FINAL INVESTIGATION REPORT OF INCIDENT TO M/s AIR INDIA, A-320 AIRCRAFT, VT-CIH ON 19.12.2023 AT MUMBAI

GOVERNMENT OF INDIA
OFFICE OF DEPUTY DIRECTOR GENERAL OF CIVIL AVIATION (WR)
INTEGRATED OPERATIONAL OFFICE COMPLEX, SAHAR ROAD,
VILEPARLE (E), MUMBAI – 400099

Foreword

In accordance with Annex 13 to the Convention on International Civil Aviation Organization (ICAO) and Rule 13(1) of Aircraft (Investigation of Accidents and Incidents), Rules 2017, the sole objective of the investigation of an incident shall be the prevention of accidents and incidents and not to apportion blame or liability.

This document has been prepared based upon the evidences collected during the investigation, opinion obtained from the experts, and laboratory examination of various components, etc. The opportunity was accorded to all the parties to participate during the course of investigation. Consequently, the use of this report for any purpose other than for the prevention of future accidents or incidents could lead to erroneous interpretations.

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ABBREVIATIONS

A/c	Aircraft
Aircraft	Incident Aircraft
AD	Airworthiness Directive
ADF	Automatic Direction Finder
AME	Aircraft Maintenance Engineer
AMM	Aircraft Maintenance Manual
ARC	Airworthiness Review Certificate
ATC	Air Traffic Control
BA	Breath Analyser
CEOD	Continuous Engine Operational Data
CG	Center Of Gravity
CNR	Customer Notification Reports
CSN	Cycles Since New
CVR	Cockpit Voice Recorder
DGCA	Director General Of Civil Aviation, India
DME	Distance Measuring Equipment
e-AIP	Electronic- Aeronautical Information Publication
ECAM	Electronic Centralized Aircraft Monitor
EEC	Electronic Engine Control
EGT	Exhaust Gas Temperature
EHM	Engine Health Monitoring
ELT	Emergency Locator Transmitter
ESN	Engine Serial Number
FDR	Flight Data Recorder
FDU	Fire Detection Unit
FO	Co-Pilot/ First Officer
GPS	Global positioning system
ILS	Instrument Landing System
IR	Instrument Rating
IST	Indian Standard Time
LH ENG	Left Hand Engine
MCDU	Multi-Function Control And Display Unit
MEL	Minimum Equipment List
NDT	Non-Destructive Testing
Operator	FTO Holding Approval
PF	Pilot Flying
PIC	Pilot In Command
PM	Pilot Monitoring
RADAR	Radio Detection And Ranging
RH	Right Hand
Tower	ATC Tower
TSM	Trouble Shooting Manual
TSN	Time Since New
UTC	Coordinated Universal Time
VOR	Very high frequency Omni Range

FINAL INVESTIGATION REPORT OF INCIDENT TO M/s AIR INDIA, A-320 AIRCRAFT, VT-CIH ON 19.12.2023 AT MUMBAI.

GENERAL INFORMATION

1.	**Aircraft**	**Type**	A320-251N
		Nationality	Indian
		Registration	VT-CIH
		Flight No	AI-814
2.	**Owner**		M/s Avolon Aerospace (Ireland) AOE 138 Ltd.
	Operator		M/s Air India Ltd.
3.	**Pilot In- Command**		ATPL holder
	Co-Pilot		ATPL holder
	Extent of Injuries		Nil
4.	**Date and Time of Incident**		19.12.2023, 19:41hrs UTC (01:11hrs IST on 20.12.2023)
5.	**Place of Incident**		Mumbai Airport
6.	**Geographical location of site of Occurrence (Lat. Long.)**		190530N 0725158E
7.	**Last point of Departure**		Delhi (VIDP)
8.	**Intended Place of Landing**		Mumbai(VABB)
9.	**No. of Personnel On-Board**		167 (including 2 cockpit & 5 cabin crew)
10.	**Type of Operation**		Scheduled
11.	**Phase of Operation**		Landing roll
12.	**Type of Incident**		LH Engine fire warning

(All timings in this report are in UTC unless specified).

SYNOPSIS:

On 19th December 2023, M/s Air India Limited Flight AI-814, Airbus A320-251N aircraft bearing registration VT-CIH, was operating a scheduled flight from Delhi to Mumbai.

Upon landing in Mumbai, the Captain reported that "LH ENG Fire warnings during landing roll, after reaching 70 knots (Reversers were stowed). The aircraft was stopped on the runway, ECAM actions were carried out, the fire P/B pushed and both fire agents were discharged. The fire indication extinguished, and the aircraft taxied back to the bay with single Engine." There was no injury to the crew and passengers. There was no damage sustained to the aircraft. However, there was damage due to fire inside the LH engine.

The incident has been investigated by Investigator In-Charge and a member, appointed by DGCA, India vide letter no. DGCA-15018(01)/2/2024-DAS dated: 24.01.2024 in the exercise of power under Rule 13(1) of the aircraft (Investigation of accidents and incidents) Rules 2017.

The cause of the incident has been determined to be a 'fuel leak' caused by cracks/failure in the weld of fuel manifold that led to the fire in LH engine. The root cause of crack in the weld of the fuel manifold is determined as low cycle fatigue.

1. FACTUAL INFORMATION

1.1 History of the Flight:

On 19.12.2023, M/s Air India Limited, Airbus A320-251N aircraft VT-CIH was scheduled to operate flight AI-814 from Delhi (VIDP) to Mumbai (VABB). This was the aircraft's first planned sector for the day and second planned sector for both the cockpit crew.

Prior to the incident flight, the aircraft VT-CIH had earlier operated the sector Ahmedabad to Delhi on 18.12.2023. After landing in Delhi, it was reported in the PDR by the crew that "LH engine Fire loop A Fault appeared on ECAM and LH Engine fire light on the Engine master panel was unserviceable during the flight". These reported snags were subsequently addressed and rectified by the AME in Delhi. "LH engine Fire loop A Fault" which had been already under MEL, was revoked. Following refueling and a daily inspection, the aircraft was released by AME for its next flight AI-814 at Delhi on 19.12.2023.

On 19.12.2023, both crew reported around 11:30hrs UTC and performed a BA test in Mumbai. They operated their first flight of the day, on another aircraft from Mumbai to Delhi. After landing in Delhi at 15:56hrs UTC, both crews were debriefed for their next flight AI-814 on the VT-CIH aircraft. An external walk around pre-flight inspection was carried out by both crew members and found satisfactory.

At 16:56hrs UTC, the aircraft chocks were removed for departure and the flight AI-814 was operated from Delhi (VIDP) to Mumbai (VABB) with 167 persons on board, including seven crew members. The takeoff till approach for landing was uneventful.

An ILS stabilized approach for runway 09 in Mumbai was carried out with full flaps, followed by an uneventful landing at 19:40hrs UTC. During the landing roll, auto brakes low was preselected, full reversers were used and once the aircraft speed reduced to

70kts, the reversers were moved from max to reverse idle. Subsequently, a master caution warning for "LH engine fire" was triggered.

The aircraft was brought to a complete stop on the runway near N5, reversers were stowed, and parking brakes were applied. ATC was informed of LH Engine fire warning with a May Day call and the cabin crew was alerted. Procedures including ECAM actions were followed by the crew. Engine master switch was shut off. Engine fire PB Switch was pushed. Both fire extinguishing agents (1 & 2) were discharged. After completion of ECAM actions, the fire warning indications went off.

Subsequently, an external inspection of the aircraft was conducted by the airport fire manager, who reported no signs of engine fire or smoke. The May Day call was cancelled, as was the alert to the cabin crew. With clearance from the airport fire manager and ATC, the aircraft was taxied with RH engine running and was safely parked at stand K1 (escorted by the fire tenders). There was no injury to the crew and passengers and no smoke or fire was observed. There was no external damage sustained by the aircraft. However, there was damage due to fire inside the LH engine.

1.2 Injuries to Persons:

Injuries	Crew	Passengers	Others
Fatal	Nil	Nil	Nil
Serious	Nil	Nil	Nil
Minor/ None	0/2+5	0/160	

1.3 Damage to Aircraft & Engine:

There was no damage to the airframe of the aircraft and no external damages to both the engines. The affected LH engine was replaced with a new engine due to following observations on LH engine:

In LH engine, lacquer deposits were found on fuel manifold / tubes on LHS of core engine, around 0900 to 1000 O'clock position. And black soot deposits were found around 1000 to 1200 O'clock position of LHS of core engine.

Details of replaced LH engine: OFF S/N: 598879, ON S/N: 598196

1.4 Other Damage:

Nil

1.5 Personnel Information:

Details	PIC	FO
Age / Sex	39yrs/Female	37yrs/ Male
License	ATPL	ATPL
Date of Issue	27.06.2016	05.09.2019
Valid up to	26.06.2026	04.09.2024
Category	Aeroplane	Aeroplane
Date of Class I Medical Exam	24.01.2023	21.08.2023
Class I Medical Valid up to	23.01.2024	25.08.2024
Date of Issue of FRTO License	13.07.2009	23.11.2019
FRTO License Valid up to	06.02.2025	22.11.2024
Total Flying Experience	3728:40hrs	3970:23 hrs
Total Flying Experience as PIC	434:25 hrs	NIL
Total Flying Experience on Type	592:26 hrs	3732:17 hrs

Total Flying Experience as PIC on Type	331:37 hrs	NIL
Total Flying Experience in last 1 year	453:21 hrs	686:47 hrs
Total Flying Experience in last 6 months	341:54 hrs	321:00 hrs
Total Flying Experience in last 30 days	78:30 hrs	82:56 hrs
Total Flying Experience in last 7 days	25:54 hrs	19:43 hrs
Total Flying Experience in last 24 hours	07:36 hrs	07:36 hrs
Duty Time last 24 hours	11:46 hrs	11:46 hrs
Rest before the incident flight	14:24hrs	14:24hrs
Ratings	BE-76, B737-800, B777, A320	C-172/PA-34/A320
Pilot Proficiency Check (PPC) done on	22.10.2023	13.10.2023
PPC due on	21.01.2024	12.04.2024
IR Test done on	22.10.2023	13.10.2023
IR Test valid till	21.10.2024	12.10.2024
Line Check done on	07.05.2023	27.11.2023
Line Check valid till	06.05.2024	27.11.2024

Upon scrutiny of the records, it was revealed that both PIC and FO were ATPL holders with valid licenses to operate the incident flight. The PIC and FO had not exceeded the flight duty time/flight time limitations as laid down in the prevailing regulations. None of them had been involved in any incidents in past three years.

1.6 Aircraft Information:

1.6.1 Airframe:

The Airbus A320-251N, equipped with CFM LEAP-1A26 engines, features a modern and efficient airframe designed to enhance performance and fuel efficiency. The airframe incorporates advanced materials, including composites and lightweight alloys, to reduce weight and improve aerodynamic efficiency. The wing design, with sharklets (wing tip devices), reduces drag and increases lift, contributing to lower fuel consumption. The fuselage is optimized for a comfortable passenger experience with a wider cabin and quieter operations. Overall, the A320-251N's airframe, combined with the LEAP-1A26 engines, provides significant improvements in fuel efficiency, environmental performance, and operational cost-effectiveness compared to previous generations. Engine details are provided in Table: 1.

Table: 1

Designation	**Engines**	**Certification**	**Take-off thrust**	**Maximum continuous**
A320-251N	CFM LEAP-1A26	31.05.2016	120.64 kN (27,120 lbf)	118.68 kN (26,680 lbf)

The Aircraft VT-CIH (ASN: 8030) was manufactured in year 2018. The aircraft is owned by M/s Avolon Aerospace (Ireland) AOE 138 Ltd & leased to M/s Air India Ltd. and registered with DGCA in the name of M/s Air India Ltd. with usual station mentioned as Delhi. The aircraft is registered under Category 'A' and issued Certificate of Registration No. 4874 on 05.02.2018 and is valid till 30.01.2030.

The Certificate of Airworthiness Number 6977 under 'Normal' category with subdivision "Passenger/Mail/Goods" was issued by DGCA on 06.02.2018. The specified minimum operating crew is "two" and the maximum all up weight is 79,000Kgs. ARC was issued on 24.01.2023 and is valid till 31.01.2024.

The aircraft and its engines were being maintained as per the maintenance program, approved by DGCA, consisting of Calendar Period/ Flying Hours based maintenance.

As per the approved weight schedule, the Empty weight of the aircraft is 43,414kg. The maximum usable fuel quantity is 18623kg. The maximum payload with fuel tanks full is 15286kg. Empty weight CG is 18.854 meter aft of datum.

Total block fuel for Delhi to Mumbai sector was 9100kg of which 5490kg was consumed during the flight sector. As per flight plan the max landing weight was 63898kg. The load sheet of the incident sortie was calculated correctly and the CG was within limits.

All the concerned Airworthiness Directive, mandatory Service Bulletins, DGCA Mandatory Modifications on this aircraft and its engine were complied with as on date of incident. The last 2A Inspection check was carried out on the subject aircraft on 06.08.2023. The last major inspection was 1A+1B+C inspection was carried out on 01.11.2023 and the aircraft had logged a total of 20335:03 airframe hours/ 9850 aircraft cycles before the incident.

As per Load and trim sheet, the All up weight of the aircraft and its CG were found to be within limits. No relevant Snags/ Defect had been reported in the last one month prior to this incident. There were no relevant MEL items were active during the incident flight.

1.6.2 Power plant:

The LEAP-1A26 engine is developed by M/s CFM International, a joint venture between GE Aviation and Safran Aircraft Engines.

The LEAP-1A26 is a more advanced engine, part of the LEAP (Leading Edge Aviation Propulsion) family, designed to power the latest generation of single-aisle aircraft, including the Airbus A320neo. The LEAP-1A26 incorporates cutting-edge technologies such as 3D-printed components, advanced composite materials, and a high-efficiency combustor, which contribute to significant improvements in fuel efficiency, emissions, and noise reduction compared to previous engines. The LEAP-1A26 also features a higher bypass ratio and advanced aerodynamics, making it one of the most efficient engines in its class. The details of both engines are provided in Table: 2.

Table: 2

Engine Serial no.	**TSN (hrs)**	**CSN**
LH Engine: 598879	14242:37	6918
RH Engine: 598657	15494:30	7779

The details of the affected LH engine are as follows:

a. The subject LH Engine (Serial no: 598879) was installed on the aircraft on 18.09.2022, while it had accumulated 8952hrs TSN and 4561 CSN on the day of the incident.

b. 3A Inspection check was carried out on the subject engine on 10.07.2023. Last Fuel nozzle last replacement was done on 11.07.2023. Number of cycles flown post fuel nozzle replacement till the event is 821CSN. Bore scope inspection of Blades of LPT 7th stage was carried out on 16.07.2023. After all these inspection, no snag/fault was mention in the engine log book till the date of the incident.

c. From Techlog pages there were repetitive Snags/ Defect was reported on LH engine in the last one month prior to this incident provided in Table: 3. However, it was not contributing to this incident as actual fire was there in this case and fire warning also triggered in LH Engine.

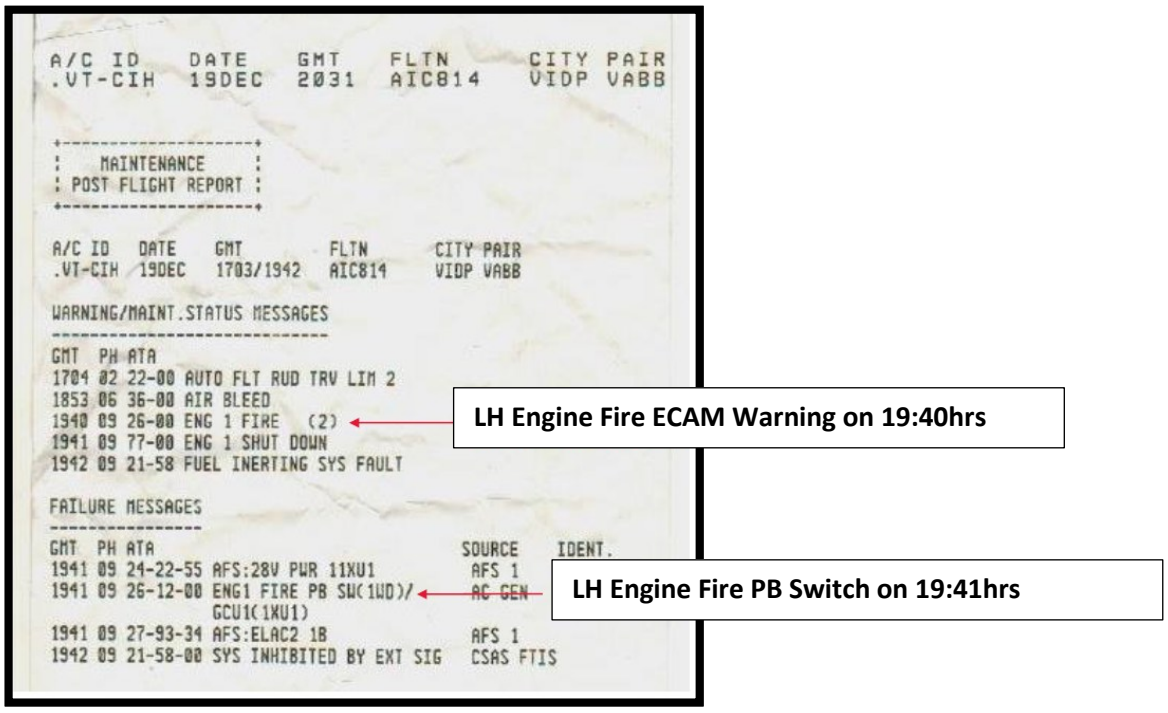
Table: 3

Sl No	Snag history	Date of the snag reported in the flight
1	LH Engine fire loop 'A' fault	18.12.2023 (Previous Sector), 08.12.2023, 27.11.2023, 23.11.2023
2	LH Engine light on Engine Master panel unserviceable	18.12.2023 (Previous Sector), 10.12.2023, 30.11.2023

d. Prior to the incident flight, the aircraft VT-CIH had previously operated the sector AMD-DEL sector on 18.12.2023. After landing in Delhi, it was reported in the PDR by the crew that the "LH engine Fire loop A Fault appeared on ECAM and the LH Engine fire light on Engine master panel was unserviceable". The TSM task 26-12-00-810-803-A was referred & the 431 VCI and 450 VTI contacts were cleaned. An FDU-1 test was carried out & found to be satisfactory. Further, fire light on engine master panel was checked & found to be functioning properly. The "LH engine Fire loop A Fault" which was already under MEL, was revoked by the AME in Delhi on 19.12.2023 prior to the incident flight.

Post Incident Rectification:

e. Post flight report revealed that the following faults in the aircraft, where LH Engine (ENG 1) fire ECAM warning triggered during landing roll phase. (Refer Photograph# 1)



(Photograph# 1: Post flight report of incident flight)

f. During the walk around inspection by the arrival AME at the bay, no external damage or evidence of fire were observed to the aircraft and engine. Also, there was no fuel/hydraulic fluid/oil/air leak was observed externally. Engine oil quantity and hydraulic fluid quantity was found above minimum limit.

g. After shifting the aircraft to the hanger, no signs of visible fire were observed on LH engine during external checks. The same was informed to CFM (OEM) & as per CFM recommendations; AMM TASK 72-00-00-200-821-A. (Procedure after Engine Fire or Use of Fire-Extinguishing Agents) was referred.

h. On 21.12.2023, Visual inspection of Engine Fire Detection System was carried out as per AMM task 26-12-00-200-803-A. Operational test of Engine Fire & Overheat detector from MCDU was performed & same was found satisfactory.

i. Further, visual inspection of LH Engine Pylon 3WD1/4WD1, 4000WD1/4000WD2, 4001WD1, 4001WD2, 4002WD1, 4002WD2 & Harness 31WD1, 31WD2, 41WD1, 42WD2 was carried out. Then LH Engine Pylon Loop A & B were found covered in Black sooth & reaming loop were visually found okay.

j. Thereafter on 22.12.2023, on further troubleshooting, no fuel or hydraulic leak and no air Leak was observed. Thereon, the Flex Hose was checked & found the bend is outboard as per AMM 78-36-51-400-04.

k. Further the following mentioned observations were made on LH Engine:

   i. Black sooty deposits in below the pylon area at around 12^0 clock position.
   ii. AMM 72-00-00-200-821-A was followed. As per this, engine is required to be replaced. But the source of leak which caused the fire was needed to be analyzed.
   iii. To identify the source of leak, pylon panels 13bl, 472br, 413cl, 413al, 415al, 471al, 415bl, 415cr and 471cl were opened, no fuel leak observed in pylon area.
   iv. Wet motoring carried out as per AMM 73-29-00-740-822-A, fuel leak observed at 6^0 clock position (B sump drain line, at the attachment to the casing), which is normal. Other than that, there was no fuel leak observed post event during wet motoring.

l. The above observations were shared with CFM and in order **to identify the exact location of fuel leak,** CFM recommended "to inspect fuel nozzle and fuel manifold for leaks, refer to AMM Task 73-11-30-200-802-A and get access to B nut to verify torque value." Following are the observations:

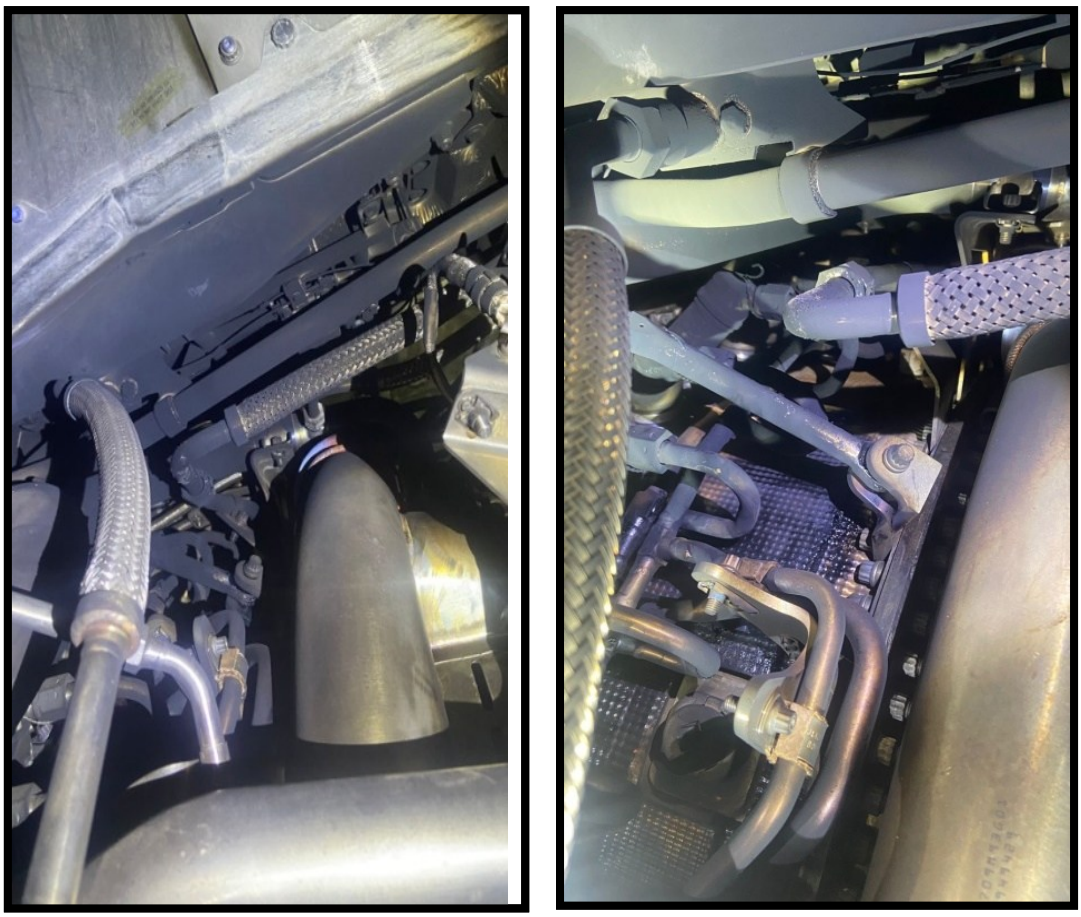
   i. Visual Inspection of each fuel nozzle B-Nut was carried out & no leak observed. Only cocking and Black soot observed on 9'o clock position & 1100-1130 O' Clock position fuel nozzle. (ie, Nozzle no:14,15,16,17,18 & 19).

   ii. Thereafter, all fuel nozzles were inspected for safety cable & found satisfactory & no markings were observed on the fuel nozzle & no leakage was observed from the fuel nozzle. (Refer Photograph 2).

   iii. And, torque check of the fuel nozzle B-nut was carried out as per AMM 73-11-30-400-802A &one B-nut torque value was found to be less than the required torque.

m. CEOD data download from EEC was performed for both channels A and B on engine ESN 598879 and the data was uploaded to the server. No abnormalities were found during the CEOD analysis performed by CFM to identify a suitable root cause of a fuel leak or a direct to leading indicator for on-wing intervention.

n. In addition, as recommended by CFM, multiple tasks were performed. As the source of fuel leak was not detected, the engine was removed for MRO intervention. Thus, LH Engine (ESN: 598879) was replaced with other serviceable engine (Sl No: 598196).



(Photograph# 2: Engine fire signs on LH engine (ESN) 598879)

1.7 Meteorological Information:

"METAR VABB 191930Z 06005KT 2200 FU FEW020 SCT100 26/13 Q1014 NOSIG="

The METAR report for VABB (Chhatrapati Shivaji Maharaj International Airport, Mumbai) on 19.12.2023 at 19:30 UTC indicates the following:

Wind is from the northeast at 060 degrees at 5 knots. Visibility is 2200 meters due to smoke. There are a few clouds at 2000 feet and scattered clouds at 10,000 feet. The temperature is 26°C, the dew point is 13°C, and the atmospheric pressure is 1014 hPa. The report ends with "NOSIG," indicating no significant weather changes are expected.

1.8 Aids to Navigation:

Aircraft is equipped with navigation aids such as ADF, ILS, GPS, VOR, DME, ATC Transponder Mode S and Weather Radar, Radio Altimeter, TCAS & ELT. All navigational aids were reported to be available.

Runway 09 at Mumbai Airport is equipped with Cat IIIB ILS (Localizer and Glide path) & Approach Lighting System. Other navigation aids installed at Mumbai Airport include NDB, DVOR and DME with Precision and Non-Precision approach procedures. It has also a secondary surveillance RADAR for providing route navigation services. There were no known navigation aid difficulties reported by the crew.

1.9 Communication:

Aircraft is equipped with Very High Frequency transmitter & receiver set, High Frequency transmitter & receiver set and Satellite transmitter & receiver set.

There was always two-way communication established between the ATC and aircraft.

1.10 Aerodrome Information:

Chhatrapati Shivaji Maharaj International Airport is an international airport located in Mumbai. The runway available is an instrument runway of orientation Runway 09/Runway 27 and Runway 14/ Runway 32.

As per latest e-AIP effective 30.11.2023, the declared distances are provided in the Table: 4

Table: 4

RWY Designator	TORA (M)	TODA (M)	ASDA (M)	LDA (M)
14	2871	2871	2871	2471
32	2871	2871	2871	2673
09	3188	3188	3188	3048
27	3448	3448	3448	2965

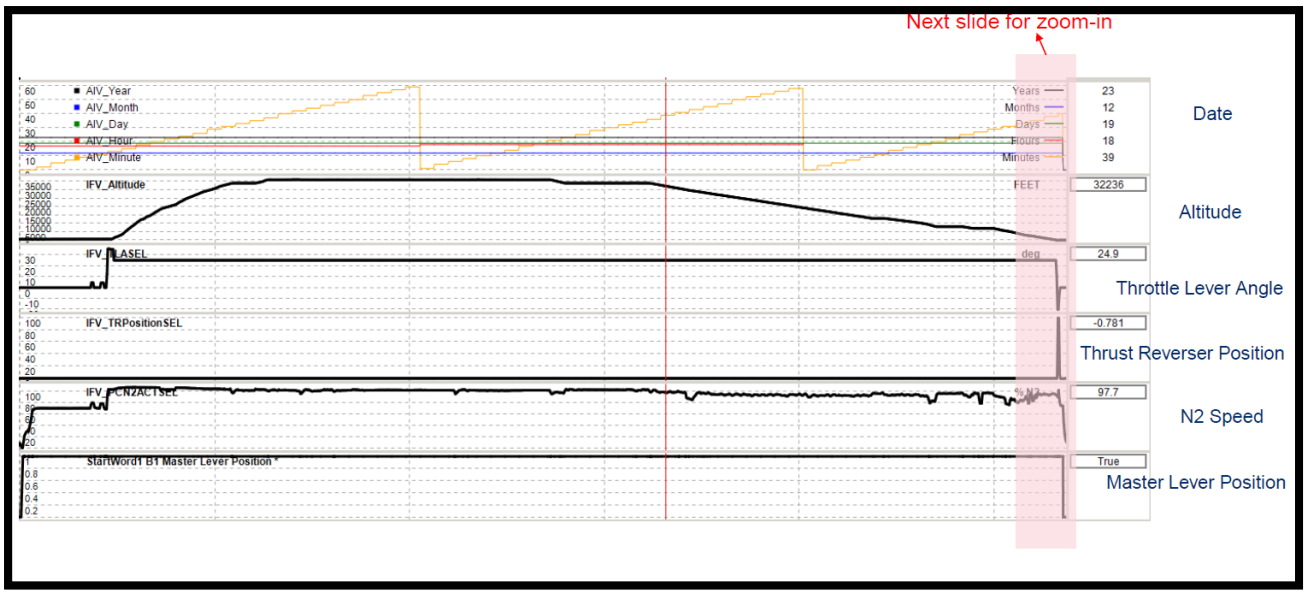
1.11 Flight Recorders:

1.11.1 DFDR:

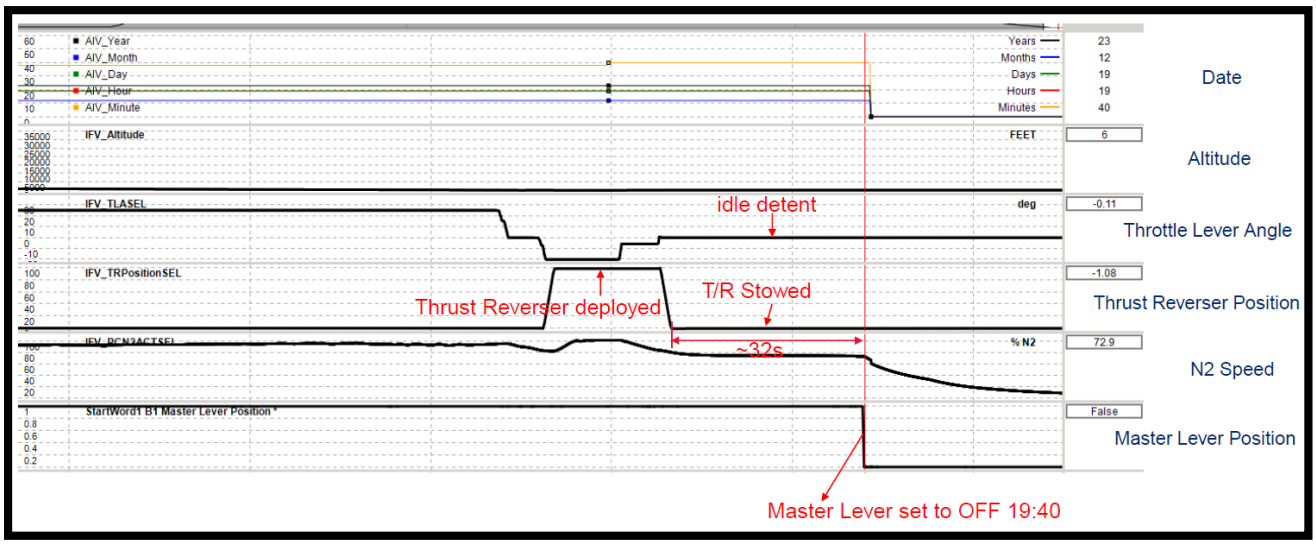
DFDR for the subject incident flight was analyzed. Engine start was normal for both the engines with all parameters in within range. The aircraft's takeoff, en-route flight and Landing all were normal. However, LH Engine Fire warning observed during landing roll. Subsequently, Crew actions were also observed.

a. 17:14:22 UTC: Aircraft lift off time
b. 19:40:05 UTC: Aircraft touch down time
c. 19:40:07 UTC: Aircraft thrust reversers were deployed for both engines.
   For LH Engine:
d. 19:40:24 UTC: (at 61.5 knots ground Speed), Master Caution got triggered & then after 1 second, LH Engine FIRE warning generated.
e. 19:40:28 UTC: LH Engine EGT started rising from 544 degrees Celsius & rose up to maximum of 653 degree Celsius.
f. 19:40:52 UTC: LH Engine EGT started decreasing.
g. 19:41:01 UTC: LH Engine Master was switched off.
h. 19:41:11 UTC, FIRE PB switch of LH Engine was pulled out & thereafter, LH Engine FIRE Warning got disappeared at 19:41:21 UTC.

The graphical representation of DFDR Data of event flight is provided below. Throttle lever angle and Thrust lever position, N2 speed and Master lever position with respect to LH Engine is represented along with altitude in the below graph. (Refer Graph 1 & Graph 2 (zoom in view)).



(Graph# 1: DFDR Analysis of event flight VT-CIH, where zoom-in referred in Graph# 2)



(Graph# 2: DFDR Analysis (zoom-in portion referred in Graph#1) of event flight VT-CIH)

1.11.2 CVR:

CVR Transcript for flight AI-814/VT-CIH on 19.12.2023 is given below:

AGENCY	TIME in UTC (hh:mm:ss)	COMMUNICATION
Aircraft Call Out	20:07:38	RETARD……RETARD……RETARD……RETARD
FO (PM)	20:07:44	Spoilers…..Reverse Green…..DECEL
FO	20:07:52	70kts
Aircraft	20:07:58	Auto Brake OFF
Aircraft	20:08:00	MASTER WARNING
FO	20:08:04	LH Engine FIRE
FO	20:08:09	Cancelling the Warning

ATC	20:08:14	Further right D1
FO	20:08:14	Stand By……Stand By
PIC (PF)	20:08:18	We have Engine Fire Sir….MAY DAY, MAY DAY, MAY DAY, AIR INDIA 814
PIC	20:08:25	OK, aircraft stopped, OK when aircraft stopped parking brakes ON, MAY DAY, MAY DAY, MAY DAY, AIR INDIA 814
PIC	20:08:29	CABIN CREW ALERT
FO	20:08:30	ATTENTION CREW AT STATIONS
PIC	20:08:32	LH Engine MASTER OFF
PIC	20:08:35	LH Engine Master is OFF
PIC	20:08:38	LH Engine FIRE PUSH BUTTON PUSH
PIC	20:08:40	LH Engine FIRE PUSH BUTTON
FO	20:08:43	LH Engine FIRE PUSH BUTTON PUSH
FO	20:08:48	AGENT 1 DISCHARGE
FO	20:08:50	AGENT 1 DISCHARGE
FO	20:08:54	AGENT 2 DISCHARGE
PIC	20:09:10	Tower Air India 814
ATC	20:09:15	Air India 814 Fire Brigade approaching, report status.
PIC (PM)	20:09:20	Sir our indication showing Fire Extinguisher, Requesting all assistance
PIC	20:09:22	ROGER Ma'am Fire Tender approaching shortly
FO	20:09:28	Do you want to Cancel Alert – Passenger Announcement
PIC	20:09:30	CANCEL ALERT, Passenger to remain seated
FO	20:09:50	We will CANCEL the URGENCY in ……(Speech was not clear)
PIC	20:09:54	Tower Air India 814
ATC	20:10:00	Air India 814 Tower
PIC	20:10:02	Sir requesting assistance if someone can visually identify if there is fire outside
ATC	20:10:08	ROGER, Fire tender is behind you please stand by
ATC	20:10:25	Air India 814 surrounded by fire extinguishers, will advise shortly
PIC to Cabin Crew	20:10:34	Ma'am we have an engine fire warning (conversation obscure). OK so we are just waiting for the fire extinguisher to tell us
ATC	20:11:13	Fire Manager Bombay Tower, report status when able Sir
Fire Watch Tower	20:11:19	Mumbai Fire Watch Tower any message for us Sir
ATC	20:11:23	Affirm Sir the aircraft is requesting. Sir, confirm can you see any visual fire
Fire Watch Tower	20:11:26	Nahi, Sir
ATC	20:11:27	ROGER
ATC	20:11:35	Air India 814, as per the fire manager no visible fire on the aircraft
PIC	20:11:39	Thank you, Sir.

FO to PIC	20:11:43	So, let's see we don't have LH Engine, there is no indication. So, no need for Emergency Evacuation Checklist, OK
PIC to FO	20:11:53	We have pushed the push button; both the agents are discharged and after that the fire has gone out
PIC	20:11:55	Sir any smoke coming out from the engine
ATC	20:11:58	Will advise Ma'am
ATC	20:12:01	Fire managers confirm any smoke visible
Fire Manager	20:12:49	Air India, Fire Manager, do you have any trouble inside cockpit
FO	20:12:51	We had an engine fire warning, Engine Fire on Engine No-1, on the left engine
Fire Manager	20:13:23	Copied left engine. Our observation is going on Sir, nothing is visible from outside
ATC	20:13:26	Air India 814 Stand By will advise further
FO	20:13:27	OK, so we don't have normal breaking as LH Engine has gone, we can taxi
Fire Manager	20:13:50	Air India, Fire manager, from my side it is clear
PIC	20:13:51	OK, thank you so much
PIC	20:14:09	Sir the fire manager is saying that from his side the aircraft is clear
ATC	20:14:13	Air India 814 ROGER
ATC	20:14:43	Air India 814 confirm your engine are running
PIC	20:14:48	Sir we have shut down LH Engine on which we had the fire indication, but we can vacate the Runway
ATC	20:14:55	ROGER, fire manager confirm it is OK if Air India will be taxying on one engine
Fire Manager	20:14:58	That is affirm, my two vehicles will follow aircraft up to the bay
ATC	20:15:26	ROGER Air India 814 vacate Runway by N5 and further taxi by N1
Further parking and securing of aircraft as per the SOP.		

1.12 Wreckage and impact information:

Not applicable

1.13 Medical and pathological information:

The operating crew underwent the Pre-Flight BA Examination before operating the first flight of the day in Mumbai and the result was found to be negative.

1.14 Fire:

There was LH Engine fire indication light in cockpit for which both the Fire Extinguisher bottles were discharged and the LH Engine fire indication light went off. Further during troubleshooting, black-soot and carbon deposits was observed inside the LH Engine which confirmed the actual Fire.

1.15 Survival Aspects:

No human injuries were reported in the incident. The incident was survivable.

1.16 Tests and research:

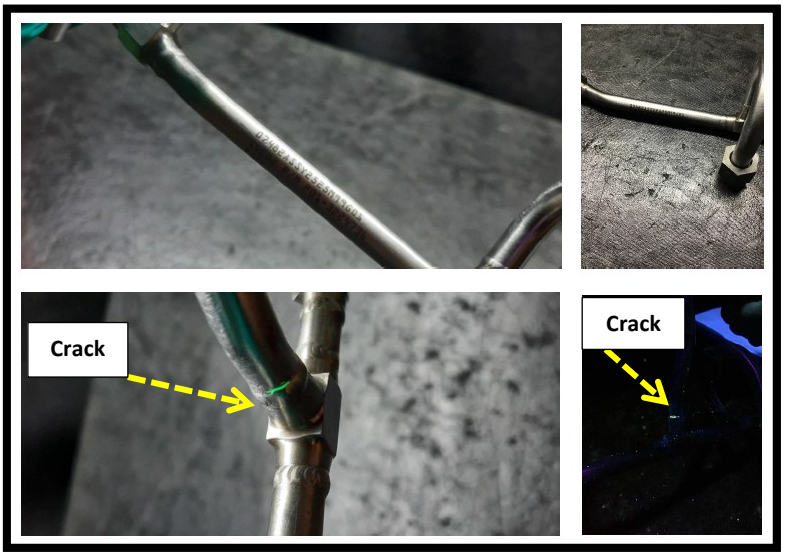
M/s CFMI's Engine Shop report (dated 07.06.2024) for ESN 598879 (subject incident engine) and ESN 598655:

a. M/s Air India **had reports of fire** on ground related to fuel leaks from cracked LEAP-1A fuel manifold on two engines in their fleet:

i. On 19.12.2023, ESN: 598879 of aircraft VT-CIH (subject incident Flight no: AI-814): Crack was found at the weld area of the manifold part number 2525M99G01.

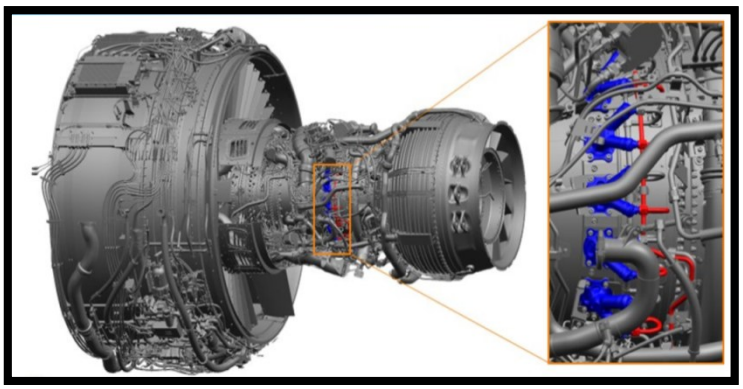
ii. On 29.05.2023, ESN: 598655 of aircraft VT-EXK: Fuel Manifold PN 2525M99G01 found with crack at the welding joint near to the Fuel Nozzle location #18.

b. The shop visit reports from ESN 598879 and ESN 598655 provided by M/s GEES-M (GE Engine Services-Malaysia) both concluded that the cause of the fuel leak that led to the fire was from cracks in the weld of the fuel manifold 2525M99G01 (Refer photograph 2).

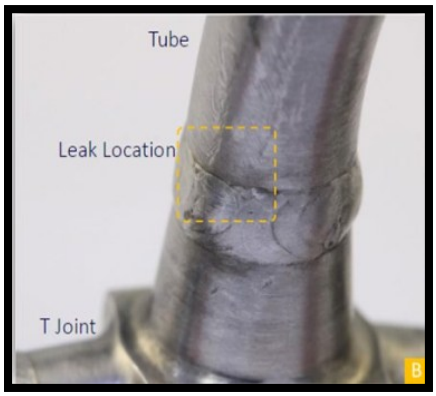


(Photograph# 2: Fuel Manifold of ESN 598879 showing crack along with its SEM (Scanning electron microscopy) Image)

c. The fuel manifold in a sample engine and the pattern of crack at weld area of the fuel manifold is shown below. (Refer photograph 3 & 4).



(Photograph# 3: 3-D Model of LEAP-1A Engine showing Fuel Manifold (in red))



(Photograph# 4: Pattern of crack in Fuel Manifold for low cycle fatigue)

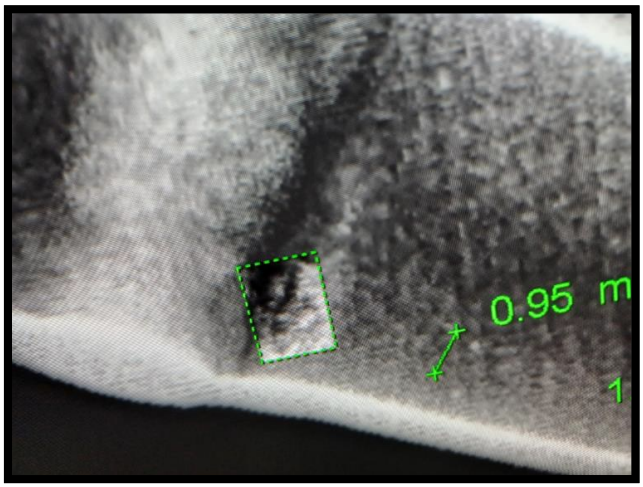
d. The fuel manifolds are external hardware on the engine, so bore scope inspection is not needed as part of the investigation for these events. However, BSI and other NDT tests were carried out on ESN 598879 at M/s GE, Pune is given below in Table: 5

Table: 5

TEST	Findings
1. Fluid Penetrant Inspection (FPI)	Multiple small cracks ('fork-spoon' appearance) clustered together totalling to approx. 0.25in circumferentially. (Refer Photograph# 5)
2. Fixture/dimensional check	Part fitted better in fixture. It's distorted but much less than 598-655.
3. X-ray	Confirmed crack/defect presence
4. Wall thickness check	Conforming to wall thickness requirements (Refer Photograph# 6)
5. Borescope Inspection (BSI)	Showed presence of fuel-cocking on tube ID side. (Refer Photograph# 7)

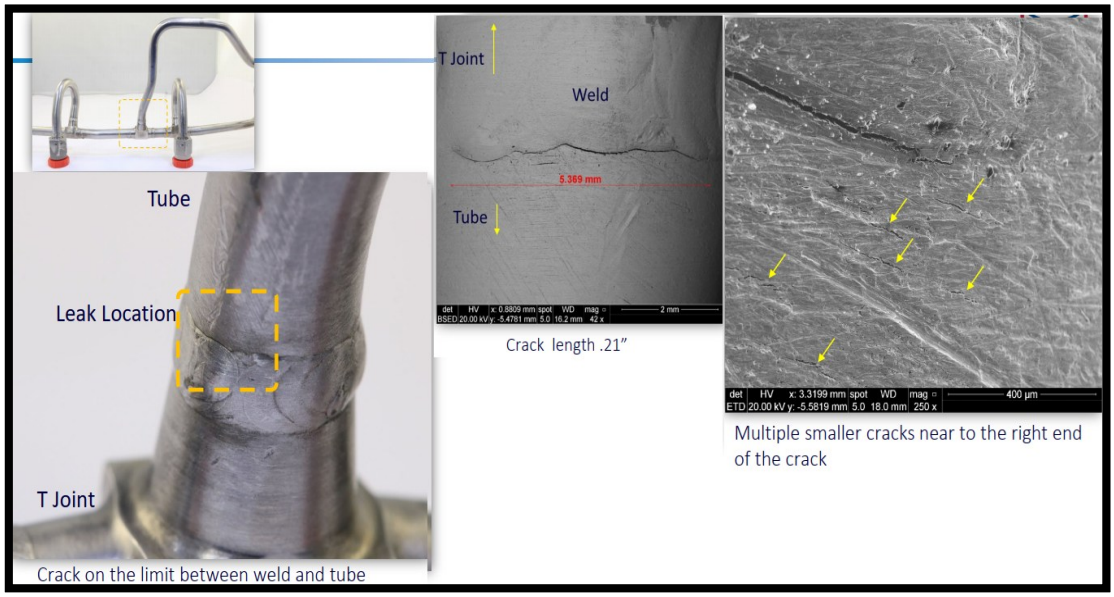
(Photograph# 5: FPI of fuel manifold)

(Photograph# 6: Dimension check)



(Photograph# 7: X-Ray of fuel manifold)

e. Metallographic summary/metallurgical analysis of crack observed in the fuel manifold of engine ESN 598655 for previous similar case of 29.05.2023 on aircraft VT-EXK provided below for reference: (Refer photograph 8).



(Photograph# 8: Specimen diagram for crack developed due to low cycle fatigue failure)

f. M/s CFMI has terminated the metallographic evaluation of involved engine (ESN 598879) fuel manifold as the root cause cracks in the weld of the fuel manifold 2525M99G01 is determined as consistent with low cycle fatigue, as similar observation was made during metallurgical analysis of the other engine ESN 598655.

g. Comparison of both engines timeline till the date of incident is provided in Table 5:

Table: 5

Parameters	ESN: 598879 (VT-CIH)	ESN: 598655 (VT-EXK)
Engine time since new (ETSN)	14,242	12,932
Engine cycle since new (ECSN)	6,918	6,364
Time since last shop visit (TSLSV)	5,291	3,016
Cycles since last shop visit (CSLSV)	2,357	1,344

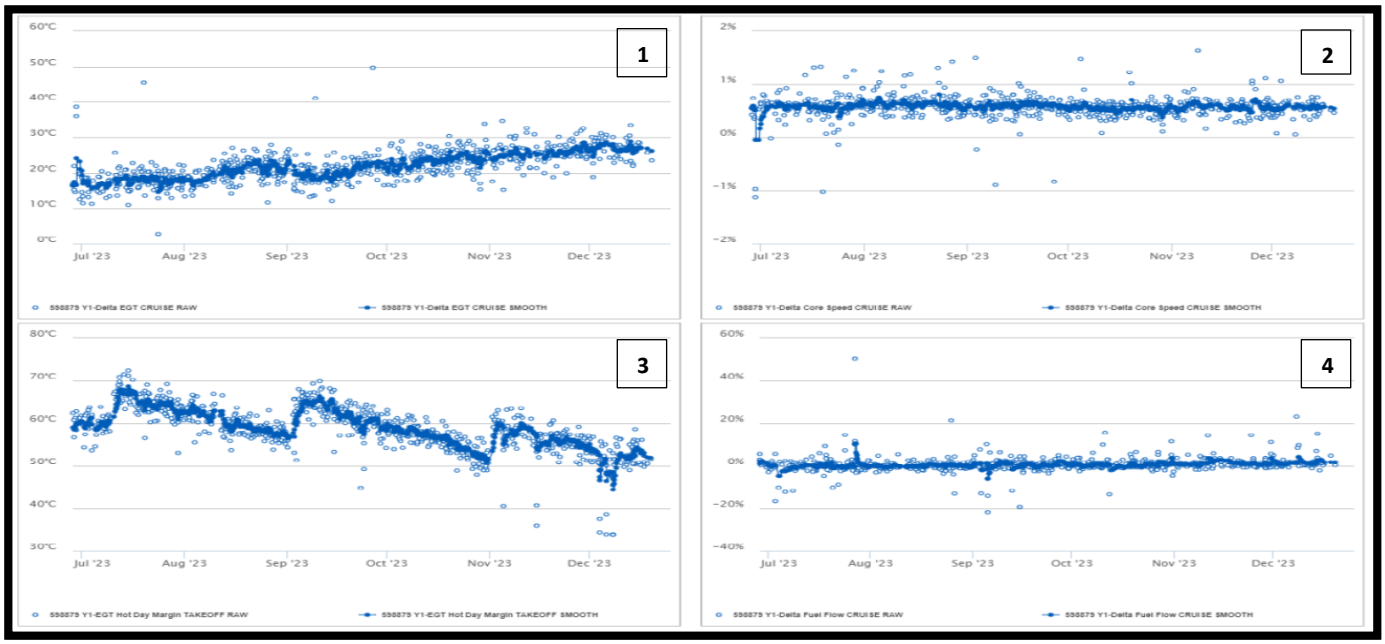
Clarification and information received from M/s CFM wrt Fuel Manifold Leak Under cowl Fire

h. In ESN 598879, the torque value of fuel nozzle 13 was found less during post incident troubleshooting. As per the CFM clarification, the fuel nozzle b-nut torque check that was performed on ESN 598655 did have two findings of breakaway torque measurement of 204 lbf.in, but these were just findings and not the root cause of the fuel leak that led to the fire on ESN 598655.

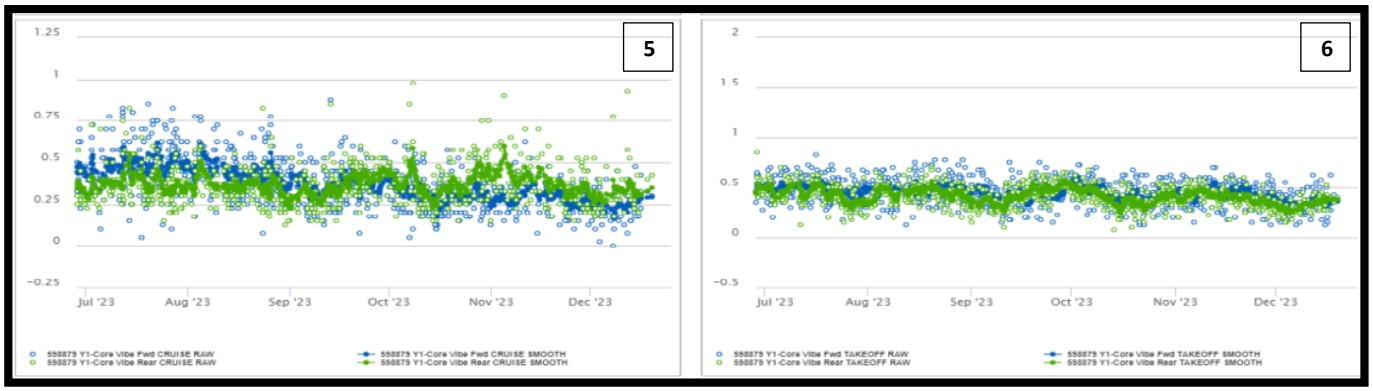
i.e., there is not a breakaway torque requirement in the ESM or AMM for fuel nozzle b-nuts. Hence, this lower torque value of fuel nozzle is not contributing to the fuel leak on both engines.

i. The fuel manifold cracks that were observed on ESN 598879 and 598655 would not have been led to a shift in engine performance that would have been detectable via CEOD analysis.

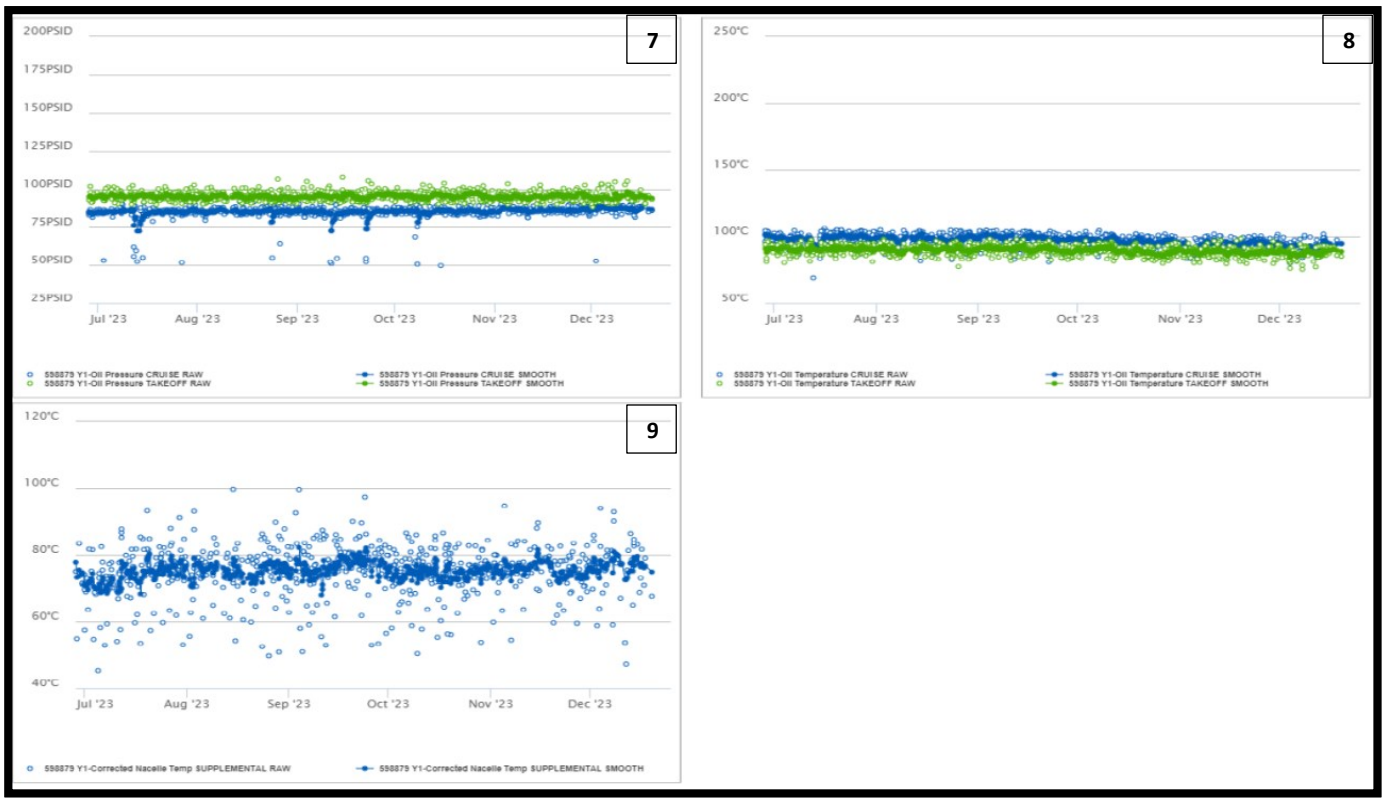
j. As per CEOD analysis report by CFM, there was no significant shift observed in engine performance of ESN 598879 CFM Engine for EHM from 28.06.2023 – 25.12.2023 (i.e. for 180 days). Trend analysis of engine ESN 598879 during the last six months till the incident is provided below: (Refer Graph 3, 4 and 5).



(Graph# 3: Representing trend on Delta EGT during Cruise (1) and Delta core speed during Cruise (2), EGT Hot day margin take-off (3), Delta fuel flow cruise (4))



(Graph# 4: Representing trend on Core vibration forward & rear during Cruise (5) and core vibration forward and rear during take-off (6))



(Graph# 5: Representing trend on Oil pressure during Cruise & take-off (7), Oil temperature during Cruise & take off (8) and corrected nacelle temperature supplemental (9))

k. CNR was not represented for last 300 Flight Cycles by CFM. For the ESN 598879, the last CNR was sent in November 2023 (PSS Freezing). Another CNR was sent in May 2023 about the Fuel Nozzle Pilot Orifice. - For the ESN 598655, the last CNR was sent in October 2022 and it was a Water wash advisory.

l. The CNRs that were issued for ESN 598879 and 598655 did not relate to the fuel manifold cracks that were observed on these two engines. There are not any LEAP CNRs currently available to detect the type of fuel leaks from the fuel manifold cracks on ESN 598655 and 598879.

m. There are no Airworthiness Directives related to affected fuel manifold P/N 2525M99G01 till the date of incident.

1.17 Organizational and Management Information

Air India Limited, a scheduled Indian airline owned by the prestigious Tata group, is headquartered in Gurugram. The airline holds a valid Air Operator Certificate No. S-9 in the "Passenger and Cargo" category, issued by DGCA and valid until 30.06.2028. Its fleet includes Airbus A319, A320, A321, A320NEO, and Boeing B747, B777, and B787 aircraft, recently adding the Airbus A350. As India's largest international carrier, Air India operates major hubs at Indira Gandhi International Airport in New Delhi and Chhatrapati Shivaji International Airport in Mumbai.

The company is headed by the Chief Executive Officer and Managing Director, supported by a team of professionals across various departments. The Flight Safety Department is headed by the Chief of Flight Safety, approved by the DGCA. There have

been no significant recent changes in the management structure. At all domestic and international stations, engineering and ground handling functions are subcontracted to local agencies. Air India has established procedures for evaluating subcontractors before awarding contracts, detailed in the Air India Ground Handling Operational Manual, Engineering Procedure Manual, and Corporate SMS Manual.

1.18 Additional Information

Nil

1.19 Useful or Effective Investigation Techniques

Nil

2. ANALYSIS

On 19.12.2023, M/s Air India Limited Flight AI-814, Airbus A320-251N aircraft bearing registration VT-CIH, while operating a scheduled flight from Delhi to Mumbai, got LH Engine fire warning during landing roll.

2.1 Operational aspects:

Both the flight crew members (ATPL holders) were medically fit, had valid license, provided adequate rest, and found to be within FDTL limits before they operated flight AI-814 (Delhi -Mumbai) on 19.12.2023. Their Breath Analyzer records indicated that they were not under the influence of alcohol. Flight AI-814 was the first flight of the day for VT-CIH aircraft and second flight of the day for both the flight crew. The PIC performed the duties of the Pilot Flying (PF) and FO performed the duties of Pilot Monitoring (PM).

On 19.12.2023, while operating AI-814, sector DEL-BOM, the flight was uneventful until it landed at Mumbai Airport. However, on landing roll, after 70 knots, "LH Engine Fire Warning" got triggered.

As such, the aircraft was stopped on the RWY & the respective ECAM actions were performed by the operating crew, where LH Engine master switch was shut off and LH Engine fire PB Switch was pushed & both fire extinguishing agents (1 & 2) were discharged.

Thereafter, the fire indication got extinguished & the aircraft was safely taxied to the bay using RH Engine.

In view of above deliberations, the crew actions were not the contributory factor to the incident.

2.2 Aircraft Aspects:

2.2.1. Airworthiness of the aircraft

The aircraft had a valid Certificate of Airworthiness and the ARC had been valid as on the date of the incident. As per the records, the aircraft had been maintained in accordance with the Approved Maintenance Program.

The incident involved LH engine (Sl no: 598879) had accumulated a total of 14242:37hrs TSN and 6918 CSN as on the day of the incident. It was installed with the aircraft on 18.09.2022, while it had accumulated 8952hrs TSN and 4561 CSN on the day of the incident.

The aircraft and its engines were being maintained as per the maintenance program, approved by DGCA. All the concerned AD, mandatory SBs, and DGCA mandatory modifications on this aircraft and its engine were complied with as on date of the incident.

3A Inspection check was carried out on the subject engine on 10.07.2023 after which no snag/fault was mention in the engine log book. Fuel nozzle last replacement was on 11.07.2023. Number of cycles flown post fuel nozzle replacement till the event is 821CSN.
The last major inspection was (1A+1B+C) carried out on 01.11.2023 and the aircraft had logged a total of 20335:03 airframe hours/ 9850 aircraft cycles and LH engine (Sr.no. 598879) logged 13636:47 hrs/6691 cycles before the incident.

Scrutiny of tech-log pages reveals that repetitive Snags/ Defect on "LH Engine fire loop 'A' fault and LH Engine light on Engine Master panel unserviceable" were reported in the last one month prior to this incident. However, it was not contributing to this incident as actual fire was there in this case and fire warning also triggered in LH Engine.

For the defect reported in the previous sector before the incident, "LH engine Fire loop A Fault" which was already under MEL, was revoked by the AME at Delhi on 19.12.2023 and rectification for "LH Engine fire light on Engine master panel unserviceable" was also carried out and cleared the snag prior to the incident sector. And, there was no MEL active relevant to the incident.

Prior to the operation of the subject incident flight, the AME had carried out pre-departure check, General Visual Inspection (GVI) of the LH engine and its drains, finding no abnormalities or leaks. There were no faults or status messages relevant to that engine observed in the ECAM page PFD. The aircraft was loaded within the CG limits. The engine start after pushback was normal, and no messages were reported by the PIC.

Therefore, the aircraft and LH Engine was airworthy as on the date of the incident.

After the Incident, Post flight report and DFDR revealed soon after full reversers were used and speed reduced below 70kts, LH Engine fire ECAM warning triggered during landing roll. Subsequently, LH Engine EGT also seen increased from 544 degrees Celsius & rose up to maximum of 653 degree Celsius and further reduced. LH Engine Master was switched off and FIRE PB switch of LH Engine was pulled out & thereafter, LH Engine FIRE Warning disappeared. Upon external inspection of the aircraft, the airport fire manager also reported no signs of engine fire or smoke.

During the walk around inspection by the arrival AME, no damage or evidence of fire were observed to the aircraft and engine. Also, there was no fuel/oil/hydraulic/air leak was observed externally. Engine oil quantity and hydraulic fluid quantity was found above minimum limit.

2.2.2. Engine Investigation

During the inspection of the arrival aircraft at the NEC hanger Mumbai Airport, external checks of the LH engine were performed, and no visible signs of fire were observed by the AME. The findings were reported to CFM, and as per CFM's recommendations, AMM procedure with respect to Engine Fire or use of Fire-Extinguishing agents was referred. A visual inspection and operational test of Engine Fire & Overheat detector were performed & both were found satisfactory.

Subsequently, a visual inspection of the LH Engine pylon and harness was carried out, and it was found that **Pylon Loops A & B were covered in black soot**, while rest were satisfactory.

During further troubleshooting, no fuel, hydraulic or air leaks were observed. A detailed inspection of the LH Engine revealed **black sooty deposits below the pylon area at approximately 12^0 clock position.** As per AMM 72-00-00-200-821-A inspections, the engine deemed to be replaced; however, the source of the leak which caused the fire was not detected. To identify the source of the leak, multiple pylon panels were opened and no fuel leak was found in the pylon area. Additionally, during Wet Motoring inspection, a fuel leak was observed at the 6^0 clock position (B sump drain line, at the attachment to the casing), which is considered normal. No other fuel leaks were observed.

The above observations were shared with CFM **to identify the exact location of fuel leak.** As per CFM recommendations, a visual inspection of each fuel nozzle B-nut was carried out, and no leaks were observed. **Only cocking and Black soot was observed on 9^0 clock position & 11-11:30^0 clock positions of the fuel nozzle. All fuel nozzles were then inspected for safety cables, and the results were found to be satisfactory. No markings were observed on the fuel nozzles, and no leakage was detected.** Subsequently, a torque check of the fuel nozzle B-nut was carried out, and it was found that the torque value of one B-nut was less than the required torque. However, as per the CFM clarification, this lower torque value of fuel nozzle was determined to be merely a finding and not a contributing factor to the fuel leak.

During CEOD analysis performed by CFM to identify a suitable root cause of a fuel leak or any direct leading indicators for on-wing intervention, no abnormalities were found. Also, no significant shift in engine performance was observed in the past six months prior to the incident. According to EHM, no abnormal engine performance trends were reported in the past six months prior to the incident.

After performing multiple tasks as recommended by CFM, the exact source of fuel leak was not detected. Therefore, the LH Engine was replaced with other serviceable engine for MRO intervention and further detailed inspections.

The shop visit reports for ESN 598879, provided by M/s GEES-M, concluded that the cause of the fuel leak that led to the fire was from cracks in the weld of the fuel manifold 2525M99G01. During borescope inspection, presence of fuel-cocking was observed on tube ID side. Crack/defects were detected during Fluid Penetrant Inspection and X-RAY analysis.

A similar engine fire incident was reported by M/s Air India in their fleet on 29-May-2023, where fuel leaks were observed from the same cracked fuel manifold on other LEAP-1A engines ESN: 598655 during metallographic analysis. Hence, M/s CFMI has terminated the metallographic analysis of subject incident involved engine (ESN 598879) as the root cause of cracks in the weld of the fuel manifold 2525M99G01 was determined as consistent with low cycle fatigue (based on the metallurgical analysis of the other engine ESN 598655).

There are no CNRs issued for ESN 598879 and 598655 till the incident date regarding the fuel manifold cracks observed on these engines, and no LEAP CNRs are currently available from the OEM to detect the type of fuel leaks caused by these cracks. Additionally, there are no Airworthiness Directives related to affected fuel manifold P/N 2525M99G01 have been issued till the date of the incident.

2.3 Weather:

The METAR report for VABB on 19.12.2023 at 19:30 UTC shows northeast winds at 05knots, visibility of 2200meters due to smoke, a few clouds at 2000feet, and scattered clouds at 10,000feet. The temperature is 26°C, dew point 13°C, and atmospheric pressure 1014hPa. No significant weather changes are expected. Thus, it is inferred that the weather is not a factor to the incident.

3. CONCLUSION

3.1 Findings

3.1.1 The Airworthiness Review Certificate of the aircraft was valid and the aircraft was maintained in accordance with the approved maintenance program.

3.1.2 The aircraft was airworthy before the release for incident flight.

3.1.3 No relevant snags/defects were reported in the last month prior to this incident. There was no MEL relevant to this incident flight. From Post flight report, no snag history associated with the affected LH engine was noticed in the past 3 sectors of the aircraft.

3.1.4 LH engine (Sl no: 598879) had accumulated a total of 14242:37hrs TSN and 6918 CSN as of the day of the incident. After being installed on this aircraft on 18.09.2022, LH engine had accumulated 8952hrs TSN and 4561 CSN by the day of the incident.

3.1.5 LH engine Fuel nozzle last replacement was on 11.07.2023. Number of cycles flown post fuel nozzle replacement till the event is 821CSN.

3.1.6 Last major inspection of the aircraft and engine i.e. 1A+1B+C inspection were carried out on 01.11.2023, where LH engine had accumulated 13636:47hrs/ 6691cycles prior to the incident flight.

3.1.7 The LH engine was deemed airworthy as of the incident date.

3.1.8 The aircraft was loaded within the CG limits.

3.1.9 AME pre-departure check, found no abnormalities; normal engine start reported.

3.1.10 The weather reported was fine and is not a factor to the incident.

3.1.11 Both PIC & FO were medically fit and within FDTL limits for Flight AI-131. Both had a valid license to fly the aircraft and their medical was also valid at the time of the incident. The crew members held valid licenses, received adequate rest, and operated the first flight of the day.

3.1.12 The Pilot in Command (PIC) served as Pilot Flying (PF), and the First Officer (FO) as Pilot Monitoring (PM).

3.1.13 Takeoff till landing approach was uneventful.

3.1.14 During landing roll, when aircraft speed reduced to 70kts, thrust reversers were moved from max to reverse idle, master caution warning for “LH engine fire” was triggered. After stopping the aircraft, ATC was informed of LH Engine fire warning with May Day call and cabin crew was alerted. Procedures including ECAM actions were followed. Engine master switch was shut off. Engine fire PB Switch was pushed. Both fire extinguishing agents (1&2) were discharged. After completion of ECAM actions, fire warning indications went off.

3.1.15 Subsequently, aircraft was externally inspected by airport fire manager and no signs of engine fire or smoke were reported.

3.1.16 There was no injury reported to the crew or passengers or any outside person.

3.1.17 During the walk around inspection by the arrival AME, no damage or evidence of fire were observed to the aircraft and engine at the parking bay. Also, there was no fuel/oil/hydraulic/air leak was observed externally. Engine oil quantity and hydraulic fluid quantity was found above minimum limit.

3.1.18 From scrutiny of DFDR and CVR recording and transcript, crew actions were satisfactory.

3.1.19 During post incident troubleshooting, **cocking and black soot were observed between the 9^0-$11{:}30^0$ clock positions on the fuel nozzle/manifold of the LH engine** (viewed from the rear of the engine). Additionally, black sooty deposits were found below the pylon area near the 12^0 clock position of the LH engine. These findings indicate the presence of an actual fire in the LH engine.

3.1.20 Fuel leak was not observed post-event during wet motoring inspection.

3.1.21 Since no fuel leak was detected, the LH engine was replaced and sent to CFM (OEM) for a shop investigation to identify the exact source of the fuel leak.

3.1.22 During shop investigation by M/s GEES-M, fuel leak was observed from fuel manifold area on LH engine ESN 598879.

3.1.23 The CFM investigation identified a crack in the weld area of the fuel manifold (part number 2525M99G01) of the LH engine as a potential cause of the fuel leak, which triggered the LH engine fire warning.

3.1.24 According to CFM's clarification, a small amount of fuel leakage from fuel manifold cracks as observed on ESN 598879, would not cause any significant changes in the engine trend data.

3.1.25 As per CEOD analysis report by CFM, there was no significant shift observed in engine performance of (ESN 598879) in the past six months prior to the incident.

3.1.26 As per EHM, no abnormal engine performance trends were reported prior to the incident in the past six months.

3.2 Probable Causes

The crack in the weld of the fuel manifold of the LH engine caused the fuel leak, which eventually led to the LH Engine fire warning. The root cause of crack in the weld of the fuel manifold is determined as low cycle fatigue.

4. SAFETY RECOMMENDATIONS :

4.1 DGCA Hqrs may advise the operator to introduce preventive measures in coordination with OEM.

4.2 Any other action deemed fit by DGCA HQ based on findings made in the report.

YOGESH ANKUSHRAO KAKDE
2025.03.12 18:25:12

(Yogesh Kakde)
Air Safety Officer
Member

Digitally signed by Binitha Michael
Date: 2025.03.12 18:47:39+05'30'

(Binitha Michael)
Assistant Director Air Safety
Investigator In-charge/VT-CIH

Date: 12.03.2025
Place: Mumbai