**FINAL**

KNKT.08.07.16.04

# NATIONAL TRANSPORTATION SAFETY COMMITTEE

Aircraft Accident Investigation Report

**PT. Garuda Indonesia**
**PK – GZN**
**Boeing Company 737-400**
**Syamsudin Noor Airport, Banjarmasin, Kalimantan**
**Republic of Indonesia**

**23 July 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 / NTSC | Komite Nasional Keselamatan Transportasi / 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 23 July 2008, a Boeing 737-400 aircraft, registered PK-GZN, was being operated on a scheduled passenger service from Soekarno–Hatta Airport, Jakarta to Syamsudin Noor Airport, Banjarmasin. There were 121 persons on board; two pilots, five flight attendants, and 114 passengers including one child and two infants.

The pilots reported that the touchdown was normal. When the aircraft slowed to about 60 knots, the pilot in command (PIC) applied manual braking and shortly after, the ANTI SKID INOP light illuminated. The PIC then performed the standard memory items of the Emergency Check List, and continued taxiing to the apron. As the PIC turned the aircraft to the right to enter taxiway B he heard a sound that he associated with a tire bursting, so he stopped the aircraft.

Engineers who inspected the aircraft on the apron, prior to the passengers disembarking, informed the PIC that the number-one main landing gear axle was broken, and detached from its strut. The number-two tire had burst.

None of the aircraft’s occupants were injured, and they disembarked normally using airstairs.

The investigation found that an undetected fatigue crack in the number-one main landing gear axle had originated from a corroded hole in the brake assembly attachment flange. The fatigue crack propagated toward the flange and the axle wall, reaching a length of about 6 cm before a fast final fracture occurred.

On 5 August 2008, the operator’s maintenance organization issued engineering orders that required increased inspection schedules for Boeing 737 main landing gear axles, because the axle had failed at a time significantly short of the manufacturer’s specified component life.

On 6 August 2008, the National Transportation Safety Committee (NTSC) 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 23 July 2008, a Boeing 737-400 aircraft, registered PK-GZN, was being operated on a scheduled passenger service from Soekarno–Hatta Airport, Jakarta[1] to Syamsudin Noor Airport, Banjarmasin. There were 121 persons on board; two pilots, five flight attendants, and 114 passengers including one child and two infants. The pilot in command (PIC) was the handling pilot, and the copilot was the support/monitoring pilot.

Runway 10 at Syamsudin Noor was being used for the landing. The pilots subsequently reported that the touchdown at 0906 UTC[2] was normal. When the aircraft slowed to about 60 knots, the PIC applied manual braking and shortly after, the ANTI SKID INOP light illuminated. The PIC then performed the standard memory items of the Emergency Check List and continued taxiing to the apron.

The PIC reported that while taxiing to the apron the aircraft was tending to turn to the left, so he decided to reduce the taxi speed. As the PIC turned the aircraft to the right to enter taxiway B he heard a sound that he associated with a tire bursting, so he stopped the aircraft.

Engineers who inspected the aircraft on the apron, prior to the passengers disembarking, informed the PIC that the number-one[3] main landing gear axle was broken, and had separated from its strut. The number-two tire had burst.

None of the aircraft's occupants were injured, and they disembarked normally using airstairs.

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1 Jakarta Soekarno-Hatta Airport will be named Jakarta for the purposes of this report.

2 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, Centre Indonesian Standard Time (WITA) is UTC+ 8 hours.

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

## 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 | 114 | 121 | Not applicable |
| TOTAL | 7 | 114 | 121 | - |

## 1.3 DAMAGE TO AIRCRAFT

The number-one main landing gear axle was broken and detached from its landing gear strut. The number-two tire had burst. There was no other damage to the aircraft.

## 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 accident.

## 1.6 AIRCRAFT INFORMATION

### 1.6.1 General

| | | |
|---|---|---|
| Registration Mark | : | PK-GZN |
| Manufacturer | : | Boeing Company |
| Country of Manufacturer | : | United States of America |
| Type/ Model | : | B737-400 |
| Serial Number | : | 29209 |
| Date of manufacture | : | 16 December 1998 |
| Certificate of Airworthiness | | |
| Valid to | : | 20 November 2008 |
| Time Since New | : | 29,374 hours |
| Cycles Since New | : | 15,218 cycles |

### 1.6.2 Landing gear data

**Main landing gear number one**

| | | |
|---|---|---|
| Part number | : | 65-73761-127 |
| Serial number | : | MCO6171P3087 |
| Date installed | : | 15 December 1998 |
| Time Since New | : | 29,374 hours |
| Cycles Since New | : | 15,218 cycles |
| Time Since Inspection | : | 29,374 hour |
| Cycles Since Inspection | : | 15,218 cycles |
| Overhaul limit calendar | : | 10 years |
| Overhaul limit cycles | : | 21,000 cycles |
| Calendar Time Since New | : | 9 years, 7 months, 8 days |
| Cycles Since New | : | 15,218 cycles |

**Main landing gear number two**

| | | |
|---|---|---|
| Part number | : | 65-73761-128 |
| Serial number | : | MCO06172P3087 |
| Date installed | : | 15 December 1998 |
| Time Since New | : | 29,374 hours |
| Cycles Since New | : | 15,218 cycles |
| Time Since Inspection | : | 29,374 hours |
| Cycles Since Inspection | : | 15,218 cycles |
| Overhaul limit calendar | : | 10 years |
| Overhaul limit cycles | : | 21,000 |
| Calendar Time Since New | : | 9 years, 7 months, 8 days |
| Cycles Since New | : | 15,218 cycles |

Existing landing gear maintenance program:

- Overhaul at 10 years or 21,000 cycles (CAMP No. 3211020200) estimated due on 14 December 2008.
- Life Limited Part (LLP) replacement at 75,000 cycles, remaining 59,782 cycles.

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 investigation.

## 1.8 AIDS TO NAVIGATION

Not relevant to this accident investigation.

## 1.9 COMMUNICATIONS

Communication between Air Traffic Services and the crew was normal.

## 1.10 AERODROME INFORMATION

Not relevant to this accident investigation.

## 1.11 FLIGHT RECORDERS

The aircraft was equipped with a Solid State Digital Flight Data Recorder (SSFDR) part number 980-4700-001 serial number 2375 and a Solid State Cockpit Voice Recorder (SSCVR) part number S200-0012-00 serial number 1040.

The flight recorders were quarantined by the National Transportation Safety Committee investigators. The Flight Data Recorder was downloaded for the investigation, and the data showed that the landing loads were normal. There were no significant events during the landing.

No useful information about the approach and landing was obtained from the cockpit voice recorder. The recorded data for the approach and landing was overwritten during the post-accident ground handling period, because electrical power was still applied to the recorder.

## 1.12 WRECKAGE AND IMPACT INFORMATION

The number-one main landing gear axle fractured.

**Figure 1: The fractured axle of the number-one main landing gear**

## 1.13 MEDICAL AND PATHOLOGICAL INFORMATION

Not relevant to this accident investigation.

## 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

Address : 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) by a National Transportation Safety Committee (NTSC) investigator. The laboratory report is at Appendix A.

The facts from the ITB Laboratory report include:

- The failure was of a fatigue mode as clearly indicated by beach marks.
- The fatigue crack originated from one of the brake mounting holes approximately at 5 o'clock position, propagating inward.
- The number of beach marks corresponded to the landing cycles.
- The fracture surface beyond the fatigue crack propagation was the final fast failure.

**Figure 2: The broken axle**

**Figure 3: The crack at the hole edge propagated inward**

**Figure 4: Beach marks on the fracture surface.**

**Figure 5: Beach marks propagating from the hole edge**

**Figure 6: Corroded surface**

Laboratory examinations were also performed by the US national Transportation Safety Board (NTSB) and the Boeing Company's Material & Process Technology (M&PT) Workshop. The ITB laboratory report (see Part 6, Appendix A), and the Boeing M&PT report (see Part 6, Appendix B), concluded similar failure mechanisms.

The facts from the Boeing M&PT report include:

1) Examination of the fracture surface revealed that the origin was located at the surface of one of holes in the brake flange.

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 inch before final fracture through the axle wall occurred by ductile separation.

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.

**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.

The overhaul inspection is required in accordance with the Boeing Overhaul Manual at intervals not exceeding 10 years time in service or 21,000 cycles.

The landing gear assembly had been in service for 9 years, 7 months, and 8 days, and 15,218 cycles.

## 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 NUMBER-ONE AXLE

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

- The failure was due to a fatigue failure mechanism.
- The fatigue crack initiated from a corroded hole at the brake attachment flange.
- The fatigue crack propagated to about 6 cm from the hole edge until a 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 OVERHAUL PROGRAM

The next landing gear overhaul was predicted, in accordance with the manufacturer's overhaul schedule, for December 2008, which was 4 months after the accident. The fatigue crack had prematurely propagated with respect to the predicted overhaul schedule.

# 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 a length of about 6 cm before a fast final fracture occurred.
- The fatigue crack had extensively and prematurely propagated with respect to the manufacturer's overhaul schedule.

## 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 a length of about 6 cm before 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 BOARD (NTSB)

Referencing Boeing Company and Summit Aerospace actions

On 20 July 2009, the National Transportation Safety Board (NTSB) informed the National Transportation Safety Committee (NTSC) that:

> Boeing has completed their metallurgical examinations and has responded to your [NTSC] three part recommendation.

> 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.

Copies of the Summit Aerospace modified inspection cards were supplied to the NTSC.

The NTSB Accredited Representative informed the NTSC that he had “contacted the Federal Aviation Administration on this subject and they are aware of the safety actions that Boeing and Summit have taken”.

The NTSB also informed the NTSC that “recently, the DGAC of Morocco reported another B-737-400 main landing gear brake flange cracking and axle fracture event. NTSB plan to closely follow this event for comparison with the Garuda failures”. The NTSB Accredited Representative advised the NTSC that he will keep the NTSC “informed of the relevant findings, as well as follow-on actions that may be required”.

## 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 RECOMMENDATIONS

Following the timely Safety Action taken by Garuda Indonesia, the NTSC issued the following recommendations on 6 August 2008.

**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 (EASA) 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.

**EASA response dated 25 August 2008.**

The EASA Head of Safety Analysis and Research advised the NTSC that as the recommendation involves the responsibility of the US FAA, he had notified the FAA manager of the recommendation Branch about the NTSC recommendation. Based on action issued by the FAA, the EASA will do the necessary progress in order to enhance the safety of the European fleet.

# 6 APPENDIX

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

METALLURGICAL OBSERVATION

ON THE FAILED MAIN LANDING GEAR AXLE OF

GARUDA INDONESIA BOEING 737-400 PK GZN

AT SYAMSUDDIN NOOR AIRPORT, BANJARMASIN, INDONESIA

ON 23 JULY 2008

1. Failed Component

   A Boeing 737 aircraft of Garuda Indonesia PK GZN experienced a failure on its L/H main landing gear axle, i.e. at no.1 wheel position. The failed axle is shown in Fig.1.

2. Observation's Objective

   The objective is to reveal the mode of failure as well as to find the crack origin and its propagation

3. Fractography

   The crack and the fracture are represented in Fig. 2, 3, and 4. In order to have an accurate observation on the fracture surface, a cut had to be made by an EDM (Electro Discharge Machining) process as shown in Fig.5, i.e. a cut starting from the brake mounting hole.

   Observation on the crack surface can be summarized as follows:

   The failure is of a fatigue mode as clearly indicated by beach marks.

   The crack was originated from one of the brake mounting holes approximately at 5 o'clock position, propagating inward.

   The beach marks correspond to the landings. Therefore the number of beach marks indicates the number of landing cycles until the final failure occurred.

The fracture surface beyond fatigue crack propagation is the final fast catastrophic failure.

**Figure 1: The failed axle of the L/H Main landing Gear**

**Figure 2: The broken axle**

**Figure 3: The crack at the hole edge propagated inward**

**Figure 4: Beach marks on the fracture surface.**

**Figure 5: Beach marks propagating from the hole edge**

**Figure 6: Corroded surface**

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

Enclosure A to 66-ZB-H200-ASI-18456

M&PT
Material & Process Technology

**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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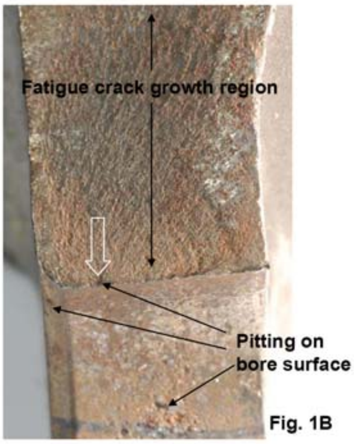
**ACKNOWLEDGEMENTS:**

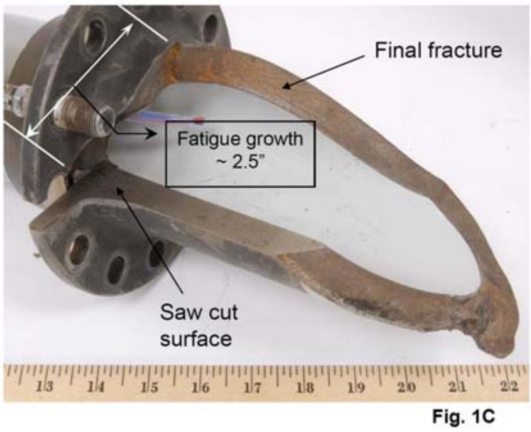
Martin Farris – photography, metallurgical laboratory support
Mike Davis – magnetic particle inspections


## Figure 1:

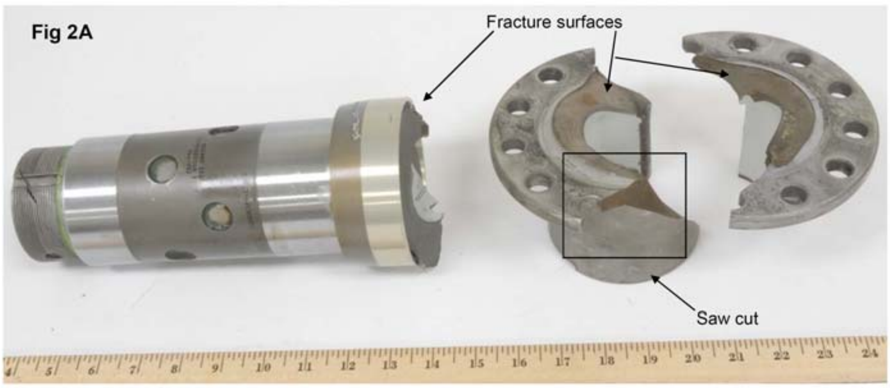
First occurrence:

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




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



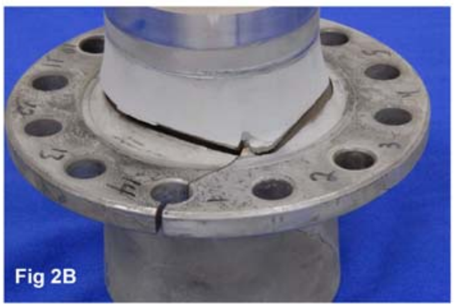




**Figure 2:** Photographs showing the as-received condition of submitted axle segments. Note that crack emanated from flange hole and progressed in a helical direction through the axle wall.

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.

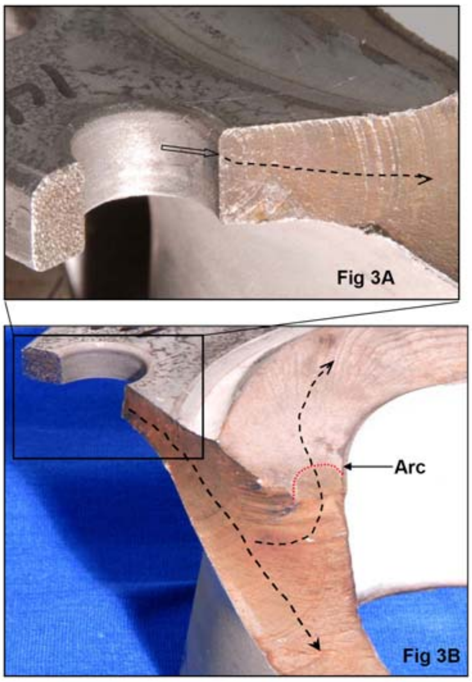



**Figure 3A & 3B:** Photographs showing fracture surface details.

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 indicted 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





**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.

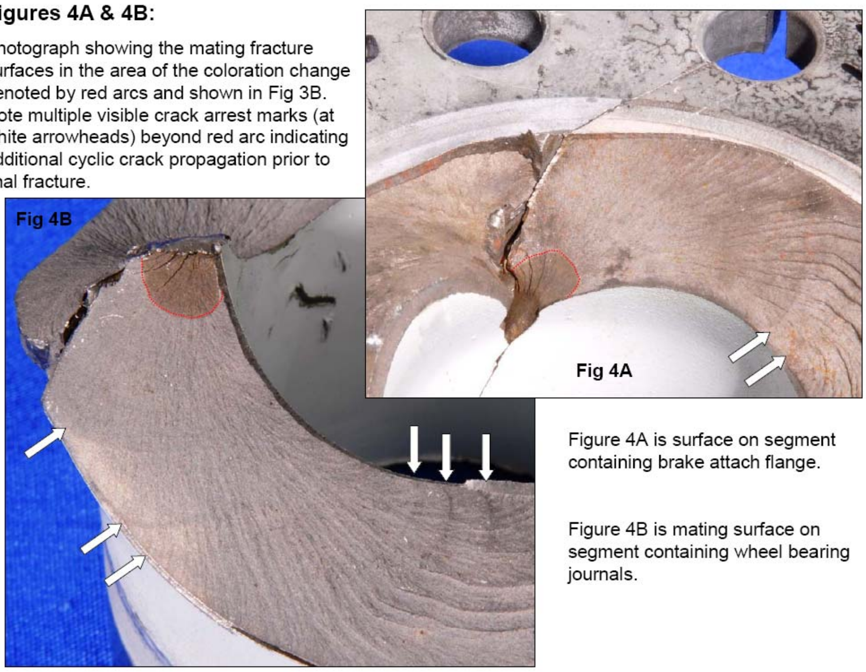



Figure 4A is surface on segment containing brake attach flange.

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

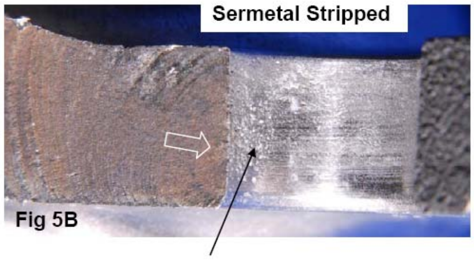
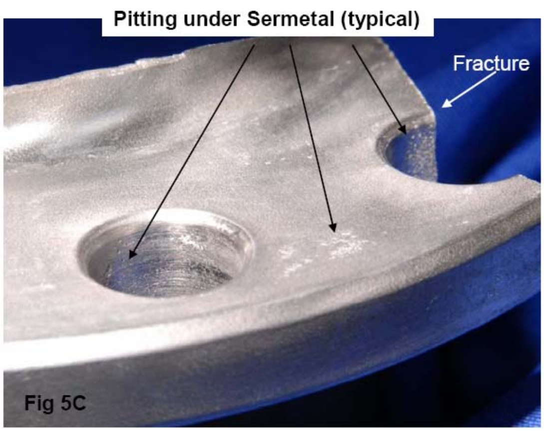




Figure 5A: Bore surface at fracture origin (arrow) with Sermetel coating in place.

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



**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 32-41-41-494-018

(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 ——————-