FINAL INVESTIGATION REPORT ON AIR TURN BACK INCIDENT DUE TO LOSS OF PRESSURIZATION TO M/s AIR INDIA LTD BOEING 787-800 AIRCRAFT VT-ANU ON 06/03/2019 AT DELHI

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

FOREWARD

This investigation is performed in accordance with The Aircraft (Investigation of Accidents and Incidents) Rules 2017 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.

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.

CONTENTS

ABBREVIATIONS

A/c	Aircraft
ADF	Automatic Direction Finder
AHM	Aeroplane Health Monitoring
Aircraft	Incident aircraft
AME	Aircraft Maintenance Engineer
ARC	Airworthiness Review Certificate
ASDA	Accelerate Distance Available
ATC	Air Traffic Control
ATPL	Air Transport Pilot's License
CB	Circuit Breaker
CPL	Commercial Pilot's License
CSN	Cycles Since New
CVR	Cockpit Voice Recorder
DDG	Dispatch Deviation Guide
DEL	Delhi Airport
DGCA	Director General of Civil Aviation, India
DME	Distance Measuring Equipment
DVOR	Directional Very high frequency Omni Range
EDDF	Frankfurt Am Main Airport
EE	Electronic Equipment
EICAS	Engine Indication and Crew Alerting System

ELT	Emergency Locator Transmitter
FCOM	Flight Crew Operating Manual
FDR	Flight Data Recorder
FDTL	Flight and Duty Time Limitations
FIM	Fault Isolation Manual
FL	Flight Level
FO	Co-Pilot/ First Officer
FRA	Frankfurt Am Main Airport
FRTO	Flight Radio Telephone Operator
GPS	Global Positioning System
HZ	Haze
IATA	International Air Traffic Association
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
INOP	Inoperative
IR	Instrument Rating
LDA	Landing Distance Available
LH	Left Hand
MEL	Minimum Equipment List
MFD	Multi-Functional Display

MMO	Maximum Operating Mach number
NDB	Non Directional Beacon
NNC	Non- Normal Checklist
NOSIG	Non significant
Operator	AOP holder of the incident aircraft
PIC	Pilot in Command
PPC	Pilot Proficiency Check
QNH	Pressure setting to indicate elevation
RADAR	Radio Detection and Ranging
RH	Right Hand
SCT	Scattered
STD	Scheduled Time of Departure
TCAS	Traffic Collision Avoidance System
TODA	Take-off Distance Available
TORA	Take-off Run Available
TSN	Time Since New
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VIDP	Delhi Airport
VOR	Very high frequency Omni Range
VMO	Maximum Operating Velocity

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1.	**Aircraft Type**	Boeing 787-800
2.	**Nationality**	Indian
3.	**Registration**	VT-ANU
4.	**Owner**	M/s Wilmington Trust SP Services (Dublin) Limited 4th Floor, 3 George's Dock, IFSC, Dublin 1, Ireland
5.	**Operator**	M/s Air India Ltd
6.	**Pilot In- Command**	Airline Transport Pilot's License Holder
7.	**Extent of Injuries**	Nil
8.	**Date and Time of Incident**	06/03/2019 08:53hrs
9.	**Place of Incident**	Delhi
10.	**Geographical location of site of Occurrence (Lat. Long.)**	Enroute
11.	**Last point of Departure**	Delhi, India
12.	**Intended Place of Landing**	Frankfurt, Germany
13.	**No. of Passengers On-Board**	199
14.	**Type of Operation**	Schedule, Passenger
15.	**Phase of Operation**	Climb
16.	**Type of Incident**	Air Turn Back due to loss of pressurization

All timings in this report are in UTC.

SYNOPSIS:

On 06th March 2019, M/s Air India Ltd Boeing 787-800 aircraft VT-ANU was involved in air turn back incident due to loss of pressurization during climbing while operating flight AI-121 (VIDP-EDDF).

While carrying out cockpit preparation procedures for AI-121, PIC observed status message of EQUIP OVBD VLV AFT. MEL 21-27-24-01 'Aft EE Cooling Overboard Exhaust (Skin Flush) Valve' was invoked by Aircraft Maintenance Engineer and VT-ANU was released to service. After engine start EQUIP OVBD VLV AFT advisory came on EICAS indicating that the Aft equipment cooling system overboard exhaust valve was failed in the open position, however aircraft taxied out as crew were unaware about the same. While lining up on runway 29 EQUIP OVBD VLV AFT advisory message came again on EICAS which was acknowledged and overridden by crew.

Aircraft took off at 08:42hrs from Runway 29. Few minutes later during climb, cabin altitude was observed to be at 8200ft and cabin altitude rate was observed to be rising. While passing 21000ft, EQUIP OVBD VLV AFT advisory message came again on EICAS along with the non-normal checklist on MFD. While carrying out NNC, CABIN ALTITUDE AUTO MASTER CAUTION was activated as crew put both the outflow valve switches to MANUAL. The crew leveled off the aircraft at 22000ft in coordination with ATC and continued with NNC. While opening both outflow valves manually as per NNC, crew observed cabin altitude increased rapidly and hence both the outflow valves were closed. However, the cabin altitude kept rising and became excessive at 08:54hrs leading to activation of CABIN ALTITUDE master warning. As per CABIN ALTITUDE NNC, crew immediately started descent with permission of ATC for 10000ft, donned oxygen masks and deployed passenger oxygen masks by using passenger oxygen switch. Aircraft reached 10000ft at 08:57hrs and CABIN ALTITUDE master warning was deactivated at 08:59hrs. Aircraft carried out uneventful landing at 10:04hrs on Runway 29 at Delhi after jettisoning fuel. The maximum pressure altitude attained by aircraft was 22015ft, peak cabin altitude was registered as 16573ft and minimum cabin pressure was recorded as 7.78psi during incident flight. No human injury was reported in the incident.

Director General of Civil Aviation ordered the investigation of the incident by appointing Investigator In-charge vide order no. DGCA-15018(1)/4/2019-DAS dated 7th March 2019 under Rule 13(1) of The Aircraft (Investigation of Accidents and Incidents) Rules 2017. Investigation concluded that non-adherence to the maintenance procedure by departure AME (Engineer# 2) while invoking MEL 21-27-24-01 and disregard of the said MEL procedure by the cockpit crew resulted in pressurization failure during flight. Lack of awareness of the EE cooling system by cockpit crew was the contributory factor.

1. FACTUAL INFORMATION:

1.1 History of Flight:

M/s Air India Ltd Boeing 787-800 aircraft VT-ANU, was scheduled to operate flight no. AI-121 (sector Delhi - Frankfurt) on 6th March 2019 at 08:05hrs with 209 persons on-board including 02 cockpit crew and 08 cabin crew. The aircraft was under the command of PIC (ATPL holder). PIC was the pilot flying and First Officer was pilot monitoring.

Aircraft VT-ANU arrived at Delhi on 06.03.2019 at 05:25hrs after completing flight AI-120 (FRA-DEL). No defect was recorded for the sector FRA-DEL. Subsequently, transit check was carried out and aircraft was released for departure of the flight AI-121.

PIC and First Officer reported for flight duty at 06:42hrs and 06:33hrs respectively for the flight AI-121. They reached aircraft 45 minutes prior to scheduled departure time after completion of flight briefing. The First Officer completed preflight external checks wherein no abnormality was observed. PIC, while carrying out cockpit preparation procedures, observed EICAS status message of EQUIP OVBD VLV AFT and informed Engineer# 1 (Cat 'A' license holder) who was allocated the departure of flight AI-121. Cockpit preparation and briefing was completed for LH departure.

The allocated B2 AME for flight AI-121 had already left the aircraft VT-ANU after completing certifications and he was busy in carrying out maintenance on other aircraft. Engineer# 1 did not have authorization to carry out defect rectification. Therefore, Engineer# 2 (Cat 'B2' license holder) was called for rectification of the defect. Engineer# 2 reached at the aircraft VT-ANU at about 08:00hrs as he was busy in defect rectification of other aircraft. It was observed by Engineer# 2 that EQUIP OVBD VLV AFT EICAS status message was active and correlated with maintenance message '21-22420- Aft EE Cooling Exhaust Overboard (Skin Flush) Valve position feedback has failed'. Engineer# 2 carried out ground test & recycled CB for Aft EE Cooling Overboard Exhaust (Skin Flush) Valve however the status message remained active and defect could not be rectified.

Engineer# 2 decided to invoke the MEL 21-27-24-01 Category 'C' for 'Aft EE Cooling Overboard Exhaust (Skin Flush) Valve' to avoid further delay. As per the MEL maintenance procedures, he opened the Circuit Breaker for OVERBOARD VLV-AFT EQUIP CLG on flight deck MFD and locked with INOP tag, however 2nd and 3rd step to manually close the valve with 3/8inch (10mm) socket drive were not carried out. Engineer# 2 briefed crew about the invoked MEL. Crew also discussed the operational procedures described for MEL.

Aircraft was released to service under MEL 21-27-24-01 Category 'C' for 'Aft EE Cooling Overboard Exhaust (Skin Flush) Valve' by Engineer# 2. Aircraft chocked off from bay B-26 at 08:24hrs. After engine start EQUIP OVBD VLV AFT advisory message came on EICAS at 08:26hrs indicating the aft equipment cooling system overboard exhaust valve is failed in the open position. Crew was not aware about this

message and continued to taxi as they did not notice the same. Subsequently, while lining up on runway 29 at 08:41hrs, EQUIP OVBD VLV AFT advisory message came again on EICAS which was acknowledged and overridden by crew as per their MEL understanding.

Aircraft took off at 08:42hrs from Runway 29. At around 08:49hrs during climb, crew observed EQUIP OVBD VLV AFT advisory message. PIC selected 'Air' page on the MFD and referred the non normal checklist in MFD. Subsequently, at 08:52hrs passing through 20200ft during climb, crew observed that cabin altitude has increased to 8200ft and requested ATC to level off at 22000ft. The cabin altitude was also observed to be rising at more than 800ft/m.

At 08:53hrs, passing 21000ft, EQUIP OVBD VLV AFT advisory message came again on EICAS with Non-normal checklist on Lower Head Down Display. The NNC lead crew to put both the outflow valve switches to MANUAL and then move both the outflow valve manual switches to OPEN until the outflow valve indications show fully open to depressurize the airplane. As per NNC, crew put both the outflow valve switches to MANUAL which caused CABIN ALTITUDE AUTO MASTER CAUTION to be activated at 08:53:50hrs.

Aircraft levelled off at 22000ft on approval of ATC and crew continued with NNC. While opening out flow valves manually as per NNC of EQUIP OVBD VLV AFT, crew observed that the cabin altitude rose rapidly and hence both the outflow valves were closed. The cabin altitude kept rising and became excessive at 08:54:06hrs leading to activation of CABIN ALTITUDE Master Warning.

As per CABIN ALTITUDE NNC, crew immediately started descent with permission of ATC for 10000 ft, donned oxygen masks and deployed passenger oxygen masks by using passenger oxygen switch. Aircraft reached 10000ft at 08:57:30hrs and CABIN ALTITUDE master warning was deactivated at 08:59:18hrs. The maximum pressure altitude attained by aircraft was 22015ft during incident flight. Peak cabin altitude was registered as 16573ft and minimum cabin pressure was recorded as 7.78psi at 08:55hrs during descent.

Aircraft landed uneventfully at 10:04hrs on Runway 29 after jettisoning fuel and parked on stand R2 at 10:11hrs (chocks on). No human injury was reported in the incident.

Before Start Procedure, Engine Start Procedure, Before Taxi Procedure, Before Takeoff Procedure, Takeoff Procedure, Descent Procedure, Approach Procedure, Landing Procedure, After Landing Procedure and Shutdown Procedure were carried out as per FCOM.

Aircraft's take-off weight was 2,11,798kg and landing weight was approximately 1,71,160kg, which was within limits.

1.2 Injuries to Persons:

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Serious	0	0	0
Minor	0	0	0
None	10	199	

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:

Age	43years Male
License	ATPL
Date of Issue	01/05/2007
Valid up to	24/06/2020
Category	Aeroplane
Date of Class I Medical Exam	11/07/2018
Class I Medical Valid up to	10/07/2019
Date of Issue of FRTO Licence	17/03/2012
FRTO Licence Valid up to	17/03/2022
Date of IR/ PPC	26/12/2018
Total Flying Experience	10023:46hrs
Total Flying Experience on Type	3351:56hrs
Total Flying Experience as PIC on Type	3334:21hrs

Total Flying Experience in last 1 year	794:05hrs
Total Flying Experience in last 6 months	371:35hrs
Total Flying Experience in last 30 days	66:49hrs
Total Flying Experience in last 7 days	18:10hrs
Total Flying Experience in last 24 hours	00:00hrs
Duty Time last 24 hours	00:00hrs
Rest before the incident flight	44hrs
Ratings	As PIC: Cessna 172, Duchess 76, Boeing 737-800, Boeing 787-800 As FO: Airbus 310-300, Boeing 747-400, Boeing 737-800, Boeing 787-800

First Officer:

Age	48years 09month Male
License	CPL
Date of Issue	15/10/2008
Valid up to	13/10/2020
Category	Aeroplane
Date of Class I Medical Exam	03/07/2018
Class I Medical Valid up to	12/07/2019
Date of Issue of FRTO Licence	15/10/2008
FRTO Licence Valid up to	24/06/2020
Date of IR/ PPC	11/11/2018
Total Flying Experience	1174:24hrs

Total Flying Experience on Type	1174:24hrs
Total Flying Experience in last 1 year	912:35hrs
Total Flying Experience in last 6 months	441:08hrs
Total Flying Experience in last 30 days	78:24hrs
Total Flying Experience in last 7 days	18:32hrs
Total Flying Experience in last 24 hours	00:00hrs
Duty Time last 24 hours	00:00hrs
Rest before the incident flight	72hrs
Ratings	As PIC: Cessna 172, Duchess 76, As FO: Boeing 787-800

PIC and First Officer was examined for consumption of alcohol at Delhi at 06:42hrs and at 06:33hrs respectively on 06/03/2019 before carrying out incident sector (flight no. AI-121) and found fit for flying.

PIC and First Officer had adequate rest before they operated flight on 6th March 2019. Upon scrutiny of the records, PIC and First Officer were found to be within limits of FDTL.

Performance of PIC and First Officer was found satisfactory during IR/PPC checks carried out in last one year. No adverse remarks were found to be recorded in their respective assessment forms. They did not have any past incident history with the operator.

PIC submitted during his interview that he was briefed by Engineer# 2 after invoking MEL 21-27-24-01 that if the message EQUIP OVBD VLV AFT appears again after engine start, it should be disregarded.

First Officer submitted during his interview that he was not aware about the operations note of MEL as he did not go through complete MEL due time constraint. He was briefed by PIC that advisory message EQUIP OVBD VLV AFT will come after engine start as briefed by engineer.

Departure AME (Engineer# 2):

Age	54years Male
License	AME
Date of Issue	11/12/2015
Valid up to	06/02/2021
Category	Avionics
Sub Category	B2
Endorsements	Boeing 787-800 (GENX-1B) Boeing 777-200/300 (GE 90) Boeing 777-200/300 (PW 4000) Boeing 747-400 (PW 4000) Boeing 747-300 (GE CF6) Boeing 747-200 (PW JT9D) Airbus A310 (GE CF6)

The departure AME (Engineer# 2) had reported at 02:30 hrs for the duty in normal shift on 06.03.2019. He was carrying out maintenance of another aircraft when he was called to attend the snag of EQUIP OVBD VLV AFT on VT-ANU. Engineer# 2 reached at the aircraft VT-ANU at about 08:00 hrs.

During interview with the departure AME, he submitted that after invoking MEL 21-27-24-01 he showed related page of MEL book to captain with maintenance and operations note. No further communication was done with operating crew. He further submitted that the 2nd and 3rd step of MEL 21-27-24-01 maintenance procedures to manually close the valve with 3/8inch (10mm) socket drive were not followed as he perceived by tapping the valve that it was in closed position. No other maintenance staff was involved with departure AME for attempting rectification and invoking MEL. Further, departure AME also submitted that he had never invoked MEL 21-27-24-01 earlier.

1.6 Aircraft Information:

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

Aircraft Registration	VT-ANU

Type of Aircraft	Boeing 787-800
Aircraft Serial No.	36292
State of Manufacturing	United States of America
Manufacturing year	2015
Owner	M/s Wilmington Trust SP Services (Dublin) Limited 4th Floor, 3 George's Dock, IFSC, Dublin 1, Ireland
Operator	M/s Air India Ltd
Certificate of Airworthiness number and issue date	6683 dated 02/04/2015
ARC number and Validity	ANU/6683/ARC 2ND/2018069 Valid up to 07/04/2019
A/c TSN / CSN	16937:09/ 3424
Maximum All Up Weight authorized	2,27,930kg
Minimum crew necessary	Two
Engine Type	# 1 (LH): GEnx-1B67 # 2 (RH): GEnx-1B67
Last major check (2A Check) carried out	On 14/02/2019 at 16650:24hrs A/c TSN/ 3372 A/c CSN
Next schedule maintenance due at (A Check)	At 17650:24hrs A/c TSN
Aircraft Take-off Weight	2,11,798kg
Aircraft Landing Weight	1,71,160kg
Maximum Landing Weight	1,72,365kg
Fuel On-board before Flight	62,700kg
Centre of Gravity	Within limits

Pressurization system related maintenance tasks are covered under approved scheduled maintenance programme. All scheduled maintenance tasks related to pressurization/ relevant system which were due, were completed before the incident flight. Aft equipment cooling overboard exhaust valve is an on-condition maintenance item.

Before operating flight AI-121 on 06.03.2019, transit check was carried out and the same was found satisfactory. There were no active status messages noticed on the relevant aircraft systems/ component during transit check. No relevant messages observed in Inbound Flight Deck Effects, Present Leg Faults and Existing Faults during transit check. No defect was recorded by the crew for the inbound sector FRA-DEL and no relevant snag was open for rectification. There was no active MEL on the relevant aircraft system/ components and existing MELs were valid when the aircraft was released to service for AI- 121 on completion of transit check.

Post completion of transit check, the EQUIP OVBD VLV AFT status message was noticed by crew during cockpit preparation and subsequently the aircraft was released by Departure AME under MEL 21-27-24-01 Category 'C' for 'Aft EE Cooling Overboard Exhaust (Skin Flush) Valve'. The entry made by departure AME for invoking MEL in the sector page report was as follows: 'EQPMT COOLING VLV AFT MEL on EQOMP COOLING AFT VLV CB LOCK OPEN AS PER DDG 21-27-24-01 CAT C VALID TILL 15/03/2019'.

Later, aircraft made air turn back to Delhi due to EICAS advisory message EQUIP OVBD VLV AFT during flight and the rising cabin altitude followed by CABIN ALTITUDE warning. It was observed from the AHM that EICAS status messages of EQUIP CLG SMOKE DET AFT 1 and EQUIP EXHAUST FAN AFT were also recorded during the flight.

Pilot Defect Report of the incident flight was as follows:
'A/c released under MEL EQPMT COOLING VLV AFT 21-27-24-01. Procedure was briefed and noted. After engine start as per MEL advisory message came on EICAS which was acknowledged and Ops found normal. Airborne at 0842Z, passing 19000ft (+) advisory message with checklist EQUIP OVBD VLV AFT came. Along with that cabin altitude was checked at 8200ft (Amber) and rising at the rate of +800ft. NNC was carried out but contrary to A/c and cabin alt. status checklist asked to open outflow valves to be opened manually. While trying to open outflow valves as per NNC cabin altitude rose rapidly. Hence it was manually closed but cabin altitude could not be controlled and it rose to 13800ft. Followed by cabin altitude warning and procedure was followed for CABIN ALTITUDE NNC and descended to 10000ft. Fuel jettison was carried out and diverted to Delhi and normal landing was carried out.'

During physical inspection by AME (Cat 'B1' license holder) on arrival, following observations were made:

- Equipment Cooling Maintenance Page was not indicating the position of the Aft EE Cooling Overboard Exhaust (Skin Flush) Valve.
- Aft EE Cooling Overboard Exhaust (Skin Flush) Valve was in open (near full open) position.
- Full and free movement of the valve was checked using the socket drive tool and found satisfactory (the valve was free to move).
- Oxygen masks were found deployed in all locations in the cabin except at following locations:
  - 12-DEF, 16-DEF and 40-DEF seats
  - L3 & L4 crew station
  - L3 & L4 door washroom
  - 3F-1L toilet
- The CB for Aft EE Cooling Overboard Exhaust (Skin Flush) Valve was found OPEN and tagged INOP.
- Operation of outflow valves in manual mode was performed on ground and found to be satisfactory.

EQUIP OVBD VLV AFT EICAS advisory message recorded during the incident flight had following correlated maintenance messages:

- 21-22420- Aft EE Cooling Exhaust Overboard (Skin Flush) Valve position feedback has failed.
- 21-22440- Aft EE Cooling Exhaust Overboard (Skin Flush) Valve 28VDC power has failed.

A callout was issued to carry out rectification post incident. During rectification, FIM task relevant to maintenance message 21-22420 was carried out and following was observed:

- Wiring check between pins of connector at the valve and pins of connector at remote data concentrator 07 was carried out and found satisfactory.
- Aft EE bay-L CCS remote data concentrator 07, M424000 was found satisfactory.

Further, during the rectification, following components were replaced:

- Aft EE cooling Overboard Exhaust (Skin flush) valve:
  P/N: 7010408H03 OFF S/N: HSC258648
- Aft EE cooling exhaust fan:
  P/N: 7010501H03S02 OFF S/N: 01206
- Aft EE cooling exhaust smoke detector:
  P/N: 61423-7010303H01 OFF S/N: ADF2752

The aircraft was released to service on 31/05/2019 at 08:49hrs for Delhi- Kolkata (AI-020) after completing the rectification action. Post release on 31/05/2019, Pilot Defect Report for one month were scrutinized and found that the defect did not reoccur.

While scrutinizing the tech log, following history of snags related to EQUIP OVBD VLV AFT messages were observed to be reported in PDR:

Date	Flight	Sector	Snag	Rectification
21/02/2019	933	COK-DXB	EQUIP OVBD VLV AFT status message	NIL EICAS on arrival. MM not active. Its norm.
21/02/2019	934	DXB-COK	Status message: EQUIP OVBD VLV AFT	MM not active on ground.
22/02/2019	306	DEL-NRT	Status: EQUIP OVBD VLV AFT	MM 21-22420 (active) showed. So equip cooling aft system ground test passed i.a.w. FIM 21-20-F7-60A-421A

Apart from the above, EICAS Status message of EQUIP OVBD VLV AFT correlated with maintenance message 21-22420 were found to be recorded in an 'inactive state' in many sectors of previous one month as observed from AHM fault summary reports, which reflects that the snag was intermittent in nature.

1.7 Meteorological Information:

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

Time	0800	0830	0900	1000
Wind	300º / 18knots	300º / 11knots	300º / 18knots	300º / 15knots
Visibility	5000meter	5000meter	5000meter	5000meter
Clouds	FEW100	FEW100	SCT100	SCT100
Weather	HZ	HZ	HZ	HZ
Temperature	24ºC	24ºC	24ºC	24ºC
Dew Point	07ºC	05ºC	05ºC	06ºC

QNH	1012hPa	1012hPa	1012hPa	1011hPa
Trend	NOSIG	NOSIG	NOSIG	NOSIG

Aircraft take-off and landing was performed on Runway 29 of IGI airport, Delhi. The actual weather conveyed to crew while giving takeoff clearance at 08:40hrs was Winds: 300^{o} 08knots; and while giving landing clearance at 10:01hrs was Winds: 280^{o} 10knots. 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.

Runway 29 at IGI Airport, Delhi is equipped with Cat IIIB ILS (Localizer and Glide path) & Approach Lighting System. Other navigation aids installed at IGI Airport, Delhi include NDB, DVOR and DME with Precision and Non-Precision approach procedures. It has also a secondary surveillance RADAR for providing route navigation services.

There were no known navigation aid difficulties reported by the crew.

1.9 Communication:

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

1.10 Aerodrome Information:

Indira Gandhi International Airport (IATA: DEL, ICAO: VIDP) is the primary international airport of the National Capital Region of Delhi. IGI Airport, Delhi is being operated, managed and developed by Delhi International Airport Limited, a consortium led by the GMR Group. The ATC is controlled by Airports Authority of India.

The elevation of the airport is 778ft, and it has three runways: runway 11/29, runway 10/28 and runway 09/27. As per the electronic Aeronautical Information Publication (e-AIP) of IGI Airport, declared distances for runways are as under:

Runway	TORA (m)	TODA (m)	ASDA (m)	LDA (m)
29	4430	4430	4430	2970

Aerodrome category for rescue & firefighting is CAT-10 for all the facilities of IGI Airport. Type of operations permitted is IFR/VFR.

1.11 Flight Recorders:

The observations made on CVR readout is as follows:

The CVR readout commenced at 08:15hrs. The MEL briefing by AME to the crew was already completed by this time. The push back commenced at 08:24hrs. Taxi and take off briefing was completed followed by Before Start checklist. Both engines were started normally, all external sources removed and the aircraft taxied out for departure from Runway 29 after performing the Before Taxi checklist. No announcement/ discussion between crew were heard w.r.t. EQUIP OVBD VLV AFT during engine starting or after engine start. After completing runway entry procedures while lining up on runway 29 at 08:41hrs EQUIP OVBD VLV AFT was announced by FO. PIC asked FO to override the checklist. Aircraft took off after completion of Before Take Off checklist. The After Take Off checklist was also completed.

Crew requested for climb to FL380 however ATC gave clearance for climb to FL 260. While passing 13736ft at 08:49hrs, EQUIP OVBD VLV AFT was announced by FO. PIC advised FO to refer the checklist. Meantime on noticing the cabin altitude to be more than 8000ft PIC directed FO to request ATC to level at FL220 which was immediately approved by ATC. The NNC was started and PIC advised FO to put both the valves on Manual. Both the outflow valves were put on Manual at 08:53hrs which caused the activation of Master Caution. Aural caution was heard at 08:53hrs. No evidence was available in CVR w.r.t. opening and closing of outflow valves at this stage as per NNC as claimed by crew.

Subsequently at 08:54hrs Master Warning caused by excessive cabin altitude was also heard. Immediately, as per Cabin Altitude checklist, crew requested for descent to FL100 which was approved by ATC. At 08:54hrs, crew oxygen masks were donned as oxygen flow sound could be heard in CVR. Crew deployed passenger oxygen masks at 08:54hrs and subsequently completed CABIN ALTITUDE checklist.

Crew intimated ATC regarding their intentions to return back to Delhi. Descent checklist was completed and fuel jettisoning was carried out in coordination with ATC.

Approach briefing was also carried out and aircraft landed at 10:04hrs on Runway 29 after completing standard Landing Procedures. Subsequently, After Landing and Engine Shut Down procedures were also followed.

Before Start Procedure, Engine Start Procedure, Before Taxi Procedure, Before Takeoff Procedure, Takeoff Procedure, Descent Procedure, Approach Procedure, Landing Procedure, After Landing Procedure and Shutdown Procedure were carried out as per FCOM. Passenger announcement was made by PIC at regular intervals.

Following are the salient observations made from FDR readout:

TIME (hrs)	EVENTS
08:28:40	Both engines at 20% N1 after pushback.
08:42:53	Take off. Cabin Altitude-756ft, Pressure Altitude-754ft
08:43:28	Cabin Altitude-996ft, Pressure Altitude-2004ft
08:45:20	Cabin Altitude-1489ft, Pressure Altitude-5000ft
08:47:22	Cabin Altitude-3710ft, Pressure Altitude-10000ft
08:50:06	Air Page displayed on SYS menu on MFD
08:50:18	Cabin Altitude-6070ft, Pressure Altitude-15000ft
08:52:44	Cabin Altitude-8241ft, Pressure Altitude-20232ft
08:52:50	Cabin altitude rate (Cabin rate of climb) started increasing.
08:53:50	Cabin Altitude-9580ft, Pressure Altitude-22013ft Master Caution activated. EICAS caution- CABIN ALTITUDE AUTO generated (Condition: Loss of complete automatic control or manual mode selected for both outflow valves).
08:53:51	Peak Pressure Altitude registered, i.e. 22015ft Aircraft leveled off hereafter.
08:54:06	Cabin Altitude-10002ft, Pressure Altitude-22002ft Cabin Altitude became excessive and Master Warning activated. EICAS warning- CABIN ALTITUDE generated. Master Caution active.
08:54:11	Master Caution and Master Warning deactivated (Aural cancelled).
08:54:17	Maximum cabin altitude rate was recorded, i.e. 5830ft/ minute
08:54:26	Descent started.
08:54:46	Passenger Oxygen ON (selected manually by crew)
08:55:31 to34	Minimum cabin pressure recorded, i.e. 7.78psi

TIME (hrs)	EVENTS
08:55:33	Peak Cabin Altitude registered, i.e. 16573ft
08:57:30	Descent stopped at 10036ft.
08:59:18	Cabin Altitude-9717ft, Pressure Altitude-10001ft CABIN ALTITUDE EICAS deactivated.
09:20:51	Fuel jettisoning started.
09:40:31	Fuel jettisoning completed.
10:04:08	Aircraft touchdown.
10:04:11	Passenger Oxygen OFF
During descent to flight level 10000ft, Descent Speed High FL300-FL90 FOQA exceedance was generated from 08:56:42hrs to 08:57:06hrs, however there was no overspeed (V_{MO}/M_{MO}) exceedance noticed from the FDR.	
FDR does not record the position of Aft EE Cooling Exhaust Overboard (Skin Flush) Valve and outflow valves.	

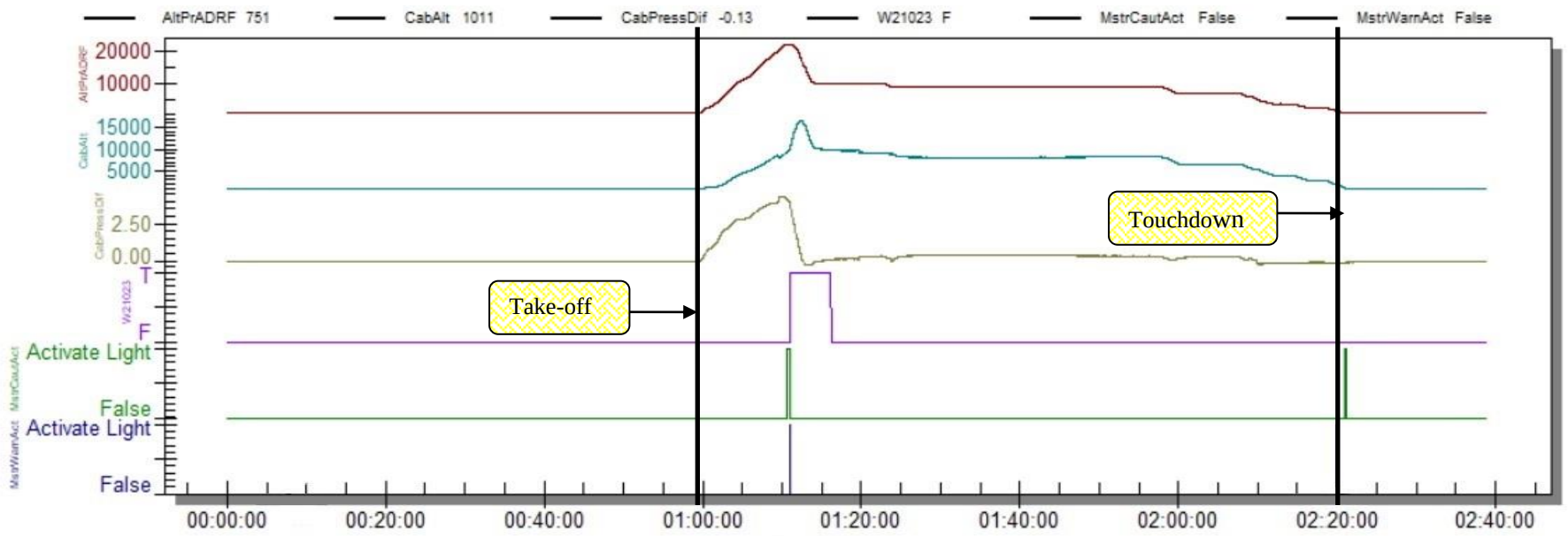


Figure # 1 Graphical representation of FDR data
(Pressure altitude Vs Cabin altitude Vs Cabin pressure differential Vs Master caution Vs Master warning Vs Time)

W21023- CABIN_ALTITUDE T: Cabin Altitude is excessive

The above graph depicts that the cabin altitude started climbing as soon as the aircraft started climbing. After about 10 minutes of take-off, the cabin altitude started rising rapidly. One minute later, master caution was activated (due to both outflow valves selected to be in manual mode) followed by master warning (due to excessive cabin altitude). Pressure altitude started decreasing immediately after generation of master warning depicting that the aircraft started descent as per NNC of CABIN ALTITUDE. The cabin altitude continued to rise at higher rates during descent and inversely cabin pressure differential started decreasing substantiating the loss of cabin pressure. Cabin altitude reached to its peak value 16573ft at 08:55:33hrs during descent. CABIN ALTITUDE EICAS (excessive cabin altitude) stayed for 05 minutes 12 seconds.

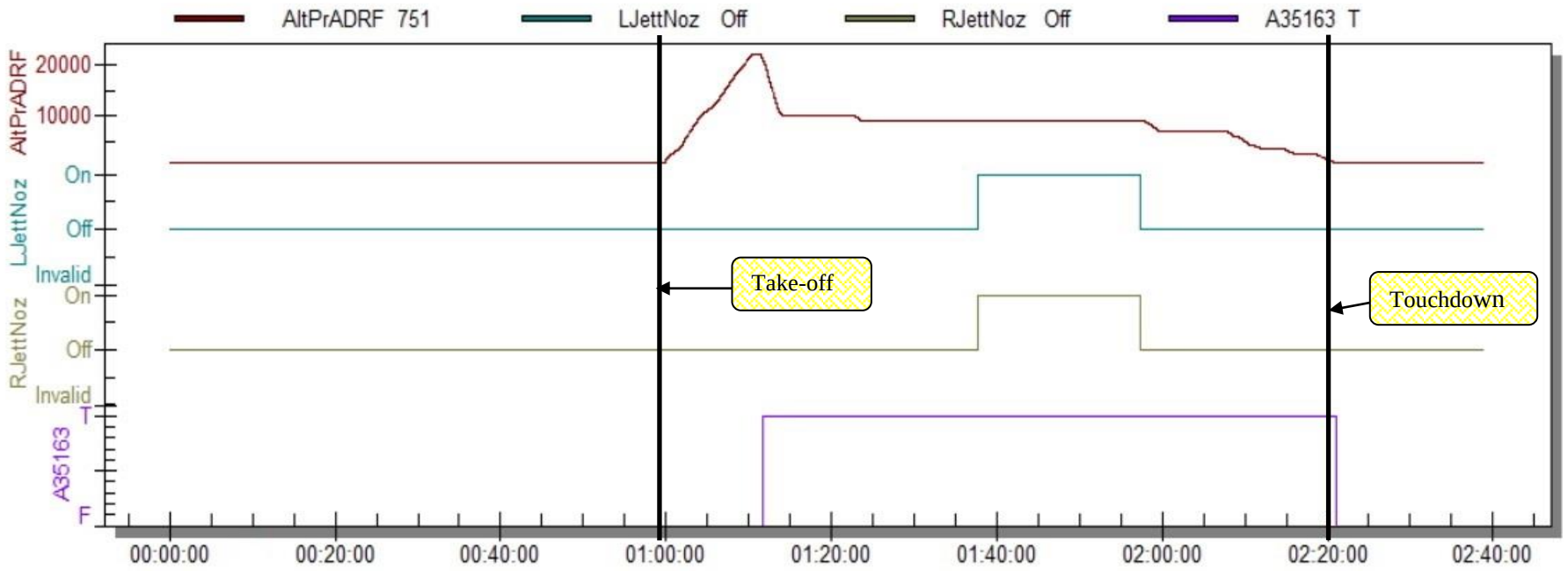


Figure # 2 Graphical representation of FDR data
(Pressure altitude Vs L & R Jettison nozzle Vs Passenger Oxygen status Vs Time)

A35163- PASS _OXYGEN_ON T: Passenger oxygen system is ON either automatically or by pushing passenger oxygen switch 'ON'

The above graph depicts that the passenger oxygen was selected ON by the crew as per the CABIN ALTITUDE NNC and it remained in ON position till landing. The fuel jettisoning was carried out from both the jettisoning nozzles for about 20 minutes in order to reduce the weight of the aircraft.

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 Delhi and tested negative for consumption of alcohol.

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:

The following incident involved Aft EE cooling Overboard Exhaust (Skin flush) valve was tested for its serviceability at M/s Collins Aerospace, Wroclaw.

- Aft EE cooling Overboard Exhaust (Skin flush) valve:
  P/N: 7010408H03
  S/N: HSC258648

As per the report of M/s Collins Aerospace, the valve was found to be outside of test limits for Door Closure flushness tests and hence confirmed 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:

- As per DDG procedure for releasing the aircraft under MEL 21-27-24-01:

BOEING 787 MINIMUM EQUIPMENT LIST & DISPATCH DEVIATION GUIDE	AI/ENGG/MEL/B787		
	ATA - 21		
AIR CONDITIONING	Issue-IV	Rev-5	NOV 2017

ITEM	DESCRIPTION	CATEGORY	NUMBER INSTALLED	NUMBER REQUIRED FOR DISPATCH	REMARKS OR EXCEPTIONS
21-27-24	Aft EE Cooling Overboard Exhaust (Skin Flush) Valve				
21-27-24-01	787-8	C	1	0	(M) May be inoperative provided: a) Valve is deactivated closed, b) Aft equipment cooling supply fan smoke detector operates normally. c) For ground operations at pressure altitudes 8,000 feet or higher, forward and aft outflow valves operate normally, d) For ground operations at OAT 24 degrees C or higher, aft outflow valve operates normally, and e) For ground operations at OAT 30 degrees C or higher, both packs are selected on or conditioned air is supplied to the airplane.

MAINTENANCE (M)

Deactivate the aft equipment cooling overboard exhaust valve closed (AMM DDG 21-27-24).

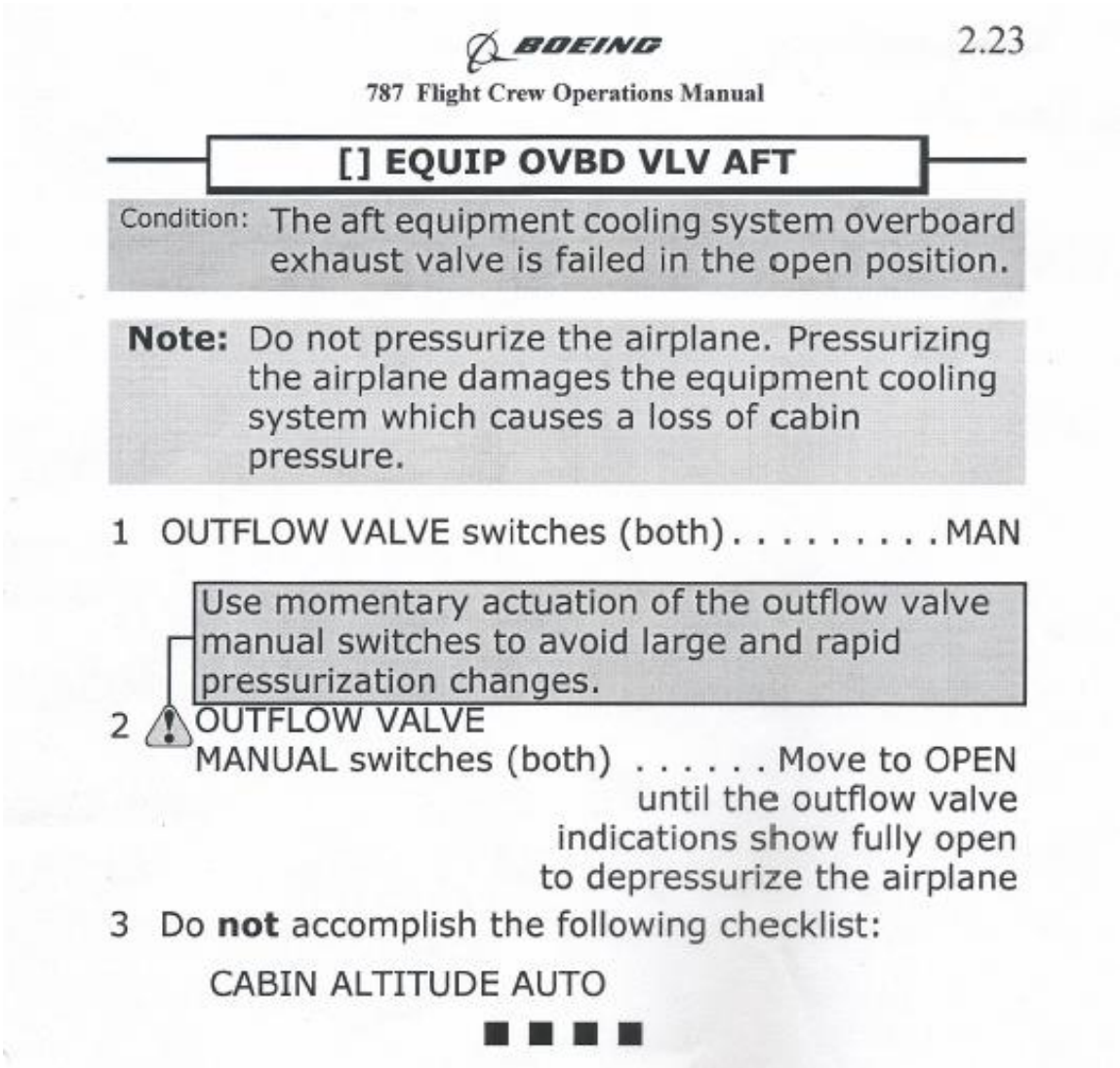
1. Using a flight deck multi-function display only, open circuit breaker OVERBOARD VLV-AFT EQUIP CLG and lock with an INOP tag.
2. Gain access to valve open/close socket.
3. Turn the valve to the closed position using a 3/8 inch (10mm) socket drive.

OPERATIONS NOTE

After engine start, EQUIP OVBD VLV AFT advisory message indicates the Aft EE Cooling Overboard Exhaust Valve has opened.

- Approved MEL Preamble para 2.1.1.1 states that 'If, however, after door closure and before take-off, any defect is detected, the operating crew will follow the appropriate Non-normal procedure for EICAS Alert Messages (Warning, Caution or Advisory), refer the corresponding MEL provision, continue the flight if there is no (M) and / or (O), which has impact on performance of the flight, and adhere to all applicable limitations. Report the defect in the Technical Log for suitable action at next station, as appropriate'.

❖ As per the NNC of EQUIP OVBD VLV AFT EICAS advisory message:



[] EQUIP OVBD VLV AFT

Condition: The aft equipment cooling system overboard exhaust valve is failed in the open position.

Note: Do not pressurize the airplane. Pressurizing the airplane damages the equipment cooling system which causes a loss of cabin pressure.

1 OUTFLOW VALVE switches (both) . . . . . MAN

Use momentary actuation of the outflow valve manual switches to avoid large and rapid pressurization changes.

2 ⚠ OUTFLOW VALVE MANUAL switches (both) . . . . . Move to OPEN until the outflow valve indications show fully open to depressurize the airplane

3 Do **not** accomplish the following checklist:

CABIN ALTITUDE AUTO

■ ■ ■ ■

❖ As per CABIN ALTITUDE NNC:

[ ] CABIN ALTITUDE

Condition: Cabin altitude is excessive.

1 Don the oxygen masks.

2 Establish crew communications.

3 Check the cabin altitude and rate.

4 **If** the cabin altitude is uncontrollable:

PASS OXYGEN switch . . . . . Push to ON and hold for 1 second

Without delay, descend to the lowest safe altitude or 10,000 feet, whichever is higher.

To descend:
- Move the thrust levers to idle
- Extend the speedbrakes
- If structural integrity is in doubt, limit airspeed and avoid high maneuvering loads
- Descend at Vmo/Mmo

Caution! Autopilot and flight director descent near Vmo/Mmo may result in overspeed excursions due to wind and temperature changes. Pilot intervention via FLCH speed or manually flown pitch adjustment may be necessary to remain below Vmo/Mmo.

5 **If** the cabin altitude is controllable:

Continue normal operation.

6 If the flight deck or cabin temperature becomes excessively hot or cold, consider doing the Cabin Temp Hot or Cabin Temp Cold checklist.

■ ■ ■ ■

❖ Equipment cooling system:

The equipment cooling system uses a flow of cooling air to remove heat from electronic units. There are three EE (Electronic Equipment) cooling systems:

- Forward EE (Electronic Equipment) cooling system
- Aft EE (Electronic Equipment) cooling system
- Miscellaneous EE (Electronic Equipment) cooling system

❖ Aft Equipment Cooling System:

The aft EE (Electronic Equipment) cooling system moves air through EE (Electronic Equipment) in the aft EE (Electronic Equipment) bay to decrease the heat in the equipment. It provides cooling and ventilating air for the aft E/E equipment compartment and heating/ventilating air for aft cargo compartment.

The aft system uses internal fans and valves to direct cabin air to the aft equipment bay and ventilates the warm exhaust air to a dedicated overboard exhaust valve or aft cargo compartment. There are two cooling system supply fans, a primary and a backup. If the primary supply fan fails, the backup supply fan operates automatically.

Operation:

- One of the 2 supply fans pulls air from the left sidewall through a barrier filter.
- The supply fan pushes the air through the supply override valve.
- The air flows around the flow/temperature sensors and smoke detector and out to the electronic equipment.
- An exhaust fan pulls the hot air from the electronic equipment through hoods and piccolo ducts.
- The exhaust fan then pushes the air around a smoke detector and through the overboard exhaust valve and the cargo heat supply valve.

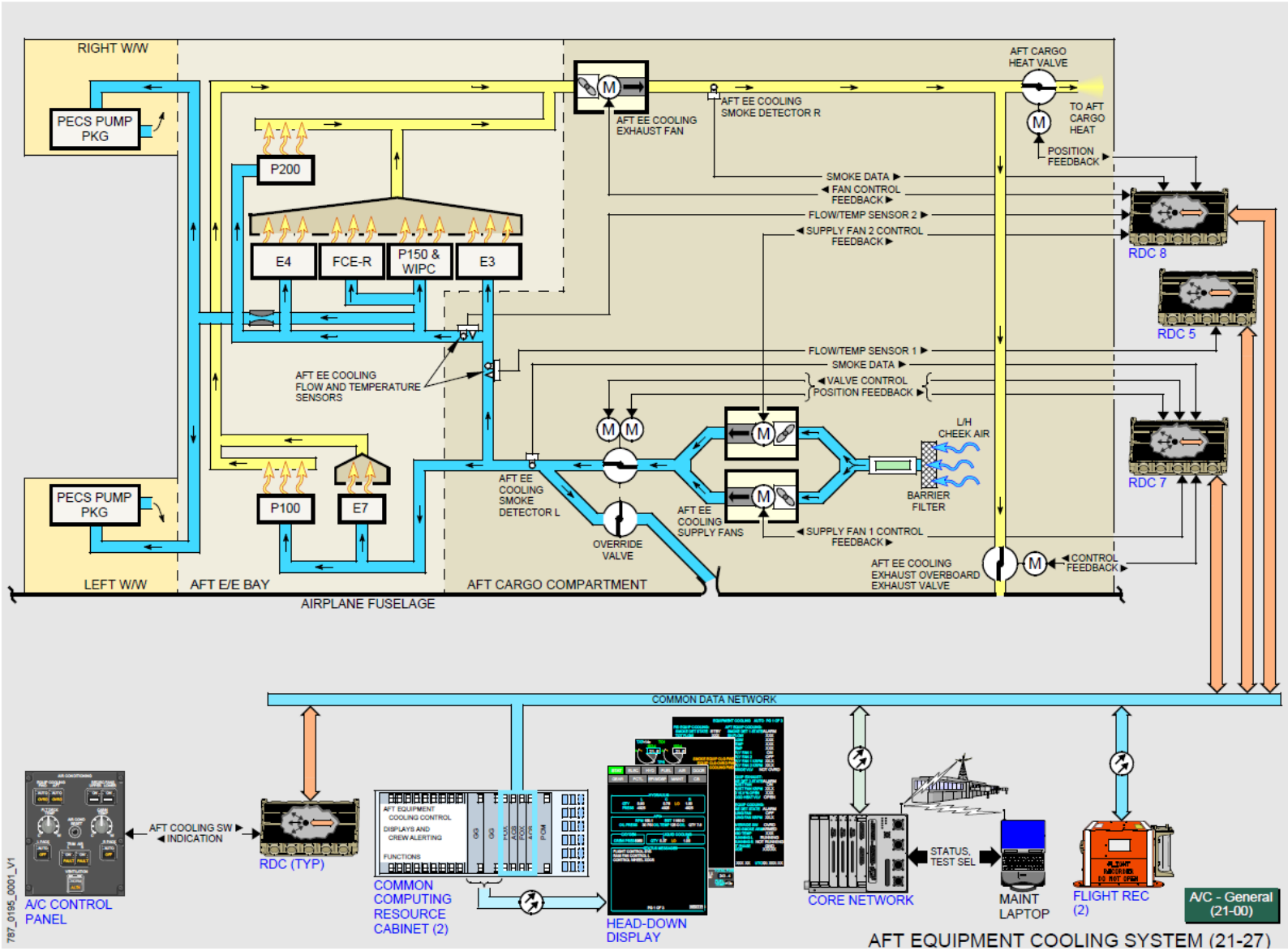


Figure # 3 Aft Equipment Cooling System

❖ Aft EE Cooling Exhaust Overboard (Skin Flush) Valve:

The aft EE (Electronic Equipment) cooling exhaust overboard exhaust (skin flush) valve opens to send aft EE (Electronic Equipment) cooling exhaust air directly out of the airplane. The EE cooling application software in the Common Core System controls the operation of the valve.

The valve is a flush-fit hinged door operated by a 28v dc motor actuator. It uses a linear actuator to control the valve position. The valve is under the aft cargo floor and goes through the fuselage externally with a flush fit. The valve has a 7 in. (18 cm) bore. A manual drive tool can open or close it on the ground.

These are the 2 positions for the aft EE cooling exhaust overboard (Skin Flush) valve:

- Open to the overboard (OVBD) position
- Closed

The inlet to the valve is the outlet duct from the aft EE (Electronic Equipment) cooling exhaust fan. The parallel connection is to the duct that goes to the aft cargo heat valve. Usually, the skin flush valve opens to let some or all of the EE (Electronic Equipment) cooling exhaust air go directly out of the airplane instead of through the aft cargo heat valve. This helps to control the temperature of the aft cargo compartment.

EQUIP OVBD VLV AFT message indicates that the aft equipment cooling overboard valve is failed in the open position. Pressurizing the airplane with this valve open leads to a large pressure differential between the cabin and equipment cooling duct. This causes duct failure and subsequent loss of cabin pressure through the equipment cooling overboard valve.

Figure # 4 Aft EE Cooling Exhaust Overboard (Skin Flush) Valve

- ❖ As per FIM document DMC-8787-A-21-20-F7-60A-421A-A, following are probable causes which could generate Maintenance Message 21-22420:
  - Defective wiring between pins of connector at the valve and pins of connector at remote data concentrator 07.
  - Defective Aft EE cooling exhaust overboard (skin flush) valve.
  - Defective Aft EE bay-L CCS remote data concentrator 07, M4240007.

1.19 Useful or Effective Investigation Techniques: None.

2. ANALYSIS:

2.1 Engineering aspects:

Airworthiness Review Certificate of the aircraft was valid up to 07/04/2019. Aircraft TSN was 16937:09hrs and CSN was 3424. Last major maintenance, i.e., 2A Check, was accomplished on 14/02/2019 at 16650:24hrs A/c TSN/ 3372 A/c CSN and next A check was due at 17650:24hrs A/c TSN. Aircraft was departed with valid Certificate of Release to Service on 06/03/2019.

Aircraft completed the arrival sector with NIL snags before the incident flight and was subjected to Transit Inspection by authorized personnel before it was released to service for the incident flight. No abnormality was observed during preflight external checks by the crew. Aircraft Load & Trim sheet was prepared. Take-off weight, landing weight and Centre of Gravity were found within limits. Scrutiny of the maintenance records reveals that no scheduled maintenance was due on pressurization system, no relevant snag open for rectification and no active MEL invoked with regard to relevant aircraft systems before the incident flight. The defects recorded by crew about EQUIP OVBD VLV AFT status message on 21/02/2019 & 22/02/2019 were found to be rectified. The history of defects & its rectification was not considered a contributory factor to the incident as aircraft operated for more than 10 days without any active snag being reported after rectification.

The EQUIP OVBD VLV AFT status message was noticed by crew during cockpit preparation and the Departure AME was called for rectification. Departure AME alone had attempted rectification and released the aircraft under MEL 21-27-24-01 Category ‘C’ for ‘Aft EE Cooling Overboard Exhaust (Skin Flush) Valve’ to avoid further delay as he could not isolate the snag.

MEL 21-27-24-01 maintenance procedures describe 3 steps to deactivate the valve in closed condition for dispatch:

1. Using flight deck multi-function display only, open Circuit Breaker OVERBOARD VLV-AFT EQUIP CLG and locked with an INOP tag

2. Gain access to valve open/ close socket
3. Turn the valve to the closed position using a 3/8inch (10mm) socket drive

Departure AME followed only 1st step of MEL 21-27-24-01 maintenance procedures while invoking MEL, i.e. disconnected the valve actuator electrically by opening CB, however 2nd and 3rd step were not carried out. Departure AME claimed that the valve was in closed position and hence presumed that the 2nd and 3rd step of MEL maintenance procedures were not required to be done. However, contrary to the claim of departure AME, the Aft EE Cooling Overboard Exhaust (Skin Flush) Valve was observed to be in open (near fully open) position on arrival of the incident flight. Considering the fact that the electrically deactivated valve cannot operate in flight, the claim of departure AME that the valve was in closed position while invoking MEL is not justified. Therefore, it is concluded that the DDG procedures pertaining to point no. 2 & 3 for MEL 21-27-24-01 were not followed and valve was not in the desired position before dispatch as required by MEL 21-27-24-01. Sector page entry made by departure AME and EQUIP OVBD VLV AFT advisory message generated after engine start substantiate that the same. Departure AME reached at the aircraft at about 08:00hrs, just five minutes before STD, which could have contributed in releasing the aircraft without ensuring the complete procedures as required by MEL.

History of snags & AHM reports prior to incident flight substantiate that the valve was generating intermittent faults and finally failed on 06/03/2019. As per the report of the M/s Collins Aerospace, the Aft EE Cooling Exhaust Overboard (Skin Flush) valve was confirmed defective, i.e. outside of test limits for Door Closure flushness tests. Hence the reason for the EQUIP OVBD VLV AFT advisory/ status messages generated throughout the flight and in previous sectors is attributed to the defective Aft EE Cooling Exhaust Overboard (Skin Flush) valve. The defect did not repeat after replacement of the valve substantiates the same.

Wiring check and Remote Data Concentrator 07 revealed no abnormality during fault isolation carried out as per FIM of correlated maintenance message 21-22420. This fact along with the M/s Collins Aerospace report confirms that the maintenance message '21-22420- Aft EE Cooling Exhaust Overboard (Skin Flush) Valve position feedback has failed' was generated due to defective Aft EE Cooling Exhaust Overboard (Skin Flush) Valve.

The maintenance message '21-22440- Aft EE Cooling Exhaust Overboard (Skin Flush) Valve 28VDC power has failed' was generated due to no power was available to valve as the CB was locked OPEN by the departure AME as per MEL 21-27-24-01.

Generation of master caution and CABIN ALTITUDE AUTO was attributed to the crew action of putting both outflow valves to manual which was as per NNC of EQUIP

OVBD VLV AFT. Generation of master warning and CABIN ALTITUDE was attributed to the excessive cabin altitude occurred due to loss of pressurization caused by open Aft EE Cooling Exhaust Overboard (Skin Flush) Valve.

EICAS status messages EQUIP CLG SMOKE DET AFT 1 and EQUIP EXHAUST FAN AFT recorded in AHM were generated due to failure of smoke detector and exhaust fan caused by airflow due to open Aft EE Cooling Exhaust Overboard (Skin Flush) valve.

Non adherence to the DDG maintenance procedures by Departure AME while invoking MEL 21-27-24-01 resulted in releasing the aircraft to service in an unairworthy condition causing the loss of cabin pressure during flight.

2.2 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 06/03/2019. Medical fitness & FDTL of the crew was not a factor to this incident.

PIC and First Officer reported for duty well in time and completed flight briefing and preflight external checks wherein no abnormality was observed. PIC observed EICAS status message of EQUIP OVBD VLV AFT while carrying out cockpit preparation procedures and the same was conveyed to AME. Departure AME invoked MEL 21-27-24-01 and released the aircraft after briefing crew about the invoked MEL.

Operations note of the MEL provides information to the crew that an EICAS advisory of EQUIP OVBD VLV AFT after engine start indicates that the Aft EE Cooling Exhaust Overboard (Skin Flush) Valve has opened. EQUIP OVBD VLV AFT advisory message came on EICAS after engine start however crew continued to taxi being unaware about this message. No announcement/ discussion between crew were heard in CVR with respect to EQUIP OVBD VLV AFT during engine starting or after engine start, Whereas, crew should have checked & verified for presence of EQUIP OVBD VLV AFT advisory message after engine start considering operations note of MEL 21-27-24-01. Subsequently while lining up on runway 29, crew noticed EICAS advisory message EQUIP OVBD VLV AFT however the same was not correlated with operations note of MEL, instead, it was acknowledged and overridden. Had the crew understood the MEL correctly and aware about the consequences of the open Aft EE Cooling Exhaust Overboard (Skin Flush) Valve, they would not have proceeded for takeoff. It can be inferred that the briefing/ discussion between the crew with regards to the operational consequences of the MEL was deficient. Crew claimed to have discussed & noted MEL procedures however, their actions do not substantiate the same.

Crew claimed that they received briefing from departure AME that if advisory message EQUIP OVBD VLV AFT comes after engine start, it should be disregarded however the departure AME did not agree to the same. The content and veracity of MEL briefing/ discussions could not be ascertained during the investigation due lack of evidences.

Appropriate NNC was not referred by crew after getting EICAS advisory message EQUIP OVBD VLV AFT while lining up as required by approved MEL Preamble para 2.1.1.1. The Note of EQUIP OVBD VLV AFT NNC clearly states that 'Do not pressurize the airplane. Pressurizing the airplane damages the equipment cooling system which causes a loss of cabin pressure.' If crew had referred to the appropriate NNC for EQUIP OVBD VLV AFT EICAS advisory message during line up, then they would not have proceeded for takeoff as aircraft cannot be pressurized with open Aft EE Cooling Exhaust Overboard (Skin Flush) Valve.

Non normal procedures of CABIN ALTITUDE master warning and EQUIP OVBD VLV AFT EICAS advisory message, which was generated during climb, were followed by crew. Normal procedures namely Before Start Procedure, Engine Start Procedure, Before Taxi Procedure, Before Takeoff Procedure, Takeoff Procedure, Descent Procedure, Approach Procedure, Landing Procedure, After Landing Procedure and Shutdown Procedure were also carried out as per FCOM.

2.3 Circumstances Leading to the Incident:

Aircraft was prepared for departure for flight DEL-FRA after completion of transit check with NIL discrepancies. Subsequently, on noticing the EICAS status message of EQUIP OVBD VLV AFT, departure AME was called to aircraft and he reached at aircraft just about five minutes before STD. As he could not isolate snag he decided to invoke MEL 21-27-24-01 which requires aircraft to be released with Aft EE Cooling Exhaust Overboard (Skin Flush) Valve deactivated in closed condition. Departure AME deactivated the valve by opening & locking CB but did not ensure that the valve is in closed position by following 2nd & 3rd step of MEL maintenance procedures. Aircraft released after carrying out briefing for MEL. On starting engines, EQUIP OVBD VLV AFT EICAS advisory came which substantiated that the Aft EE Cooling Exhaust Overboard (Skin Flush) Valve was not in closed position, however, crew continued taxi operations being unaware about the EICAS advisory. The EICAS advisory again displayed while lining up on runway 29, but crew disregarded the same for lack of correct MEL understanding and awareness on Aft EE Cooling system. Appropriate NNC was not referred by crew at this time as required by approved MEL Preamble para 2.1.1.1. The cabin altitude started climbing as soon as the aircraft started climbing. During climb again crew observed EQUIP OVBD VLV AFT EICAS advisory. While analysing the situation they noticed that the cabin altitude was higher than normal and

cabin altitude was climbing. The NNC for EQUIP OVBD VLV AFT EICAS advisory was started and aircraft levelled at 22000ft in coordination with ATC. Subsequently, master caution for CABIN ALTITUDE AUTO was generated on putting both outflow valves to manual as per NNC. The outflow valves were open marginally but on observing high rate of cabin altitude both the outflow valves were closed again. The cabin air was being leaked through the open Aft EE Cooling Exhaust Overboard (Skin Flush) Valve and the cabin altitude was rising continuously. The cabin altitude could not be controlled and became excessive followed by master warning for CABIN ALTITUDE. Crew immediately started descent with permission of ATC as per the NNC of CABIN ALTITUDE. All the NNC actions for CABIN ALTITUDE EICAS including deployment of passenger oxygen masks were completed and the cabin altitude came within limit at pressure altitude of 10001ft. During the flight, the aircraft could not be pressurized due to open Aft EE Cooling Exhaust Overboard (Skin Flush) Valve. The cabin air caused failure to the smoke detector and exhaust fan located on the flow path while being leaked through the open valve.

3. CONCLUSION:

3.1 Findings:

- Airworthiness Review Certificate of the aircraft was valid up to 07/04/2019. Take-off weight, landing weight and Centre of Gravity were found within limits.
- Both crew members had valid licenses while operating incident flight. Medical fitness & FDTL was not a factor to this incident.
- The defect reported on 21/02/2019 & 22/02/2019 and its rectification was not a contributory factor to the incident.
- No abnormality was observed during preflight external checks by the crew. PIC observed EICAS status message of EQUIP OVBD VLV AFT while carrying out cockpit preparation procedures.
- Departure AME followed only 1st step of MEL 21-27-24-01 maintenance procedures, however 2nd and 3rd step were not carried out. The Aft EE Cooling Exhaust Overboard (Skin Flush) Valve was electrically deactivated but not in desired position (closed) before dispatch as required by MEL 21-27-24-01. The claim of departure AME that the valve was in closed position while invoking MEL could not be justified.
- The non adherence to the DDG maintenance procedures while invoking MEL 21-27-24-01 resulted in releasing the aircraft to service in an unairworthy condition. The aircraft could not be pressurized due to open Aft EE Cooling Exhaust Overboard (Skin Flush) Valve.
- Departure AME was probably under the time pressure while carrying out fault isolation/ MEL invoking as he arrived at aircraft just about five minutes before

STD which could have contributed in releasing the aircraft without ensuring the complete procedures as required by MEL.

- The content and veracity of MEL briefing/ discussions between Departure AME and crew could not be ascertained during an investigation due lack of evidences.
- After engine start EQUIP OVBD VLV AFT advisory message came on EICAS however crew continued to taxi as they did not notice the same. Crew did not check for presence of EQUIP OVBD VLV AFT advisory message after engine start as required by operations note of MEL 21-27-24-01.
- While lining up on runway 29, EQUIP OVBD VLV AFT advisory message came again on EICAS which was disregarded by crew. Crew lacked correct understanding of MEL and awareness of the EE cooling system. Appropriate NNC was not referred by crew at this time as required by approved MEL Preamble para 2.1.1.1.
- Briefing/ discussion between the crew with regards to the operational consequences of the MEL was found to be deficient. Disregard with respect to MEL procedures was evident as they claimed to have discussed & noted MEL procedures however, their actions do not substantiate the same.
- Crew followed NNC for EICAS advisory message EQUIP OVBD VLV AFT, which was generated during climb, and EICAS CABIN ALTITUDE master warning.
- Normal standard procedures for all the phases of flight were carried out by cockpit crew as per FCOM.
- As per the report of the M/s Collins Aerospace, the Aft EE Cooling Exhaust Overboard (Skin Flush) valve was confirmed defective, i.e., outside of test limits for Door Closure flushness tests.
- The reason for the EQUIP OVBD VLV AFT advisory/ status messages and correlated maintenance message '21-22420- Aft EE Cooling Exhaust Overboard (Skin Flush) Valve position feedback has failed' was attributed to the defective Aft EE Cooling Exhaust Overboard (Skin Flush) valve. No abnormalities in wiring and Remote Data Concentrator 07 were observed and the defect did not repeat after replacement of the valve.
- The maintenance message '21-22440- Aft EE Cooling Exhaust Overboard (Skin Flush) Valve 28VDC power has failed' was generated as the valve was electrically deactivated as per MEL 21-27-24-01.
- Generation of master caution and CABIN ALTITUDE AUTO was attributed to the crew action as per NNC of EQUIP OVBD VLV AFT.
- Generation of master warning and CABIN ALTITUDE was attributed to the excessive cabin altitude occurred due to loss of pressurization caused by open Aft EE Cooling Exhaust Overboard (Skin Flush) Valve.
- EICAS status messages EQUIP CLG SMOKE DET AFT 1 and EQUIP EXHAUST FAN AFT were consequential.

3.2 Causes:

Non adherence to the maintenance procedure by departure AME while invoking MEL 21-27-24-01 and disregard of the said MEL procedure by the cockpit crew resulted in pressurization failure during flight. Lack of awareness of the EE cooling system by cockpit crew was the contributory factor.

4. SAFETY RECOMMENDATIONS:

- Action as deemed fit by DGCA Hqrs on both cockpit crew members and departure AME in view of the above findings.
- Operator may be advised to develop suitable procedures containing the scope of MEL briefing between AME and cockpit crew while releasing the aircraft under MEL.

PATHIK MAHESHBHAI VAGHELA

Digitally signed by PATHIK MAHESHBHAI VAGHELA
Date: 2021.12.01 16:30:07 +05'30'

(Pathik Vaghela)
Investigator-In-Charge, VT- ANU

Date: 01/12/2021
Place: Mumbai

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