EXTREME ANGULAR ACCURACY BEARINGS

Client Problem

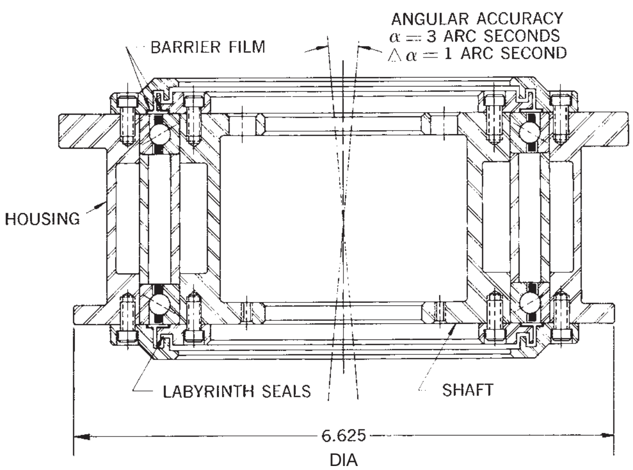
To provide a set of bearings which maintain an extreme precise angular accuracy of the center line of the shaft to the housing. The angular accuracy requirement was a non-repeatable error (∅a) of one arc second, and a repeatable error (a) of three arc seconds.

RBC Recommendation

Bearings should be made to the most precise geometric tolerances possible. The bearings should be preloaded to overcome the minor surface imperfections of the balls and raceways. They should also be part of a cartridge incorporating the housing and shaft.

RBC Bearing Solution

Bearings were made as part of the cartridge assembly and all angular measurements for accuracy were made relative to the housing and shaft. Bearings were preloaded and spaced axially to help overcome geometric inaccuracies of the bearing. The bearing raceways and balls were made from Consumable Electrode Vacuum Melted AISI 440-C material. As the bearings had to operate in a vacuum, the separator material necessitated a special open weave phenolic material impregnated with a special silicone oil. To prevent migration of the oil from the cartridge assembly, the labyrinth seal was coated with a barrier film.



INTEGRAL BEARING ASSEMBLY

Client Problem

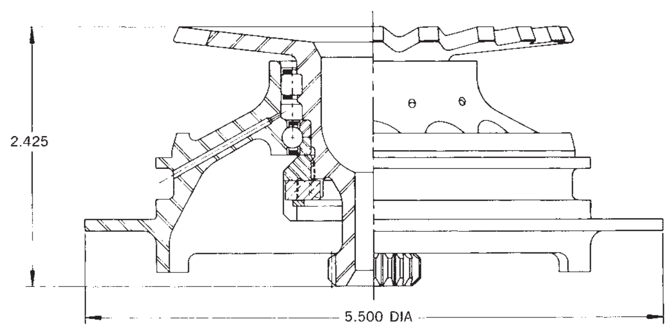
Save space and weight in an application involving a power take-off drive from a high speed gearbox.

RBC Recommendation

Make the races of the bearing integral with the housing and possibly with the gear shaft.

RBC Bearing Solution

The bearing housing was designed to incorporate the outer raceway of the roller bearing and the outer raceway of the split inner race ball bearing. In order to increase the reliability of the rolling contact surfaces in the housing, the housing was manufactured from AISI M-50 material Consumable Electrode Vacuum Melted. The gear was made integral with the shaft which also contained the inner raceway of the roller bearing. The gear shaft was manufactured from Consumable Electrode Vacuum Melted AISI-9310 material; case hardened to Rc 61-64 on the gear tooth surface and in the roller bearing raceway. In order to facilitate lubrication of the bearings in the restricted area, lubrication holes were drilled through the housing into the space between the two bearings. The lubrication was fed through these holes from an annular groove in the housing. The two halves of the split inner race were retained to the gear shaft by the use of a lock nut, clamping the races axially. The combined integral assembly of bearings, gear shaft and housing provided the desired space and weight reduction and gained improved operational accuracy. In addition, it afforded easier installation into the gearbox.



ENGINEERING DATA

THIN SECTION GEARED BEARING

Client Problem

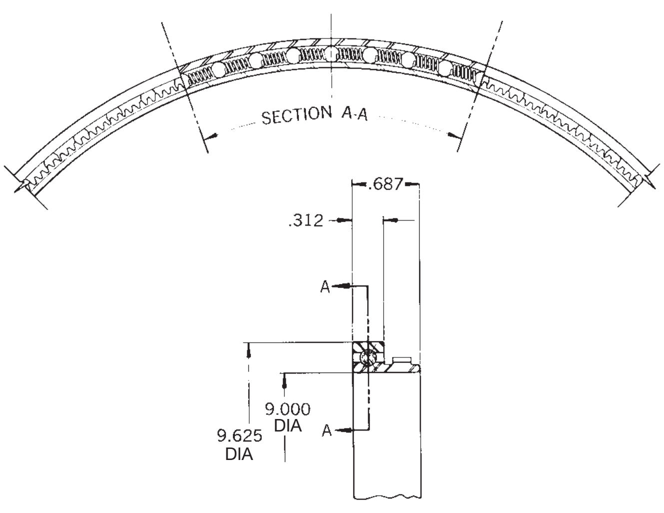
A radar antenna drive had only limited space available for its support bearings.

RBC Recommendation

Use a thin section rather than a standard section radial ball bearing, thus achieving a significant weight reduction. Incorporate a gear as part of the inner ring to obtain improved accuracy and simplify the assembly.

RBC Bearing Solution

The thin section bearing utilizes coil springs as spacers between the balls instead of a conventional separator to further reduce weight and lower bearing torque. The inner race of the bearing was extended and the gear was cut on this extended portion of the inner race. The incorporation of the gear into the inner race eliminated the necessity of a shaft clamping mechanism, etc., which would be required if the gear were separate from the bearing. Integrating the gear profile into the inner race increased the accuracy of the gear to bearing concentricity. The bearing was manufactured of the following materials: the balls and outer race are from AISI-440-material; the inner race manufactured from AIS1-8620 material, carburized and hardened in the raceway area to Rc 58-60.



ROLLER, THRUST AND ANGULAR CONTACT BALL BEARING

Client Problem

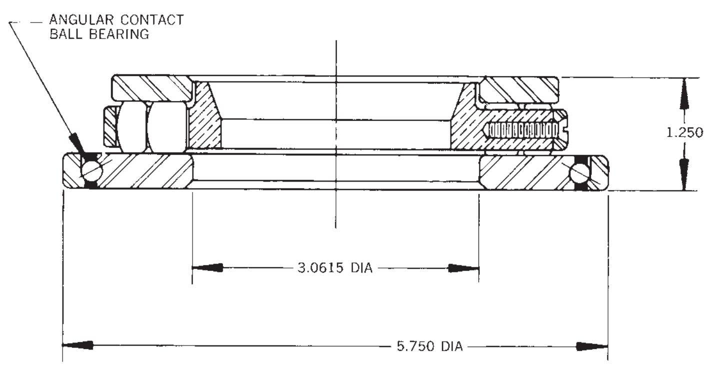
Cost reduction of an existing hydraulic pump swash plate assembly.

RBC Recommendation

Utilize an integral bearing assembly which combines a roller thrust bearing and an angular contact ball bearing.

RBC Bearing Solution

The original swash plate design in the hydraulic pump utilized a roller thrust bearing to handle the thrust load and a separate angular contact radial ball bearing to handle radial loads; and radially locate the swash plate assembly. The usage of two separate bearings required complex machining of the housing and swash plate with close control of tolerances, to eliminate excessive radial eccentricity of the swash plate assembly. In the original design, which utilized two separate bearings, it was necessary to mount the bearings axially adjacent to each other. The recommended bearing design decreased the axial space required for bearings, resulting in a size and weight savings. A combined bearing assembly is usually lower in cost than two separate bearings. The technique of integrating two bearings usually simplifies an assembly where two bearings had been utilized, or where problems have arisen relative to running accuracy, overall size or weight.



SELF-ALIGNING BEARING OPERATING IN LIQUID POLYETHYLENE

Client Problem

A rolling contact bearing was required on a vertical shaft which rotated in a catalytic-polyethylene autoclave. Blind assembly of the bearing and shaft which weighed approximately 10,000 pounds was necessary, due to the autoclave design.

RBC Recommendation

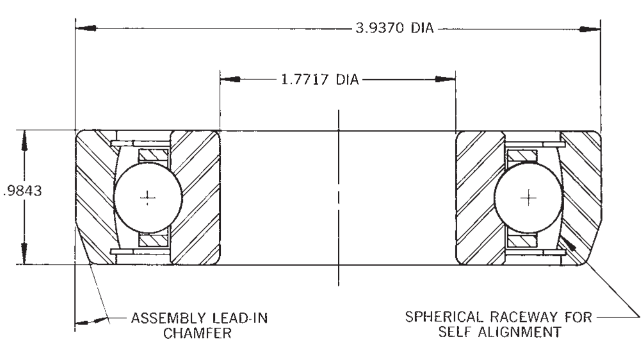
Use radial ball bearing incorporating a self-aligning raceway made from corrosion resistant materials. The bearings should be capable of withstanding operating temperatures as high as 650°F, and capable of operating with liquid polyethylene as the lubricant.

RBC Bearing Solution

The bearing was manufactured from AISI-440-C material, specially heat treated to resist softening at the high operating temperatures. The separator material was L-605 cobalt alloy which offered the necessary wear resistance.

To solve the client's problem of inserting the eighteen foot long assembly into a blind housing, a large lead-in chamfer was formed on the outside of the bearing. This lead-in chamfer provided for easy insertion of the bearing into the housing.

The previous bearing installation did not allow any shaft misalignment, resulting in bent shafts which were then unacceptable for further use. The self-aligning feature of the outer raceway permitted the bearing to misalign while rotating, allowing for shaft distortion as the shaft went through critical speeds.



SENBAL BEARING

Client Problem

A fluidic gyroscope required a gimballing, self-aligning bearing which would rotate at high speed. The bore of the bearing was to form part of the fluidic metering and sensing system.

RBC Recommendation

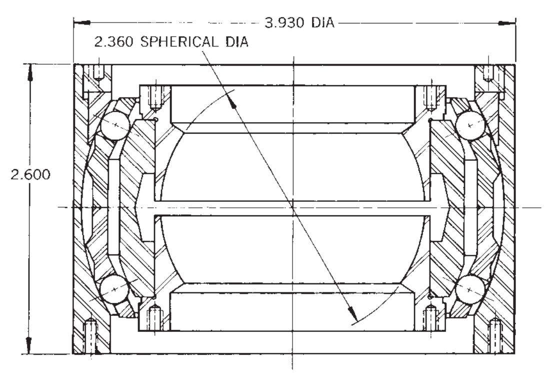
Use a double row, self-aligning spherical ball bearing with spherical outer and inner raceways. The two rows of balls should be preloaded to obtain the running accuracy needed for the fluidic metering system in the bore of the bearing.

RBC Bearing Solution

The double row spherical self-aligning ball bearing was designed with a removable portion of the spherical outer raceway to allow for preloading of the two rows of balls.

With the possibility of different rotational speeds of the two rows of balls, each row of balls had its own separator. To guide the separators, a special configuration was machined on the outside of the separator to allow for each separator to be guided at two points of contact with the spherical outer raceway.

The fluidic metering portion was made as a separate unit, press fitted into the bore of the bearing.



TYPICAL APPLICATIONS

1200°F OSCILLATING BEARING

Client Problem

A high temperature rolling contact, oscillating bearing for operation at 1200°F, subjected to high vibration loads.

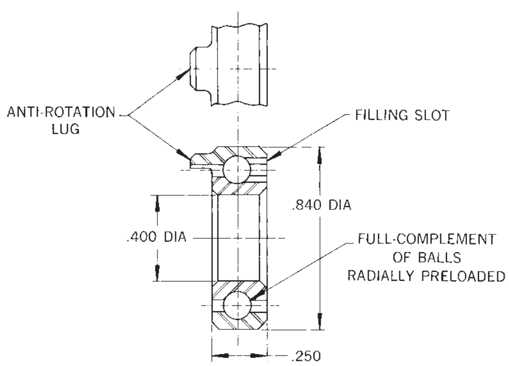
RBC Recommendation

Design a rolling contact bearing with radial preload to overcome false brinelling which may occur in the high vibration environment. Bearings should be made from a corrosion resistant, high-temperature alloy.

RBC Bearing Solution

The bearing was manufactured of Stellite® 6B material which was cold worked by an RBC proprietary process to obtain a hardness of Rockwell C-53 minimum in the raceway areas. The balls of this bearing were made from L-605 cobalt alloy. The bearing was of full complement design with a filling slot for insertion of the balls, and negative radial clearance of line to line to .0003" tight.

The lubricating film which is generated by the cobalt alloy races and balls permitted this bearing to operate without any additional lubricant. The increased hardness of the raceways to Rockwell C-53 minimum produced a bearing which was capable of operating up to 1200°F with extreme wear resistance.



GEARBOX BEARINGS WITH SELF LUBRICATING SEPARATORS

Client Problem

Bearings were needed for operation in high-temperature gearboxes at 600°F to 650°F. Conventional lubrication such as oil was not available, therefore the bearings would have to be self-lubricating.

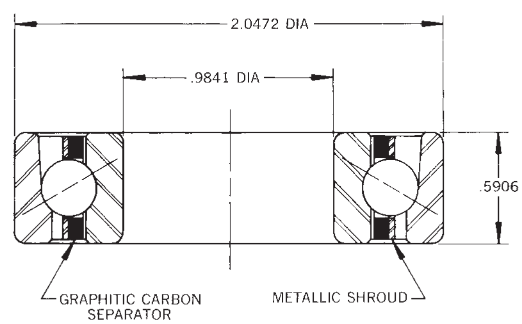
RBC Recommendation

Use bearings of high-temperature, heat treated AISI-440-C material. Incorporate in these bearings RBC developed proprietary graphitic carbon separators, to act as the bearing lubricant.

RBC Bearing Solution

Angular contact ball bearings were designed, utilizing an inner land guided separator of graphitic carbon material. The separator was reinforced on its outside diameter with a metallic shroud to withstand the centrifugal forces from high operating speeds and resist fracturing, which could result from the tremendous acceleration rate of the bearing rotation.

To facilitate a break-in period required for transfer of the self-lubricating material from the graphitic carbon separator to the rolling contact surfaces, the balls and raceways were coated with an impinged, tungsten-disulfide dry-film lubricant of approximately .000020" in thickness. With the dry film lubricant on the raceways and balls, the bearings were capable of operating at the required speed without any break-in period normally required for bearings incorporating dry, self-lubricating separators.



Stellite® is a registered trademark of the Deloro Stellite Company, Inc.

HIGH TEMPERATURE, ACTUATOR THRUST BEARINGS

Client Problem

A high temperature thrust bearing was needed to support the reactive thrust of a ball screw actuator. Bearings had to be capable of operating at approximately 850°F.

RBC Recommendation

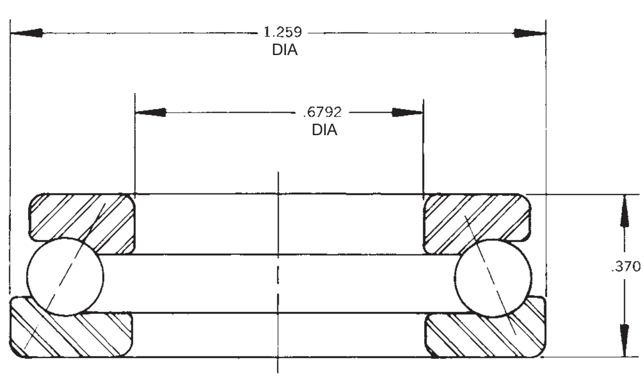
Use bearings of high temperature tool steel to withstand the applied loads at the high operating temperature.

RBC Bearing Solution

Bearings were manufactured from CEVM M-2 tool steel with a full complement of sixteen .187 diameter tungsten carbide balls. The bearing was designed having a contact angle of 60° to handle the high thrust load and some radial loading.

The races were coated with a proprietary dry-film lubricant applied to the raceways of the bearings prior to installation of the bearing in the application.

The significant design feature which allows the bearings to operate at 850°F and at speeds up to 750 RPM without excessive wear is the combination of the tungsten carbide balls running against the M-2 tool steel raceways. Similar designs using M-2 tool steel balls had worn very rapidly at relatively short periods of application at the operating temperatures.



NON-MAGNETIC BEARING

Client Problem

A newly designed rotating magnetometer for ore analysis required a non-magnetic bearing.

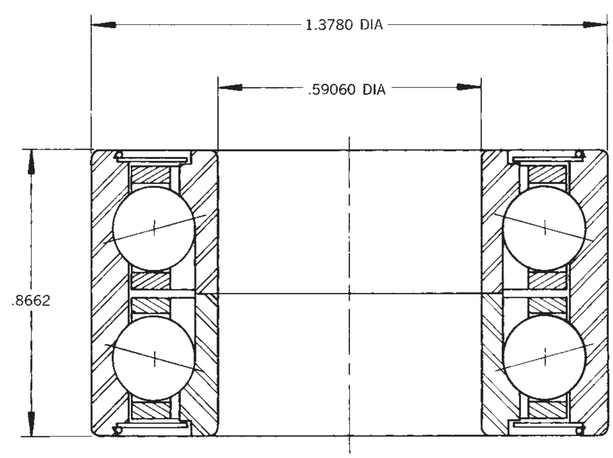
RBC Recommendation

Use a bearing with the raceways and balls made of a material which would be capable of operating under the loads and possess the lowest magnetic permeability. The loading combined thrust, radial and moment loads which required a duplex pair of bearings.

RBC Bearing Solution

Manufactured the bearing from Berylco 25 material. This material was used for the inner and outer races, balls and shields. The separator was manufactured of a phenolic material.

The bearing was designed as a common outer duplex DB pair, lightly preloaded. To reduce contamination possibility, shields were incorporated. The bearing was lubricated by grease plating the raceways with MIL-PRF-23827 lubricant.



TYPICAL APPLICATIONS

1400°F SELF-ALIGNING BALL BEARING

Client Problem

A hinge bearing on the exhaust ducts of a jet engine used to propel and lift a ground effect vehicle machine.

RBC Recommendation

Use a double row angular contact ball bearing in a self-aligning housing. Bearing materials to be made of corrosion and heat resistant material.

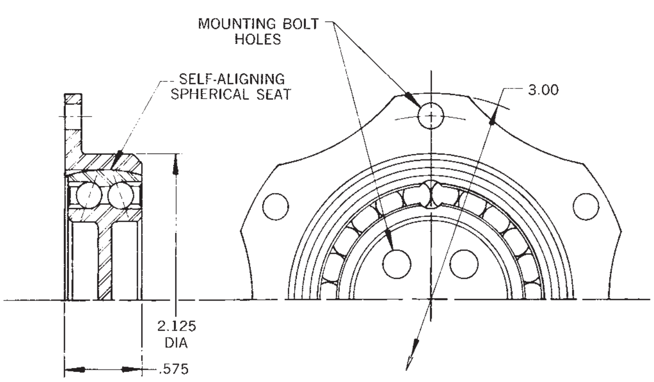
RBC Bearing Solution

The double row ball bearing cartridge unit utilizes L-605 material for the raceway and balls. The bearing was mounted in a self-contained spherical housing to compensate for misalignment of the shaft during operation, which occurs due to temperature differentials between the frame and the exhaust nozzles.

The races were made by a special RBC developed proprietary race hardening technique.

With this technique the L-605 cobalt alloy material is work hardened and then heat treated to a Rockwell C-53 minimum.

The bearing operated for 50 hours with 1400°F exhaust gas passing through the bearing without any significant wear.



SPHERICAL, METAL-TO-METAL BEARINGS

Client Problem

A manufacturer of commercial aircraft required a landing gear support trunion bearing.

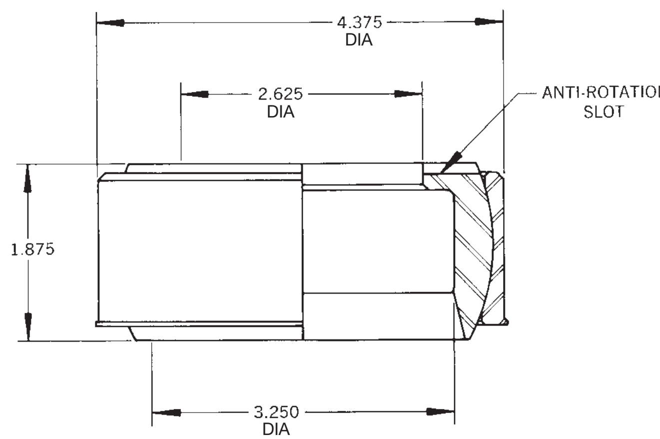
Bearing must have low radial and axial clearances.

RBC Recommendation

Use a metal-to-metal spherical plain bearing. It should have a dry film lubricant on its spherical bearing surfaces. The bearing should be fabricated from corrosion resistant material.

RBC Bearing Solution

With the clearances required, .0010/.0030 radial and .009 max. axial, assembly of match ground components was necessary. Swaging a bearing of this size would not result in reliable clearance control. The outer race was assembled to the ball by deforming it under radial pressure to an elliptical shape to allow the insertion of the ball. Once the ball is inserted, the pressure is removed from the outer race, allowing it to return to its original shape.



FOOD PROCESSING EQUIPMENT BEARINGS

Client Problem

Relatively short life was obtained on bearings made of 316 stainless steel in food processing equipment. 316 stainless steel was required to prevent contamination of the food products.

RBC Recommendation

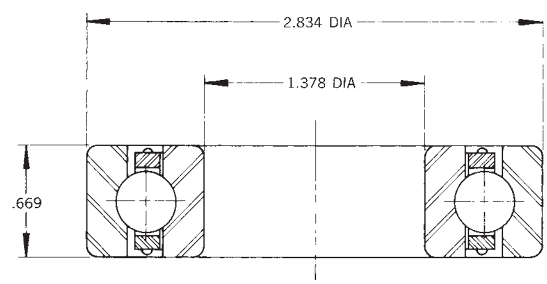
Use a harder, more wear resistant material which would still be resistant to the corrosive fluids of the processed food and prevent contamination.

RBC Bearing Solution

A search of various materials which were resistant to the food products handled by this particular piece of equipment brought to light that certain cobalt alloys could be used without any fear of contamination or corrosion.

In order to increase the wear resistance of the cobalt alloys, they were cold worked in the raceways to increase the hardness and thereby increase the wear resistance.

The alloy used for the raceways and the balls was L-605. Separator material was 17-4 PH.



CHEMICAL PROCESSING EQUIPMENT BEARINGS

Client Problem

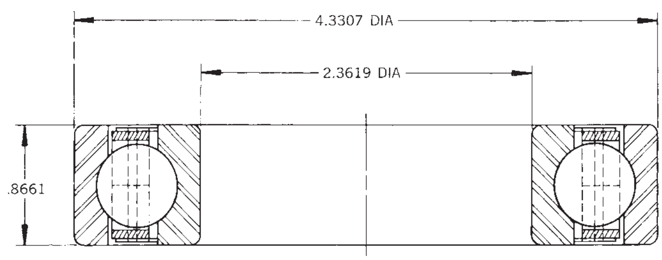
Bearings exposed to photographic-processing chemical solutions were failing. Bearings being used were made of AISI-440-C material, sealed, and grease lubricated.

RBC Recommendation

Use a bearing of a different alloy; make the separator self-lubricating and run the bearing in the chemical solutions.

RBC Bearing Solution

The bearing used cobalt alloy balls and races and a self-lubricating separator of Fiberglass reinforced TFE. To give additional strength to the riveted separator in this bearing, side plates of 300 series stainless steel were added to the separator.



CRYOGENIC BEARINGS

Client Problem

High speed ball and roller bearings for use in cryogenic equipment. Bearings should also operate in cryogenic liquid or gaseous environment.

RBC Recommendation

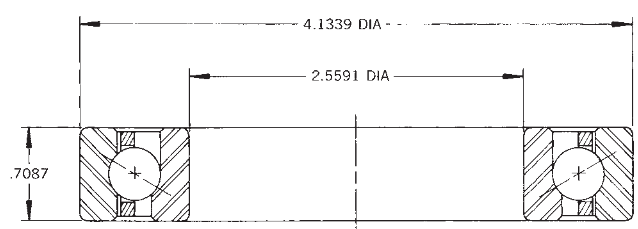
Use bearings of a corrosion resistant material such as AISI-440-C and incorporate a self-lubricating material for the separators.

RBC Bearing Solution

Ball and roller bearings of ABEC-5 tolerance grade were made of AISI-440-C material, with special sub-zero treatment in liquid nitrogen. This sub-zero treatment gave the bearings the dimensional stability necessary for operating in cryogenic equipment.

The bearing separators were made of Teflon® reinforced Fiberglass.

This basic bearing design criterion has been used in almost all liquid hydrogen and oxygen turbo pumps used in present day rocket engines.



Teflon® is a registered trademark of DuPont.

SELF-LUBRICATING MAIN SHAFT BEARING

Client Problem

Mainshaft bearing for a vertical lift engine. For weight reduction, the bearing should be self-lubricating to eliminate a portion of the engine lubricating system.

Speed of the 85mm bore bearing was 16,000 RPM. The bearing, located in turbine end of the jet engine, accommodates axial shaft expansion.

RBC Recommendation

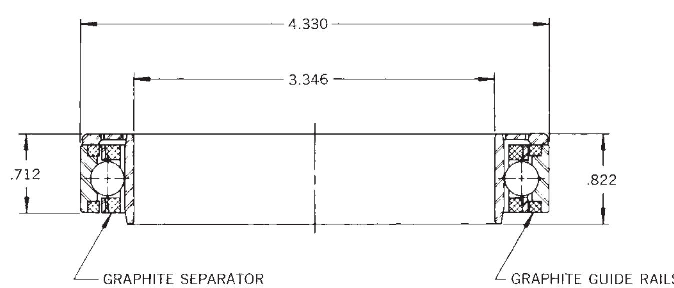
Use a ball bearing with races and balls made from wear-resistant materials. Lubricate the bearing with a shrouded self-lubricating graphite separator. Make the inner race cylindrical to accommodate the axial shaft expansion.

RBC Bearing Solution

Bearing was manufactured from CEVM AISI-M50 material for the races and balls.

The separator of shrouded graphite was outer land guided on two graphite rings, pressed into the outer race ring.

To prevent damage to the graphite while inserting the shaft into the bearing, a side plate was added which prevented any accidental contact of the shaft with the graphite separator. To allow for the excess graphite to purge from the bearing, holes were put in the protective side plate.



NUCLEAR REACTOR BEARING

Client Problem

Bearing to accommodate the thrust load in a control rod drive mechanism. Bearing is lubricated with chemically pure water, de-ionized and de-oxygenated.

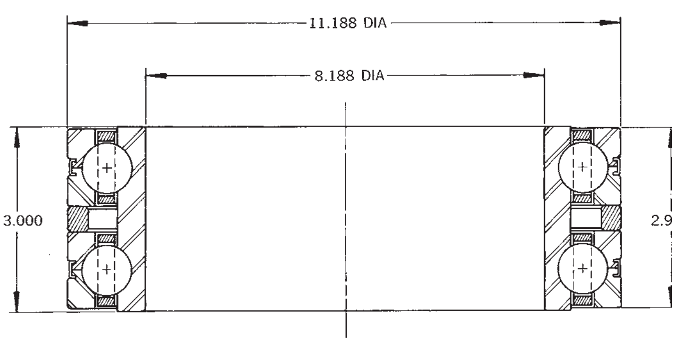
RBC Recommendation

Use a double row ball bearing, tandem ground for thrust sharing to obtain the life required. Because radial support of the inner race is marginal, the inner race for both rows should be ground on the same ring.

RBC Bearing Solution

The double row ball bearing was made of cobalt alloy materials, the separator of 17-4 PH.

To obtain the maximum capacity in this double gothic arch thrust bearing, the outer races are split, permitting the maximum quantity of balls in each row. Thrust sharing of two rows is accomplished by accurate match grinding of the spacer ring to fit the gap between the outer races, and by matching the contact angle in both rows equal within two degrees.



BALL BEARINGS FOR VACUUM OPERATION

Client Problem

A high speed ball bearing, to run at temperatures up to 1000°F

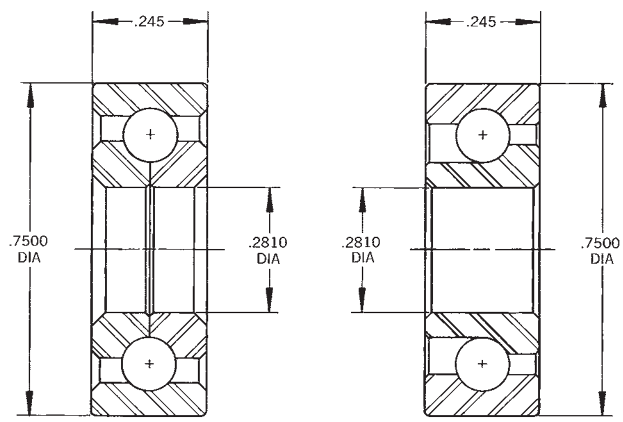
RBC Recommendation

Use bearing of wear resistant, high temperature tool steel. Bearing lubricant should be dry and not sublimate.

RBC Bearing Solution

The bearings were made of T-5 tool steel which has high hardness and wear resistance at 1000°F. The bearings contain a full complement of balls and no separator.

The lubricant was an ultra-thin layer of silver deposited on the balls. The bearings were manufactured without any snap which may abrade the silver on the balls.



TYPICAL APPLICATIONS

TURBO-MACHINERY ROLLER BEARING

Client Problem

A high speed mainshaft roller bearing was failing due to skidding. Insufficient load on the bearing was the cause of skidding.

RBC Recommendation

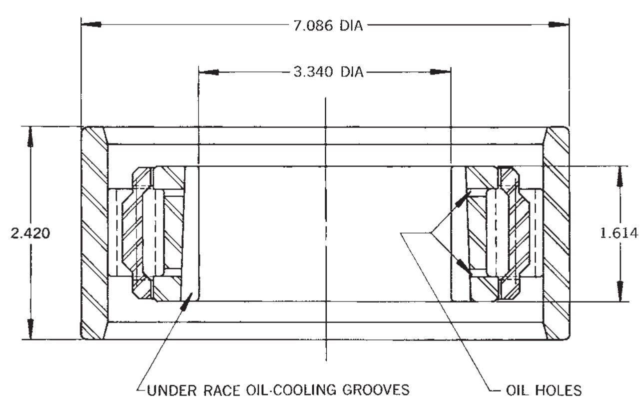
Use a pre-loaded roller bearing to overcome the skidding problem.

RBC Bearing Solution

The roller bearing was designed with hollow rollers which provided a radial internal preload between the inner and outer races.

The bearing has an inner land guided separator. The viscous drag between the separator and the inner race land diameter promotes the rotation of the separator.

To provide for cooling the inner race, under race cooling grooves were located in the bore of the inner race.



DRUSBA BEARING

Client Problem

A large diameter bearing to support a platform. The platform and portion of the bearing operate in an anisotropic quantum electrodynamic field, while in a vacuum.

RBC Recommendation

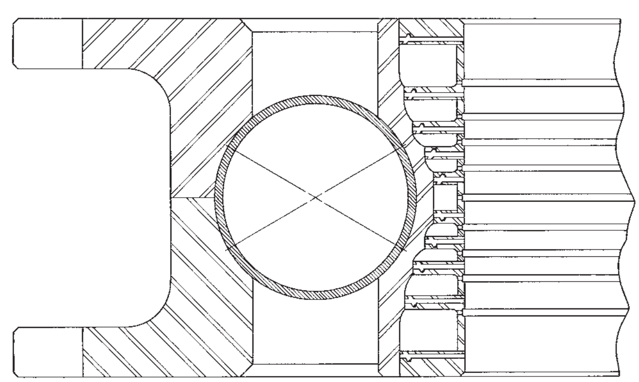
A 4-point contact pre-loaded ball bearing. Provide means for heat addition or removal to maintain the desired pre-load. Temperature variations occur due to the field; the outer ring normally has a higher temperature than the inner ring.

RBC Bearing Solution

A split outer race, full-complement ball bearing to be made of Cobenium rings, and sodium filled Cobenium balls. The raceways and balls were gold plated. The gold is the lubricant.

The inner ring of the bearing contains heating or cooling chambers. These are formed by electron beam welding the annular members to the ring. The fluid flowing through the chambers is controlled relative to rate of flow and temperature, depending upon the specific race area temperature serviced by that chamber. This permits control of the geometric configuration of the inner race and preload.

The sodium filled balls are used for heat transfer between the rings.



WATER-LUBRICATED BEARINGS

Client Problem

Long-life, wear-resistant bearings for running in water.

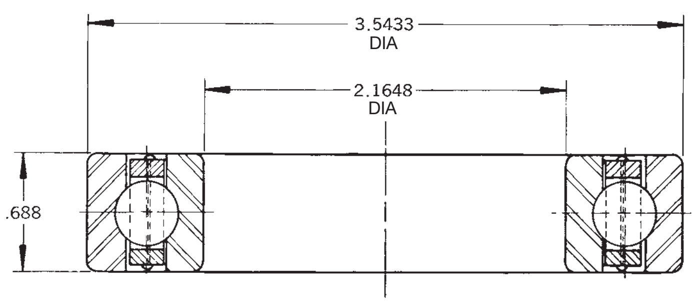
RBC Recommendation

Use bearings of cobalt alloys for maximum corrosion and wear resistance. Design the bearing with race curvatures and clearances to compensate for the lack of lubricity of the water.

RBC Bearing Solution

Bearing rings were made of L-605 cobalt alloy. An RBC developed cold working technique was used to increase the hardness of the alloy to Rc 53 minimum after heat treatment, for increased wear resistance. Normal cold worked and heat treated hardness of this alloy is Rc 47.

The separators in the bearings were made from 17-4 PH corrosion resistant material, heat treated to increase wear resistance.



OPTICAL PRECISION BEARINGS

Client Problem

Support a 14" diameter rotating tube which contained lenses. Minimal radial runout was required to prevent distortion of the image by the lenses. Bearings should be low in torque and corrosion resistant, pre-lubricated, suitable for a vacuum operation.

RBC Recommendation

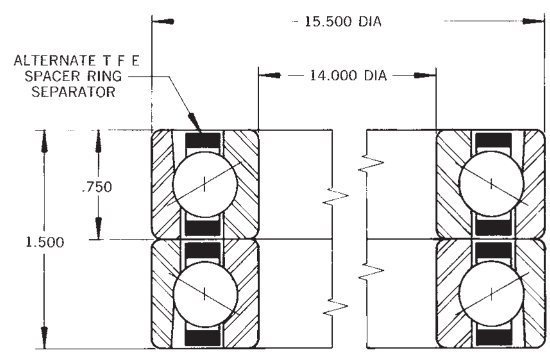
The rotating tube should be supported with duplex pairs of bearings, DB mounted, preloaded, with minimal lubrication of a low vapor pressure lubricant.

RBC Bearing Solution

Duplex DB pair of bearings, pre-loaded, were manufactured of passivated AISI-440-C corrosion resistant steel.

The radial and axial runouts were held to the following: radial runout, inner, .0002 T.I.R.; outer, .0003 T.I.R.; axial runout, inner, .0002 T.I.R.; outer, .0003 T.I.R. The separator consisted of TFE rings around alternate balls for low starting and running torque.

Bearings were lubricated with a special lubricant and then centrifuged at 100 g's for 10 minutes to remove the excess oil.



TYPICAL APPLICATIONS

CAMERA MOUNT BEARING

Client Problem

A lightweight, low torque bearing for use in an aerial camera assembly.

RBC Recommendation

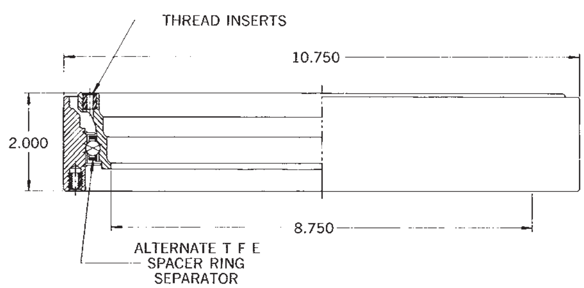
Use a bearing with rings made of aluminum, and hard anodize the raceway areas.

RBC Bearing Solution

The original steel bearing design which was a double row angular contact ball bearing in an aluminum housing was replaced with a single row, 4 point contact bearing, with the rings manufactured of 7075-T-651 aluminum. The raceways of both rings were hard anodized and ground after hard anodizing. Balls were of passivated AISI-440-C.

This construction utilizing the aluminum material, reduced the overall weight of the bearing assembly from over 7 lbs. in the original design to 3.8 lbs. in the finished unit.

In order to obtain a low running and starting torque, alternate balls in the raceway were surrounded with TFE separator and the raceways were grease-plated. The bearing running torque was below 1 inch lbs. with the starting torque being below 2 inch lbs.



TURBO-MACHINERY BALL BEARING

Client Problem

A ball bearing running at 2.2 million DN*, with no load, was failing due to the fatigue of the outer race, and ball skidding. Fatigue failures had been occurring due to the large number of stress cycles, caused solely by the centrifugal force of the balls.

RBC Recommendation

Reduce the number of balls in the bearing, thereby reducing the number of stress cycles on the outer race.

Make the separator a lightweight steel design. Reduction of the separator and ball mass would reduce the inertial resistance, thereby reducing skidding. Change material from AISI-52100 to a tool steel to increase resistance to skid damage.

RBC Bearing Solution

Bearing races and balls were made from CEVM AISI-M50 tool steel. The separator was manufactured from AISI-4340 material, hardened to Rc 26-32 and silver plated.

The number of balls was reduced from twenty to eight balls, reducing the number of stress cycles by sixty percent.

The separator configuration permitted an increase of lubricant flow through the bearing for cooling and lubrication.

*DN = D, bearing bore in (mm) - N, shaft speed in (RPM).