

FINAL

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**NATIONAL
TRANSPORTATION
SAFETY
COMMITTEE**

Aircraft Accident Investigation Report

**PT. Garuda Indonesia
PK – GZI
Boeing Company 737-400
Ngurah Rai Airport, Denpasar, Bali
Republic of Indonesia**

28 October 2008



**NATIONAL TRANSPORTATION SAFETY COMMITTEE
MINISTRY OF TRANSPORTATION
REPUBLIC OF INDONESIA
2010**

This Report was produced by the National Transportation Safety Committee (NTSC), Karya Building 7th Floor Ministry of Transportation, Jalan Medan Merdeka Barat No. 8 JKT 10110, Indonesia.

The report is based upon the investigation carried out by the NTSC in accordance with Annex 13 to the Convention on International Civil Aviation, Aviation Act (UU No.1/2009), and Government Regulation (PP No. 3/2001).

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GLOSSARY OF ABBREVIATIONS

AD	Airworthiness Directive
AFM	Airplane Flight Manual
AGL	Above Ground Level
ALAR	Approach-and-landing Accident Reduction
AMSL	Above Mean Sea Level
AOC	Air Operator Certificate
ATC	Air Traffic Control
ATPL	Air Transport Pilot License
ATS	Air Traffic Service
ATSB	Australian Transport Safety Bureau
Avsec	Aviation Security
BMG	Badan Meterologi dan Geofisika
BOM	Basic Operation Manual
°C	Degrees Celsius
CAMP	Continuous Airworthiness Maintenance Program
CASO	Civil Aviation Safety Officer
CASR	Civil Aviation Safety Regulation
CPL	Commercial Pilot License
COM	Company Operation Manual
CRM	Cockpit Recourses Management
CSN	Cycles Since New
CVR	Cockpit Voice Recorder
DFDAU	Digital Flight Data Acquisition Unit
DGCA	Directorate General of Civil Aviation
DME	Distance Measuring Equipment
EEPROM	Electrically Erasable Programmable Read Only Memory
EFIS	Electronic Flight Instrument System
EGT	Exhaust Gas Temperature
EIS	Engine Indicating System
FL	Flight Level
F/O	First officer or Co-pilot
FDR	Flight Data Recorder
FOQA	Flight Operation Quality Assurance
GPWS	Ground Proximity Warning System
hPa	Hectopascals
ICAO	International Civil Aviation Organization

IFR	Instrument Flight Rules
IIC	Investigator in Charge
ILS	Instrument Landing System
Kg	Kilogram(s)
Km	Kilometer(s)
Kt	Knots (NM/hour)
Mm	Millimeter(s)
MTOW	Maximum Take-off Weight
NM	Nautical mile(s)
KNKT /	Komite Nasional Keselamatan Transportasi /
NTSC	National Transportation Safety Committee
PIC	Pilot in Command
QFE	Height above aerodrome elevation (or runway threshold elevation) based on local station pressure
QNH	Altitude above mean sea level based on local station pressure
RESA	Runway End Safety Area
RPM	Revolution Per Minute
SCT	Scattered
S/N	Serial Number
SSCVR	Solid State Cockpit Voice Recorder
SSFDR	Solid State Flight Data Recorder
TS/RA	Thunderstorm and rain
TAF	Terminal Aerodrome Forecast
TSN	Time Since New
TT/TD	Ambient Temperature/Dew Point
TTIS	Total Time in Service
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

SYNOPSIS

On 28 October 2008, a Boeing 737-400 aircraft, registered PK-GZI, registered PK-GZI, was being operated on a scheduled passenger service from Adisucipto Airport, Yogyakarta to Ngurah Rai Airport, Denpasar. There were 139 persons on board; two pilots, five flight attendants, and 132 passengers.

After landing, while the aircraft was being taxied to the apron, the number-one main wheel axle failed.

The left main landing gear had been overhauled by a United States Federal Aviation Administration approved workshop in the USA. After the overhaul on 28 August 2008, the landing gear was installed on PK-GZI on 24 October 2008. The failure occurred on 28 October 2008. At the time of the failure, the landing gear had completed 15,345 cycles since new, and 7 cycles since overhaul.

The investigation found that an undetected fatigue crack in the number-one main landing gear axle originated from a corroded hole in the brake assembly attachment flange. The fatigue crack propagated toward the flange and the axle wall, reaching about 8 cm long until a fast final fracture occurred. The accident occurred on the seventh landing after the installation of the overhauled main landing gear.

Laboratory examinations on the failed axle were conducted in Indonesia and the USA. Two areas of evidence supported that the crack was present before the inner cylinder was last overhauled.

On 5 August 2008, the operator's maintenance organization issued engineering orders that required increased inspection schedules for main landing gear axles, because the axle had failed at a time significantly short of the manufacturers specified component life.

On 6 August 2008, the National Transportation Safety Committee issued recommendations to the Directorate General of Civil Aviation, the US Federal Aviation Administration, the Boeing Company, and the European Aviation Safety Agency, with respect to reviewing the overhaul and inspection requirements for Boeing 737 main landing gear axles.

On 20 July 2009, the US National Transportation Safety Board (NTSB) informed the NTSC that "Boeing plans to revise the AMM [Aircraft Maintenance Manual] to add and highlight the importance of visually inspecting the brake flange location part for corrosion and/or damaged Sermetal finish during normal maintenance activities. In addition, Summit Aerospace [component overhaul facility] has taken several safety enhancement actions by adding a fluorescent penetrant inspection in addition to the existing magnetic partial inspection, and revised the relevant magnetic partial inspection techniques to enhance the inspection."

1 FACTUAL DATA

1.1 HISTORY OF THE FLIGHT

On 28 October 2008, a Boeing Company 737-400 aircraft, registered PK-GZI, was being operated on a scheduled passenger service from Adisucipto Airport, Yogyakarta to Ngurah Rai Airport, Denpasar. There were 139 persons on board; two pilots, five flight attendants, and 132 passengers.

The aircraft touched down on Denpasar runway 09 at 1412 UTC¹. While the aircraft was being taxied to the apron, the number-one² main wheel axle failed.

None of the aircraft's occupants were injured.

1.2 INJURIES TO PERSONS

Table 1: Injuries to persons

Injuries	Flight crew	Passengers	Total in Aircraft	Others
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	Not applicable
Nil Injuries	7	132	139	Not applicable
TOTAL	7	132	139	-

1.3 DAMAGE TO AIRCRAFT

The number-one main landing gear axle was broken and detached from its landing gear strut.

¹ The 24-hour clock used in this report to describe the time of day as specific events occurred, is in Coordinated Universal Time (UTC). Local time, Western Indonesian Standard Time (WIB) is UTC+ 7 hours.

² Main landing gear wheels are numbered one to four, with wheel number one the left outboard, and wheel number four the right outboard.



Figure 1: The number-one wheel and axle.

1.4 OTHER DAMAGE

No other damage was reported.

1.5 PERSONNEL INFORMATION

The pilots held valid licenses and ratings for the operation of the aircraft. This section covering flight crew is not relevant to this serious incident.

1.6 AIRCRAFT INFORMATION

1.6.1 General

Registration Mark	: PK-GZI
Manufacturer	: Boeing Company
Country of Manufacturer	: United States of America
Type/ Model	: Boeing 737-400
Serial Number	: 29204
Date of manufacture	: 1998
Certificate of Airworthiness	
Valid to	: 20 July 2009
Time Since New	: 31,456 hours
Cycles Since New	: 16,186 cycles

1.6.2 Landing gear data

Main landing gear number one

Part number	: 65-46116
Serial number	: MC 06099P3051
Date installed	: 24 October 2008
Time Since New	: 30,243 hours
Cycles Since New	: 15,345 cycles
Cycles Since Inspection	: 7 cycles
Overhaul limit calendar	: 10 years
Overhaul limit cycles	: 21,000 cycles

The aircraft's first owner was Sailplane Leasing Ltd. It was operated by Aeroflot with Certificate of Airworthiness Number A16WE E2GL.

The next operators were:

- Aeroflot (Reg. VP-BAL) from 17 July 1998 to December 2003. During that time the aircraft was flown from 7 hours 57 minutes total time in service, to 17,640 hours and 49 minutes, and from 9 cycles to 6,494 cycles.
- Garuda Indonesia (Reg. PK-GZI) commenced operating the aircraft on 22 January 2004 until the date of the accident on 8 November 2008. During that time the aircraft was flown from 17,640 hours and 49 minutes total time in service, to 31,456 hours, and 6,494 cycles to 16,186 cycles.

1.6.3 Landing gear data

The left main landing gear had been overhauled by a United States of America (USA) Federal Aviation Administration (FAA) approved workshop in the USA. After the overhaul on 28 August 2008, the landing gear was installed on PK-GZI on 24 October 2008. The failure occurred on 28 October 2008. At the time of the failure, the landing gear had completed 15,345 cycles since new, and 7 cycles since overhaul.

At the time the aircraft was dispatched for the flight it was certified as being airworthy.

1.7 METEOROLOGICAL INFORMATION

Not relevant to this accident.

1.8 AIDS TO NAVIGATION

Not relevant to this accident.

1.9 COMMUNICATIONS

Communication between Air Traffic Services and the crew was normal.

1.10 AERODROME INFORMATION

Not relevant to this accident.

1.11 FLIGHT RECORDERS

The aircraft was equipped with a Solid State Digital Flight Data Recorder (SSFDR) and a Solid State Cockpit Voice Recorder (SSCVR) with a 30 minutes recording time.

The flight recorders were quarantined by the National Transportation Safety Committee investigators. The Flight Data Recorder was downloaded for the investigation, and the data revealed the G forces and landing speed of the seven flights on the day of the accident as follows:

Sector	Route	G Force	Speed
1	Jakarta – Balikpapan	1.3	134
2	Balikpapan – Jakarta	1.3	120
3	Jakarta – Denpasar	1.4	140
4	Denpasar – Surabaya	1.4	132
5	Surabaya – Denpasar	1.3	140
6	Denpasar – Yogyakarta	1.4	127
7	Yogyakarta – Denpasar	1.1	137

The G forces and landing speeds were normal.

1.12 WRECKAGE AND IMPACT INFORMATION

The number-one main landing gear axle fractured.



Figure 2: The fractured number-one axle showing that the failure occurred near the brake attachment flange

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

No medical or pathological investigations were conducted as a result of this accident, nor were they required.

1.14 FIRE

There was no pre- or post-accident fire.

1.15 SURVIVAL ASPECTS

None of the occupants were injured, and they vacated the aircraft unaided via airstairs.

1.16 TESTS AND RESEARCH

Not relevant to this accident investigation.

1.17 ORGANIZATIONAL AND MANAGEMENT INFORMATION

Operator: PT. Garuda Indonesia
Management Building 3rd Floor
Garuda Maintenance Facility
Soekarno-Hatta Airport
Jakarta 19130

1.18 ADDITIONAL INFORMATION

A metallurgical laboratory examination was performed on the broken axle at the laboratory of metallurgical engineering of the Institute of Technology, Bandung (ITB). The ITB laboratory report is at Part 6, Appendix A.

The crack on the axle originated from one of the brake assembly attachment holes at the axle flange.

The crack propagated about 8 cm until a fast final failure occurred.



Figure 3: View of the fracture surface. The fatigue crack initiated from the 5 o'clock attachment hole

Portions of the crack were present at least 43 cycles before the inner cylinder was last overhauled. The crack was present about 50 cycles before the failure.

Laboratory examinations were also performed by National Transportation Safety Board (NTSB), and the Boeing Company Material and Process Technology Workshop (M&PT). The ITB and M&PT reports concluded similar failure mechanisms.

Furthermore, the M&PT found that there were two areas of evidence that supported that portions of the crack were present before the inner cylinder was last overhauled. One item of evidence was the presence of discoloration on the fracture surface due to heat tinting during overhaul activities. The other evidence was the presence of Sermetal deposits on the crack, which occurred during the overhaul process. The Boeing Company M&PT report is at Part 6, Appendix B.

Boeing Company Overhaul Manual

The Boeing Company Overhaul Manual (32-11-11 page 301) states:

Examine the brake attachment flange on inner cylinder (62) for signs of cracks. If there are cracks, they will start from the brake mounting holes and could go inwards (toward axle) or outward (toward outer edge of brake flange). No more than four holes can have cracks that go outward. Refer to SB 32-1081 for more data.

1.19 USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES

The investigation was conducted in accordance with NTSC approved policies and procedures, and in accordance with the standards and recommended practices of Annex 13 to the Chicago Convention.

2 ANALYSIS

2.1 DETACHMENT OF WHEEL NUMBER-ONE

The investigation determined that the progress of the fatigue crack in the main landing gear axle number-one as follows:

- The failure mechanism was a fatigue failure.
- The fatigue crack originated from a corroded hole of the brake attachment flange.
- The fatigue crack propagated about 8 cm from the origin until a fast final fracture occurred.

The corrosion at the attachment hole increased the stress concentration locally.

The investigation determined that main wheel number-one, together with axle number-one separated from the landing gear assembly due to the propagation of a fatigue crack.

The investigation considered that based on these facts, maintenance activities related to axles and brake flanges should include detection and prevention of corrosion.

2.2 QUALITY OF THE OVERHAUL (OVERHAUL PROCESS)

The accident occurred on the seventh landing after the installation of the overhauled main landing gear.

The US National Transportation Safety Board (NTSB) confirmed the Boeing Company Material and Process Technology Workshop (M&PT) report's findings. The report concluded that the crack was present at the time of overhaul. However, the crack was not detected during the overhaul.

3 CONCLUSIONS

3.1 FINDINGS

- The aircraft was certified as being airworthy at the time of accident.
- Both pilots held valid licenses and ratings for the operation of the aircraft.
- A fatigue crack in the main landing gear axle originated from one corroded hole in the brake assembly attachment flange.
- The fatigue crack propagated toward the flange and the axle wall, reaching about 8 cm long until a fast final fracture occurred.
- The fatigue crack, which had extensively propagated, was present prior to the overhaul, and was not detected during the overhaul.
- The accident occurred 7 cycles after the installation of the overhauled left main landing gear.

3.2 CAUSES

- An undetected fatigue crack in the number-one main landing gear axle originated from a corroded hole in the brake assembly attachment flange.
- The fatigue crack propagated toward the flange and the axle wall, reaching about 8 cm long until a fast final fracture occurred.

4 SAFETY ACTIONS

4.1 PT. GARUDA INDONESIA

On 5 August 2008, Garuda Indonesia informed the National Transportation Safety Committee that it had taken the following safety actions.

- a) Amended its inspection policies and procedures (Continuous Airworthiness Maintenance Program) with respect to Boeing 737-300/400/500 series aircraft main landing gear assemblies, which requires maintenance inspection to:
- b) Conduct one time inspections, in accordance with Garuda Indonesia Engineering Order B3/P32-00-0354R1, on Landing Gear Assemblies on all Garuda Indonesia Boeing 737-300/400/500 series aircraft which have accumulated 15,000 Cycles Since Overhaul as of 23 July 2008, are to be performed before 17 August 2008. The inspections are non destructive using ultrasonic method for the outer surface of the axle root and eddy current method for the flange area (including brake attach flange, flange holes and adjacent axle surfaces).
- c) In accordance with Garuda Indonesia Engineering Order B3/S32-00-0355 perform non destructive inspection on Main Landing Gear Brake Attachment Flange on Inner Cylinder Assembly using Eddy Current method and outer surface of axle root using Ultrasonic method during every "C" Check.
- d) If during inspection, crack or severe damage indicates in one or more brake mounting holes, or any other parts of the assembly, the Landing Gear Inner Cylinder Assembly should be replaced with a serviceable one.

4.2 NATIONAL TRANSPORTATION SAFETY COMMITTEE

On 24 November 2009 the NTSC issued the following recommendations with the issue of Preliminary Report KNKT.08.10.24.04.

As result of this investigation to date, the National Transportation Safety Committee (NTSC) proposes several recommendations, to overcome identified safety deficiencies.

The investigation into the 28 October 2008 main landing gear axle failure of Boeing 737-400 aircraft, registered PK-GZI, has identified that the fracture also originated in a brake attachment flange of the main landing gear axle. The component had completed eight flight cycles since overhaul at a US Federal Aviation Administration (FAA) approved overhaul workshop. The axle assembly had completed 15,352 flight cycles since new.

The investigation to date indicates that the crack commenced more than 50 flight cycles before the failure. Therefore, the NTSC reiterates the safety action taken by Garuda Indonesia on 5 August 2008 and the recommendations made to the Boeing Company and the US FAA via the US National Transportation Safety Board (NTSB), and the European Aviation Safety Agency (EASA), on 6 August 2008, to overcome identified safety deficiencies.

4.3 BOEING COMPANY

On 11 February 2010, the National Transportation Safety Board advised the National Transportation Safety Committee that:

“Boeing has revised the Airplane maintenance Manual (AMM) to provide for enhanced visual inspection of the coating on the brake attachment flange at each brake change. The revised AMM inspection is included for your information.”

The Boeing AMM revision is at Appendix C.

5 SAFETY RECOMMENDATIONS

On 6 August 2008, the National Transportation Safety Committee (NTSC) issued the following safety recommendations as a result of findings in the investigation of a failed main landing gear axle on a Boeing 737 aircraft, registered PK-GZN, which occurred on 23 July 2008. The recommendations are reiterated as follows.

Directorate General of Civil Aviation

Recommendation KNKT/08.16.07.03 A

The National Transportation Safety Committee recommends that the Directorate General of Civil Aviation of the Republic of Indonesia require that Indonesian operators of Boeing 737-200/300/400/500 series aircraft affected by The Boeing Company Overhaul Manual (32-11-11 page 301) instructions to:

- a) Conduct one-time non destructive inspections on Landing Gear Assemblies on all Boeing 737-300/400/500 series aircraft which have accumulated 15,000 Cycles Since Overhaul. Specifically, the inspections should be conducted on the outer surface of the axle root and the flange area (including brake attach flange, flange holes and adjacent axle surfaces).
- b) Conduct Eddy Current inspections of the brake attachment flange on inner cylinder and Ultrasonic inspections of the outer surface of axle root of Boeing 737-200/300/400/500 series aircraft at each 'C' check inspection;
- c) Replace Inner Cylinder/Sliding Member assemblies whenever a crack is found in one or more brake mounting holes or any other part of the assembly.

United States Federal Aviation Administration

Recommendation KNKT/08.16.07.03 B

The National Transportation Safety Committee of the Republic of Indonesia recommends that the US Federal Aviation Administration require the Boeing Company to amend the Boeing 737 Overhaul Manual (32-11-11 Page 301) to require operators of Boeing 737-200/300/400/500 series aircraft affected by Overhaul Manual (32-11-11 page 301) instructions to:

- a) Conduct one-time non destructive inspections on Landing Gear Assemblies on all Boeing 737-300/400/500 series aircraft which have accumulated 15,000 Cycles Since Overhaul. Specifically, the inspections should be conducted on the outer surface of the axle root and the flange area (including brake attach flange, flange holes and adjacent axle surfaces).
- b) Conduct Eddy Current inspections of the brake attachment flange on inner cylinder and Ultrasonic inspections of the outer surface of axle root of Boeing 737-200/300/400/500 series aircraft at each 'C' check inspection;
- c) Replace Inner Cylinder/Sliding Member assemblies whenever a crack is found in one or more brake mounting holes or any other part of the assembly.

United States Federal Aviation Administration

Recommendation KNKT/ 08.16.07.03 C

The National Transportation Safety Committee of the Republic of Indonesia recommends that the US Federal Aviation Administration require operators of Boeing 737-200/300/400/500 series aircraft affected by Overhaul Manual (32-11-11 page 301) instructions to:

- a) Conduct one time non destructive inspections on Landing Gear Assemblies on all Boeing 737-300/400/500 series aircraft which have accumulated 15,000 Cycles Since Overhaul. Specifically, the should be conducted on the outer surface of the axle root and the flange area (including brake attach flange, flange holes and adjacent axle surfaces).
- b) Conduct Eddy Current inspections of the brake attachment flange on inner cylinder and Ultrasonic inspections of the outer surface of axle root of Boeing 737-200/300/400/500 series aircraft at each 'C' check inspection;
- c) Replace Inner Cylinder/Sliding Member assemblies whenever a crack is found in one or more brake mounting holes or any other part of the assembly.

Boeing Company

Recommendation KNKT/ 08.16.07.03 D

The National Transportation Safety Committee of the Republic of Indonesia recommends that the Boeing Company amend the Boeing 737 Overhaul Manual (32-11-11 Page 301) to require operators of Boeing 737-200/300/400/500 series aircraft affected by The Boeing Company Overhaul Manual (32-11-11 page 301) instructions to:

- a) Conduct one-time non destructive inspections on Landing Gear Assemblies on all Boeing 737-300/400/500 series aircraft which have accumulated 15,000 Cycles Since Overhaul. Specifically, the inspections should be conducted on the outer surface of the axle root and the flange area (including brake attach flange, flange holes and adjacent axle surfaces).
- b) Conduct Eddy Current inspections of the brake attachment flange on inner cylinder and Ultrasonic inspections of the outer surface of axle root of Boeing 737-200/300/400/500 series aircraft at each 'C' check inspection;
- c) Replace Inner Cylinder/Sliding Member assemblies whenever a crack is found in one or more brake mounting holes or any other part of the assembly.

European Aviation Safety Agency

Recommendation KNKT/ 08.16.07.03 E

The National Transportation Safety Committee of the Republic of Indonesia recommends that the European Aviation Safety Agency require operators of Boeing 737-200/300/400/500 series aircraft affected by The Boeing Company Overhaul Manual (32-11-11 page 301) instructions to:

- a) Conduct one-time non destructive inspections on Landing Gear Assemblies on all Boeing 737-300/400/500 series aircraft which have accumulated 15,000 Cycles Since Overhaul. Specifically, the inspections should be conducted on the outer surface of the axle root and the flange area (including brake attach flange, flange holes and adjacent axle surfaces).

- b) Conduct Eddy Current inspections of the brake attachment flange on inner cylinder and Ultrasonic inspections of the outer surface of axle root of Boeing 737-200/300/400/500 series aircraft at each 'C' check inspection;
- c) Replace Inner Cylinder/Sliding Member assemblies whenever a crack is found in one or more brake mounting holes or any other part of the assembly.

6 APPENDIX

6.1 APPENDIX A: LABORATORY OF METALLURGICAL AND MATERIAL ENGINEERING OF THE INSTITUTE OF TECHNOLOGY, BANDUNG (ITB) REPORT.

DRAFT REPORT

METALLURGICAL OBSERVATION
ON THE FAILED MAIN LANDING GEAR AXLE OF
GARUDA INDONESIA BOEING 737-400 PK GZI
AT NGURAH RAI AIRPORT, BALI ON 28 OCT 2008

1. REFERENCE

This observation is performed in response to NTSC (KNKT) Department of Transportation RI, letter no. KNKT/175/X/KTJ/08 dated 30 October 2008.

2. OBSERVATION



Figure 1: Broken axle. Failure occurred near the brake attachment flange



Figure 2: Fracture surface: final failure. Fatigue crack was initiated from the 5 o'clock attachment hole.



Figure 3: Beach marks started from the hole, propagated inward toward the axle.



Figure 4: The appearance of fracture surface on the matching piece. Beach-marks reached approximately 8 cm from the hole.

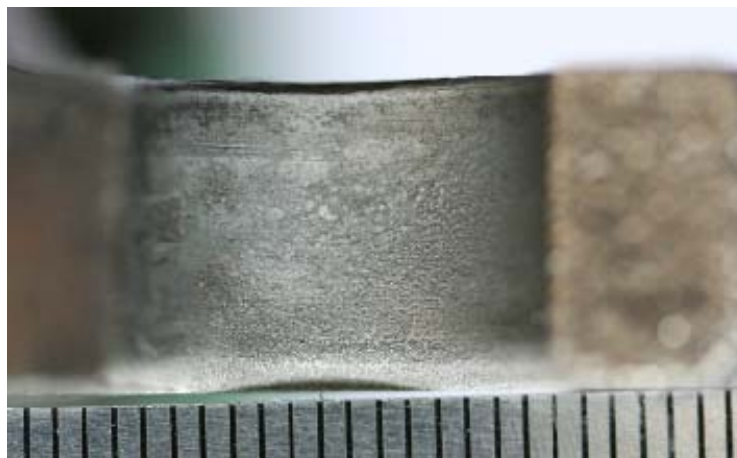


Figure 5: Fretting/corrosion pits on the surface of the flange hole

3. CONCLUSION:

- a. The fatigue crack had propagated up-to 8 cm from the origin.
- b. The beachmark is certainly of large number of cycles. The failure occurred at 8 flight cycles after the overhaul at SUMMIT Aerospace, USA.
- c. Fretting/corrosion pits were observed on the surface of the flange hole.
- d. The fatigue crack was initiated from that fretting pits.

4. QUESTION

Questions arise from the investigation are as follows:

- a. Why during the overhaul the crack was not detected?"
- b. Is the MPI (Magnetic Particle Inspection) effective to detect such a crack?"

Bandung, 8 November 2008

Laboratory of Metallurgy & Materials Engineering

Faculty of Mechanical and Aerospace Engineering ITB

Dr. ir. Arif Basuki

6.2 APPENDIX B: MATERIAL & PROCESS TECHNOLOGY WORKSHOP BOEING REPORT (FRACTURE ANALYSIS REPORT)



Investigation participants: Per ICAO Annex 13,
do not release this information without NTSC consent.

FRACTURE ANALYSIS REPORT

Engineering Report No.: MS13368

Date: 21 May 2009

Part Information

Design Drawing Part Name: Inner Cylinder, Main Landing Gear
Responsible Design Group: Landing Gear Design Center
Part No.: 65-46116
ATA Index: 3210-20

Airplane Information

Customer: Garuda (GIA)
Model: 737-400

First Event

Registry No.: PK-GZN
Line Position No.: 3,087
No. of Landings: 15,140 cycles since new, never overhauled

Second Event

Registry No.: PK-GZI
Line Position No.: 3,051
No. of Landings: 15,345 cycles since new, 7 cycles since overhaul

Material Information

Material: 4340M Steel
Material Specification: BMS 7-26
Heat Treat: 275 – 300ksi
Finish (brake flange and attach holes only):
a) Original drawing requirement: Apply Sermetel No. 249 coating (BMS 14-4, Type 2) to brake flange, and F-20.02 (one coat BMS 10-11 primer) to bolt holes.
b) Overhaul requirement per CMM 32-11-11: Apply Sermetel No. 249 coating (BMS 14-4, Type 2) to entire flange surfaces, including holes.

BACKGROUND

Between July and October 2008, GIA experienced two main landing gear axle fracture events. In the first event, the component had been originally delivered on the airplane, and had never been overhauled. The second fracture occurred on a component which had been overhauled seven cycles prior to the event. In both cases, the Indonesian NTSC performed an initial analysis of the fractures, and the parts were subsequently provided to Boeing for additional evaluation with the findings summarized in this report.

RESULTS and CONCLUSIONS;

I: First Event

- 1) Figure 1 shows the as-received condition the portion of the inner cylinder that was submitted to Boeing. The right hand side axle fractured between the brake flange and the vertical post section of the inner cylinder (fig. 1A). Examination of the fracture surface revealed that the origin was located at the surface of one of holes in the brake flange (white arrow in figure 1B).
- 2) The bore surface exhibited scattered corrosion pitting which served as the initiation site for the fracture which occurred by a fatigue mechanism. The crack propagated by fatigue for a length of approximately 2.5" before final fracture through the axle wall occurred by ductile separation (figure 1C).
- 3) The holes in the brake flange exhibited loss of the original primer. Deterioration of this protective finish can lead to fretting damage and corrosion pitting of the base metal, with both conditions capable of contributing to fatigue crack initiation.
- 4) Spectrochemical analysis and hardness tests confirmed that the inner cylinder had been fabricated from material per BMS 7-26, heat treated to the 275 – 300ksi condition in accordance with drawing requirements.

II: Second Event

- 1) Figure 2 shows the as-received condition of the fractured axle segments that were submitted to Boeing. The fracture emanated from a bolt hole on the brake flange and progressed in a helical direction through the axle wall.
- 2) Examination of the fracture surface revealed that the origin was located at the surface of one of the holes in the brake flange (arrowhead in figure 3A). Crack initiation and propagation were the result of a fatigue mechanism.
- 3) The fracture surface exhibited two distinct colors (figure 3B). The majority of the surface displayed light oxidation consistent with heat tinting which develops when alloy steel is exposed to temperatures of approximately 350F - 400F. This is the temperature used at overhaul for stress relief and hydrogen relief bakes. The remainder of the fracture surface was dull gray, typical of a fairly recent separation event. The presence of the oxidation suggests that the discolored portions of the crack were present when the inner cylinder was last overhauled.
- 4) Electron microprobe analysis of residues on the discolored fracture face revealed the presence of constituents of Sermetel coating. This finding supports the assertion that portions of the crack were present in the axle during the last overhaul of the inner cylinder, such that Sermetel could become deposited on the fracture face.

5) The fracture throughout the discolored region was the result of fatigue propagation which had progressed for a distance of approximately 3” to reach the terminus identified by the red arc. Several crack arrest marks were also visible on the gray colored fracture surface beyond the arc (figures 4A and 4B). These marks indicated that this portion of the fracture was due to incremental ductile separation which occurred once the part was returned to service after overhaul.

6) Stripping of the Sermetel coating on the flange and bolt holes in the area of the fracture revealed the presence of underlying corrosion pitting in the base metal (figure 5A – 5C). The fracture initiated from one of the areas of heavy pitting (figure 5B).

7) Spectrochemical analysis and hardness tests confirmed that the inner cylinder had been fabricated from material per BMS 7-26, heat treated to the 275 – 300ksi condition in accordance with drawing requirements.

DISCUSSION:

In both events, fatigue cracking initiated at areas of corrosion pitting that was present on the bolt holes of the brake flanges. Propagation was also due to fatigue in both cases, with cracks reaching lengths of approximately 2.5” – 3” before final fracture of the axles. In the first event, deterioration of the protective finishes on the bore surfaces lead to the observed corrosion and subsequent fracture.

In the second event, cracking appears to have been present at the time of overhaul, which had initiated at corrosion that had also developed before overhaul. The evidence collected during this investigation indicates that the part was refinished and returned to service where it accumulated seven flight cycles before the axle fracture event.

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Martin Farris – photography, metallurgical laboratory support
Mike Davis – magnetic particle inspections



Fig. 1A

Figure 1:

First occurrence:

Fatigue crack initiation at pitting on bore (white arrow Fig 1B). Crack propagation by fatigue for ~2.5" prior to final separation (Fig 1C).

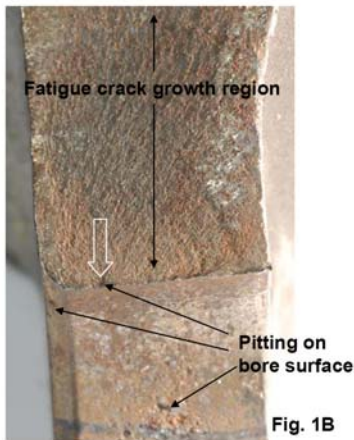


Fig. 1B

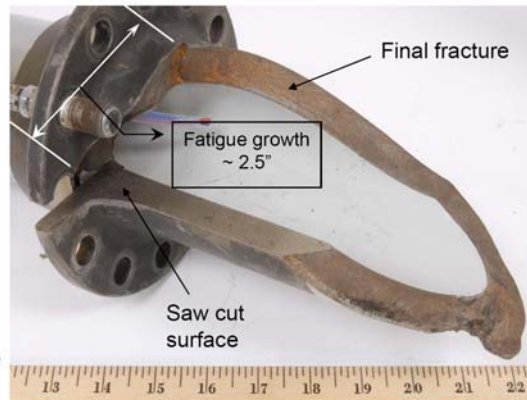


Fig. 1C

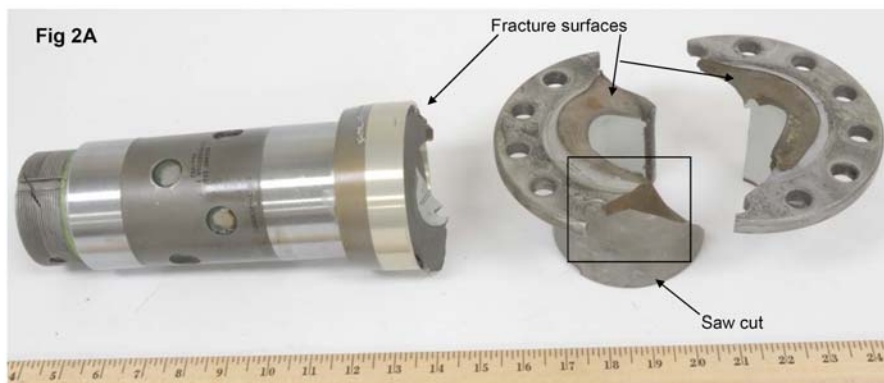


Fig 2A



Fig 2B

Figure 2: Photographs showing the as-received condition of submitted axle segments. Note that crack emanated from flange hole and progressed in a helical direction through the axle wall.

Fig 2A shows pieces separated to expose fracture path. Box in Fig. 2A indicates area of fracture presented in figure 3. Fig 2B show relationship between axle segments when fitted together.

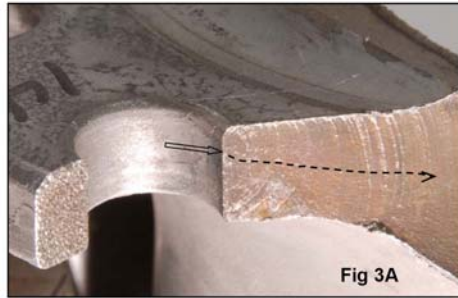


Figure 3A & 3B: Photographs showing fracture surface details.

Fig. 3A shows the fracture initiation site located at surface of brake flange bolt hole indicated by arrowhead. Initiation and propagation were the result of a fatigue mechanism with crack growth in the direction indicated by dashed arrow.

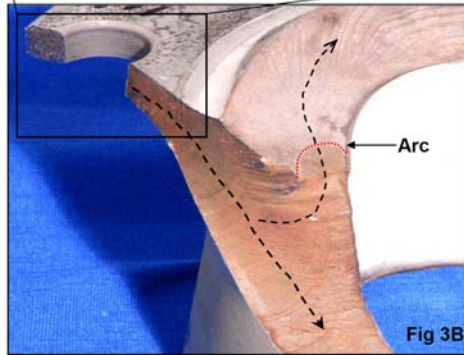


Fig. 3B shows the crack propagation path as indicated by dashed black arrows. Note change in coloration on the fracture surface indicated by the dashed red arc. The bronze color inside the arc was consistent with light heat tinting oxidation. The dull gray color outside the arc was free of oxidation and corrosion, and consistent with a more recent fracture.

The transition area associated with the arc is shown in detail in figure 4

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Figures 4A & 4B:

Photograph showing the mating fracture surfaces in the area of the coloration change denoted by red arcs and shown in Fig 3B. Note multiple visible crack arrest marks (at white arrowheads) beyond red arc indicating additional cyclic crack propagation prior to final fracture.

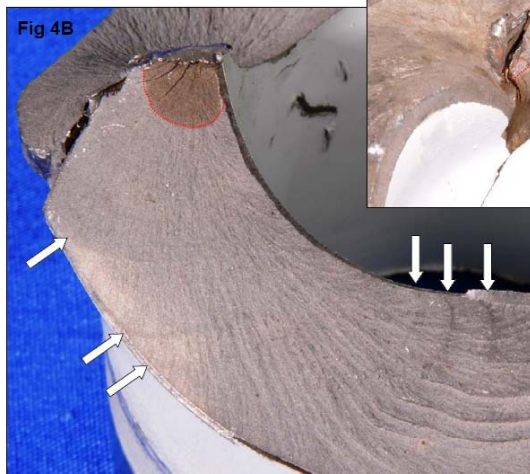


Figure 4A is surface on segment containing brake attach flange.

Figure 4B is mating surface on segment containing wheel bearing journals.

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Figure 5A: Bore surface at fracture origin (arrow) with Sermetel coating in place.

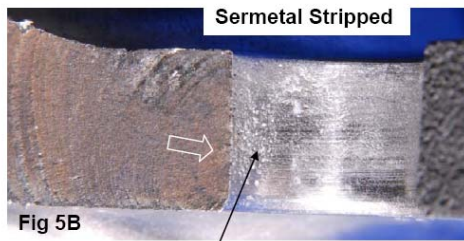


Figure 5B: Bore surface at fracture origin (arrow) with Sermetel removed which exposed underlying corrosion pitting in base metal.

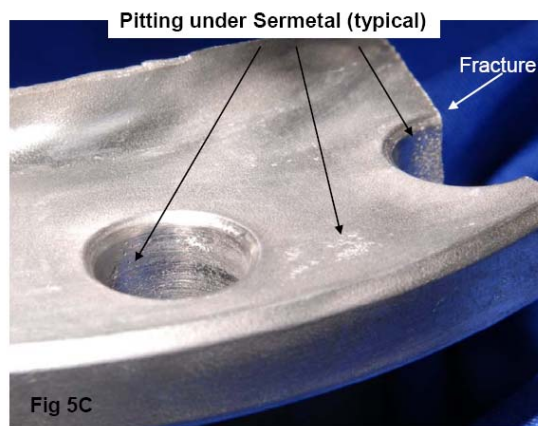


Figure 5C: Flange and bore surface adjacent to fracture with Sermetel removed to expose underlying base metal pitting.

6.3 APPENDIX C: AIRCRAFT MAINTENANCE MANUAL B737-300/400/500 ATA CHAPTER 32-41-41 PAGE 403 DATED 25 SEPTEMBER 2009



**737-300/400/500
AIRCRAFT MAINTENANCE MANUAL**

GIA 320

SUBTASK 32-41-41-864-082

(14) If you will replace the brake that you removed, and the new brake assembly does not have the inner part of the brake disconnect installed, do the steps that follow:

- (a) Use a wrench and the brake disconnect valve socket, SPL-9803 to remove the inner part of the brake disconnect valve from the brake.

NOTE: When you remove the disconnect valve from the brake, do not spill hydraulic fluid on the brake or adjacent structure.

- (b) Remove the O-ring and the backup rings. Discard the O-rings.

GIA ALL

SUBTASK 32-41-41-214-016

(15) Visually examine the brake attachment flange, including the bores, for corrosion pits, fretting, cracks or damage to the protective coating.

- (a) If corrosion is found, repair the inner cylinder to completely remove the corrosion per OHM 32-11-11 (PAGEBLOCK 32-11-85/801)
- (b) If damage to the protective coating is found, such as chipping, peeling, flaking or wear, or if base metal is exposed do these steps:
 - 1) At the next scheduled maintenance opportunity, remove the existing protective coating.
 - 2) Visually inspect the brake flange bores for evidence of damage such as corrosion, scratches or fretting of the base metal.
 - 3) If no base metal damage exists, reapply the protective coating.
 - 4) If damage is found, repair the inner cylinder to completely remove the corrosion per OHM 32-11-11 (PAGEBLOCK 32-11-85/801).

- (c) If no corrosion is found, proceed to the next step.

SUBTASK 32-41-41-214-017

(16) Visually examine the main gear axle between the brake mounting flanges for signs of corrosion.

- (a) If corrosion is found, repair the corrosion per OHM 32-11-11 (PAGEBLOCK 32-11-21/401).

SUBTASK 32-41-41-484-018

(17) Do a check for signs of heat damage on the axle brake flanges.

- (a) If there are signs of heat damage, repair the main gear axle (PAGEBLOCK 32-11-85/801).

----- END OF TASK -----



D6-37601

32-41-41

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Sep 25/2009