FINAL INVESTIGATION REPORT

SERIOUS INCIDENT OF PIAC FLIGHT PK-363 (SECTOR ISB – UET), B737-300 AIRCRAFT REG # AP-BFT AT QUETTA ON 08TH MARCH, 2013

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Synopsis

The serious incident was reported to Safety Investigation Board (SIB) by Pakistan International Airlines Corporation (PIAC) through Mandatory Occurrence Report (MOR) **(Appendix 'A')** and was notified in accordance with ICAO Annex-13 by SIB **(Appendix 'B')**. Accredited Representative (ACCREP) was appointed by United States of America (state of design), and investigation was conducted by SIB Pakistan (state of registry and occurrence). Director General of Pakistan Civil Aviation Authority (PCAA) issued Memorandum **(Appendix 'C')** vide Letter no. HQCAA/1901/358/SIB/140 dated 11th March, 2013 authorizing SIB, Pakistan to investigate the incident.

The aircraft experienced failure of Upper Torsion Link of Left Main Landing Gear (LMLG) after landing due to shimmy and was stopped on the runway. High speed, low sink rate landing in presence of more than specified play in the LMLG shimmy damper linkages was the cause of occurrence. Failure of LMLG shimmy damper packing due to improper assembly by using only one ring backup instead of two, also contributed. Most probably debris of the failed packing / ring backup interfered with the operation of the shimmy damper and deteriorated its damping capability.

1. FACTUAL INFORMATION

1.1 **History of the Flight**. The PIAC aircraft Registration No AP-BFT was operating flight PK-363 from Islamabad to Quetta on 8th March, 2013. The flight remained uneventful till landing. At 1116 (UTC), after landing at Quetta, the cockpit crew experienced severe vibrations and aircraft started to pull towards left. The aircraft was kept on the runway by cockpit crew while taking remedial actions. On post flight inspection, it was observed that Left Main Landing Gear (LMLG) Upper Torsion link had broken.

1.2 **Injuries to Persons**. No one onboard the mishap aircraft received any injury as a result of this occurrence.

1.3 **Damage to Aircraft**. The aircraft LMLG Upper Torsion Link was found fractured at larger lightening. Shimmy damper upper portion containing hydraulic lines and manifold got dislodged from shimmy damper actuator. The hydraulic fluid lines to the LMLG brake assembly were also found damaged.

Fractured Upper Torsion Link and damaged Shimmy Damper

LMLG tire marks

1.4 **Other Damages**. There was no other damage reported as the result of this incident.

1.5 **Personnel Information.** The cockpit crew information is appended below:

Captain

- Date of Birth : 02nd September, 1970
- Medical Certificate validity : 31st May, 2013
- ATPL No. : ATPL-1356
- Date of Last Simulator Check : 08th October, 2012
- Total Flying Experience : 11282:00 Hrs
- Total Command Experience : 608:00 Hrs
- On Type Command Experience : 426:00 Hrs

First Officer

- Date of Birth : 10th March, 1981
- Medical Certificate validity : 31 May, 2013
- CPL No. : CPL-2883
- Date of Last Simulator Check : 14th February, 2013
- Total Flying Experience : 517:00 Hrs

1.6 **Aircraft Information**

Aircraft Registration	AP-BFT
Aircraft Make and Model	Boeing B737-300
Manufacture Serial No (MSN)	23298
Manufacturing Year	1986
Aircraft Hours / Cycles	67372 / 58533

1.6.1 **Aircraft Scheduled Inspections Accomplished**

INSPECTION TYPE	INSPECTION INTERVAL	DATE ACCOMPLISHED	Flight Hours (FH)	Next Due On (FH)
Check-C	4000 FH	17th July, 2012	65196	69196
Check-4A	250 FH	18th Feb, 2013	67168	67418

1.6.2 Following maintenance tasks were performed during above stated checks.

1.6.3 Both upper and lower torsion links of LMLG were replaced during Check-C.

1.6.4 During Check-C and Check-4A task card B32-11-00-6C-1 (Main Landing Gear Torsion Link Free Play / Inspection of Apex joint) was performed. This task card ensures 0.005" gap between Apex Nut and adjacent thrust washer and 2.7" gap between two spherical thrust washers.

1.6.5 During Check-C operator's local task card 737-32-11-81-LH (Inspection / Adjustment of Torsion Links) was performed. While performing this task card Shimmy Damper was removed and Spherical Thrust Washers, Shimmy Damper Piston and Torsion Links' mating flange / bushings were inspected.

1.6.6 The daily inspection / servicing of the aircraft were carried out on 8th March, 2013 prior to the departure of flight PK-363 at Islamabad and no defect was recorded. No anomaly in any of the aircraft system performance was observed by cockpit crew before and during the flight till landing of the aircraft at Quetta airport.

1.7 **Meteorological information**. On 08th March, 2013 at 1100 (UTC) the weather reported by meteorological department QIAP, Quetta at the time of landing is appended below:

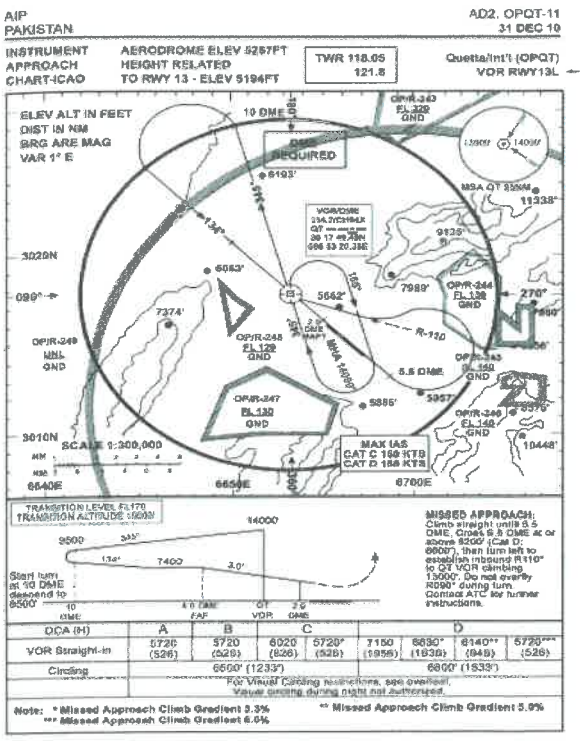
Vis	Outlook	Clouds	Wind	QNH	Temp	Weather Warning
4Km	Haze	2SC 40 2AC 10	220/18 Gust 25 Kts	1020	24^0 C	Dust raising wind

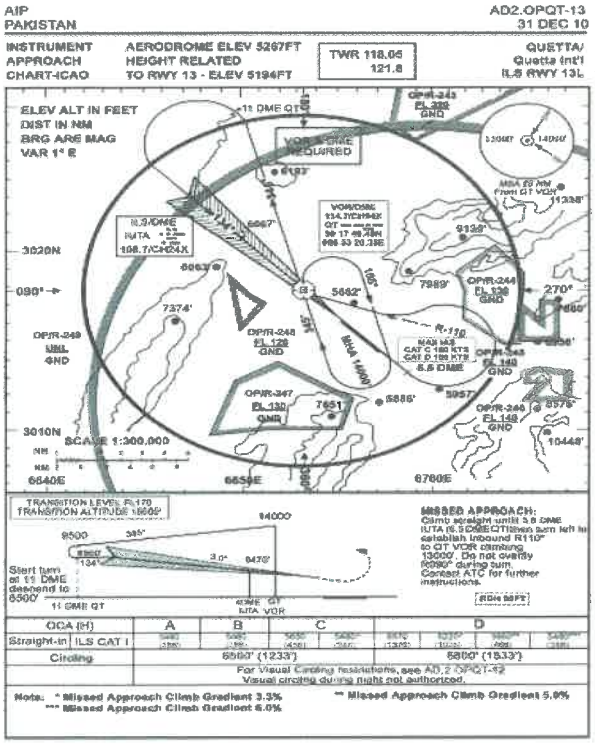
1.8 **Aids to Navigation**. The aircraft was equipped with serviceable ADF, VOR / DME and ILS equipment for the safe conduct of flight. All the ground equipment related to ADF, VOR / DME and ILS at destination airport was found serviceable at the time of occurrence.

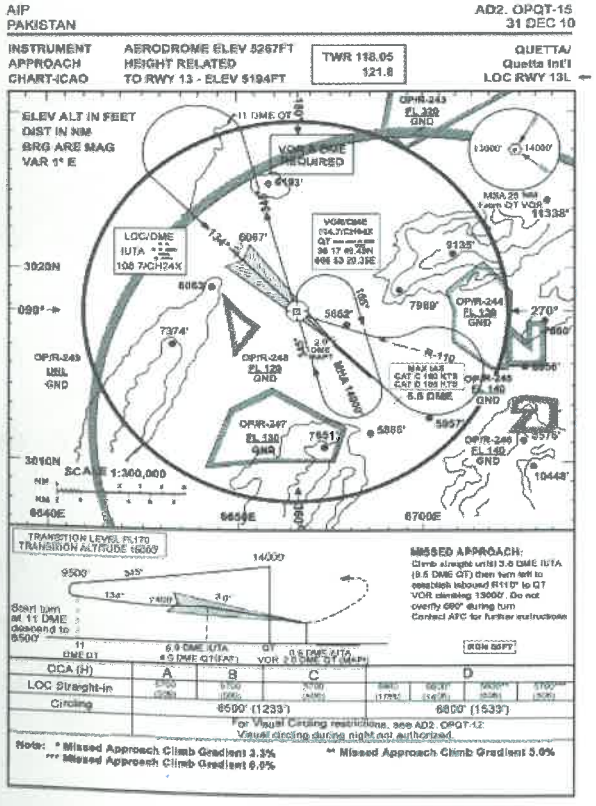
1.9 **Aids for Communication**. Boeing B737-300 aircraft was equipped with serviceable two VHF and one HF radio set for its two way radio contact with all concerned / relevant agencies during the conduct of flight.

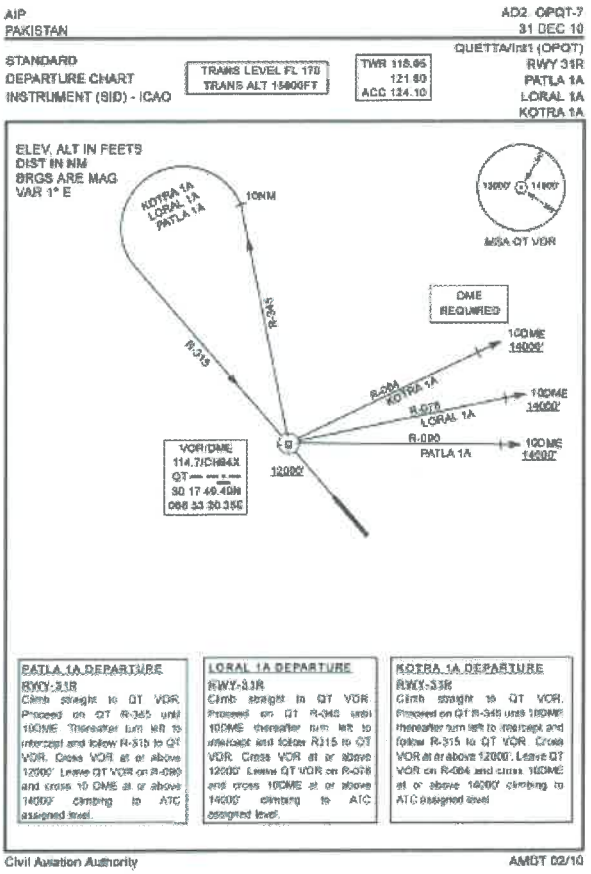
1.10 **Aerodrome information**

1.10.1 The QIAP Quetta standard arrival chart along with ILS approach runway 13L are appended on the next page:


AIP
PAKISTAN
AD2. OPQT-11
31 DEC 10
INSTRUMENT APPROACH CHART-ICAO
AERODROME ELEV 5267FT
HEIGHT RELATED
TO RWY 13 - ELEV 5194FT
TWR 118.05
121.8
Quetta/Int'l (OPQT)
VOR RWY13L
ELEV ALT IN FEET
DIST IN NM
BRG ARE MAG
VAR 1° E
10 DME QT
DME REQUIRED
MSA QT 25NM
11338'
3020N
090°
3010N
SCALE 1:300,000
6540E
6650E
6700E
TRANSITION LEVEL FL170
TRANSITION ALTITUDE 15000'
MISSED APPROACH:
Climb straight until 5.5 DME, Cross 5.5 DME at or above 8200' (Cat D: 9000'), then turn left to establish inbound R110° to QT VOR climbing 13000'. Do not overfly 090° during turn. Contact ATC for further instructions.
Start turn at 10 DME descend to 8500'
OCA (H)
A
B
C
D
VOR Straight-in
5720 (526)
5720 (526)
6020 (826)
5720* (526)
7150 (1956)
6830* (1636)
8140** (946)
5720*** (526)
Circling
6500' (1233')
6800' (1533')
For Visual Circling restrictions, see overleaf.
Visual circling during night not authorized.
Note: * Missed Approach Climb Gradient 3.3%
** Missed Approach Climb Gradient 5.0%
*** Missed Approach Climb Gradient 6.0%
Civil Aviation Authority
AMDT 02/10


AIP
PAKISTAN
AD2.OPQT-13
31 DEC 10
INSTRUMENT APPROACH CHART-ICAO
AERODROME ELEV 5267FT
HEIGHT RELATED
TO RWY 13 - ELEV 5194FT
TWR 118.05
121.8
QUETTA/
Quetta Int'l
ILS RWY 13L
ELEV ALT IN FEET
DIST IN NM
BRG ARE MAG
VAR 1° E
11 DME QT
VOR & DME REQUIRED
MSA 25 NM From QT VOR
11338'
ILS/DME IUTA 108.7/CH24X
3020N
090°
3010N
SCALE 1:300,000
6540E
6650E
6700E
TRANSITION LEVEL FL170
TRANSITION ALTITUDE 15000'
MISSED APPROACH:
Climb straight until 5.5 DME IUTA (5.5 DME QT)then turn left to establish inbound R110° to QT VOR climbing 13000'. Do not overfly 090° during turn. Contact ATC for further instructions.
Start turn at 11 DME descend to 8500'
OCA (H)
A
B
C
D
Straight-in ILS CAT I
Circling
6500' (1233')
6800' (1533')
For Visual Circling restrictions, see AD 2 OPQT-12
Visual circling during night not authorized.
Note: * Missed Approach Climb Gradient 3.3%
** Missed Approach Climb Gradient 5.0%
*** Missed Approach Climb Gradient 6.0%
Civil Aviation Authority
AMDT 02/10


AIP
PAKISTAN
AD2. OPQT-15
31 DEC 10
INSTRUMENT APPROACH CHART-ICAO
AERODROME ELEV 5267FT
HEIGHT RELATED
TO RWY 13 - ELEV 5194FT
TWR 118.05
121.8
QUETTA/
Quetta Int'l
LOC RWY 13L
ELEV ALT IN FEET
DIST IN NM
BRG ARE MAG
VAR 1° E
11 DME QT
VOR & DME REQUIRED
MSA 25 NM From QT VOR
11338'
LOC/DME IUTA 108.7/CH24X
3020N
090°
3010N
SCALE 1:300,000
6540E
6650E
6700E
TRANSITION LEVEL FL170
TRANSITION ALTITUDE 15000'
MISSED APPROACH:
Climb straight until 5.5 DME IUTA (5.5 DME QT) then turn left to establish inbound R110° to QT VOR climbing 13000'. Do not overfly 090° during turn Contact ATC for further instructions
Start turn at 11 DME descend to 8500'
OCA (H)
A
B
C
D
LOC Straight-in
Circling
6500' (1233')
6800' (1533')
For Visual Circling restrictions, see AD2. OPQT-12
Visual circling during night not authorized.
Note: * Missed Approach Climb Gradient 3.3%
** Missed Approach Climb Gradient 5.0%
*** Missed Approach Climb Gradient 6.0%
Civil Aviation Authority
AMDT 02/10


AIP
PAKISTAN
AD2. OPQT-7
31 DEC 10
STANDARD DEPARTURE CHART INSTRUMENT (SID) - ICAO
TRANS LEVEL FL 170
TRANS ALT 15000FT
TWR 118.05
121.80
ACC 124.10
QUETTA/Int'l (OPQT)
RWY 31R
PATLA 1A
LORAL 1A
KOTRA 1A
ELEV. ALT IN FEET
DIST IN NM
BRGS ARE MAG
VAR 1° E
KOTRA 1A
LORAL 1A
PATLA 1A
10NM
MSA QT VOR
DME REQUIRED
10DME 14000'
R-345
R-315
R-084 KOTRA 1A
R-078 LORAL 1A
R-090 PATLA 1A
VOR/DME 114.7/CH84X
QT 30 17 49.40N 066 53 30.35E
12000'
PATLA 1A DEPARTURE
RWY-31R
Climb straight to QT VOR. Proceed on QT R-345 until 10DME. Thereafter turn left to intercept and follow R-315 to QT VOR. Cross VOR at or above 12000'. Leave QT VOR on R-090 and cross 10DME at or above 14000' climbing to ATC assigned level.
LORAL 1A DEPARTURE
RWY-31R
Climb straight to QT VOR. Proceed on QT R-345 until 10DME thereafter turn left to intercept and follow R315 to QT VOR. Cross VOR at or above 12000' Leave QT VOR on R-078 and cross 10DME at or above 14000' climbing to ATC assigned level.
KOTRA 1A DEPARTURE
RWY-31R
Climb straight to QT VOR. Proceed on QT R-345 until 10DME thereafter turn left to intercept and follow R-315 to QT VOR. Cross VOR at or above 12000'. Leave QT VOR on R-084 and cross 10DME at or above 14000' climbing to ATC assigned level.
Civil Aviation Authority
AMDT 02/10

4. ATS unit call sign Language(s)	Quetta Tower (English)
5. Transition altitude	15000 FT
6. Remarks	-

OPQT AD 2.18 ATS COMMUNICATION FACILITIES

Service designation	Call sign	Frequency	Hours of operation	Remarks
1	2	3	4	5
TWR	Quetta Tower	118.050 MHZ 121.5 MHZ	HS	VHF range limited to 25NM on VOR R042 and R167 Emergency only
APRON	Quetta Tower	121.8 MHZ	HS	
G/A/G	Radio	5601	HS	
G/A/G	Radio	2923		

OPQT AD 2.19 RADIO NAVIGATION AND LANDING AIDS

Type of aid. CAT of ILS (VAR VOR/ILS)	ID	Frequency	Hours of operation	Site of transmitting antenna coordinates	Elevation of DME transmitting antenna	Remarks
1	2	3	4	5	6	7
LLZ 13L ILS CAT-1	IUTA	108.7 MHz	H24			1235FT after RWY end.
GP / TDME 13L	Dots / Dashes	330.5 MHz / CH 24X	H24			966FT after THR 350FT offset.
➡ NDB	QT	348 KHZ	HJ	* 3015N 06656E		-
➡ VOR/DME (1°E/1995)	QT	114.7 MHZ CH 94 X	H24	301749.49N 0665320.35E	1567.3M	-
BS	Radio Pakistan	366 KHZ	HX	301207.02N 0670947.28E		-

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	THR 1583 M / 5194 FT
31R	316°			30 14 24.69N 066 57 06.38E	THR 1605 M / 5267 FT

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	-	

1.11 **Flight Recorders**. Cockpit Voice Recorder (CVR) and Flight Data Recorder (FDR) were intact and retrieved successfully. The relevant data was used for the purpose of investigation.

1.12 **Wreckage and Impact Information**. The aircraft remained intact after landing and was stopped on the runway.

1.13 **Medical and Pathological Information**. Not applicable.

1.14 **Fire**. There was no evidence of in-flight or on-ground fire.

1.15 **Survival Aspects**. The passengers were disembarked by normal method using passenger steps.

1.16 **Test and Research**. Dimensional checks, strip examination of damaged LMLG components and assemblies and failure mode / fractographic analysis of torsion link was performed.

1.17 **Organisational and Management Information**. Not applicable.

1.18 **Additional Information.** Not applicable.

1.19 **Use of Effective Investigation Techniques**. Standard investigation procedure and techniques were used.

2. ANALYSES

2.1 The mishap flight took off from BBIAP, Islamabad as per plan. The flight remained uneventful till touchdown during landing at QIAP, Quetta.

2.2 The aircraft landed through normal ILS approach at 1116 UTC on runway 13L QIAP, Quetta.

2.3 The touchdown was normal and within the desired touchdown zone.

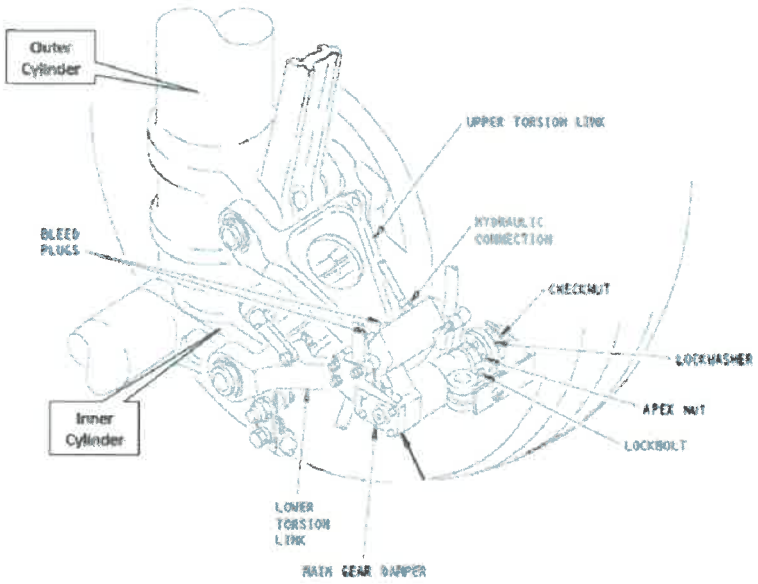
2.4 The aircraft touched down on runway heading 134^0 in almost wings level state as per the recorded parameters of FDR. After landing severe vibrations were felt by cockpit crew from under the belly.

2.5 The cockpit crew applied the remedial actions to keep the aircraft under control and on the runway surface.

2.6 The aircraft was switched off on the runway and passengers were disembarked using steps as per normal procedure.

2.7 The remedial actions as per the QRH and FCOM by the cockpit crew were prompt, to keep the aircraft under control and on prepared runway surface after encountering the LHS MLG anomaly.

2.8 The axle of the wheels is mounted on the inner cylinder. The torsion links and shimmy damper assembly prevents pivot of the inner cylinder inside the outer cylinder (torsional movement). The torsional vibrations are prevented by the shimmy damper.



Torsion Links and Shimmy Damper Assembly

2.9 The Boeing Fleet Team Digest article 737-FTD-32-11001, last reviewed 5th October, 2012 **(Appendix 'D')** discusses shimmy event reasons and preventive measures. The summary of the root causes is presented below:

2.9.1 More than specified clearance / play at the shimmy damper Apex Joint and bushings of the Torsion Links and mating bushings on the inner / outer cylinder.

2.9.2 Landing with extremely low sink rates allows landing gear struts to remain in extended position for relatively longer period. While the struts are in extended position the mechanical advantage of the shimmy damper is reduced.

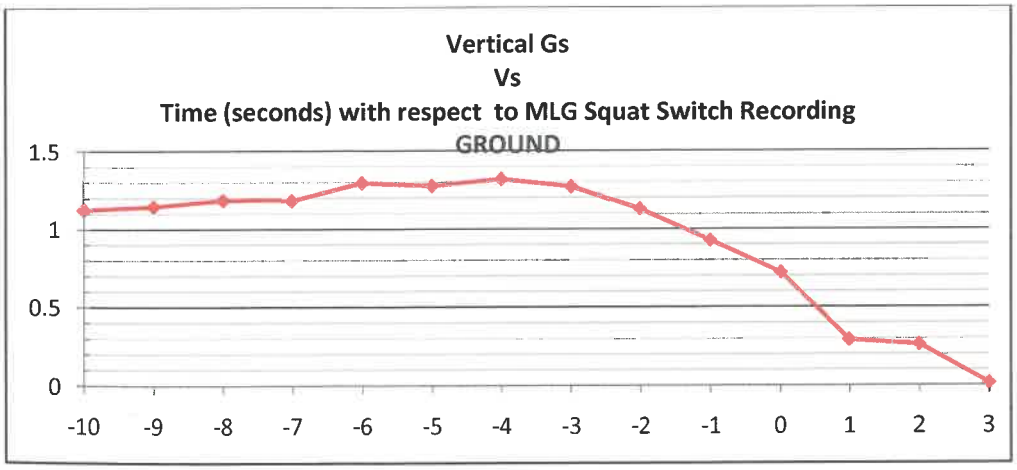
2.9.3 The internal hydraulic leaks, presence of entrapped air and damage to shimmy damper hardware.

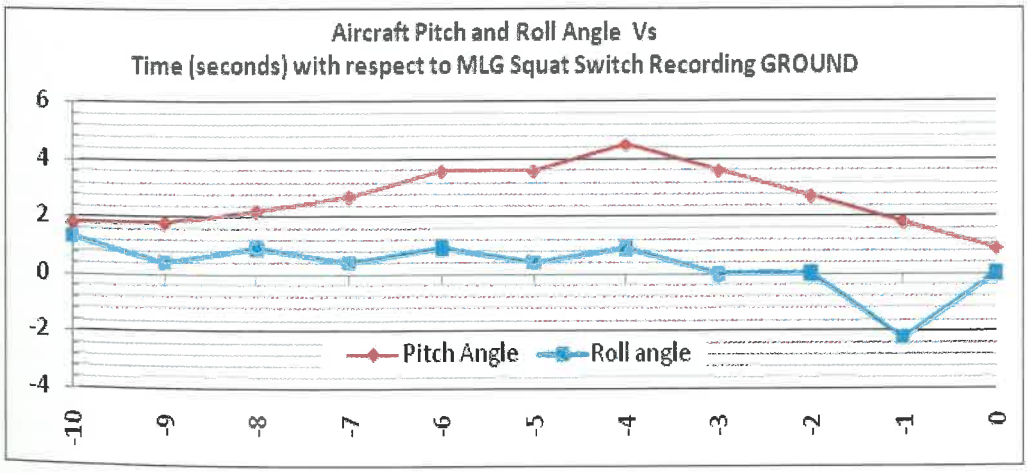
2.9.4 Over servicing of the landing gear strut also keeps the struts in extended position and thus reduces the mechanical advantage of the shimmy damper mechanism.

2.10 The FDR data of pertinent landing parameters vs time in seconds with reference to Main Landing Gear (MLG) squat switch sensing GROUND is shown in following plots. The squat switch parameter records GROUND when main landing gear strut gets compressed under aircraft weight and corresponds to zero on the horizontal axis in the plots shown. Three of the plots also compare FDR parameters of the mishap flight with another shimmy event flight and some of the normal landing flights.

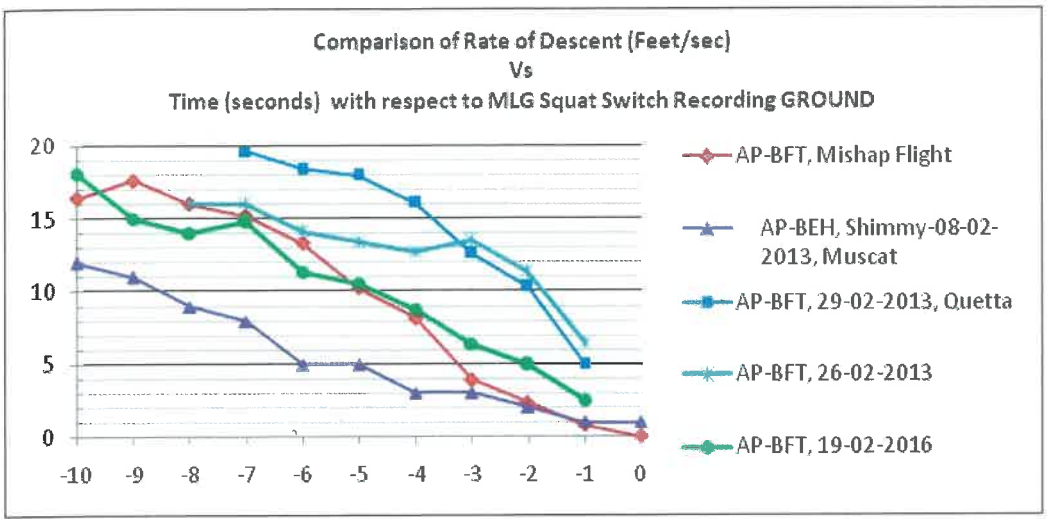
2.11 The peak in vertical acceleration roughly corresponds with the initial contact of the aircraft with runway surface. The roll angle at time of touchdown was very close to zero and pitch angle was approximately 4° pitch up. The aircraft made an almost wings level touch down on main wheels.

2.12 The transition of the landing gear squat switches to the GROUND was recorded approximately 3-4 seconds after peak vertical acceleration (touchdown). This implies that landing gear struts remained extended for approximately 3-4 seconds after the touchdown.

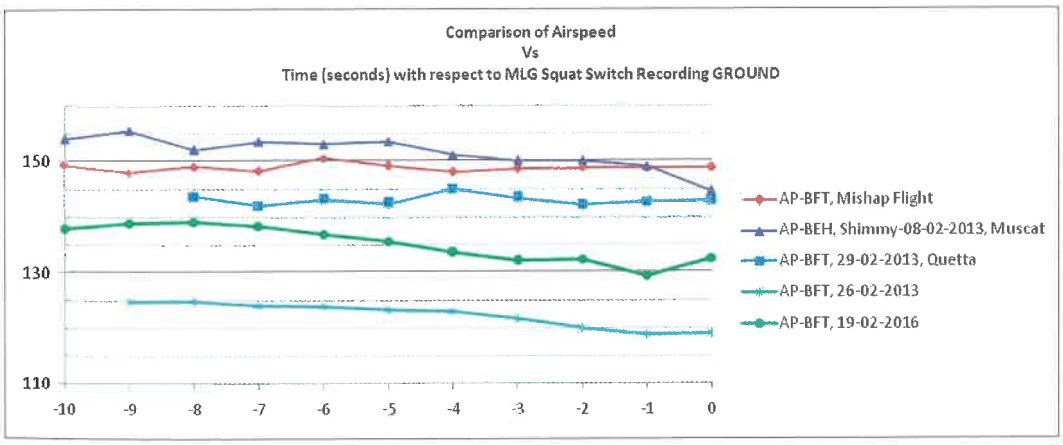




2.13 The sink rate of the aircraft was calculated using Radio Altitude. Though the calculated sink rate is not a direct measure of compression rate of the landing gear strut but it does provide a qualitative indication. The comparison plot shows that aircraft sink rate in case of both shimmy event flights before the compression of the landing gear struts (squat switch sensing GROUND) is showing similar pattern and was very low in comparison to normal flights.



2.14 The Computed Air Speed (CAS) at the time of touchdown was approximately 149 knots which is a relatively high speed as evident from the comparison plot presented below:



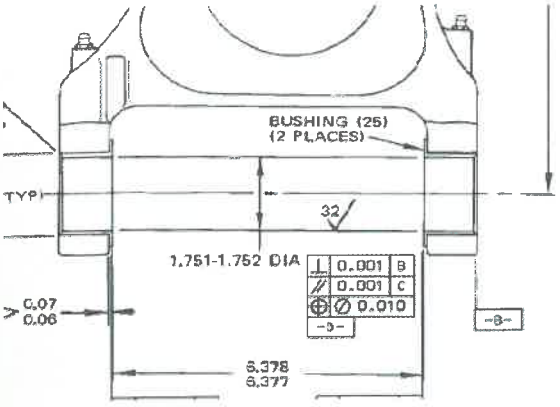
2.15 The assembled landing gear checks like "Torsion Links Apex Joint Check" with the help of a feeler gage and "Torsional Free Play Check" with the help of dial indicator in accordance with the applicable AMM are effective indicators of wear of the linkages of shimmy damper mechanism. Since the related parts got damaged during the occurrence therefore, these checks were not possible.

2.16 The measurement of wear of the bushing of torsion links was used as an indirect method of ascertaining the condition of play of the assembled linkages of the shimmy damper system. More than specified wear of the bushings would invariably cause more than specified play in the assembled system.

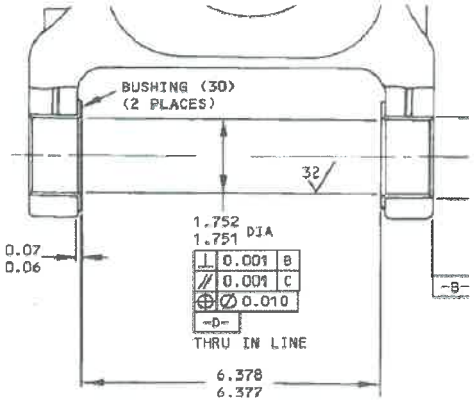
2.17 Design wear limit of Upper torsion link assembly inner flange (with bushes) is 6.377 to 6.378 inches and service wear limit (max) is 6.382 inches as per Component Maintenance Manual (CMM) 65-73761. The actual measurement of the damaged

Upper Torsion link assembly inner flange (with bushes) was found as 6.383 inches, which would result into relatively more play.

2.18 Design wear limit of Lower Torsion Link assembly inner flange (with bushes) is 6.377 to 6.378 inches and service wear limit (max) is 6.382 inches as per CMM 65-73761. The actual measurement of Lower Torsion Link assembly inner flange (with bushes) was found as 6.379 inches.

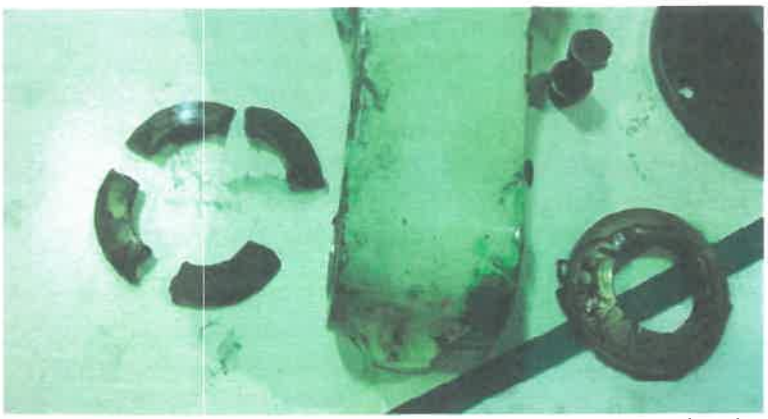


Upper Torsion Link Drawing



Lower Torsion Link Drawing

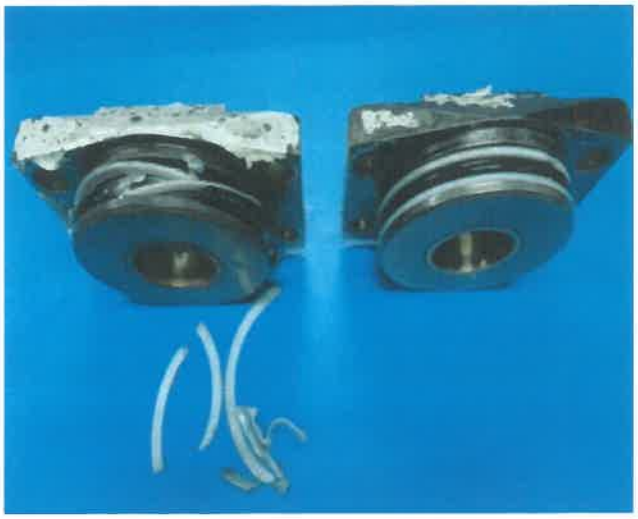
2.19 Lower Torsion Link upper lug outer flange's inboard side bush was found broken into four pieces, whereas outboard side bush was intact. Inner diameter (Average) of Spherical bush in lower torsion link upper lug was measured as 0.998 inches which is also within design limits (0.99 to 1.01) inches as per applicable CMM. The damage pattern of the bush indicated failure under compressive loads, which most probably were encountered during shimmy event.



Lower Torsion Link upper lug damaged and intact bush

2.20 The failure mode analysis of the Upper Torsion Link was performed at Institute of Space Technology (IST), Failure Analysis Center (FAC). The FAC analysis report **(Appendix 'E')** concluded that part failed due to bending overload and no evidence of fatigue failure was found.

2.21 Shimmy damper assembly Part No. 65-44771-4, Serial No. 1821-91 was disassembled and checked as per CMM 65-44771-4. During this examination one out of two Ring Backup (Teflon seal), one was found missing and the available Ring Backup (Teflon seal) and Packing (O-ring) was found damaged.



Damaged vs Intact Ring Backup

2.22 The mishap Shimmy Damper was released from PIAC Hydraulic shop on 2nd August, 2011 by re-using Rings Backup (Teflon seals) as Boeing maintenance instructions do not specify to replace the Ring Backup (Teflon seal). Shop release maintenance records were reviewed and found that PIAC shop staff also assumes Packing (O-ring) as "On-Condition" item rather than once use consumable in contrast to applicable Boeing maintenance instructions. The re-use of the Packing increases the chances of it getting damaged during subsequent operation. Similarly if one of the Ring backup is missing then Packing (O-ring) would not be fully supported and is likely to get extruded and damaged during operation.

2.23 Incorrect installation or presence of nicks, cuts, burs on Ring Backup during installation is most common cause of damage to Packing (O-ring). When packing is damaged hydraulic leakage, air entrapment or debris of the damaged parts may interfere with the proper functioning of shimmy damper. Exact reason and time of damage to Ring Backup and Packing could not be established. Since there was no reported Hydraulic Fluid leakage prior to mishap flight and even after the incident no signs of leakage were observed, therefore, possibly the damage took place during the shimmy event, perhaps the extent of damage to sealing capability and operation time with damaged Ring Backup was not enough to result into fluid leakage.

2.24 In-effective shimmy damper mechanisms due to trapped air, internal leaks / failures of shimmy damper, over inflation of shock struts and more than specified clearance / play in the associated linkages results in torsional vibrations of the wheel assembly. If the vibrations approach the natural frequency of assembly then resonance phenomenon (large amplitude vibrations) is excited which is called Shimmy event. The zigzag tire marks on the runway are characteristic indication of the shimmy event.

2.25 The landing parameters like high landing speed (more likely at high altitude airports like Quetta) coupled with low sink rate touchdowns results in landing gear strut staying un-compressed for longer than normal time which reduces the mechanical efficiency of the shimmy damper mechanism. The low sink rate just before touchdown in presence of more than specified play in the assembly or defective shimmy damper is more likely to trigger shimmy event in a particular landing.

2.26 The large amplitude vibrations exert excessive load on associated linkages, resulting into failure of the torsion links and / or shimmy damper actuator.

3. CONCLUSION

3.1 Findings

3.1.1 The flight remained uneventful till touchdown during landing at QIAP, Quetta.

3.1.2 The aircraft landed through normal ILS approach at 1116 (UTC) on runway 13L QIAP, Quetta.

3.1.3 The touchdown was normal and within the desired touchdown zone.

3.1.4 After landing severe vibrations were felt by cockpit crew from under the belly which increased in intensity with the reduction in aircraft speed.

3.1.5 The cockpit crew applied the remedial actions to keep the aircraft under control and on the runway surface.

3.1.6 The aircraft was switched off on the runway and passengers were disembarked normally.

3.1.7 The FDR analysis indicated that touchdown of the mishap flight was at low sink rate and landing gear strut remained extended for about 3-4 seconds after the touchdown. The touchdown speed was also relatively high.

3.1.8 The dimensional check of the Upper Torsion Link bushing showed that the bushings were worn beyond the specified limits. The wear of the Lower Torsion Link bushings was beyond design limit but within service wear limit.

3.1.9 The out of specified limit wear of the bushings of the Upper Torsion Link and very close to allowable maximum wear of Lower Torsion Link was most probably responsible for creating more than specified play in the Shimmy Damper mechanism which when coupled with low sink rate touchdown triggered the shimmy event.

3.1.10 The failure mode and fractographic analysis of the Upper torsion Link concluded that that there was no material deficiency or signs of fatigue failure. The part failed under overload condition due to shimmy event.

3.1.11 During tear down examination of Shimmy Damper, the Packing (O-ring) was found damaged and out of two Rings Backup (Teflon seals) one was missing while one was damaged.

3.1.12 The exact reason and time of failure of the Packing could not be established. The circumstantial evidence supported the possibility of its failure during shimmy event because of missing Ring Backup and possible re-use of the Packing.

3.2 Cause of Occurrence

3.2.1 The incident took place due to LMLG Shimmy as a result of touchdown with very low sink rate combined with more than specified play present in the linkages of Shimmy Damper at relatively high-speed.

3.2.2 Failure of Shimmy Damper Packing due to improper assembly by using only one Ring Backup instead of two and possible reuse, also contributed. Most probably debris of the failed seals interfered with the operation of the Shimmy Damper and further reduced its damping capability thus aggravating the shimmy event.

4. SAFETY RECOMMENDATIONS

4.1 The operator (PIAC) to perform One Time Check / Inspection on Boeing 737-300 fleet to ensure following as per applicable AMM / Publications:

4.1.1 Removal and disassembly of all Shimmy Dampers and 100% replacement of all consumables.

4.1.2 Check / Adjustment of gap of Apex Joint of Main Landing Gear Torsion Link.

4.1.3 Check / Adjustment of Torsional Free Play.

4.1.4 Bleeding of installed Shimmy Damper.

4.2 The operator (PIAC) to brief all Boeing 737-300 operating cockpit crews to adhere to Boeing recommended procedures & techniques of landing especially at higher elevation airports so as to ensure maximum efficiency of shimmy damper mechanism.