FINAL INVESTIGATION REPORT

SERIOUS INCIDENT OF VISION AIR VIS-1104 (LHE – KHI) BOEING 737-200 AIRCRAFT REG NO AP-BKE NO 1 ENGINE FAILURE DURING INITIAL CLIMB ON 9 MAY 2016 AT AIIAP, LAHORE

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THE AAIB PAKISTAN ICAO ANNEX 13 AIRCRAFT ACCIDENT INVESTIGATION BOARD TEAM

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Synopsis

On 09 May 2016 at about 0407 hrs Pakistan Standard Time, a Boeing 737-200, Registration No AP-BKE operated by Vision Air, experienced No 1 (left) engine failure during initial climb (4000') from Allama Iqbal International Airport (OPLA) - Lahore, Pakistan. The flight crew heard a loud "thud" followed by No 1 engine failure, smoke in the cockpit and engine flame out. The crew declared an emergency and diverted back to Lahore where a safe landing was made. It was a scheduled cargo flight from Lahore to Jinnah International Airport (OPKC) - Karachi, Pakistan. The serious incident was reported to Aircraft Accident Investigation Board (then SIB), Pakistan by the operator through a Mandatory Occurrence Report. This incident was notified in accordance with ICAO Annex-13. Aviation Division, Government of Pakistan issued memorandum vide letter No HQCAA/1901/378/SIB/313 dated 18 May, 2016 for inquiring into circumstances under which the occurrence took place and to recommend suitable measures to prevent a recurrence.

1. FACTUAL INFORMATION

1.1 **History of the Flight**. It was a scheduled cargo flight from Lahore to Karachi with 04 crew aboard. Just after takeoff from runway 18L at 0407 hrs local time while passing through 4000' IND, pilot of the aircraft requested an emergency landing runway 36R due failure of Engine No 1 (smoke was observed in the cockpit). Aircraft was vectored for ILS runway 36R and made a safe landing.

1.2 **Injuries to Persons.** NIL.

1.3 **Damage to Aircraft**. NIL.

1.4 **Other Damages**. NIL.

1.5 **Personnel information.** N/A

1.6 **Aircraft Information**.

Aircraft Details	
Aircraft Make & Model	B737-229C
Registration Marking	AP-BKE
Manufacturer Serial No.	20915
Year of Manufacturer	1975
C of A validity	Till 21-04-2017
Type of C of A	Charter Operation & Aerial Work

Certification of Registration issue date	22nd March, 2013
Last Maint review performed on	28-03-2016
Daily Inspection on	06-05-2016
Total Aircraft hours / cycles / landings	58,789:36 hrs / 52,853 / 52,853
Check-C	TSN:56,490 hrs by Southern Cross Aviation on 27-09-2010
Check-A	TSN: 58,643 hrs on 22-02-2016
No 1 Engine Details	
Make / Model / S No	P&W / JT8D-15A / 709245
Time Since New (TSN)	TSN:49,210 hrs CSN:31,707
Next Overhaul due hrs / cycles / Date	Engine is on condition
Time hrs / cycles, date of last shop visit	TSN: 48,192 hrs CSN:30,996, 12 Dec, 2013
Reason of last shop visit, shop location and identification info	LLP replacement by Atlantic Gas Turbine Florida.

1.6.1 The last engine shop visit was in December 2013 at Atlantic Gas Turbine Center (AGTC) in Florida, USA. During the repair a hot section inspection was performed, life limited parts were replaced and applicable airworthiness directives (ADs) were completed.

1.6.2 The Pratt & Whitney JT8D-15A is an axial flow, dual spool, low bypass ratio turbofan engine that features a six stage low pressure compressor (LPC), a seven stage high pressure compressor (HPC), a nine can-annular combustor, a single stage high pressure turbine (HPT) and a three stage low pressure turbine (LPT). The engine has a hydro mechanical fuel control.

1.6.3 According to the Federal Aviation Administration (FAA) type certificate data sheet E2EA Revision 31, dated August 28, 2007, the JT8D-15A has a maximum takeoff (5 minutes) static sea level thrust rating of 15,500 lbs and a maximum continuous static sea level thrust rating of 13,750 lbs.

1.6.4 All directional references to front and rear, right and left, top and bottom, and clockwise and counterclockwise are made aft-looking-forward (ALF). A cross section of the engine and flange identification diagram are shown below in Figures 1 and 2.

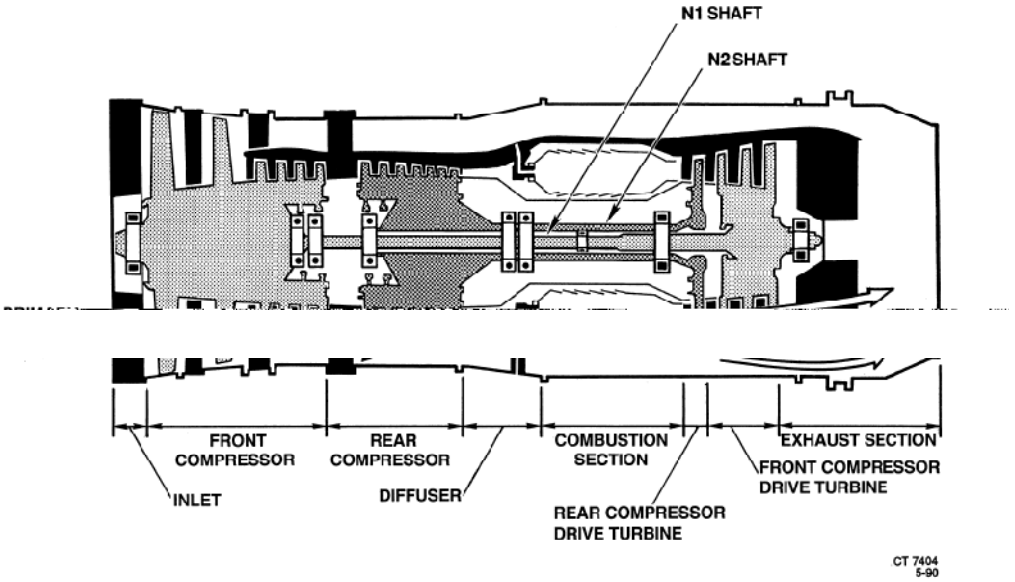


Figure 1 : JT8D Cross Section

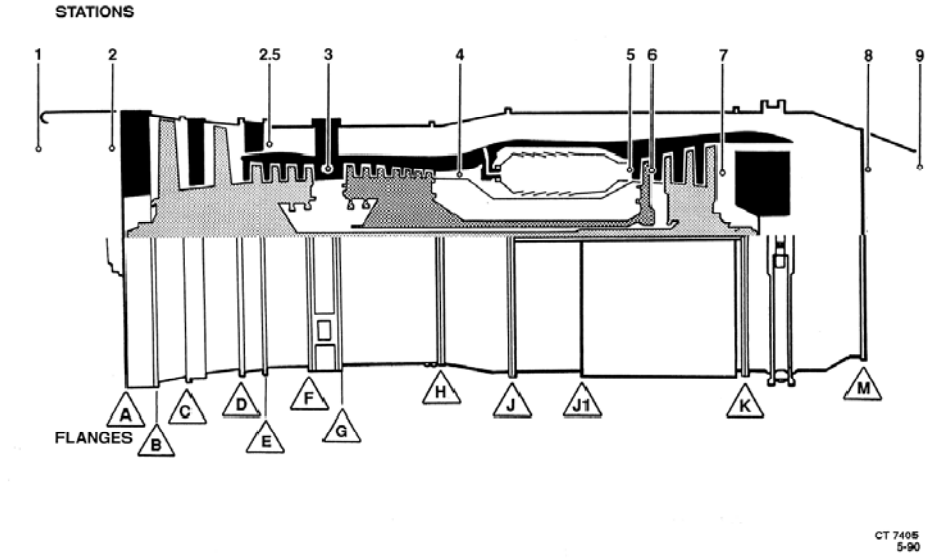


Figure 2 : JT8D-15A Flange Identification Diagram

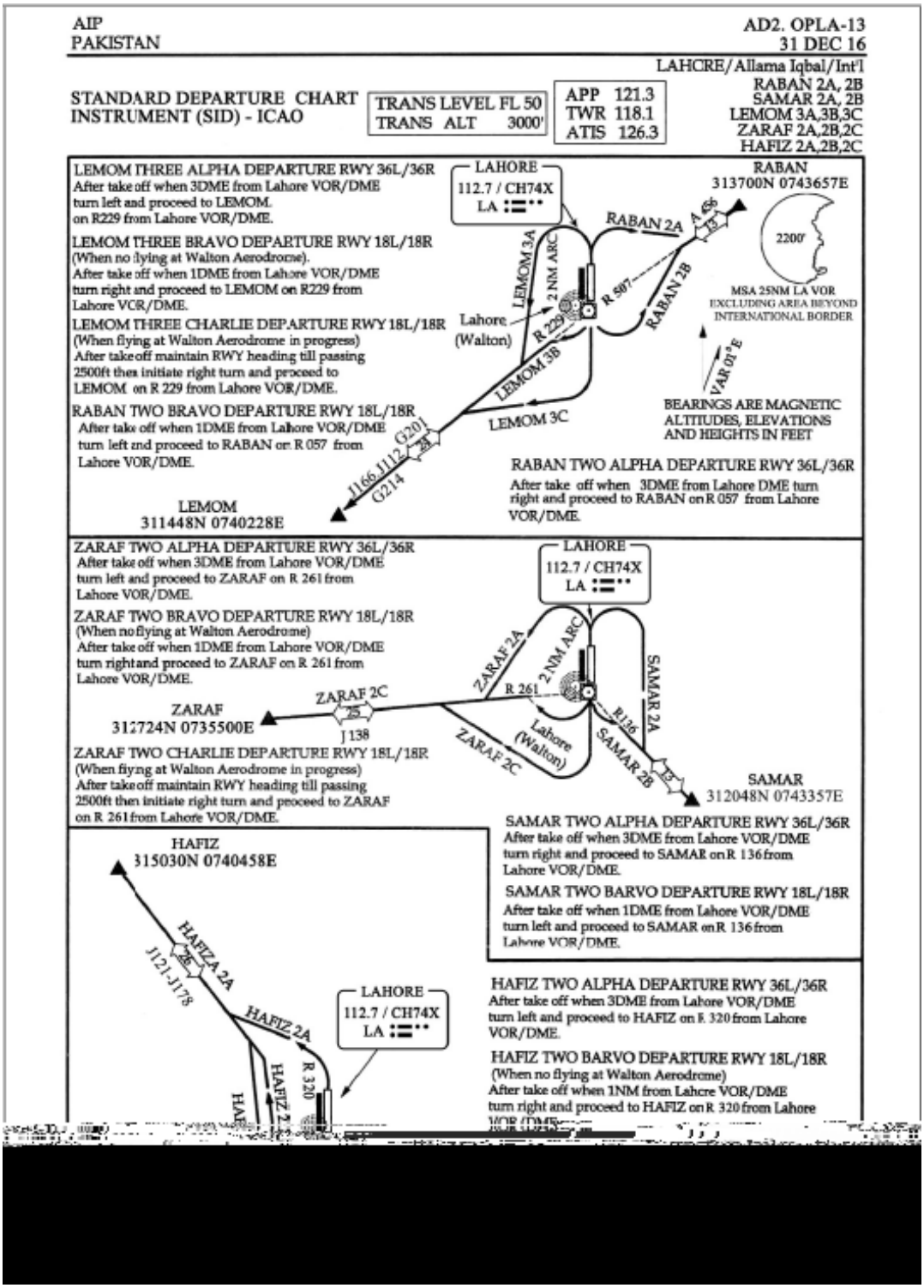
1.6.5 The aircraft was being maintained in accordance with the approved maintenance schedule and there was no previous reported defect which could contribute towards the occurrence. No inspection or life component of the aircraft and power plant was overdue. The documented defects were scrutinized and there was no reported defect of similar nature in last six months. A record on compliance of applicable Airworthiness Directives (ADs) since 1972 was reviewed which indicated compliance as required.

1.7 **Meteorological Information. Not applicable**

1.8 **Aids to Navigation**. Boeing 737-200 AP-BKE aircraft was equipped with serviceable ADF, VOR/DME, ILS and GPS equipment for the conduct of flight operations. All the ground equipment installed at AIIAP, Lahore related to ADF, VOR / DME and ILS were found serviceable at the time of occurrence.

1.9 **Communications.** Boeing 737-200 AP-BKE aircraft was equipped with UHF and VHF sets for radio contact with all concerned / relevant agencies during the conduct of flight.

1.10 **Aerodrome Information**. The AIIAP, Lahore detailed aerodrome data is appended below :



STANDARD DEPARTURE
INSTRUMENT CHART (SID)

TRANSITION LEVEL	FL 50
TRANSITION ALT	3000'

TWR	118.1
APP	121.3
ATIS	126.3

LAHORE/
Allama Iqbal Int'l
LARDO 1A, 1B
SARPO 1A 1B

BEARINGS ARE MAGNETIC

[redacted]

OPLA 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
18L	180°	3360 x 46	PCN 85/R/B/X/U (concrete)	313211.94N 0742417.44E	THR 216.9M / 712 FT
36R	360°			313023.30N 0742415.49E	THR 215.1M / 706 FT
18R	180°	2743 x 46	PCN 55/F/C/X/T	313202.14N 0742410.18E	THR 216.5M / 710 FT
36L	360°			313033.13N	THR 214.8M / 705 FT

[redacted]

OPLA AD 2.18 ATS COMMUNICATION FACILITIES

Service designation	*Call sign*	*Frequency*	*Hours of operation*	*Remarks*
1	2	3	4	5
TWR	Lahore Tower	118.1 MHz	H24	Primary

[redacted]

1.11 **Flight Recorders**. Data from Flight Data Recorder (FDR, Part No 980-4700-003, S No 12373) was retrieved at NTSB and used for the purpose of investigation. The FDR report by NTSB confirmed that the failure of No 1 engine occurred at radio altitude of 525 feet. The FDR data showed multiple occurrences of missing and invalid parameters. Given the limited parameter set of this old variant of the engine, it was not possible to determine the cause factors of the engine failure based on the FDR data.

1.12 **Wreckage and Impact Information**. N/A

1.13 **Medical and Pathological Information**. N/A

1.14 **Fire**. Not applicable

1.15 **Survival Aspects**. N/A

1.16 **Test and Research**. The failed No 1 engine was shipped to an OEM certified facility M/s Atlantic Gas Turbine Center, Miami, USA. A tear down examination was conducted on 11 September, 2018 under the supervision of appointed accrep of NTSB. Following reports were shared based on this activity :

1.16.1 Field Notes on the tear down examination activity

1.16.2 Metallurgical Final Analysis Report

1.16.3 Power Point Presentation of World conference held in May 2008 on HPT blades failures / it's preventive measures on JT-8D engines

1.17 **Organisational and Management Information**. M/s Vision Air is a Pakistan registered organisation established to provide chartered aerial services vide Charter Licence No 003/2007 Class-II (Domestic & International). After this serious incident, M/s Vision Air defaulted on various laid down investigation steps given in CAA Rules-1994 and ICAO Annex-13. Consequently, the investigation process got inordinately delayed. Following deviations were noted on part of management at M/s Vision Air:

1.17.1 Maintenance personnel at OPLA performed a visual inspection of the engine and reported bird feathers in the intake and low pressure compressor. However investigations at later stages in Pakistan by AAIB and in USA by NTSB confirmed that there was no evidence of any bird strike / ingestion into the engine.

1.17.2 M/s Vision Air tried to dismantle / strip the engine at its own while neither having any instructions from AAIB nor the capability (Tools, publications, trained manpower and required infrastructure) to do so.

1.17.3 M/s Vision Air maintained a stance for a considerable period of time that there was no need to send this engine to any OEM certified facility contrary to the instructions by AAIB.

1.17.4 After a series of interactions, although M/s Vision Air agreed to the essential requirement mentioned at para 1.17.3 above, still resisted to spot an MRO facility and continued making un-usual delays in the shipment process. Ultimately, in order to intervene, her Air Operation Certificate (AOC) renewal process was halted by the Federal Govt to get the desired response.

1.18 **Additional Information.**

1.19 **ATC Tape Extracts.** Following ATC Tape Extracts were obtained.

1.19.1 Tape extracts of approach frequency 121.3 MHz

1.19.2 Tape extracts of aerodrome frequency 118.1 MHz

1.19.3 Tape extracts of ground movement control frequency 118.4 MHz

1.19.4 Tape extracts of aerodrome – approach coordination

1.19.5 Radar video transcript

1.20 **Crew Resource Management (CRM). N/A**.

1.21 **Use of Effective Investigation Techniques**. Standard investigation tec were utilized to carry out the investigation.

2. ANALYSIS

2.1 Post occurrence inspection of the inlet stage of engine compressor was th examined, however found no damage or any blood spots due bird strike a below :

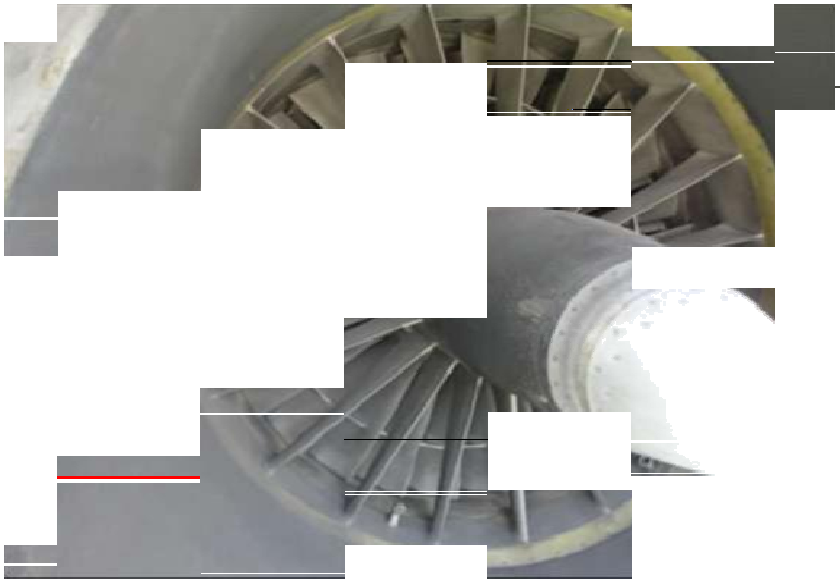


Figure 3 : *First Stage / Inlet of No 1 Engine found clear*

2.2 The blades of last stage of engine low pressure turbine were found dam shown below :

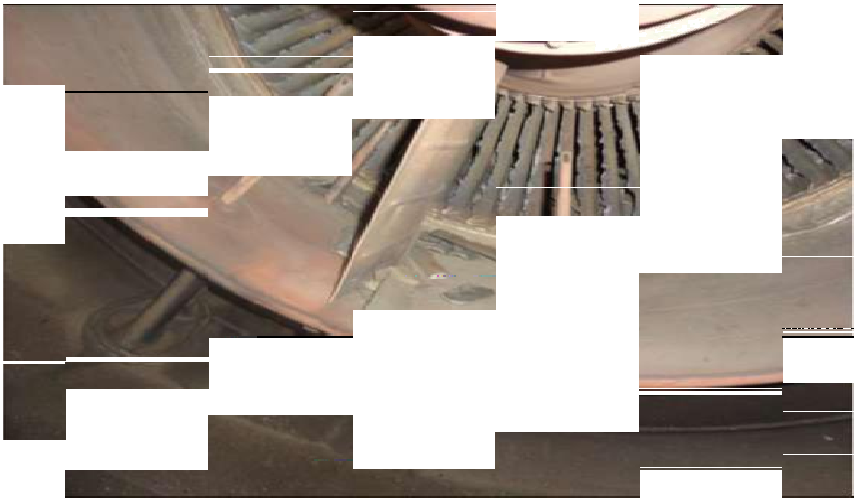


Figure 4 : *Visual inspection of the last Stage of No 1 Engine indicates damaged LPT blades and NGVs*

cutting the case. Visual observations of damage were made as viewed aft through the second stage LPT stator vanes (S2) and forward through the fourth stage stator vanes (S4). The S2 vanes were all present and complete. Three consecutive S2 vanes at the 9 o'clock position (6 o'clock position as received) had leading edge damage near the outer diameter platform and the remaining S2 vanes had minor leading edge airfoil damage (Photo 6). All S2 vane had severe trailing edge impact damage and material loss along the vane span.

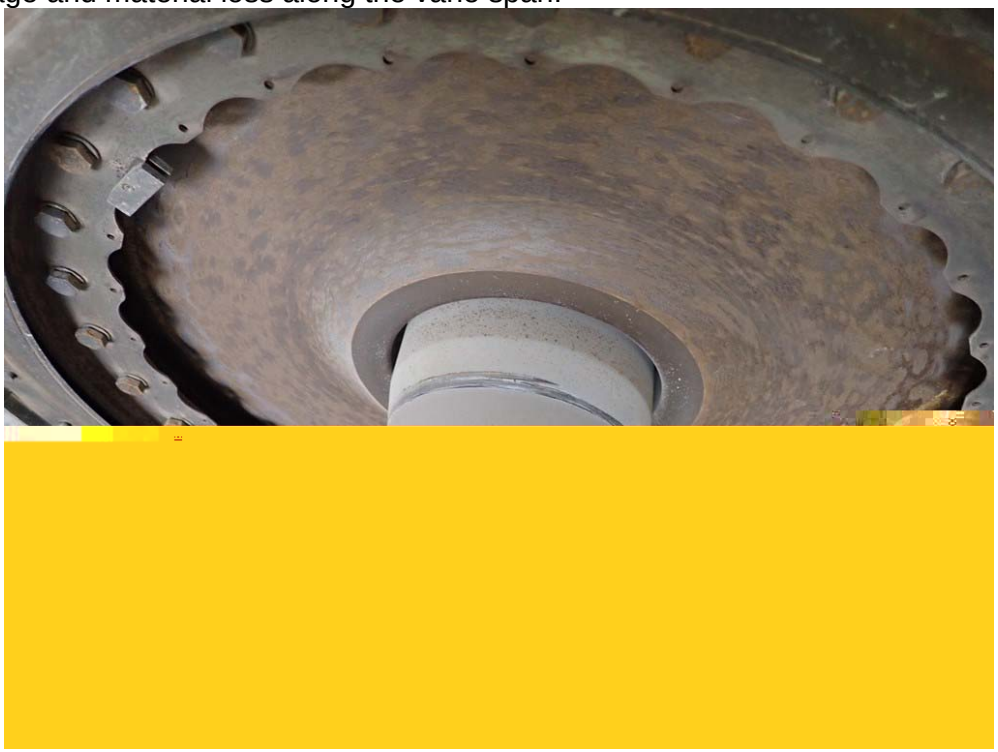


Photo 5- N1 Shaft Rub

Photo 6- (L) S2 LPT Vanes, Leading Edge (R) S2 Vane Damage, 9 o'clock

2.11 The second stage LPT rotor blades (T2) were all separated at random airfoil span wise locations between the blade platform and the mid-span. The third stage LPT stator vanes (S3) were all fractured and separated, the inner and outer diameter vane platforms remained in place. The third stage LPT rotor blades (T3) were all separated near the blade platform. The fourth stage LPT stator (S4) vanes were present and complete but had severe impact damage on both the leading and trailing edges along the entire vane span. The fourth stage LPT rotor blades (T4) were all separated near the blade platform (Photo 7). Loose metal fragments were resting at the 6 o'clock position between the LPT stages.

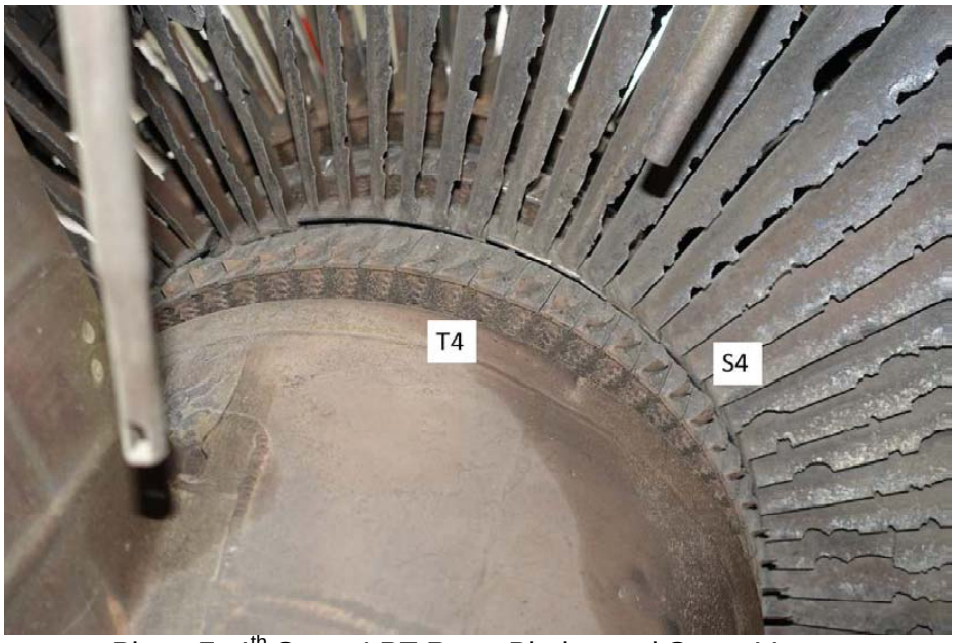


Photo 7- 4th Stage LPT Rotor Blades and Stator Vanes

2.12 The LPT case had evidence of internal impact damage resulting in minor deformations directed radially outboard from the engine axis, in line with the T2 and T3 planes of rotation that could be felt tactilely on the case exterior surface. The exhaust case had larger, visible impact deformations radially outboard from the engine axis in line with the T4 plane of rotation (Photo 8). The exhaust case struts exhibited impact damage on the leading edge. All exhaust gas temperature (EGT) probes were intact with minor impact damage.

Photo 8- Exhaust Case Impact Deformation

2.13 The turbine rear bearing cover was missing multiple bolts. The bolts that were present were not torqued and two of the bolts were the wrong length. When the cover was removed, the No. 6 bearing cover, No. 6 outer race, the No. 6 bearing retainer, and No. 1 bearing retainer were loose inside the No. 6 bearing

compartment. The No. 6 bearing scavenge pump was missing. During the above strip examination process, 11 HPT blades were isolated to be suspected cause of the engine failure. Accordingly, these 11 HPT blades were examined at the Material Processes Engineering (MPE) facility of the OEM Pratt & Whitney, USA where detailed material testing of these HPT blades was accomplished followed by generating a forensic report. Top image shows the pressure side of the eleven 1st stage HPT blades, while the bottom image shows the suction side. The blue box indicates the blade found to have fatigue on its fracture surface.

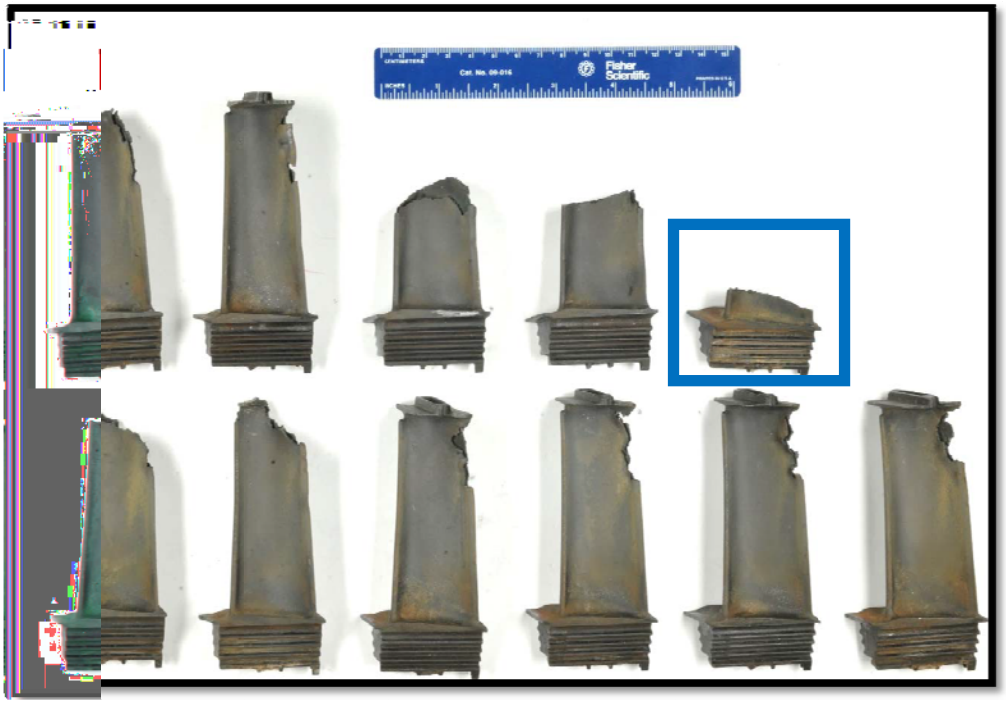


Photo 9- HPT Blades (Inner side view)

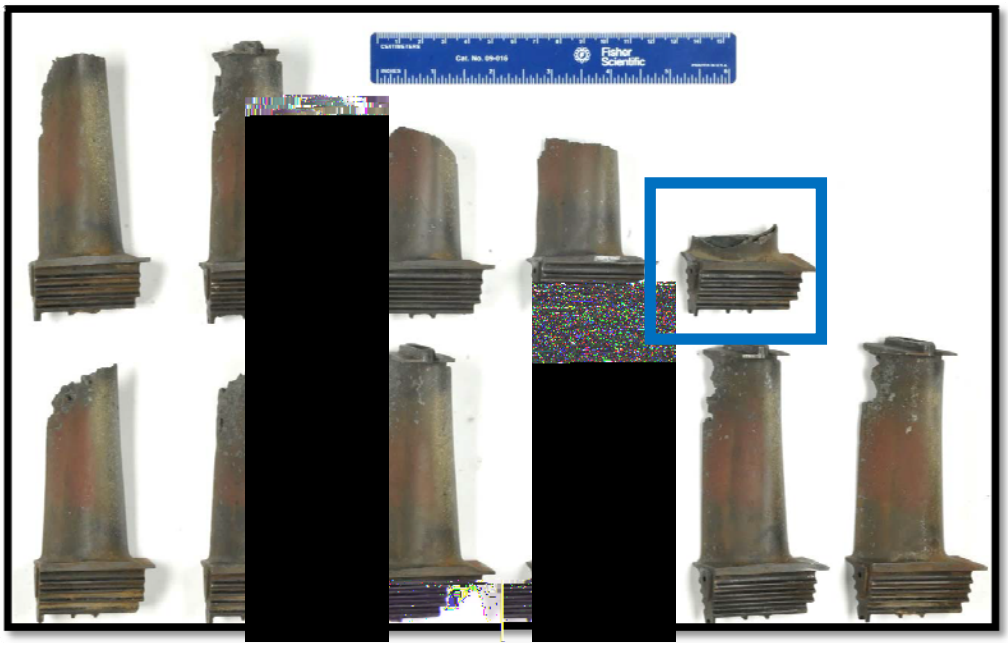


Photo 10- HPT Blades (Outer side view)

2.14 Eight (8) of the blades had sustained impact damage near the blade tip and outboard half of the trailing edge. Two (2) HPT blades were found to have fractured at ~65% span via overstress. The remaining blade had fractured at ~10% span, and exhibited a fatigue progression immediately adjacent coarse textured region near the trailing edge. The fatigue origin was located on the suction side of the blade, ~0.040" from the trailing edge. The fatigue progression was too severely oxidized to determine if it was high cycle fatigue or low cycle fatigue. Metallurgical examination of the coarse textured region revealed multiple oxide filled cracks that were connected to the fracture surface. Metallurgical examination of the origin area revealed **trans-granular features** consistent with fatigue. The microstructure and chemical composition of the blade were consistent with properly processed Mar-M-247 nickel alloy. The blade coatings were found to be acceptable, and no alloy depletion, sulfidation, inclusions or other material anomalies were observed.

2.15 Based on the abovementioned two activities i.e. strip examination and material testing on the eight HPT blades revealed that the entire sequence of events started with a fatigue on one of the HPT blades and rest all damages were consequence of the same. Due to severe oxidation on the HPT blade surface, the OEM couldn't determine if it was high cycle fatigue or low cycle fatigue.

2.16 Based on the industry data it was revealed that failure of engine blades was a known weak area since 1990. The OEM has recommended followings:

2.16.1 Excessive blade metal temperature results in stress-rupture over time.

2.16.2 Internal wall inter-granular corrosion attack results in blade cracking and fractures.

2.16.3 Inter-granular Attack (IGA) and radial cracking is usually found on blades that have been repaired.

2.16.4 For the best results, new blades be installed instead of refurbished.

2.16.5 If refurbished blades are used, limit such use to blades that have been refurbished not more than two times at an approved facility by P&W.

2.16.6 All blades that are stripped of the coating should receive ultrasonic wall thickness inspection.

2.17 The incident blade from this engine event exhibited fatigue progression originating from the suction side of the airfoil trailing edge. This is only the second documented HPT blade fracture due to fatigue origination from the airfoil trailing edge and does not conform to any of the three most common causes of HPT blade fractures and cracking which are :

2.17.1 Stress rupture

2.17.2 Internal wall intergranular attack (IGA); and

2.17.3 Thin wall condition

2.18 This particular engine Model No JT8D-15, S No P709245 had gone through an overhauling cycle at an OEM certified facility (M/s Atlantic Gas Turbine Center) in October-December, 2013. During this maintenance, these HPT blades were inspected and declared serviceable / certified by FAA as well, however, after operating for only 1013 hrs, one of the HPT blade failed prematurely. The OEM thus requires further research and improvement to address such particular failures.

3. CONCLUSIONS

3.1 **Findings**

3.2 Post occurrence inspection of the inlet stage of engine compressor was thoroughly examined, however found no damage or any blood spots due bird strike contrary to the documented discrepancy by the operator.

3.3 The blades of last stage of engine low pressure turbine were found damaged.

3.4 M/s Vision Air tried to dismantle the engine neither having any instructions from AAIB nor in possession of required tools, publications, jigs / fixtures, trained manpower and the infra-structure. The operator couldn't make any access to the failed hot section of the engine.

3.5 The engine was dispatched to an OEM certified MRO facility, Atlantic Gas Turbine Center, Miami, USA where it was strip examined in the presence of NTSB's appointed accredited representative.

3.6 During tear down examination process, no indication of bird hit was observed.

3.7 11 blades of 1st stage HPT were found fractured and were suspected to be the cause of this engine failure.

3.8 Material testing of 11 fractured blades confirmed that out of these 11, one blade had failed due to fatigue however rest was a collateral damage.

3.9 The industry data revealed that failure of engine HPT blades was a known weak area since 1990 on this model of the engine. However, this particular failure is second documented HPT blade fracture due to fatigue originating from the airfoil trailing edge.

3.10 The OEM had issued various proactive measures since then which had significantly controlled this blades failure trend.

3.11 This particular engine had gone through a major maintenance at an MRO (an OEM certified overhauling facility in USA) by December, 2013. Considering that all the OEM advised preventive measures were in place, the engine failed prematurely after operating for 1013 hrs only since its last visit to the MRO.

3.12 This premature failure of the blades indicates that the OEM (M/s P&W) needs to re-visit her already in place preventive measures to avoid such recurrences.

3.13 **Cause of Occurrence.** The engine in-flight shut down took place due to premature failure of one of the 1st stage HPT blade fracture due to fatigue originating from the airfoil trailing edge.

4. SAFETY RECOMMENDATIONS

4.1 The OEM, M/s P&W, USA is requested to re-visit her already in place preventive measures and incorporate additional step(s) to avoid such failures to further improve the reliability of JT8D engines.

4.2 It took more than two years that the operator was able to ship the failed engine to the intended MRO facility in USA. All the presented reasons by the operator were found to be avoidable. In order to avoid such un-precedent delays, CAA Pakistan is requested to issue following specific instructions to M/s Vision Air :

4.2.1 Institute measures to avoid documenting incorrect discrepancies in the aircraft documents.

4.2.2 The aircraft parts / engine involved in an accident or serious incident are adequately preserved and must not be tempered.

4.2.3 The instructions issued by AAIB regarding handling of the aircraft components / engine must be adhered in letter and spirit.