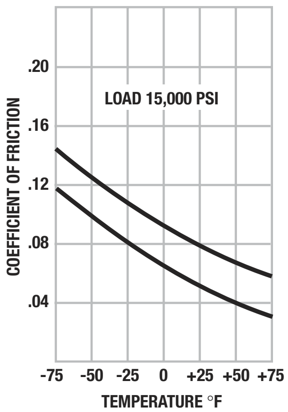


FIGURE 9: Coefficient of friction vs. temperature

Coefficient of friction for a spherical bearing is:

$$\mu = \text{Torque} / \text{Ball Spherical Radius} \times \text{Load}$$

For a journal bearing, the shaft radius is substituted for the ball spherical radius in the above formula. The coefficient will vary depending on the liner system, and it is also affected by load and temperature. It should be noted that self-lubricating bearings require a break-in period to start the lubrication process. Typically the coefficient of friction will decrease by 50% after break-in. Figure 8 shows the effect of load on the coefficient of friction for the RBC liner systems. Figure 9 shows the effect of temperature on the coefficient of friction.

Fluid compatibility and contamination will affect wear rate or bearing life. RBC liner systems have been extensively tested in many environments. Testing includes both application qualification tests and SAE tests for MS qualifications. The thermoset resins and adhesives used by RBC are essentially impervious to the fluids encountered in aerospace applications. The following is a partial list of the fluids in which various RBC liner systems have been tested:

Phosphate Ester Hyrdaulic Fluid
TT-S-735, Type VII Test Fluid, JP Jet Fuel
MIL-L-7808 Lubricating Oil
MIL H-5606 Hydraulic Oil
MIL-H-83282 Hydraulic Oil
MIL-A-8243 De-Icing Fluid
MIL-T-5624 Turbine Fuel
1-1-1 Trichloroethane
Water
MIL-PRF-87937 Aerospace Detergent
MIL-STD-810, Salt Spray
MIL-STD-810, Fungus
Sand and Dust
Liquid Nitrogen, N2
Vacuum
Aerospace Cleaning Detergents

While these fluids will not attack the liner system, it should be noted that fluids may increase the wear rate of the liners. The fluids tend to flush out the PTFE particles that coat the mating surfaces. This interferes with the natural PTFE self-lubricating process and thus increases wear.

Solid particle contaminants of dirt and dust tend to become imbedded into the relatively soft liner surfaces. If the particle contamination is abrasive, it will begin to wear the mating surface of the ball or shaft. Should contamination be particularly severe, bearings can be provided with card coatings or seals.

BEARING INSTALLATION

Proper installation of plain bearings will help to assure that maximum life will be obtained. Improper assembly may damage liners, cause excessive loading, or in other ways decrease the useful life of the bearing.

Housing fit for a metal-to-metal spherical bearing is recommended to be from 0.0000 to 0.0010 in. (.025mm) loose. Press fitting these bearings into the housing may remove the initial radial clearance causing the bearings to lock up. Thermal expansions of materials must also be considered

Housing fit for a self-lubricating spherical bearing is recommended to be from 0.0002 in. tight to 0.0008 in. loose or 0.005mm tight to 0.020mm loose for a metric bearing. For example, a bearing having an outside diameter of 1.0000 in. to 0.9995 in. should be inserted into a housing having an inside diameter of 0.9998 in. to 1.0003 in. A bearing having an outside diameter of 25.000mm to 24.987mm should be inserted into a housing having an inside diameter of 24.995mm to 25.020mm. Where tighter than recommended fits are used, the bearing will become radialy pre-loaded. This will result in increased bearing starting torque. The recommended fit is applicable for bearings with outside diameters up to 2.500 in. (63.5mm). For larger bearings or for special materials or applications consult the appropriate RBC Aerospace Bearings sales engineer.

An increase in pre-load torque is beneficial in high frequency vibration conditions and in solid particle contaminated environments. Pre-load torque is not additive to the frictional torque due to an applied load.

The housing fit for journal bearings should be 0.0005 in. (0.013 mm) tight to 0.0020 in. (0.050 mm) tight for bearings up to 4.0 in. or (100mm) in diameter. Care must be taken in selecting housing and shaft diameters to assure that there is not an interference fit between the bearing bore and the shaft. The following formulas may be used to determine the reduction in bore diameter due to a tight housing fit:

$$y_a = \frac{2\Delta\left(\frac{b}{a}\right)}{\left[\left(\frac{b}{a}\right)^2 + 1\right] + k_2\left[\left(\frac{b}{a}\right)^2 - 1\right]}$$

Case 1. Different housing and bearing materials

$$y_a = \Delta\left(\frac{a}{b}\right)$$

Case 2. Same housing and shaft material

Where:

a = bearing bore
b = housing bore
d_1 = Poission's ratio for bearing material
d_2 = Poission's ratio for housing material
y_a = amount of reduction in bore size
Δ = amount of interference fit
E_1 = modulus of elasticity of bearing material
E_2 = modulus of elasticity of housing material

$$K_2 = \text{constant} = \frac{E_1}{E_2}(1 + d_2) - d_1$$

In both of the above cases a massive housing is assumed.

Dissimilar materials must be considered when operating **at low or high temperatures** or when a large bearing is being used. When the materials for the housing and bearing backing or the shaft and the inner ring are not the same, loss of fit in the housing and contraction of the bearing bore must be considered. Calculations of loss of fit and bearing bore contraction are necessary to prevent the bearings from turning in the housing and also to prevent a tight fit between the bearing and the shaft.

To determine how much a housing bore or a bearing diameter changes in size as a result of temperature change, use the following formula:

$$\delta = \alpha \text{ x } \Delta \text{ x } \Delta T$$

Where:

δ = change in diameter
α = coefficient of thermal expansion
Δ = housing or bearing diameter
ΔT = temperature change

Contraction of the bearing may be calculated using the formulas shown above in the housing fits for journal bearings section.

Shaft fit for metal-to-metal spherical bearings is not to be less than 0.0005 in. (0.013mm) loose at operating temperature.

Shaft fit for self-lubricating spherical bearings with unlined bores is recommended to be 0.0001 in. to 0.0010 in. loose (0.003mm to 0.025mm loose) in standard applications. For example, a bearing having a bore diameter of 0.7495 in. to 0.7500 in. should be assembled onto a shaft having an outside diameter of 0.7494 in. to 0.7490 in. Similarly a bearing having a bore diameter of 20.003mm to 19.991mm should be assembled onto a shaft having an outside diameter 19.978mm to 19.988mm. This is applicable for bearings, which have unlined bores and with bore diameters up to 1.500 in. (38mm). If the bore of the bearing inner ring is lined a shaft fit of 0.0000 in. to 0.0015 in. loose (0.000mm to 0.038mm loose for metric bearings) is recommended. For special applications or for bearings with bores larger than 1.500 in. (38mm) consult RBC engineering.

Shaft fits for journal bearings, where slow oscillating or low rotational speeds are coupled with high loads, are recommended to be from 0.0005 in. (0.013 mm) loose to 0.0030 in. (0.76 mm) loose. Contraction of the bearing bore caused by a heavy press fit in the housing or by thermal contraction must be considered. See housing fit above.

BEARING INSTALLATION

A hammer or other mechanism that induces a shock load on the bearing should never be used. The corner of the housing bore should have a radius or chamfer that has a smooth transition to the housing bore. The bearing should be aligned to the bore and a constant steady force applied to seat the bearing. A tool, which pilots on the bearing bore and which applies load to the outer ring face, is recommended. See Figures 11 and 12.

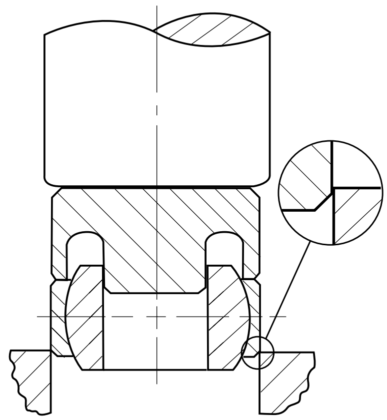


FIGURE 11: Spherical bearing assembly tool

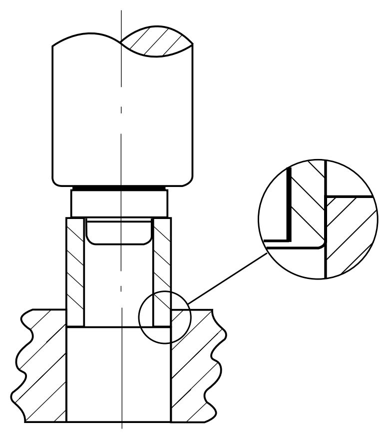
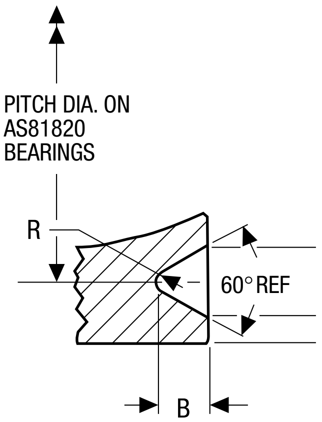


FIGURE 12: Journal bearing assembly tool

Bearing installations per the specification NAS 0331 are recommended.

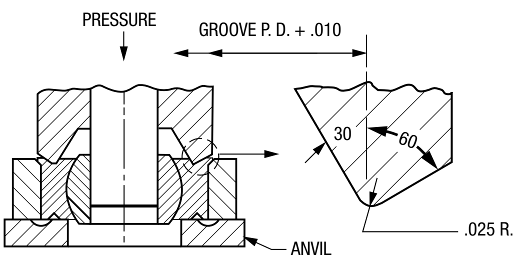
GROOVE DIMENSIONS — SPHERICAL BEARINGS

	BEARING BORE SIZE		B	R
INCH SERIES (Dimensions in inches)	NARROW WIDE	-03 TO -04 -03 TO -05	.015 .030	.005 .015
	NARROW WIDE	-05 TO -07 -06 TO -10	.025 .040	.010 .020
	NARROW WIDE	-08 TO -16 -12 TO -16	.045 .060	.010 .020
METRIC SERIES (Dimensions in mm)	NARROW WIDE	-12 TO -20 -5 TO -8	0.5 0.7	0.13 0.25
	NARROW WIDE	-25 -10 TO -17	0.7 0.9	0.13 0.38
	WIDE	-20 TO -25	1.2 1.4	0.13 0.38



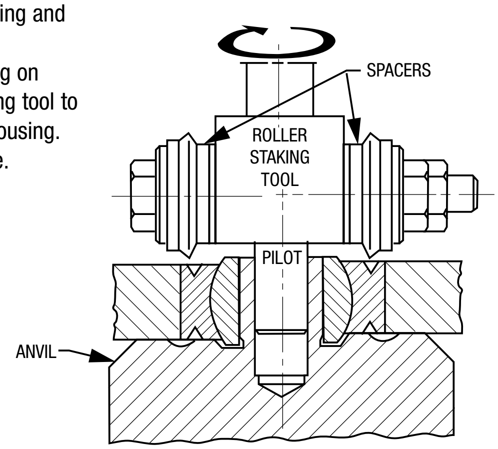
SWAGING PROCEDURE

1. Press bearing into housing and locate on center.
2. While supporting bearing on anvil, apply pressure to swaging tool (no rotation). To stake outer race over housing. Repeat on opposite side.



ROLLER STAKING PROCEDURE

1. Press bearing into housing and locate on center.
2. While supporting bearing on anvil, rotate roller staking tool to stake outer race over housing. Repeat on opposite side.



PLAIN BEARINGS