

ORIGINAL

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CIVIL AVIATION AUTHORITY
PAKISTAN

AIRCRAFT INCIDENT INVESTIGATION REPORT
PAKISTAN INTERNATIONAL AIRLINES
BOEING-737 AP-BCB
ON 20 APRIL 2004

AT

QUETTA INTERNATIONAL AIRPORT
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FINAL REPORT

SERIOUS INCIDENT TO PIAC B-737 PK-329 AP-BCB AT QUETTA ON 20TH APRIL 2004

1. **Authority:** Director General Civil Aviation Authority Memorandum HQCAA/1901/290/SIB dated 26th April 2004.

2. **Synopsis:** On 20th April 2004, Boeing 737 operating PK-329 felt severe vibrations after landing. Aircraft turning control was lost and it kept moving left and right in an uncontrolled manner till it stopped 2000 feet short on active runway. During post inspection all four wheels were found damaged. A number of small metal pieces of shimmy dampers and torsion links were found along with the marks of tires on runway. The tyres were found damaged by broken hydraulic lines and torsion links. The Quetta runway remained blocked for 24 hours as the aircraft was not in a tow able condition.

3 Technical Investigation

Initial damage to wheel Assemblies

3.1 Runway inspection for scratch marks and collection of broken metallic pieces revealed that right upper torsion link broke after landing and caused damage to shimmy damper. In the absence of torsion link and dampening by shimmy damper the wheel assembly was free to turn left and right. The free movement of right main wheel assembly affected the left wheel and continuous turning of aircraft in a zig-zag manner resulted in the damage of left wheel torsion links and shimmy damper. The broken metallic parts which remained attached with the strut assembly, damaged wheels and tyres very badly. However luckily no tyre burst took place. The detailed analysis of entire damages revealed that all damages were result of right lower torsional link failure during landing.

Examination of Broken Parts

3.2 Inspection with the help of magnifying glass indicated a sudden instant failure of various parts. There were no visible ductile elongations at broken cross sections, implying absence of any fatigue failure. However it may be noted that the torsion links are made of relatively brittle material hence even, had there been some fatigue, the effects would not have been registered in any ductile manner. The remaining portion of RH lower torsion link was preserved for further analysis.

LH Shimmy Damper

3.3 It was complete along with upper and lower torsion links. There were scratches on various faces and corners due to distortions. The piston had bent and was stuck in its chamber. The outer body was intact and there was no external hydraulic leak.

RH Shimmy Damper

3.4 Right Main Landing Gear Shimmy damper was found hanging with its hydraulic pipes as its piston shaft had broken. The torsion link was still attached with wheel strut. However the upper half of lower torsion link was missing.

Torsion Link Failure Analysis

3.5 The parts around torsion links were examined for any pre-occurrence damage which could have caused the failure. It was noted that all the marks, scratches and minor dents were fresh and due to brakeage of shimmy dampers and entanglement of broken hydraulic lines with wheel strut components during landing roll. The torsion links and shimmy dampers were brought to landing gear shop for fracture analysis.

Main Landing Gear Lower Torsion Link Fracture Analysis

3.6 Boeing's technical literature was studied for probable causes of failure. It was learnt that main landing gears torsion free play inspections were given importance and require professional approach to ensure these parts in required tolerance limits (**See Appendix A** for Task 32-11-00-206-001 Boeing's Maintenance Manual). Investigations revealed that no person either at technical services or at line maintenance was conversant with the use of tools, gauges and recording of measurements given in this particular task. The tool issue records did not substantiate that this task was performed using proper tools.

History of Torsion Link Failure and Boeing Service Letter

3.7 Further scrutiny of technical literature revealed that a Service Letter No 737-SL-32-057 dated 5 July 1994 for Main Landing Gears Torsion Link Fractures has emphasized the importance of ensuring proper torsion free play and wear limits of all link joints (**See Appendix "B"**). It was learnt that since 1989, a number of operators had reported thirteen such failures; however it was not given serious consideration to avoid similar failure in PIA, rather a number of serious weaknesses in maintaining torsion links were observed during investigation. These were related to maintaining wear limits of various bushes, washers, and pins which are subject to wear and tear during taxiing, landing and extension/retraction of landing gears.

Non Standard Maintenance Practices

Investigations revealed that:

- a) Technicians and engineers were having extremely inadequate knowledge in relation to design limits and wear limits of torsion link (Ref Fig 601 sheet 3 page 603 MM 32-11-51 attached as **Appendix "C"**).
- b) Even the design and wear limits were not recorded in accordance with Main Landing Gear Dampers Inspection procedure given on page 601 for Task 32-11-81-001 (**See Appendix "D"**).
- c) Standards Tools and Equipment were neither available and nor the technician were aware of their use and importance. Refer task No **32-11-00-206-001**.
- d) There were no previous records of all such wear and play measurements for **aircraft under investigation**.
- e) Boeing 737 AP-BCC was checked for torsional free play and play was found beyond limit for both landing gears (**See Appendix-"E"**).

Discussion and Analysis

- 3.8 On site examination provided substantial evidence to conclude that the cause of occurrence was metallurgical failure of right hand lower torsion link. The fracture surface did not reveal any elongation implying absence of fatigue failure. However it is emphasized again that the material of torsion link is relatively brittle hence fatigue evidence is unlikely to be registered. The elongations would appear if the stresses beyond limit are applied for significant number of cycles.

Probable cause of Failure

- 3.9 The cause of failure under these circumstances could either be improper free play of torsion link or existence of out of wear limits washers, bushes or pins at the links. The play or clearances between various parts will result into sudden high stresses and cause instantaneous failure during operation.

Examination of Maintenance Records

3.10 Scrutiny of records and observations during study of inspection/check procedures revealed that this particular inspection is not given due importance by engineering personnel. There were no records of measurements to determine existing wear and tear of parts for monitoring. The most vital and fundamental inspection as per Fig 601 sheet 3 page 603 MM 32-11-51 attached as Appendix "C") and page 601 for Task 32-11-81-001 (See Appendix "D") is not recorded by engineering. The same could not be done on damaged parts. However the investigations into maintenance practices in this particular area of inspections and checks were conclusive that torsion link has failed either due to improper play or worn out parts at the common fulcrum.

Carrying out Wear Limits Inspection

3.11 SIB team requested Technical Services to arrange a demonstration to show inspections for "**Torsion Link Free Play**" and recording of "**wear limits**" as per maintenance manual. It was required to study and appreciate the technical knowledge and professional attitude of technicians and engineers at PIAC Engineering.

Lack of knowledge and skill for Inspection by Measurements

3.12 It was learnt that these measurements were not recorded earlier and hence there was no technician or even engineer who could demonstrate the same with confidence. Generally technicians were not familiar with measurements to be conducted for accomplishment of the TASK 32-11-00-206-001. It may be noted that measurement is the fundamental activity of the inspection. The intent of inspection is to ensure that a torsion link or any washer, pin or joint conforms to the standard size and shape recommended by manufacturer. The examination of the parts during maintenance falls in the province of inspection which basically can be done in two ways

- (a) **By attributes**, with the use of gages to determine if the product is good or bad, resulting in a yes or no, go or not-go decision.
- (b) **By variables**, with the use of calibrated instruments to determine the actual dimensions of the product for comparison with the size desired.

3.13 In aviation Electronics Centralized Aircraft Monitoring System (ECAM) for aircrew is an attribute type system which inform aircrew regarding the bad or good status of a system. Whereas all critical inspections by ground crew are carried out by recording variable measurements such as tyre pressure.

Ignorance to Inspection by Measurements

3.14 Measurement is the generally accepted industrial term for inspection by variables. Gauging (or gauging) is the term for determining whether the dimension or characteristic is large or smaller than the established standard or range of acceptability. Variable types of inspection generally take more time and are more expensive than attribute inspection, but they give more information because the magnitude of the characteristic is known in some standard unit of measurement. However our investigations show that measurements during **torsion free play check** and **shimmy damper installation check inspections** were not carried out either by gauging or through measuring variables. This is not a minor maintenance mal-practice; it is a non serious attitude towards safety of airplane and passengers. The free rotation of both main landing gears could have resulted in an accident. It was the aircrew's professional handling that averted an accident.

Attitude towards Investigation

3.15 It was astonishing that AME Mr. Khusro who was detailed to demonstrate the task could not satisfy SIB regarding procedure for measurements during torsion free play check and inspections for wear limits. As a matter of fact the individual displayed a very casual attitude. He presented a wooden bar removed from a wooden crate with nails on it as a tool for measuring torsion link free play. It may be noted that the task as per Para 3 B of 32-11-00-206-001 requires a wooden bar (2x4-approximately 10 feet long) to apply force on tyres as shown on page 5 Appendix "A".

3.16 This was not expected and shows the attitude of a quality control engineer towards aviation safety. It also represents the prevailing culture in PIA where importance of training, quality assurance and aviation safety are not given due recognition.

CONCLUSION

4.1 The occurrence is attributed to material failure of the lower torsional link of right landing gear. The cause of material failure is improper maintenance of torsion links and associated parts.

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FINDINGS

5.1 Occurrence

- (a) Severe vibrations were felt in cockpit and passenger cabin during landing.
- (b) Aircraft movement was zig-zag till it stopped on active runway, 2000 feet short.
- (c) Shimmy dampers and torsion links on left and right main landing gear were found damaged and wheel assemblies were free to rotate.
- (d) The right MLG lower torsion link was found cracked at lightening hole and half portion was missing. The half portion of RH lower torsion link was not found at or around the runway.
- (e) The fracture/failure of torsion link resulted in free rotation of MKG causing further damages.
- (f) The right MLG shimmy damper also broke from its piston due to uncontrolled movements.
- (g) There were no injuries to passengers on board and aircraft damage was restricted to wheel assemblies.

5.2 Cause of Occurrence

- (a) Records of previous Torsion Free play inspection as per Task 32-11-00-2-6-001, Boeing 737 Maintenance Manual, were not maintained by line maintenance.
- (b) Maintenance personnel were not found conversant with procedures, tools and measurement of wear limits of torsion link as per MM 32-11-51 Page 603 Fig 601.
- (c) There were no records of inspection check measurement required by procedure given for Task 32-11-81-001 Page No 32-11-81. The wear and tear of torsion link joints could not be established due to damages to the parts.
- (d) Torsion Free play check of Boeing 737 AP-BCC was carried out and found out of limits.

- (e) Service letter 737-SL-32-057 dated 5th July 1994 was not given due importance while maintaining Torsion check Free play.
- (f) Lower Torsion link of right Main Landing gear broke either at or shortly after landing at lightening hole due to excessive free play.
- (g) The excessive free play of torsion link can either be attributed to improper free play inspection or worn out bushes, washers or pins.

5.3 Finalization of Incident

The occurrence is finalized as:

Human Factor - Avoidable.

Material failure due to Non Compliance of Inspection and Check procedures as per Boeing Maintenance Manual procedures 32-11-51 and 32-11-81-001.

The cost of occurrence includes:

- a. Cost of damaged aircraft parts (wheels, shimmy dampers and torsion links (30, 000 US \$).
- b. Loss of expected revenue due to Aircraft being on ground repairs for 2 days: (30, 000 US \$).
- c. Cost of man-hour. (1,000 US \$).
- d. Cost of rescue Fokker Flight from Karachi to Quetta (10, 000US \$.)
- e. The losses due to Quetta runway closure for 24 hrs are not included.

Total Approximate Loss 0.1 Million US \$.



(SYED NASEEM AHMED)
Wg Cdr (Retd)
Technical Member

04 June 2005



(SHADAB HASNAIN)
Air Commodore
Investigation Incharge

06 June 2005

RECOMMENDATIONS

6.1 Director Engineering is to ensure that:

- (a) Main Landing Gear Torsion Links Free play inspection when required is carried out by trained maintenance personnel and standard Tools and Equipment is used as per Boeing Maintenance Manual Task 23-11-00 -206-001.
- (b) Engineering personnel are properly trained to inspect and ensure that **torsion free play** of each MLG is **in tolerance** to make sure that the MLG **shimmy is dampened** as per Boeing Maintenance Manual page 32-11-51 FIG 601.
- (c) Whenever MLG torsion links or shimmy damper is installed all values are recorded as per 32-11-51 and 32-11-81 respectively.
- (d) Maintenance personnel are trained for inspections of critical dimensions to determine that bushes, washers and pins at torsion links and shimmy dampers are within wear limits as per 32-11-51 and 32-11-81 respectively.
- (e) Engineering personnel with causal attitude and irresponsible behavior are remanded.