



**FINAL INVESTIGATION REPORT ON
FUEL LEAK INCIDENT TO
M/s AIR INDIA LTD BOEING 787-800 AIRCRAFT VT-ANE ON
21/08/2017 AT MUMBAI**

**GOVERNMENT OF INDIA
O/o, DIRECTOR AIR SAFETY, WESTERN REGION,
NEW INTEGRATED OPERATIONAL OFFICE COMPLEX,
SAHAR ROAD, VILE PARLE (EAST), MUMBAI-400099**

OBJECTIVE

This investigation is performed in accordance with The Aircraft (Investigation of Accidents and Incidents) Rules 2012 of India.

The sole objective of this investigation is to prevent aircraft accidents and incidents. It is not the purpose of this investigation to apportion blame or liability.

FOREWARD

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

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ABBREVIATIONS

A/c	Aircraft
ADF	Automatic Direction Finder
AI	M/s Air India Ltd
AI-Mumbai	M/s Air India Operations, Mumbai airport
Aircraft	Incident aircraft
AME	Aircraft Maintenance Engineer
APU	Auxiliary Power Unit
ARC	Airworthiness Review Certificate
ARFF	Aerodrome Rescue and Firefighting
ATC	Air Traffic Control
ATD	Actual Time of Departure
ATIS	Air Traffic Information Services
ATPL	Air Transport Pilot's License
CB	Cumulonimbus clouds
CSN	Cycles Since New
CVR	Cockpit Voice Recorder
DME	Distance Measuring Equipment
DP	Dew Point
EASA	European Aviation Safety Agency
EGLL	London Heathrow Airport
EICAS	Engine Indication and Crew Alerting System

ELT	Emergency Locator Transmitter
FAA	Federal Aviation Administration, United States of America
FCOM	Flight Crew Operating Manual
FCP	Fuel Control Panel
FDR	Flight Data Recorder
FTDL	Flight and Duty Time Limitations
FM	Follow Me vehicle
FO	Co-Pilot/ First Officer
FOD	Foreign Object Debris
FQMS	Fuel Quantity Management System
FRB	Flight Report Book
FRTO	Flight Radio Telephone Operator
FT	Fire Tender
GPS	Global Positioning System
Ground	Surface Movement Control
IATA	International Air Traffic Association
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IR	Instrument Rating
LH	Left Hand

MEL	Minimum Equipment List
OMA	M/s Oman Air
Operator	AOP holder of the incident aircraft
OVC	Overcast
PDR	Pilot Defect Report
PF	Pilot Flying
PIC	Pilot in Command
PM	Pilot Monitoring
QNH	Pressure setting to indicate elevation
RADAR	Radio Detection and Ranging
RCP	Refuel control panel
RH	Right Hand
SCT	Scattered
SMC	Surface Movement Control
TCAS	Traffic Collision Avoidance System
TSN	Time Since New
UTC	Coordinated Universal Time
VABB	Mumbai Airport
VFR	Visual Flight Rules
VOR	Very high frequency Omni Range

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1.	Aircraft Type	Boeing 787-800
2.	Nationality	Indian
3.	Registration	VT-ANE
4.	Owner	M/s Celisa Aircraft LLC C/o Wilmington Trust Company, 1100 North Market Street, Wilmington, Delaware 19890-1605, USA
5.	Operator	M/s Air India Ltd
6.	Pilot In- Command	Airline Transport Pilot License Holder
7.	Extent of Injuries	Nil
8.	Date and Time of Incident	21/08/2017 01:26 hrs
9.	Place of Incident	Mumbai
10.	Geographical location of site of Occurrence (Lat. Long.)	19°05'25.9"N, 72°52'25.5"E
11.	Last point of Departure	Mumbai, India
12.	Intended Place of Landing	Heathrow Airport, London, United Kingdom
13.	No. of Passengers On-Board	218
14.	Type of Operation	Schedule, Passenger
15.	Phase of Operation	Taxi (to the runway)
16.	Type of Incident	Fuel leak

All timings in this report are in UTC.

SYNOPSIS:

On 21st August 2017, M/s Air India Ltd Boeing 787-800 aircraft VT-ANE was involved in fuel leak incident during taxi to the runway while operating flight AI - 131 (VABB-EGLL).

Aircraft chocked off at 01:16 hrs and started taxiing at 01:21 hrs. After about 02 minutes in the taxi to the Runway 27, fuel imbalance message was displayed on EICAS. Crew carried out the action as per FCOM. The crew of M/s Oman Air flight OMA-202, which was taxiing behind VT-ANE, observed the fuel coming out from the RH wing of VT-ANE and reported same to SMC. SMC informed VT-ANE about the fuel leak immediately. Aircraft stopped on taxiway and crew switched off both the engines at 01:31 hrs. Subsequently fuel leak stopped and the aircraft was towed back and parked on bay R2 at 02:12 hrs. Engines were running for a period of approximately 13 minutes. Aircraft departed with total 52,600 Kg of fuel and returned to bay R2 with 50,100 Kg of fuel. Approximately 1850 Kg of fuel was leaked from the aircraft. The incident occurred in day time when the reported visibility was 2500 meter and rain was prevailing. No human injury was reported in the incident.

Director General of Civil Aviation ordered the investigation of the incident by appointing Inquiry Officer vide order no. AV.15017/76/2017-AS dated 23rd August 2017 under Rule 13(1) of The Aircraft (Investigation of Accidents and Incidents) Rules 2012. In absence of the conclusive evidence and comments made by M/s Boeing, it is suspected that incident could have been probably caused by presence of FOD in a right main tank boost pump outlet check valve, which caused the fuel from centre tank to flow into the RH main tank and subsequently to the surge tank till the override/ jettison pumps were switched off. The continued presence or location of FOD could not be established during investigation.

1. FACTUAL INFORMATION:

1.1 History of Flight:

M/s Air India Ltd Boeing 787-800 aircraft VT-ANE, was scheduled to operate flight no. AI-131 (sector Mumbai – London) on 21st August 2017 at 01:00 hrs with 228 persons on-board including 02 cockpit crew and 08 cabin crew. The aircraft was under the command of PIC (ATPL holder). First officer (ATPL holder) was the pilot flying as he was under the command training and doing Supervised Line Flying. PIC was the approved Type Rated Instructor and was pilot monitoring. The aircraft pushed back from bay V11 at 01:16 hrs without any relevant snag. Engines were started at 01:18 hrs, before taxi checks were done and aircraft started taxiing at 01:21 hrs.

The aircraft was subjected to refueling for the flight AI-131 under the supervision of the night shift AME (B1 license holder). Refueling was started at 00:10 hrs and completed at 00:34 hrs. The final fuel quantities after the refueling were:

Left tank (Kg)	Center tank (Kg)	Right tank (Kg)	Total (Kg)
16,600	19,400	16,600	52,600

Before the commencement of fueling, the system test was conducted on refueling panel and Nil fault was noted. The fueling was done in AUTO mode and after completion of the same it was ensured that all lights were OFF and all switches were in normal position in the refueling panel. Refueling panel was closed thereafter. Final readings shown on the refueling panel were compared with flight deck readings by night shift AME and found to be matching. Final readings were then entered into FRB by night shift AME.

There was no snag/ fault history and no leak observed at any place by night shift AME while doing walk around inspection after completion of refueling.

Transit check including pre-departure check was carried out on the aircraft by night shift AME except closure of aft cargo door and L2 main entry door as the passenger boarding and cargo boarding was in progress. By this time morning shift AME (B1 license holder) reported at the aircraft. Night shift AME handed over the aircraft to morning shift AME for final release as the shift ended.

Post completion of cargo loading and closure of aft cargo door, morning shift AME had carried out complete walk around inspection again for final release of aircraft and did not observe any discrepancy. Certificate of Release to Service was issued. Upon completion of passenger boarding, L2 main entry door was closed and pushback started after getting clearance from the PIC.

After pushback, crew started both engines, given thumbs up signal to morning shift AME and started taxiing. Till this time no snag/ discrepancy was reported by PIC to morning shift AME. At the time of starting of engines the total fuel available was 52,400 Kg.

After about two minutes into the taxi at 01:23 hrs, 'Fuel Imbalance' EICAS message was displayed in the cockpit. Crew carried out action as per FCOM and continued taxiing.

M/s Oman Air flight OMA-202 was taxiing behind AI-131. Cockpit crew of OMA-202 noticed the fuel coming out from the right wing of AI-131 aircraft. OMA-202 informed the same to SMC at 01:25 hrs.

SMC immediately informed the AI-131 about fuel coming out from its right wing and asked AI-131 to hold position on taxiway N1.

On monitoring the conversation about fuel leak on frequency 121.9 Mhz, ARFF team was deployed to the site along with Fire Tender-3, 5 & 6. Fire Tenders reported at site at 01:26 hrs. Follow me had also reported at site at 01:27 hrs.

By this time crew noticed that 1,000 Kg of fuel was already lost from aircraft and they decided to return back. AI-131 requested SMC at 01:27 hrs to take left on M6 to which SMC agreed and directed AI-131 to take left on M6 and hold short of M5 on taxiway M. Aircraft then taxied to taxiway M and held its position short of taxiway M5 at 01:29

hrs (Refer Figure# 1). Number of calls were given by SMC, Fire Tender and Follow me for AI-131 to shut down the engine.

Both the engines were shut down at 01:31 hrs post starting of APU. It was confirmed by Fire Tender and Follow me at 01:32 hrs that heavy fuel leakage has been stopped and only small amount of fuel was coming out.

The morning shift AME reached to the site at 01:51 hrs and while walking around observed that the fuel is coming out from RH surge tank vent scoop. All other areas like APU, both engine drains, refuel control panel and LH surge tank vent scoop were normal and had no sign of fuel leak/ any discrepancy. Drops of fuel were still coming out which was confirmed by morning shift AME to be from RH surge tank vent scoop only.

At 02:00 hrs towing was commenced and aircraft was followed by Fire Tender-6 till it got fully parked at bay R2 at 02:12 hrs.

Morning Shift AME went into the cockpit and observed that fuel imbalance EICAS message was present. There was no status message related to any system. There were no existing faults, existing flight deck faults, present leg faults and inbound flight deck defects. There was no maintenance message about fuel chapter. Further, fuel quantity indicators were showing following readings:

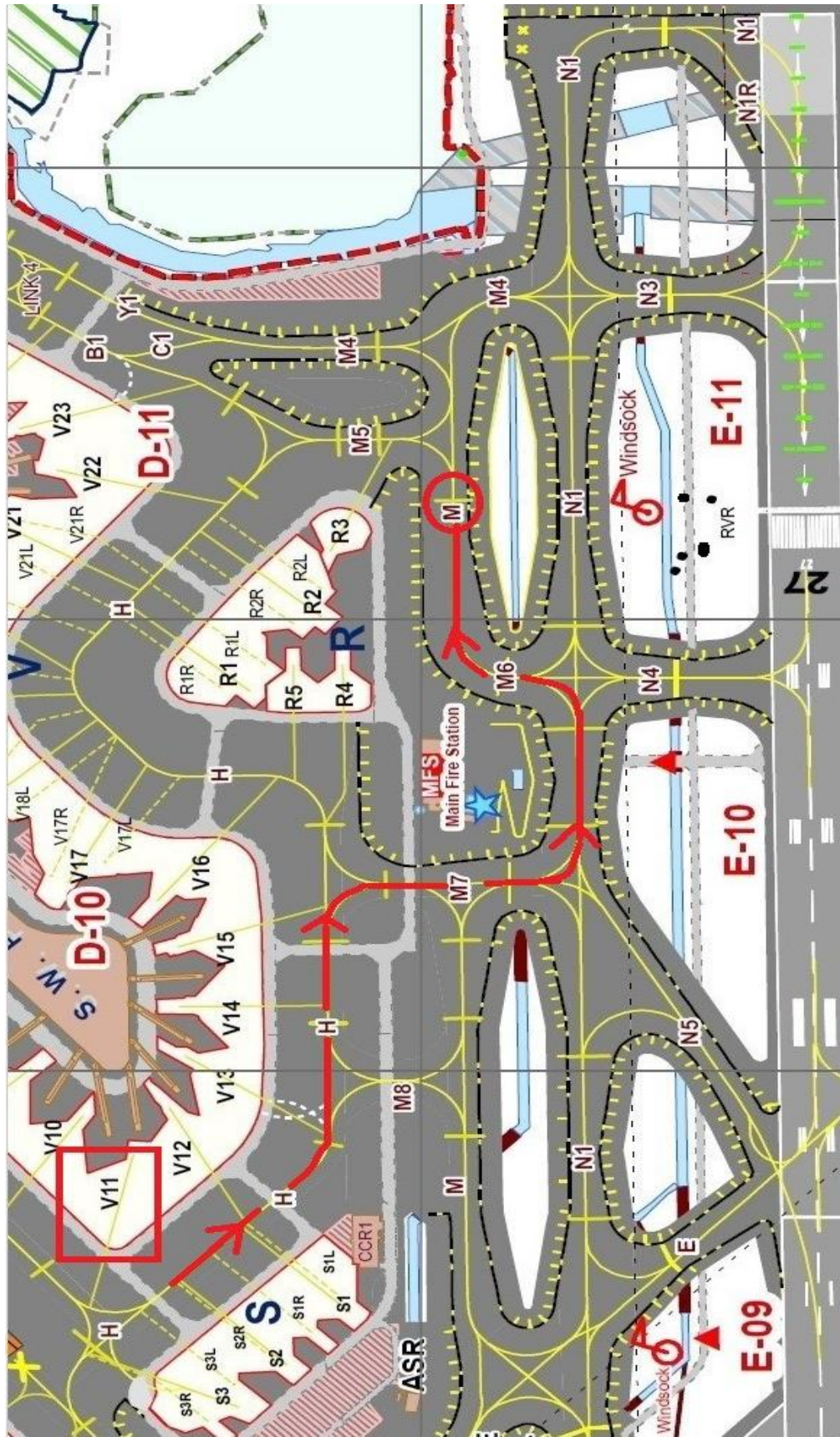
Left tank (Kg)	Center tank (Kg)	Right tank (Kg)	Total (Kg)
16,200	16,700	17,200	50,100

Subsequently, morning shift AME came out and inspected refueling panel for any irregularity. No external leak was observed with RH main tank full. It was observed that red overfill light was flickering and all other switches and lights of refuel and defuel valves in normal condition. He tried to reset the red overfill light but the light did not go due presence of fuel in RH surge tank.

The RH surge tank was drained for approximately 45 minutes followed by red overfill light reset on refueling panel.

Further, morning shift AME did fuel balancing and observed that concerned valves were operating normally and balancing was being done in normal way. The aircraft was then shifted to hanger for further rectification.

Taxiway N1 and a portion of taxiway M (between taxiway M6 & M4) was cordoned off due fuel spillage. The taxiway N1 was cleared for normal operations at 02:20 hrs and taxiway M (portion between taxiway M6 & M4) was cleared for normal operations at 03:04 hrs. The spillage area was cleared by using saw dust, soak pad, cleaning machine & water (water used was from Fire Tender-3). As per the ARFF services report, approximately 24000 liters of water was utilized to clear the spillage area.



Figure# 1 Location of incident

1.2 Injuries to Persons:

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Serious	0	0	0
Minor	0	0	0
None	10	218	

1.3 Damage to Aircraft: There was no damage to the aircraft.

1.4 Other Damage: There was no other damage.

1.5 Personnel Information :

Pilot- In-Command (details as on prior to incident flight):

Age	54 years 05 months Male
License	ATPL
Date of Issue	21/10/1987
Valid up to	20/01/2021
Category	Aeroplane
Date of Class I Medical Exam	07/06/2017
Class I Medical Valid up to	08/06/2018
Date of Issue of FRTO Licence	14/05/1984
FRTO Licence Valid up to	27/01/2022
IR rating	IR: 19/04/2017
Total Flying Experience	16001:00 hrs
Total Flying Experience on Type	2661:39 hrs
Total Flying Experience in last 1 year	672:04 hrs

Total Flying Experience in last 6 months	259:24 hrs
Total Flying Experience in last 30 days	40:45 hrs
Total Flying Experience in last 7 days	02:20 hrs
Total Flying Experience in last 24 hours	Nil
Duty Time last 24 hours	Nil
Rest before the incident flight	54 hrs
Ratings	As PIC: Pushpak, Cessna 172, Cessna A 152, Airbus 310, Boeing 747-200/300/400, Boeing 777, Boeing 787-800 As FO: Airbus 310, Boeing 747-200/300/400, Boeing 777

As per the records, PIC was approved as Type Rated Instructor on Boeing 787 aircraft. He was declared 'Temporarily Medically Unfit for Flying' several times from February 2014 till March 2017. PIC also had an open rating license for all type of aeroplane having an all up weight not exceeding 5,700 Kg.

He had undergone Breath Analyzer test for consumption of alcohol at Mumbai at 23:21 hrs on 20/08/2017 before carrying out Mumbai-London sector (flight no. AI-131) and found fit for flying.

PIC was having adequate rest before he operated flight on 21st August 2017. Upon scrutiny of the records, PIC was found to be within limits of FDTL.

Previous Incident History: As per the operator, PIC was found free of records for incidents/ accidents for last 03/10 years.

First Officer (details as on prior to incident flight):

Age	39 years 01 month Male
License	ATPL
Date of Issue	15/10/2007
Valid up to	14/10/2020
Category	Aeroplane

Date of Class I Medical Exam	23/09/2016
Class I Medical Valid up to	30/09/2017
Date of Issue of FRTTO Licence	11/09/2007
FRTTO Licence Valid up to	10/09/2017
IR rating	IR: 03/07/2017
Total Flying Experience	9384.51 hrs
Total Flying Experience on Type	17:30 hrs
Total Flying Experience in last 1 year	333:40 hrs
Total Flying Experience in last 6 months	17:30 hrs
Total Flying Experience in last 30 days	17:30 hrs
Total Flying Experience in last 7 days	17:30 hrs
Total Flying Experience in last 24 hours	Nil
Duty Time last 24 hours	Nil
Rest before the incident flight	60 hrs
Ratings	As PIC: Cessna 152A, Piper PA 23-250 Aztec, Airbus A-320/319/321 As FO: Airbus A-320/319/321, Boeing 787-800

He had undergone Breath Analyzer test for consumption of alcohol at Mumbai at 23:14 hrs on 20/08/2017 before carrying out Mumbai-London sector (flight no. AI-131) and found fit for flying.

PIC was having adequate rest before he operated flight on 21st August 2017. Upon scrutiny of the records, PIC was found to be within limits of FDTL.

Previous Incident History: As per the operator, FO was found free of records for incidents/ accidents for last 03/10 years.

Night Shift AME (details as on prior to incident flight):

Age	52 years 02 months Male
License	AME
Date of Issue	10/11/2015
Valid up to	29/12/2020
Category	Aeroplanes Turbine
Sub Category	B1
Endorsements	Airbus A-310 (GE CF6) Airbus A-300 B4 (GE CF6) Boeing 747-400 (PW 4000) Boeing 777-200/300 (PW 4000) Boeing 777-200/300 (GE 90) Boeing 787-800 (GENX-1B)

Morning Shift AME (details as on prior to incident flight):

Age	54 years 06 months Male
License	AME
Date of Issue	09/11/2015
Valid up to	29/12/2020
Category	Aeroplanes Turbine
Sub Category	B1
Endorsements	Airbus A-310 (GE CF6) Airbus A-300 B4 (GE CF6) Boeing 747-400 (PW 4000) Boeing 777-200/300 (PW 4000) Boeing 777-200/300 (GE 90) Boeing 787-800 (GENX-1B)

1.6 Aircraft Information:

The details provided below are as on prior to the incident flight.

Aircraft Registration	VT-ANE
Type of Aircraft	Boeing 787-800
Aircraft Serial No.	36280
State of Manufacturing	USA
Manufacturing year	2013
Owner	M/s Celisa Aircraft LLC C/o Wilmington Trust Company, 1100 North Market Street, Wilmington, Delaware 19890-1605, USA
Operator	M/s Air India Ltd
Certificate of Airworthiness number and issue date	6578 dated 01/12/2013
ARC number and Validity	ANE/6578/ARC 2 ND /2016/265 Valid up to 01/12/2017
A/c TSN / CSN	16105: 20 hrs / 3338
Maximum All Up Weight authorized	2,27,930 Kg
Minimum crew necessary	Two
Engine Type	# 1 (LH): GEnx-1B67 # 2 (RH): GEnx-1B67
Engine Sl no.	# 1 (LH): 956-210 # 2 (RH): 956-242
Last major check (A1+A2+A4 Check) carried out	On 05/08/2017 at 15898:37 hrs A/c TSN/ 3295 A/c CSN
Next schedule maintenance due at (A1 Check)	16898:37 hrs A/c TSN
Aircraft Take-off Weight	2,02,247 Kg

Fuel On-board before Flight	52,600 Kg
Type of fuel used	Jet A-1
Specific Gravity of fuel used	0.782 Kg/ liter (as per FRB)
Fuel tank capacity	LH & RH main tank: 21,085 liters Center tank: 84,036 liters LH & RH Surge tank: 617 liters

After completion of Pre-departure/ transit check, aircraft was released to service on 21/08/2017 at Mumbai for sector Mumbai-London (flight no. AI-131). The Scheduled Departure Time of the flight AI-131 was 01:00 hrs and the aircraft pushed back at 01:16 hrs. Scrutiny of the maintenance records reveals that there was no relevant snag open for rectification and there was no active MEL invoked with regard to relevant aircraft systems. There was no leak observed at any place on aircraft and no snag/ discrepancy was reported by PIC to AME during release of the aircraft from Mumbai. The incident flight was the first flight of the day.

Aircraft take-off weight as per the Load & Trim sheet was 2,02,247 Kg and fuel on-board before departure was 52,600 Kg. As per the Load & Trim sheet, the Centre of Gravity was within limits.

Aircraft was airworthy before the incident flight.

Aircraft held its position on the taxiway M and engines were shut down to arrest the fuel leakage. Pilot Defect Report of the incident flight was as follows:

‘During taxi:

- Fuel imbalance message
- Informed that fuel leaking from right wing
- Engine shut down and towed to bay’

On arrival of aircraft at R2 bay, it was observed in the cockpit that fuel imbalance EICAS message was present. No status message was present related to any system. There were no existing faults, existing flight deck faults, present leg faults and inbound flight deck defects. There was no maintenance message about fuel chapter. Fuel in LH, Center and RH tank was observed to be 16,200 Kg, 16,700 Kg and 17,200 Kg respectively. No external leak was observed with RH main tank full. RH Surge tank was observed to be filled with fuel and red overfill light in the refueling panel was flickering. After draining RH surge tank, morning shift AME did fuel balancing and

observed that concerned valves were operating normally and balancing was being done in normal way.

The aircraft was shifted to hanger for carrying out rectification on the Pilot Defect Report. Following rectification action was carried out:

- a) The RH main tank 'volumetric shut off' function was checked by transferring fuel from center tank to RH main tank. Fuel transfer stopped at 16,700 Kg.
- b) Fuel quantity rise check in LH and RH main tank carried out by pressurizing centre tank pumps. No rise in fuel quantity noticed in the following cases:
Case 1: With defuel valve OFF, center tank pumps ON and cross feed valve OPEN
Case 2: With defuel valve OPEN, center tank pumps ON and cross feed valve OPEN
- c) The engines were started and idle run-up was carried out with cross feed valve OPEN and all fuel pumps ON (center tank feeding both engines), it was observed that there was no change in fuel quantity in the LH or RH main tank.
- d) Defueling check was carried out.
- e) As a precaution the right inboard refuel valve actuator was replaced. The LRU replacement test passed. NIL status messages and NIL active messages noted. All operation and indication was checked and found satisfactory.

The aircraft was released for service after completion of above rectification action and operated flight AI-310 (Mumbai-Delhi) on 22/08/17 at 1435 ATD. Subsequently, there was no report of un-commanded fuel transfer received.

This matter was also taken up by M/s Air India with M/s Boeing for:

1. Probable cause of the fuel spillage
2. Any additional maintenance actions required to be taken
3. Boeing's recommendations to prevent fuel spillage events in future

As per response of M/s Boeing:

1. This event could have been a result of presence of FOD in a right main tank boost pump outlet check valve. As M/s Air India Ltd had flown multiple times after the datum event without further imbalance reports, the suspect FOD could have been dislodged from the pump and passed into the engine screen.
Since Air India Limited pressurized the feed manifold with the Override/Jettison pumps ON (with the defuel valve in both the OPEN and CLOSED position) and saw no changes in fuel quantity indication, M/s Boeing did not indict the defuel valves or the refuel valves.

2. M/s Boeing did not advise additional operational checks relative to that which M/s Air India Ltd had already completed. However, M/s Boeing advised to check for suspected FOD in the right engine's main fuel pump strainer as without additional reports of un-commanded fuel transfer, suspected FOD was not expected to still be stuck in the check valves.
3. As un-commanded fuel transfer events are typically caused by presence of FOD in the boost pump outlet check valves, Boeing recommends using extreme caution to eliminate FOD when re-installing boost pumps and anytime the tank is broken into.

Based on advice of M/s Boeing, right engine's main fuel pump strainer was inspected for FOD on 02/11/2017 and no discrepancy was observed. Further, there was no maintenance done on the RH main tank and the boost pumps were not replaced recently. The same was reported back to M/s Boeing for the possible cause. M/s Boeing responded that -- they cannot conclusively determine the root cause. However, this event could have been a result of presence of FOD in a right main tank boost pump outlet check valve. As Air India has not observed further imbalance reports, the suspect FOD could have been dislodged from the pump during the subsequent tank to tank fuel transfers. The location, or continued presence, of suspect FOD cannot be positively identified.

1.7 Meteorological Information:

Meteorological information is provided by Indian Meteorological Department in every 30 minutes. The weather at Mumbai, as per Indian Meteorological Department, was reported as follows:

Time	0030	0100	0130
Wind	160/ 03 Knots	110/ 03 Knots	100/ 06 Knots
Visibility	2200 meter	2500 meter	2200 meter
Clouds	SCT012 SCT018 FEW030CB OVC090	SCT012 SCT018 FEW030CB OVC090	SCT012 SCT018 FEW030CB OVC090
Precipitation	Drizzle	Drizzle	Drizzle
Temperature	24 °C	24 °C	24 °C
Dew Point	23 °C	23 °C	23 °C
QNH	1001 hPa	1001 hPa	1002 hPa

Actual weather as per ATIS information at 0010 hrs on 21/08/2017 was as follows: Winds: 210/08, Visibility: 2200 meter, Temperature/DP: 23/23, QNH: 1001 hPa.

During taxiing, rain was prevailing at the airport. Meteorological report was available with the crew for briefing before flight. Weather was not a factor to this incident.

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.

1.9 Communication:

Aircraft is equipped with Very High Frequency transmitter & receiver set, High Frequency transmitter & receiver set and a set for satellite communication. There was always two-way communication established between the SMC and aircraft.

1.10 Aerodrome Information:

Chhatrapati Shivaji International Airport (IATA: BOM, ICAO: VABB) is being operated, managed and developed by Mumbai International Airport Limited, a consortium led by the GVK Group. The ATC is controlled by Airports Authority of India.

The elevation of the airport is 37 ft, and it has two runways: runway 09/27, 3448 m x 60 m and runway 14/32, 2871 m x 45 m. The airport is equipped with Surface Movement Guidance and Control System.

Aerodrome category for rescue & firefighting is CAT-10. Type of operations permitted is IFR/VFR.

1.11 Flight Recorders:

Relevant portion of CVR & SMC tape transcript is reproduced below:

TIME (hrs)	FROM	CONVERSATION
01:21:07	PM	AI-131 REQUEST TAXI
01:21:12	SMC	AI-131 GROUND TAXI VIA T-H-HOLD SHORT M7 ONCE CLEAR OF EXPRESS TO PASING ABEAM G4
01:22:54	SMC	AI-131 TAXI H HOLD SHORT OF M7

TIME (hrs)	FROM	CONVERSATION
01:22:58	PM	H HOLD SHORT M7 AI-131
01:24:05	SMC	AI-131 TAXI M7-N1-HOLDING POINT RUNWAY 27
01:24:09	PM	M7-N1-HOLDING 27 AI-131
01:24:13	PF	MIKE 7 NOVEMBER 1 HOLDING POINT 27 CHECKED
01:24:44	OMA	GROUND NAMASHKAR OMA-202 TAXI M7 TO HOLD SHORT N1
01:25:00	SMC	OMA-202 TAXI M7- N1- N3-HOLDING POINT RUNWAAY 27
01:25:06	OMA	M7- N1- N3-HOLDING POINT RUNWAAY 27 OMA-202 THANK YOU
01:25:52	OMA	AND GROUND, AIR INDIA 787 JUST AHEAD OF US, THERE IS FUEL COMING FROM THE RIGHT TANK IF THEY CAN CHECK IT UP
01:25:54	PF	OUT OF TERMINAL AREA A TAKE OFF BRIEFING TAKE MODES LNAV, VNAV, HEADING 271, ALTITUDE 14000FT, DTU-----132-----92.1----- FLAPES 5 STAB TRIM 4, GREEN BAND, RUBBER TRIM 0
01:26:01	SMC	STATION CALLING?
01:26:02	OMA	THIS IS OMAN AIR 202, AIR INDIA AHEAD OF US THERE IS FUEL COMING FROM THE RIGHT TANK RIGHT WING
01:26:08	SMC	ROGER, AI-131 HOLD POSITION
01:26:11	PM	AI-131
01:26:19	SMC	OMA-202 HOLD POSITION
01:26:20	OMA	HOLDING POSITION, OMA-202
01:26:24	PM	AI-131 HOLDING ON N1

TIME (hrs)	FROM	CONVERSATION
01:26:27	SMC	AI-131 CONFIRM MONITORED
01:26:31	SMC	AI-131, OMAN AIR REPORTED FUEL COMING OUT FROM YOUR RIGHT TANK
01:26:42	PM	YES. WE ARE CHECKING THAT SIR
01:26:46	UNIDETIFIED	CONTINUOUS FLOW COMING OUT FROM THE RIGHT TANK
01:26:49	SMC	SAY AGAIN
01:26:51	UNIDETIFIED	CONTINUOUS FLOW
01:26:52	PF	CONTINUOUS FLOW
01:26:54	PM	YEAH OKAY
01:27:02	PM	WE HAVE LOST ONE TONNE ALREADY YAAR
01:27:05	PF	YES
01:27:15	PM	CHECK THE ENGINE FLOW
01:27:20	PM	BALANCE
01:27:21	SMC	OMA-202 TAXI H NOW, CONTINUE ON H, HOLD SHORT OF M5
01:27:24	PF	WE WILL GO BACK?
01:27:26	OMA	CONTINUE ON H, HOLD SHORT OF M5 OMA-202
01:27:27	PF	BECAUSE WE HAVE LOST ONE TONNE ALREADY SO WE MIGHT AS WELL GO BACK
01:27:30	PM	--GARBLED--
01:27:56	PM	OMAN AIR AI-131, YOU STILL NOTICING ANY FUEL COMING OUT OF OUR WING
01:28:00	OMA	YES AFFIRMATIVE THERE IS STILL LOT OF FUEL COMING OUT
01:28:02	PM	OKAY COPIED

TIME (hrs)	FROM	CONVERSATION
01:28:03	OMA	AND THE FIRE TRUCK IS BEHIND YOU
01:28:05	PM	ALRIGHT THANKS
01:28:17	PM	THERE IS FUEL IMBALANCE BECAUSE OF THAT
01:28:19	PF	ITS COTINUOUS FLOWING
01:28:22	PM	CONTINUOUSLY FLOWING
01:28:35	PF	AND HOLD SHORT M5
01:28:36	PM	M5
01:28:56	SMC	FROUND FIRE TENDER 6, AIR INDIA 788 REPORTED CONTINUOUS FUEL SPILLAGE FROM RIGHT TANK. PROCEED TO TAXIWAY M IMMEDIATELY AND CHECK
01:29:12	SMC	HOLD SHORT M5
01:29:14	PM	HOLDING SHORT M5, AI-131
01:29:24	FM5	GROUND FOLLOW ME 5, SIR ADVISE AIRCRAFT TO HOLD POSITION
01:29:27	SMC	AI-131 HOLD POSITION NOW
01:29:29	PM	HOLDING POSITION AI-131
01:29:32	FM5	FOLLOW ME 5 ADVISE AIRCRAFT TO SHUT DOWN THE ENGINE
01:29:36	SMC	AI-131 SHUT DOWN THE ENGINES NOW
01:29:38	PM	YEAH STANDING BY. OKAY START THE APU
01:29:43	SMC	AI-131 REPORT WHEN ENGINE IS SHUT DOWN
01:29:46	PM	YEAH WE ARE STARTING THE APU AND WILL SHUT DOWN
01:29:48	SMC	ROGER

TIME (hrs)	FROM	CONVERSATION
01:29:50	PF	PARKING BREAK SET
01:30:11	PF	SHALL WE DO THE AFTER LANDING CHECKLIST
01:30:13	PM	AFTER LANDING. TAKE THIS OUT.
01:30:20	OMA	AIR INDIA IT IS ADVISABLE FOR YOU, IF YOU JUST SHUTDOWN THE RIGHT ENGINE, THERE IS A LOT OF FUEL COMING OUT
01:30:26	PM	OKAY, SHUTTING DOWN THE RIGHT ENGINE
01:30:39	FM5	GROUND FOLLOW ME 5 ENGINE IS STILL ON SIR?
01:30:44	SMC	AI-131 SHUT DOWN THE ENGINE SIR
01:30:46	PM	JUST WAITING FOR THE APU TO COME ON SIR
01:30:48	SMC	ROGER
01:31:10	PM	APU RUNNING
01:31:27	SMC	FIRE TENDER 5 GROUND
01:31:30	FT5	ADVISE AIR INDIA PILOT TO CUT OFF ENGINE BECAUSE THE FUEL LEAK IS VERY HEAVY
01:31:37	SMC	AI-131 EXPENDITE CUTTING OFF YOUR ENGINE SIR
01:31:43	PM	WE HAVE ALREDY SHUT OFF OUR ENGINE, 2 MINUTES BACK
01:31:52	PM	CONFIRM COPIED AI-131
01:31:56	SMC	AI-131 GROUND
01:31:58	PM	BOTH THE ENGINES SHUT DOWN SIR SINCE LAST COUPLE OF MINUTES
01:32:00	SMC	CONFIRM BOTH THE ENGINES SHUT DOWN NOW

TIME (hrs)	FROM	CONVERSATION
01:32:02	PM	AFFIRM
01:32:04	UNIDENTIFIED	AND FUEL LEAK STOPPED NOW
01:32:07	SMC	ROGER
01:32:25	SMC	FIRE TENDER 6 CONFIRM FUEL LEAKAGE HAS STOPPED NOW
01:32:29	FM5	GROUND FOLLOW ME 5, IT IS AFFIRMATIVE. IT IS IN SMALL AMOUNT NOW
01:32:33	SMC	ROGER
01:32:35	FT5	MUMBAI GROUND FIRE TENDER 5 FUEL LEAKAGE NEGATIVE SIR
01:34:03	SMC	FOLLOW ME 5 REPORT SITUATION NOW
01:34:06	FM5	GROUND FOLLOW ME 5 AMOUNT OF FUEL LEAKAGE IS IN SMALL AMOUNT NOW
01:34:12	SMC	ROGER
01:34:13	FM5	FUEL LEAKAGE IS STILL ON
01:34:15	SMC	ROGER
01:34:20	PM	PUMPS ARE OFF, WHY IS THE FUEL STILL COMING OUT?
01:34:24	PF	LINE SIR. REMAINING FUEL IN THE LINE MUST BE COMING OFF
01:34:29	SMC	AI-131 UNDERSTAND ALL ENGINES ARE SHUT DOWN NOW
01:34:32	PM	YEAH, WE HAVE SHUT THE ENGINES DOWN. THE PUMPS ARE OFF. WE ARE JUST WAITING FOR THE GROUND SUPPORT NOW

Following are the salient observations made from FDR readout:

TIME (hrs)	EVENTS
01:16:34	Push back started.
01:18:26	Engines started.
01:19:13	Fuel flow to both the engines started.
01:19:26	Aircraft ground speed was recorded zero probably indicating the completion of push back.
01:20:17	All main tank pumps turned ON.
01:20:25	Both center tanks Override/ Jettison pumps turned ON.
01:21:23	RH main tank fuel quantity started increasing.
01:21:25	Center tank fuel quantity started decreasing.
01:21:54	Aircraft started taxiing.
01:23:21	Fuel Imbalance message came up. Difference in LH & RH main tank fuel quantity was observed to be 700 Kg. LH main tank fuel: 16,400 Kg Center tank fuel: 19,000 Kg RH main tank fuel: 17,100 Kg Aircraft taxi speed: 9.9 knots
01:23:33	RH main tank fuel quantity reached to its maximum value as recorded by FDR and remained same till the aircraft returned to bay R2. LH main tank fuel: 16,400 Kg Center tank fuel: 18,900 Kg RH main tank fuel: 17,200 Kg
01:25:13	Fuel in center tank: 18,300 Kg.
01:25:15	Cross feed valve opened.
01:25:37	LH main tank pumps put OFF.
01:26:39	LH main tank pumps put ON.
01:26:43	Cross feed valve closed.

TIME (hrs)	EVENTS
01:29:34	Aircraft stopped on taxiway M.
01:30:28	Engine# 2 fuel flow became zero.
01:31:01	Both override/ jettison pumps of center tank put OFF.
01:31:11	Both override/ jettison pumps of center tank put ON.
01:31:14	Engine# 1 fuel flow became zero.
01:31:14	Both engines shut down.
01:31:49	All pumps, except LH main tank aft pump, put OFF.
----	LH main tank aft pump was observed to be ON before the push back and after engine shutdown indicating the APU was fed by LH main tank.
----	The fuel flow to both the engines kept on varying mainly around 1400 lbs/ hr to 1500 lbs/ hr.
----	Standard procedures were followed by the cockpit crew before and after the incident.

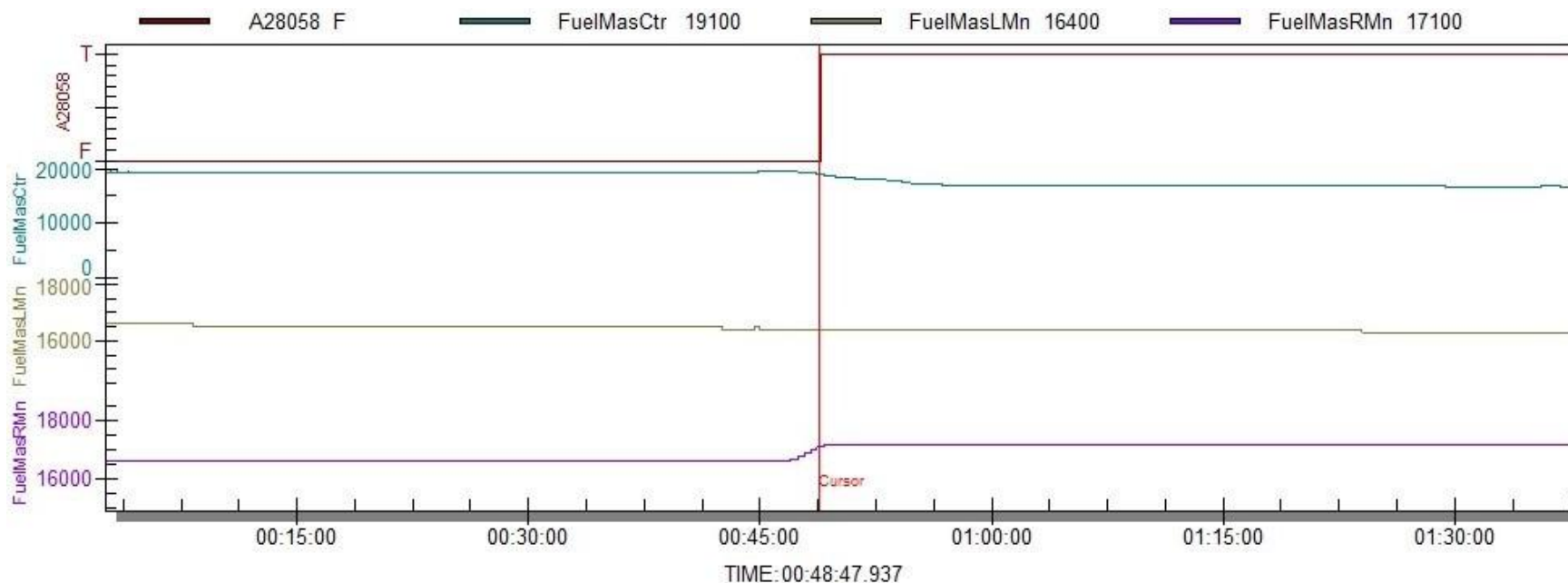


Figure # 2 Graphical representation of FDR data

A28058- FUEL_IMBALANCE

T: Fuel imbalance recorded (Fuel imbalance will be set when the difference between the main tanks exceeds the allowable quantity for a period greater than 30 seconds)

F: No Fuel imbalance recorded

The decrease in center tank fuel quantity and increase in RH main tank quantity substantiates that the fuel is being transferred from center tank to RH main tank. At the time of Fuel Imbalance message, the fuel quantities of LH main, centre and RH main tanks were 16,400 Kg, 19,000 Kg and 17,100 Kg respectively.

Graph shown above corresponds to the condition just before Fuel imbalance message. Time shown in the graph is the elapsed time of FDR recording.

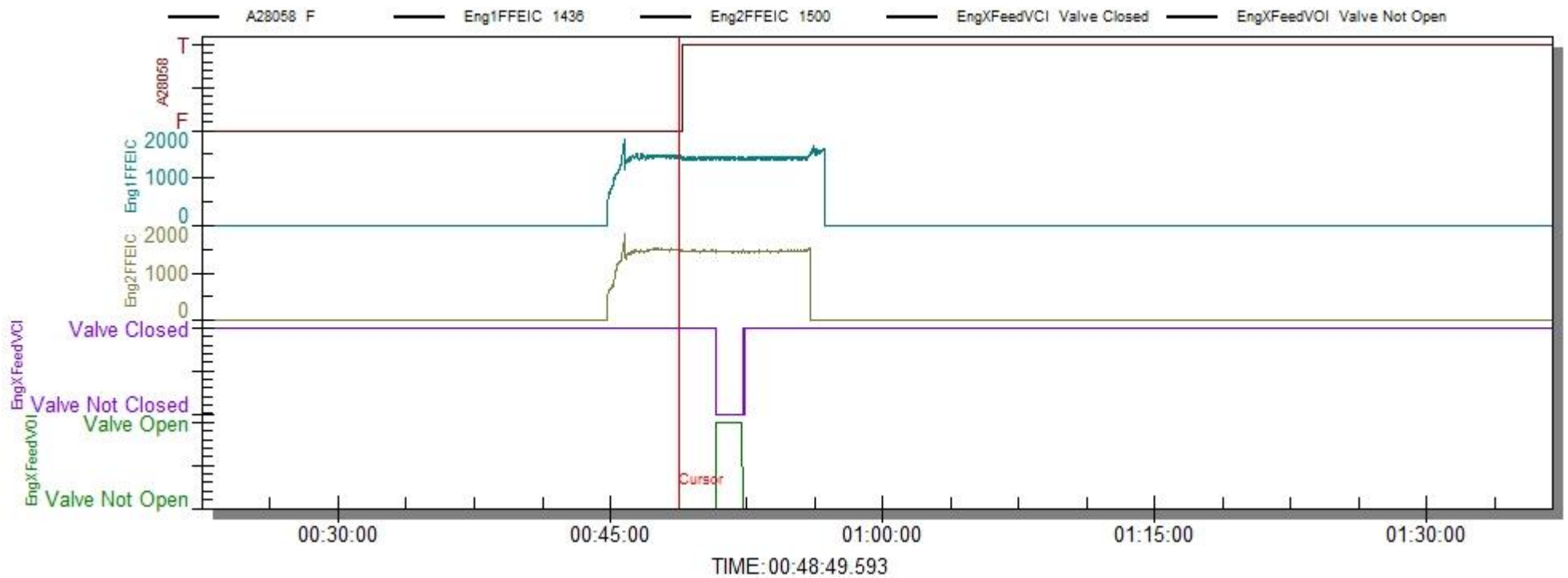


Figure # 3 Graphical representation of FDR data

After the fuel imbalance message crew put the cross feed valve to OPEN position as per FCOM procedure.

Graph shown above corresponds to the condition just before Fuel imbalance message. Time shown in the graph is the elapsed time of FDR recording.

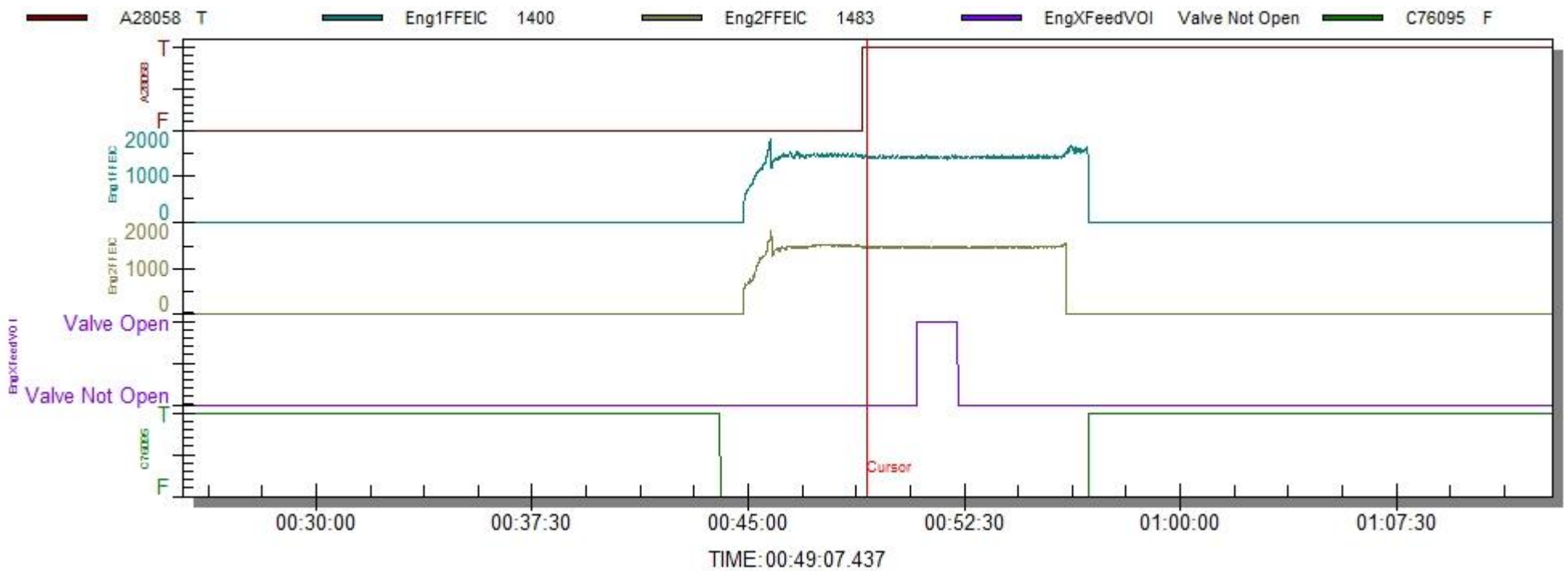


Figure # 4 Graphical representation of FDR data

C76095 - ENG_SHUTDOWN_GE

T: Both engines were shutdown on the ground by the fuel control switches or engine fire switches

F: Conditions mentioned in 'T' above is not fulfilled

Graph shown above corresponds to the condition just after Fuel imbalance message. Time shown in the graph is the elapsed time of FDR recording.

1.12 Wreckage and impact information: Nil.

1.13 Medical and pathological information: Both the crew had undergone Pre-flight medical examination before operating the flight at Mumbai, tested negative for consumption of alcohol and found fit to operate flight.

1.14 Fire: There was no fire before or after the incident.

1.15 Survival Aspects: No human injuries were reported in the incident.

1.16 Tests and research:

During rectification, the inboard refuel valve actuator (Part no.: 53-0037, Serial no.: 48106603) of RH tank was replaced on precautionary measures. The removed component was tested for its serviceability at FAA/EASA approved repair station and found not defective.

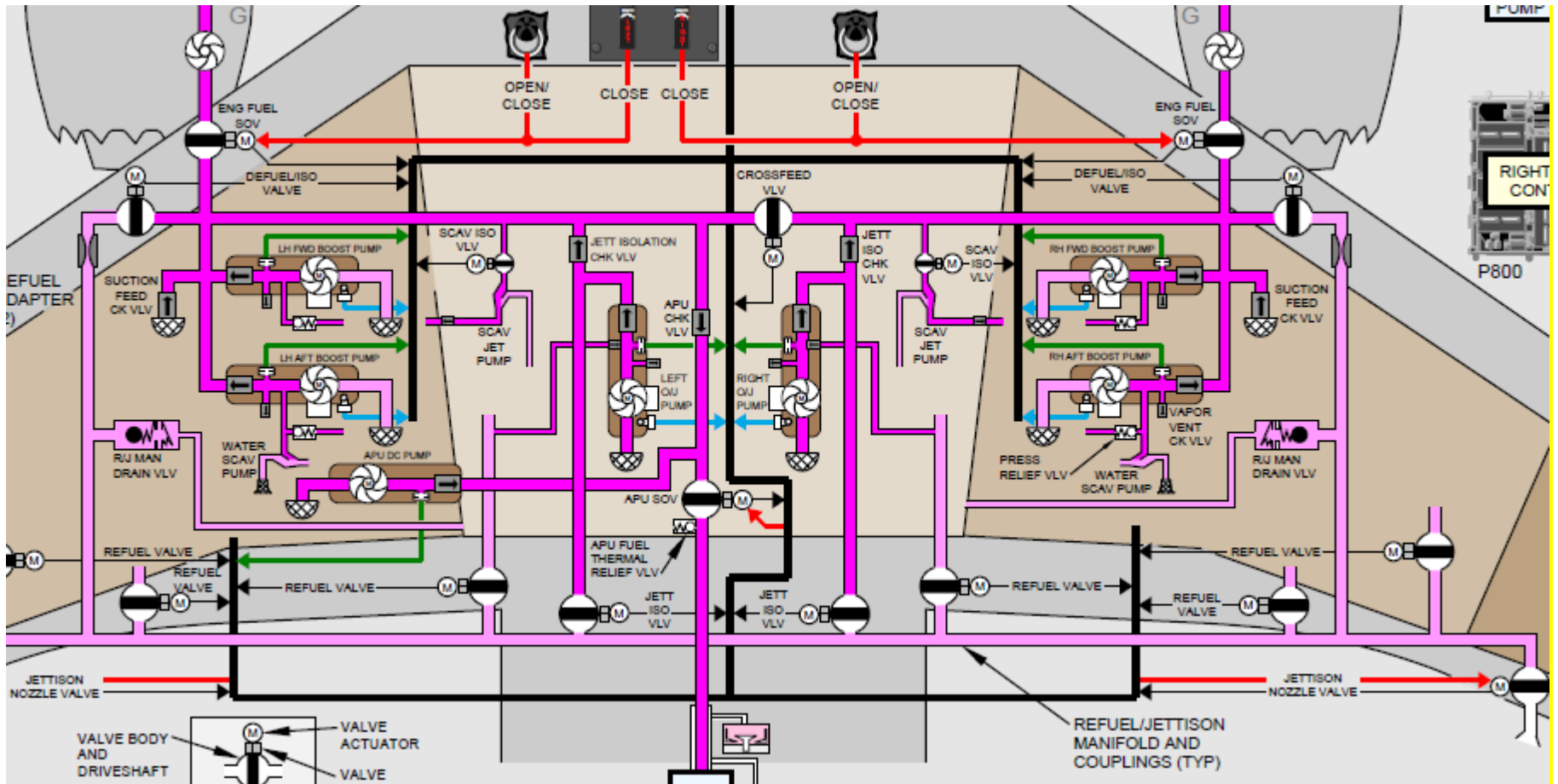
1.17 Organizational and Management Information:

Air India is a scheduled airline owned by M/s Air India Ltd, a government-owned enterprise, and operates its flights on domestic and international sectors with a fleet of Boeing 747, Boeing 777, Boeing 787, Airbus 319, Airbus 320 and Airbus 321 aircraft. M/s Air India Limited is headquartered at New Delhi.

Air India is the largest international carrier of India. Over 40 international destinations are served by Air India across four continents. The airline became the member of Star Alliance on 11 July 2014.

1.18 Additional Information:

❖ Pressure Refueling System:



Figure# 5 Pressure Refueling System

System Description:

Pressure refuel system is operated with the Refuel Control Panel (RCP). Selections of fuel load data and the positions of the refuel valve switches go to the FQMS function. The refuel door proximity sensor gives a signal that the RCP door is open. This signal gives power to the RCP. The FQMS controls the pressure refueling system. The FQMS function receives the RCP and fuel quantity data. The FQMS function controls the refuel valve body and driveshaft. The FQMS function sends data to open and close the refuel valve body and driveshaft with the refuel valve actuators. The refuel adapters connect the fueling nozzles to the refuel/jettison manifold components. Fuel from the refuel/jettison manifold tubes goes to the refuel valve body and drive shaft. The valve bodies open to let fuel go into the tanks and close to stop the fuel. To transfer fuel from one tank to a different tank, the RCP and the FCP (Fuel Control Panel in cockpit) are used.

❖ Engine fuel feed system:

The engine fuel feed system uses fuel boost pumps and override/jettison (O/J) pumps to make fuel pressure for the engines.

The fuel pumps pressurize the fuel that goes to the engine fuel feed manifold. There are 6 fuel pumps in the engine fuel feed system:

- Override/jettison (O/J) pumps (2)
- Fuel boost pumps (4)

The 2 O/J pumps are in the center fuel tank. The O/J pumps supply center tank fuel to the engines and the APU. When the O/J pumps are on, they make more pressure than the fuel boost pumps. Because of this, center tank fuel is supplied before the main tank fuel.

There are 2 fuel boost pumps for each main tank (4 total). The main tank fuel boost pumps supply main tank fuel to the engines and APU. Each boost pump has a pressure relief valve downstream of the pump. The pressure relief valve releases fuel from the system if the boost pump pressure is too high. This is to make sure that the O/J pump pressure overrides the fuel boost pump pressure. This makes sure that the center tank fuel is used first.

Each boost pump has an outlet check valve downstream of the pressure relief valve. Check valve allows fuel flow in one direction and prevent flow in the other direction. The higher pressure of the O/J pumps closes (overrides) the outlet check valves of the main tank boost pumps to make sure fuel from the center tank is used before main tank fuel.

❖ Fuel storage:

Following three storage tanks hold fuel:

- Left main tank
- Right main tank
- Center tank

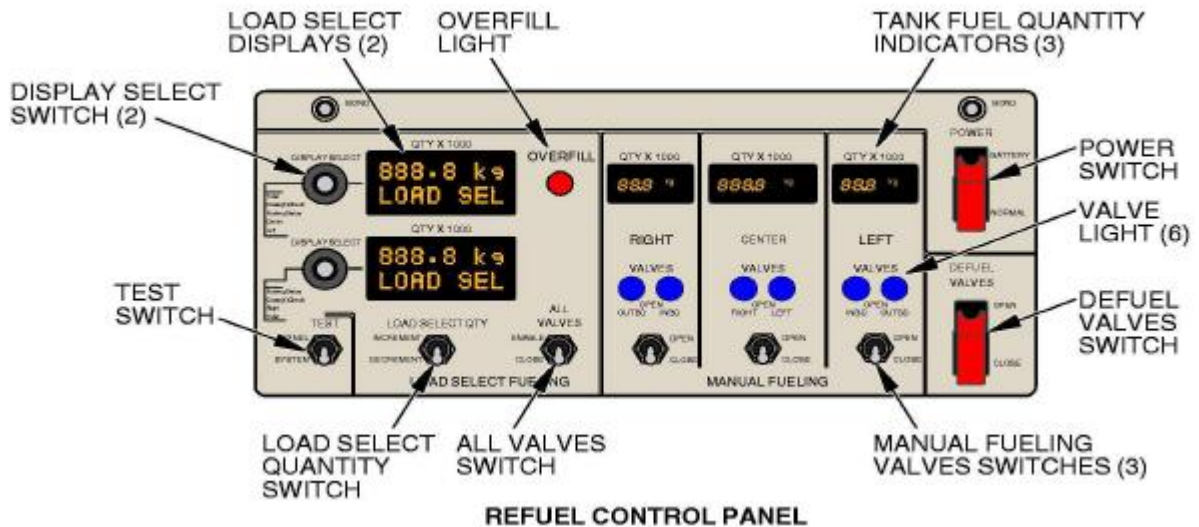
Each of the main tanks has a capacity of 21,085 liters. The center tank has a capacity of 84,036 liters.

Two surge tanks are outboard of each main tank. The surge tanks collect fuel overflow and supply an air vent. Each surge tank has a capacity of 617 liters.

❖ Refuel Control Panel:

The refuel control panel (RCP) controls refuel, defuel, and fuel transfer operations. The RCP is under the left wing outboard of the engine at the refuel station. The RCP gets power when the RCP door is open.

The RCP gives input for control to the fuel quantity management system (FQMS) function. The RCP gives status messages and the fuel quantity indication for each fuel tank. The RCP also gives status messages for fuelling system modes, for example REFUELING or DEFUELING. The RCP uses LEDs for all lights and displays.



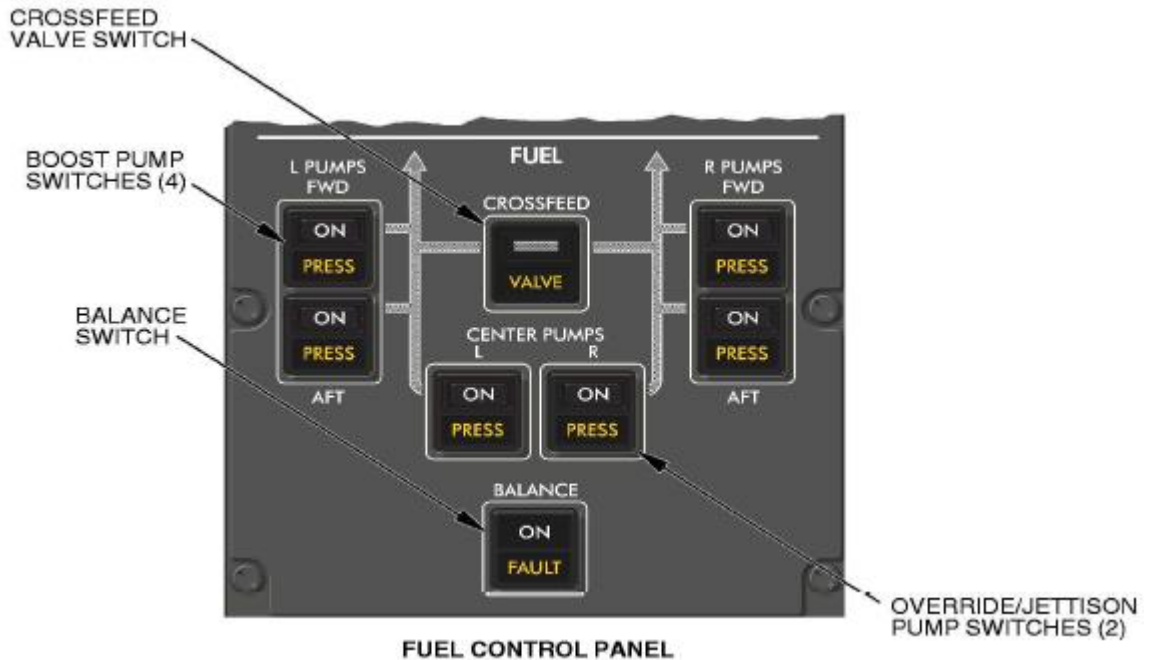
Figure# 6 Refuel Control Panel

The defuel valves switch sets the RCP for a defuel procedure. When the switch is in the OPEN position, the defuel/isolation valves open. When the switch is in the CLOSE

position, the defuel valves close. The load select display shows a value equal to the total fuel indication. The overfill light comes on if the FQIS senses an overfill condition.

❖ Fuel Control Panel:

Fuel control Panel (FCP) is located in the cockpit for crew to operate the fuel system. Panel consists of switches for all main tank pumps and center tank pumps, crossfeed valve switch and fuel balance switch.



Figure# 7 Fuel Control Panel

❖ Fuel balance system:

The balance function transfers fuel between main tanks, on the ground or in flight. Balance operation stops when fuel quantity in main tanks is equal within 200 lbs. Fuel balancing is accomplished by using either the fuel balance system (automatic) or the manual crossfeed.

1. Automatic operation by Fuel Balance switch:

The fuel balance system is initiated by pushing the fuel balance switch. When Fuel Balance switch is selected following happens-

- A defuel/isolation valve opens on the heavier side
- The inboard refuel valve opens on the lighter side
- Fuel flows through the refuel/jettison manifold and corrects the imbalance.

The fuel balance system may be used in any phase of flight. It can be used on the ground if the engines are shutdown and the APU is running. Automatic fuel balance operation is inhibited for the any of the following reasons:

- refueling, defueling and ground transfer of fuel (using the refuelling control panel)
- prior to engine start and the APU is off
- the fuel balance system is failed
- a center tank pump is on
- on the ground and one or both engines are running
- in flight and the fuel jettison system is active, or the FUEL DISAGREE or FUEL QTY LOW message shows

2. Manual balancing by using cross feed valve and fuel pumps:

Manual crossfeed is initiated by opening the crossfeed valve and turning off the fuel pump switches for the fuel tank that has the lower quantity. This will allow the heavier to feed both the engines. Crossfeed may be done in any phase of flight.

Note: Manual fuel transfer between main tanks can only be possible by opening the defuel/ isolation valves and refuel valves from the refuel control panel and operating concerned pumps from cockpit.

❖ Fuel imbalance:

When the fuel quantity in left and right main tanks differ by a predetermined quantity, the EICAS alert message FUEL IMBALANCE displays. The difference in fuel quantity which causes the FUEL IMBALANCE message to be displayed varies with total main tank fuel quantity.

Crew to carry out following actions for fuel imbalance as per non-normal checklist of FCOM:

Condition: There is a fuel imbalance between the main tanks.

Objective: To decide if a fuel leak is suspected. To balance fuel if a fuel leak is not suspected.

1. If an engine has low fuel flow and unusual engine indications, the FUEL IMBALANCE message may show due to engine damage instead of a fuel leak.
2. The FUEL IMBALANCE message may be caused by a fuel leak or a fuel imbalance.
3. A fuel leak should be suspected if one or more of the following are true:

- The total fuel remaining on EICAS is less than the planned fuel remaining.
 - An engine has excessive fuel flow.
 - On PROGRESS page 2, the totalizer is less than the calculated fuel.
4. FUEL BALANCE switch Push to Off
Ensure the ON light is extinguished.
 5. FUEL CROSSFEED switch On
 6. If Left main tank quantity is low:
FUEL L PUMPS switches (both) Off
Do not accomplish the following checklists:
FUEL PUMP L AFT
FUEL PUMP L FWD
 7. When fuel balancing is complete:
FUEL L PUMPS and R PUMPS switches (all) On
FUEL CROSSFEED switch. Off

1.19 Useful or Effective Investigation Techniques: None.

2. ANALYSIS:

2.1 Operational aspects:

Both the crew members were medically fit, had valid license, had adequate rest and found to be within FDTL limits before they operated flight on August 21st 2017. Medical fitness & FDTL of the crew was not a factor to this incident.

AI-131 was scheduled to depart at 01:00 hrs and pushed back at 01:16 hrs. Delay of 16 minutes is not a factor to this incident.

Crew had carried out ‘Before Taxi checks’.

Fuel transfer from center tank to RH main tank started around one minute after starting of center tank override/ jettison pumps. Within around two minutes, quantity of fuel transferred from center to RH main tank had created enough difference between fuel quantities of LH & RH main tanks which caused fuel imbalance EICAS message to be displayed. The difference between fuel quantities of LH and RH main tank was 700 Kg when the fuel imbalance EICAS message was displayed.

Crew put cross feed valve to OPEN and switched off the LH main tank pumps which was in accordance with the FCOM.

After 12 seconds of the fuel imbalance EICAS message, at 01:23:33 hrs, RH main tank quantity reached to its maximum recorded value, i.e. 17,200 Kg. This value remained same till the aircraft returned to bay R2. Therefore, it is considered that at this time the

RH main tank had become full and any further fuel coming from center tank would go into RH surge tank. Center tank was having 18,900 Kg fuel at 01:23:33 hrs.

Capacity of RH surge tank is 617 liters/ 482.4 Kg (at Specific gravity: 0.782 Kg/liter).

At 01:25:13 hrs fuel in center tank was 18,300 Kg, reduced by 600 Kg since the RH surge tank started getting filled. This decrease in 600 Kg of fuel from center tank (fuel consumed by engines + fuel transferred to RH main tank) implies that quantity of fuel transferred from center tank has probably gone beyond the capacity of RH surge tank (482.4 Kg) resulting in fuel coming out from RH surge tank. Hence, probably around 01:25:13 hrs, RH surge tank became full and fuel had started coming out through RH surge tank vent scoop. This fuel leakage was noticed by crew of M/s Oman Air flight OMA-202, which was taxiing behind AI-131, and informed to SMC at 01:25:52 hrs.

SMC immediately informed the AI-131 about fuel leak and later AI-131 was asked to hold on taxiway M where both the engines were shut down post starting of APU. The fuel coming out of the RH surge tank was reduced significantly and later gradually stopped upon switching off both the override/ jettison pumps of centre tank thereby stopping the fuel transfer from centre tank to RH main tank. Aircraft then towed to bay R2. Aircraft departed with total 52,600 Kg of fuel and returned to bay R2 with 50,100 Kg of fuel.

ARFF team and Follow Me reached promptly at site and helped AI-131 & SMC in controlling the situation. Taxiway N1 and a portion of taxiway M (between taxiway M6 & M4) was cordoned off which was later cleared for normal operations after clearing the fuel spillage.

Fuel quantities at the time of departure and arrival were as under:

	Left tank (Kg)	Center tank (Kg)	Right tank (Kg)	Total (Kg)
Departure	16,600	19,400	16,600	52,600
Arrival	16,200	16,700	17,200	50,100

It is observed that the difference between fuel quantities at the time of arrival and departure was 2500 Kg out of which the decrement of 400 Kg fuel in the LH main tank was attributed to the APU consumption. Further, remaining difference of 2100 Kg of fuel was attributed to the fuel consumed by both the engines and fuel leaked.

Both the engines were observed to be running for approximately 13 minutes out of which the fuel flow was observed to be present for approximately 12 minutes on Engine# 1 and for approximately 11 minutes on Engine# 2.

The fuel flow to both the engines kept on varying mainly around 1400 lbs/ hr to 1500 lbs/ hr. Hence, to calculate the total fuel consumed by both the engines the hypothetical average value has been taken, i.e. 1450 lbs/ hr (24.17 lbs/ minute).

Total fuel consumed for both the engines = fuel flow x time = 24.17 lbs/ minute x 23 minutes (both engines) = 555.91 lbs (252.15 Kg).

Therefore, the amount of fuel leaked is 2100 Kg – 252.15Kg = 1847.85 Kg. Approximately 1850 Kg of fuel was leaked from the aircraft.

The analysis of DFDR and position of valves/ switches/lights on RCP substantiates that the fuel transfer from center to RH main tank was un-commanded and crew actions were in accordance with the standard procedures. Hence, crew actions were not a factor to this incident.

2.2 Engineering aspects:

Airworthiness Review Certificate of the aircraft was valid up to 01/12/2017. Aircraft departed with valid Certificate of Release to Service on 21/08/2017. Aircraft was subjected to Transit Inspection schedule by authorized personnel before it was released to service. The incident flight was a first flight of the day. Scrutiny of the maintenance records reveals that there was no relevant snag open for rectification and there was no active MEL invoked with regard to relevant aircraft systems. There was no maintenance message about fuel chapter. Aircraft Load & Trim sheet was prepared and Centre of Gravity was found within limits. Refueling of aircraft was done in AUTO mode and no abnormality was observed during refueling. After refueling the switches/ lights/ valves on the refuel control panel were normalized. There was no snag/ fault history and no leak observed after refueling and during release of aircraft. No discrepancy was reported by crew at the time of release of aircraft. No other abnormality in the operation of aircraft was reported by the crew except fuel imbalance EICAS message. During walk around inspection at holding point on taxiway M, morning shift AME observed that fuel coming out from RH surge tank vent scoop. All other areas like APU, both engine drains, refuel control panel and LH surge tank vent scoop were normal and had no sign of fuel leak/ any discrepancy. No status message was present related to any system after shut down of engines. There were no existing faults, existing flight deck faults, present leg faults and inbound flight deck defects also. Fuel balancing was done by morning shift AME at R2 bay and observed that concerned valves were operating normally and balancing was being done in normal way. Rectification was carried out for the PDR entry and NIL discrepancy observed. The inboard refuel valve actuator of RH tank, which was replaced on precautionary measures during rectification, was not found defective. The aircraft was released for service after completion of rectification action and subsequently there was no report of un-commanded fuel transfer received.

Thus, the aircraft was considered airworthy and serviceable before the incident flight. Hence, airworthiness and serviceability of the aircraft was not a factor to this incident.

2.3 M/s Boeing's comments:

No discrepancies were noticed during the rectification on the Pilot Defect Report and M/s Boeing did not advise any further maintenance checks relative to that which M/s Air India Ltd had already completed. Further, there was no report of un-commanded fuel transfer received subsequent to release of aircraft after incident flight.

As the rectification action did not reveal any discrepancy, M/s Boeing was contacted for probable cause. M/s Boeing did not indict the defuel valves or the refuel valves. M/s Boeing suspected presence of FOD in a RH main tank boost pump outlet check valve as probable cause of this incident as un-commanded fuel transfer events are typically caused by FOD caught in the boost pump outlet check valves. This presence of FOD could be due to recent maintenance activity on the RH main tank or recent replacement of the boost pumps of the tank.

However, there was no recent maintenance activity performed on the RH main tank and RH boost pumps were not replaced recently. Further, as per advice of M/s Boeing, right engine's main fuel pump strainer was also inspected for suspected FOD, but no discrepancy was observed. Hence, M/s Boeing concluded that-

- the root cause of the incident could not be conclusively determined.
- this incident could have been a result of presence of FOD in a right main tank boost pump outlet check valve.

M/s Boeing further opined that, as M/s Air India Ltd has not observed further imbalance reports, the suspect FOD could have been dislodged from the pump during the subsequent tank to tank fuel transfers and the location, or continued presence, of suspect FOD cannot be positively identified.

2.4 Circumstances leading to incident:

It has been ascertained that the fuel transfer from center to RH main tank was un-commanded, crew actions were in accordance with the standard procedures and aircraft was airworthy before the incident flight. No abnormalities were observed during rectification and none of the component found defective in shop investigation. Further, the presence of FOD in boost pump outlet check valves could not be established.

In absence of the conclusive evidence and comments made by M/s Boeing, it is suspected that incident is probably caused by presence of FOD in right main tank boost pump outlet check valve which caused the fuel from centre tank to flow into the RH

main tank and subsequently to the surge tank till the override/ jettison pumps were switched off. However, the location, or continued presence, of suspected FOD could not be positively identified as it could have been dislodged from the pump during the subsequent tank to tank fuel transfers.

3. CONCLUSION:

3.1 Findings:

- Airworthiness Review Certificate of the aircraft was valid up to 01/12/2017.
- Aircraft was departed with valid Certificate of Release to Service on 21/08/2017.
- Refueling of aircraft was done in AUTO mode and no abnormality was observed during refueling.
- There was no snag/ fault history and no leak observed after refueling and during release of aircraft.
- Aircraft departed with total 52,600 Kg of fuel.
- No other abnormality in the operation of aircraft was reported by the crew except fuel imbalance EICAS message.
- Fuel was being transferred from center tank to RH main tank leading to display of fuel imbalance EICAS message in cockpit.
- Fuel leak was observed from RH surge tank vent scoop and all other areas were normal and had no sign of fuel leak/ any discrepancy.
- Fuel leakage was gradually stopped after the override/ jettison pumps were switched off.
- All switches/ lights/ valves on RCP were in normal position.
- Aircraft was towed to bay R2 subsequent to shut down of engines.
- Aircraft returned to bay R2 with 50,100 Kg of fuel.
- Approximately 1850 Kg of fuel was leaked from the aircraft.
- No status message was present related to any system after shut down of engines. There were no existing faults, existing flight deck faults, present leg faults and inbound flight deck defects also.
- After aircraft returned to R2 bay, fuel balancing was observed to be done in normal way and concerned valves were operating normally.
- Fuel transfer from center tank to RH main tank was un-commanded.
- During rectification NIL discrepancy was observed none of the component found defective in shop investigation.
- Subsequent to incident flight, no report of un-commanded fuel transfer received.
- Airworthiness and serviceability of the aircraft was not a factor to this incident.
- Both crew members were having valid licenses while operating incident flight.
- Medical fitness & FDTL of the crew was not a factor to this incident.
- Crew had carried out 'Before Taxi checks'.

- Crew carried out actions as per FCOM.
- Crew actions were not a factor to this incident.
- There was no recent maintenance activity performed on the RH main tank and RH boost pumps were not replaced recently before the incident flight.
- No discrepancy was observed during inspection of right engine's main fuel pump strainer. Hence, presence of FOD could not be established.
- As per M/s Boeing, this incident could have been a result of presence of FOD in a right main tank boost pump outlet check valve whose continued presence or location cannot be identified.

3.2 Causes:

Exact cause of the fuel leak could not be ascertained. However, it is suspected that the presence of FOD, in the Right main tank boost pump outlet check valve, has contributed to the fuel leak.

4. SAFETY RECOMMENDATIONS: Nil.



(Pathik Vaghela)
Inquiry Officer, VT- ANE

Date: 21/07/2020

Place: Mumbai

-----END OF REPORT-----