Landing gear failure, Boeing 737-204ADV (EI-CJC), Dublin, Ireland, June 8, 2004.

Micro-summary: **The undercarriage failed to retract on this Boeing 737-200, so the flight returned to the airport of departure.**

Event Date: **2004-06-08 at 0945 UTC**

Investigative Body: **Air Accident Investigation Unit (AAIU), Ireland**

Investigative Body's Web Site: **http://www.aaiu.ie/**

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FINAL REPORT

AAIU Synoptic Report No: 2006-007
AAIU File No: 2004/0030
Published: 5/05/06

In accordance with the provisions of SI 205 of 1997, the Chief Inspector of Accidents, on 8 June 2004 appointed Mr. John Hughes as the Investigator-in-Charge to carry out a Field Investigation into this occurrence and prepare a Synoptic Report.

Aircraft Type and Registration:	B737-204ADV, EI-CJC
No. and Type of Engines:	2 x P & W JT8D
Aircraft Serial Number:	22640
Year of Manufacture:	1982
Date and Time (UTC):	8 June 2004 @ 09.45 hrs
Location:	Dublin Airport
Type of Flight:	Commercial
Persons on Board:	Crew - 2 Passengers - 112
Injuries:	Crew - Nil Passengers - Nil
Nature of Damage:	Left Hand main landing gear trunnion pin sheared
Commander's Licence:	Irish Air Transport Pilot Licence
Commander's Details:	Male, aged 46 years
Commander's Flying Experience:	12,000 hours total
Information Source:	Aer Rianta Duty Officer

SYNOPSIS

Shortly after take off, the undercarriage failed to retract and the aircraft returned to the airport of departure where it landed safely. On arrival on stand, an inspection was initiated, during which it was discovered that the left hand (LH) main landing gear (MLG) trunnion pin had sheared.

1. FACTUAL INFORMATION

1.1 History of the Flight

The flight to Aberdeen departed Runway (RWY) 28 at Dublin Airport at 09.45 hrs. After take off, the flight crew found that the LH landing gear would not retract. They advised Scottish ATC that they were returning to Dublin as they were having an undercarriage problem.

The aircraft made a "Flap 40" landing on RWY 28 at 10.40 hrs and taxied to Stand 12. The Operator's technical staff inspected the undercarriage and observed a fractured coupling, which effectively disconnected the undercarriage actuator from the LH landing gear. This fault would not allow the main gear to retract when the aircraft was airborne. No other defects or damage was found and there were no injuries as a result of this incident. The fractured coupling, known as a trunnion pin, was removed from the aircraft and dispatched to the aircraft manufacturer for laboratory examination.

1.2 Aircraft Information

1.2.1 Trunnion Pin History

The LH main landing gear trunnion pin Part No. 65-46113-16, Serial No. LMC0422 failed at the outboard end at the MLG actuator attachment point **(Appendix A)**. This trunnion pin assembly had been fitted, "in overhauled condition", on another aircraft of the fleet, EI-CKQ (B737-2K2) on 25 June 1999. It was removed from that aircraft as unserviceable on 22 February 2000 during a P12 check in the UK and had 52,887 cycles since new (CSN) and 1511 cycles since last overhaul (CSO) at that stage. The overhaul period for this component is 16,000 cycles and the pin should be scrapped at 75,000 cycles.

1.2.2 Component Inspection by Contractor

Prior to its last overhaul, the UK contractor inspected the component and submitted it for NDT (Non Destructive Testing). An MPI (Magnetic Particle Inspection) was carried out and the worksheet indicated *"cracks on the inside face of fork-chrome"*. Following a check of the pin dimensions in accordance with the Overhaul Manual (OHM 32-16-01) the component was then forwarded to a sub-contractor and the following repair order specified:

Trunnion pin requires rework iaw OHM Chapter 32-16-01, Fig 406, revision 69 dated Nov 1/99.

1.2.3 Component Overhaul by Sub-contractor

Trunion pin shop servicing, in accordance with the aircraft manufacturers instructions, may include some or all of the following (not necessarily in the given sequence) as required by the Overhaul Practices Manual (OPM) and the OHM:

- Removal of Existing Corrosion (per fig.406, OHM 32-16-01)
- Magnetic Particle Inspections (per OPM 20-20-01)
- Removing of Existing Plate (per OPM 20-30-02)
- Shot peening of all Reworked Areas (per OPM 20-10-03)
- Nitol Etch Inspection (per OPM 20-10-02)
- Pre Plate Bake (per OPM 20-10-02)
- Hard Chrome Plate (per OPM 20-42-03)
- Post Plate Bake (per OPM 20-42-03)
- LHE Cadmium Plate (as per OPM 20-42-01)
- Post Plate Bake (per OPM 20-42-01)
- Application of BMS 10-11 primer and BMS 10-60 Grey top coat

The sub-contractor carried out the above processes in areas where the pin was *reworked.* An MPI inspection was carried out at the beginning of the work and also on completion, but no indications of cracks were found. They were not aware of any prior NDT inspection having revealed crack indications on the inner faces of the fork. The plating was considered satisfactory at the time of sub-contractor inspection.

They carried out the following work:

- Bushes removed and replaced.
- Removal and replacement of chrome under the head of the pin.
- Outer diameter crome plate polished.
- Check of pin dimensions before and after rework.

The item was then returned to the Contractor on 15 May 2000 with an attached JAA Form One as *Overhauled.*

1.2.4 Release by Contractor

Subsequently the component was released by the Contractor on 15 August 2000, complete with a 1/16 inch undersized nut, back to the Operator on a similar JAA Form One as *Overhauled.* The release certificate states that the component was overhauled in accordance with the aircraft's Overhaul Manual (OHM) Chapter 32-16-01 dated 1 November 1999 and released with a 1/16″ undersize nut. There were no records available to indicate when the pin had been modified with this undersize nut. The pin had not been received by either the Contractor or the Sub-contractor at any other time.

The final detailed report issued by the Contractor following overhaul stated:

"Unit inspected, NDT inspection revealed crack indications on inner faces of fork, corrosion was also found under head of bolt causing chrome plate to "lift" from O.D., also threads corroded. Due to extent of work required unit overhauled."

The pin was returned to stock and was fitted to EI-CJC on the 10 Jan 2003, during a P12 check. It accumulated a further 3546 cycles on EI-CJC up to it's removal on the 8 June 2004, giving it a total of 56,433 CSN.

1.2.5 Background

The aircraft manufacturer's say that no trunnion pin fracture has ever resulted in gear collapse. Fracture of the outboard end of the trunnion pin results in the retract actuator being disconnected from the gear. After such a failure, it is not possible to retract the gear.

1.3.1 <u>Manufacturer Technical Analysis</u>

The results of the manufacturer's laboratory analysis of the pin concluded the following:

1. Fracture of the lugs was due to poor chrome plating and chrome plate grinding damage on the inner face of the lug adjacent to the anti-rotation bolthole flange.

2. The chrome plating exhibited poor adhesion characteristics and numerous through-thickness chicken wire cracks. The severe cracks in the plating are indications of poor plating techniques.

3. The crack propagation mode, which led to the fracture, was due to Stress Corrosion Cracking (SCC). Final fracture occurred in the primary fracture lug as well as in the adjacent lug by ultimate tensile separation.

4. The grinding damage most likely resulted in a thin overtempered martensite layer found beneath the chrome plating on the inner face of the lug. However, the bulk of the trunnion pin material confirmed that the part was fabricated from the drawing specified 4340M alloy steel in the 275-300 ksi heat treat condition.

1.4 Aircraft Manufacturers Response

The aircraft manufacturer stated that whether the crack indications are in the chrome plate or the base metal, they recommend that the part be replaced with a serviceable part *(which occurred)*. The part with the crack may then be determined to be un-repairable and scrapped, or if the crack can be completely removed within OHM limits, there is an option to machine away the defect and completely overhaul the part. If there is any doubt about the repairability, the condition should be reported to the aircraft manufacturer.

Chrome plating on the lug faces is not a drawing requirement but is allowed per the overhaul manual (OHM 32-16-01).

A similar incident occurred on another operator's B737-548 and this was investigated and Report No. 2005-006 issued by the AAIU. As a result of Safety Recommendation SR 03 of 2005 made in that report, the aircraft manufacturer promised to review the requirement for a more frequent inspection of this pin. The FAA agreed with this recommendation under their own Safety Recommendation 05.108. In September 2005, the aircraft manufacturer responded to the FAA and stated that maintenance intervals requested by Safety Recommendation 05.108 was a mandated action of AD 90-25-01 already in place for the B737 aircraft fleet. The effective date of this AD was 31 December 1990. This AD references manufacturer document *D6-38528 "Aging Airplane Corrosion Prevention and Control Program, Model 737"*.

This CPCP program, details of which should be agreed between the operator and the manufacturer, stipulates that landing gear be maintained such that corrosion damage occurring between successive inspections does not exceed "Level 1". Level 1 corrosion is defined as corrosion damage that is local, and can be reworked or blended out within allowable limits as defined by the manufacturer. The manufacturer states that implementation of the Program could result in decreased inspection intervals.

The FAA recorded this as "Acceptable Action" and Safety Recommendation 05.108 was classified as "Closed".

1.5 Aircraft Operators Response

The Operators requirement was to comply with the CPCP programme in its entirety, report its findings back to the manufacturer and amend its programme based on its findings.

2. ANALYSIS

The worksheets show that the Contractor became aware through a scheduled inspection carried out during the Check that there were cracks on the inside chrome face of the fork. The Sub-contractor's NDT however, picked up deficiencies elsewhere and rectified these. Their NDT did not signal that there were cracks on the inside face of the fork, and the plating there must have been considered satisfactory at the time of inspection. The aircraft manufacturer's report confirms the existence of extensive chrome plate peeling and cracking on the inner surface of the fork in the same area where cracks in the chrome were earlier detected by the Contractor.

The overhaul life of this component is 16,000 cycles. The pin had completed 1,511 cycles since overhaul when it was discovered to be unserviceable and despatched for its last shop visit. It then completed 3,546 cycles before fracture. It is not known how many times the pin was overhauled during its life or at what stage the original grinding damage and poor plating had taken place. It would be safe to say that this pin was overhauled at least 4 times in 56,433 cycles and that it was over 20 years in service on the 737-200. Not withstanding their full compliance with all legal requirements and the best endeavours of the Operator, Contractor and Sub-contractor in its removal, inspection, and overhaul, the pin may have been unwittingly installed on EI-CJC in an unserviceable condition.

The failure of this trunnion pin can be attributed to a shop servicing event and could not be related to the Operators "usage of this aircraft or other aircraft in the same fleet" (ref: AD 90-25-01). The Investigation is of the opinion that a realistic decreased inspection period, as in a CPCP program, may not have caught the above pin condition before its failure.

This Operator has since disposed of all 737-200 aircraft

3. CONCLUSIONS

(a) Findings

1. Prior to the last rework on the pin, there were crack indications, found by the Contractor, in the chrome plating on the inner face of one of the fork lugs.

2. The plating in this area was deemed satisfactory by the sub-contractor and the area was not reworked.

3. Failure of the fork was due to a fracture in the area of the original crack indications in one lug followed by the ultimate tensile separation of the remaining lug.

(b) Cause

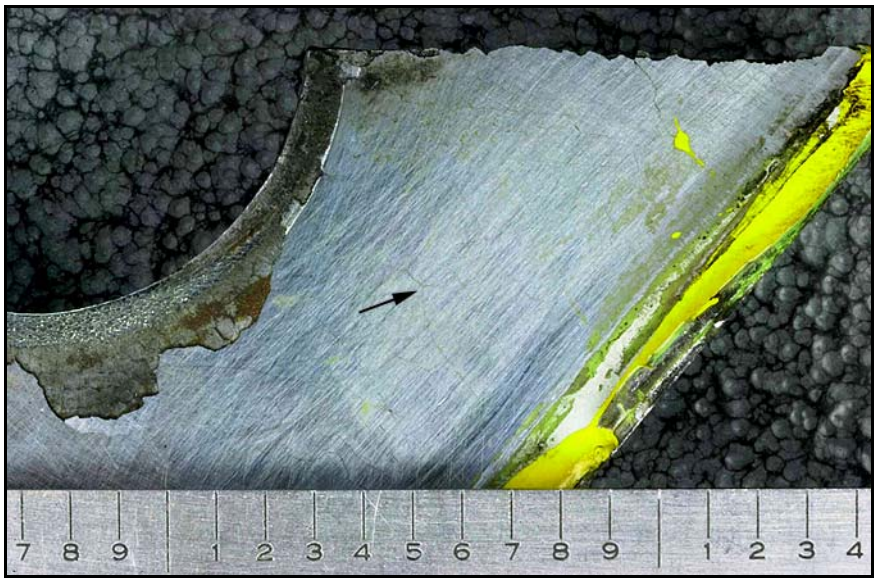
The crack propagation mode, which led to the fracture, was due to Stress Corrosion Cracking (SCC).

4. SAFETY RECOMMENDATIONS

4.1 This Report does not sustain any Safety Recommendations

APPENDIX A

The white arrows denote the fracture origin region of the lug adjacent to the flange, which fractured first. The black arrow shows where chrome plating has flaked off the inner lug face.



The chrome plating on the inner surface of the fracture lug exhibits severe through-thickness cracking. The black arrow shows an area of "chicken wire cracking."

(Photos- courtesy of the Aircraft Manufacturer)