



PAKISTAN CIVIL AVIATION AUTHORITY
(SAFETY INVESTIGATION BOARD)



FINAL REPORT

SERIOUS INCIDENT OF M/S PIAC FLIGHT PK-352
BOEING 737-300 AIRCRAFT, REG # AP-BEH ON
20TH FEBRUARY, 2012 AT QIAP, QUETTA

FINAL REPORT

INVESTIGATION INTO SERIOUS INCIDENT OF M/S PIAC FLIGHT PK-352 BOEING 737-300, REG # AP-BEH (SECTOR KHI – UET – ISB) AT QIAP, QUETTA ON 20TH FEBRUARY, 2012

Synopsis

On 20th February, 2012 M/s PIAC Flight PK-352 Boeing 737-300, Reg # AP-BEH, operating from Karachi to Islamabad via Quetta, landed at Quetta International Airport (QIAP), Quetta. After landing on Runway 13L, severe vibrations were observed from under carriage area which increased gradually. ATC also reported smoke from left side. Aircraft was stopped on the runway centre line at 10000 ft distance. All passengers were disembarked through stairs and carried to terminal building area. On post flight, "Torsion Links" of Left Landing Gear and Shimmy Damper assembly were found broken along with 01 inboard tyre burst. A number of small metal pieces of Shimmy Damper and Torsion Links were found along with severe rubbing marks of tyres on the runway.

Authority

DG CAA issued notification vide Letter No HQCAA/1901/347/SIB/147 dated 21st February, 2012 authorizing Safety & Investigation Board, PCAA to investigate the accident is attached as Appendix "A".

1. FACTUAL INFORMATION

- 1.1 **History of the Flight.** The aircraft was declared serviceable by the M/s PIAC airworthiness staff at JIAP, Karachi. The aircraft took off from Karachi at 0743UTC and proceeded as per plan on Karachi – Quetta – Islamabad sectors without encountering any operational or maintenance abnormality en-route till touchdown at QIAP, Quetta.
- 1.2 **Injuries to Persons.** No one onboard the mishap aircraft received any minor / major injury as a result of this occurrence.
- 1.3 **Damage to Aircraft.** As a result of the said occurrence, M/s PIAC B737-300 aircraft (Reg # AP-BEH) did not experience any structural damage except minor damages to the left main landing gear assembly and its components.
- 1.4 **Other Damages.** No other apparent damage was observed to the runway surface / services.

- 1.5 **Cockpit Crew Information.** There was a set of two pilots onboard the aircraft including Captain and First Officer. The cockpit crew detailed data is attached as Appendix "B", however brief details are as under:

(a) **Captain Tayyeb**

- Date of Birth : 04 September, 1951
- ATPL No : 1055 (A)
- Medical Validity Date : 31 May, 2012
- Total Flying Experience : 10525:00 hrs
- Flying Hrs on B737-300 : 2629:00 hrs
- CRM Refresher Validity : 27 September, 2012

(b) **First Officer (FO) Zaib u Nisa**

- Date of Birth : 10 October, 1982
- CPL No : 2565 (A)
- Medical Validity Date : 30 June, 2012
- Total Flying Experience : 1159:00 hrs
- Flying Hrs on B737-300 : 498:00 hrs
- CRM Refresher Validity : 27 September, 2012

- 1.6 **Aircraft Information.** The Boeing 737-300 (Reg # AP-BEH) aircraft was inducted on the inventory of M/s PIAC on 10th September, 1992. The detailed aircraft and engine related data is appended below:

1.6.1 **Aircraft.**

- Aircraft Make and Model : Boeing 737-300
- Serial No : 25504
- Date of Manufacture : September, 1992
- Registration Marking : AP-BEH
- Total Aircraft Hours : 32276
- Total Cycles : 24380

1.6.2 **Scheduled Inspections Accomplished**

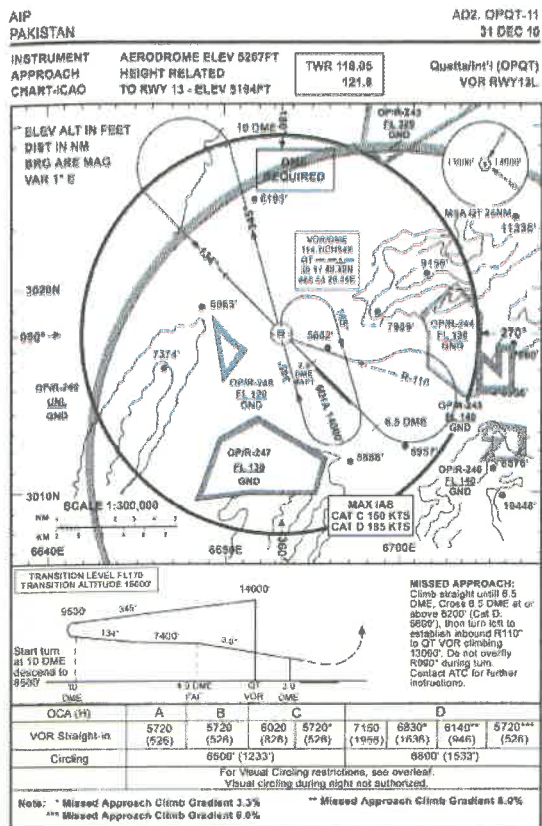
INSPECTION TYPE	DATE ACCOMPLISHED	HOURS AT LAST INSPECTION
Check 'A'	01 February, 2012	32109
Check '4A'	06 January, 2012	31870
Check 'C'	05 October, 2011	30865

- 1.6.3 The daily inspection / servicing of mishap aircraft was carried out on 20th February, 2012 prior to the departure of Flight PK-352 and no defect was

recorded. No anomaly in the aircraft system performance was recorded before and during the flight till mishap aircraft touchdown at runway 13L at QIAP, Quetta.

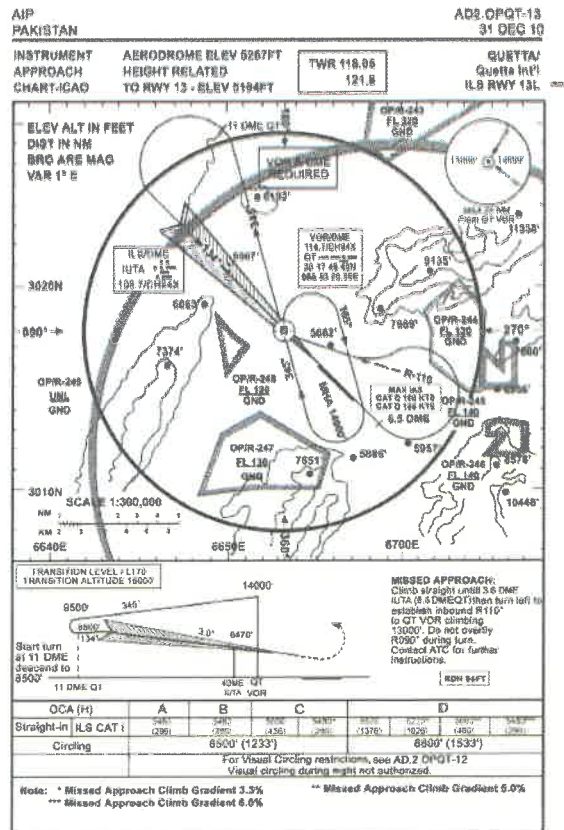
- 1.7 **Meteorological information.** On 20th February, 2012 the weather reported by meteorological department QIAP, Quetta at 0700UTC was general weather thunderstorm with visibility 4000 m, wind SW/30 kts, clouds 1CB, 5SCCu and 4AC, QNH 1016.2 along with thunderstorm rain warning till 0800UTC. The reported QIAP, Quetta weather at 0800UTC was general weather thunderstorm with visibility 4000 m, wind SW/36 kts, clouds 1CB, 4SCCu and 4AC, QNH 1014.9 along with thunderstorm rain warning till 1100UTC. The reported QIAP, Quetta weather at 0900UTC was general weather thunderstorm with visibility 4000 m, wind SW/36 kts, clouds 1CB, 5SCCu and 5AC, QNH 1013.8 along with thunderstorm rain warning till 1100UTC (Refer Appendix "C").
- 1.8 **Navigation Aids Availability.** Boeing 737-300 aircraft was equipped with serviceable ADF, VOR / DME and ILS equipment for the conduct of flying operations. All the ground equipment related to ADF, VOR / DME and ILS was found serviceable at the time of occurrence.
- 1.9 **Communication Aids Availability.** Boeing 737-300 aircraft was equipped with serviceable two VHF and one HF radio set for its two way radio contact with all concerned / relevant agencies during the conduct of flight.
- 1.10 **Type of Fuel used.** The aircraft was refuelled with JET A1 fuel. The sample of the fuel taken from the source was tested for contamination. The Fuel Test report did not reveal any abnormality.
- 1.11 **Impact Information.** The aircraft landed within the authorized landing parameters as per the DFDR data, however due to the technical problem with one of the sub-assembly of left main landing gear, the torsional link after landing did not perform its function as per the designed parameters.
- 1.12 **Aids to Navigation.** All the navigation aids were available and serviceable at Quetta International Airport at the time of occurrence.
- 1.13 **Aids to Communications.** All the communication facilities were available and serviceable at Quetta International Airport at the time of occurrence.
- 1.14 **Aerodrome information**
 - 1.14.1 The charts for VOR and ILS approach runway 13L are appended below along with the detailed aerodrome data.





Civil Aviation Authority

AMDT 02/10



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OPQT AD 2.12 RUNWAY PHYSICAL CHARACTERISTICS

Designations RWY NR	True bearing	Dimensions of RWY (M)	Strength (PCN) and surface of RWY and SWY	THR coordinates	THR elevation and highest elevation of TDZ of precision APP RWY
1	2	3	4	5	6
13L	136°	3658 x 46	52/F/A/X/T Bitumen	30 15 50.76N 066 55 32.12E 30 14 24.09N 066 57 08.38E	THR 1563 M / 5194 FT THR 1605 M / 5267 FT
31R	316°				

Note: Parallel taxi track / RWY (12000ft x 110ft) direction 13R / 31L is in use by military aircraft only. The same is painted with RWY designator, centre line and threshold marking.

Designations RWY NR	Slope of RWY / SWY	SWY dimension (M)	CWY dimension (M)	Strip dimension (M)	Obstacle Free Zone
7	8	9	10	11	12
13L	-	267	-	-	-
31R	-	274	-	-	-

OPQT AD 2.13 DECLARED DISTANCES (M)

Designations RWY NR	TORA	ASDA	TODA	LDA	Remarks
1	2	3	4	5	6
13L	3658	3925	3925	3658	-
31R	3658	3932	3932	3658	-

OPQT AD 2.14 APPROACH AND RUNWAY LIGHTS

Designations RWY NR	APCH LGT type LEN INTST	THR LGT colour WBAR	VASIS (MEH) PAPI	TDZM LGT LEN	RWY Centre line LGT Length, spacing, colour, INTST	RWY EDGE line LGT Length, spacing, colour, INTST	RWY End LGT spacing colour WBAR	SWY LGT LEN (M) colour	Remarks
1	2	3	4	5	6	7	8	9	10
13L	PALS CAT-II LIH	GREEN	PAPI Left 2.75°	-	-	3658 M, 30 M, WHITE, LIL	RED	-	Strobe LGT
31R	PALS CAT-I LIH	GREEN	PAPI Left 3°	-	-	-	RED	-	-

- 1.15 **Medical and Pathological Information.** Following the incident on 20th February, 2012 at QIAP, Quetta Blood and Urine samples of Captain and First Officer were collected which did not reveal any abnormality (Refer Appendix "D").
- 1.16 **Fire.** No pre / post occurrence air / ground fire indications by Captain, First Officer of aircraft and evidences of same by Investigation Team Members were observed.
- 1.17 **ATC Tape Extract.** ATC Tape Extracts (Refer Appendix "E") were retrieved for detailed analysis.
- 1.18 **Cockpit Voice Recorder (CVR) / Digital Flight Data Recorder (DFDR).** CVR and DFDR were retrieved for analyses by investigation team. The CVR and DFDR data was made available by using PIA facilities and detailed discussions on available data were conducted during analysis phase.
- 1.19 **Crew Resource Management (CRM).** At the time of occurrence, Captain of aircraft was the Pilot Flying (PF) whereas FO was Pilot Not Flying (PNF). Both the cockpit crew had valid CRM certification at the time of said occurrence.

2 ANALYSES

2.1 Operational Analysis

- 2.1.1 The mishap Flight PK-352 took off from JIAP, Karachi as per plan for QIAP, Quetta.
- 2.1.2 The flight remained uneventful till touchdown during landing at QIAP, Quetta.
- 2.1.3 The aircraft landed at Quetta in a high crosswind conditions (within the permissible limits of OEM) at recommended speed.
- 2.1.4 The aircraft touched down at a crab angle of 5.22° along with left bank of 1.8° as per the recorded parameters of DFDR which are well within the authorized limits (Refer DFDR Data and Boeing company input on crab angle contribution towards the occurrence attached as Appendix "F" and "G"). These set of conditions started the initial vibrations / shimmy event due to outboard tyre touching the ground first.
- 2.1.5 After landing smoke was also reported by ATC Tower from landing gear area and vibrations were experienced by cockpit crew from left landing gear area which increased in intensity with the reduction in speed of aircraft.
- 2.1.6 The cockpit crew applied the remedial actions to keep the aircraft under control and on the runway surface.

- 2.1.7 The aircraft was switched off on the runway and passengers were disembarked normally.
- 2.1.8 All the emergency services responded very promptly and reached the aircraft.
- 2.1.9 The DFDR and CVR were preserved for subsequent data analyses.
- 2.1.10 The DFDR and CVR data was downloaded at M/s PIAC facility at JIAP, Karachi.
- 2.1.11 The detailed analyses of the data revealed that all the landing parameters were well within the authorized limits of the OEM.
- 2.1.12 The remedial actions as per the QRH and FCOM by the cockpit crew were correct and prompt, to keep aircraft under control and on prepared runway surface after encountering the left main landing gear anomaly.

2.2 Technical Analysis

2.2.1 History of Aircraft.

- 2.2.1.1 Aircraft documents check for the last six months did not reveal any abnormality with landing gears system.
- 2.2.1.2 There was no outstanding snag in the aircraft before the scheduled flight PK-352.
- 2.2.1.3 The walk around inspection was accomplished on 20th February, 2012 and no discrepancy was observed / reported related to Main Landing Gears (MLG).
- 2.2.1.4 Aircraft scheduled maintenance was performed as per the Aircraft Maintenance Schedule (AMS).
- 2.2.1.5 Both upper and lower Torsion links of Left MLG (Main Landing Gear) were replaced during last major inspection Check 'C' accomplished in October, 2011 at PIAC Aircraft Overhaul (ACOH).
- 2.2.1.6 The last inspection for renewal of Certificate of Airworthiness (C of A) was carried out on 19th August, 2011.
- 2.2.1.7 As per the annual quality audit plan, shake down inspection on AP-BEH was performed by QA (PIA) and Dte of Airworthiness CAA, Pakistan on 9th October, 2011. No abnormality related to the landing gears was observed.
- 2.2.1.8 Following checks related to the MLG were accomplished during the last Check 'C' and Check '4A':-
- 2.2.1.8.1 MLG visual inspection, vide task card no B32-11-00-6A-1.



- 2.2.1.8.2 Inspection of apex joint of MLG Torsion links, vide Task Card No. B32-11-00-6C-1.
- 2.2.1.8.3 Inspection / Adjustment of Torsion Links, vide Local Task Card No. 737-AMM-32-11-81.
- 2.2.1.8.4 Upper and lower torsion links free play check, vide B32-11-00-6B-1.

2.2.2 Wreckage Information

- 2.2.2.1 After the occurrence the survey of accident site was conducted on 22nd February, 2012 and all the evidences were preserved through digital photography. The pictorial view of the site is as follows:



2.2.3 Test and Research

- 2.2.3.1 The broken parts of torsion links (both upper and lower) and shimmy damper were dispatched to Boeing Company, USA for failure mode analysis.
- 2.2.3.2 Boeing company carried out the analysis based on visual inspection and their experience. The detailed report is attached as Appendix "H". The salient points of analysis are:
- 2.2.3.2.1 *Although a formal metallurgical analysis of the fractured torsion links was not performed, Boeing performed a detailed visual examination and believes that both links fractured as a result of ductile overload and not fatigue.*
- 2.2.3.2.2 *Both of the spherical bushings installed at the apex of the lower torsion link were fractured. Grease on the fracture surfaces suggested that they may have been damaged prior to the event.*
- 2.2.3.2.3 *The piston and 65-54358-2 thrust washer exhibited excessive wear.*



2.2.3.2.4 A functional test of the damper was not performed due to the damage found on the damper.

2.2.3.2.5 No significant wear was found on the torsion links pin bores.

2.2.3.2.6 No significant wear was found on the face-to-face dimensions of the torsion link bushings.

2.2.3.3 **Based on the above, Boeing believes the most likely cause of the shimmy event was excessive play in torsion link apex joint.**

2.2.4 **Suggested Actions.** Boeing suggested the following remedial actions:

2.2.4.1 Ensure that torsion link apex joints on 737-CL airplanes are carefully maintained. Refer to Maintenance Planning Data document (MPD) item B32-11-00-6C-1/-2. This item requires a free play check at the torsion link apex at a 1C interval. The check is provided in AMM 32-11-81/501.

2.2.4.2 Other in-service wear limits for the torsion link apex are provided in AMM 32-11-51.

2.2.4.3 Operators may wish to consider periodically disassembling the apex joint and examine the spherical thrust washers, the damper piston and mating torsion link bushing for wear.

2.2.4.4 Periodic bleeding of the damper is also recommended for purging out the contaminants that can accumulate over time. If air is found during the purging process, the compensator may not be functioning correctly and the shimmy damper assembly should be replaced.

2.2.5 Damage to Aircraft

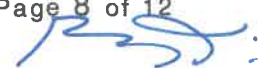
2.2.5.1 The Pilot-in-command was unable to continue taxi after landing and stopped at a distance of 10000 feet from threshold RW-18.

2.2.5.2 Torsion Links of left Main Landing Gear (MLG) and Shimmy Damper assembly were found broken. Upper Torsion Link P/N : 65-67963-3, Serial No. P02287 was found broken from the apex joint, and Lower Torsion Link P/N : 65-46102-21, Serial No. 4026 from its larger lightening hole.

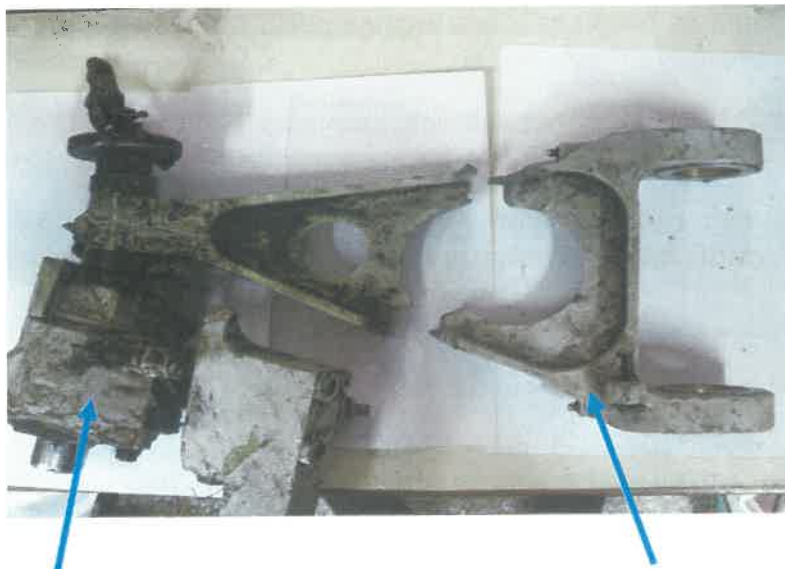
2.2.5.3 Shimmy Damper, P/N : 65-44771-3, Serial No. P-926-92 was found damaged and Compensator was found separated from the Shimmy Damper.

2.2.5.4 Inboard Tyre P/N : 65-58256-206, Serial No. 12169 was found burst and outboard tyre P/N : 65-58256-206, Serial No. H0589 was found deflated and damaged.

2.2.5.5 A number of small metal pieces of shimmy damper and torsion links were found along with the marks of tyres on runway.



2.2.5.6 Hydraulic hoses of Brake and Shimmy Damper assemblies were also found damaged, which were consequential to torsion links' breakage.



Damper and Compensator

Lower Torsion Link

3 Findings

3.1 Operational

- 3.1.1 The mishap Flight PK-352 took off from JIAP, Karachi as per plan for QIAP, Quetta.
- 3.1.2 All the aircraft systems' performance remained normal throughout the flight.
- 3.1.3 The flight remained uneventful till touchdown during landing at QIAP, Quetta.
- 3.1.4 The aircraft landed at Quetta in a high crosswind conditions (within the permissible limits of OEM) at recommended speed.
- 3.1.5 The aircraft touched down at a crab angle of 5.22° along with left bank of 1.8° as per the recorded parameters of DFDR. These set of conditions started the initial vibrations / shimmy event due to outboard tyre touching the ground first.

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- 3.1.6 After landing smoke was also reported by ATC Tower from landing gear area and vibrations were experienced by cockpit crew from left landing gear area which increased in intensity with the reduction in speed of aircraft.
- 3.1.7 The cockpit crew applied the correct and prompt remedial actions to keep the aircraft under control and on the runway surface after encountering the left main landing gear anomaly.
- 3.1.8 The aircraft was switched off on the runway.
- 3.1.9 All the emergency services and the operator's technical staff responded very efficiently and reached the aircraft.
- 3.1.10 The passengers were disembarked and dispatched to terminal building on transports.
- 3.1.11 The DFDR and CVR data was downloaded at M/s PIAC facility at JIAP, Karachi.
- 3.1.12 The detailed analyses of the DFDR data revealed that all the landing parameters were well within the authorized limits of the OEM.

3.2 Technical

- 3.2.1 After landing severe vibrations were felt from left landing gear due to breakage of both upper and lower torsion links and the shimmy damper assembly.
- 3.2.2 The broken torsion links and shimmy damper were examined and analysed by M/s Boeing.
- 3.2.3 Both links fractured as a result of ductile overload and not fatigue.
- 3.2.4 Both the spherical bushings installed at the apex joint of the lower torsion link were fractured. The grease on fractured surfaces suggested that they might have been damaged prior to the event.
- 3.2.5 The piston and thrust washers exhibited excessive wear.
- 3.2.6 The most likely cause of torsion links breakage has been determined to be excessive play at the apex joint.
- 3.2.7 Shimmy damper assembly was not functionally tested by Boeing due to the nature of damage to it. Hence, contribution of the shimmy damper in the incident could not exactly be ascertained.



4 **Conclusion**

- 4.1 The aircraft landed at Quetta in a high crosswind conditions (within the permissible limits of OEM) at recommended speed.
- 4.2 The aircraft touched down at a crab angle of 5.22° along with left bank of 1.8° as per the recorded parameters of DFDR. These set of conditions started the initial vibrations / shimmy event due to outboard tyre touching the ground first.
- 4.3 After initiation, the vibrations kept on increasing due to pre-existent excessive play at the apex joint of torsion links and resulted into damage to thrust washer and spherical bushing on the piston rod of shimmy damper assembly.
- 4.4 Both torsion links broke as a result of excessive vibrations which could not be damped out by the shimmy damper and resulted into the said serious incident.

5 **Finalization**

- 5.1 The excessive play at the apex joint of torsion links most probably resulted into excessive shimmy of left main landing gear assembly and caused the occurrence.

6 **Safety Recommendations**

- 6.1 All operators are to ensure that apex joints on Boeing 737-CL airplanes are carefully maintained as per the Maintenance Planning Document (MPD) item B32-11-00-6C-1/-2.
- 6.2 All operators are to ensure that free play check of the torsion link apex joint is carried out on every 1C interval as per AMM 32-11-81/501 and all other in-service limits are checked as per AMM 32-11-51.
- 6.3 M/s PIAC engineering is to review, prescribe and implement the periodicity of disassembling the apex joint on Boeing 737-CL airplanes to examine wear of the spherical thrust washers, the damper piston and mating torsion link bushing.
- 6.4 All operators are to review, prescribe and implement the periodicity of carrying out bleeding of the damper on Boeing 737-CL airplanes for purging out the contaminants that can accumulate over time.
- 6.5 All operators are to ensure that the purging process is carefully examined. If air is found during this process, the compensator may not be functioning correctly and in all such cases, the shimmy damper assembly should be replaced.



- 6.6 CAA Pakistan is to ensure that all safety recommendations mentioned above are religiously implemented by all operators and inspected by airworthiness surveyors / inspectors during scheduled / unscheduled inspections and same be documented accordingly.



PHOTOS 1 AND 2
SHIMMY DAMPER AND LOWER TORSION LINK - AS RECEIVED

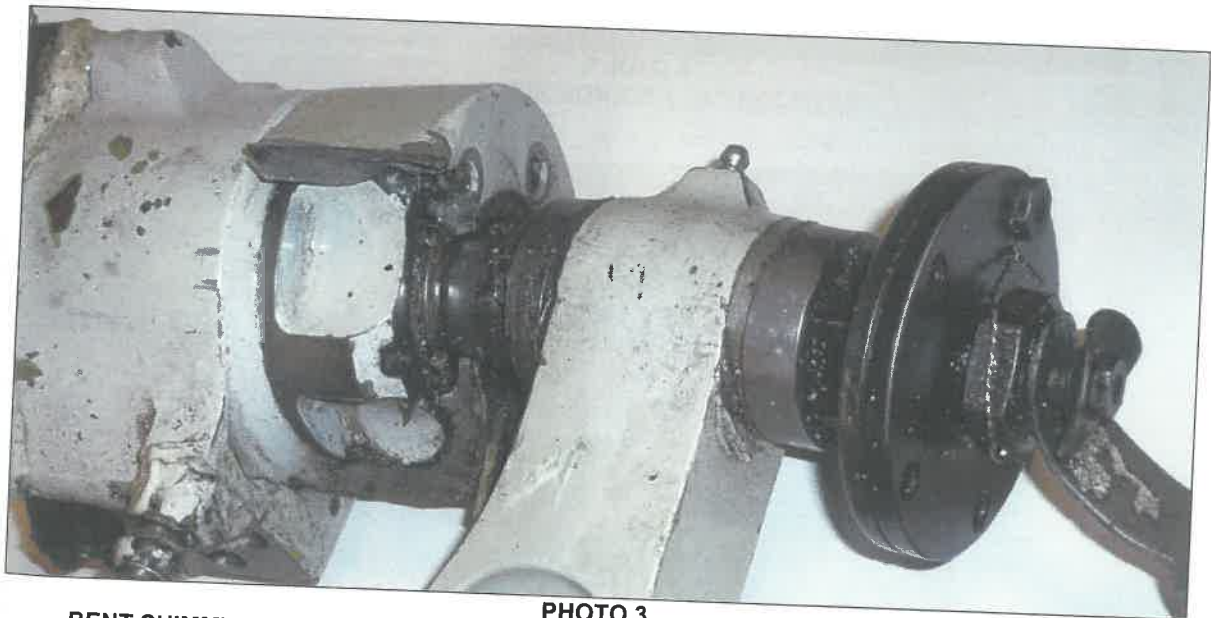


PHOTO 3
BENT SHIMMY DAMPER PISTON AND FRACTURED UPPER TORSION LINK - AS RECEIVED









PHOTO 4
UPPER TORSION LINK - AS RECEIVED



PHOTO 5
UPPER TORSION LINK - AS RECEIVED

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