Fundamentals
M7
MAINTENANCE PRACTICES

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M7.11
Bearings

EASA Part-66
CAT B1

Training Manual

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M7 MAINTENANCE PRACTICES

M7.11 BEARINGS

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LUBRICATION REQUIREMENTS OF BEARINGS

General

Application

Bearings are used to support the journals of shafts and axles.

Types of bearings

Journal/Roller Bearings

Bearings for supporting journals, which are designed to accept forces at right-angles to the drilling axis, are called journal bearings or roller bearings.

Pivot/Axial Bearings

Bearings for pivot journals, which are designed to accept forces in a longitudinal direction, are called pivot bearings or axial bearings. These are different to sliding bearings or anti-friction bearings.

Sliding Bearing

The journal of a sliding bearing operates in a bearing box, a bearing bushing or directly in the bearing body.

Bearings for large journal diameters and bearings that cannot be pushed over the shafts during assembly (e.g. crankshafts) must be two-part bearings.

To decrease friction between journal and bearing, a continuous lubrication film has to exist. For this, bearing play is necessary.

The amount of bearing play depends on the demands the bearing is subjected to and the lubricant.

Sliding bearings are resistant to push forces, they operate with little noise and they are suitable for both slow and fast rotational journal speeds.

Their high starting resistance, however, is disadvantageous. They also require continuous maintenance.

Anti-Friction Bearing

There are five basic types of anti–friction bearings:

- tapered bearings
- needle bearings
- ball bearings
- spherical bearings
- cylindrical bearings.

Each is named for the type of rolling element it employs.

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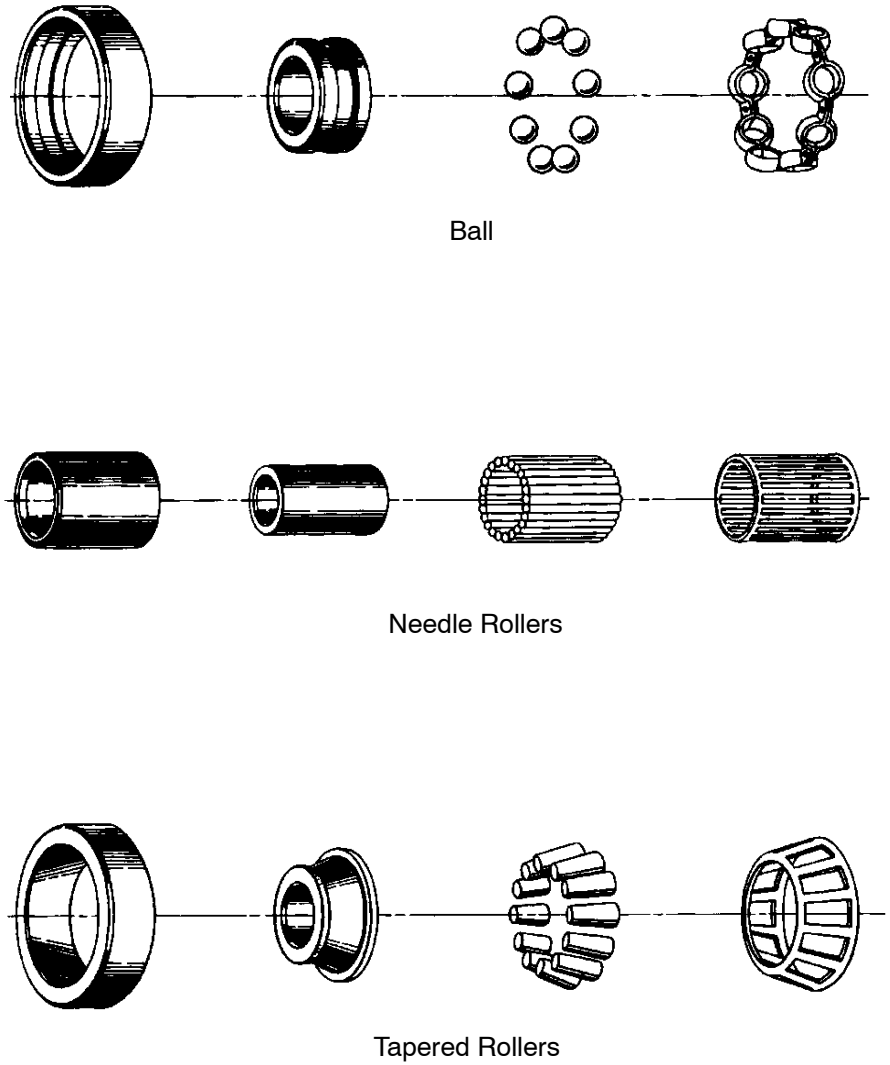


Figure 1 Common Anti-Friction Bearing Types

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Lubrication

Lubrication Tasks

Correct lubrication is vital in all kinds of bearings. It provides a film that separates the bearing's moving parts. This action reduces friction and prevents wear. Additionally it carries away heat and protects bearing surfaces from corrosion.

Conservation

Bearings are protected with a preservative coating during storage and shipment. This is NOT a lubricant. However, it IS compatible with the relevant lubricant and need not be washed off prior to installation, but it is essential to lubricate the bearing at installation.

Lubricant

Grease is one of the most popular lubricants. It should be packed into the bearing so that it will coat between the rollers and cage. In the case of a tapered bearing, forcing grease through the bearing from the large to the small end will ensure correct distribution. Any excess grease should be smeared on the outside of the rollers.

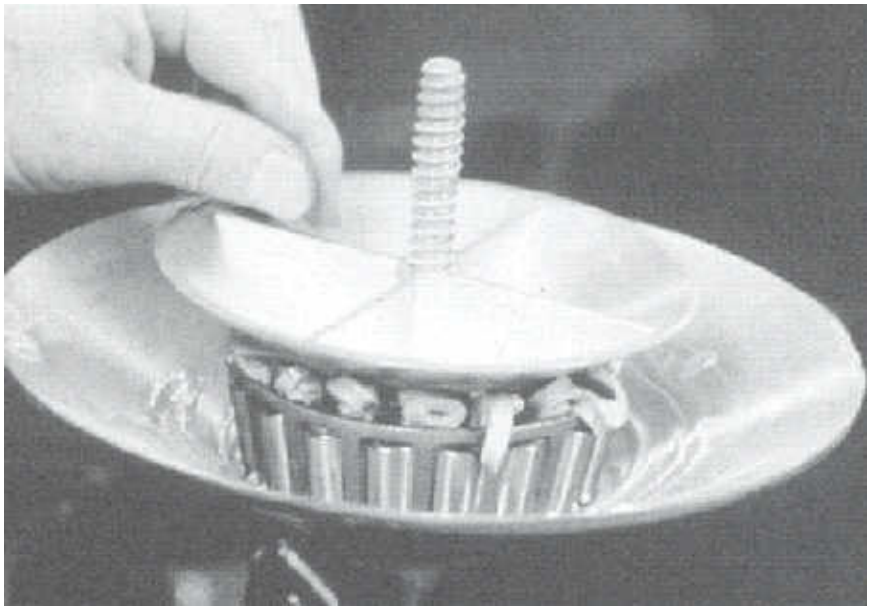
WARNING: IT IS IMPORTANT NOT TO OVER-GREASE BEARINGS. TOO MUCH GREASE IN THE HOUSING WILL INCREASE THE INTERNAL FRICTION AND GENERATE EXTREMELY HIGH TEMPERATURES; POTENTIALLY A FIRE HAZARD.

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Conservation for storage and shipment is NOT a lubricant.



Typical bearing lubrication tool.

Figure 2 Bearing Lubrication

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DEFECTS IN BEARINGS AND THEIR CAUSES

Bearing defects

Excessive Loads

Excessive loads usually cause premature fatigue.

Tight fits, brinelling and improper preloading can also bring about early fatigue failure.

This type of failure looks the same as normal fatigue, although heavy ball wear paths, evidence of overheating and a more widespread spalling (fatigue area) are usually evident with a shortened life. The solution is to reduce the load or redesign using a bearing with greater capacity.

Overheating

Symptoms are discoloration of the rings, balls and cages from gold to blue. Temperatures in excess of 400°F (200°C) can anneal the ring and ball materials. The resulting loss in hardness reduces the bearing capacity causing early failure.

In extreme cases, balls and rings will deform. The temperature rise can also degrade or destroy lubricant. Common culprits are heavy electrical heat loads, inadequate heat paths and insufficient cooling or lubrication when loads and speeds are excessive.

Thermal or overload controls, adequate heat paths and supplemental cooling are effective cures.

Reverse loads

Angular contact bearings are designed to accept an axial load in one direction only.

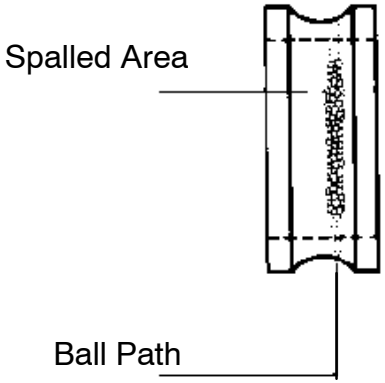
When loaded in the opposite direction, the elliptical contact area on the outer ring is truncated by the lower shoulder on that side of the outer ring. The result is excessive stress and an increase in temperature, followed by increased vibration and early failure.

Failure mode is very similar to that of heavy interference (tight) fits. The balls will show a grooved wear band caused by the ball riding over the outer edge of the raceway.

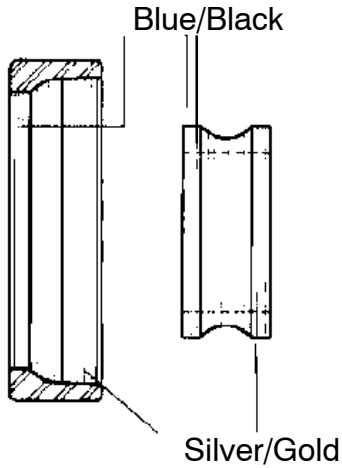
Corrective action is to simply install the bearing correctly. Angular contact bearings must be installed with the resultant thrust on the wide face (which is marked “thrust“) of the outer ring and the opposite face of the inner ring.

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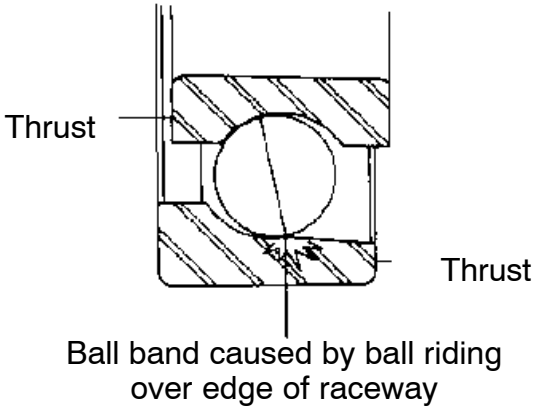
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Excessive Loads



Overheating



Reverse Loading

Figure 3 Bearing Defects (1)

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BEARING DEFECTS AND THEIR CAUSES (CONTD.)

False Brinelling

False brinelling (elliptical wear marks in an axial direction at each ball position with a bright finish and sharp demarcation, often surrounded by a ring of brown debris) indicates excessive external vibration. A small relative motion between balls and raceways occurs in non-rotating ball bearings that are subject to external vibration.

When the bearing isn't turning, an oil film cannot be formed to prevent raceway wear. Wear debris oxidizes and accelerates the wear process.

Correction by isolating bearings from external vibration and using greases containing antiwear additives (such as molybdenum disulphide) when bearings only oscillate or reverse rapidly, as in actuator motors.

True Brinelling

Brinelling occurs when loads exceed the elastic limit of the ring material. Brinell marks show as indentations in the raceways which increase bearing vibration (noise).

Severe brinell marks can cause premature fatigue failure.

Any static overload or severe impact can cause brinelling.

Examples include:

- Using hammers to remove or install bearings,
- dropping or striking assembled equipment, and
- pressing a bearing onto a shaft by applying force only to the ring being press-fitted, e.g. do not push the outer ring to force the inner ring onto a shaft.

Normal Fatigue Failure

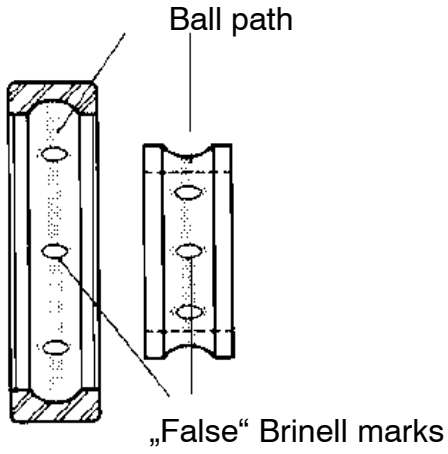
Fatigue failure (usually referred to as spalling) is the fracture of the running surfaces and subsequent removal of small, discrete particles of material.

Spalling can occur on the inner ring, outer ring or balls. This type of failure is progressive and, once initiated, will spread as a result of further operation. It will always be accompanied by a marked increase in vibration, indicating an abnormality.

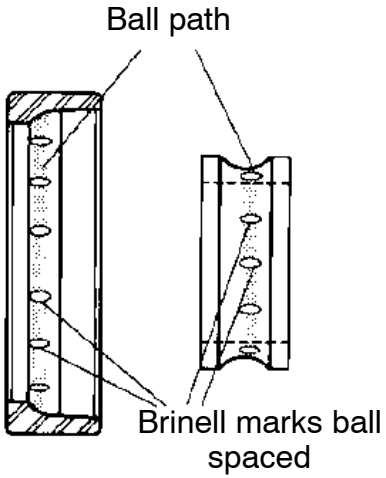
The remedy is to replace the bearing or consider redesigning to use a bearing having a greater calculated fatigue life.

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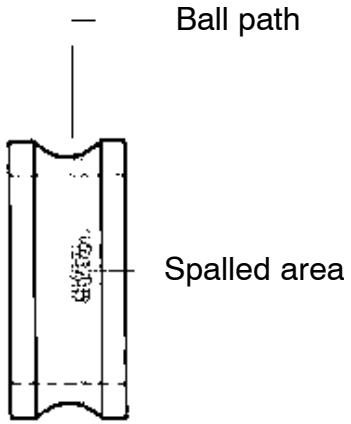
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False Brinelling



True Brinelling



Normal Fatigue Failure

Figure 4 Bearing Defects (2)

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BEARING DEFECTS AND THEIR CAUSES (CONTD.)

Contamination

Contamination is one of the leading causes of bearing failure. Contamination symptoms are denting of the bearing raceways and balls, resulting in high vibration and wear. Contaminants include airborne dust, dirt or any abrasive substance that finds its way into the bearing. Principle sources are dirty tools, contaminated work areas, dirty hands and foreign matter in lubricants or cleaning solutions. Clean work areas, tools, fixtures and hands help reduce contamination failures. Keep grinding operations away from bearing assembly areas and keep bearings in their original packaging until you are ready to install them.

Seals are critical - damaged or inoperative seals cannot protect bearings from contamination.

Lubricant Failure

Discolored (blue/brown) ball tracks and balls are symptoms of lubricant failure. Excessive wear of balls, ring and cages will follow, resulting in overheating and subsequent catastrophic failure.

Ball bearings depend on the continuous presence of a very thin - millionths of an inch - film of lubricant between balls and races, and between the cage, bearing rings and balls.

Failures are typically caused by restricted lubricant flow or excessive temperatures that degrade the lubricant's properties. Any steps taken to correct improper fit, control preload better and cool the shafts and housings will reduce bearing temperatures and improve lubricant life.

Corrosion

Red/brown areas on balls, cages or bands of ball bearings are symptoms of corrosion. This condition results from exposing bearings to corrosive fluids or a corrosive atmosphere. The usual result is increased vibration followed by wear, with subsequent increase in radial clearance or loss of preload. In extreme cases, corrosion can initiate early fatigue failures. Correct by diverting corrosive fluids away from bearing areas and use integrally sealed bearings whenever possible. If the environment is particularly hostile, the use of external seals in addition to integral seals should be considered. The use of stainless steel bearings is also helpful.

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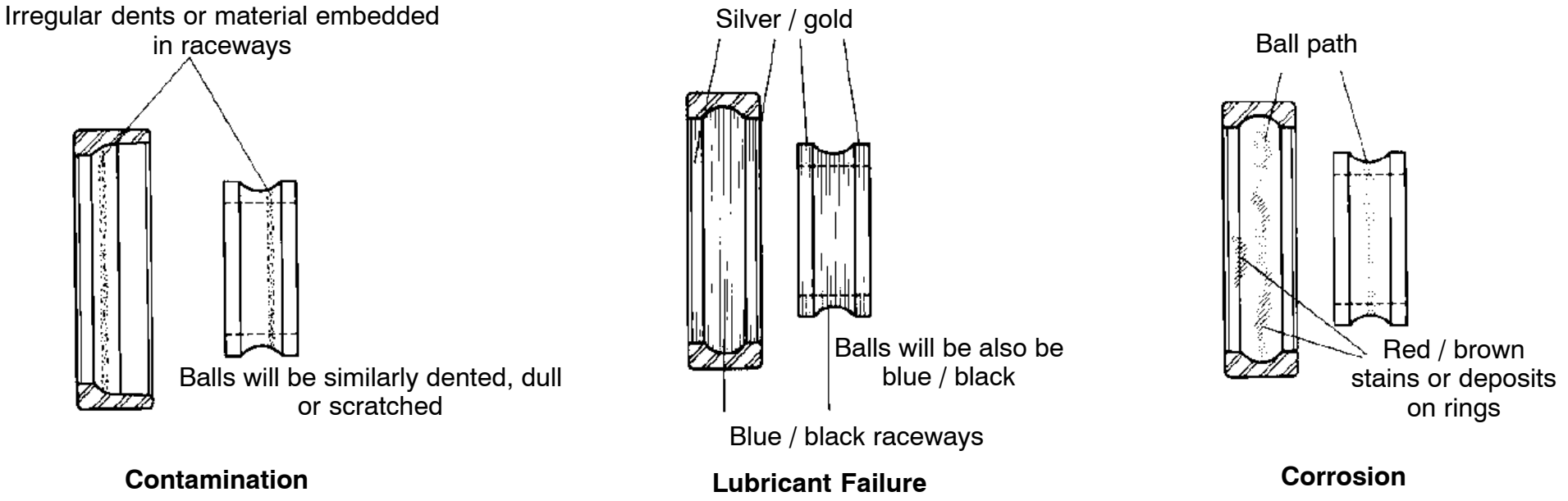


Figure 5 Bearing Defects (3)

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BEARING DEFECTS AND THEIR CAUSES (CONTD.)

Misalignment

Misalignment can be detected on the raceway of the non-rotating ring by a ball wear path that is not parallel to the raceway edges. If misalignment exceeds 0.001in/in you can expect an abnormal temperature rise in the bearing and/or housing and heavy wear in the cage ball-pockets.

The most prevalent causes of misalignment are:

- bent shafts
- burrs or dirt on shaft or housing shoulders
- shaft threads that are not square with shaft seats, and
- locking nuts with faces that are not square to the thread axis.

The maximum allowable misalignment varies greatly with different applications, decreasing, for example, with speed. Appropriate corrective action includes:

- inspecting shafts and housings for runout of shoulders and bearing seats
- use of single point-turned or ground threads on non-hardened shafts and ground threads only on hardened shafts, and
- using precision grade locknuts.

Tight Fits

A heavy ball wear path in the bottom of the raceway around the entire circumference of the inner ring and outer ring indicates a tight fit. Where interference fits exceed the radial clearance at operating temperature, the balls will become excessively loaded. This will result in a rapid temperature rise accompanied by high torque. Continued operation can lead to rapid wear and fatigue.

Corrective action includes a decrease in total interference - better matching of bearings to shafts and housings - taking into consideration the differences in materials and operating temperatures. Increased radial clearance will also increase bearing life under the above conditions.

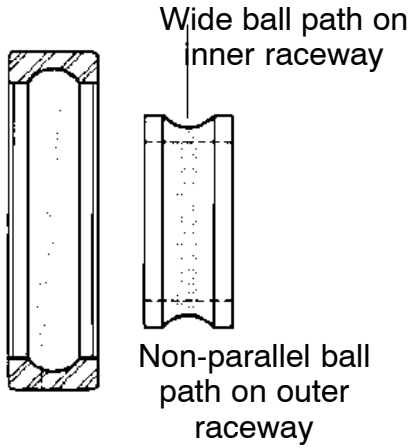
Loose Fits

Loose fits can cause relative motion between mating parts. If the relative motion between mating parts is slight but continuous, fretting occurs. Fretting is the generation of fine metal particles which oxidize, leaving a distinctive brown color. This material is abrasive and will aggravate the looseness.

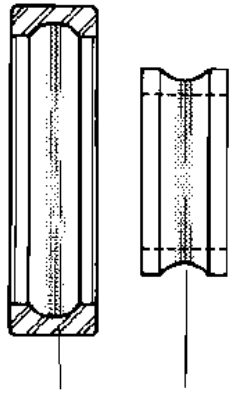
If the looseness is enough to allow considerable movement of the inner or outer ring, the mounting surfaces (bores, outer diameters, faces) will wear and heat, causing noise and runout problems.

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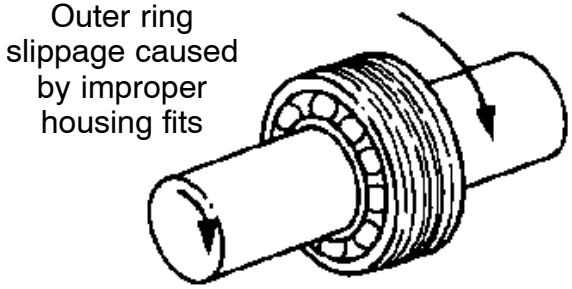


Misalignment



Discolored, wide ball path at bottom of raceways

Tight Fits



Loose Fits

Figure 6 Bearing Defects (4)

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TESTING, CLEANING AND INSPECTION OF BEARINGS

Installation and Removal of Bearings

General

Installation and removal of Boeing aircraft bearings is described in the Boeing Process Specification BAC 5435.

Removal of Bearings

When removing bearings, the following basic rules must be observed:

- Use the correct removal tools.
- Avoid damage to the structure when using the circular cutting guide.
- The circular cutting guide must have an exterior diameter which is sufficiently large so that only the flange will be cut.
- The lower and upper tool must be equipped with adequate bushing guides or guide pins.
- If possible, use a column-type drilling machine as the drive.
- After the flange has been cut free, the bearing has to be squeezed out with an ejection tool.

Installation of Bearings

For the installation of bearings, the following basic rules must be observed:

- Check drilling surface and bearings for satisfactory condition
- Apply surface protection
- Install bearing with a drawing die and make sure that the projecting length is central
- Roll the bearing with tools
- Check flange
- Test the bearing with testing load - if necessary seal gap.

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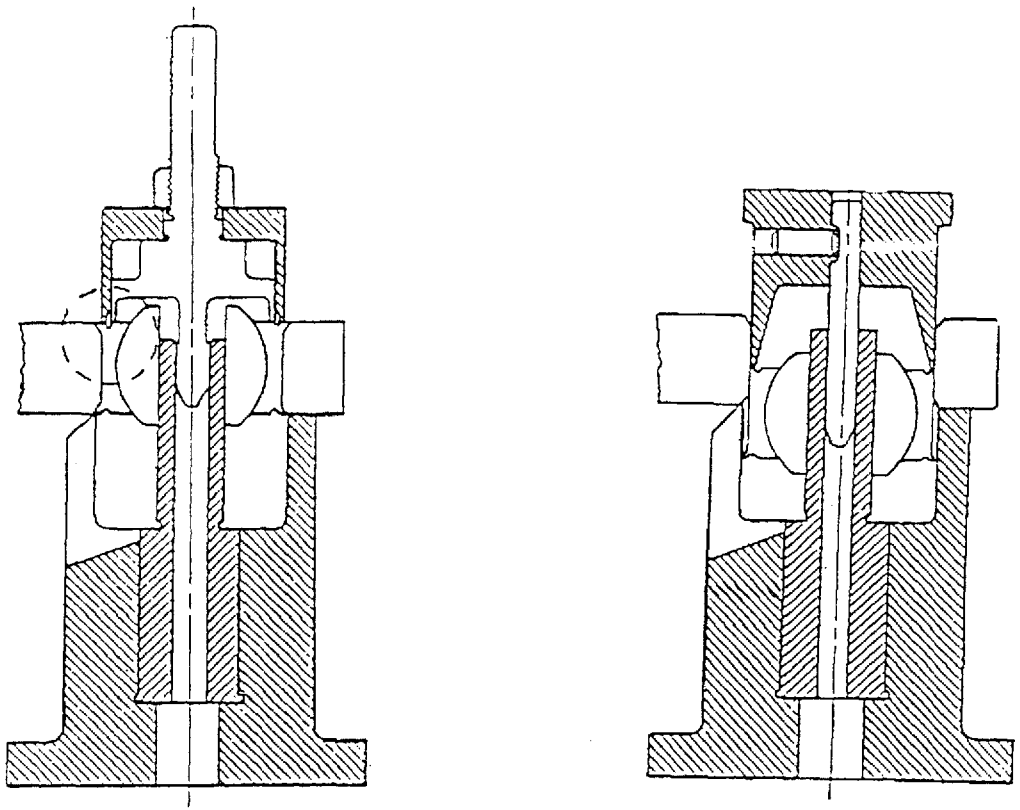


Figure 7 Bearing Removal Tooling

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Installation of anti-friction bearings

When installing anti-friction bearings in components and aircraft controls (elevator, aileron and rudder), the following instructions must be observed unless otherwise defined in special instructions (refer to process specification).

Bearings that cannot be disassembled

Check bearings manually for smooth operation; bearings that are considered satisfactory may be installed. Bearings that don't operate smoothly or show signs of jamming are not suitable for installation.

Bearings that can be disassembled

Check bearings manually for smooth operation. Bearings that are considered as satisfactory may be installed. Bearings that do not operate smoothly or show signs of jamming must be disassembled and subjected to visual inspection and greasing according to the following instructions:

- The following treatment of bearings has to be performed in a well-ventilated, dust-free room with a constant temperature (20°C).
- Optimum cleanliness during the entire treatment is essential.
- Remove clamping rings and cover plates carefully. Rinse the bearings manually in a container filled with Inhibisol until all grease and other residue has been removed.
- Rinse the cleaned bearings in a second container filled with the same cleaning solution, and then rinse for a third time in another container with the same cleaning solution.
- Cleaning fluids which are used for cleaning and rinsing have to be renewed depending on the number of bearings to be treated, but a minimum of one change per day must be carried out.
- In the case of filtering used cleaning fluids for reuse, filter systems that will remove 98% of all foreign material larger than 10 microns must be used.
- Dry the completely clean bearings with a gentle stream of air. The bearing should not be allowed to rotate.
- After drying, the bearing has to be half-filled with grease MIL G 3278+Z. Use Nirosta spatula. Bearings have to be greased within two hours of the final rinse!
- Treat the outer bearing with a thin film of the same grease that was used for filling. Re-install cover plates and clamping rings.

ATTENTION: Do not touch the bearings with bare hands during cleaning, drying and greasing. Use rubber gloves or tongs.

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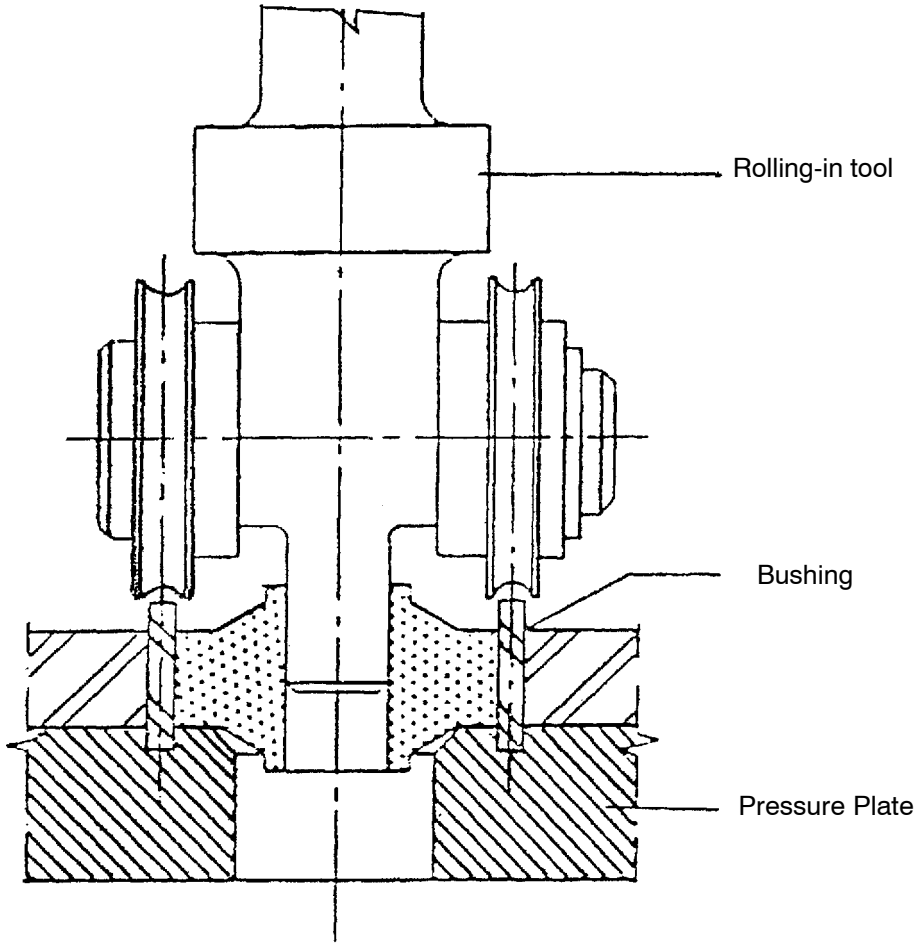


Figure 8 Bearing Installation Tooling

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