

## Office of the Dy. Director General of Civil Aviation (Northern Region)



**Investigation Report On In-flight Engine Shut-Down  
Incident to M/s Air India Aircraft VT-EXV on 05.01.2019**

## FOREWORD

In accordance with Annex 13 to the International Civil Aviation Organisation Convention and the Aircraft (Investigation of Accidents & Incidents) Rules 2017, the sole objective of this investigation is to prevent aviation incidents and accidents in the future. It is not the purpose of the investigation to apportion blame or liability.

This report has been prepared based upon the evidences collected during the investigation and opinions obtained from the experts. Consequently, the use of this report for any purpose other than for the prevention of future incidents /accidents, could lead to erroneous interpretations.

## GLOSSARY

1.	ACOC	Air Cooled Oil Cooler
2.	ALTP	Airline Transport Pilot's License
3.	A/P	Auto Pilot
4.	ATC	Air Traffic Control
5.	ATS	Air Traffic Services
6.	CAR	Civil Aviation Requirements
7.	CPL	Commercial Pilot License
8.	CSN	Cycles Since New
9.	CVR	Cockpit Voice Recorder
10.	FDR	Flight Data Recorder
11.	DGCA	Directorate General of Civil Aviation
12.	ECAM	Electronic Centralized Aircraft Monitoring
13.	ESN	Engine Serial Number
14.	ETA	Expected Time of Arrival
15.	ETD	Expected Time of Departure
16.	F/D	Flight Director
17.	F/O	First Officer
18.	FADEC	Full Authority Digital Engine Control
19.	FCOM	Flight Crew Operations Manual
20.	FCTM	Flight Crew Techniques Manual
21.	FDR	Flight Data Recorder
22.	FIR	Flight Information Region
23.	FMS	Flight Management System

24.	FMU	Fuel Metering Unit
25.	FOB	Fuel On-board
26.	FOHE	Fuel Oil Heat Exchanger
27.	FRTOL	Flight Radio Telephone Operator's Licence
28.	FRV	Fuel Return Valve
29.	ICAO	International Civil Aviation Organisation
30.	IDG	Integrated Drive Generator
31.	IFR	Instrument Flight Rules
32.	IFSD	In-flight Shut-down
33.	ILS	Instrument Landing System
34.	LH	Left Hand
35.	MFF	Main Fuel Filter
36.	MFP	Mail Fuel Pump
37.	NOTAM	Notices to Airmen
38.	OFP	Operational Flight Plan
39.	P/N	Part Number
40.	PDR	Pilot Defect Report
41.	PF	Pilot Flying
42.	PFR	Post Flight Report
43.	PIC	Pilot In-Command
44.	PM	Pilot Monitoring
45.	RH	Right Hand
46.	QRH	Quick Reference Handbook
47.	RWY	Runway

48.	SB	Service Bulletin
49.	SCF-PP	System Component Failure-Power Plant
50.	SFH	Servo Fuel Heater
51.	SNY	Supernumerary Crew
52.	SOP	Standard Operating Procedure
53.	STD	Standard Time of Departure
54.	TSN	Time Since New
55.	TLA	Throttle Lever Angle
56.	UTC	Coordinated Universal Time
57.	VFR	Visual Flight Rules
58.	VHF	Very High Frequency

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**Investigation Report On In-flight Engine Shut-Down Incident to M/s Air India**  
**Aircraft VT-EXV on 05.01.2019**

## 1. Aircraft

Type : AIRBUS A320-251N  
 Nationality : INDIAN  
 Registration : VT-EXV

## 2. Owner : CELESTIAL AVIATION TRADING 64 LIMITED

Operator : AIR INDIA LTD.

## 3. Pilot-in-Command : ALTP Holder

Extent of injuries : NIL

Co-Pilot/First Officer : CPL Holder

Extent of injuries : NIL

## 4. Date of incident : 05.01.2019

Time of incident : 16:23 UTC

## 5. Place of Incident : En-route in Cruise

## 6. Co-ordinates of incident site : En-route in Cruise

## 7. Last point of Departure : VTBS (SUVARNABHUMI AIRPORT, BANGKOK )

## 8. Intended place of Landing : VIDP (INDIRA GANDHI INTERNATIONAL AIRPORT, DELHI)

## 9. No. of passengers on board : 132(excluding crew)

## 10. Type of operation : SCHEDULED COMMERCIAL AIR TRANSPORT OPERATION

## 11. Phase of operation : EN-ROUTE

## 12. Type of Incident : SCF-PP

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

**Synopsis:-**

M/s Air India Airbus A-320-251N (neo) aircraft VT-EXV operated flight AIC-335 of 05.01.2019 from Bangkok to Delhi. En-route during cruise the operating crew received ECAM warnings regarding disagreement between the FUEL USED and Fuel On-Board. After carrying out necessary assessments to isolate the fuel leak, the operating crew shutdown engine#2 and diverted the aircraft to Kolkata. A single engine landing was performed at Kolkata by 17:01 UTC.

DGCA-India, vide Order No DGCA-15019(1)/1/2019-AS dated 07.01.2019 instituted investigation of the occurrence under Rule 13 (1) of Aircraft (Investigation of Accidents and Incidents), Rules 2017 by an Investigation-In-Charge.

The cause of the incident was fatigue failure of fuel hose connecting the Main Fuel-Oil Heat Exchanger to the Engine driven FUEL PUMP.

## **1. Factual Information**

### **1.1 History of flight:**

M/s. Air India Airbus A-320-251 neo aircraft VT-EXV operated a scheduled flight AIC-335 on 05.01.2019, from Bangkok to Delhi. There was a total of 145 personnel on-board (including crew) for the flight sector.

Both the cockpit crew members had undergone the pre-flight breath analyser test at Kolkata prior to starting the first leg of the flight duty and were cleared to operate the flight.

The operating flight crew had operated the previous flight sector from Kolkata to Bangkok and PIC was the Pilot Flying. The aircraft had departed from Kolkata at 10:00UTC and reached Bangkok at 12:55UTC. The PIC performed the necessary transit inspection of the aircraft at Bangkok and he did not report any abnormalities; after which the crew operated the incident sector (Bangkok- New Delhi).

The planned fuel for the sector from Bangkok to Delhi was 12.6tonnes, however anticipating for extended holding at Delhi the final block fuel at departure was finalised by the crew as 13.5 tons. The aircraft got airborne from Bangkok at 14:47 UTC. PIC was the Pilot Flying for this sector.

Crew monitored both Fuel on-board and BURN FOB at waypoints en-route as required and made record of the same in the flight navigation log, the flight was uneventful till waypoint ‘PTN’. At 16:03UTC an ECAM warning was generated indicating a disagreement between the Fuel on-board and the fuel used. The aircraft was in contact with Yangon ATC at this point of time.

The cockpit crew called for the SNY (supernumerary crew-PIC rated) from the cabin and he assisted the flight crew in carrying out the fuel leak procedure. Four(04) minutes after ECAM warning generation the flight crew was advised by Yangon ATC to contact Kolkata ATC. The crew was unable to locate any visual evidence of leaks from the aircraft’s RH wing or engine. The operating crew coordinated with Kolkata ATC with the help of two other aircrafts, who relayed the messages for AIC-335, as aircraft was unable to contact Kolkata ATC on radio. However, the crew was able to receive the radio broadcast from Kolkata ATC. Upon reaching waypoint ‘IBITA’ the fuel on-board had reduced to 8.5tons against an expected 9.5 tons.

The flight was diverted to Kolkata, and ‘MAYDAY’ was declared by the crew with SQWAK code set to ‘7700’. Following the procedure, crew suspected fuel leak from Engine #2, as Engine#2 fuel consumption was observed to be approximately 180kg more than Engine#1 in 15 minutes. Subsequently Engine#2 was shut-down at 1625UTC by the operating crew and descended the aircraft to lower flight levels, and continued to descent in co-ordination with Kolkata ATC. After shutdown of engine#2 the fuel leak stopped.

After landing at Kolkata fuel leak was observed from Engine #2 and during wet motoring, fuel was found leaking from the fuel hose connecting Main Heat Exchanger to Main Fuel pump.

### **1.2 Injuries to persons:**

Injuries	Crew	Passengers	Others
Fatal	Nil	Nil	Nil
Serious	Nil	Nil	Nil
Minor/None	Nil/07+06(supernumerary crew)	Nil/132	

Total Personnel on Board : 145

### **1.3 Damage to aircraft:**

After landing at Kolkata, during wet motoring inspection fuel leak was isolated from the fuel hose connecting Main Heat Exchanger to Main Fuel pump.

The damaged Fuel hose (P/N:- 362-110-422-0 ) was replaced. Damage was limited to the fuel hose and no other damage was reported.

### **1.4 Other damages:**

Nil

### **1.5 Personnel information:**

Cockpit was manned at the time of occurrence by Crew of M/s Air India. The details of the licences and ratings are as detailed below:-

<b>Personnel Information :</b>		
<b>Details</b>	<b>PIC</b>	<b>First Officer</b>
a) Type of license	ATPL holder	CPL holder
b) Valid upto	05/11/2021	18/07/2022
c) Date of Initial issue	06/11/2012	19/07/2012
d) Class of license	Multi Engine Land	Multi Engine Land
e) Category of license	Aeroplane	Aeroplane
f) D.O.B	22/04/1988	12/11/1984
g) Aircraft Ratings	Cessna 152A, P-68C , A-320/319/321	Cessna 172, PA-34, A-320/319/321
h) Date of Endorsement as PIC	30/06/2016	N/A
i) Date of last Medical Exam	03/08/2018	10/09/2018
j) Medical Exam validity	03/08/2019	28/09/2019
k) FRTOL Valid upto	05/11/2021	18/07/2022
l) Instrument Rating	20/11/2018	08/11/2018

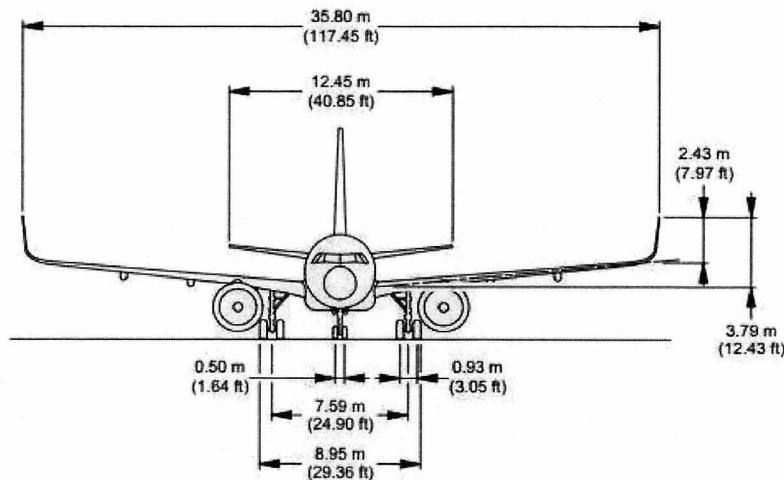
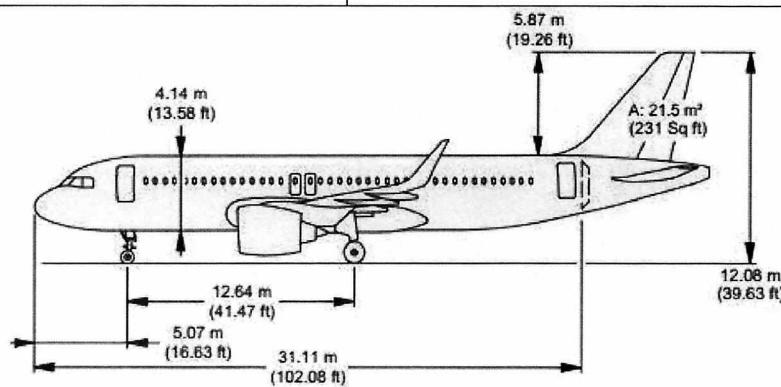
<b>Details</b>	<b>PIC</b>	<b>First Officer</b>
m) Date of Last LR check	20/11/2018	09/11/2018
n) Date of last Proficiency Check	24/06/2018	09/06/2018
o) Total flying experience	5880 hrs	1460 hrs
p) Experience on Type	5680 hrs	710 hrs
q) Experience as PIC on Type	1505 hrs	N/A
r) Last flown on Type(date)	02/01/2019	02/01/2019
s) Total flying experience in last 180 days	432 Hrs	342 hrs
t) Total flying experience in last 30 days	73hrs	44 hrs
u) Total flying experience in last 7 days	19 hrs	13 hrs
v) Total flying experience in last 24 hrs.	NIL	NIL
w) Rest before duty	71hrs 45 min	62 hrs 20 min

### **1.6 Aircraft information:**

Airbus A-320 neo is a twin engine aircraft offered with either CFM LEAP 1A or PW 1100 engine options; VT-EXV is fitted with LEAP 1A engines manufactured by CFM. The aircraft is equipped with winglets (sharklets). The aircraft is certified in Normal category, for day and night operation under VFR & IFR.

<b>1.6.1 Aircraft:-</b>	
a) Manufacturer	AIRBUS
b) Type	AIRBUS A320-251 NEO
c) Owner	CELESTIAL AVIATION TRADING 64 LIMITED
d) Operator	AIR INDIA LTD.
e) Manufacturer Serial no.	7662
f) Year of Manufacture	2017
g) Certificate of Airworthiness issue date	20.07.2017
h) Airworthiness Review Certificate	Issue Date: 10.07.2018 Validity:- 19.07.2019
i) Category	NORMAL

j) Certificate of Registration	C of R No.4789 Validity:- 04.07.2029
k) Minimum Crew Required	02 Cockpit Crew
l) Maximum All Up weight	79000 Kg
m) Last Major inspection	3A Check 31.12.2018
n) Last inspection	Layover check on 03.01.2019
o) Airframe Hrs since new	5177.40
p) Airframe hours since last C of A	1682.48
q) Status of Airworthiness Directive, Service Bulletins, DGCA Mandatory Modifications	Complied



General Dimensions of A320-251N

<b>1.6.2 Engine:-</b>	<b>LH</b>	<b>RH</b>
a) Manufacturer	CFM	CFM
b) Type	LEAP-1A26	LEAP-1A26
c) Engine Serial no.	598274	598277
d) Time Since new(TSN)	3915.30	3847.12
e) Cycles since new(CSN)	1997	1974
f) Time since last shop visit(TSV)	1745.55	1079
g) Cycle since last shop visit(CSV)	894	596
h) Last Major Inspection Carried out	3A check on 31.12.2018	3A check on 31.12.2018
i) Last inspection Carried out	Layover check on 03.01.2019	Layover check on 03.01.2019
j) Type of Fuel used	JET-A1	JET-A1

The subject engine (ESN: 598277) was sent to CFM shop for compliance of SB 72-00-0167 related to HPT rotor stage 2 disk.

At the same time retrofit has been applied to change -420 by -422, SB 72-00-0145-01A-930A-D has been applied in August' 2018 at TSN/CSN: 2439/1197.

### **1.6.3 Fuel System (CFM-LEAP 1A):-**

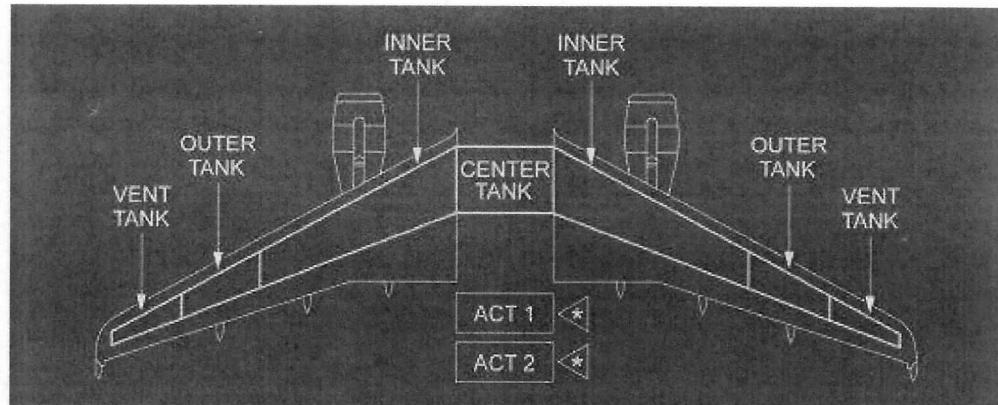
#### **1.6.3.1 Fuel Tank:**

The fuel is stored in the aircraft wings and in the center tank. The wings have inner and outer tanks. There is a vent surge tank outboard of the outer tank in each wing. When the aircraft has been refueled to maximum capacity, the fuel can expand by 2 % (20 °C temperature rise) without spilling.

There is an overpressure protector in each vent, outer and inner tank and between the center tank and the left inner tank.

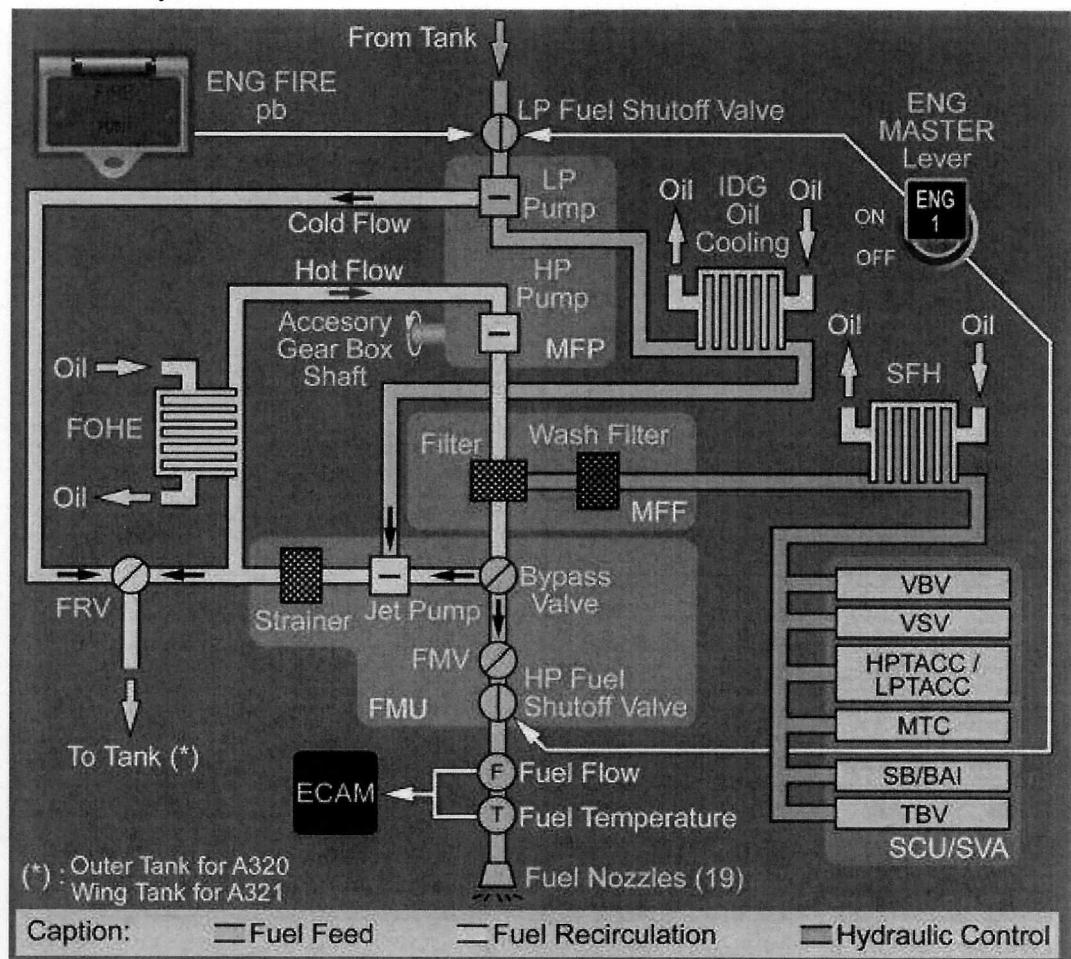
<b>USABLE FUEL</b>					
		<b>OUTER TANKS</b>	<b>INNER TANKS</b>	<b>CENTER TANK</b>	<b>TOTAL</b>
<b>VOLUME</b>	(liters)	864 x 2	6 874 x 2	8 248	23 724
	(US gallons)	228 x 2	1 816 x 2	2 178	6 267
<b>WEIGHT</b>	(KG)	678 x 2	5 396 x 2	6 474	18 623
	(LB)	1 494 x 2	11 896 x 2	14 274	41 054

*Fuel density : 0.785 kg/l or 6.551 lb/US Gal .*



Fuel tank configuration A320neo

### 1.6.3.2 Fuel System:



Schematic of Fuel System-A320neo- LEAP-1A engine

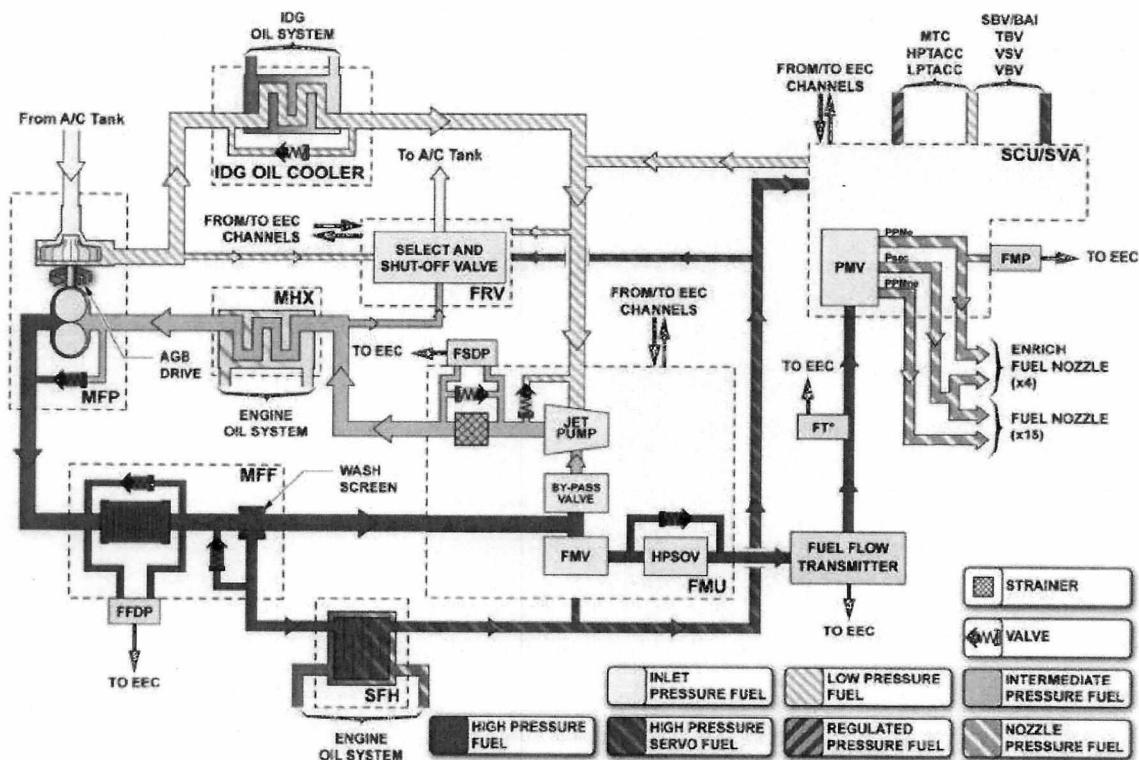
The main fuel-pump system moves the fuel from the wing tanks to the engines. The system has two main fuel-pumps (main pumps) in each wing. The pumps operate at the same time, but if a main pump has a failure (or is set to OFF) the other pump automatically supplies

fuel. The closed cross-feed divides the engine supply system into two parts. Each part contains two main fuel-pumps which supply one engine. When the cross-feed valve is open, it is possible for one fuel-pump to supply fuel to the two engines.

The accessory gearbox shaft drives the Main Fuel Pump (MFP) that contains an LP pump and an HP pump.

### FUEL PUMP LP STAGE

The fuel from the fuel tanks flows through the LP pump. The MFP delivers centrifugal boost stage discharge flow to the FMU, after first going through the IDG oil cooling, and flow to the FRV.



Schematic of Fuel System-A320neo- LEAP-1A engine

### FUEL/OIL HEAT EXCHANGER (FOHE)/MAIN HEAT EXCHANGER

The fuel/oil heat exchanger uses cold fuel from the Fuel Metering Unit (FMU) to cool the oil. Oil from the lubrication system enters the FOHE, via the Servo Fuel Heater (SFH) and the Air Cooling Oil Cooler (ACOC), and flows around the fuel tube in the matrix. The FADEC controls the fuel and the engine oil temperature.

### IDG COOLING

The Integrated Drive Generator (IDG) fuel/oil heat exchanger enables to cool the IDG oil. The FADEC controls the fuel and the engine oil temp

### **FUEL PUMP HP STAGE**

The MFP provides high pressure gear stage discharge flow to the MFF, and receives bypass flow from the FMU. A bypass valve on the MFP protects the fuel system from overpressure.

### **FUEL METERING UNIT**

The Fuel Metering Unit (FMU) controls the fuel flow to the combustion chamber, via the Fuel Metering Valve (FMV), in order to obtain the required engine thrust.

#### **1.6.3.3 Brief description of the history of fuel tube located between main heat exchanger and Fuel Pump:**

The Airbus A320-251N aircraft's of M/s Air India (including VT-EXV) were delivered with fuel tube P/N 362-110-420-0 located between main heat exchanger and Fuel Pump initially. Due to identification of the leak issue CFM had issued SB 72-00-0115 to replace this Fuel Tube every 1200 FH, which was being complied in the Air India's fleet of A320-251N.

CFM then came out with SB 72-00-0145 as a final fix to arrest the leak issue of old fuel tube P/N 362-110-420-0 by replacing it with modified fuel tube P/N 362-110-422-0.

In due course of time, as this modified fuel tube P/N 362-110-422-0 also exhibited fuel leak issue, CFM issued SB 72-00-287 in November 2018 advising a replacement at every 1200 hours. For Fuel Tube which has done more than 1200 hours a tolerance was given for 60 days from effective date of SB i.e. 26<sup>th</sup> November 2018.

As per the CFM data, worldwide there were already 37 cases of Fuel leak reported since July 2018 till April 2019 on the modified hose (P/N 362-110-422-0). The fuel leak incident of VT-EXV of 05.01.2019 was the first incident leading to an IFSD.

Other than the IFSD incident , M/s Air India had 01 case of Fuel leak from the modified Fuel Tube P/N 362-110-422-0 till date, one on VT-CIM (Factory fitted Fuel Tube replaced after 290 FH).

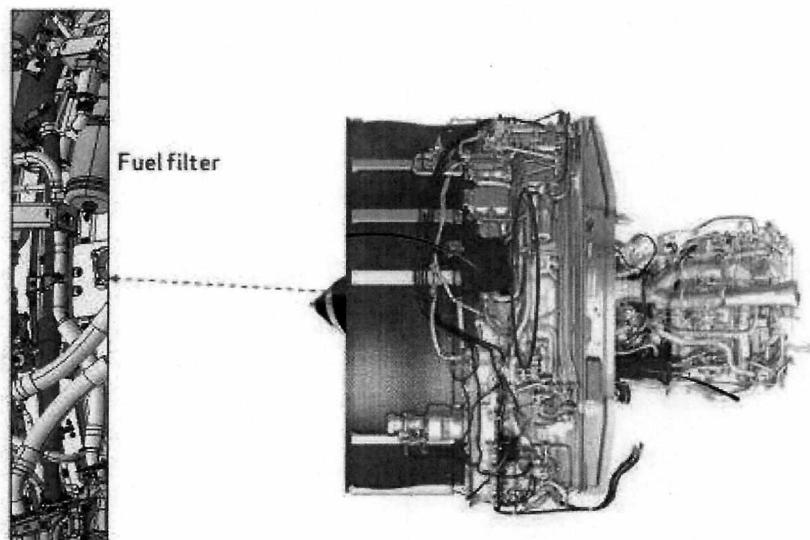
As per available information there was no fuel leak reported from old P/N tube 362-110-420-0 in Air India fleet of LEAP-1A engine's.

Though there has been design variation for the fuel hose, the routing of the hose has remained the same, only the material of the hose was changed.

As per M/s CFM 20 fuel hose 362-110-422-0 was sent to Air India on January 04<sup>th</sup> 2019 and 30 more on January 17<sup>th</sup> 2019. SB 72-00-287 (issued November 26th 2018) was revised to extend SB time compliance from 30 to 60 days on December 18<sup>th</sup> 2018.

Further M/s Air India reported that, CFM recommended to start with retrofit of the ones with higher TSN, as certain engines had already crossed the threshold and due non-availability of adequate number of the new fuel hose to replace the old ones.

As on date of incident, 38 CFM LEAP 1A engines in service with M/s Air India had already completed more than 1200 hours since last replacement of the subject fuel hose. This included the fuel hose (P/N: 362-110-422-0), which was installed on the LH engine of VT-EXV(ESN:598274) . This could be attributed to the non-availability of fuel hoses from M/s CFM.



**Fuel Hose routing**

**Identified root cause:**

- Crack propagation in the flex hose due to interaction between hose frequency response and fuel system.
- Range of Flight hours: Min: 132, Max: 2814
- Range of Flight cycles: Min: 58, Max: 1286

**Low time failure improvement:**

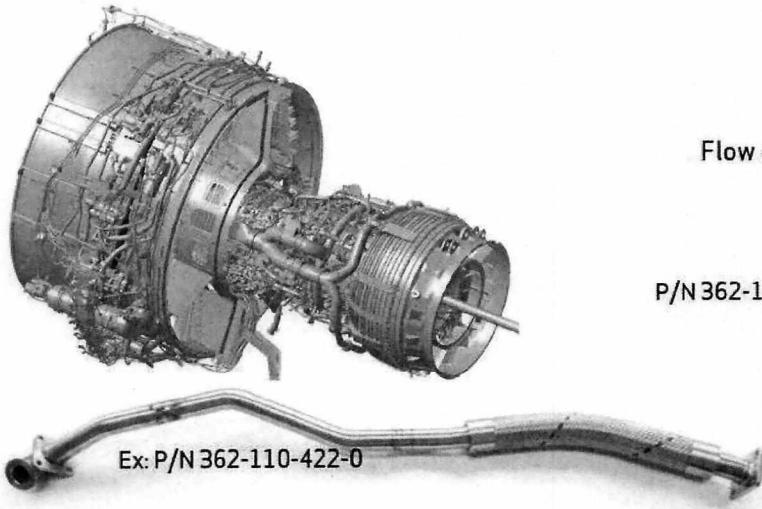
- 3 failed parts with TSN/CSN < 300/160
- On those parts crack located at welding location
- Weld location moved to avoid low time failure

Further, a new hose design has been introduced by CFM vide SB 72-00-0344 (dated 13th September 2019), fuel tube P/N 362-110-423-0, a new Bracket P/N 362-230-621-0 and new Loop-hinged clamps P/N 649-412-867-0. The hose technology is changed from Inner ‘metallic convoluted’ to ‘inner smooth’ PTFE to improve reliability. Air India has already complied with the SB on more than 40 of the affected engines.

EIS configuration 362-110-420-0  
Design change #1 362-110-422-0  
Design Change #2 362-110-423-0

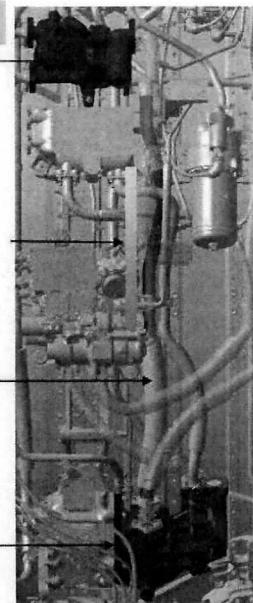
Same routing for all configuration

MHX

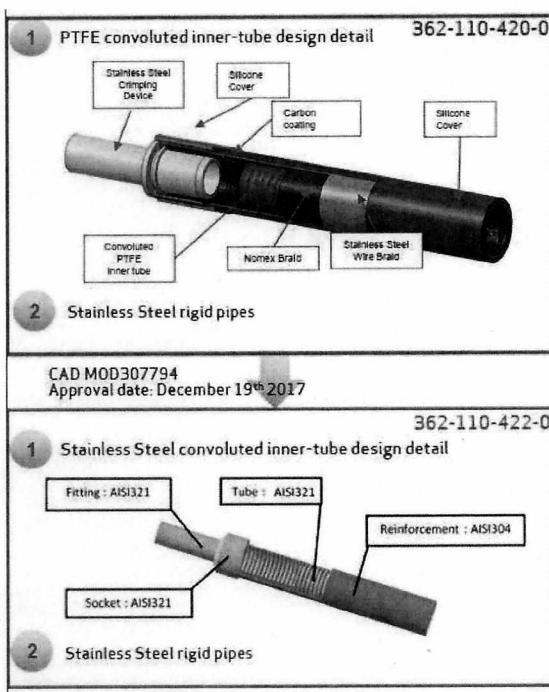


P/N 362-110-42x-0

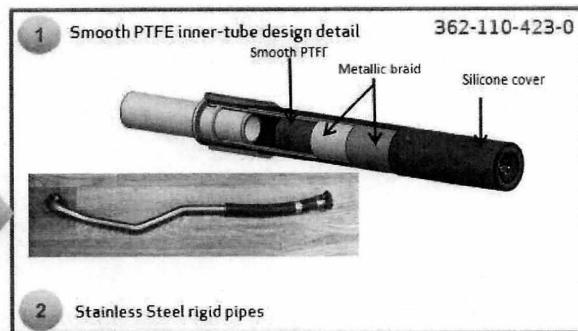
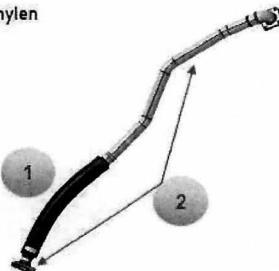
MFP



Fuel hose P/N 362-110-42x-0 of LEAP-1A connected from MFP to MHX equipments and routed on fan frame.



CAD: Change In Design  
PTFE: PolyTetraFluoroEthylene



Design changes to the fuel hose connecting the Main Fuel-Oil Heat Exchanger to the engine driven Fuel Pump

#### **1.6.4 Flight Navigation log :-**

The following extract has been deduced from the flight navigation log used by the operating crew:

POSN LAT/LONG	DIST DTGO	ETA ATA	CBO FREM REQF	BURN FOB
TEMPO N14110E099552	26 1583	1500 1501	1311 11299 10535	1250 12260
TARED N14263E099315	28 1555	1503 1505	1533 11077 10313	1480 12040
BETNO N15059E098125	41 1514	1514 1514	2059 10551	-- 11450
PTN D115.60 N16485E094462	178 1244	1544 1545	3119 9491 8727	3010 10600
IBITA N18552E091598	203 1041	1611 1612	4079 8531 7767	4060 8540

Note: Extra fuel of 900kg was uplifted at Bangkok based on crew discretion. The CBO, FREM and REQF in Nav log used by the crew were not updated and hence did not include the extra fuel.

#### **1.6.5 Post-Flight maintenance report (PFR):-**

A/C ID      DATE      GMT      FLTN      CITY PAIR  
 VT-EXV      05Jan      1435/1704      AI0335      VTBS VECC

##### **MAINTENANCE**

##### **POST FLIGHT REPORT**

##### **WARNING/MAINT.STATUS MESSAGES**

GMT	PH	ATA
1436	02	310000 C/B TRIPPED REAR PNL S-V
1436	02	770000 ENG 2 FADEC
1449	06	310000 C/B TRIPPED REAR PNL S-V
1603	06	284600 FUEL FUSED/FOB DISAGREE
1625	06	220000 AUTO FLT A/THR OFF
1627	06	770000 ENG 2 SHUT DOWN
1701	08	780000 ENG 2 FADEC SYS FAULT

##### **FAILURE MESSAGES**

GMT	PH	ATA	SOURCE IDENT
1435	02	731147	ENG2D-0186-FUEL STRAINERIMPEND BYPASS EIU2FADEC
1702	08	732100	ENG2D-0502-EOS BIT TESTSKIP EIU2FADEC
1702	08	732100	ENG2B-0536-EOS SHUTDOWN EIU2FADEC

**1.6.6 FCOM Reference: FUEL F. USED/FOB DISAGREE**

FUEL F. USED/FOB DISAGREE									
ANNUNCIATIONS									
<u>Triggering Conditions:</u>									
This alert triggers when the difference between the initial FOB and the actual FOB + fuel used is significant.									
<u>Flight Phase Inhibition:</u>									
FUEL LEAK PROC..... APPLY									

**1.6.7 QRH Checklist:-**

The QRH checklist as re-produced below indicates the task sharing and responsibilities of the PF and PM.

**ABNORMAL AND EMERGENCY PROCEDURES / FUEL LEAK****LAND ASAP**

- **Leak from engine/pylon confirmed by excessive fuel flow or visual check:**

THR LEVER (affected engine).....IDLE

ENG MASTER (affected engine).....OFF

FUEL X FEED.....AS RQRD

DO NOT RESTART AFFECTED ENGINE.

- **Leak from engine/pylon not confirmed or leak not located:**

FUEL X FEED.....MAINTAIN CLOSED

CTR TK L XFR.....OFF

CTR TK R XFR.....OFF

INNER TANK FUEL QUANTITIES.....MONITOR

- If one inner tank depletes faster than other by at least 300 kg (660 lb) in less than 30 min:

THR LEVER (engine on leaking side).....IDLE  
 ENG MASTER (engine on leaking side).....OFF  
 FUEL LEAK.....MONITOR

- If leak stops:

ENGINE LEAK CONFIRMED  
 CTR TK L XFR.....ON  
 CTR TK R XFR.....ON  
 FUEL X FEED.....AS RQRD  
 DO NOT RESTART AFFECTED ENGINE

- If leak continues (after engine shutdown):

WING LEAK SUSPECTED  
 ENGINE RESTART.....CONSIDER  
 CTR TK XFR (non-leaking side).....ON

**CAUTION** Do not apply the FUEL IMBALANCE procedure. Approach and landing can be done, even with one full wing/one empty wing.

- If both inner tanks deplete at a similar rate:

LEAK FROM CENTER TANK OR APU FEEDING LINE SUSPECTED

- If fuel smell in cabin:

APU.....OFF

- When fuel quantity in one inner tank less than 3 000 kg (6 600 lb):

CTR TK L XFR.....ON  
 CTR TK R XFR.....ON

- For landing: DO NOT USE REVERSERS

#### **1.6.5 Pilot Defect Report (PDR):-**

The defect report made by the Pilot at Kolkata states the following:-

FUEL FUSED/FOB Disagree ECAM

Fuel leak confirmed in air from engine #2.

Fuel leak checklist followed. After engine#2 shutdown, fuel leak stopped.

#### **1.7 Meteorological information:**

Weather was not a contributory factor.

### **1.8 Aids of navigation:**

All aids to navigation were serviceable. No un-serviceability was reported.

### **1.9 Communication:**

Two way radio communications was available between aircraft and ATC. Neither the crew nor did the ATC unit report any un-serviceability.

During the cruise phase of flight when the fuel leak was detected, the operating crew was unable to contact ATS Kolkata. Hence, two other aircraft's helped the subject aircraft in relaying communications between Kolkata ATC and VT-EXV.

### **1.10 Aerodrome information:**

Not applicable.

### **1.11 Flight recorders:**

#### **1.11.1 CVR:-**

The aircraft was installed with a Solid State Cockpit Voice Recorder capable of recording two(02) hours of cockpit communications. The CVR data was retrieved and was utilised in the investigation. Following are the observations made:-

1. En-route from Bangkok to Delhi, the crew receive their final clearance for cruise level FL380 by relative time 25:31.
2. The discussion between the cockpit crew members did not indicate that, either of them noticed the discrepancy of the fuel figures prior to the system generated ECAM warning.
3. During cruise at the cleared FL380 by relative time 38:49, the crew received ECAM warning: "Fuel-Fuel used/FOB disagree-Fuel leak procedure apply". A post ECAM alert calculation of the fuel remaining indicated that the crew found a discrepancy of 1 ton fuel. Crew discussed that the fuel check at waypoint "BETNO" was satisfactory. The SNY captain travelling on the flight came into the cockpit at this time.
4. By relative time 41:00 the crew discussed the Fuel leak detection procedure and calculated the fuel remaining and fuel consumed at 05 minute interval.
5. At relative time 42:50, Yangon ATC informed the crew that radar service is terminated and advised them to contact Kolkata ATC. However, the crew was unable to contact Kolkata ATC.
6. By relative time 43:55, the First officer was assigned with the task of visually inspecting the RH engine and wing for any leaks and was sent to the cabin. He returned and updated that, there is no visual confirmation of a fuel leak from the RH wing or engine.
7. At relative time 54:36, the crew calculated that in 13minutes, the fuel discrepancy between LH and RH inner wing tanks was about 140kg. Hence they calculated that, the rate of fuel loss is above the checklist advisory limit of 300kg in 30minutes.

8. Since crew was unable to contact Kolkata ATC, two other aircraft's relayed the communications for AIC-355 by relative time 59:30, wherein 'MAYDAY' was relayed and informed that they were diverting to Kolkata.
9. By relative time 01:00:57 the crew shut-down Engine#2(RH engine) and started descending to lower level.
10. 05 minutes after shutdown of Engine#2 the crew calculated the fuel remaining and confirmed fuel leak from Engine#2. As per checklist the crew decided not to restart engine#2 and continued to take account for the fuel remaining till landing at Kolkata.

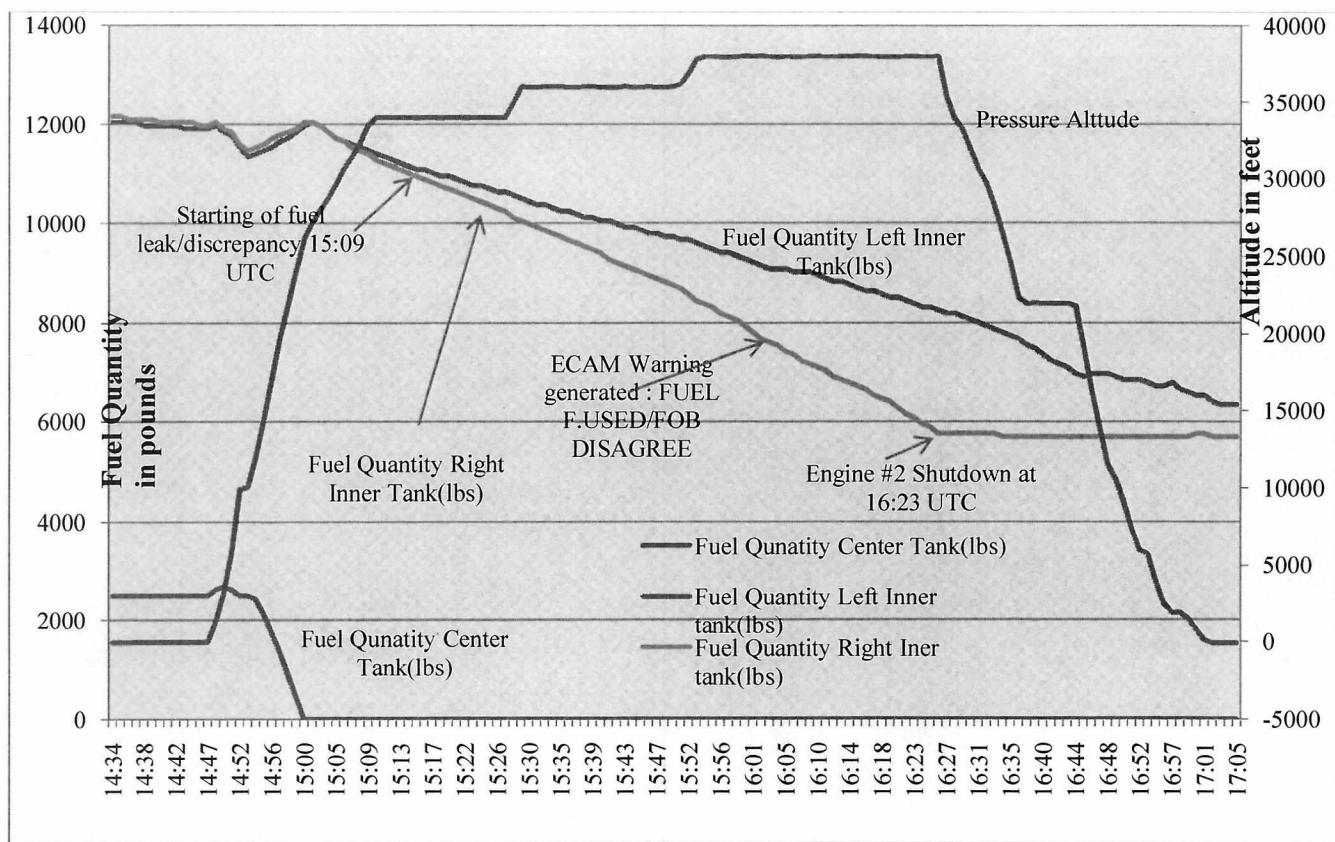
### **1.11.2 DFDR:-**

The aircraft was installed with a Solid State Flight Data Recorder. The recording of the unit was retrieved and salient points are as interpreted below:-

1. The aircraft took-off from Bangkok at 14:47UTC.
2. Fuel consumption of Engine#1 and Engine#2 remained almost same and within specified limits for the flight till 15:09UTC.
3. Around 15:09:30 UTC passing 33500ft the FUEL remaining in RH inner tank started to deplete at a faster rate, though the consumption of both engines remained same. Fuel remaining in LH inner tank at this time was 5196kg (11456lbs) and Fuel remaining in RH inner tank was 5167kg (11392lbs).
4. By 15:14UTC the fuel remaining in LH inner tank was 5051kg (11136lbs) and in RH inner tank was 4993kg (11008lbs). The total fuel on-board along with outer tanks(1472lbs\*2) was 11378kg.
5. By 15:20:10UTC the fuel remaining in LH inner tank was 4964kg (10944lbs) and in RH inner tank was 4847kg (10688lbs).
6. By 15:44UTC the fuel remaining in LH inner tank was 4499kg (9920lbs) and in RH inner tank was 4122kg (9088lbs). The total fuel on-board along with outer tanks(1472lbs\*2) was 9955kg.
7. At 15:53:30 the aircraft reached its planned cruise level of 38000ft.
8. At 16:03:46UTC the ECAM-FUEL PAGE was AUTO displayed and crew was alerted about the disagreement between fuel consumption and Fuel on-board by an ECAM message. The fuel remaining at this point of time in Left inner tank was 4122kg(9088Lbs) and Right inner tank was 3454kg(7616Lbs).The difference in fuel remaining in LH and RH tank was 880kg.
9. The fuel remaining At 16:13:30UTC in Left inner tank was 4006kg(8832Lbs) and Right inner tank was 3106kg(6848Lbs). The RH inner tank fuel depleted 232 kg more than LH inner tank in 10 minutes.
10. By 16:23:00UTC the fuel remaining in Left inner tank was 3802kg(8384Lbs) and Right inner tank was 2757kg(6080Lbs).Hence, in 20 minutes the RH inner tank fuel depleted 399 kg more than LH inner tank.
11. At 16:25:30UTC engine#2 TLA was retarded by the crew to IDLE, followed by shutdown of the engine #2 by the operating crew. The fuel remaining in Left inner tank was

3773kg(8320Lbs) and Right inner tank was 2670kg(5888Lbs). The aircraft then diverted to Kolkata and made a continuous descent till touchdown.

12. The aircraft landed at Kolkata at 17:01:30UTC. The aircraft taxied under its own power and was parked on stand C-5.



**Fuel Quantity (Center tank, LH Inner tank and RH Inner tank) and Pressure altitude Vs Time**

#### **1.12 Wreckage and impact information:**

Not applicable.

#### **1.13 Medical and pathological information:**

Not applicable.

#### **1.14 Fire:**

There was no fire or smoke during or following the incident.

No fuel accumulation is expected in the fan compartment as the fuel leak rate can be a maximum of 16.2ton/hr, which is less than the engine drain capability of 20.7 ton/hr. Further

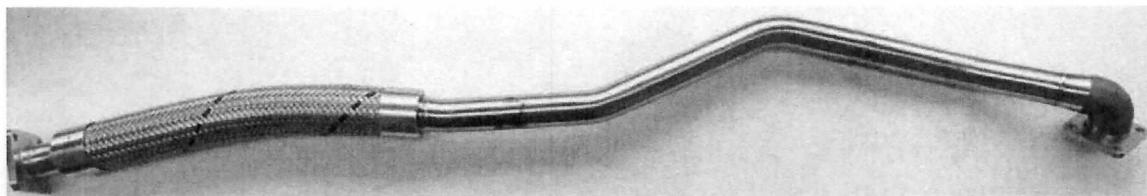
M/s CFM has calculated that there is no fire risk in the fan compartment in case of a fuel leak.

#### **1.15 Survival aspects:**

The incident was survivable. There was no injury reported to the passengers, crew or any other ground personnel.

#### **1.16 Tests and research:**

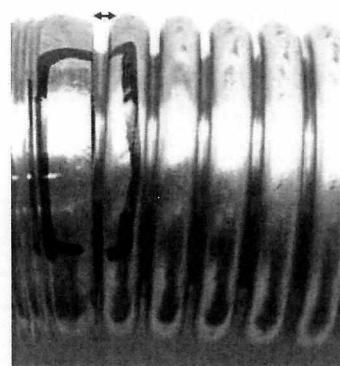
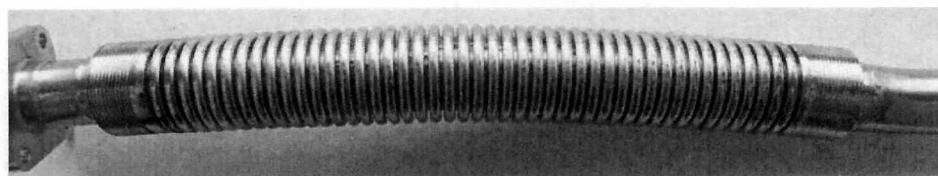
The fuel hose P/N:- 362-110-422-0 was sent to M/s CFM for shop inspection/checks.



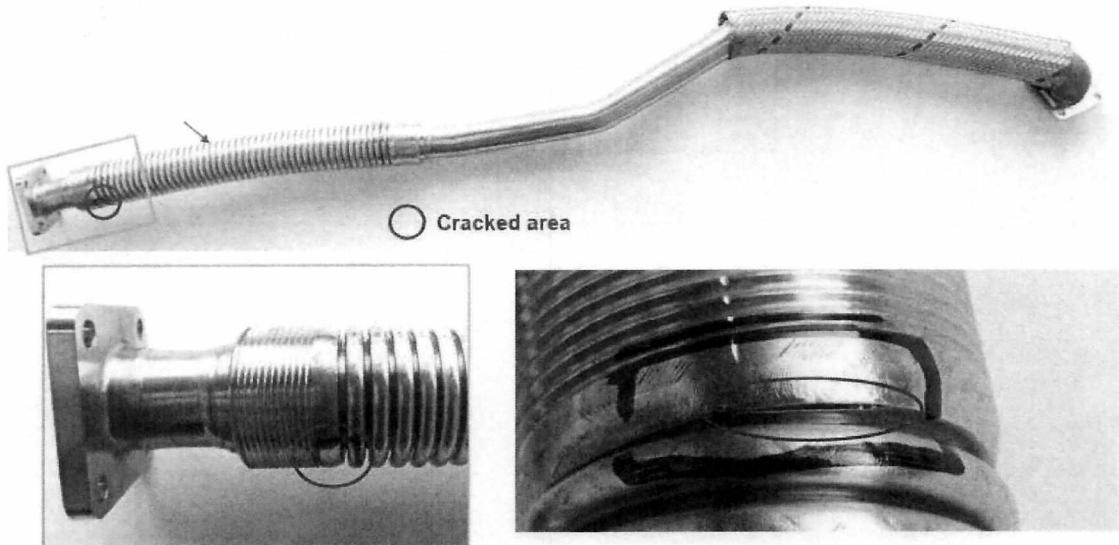
Fuel hose P/N:- 362-110-422-0

After examination carried out on the fuel hose, following findings were reported:-

1. A slight permanent "C" shape deformation of the convolute.



2. A crack located in extremity of the weld seam between the rigid part and the convoluted part (at marking side) measuring about 0.47 in (12.1mm) long. The crack opening varies greatly depending on the bending stress applied to the hose.



3. A leak was confirmed during a test with less than 43.51 PSI(3 bar) in the flexible part of the tube.
4. A permanent shape deformation of the first convolute.

During fractographic examinations carried out after opening of the crack, following were reported:-

1. A transgranular fracture surface in HCF vibratory fatigue under an unilateral bending mode, initiated on the inner wall side at the junction of the weld seam and the convolute which forms a 90° angle.
2. The examinations of the fuel hose did not indicate any metallurgical anomaly.

At the time of failure the fuel hose had accumulated 1079hrs since installation on ESN 598277.

The crack propagation in the flex hose was concluded by M/s CFM, to be due to interaction between hose frequency response and fuel system.

Further, the following estimates were drawn by M/s CFM on the fuel leak:

Fuel pressure (psi/MPa) and rate of flow through the fuel hose:

	Pressure, psig	Fuel flow, kg/hr
TOGA	337	15523
MCT	330	16207
TOC	358	15199
Ground IDLE	250	11646

Estimated rate of loss of fuel from the damaged hose (based on damage observed on fuel hose during shop inspection):

	Fuel flow, litre/hr	Fuel flow, kg/hr
TOGA	1470	1161
MCT	1455	1149
TOC	1515	1196
Ground IDLE	1152	910

### **1.17 Organizational & Management Information:-**

M/s Air India Ltd. is the national carrier airline of India. The airline is holding a valid Air Operator Certificate no. S-9 issued by DGCA valid upto 30.06.2023. The airline is a government-owned enterprise. It operates a fleet of Airbus A-319, A-320, A-321, A-320neo and Boeing B-747, B-777, B-787 aircraft serving domestic and international destinations. The airline has its main operating and maintenance hubs at Indira Gandhi International Airport, New Delhi and Chhatrapati Shivaji International Airport, Mumbai.

### **1.18. Additional information:**

Nil.

### **1.19 Useful or effective investigation techniques:-**

Nil.

## **2. Analysis:-**

### **2.1 Operational handling of the aircraft:-**

PIC was the PF operating the sector. Both the flight crew were holding valid licenses for operating the type of aircraft and had sufficient flying experience for the duties assigned to them. The crew members had also undergone the differences training conducted by M/s Air India for operating A-320 neo aircraft.

The flight leg from Kolkata to Bangkok was operated by the same set of crew and the flight was uneventful. Post landing at Bangkok, the PIC performed a walk-around inspection and did-not report any abnormalities.

The AME at Bangkok also did not report any abnormalities/record any findings. The take-off was performed by the PIC (who was the PF for the flight from Bangkok-Delhi).

The aircraft took-off from Bangkok at 14:47:31UTC. The aircraft continued to climb en-route and reached a maximum altitude of 38000ft, while in Yangon FIR at 15:53:28 UTC.

The fuel readings recorded against time check (1500UTC) at waypoint TEMPO were 1250kg(Fuel Burn) and 12260kg(Fuel-on board); and as per FDR data the Fuel-on board at this point of time was 12221kg.

The fuel readings recorded against time check (1505UTC) at waypoint TARED were 1480kg(Fuel Burn) and 12040kg(Fuel-on board); and as per FDR data the Fuel-on board at this point of time was 11960kg.

The fuel readings recorded against time check (1514UTC) at waypoint BETNO were 11450kg(Fuel-on board) and Fuel Burn was not recorded; and as per FDR data the Fuel-on board at this point of time was 11379kg.

The crew did not detect the fuel leak form the fuel readings taken at waypoints en-route, as the fuel readings recorded against time check (1545UTC) at waypoint PTN was found to be recorded as 3010kg(Fuel Burn) and 10600kg(Fuel-on board); whereas as per FDR data the fuel remaining on-board at this point of time was only 9899kg. The discussion between the cockpit crew members did not indicate that, either of them noticed the discrepancy of the fuel figures prior to the system generated ECAM warning.

The crew became aware of the fuel discrepancy only on activation of the ECAM generated warning at 1603UTC. After activation of the ECAM warning the SNY(SUPERNUMERARY CREW-PIC RATED) was called to the cockpit and he assisted the crew in the further actions. The First officer performed the visual check of RH engine and wing and did not find any trace of fuel leak, following which the crew calculated the drop in fuel levels in RH and LH wing inner tanks for 06, 13 minutes and they ascertained that RH wing inner tank fuel depletion would be more than 300kg in 30 minutes in comparison to the LH inner wing tank reduction. The flight was diverted to Kolkata and a "MAYDAY" was declared. The RH side wing tank fuel depletion was calculated to be more than the fuel consumption of the RH engine. Following QRH procedures, the RH engine was shutdown at 16:27UTC and crew further monitored the fuel remaining w.r.t time and confirmed the fuel leak was from Engine#2. The fuel levels stabilised after shutdown of Engine#2. Hence, Engine#2 was maintained in the shutdown condition until landing at Kolkata.

## **2.2 Serviceability of the aircraft:-**

The aircraft VT-EXV was issued a Certificate of Registration on 20.07.2017 by DGCA-INDIA and its last ARC was issued on 10.07.2018 valid till 19.07.2019. The last major inspection was 3A check performed on 31.12.2018 and layover inspection performed on 03.01.2019. The aircraft had accumulated a total of 5177hrs since new. On the date of occurrence, the aircraft had operated 03 flight sectors (Kolkata –Jaipur, Jaipur-Kolkata and Kolkata-Bangkok), without any defects being reported in any of these sectors prior to the occurrence sector.

The involved engine ESN: 598277 was installed at #2(RH) location, had accumulated a total of 3847.12 hours since new and 1974 cycles since new. The engine had accumulated 1079 hours since last shop visit and 596 flight cycles since last shop visit.

A fuel hose of P/N: 362-110-420-0 was installed between main heat exchanger and Fuel Pump on engine 598277 at the time of delivery of aircraft to M/s Air India.

The subject engine (ESN: 598277) was sent to CFM shop for application of SB 72-00-0167 (Inspection and repair HPT rotor stage 2 Disk) in August 2018. At the same time retrofit had been applied for introduction of new fuel tube between fuel pump and main heat exchanger (i.e., P/N: 362-110-420-0 replacement by 362-110-422-0) SB 72-00-0145 had been applied on 30.08.2018 at Engine TSN/CSN: 2439/1197.

Later due to identification of the leak issue on modified fuel tube P/N 362-110-422-0, CFM issued SB 72-00-287 in November 2018 advising a replacement of the hose at every 1200 hours. As per M/s CFM data, 20 fuel hose -422(P/N) were sent to Air India on 04<sup>th</sup> January 2019 and 30 more on 17<sup>th</sup> January 2019. SB 72-00-287 (issued November 26th 2018) was revised to extend SB time compliance from 30 to 60 days on December 18th 2018.

Hence, it is clear that as sufficient number of hose was not available for replacements, the SB compliance window was extended.

Further, as certain engines had already crossed the threshold and due non-availability of adequate number of the new fuel hoses to replace the old ones, CFM recommended to start with retrofit of the ones with higher TSN. As on date of incident, 38 CFM LEAP 1A engines in service with M/s Air India had already completed more than 1200 hours since last replacement of the subject fuel hose. This included the fuel hose (P/N: 362-110-422-0) installed on the LH engine of VT-EXV. This could be attributed to the non-availability of fuel hoses from M/s CFM.

However, this is not considered as a contributory factor as the fuel hose under discussion installed on ESN: 598277 had only logged 1079 hours since installation.

During shop inspection a crack located in extremity of the weld seam between the rigid part and the convoluted part (at marking side) measuring about 0.47 in (12.1mm) long. A leak was confirmed during a test from the flexible part of the tube. The findings made during analysis of the hose revealed that the failure was similar to the previous failures of the fuel hose of same part number.

The fuel leak incident of VT-EXV dated 05.01.2019 was the 31st case but the first incident leading to an IFSD due to fuel leak from fuel hose P/N: 362-110-422-0.

### **2.3 Circumstances leading to the incident:-**

The Airbus A320-251N aircraft's of M/s Air India (including VT-EXV) were delivered with fuel tube P/N 362-110-420-0 located between main heat exchanger and Fuel Pump initially. Due to identification of the leak issue CFM had issued SB 72-00-0115 to replace this Fuel Tube every 1200 FH, which was being complied in the Air India's fleet of A320-251N. CFM then came out with SB 72-00-0145 as a final fix to arrest the leak issue of old fuel tube P/N 362-110-420-0 by replacing it with modified fuel tube P/N 362-110-422-0.

The fuel hose P/N: 362-110-420-0 located between main heat exchanger and Fuel Pump was installed on engine 598277 at time of delivery of aircraft(VT-EXV) to M/s Air India. The engine was sent to shop for application of SB 72-00-0167 (Inspection and repair HPT Stage 2 Disk + HPTS1 Shrouds) in August 2018. At the same time retrofit had been applied for introduction of new fuel tube between fuel pump and main heat exchanger part number -420 replacement by - 422, SB 72-00-0145-01A-930A-D has been applied on August 30th 2018 at TSN/CSN : 2430/1186.

In due course of time, as this modified fuel tube P/N 362-110-422-0 also exhibited fuel leak issue, CFM issued SB 72-00-287 in November 2018 advising a replacement at every 1200 hours. Since, adequate number of replacement fuel hose's were not delivered in time for replacements, regarding Fuel Tube which has done more than 1200 hours a tolerance was given for 60 days from effective date of SB i.e. from 26<sup>th</sup> November 2018.

The PIC was the PF operating the flight leg from Bangkok to Delhi. The aircraft departed from Bangkok at 14:14UTC, in a serviceable condition without any defects. The AME at Bangkok also did not report any abnormalities/record any findings. The aircraft took-off from Bangkok at 14:47UTC and reached a maximum altitude of 38000ft, while in Yangon FIR at 15:53UTC.

The fuel readings recorded en-route at designated waypoints was co-related with the DFDR fuel figures. However, the fuel readings recorded against time check (1514UTC) at waypoint BETNO was found to be recorded as 11450kg (Fuel-on board) and Fuel Burn was not recorded; as per DFDR data the fuel remaining on-board at this point of time was only 11379kg. Also, the fuel readings recorded against time check (1545UTC) at waypoint PTN was 3010kg(Fuel Burn) and 10600kg(Fuel-on board); whereas as per FDR data the Fuel-on board at this point of time was only 9899kg. The discussion between the cockpit crew members did not indicate that, either of them noticed the discrepancy of the fuel figures prior to the system generated ECAM warning at 1603UTC.

No evidence of fuel leak was located from the RH wing or engine#2 by the crew when they performed a visual inspection. When the crew calculated depletion of fuel levels in RH and LH inner tanks for 06, 13 minutes, they ascertained that fuel reduction from the RH wing inner tank was more than the fuel consumption of the RH engine.

Following QRH procedures, the RH engine was shutdown and crew further monitored the fuel remaining w.r.t time and confirmed the fuel leak was from Engine#2. The fuel level discrepancy stabilised after shutdown of Engine#2. Hence, Engine#2 was maintained in the shutdown condition until landing at Kolkata. Upon landing at Kolkata fuel leak was observed from Engine #2 and during wet motoring, fuel was found leaking from the fuel hose connecting Main Heat Exchanger to Main Fuel pump.

During shop inspection, a crack was confirmed and located in extremity of the weld seam between the rigid part and the convoluted part measuring about 0.47 in (12.1mm) long. Fuel leak was confirmed during the test in the flexible part of the tube. The findings made during

analysis of the hose revealed that the failure was similar to the previous failures of the fuel hose of same part number.

The fuel loss from the RH wing tank was about 1100kg in the time period of about 70mins, which is similar to the calculations made by M/s CFM during the shop inspection.

### **3. Conclusion:-**

#### **3.1 Findings:-**

1. The aircraft was having a valid Certificate of Registration and Airworthiness Review Certificate at the time of incident
  2. The aircraft was maintained in accordance with the certified aircraft maintenance program and applicable Airworthiness Directive, Service Bulletins were complied with.
  3. The Operating cockpit crew members were having valid licences and ratings for operating the aircraft.
  4. Both the operating crew members were subjected to pre-flight medical test at the starting of the flight cycle at Kolkata (previous sector) and after a ‘negative’ result for alcohol breath analyser test, they were cleared for flight operations.
  5. The aircraft was released from Bangkok for a scheduled revenue passenger flight in a serviceable condition. There were no defects reported prior to the occurrence sector or any items under MEL.
- Post landing at Bangkok, the PIC performed a walk-around inspection and did-not report any abnormalities.
- The AME at Bangkok also did not report any abnormalities/record any findings. The take-off was performed by the PIC (who was the PF for the flight from Bangkok-Delhi).
6. PIC was the Pilot Flying and the First Officer was the Pilot Monitoring, for the flight sector.
  7. Flight Duty Time of both the crew members was within the specified limits.
  8. The crew did not log the BURN fuel on the Nav log at waypoint BETNO.
  9. Fuel consumption of Engine#1 and Engine#2 remained almost same and within specified limits for the flight till 15:09UTC. However, after 15:09:30 UTC the FUEL remaining in RH inner tank started to deplete at a faster rate, though the consumption of both engines remained same. Fuel remaining in LH inner tank at this time was 5196kg (11456lbs) and Fuel remaining in RH inner tank was 5167kg (11392lbs).
  10. The discussion between the cockpit crew members did not indicate that, either of them noticed the discrepancy of the fuel figures prior to the system generated ECAM warning.
- The operating crew was alerted by an ECAM alert message at 1603 UTC about the fuel imbalance.
- The crew did not detect the discrepancy in fuel figures from the fuel readings recorded against time check (1545UTC) at waypoint PTN. It was found to be recorded as 3010kg(Fuel Burn) and 10600kg(Fuel-on board); whereas as per FDR data the fuel at this point of time was only 9898kg.
11. The SNY(Supernumerary crew-PIC rated) was called to the cockpit after the ECAM alert regarding fuel discrepancy.

12. Since the RH inner tank fuel quantity depleted faster than LH inner tank by more than 300 kg (660 lb) in less than 30 min at 16:27 UTC engine#2 was shut-down by the operating crew.
13. Fuel monitoring was performed by the crew and they did not observe any further fuel reduction from RH side wing tanks after shut-down of engine#2, and fuel leak was confirmed from the RH engine/pylon. The engine#2 remained in the shut-down state for the remainder of the flight.
14. Approximately 1045kg of fuel was lost due to fuel leak from the damaged fuel hose. There was no in-flight disintegration of any part and the damage was only reported to the fuel hose.
15. There was no fire due to the fuel leak.
16. Crew actions after being alerted by the ECAM message were satisfactory and in compliance of the checklists.
17. As on date of incident, 38 CFM LEAP 1A engines in service with M/s Air India had already completed more than 1200 hours since last replacement of the subject fuel hose. This included the fuel hose (P/N: 362-110-422-0) installed on the LH engine of VT-EXV. This could be attributed to the non-availability of fuel hoses from M/s CFM.
18. A crack was confirmed and located in extremity of the weld seam between the rigid part and the convoluted part of the fuel tube, measuring about 0.47 in (12.1mm) long. Fuel leak was confirmed during the test in the flexible part of the tube.  
A transgranular fracture surface in HCF vibratory fatigue under an unilateral bending mode, initiated on the inner wall side at the junction of the weld seam and the convolute. Crack propagation in the flex hose due to interaction between hose frequency response and fuel system.
19. The findings made during shop analysis of the hose revealed that the failure was similar to the previous failures of the fuel hose of same part number.  
The fuel loss from the RH wing tank was about 1100kg in the time period of about 70mins, which is similar to the calculations made by M/s CFM during the shop inspection.

### **3.2 Probable cause:-**

The cause of the incident was fatigue failure of fuel hose connecting the Main FUEL-Oil Heat Exchanger to the Engine driven FUEL PUMP.

### **4. Safety Recommendations:-**

1. Since the re-designed fuel hose is currently made available for retrofit and is under implementation; it may be monitored by DGCA. Therefore no further recommendation is considered necessary at this stage.



(LINJU VALAYIL PHILIP)  
Assistant Director Air Safety  
Investigator-In-Charge

Date: 30/12/2019  
Place: New Delhi