HQCAA/1901/312/SIB

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PAKISTAN CIVIL AVIATION AUTHORITY

(SAFETY & INVESTIGATION BOARD)

AIRCRAFT INCIDENT INVESTIGATION REPORT

PAKISTAN INTERNATIONAL AIRLINES

AIRBUS 310, REG. NO. AP-BDZ

ON 21 NOVEMBER 2006

AT

ISLAMABAD

FINAL REPORT

SERIOUS INCIDENT TO M/S PIAC A-310, AP-BDZ ON 21 NOVEMBER 2006 AT ISLAMABAD

Authority: Director General Civil Aviation Authority Memorandum No. HQCAA/1901/312/SIB dated 24 November 2006.

Synopsis:

On 21st November 2006, PIA 308 Flight was descending for Islamabad, at flight level 22000; it experienced a sudden steep dive at an extra ordinary rate, to flight level 16000. It caused minor injuries to passengers and cabin crew. The incident was reported to Airport Management by passengers and later documented by Air Traffic Services through daily incident occurrence report. It was discovered from digital flight data recorder (DFDR) that the aircraft has operated at speed, Mach number and negative Gs beyond it's maximum limits resulting in excessive vertical load factor on the aircraft structure.

DG CAA ordered investigation into the serious incident and it was notified to manufacturer and ICAO headquarters in accordance with ICAO Annex 13. The investigation revealed that aircraft received orders from auto pilot for pitch down and power advance due to some erroneous input to air data computer because of ice formation at a pitot pressure sensor on Captain's side. However the aircrew could not appreciate that the speed shown on Captain's side is lesser than the actual speed of the aircraft, hence, the situation was aggravated when corrective actions to increase the speed by advancing the throttles were taken by aircrew. It was further learnt that aircraft had experienced a similar defect on 21st October 2006 and was released for service without any defect diagnosis. After the incident on 21st Nov 06, it was released for service within one hour at Islamabad, and would had been flying with passengers without crucial structural inspections; had Dy DG not instructed to analyse DFDR before it's release to service. It was ferried to Karachi on 22nd Nov and remained on ground for five days for inspections before release to service. However when Airbus expert observed the DFDR data, their experts advised special inspections for a flight operated in excess of maximum velocity and maximum mach number (VMO/MMO) for which the aircraft remained grounded for 27 days. When put in operations on 28th December, 2006, it again experienced similar drop of speed on 8th and 11th January 2007. Airbus now advised to remove pitot pressure sensor, which was found short circuiting during destructive analysis at Goodrich Sensors and Integrated Systems USA.

The investigation and analysis once again have exposed lack of situational awareness on part of aircrew and absence of systematic defect analysis on part of Quality System at Engineering and Maintenance at PIAC.

1. Factual Information

1.1 **Type of Aircraft** : Airbus-310

1.2 **A/C Registration** : AP-BDZ

1.3 **Flight Number** : PK-308. KHI-ISB 21st November 2006

1.4 **Crew Information** : Captain Sarwat Hayat, F/o Aurangzeb Khan

1.4.1 **PILOT IN COMMAND**

a.	Name	:	Sarwat Hayat
b.	Position in the Cockpit	:	Captain Left Seat
c.	Date of Birth	:	12-12-1951
d.	Type of License and No.	:	ATPL 758
e.	Medical Date with status	:	22-12-2006 Normal
f.	Ratings	:	P-I (A-310)
g.	Type Held	:	B-747(P2)A300(P2) B-737(P1&2) F27(P1&2)
h.	Type Current	:	A-310-300
i.	Assistant/Flight Instructor Ratings	:	None
j.	Check Ratings	:	None
k.	Flying Experience (Grand Total)	:	14231:00 Jan 2007
l.	Total in Command	:	5955.00 Jan 2007
m.	Total in Command on the type Accident/Incident occurred	:	1834.00 Nov 2006
n.	Where Trained	:	Toulouse France
o.	Date of Joining the Organization	:	08-02-1981

1.4.2 **CO-PILOT**

a.	Name	:	Aurangzeb Khan
b.	Position in the Cockpit	:	First Officer Right Seat
c.	Date of Birth	:	10-02-1958
d.	Type of License and No.	:	ATPL 1100
e.	Medical Date with status	:	20-11-2006 Normal
f.	Ratings	:	P-2 (A-310)
g.	Type Held	:	A300(P-2) A310(P2) B-737(P2) F27(P2)
h.	Type Current	:	A-310-300
i.	Assistant/Flight Instructor Ratings	:	None
j.	Check Ratings	:	None
k.	Flying Experience (Grand Total)	:	8809:00

l.	Total in Command	:	297:00 S Engine
m.	Total in Command on the type Accident/Incident occurred	:	Nil
n.	Where Trained	:	Amman - Jordan
o.	Date of Joining the Organization	:	29-08-1990

1.5 **Date of Occurrence**: 21st November 2006 (See **Appendices A & B** for incident report by ATS and airport manger's report.

1.6 Air Crew was subjected to a medical examination and the results were negative (See **Appendix 'E'**).

1.7 **Air Traffic Services:** It was revealed that the ATS has no clue about the incident which took place in its control. The duty traffic controller report is attached as **Appendix 'F'**.

1.8 The radar track of the flight is given in **Appendix 'G'**.

1.9 **Weather:** There was no turbulence or any other warning issued by ATS (See **Appendix 'H'**).

1.10 **ATC Tape Extracts:** There incident was not announced by aircrew. The ATC conversation is attached as **Appendix 'J'.**

1.11 **DFDR: The investigation report produced by Airbus contains** relevant data which explains the incident and is attached as **Appendix 'K'.**

1.12 **CVR: The recording of the cockpit area microphone (CAM) was analysed but there was no significant information.**

1.13 **Defect History:**

1.13.1 A defect of similar nature was observed and reported on this aircraft on 21 Oct 06 / GLA-LHE sector. The defect reporting and rectification are as follows.

"During Cruise at FL 330 1) ENG Trim failed 2) TRP failed & throttles went to maximum thrust 3) Capt. speed tape failed showing 80 knots 4) Capt. FAC failed 5) Auto pilot pitched down violently and disengaged."

1.13.2. Rectification at LHE:

(a) As per BITE PMC #2 failed and same carried forward

(b) AFS test found satisfactory. Auto Throttle & TRP function normal

(c) Both ADCs checked for installation and found ok C.B recycled ADS test carried out and found satisfactory.

(d) Both FAC show no BITE. C.B recycled. AFS BITE carried out and found satisfactory.

(e) Autopilot checked in all modes and found satisfactory. Both FMCs test carried out and passed."

1.13.3. At KHI, PMC #2, ADC #1 & ADC #2 were replaced. These LRUs were later on found serviceable in shop.

2. Technical Investigation

2.1 The Occurrence

2.1.1 The aircraft was descending from FL 34 for Islamabad approach in auto pilot mode. While in descend in slight turbulent weather conditions (reported by aircrew), vertical speed was constant at minus 2000 feet per minute and aircraft speed was 270 knots with Mach number 0.62. These were normal conditions but from here the speed decreases to 260 knots and Mach number to 0.60. It was accompanied by a slight thrust increase resulting in N1 increase. In the next phase as per DFDR data the aircraft computed air speed suddenly dropped from 265 knots to 35 knots within 17 seconds. In these 17 seconds the thrust levers have moved from 43° to 68° position and then from 68 degree to 83 degree; meaning that power was advanced by auto throttle and subsequently by aircrew to maximum position. The aircraft pitch attitude also increases from -1 degree nose down to -8 degree nose down. This sudden nose down and thrust advance caused the aircraft to dive with a maximum rate of vertical descend as high as **12000 feet per minute and aircraft relative air speed as high as 471 knots.** The aircraft maximum permissible vertical speed is 340 knots, hence aircraft did cross this limit by 131 knots; a condition which causes loads in excess of permissible loads on aircraft structure. Under these conditions the structure including engines experience stresses beyond yield factor of safety which result in permanent strains. Hence in addition to investigation into the cause of occurrence, the aircraft is subjected to a series of structural inspections to determine whether there were any ill effects on the aircraft or engine structure or not; and would it be safe to fly the aircraft?. The details of such inspections are given in **Appendix 'N'** and **'N-2'** as per aircraft maintenance manual (AMM 05-051-17) and Airbus Industries "**Special Package**" respectively.

2.2 DFDR Analysis

2.2.1 The relevant parameters are given in **Appendix 'K', which** shows the changes in altitude, speed, pitch angle, vertical speed, VMO warnings, auto pilot engagement and disengagement times and elevator / stabilizer position. Analysis of the flight parameters indicate that the computerized airspeed is erroneous and the same when fed to air data computer causes the thrust lever to move and set course for the event. The salient facts from DFDR for understanding the occurrence are explained in the final report by Airbus attached as **Appendix 'K-1'**.

2.3 Sequence of the facts from DFDR

2.3.1 **Since 12.21.31 GMT** Aircraft in descent in slight turbulence weather conditions. Vertical speed is constant according to pressure altitude rate of descent (-2000 ft/min). Autopilot number 2 is engaged. Autopilot modes and targets are not recorded. Auto-throttle mode and engagement status are not recorded. Thrust levers are both on IDLE position (43^0 Thrust Resolver Angle "TRA"). Speed is 270 Kt and Mach is 0.62. Engines inlets anti ice valves are opened.

2.3.2 **At 12.22.28 GMT** The speed decreases to 260 Kt and Mach decreases to 0.6. The thrust increases (slight throttle levers movement with N1 increase).

2.3.3 **12.22.32 GMT to 12.22.49 GMT** When descending through 23,000 ft, the recorded computed airspeed CAS drops suddenly from its current value (265 Kt) and reaches 35 Kt in 17 seconds. Similarly the Computed Mach drops very rapidly from 0.62 down to 0.1 in 17 seconds: LONG parameter (longitudinal load factor) becomes negative (-0.1g). Total Air temperature (TAT) is recorded at -8^o C. From 12.22.34 GMT to 12.22.40 GMT, throttle levers move from 43^0 TRA (idle) to 68^o TRA (climb). Engine thrust (N1) increases accordingly.

2.3.4 **From 12.22.40 GMT to 12.22.49 GMT**, throttle levers move from 68^o (CLIMB) to 83^o (full forward stop). The pitch attitude decreases from -1^0 noses down to 8^o nose down.

2.3.5 **From 12.22.40 GMT to 12.22.49 GMT**, the recorded horizontal stabilizer position (THS or 'STAB') is recorded from -1.4^o noses up to about -0.9^0 nose up (reduced nose up order/global nose down order). At GMT 12.22.42, the crew take over with autopilot disconnections and nose down orders (positive elevators deflection up to +3 noses down).

2.3.6 CAS1 and Mach 1 reach their minimum recorded value at 12.22.49 GMT with respectively 35 Kt and 0.1 whilst the estimated rate of descent (from pressure altitude rate of decrease) is -3000 ft/min increasing.

2.3.7 **From 12.22.44 GMT,** the recorded angle of attack is zero and remains zero for 12 seconds.

2.3.8 **12.22.50 GMT** Autopilot number 2 is reengaged but disconnects thereafter in the presence of recorded nose down orders on elevators.

2.3.9 Levels of vertical load factor increase (values of 0.45g and +1.3 g).

2.3.10 **12.23.05 GMT** Over speed warning is triggered when crossing 20,500 ft, with CAS1 recorded at 108 Kt and MACH1 at 0.24. The over speed warning lasts one min. In the meantime, the crew maintain a nose down order (positive elevators position is rerecorded).

2.3.11 **12.23.08 GMT** A+3.14° nose down order on elevators is recorded. The pitch attitude further decrease to -15.8° nose down and the aircraft experience a vertical load factor excursion to -0.33g.

2.3.12 Average nose down order then increases on elevators (from +1° nose down average to +2° nose down average). Levels of vertical load factor increase.

2.3.13 Estimated altitude rate of descent increases to -12000 ft/min according to the rate of decrease in pressure altitude (ALT parameter).

2.3.14 **12.23.23 GMT to 12.23.39 GMT** The recorded horizontal stabilizer position (STAB) is recorded from -1.0° nose up to -2.8° nose up. This corresponds to a global nose up order. The pitch attitude increases.

2.3.15 The crew increase the nose down order: first the orders increase to +3° nose down average on elevators (12.23.24 GMT) then to +5° nose down average on elevators (12.23.34 GMT).

2.4 **12.23.29 GMT to 12.23.33 GMT**

2.4.1 Minimum recorded altitude value is reached (16100 ft).

2.4.2 CAS is recorded at its maximum value of 471 Kt = VMO +131 Kt.

2.4.3 The Mach is recorded at its maximum value of 0.9=MMO +0.06

2.4.4 Maximum vertical load factor recorded value is reached (+2.59g).

2.5 **12.23.38 GMT to 12.23.44 GMT**

2.5.1 Thrust is reduced from full thrust to idle thrust.

2.5.2 The over speed warning ceases when the recorded CAS1 decreases through VMO (340 Kt).

2.5.3 The altitude is increasing through 19000 ft.

2.5.4 Prompt variations previously recorded on AOA and load factors cease.

2.5.5 From 12.24.17 GMT

2.5.6 The autopilot is re-engaged and the flight is continued.

3. Investigation and Analysis

3.1 The investigations and analysis is focused to determine the cause of occurrence, reasons for auto throttle movement which caused aircraft to dive, quality of aircrew actions to control the situation and ground crew procedures and professionalism to appreciate the aircraft system behaviour in the light of repeated pilots reported defects. The aircraft was also subject to special inspections which were necessary as it had crossed maximum speed and load factor; the quality of these inspections is also part of analysis.

3.2 As per Airbus and Goodrich analysis the occurrence took place due to ice formation at Captain's side probe which measures dynamic pressure from the atmosphere i.e. a physical quantity sensed by sensor for computing air data which in turn provides air speed, vertical velocity, altitude and other derivatives for various systems; the same inputs are also provided to auto pilot system through air data computers. The basic inputs are atmospheric temperature, static pressure at a particular altitude or level of flying and dynamic pressure which builds up as a result of aircraft speed.

3.3 This, was in fact a rare incident, reported by the pilot and required maintenance actions in two distinct areas i.e. :

(a) Determination of the cause of occurrence, as to why the aircraft went into a dive from 22000 feet to 16000 feet in a way that implied rectifications should ensure non-occurrence of a similar incident.

(b) Inspections of the aircraft structures for ill effects, if any, as a result of crossing the maximum speed, Mach number and G factor.

3.4 In order to appreciate the quality of rectification and approach for defect diagnosis it is important to understand as to how aircraft initially went into an indicated speed drop on Captain's side followed by a sudden in dive and real speed increase by auto throttle and air crew actions, it would be appropriate to understand the Flight Environment Data – Description and Operations system of the aircraft, attached as **Appendix 'L'**. It will also be helpful to judge aircrew reaction and handling on realisation of abnormal conditions.

3.5 Flight Environment – Description and Operation A-310

3.5.1 The flight environment data is provided by static and pitot probes, total air temperature probes and alpha probes. This information is used for computation of altitude, airspeed, VMO, Mach number, Static air temperature and Total air temperature

3.5.2 There are three available independent airspeed indications on the aircraft which use their own, static and total probes as a source of pressure information. The aircraft is equipped two Air Data Computers and a standby system for elaboration of this independent airspeed information through Primary Flight Display (PFD), Standby Air Speed Indicators (ASI) and Vertical Speed – TCAS Indicators. In addition there are three altimeters including one in meters. For these indications static and pitot probes are installed on aircraft structure.

3.5.3 One probe is installed on the left side of the fuselage which provides dynamic pressure for Captain's instruments. Two static probes; one on each side of the fuselage are installed to provide average static pressure after compensation for possible errors due to sideslip. See **Appendix 'L'** for details of the system. These parameters are used by the air data computer (ADC) for computation of Computed Air Speed. The computed airspeed known as CAS1 is computed by ADC1. Similarly, MACH parameter on DFDR and Captain's instruments is known as MACH-1 which is also computed by ADC1.

3.5.4 Similar arrangements are duplicated for First Officer i.e. one probe and two independent static probes to average static pressures for compensating possible errors due to sideslip. These parameters are used by the air data computer (ADC2) for computation of CAS2, **however it is not recorded on the DFDR. Mach-2 is also not recorded on flight data either**.

3.5.5 Finally there is a Standby (STBY) Air Data system which includes one probe (Pt3) on the left side of the fuselage and two static ports: one on each side of the fuselage (averaged as Ps3) to compensate for possible errors due to sideslip. These parameters are used by the standby system to provide direct reading of the STBY speed (CAS3). **CAS3 is not recorded on the gathered flight data. MACH3 is not**

recorded on flight data.

3.5.6 It is important to note that for each system i.e. CAPT, F/0 and STBY, the indicated airspeed is a direct function of the difference between the total pressure (Pt) measured by the probe and the static pressure (Ps) measured by the static ports. **See Appendix 'L' Page 11 and 12 for details of the system to appreciate as to how many indications are available to aircrew for decision making.**

3.5.7 **Conclusion:** If there is any problem with the probe of captain's instruments, the airspeed on captain's instrument will be affected and the same will be recorded by DFDR. **However the first Officer's and Standby indicators will indicate correct speeds but will not be recorded on DFDR.**

3.6 Ice Protection System and effects of probable defects at Captain's side pitot sensor:

3.6.1 In order to guard against formation of ice at different flight levels and humidity conditions; each pressure sensor is equipped with internal electrical heating system. The ice protection system of the probes does not affect the independence of the three channels (CAPT, F/0, STBY) where a warning is provided to indicate probe-heating malfunction of each probe **Refer AMM chapter 30 -31-00 for details at Appendix 'L-1')**. In severe icing conditions, the ice build up rate may temporarily exceed the anti-icing/de-icing capability of the heater. Or conversely if a heating system is weak, ice formation may start under normal environments. Therefore either an encounter of severe icing conditions by a probe or the loss of probe heating efficiency can result in ice formation which in turn will give erroneous airspeed indications on the respective system. In either of the situations a probe can be totally or partially or intermittently blocked by ice and the resulting airspeed indications for that probe would be as follows:.

(a) If Only the head of the probe is blocked by ice (drain hole is free): the trapped total pressure (Pt) drops quickly towards the static pressure (Ps). As a result, the airspeed (function of Pt-Ps) drops quickly and remains affected until the heater overcomes the ice build up (generally just a few seconds).

(b) If the drain holes are also blocked: the trapped Pt remains

constant whatever the change of airspeed and altitude. In descent the Ps increases therefore (Pt-Ps) decreases and so does the airspeed. Therefore whatever the 'blocking mode', icing will always lead to an indicated airspeed that is lower than the actual (or 'real') airspeed.

3.7 Causes for auto throttle activation and sudden dive

3.7.1 The indicated speed of the aircraft is function of static and dynamic pressure measured by static and pitot probes. If the probe is partially or fully blocked due to icing then during descent with a partially or totally blocked sensor on Captain side the total pressure either decreases or stays at the value prior to the obstruction of the sensor (blocked hypothesis)

3.7.2 Therefore the difference (Pt-Ps) can only decrease and the airspeed which is a function of difference between total and static pressures can only decrease and will continue to decrease as long as the icing conditions are present on the probe.

3.7.3 The prompt recorded CAS1 speed drop down to 40 kt is consistent with icing conditions at the level of the head of the Captain (Ptl) (with the drain hole free i.e. without any ice formation) resulting in lower than actual total pressure on Captain side (Ptl), hence lower than actual airspeed (due to Ptl -Psi decrease). The airspeed drop is event more sudden as the Static pressure (Psi) does increase with fast altitude decrease from 22,000 ft to 16,000 ft at a rate of 12,000 ft/mm.

3.7.4 The recovery of the recorded CAS1 after reaching 40 Kt is consistent with the disappearance of these icing conditions on the Captain probe whilst ice is melting on the probe head and airflow becoming less restricted inside the tube; hence the recorded speed is progressively back to actual airspeed.

3.7.5 The actual airspeed build up (from 270 Kt toward 471 Kt) is consistent with an aircraft descending at a high rate of descent (-12,000 ft/mm), in a nose down attitude (from +10 nose up to 8° nose down, then to *15* ° nose down) with full thrust.

3.7.6 The activation of VMO warning indicates that the actual airspeed did

increase from initial value of 270 Kts toward maximum recorded value of 471 Kts through maximum velocity of 340 Kt.

3.7.7 (CAS1) indication was erroneous, at least the (non-recorded) airspeed indication on First Officer side (CAS2) valid at that time because the over speed warning logic uses both sources (CAS1, CAS2) for activation and uses VMO value as a threshold.

3.7.8 In view of the above, it is confirmed that the most probable scenario to explain the recorded CAS1 prompt airspeed decrease to 40 kt followed by a CAS1 speed increase up to 471 Kt is the encounter of severe icing conditions from the probe on Captain side (followed by a de-icing) when the aircraft was really accelerating in a steep descent.

3.7.9 Though the CAS1 indication was erroneous, but at least the (non-recorded) airspeed indication on First Officer side (CAS2) was valid at that time because the over speed warning logic uses both sources (CAS1, CAS2) for activation and uses VMO value as a threshold. Hence the VMO and MMO warnings were recorded on DFDR.

3.7.10 **Conclusion:** During descent with a partially or totally blocked probe on Captain Side the Total pressure (Ptl) either decreases or stays at the value prior to the obstruction of the sensor (blocked hypothesis). Resultantly the airspeed will either show a decrease or remain constant. In this case the air speed after probable ice formation started decreasing; to which the auto throttle reacted and power was advanced, the aircrew could not appreciate the problem and on observing the air speed dropping to 40 Kt advanced the throttle further to maximum. This aggravated the situation and aircraft crossed maximum permissible speed, Mach number and negative Gs.

3.8 Release of the aircraft for ferry and normal flying after the Incident

3.8.1 In the light of the above technical data, let us now analyse another extremely important area i.e. the quality of maintenance by ground crew and defect diagnosis after the occurrence. The Pilot reported the following defect after the incident on 21st November ,2006

"During descend out of 22000 feet in clear air, aircraft went in a dive and crossed VMO. At the time of incident, Autopilot #2 was engaged

which tripped but later on re-engaged successfully and completed rest of the flight."

3.8.2 The **"Investigation Report"** produced by Technical services Quality System PIA Engineering and Maintenance is attached as **Appendix 'M'** As per the report, **at Islamabad**

a. ***AFS test and ADS test were carried out and no BITE observed***
b. ***All inspections as per AMM-05-51-17 were carried out and found satisfactory (See Appendix "M" for details).***

3.8.3 Aircraft was then ferried to main base Karachi during which no abnormality of any system was observed The tech log shows the following rectification at at Karachi.

a. **"AFS and ADS tests and all inspections as per AMM 05-51-17 were again carried out and found satisfactory"**.
b. "Air Data Computers 1&2, FAC 1&2, Angel of Attack Sensors 1, 2 & 3, FCC 1 & 2 and TCC#1 were replaced for shop check as a preventive maintenance".

3.9 Analysis of the inspection for flight in excess of VMO/MMO

3.9.1 Scrutiny of the tech Log write ups and interviews with a number of witnesses indicate that the important structural inspections for crossing maximum velocity, Mach number and G_s were carried out in a very non-professional manner. It simply says "All inspection as per Aircraft Maintenance Manual (AMM) were carried out and found satisfactory". Refer **Appendix 'N'** for details of inspection requirements. The analysis further reveals that at Islamabad:

a) The inspections were completed within an hour.
b) It is technically impossible to perform all the inspections as per AMM 05-51-17 in dark night by one person in one hour.
c) The tech log book does not show any documentation of the inspections and man-power involved.

3.10 These inspections were carried out without any NDI techniques and senior maintenance personnel did not realise the importance of these inspections. It may be noted that DDG while proceeding to Brussels passed a message that aircraft should not be released without analysing the DFDR; it was this message that the aircraft was grounded otherwise PIA could have released

this aircraft after a paper inspection. The message was received by airworthiness surveyor at Islamabad through Acting Director Airworthiness. However, in the absence of any predetermined procedure for grounding and clearing the aircraft for ferry or for normal flying, the next day i.e. on 22nd November 2006 there was total chaos and confusion regarding the status of the aircraft. The evidence recorded during interviews of a number of engineers from CAA and PIA, confirms that it was not clear as to who had grounded the aircraft and who would clear it for ferry. DDG, DAW and acting DFS were not available for any decision. The tech log shows that aircraft was ferried to Karachi, on the permission by President SIB, which is in comprehensible; as neither the President SIB is authorised to ground an aircraft nor he has the necessary certification for releasing an aircraft to service.

3.11 The analysis further reveals that VMO/MMO inspections at Karachi were also directionless and lacked any analysis of the situation. As per Airbus Aircraft Maintenance Manual Chapter 05-51-17 inspections are required following a flight crew report and /or information provided by the Flight Data Acquisition Unit when:

a. A flight in excessive turbulence, which is defined as one where the normal flight manoeuvring limits are exceeded i.e. greater than + 2.5g to – 1g clean or + 2g to – 0g flaps down.

b. A flight in excess of VMO, which is defined with speed above VMO + 20 kts.

c. A flight in excess of MMO, which is defined with MACH number above MMO + 0.02M.

d. A flight in excess of VMO/MMO, which is defined with speed above VMO/MMO and with a load factor greater than 1.2g.

3.12 The AMM also says that "Operators may, at their own discretion or at the direction of their airworthiness authority, use non-destructive test techniques in compliance with the aircraft non-destructive test manual (NTM). Any work upon a system, as a result of the inspection for damage, that entails the disconnection or removal or components, pipes, ducts, cables electrical connectors and mechanical linkages must be followed by a functional test of the system affected". However PIA engineering could not appreciate the gravity of the situation when an aircraft has crossed the VMO by 131 knots, and encountered vertical load factor excursion between -0.33g and +2.59g. It

is concluded that aircraft after crossing VMO/ MMO, was ferried to Karachi without relevant inspections and release to service, hence it was a safety risk. The qualities of inspections at Karachi too, are doubtful as no NDT was used and naked eye inspections did not reveal any ill effects.

Treatment to defects reported by Aircrew

3.12.1 In order to analyze the maintenance system for handling defects of a particular system of a particular aircraft; such as auto pilot defects on AP-BDZ, one year history of defects related to auto pilot #2 and speed/Mach was analysed. It has been summarized and attached as **Appendix 'N-1'.**

3.12.2 The analysis shows that pilots have reported 36 defects related to auto pilot #2 on this aircraft before the occurrence of 21 November 2007. There are again 16 similar defects reported by aircrew till 11 Jan 2007. The rectification after every pilot report is similar. The rectifications are typical of following:

(a) Circuit Breakers recycled and system found normal.
(b) System checked-found satisfactory.

The **Appendix "N-1"** also shows defect relating to the speed and Mach number indications for one year before the occurrence (15 defects) and after the occurrence till 11 January 2007 (Four Defects). The rectifications are again **"Checked found – satisfactory.** The aircrew reports that aircraft went into a dive on 1st January, 2006. Aircrew write up says **"SNAGS STILL PERSISTS"**

3.12.3 Carrying out operational power on checks and releasing aircraft for service without detecting the root cause of repeated pilots reports on same system; is a weakness of a maintenance organization in general and of any Quality Management System in particular. It indicates absence of any central monitoring of the defects. Aircrew is reporting a particular defect again and again; technicians are not able to duplicate that defect on ground and therefore clearing the defect report without any rectification.

3.12.4 It appears that the maintenance managers, in general, and **Quality System** managers in particular did not analyse the situation and hence

a defect prevailed till a series of incidents took place.

3.12.5 After the crucial incident the aircraft was released for normal flying on 25th November, 2006. It flew 26 sectors with passengers on board as an airworthy aircraft till 1st December, 2006. By now Airbus experts had analysed DFDR data, pilot reported defects **(PIREP)** and rectifications carried out by PIA after incidents on 21 October and 21 November; and Airbus grounded the aircraft for structural inspections on 1st December 2006, based on the DFDR data which indicated VMO exceeding by 131 Kts and vertical load excursion between -0.33g and +2.59g, Airbus realised that the inspections carried out by PIA at Islamabad and Karachi were not adequate to detect ill effects on aircraft structures. Hence Special Inspections Package was advised by **Airbus Industries see Appendix 'N-2'**. On completion of these inspections aircraft was released for normal flying on 28 December 2006, after being on ground for 27 days.

3.12.6 However as the basic defect was still not identified, therefore the aircraft again exhibited a similar behaviour on Captain's side speed indicator on 8th and 11th Jan 2007. PIA reported the following event to Airbus.

"On 8th Jan 2007 while cruising at Flight level 34000, Captain side PDF speed tape started decreasing and went down to 75 Kts. The thrust went full forward to compensate for the loss in speed. Auto throttle was disengaged, as it was a false indication keeping in the previous history of this aircraft. Speed tape (Flight Envelope) started fluctuating between 75 Kts and 270 Kts at the same time engine trim fault actuated along with ECAM activation. Speed fluctuation continued for some time, ADC 2 was selected for continuation of flight"

3.12.7 Airbus investigation report for incident on 8th January is attached as **Appendix 'O'. It concludes that:**

(a) **The air speed fluctuation recorded on side 1 is most probably due to pitot probe (ADC1) partially blocked by ice.**

(b) **ADC 1 is not declared faulty and thus still used by ATHR, which reacts to the speed fluctuation.**

(c) **No over speed has been recorded.**

3.13 It recommended following maintenance actions

3.13.1 Pitot probe heating (all pitot probes & AOA sensors)

3.13.1.1 Functional test of the Probe heating system:

3.13.1.2 AMM task 30-31-00 Pb501

3.13.1.3 Pitot probe heating malfunction

3.13.1.4 TSM Task 30-31-00-004-001 SHEET 01/01 Fig 104

3.13.2 Pitot probe maintenance actions.

3.13.2.1 Removal of pitot probes 1 & 2.

3.13.2.2 Despatch of pitot probe number 1 to BF Goodrich for analysis.

3.13.2.3 Inspection check of the pitot lines

3.13.2.4 AMM task 34-11-15 Page Block 601

3.13.2.5 Air data leak test (both pitot and static probes)

3.13.2.6 AMM task 30-10-00 Page block 501

3.13.3 **The incident of 11 January 2007:** PIA reported that during flight speed went to VMO but not exceeded it. The airbus could not confirm any hypothesis as the DFDR did not recorded any significant parameters. However the incident again pointed out the there still exist some defect. The Airbus report is attached as **Appendix "P".** The Aircraft remained on ground for 5 days.

3.14 Investigation into Captain's Side Pitot – Probe

3.14.1 As discussed earlier, the cause of occurrence is partial or complete ice formation on the Captain Side Pitot Sensor. Ice formation as a probable cause was communicated by Airbus in on its initial findings received by PIA on 04 December 2006. The initial report says "As per preliminary analysis, the recorded CAS1 speed drop at the beginning of the event is due to probable pitot probe icing on Captain Side. Therefore Airbus recommends performing AMM 30.31.00 Pb 501 (probe ice protection checks attached as **Appendix 'L-1'**), with particular attention to Pt1 (Captain Pitot) probe ice protection check. No autopilot malfunction and no other system malfunction was highlighted as per preliminary analysis".

3.14.2 However, PIA engineering could not appreciate the limitation of an operational check on ground that, despite of the fact that heater circuit was found complete during continuity check, there might be some ice

formation in the air at higher attitudes due to some problem with lower heating efficiency etc.

3.14.3 It continued carrying out operational checks as per AMM 30-31-00 pb 501 without realising that there could be some problem requiring replacement of Captain's sensor. At the same time a number of LRUs were removed for shop check. However in the absence of any discrete analysis of the situation at any level, the pitot probe was not removed till 11 January when the aircraft again behaved in a similar manner. The incident of 08 and 11 Jan were reported to Airbus, and it also advised PIA to remove and dispatch Captain's side pitot probe to Goodrich for failure analysis. It is not clear as to who actually decided to remove Captain's Side Pitot probe as per Tech Log book entry attached as **Appendix 'O-1'**, it was removed on 11 Jan 2007 as per Deputy Chief Engineer's instructions; where as per an email message from Airbus sent on Friday Jan 12, 2007 at 03:34 p.m., it was advised to replace Pitot Probe 1 and send it to vender for expertise, attached as **Appendix 'O-2'**.

3.14.4 The formation of ice, as a probable cause, was first communicated to PIA on 4th December 2006 in preliminary findings by Airbus. Since then ice formation as a probable cause had been intimated to PIA engineering at different occasions and maintenance actions were focused on the operational and functional checks of air speed indication system. A number of LRUs are sent for the shop checks but the most important component i.e. the sensor is not replaced. The decision to replace Captain Side Pitot Probe should have been an out come of effective defect diagnosis by Quality System rather than on the advice of Airbus after four incidents and a series of maintenance actions.

3.15 Goodrich "Failure Analysis Report"

The Goodrich "Failure Analysis Report is attached as **Appendix 'Q-1'** and **'Q-2'**. The report attributes corrosion and contamination as cause of heater failure. The salient findings of the report are:

a) Historically, this has been a common failure mode of pitot probes.

b) Pitot probe part number 0851 HV, serial number 213667 was manufactured on May 1, 2002, hence had provided good service to PIA since new i.e. 21 month beyond 3 years warranty period.

c) The exterior of the probe's sensing head was in good condition with very little corrosion due to the electro less nickel plating.

d) It was immediately evident upon initial heather tests however, that the heater was damaged.

e) Heater element sheath was severely corroded in the probe's nose (just in side the pitot in let) leading to moisture and contamination getting into heater insulation.

f) Eventually there was dielectric break down which caused melting of heater wire that in turn resulted in dividing the wire into two portions.

g) Both open ends of wire were fused to the case, hence a portion of heater was still working when put on during operational checks or service.

h) The probe was not de-icing properly and yet not annunciating a failure in the cockpit, a unique heater element failure.

i) Goodrich is of the opinion that continuity check is not the method used for failure detection in service.

j) **Conclusion:** The Goodrich report, specifically, does not attribute poor maintenance as cause of corrosion and ultimate failure. However analysis of maintenance procedures and checks during rectification point out that poor maintenance is the cause of corrosion. Goodrich has provided a comprehensive component maintenance manual and Airbus has provided a number of maintenance checks to avoid corrosion and detect any deterioration of its function. Omission such as not covering the pitot probe sensor during washing and not cleaning sensors properly could have led to initiation of corrosion. The corrosion once initiated would continue and cause breakage of heater seal. The seal once broken will continuously admit moisture and contaminants. That is why 80% area of heater sheath was found corroded. However the defect could not be detected during maintenance operational checks and ultimately the heater element was short circulated to the case – making the heater ineffective for positive de-icing under all flight conditions.

4. Findings

4.1 Occurrence

4.1.1 The weather is not a causal factor to the sudden vertical descent of the aircraft.

4.1.2 The ATC tape extract shows that no abnormality was reported by aircrew.

4.1.3 The aircraft was in descent with autopilot engaged and with auto thrust probably also engaged with a speed of 270 Kt.

4.1.4 When descending through 23,000 ft, the recorded speed from ADCI (CASI) dropped rapidly from its current value (270 Kt) and reached 40 Kt within 16 seconds.

4.1.5 In these conditions the auto thrust (using ADCI data) reacts to the speed decrease by ordering a thrust increase (throttle levers move from 43°, **corresponding to thrust resolver angle at idle, to** 68° corresponding to **thrust resolver angle for climb**.

4.1.6 In these conditions, with full thrust order and nose down orders maintained, the actual aircraft speed builds up toward VMO whilst the rate of descent increases significantly up to 12,000 ft/mm.

4.1.7 Over speed warning is triggered when crossing 20,500 ft indicating that the airspeed from Air Data Computer No 2 is valid at this time (over speed warning triggers after crossing VMO=340 kt with either CASI or CAS2). Nose down orders are still recorded and pitch attitude further decrease to -15° nose down. In the meantime, increased vertical load factor excursions are recorded.

4.1.8 At this time, the CAS1 recovers progressively from the probable icing conditions (CAS1 records 100 Kt increasing). The crew maintains a nose down order with over speed warning still active and lasting for one minute. The aircraft is now flying in over speed conditions with actual speed increasing beyond VMO by 131 Kts and at high rate of descent (-12,000 ft/mm).

4.1.9 The Mach number is exceeded by 0.6 and maximum vertical load recorded is +2.5 G.

4.1.10 When reaching 16,000 ft, the CAS1 has recovered from probable icing conditions and now shows 471 Kt.

4.1.11 During the event, the aircraft experienced vertical load factor excursions between - O.33g and +2.59g. Aircrew action of putting the aircraft in dive aggravated the situation.

4.2 Aircrew Actions

4.2.1 The recorded CAS1 keeps decreasing due to probable icing conditions, the crew take over with autopilot disconnection and nose down orders (positive elevators deflection). The pitch attitude decreases from +10° nose up to -8° nose down.

4.2.2 As the recorded speed (CAS1) keeps decreasing (whilst actual speed still builds up), the crew further increased the thrust (with throttles moving to full forward stop) and still order a nose down on control column (positive elevators deflection). The Crew disconnected the auto pilot and put the aircraft in a dive.

4.2.3 Actions taken were in a hurry without monitoring other instruments, where specifically stand by and first officer CAS indicators were showing correct speeds.

4.2.4 Aircrew did not make any announcement to the passengers.

4.2.5 Aircrew did not inform ATC of the incident or about the injuries to passengers.

4.3 Maintenance Failures

4.3.1 The occurrence took place due to poor maintenance of pitot probe which developed corrosion and its heater element got open due to short circuiting.

4.3.2 The treatment to repeated defects reported by aircrew is not monitored by any significant defect trend analysis by Quality Systems.

4.3.3 Tech records of AP-BDZ for last one year show 51 defects on auto pilot system but rectifications were limited to operational checks; hence the actual defect remained unidentified and not rectified.

4.3.4 AP-BDZ's history shows that 19 times pilots have reported defects

related to speed/Mach number indications but the rectifications were confined to routine operational checks and replacement of LRUs without any analysis.

4.3.5 There is no standard written laid down procedure either at CAA or at PIA to ground an aircraft after a serious occurrence; and if grounded, for releasing it to normal operations.

4.3.6 Had DDG CAA not asked to analyse DFDR before releasing it to flight; the aircraft would had been flying without VMO/MMO inspections. There is no analyst at PIA to interpret the DFDR data.

4.3.7 The aircraft flew from Islamabad to Karachi as ferry flight, but was not airworthy.

4.3.8 The inspections for VMO/MMO and vertical load incursions were carried out at Islamabad within one hour and not documented properly. The same were repeated at Karachi in few days. All inspections were carried out visually and no parts were cleaned for an inspection using Non Destructive Techniques.

4.3.9 The quality of inspections for flight in excess of VMO/MMO is still doubtful i.e. there might be some ill effects on structures but could not be detected through general visual inspections. No Non Destructive Techniques for inspections were employed.

4.3.10 Probe S. No. 0851 HV,S/N 213667 was despatched Goodrich without the information / permission of SIB, CAA. The vendor carried out a destructive analysis and thus evidence on which findings are based has been lost.

5. Observations

5.1 The Mandatory Occurrence Reporting system as per SMS Manual of PIA is not working effectively. The occurrence was not promptly reported by aircrew. Airport management came to know through passengers that an incident had taken place resulting injuries to passengers.

5.2 PIA Engineering and Maintenance and the Quality System, both did not realize that as to what extent the aircraft structure had been affected by crossing the vertical speed limits. The aircraft was released for service after routine inspections for crossing vertical speed by 20 knots. The detailed structural inspections were carried out on advice of Airbus. The same decision should have been taken by PIA.

5.3 The Captain's pitot sensor was dispatched to Goodrich for investigation without SIB permission and information, the Goodrich carried out destructive testing which resulted into loss of evidence.

5.4 The original technical log books containing inspections for flight in excess of VMO/MMO at Karachi are missing. It reflects lack of standard procedures to safeguard basic /original documents. It is considered a grave system failure.

5.5 PIA was requested to estimate and intimate the "cost of occurrence", but it could not. PIA must have a system to calculate cost of each occurrence.

6. Recommendations

6.1 Importance of Situational Awareness be re-emphasized during training and CRM refresher courses.

6.2 Emphasis be made to encourage the crew to make an announcement for the comfort of passengers.

6.3 ATC must be informed of all events.

6.4 PIA Flight Safety and Operations to carry out a study to identify aircrew members who are likely to perform poorly during emergency handling; and take specific measures to ensure their operational fitness .

6.5 PIAC to initiate a study for integration of Quality System and Corporate Safety under one executive who reports directly to Chief Executive to avoid such failures. (Refer Recommendation 4.1, investigation report into Airbus A-310, AP-BGP serious incident on 31.03.2005)

6.6 Director Engineering in coordination with Airworthiness Directorate (PCAA) to define the term "Repeat Defect" in such a manner that if an aircraft system is showing defects repeatedly; it is given an alert level status and remedial actions are taken by Quality System. The new definition be inserted in the maintenance exposition manual.

6.7 Director Airworthiness (PCAA) is to ensure that Airworthiness Inspectors/Surveyors have a standard procedure to point out to PIAC Engineering regarding failure of Quality Systems to monitor such chronic defects.

6.8 FS & HSE to issue SOP that When ever an aircraft, aircraft parts, CVR, DFDR or any component are subject of investigation by SIB, its dispatch to vendor/manufacturer be executed only through SIB (CAA).

6.9 SOP for the safe handing taking over of technical documents and their retention at Cardex be issued and implemented by Quality Systems.

Finalization

Primary: Ice formation on the Captain's Probe

(i) Maintenance Failure

Absence of Systematic Defect Trend Analysis

(ii) Human Factor – Air Crew

Break in Situational Awareness and poor emergency handling