

FINAL REPORT ON INCIDENT TO M/S INDIGO AIRLINES AIRBUS A320
AIRCRAFT VT-ITF AT Mumbai ON 21/01/2017

1. Aircraft Type : Airbus A 320
- Nationality : INDIAN
- Registration : VT - ITF
2. Owner : HKAC Leasing 6860 Limited, Ireland
3. Operator : IndiGo Airlines
4. Commander – in –Command : ATPL holder on type
- Extent of injuries : Nil
5. First Officer : ATPL Holder qualified on type
- Extent of injuries : Nil
6. Place of Incident : Mumbai (VABB / BOM)
7. Date & Time of Incident : 21st January 2017 15:52 UTC
8. Last point of Departure : Mumbai (VABB/ BOM)
9. Point of intended landing : Delhi (VIDP/ DEL)
10. Type of operation : Schedule Operation
11. Crew on Board : 02 + 04
- Extent of injuries : Nil
12. Passengers on Board : 165
- Extent of injuries : Nil
13. Phase of operation : Take Off Run
14. Type of incident : #1 Engine stall during take-off run

(ALL TIMINGS IN THE REPORT ARE IN UTC)

SUMMARY

M/s IndiGo Airlines A320 NEO aircraft VT-ITF (MSN 6860) operating the scheduled flight 6E-248 (Mumbai to Delhi) was involved in an incident at Mumbai (VABB/BOM) on 21st January 2017. There were 165 passengers including six crew members on board the aircraft.

The aircraft VT – ITF had earlier operated scheduled flight (Kolkata – Mumbai). The flight from Kolkata was uneventful and landed safely at Mumbai. No ECAM message was triggered during the flight.

After the transit inspection the aircraft was cleared for flight. No Engine related snag was reported from the flight crew after the flight. There were no MELs on the aircraft prior to flight.

After lining up for take-off at 15:53:50 UTC on runway 27, N1 of both the engines were increased to 50% and later to 80%. During take-off run suddenly N1 of Eng1 was reduced to 37% from 80% within 3 seconds. Engine stall warning triggered and low speed rejected take-off was carried out at 73 knots approx.

The aircraft taxied back to bay safely. Passengers were deplaned normally. The incident was reported by M/s IndiGo to DGCA immediately. DGCA ordered an Inquiry under rule 13 (b) of Aircraft (Investigation of Accidents and Incidents), Rules 2012 to investigate into the cause of the incident.

1. FACTUAL INFORMATION

1.1 History of the flight

M/s IndiGo Airlines Airbus A320 NEO aircraft VT-ITF (MSN 6860) operating scheduled flight 6E-248(Mumbai – Delhi) was involved in an incident at Mumbai on 21st January 2017 due to Engine stall. The flight was under the command of PIC holder of ATPL license with co-pilot both duly qualified on type. There were 165 persons including six crew members on board the aircraft.

The Flight crew had availed sufficient rest prior to commencement of flight for the sector Mumbai to Delhi. The crew had undertaken the pre-flight medical test prior to flight and same was negative.

As per engineering records there was no snag/leakage reported on the aircraft power system on any of the previous sectors. Also, no related MEL was there. After the arrival from Kolkata, the AME at Mumbai had carried out the transit inspection and released the aircraft for flight (Mumbai-Delhi).

The weather at the time of departure from Mumbai was fine and reported visibility as 2200 metres. The aircraft taxied normally and lined up for runway 27 at time 15:53 UTC. As per DFDR during take-off roll throttle lever was moved to flex gate and N1 of both engines increased to 80 %. After 3 seconds N1 of ENG1 was reduced 37% from 80% and engine stall warning triggered. Subsequently, low speed rejected take off was done by the crew at 73 Knots followed by ECAM actions.

After arrival at bay, the passengers were deplaned normally. No injury was sustained by any person on board during deplaning. There was no fire.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	Nil	Nil	Nil
Serious	Nil	Nil	Nil
Minor/None	6	165	---

1.3 Damage to Aircraft:

There was no external damage, however the #1 engine sustained substantial internal damage with liberation of engine fan blade parts.

1.4 Other damage: NIL

1.5 Personnel information

1.5.1 Pilot – in – Command

AGE : 36 Years 4 Months

License : ATPL Holder

Category : ATPL

Endorsements as PIC : Airbus 320

Date of Med. Exam. : 20th September 2016

Med. Exam valid upto : 19th March 2017

FRTQ License : Valid

Total flying experience : 4648:21 hours

Experience on type : 4000 hours

Experience as PIC on type : 727:55 hours

Total flying experience during last 180 days : 352:35 hours

Total flying experience during last 90 days : 168:34 hours

Total flying experience during last 30 days : 55:12 hours

Total flying experience during last 07 Days : 16:09 hours

Total flying experience during last 24 Hours : 7:51

1.5.2 Co-Pilot

AGE : 25 Years

License : CPL Holder

Category : CPL

Endorsements as PIC : DA 40 / DA42

Other Endorsement : A320 as co-pilot

Date of Med. Exam : 24th January 2017

Med. Exam valid upto : 23rd January 2018

FRTD License : Valid

Total flying experience : 1607:30 hours

Experience on type : 1407: 25 hours

Experience as PIC on type : Nil

Total flying experience during last 180 days : 438:51 hours

Total flying experience during last 90 days : 190:18 hours

Total flying experience during last 30 days : 64:26 hours

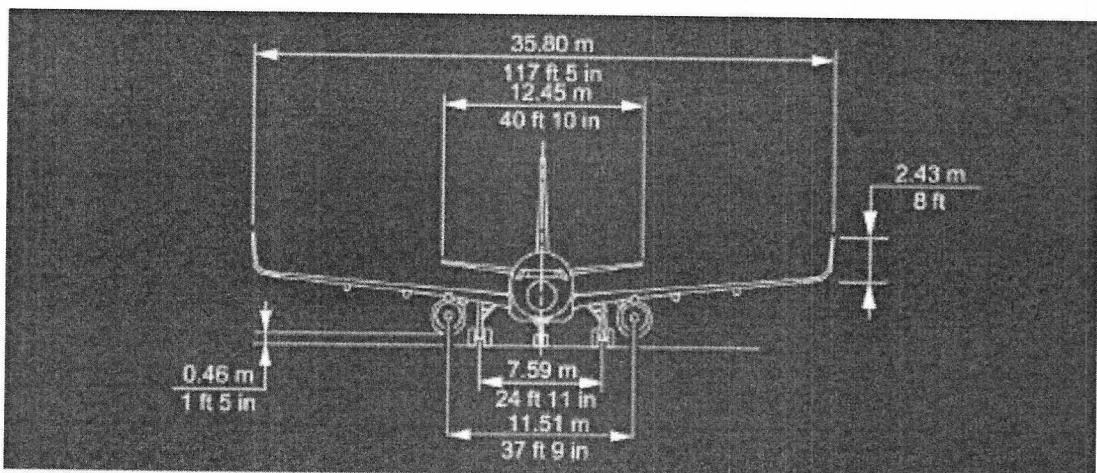
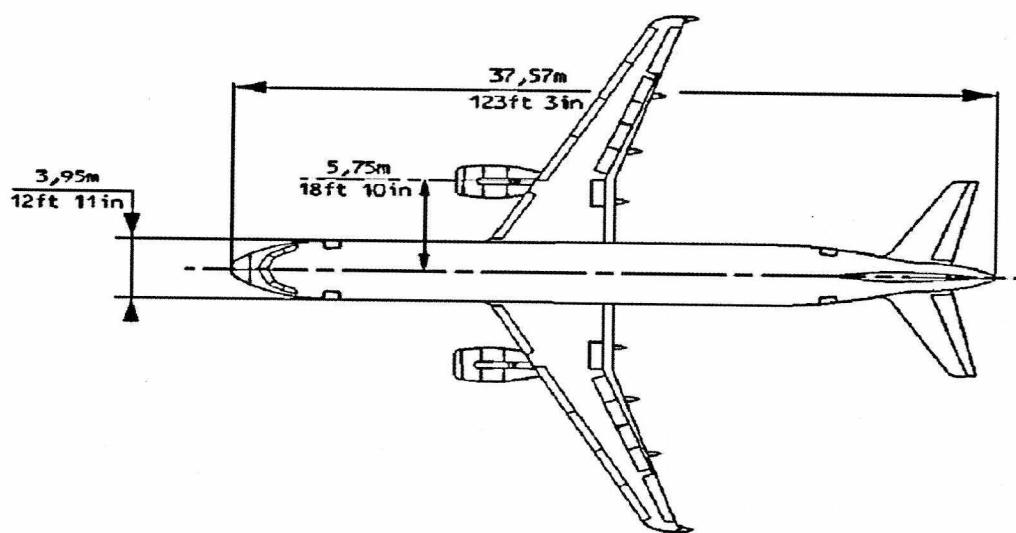
Total flying experience during last 07 Days : 13:34 hours

Total flying experience during last 24 Hours : 3:52 hours

Both the operating crew were not involved in any serious incident/ accident in past. Both the operating crew were current in all training and had adequate rest prior to roster for the incident flight.

1.6 Aircraft Information:

The A320 is a subsonic, medium-range, civil transport aircraft. The aircraft has two high bypass turbofan engines manufactured by M/S Pratt and Whitney's Pure Power PW -1100G – JM. The aircraft is designed for operation with two pilots and has passenger seating capacity of 180.



The aircraft is certified in Normal (Passenger) category, for day and night operation under VFR & IFR. The maximum operating altitude is 39,000 feet and maximum take-off weight (brake release) is 73500 Kg. The Maximum Landing weight

is 67400 Kg. The Aircraft length is 37.57 meters, wingspan is 35.80 meters and height of this aircraft is 11.75 meters. The distance between main wheel centres is 7.59 meters. The distance between engines is 11.51 meters and Engine Ground Clearance is 0.46 meters.

Airbus A320 aircraft VT-ITF (MSN 6860) had been manufactured in April 2016. The aircraft was registered with DGCA under the ownership of HKAC Leasing 6860, IRELAND Limited. The aircraft is registered under Category 'A' and the Certificate of registration No. 4664 issued on 3rd May 2016.

The Certificate of Airworthiness Number 6774 under "Normal category" subdivision Passenger / Mail / Goods was issued by DGCA. The Aircraft is holding a valid Aero Mobile License No A-002/124-RLO (NR) at the time of incident. At the time of incident the Certificate of Airworthiness was current and was valid till suspended/ cancelled by DGCA.

The aircraft was operated under scheduled operator's permit No. S – 09 and which was valid till 02/08/2017. Prior to the flight the aircraft was holding a valid certificate of flight release. As on 21st January 2017 the aircraft VT – ITF had logged 2581:29 Airframe Hours and 1586 cycles.

The Aircraft was last weighed on 5th April 2016 at Toulouse, France and the weight schedule was prepared and duly approved by the O/o DDG (NR) DGCA, New Delhi. As per the approved weight schedule the empty weight of the aircraft is 39631.298 Kg. Maximum usable fuel quantity is 18622 Kg. Maximum payload with fuel and oil tanks full is 11656.197 Kg. Empty weight CG is 18.801 meters aft of datum. As there has not been any major modifications affecting weight and balance since last weighing, hence the next weighing was due on 4th April 2021. Prior to the incident flight the weight and balance of the aircraft was well within the operating limits.

The aircraft and engines were being maintained under continuous maintenance as per maintenance program consisting of calendar period based maintenance and flying hours/ cycles based maintenance as per maintenance program approved by O/o DDG (NR) DGCA, New Delhi.

The last major inspection (A check) was carried out at 2435 FH and 1504 landings on 1st January 2017 at Delhi. Subsequently, all lower inspections (Pre - flight checks, layover checks, weekly checks) were carried out as and when due before the incident.

All the concerned airworthiness directive, mandatory service bulletins, DGCA mandatory modifications on this aircraft and its engine has been complied with as on date of incident.

All the transit Inspections were carried out as per approved Transit Inspection schedules and all the higher inspection schedules include checks 1 inspection were carried out as per the manufacturer's guidelines as specified in Maintenance Program and are approved by the Continuing Airworthiness Manager (Post Holder for Continuous Airworthiness).

The last fuel microbiological test was done on 5th October 2016 at Delhi Spectro Analytical Labs limited and the colony count was within acceptable limits.

The left Engine S/N P770139 had logged 2581 FH / 1586 cycles and the right Engine S/N P770140 had logged 2581FH / 1586 cycles. There was no defect report on the engine on the previous flight.

After the induction of Neo aeroplanes in India, the P&W engine (PW -1100G – JM) installed on the aeroplane had several failures in air and on ground. The airworthiness directorate is constantly monitoring its performance/operation with the airlines. Also, the OEM is in the process of carrying out modifications on the affected part to reduce its failure rate.

Previously an engineering maintenance sheet/off job sheet was raised for Borescopic inspections of the combustion chamber and various dispositions were taken from the manufacturer i.e. Pratt and Whitney.

PW139 - Left Engine (S/N P770139)

P&W disposition and summary of Borescope Inspection (BSI) on Left Engine-P770139.

BSI	BSI performed Date
First BSI	24th August 2016
Second BSI	24th September 2016
Third BSI	26th October 2016
Fourth BSI	9th January 2017

Description:

First BSI: 24th August 2016

Operator's Observation:

1. Minor crack /lift off observed on quantity 01 outer liner segment
2. Minor ceramic coating loss observed on number of Fuel nozzle deflectors.
3. On quantity 02 inner liner segments multiple cracks observed.

P&W disposition

Based on the borescope photos provided of the engine P770139's combustion chamber, Pratt & Whitney Engineering recommended that the next borescope inspection be conducted at a reduced interval of 350 hours as noted in Engineering

Authorization (EA) 13CCD69 revision C. As per this EA, a borescope inspection of the 1st stage HPT blades is required to be performed.

M/s Indigo obtained P&W disposition for the above observations:

Second BSI: 24th September 2016

Operator's Observation and P&W Dispositions:

1. Observed unchanged 1" crack in Inboard Liner L2 (IBL2)& crack with raised material in Outboard Liner L1 (OBL1). Additional 1" crack found in same OBL1 segment.

P&W disposition: If the crack is greater than 0.750 inch (19.050 mm) length maximum. Continued reduced inspection interval of 350 hours & required BSI of 1st HPT blade.

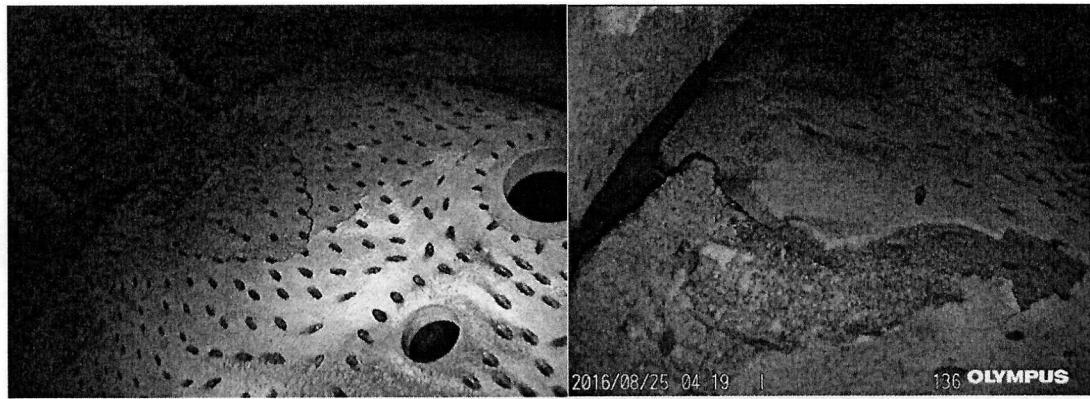


Figure 1 Unchanged 1" Cracks in IBL2 on 24th August 2016

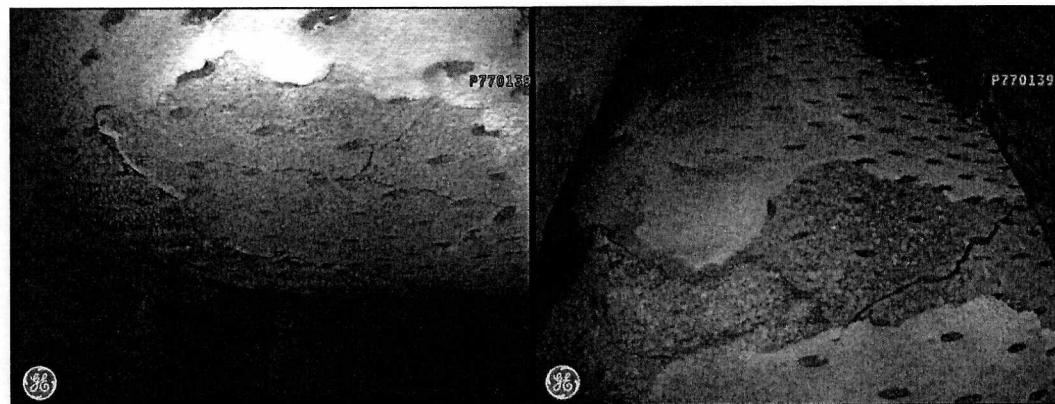


Figure 2 Crack more than 0.750" in IBL2 Segment.

Figure 3 Additional 1" crack now in OBL1 segment

2. Observed bow wake distress in 1st vane LE platform.

P&W disposition: All quantities up to 0.080 inch wide all around are permitted if the metallic undercoat is there. Continued reduced inspection interval of 1350 hours.

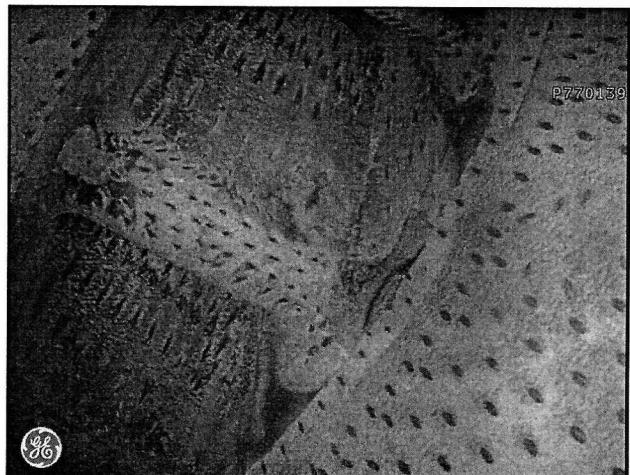


Figure 4 Bow wake distress in 1st vane LE platform.

3. Observed burn-through less than 0.5" (12.7 mm) length

P&W disposition: Any burnback or burn through less than 0.500 inch length maximum. It is within limits and continued reduced inspection interval for monitoring progression.

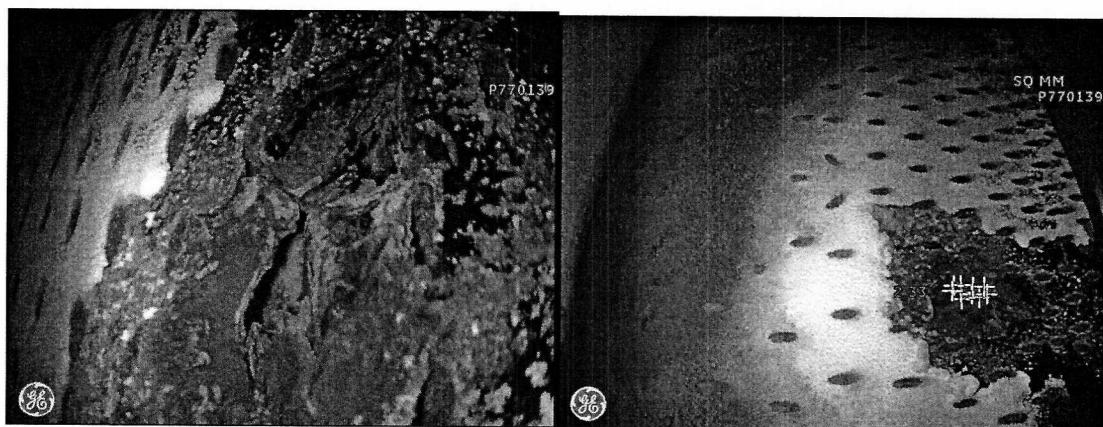


Figure 5 Burn Through less than 0.5"(12.7mm) length

Third BSI: 26th October 2016

Operator's Observation and P&W Dispositions:

1. Crack <0.750" within zone A (Bulkhead segment)

P&W Disposition: Any crack between 0.000 – 0.750 inch length maximum.

Permitted for inspection interval of 750 hours.



Figure 6 Bulkhead Shell for cracking in zone A

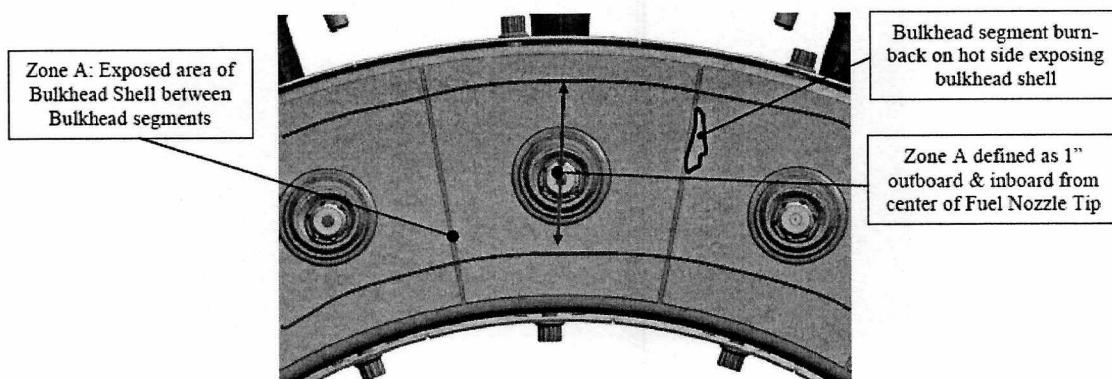


Figure 12: Bulkhead Shell Area Definition, Combustor Hood Removed for Reference - (Applies to cold side of part and hot side of part (shown))

2. Crack is greater than 0.750" in rear Inner segment.

P&W Disposition: Cracks with a length of less than 2000 inches, separated by less than 1500 inches and more than 0.750 inches from the circumferential edge. Permitted for inspection interval of 750 hours.

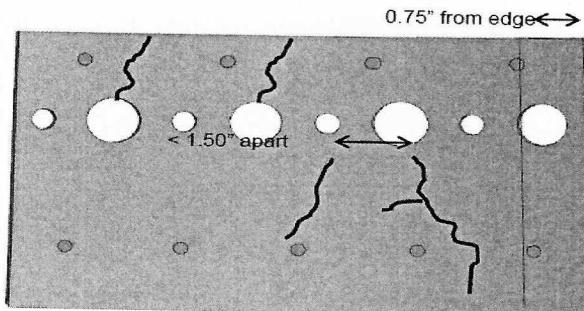


Figure 28: Rear Liner Panel – 750 EFH Interval

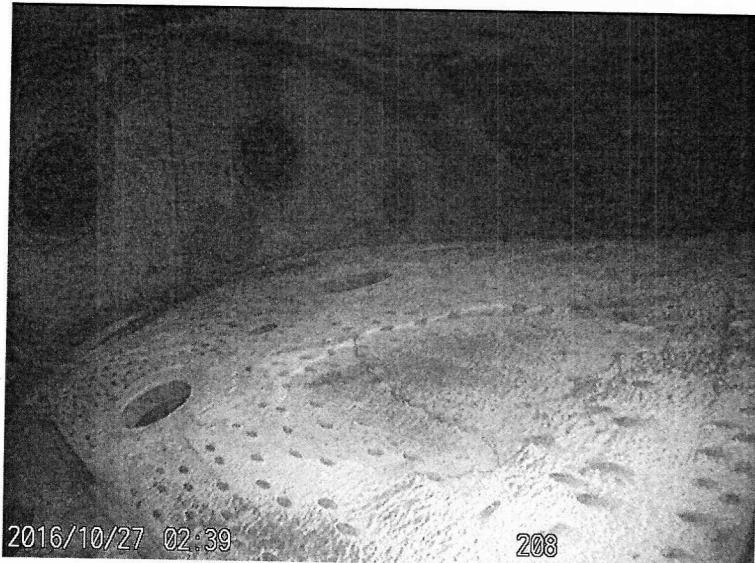


Figure 7 rear inner and outer liner segments for cracks.

3. Crack full segment axial length (Fwd Outer segment)

P&W disposition: 1 crack that is upto the linear segment axial length, separated from other cracks by more than 2.500 inches and more than 0.650 inches from the circumferential edge. Permitted for inspection interval of 750 hours.

Any burn back or burn through less than 0.700 inch length maximum. Permitted for inspection interval of 1500 hours.



Figure 8 Full segment view (FWD outer segment)

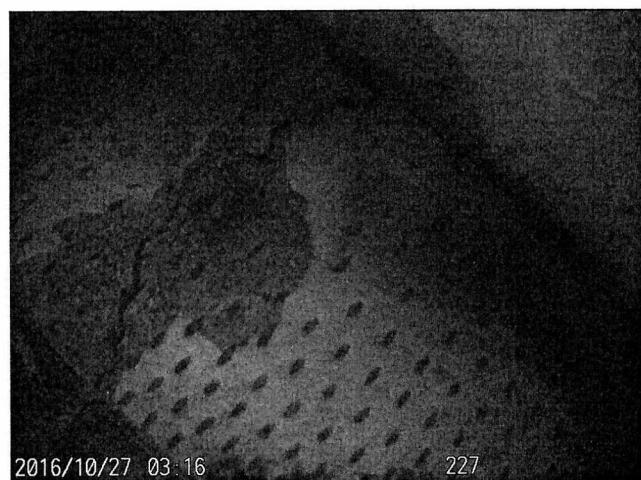


Figure 9 Close-up of full axial length crack (Fwd Outer segment)

Fourth BSI: 9th January 2017

Operator's Observation:

1. Stud that appears partially attached to segment.

P&W disposition:

Any cracking that causes partial detachment or exposure of stud. Permitted for inspection interval of 375 hours.



Figure 10 cracking that has led to 1 partially detached stud (OBL1 segment)

P&W- Right Engine (S/N P770140)

PW disposition and summary of BSI on P770140

BSI	BSI performed Date
First BSI	20 th August 2016
Second BSI	20 th September 2016
Third BSI	23 rd October 2016
Fourth BSI	23 rd November 2016
Fifth BSI	27 th December 2016
Sixth BSI	31 st December 2016
Seventh BSI	2 nd January 2017

Eighth BSI	5 th January 2017
Ninth BSI	7 th January 2017
Tenth BSI	10 th January 2017
Eleventh BSI	13 th January 2017
Twelfth BSI	15 th January 2017

First BSI: 20th August 2016

Operator's Observations:

Measurement could not be taken due equipment issues, however as no dimensions for any CC parts given in the AMM / EA13CCD69 Rev C, so even the reference measurement could not be taken.

Fuel nozzles and the deflector –

- Significant Crack in Qty 01 deflector was observed.
- Another deflector segment , coating loss was observed

CC outer liner segment –

- Significant Crack observed in the outer liner segment
- Crack observed in the outer liner segment

NGV

- Found satisfactory

Based on the crack on the Deflector and Crack on Outer CC liner segment, engine may be subjected to the reduced inspection interval, based on the below EA-13CCD69 Rev C conditions. The conditions are reproduced below:

Front and rear inner liner segments, front and rear outer liner segments, and bulkhead segments for cracks (including igniter segment) (with or without burning).

- Cracks less than 0.500 inch (12.700 mm) length maximum - Permitted for inspection interval of 1,350 hours
- Cracks from 0.500 – 0.750 inch (12.700 – 19.050 mm) length maximum. - Permitted for inspection interval of 675 hours.
- Cracks greater than 0.750 inch (19.050 mm) length maximum - Permitted for inspection interval of 350 hours. Also requires borescope inspection of 1st HPT Blade.

P&W Disposition:

For engine P770140, the crack in the outer burner liner segment is estimated to be 0.858 inch length. As per EA 13CCD69 revision C the engine is to be inspected in 350 hours and the 1st HPT blade needs to be inspected by borescope.

Second BSI: 20th September 2016.

1. Observed crack greater than 0.750" in Outer Forward Segment & burnback less than 0.500" on Outer Forward segment.

P&W Disposition: Crack greater than 0.750 inch length maximum. Permitted for inspection interval of 350 hours. Also requires boroscope inspection of 1st HPT blades. Any burnback or burn – through less than 0.500 inch length maximum. Permitted for inspection interval of 1350 hours.

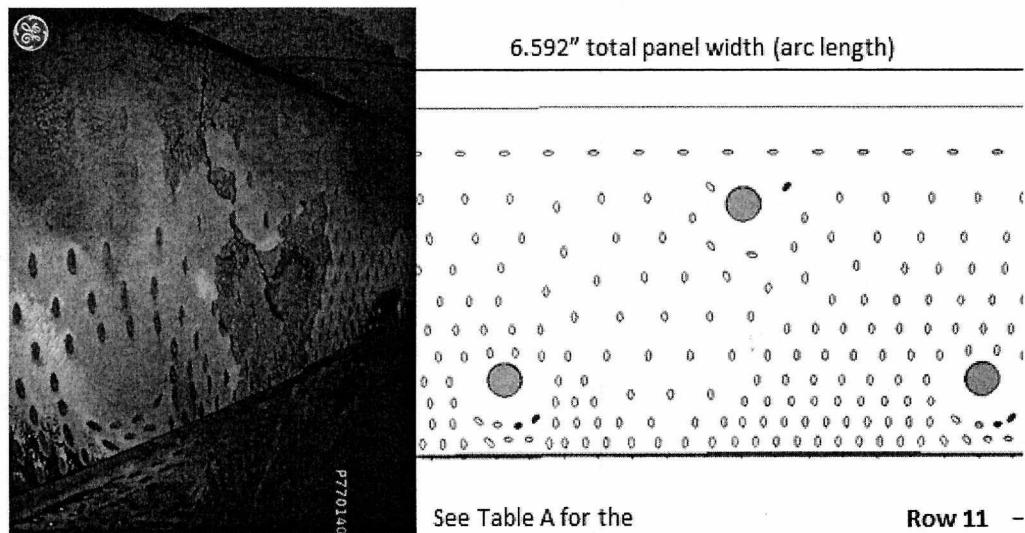


Figure 11 Crack greater than 0.750 inch in the OBL 1 Segment.



Figure 12 Burn back less than 0.500 in OBL1 Segment.

Third BSI: 23rd October 2016

As per inspection criteria continued at 350 hours.

Fourth BSI: 24th November 2016

Operator's Observation.

No significant propagation in the distress was observed from the last inspection.
Based on our assessment, the inspection interval should be enhanced from 350 Hrs.

repeat to 375 Hrs. as per EA, as the burn back in the outer liner segment was observed to be more than 0.9 inches.

P&W disposition:

The P&W reviewed the pictures and concur with the repeat inspection interval of 375 hrs.

Fifth BSI: 27th December 2016; Sixth BSI: 31st December 2016; Seventh BSI: 2nd January 2017

Combustor Lead the Fleet repeat 375-hour combustor BSI discovered a stud fully disconnected from the segment in OBL1 which requires removal of the engine within 10 cycles per current EA 16CCE00 limits. This EA will extend the 10 cycle limit up to two more times to a total of 30 additional cycles.

P&W Disposition:

Perform repetitive borescope inspection at up to 10 – Cycles intervals on P770140 and provide results to P&W, according to the process given in EA. The repetitive inspections are not to exceed a total of 30 cycles.

Eighth BSI: 5th January 2017; Ninth BSI: 7th January 2017; 10th BSI: 10th January 2017; Eleventh BSI: 13th January 2017

Combustor Lead the Fleet repeat 375-hour combustor BSI discovered a stud fully disconnected from the segment in OBL1 which requires removal of the engine within 10 cycles per current EA 16CCE00 limits. This EA will extend the 10 cycle limit up to two more times to a total of 30 additional cycles.

P&W Disposition:

Monitor combustor OBL1 stud condition at reduced intervals while keeping the aircraft in service, if possible, until a spare is received.

Operator's Observation:

Exposed stud (post) in front outer liner segment is missing. However, No downstream damage to HPT-1 NGV's/rotor blades or HPT-2 NGV's/rotor blades was observed.

As per E.A: 16CCH24 Rev. 01, repeat inspection to be performed until 30 cycles are reached

P&W disposition: Permitted for 375-hour interval (per EA 16CCE00) as HPT BSI already performed and cleared from BMOD, stud also found outside flow path.

1.6.1 Engines:

The Aircraft has two Pratt and Whitney's PurePower 1100G – JM engines that supply power to the aircraft. The engines are turbofan that have:

- A high bypass ratio
- A full authority Digital Engine Control (FADEC),
- A fuel System,
- An oil system,
- An air system,
- A thrust reverser system,
- An ignition system and a start system.

The engine has two compressor turbine assemblies

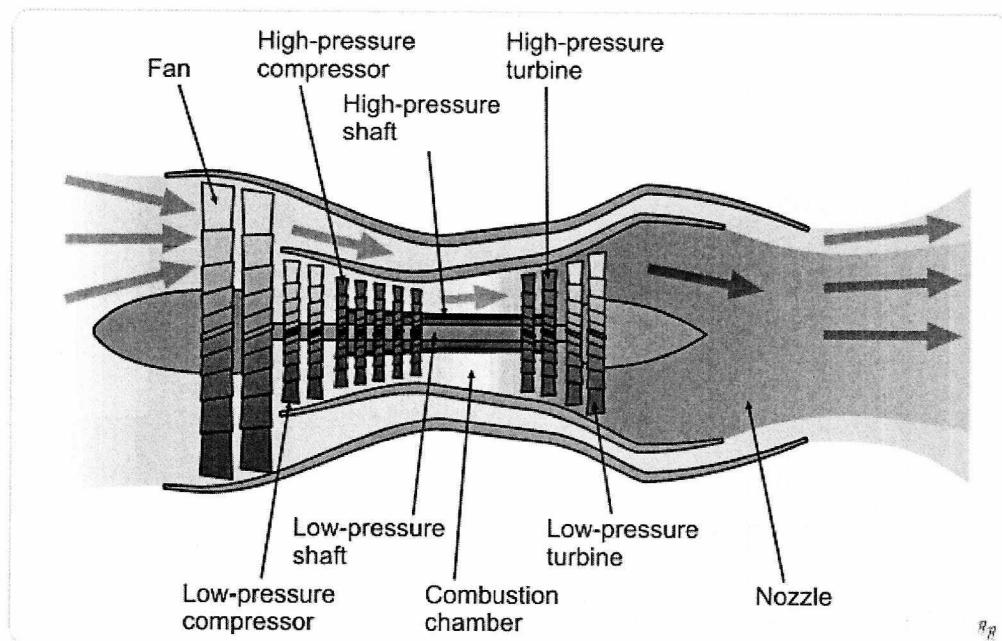
- The Low Pressure (LP) compressor turbine assembly
- The High Pressure (HP) compressor turbine assembly.

The engine operates when the LP compressor, compresses the air. Then, the air is divided into two flows. Most of the air flows out of the core engine, and provides most of the engine thrust and the remaining air enters the core engine. The HP compressor compresses the air that enters the core engine. The fuel is added to and mixed with the compressed air of the core engine. This mixture is ignited in the

combustion chamber and the gas that results from combustion drives the HP and the LP turbines. The rotation speed of the fan provides the N1 engine parameter. The rotation speed of the HP rotor provides the N2 engine parameter. The N1 and N2 engine parameters appear on the Engine/Warning Display (E/WD). The N1 and N2 engine parameters are current rotation speeds displayed in percentage.

The FADEC uses:

- The N1 engine parameter to compute the applicable engine thrust,
- The N1 and N2 engine parameters for engine control and monitoring.



1. LP Compressor Turbine Assembly

The LP compressor turbine assembly has following components: -

- One LP compressor,
- One Fan Drive Gear System (FDGS),
- One LP shaft,
- One LP turbine.

The FDGS is a planetary gear reduction unit that connects the LP shaft to the LP compressor. LP shaft connects the LP compressor to the LP turbine. The LP compressor has a fan and 3 stages, and the LP turbine has 3 stages.

2. HP COMPRESSOR TURBINE ASSEMBLY

The HP compressor turbine assembly has:-

- One HP compressor,
- One HP shaft,
- One HP turbine.

The HP shaft connects the HP compressor to the HP turbine. The HP compressor has a fan and 8 stages, and the HP turbine has 2 stages.

3. COMBUSTION CHAMBER

The combustion chamber burns a mixture of fuel and high pressure (HP) air. The FADEC controls the fuel/air mixture in accordance with the position of the thrust lever and the aircraft operating conditions. The combustion chamber is an annular assembly with fuel nozzles and two igniters. The combustion chamber is between the HP compressor and the HP turbine.

4. ACCESSORY GEARBOX

The accessory gearbox drives various accessories with mechanical power via the HP shaft for the operation of the engine and the aircraft systems.

The accessory gearbox of each engine operates

- The oil feed pump that provides the oil system with oil.
- The main engine fuel pump that provides the combustion chamber with fuel.
- The engine-driven hydraulic pumps that pressurize the GREEN and the YELLOW hydraulic systems.
- The engine-driven generators that are the primary source of electrical power.
- The FADEC alternator that provides the FADEC with electrical power.

- The pneumatic starter that enables the engine start.

1.7 Meteorological information

At the time of landing, the following weather was reported by ATC.

VABB 211500Z 03006KT 2200 FU NSC 28/13 Q1016 NOSIG=

VABB 211530Z 01004KT 2200 FU NSC 28/13 Q1016 NOSIG=

VABB 211600Z 03005KT 2200 FU NSC 28/12 Q1016 NOSIG=

VABB 211630Z 15006KT 2200 FU NSC 28/12 Q1017 TEMPO 1500 FU=

1.8 Aids to navigation

At Mumbai Chhatrapati Shivaji International Airport two bi-directional runway are available. The orientation of which is 09/27 and 14/32. Except for runway 32, the DME and ILS approach is available for all the other three approaches at Mumbai. PAPI is available for both sides of all the runways. The A320 family of aircraft is fitted with all modern navigational equipment including the DME and ILS systems.

1.9 Communications

There was always two ways communication between the ATC and the aircraft.

1.10 Aerodrome information Chhatrapati Shivaji International airport in Mumbai, India

ICAO :VABB

Co-ordinates

ARP : N 19° 05' 30.00"

E 72° 51' 58.00"

Elevation : 39 Ft.

Runway Orientation and dimension

The Airport have two runways

Orientation- 14/32 and 09/27 and Dimension

Runway and Taxi Tracks Markings Standard as per the requirements of Annex- 14

Met Services

MET services are available at the airport. TAF, Trend Forecast and Briefing is available.

Navigation and Landing Aids

LLZ, GP, DVOR, ILS, ASDE, ASMGCS, LM, LO

ATS Communication Facilities

Mumbai Radar 127.9 MHZ

Mumbai Approach 119.3/127.9 MHZ

Mumbai Tower 118.1 MHZ

Mumbai Ground 121.9/121.85/121.75 MHZ

1.11 Flight recorders: The Cockpit Voice Recorder (CVR) and the Digital Flight Data Recorder (DFDR) was downloaded for investigation.

CVR: Make: HoneywellPart No.980-6032-023S/N: 05091

The CVR of the incident flight was analysed and following are the observations:

1. At relative time 01.53.38the crew completed the before take-off (T/O) checklist.

2. At time 01.56.08 aircraft was cleared to taxi to R/W 27. Thereafter ATC informed surface wind as 030/40 kts and cleared aircraft for T/O from R/W 27.
3. As the Aircraft rolled at approximate speed of 60/70 kts, thud noise was observed twice and Captain announced stop and informed ATC about rejecting T/O.
4. ATC informed 6E-248, to vacate via Echo.
5. Captain called for ECAM action—Engine1 fail checklist.
6. First Officer – Carried out the engine fail checklist as per ECAM.
7. At Time 01.58.19 ATC asked 6E-248 like to return? The captain informed that they would like to return due engine failure.

DFDR: Make: Honeywell, Part No.980-4750-002, S/N: 04247

The DFDR was downloaded. The incident flight and the previous flight was analysed and following are the observations:-

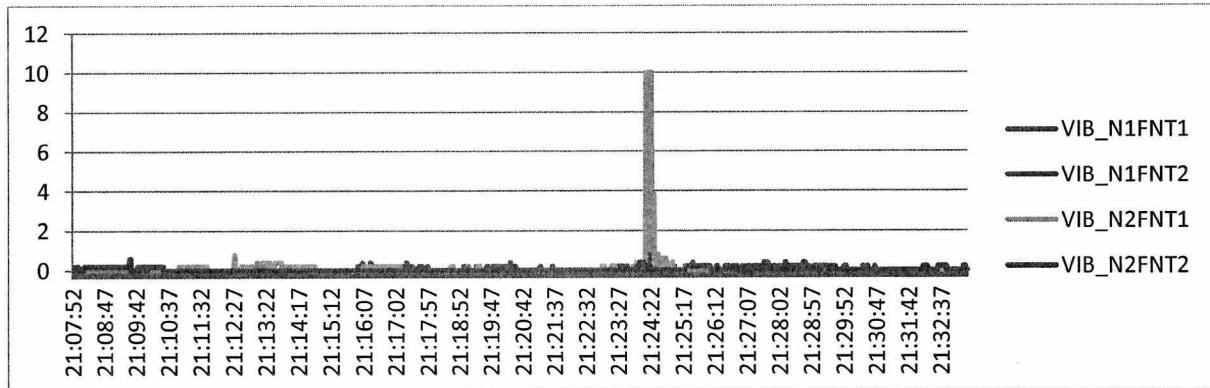
Previous Flight No: 596 (CCU – BOM) Dated 21st January 2017

1. All parameters were found to be within limits. No abnormalities were observed.
2. Maximum Vibration was recorded was 1.2, 1, 0.6 and 1 units on Engine 1 N1, Engine 2 N1, Engine 1 N2 and Engine 2 N2 respectively.
3. Maximum EGT recorded was 958 degree C and 942 degree C on Engine1 and Engine 2 respectively.
4. EGT Limits of PW (NEO) Engines are 1018deg C during starting, 1043 degree C at MCT and 1083 degree C during Take-off and Go-Around.
5. No exceedance was recorded for this sector.

No snag or ECAM related to engine triggered during the flight. Vibration levels and all other related parameters of both the engines were found under limits. No abnormality was observed during this flight.

Incident Flight No: 6E 248 (BOM – DEL) Dated 21st January 2017

1. At relative time 15:53:50 (UTC), after lining up for take-off from RWY 27, thrust leavers (TLAs) were moved forward 15 degree approx. N1 on both Engines increased to 50%. (FLX Temperature was set at 62 degree).
2. At 15:54:01 (UTC), TLA was moved to FLX gate.
3. Ground Speed started to increase. N1 of both Engines increased to 80 %.
4. Max ground speed recorded was 73 knots.
5. At 15:54:11 (UTC), there was reduction in Eng1 N1 from 80 to 37% within 3 seconds.
6. At 15:54:14 (UTC), TLAs were brought back to Max Reverse. Eng1 N1 vibration increased from 0.2 to 6 units during this period. Eng1 N2 vibration increased from 0.4 to 10 units. EGT 1 increased to 937 degrees.
7. Maximum Vibration was recorded was 10, 1.2, 10, and 0.6 units on Eng1 N1, Eng2 N1, Eng1 N2 and Eng2 N2 respectively.
8. Maximum EGT 2 recorded was 851 degree C.
9. Maximum EGT 1 recorded was 998 degree C.
10. Aircraft vacated via E and returned back to bay.



1.12 Wreckage and impact information

Other than the internal damage to # 1 engine there was no other damage on the aircraft.

1.13 Medical and pathological Information

Both the cockpit crew and all four cabin crew had undergone Breath analyser check during the pre-flight medical check prior to the flight at Mumbai and were found negative.

1.14 Fire

There was no fire.

1.15 Survival aspects

The incident was survivable.

1.16 Tests and research

The engine was inducted into Columbus Engine Centre (CEC) for disassembly, inspection, and overhaul on June 26, 2017. Representatives from Pratt & Whitney (PW) and the FAA were present during the detailed engine disassembly the week of July 10th, 2017. Reference 1 provided a field report from the FAA Engine Certification Office published following the engine dis-assembly in CEC. The combustion chamber was removed and sent to Pratt & Whitney's East Hartford facility for further evaluation and was received on July 21st. This report supplements reference 1 with IAE observations from CEC engine teardown and combustor inspections which were performed at P&W facilities in East Hartford CT.

Investigative Findings:

Combustor/Diffuser:

No sign of major distress or fire on the outer combustor/diffuser case (Figure 2). The fuel nozzles (Figure 3) are consistent with field run hardware, including the number 1 nozzle which is located near the burn through (Figure 4).

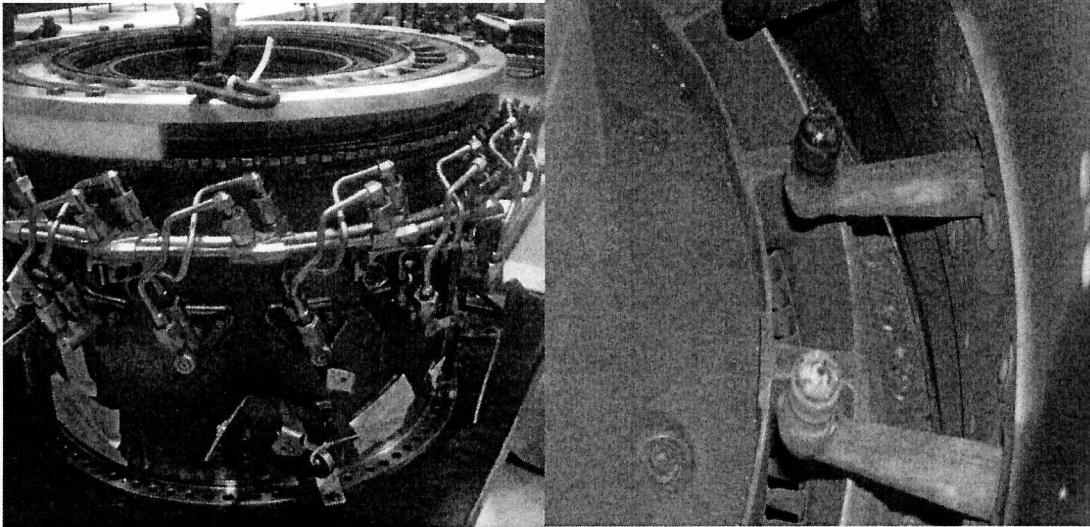


Figure 2: Diffuser case module

Figure 3: Installed Fuel Nozzles

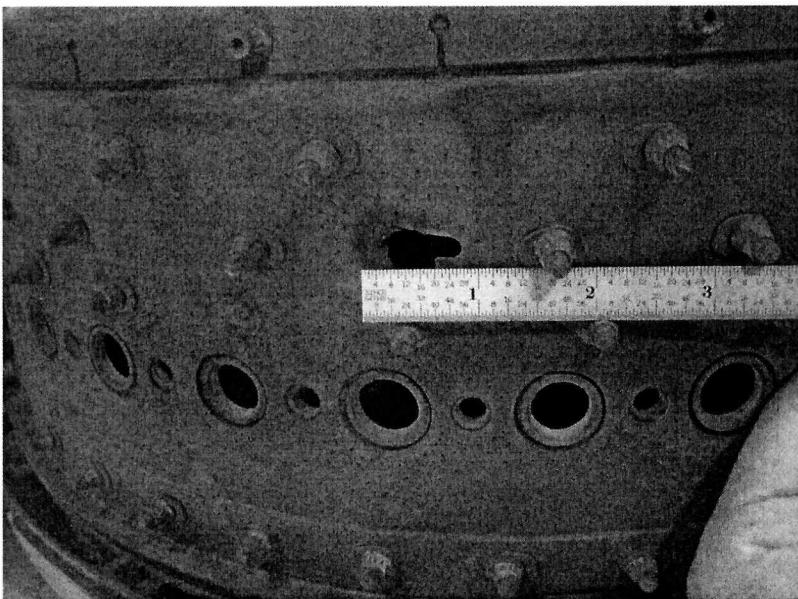


Figure 4: Hole in combustor liner with ruler for reference

A burn through hole is located at the 12:30 position on the combustion chamber outer liner and floatwall liner segment where a stud is typically located. The hole is 0.4 inches by 0.7 inches in dimensions (Figure 4). The metal around the perimeter of the hole is bent inwards (Figure 5), the stud is missing and was not found during investigation.

There are no other visible burn through holes on the inner or outer liner. The remaining studs were tight when felt by hand. These studs are approximately 0.5

inches long and secured with a washer and nut (Figure 4). There is coating and parent material loss on multiple combustor floatwall segments on the outer and inner liners (Figure 6). The bulkhead also shows coating loss and cracks in the parent material. The number 1 floatwall segment where the burn through hole is located is missing 25% of parent material.

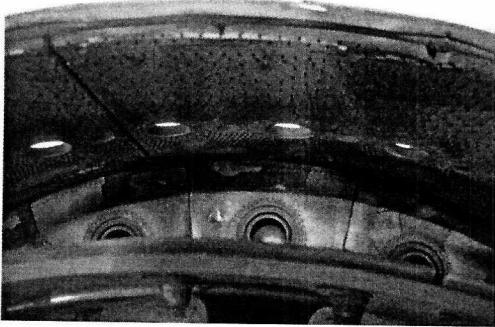


Figure 6: Floatwall segments and bulkhead

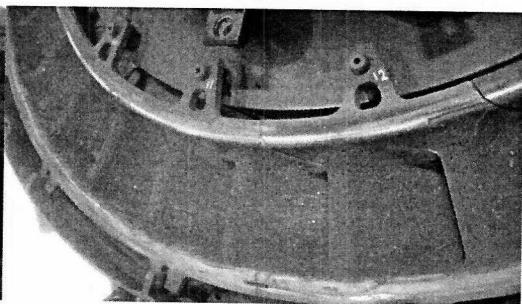


Figure 8: Black residue on 1ststage nozzle guide vanes

High Pressure Turbine (HPT):

The 1st stage HPT vanes are all intact. The pressure side of the all the vanes has a layer of black residue on the majority of their surfaces (Figure 8). This finding is consistent with exposure time on this engine and the event. Coating erosion was noted on the trailing edges on the non-pressure side for the majority of vanes.

All 1st stage blades and disk are intact. Three blades have impact damage on the non-pressure side on the outer 50% of their span (Figure 10). These three blades exhibited displacement of the trailing edge forward at the damage location. There was coating loss on the leading edge on majority of blades.

The pressure side of all the blades have black residue. Five blades had impact damage on the pressure side on the leading edge near the tip, the largest of which was 0.3 inches spanwise and 0.1 inches chordwise.

All 2nd stage vanes are intact. The leading edge of the non-pressure side has coating loss. There is one blade with an impact indication at the centre of the trailing edge on the non-pressure side (Figure 11).

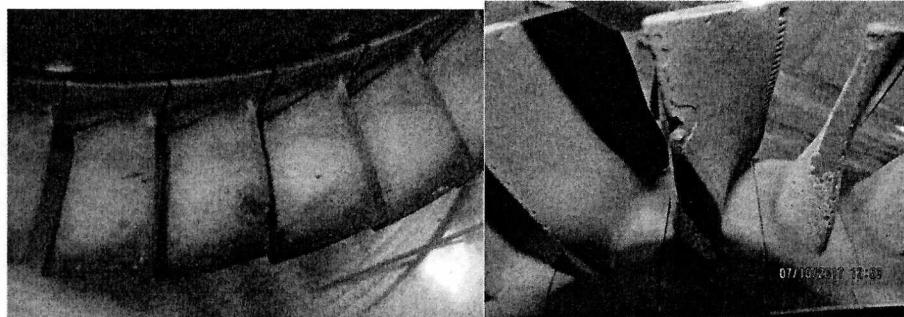


Figure 10: Impact damage on 1st stage HPT blade Figure 11: Impact damage on 2nd stage HPT blade

Low Pressure Turbine (LPT):

The LPT external case has no indications of uncontainment, case rupture, or fire. The LPT could be rotated by hand with shaft and all stages rotated concurringly. No loose debris was found within the LPT prior to teardown.

Multiple rub indications were found along the same side of the LPT shaft. The largest rub extended half of the shaft circumference and was 7/8 inches wide (Figure 13, right hand photo, bottom rub).

The 1st stage LPT blades and disk are all intact. Five blades had one impact indication each on the outer 50% span of the leading edge (Figure 14). The approximate dimensions of the largest indication are 0.1 inches spanwise and 0.075 inches chordwise. There was no impact damage on the non-pressure side.

All 2nd stage LPT vanes are intact with no signs of impact indications. All 2nd stage blades and disk were intact. Five blades had one impact indication each on their leading edge on their outer 50% span. The largest was 1/8 inches spanwise and 1/16 inches chordwise (Figure 15). Two blades had dents on the nonpressure side trailing edge. The 2nd stage LPT disk has no signs of distress.

All 3rd stage blades were visibly damaged (Figure 16). An arc encompassing 40% of the disk had blades fractured above and close to the platform (1:00 to 6:00 in Figure

16). The remaining blades were fractured randomly between 0-3 inches, which is less than 50% of original span.

The 3rd stage disk was intact with no visible signs of distress. Multiple 3rd stage vanes have trailing edge damage with material missing. The damage was predominately in the outer 50% of span (Figure 17). The largest area of material missing was 0.6 inches spanwise and 0.3 inches chordwise. Several vanes had material missing on the aft edge of their outer platform. The leading edges of the 3rd stage vanes showed no signs of impact indications.

The combustion chamber was then removed and returned to Pratt and Whitney for disassembly and further detailed visual evaluation. Combustor P/N 30G4038 is the current Bill of Material combustor and termed the "Block B" configuration. As mentioned during the field report, the major distress was located at the 12:30 position (aft looking forward) on the row 1 OBL panel segment. The burn through corresponded with a location where there is a panel attachment stud (Figure 18).

The Outer Burner Liner (OBL) and Inner Burner Liner (IBL) were disassembled and the floatwall segment panels were removed. An examination of the parts showed that the OBL row 1 panel 1 was missing a stud and the panel had fractured axially down the middle (Figure 19). All of the OBL row 1 panels exhibited coating loss and signs of thermal distress. All of the OBL row 2 panels exhibited minor coating loss.

The IBL row 1 panels exhibited coating loss and minor thermal distress on panels 4 and 6. All of the IBL row 2 panels exhibited only minor coating loss. The bulkhead segments were removed and all showed signs of coating loss, with 16 of the 18 also showing various levels of thermal distress.

Figure 13: multiple rubbing indications on LPT Shaft

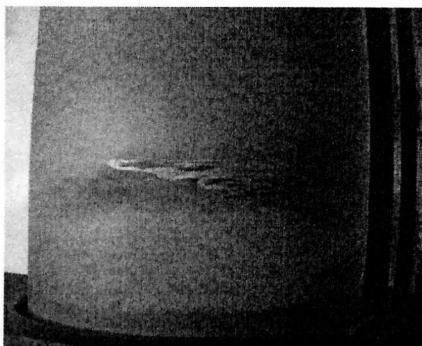


Figure 18: Outer Combustion Chamber Burn

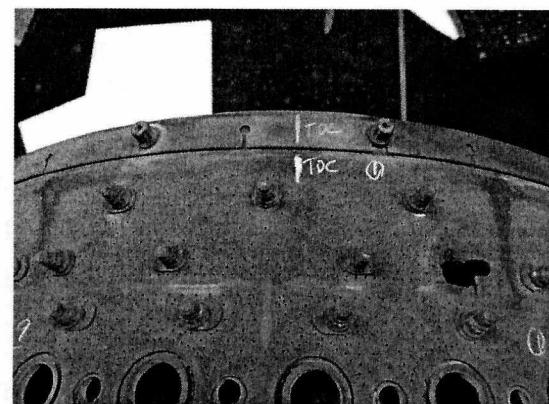


Figure 16: 3rd stage rotor/blades removed from LPT

Conclusion:

The combustor floatwall segments displayed coating thermal distress throughout including localized areas of parent material loss. There was a burn through hole at the 12:30 position on the combustion chamber outer liner and floatwall segment where a stud is typically located. The distress in the combustor of this engine is within PWs experience for a Block B combustor configuration, and was on a recurring inspection interval for combustor distress.

The stud was missing and was not found during investigation. The HPT blades and vanes were noticed to have impact damage and coating loss. All LPT 3rd stage blades were fractured above platform and within 50% of span. The likely sequence of events is that the combustor stud, nut, and washer liberated as one piece, which has a combined mass of 0.144 oz. The liberated piece of material was ingested into the gas path of the engine and travelled through the HPT and LPT impacting and damaging the blades and vanes as it went through, and ultimately impacting and liberating the 3rd stage LPT blades. Component bench testing of the LPT 3rd blade shows the mass of the stud, nut and washer would result in significant damage to the leading edge of the 3rd blade. This damage would reduce the fatigue capability of the blade leading to blade fracture consistent with the P770139 event.

Corrective Action / Recommended References:

This is the first instance of this type of failure on a PW1100G-JM engine. As this engine was currently under a recurring inspection interval, PW has revised its combustion chamber limits specifically regarding how much distress is allowed around panel attachment studs. The new limit was released on Engineering Authorization (EA) 16CCE00A on February 1, 2017 and is consistent with proven limits on legacy PW commercial engine products.

1.17 Organizational and management information:

M/s IndiGo is a scheduled airline with a current fleet of 171 Airbus A-320 and 11 ATR 72 aircraft operating flights on domestic and international sectors. The company is in operation from last 12 years. The Company is headed by CEO assisted

by a leadership team of professional of various departments. The flight operation is headed by V.P. Flight Ops who holds current license on Airbus A-320. The Flight Safety Department is headed by Chief of Flight Safety approved by DGCA who is a pilot with a current license of Airbus A-320. The Chief of Safety reports directly to the CEO.

1.17 Additional information:NIL

1.18 Useful or effective investigation techniques: NIL

2. ANALYSIS

2.1 Serviceability of the aircraft

Airbus A320 aircraft VT-ITF (MSN 6860) was manufactured by M/s Airbus, France in year 2012. The aircraft is registered under the ownership of M/s HKAC Leasing 6860 Limited, Ireland. On the day of incident the aircraft VT-ITF had logged 2581.29 Airframe Hours and 1586 cycles.

The aircraft was holding a valid Certificate of Airworthiness and was valid till 27 Mar 2017. This aircraft was operated under Scheduled Operator's Permit No. S-19 and which was valid till 02 Aug 2017. Prior to flight, the aircraft was holding a valid Certificate of Flight Release.

There was no major modification carried out on the aircraft affecting weight & balance. Subsequently all lower inspections/schedules, till the last flight prior to incident was carried out as per the maintenance programme.

All the concerned Airworthiness Directive, Service Bulletins, DGCA Mandatory Modifications on this aircraft and its engine were found complied with. Transit Inspections are carried out as per approved Transit Inspection schedules and all the higher inspection schedules include checks 1 inspection as per the manufacturer's guidelines as specified in Maintenance Program and are approved by the Continuing Airworthiness Manager (Post Holder for Continuous Airworthiness).

The aircraft and Engines were being maintained under continuous maintenance as per maintenance program consisting of calendar period based maintenance and flying Hours/ Cycles based maintenance as per maintenance program approved by Regional Airworthiness office, New Delhi. M/s Indigo was also following up with the OEM for the additional checks required on the engines due to high rate of engine component failure/engine change. M/S Indigo had also kept the O/o DDG (NR) apprised of all the correspondence with the OEM in this regard.

There was no in-flight disintegration of any part of the aircraft and it was confined around its final rest position. Prior to the incident flight the aircraft had operated flight Kolkata-Delhi and no snag was reported on the aircraft.

From the above it is inferred that the aircraft was serviceable prior to operating a flight out of Mumbai. However the #1 engine was under distress and was continuously under close monitoring. The last borescope inspection was carried out for #1 engine on was 09/01/2017. The P&W was aware of the dislodged bolt in the combustion chamber, however gave the disposition for the next 375 hours for operating. The engine failed on 21/1/2017 after logging only 290 hrs approx. The P&W giving disposition for the operation of the engine with the above conditions is a factor to the incident.

2.2 Circumstances leading to the Incident

The neo engines were inducted into service by M/s Indigo Airlines in March 2016. However, ever since their induction, a number of component failures on the engines have been reported primarily:

1. No. 3 bearing compartmental seal
2. Chip detector in accessory gearbox
3. Erosion in combustion chamber
4. Detection of cracks/lift offs in the inner and outer liner of combustion chamber

On the advice of the manufacturer P&W, the borescopic inspection were being carried out at shorter intervals to detect the failure on ground before it occurs during a flight. A number of borescopic inspections were carried out on the engine to detect any

abnormality and the engine (P770139) was kept in service based on the dispositions given by the OEM to M/s Indigo Airlines.

During the fourth borescopic inspection on 9th January 2017, the operator had reported that 'Stud appears partially attached to segment'. The OEM had given a disposition stating that any cracking that causes partial detachment or exposure of stud is permitted for inspection interval of 375 hours.

During investigation, the combustor floatwall segments displayed coating thermal distress throughout including localized areas of parent material loss. There was a burn through hole at the 12:30 position on the combustion chamber outer liner and floatwall segment where a stud is typically located. The stud was missing and was not found during investigation.

Investigation also revealed that the HPT blades and vanes were noticed to have impact damage and coating loss. All LPT 3rd stage blades were fractured above platform and within 50% of span. The likely sequence of events is that the combustor stud, nut, and washer liberated as one piece, which was ingested into the gas path of the engine and travelled through the HPT and LPT impacting and damaging the blades and vanes as it went through, and ultimately impacting and liberating the 3rd stage LPT blades.

Component bench testing of the LPT 3rd blade shows the mass of the stud, nut and washer would result in significant damage to the leading edge of the 3rd stage which would reduce the fatigue capability of the blades leading to blade fracture which is consistent in this instant case.

3 CONCLUSIONS

3.1 Findings

1.1. Findings:

- a) The Certificate of Airworthiness and the Certificate of Registration of the aircraft was valid on the date of incident.
- b) The certificate of flight release was valid on the day of incident.
- c) All the concerned Airworthiness Directive, Service Bulletins, DGCA Mandatory Modifications on this aircraft and its engine were found complied with.
- d) Both the Pilots were appropriately qualified to operate the flight.
- e) There was no external damage to the aircraft.
- f) There was no fire in the aircraft.
- g) No Engine related snag was reported from the flight crew after the flight and there were no MELs on the aircraft prior to flight.
- h) At 15:53:50 UTC during take-off run suddenly N1 of Engine 1 was reduced to 37% from 80% within 3 seconds and engine stall warning was triggered.
- i) Low speed rejected take-off was carried out at 73 knots approx.
- j) The aircraft was taxied to bay and passengers were deplaned normally. There were no injuries to passengers and crew.
- k) The aircraft and engines were being maintained under continuous maintenance as per maintenance program approved by O/o Deputy Director General, DGCA, Mumbai.
- l) The last major inspection (A check) was carried out at 2435 FH and 1504 landings on 1st January 2017 at Delhi.
- m) The left Engine S/N P770139 had logged 2581 FH and 1586 cycles and the right Engine S/N P770140 had logged 2581FH and 1586 cycles. There was no defect report on the engine on the previous flight.
- n) Borescopic inspections were carried out for engines P770139 and P770140. Based on the photographs provided, OEM recommended that the borescope inspections be conducted at a reduced interval of 350 hours along with borescope inspection of 1st stage HPT.
- o) During investigation post incident, a burn through hole (0.4 inches by 0.7 inches in dimensions) at 12:30 position on the combustion chamber outer liner

- and floatwall liner segment where a stud is typically located was observed. The stud was missing and was not found during investigation.
- p) Borescopic inspection on engine P770139 carried out by M/s Indigo on 9th January 2017 showed that stud appeared partially attached to segment. OEM gave a disposition permitting inspection interval of 375 hours. However the engine failed on 21/1/2017 after logging only 290 hrs approx. The 1st stage LPT blades were intact with five blades having impact indication. The 2nd stage LPT vanes were intact with no impact indication. The 3rd stage LPT vanes were visibly damaged with material missing.

3.2 Probable cause of the Incident:

The stud (bolt) in the combustion chamber got liberated during engine operation which travelled through the HPT and LPT and ultimately impacted and damaged the 3rd stage LPT blades resulting in engine stall.

The OEM disposition permitting an inspection interval of 375 hours after detecting a partially attached stud in the combustion chamber, is a contributory factor for the incident.

4 SAFETY RECOMMENDATIONS:

1. No recommendation is made at this stage as the P&W engine PW -1100G – JM is still under observation by the Airworthiness Directorate of DGCA and also it is undergoing component modifications by the OEM.



A X Joseph
Deputy Director-Air Safety

Inquiry Officer: VT-ITF

Date: 3rd January 2019

Place: New Delhi