SAE Aerospace
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AEROSPACE INFORMATION REPORT

AIR5883

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Landing Gear Shock Struts Bearing Selection

RATIONALE

AIR5883 has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE

1.1 This document defines the criteria used for the selection of landing gear shock strut upper and lower bearings.

1.2 Common problems associated with shock strut bearings are presented

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

ARP1311 Aircraft Landing Gear

AIR1494 Verification of Landing Gear Design Strength

AIR1594 Plain Bearing Selection for Landing Gear Applications

ARP4912 Design Recommendations for Spare Seals in Landing Gear Shock Struts

ARP5429 Landing Gear Fatigue Tests with Equivalent Damage Spectra

AS81820 Bearings, Plain, Self-aligning, Self-lubricated, Low Speed Oscillation

AS81934 Bearing, Sleeve, Plain and Flanged, Self-lubricated

2.2 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch/.

MIL-L-8552C Landing Gear, Aircraft Shock Absorber (Air-oil type)

3. DEFINITIONS

3.1 LADDER CRACKING

Lateral cracks found on the chrome surface of the shock strut piston.

3.2 SLIP-STICK

A stiction effect caused by friction. This phenomenon is also known as ratcheting.

3.3 LINER DE-LAMINATION (LINED BEARINGS)

The removal of the liner material from the metallic backing.

3.4 ALLOWABLE LINER WEAR (LINED BEARINGS)

A lined bearing is considered no longer serviceable when a portion of the wear coating has been worn to a degree that could affect the shock strut operation. Wear definition of the liner material is usually related to the maximum allowable clearance between the bearing and the cylinder or the bearing and the piston.

4. BEARING MATERIALS SELECTION

The following suggested criteria are to be considered:

4.1 Wear

Depending on the type of the aircraft and its intended utilization, suitable materials will be selected. Wear is also a function of the mating surface material and finish.

4.2 Friction

Although the material with the lowest friction is desired, consideration should be given to other aspects such as shimmy, which can be reduced with a higher friction material. However, it is important to note that friction is not a primary means of controlling shimmy since it is a function of many other factors.

Other friction characteristics to be considered when selecting the type of bearing can be summarized as follows:

4.2.1 The liner behavior with the contact material of the landing gear as well as the type of plating/coating used. Contact materials can be steel, chrome plated steel, HVOF coated steel, aluminum, hard anodized aluminum, plasma coated aluminum, titanium.

4.2.2 Some bearing materials exhibit an increasing friction under light loads then reverse that behavior as the load is continuously increased.

PTFE lubricated bearing materials normally require a break-in period to start the lubrication process. Therefore, these types of bearings can have a substantially different coefficient of friction in their new installed condition compared to their broken-in condition.

4.2.3 Heat caused by friction can be detrimental to elastomer seal performance.

4.3 Heat Dispersion

The heat dispersion characteristics of the selected bearing material must be evaluated. Generally materials with good dispersion properties are recommended. However, Composite and non-metallic materials are inherently non-conductive. In this case, the cooling is provided by the fluid environment in the landing gear (wet bearing applications only).

4.4 Cost

As in 4.1, depending on the type of aircraft and its intended utilization, the material selection should consider the lowest life cycle cost.

4.5 Weight

Bearings with a liner usually offer lower weights than an all-metal bearing.

4.6 Bearing Capacity

A higher bearing capacity will result in a shorter bearing, hence resulting in a lower weight. A self-lubricated bearing operating with high unit stresses (PSI loading) will result in shorter life.

4.7 Bearing Materials

Bearing materials can be categorized into three categories: metal, lined, and non-metallic resins.

4.7.1 Metal

The most common material used is Al Ni bronze. Some applications made use of copper beryllium (copper beryllium is not recommended for environmental reasons).

4.7.2 Lined

Since liners are non-conductive materials, consideration should be given for gear bonding requirements. Several types of liner are available for use:

4.7.2.1 Teflon impregnated cloth type

4.7.2.2 Phenolic Cotton Fabric Bearing

This type is used on some shock struts for weight saving. However, it has been known to swell when in contact with water or moisture, causing binding or slip stick. It is therefore recommended to pay design consideration on the environment for this type of bearings.

4.7.2.3 Sprayed or molded

4.7.2.4 Teflon Coating on a Metal Shell

Resin/teflon wear coating with fabric reinforcement, bonded to a metal shell or sleeve

4.7.2.5 A combination of a porous bronze matrix impregnated with PTFE/Lead bearing material on a steel or bronze backing shell.

4.7.3 Non-Metallic Resins

Several bearing-grade homogenous non-metallic resins can be molded and fit into existing gland standards. Such designs may reduce the potential threat of wearing through a bearing liner.

4.8 Contaminants

Selected bearing liner systems are usually qualified to either AS81934 or AS81820. However, additional testing to verify the bearing performance under extended contamination levels is recommended since these specifications are not appropriate for shock strut bearings. The type of contamination and its level will vary depending on the application. It is therefore important to understand the environment under which the shock strut will operate in order to define the contamination testing.

5. COMMON PROBLEMS ENCOUNTERED WITH SHOCK STRUTS BEARINGS

5.1 Ladder Cracking

This phenomena is found on some shock struts, and it is assumed to be caused by heat damage occurring between the lower bearing and the piston due to high speed and extremely high localized contact stresses, resulting in streaks or radial travel marks on the chrome plated pistons usually associated with localized burn marks on the base metal.

Although this issue is not very well understood, heat damage can be caused by high rake angle of the shock strut. A maximum rake angle limitation to avoid heat damage cannot be applied to all shock struts since it is a function of the specific landing gear geometry.

5.2 Localized Burns

This is believed to be the result of partial contact of the upper bearing onto the inner diameter of the cylinder

5.3 Slip-Stick (Stiction)

This phenomenon reveals itself during low speed taxi or during towing by producing a bumpy and noisy ride. Braking stability is also affected since one shock strut could be at a significantly different stroke position than the other one. Bearings with stiction problems might cause the aircraft to suddenly drop during loading or during fueling. This problem is usually caused by a high friction bearing material but could also be caused by a low bearing pressure or piston ovalization.

5.4 Uneven Wear

Uneven wear is caused by an inadequate method of bearing retention or by the ovalization of the bearing.

5.5 Premature Wear

This is caused by a wrong material selection or by a higher than expected contact pressure.

5.6 Liner Chipping/Tearing or De-bonding (Sprayed and Molded Liners)

This can result in shock strut contamination and substrate corrosion. Anodizing of the base aluminum metal of shock strut bearings should be done prior to bonding/molding

5.7 Liner Detachment or De-bonding (Lined Bearings)

This can result in shock strut contamination and substrate corrosion. Anodizing of the base aluminum metal of shock strut bearings should be done prior to bonding/molding.