

AEROSPACE INFORMATION REPORT

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(R) Landing Gear Component Heat Damage

RATIONALE

This document is being revised to expand the discussion about service induced heat damage on high strength steel landing gear components beyond the shock strut inner cylinder sliding surfaces. This revision includes examples of heat damage on outer cylinders, inner cylinder pivot bores, and truck pivot pins. Also included is more information about inspection methods and repair procedures to address heat damage at overhaul.

AIR5913A has been reaffirmed to comply with the SAE Five-Year Review policy.

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Documents

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Figure 4	Inner diameter surface of an outer cylinder with a crack and transferred bushing material (left), and evidence of base metal heat damage revealed by nital etch inspection (right).....	6
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1. SCOPE

The purpose of this report is to outline types of in-service heat damage that have been observed in high strength steel landing gear components, with an emphasis on a particular type that is referred to as "Ladder Cracking" which can develop in landing gear shock struts. The report discusses how ladder cracking can be detected visually and evaluated by non-destructive inspection methods, and how it can be repaired at overhaul with the prior approval of the Original Equipment Manufacturer. This report also describes the use of a bearing material that has resolved this problem without introducing other problems. Examples of other types of service induced heat damage are also discussed.

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 +1 724-776-4970 (outside USA), www.sae.org.

AMS2440	Inspection of Ground, Chromium Plated Steel Parts
AIR1594	Plain Bearing Selection for Landing Gear Applications
AIR5883	Landing Gear Shock Struts Bearing Selection
AIR5885	Landing Gear Common Repair
ARP4462	Barkhausen Noise Inspection for Detecting Grinding Burns in High Strength Steel Parts
ARP4915	Disposition of Landing Gear Components Involved in Accidents/Incidents

2.2 Other Publications

AD-D127069	Consideration of Mechanical, Physical, and Chemical Properties in Bearing Selection for Landing Gear of Large Transport Aircraft. Author: Fewtrell, H. E., published 1983. http://ammtniac.alionscience.com/ammt/iacdocs.do?B119661
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3. BACKGROUND

Airline experience has shown that, under certain load conditions, Aluminum Nickel Bronze bearings operating on bare and chrome plated high strength steel, have resulted in the generation of severe thermal spikes over small discrete areas which have caused cracking of the steel and in some cases, the cracking has resulted in major component fractures.¹

3.1 Landing Gear Configuration

Heat damage in landing gear shock struts primarily occurs in cantilever type designs where high lateral bearing loads result from the drag and side loads acting on the gear during typical landing and ground maneuvering operations. A typical cantilever landing gear that encounters this type of heat damage is shown in Figure 1.

¹ See 3.5 for other testing.

Figure 1 - Boeing 767 main gear

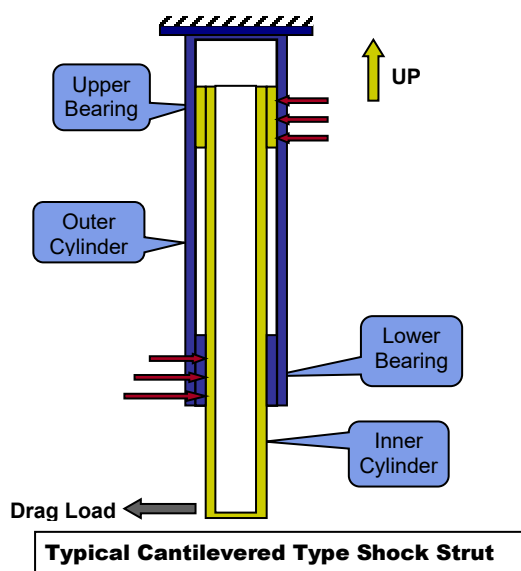


Figure 2 - Shock strut sketch

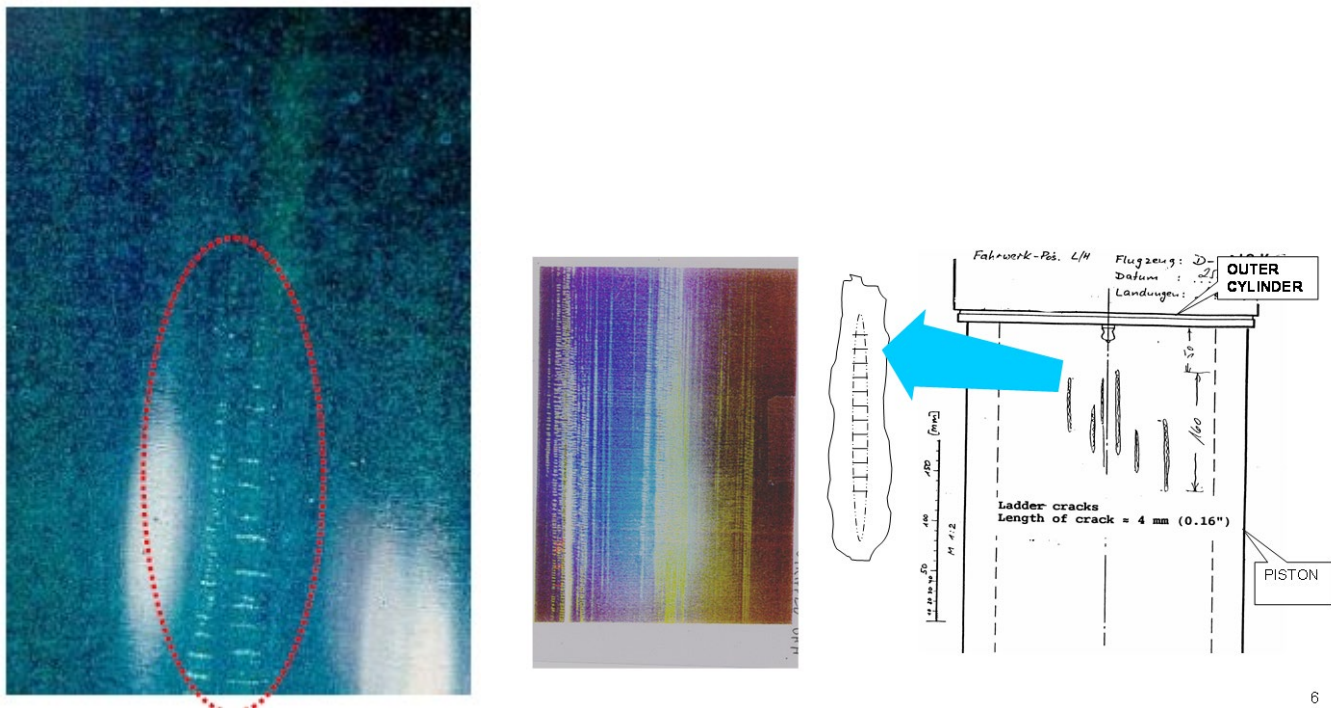
The type of strut illustrated in Figure 2 is comprised of a piston/inner cylinder supported by and able to slide inside the outer cylinder. Drag and side loads exert a considerable force on each of the sliding bearings which usually have a designed projected bearing pressure of around 6000 psi. However, due to deflections and ovalization, the bearing loads are concentrated at the open end of the lower bearing and they can be considerably higher than 6000 psi.

There have been many different design concepts to alleviate the problem of high bearing pressures. Self-aligning, bell mouthed, wetted lower bearing, non-metallic and other bearing concepts have met with some success.

3.2 Heat Damage Mechanism and Detection

In-service heat damage is commonly caused by rapid motion between parts accompanied by high bearing pressure in a localized area. This type of action generates very rapid localized frictional heating along with thermal expansion and contraction. In the low alloy steel material used to fabricate most shock strut inner and outer cylinders, if the temperature is high enough from this localized heating, microstructural changes will occur which can cause the formation of over-tempered martensite (aka OTM or re-tempering) and un-tempered martensite (aka UTM or re-hardening). These phase changes are also accompanied by rapid volumetric changes. Together, these behaviors generate tensile stresses in the material which can cause base metal cracking high temperature sufficient to produce over-tempered martensite (aka OTM or re-tempering) and un-tempered martensite (aka UTM or re-hardening) in the low alloy steel material used in fabrication of most shock strut inner and outer cylinders. The substrate or base metal cracking which often occurs in the un-tempered areas, or at the boundary between UTM and OTM regions. Sometimes the cracks do not propagate beyond the heat damaged area, but depending on the location on the part, the cracks may propagate in service by fatigue or stress corrosion cracking mechanism.

It is not possible to visually determine if base metal heat damage is present in landing gear shock struts, but when it does occur, it is typically accompanied by changes to the appearance of the chrome plating in the affected area. Visible evidence of possible damage can consist of bearing material transfer onto the chrome plate, darkened streaks, and/or smeared, chipped, or flaking plating. More severe cases of damage can be detectable by the naked eye as evidenced by plating breakdown in the form of multiple linear cracks that are oriented like rungs of a ladder, creating a condition commonly referred to as "Ladder Cracks" (see Figure 3). These cracks sometimes penetrate the substrate material and have led to a structural failure or rejection of the damaged part.



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Figure 3 - Ladder cracks
(magnetic particle indications evident in the photo to the left)

Heat damage has also been found on the inside of steel outer cylinders in the area where the upper bearing slides. Heat damage can also occur on journal bearing type joints such as truck pivot pins and their mating surfaces when extreme truck pitching causes high levels of frictional heating at the interfaces. Joints under high bearing pressures which are subject to slight movement can also be susceptible to heat damage if not properly lubricated with grease. Figures 4 and 5 show magnetic particle and nital etch inspection results that revealed base metal cracking and heat damage on pivot bore lugs of an inner cylinder.