Final Investigation Report
on
Serious Incident of Airbus A 320 aircraft VT-ATF operated by M/S Air India Express at Bengaluru Airport on 18 May 24

Aircraft Accident Investigation Bureau
Government of India
Ministry of Civil Aviation

FOREWORD

In accordance with Annex 13 to the Convention on International Civil Aviation Organization (ICAO) and Rule 3 of Aircraft (Investigation of Accidents and Incidents), Rules 2017, the sole objective of the investigation of an Accident/Incident shall be the prevention of accidents and incidents and not to apportion blame or liability. The investigation conducted in accordance with the provisions of the above-mentioned rules shall be separate from any judicial or administrative proceedings to apportion blame or liability.

This document has been prepared based upon the evidence collected during the investigation, opinion obtained from the experts and laboratory examination of various components. Consequently, the use of this report for any purpose other than for the prevention of future accidents or incidents could lead to erroneous interpretations.

Contents

GLOSSARY

AAIB	Aircraft Accident Investigation Bureau
AMSL	Above Mean Sea Level
ARC	Airworthiness Review Certificate
ASR	Airport Surveillance Radar
ATC	Air Traffic Control
AUW	All Up Weight
C of A	Certificate of Airworthiness
F/O	First Officer
FCOM	Flight Crew Operation Manual
FCTM	Flight Crew Training Manual
Hrs	Hours
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ILS	Instrument Landing System
LLZ	Localiser
MEL	Minimum Equipment List
MLG	Main Landing Gear
MTOW	Maximum Take Off Weight
NDB	Non-Directional Beacon
NLG	Nose Landing Gear
NM	Nautical Miles
PA	Passenger Address
PF	Pilot Flying
PIC	Pilot in Command
PM	Pilot Monitoring
QRH	Quick Reference Handbook
RA	Radio Altitude
SB	Service Bulletin
VMC	Visual Meteorological Conditions
VOR	VHF Omni directional Range
UTC	Universal Time Coordinated
NVM	Non- Volatile Memory
MAC	Mean Aerodynamic Chord
TLA	Throttle Lever Angle
SIC	Safety Investigation Coordinator

BSI	Boroscope Inspection
DVOR	Doppler VHF Omni Range
DME	Distance Measuring Equipment
EGT	Exhaust Gas Temperature
HHMPI	Hand Held Multipurpose Interface
PCMCIA	Personal Computer Memory Card International Association
ECAM	Electronic Centralized Aircraft Monitoring

Aircraft and Serious Incident details of Airbus A-320 Aircraft VT-ATF on 18 May 24			
1.	**Aircraft**	**Type**	**AIRBUS A320 – 216 WITH CFM 56 5B ENGINES**
		Nationality	**Indian**
		Registration	**VT-ATF**
2.	**Owner**		**M/S Air India Express limited**
3.	**Operator**		**M/S Air India Express limited**
4.	**Country of Manufacture**		**FRANCE, AIRBUS**
5.	**Pilot**		**ATPL License Holder**
6.	**No. of Persons on board**		**185(179 passengers (177+2 infants) + 6 crew)**
7.	**Date & Time of Serious Incident**		**18.05.2024 & 17:32 UTC**
8.	**Place of Serious Incident**		**BENGALURU INTERNATIONAL AIRPORT (VOBL)**
9.	**Co-ordinates of Site, AMSL**		**13°12'25.79"N (Latitude), 77° 42'15"E (Longitude)**
10.	**Last point of Departure**		**BENGALURU INTERNATIONAL AIRPORT (VOBL)**
11.	**Intended landing place**		**COCHIN INTERNATIONAL AIRPORT (VOCI)**
12.	**Type of Operation**		**Scheduled Commercial**
13.	**Phase of operation**		**During Climb**
14.	**Type of Occurrence**		**Serious Incident**
15.	**Extent of Injuries**		**Minor (10 passengers)**

(All the timings in this report are in UTC unless otherwise specified)

SYNOPSIS

On 18.05.2024, Air India Express scheduled flight No AIX – 1182 took off from Kempegowda International Airport, Bengaluru at 1732 UTC for Cochin International Airport on VT – ATF aircraft. The aircraft had total 185 POB including 06 crew members. While the aircraft was on its initial climb, the crew heard a bang sound from the right side of the aircraft. The crew also noticed small fluctuation in N1 RPM of No.2 engine and yellow hydraulic System fault momentarily. The No.2 engine stall warning also came on momentarily and went off. The cabin crew on the R2 informed the crew on intercom about fire on right side of the aircraft/engine; however, the crew did not get any warning or indication of fire on the flight deck. The PIC and PM discussed the situation and decided to return to Bengaluru airport. In view of the fire "May Day" was declared by the PIC and a safe landing was executed at Bengaluru International Airport in coordination with the air traffic services. As per the crew statements both the fire extinguishers were operated to extinguish the fire after landing but the fire still persisted. After the aircraft exited the runway and stopped at link 'H' the Crash Fire tenders (CFT) discharged the foam into the engine and extinguished the fire. The crew ordered emergency evacuation of the passengers. All the four slides were deployed by the cabin crew and all the passengers and crews exited from the aircraft safely. 10 passengers suffered minor injuries during exiting from the slides. Injured passengers were treated at the local hospital and were declared fit for travel. Physical inspection of the engine oil quantity in the engines revealed 17.5 Quarts on No.1 engine and 7.5 Quarts on No.2 engine.

The occurrence was classified as a Serious Incident by AAIB and Sh. Sanjay Kumar Singh, Director, AAIB was appointed as Investigator – In – Charge along with Sh. Rajendra Pratap Singh, Senior Consultant as Investigator to investigate into the probable cause(s) of the serious incident, vide Order No. INV.12011/02/2024-AAIB dated 21st May 2024 under Rule 11 (1) of Aircraft (Investigation of Accidents and Incidents), Rules 2017.

1. Factual Information

1.1 History of Flight

On 18.05.2024 aircraft VT-ATF was planned for a scheduled flight from Bengaluru to Kochi. Prior to the incident flight the aircraft had operated 05 flights at different sectors (BLR- LKO, LKO-BLR, BLR-JAI, JAI-PNQ and PNQ-BLR). All previous flights were operated by different sets of crews.

Pilot in Command was pilot flying and Second in Command pilot monitoring for the incident flight. Aircraft was prepared for Maximum Landing weight of 66 Ton and Maximum Take - Off weight of 73.5 Ton with actual take – off weight of 63757 Kgs and actual landing weight of 63104 Kgs. Incident flight was the first flight of the day for the crew set. There were 179 passengers and 06 crew on board.

Preflight external checks showed satisfactory condition of aircraft. The aircraft had chocks off at 17:20 UTC.

At 17:29:39 UTC, aircraft took off from VOBL airport, runway 27 R in FLEX mode (Thrust levers in Flex notch and Flex Temp; 54 deg C). Flight crew knew there was a weather in the departure path. At 17:29:52 UTC, crossing 400ft RA, aircraft performed a right turn with bank angle reaching up to +18.3 deg. At 17:29:57 UTC, crossing 600 ft RA both Thrust Levers were pulled to Climb Notch. As per pilot, at appx 600ft after the thrust levers were placed in climb detent severe jolts accompanied with loud bangs were experienced. Captain levelled Wings at 17:30:20 UTC. Senior Cabin Crew informed the flight crew about fire on right engine.

At 17:30:32 UTC, crossing 1300ft RA, N1A2 (N1A from engine 2) suddenly dropped from 85% to 69% then recovered back to 85% in 2 seconds (while N1A1, N1A from engine 1, remained at 85%). PIC noticed the fluctuation of N1 in gauges. As a consequence, Aircraft rolled to the right with bank angle reaching up to +2.8°. EGT2 suddenly jumped from +728°C to +782°C then continued increasing progressively during 30s until 838° whereas EGT1 stabilized around 750°C. PS3 from Engine 2 decreased from 280 to 180 PSI, then recovered back in 2s (while PS3 from Engine 1 remained stable).

At 17:31:00 UTC, while N1As were also stable at 87%, Engine 2 N2 vibrations started to increase from 0.8 CU.

At 17:31:05 UTC, the ATHR commanded a N1A reduction to both engines in accordance with the AP longitudinal mode change and both N1A1 and N1A2 started to decrease accordingly. EGT1 and EGT2 started to decrease at the same speed respectively from 750° and from 838°, respectively towards 700° and 800°.

At 17:31:11 UTC, crossing 2000ft RA (4900ft QNH), ECAM HYD Y LO LVL triggered for 1s. Pilot noticed the yellow hydraulic system fault.

At 17:31:17 UTC, crossing 2200ft RA (5200 ft QNH), while N1A1 and N1A2 were evolving similarly and were equal at 78%, N1A2 started to decrease from 78%. While PS31 and PS32 were evolving similarly and were equal to 240PSI, PS32 suddenly reduced to 180PSI. Aircraft rolled to the right with bank angle reaching up to +4.6°. Thrust asymmetry started to be countered by rudder and ailerons. The ENG2 STALL and its associated master caution triggered in the cockpit.

At 17:31:18 UTC, the Thrust Lever 2 was pulled to the IDLE notch. 1s later: - N1A2 started to decrease accordingly. EGT2 reached 838° and then started to decrease until 640° (reached 15s later).

At 17:31:23 UTC, the Thrust Lever 1 was pushed to the MCT notch. N1A1 increased to 89%. APU was switched on.

At 17:31:26 UTC, N1A2 was 32% and decreasing. Engine 2 N2 vibrations reached 4.2 CU and started to decrease. 1 second later, Engine 2 N1 vibrations reached 5.0 CU (for 1 second) and started decreasing further. Pilot called ATC and declared MAY DAY.

At 17:35 UTC, the aircraft descended from 6000ft QNH and turned back to VOBL airport.

During the descent, the oil quantity of engine 2 decreased to 6 Quarts until touchdown.

At 17:41:43 UTC, the aircraft touched down at VOBL airport with Landing weight of 63.0 T (< MLW = 66.0T). During the rollout, both reversers (REV IDLE notch) were deployed for 24s.

At 17:42:58 UTC, aircraft came to a stop, and the Parking Brake was applied. At 17:43:24 UTC, the Master Lever of the Engine 2 was set to OFF. At 17:44:24 UTC, the Master Lever of the Engine 1 was set to OFF position.

A few seconds later, SCC called the PIC and informed that Fire on the Starboard Side still persisted. Both the flight crew exercised the emergency evacuation procedure. PIC discharged both the fire extinguisher bottles into the right engine. The fire was still there. Thereafter, PIC initiated evacuation from the Left Side of the Aircraft. LH slides were used. PIC and SIC coordinated the evacuation of passengers on the taxiway. ARFF extinguished the Fire of RH Engine. Evacuation of passengers was also done from RH after confirmation from ARFF. PIC and SIC carried out post evacuation Checks. Crew took the count of the passengers as they were transported to Terminal Building into the coaches. Two minutes later crew were moved to dispatch.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	NIL	NIL	NIL
Serious	NIL	NIL	NIL
Minor/ ~~None~~	NIL	10	NIL

1.3 Damage to Aircraft

The damage started with sequence of event in air. A possible Engine fire event was reported by the Senior cabin crew. Flames were observed from the RH Engine Exhaust (Fig1&2).

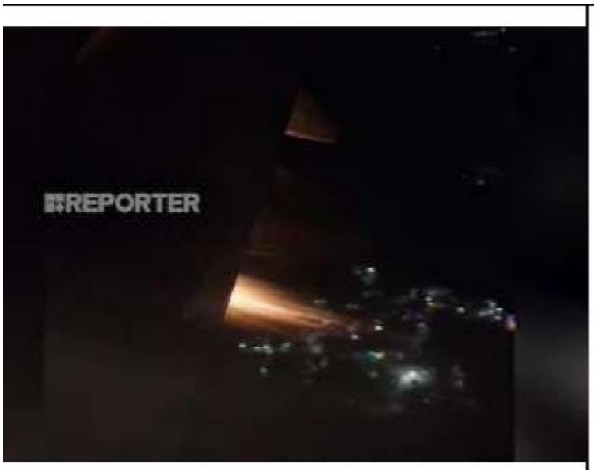


Fig 1 Flames from Engine.2 during climb

Fig 2 Flames from Engine 2 at landing

Fig 3 Engine tail Cone Condition

Fig 4 Engine Inlet condition post Fire Extinguishing action by ARFF

At around 0300 Hours IST, L2 escape slide was removed to gain access into the Aircraft, followed by switching on of the Auxiliary Power Unit by M/s AIX Connect Private Limited Engineering staff for opening of the cargo doors for baggage removal.

Thereafter, rest of the 3 deployed escape slides were also removed. During visual inspection, following were observed:

i. Engine 2 Pressure relief door was open. (Fig5).

Figure 5

ii. Engine 2 fan blades were hard to rotate

iii. In the cockpit, on the SD page; Engine No. 2 oil quantity was observed to be 6 Quarts, whereas Engine No. 1 oil quantity observed was 16.5 quarts (Fig 6).

Figure 6

iv. On overhead fire panel, Engine No. 2 fire button depressed with agent 1 discharge light on as shown in the picture below (Fig7).

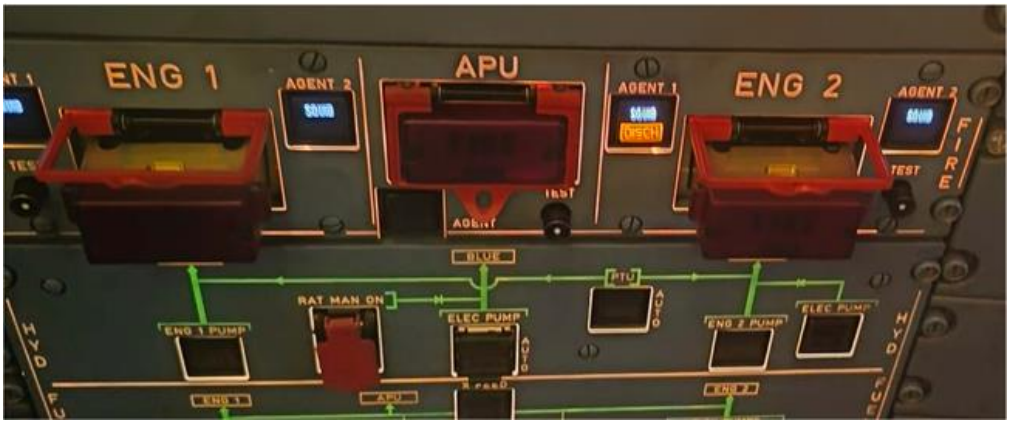


Figure 7

On 19.05.2024, Engine #02 fan cowl and thrust reverser cowl were opened for inspection. Externally, there were no burn marks or any damages to the Aircraft. No traces of oil, fuel and hydraulic fluid were found. Engine Magnetic Chip Detector were for checking and found abnormal contamination of magnetic debris (Fig8).

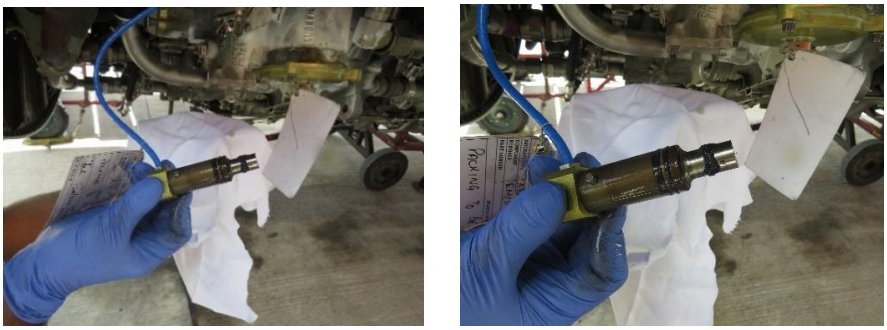


Figure 8

The following inspections were carried out:

i. Oil drained from the oil tank into a sample jar
ii. Fuel drained from the fuel filter drain into a sample jar,
iii. Fuel drained from RH ring drain point into a sample jar,
iv. Scavenge screens plugs were checked for particles and observed particles from No. 3 scavenge screen plug (forward sump).
v. Carried out Boroscope Inspection of High-Pressure Compressor Rotor for stage 1 & 2, found to be Satisfactory.
vi. Carried out Boroscope inspection of Low-Pressure Turbine stage 1 found to be satisfactory. All blades were with white deposits, carbon deposits and one blade trailing edge with blend repair observed on the 2nd, 3rd and 4th stage.
vii. Carried out Boroscope inspection of High-Pressure Turbine and found aft blade retainer outer seal dislodged from the position. All blades leading edge discolored with black. Unable to see thermal barrier coat (TBC).
viii. Post Flight Report: As per the post flight report following events were recorded: (Engine, Stall). Hydraulic Reservoir Low Level message recorded. Along with the above, operational test of engine fire and overheat detection from MCDU was carried out and found to be satisfactory. Connectors 2WD2-A and 2WD2-B from ENG #2 (2WD2) were disconnected. The resistance measured between pin J & K on both the connectors and found values within limit (1511 ohms for loop a and 1501 ohms for loop b), the required values are between 1425 ohm and 1575 ohm. Aircraft was normalized and operational test of loop/squib test carried out and found to be satisfactory.
ix. Load report reviewed, observed code 7000. No Hard landing was recorded. All the values were within range. Hence no further maintenance action required.

Fig 9 Aircraft after landing and emergency evacuation, with all sides deployed

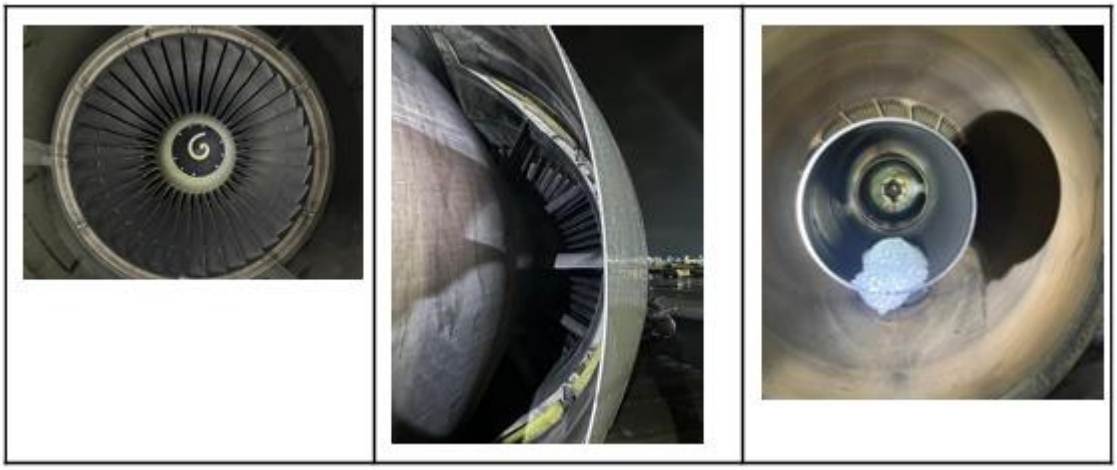


Fig 10 Engine Inlet Conditions

Pictures of the engine 2 taken after extinguishing the fire by the fire brigade showed no damage on the engine inlet and exhaust areas but some oil traces were observed (Fig10).

Under mentioned systems of the aircraft were inspected for defects or damages and nothing abnormal was found in any of the systems:

- Nacelle structure and systems
- the air intake cowl
- the fan doors cowl the
- thrust reverser system
- the fire barrier
- pylon structure
- wing structure

The initial observations of the investigating team are as follows: -

- Physical Examination of engine revealed that the engine oil Quantity was 7.5 Quarts in No.2 engine whereas the engine oil Quantity was 17.5 Quarts in the No. 1 engine. As per the records, both the engines had 17.5/17.0 Quarts engine oil respectively before the last take off. The previous engine oil topping up was done on 17.05.2024 at 21:30:00 hrs. IST (0300 UTC). (3.0 Quarts on engine No.1 & 2.0 QRT an engine No.2). The aircraft has flown 09:14 hrs. after the last top up of the engine oil inclusive of the incident flight. The Oil consumption rate was 0.187 lts/hr.

1. As per Post Flight report ENG 2 Stall warning/ Maintenance Message reported in phase 6 (climb) of flight.
2. No Visual damage observed in inlet and exhaust areas.
3. No damage on Fan cowl or T/R cowl observed.
4. Manual rotation of Fan blade caried out, found hard to rotate.
5. Oil Qty at departure was 17.5 Quarts post landing observed 7.5 Quarts (Fig11) Suspected oil Leak.

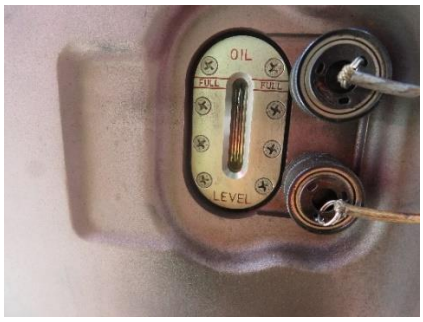


Figure 11

6. External fire extinguisher (Aqueous Film Forming Foam (AFFF)) type used into engine no # 2 thru Fire tender.
7. Inlet cowl Anti ice discharge vent door Blow out reported post landing.

1.4 Other damage

Maintenance activities carried out as per TSM TASK 73-00-00-810-866 (pertaining to Stall Checks), TSM TASK 72-00-00-810-801(Trouble Shooting for Tail Pipe Fire) and AMM TASK 72-00-00-200-007-A (A procedure after Engine Fire or use of Fire Extinguishing Agent). Scavenge screen plugs were checked for metal/magnetic particles. Observed particles from three scavenge screen plugs (forward sump) (Fig12).

Fig 12 Whiteish/ Greyish particles up to several centimetres long

Boroscopic examination was carried out and following were the findings:

LPT Stage 2 - White deposits and carbon deposits were seen on all the blades. One blade trailing edge was found with blend repair.

All the stages were found with white deposits on the blades

Inspection of HPT revealed AFT Blade retainer out of seal and wire dislodged from the position. All blades leading edges were discolored with black soot marks.

During the inlet inspection found AFT acoustical panel leading edge damaged from at 6'o clock to 8'o clock.

No other abnormalities were noticed.

1.5 Personnel Information

Crew Information – PIC

Nationality	Indian
Date of Joining Organisation	11 Oct 2023
Age	34
License	ATPL - 5819
Date of Issue	02 May 2014
Valid up to	01 May 2026
Category	Aeroplane
Date of Class I Med. Exam	18 Nov 2023
Class I Medical Valid up to	17 Dec 2024
Date of issue FRTOL License	20 Nov 2009
FRTO License Valid up to	19 Nov2024
IR rating and Instructor rating	11 Aug 2024
Total flying experience	8429:03 Hours
Total flying experience on type	5526:28 Hours
Total flying experience during last 1 year	501:23 Hours
Total flying experience during last 6 Months	310:26 Hours
Total flying experience during last 30 days	48:28 Hours
Total flying experience during last 07 Days	9:13 Hours
Total flying experience during last 24 hrs	15 min
Rest period before flight in hrs	18 Hours
Ratings	A320, E190, E170, DHC8, P68, C172
Date of latest Flight Checks, Ground Classes & Refresher	Annual Line Check – 15 Nov 2023 Pilot Proficiency Check – 23 March 2024 Instrument Rating – 12 Aug 2023 Ground Refresher – 30 Oct 2023

Crew Information – Co Pilot

Nationality	Indian
Date of Joining Organisation	Transferred from AI on 12th September 2023
Age	40
License	5620
Date of Issue	05 Dec 2013
Valid up to	03 Dec 2025
Category	ATPL
Date of Class I Medical Exam	01 March 2024
Class I Medical valid up to	03 March 2025
Date of issue FRTOL License	30 Apr 2010
FRTO License valid up to	21 Jul 2025
IR rating and Instructor rating	01 May 2025

Total flying experience	8400 Hours
Total flying experience on type (A320)	8100 Hours
Total flying experience during last 1 year	303:58 Hours
Total flying experience during last 6 Months	303:58 Hours
Total flying experience during last 30 days	47:45 Hours
Total flying experience during last 07 Days	9:40 Hours
Total flying experience during last 24 hrs	15 min
Rest before the incident flight (in Hrs) as on 18.05.2024	19 Hours.
Ratings	A320, C172, PA334
Date of latest Flight Checks, Ground Classes & Refresher	Flight 17-Dec-2013 Sim 02-May-2024 Ground Refresher 18-Sep-2023 to 07-Oct-2023 (OCC)

Cabin Crew Information

Sl. No.	Aircraft Type	Type of training	Training Date	Valid up to
01	A320	Annual recent training	14.08.2023	13.08.2024
02	A320	Annual recent training	22.08.2023	21.08.2024
03	A320	Annual recent training	14.08.2023	13.08.2024
04	A320	Annual recent training	14.08.2023	13.08.2024

1.6 Aircraft Information

The A320-216 is a subsonic, medium-range, civil transport aircraft. The aircraft has two high bypass turbofan CFM56-5B6/3 engines. The aircraft is designed for operation with two pilots and has been configured by M/s Air India Express for 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 of the aircraft is 39,100 feet and maximum takeoff weight is 73500 Kgs. The Maximum Landing weight is 66000 kg. The Aircraft length is 37.57 meters; wingspan is 34.1 meters and height of this aircraft is 11.755 meters. The distance between main wheel center is 7.59 meters. The distance between engines is 11.51 meters and Engine Ground Clearance is 0.56 meters (Fig14).

The aircraft was equipped with CFM56-5B6/36/3 Engine. The CFM56-5B6/3 engine is a high bypass, dual rotor, axial flow, advanced technology turbofan. It is supported by the wing pylon and streamlined by cowlings. The description of the Engine and its various modules relevant to the investigation are given below. The CFM56-5B engine consists of two independent rotating systems: The low-pressure system rotational speed is designated N1. The high-pressure system rotational speed is designated N2. The primary airflow passes through the inner portion of the fan blades and is directed into a booster, also called a Low-Pressure Compressor (LPC).

The flow through the primary path enters a High-Pressure Compressor (HPC) and goes to a combustor. Mixed with fuel and ignited, the gas flow provides energy to a High-Pressure Turbine (HPT) and a Low-Pressure Turbine (LPT) producing approximately 20% of the total thrust.

The secondary airflow passes through the outer portion of the fan blades, the Outlet Guide Vanes (OGV's) and exits through the nacelle discharge duct, producing approximately 80% of the total thrust. It also plays a role in the thrust reverse system (Fig13).

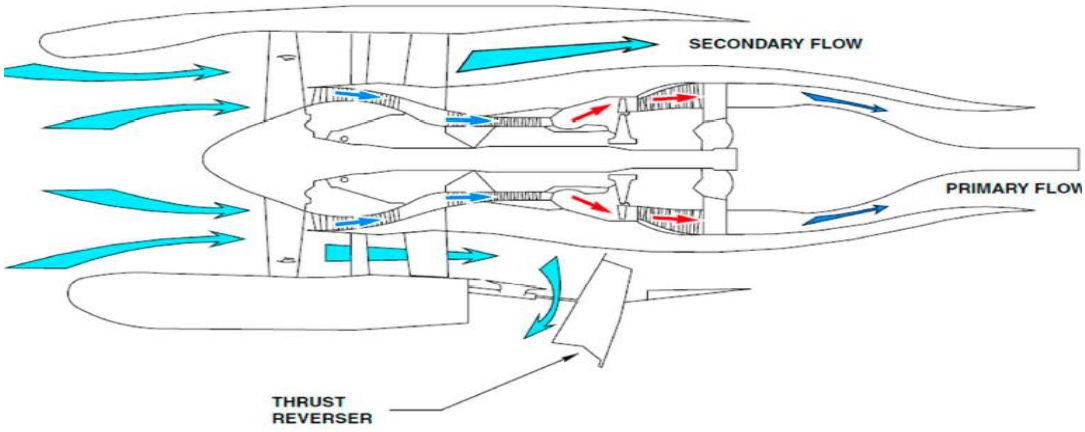


Figure 13

The engine rotors are supported by 5 bearings, identified as numbers 1 through 5, where No 1 is the most forward and No 5 the most aft. These bearings are housed in 2 dry sump cavities provided by the fan and turbine frames. The forward sump cavity houses No 1, No 2 and No 3 bearings: No 1 and No 2 bearings hold the fan shaft. No 3 bearing holds the front of the HP shaft. The rear sump cavity houses No 4 and No 5 bearings: No 4 bearing holds the rear of the HP shaft. No 5 bearing holds the rear of the LPT shaft (Fig15,16&17).

Engine structural rigidity is obtained with short lengths between two main structures (frames). The accessory drive system uses energy from the high-pressure compressor rotor to drive the engine and aircraft accessories. It also plays a major role in starting. The Intermediate Gearbox (IGB) transfers torque between the HPC front shaft and the accessories. It also supports the front end of the core engine. It is located in the fan frame sump and is bolted to the forward side of the fan frame aft flange. It is only accessible after different engine module removals. The IGB contains the following parts: Horizontal bevel gear (with coupling/locking nut). Radial bevel gear. No 3 bearing (ball and roller). Rotating air/oil seal.

The No. 3 Bearing

The No. 3 bearing assembly consists of a ball bearing (No.3B) and a roller bearing (No.3R). The assembly is installed between the IGB housing and horizontal bevel gear. The No. 3 bearing acts as a core engine thrust bearing and provided axial positioning of the forward end of the HPC rotor. The roller bearing is located directly after the ball bearing and radially positions the core engine rotor. The bearing and gear are lubricated and cooled by oil, supplied through the forward sump oil manifold assembly.

The No. 4 Bearing

The No 4 bearing takes up the radial loads generated by the High-Pressure Turbine rotor. It is a roller bearing, installed between the HPT rear shaft and the LPT shaft, at the front of the LPT shaft hub. The bearing outer race is housed in the HPT rear shaft bore. Its inner race is bolted to the front face of the LPT shaft integral hub. The No 4 bearing inner race has a shoulder, which acts as an emergency bearing in case of roller failure. The forward end of the inner race has seal teeth that rub against an abradable coating located on the No 4 bearing forward rotating oil seal, thus acting as one of the sump air/oil seals (Fig18).

Aircraft VT-ATF (MSN 6015) had been manufactured in year 2014. The aircraft was registered with DGCA under the ownership of M/s Air India Express Limited. The aircraft was issued Certificate of Registration No. 4491/6 on 20.03.2014. The Certificate of Airworthiness Number 6600 under "Normal category" subdivision “Passenger / Mail / Goods” was issued by DGCA on 20.03.2014. The validity of the C of A is subject to the validity of Annual Review Certificate and the same was issued on 28.03.2024 and was valid till 28.03.2025. The specified minimum operating crew is two and the maximum all up weight is 73500 Kgs. The Aircraft was holding a valid Aero Mobile License at the time of incident which was valid till 28.03.2025. As on date of incident, the aircraft had logged 32627 Airframe Hours and 21974 cycles.

The RH CFM56-5B6/3 engine serial number 569159 was removed on 18-Feb-2022 due to LLP Removal with TSN 25913:51 hours and CSN 17311 was inducted into GE Aircraft Engine Services, Malaysia for repair and was allocated GEESM Work Order Number 10187463.On receipt at GE Aircraft Engine Services, Malaysia the engine was subjected to incoming inspection and engine health checks. The incoming health checks of the main engine filters and magnetic chip detectors (MCD's) deemed satisfactory with no finding. Borescope inspection was not performed during incoming due to all modules will be removed and disassembled. A full performance test of the engine was carried out in accordance with ESM 72-00-00. Engine was tested on 24 June 2022 for 5B24/3 ratings. The EGT margin achieved was 114.87 degrees C (HD/TO) respectively.

Subsequently, all lower inspections (Pre-flight checks, Service Checks, Weekly Checks) were carried out as and when due before the incident. The aircraft was last weighed on 21.03.2020 at Hyderabad and the weight schedule was prepared and duly approved by DGCA. As per the approved weight schedule, the Empty weight of the aircraft is 41877 Kg Maximum Usable Fuel Quantity is 18970 Kg. Maximum payload with fuel tanks full is 11718 Kg. Empty weight CG is 18.96% of MAC (Mean Aerodynamic Chord). As there has not been any major modification affecting weight & balance since last weighing, hence the next weighing is due on 20.03.2025(at the time of Incident). The weight and balance of the aircraft was well within the operating limits. The aircraft was equipped with CFM56-5B6/3 engines.

The details of the Engines are given below: - Details RH Engine LH Engine Serial Number: 569159: 569158 Date of Manufacture: 28.01.2014: 22.01.2014 Last Major Inspection: 26.06.2022: 26.06.2022 Total Engine Hours/Cycles: 32627.14 / 21974: 32475.47 / 21852

The RH Engine had completed 6713.49 Hrs /4663 Cycles since the last shop visit. All concerned Airworthiness Directives, mandatory Service Bulletins, DGCA Mandatory Modifications on this aircraft and its engine has been complied with as on date of event.

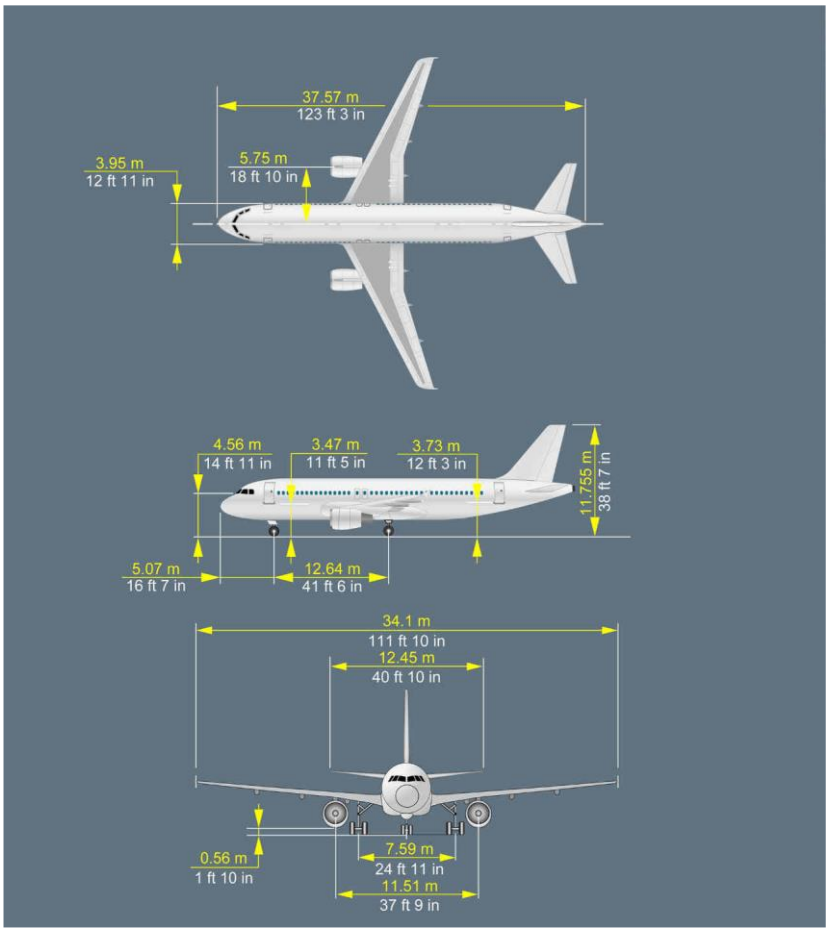


Figure 14

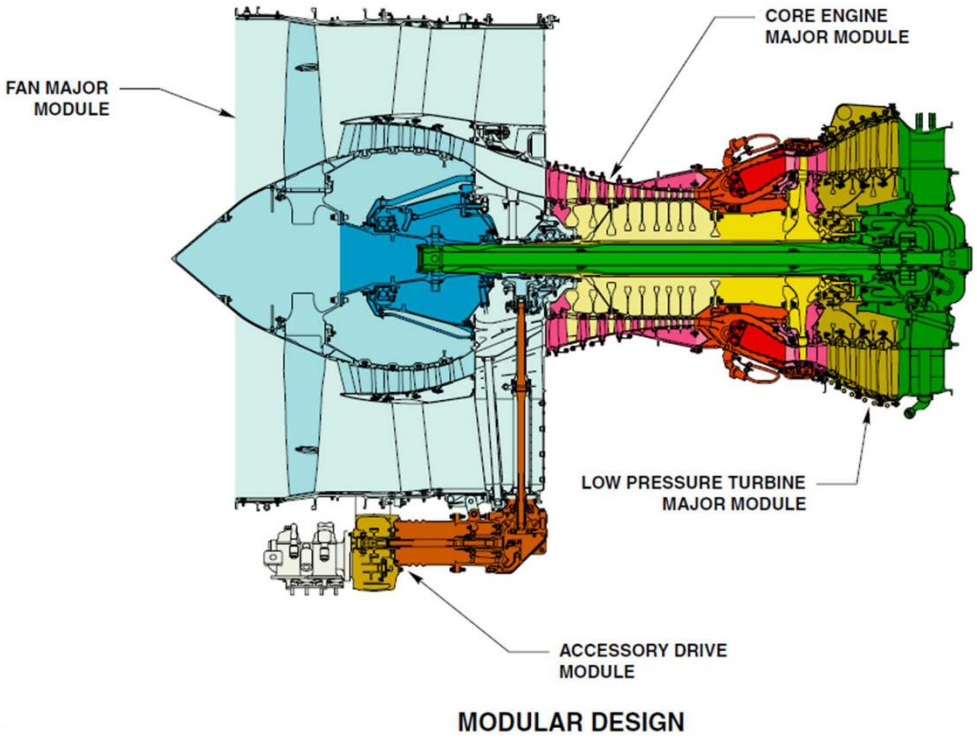


Figure 15

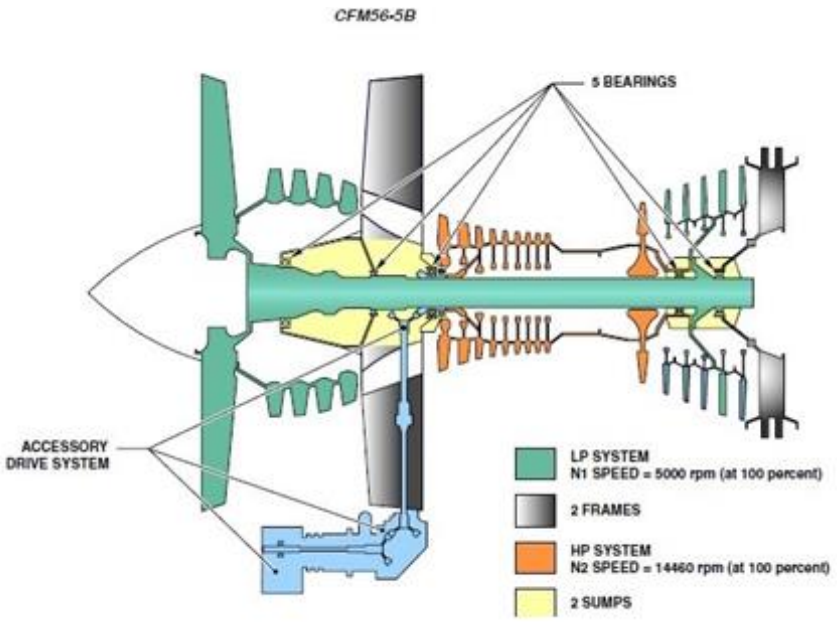


Figure 16

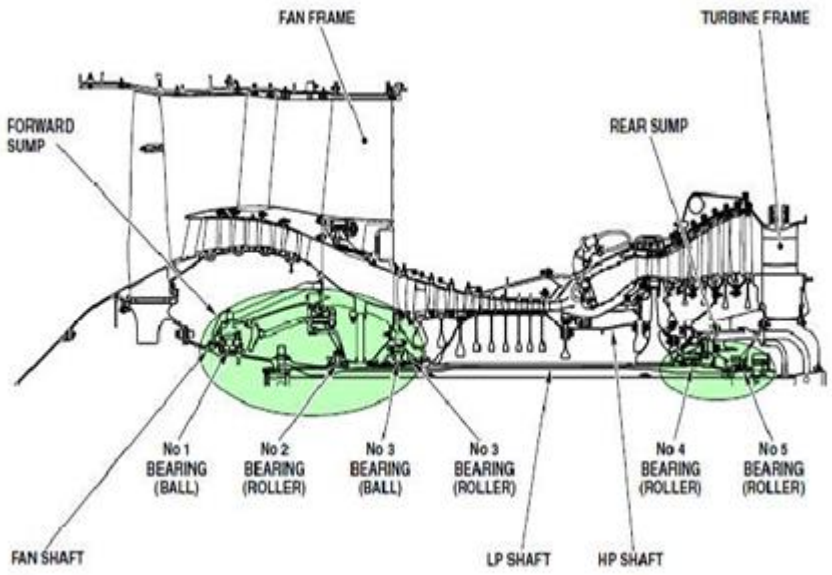


Figure 17

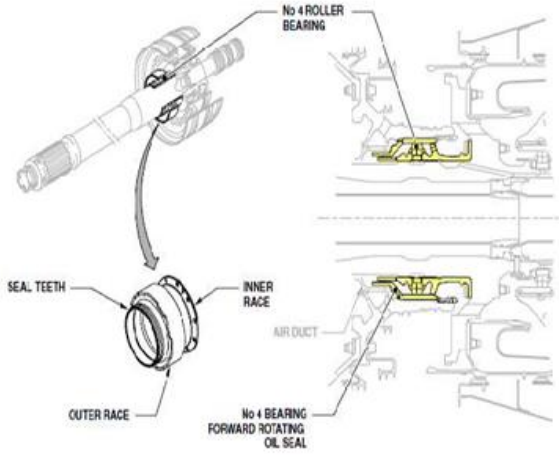


Figure 18

Aircraft Model	Airbus A320 – 216
Aircraft S/N	VT – ATF
MSN	6015
Year of Manufacturer	2014
Name of Owner	Air India Express
C of R	12.03.2024
C of A	20.03.2014
Category	Normal
C of A Validity	28.03.2025
ARC issued on	20.03.2014
ARC valid up to	28.03.2025
Weight Schedule Approval	Recomputed on 05.03.2024
Insurance Validity	Valid thru 30.03.2025
Noise Certificate Issue	Issued on 20.03.2024
Aircraft Empty Weight & Empty weight CG	41,877 kg
Maximum Take-off weight	73,500 kg
Date of Aircraft Weighment	21.03.2020
Empty Weight	41,877 kg
Max Usable Fuel	18,970 kg
Max Payload with full fuel	63,757 kg
Next Weighing due	20.03.2025
Total Aircraft Hours	32627 Airframe Hours
Last major inspection	18.02.2022
List of Repairs carried out after last major inspection till date of incidence	Verified
Engine Type	CFM56-5B6/3
Engine Sl. No. (LH)	569158
Date of Manufacture (LH)	22.01.2014
Last major inspection (LH)	22.06.2022
List of Repairs carried out after last major inspection till date of incidence (LH)	Verified
Total Engine Hours/Cycles (LH)	32475.47/21852

Engine Sl. No. (RH)	569159
Date of Manufacture (RH)	28.01.2014
Last major inspection (RH)	26.06.2022
TSN	32627:14 Hours
CSN	21,974
List of Repairs carried out after last major inspection till date of incidence (RH)	Verified
Total Engine Hours/Cycles (RH)	21836 Hours
Oil Consumption Rate	0.187
Last BSI Findings	Nil
Oil used on	ETO 2380
Aero mobile License	28.03.2025
AD, SB, Modification	Complied

1.7 Meteorological Information

METAR data for the VOBL (Bengaluru International Airport Limited) at 1730 UTC is shown in the tabular column given below:

S. No.	Description	Value
01	Visibility	6000 meters
02	Wind direction	Variable
03	Wind Speed	02 Knots
04	Temperature	23°C
05	Dew Point	21°C
06	Scattered Clouds 0	360 meters
07	Scattered Clouds 8000	2400 meters
08	QNH	1011 HPA
09	QFE	908 HPA

1.8 Aids to Navigation

Navigation Aids available at Bengaluru airport are as per the table given below:

Type of Aids		**Identification**	**Frequency/ Channels**	**Geographical Coordinates of the position of the transmitting antenna**
DVOR		BIA	116.800 MHz CH115X	131232.9N 0774140.9E / 3025 FT
DME		BIA	116.800 MHz CH115X	131232.9N 0774140.9E / 3025 FT
LOC 24	LOC 27R CAT I LOC 09L CAT I LOC 27L CAT IIIB LOC 09R CAT IIIB	IDEV IBAN IDVN IBLN	108.300 MHz As ATS 109.300 MHz As ATS 111.500 MHz H24 109.900 MHz H24	131225.9N 0774059.4E 131224.6N 0774333.1E 131123.2N 0774112.3E 131121.7N 0774351.3E
GP 24	GP 27R GP 09L GP 27L GP 09R		334.100 MHz As ATS 332.000 MHz As ATS 332.900 MHz H24 338.800 MHz H24	131228.7N 0774312.1E 131229.7N 0774122.8E 131118.0N 0774325.8E 131119.0N 0774134.8E

DME ILS 24	DME ILS 09L DME ILS 27R DME ILS 27L DME ILS 09R	IBAN IDEV IDVN IBLN	CH30X / As ATS CH20X / As ATS CH52X / H24 CH36X / H24	131229.8N 0774122.7E / 3021 FT 131228.8N 0774312.1E / 2943 FT 131117.8N 0774325.8E / 2977 FT 131118.8N 0774134.9E / 2984 FT

1.9 Communications

The aircraft maintained a positive contact with ATC during the flight. The crew displayed good CRM towards decision making. The aircraft emergency was analyzed, and MAY DAY call was given. There was no ECAM warning, but crew correlated the situation w.r.t the loud bang sound and SCC input about fire from Right Engine.

173023	AXB1132	Bangalore AXB1132 Namaskar 4000 Squawk 2743
173029	APP – DEP	AXB1132 Namaskar climb to FL110 identified
173033	AXB1132	FL110 AXB1132
173039	AXB1132	Confirm climb 110
173040	APP – DEP	AXB1132 Affirm 110
173043	AXB1132	110 AXB1132
173059	AXB1132	AXB1132 Due technical request level off at 6000
173104	APP – DEP	AXB1132 approved
173121	AXB1132	RADAR requesting vectors to come back for Bangalore AXB1132
173128	AXB1132	Turn left heading 180 AXB1132 Sir we request right heading one…. Right heading 180
173143	APP – DEP	AXB1132 approved will you maintain 6000
173149	APP – DEP	AXB1132 confirm would like to maintain 6000
173152	AXB1132	Affirm would like to maintain 6000 AXB1132
173156	APP – DEP	…… Turn right heading 090 now
173158	AXB1132	Say again heading
173200	APP – DEP	Right heading 090
173202	AXB1132	Right heading 090 AXB1132
173204	APP – DEP	AXB1132 advise if any priority is required
173207	AXB1132	We do not require
173208	AXB1132	AXB…. AXB1132 would like to upgrade our situation MAYDAY we have a possible engine fire on engine no. 2
173221	APP – DEP	Roger
173223	AXB1132	And sir what is the active Runway right now
173227	APP – DEP	Expect Runway 27L
173229	AXB1132	27L copied sir request shorter vectors for Runway 27L
173236	APP – DEP	AXB1132 Roger
173250	APP – DEP	AXB1132 reconfirm possible fire on No. 2 engine right
173254	AXB1132	….. as of now we have suspected fire
173328	APP – DEP	AXB1132 if able fly heading 090
173415	APP – DEP	310 approved break break AXB1132 contact arrival 12125
173419	AXB1132	12125 AXB1132
173956	AXB1132	(…) AXB1132 Namaskar Ah….
173959	TWR2	AXB1132 Bengaluru tower namaskar wind 300 degrees 04 knots Runway 27L cleared to land
174006	AXB1132	Cleared to land Runway 27L AXB1132
174233	AXB1132	We have a possible evacuation on the parallel taxiway AXB1132
174321	TWR2	AXB1132 CFTs are proceeding towards you.
174325	AXB1132	And …. are they on the same frequency

1.10 Aerodrome Information

Kempegowda International Airport, Bengaluru has two runways

Runway designation	Length	Width	Approach lights/ILS
09L/27R	4000M	45M	CATI/CATI
09R/27L	4000M	45M	CATIII/CATIII

1.11 Flight Recorders

The aircraft is fitted with CVR and FDR model FA 2100 (L3). Both flight recorders are located in the tail compartment. The Recorder was carried to AAIB for download of the data. Post serious incidents, CVR & DFDR were in serviceable state and data has been downloaded from both the recorders for analysis. The Newly purchased recorder Lab equipment HHMPI was used and assistance of DGCA Lab was taken to download the data.

1.11.1 Digital Flight Data Recorder (Fig19).

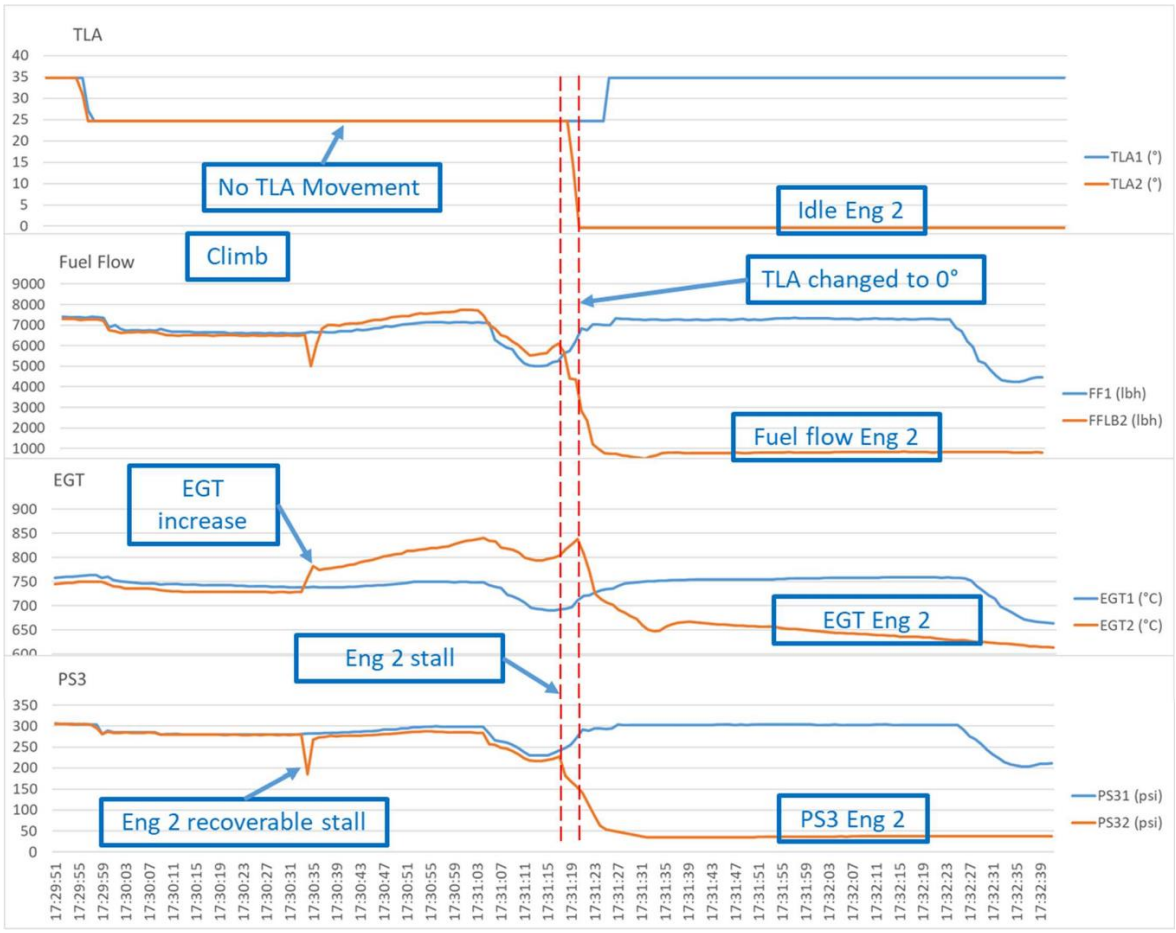


Figure 19

Initial conditions

At 17:29:39 UTC, aircraft took off from VOBL airport, runway 27R in FLEX mode (Thrust levers in FLEX notch and Flex Temp = 54°C).

At 17:29:52 UTC, crossing 400ft RA, Aircraft performed a right turn with bank angle reaching up to +18.3°. Wings leveled off at 17:30:20 UTC.

At 17:29:57 UTC, crossing 600ft RA, both Thrust Levers were pulled to CLIMB notch.

Climb - First stall

At 17:30:32 UTC, crossing 1300ft RA,

- N1A2 (N1A from engine 2) suddenly dropped from 85% to 69% then recovered back to 85% in 2 seconds (while N1A1, N1A from engine 1, remained at 85%)
  As a consequence, Aircraft rolled to the right with bank angle reaching up to +2.8°.
- EGT2 suddenly jumped from +728°C to +782°C then continued increasing progressively during 30s until 838° whereas EGT1 stabilized around 750°C.
- PS3 from Engine 2 decreased from 280 to 180 PSI, then recovered back in 2s (while PS3 from Engine 1 remained stable).

Climb - N2 vibration started increasing

At 17:31:00 UTC, while N1As were also stable at 87%, Engine 2 N2 vibrations started to increase from 0.8 CU.
At 17:31:05 UTC, the ATHR commanded a N1A reduction to both engines in accordance with the AP longitudinal mode change and both N1A1 and N1A2 started to decrease accordingly. EGT1 and EGT2 started to decrease at the same speed respectively from 750° and from 838°, respectively towards 700° and 800°.
At 17:31:11 UTC, crossing 2000ft RA (4900ft QNH), ECAM HYD Y LO LVL triggered for 1s.

Climb - Second stall

At 17:31:17 UTC, crossing 2200ft RA (5200 ft QNH),

- While N1A1 and N1A2 were evolving similarly and were equal at 78%, N1A2 started to decrease from 78%.
- While PS31 and PS32 were evolving similarly and were equal to 240PSI, PS32 suddenly jumped down to 180PSI.
- Aircraft rolled to the right with bank angle reaching up to +4.6°. Thrust asymmetry started to be countered by rudder and ailerons.

The ENG2 STALL and its associated master caution triggered in the cockpit (Fig20).

At 17:31:18 UTC, the Thrust Lever of Engine No 2 was pulled to the IDLE notch. 1s later:

- N1A2 started to decrease accordingly.
- EGT2 reached 838° and then started to decrease until 640° (reached 15s later).

At 17:31:23 UTC, the Thrust Lever 1 was pushed to the MCT notch. N1A1 increased to 89%.

At 17:31:26 UTC, N1A2 was 32% and decreasing.

- Engine 2 N2 vibrations reached 4.2 CU and started decreasing.
- 1 second later, Engine 2 N1 vibrations reached 5.0 CU (for 1 second) and started decreasing

In Flight Turn Back

At 17:35 UTC, the aircraft descended from 6000 ft on QNH and turned back to VOBL airport.
During the descent, the oil quantity of engine 2 started decreased upto 6 quarts until touchdown.

Landing and rollout

At 17:41:43 UTC, the aircraft touched down at VOBL airport with Landing Weight of 63.0T (< MLW = 66.0T).

During the rollout, both reversers (REV IDLE notch) were deployed during 24s.

At 17:42:58 UTC, aircraft came to a stop and the Parking Brake was set.

At 17:43:24 UTC, the Master Lever of the Engine 2 was set to OFF. The engine 2 oil quantity was 6 qts while engine 1 oil quantity was 16.5 qts (As viewed in cockpit).

At 17:44:24 UTC, the Master Lever of the Engine 1 was set to OFF position.

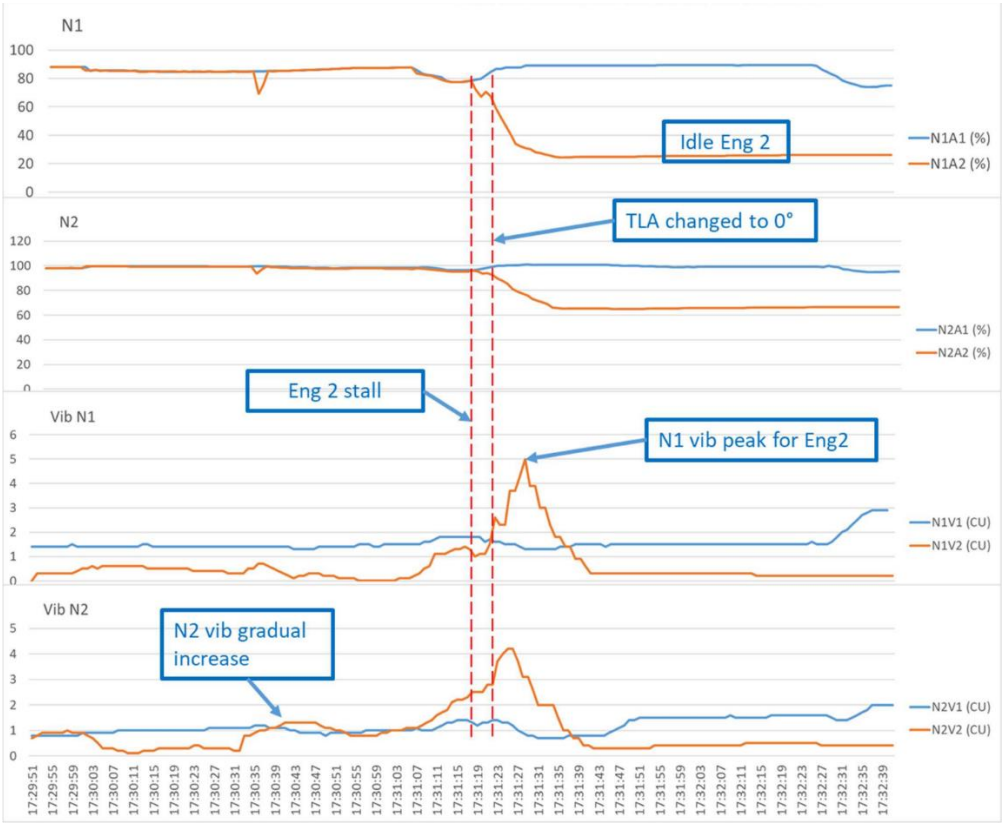


Figure 20

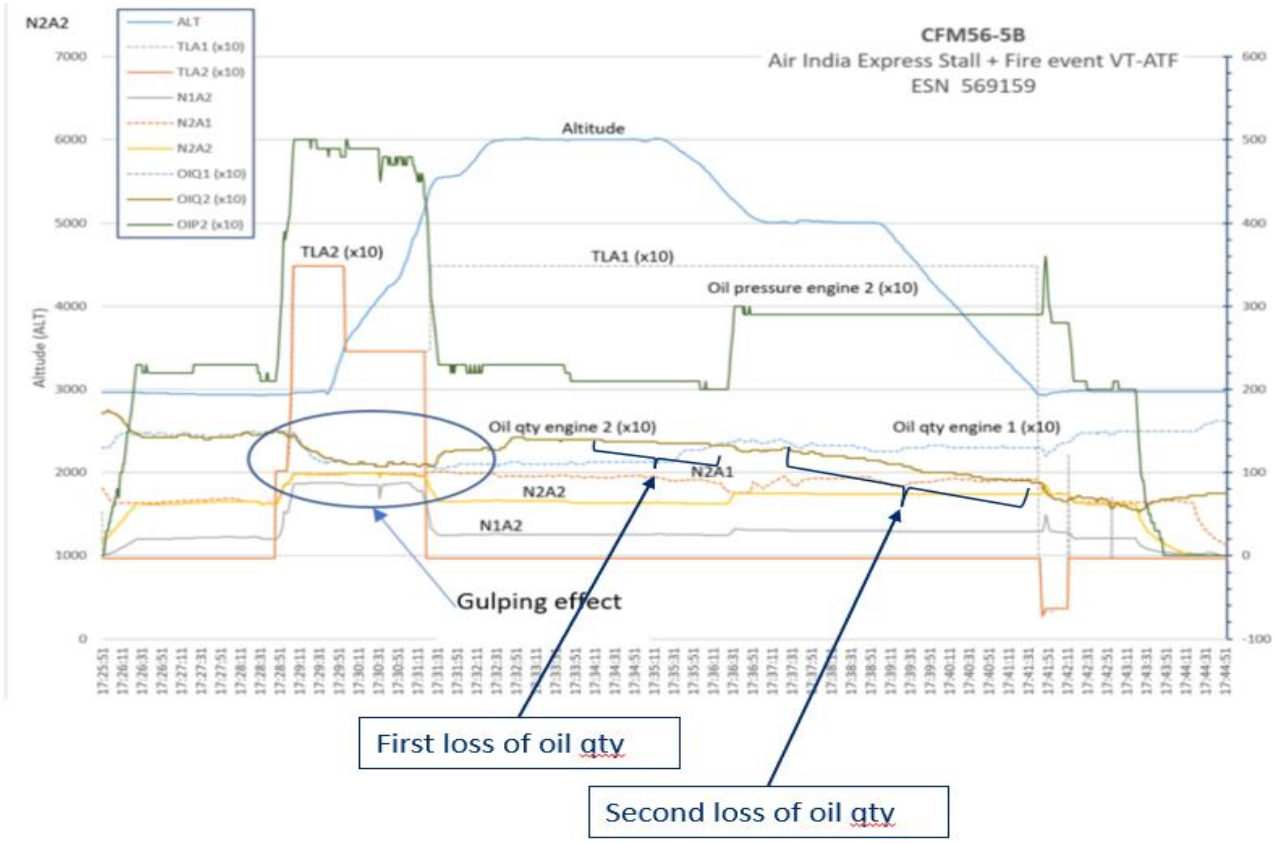


Figure 21

The FDR Plot above shows that both the stalls occurred shortly after during climb phase started. PFR indicates the Eng2 stall at 17:31 UTC which is coherent with the Flight data.

PFR indicates PH06 at the moment of Stall on ENG 2, 3s after, the TLA for ENG 2 was pushed back to 0° position.

ENG 2 stalled few moments before, during climb but was a recoverable stall without pilot intervention.

After each stall a typical increase is noted on the EGT, within AAM limits.

There is coherence in Fuel Flow, EGT and PS3 values, the typical signature of stall is confirmed.

After ENG 2 stalled for the second time, an increase in vibration values, up to 5.0 Cockpit Units was observed for the LP system and 1.5 CU for the HP system.

N2 (HP) vibration gradually increased starting from the 1st stall.

It can also be observed that once the TLA was pushed back to 0° both N1 and N2 vibration show the bigger values for the ENG2

Both stalls occurred shortly after during climb phase started. PFR indicates the ENG2 stall at 17:31 which is coherent with the flight data.

The engine parameters are coherent with the N1 reduction observed.

According to DFDR data, a gulping effect can be observed when TLA is pushed to take off. Similar behavior on engine oil quantity on both engines when TLA are pushed to take off until TLA for No. 2 engine is put at idle. Gulping effect is a decrease of oil tank level due to increase of pressure and flow rate when engine starts and goes from idle to higher N2 speed rotation. More oil is located in sump areas and scavenge lines.

After that increase in oil level of Engine No.2 in oil tank was observed. The pressure and flow rate from lube unit is normally low (TLA is put on idle), directly proportional of N2 speed.

- Gulping effect from 17:28:11 to 17:31:11 when TLA is pushed from ground idle to TO/climb for around 2 minutes (Fig21).
- When TLA pulled to idle, oil level becomes near before TLA pushed to TO/climb at 13:32:51.

  - First loss of oil quantity, ˜ 1quart in 2 minutes (between 17:34:31 et 17:36:31),

  - Second oil loss quantity, ˜ 5 quarts in 4 minutes (between 17:37:31 et 17:41:51)

  - Loss of oil increasing from 17:41:21 and 17:43:31.

The plot was generated by OEM software to correlate with in-house readout. The parameters and events were correlated with PCMCIA Card reflecting vital parameters of the Incident (Fig22).

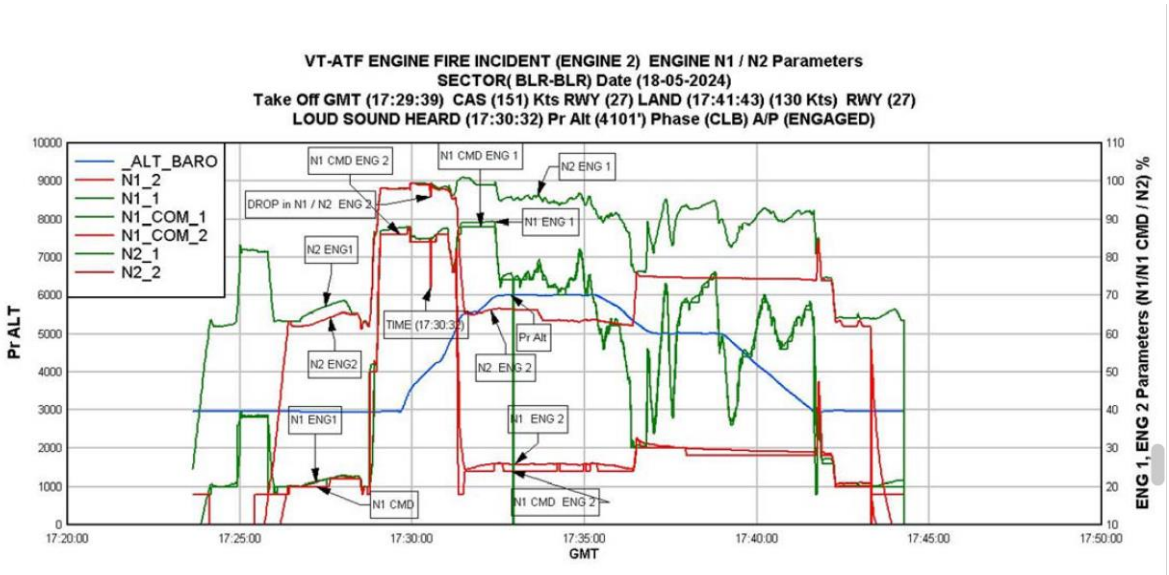


Figure 22

The crew reported engine stall in their statement post incident as well as the crew discussion recorded on the CVR. This fact could be corroborated with the FDR Data at time 17:30:33 the N2 rpm dropped from 99.06% to 93.75% and again came back to 99.63% at time 17:30:33 and 99.44% at time 17:30:34. This the most probable point of event.

During same time the fuel flow and EGT both started rising the fuel flow from 2944 to 3498 and Max 3508 (N2rpm 97.63) and EGT from 728°C to 840°C The engine N2 RPM of engine No2 was less than engine No.1 But flow and EGT both higher by 550°C and 80° C to 10°C respectively.

The engine vibration of No.2 engine also increased from 01 unit to max 5 unit for up and 4 units for MPC as compared 02 and 01 unit each on engine No1.

The engine oil quantity of No.1 and No.2 was 17.5/17 before start-up. The cockpit indications showed that the oil level of engine No1 was at 16.5 LTR and in Engine No 2. the level read as 6 LTR. Oil level engine No.1 remained at 16.5LTR till shut down the total duration of sortie was 24mins from chocks off (1720Hrs) to chocks on (1744 Hrs.) The time in the air was 12 mins (1729Hrs) to 1741hrs).

1.11.2 Engine Control Unit Data Download

ECU Part No.07482SOCN2458M04P01 Sr No. FFFD1431 MFR-63760 was sent to CFM through the ACC REP for download. The ECU was inspected visually and was in good condition. The connectors were in good condition. Some traces of humidity were observed inside the ECU casing, without any incidence on the ECU operation or the NVM download. The NVM download was carried out successfully for both the channels.

Observations of two minor faults of Class 3 were recorded on each channel of the ECU. Recorded faults were not linked to the stall, fire event and the dates of recordings were different.

1.12 Wreckage and Impact Information

Damages were confined to core of Engine No.2 only. No damage to any other part of the aircraft was observed.

1.13 Medical and Pathological Information

Pre and Post Flight BA Test of all the crew member were carried out, and all crew were tested negative.

1.14 Fire

After an uneventful takeoff, the subject aircraft experienced engine stalls, associated with jolts and bangs from Engine 2, as the aircraft had crossed the thrust reduction altitude. The flight crew was informed just after by the cabin crew that fire from engine 2 was visible. The flight crew reduced the engine 2 thrust lever to IDLE. After the event of two successive stalls and the vibrations, and increase in EGT (within limits), the engine parameters in the cockpit did not show any abnormalities. The flight crew declared MAYDAY to ATC, reporting engine fire and turned back to Bengaluru. Once the aircraft landed and came to stand still, the captain shut down Engine 2. As the cabin crew informed the flight crew that there was still fire coming from the exhaust of Engine 2, the captain discharged the fire extinguisher bottles. Fire persisted and was extinguished by the firemen. After the fire was extinguished by the fire brigade, an emergency evacuation of the passengers was performed. All the four door escape slides were deployed. The airline reported that no passenger was injured. No damage in the aircraft structure was observed after the event. The fire was contained inside the engine core and in the exhaust area and therefore no ECAM warning linked to engine fire (which addresses fire in the nacelle area) was triggered.

1.15 Survival Aspects

The incident was survivable

1.16 Tests and Research

1.16.1 Engine Teardown Activity

Pre Teardown Activity

BSI (Fig23).

Inspection of 4 LPC booster stage blades carried out as per AMM 72-21-00-291-003.No abnormality observed. Inspection result found satisfactory. Inspection of HPC rotor stage 1 to 9 as per AMM 72-31-00-290-002. No abnormality observed. Inspection result found satisfactory. Inspection of combustion chamber and HPT nozzle carried out as per AMM 72-41-00-290-001-B. No abnormality observed. Except carbon deposits on inner liner, outer liner and HPT nozzle. Same was found within limits as per AMM.

On Inspection of HPT stages as per AMM 72-52-00-290-002, it was found that aft blade retainer outer sealing ring was found disengaged from the position. All blades L/E were discolored.

Fig 23 Boroscopic Image

Inspection of LPT Stage 1-3 as per AMM 72-54-00-290-005-A o All stages with white deposits on all the blades, carbon deposits. One blend blade on stage 2 T/E with blend repair. Carried out inspection of stage 4 blades as per AMM 72-54-00-290-006A • Observed all stages with white deposits on all the blades, carbon deposits.

MCD and FWD sump analysis

Onsite inspection show:

MCD (Magnetic Chip Detector) removed and checked as per AMM 79-00-00-281-002-A found chips. Scavenge screens plugs checked for particles as per AMM 79-21-10-000-007-a. Observed particles from no: 3 scavenge screen plug (Fwd sump) (Fig24,25,26,27 &28).

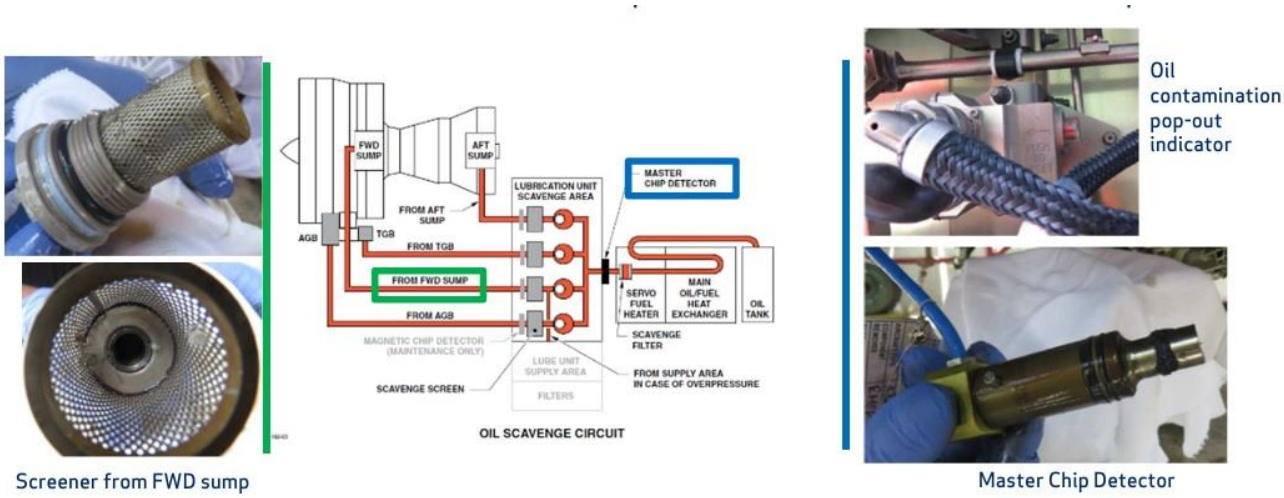


Figure 24

At Safran lab inspection:

MCD inspection:

Figure 25

The debris was analyzed but could not be identified to a specific material with high confidence (Fig25).

FWD sump inspection:

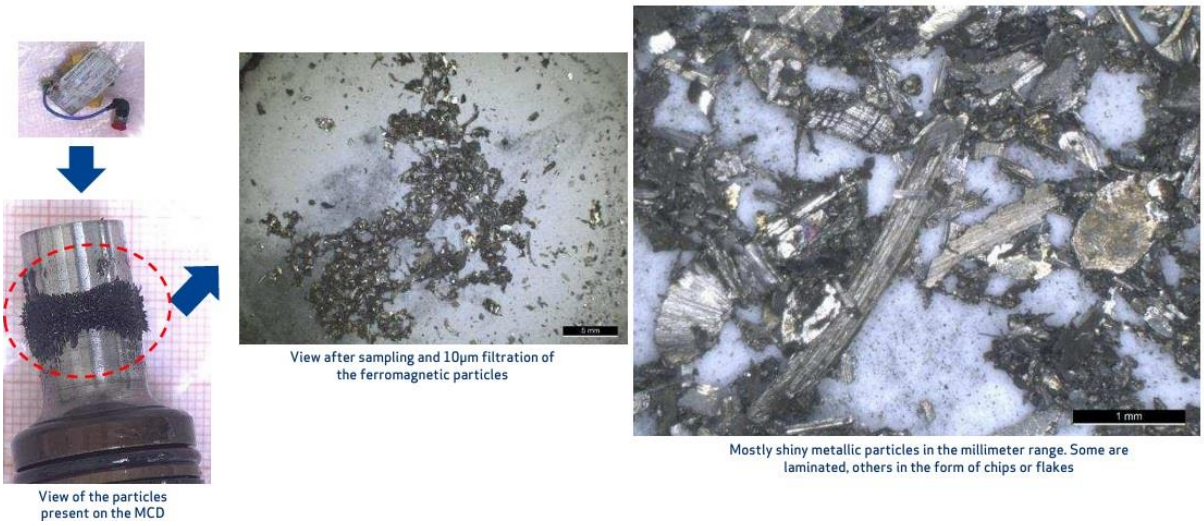
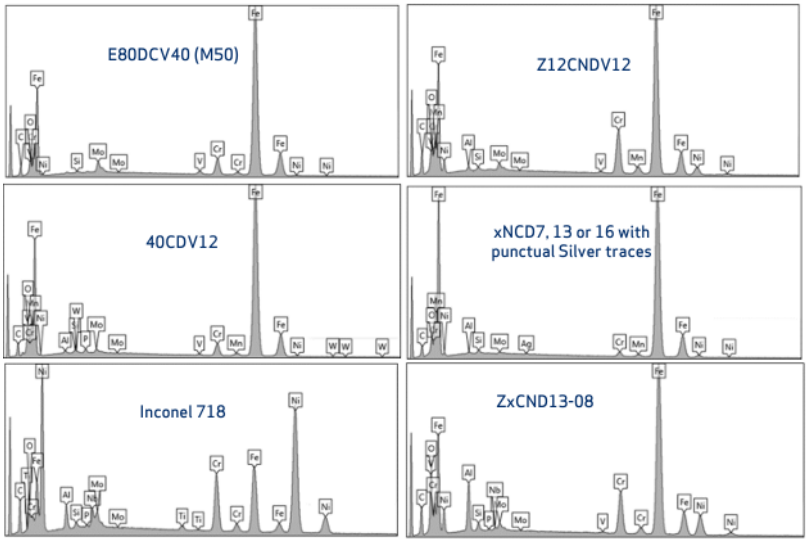


Figure 26



Suspected alloy	Proportion
xNCD7, xNCD13 and/or xNCD16	23,2%
Undetermined Nickel alloy	19,6%
NC19FeNb (Inconel 718)	16,1%
E80DCV40 (M50)	12,5%
Z12CNDV12	12,5%
40CDV12	8,9%
ZxCND13-08	7,1%
	100,0%

Données brutes

Figure 27

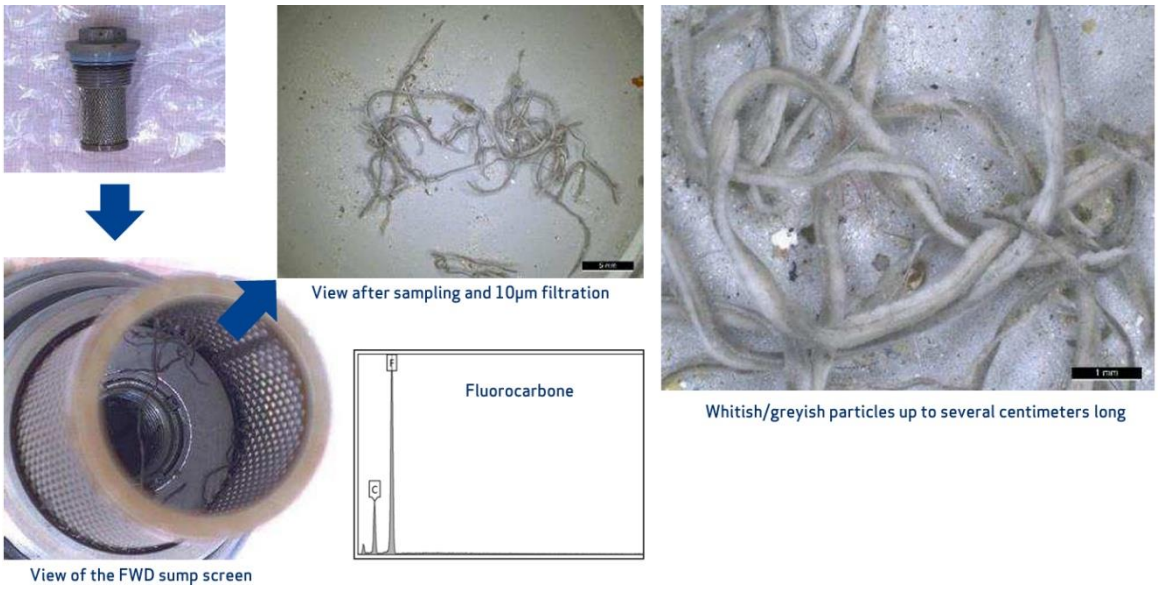


Figure 28

Engine Disassembly (Fig29).

Disassembly was performed at GE Wales from 12 to 16 Aug 24.

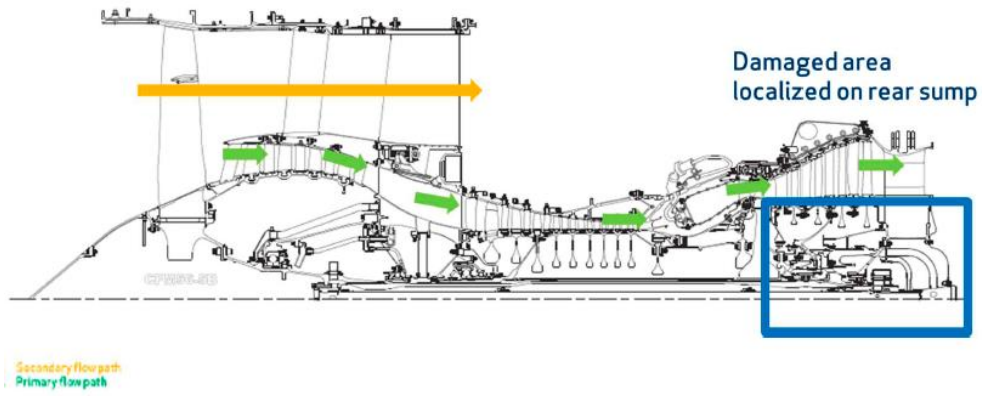


Figure 29

Before starting the disassembly, external visual examination was performed. Blackish deposit on LPTACC system observed (Fig30).

Fig 30 Blackish deposit on LPTACC system

Main Disassembly Findings

Fig 31 Oil traces and black deposit found on exhaust plug at 06:00 position.

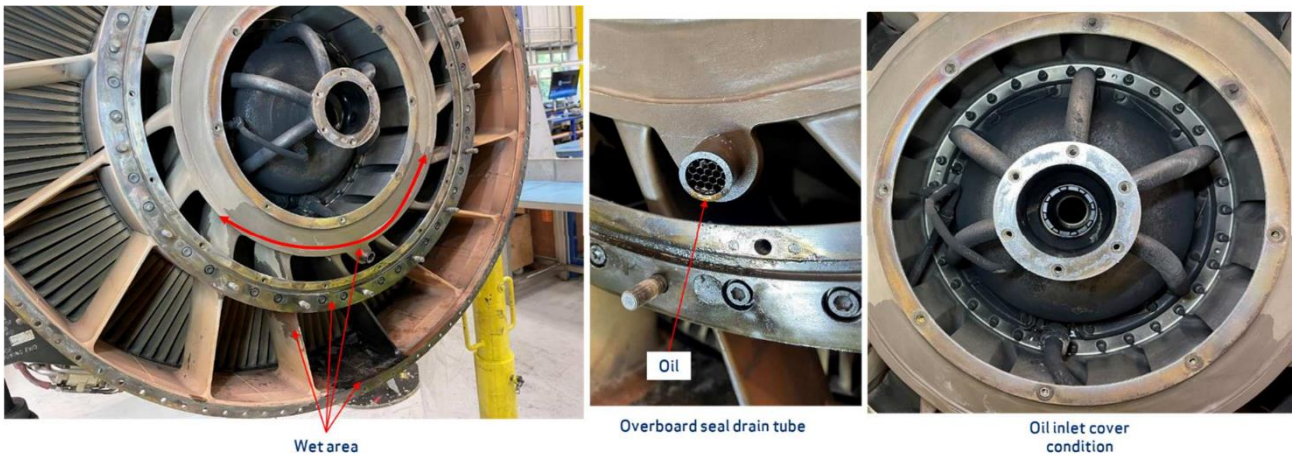


Fig 32 Wetness area on aft side of LPT observed with pollution after flange assembly removal.

Localized wetness area is a sign of oil leak from aft sump. #4 and #5 bearing and the lubrication system are localized in the sump area (Fig31&32).

LPT major module is put at piece part and #4 bearings found broken. No traces of fire under disk cavities (Fig33).

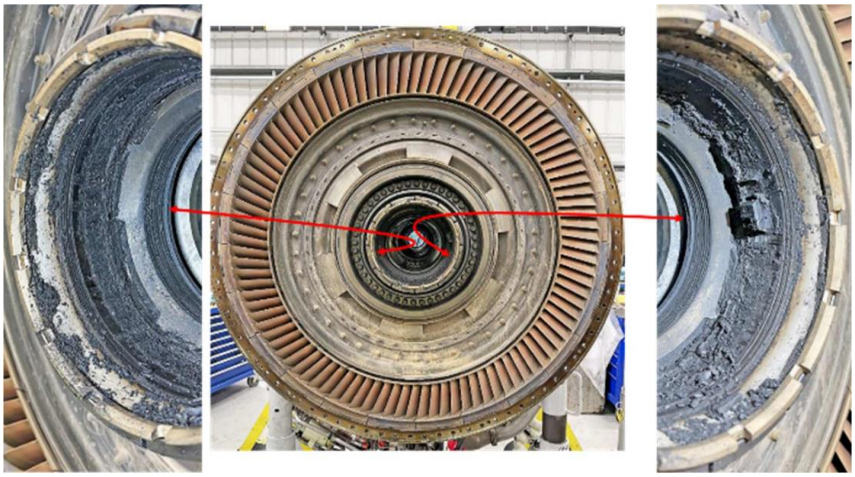


Fig 33 No. 4 roller bearing outer race condition: 2 rollers seized on raceway

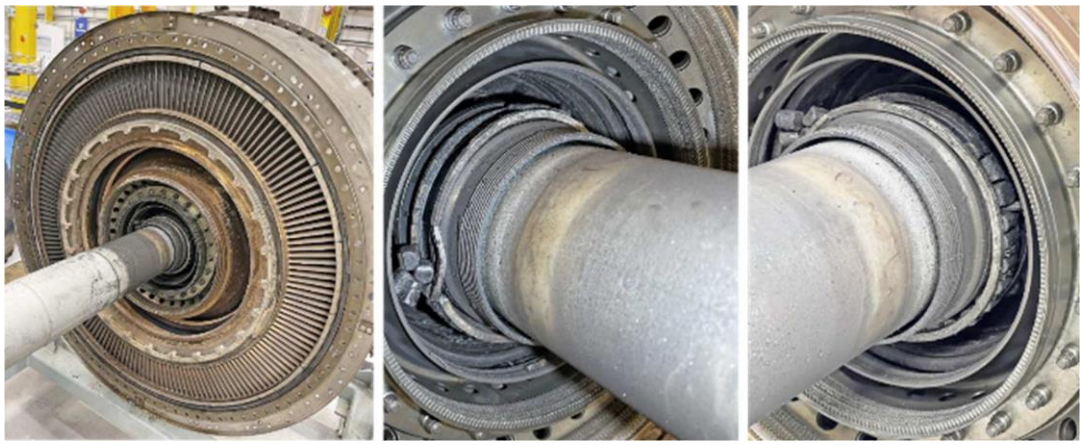


Fig 34 No. 4 roller bearing inner ring condition: fractured cage + rollers found liberated

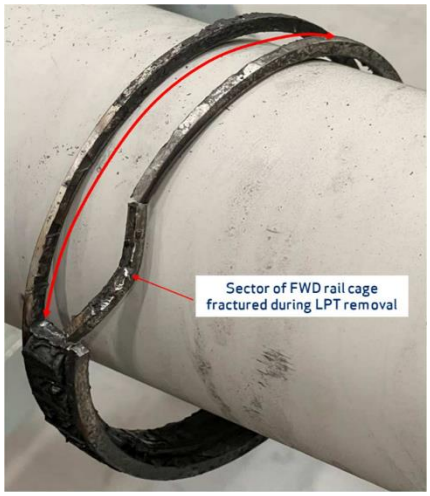


Fig 35 Cage spacers fractured and associated rollers liberated onto a sector of ~180°

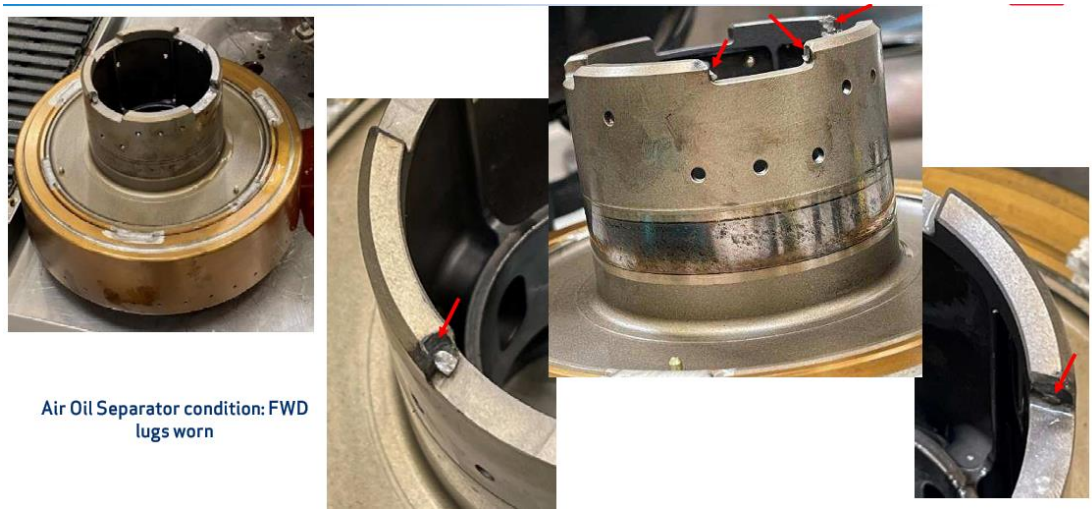


Figure 36

Significant Observation

Holes inside air oil separator and low-pressure turbine shaft are not plugged or with pollution inside. Oil is free to go from oil supply tube to air oil separator and #4 & #5 bearings. No lack of oil to lubricate bearings is identified.

Axial gap is identified with no expected shape and contact between air oil separator (AOS) and Centre Vent Tube (CVT) (blue circle) (Fig37&38).

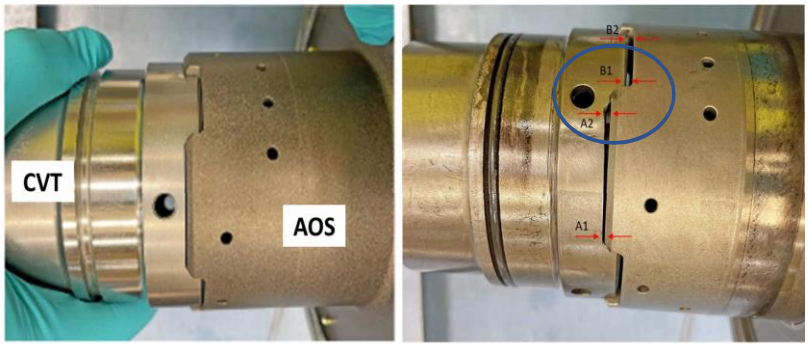


Figure 37

Lug	Measurement 1	Measurement 2
A	-1.40 mm	-1.30 mm
B	-1.09 mm	-0.84 mm
C	-0.54 mm	-0.54 mm
D	-0.25 mm	-0.08 mm
E	-0.15 mm	-0.15 mm
F	-0.04 mm	-0.39 mm
G	-0.70 mm	-0.45 mm
H	-0.78 mm	-1.20 mm

An axial gap is there due to Centre Vent Tube repair with non-conformance radius. An analysis between design intent and axial gap measured shows that there is no impact on lubrication for both bearings.

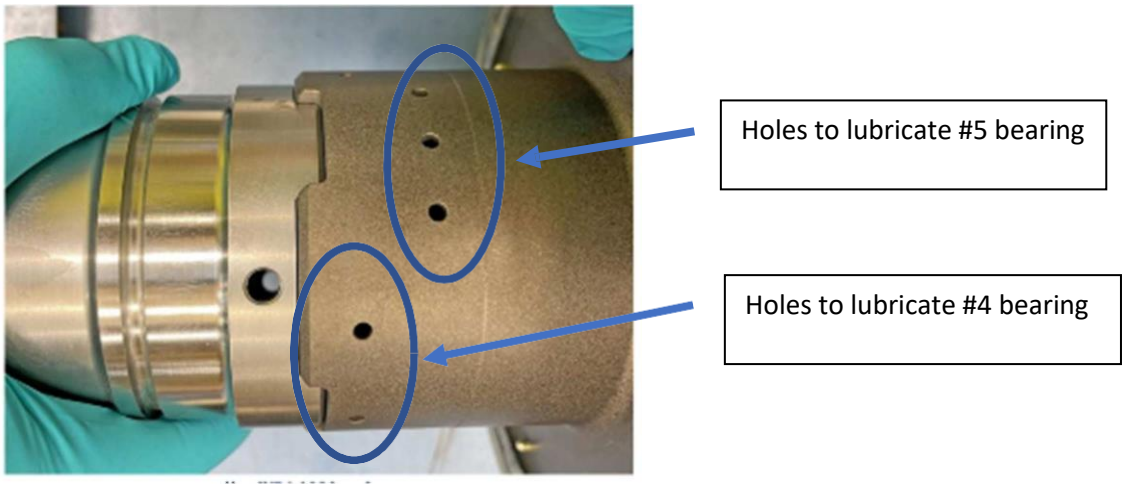


Figure 38

Poor geometry on CVT with heavy interference on lugs could liberate some debris through lubrication system(Fig39).

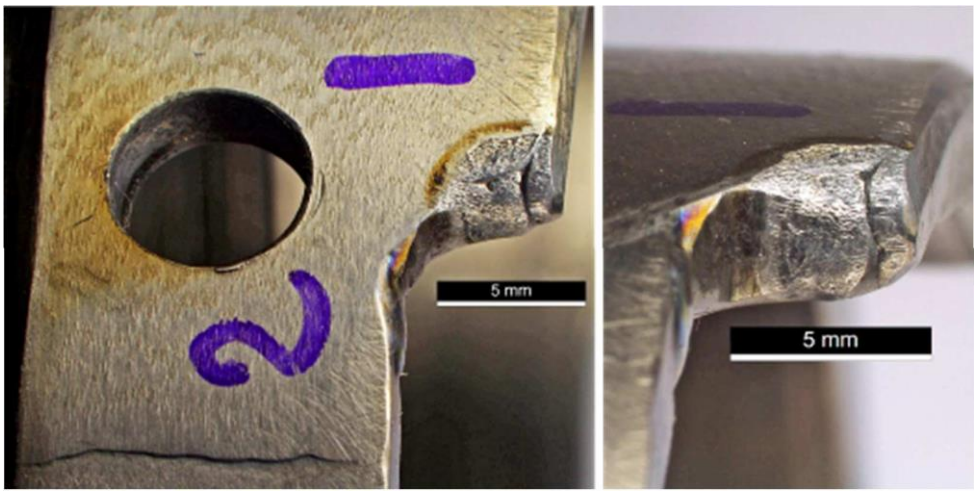


Figure 39

Lugs repairs are authorized on CVT and AOS as per Engine Overhaul Manual:

- ESM / CVT / All slots' faces can be repaired by the Task 72-55-06-300-010 Repair #010 (WELD BUILD- UP OF THE REAR SLOTS FACES IN CONTACT WITH AIR OIL SEPARATOR)
- ESM / AOS / All drive slots can be repaired by the TASK 72-55-15-300-003 repair #003 (AIR/OIL SEPARATOR AND COVER REPAIR 003 - RECONDITIONING OF DRIVE SLOTS ON THE AIR/OIL SEPARATOR)

The metallurgical constituents or properties on CVT/AOS lugs are:

- CVT: 2 different configurations:
  Removable by the rear sump: Titanium
  Removable by the forward sump: Jethete (Z12CNDV12)
  ESN 569159 with CVT in configuration removable by the rear sump: Titanium
- AOS: Aluminium

CVT is assembled at a separate time into a separate module. No detailed dimensional inspection of the CVT is required. MROs would inspect for obvious damage (i.e. transportation) before installing in the LPT.

The installation of the AOS includes a number of checks including correct assembly of Air Oil separator (Ref Dim B) including a rotational check.

Reference:

(h) Remove the air/oil separator from dry ice and install it over the rear extension duct. To do this, engage the separator slots with the center vent tube lugs. Turn the air/oil separator by hand to make sure that the lugs engage in the slots.

NOTE: *Engage the separator offset slot with the center vent tube offset lug. The separator offset slot and tube offset lug are identified by spherical indentations.*

Different abradable and seal teeth show heavy wear and rub leading to no pressurization in rear sump and leading to external oil leak.

Report of Lab testing of Recommended items.

After the disassembly the following items were recommended for Lab analysis

- #4 bearing (outer race, inner race, rollers and cage)
- Oil inlet cover
- Flame arrestor
- Oil scavenge tube
- Oil supply tube
- Drain tube
- Center vent tube
- Air Oil Separator

Cage and #4 Roller Bearing

Rollers have been removed at Safran's laboratory before inspection (Fig40).

Rollers found liberated during disassy (qty. 14)

Rollers still in place in the cage (qty. 16)

Figure 40

No metallurgical anomaly on rollers was found due to lack of lubrication. Local overheating was observed, following #4 bearing failure (Fig41).

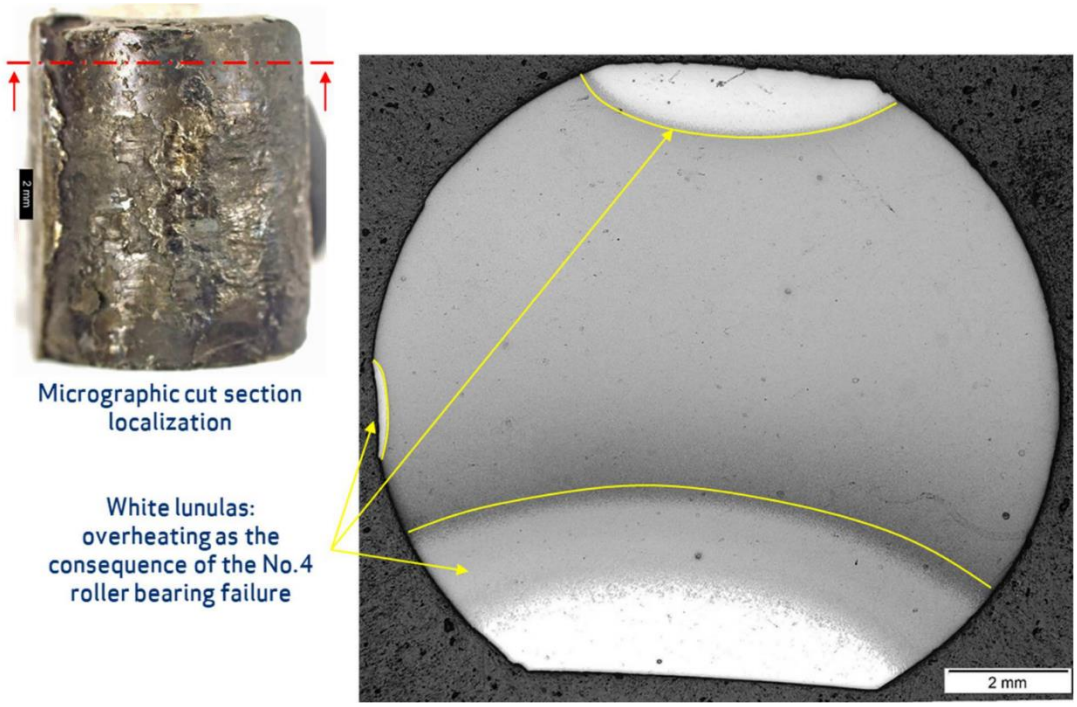


Figure 41

A comparison is made between #4 roller bearing distress after lubrication issue (full overheating of rollers and cage still in “one part” / no fatigue rupture) vs #4 roller bearing from engine 569159 (overheating limited to the flat spot worn areas and presence of cage fatigue rupture)

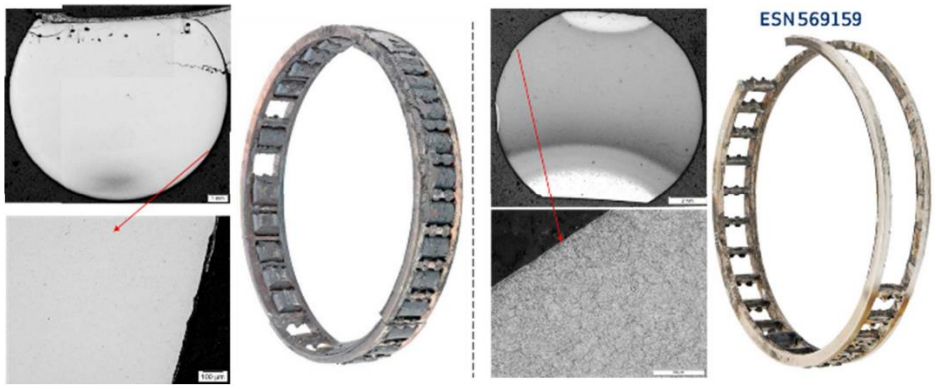


Figure 42

About the cage, fractures surfaces are observed with heavy damages and some rare evidences of fatigue propagation. No CVT/AOS particles have been found on the bearing (Fig42).

Micrographic cut section, performed on the roller bearing found with spalling vestiges showed that spalling initiation occurred/started from the surface (Fig43).

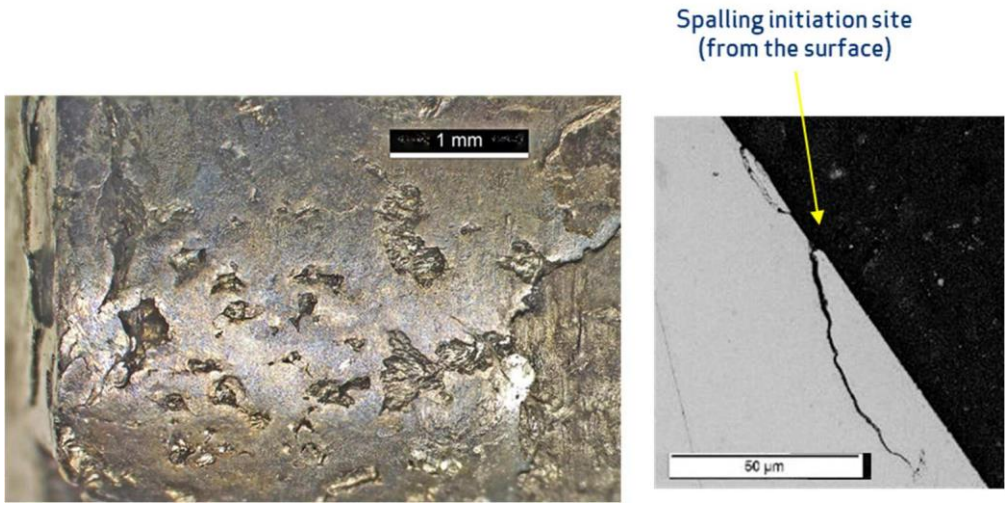


Figure 43

Based on the literature and CFM's experience, such initiation site from the surface is consistent with the presence of surface distress such as dents caused by foreign hard particles (like Alumine) or like the present case scenario particles liberated from the degradation of parts that are inside the sump (Fig44).

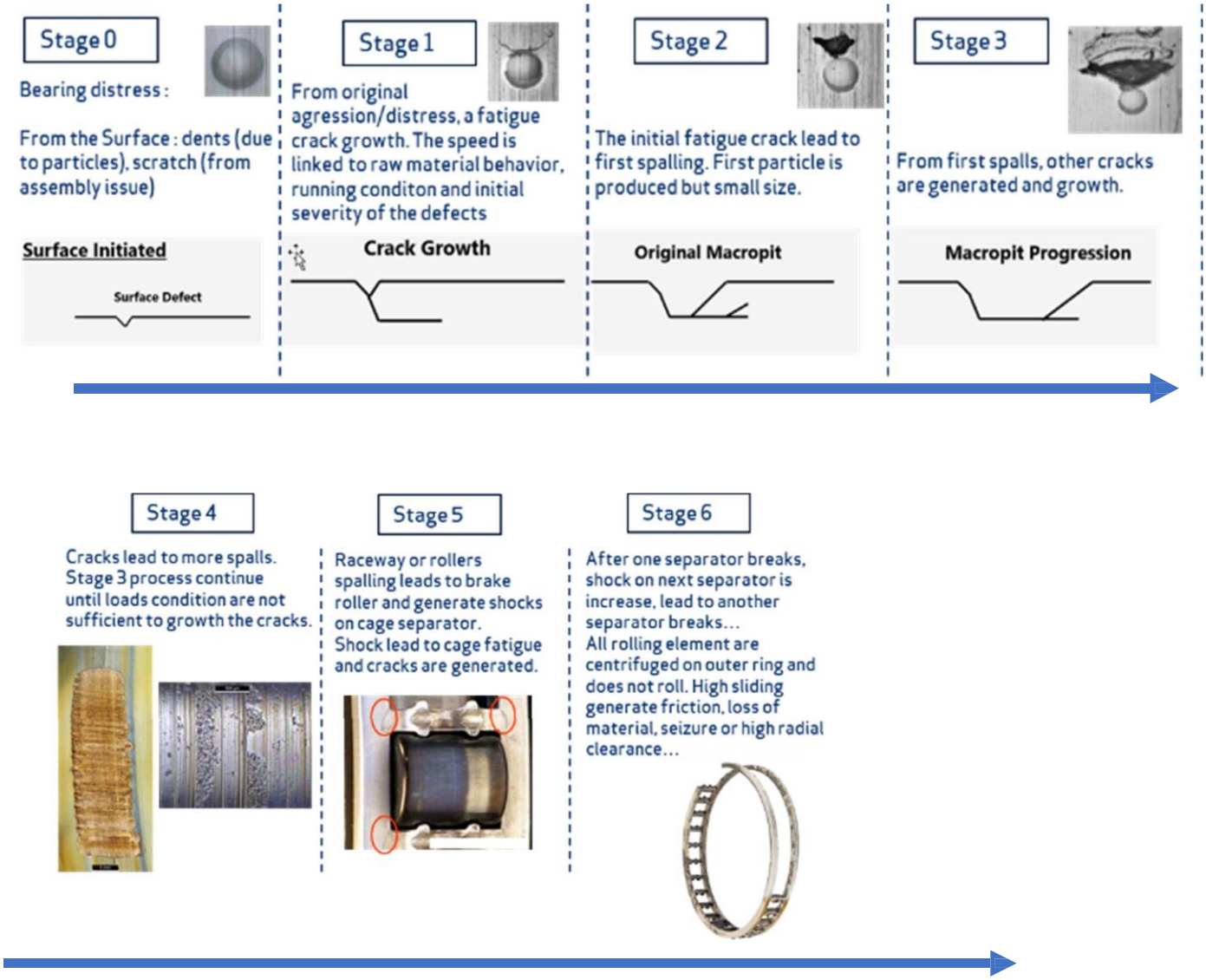


Figure 44

Outer race :

The outer ring raceway doesn't show sign of spalling degradation and there is absence of sectorial digging (Fig45).

Figure 45

Inner race:

Heavy wear found on inner ring raceway without sign of spalling degradation (Fig46).

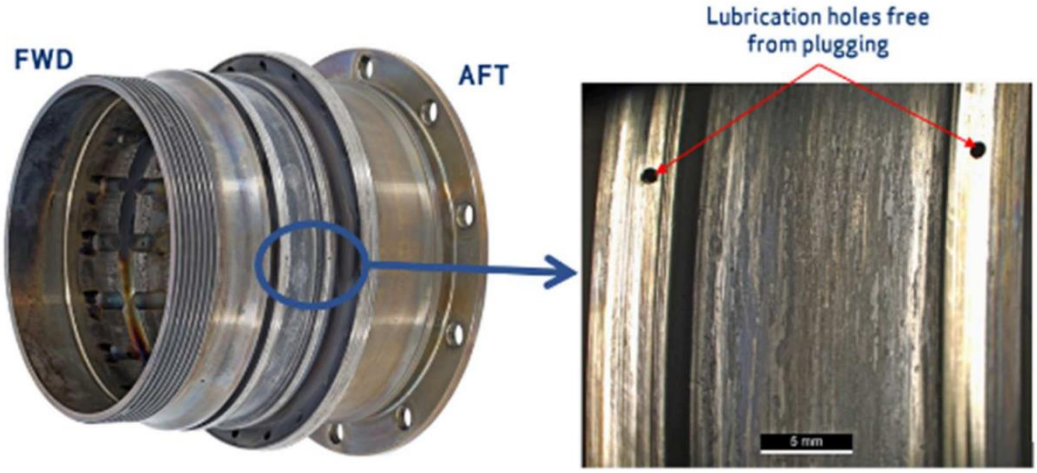


Figure 46

One lubrication hole found plugged with M50 material, consequence of #4 roller bearing distress without impact on lubrication efficiency (Fig47).

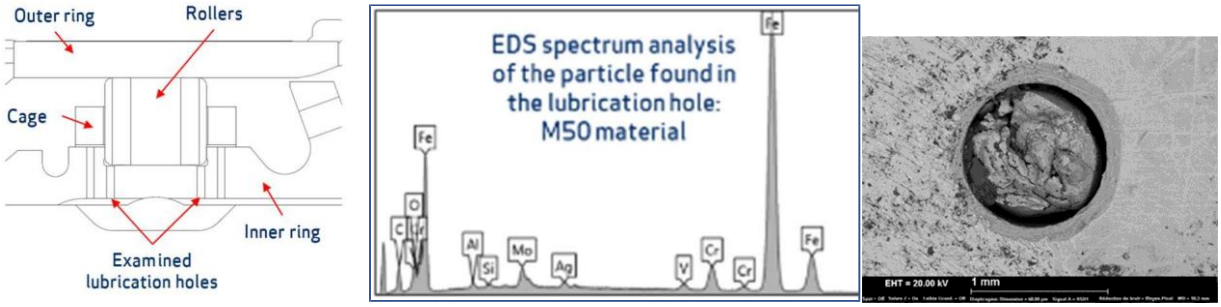


Figure 47

Oil inlet cover :

Chafing due to imbalance on oil inlet cover, representative to other damages on seal teeth leading to loss of pressurization inside sump area and oil leak (Fig48).

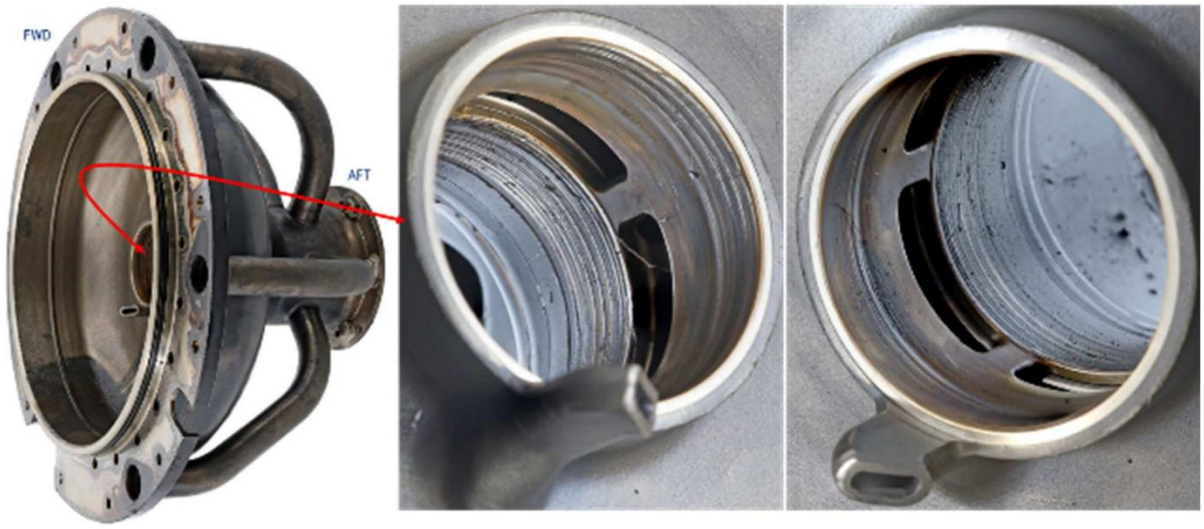


Figure 48

Oil supply and scavenge tubes:

Presence of light coked oil deposit (usual finding) inside tubes insufficient

1.17 Organizational and management information

M/s Air India Express is a scheduled airline which operates Airbus and Boeing fleet on domestic and international sectors. The Airlines Head Quarter is located at New Delhi. The Company is headed by a Chairman & Managing Director who is assisted by a team of professionals from various departments. The Flight Safety Department is headed by Chief of Flight Safety, approved by DGCA. The Chief of Safety is an Executive Director who reports directly to the Chairman. M/s Air India Express has been formed after merger of AIX Connect and Air Asia.

1.17.1 CoFS of AIX and CoFS of AIX Connect (Air Asia India) were simultaneously answering to the queries of the AAIB. No guidelines of MOC (Method of Change Document was shared with AAIB) and therefore inferred that it was not available.

1.17.2 Rule 13(1) of Aircraft (investigation of accidents and incidents) Rules 2017 (now 2025) empowers the DGCA to institute investigation into incidents and in case of serious incidents wherein the aircraft AUW is below 2250 kg and is not a turbo-jet aircraft. Rule 5 (1) a & b of Aircraft (investigation of accidents and incidents) Rules 2017 (now 2025) empowers the DG AAIB to institute investigation into accident and in case of serious incidents wherein the aircraft AUW is above 2250 kg or is a turbo-jet aircraft. The occurrence was first reported to DGCA. Later, it was reported to AAIB. On query it was informed that, as a standard practice, operator always reports any occurrence to DGCA. In this case the occurrence reporting flow was redirected from DGCA. DGCA HQ routed the Bengaluru Branch officer to the site. Later it was intimated to AAIB. AAIB also routed its go team member. The case was immediately updated to DG AAIB and it was immediately decided to categorise as Serious Incident. It was conveyed to all concerned. The representatives of both organizations were seen doing the investigation work. The material evidence was being collected by DGCA Officer as well as AAIB Officer.

1.18 Additional Information

The particle liberated due to heavy interference between the Core Vent Tube (CVT) and the Air Oil Separator (AOS) were further examined by the investigation team. In this regard a detailed set of queries was raised to understand the repair provisions, inspection possibilities and potential contribution of these components to the observed debris.

With respect to permissible repairs, it was clarified that no on-wing repair is available as pe the Aircraft Maintenance Manual (AMM). However, as per the Engine Shop Manual (ESM), repairs are permitted in a shop environment. The CVT slot faces may be repaired under Task 72-55-06-300-010, which involves weld build-up of the rear slot faces that come in contact with the AOS. Similarly, the AOS drive slots can be repaired under Task 72-55-15-300-003, which pertains to reconditioning of the drive slots on the air/oil separator and cover.

Regarding the possibility of performing a boroscope inspection (BSI) after such repairs, it was indicated that inspection through the AOS holes after the oil inlet cover may be feasible: however, it cannot be confirmed whether sufficient visibility would be available to effectively assess the condition of the repaired areas.

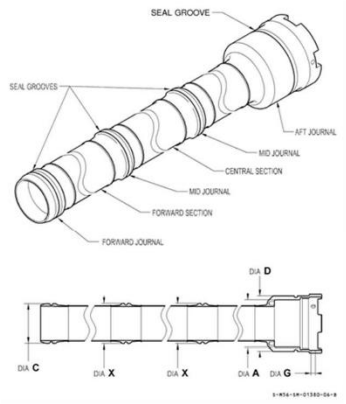
The possibility of detecting particles originating from repaired CVT or AOS components through the magnetic chip detector or oil filter was also examined. Since the CVT is made of titanium and the AOS is made of the aluminum, both of which are non-magnetic materials, any particles originating from these components would not be captured by the engine magnetic chip detector (eMCD). The particles that were recovered from the eMCD and the forward slump are therefore considered most likely to be post – event debris and not directly attributable to degradation of CVT or AOS repairs.

In response to queries regarding advisory guidance from the manufacturer, it was stated that the existing CVT and AOS repair procedures already provide the necessary instructions to ensure correct repair and proper assembly. As a best-practice measure, it was suggested that after completion of repairs, the repaired component may be checked against a new AOS to ensure proper matching and alignment, although implementing this check in a shop environment may not always be straightforward.

Evidence relating to repair of the CVT aft lugs was also examined. The repair work was carried out by BP Aero and component was subsequently routed through CFM conformances were observed on the CVT installed on Air India Express engines as well as on other CVT units identified at the GE Wales facility. BP Aero provided the relevant repair details for review.

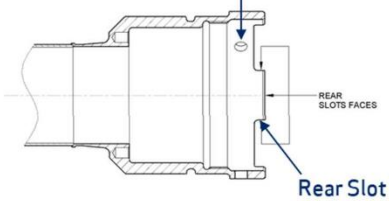
Despite detailed examination, no factual evidence of CVT or AOS material being present on the bearing surfaces could be established, as the bearing was too severely damages to allow definitive identification. However, a micrographic cut section performed on a roller that exhibited spalling traces indicated that the initiation of the spalling originated from the surface. Based on published literature and CFM's operational experience, such surface-initiated spalling is consistent with the presence of surface distress, such as dents caused by foreign hard particles (for example alumina) or particles generated from the degradation of internal sump components.

The repair agency responsible for the CVT was BP Aero. Accordingly, follow-up actions were initiated to verify whether similar repair non-conformances may have been exported to other engines in the fleet. During this review, multiple non-conformances related to Repair R007 and Repair R010 (fig 49 & Fig 50) were identified

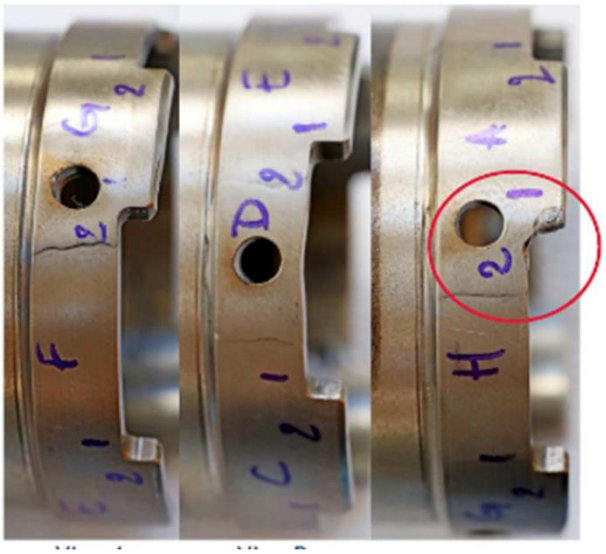


CVT – 72-55-06

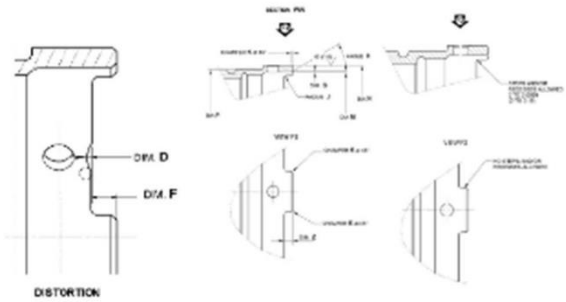
Locating Hole (Dia G) – Insp *SUBTASK 72-55-06-220-097*
Repair - R007 – Weld Build up



Rear Slot Faces – Insp *SUBTASK 72-55-06-220-097*
Repair - R010 – Weld Build up



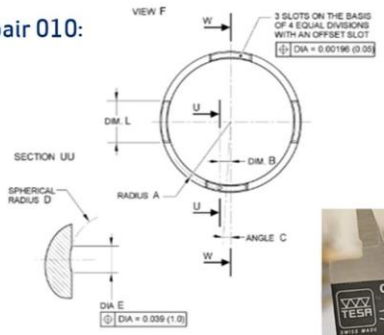
R007 – Dim D Exceeded
R007 - Dim F Exceeded
R007 – Post Weld Yellow/Blue Colour – Exceeded
R007 – Weld Bead –Not Smooth – Exceeded
R010 – Radius J – Exceeded
R010 – Dim L – Not correct along depth of Slot(See Rad J)
R010 – No steps/recesses on slots – Exceeded



Rep 007 Rep 010 Rep 010

Figure 49

Per repair 010:



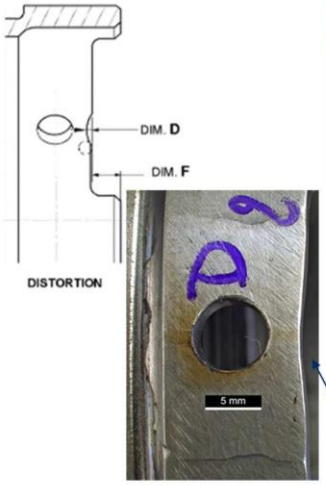
(14) Dim. L

Minimum In-Process Dimension: 0.79 (20)

Minimum Finish Dimension: 0.97965 (24,883)

Maximum Finish Dimension: 0.98169 (24,935)

Dim. L (per repair 010) out of tolerance by -2mm for the lug with weld build up still present



	Dim F	Dim D
Lug 1	5.67 mm	
	5.65 mm	
Lug 2	5.69 mm	
	5.54 mm	
Lug 3	5.57 mm	
	5.71 mm	
Lug 4	5.56 mm	
	5.30 mm	
Slot		0.36 mm

Per repair 007:

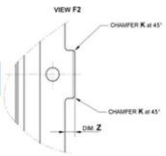
(13) Dim. F

Minimum Finish Dimension: 0.174 (4,4)

(11) Dim. D

Maximum Finish Dimension: 0.0197 (0,50)

Per repair 010:



(11) Dim. Z

Minimum In-Process Dimension: 0.075 (1,9)

Minimum Finish Dimension: 0.209 (5,3)

Maximum Finish Dimension: 0.224 (5,7)

Lugs Dim. F and D (per repair 007) and Dim. Z (per repair 010) within tolerance

Figure 50

ESN				
575104	645896	740277	779405	779970
575263	645972	740362	779490	779999
575359	658578	741425	779686	779999
575396	697667	741426	779694	877645
575399	697871	741461	779699	892636
575411	699240	741461	779718	894260
575746	721615	741709	779779	
575785	726165	741711	779841	
577835	731242	741882	779944	
645262	731813	779390	779970	

Inspector in charge on final inspection was identified and all other parts controlled by him have been listed.

1.19 Useful or effective Investigation Techniques

NIL

2. Analysis

2.1 Serviceability of the Aircraft

The aircraft had a valid Certificate of Airworthiness on the date of incident. The last major inspection on the aircraft was carried out in 18th February 2022. Hours flown after the last LLP inspection is 7870:01 Hrs (Cycles 5445). Aircraft did not have any pending snag and was neither operating under any MEL. The aircraft had clocked 32627 Airframe Hrs on the day of occurrence. Aircraft was maintained as per the approved program and was airworthy on the date of occurrence. The LH engine had clocked 32475.47 Hrs and the RH Engine had clocked 32627:14 Hrs on the day of incident. From the data the oil consumption rate as per record of RH Engine was 0.187 Q/Hr (0.5 Q/hr). Both engines were serviceable and did not have any pending snags.

From the above, it is inferred that the serviceability of the aircraft is not a contributory factor to the incident.

2.2 Operations

The flight was operated by Crew having valid Licenses and Qualifications to operate the flight. After being notified by the Cabin Crew about the fire in the RH engine. The flight crew reduced the engine 2 thrust lever to IDLE. The engine parameters displayed in the cockpit did not show abnormalities. The flight crew declared MAYDAY to ATC, reporting engine fire and turned back to Bengaluru. Once the aircraft landed and came to stand still, the captain shut down Engine 2. As the cabin crew informed the crew that there was still fire coming from the exhaust of Engine 2, the captain discharged the fire extinguisher bottles. Fire persisted and was extinguished by the firemen. After the fire was extinguished by the fire brigade, an emergency evacuation of the passengers was performed. All the four door escape slides (Fig9) were deployed. The airline reported that no passenger was injured. No damage in the aircraft structure was observed after the event. The fire was contained inside the engine core and in the exhaust area and therefore no ECAM warning linked to engine fire (which addresses fire in the nacelle area) was triggered.

From the above, it is inferred that the Crew handling of the aircraft is not a contributory factor to the incident.

2.3 DFDR/ NVM Analysis

SEQUENCE OF EVENTS AND ANALYSIS

Initial conditions

Those parameters' behaviours are consistent with a recoverable engine stall. This recoverable engine stall was not associated with an ECAM warning nor a PFR message because it was too transient.

Climb - Engine 2 N2 vibration started increasing

The ECAM HYD Y LO LVL, triggered during only 1 second, was most likely transiently triggered. Indeed, DFDR data show that the operating pressures on all 3 hydraulic systems were as expected throughout the incident flight and that the Yellow hydraulic system remained available until the end of the flight. Most likely the increasing vibration levels recorded around that time led one of the fluid level sensors of the yellow reservoir to emit inadvertent information during a short period of time (hence self-extinguishing of the alert one second later), probably due to fluid sloshing within the yellow reservoir.

Climb - Second engine 2 stall

The behaviour of the PS32 at 17:31:17 UTC is consistent with an engine stall. This stall was confirmed by the FADEC and recorded in the PFR. The teardown of the engine and additional analysis performed by CFM showed that the stall was the consequence of bearing #4 distress with debris. The most probable origin for this bearing failure is liberation of particles from the Centre Vent Tube at the level of the Air Oil Separator, which would have migrated to the bearing #4. When its thrust lever was set on IDLE, the engine 2 parameters (N1A2, N2A2, EGT2, PS32, Fuel Flow 2) answered consistently to the thrust lever movement and no longer showed abnormal behaviour or evolution. The engine 2 was kept running. Crew actions/decisions after the engine 2 stall were in accordance with the associated QRH procedure ENG 2 STALL which requests to set the thrust lever of the affected engine on IDLE and the other on MCT and to shut down the engine only if its parameters are still abnormal after this action. At that stage, according to the pilot report, the flight crew was informed by the cabin crew that flames had been seen from the engine 2 tail cone side. Picture 1 and 2 confirms flames from the exhaust of the engine 2. No ECAM warning related to ENG2 FIRE was received in the cockpit, which is consistent with the fact that it was an internal fire (inside the engine core and the exhaust area). The general visual inspection of the engine performed after the event confirmed that there was no trace of fire within the nacelle and that the fire remained inside the engine core. A peak in N2 and N1 vibrations, remaining below their alert thresholds (6 CU for LPC and 4.3 CU for HPC), reached 8 seconds after IDLE selection.

In Flight Turn Back

According to the outcomes of CFM analysis, the bearing #4 distress led to the deterioration of the sump area seal which resulted in an oil leakage outside the sump area in the exhaust area. Nevertheless, the threshold of oil quantity to trigger the ECAM advisory of oil quantity (3 qts) was not reached during the flight: at the time of engine 2 shut down, engine 2 oil quantity was 6 qts.

Landing and rollout

According to a video taken by a passenger and available in the media, sustained fire was visible in the exhaust area of the engine 2 during the rollout phase. According to the outcomes of CFM/Safran analysis, the sustained flames were caused by the oil leak inside the exhaust, leading to inflammation after the flame arrestor as the ignition conditions were present inside the exhaust: oil, temperature, airflow. According to information collected by the investigation board of India, the crew reported having shut down engine 2 as a precaution and then having discharged both fire bottles of right engine as the cabin crew informed them about fire on engine 2. Fire persisted since the fire agents are discharged into the nacelle and therefore, do not have any effect on internal fire. The fire was finally extinguished by the fire brigade, already present on the taxiway waiting for the aircraft as a MAYDAY was declared during the inflight turn back.

COMPREHENSIVE ANALYSIS

DFDR Analysis / Stall and vibe indication

Stall and fire occurred during flight, no fire alarm indication on cockpit. Below is a focus of stall indication during flight.

PFR indicates during climb at the moment of Stall on ENG 2, 3s after, the Thrust Lever Angle (TLA) for ENG2 was pushed back to 0° position.

ENG 2 stalled few moments before, during climb but was a recoverable stall without pilot intervention. After each stall a typical increase is noted on the EGT, within AMM limits.

There is coherence in Fuel Flow, EGT and PS3 values, the typical signature of stall is confirmed.

After ENG 2 stalled for the second time, it is observed an increase in vibration values, up to 5.0 Cockpit Units for the LP system and 4.2 CU for the HP system.

N2 (HP) vibration gradually increased starting from the 1st stall.

It can also be observed that once the TLA was pushed back to 0° both N1 and N2 vibration show the greatest values for ENG 2.

Conclusion of DFDR analysis is that both stalls occurred shortly after take-off. PFR indicates the ENG2 stall at 17:31 which is coherent with the flight data. The engine parameters are coherent with the N1 reduction observed.

DFDR Analysis / oil consumption:

Oil quantity at departure was 17.5 Quarts and post landing observed 7.5 Quarts (as per the oil level in notch). An oil leak is suspected. According to DFDR data we can observe a gulping effect when TLA is pushed to take off. Similar behavior on engine oil quantity on both engines when TLA are pushed to take off until TLA for #2 engine is put at idle. **Gulping effect is decrease of oil level in tank due to increase of pressure and flow rate when engine is started and set from idle to higher N2 speed rotation**. More oil is fed to sump areas and scavenge lines. After that we see oil level increasing for #2 engine in oil tank because pressure and flow rate from lube unit is normally low (TLA is put on idle), directly proportional of N2 speed. From the DFDR analysis, the loss of oil in Engine No. 2 is as follows:-

- First loss of oil quantity, 1 quart in 2 minutes (between 17:34:31 et 17:36:31),
- Second loss of oil quantity, 5 quarts in 4 minutes (between 17:37:31 et 17:41:51)
- Loss of oil increasing from 17:41:21 and 17:43:31.

NVM Analysis:

The conclusion of NVM analysis is that recorded faults are not linked to the stall, fire event and dates were different than the one of the incidents.

2.4 Operational/ Human Factors

The flight crew experienced engine stalls associated with jolts and bangs from Engine 2 as the Aircraft had crossed the thrust reduction altitude. The Flight crew was informed just after by the Cabin crew that fire from Engine 2 was visible. The pilot flying (PF) assesed the Aircraft condition wrt the parameters on display and discussed the further course of action with pilot monitoring (PM). The PF reduced the Engine 2 thrust lever to idle. The engine parameter displayed in the cockpit did not show abnormalities. The flight crew maintained MAYDAY situation reporting engine fire and turned back to Bengaluru. Once the aircraft landed and came to standstill, the captain shut down Engine 2. As the cabin crew informed the flight crew that there was still fire in the exhaust area of Engine 2, the captain discharged the fire extinguisher bottles. Fire still persisted and was extinguished by the firemen.

Crew actions/ decisions after the Engine 2 stall were in accordance with the associated QRH procedures. No ECAM warning related to Engine 2 fire was received in the cockpit which is consistent with the fact that it was an internal fire (inside the Engine core and the Exhaust area).

Operating procedures

- QRH Abnormal Procedure ENG 1(2) STALL
- FCTM - Abnormal procedures - ENGINE STALL

Additional Analysis

The engine failure scenario encountered during this flight was specific as it caused a sustained fire in the exhaust area of the engine, so without triggering ECAM warning ENG FIRE, and without affecting the engine parameters once the thrust lever was set on IDLE after the ECAM ENG STALL.
Even if the existing procedures allowed the crew to manage the event, several questions were assessed to identify potential additional operational guidance which would have been relevant in this event.

The crew action of shutting down the engine in this event has been considered. On one hand, shutting down the engine at the beginning of the fire would have allowed the exhaust area to cool down and to decrease the period of time where ignition conditions were present in the exhaust area.
On the other hand, no risk linked to this fire was identified. Indeed:

- At the engine level, the exhaust area is designed to sustain hot temperatures.
- At aircraft level, as long as the aircraft is running, the flames, expelled with the primary flow, are surrounded by the secondary flow, which thus prevents them from reaching the aircraft structure (pylon and wing). Besides, the inspectionsof the aircraft after the event showed no damage neither on the pylon nor on the wing. Then, when exposed to the fire, those parts of the structure are certified to sustain it for 5 minutes. In this event, the fire was extinguished by the fire brigade already in place at the aircraft stop location, as a Mayday was declared.

As no risk was identified with fire in the exhaust area, it was stated that the benefits of keeping the engine running (mainly keeping systems availability) should stay a crew decision depending on the overall situation of the flight.

The use of reversers in this case was also questioned, and it was stated that the use of reversers had no influence on this fire located in the exhaust area. Therefore, no benefit was seen in forbidding the use of thrust reversers in this scenario, considering the associated increased risk of mishandling of thrust levers at landing.

Human Factors at MRO Level.

M/S BP AERO missed to ensure the conformance level of weld area/Build area of CVT repair. The action was purely a human error and is attributed to alertness at shop level. **A case of human factors.** The MRO have subsequently put actions in place to reinforce control and instructions.

2.5 Circumstances leading to the incident

On the 18th of May 2024, AXB A320 MSN 6015 registered VT-ATF and equipped with CFM56 engines was scheduled for a flight from VOBL (Bengaluru, India) to VOCI (Kochi, India). After an uneventful takeoff, the subject aircraft experienced engine stalls, associated with jolts and bangs from Engine 2, as the aircraft had crossed the thrust reduction altitude The flight crew was informed just after by the cabin crew that fire from engine 2 was visible. The flight crew reduced the engine 2 thrust lever to IDLE. The engine parameters displayed in the cockpit did not show abnormalities. The flight crew declared MAYDAY to ATC, reporting engine fire and turned back to Bengaluru. Once the aircraft landed and came to stand still, the captain shut down Engine 2. As the cabin crew informed the crew that there was a fire coming from the exhaust of Engine 2, the captain discharged the fire extinguisher bottles. Fire still persisted and was extinguished by the firemen. After the fire was extinguished by the fire brigade, an emergency evacuation of the passengers was performed. All the four door escape slides were deployed. The airline reported that no passenger was injured. No damage in the aircraft structure was observed after the event. The fire was contained inside the engine core and the exhaust area and therefore no ECAM warning linked to engine fire (which addresses fire in the nacelle) was triggered. CFM established that the engine 2 stalls were the consequence of the bearing #4 distress. The most probable cause of this bearing failure would come from particles liberated because of interferences between Center Vent Tube and Air Oil Separator, which then migrated through the lubrication hole to the bearing #4. It was determined by CFM that the interferences were the result of a CVT with lugs width out of tolerance after a repair. CFM conducted a quality investigation with the MRO. The MRO have subsequently put actions in place to reinforce control and instructions. Another consequence of this bearing #4 failure was that resulting debris and unbalance led to an oil leakage in the exhaust area, causing the sustained fire. Operational procedures were reviewed to assess if additional guidance could enhance the management of this event scenario, and no operational enhancement has been identified.

3. Conclusion

3.1 Findings.

(a) The Certificate of Airworthiness, Certificate of Registration and Certificate of Flight Release of the Aircraft was valid on the day of Incident.

(b) All concerned airworthiness directives, mandatory service bulletins, mandatory modifications on the aircraft and its engines on date of incident had been complied with. There was no pending snag reported prior to the incident flight.

(c) Both operating crews were duly qualified on type A320 aircraft to operate the flight and had adequate rest prior to undertaking the flight on 18 May 2024 as per Flight Duty Time Limitations (FDTL).

(d) As per DFDR downloads, RH Engine experienced a recoverable stall in the air at 17:30:32 UTC.

(e) No fire warning or indication in the cockpit was recorded by cockpit crew. However, Fire was observed on RH Engine by passengers and cabin crew. No damage in the nacelle was observed after the event, which is consistent with the absence of fire warning in the cockpit.

(f) Crew declared MAYDAY and an emergency landing was executed at Bengaluru with only LH Engine operative.

(g) Safe emergency evacuation of all onboard was carried out as per SOP.

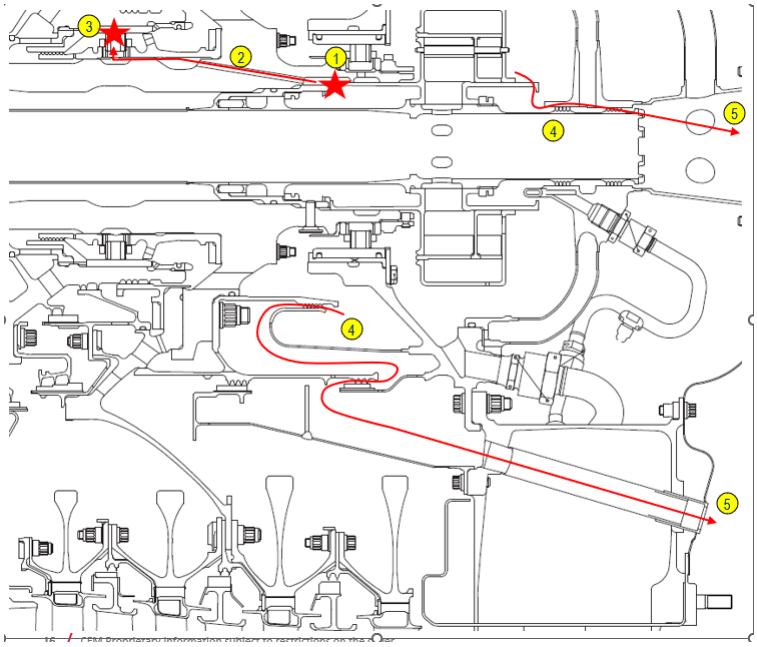
(h) The aircraft landed safely at Bengaluru. The total duration of operation was 24 mins from chocks off (1720Hrs) to chocks on (1744 Hrs.) The time in the air was 12 mins (1729Hrs - 1741hrs).

(i) No serious injuries were reported. 10 passengers suffered minor injuries and were treated by first aid at the airport.

(j) The dis-assembly of the RH Engine at GE Shop revealed damage to No.4 Bearing. 2 rollers seized on raceway of No. 4 roller bearing. HPT rear shaft outer diameter condition was worn out. The bearing inner ring condition had fractured cage and rollers found liberated. Further, disassembly revealed that Air Oil Separator FWD lugs were worn out to some extent.

(k) No damage in the aircraft structure was observed after the event.

3.2 Probable causes of the Serious Incident



The most probable cause of the engine no.2 fire was leakage of lubricating oil into the exhaust system, where it ignited under prevailing temperature and airflow conditions within the exhaust, resulting in Engine exhaust fire.

The leak is attributed to particles liberated from heavy interference between Center Venting Tube (CVT) and Air Oil Separator (AOS). **This interference was generated at last assembly in repair shop out of tolerance, after CVT repair**.

The liberated particles migrated to the No.4 roller bearing, leading to rollers spalling and progressive wear/stress of cage spacers junction. This resulted in deformation and opening of the bearing of the bearing cage under centrifugal effect causing rubbing between the cage and the outer race. The progressive degradation led to roller gathering and seizure with the outer raceway, until some rollers (qty 2) welded on the outer raceway Inner raceway and shoulder final wear by roller hard rubbing during final bearing operation as a plain bearing operation.

The failure of the No.4 bearing subsequently caused heavy wear of the aft sump abradable sealing area and associated rotor imbalance, leading to lubricating oil leakage into the exhaust system and subsequent fire.

4. Safety Recommendations

1. **DGCA and AAIB Coordination on Investigation**. The Aircraft Accident Investigation Bureau (AAIB) was established in 2012. Prior to its formation, all aircraft occurrences were categorized and investigated by DGCA (Safety Directorate). The Aircraft Accident and Incident Investigation Rules, 2017, subsequently revised in 2025, clearly laydown the framework, responsibilities, and procedures for aircraft accident and serious incident investigations in India.

Notwithstanding the above, there remains a practical requirement to ensure DGCA involvement at the time of occurrence, particularly during the initial phase when the nature and severity of the occurrence have not yet been formally categorized. In such situations, the absence of clearly defined procedures creates the risk of parallel investigations, duplication of effort, and potential compromise of evidentiary integrity and confidentiality.

Accordingly, there is a need to formulate a Standard Operating Procedure (SOP) that clearly delineates the roles and responsibilities of AAIB and DGCA during the pre-categorization phases of an occurrence. The SOP should provide a structured methodology for orderly transfer of evidence, data, and factual material collected during the initial response, ensuring full compliance with confidentiality provisions under ICAO Annex13 and the Aircraft Accident and Incident Investigation Rules,2025.

Further, it is necessary to review and refine CAR Civil Aviation Requirements (CAR) Section 5- Air Safety Series ‘C” part-I. Rev 5 dated 10 Jun 2022, to align it fully with the Aircraft Accident and Incident Investigation Rules,2025. The revision should remove all duplications, overlaps, and potential conflicts, and clearly establish that investigative functions in respect of accidents and serious incidents (aircraft AUW is above 2250 kg) rest exclusively with AAIB, while DGCA’s role remains confined to regulatory oversight, immediate safety actions, and implementation of safety recommendations.